Paving the Way for Green Hydrogen in Advancing Circular Economy: Stakeholder Management for Capacity Building and Strategic Communications for Advocacy

APEC Policy Partnership on Science, Technology and Innovation

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Asia-Pacific
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ABREVIATIONS

APEC - Asia-Pacific Economic Cooperation

BAU - Business-As-Usual

CAPE - Centre for Advanced and Professional Education

CCUS - Carbon Capture, Utilization, and Storage

CE – Circular Economy

CEPA - Communication Education Plan Awareness

CO2 – Carbon Dioxide

EE – Energy Efficiency

ET – Energy Transitions

EV – Electric Vehicle

FDIs - Foreign Direct Investments

FID - Final Investment Decision

GDP – Gross Domestic Product

GH2 - GH2

GHG – Greenhouse Gas

H2 – Hydrogen Gas

H2SS - Hydrogen Hybrid Energy Storage System

HCNG - Hydrogen-enriched Compressed Natural Gas

HETR - Hydrogen Economy and Technology Roadmap

HyPER - Hydrogen Paired Electric Racecar

IBR - Incentive-Based Regulation

IEA – International Energy Agency

IET - Institute of Engineering Thermophysics

ISB – Institute of Self-sustainable Building

kWh – Kilowatt-hour

LAC – Latin America and the Caribbean

LCOE - Levelized cost of energy

LCOH - levelized cost of hydrogen

MAAL - Malaysian Association of Applied Linguistics

MCH - Methylcyclohexane

MOSTI - Ministry of Science, Technology and Innovation

MWh – Megawatt-hour

NEP – National Energy Policy

NZE - Net Zero Emissions

O&M – Operation and Maintenance

OTEC - Ocean Thermal Energy Conversion

PV – Photovoltaic

RE – Renewable Energy

RTD – Roundtable Discussion

SEA – Southeast Asia

SEDC - Sarawak Energy Development Corporation

SME - Small and Medium-sized Enterprises

SMR - Steam Methane Reforming

STEM - Science, Technology, Engineering, and Math

TNB – Tenaga Nasional Berhad

TRL - Technological Readiness Level

UNI - Universidad Nacional de Ingeniería

USACH - Universidad de Santiago de Chile

UTP - Universiti Teknologi PETRONAS

WiGH – Women in GH2

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EXECUTIVE SUMMARY

Paving the Way for Green Hydrogen (GH2) in Advancing Circular Economy: Stakeholder Management for Capacity Building and Strategic Communications for Advocacy, is a project funded by APEC. The project is aligned to the call for NZE to advocate for clean energy. One of the signature activities of the project was capability building seminar and workshop, UTP-APEC GH2 Seminar. The seminar was a three-day event aimed at exploring the challenges and opportunities of exploiting GH2 as a key element in advancing the Circular Economy (CE). The seminar brought together distinguished speakers, content experts, and participants from Chile; China; Malaysia; Mexico; Peru; the Republic of the Philippines; the Russian Federation; Thailand; and Viet Nam. It served as an important platform for knowledge sharing, capacity building, and strategic communication for advocacy in the field of GH2.

The seminar highlighted the importance of GH2 as a clean, sustainable energy carrier and is also a useful commodity for various applications in industry & transportation with multiple benefits. It provides an alternative for various applications, contributes to global climate mitigation goals by reducing carbon emissions, creating new economic opportunities. Additionally, GH2 has the potential to help decarbonise "hard to decarbonise industries" for efforts to achieve NZE ambitions.

Overall, the UTP-APEC GH2 Seminar fostered meaningful discussions, knowledge sharing, and collaboration among experts and stakeholders. It laid the foundation for future regional collaborations on GH2, paving the way for a sustainable and low-carbon future. The seminar's outcomes and recommendations will contribute to the advancement of GH2 technologies and the CE initiatives in the APEC economies.

1.0 INTRODUCTION

1.1 Objectives of the Project

The objective of our project is to enhance capacity building on GH2 technologies, utilization, production, and value chain enhancement through advocacy to accelerate actionable strategic planning and advocacy recommendations. This objective was achieved through multiple approaches and activities that focused on knowledge exchange, best practices sharing, policy research, and network enhancement.

The aim was to exchange knowledge for capacity building by organizing seminars involving various stakeholders. The seminar served as a platform for sharing insights, experiences, and expertise on the imperatives for GH2. It facilitated collaborative learning to enhance understanding of the key factors and considerations in the development and utilization of GH2 by bringing together experts, technologists, scientists, academics, decision-makers, and other stakeholders,

The seminar was specifically dedicated to sharing best practices on thematic research group projects for the acceleration of GH2. Successful case studies were showcased including innovative approaches and practical strategies that have demonstrated effectiveness in advancing GH2 initiatives. By disseminating these best practices, we aimed to inspire and guide stakeholders to promote and implement GH2 projects.

Policy research is imperative in driving the technological innovations of the new energy vehicle ecosystem. Therefore, policy research was also undertaken to explore the effects of incentives on technological innovations within this ecosystem. The findings could provide valuable insights into the policy measures and frameworks that can effectively support and catalyse the development, adoption, and integration of GH2 technologies.

In order to ensure sustained progress and collaboration, we had prioritized the enhancement of the GH2 network within the APEC region. This network shall serve as a platform for continuous engagement, knowledge sharing, and collaboration among technologists, scientists, academics, decision-makers, and other stakeholders. By fostering a strong and interconnected network, we aim to leverage collective expertise, resources, and influence to further accelerate the development and deployment of GH2 technologies.

The project hence aimed to enhance capacity on GH2 technologies, production, and value chain enhancement through advocacy of acceleration. Through knowledge exchange, best practices sharing, policy research, and network enhancement, we will foster a collaborative environment that supports actionable strategic planning and recommendations for the advancement of GH2 within the APEC region. By leveraging the expertise and collective efforts of diverse stakeholders, we seek to drive tangible progress and contribute to a more sustainable and resilient energy future.

1.2 Relevance in the GH2 Sector

The relevance of the project in the GH2 sector is significant due to several key factors:

Global Momentum: GH2 has gained increased traction globally as a vital component of a net-zero future aspirations. Many economies and regions, including APEC economies, have recognized the potential of GH2 in reducing greenhouse gas (GHG) emissions and addressing climate change. The project aligns with this global momentum and focuses on enhancing capacity building and advocacy for GH2 within the APEC region.

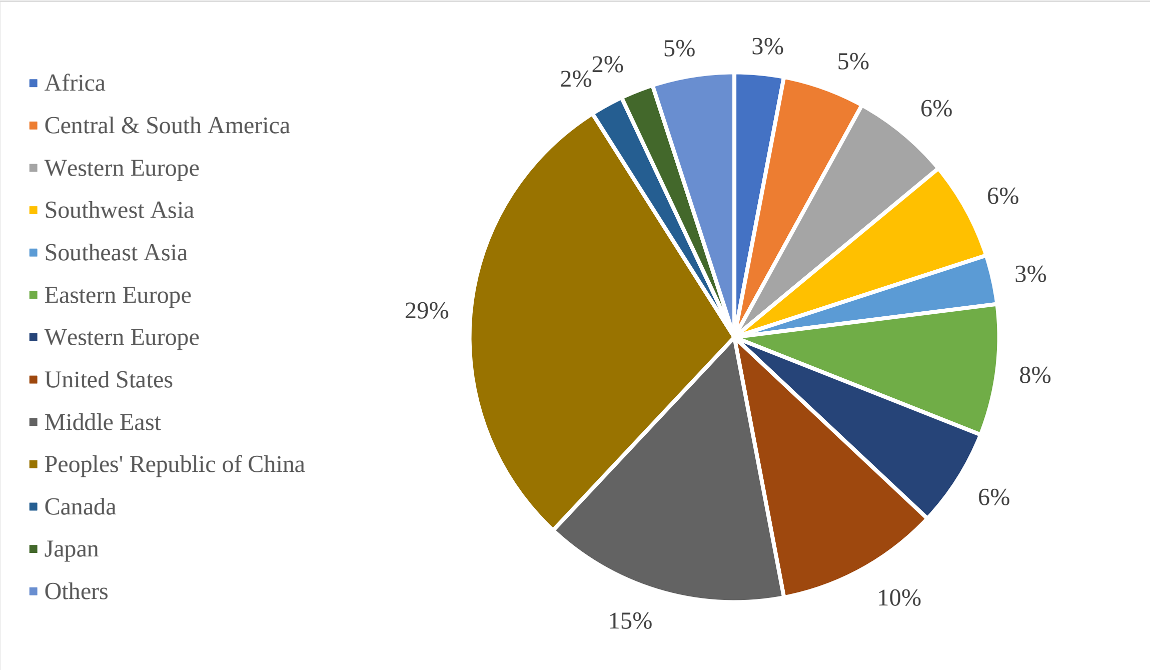


Figure 1: The forecast for 2021 is based on hydrogen demand growth in 2015-2018

Net-Zero Emissions Target: The United Nations' NZE target has set a clear objective for economies to transition to carbon neutrality. GH2, produced through a climate-neutral approach, offers a viable solution and technologies to reduce dependency on fossil fuels and achieve net-zero emissions.

CE and Sustainable Growth: The project recognizes that GH2 offers an opportunity to advance the CE and foster inclusive sustainable growth. By utilizing renewable energy (RE) sources to produce GH2, the project promotes the efficient use of resources and reduces environmental impacts. It also creates economic opportunities by establishing a new sector within the green economy, stimulating job creation and driving innovation.

Regional Focus and Collaboration: APEC economies encompass a diverse range of economies, including both developed and developing economies. The project's focus on capacity building and advocacy within the APEC region ensures that all economies, regardless of their current level of development, can benefit from and contribute to the GH2 sector. Source: IHS Markit, Rosatom State Corporation, ACTEK analysis.

In summary, the project's relevance in the GH2 sector lies in its alignment with global sustainability goals, its promotion of the CE and sustainable growth, its focus on the APEC region's diverse economies, and its potential to provide future affordable and abundant energy decarbonisation solutions. By advancing capacity and advocacy for GH2, the project contributes to the transition towards a cleaner and more sustainable, low carbon future.

1.2 Problem Statement

There is lack of policies and strategic roadmaps for the development of GH2 in the Asia-Pacific Economic Cooperation (APEC) region. While developed economies like Japan and Australia had set aggressive goals and strategies for the utilization of GH2, developing economies lagged behind in this regard. Malaysia has just launched its Green Hydrogen Roadmap in 2023. This poses a challenge in achieving the region's aggregate energy intensity reduction goal of 45% by 2035 and hinders the transition towards becoming net zero emissions (NZE) economies.

Without coordinated efforts and cross-fora collaboration, the advocacy and capacity building for GH2 lacks elaboration of sustained benefits and impact. It is essential to engage multiple stakeholders and establish structured communication channels to ensure effective advocacy and knowledge dissemination throughout the region.

Thus, the problem statement for this project was to address the lack of policies, strategic roadmaps, and stakeholder engagement for the development and adoption of GH2 in the APEC region, with the aim of supporting the region’s transition towards NZE economies and meeting international climate commitments.

2.0 RESEARCH WORK: GREEN HYDROGEN IN ADVANCING CIRCULAR ECONOMY

2.1 Pre-seminar survey document

The process of the Pre-Seminar Survey was conducted from February 2023 to May 2023. This section provides an overview of the research methodology employed in studying the production and utilization of GH2. The methodology was designed based on a developed research framework underpinned by Theory of Planned Behaviour (Figure 1), sampling from a comprehensive database and data collection. The objective of the survey was to gather relevant and reliable data to achieve the research objectives related to GH2.

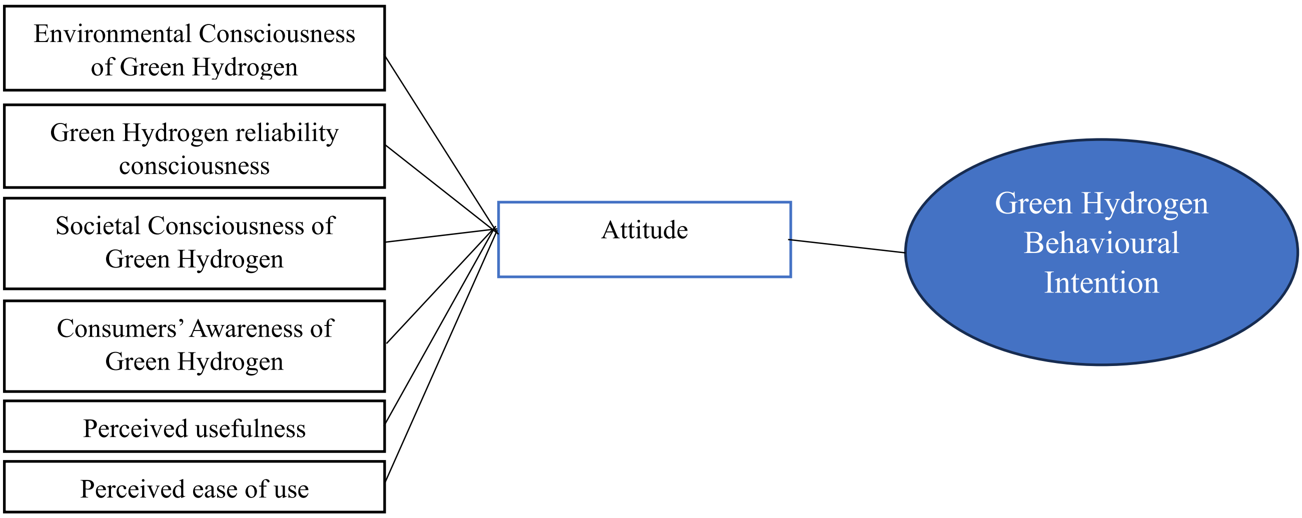


Figure 2.1: GH2 Framework adapted from Planned Behaviour Model

2.1.1 Questionnaire Design

A survey instrument was developed to address the objectives of the project. The questionnaire consisted of three (3) sections. Section A collected information on the respondents' socio-economic characteristics such as current working economy, gender, number of years in the hydrogen industry, hydrogen fuel usage, hydrogen industry that respondents were working in. Section B included several items to measure environmental consciousness of GH2, GH2 reliability consciousness, societal consciousness of GH2, consumers' awareness of GH2, perceived usefulness, perceived ease of use and attitude of the respondents towards behavioural intention of GH2. All the construct dimensions and measurement items were adapted from a comprehensive review of past research. Most of the items were not taken exactly as found in the existing literature. To confirm the objectives and desired outcomes, items were modified due to the different contexts of the research. Attention was given to ensuring clarity, consciousness, and relevance of the questions. Feedback loops and pilot testing were utilized to refine the survey instrument. In short, the complete survey document contained two parts:

Part 1. Respondents' profile: gender, experience in the hydrogen industry, hydrogen usage, and related hydrogen industry.

Part 2. Eight dimensions were included: perceived usefulness, perceived ease of use, environmental consciousness of GH2, GH2 reliability consciousness, societal consciousness of GH2, consumers' awareness of GH2, attitude and GH2 behavioural intention.

2.1.2 Sampling

Respondent Database Selection

A database was constructed to obtain a representative sample for the analyses. The database was carefully curated, focusing on individuals and organizations involved in GH2 research, development, and utilisation. The selection criteria consider factors such as expertise, industry affiliations, and geographical representation. This was to ensure a diverse and relevant pool of respondents for the study.

Reaching Respondents

Once the survey instrument had been finalized and the respondent database had been established, efforts were made to reach out to potential participants. Communication channels, including email, industry networks, and targeted online platforms, were utilized to engage with respondents. Personalized and informative messages were employed to encourage participation, highlighting the importance of their input in advancing the understanding of GH2.

2.1.3 Data Collection

Data Collection Platforms

Various data collection platforms were employed to gather information related to GH2. These included online platforms and direct interviews. The online platforms allowed for a wider reach and increased participation, while direct interviews provided in-depth insights from key stakeholders. Active engagement with industry experts and organizations involved in GH2 production and utilization ensured a comprehensive and up-to-date understanding of the field.

Procedure and Ethical Considerations

To ensure the accuracy and integrity of the data collected, a unique IP protocol was implemented as part of the data collection process. This protocol helped prevent double entries and ensured that each respondent was counted only once. By tracking and validating the IP addresses of the participants, duplicate submissions from the same individual were identified and eliminated.

Furthermore, the IP protocol also allowed for the validation of respondents' geolocation. Geolocation data provided valuable insights into the regional distribution and adoption of GH2 initiatives. By analysing the geolocation information, patterns and trends specific to different geographical areas could be identified, providing a comprehensive understanding of the global landscape of GH2 utilization.

The unique IP protocol not only safeguarded the data integrity but also enhanced the reliability and validity of the research findings. It allowed for an accurate representation of respondents from various locations, providing a well-rounded perspective on the global reach and impact of GH2 technologies.

Ethical considerations regarding privacy and data protection were strictly followed throughout the data collection process. Respondents' IP addresses and geolocation information were handled securely and in compliance with relevant data protection regulations to ensure confidentiality and anonymity. Throughout the research process, ethical considerations were given utmost importance. Participant anonymity, confidentiality, and informed consent were ensured. The research adhered to relevant ethical guidelines and regulations. Any potential risks or concerns were addressed, and the data was handled with strict confidentiality and privacy measures.

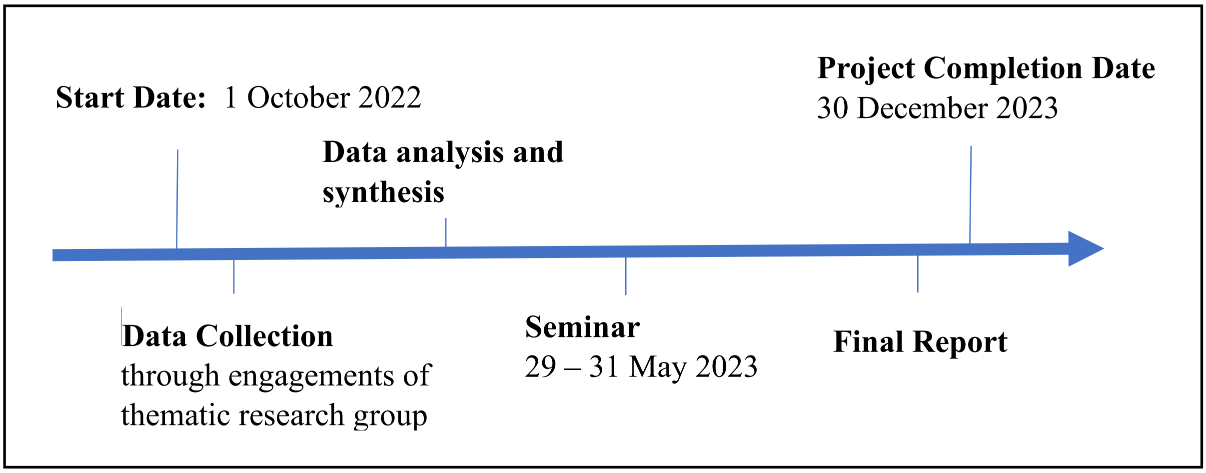


Figure 2.2: Project Timeline

2.2 The Findings

Demographic Profile of Respondents

We have successfully distributed 125 questionnaires among APEC economies and received a total of 120 completed questionnaires.

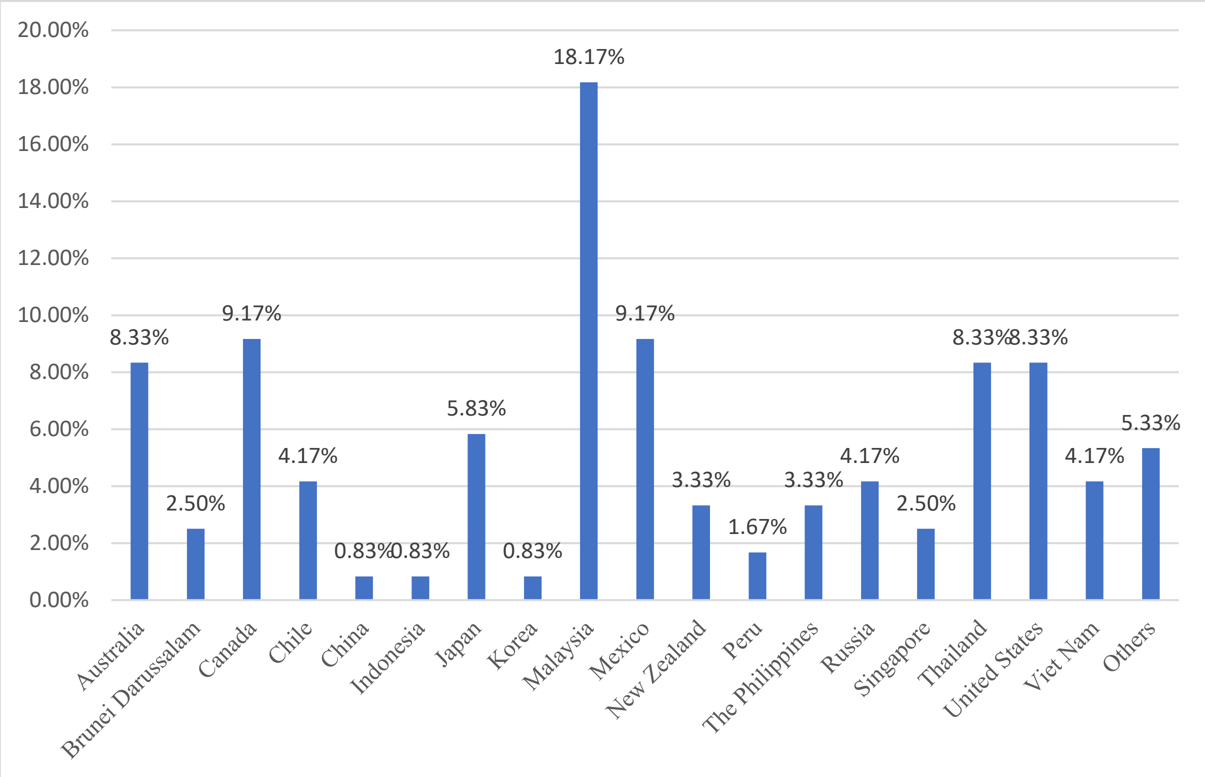


Figure 1 shows the tabulation data of the responding working economies - Malaysia (18.17%); Japan (5.83%); Canada (9.17%); USA (8.33%); Singapore (2.5%) and Australia (8.33%).

Table 1 shows that male respondents constitute 78% while female 22%. Approximately half of the respondents (51%) have experience in the hydrogen industries even though only 39% have used hydrogen fuel. Majority of the respondents indicate they are in the transportation (land and marine), related to hydrogen utilisation (34.2%), followed by energy (21.7%) and manufacturing (17%). Most of the respondents work in SMEs (35.8%) and private corporations (33.3%) and only 2.5% from other industries.

Table 1: Tabulation data of demographic characteristics of 120 respondents

Characteristics		***Frequency***	***Percentage (%)***
Gender	Male	78	78
	Female	12	22
No. of years in hydrogen industries	0-5 years	61	51
	5-10 years	38	31.67
	10-20 years	9	7.5
	More than 20 years	1	0.83
	No experience	11	9.17
Have you ever used hydrogen fuel?	Yes	47	39
	No	73	61
Hydrogen industry related to you.	Mining	6	5
	Marine-Logistic/storage	11	9.17
	Manufacturing	17	14.17
	Land-Logistic/storage	30	25
	Energy	26	21.67
	Agriculture	10	8.33
	Aerospace	9	7.5
	Others	11	9.17
Which work industry are you at the moment?	Small and medium enterprise	43	35.83
	Private corporation	40	33.3
	NGO/Non-profit organization	6	5
	Government/Public Servant	12	10
	Education institution/university	16	13.3

	Others	3	2.5

More than half of the respondents (51%) have experience in the hydrogen industries.

GH2 Behavioural Intention among APEC Economies

Section 2.2.2 discusses on GH2 behavioural intention among APEC Economies through a few determinants and the key insights are summarised as follows:

2.2.1 Descriptive Analysis

Seven (7) determinants were analysed through descriptive analysis (total average mean score). The findings indicate that Perceived Ease of Use receives the lowest score with the average mean score of 3.15. Individuals who were environmentally concerned, have a positive attitude towards RE, and perceived benefits such as reducing carbon emissions, to support and adopt GH2 technologies. Encouraging behavioural intention towards GH2 can accelerate the transition to a more sustainable and low-carbon future. The details of the findings are reflected in the diagram below.

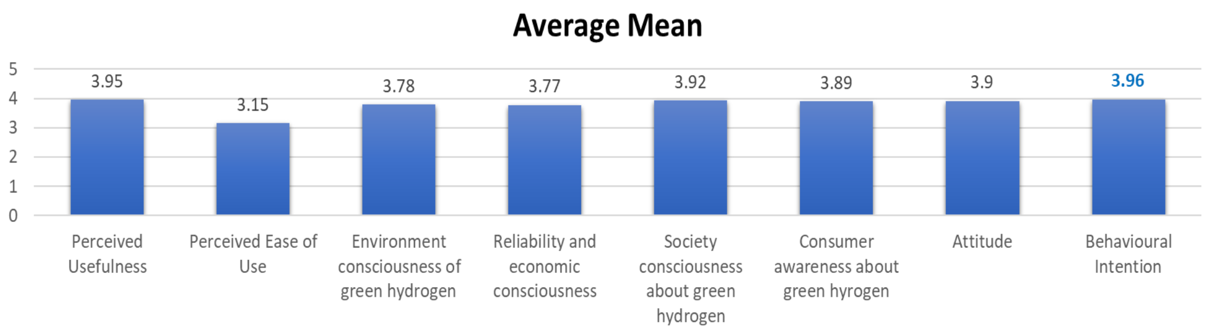


Figure 2.4: Average Mean Score for each Determinant

Key Highlights

i. Behavioral Intention shows the highest mean score among all variables which is 3.96.
ii. Perceived Usefulness, Society Consciousness and Consumer Awareness of GH are top 3 significant predictors of the GH Attitude which subsequently lead to Behavioral Intention.
iii. Encouraging behavioral intention towards green hydrogen can accelerate the transition to a more sustainable and low-carbon future.

2.2.2 Impact of Determinants on GH2 Behavioural Intention

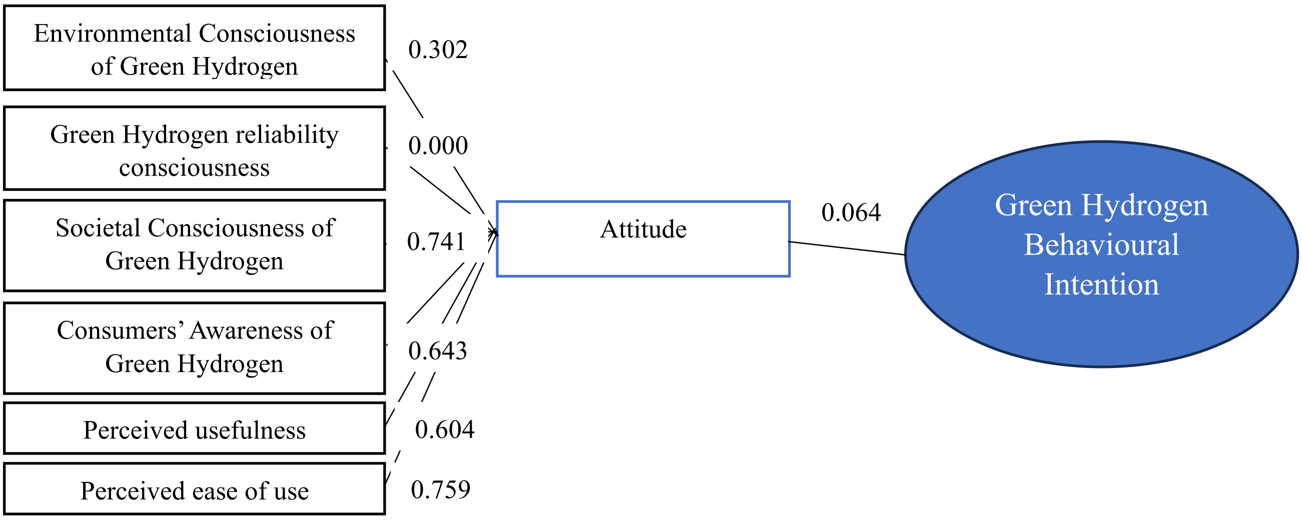


Figure 2.5: The impact and significance value of determinants toward GH2 Behavioural Intention

Key Highlights:

Important factors of GH2 adoption:

i. Perceived Usefulness
ii. Societal Consciousness
iii. Consumer Awareness

To build the GH behavioral intention, we need to prioritize the focus on perceived usefulness, societal consciousness, consumers' awareness and attitude towards Green Hydrogen adoption.

Overall, the determinants such as GH2 reliability consciousness, society consciousness of GH2 and attitude had an observable effect of increasing GH2 behavioural intention and adoption among consumers. The analysis found that these determinants gave an impact value of **34.4%** towards GH2 behavioural intention and adoption. Thus, it should be noted that there is room for improvement in enhancing the adoption in the future.

2.2.3 Qualitative - Interview Findings

The interview had been done online and the questions include:

i. Tell me about yourself.
ii. How do you see the future of green hydrogen in your economy?
iii. Do you think the public is aware of green hydrogen and its benefits?
iv. What are possible constraints to the adoption of green hydrogen in APEC economies generally and in your economy particularly? How the constraints can be minimized?
v. Are APEC economies doing enough to promote green hydrogen? If not, where are they lacking and how can they overcome the challenges?
vi. How educational institutions can play a role in the promotion, implementation, and consumption of green hydrogen?
vii. What are the (three) best possible factors/policy matters that you think are important for green hydrogen in your economy and APEC economies?

In the interview, interviewees stated that they see the use of GH will increase in future.

Person 1: "There is a lot of need especially in Viet Nam for green hydrogens in petrochemical fields. So yeah in short across it will play an important role in the energy mix here in the future."

Person 2: "If you produce hydrogen, you could export it. It's becoming a source of energy that can be transported to neighboring economies."

Person 3: *"We have land in a few places which is suitable to do solar power because then some of this land is even remote if it is close to the note of transmission line, we can do this, we have PPA."*

In the interview, interviewees stated that the public is aware of GH and its benefits but is still reluctant to adopt it in life due to its high cost and limited infrastructure.

Person 1: "Generally, they're still a big population that needed some education or briefing on this because this is something that is very important for our future, in the sense that we have to go green."

Person 2: "In the Power circle Here, people are quite aware. In academics, they conduct research on GH. The public opinion is quite positive but has some doubt of its application due to current price.*"*

Person 3: "To be honest, I think it's very limited information to the public."

In the interview, interviewees stated most consumers are still reluctant to adopt it in life due to its high cost & limited infrastructure. They suggested that the government should play a role to boost adoption by giving incentives to users.

Person 2: "There are four things that I think could be constrained: price, infrastructure, no actual pipeline and supply chain."

In the interview, interviewees stated educational institutions need to promote GH to the young generation so that they know its importance in the future.

Person 1 & 2: "I think education is important. We must educate them from primary school."

Person 3: "Absolutely important, but they need to get universities involved. I think every economy should have a dedicated university that can look at it from all the data that's available."

In the interview, interviewees stated not enough promotions from APEC economies. Hence, need to take the initiative to promote and give awareness to the public.

Person 1: "I don't think they are but of course, China is coming, very fast on this. That is something that the public has to know, and then I think if they basically know about this, they were sort of supporting the generation of hydrogen, the deliverance of hydrogen."

Person 2: "And we need to have more, more research, more feasibility studies. And then highlight projects. Government incentive either in a way of tax in, you know, some other incentive to promote the use of new technologies."

In the interview, interviewees stated education and incentive as an important factors of GH adoption.

Person 1: "I think the first one is education, you make people understand nature. We have a new way of producing green hydrogen and a cheap price."

Person 2: "The private sector will always have my motivation to adopt new technology. As long as they can see some financial incentive."

Person 3: "Make the link between the private industry and ministries involved plus the financial world because any technology will require funding."

2.3 Discussion

2.3.1.1 Key Insights on GH2 adoption

i. There is a need to advocate for **perceived usefulness,** in order to increase **societal consciousness, consumers' awareness and attitude towards GH2 utilization.** Such advocacy is imperative to build the GH2 behavioral intention.

ii. Behavioral Intention shows the highest mean score among all variables which is 3.96.

iii. Perceived Usefulness, Society Consciousness and Consumer Awareness of GH2 are top 3 significant predictors of the GH2 Attitude which subsequently lead to Behavioural Intention.

iv. Encouraging behavioural intention towards GH2 can accelerate the transition to a more sustainable and low-carbon future.

2.3.1.2 Indicators for GH2 Adoption

Quantitative and Qualitative findings were consistent in finding consumer/public awareness as one of the important factors for building attitude and behavioral intention of the consumers towards GH2. The findings also revealed Perceived Usefulness and Societal Consciousness as important contributors towards building attitude and behavioral intention of the consumers towards GH2.

The current landscape of GH2 faces several significant challenges that need to be addressed for its widespread adoption and success. One of the foremost issues is the lack of comprehensive knowledge regarding the optimum design and return on investment, which, in turn, limits the bankability of GH2 projects. This uncertainty can deter potential investors and hinder the growth of the sector.

Another hurdle is the shortage of a specialized workforce with the expertise required for GH2 production. Coupled with high operational costs, this scarcity of skilled professionals can drive up project expenses and create additional barriers to entry for many stakeholders.

Furthermore, energy losses during the production and utilization of GH2 pose a substantial challenge. These losses reduce the overall efficiency of the process and can impact the economic viability of GH2 as an energy source.

Addressing these challenges is critical to unlock the potential of GH2 as a sustainable energy solution. Additionally, understanding the dynamics of GH2 off-takers and the value they bring to the market is essential for fostering its growth and ensuring that it becomes an integral part of the clean energy.

2.3.2 Way forward for promoting the adoption of GH2

2.3.2.1 Key Factors

Education, Government incentives, Industry-Government collaboration and funding are some of the key factors that require attention to embark on GH2 in APEC economies.

2.3.2.2 Capacity Building Programs

Frequent seminars, talks and colloquiums are required at micro, meso and macro level to create awareness of GH2 in Southeast Asian economies.

2.3.2.3 Sectorial Importance

Private sector has fast potential for adopting new technology. There is need to develop their motivations by providing incentives and other support.

2.3 Changing the Lens

Mostly the world is still looking at GH2 implementation from Goods-Dominant Logic. It creates a divide between the entity creating value and the entity seeking that value. It leaves the manufacturer to determine value before the market gets it. The manufacturers are focusing much on tangible value. There is a need to look at the GH2 from Service-Dominant Logic perspective to ensure end user is involved at the definition, design and development stage. This will help to get buy-in from customers even before the deployment of solutions.

2.3.4 Redefining Supply Chain Model

Another possible reason is the Linear Supply Chain Model. A Co-Creative Value Chain model can help in market acceptance, consumer adoption and sustainable value creation.

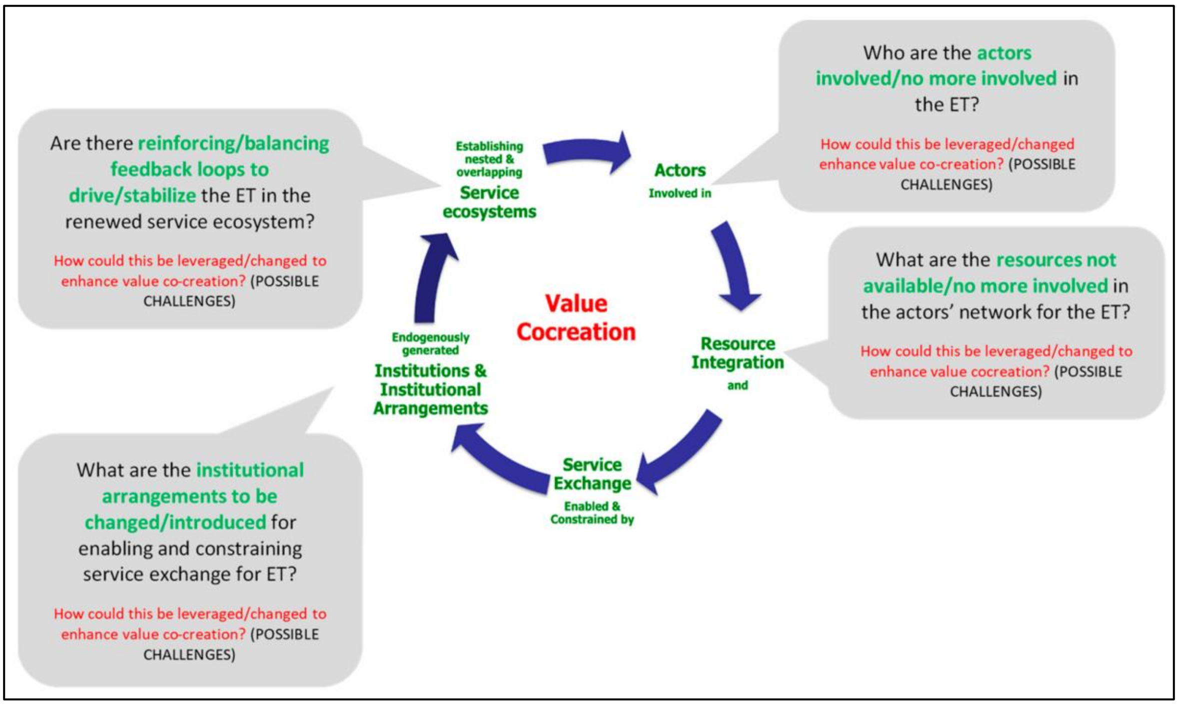


Figure 2.6: Co-Creative Value Chain model

2.3.5 Initiatives Required

The initiatives in APEC economies need further strengthening for GH2 implementation and adoption. There is a need for more research, feasibility studies, support and capacity building to flourish GH2 adoption.

3.0 THREE DAY SEMINAR

3.1 About the Seminar

The following report provides a comprehensive overview of the 3-day seminar on Green Hydrogen organized by Institute of Self-sustainable building (ISB) Universiti Teknologi PETRONAS (UTP) at the Centre for Advanced and Professional Education (CAPE) in Kuala Lumpur, Malaysia. The seminar, held from 29 - 31 May 2023, aimed to facilitate knowledge-sharing and discussions on strategies and best practice's role of GH2 in the economies of the Asia-Pacific Economic Cooperation (APEC) region.

The seminar comprised of various sessions, including sharing sessions on strategies and best practices for GH2 use acceleration, knowledge-sharing for capacity building with stakeholders, thematic research group studies, and engaging forums and discussions. The event brought together prominent experts, industry leaders, academics, and policymakers to explore ideas, share insights, and advocate for the adoption of GH2 across APEC economies.

3.2 Objectives

The objectives of the seminar were threefold. First, it aimed to facilitate a sharing session on strategies and best practices for accelerating the adoption of GH2. Through interactive discussions and presentations, participants gained valuable insights into the technologies, policies, and market dynamics associated with GH2.

Second, the seminar provided a platform for knowledge-sharing with various stakeholders on the importance for GH2 in the APEC economies region. By fostering intellectual discourse and engagement, participants gained a comprehensive understanding of the socio-economic and environmental benefits of GH2 and its potential to drive sustainable growth.

Lastly, the seminar included a focus thematic research group study involving major stakeholders. This study sought to gather ideas and views on themes and best practices to be adopted in the proposed advocacy report to governance and policy makers of GH2 in APEC economies. By harnessing the collective expertise and experiences of participants, the seminar aimed to develop actionable recommendations for promoting GH2 in the region.

3.3 Tentative of The Seminar

The first day of the seminar commenced on the morning of 29 May 2023 with an opening session that set the stage for the days ahead. Professor Ts. Dr. Mohamed Ibrahim Bin Abdul Mutalib, the Vice Chancellor of UTP, delivered a welcoming speech, setting a positive tone and emphasizing the importance of the seminar. This was followed by an opening speech from YBhg. Datuk Ts. Dr. Hj. Aminuddin Bin Hassim, the Secretary General of MOSTI, who highlighted the significance of GH2 in the context of the APEC economies. A video presentation on GH2 was shown, providing a visual introduction to the topic and highlighting its potential and role in sustainable energy systems. Associate Professor Ts. Dr. Shahrina Md Nordin, the Project Overseer and Director of the Institute of Self-Sustainable Building at UTP, then delivered a speech, providing an overview of the seminar's objectives and the importance of engaging various stakeholders in the pursuit of GH2 advocacy.

Following the opening session, the seminar dived into its first speaker session with Mr. Denish Deryushkin, who shed light on the role of hydrogen in the energy transition. Strategies and policies related to the adoption of GH2 were discussed, providing attendees with valuable insights into the current state and future prospects of this clean energy carrier and its use in varied industrial applications.

The second speaker in this session, presented by Ms. Bui Thi Hong Van, focused on the inclusion of GH2 in the global energy mix. Attendees gained a comprehensive understanding of how GH2 can contribute to a more sustainable and diversified low carbon portfolio at the international level.

After a lunch break, a stimulating forum on developing and growing hydrogen value propositions commenced. Moderated by Professor Shameem Rafik Galea, President of the Malaysian Association of Applied Linguistics (MAAL), the forum featured Mr. Denis Deryushkin and Ms. Bui Thi Hong Van as speakers. The forum explored strategies and opportunities for leveraging GH2 to create value and drive sustainable growth in various sectors.

On the second day of the seminar, the focus shifted to two compelling speaker sessions. Prof Ricardo Vega Viveros delved into the topic of GH2 as the fuel of the future, enlightening attendees on its vast potential and the transformative impact it can have on a low carbon future. Additionally, Prof Rocio Salas provided perspectives on women leaders in the energy sector and their contributions to the advancement of GH2.

The afternoon session was dedicated to a forum on creating a regional roadmap to meet the targets for clean, affordable energy by 2030, with the ultimate goal of achieving net-zero emissions by 2050. Prof Ricardo Vega Viveros and Prof Rocio Salas once again shared their expertise, while Professor Shameem Rafik Galea moderated the discussion. This forum encouraged participants to exchange ideas and develop actionable strategies to drive the adoption of GH2 in the region.

The final day of the seminar began with a sharing session by Dr. Amjad Shamim, a senior lecturer at UTP, who presented the findings of his research work. This session offered an opportunity for attendees to delve deeper into specific aspects of GH2 and gain insights from the latest research.

The subsequent speaker session, presented by Professor Ir Dr Haslenda Hashim FASc, explored the potential of GH2 and CO2 methanation for decarbonizing industries. Attendees discovered innovative approaches to reducing carbon emissions and promoting sustainability within the industrial sector.

Dr. Rezal Khairi Ahmad then took the stage to discuss the mastery of green and clean hydrogen, shedding light on the technological advancements and best practices that can accelerate the widespread adoption of this clean energy carrier.

The seminar concluded with two engaging roundtable discussions. The first discussion focused on the aspirations surrounding GH2 in APEC economies, where participants explored best practices, key success factors, and the challenges involved in its implementation. The second roundtable discussion revolved around GH2 as the fuel of the future, with participants brainstorming key strategies across multiple sectors to drive its adoption and maximize its appropriately scaled commercial potential, especially before the expected global target of 2030.

Finally, the Project Overseer delivered the closing remarks, summarizing the key takeaways from the seminar and expressing gratitude to all participants for their active engagement and valuable contributions.

Overall, the seminar was an intellectually stimulating and collaborative event, providing a platform for stakeholders to exchange ideas, share knowledge, and contribute to the advocacy for the acceleration of GH2 utilization in the APEC economies. The comprehensive program, featuring esteemed speakers, interactive forums, and insightful discussions, enabled participants to gain a deeper understanding of GH2 role in a sustainable, low carbon future.

3.4 Speakers summary presentation

The speakers invited are as follows:

Speaker 1: **Mr. Denis Deryushkin** (Head of Russian National Hydrogen Union, Russia)

Speaker 2: **Ms. Bui Thi Hong Van** (Managing Director of Angelin Energy, Viet Nam)

Speaker 3: **Prof Ricardo Vega Viveros** (Professor at Universidad de Santiago de Chile (USACH)

Speaker 4: **Prof Rocio Salas** (Professor at Universidad Nacional de Ingeniería (UNI) Peru)

Speaker 5: **Professor Ir Dr Haslenda Hashim FASc**
(Professor Chemical Engineering/Chair Resource Sustainability Research Alliance, Universiti Teknologi Malaysia)

Speaker 6: **Dr Rezal Khairi Ahmad** (Chief Executive Officer, NanoMalaysia Berhad)

3.4.1 Speaker 1

- **Mr. Denis Deryushkin**
  Head of Russian National Hydrogen Union, The Russian Federation

3.4.1.0 Summary of presentation:

In his presentation titled "**The Role of Hydrogen in Energy Transition: Strategies and Policies**," Mr. Denis highlighted the following key points:

3.4.1.1 Part 1: Introduction and Information about the Low-Carbon Hydrogen Industry

- Hydrogen plays a crucial role in the global economy.
- Major hydrogen-consuming sectors include oil refining, ammonia production, methanol production, and metallurgy.
- Steam methane reforming (SMR) is currently the primary industrial process for hydrogen production, but it has a high carbon intensity, contributing to global GHG emissions.
- Currently, hydrogen is primarily used as a feedstock or reagent in various industries, but it is emerging as a promising low-carbon energy carrier for the future.

3.4.1.2 Part 2: Hydrogen Value Chain and Factors for Accelerated Development

- Hydrogen can be produced using various technologies, and the cost and carbon footprint depend on the technology employed.
- Decarbonization efforts by major economies rely on GH2 usage.
- The development of GH2 is hindered by high costs, moderate levels of technological advancement, and safety concerns.
- Reducing technology costs is crucial for the advancement of GH2 use.

3.4.1.3 Part 3: Standardization and Certification

- Standardization and certification play vital roles in establishing a reliable and consistent hydrogen market.
- Implementing standards ensures safety, interoperability, and harmonization across the hydrogen value chain.
- Certifications help build trust and facilitate international trade in hydrogen-related technologies and products.

3.4.1.4 Part 4: Key Areas of International Cooperation

- International cooperation is crucial for the development of GH2.
- Collaboration among economies can help accelerate research, development, and deployment of GH2 technologies.
- Areas of cooperation may include knowledge sharing, joint research projects, policy harmonization, and infrastructure development.

Mr. Denis emphasized the importance of hydrogen in the energy transition, its potential applications across various sectors, the need for cost reduction and safety improvements, and the significance of international cooperation for the advancement of GH2 utilization.

3.4.2 Speaker 2

- **Ms. Bui Thi Hong Van**

  Managing Director of Angelin Energy, Viet Nam

3.4.2.0 Summary of presentation:

In her presentation titled **" GH2 Inclusion in Global Energy Mix"** Ms. Hong Van discussed the following key points:

3.4.2.1 Part 1: Hydrogen in Global Energy Mix

- Low-emission hydrogen accounted for less than 1% of global hydrogen production in 2021.
- The shift away from fossil fuels globally, driven by net-zero pledges, is leading to an increased focus on electricity, renewables, and hydrogen in the energy mix.
- The share of electricity in the global energy mix is projected to rise from 20% to 30% by 2050.

3.4.2.2 Part 2: Production and Demand

- By-product hydrogen, mainly from refineries, accounted for 21% of global hydrogen production.
- Various technology options exist for low-carbon hydrogen production, including electrolysis, fossil fuels with carbon capture, utilization, and storage (CCUS), and bioenergy.
- However, these technologies currently represent small shares of global hydrogen production.
- Electrolysis and fossil fuel and CCUS hydrogen production are projected to increase in the coming years according to different scenarios.

3.4.2.3 Part 3: Investment

- Global annual hydrogen investment needs are growing, but investment decisions are lagging behind.
- Over 1,000 hydrogen project proposals have been announced globally, with 795 planning deployment by 2030.

- USD 320 billion in direct investments into hydrogen projects have been announced through 2030, with USD 29 billion having passed the final investment decision (FID).
- Clean hydrogen supply capacity is steadily increasing, but it still represents less than 1% of the current gray hydrogen market.
- Electrolysis capacity and hydrogen refueling stations are being deployed globally, driven by strong policy signals and support schemes.

3.4.2.4 Part 4: Trade Route & Transportation

- Different hydrogen carriers such as liquid hydrogen, liquid ammonia, MCH, and methanol have advantages and challenges.
- Hydrogen offers high purity and is carbon-free, but it has challenges such as flammability, low-temperature liquefaction requirements, and the need for further infrastructure development.
- Each hydrogen carrier has its own set of advantages and challenges for trade and transportation.

3.4.2.5 Conclusion:

- Deployment of GH2 is steadily growing across the value chain, but acceleration is needed to meet net-zero goals.
- Technology plays a significant role in hydrogen development and the overall energy transition.

Ms. Hong Van highlighted the current state of GH2 in the global energy mix, the challenges and opportunities in production and demand, the investment landscape, and the trade and transportation aspects of hydrogen carriers. She emphasized the need for accelerated deployment and the importance of technology in driving the development of hydrogen and the energy transition.

3.4.3 Speaker 3

- **Prof Ricardo Vega Viveros**
  Professor at Universidad de Santiago de Chile (USACH)

3.4.3.0 Summary of presentation:

In his presentation titled "**GH2: The Fuel of the Future**" Prof. Ricardo Vega Viveros highlighted the following key points:

3.4.3.1 Environment:

- Fossil fuels (coal, oil, and natural gas) currently account for 80% of the energy consumed globally.
- Human activity, including energy production, industry, agriculture, and others, contributes to carbon emissions and the carbon footprint.
- The combustion of fossil fuels leads to air pollution and global warming.

3.4.3.2 Global Perspective:

- Hydrogen is emerging as a green energy alternative due to concerns about future energy shortages, price increases, and the depletion of fossil resources.
- The global asymmetry in fossil resource availability leads to conflicts and social inequality.
- Hydrogen is seen as a potentially competitive and sustainable energy source.

3.4.3.3 Productivity of H2 Generation and Comparative Advantages:

- Chile, in particular, offers advantages in terms of the supply and demand dynamics for hydrogen generation.
- Scales and economies of scale play a crucial role in achieving competitive advantages in hydrogen production.
- It is the economy responsibility to embrace and promote the use of hydrogen as an energy source.

3.4.3.4 H2 in Mining and Mobility:

- Hydrogen can play a significant role in the mining sector and transportation, offering clean and sustainable solutions.

- Electrolysis, a fundamental process in hydrogen production, is essential in integrating hydrogen into these industries.
- Appropriate electrolysis technologies, utilizing water and electricity, are key in enabling industrial integration.

3.4.3.5 Hydrogen as the Fuel of the Future:

- The transition to hydrogen requires considerations about the future of society and the environment.
- As fossil fuel resources become scarcer and prices increase, hydrogen emerges as a potentially competitive and sustainable energy alternative.
- The global challenges associated with fossil fuel dependency and the environmental impact make hydrogen a democratic energy solution.

Prof. Ricardo Vega Viveros emphasized the need to shift towards hydrogen as the fuel of the future, highlighting its potential to address concerns about energy shortages, price increases, environmental impact, and global conflicts arising from fossil fuel dependency. The presentation stressed the importance of productivity, comparative advantages, and the responsible integration of hydrogen into various sectors for a sustainable and democratic energy future.

3.4.4 Speaker 4

- **Prof Rocio Salas**

  Professor at Universidad Nacional de Ingeniería (UNI) Peru

  Project Manager, Women in GH2

3.4.4.0 Summary of presentation:

In her presentation on "**Women Leaders in the Energy Sector: Perspectives on GH2**" Prof. Rocio Salas highlighted the following key points:

3.4.4.1 Success Factors in the LAC Region:

- The global energy transition is promoting the decarbonization of the energy, industrial, and transport sectors.
- Hydrogen can play a vital role in decarbonizing industries where electrification is not feasible.
- Hydrogen offers a unified ecosystem, linking electric power, gas, transport, and industry.
- The availability of low-cost RE and rising natural gas prices favor the production of GH2.
- The GH2 industry creates new job opportunities, bringing together professionals from different sectors.

3.4.4.2 Women in Management Roles:

- Research suggests that diverse teams, including women in leadership positions, lead to higher profitability and better decision-making.
- Companies with women in senior management roles outperform their peers in terms of return on equity and earnings risk.
- The energy sector's transformation towards the GH2 economy requires a change in the business model and values the contributions women can make.

3.4.4.3 Perspectives on GH2:

- The RE sector has a higher percentage of women employed compared to the oil and gas sector.
- RE has the potential to be an equal employer, but more work is needed to increase women's participation across all energy sectors.
- The energy sector is expected to create 122 million jobs by 2050, with renewables accounting for 43 million of those jobs.
- Despite efforts to improve gender diversity, women's representation in senior management roles at energy firms remains low.

3.4.4.4 Promoting Diversity in GH2:

- Initiatives are needed to improve women's access to information and participation in STEM programs.
- Universities can promote diversity by encouraging female participation in STEM sectors from school to professional life.
- Women in GH2 (WiGH) is a network that aims to connect, empower, and amplify the voices of women working in the GH2 sector.
- Mentoring programs can support and empower young women in the early stages of their careers in the GH2 sector.
- Events and knowledge-sharing platforms can foster knowledge exchange and professional opportunities for women in GH2.

Prof. Rocio Salas emphasized the importance of promoting diversity and equality in the energy sector, specifically in the context of the GH2 economy. She highlighted the need for initiatives, mentorship programs, and networks to empower women and increase their representation in leadership roles. By leveraging the potential of women in the field, the energy industry can benefit from diverse perspectives and contribute to a more inclusive and sustainable future.

3.4.5 Speaker 5

- **Professor Ir Dr Haslenda Hashim FASc**
  Professor Chemical Engineering/Chair Resource Sustainability Research Alliance
  Faculty of Engineering, Universiti Teknologi Malaysia.

3.4.5.1 Malaysia Energy Transition:

Malaysia aims to achieve carbon neutrality by 2050, with plans to increase RE capacity in the power sector to 31% by 2025 and 40% by 2035.

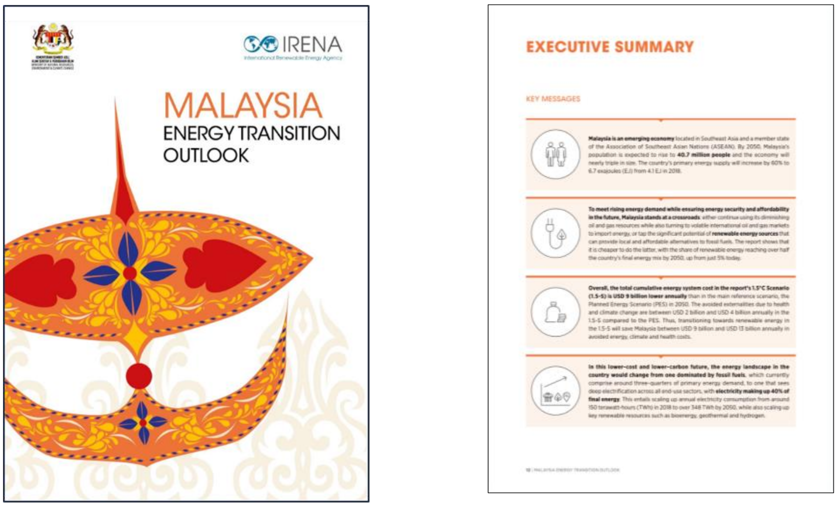


Figure 3.1: Malaysia Energy Transition Outlook

Selected Targets	2018	Low Carbon Nation Aspiration 2040
1. Percentage of urban public transport modal share	20%	50%
2. Percentage of electric vehicle (EV) share	<1%	38%
3. Alternative fuel standard for heavy transport	B5	B30
4. Percentage of Liquefied Natural Gas (LNG) as alternative fuel for marine transport	0%	25%
5. Percentage of industrial and commercial energy efficiency savings	<1%	11%
6. Percentage of residential energy efficiency savings	<1%	10%
7. Total installed capacity of RE	7,597 MW	18,431 MW
8. Percentage of coal in installed capacity	31.4%	18.6%
9. Percentage of RE in TPES	7.2%	17%

Figure 3.2: Low Carbon Nation Aspiration (LCNA) 2040

The transition to RE has economic, energy security, affordability, and environmental sustainability benefits, including GDP growth, job creation, reduced reliance on energy imports, fuel diversification, wider energy access, and lower CO2 emissions.

3.4.5.2 NEP Action Plan & Initiatives

- Enhanced and unlock potential of solar resources.
- Enhanced and unlocked hydroelectric resources.
- Enhanced and unlocked bioenergy resources.
- Explore potential new energy resources.
- Unlocked opportunities for hydrogen economy.
- Enhanced and optimize grid system connectivity.
- Enhanced the infrastructure for Electrical vehicle.
- Enhanced carbon accounting, reporting and certification.

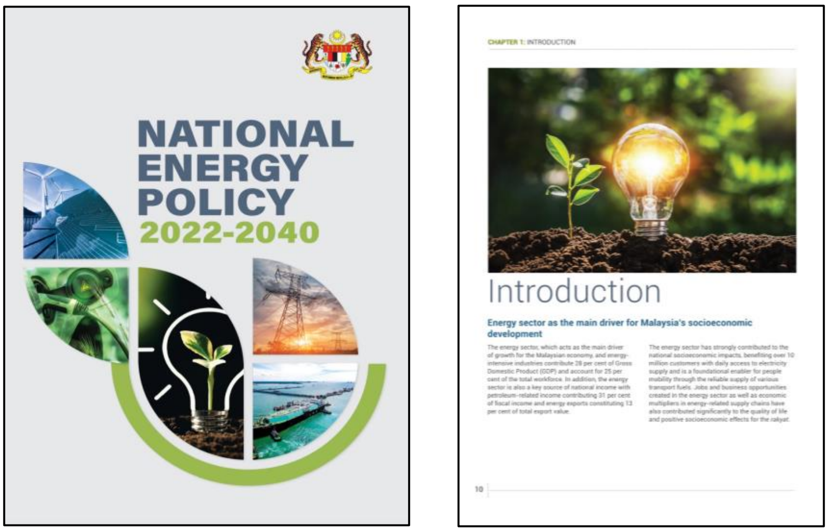


Figure 3.3: Malaysia Energy Policy 2022-2040

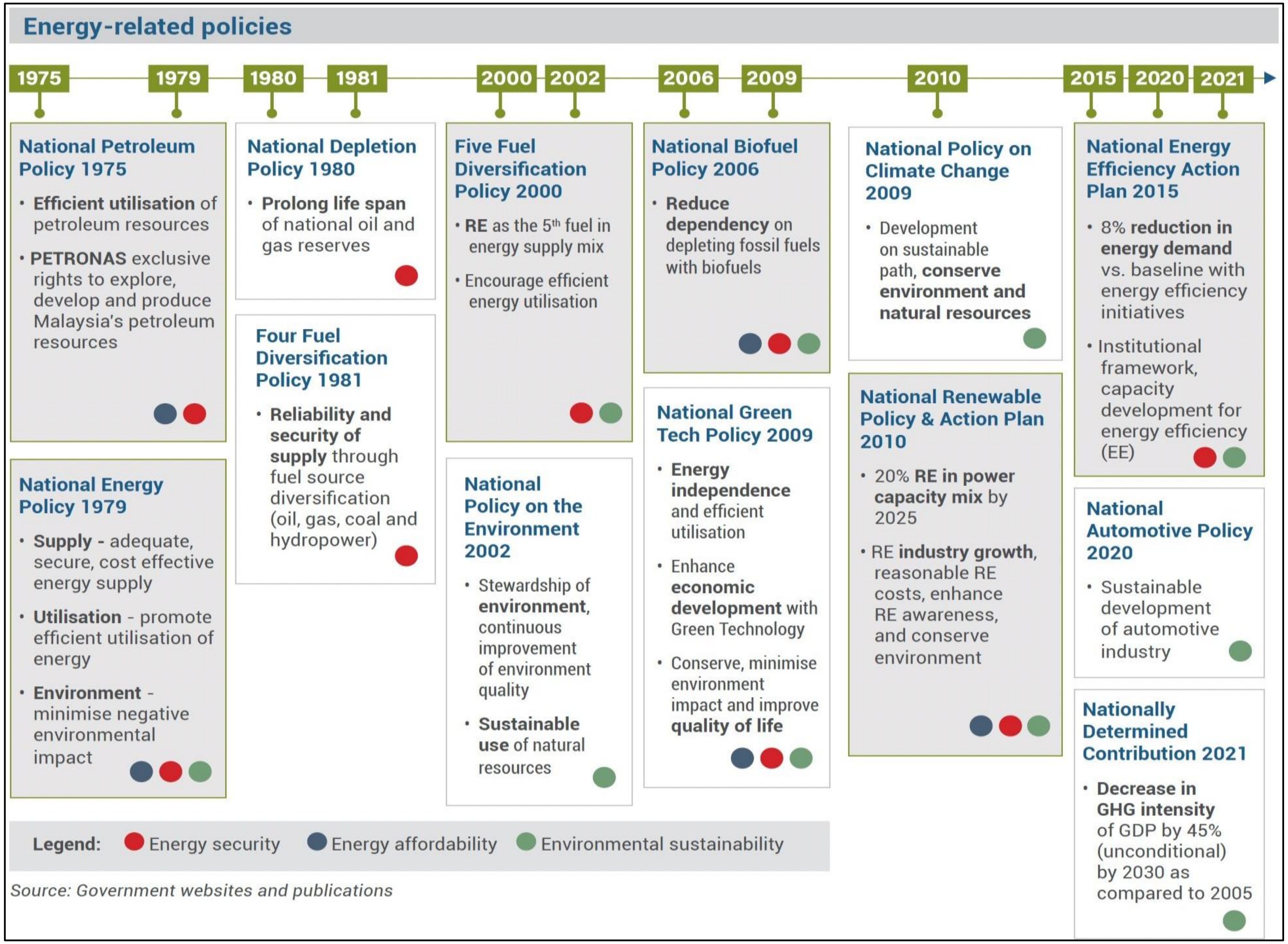


Figure 3.4: Energy related policies and roadmap

3.4.5.3 Emerging Technologies to support energy transition in 2050

90% of all decarbonization in 2050 will involve RE through direct supply of low-cost power, efficiency, electrification, bioenergy with CCS and green hydrogen.

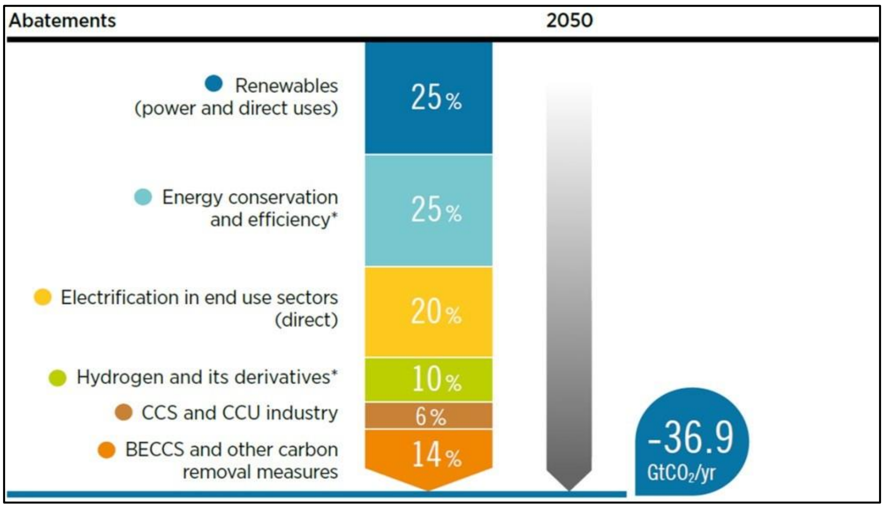


Figure 3.5: Technology solutions and investment needs

3.4.5.4 Overall Hydrogen Supply Chain Pathway:

The hydrogen supply chain model highlights three stages: hydrogen production, delivery, and end-use.

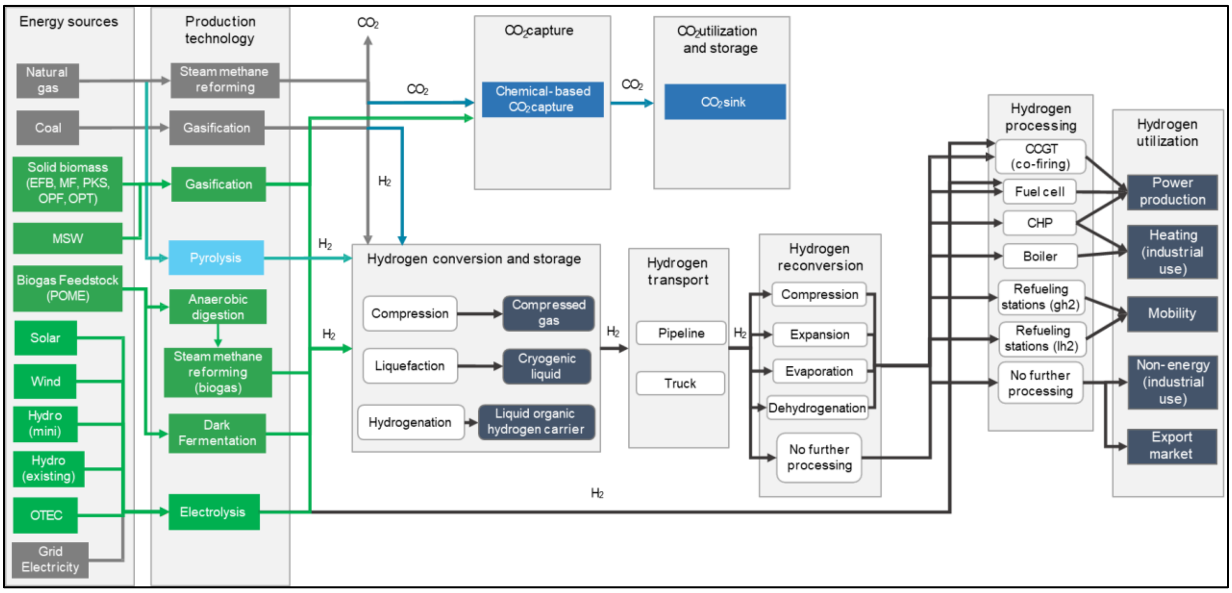


Figure 3.6: Hydrogen Supply Value Chain Model

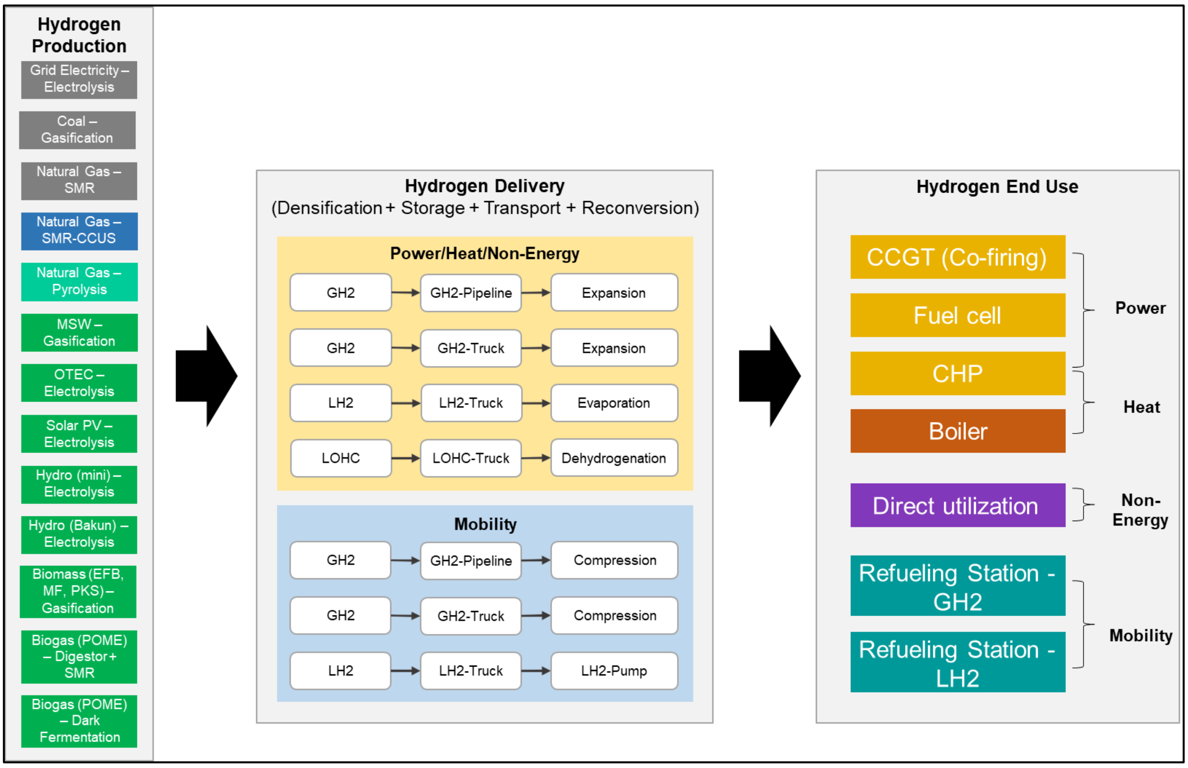


Figure 3.7: Hydrogen Supply Value Chain Model simplified into three stages.

Different cost elements and assumptions were considered, such as feedstock costs, investment, fixed and variable operation and maintenance costs, and electricity price assumptions.

3.4.5.5 Hydrogen Modelling – Manual Calculation Approach:

Manual calculation methodologies were used to estimate the costs of various hydrogen pathways, including grey hydrogen (coal gasification), blue hydrogen (natural gas with CCUS), and GH2 (biomass, solar PV).

Findings indicated that coal gasification is cheaper than natural gas steam methane reforming for grey hydrogen, natural gas SMR with CCUS is cheaper than natural gas pyrolysis for blue hydrogen, and biomass is the least-cost technology for GH2 in the short to medium term. All of the data used in the calculation were retrieved from the recent literatures (local and international sources).

Manual calculation for each of the H2 pathways was used as the methodology. No optimization methodology was applied in calculating all the H2 pathway costs. The hydrogen supply chain stages were simplified into three stages, namely Hydrogen Production, Hydrogen Delivery, and Hydrogen End Use.

Cost elements (Lifetime, availability/capacity factor, interest rate, efficiencies, and cost learning rates were taken into account in the cost calculations):

i. Hydrogen Production: Feedstock costs (e.g., biomass price, coal price, natural gas price), investment, fixed O&M, and variable O&M costs.

ii. Hydrogen Delivery: Investment, fixed O&M, and variable O&M costs (e.g., densification, storage, transport, and reconversion costs).

iii. Hydrogen End Use: Investment, fixed O&M, and variable O&M costs (e.g., power, heat, mobility, non-energy).

iv. Electricity price assumptions:

a. Non-Subsidized Tariff: Base electricity tariff of the Incentive-Based Regulation (IBR) mechanism outlined by Suruhanjaya Tenaga (ST, 2018) at MYR0.3945/kWh (MYR0.2705/kWh of generation cost + MYR0.124/kWh of transmission and grid operation costs)

b. Subsidized Tariff: Industrial electricity tariff (E1) outlined by the Tenaga Nasional Berhad (TNB, 2014) at MYR0.337/kWh.

c. Hydro Tariff (Bakun): Base electricity tariff at MYR0.0625/kWh (Sarawak Government, 2013)

d. Ocean Thermal Energy Conversion (OTEC) Tariff: Base electricity tariff at USD130/MWh (MYR0.52/kWh) (Jaafar, 2019)

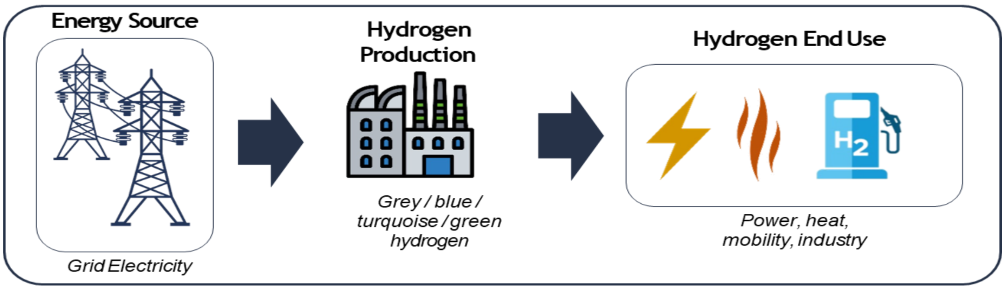


Figure 3.8: End-User-Based Hydrogen Production

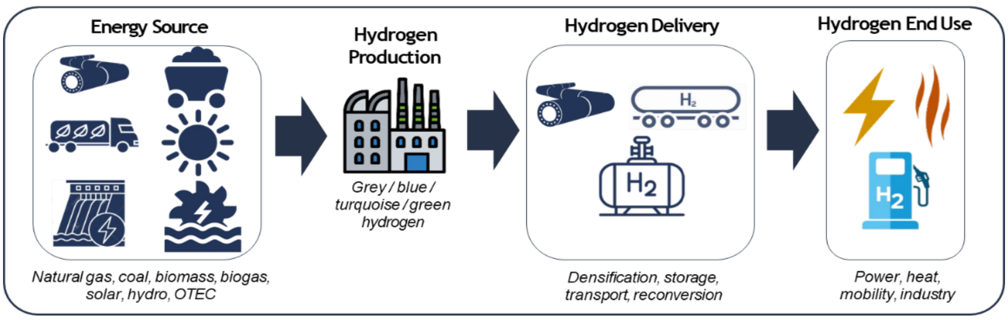


Figure 3.9: Plant-Side-Based Hydrogen Production

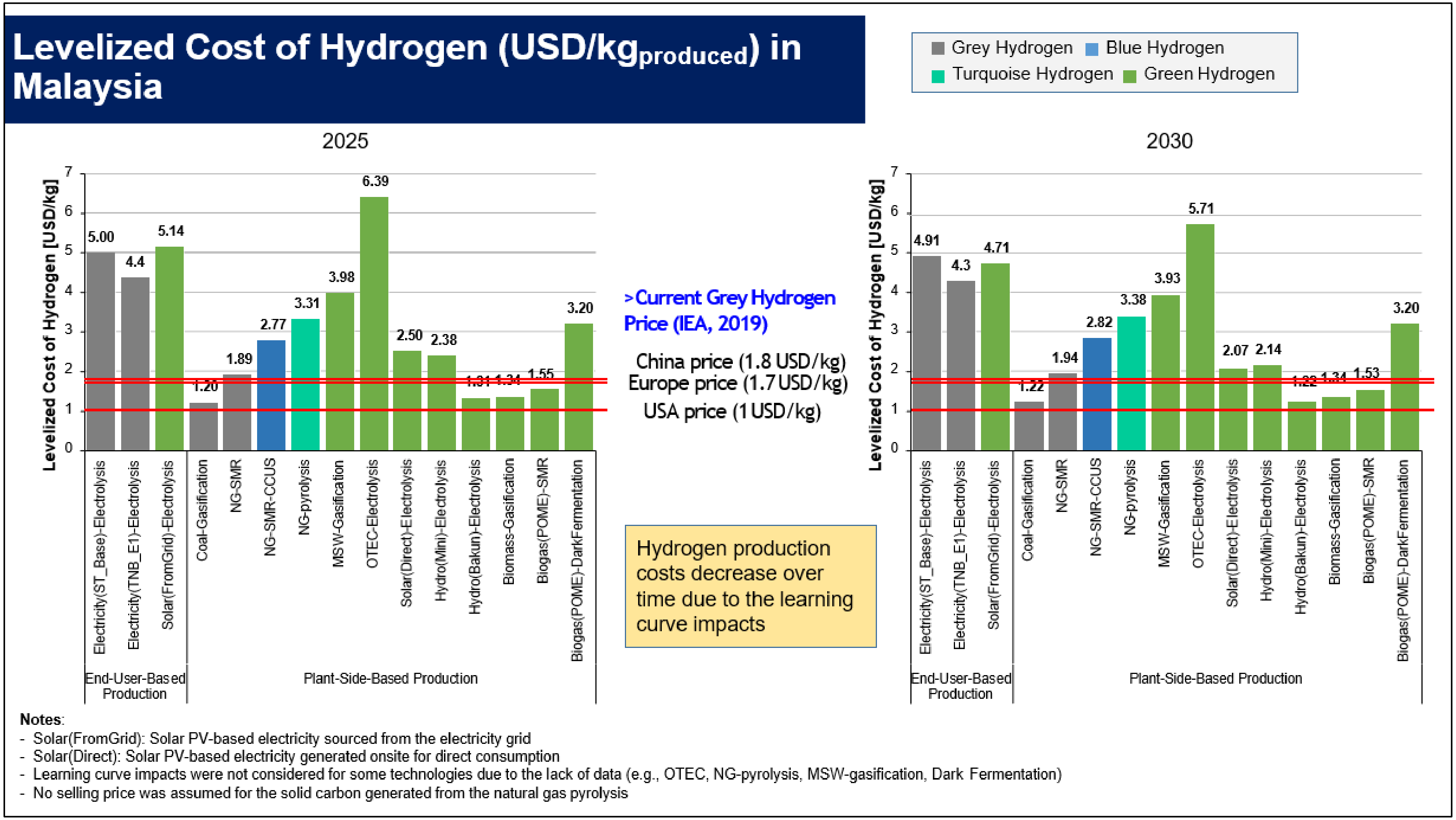


Figure 3.10: Levelized Cost of Hydrogen (2025-2030)

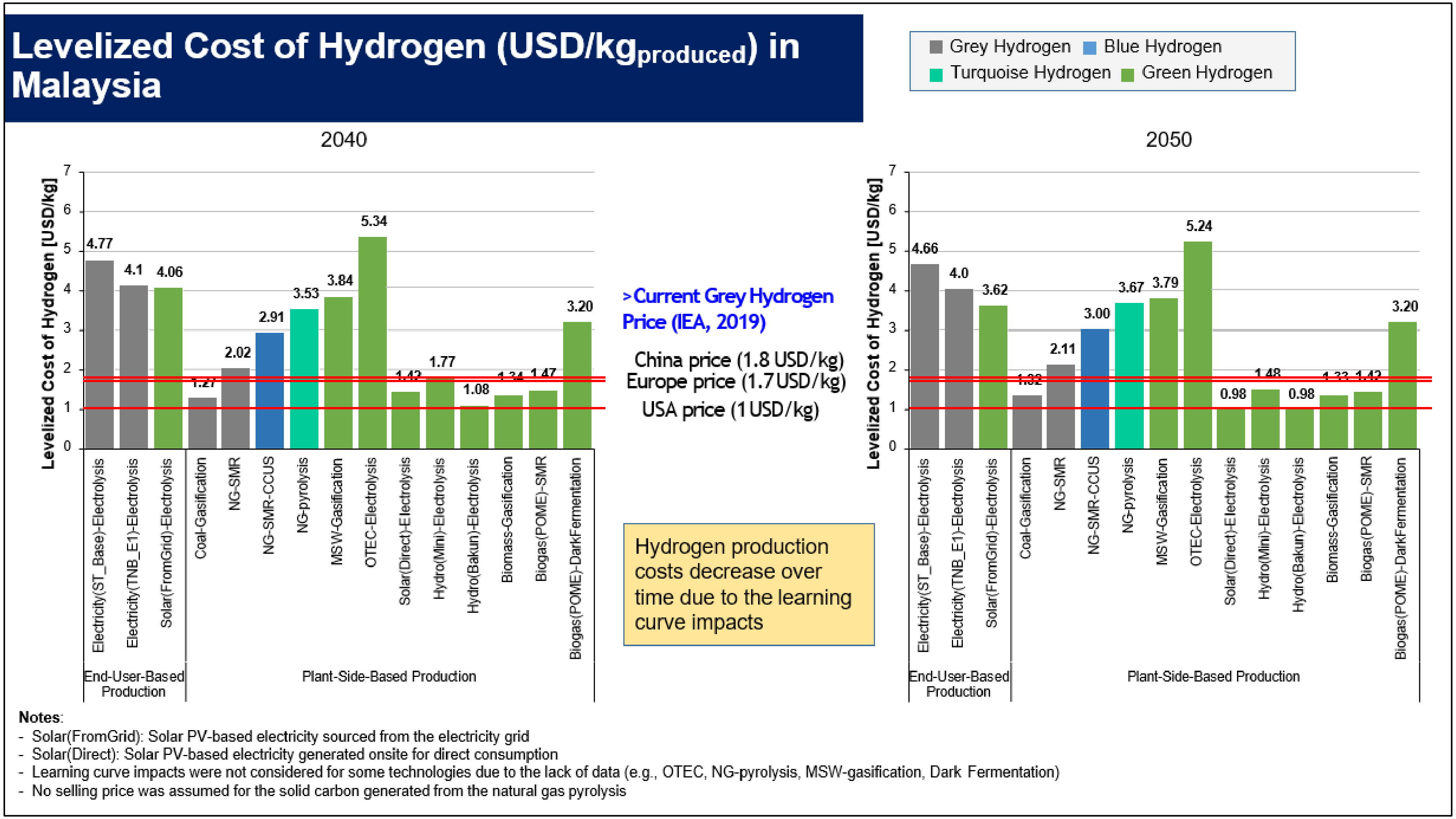


Figure 3.11: Levelized Cost of Hydrogen (2040-2050)

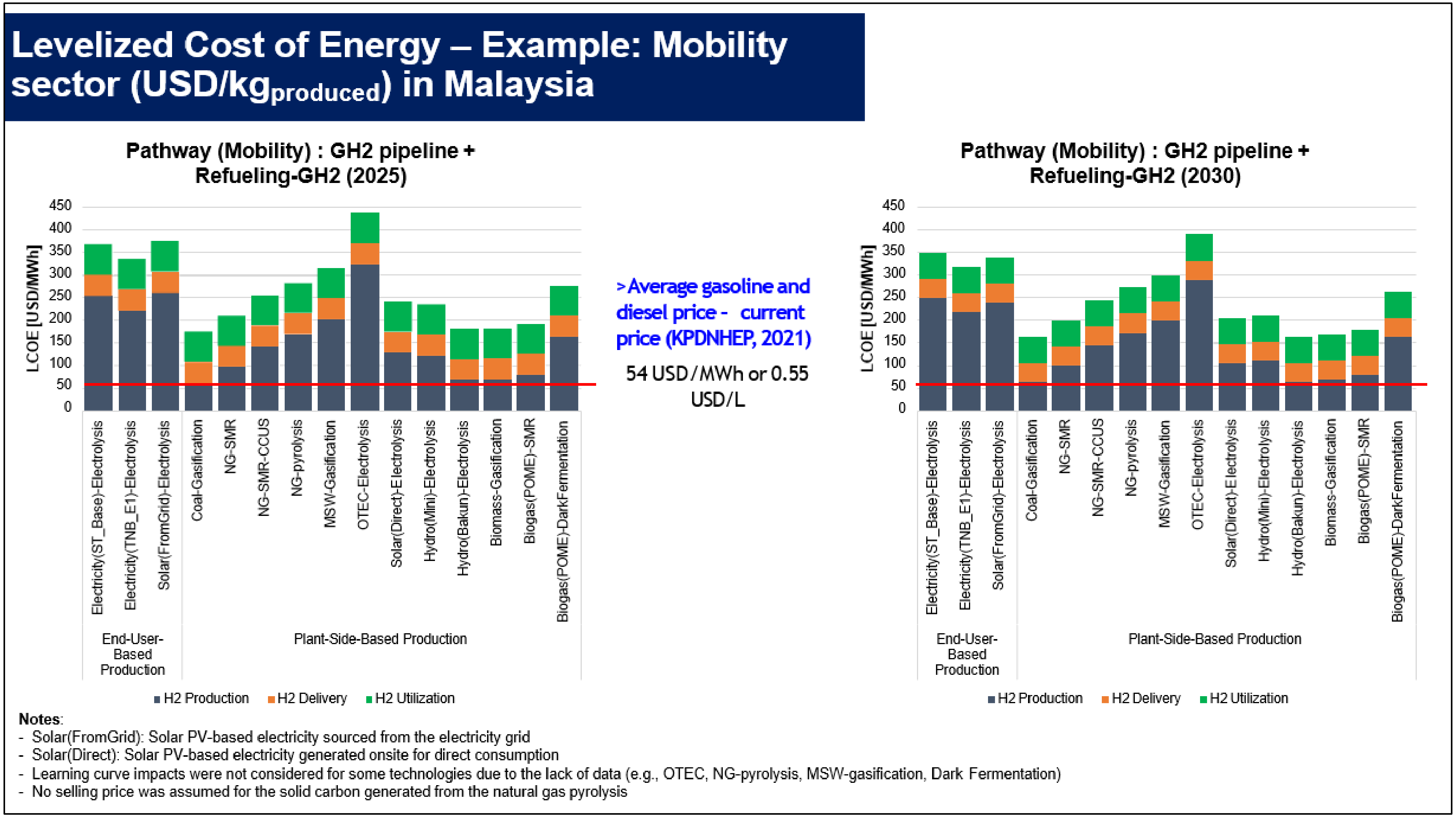


Figure 3.12: Levelized Cost of Hydrogen-Mobility sector (2025-2030)

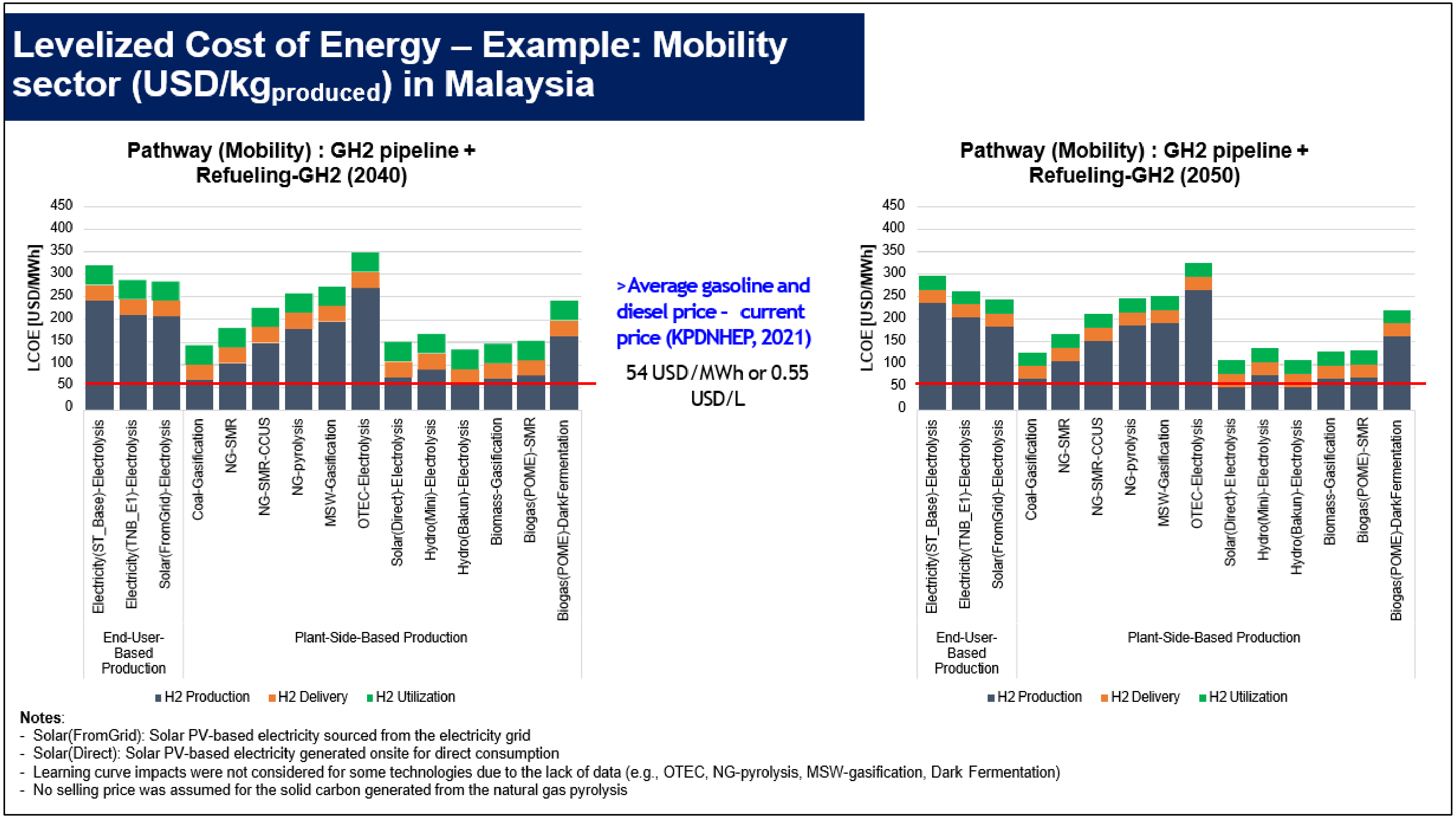


Figure 3.13: Levelized Cost of Hydrogen-Mobility sector (2040-2050)

Based on the manual calculation approach, several key findings can be identified, which includes:

- **Grey Hydrogen**: Coal gasification is less expensive than natural gas SMR to produce hydrogen (without taking into account GHG emission consideration).
- **Blue Hydrogen**: Natural gas SMR with CCUS is less expensive than natural gas pyrolysis (turquoise hydrogen).
- **Green Hydrogen**: Biomass is the least-cost technology in the short to medium term, Solar PV is the least-cost technology in the medium to long term.
- Learning curve of hydrogen production technologies plays an important role in reducing the cost of hydrogen in future.

3.4.5.6 Hydrogen Modeling – Optimization Approach:

Multi-period least-cost optimization models were employed to project hydrogen diffusion across different sectors until 2050. Levelized cost of energy (LCOE), levelized cost of hydrogen (LCOH), GHG emission reduction trends, and subsidy estimations were considered. The model incorporated sectors such as power, mobility, industrial heating, and non-energy.

Several key assumptions were used in the model, such as:

- H2 modelling is developed based on Multi-period Least-cost optimization model.
- The sectors considered in the model: Power, Mobility, Industrial Heating and Non-energy.
- The future energy demand for various energy sources was estimated using the population, GDP and historical trend with the help of NumXL tool. If there were a failure in deriving a statistically sound equation, other methods such as the distribution or growth rates from ERIA reports would be used.
- The population's projection was based on the information provided by the Department of Statistics Malaysia.
- Energy sources considered for the hydrogen production are fossil fuels (coal, natural gas), and renewables (solar, wind, hydro, biomass).

- The amount of renewable resources (feedstock) available for hydrogen production have excluded the commitment such as agricultural, export and other usage.
- GHG emission constraint was imposed, limiting total emissions from hydrogen production to no more than the projected business-as-usual (BAU) GHG emissions.
- Planning horizon for the hydrogen roadmap is 25 years (2025-2050 - assume 3 years lead time)

3.4.5.7 Way Forward and Recommendations:

Key findings:

- The optimization approach is able to quantify the least-cost pathway to implement the hydrogen in power, heat, mobility and non-energy sectors.
- Several scenarios have been successfully generated using different diffusion rates of hydrogen in all sectors.
- Least-cost hydrogen diffusion is illustrated in the non-energy sector, followed by heat sector, power sector, and mobility sector.
- The findings from manual calculation is aligned with the findings from the optimization model.
- The future work will focus on validating the hydrogen technology, emission, and cost datasets used in the modelling.
- Finalizing the modelling scenarios and analyses for the hydrogen economy roadmap.
- Recommendations include integrating spatial models for local availability considerations and incorporating emerging technologies into the hydrogen model.

Further research and validation in hydrogen modelling to improve accuracy and incorporate local factors is needed. The recommendations aimed to enhance the understanding of the hydrogen economy and optimize its implementation for decarbonizing industries in Malaysia.

3.4.6 Speaker 6

A. **Dr Ma Fanhua** from HCNG Engine R&D Laboratory, Tsinhgua University
B. **Li Fan** from Insititute of Engineering Thermophysics, Chinese Academy of Sciences
C. **Liu Zhigang** from Institute of Engineering Thermophysics (IET), Chinese Academy of Sciences

In 2020, China committed to peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060. China proposed to "build a clean, low-carbon, safe and efficient energy system, control the total amount of fossil energy, focus on improving utilization efficiency, implement RE substitution actions, deepen power system reform, and build a new type of power system with new energy as the main body.

As a participant organization in the domestic “double carbon” strategy, Chinese Academy of Science institute has conducted a lot of research into clean energy such as hydrogen energy and bioenergy as gas turbine fuels in recent years.

Hydrogen combustion is one of the institute main research works for the goal of high efficient and low emission. Hydrogen has a high calorific value, which is 3-4 times that of fossil fuels such as coke and gasoline of the same quality, hydrogen combustion can achieve zero carbon emissions. Therefore, choosing hydrogen as a fuel is one of the important ways to achieve efficient and low-carbon gas turbines.

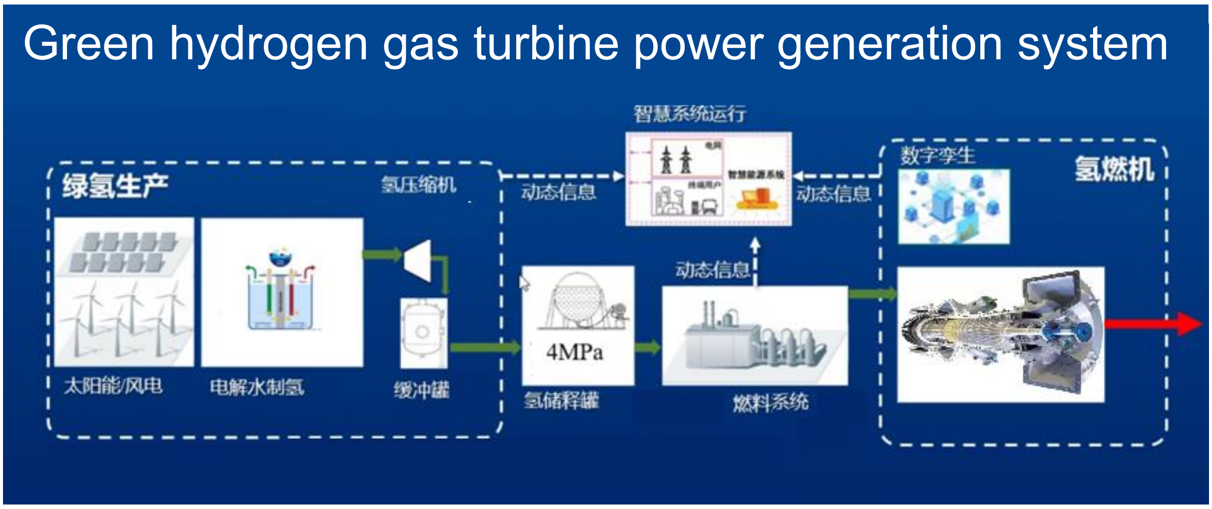


Figure 3.14: System for Green Hydrogen Gas Turbine

Figure 3.15: Gas and electricity installation planning

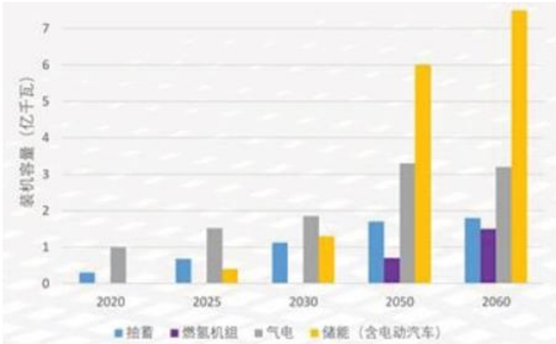


Figure 3.16: Composition of peak shaving power supply

Aiming at carbon emissions, the Chinese government requires to achieve carbon peaking by 2030 and carbon neutral by 2060. Gas turbines for power generation are an important way to support us in achieving this goal "30/60". First, Gas turbine fueled natural gas for power generation provides flexible regulation for clean energy and load fluctuation. Second, Hydrogen gas turbines are the main way to convert new energy sources from "GH2" to electricity.

3.4.6.1 Introduction to HCNG Engine

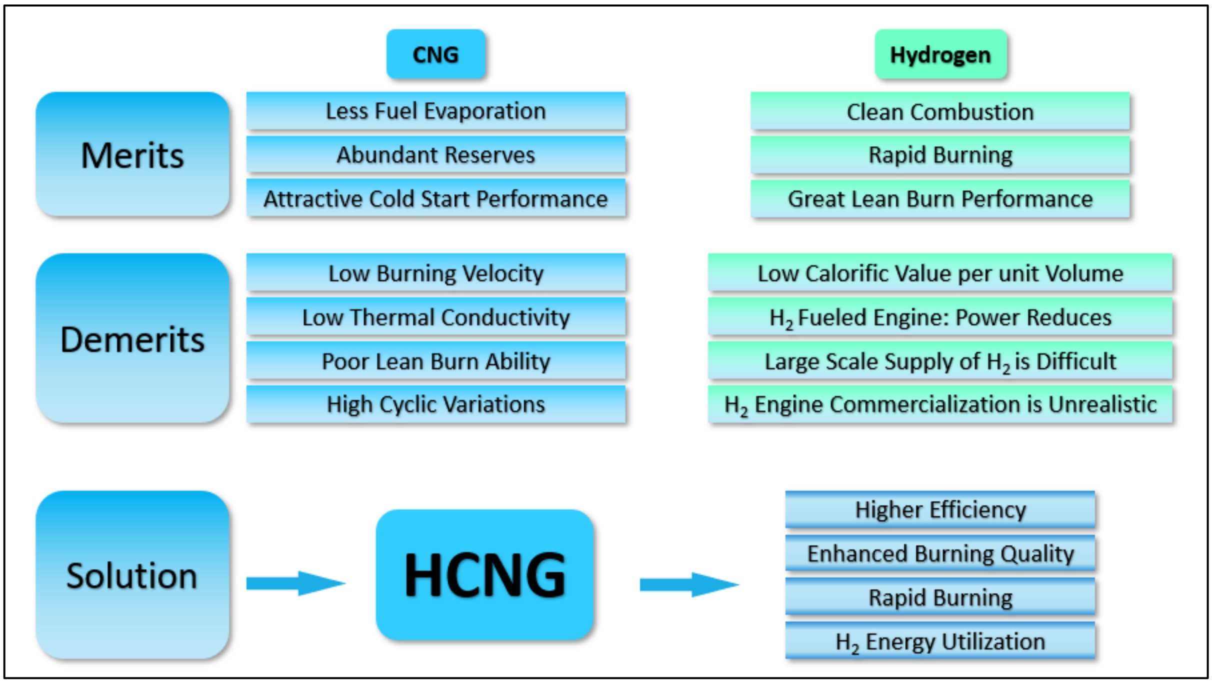


Figure 3.17: Benefits of Hydrogen CNG Engine

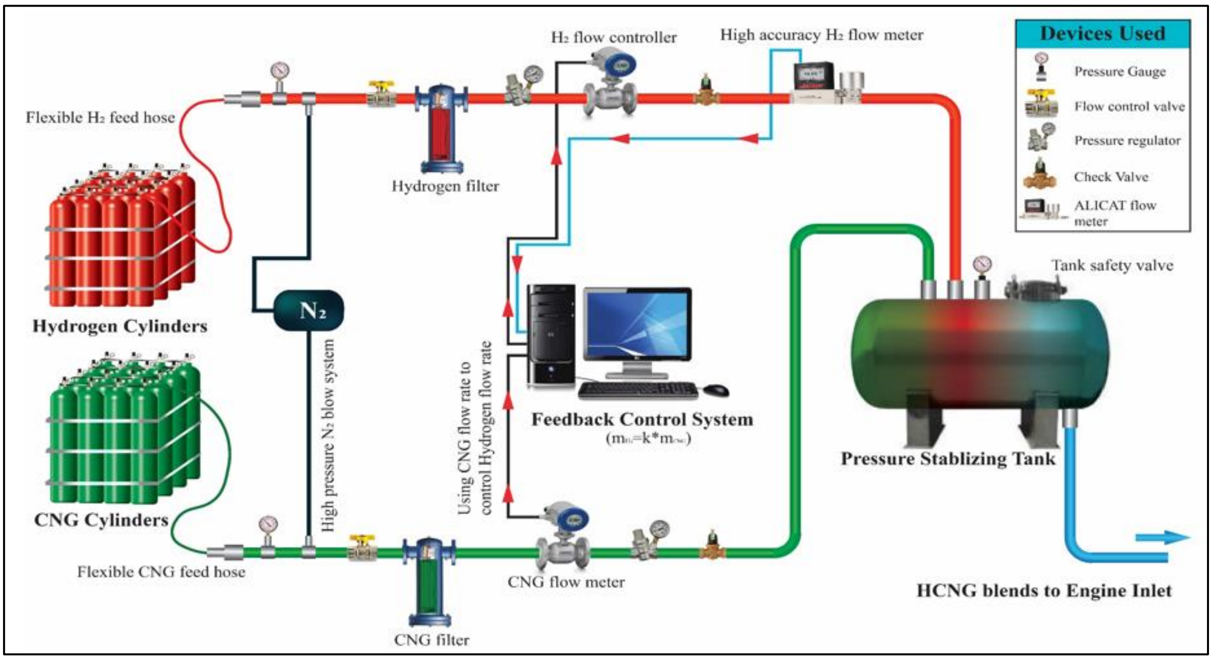


Figure 3.18: Development of On-Line HCNG Blending System

3.4.6.2 HCNG Fuel Station Development Project

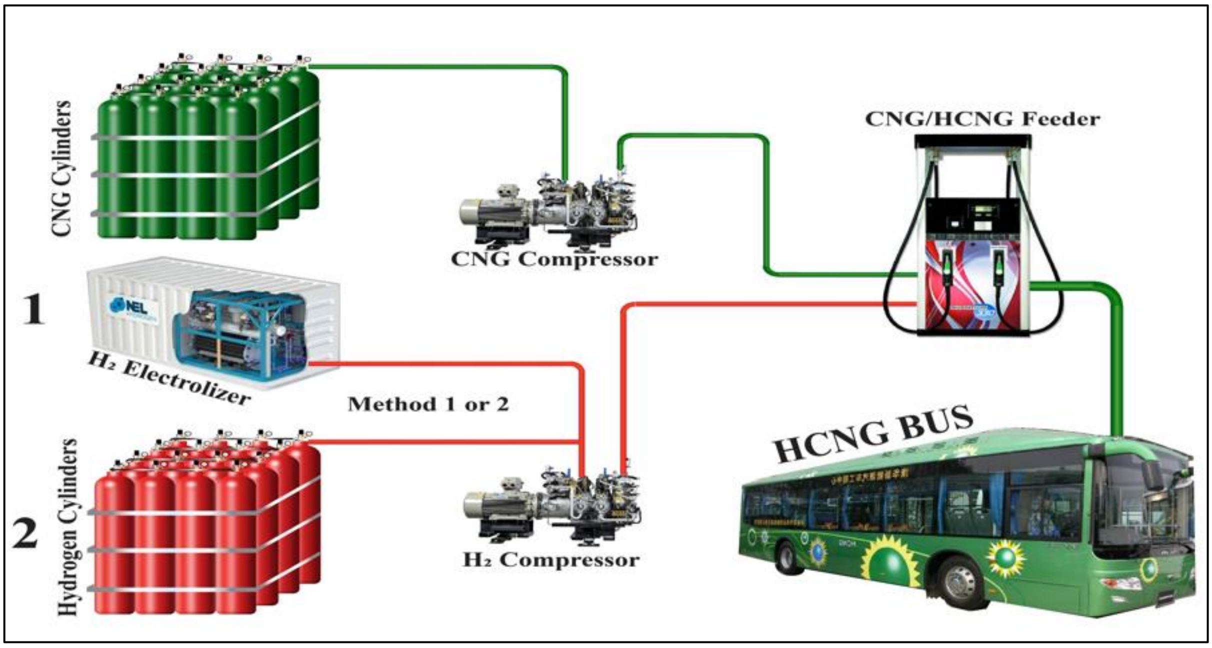


Figure 3.19: HCNG Fuel Station Development project flow

Sichuan Municipal government of China Supports HCNG bus aand HCNG Fuel Station Demonstration. By the end of 2024, 1 HCNG Fuel Station will be set up in Sichuan Province, China, and 50 HCNG buses will be demonstrated. By the end of 2025, 3-5 HCNG Fuel Station will be set up in Sichuan Province, China, and 300-500 HCNG buses will be demonstrated. By end of 2030, 30-50 HCNG fuel station will be set up in China, and 10,000 HCNG vehicles (including HCNG buses, heavy duty trucks and Taxi) will be demonstrated.

Figure 3.20: Design of HCNG Fuel Station

3.4.7 Speaker 7

- **Dr Rezal Khairi Ahmad**
  Chief Executive Officer, NanoMalaysia Berhad

3.4.7.0 Summary of presentation: "Mastering Green & Clean Hydrogen":

NanoMalaysia is a business entity operating under the Ministry of Science, Technology, and Innovation (MOSTI), focused on commercializing nanotechnology to achieve industrial revolution and technology sovereignty.

3.4.7.1 Venture Builder Model to spearhead technology and commercialisation.

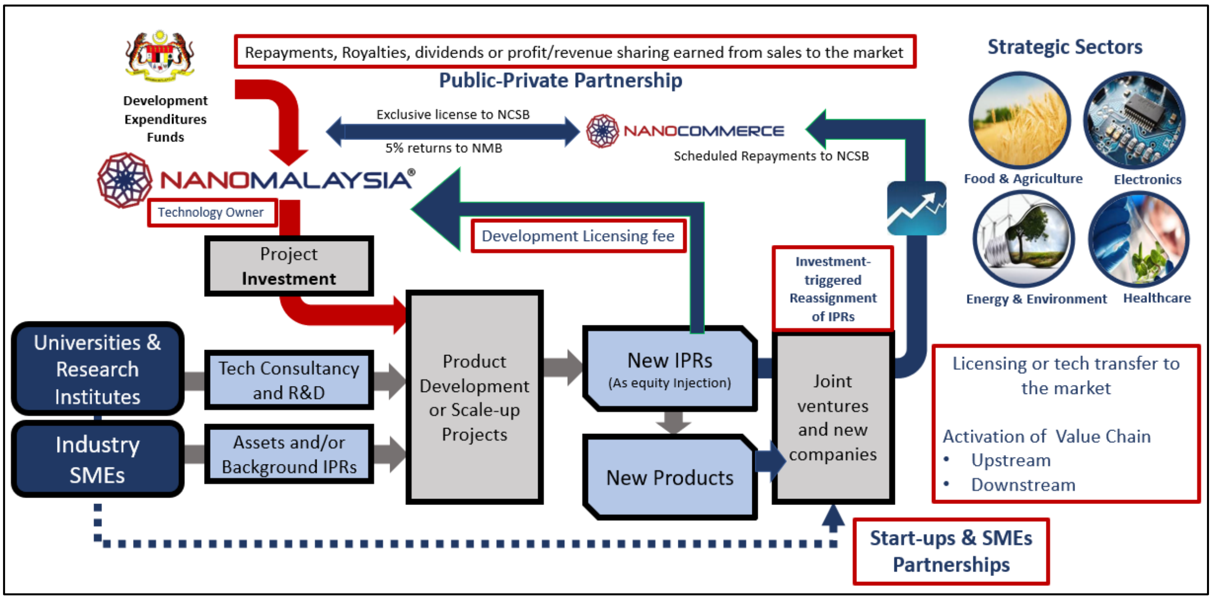


Figure 3.21: Venture Builder Model to spearhead technology and commercialisation.

3.4.7.2 Challenges for GH2:

GH2, which has zero carbon emissions, is currently the most expensive option at USD7-9/kg. Grey hydrogen, the cheapest option, costs around USD1.5/kg, but it is still more than twice the cost of fossil fuels.

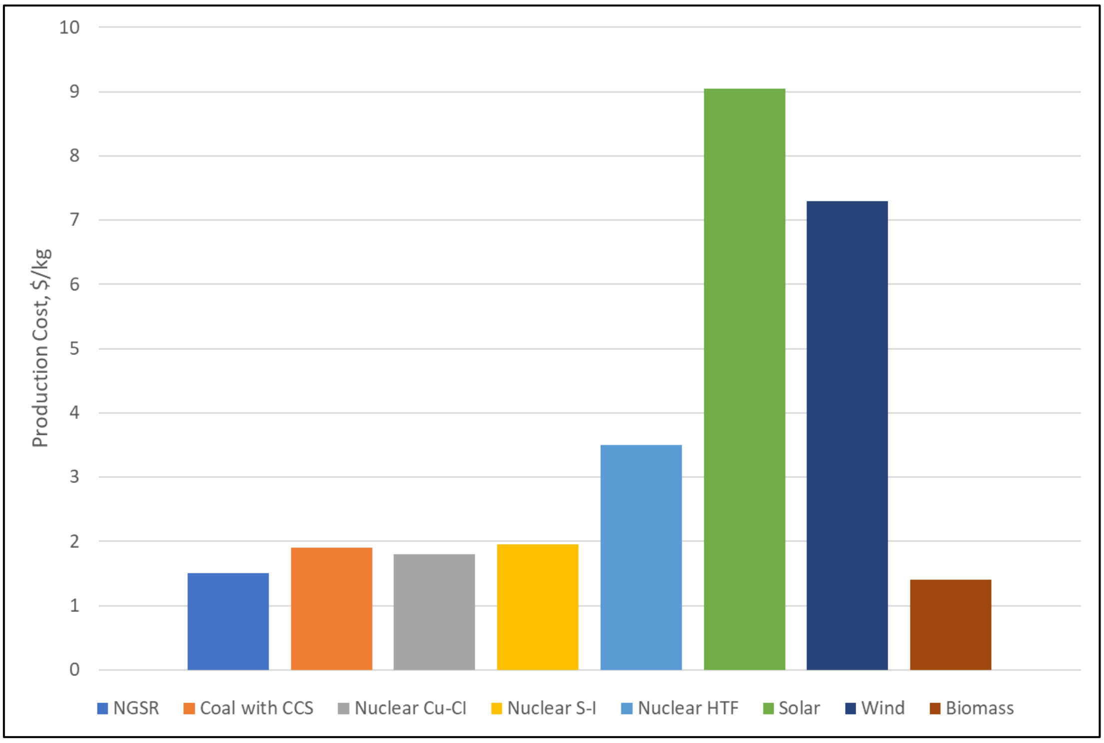


Figure 3.22: Example of Production Cost of Primary Energy Mix in Malaysia

3.4.7.3 Major Milestones towards GH2 in Malaysia:

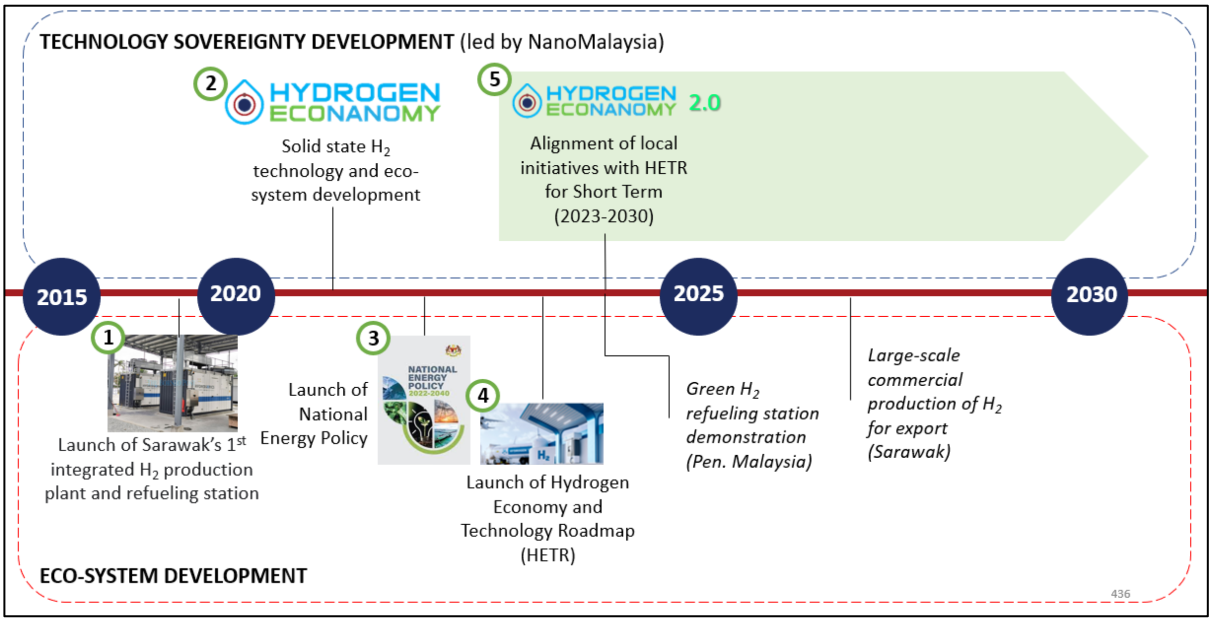


Figure 3.23: Major milestones for Green Hydrogen in Malaysia from 2015 to 2030

3.4.7.4 Sarawak's GH2 initiative

In 2019, the Sarawak Government took a significant step towards a sustainable future by inaugurating a state-of-the-art GH2 production and refuelling station located in Kuching. This cutting-edge facility possesses the remarkable capability to produce up to 130 kilograms of GH2 per day, boasting an impressive purity level of 99.999%. Spearheading this initiative is the Sarawak Energy Development Corporation (SEDC), a pivotal state agency entrusted with the task of advancing hydrogen (H2) development in alignment with its dedicated roadmap.

As part of the broader efforts to promote clean and eco-friendly transportation solutions, hydrogen bus services were introduced and have been operational since August 2019 under the auspices of Sarawak Metro. This groundbreaking venture represents a significant stride towards a more sustainable and environmentally responsible transportation infrastructure for the region.

Figure 3.24: Green Hydrogen Production launched by Sarawak Government

3.4.7.5 The Hydrogen EcoNanoMY

The Hydrogen EcoNanoMY programme under the facilitation of NMB aims to develop; local game-changer technology enabling cost-efficient production of hydrogen on-demand and on-site; Ecosystem surrounding the value chain; and Market interest in hydrogen economy both locally and internationally.

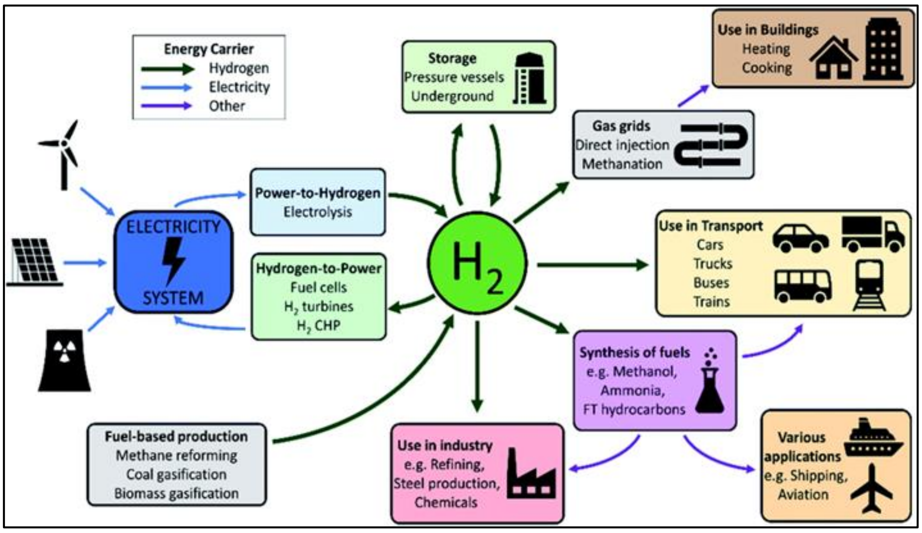


Figure 3.25: Green Hydrogen Value Chain

Hydrogen EcoNanoMY initiatives, including technologies such as the Hydrogen Paired Electric Racecar (HyPER), hydrogen reactors, range extenders for trucks and buses, NaBH4 recycling, and expanding solid-state H2 technology to aviation and maritime sectors.

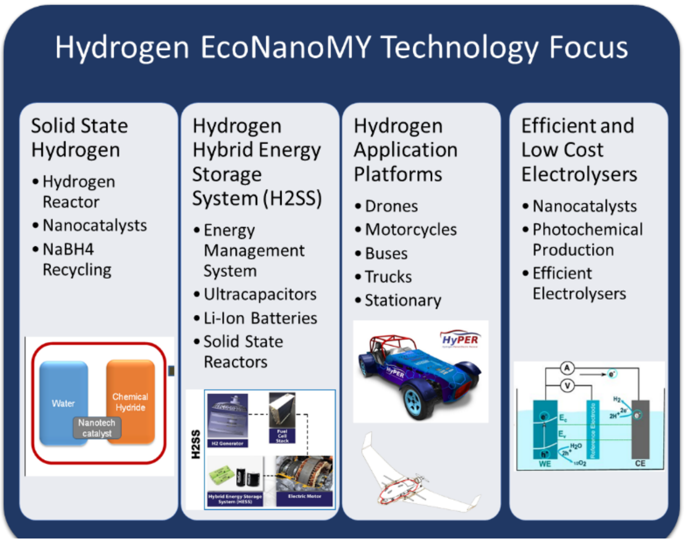


Figure 3.26: Hydrogen EcoNanoMY Technology Focus Area

3.4.7.6 Solid-State Hydrogen as baseline fuel technology for Hydrogen Paired Electric Racecar (HyPER)

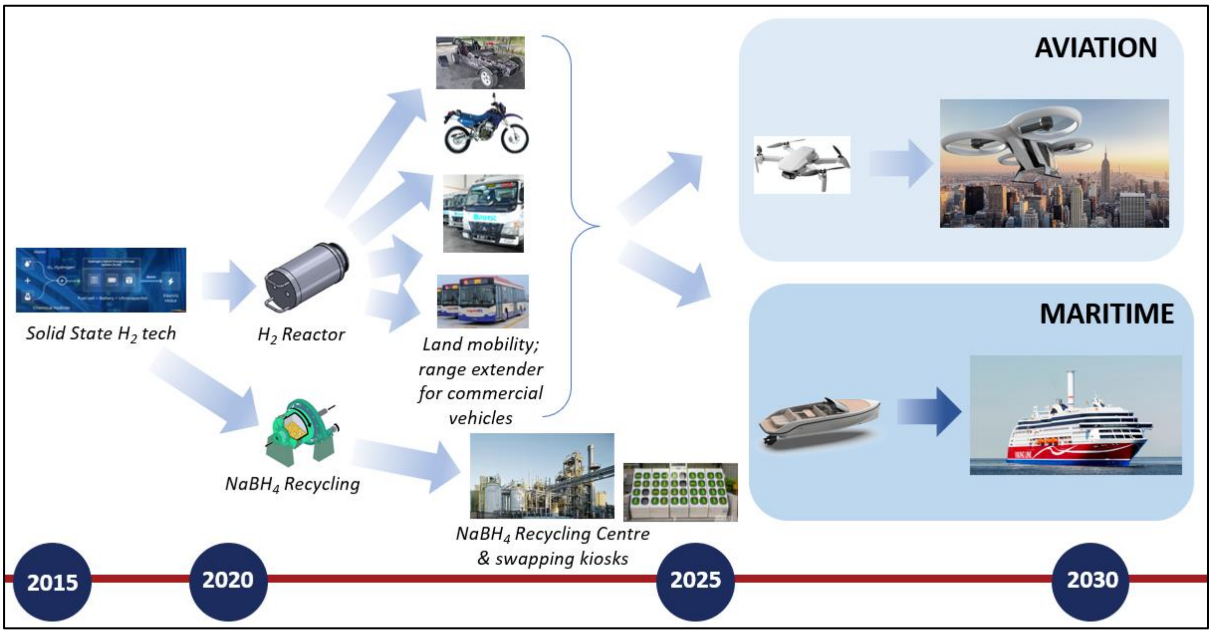


Figure 3.27: Solid State Hydrogen Roadmap

HyPER, short for Hydrogen Paired Electric Race car, represents a cutting-edge technology validation platform. It showcases the transformation from conventional internal combustion engines (ICE) to electric propulsion systems, serving as a pioneering example in this transition. One of the standout features of HyPER is its innovative Hybrid Hydrogen Energy Storage System (H2SS). This system combines multiple energy storage components to optimize performance and efficiency, making it a versatile and forward-thinking solution. The H2SS integrates a hydrogen fuel cell for on-vehicle hydrogen generation, a graphene ultracapacitor, and a lithium-ion battery, creating a comprehensive and sustainable energy storage solution that promises to drive the future of electric vehicle technology.

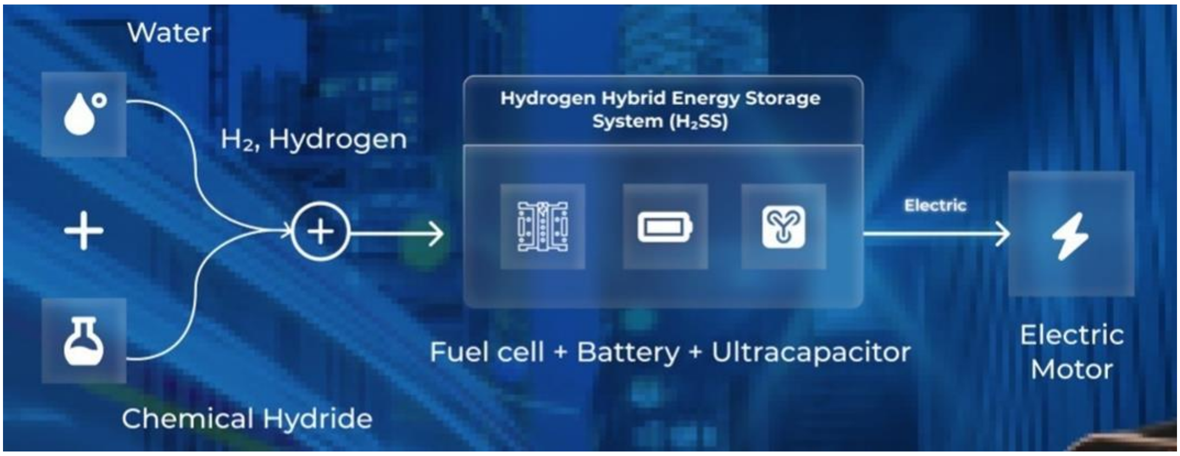


Figure 3.28: Hybrid Hydrogen Energy Storage System (H2SS)

Figure 3.29: Installed HyPER in this car

The HyPER project's success relies on key collaboration partners which include Wheelspin Malaysian Motorsports Group, EV Connection Sdn. Bhd and Admatix Solutions Sdn. Bhd.

3.4.7.7 Hydrogen Reactor

The development of a Hydrogen Reactor has been driven by the need for a safe, reliable, and versatile device that can accommodate various applications and withstand diverse environmental and user conditions in the market. This innovation incorporates a solid-state H2 reactor system, complete with a feeding mechanism known as the "cartridge.":

- Safe and proper storage of NaBH4
- Easy and efficient operations when reloading (refuelling)

What sets this reactor apart is its capacity to release H2 gas from solid-form NaBH4, resulting in significantly higher energy density. Powered by solid NaBH4 and water as feedstock, the reactor employs a nano-based catalyst to produce H2 gas on-demand, offering the flexibility of multiple "start-stop" cycles. This breakthrough technology promises to revolutionize hydrogen storage and distribution, making it a promising advancement in the field of clean energy.

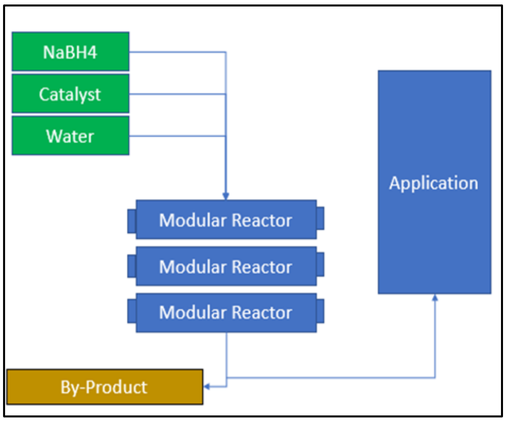


Figure 3.30: Value Chain for Hydrogen Reactor

3.4.7.7.1 Range extender for trucks and buses

The truck's conversion to an electric vehicle (EV) marks a groundbreaking first for Malaysia. Adding the Hydrogen Energy Storage System (H2SS) enables on-demand hydrogen production through hydrolysis, a safer and more cost-effective option than compressed hydrogen. The H2SS also acts as a range extender, allowing the truck to travel further without frequent recharging, enhancing efficiency and reliability. This technology is set to expand to buses as the next step in advancing sustainable transportation.

NaBH4 recycling to optimise commercialisation with a low-cost approach to produce NaBH4 at **5 times cheaper** than the current global market price.

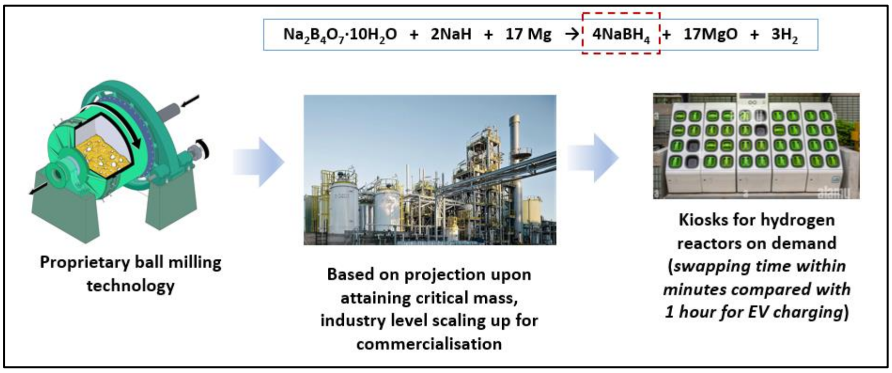


Figure 3.31: Low-cost approach with NaBH4 Recycling

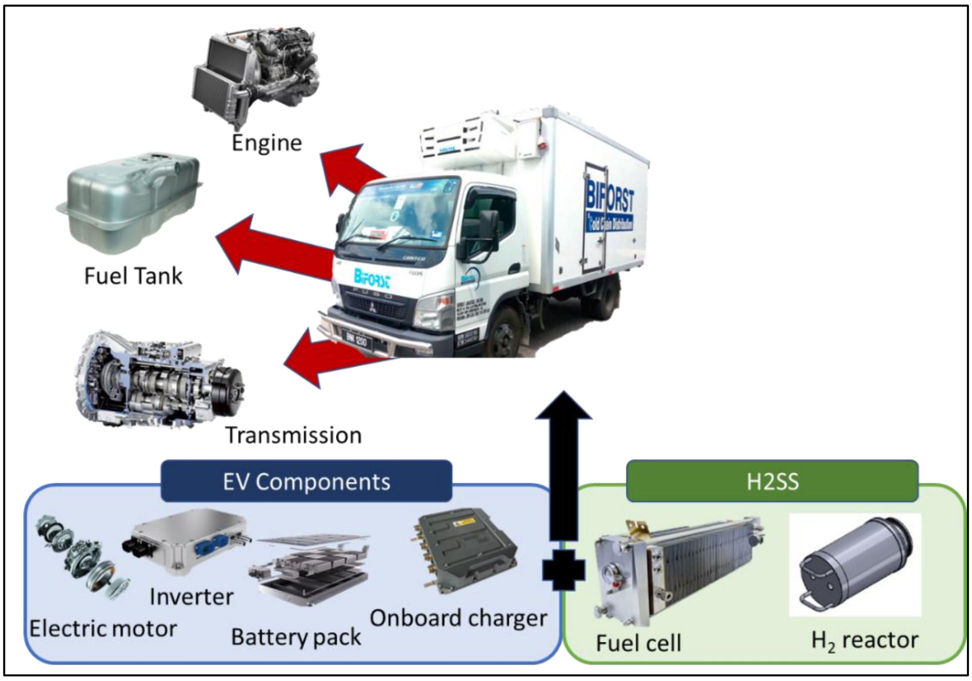


Figure 3.32: Potentially safer, lighter and cheaper solution compared to compressed hydrogen technologies.

3.4.7.8 Hydrogen Economy and Technology Roadmap (HETR)

The soon to be launched HETR developed is a long-term roadmap (till 2050) that focuses on all aspects of the energy trilemma for Hydrogen in line with the NEP's vision, objectives and strategic thrusts:

i. energy security.
ii. energy affordability; and
iii. environment sustainability.

Enabling hydrogen eco-system environment will be streamlined with HETR's strategies with long term targets to reduce green H2's LCOH to USD1/kg by 2050.

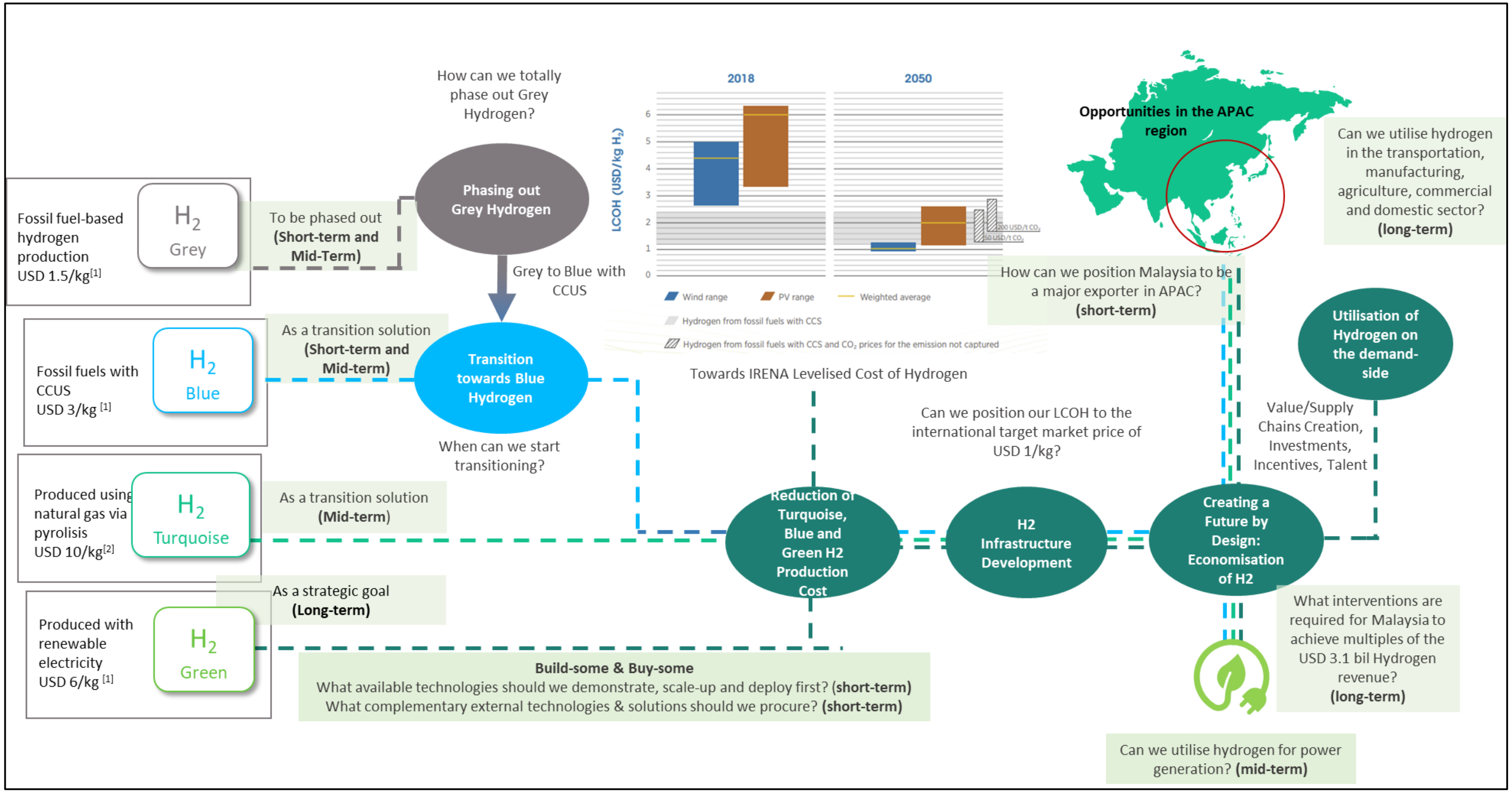


Figure 3.33: NanoMalaysia long term targets for HETR

3.4.7.9 Conclusion

In Malaysia, technology sovereignty development is a multifaceted approach centered on three key elements: firstly, establishing local industry leadership through the "Build some Buy some" strategy; secondly, nurturing local talent to ensure a sustainable technology ecosystem; and thirdly, creating opportunities for local players to actively contribute and fill gaps within the ecosystem.

In parallel, eco-system development plays a pivotal role by fast-tracking market access, attracting Foreign Direct Investments (FDIs) in advanced technologies, and serving as a technology demonstrator, particularly in the burgeoning GH2 sector. Additionally, fostering robust public-private partnerships forms a crucial part of this ecosystem development strategy.

The harmonious integration of these two strategies is imperative to jumpstart and expedite the growth of the GH2 ecosystem in Malaysia. By doing so, Malaysia not only advances its technological self-reliance but also positions itself as a global leader in environmentally sustainable technologies, contributing to a greener and more innovative future.

Dr. Rezal Khairi Ahmad emphasized the importance of aligning technology sovereignty and ecosystem development strategies to effectively accelerate the GH2 ecosystem in Malaysia. The goal is to establish local leadership, attract investments, and create opportunities for local players in the GH2 sector.

4.0 DISCUSSION ON CHALLENGES, DEVELOPMENT OF STRATEGIES AND BEST PRACTICES ON GH2-BASED ECONOMY

4.1 Challenges

While the development of GH2 offers significant potential, there are several challenges that need to be addressed in order to fully realize its benefits. These challenges include:

4.1.1 High Production Costs:

Currently, the production of GH2 is relatively expensive compared to traditional fossil fuel-based alternatives. The costs associated with electrolysis, a common method for producing GH2, are still relatively high. Further advancements in technology, economies of scale, and supportive policies are needed to reduce production costs and make GH2 more economically competitive.

4.1.2 Infrastructure Development:

The widespread adoption of GH2 requires the development of a robust infrastructure for production, storage, transportation, and distribution. This infrastructure includes GH2 production facilities, pipelines or other means of transportation, and refuelling stations. Building this infrastructure requires significant investments and coordination among various stakeholders, including government agencies, energy companies, and transportation providers.

4.1.3 Technological Advancements:

Continued research and development are necessary to improve the efficiency and performance of GH2 technologies. This includes advancements in electrolysis processes, catalyst materials, and storage methods. Enhancements in technology will help drive down costs, increase production efficiency, and improve the overall viability of GH2 as a mainstream energy source.

4.1.4 Policy and Regulatory Frameworks:

Clear and supportive policy frameworks are crucial to facilitate the development and deployment of GH2. Governments need to provide incentives, regulations, and long-term planning to encourage private investment and create a favourable market environment.

4.2 Policies of APEC Economies

Chile

- Government targets: Leading producer and exporter of GH2 by 2040.
- Policy initiatives: Investment in RE, tax incentives, regulations, and partnerships.

Indonesia

- Government targets: Producing 1.2 million tonnes of GH2 per year by 2060.
- Policy initiatives: Tax breaks and incentives for GH2 investments, domestic hydrogen roadmap, research and development investment.

Malaysia

- Government targets: Increase RE share to 40% by 2030 and 70% by 2050.
- Policy initiatives: National Hydrogen Technology Roadmap, aiming to produce 100,000 tonnes of GH2 by 2030 and 500,000 tonnes by 2050.

The Republic of the Philippines

- Government targets: GHG emissions reduction, energy independence.
- Policy initiatives: Incentives for GH2 production, creating a market for GH2, research and development investment.

The Russian Federation

- Government targets: Producing 2 million tons of GH2 by 2035.
- Policy initiatives: Tax breaks, financing, regulations, international partnerships.

Thailand

- Government targets: Carbon neutrality by 2050.
- Policy initiatives: Tax breaks for GH2 investments, domestic hydrogen roadmap, research and development investment.

Viet Nam

- Government targets: Net-zero emissions by 2050
- Policy initiatives: Incentives for GH2 production, creating a market for GH2, research and development investment.

Most APEC economies have either released or are developing a domestic hydrogen strategy. This is a positive sign that these economies are taking the development of GH2 seriously. However, there is still a lot of work to be done to bring GH2 to market. One of the biggest challenges is the cost of production. GH2 is currently more expensive than other forms of hydrogen, such as grey hydrogen, which is produced from fossil fuels. However, as the cost of RE continues to fall, the cost of GH2 is expected to come down. Another challenge is the lack of infrastructure. Currently, there is no widespread infrastructure for producing, transporting, and storing GH2. This will need to be developed before GH2 can be widely adopted.

Despite these challenges, there is a lot of potential for GH2 to play a role in the energy transition and achievement of carbon neutrality. GH2 can be used to power a variety of applications, including transportation, industry, and power generation. It can also be used to store any surplus RE, which can help to balance the grid and make it more reliable. As the cost of production comes down and the infrastructure is developed, GH2 is poised to become a major player in the global energy market.

Here are some of the key policies that APEC economies are implementing to support the development of GH2:

i. Investment in research and development: Many APEC economies are investing in research and development to improve the efficiency and cost-effectiveness of GH2 production.

ii. Provision of financial incentives: APEC economies are also providing financial incentives to businesses that invest in GH2 production and use.

iii. Creation of a regulatory framework: APEC economies are working to create a regulatory framework that will support the development of a GH2 market.

iv. Promoting inter cooperation: APEC economies are working to promote international cooperation on the development of GH2.

The development of GH2 is a complex and challenging task, but it is one that APEC economies are committed to. With continued investment and cooperation, GH2 has the potential to play a major role in the energy transition and help APEC economies achieve their carbon neutrality goals.

4.3 Key areas of cooperation

4.3.1 Standardization and certification.

Elaboration of common approaches to hydrogen standardization and certification, considering the production methods and carbon footprint. Collaboration in the development of a system of international standards in the field of hydrogen technologies.

4.3.2 Governmental support

Exchange of experience and elaboration of common approaches in the field of governmental support for the development of hydrogen energy, including the implementation of complex hydrogen projects.

4.3.3 Joint projects

Implementation of joint pilot projects and polygons in the field of low-carbon hydrogen production from natural gas and renewables. Attraction of investments into the creation of hydrogen clusters.

4.3.4 Elaboration of coordinated technologies

Elaboration of coordinated conceptual solutions for priority hydrogen technological chains to ensure their economic and climate protection efficiency. Analysis of the technological possibilities and transportation options.

4.3.5 Scientific and technological cooperation

Creation of partnerships between the companies from APEC members, participation in scientific consortiums to organize joint research in the field of hydrogen and fuel cells.

4.4 Malaysia in Green Hydrogen

In recent years, Malaysia has been actively engaged in an energy transition to address the challenges posed by climate change and to capitalize on the opportunities presented by sustainable energy sources. This transition involves a significant shift in the economy's energy policy, with a growing emphasis on GH2 as a promising solution for achieving carbon neutrality and energy security.

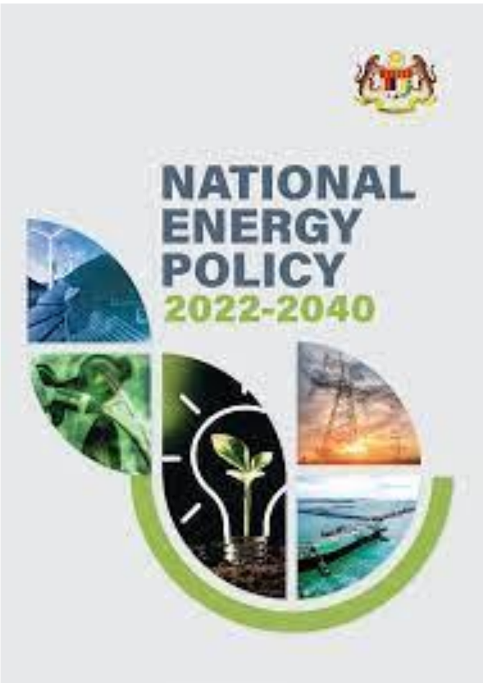
Malaysia's energy landscape has traditionally been dominated by fossil fuels, particularly oil and natural gas. However, the economy recognizes the need to reduce its GHG emissions and diversify its energy sources to ensure long-term sustainability. The government's commitment to the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement has set the stage for a comprehensive energy transition.

To facilitate the energy transition, Malaysia has been revising its energy policy framework. This includes a move towards greater reliance on RE sources such as solar, wind, and hydroelectric power. The government has implemented supportive policies and incentives to attract investments in RE infrastructure, including feed-in tariffs and tax incentives for RE projects.

One of the most significant developments in Malaysia's energy transition is the increasing focus on GH2. GH2 is produced using RE sources to electrolyze water, separating hydrogen from oxygen. This process generates no carbon emissions and offers a versatile energy carrier that can be used in various sectors, including transportation, industry, and power generation.

National Energy Policy 2022-2040 was launched on 19 September 2022 to:

i. Enhance macroeconomic resilience and energy security.
ii. Achieve social equitability and affordability; and
iii. Ensure environmental sustainability.



In reducing reliance on fossil fuel, NEP targets to shift towards EV with a target of 38% TIV by 2040. **Hydrogen (especially green)** opportunities is targeted to be unlocked as pilot and market entry programmes as well as next generation bioenergy **beginning year 2022** as shows in the table below:

Table 2: Energy Mix Growth to 2040

	2018	2040
Bioenergy	1%	▲ 4%
Solar	0%	▲ 4%
Hydropower	6%	▲ 9%
Oil Products	30%	27%
Natural Gas	41%	39%
Coal	22%	17%
TOTAL	100%	100%

Malaysia is one of the economies that is actively exploring the use of GH2 as a clean and sustainable energy source. The economy has a number of advantages that make it well-suited for the production of GH2, including:

i. Abundant RE resources, such as solar and hydroelectric power.
ii. A strategic location in Southeast Asia, which makes it well-positioned to export GH2 to other economies in the region.
iii. A government that is supportive of the development of the GH2 industry.

In recent years, there have been a number of GH2 projects announced in Malaysia. These include:

- The H2ornbill project, which is a joint venture between Japanese firms Eneos and Sumitomo, and Sarawak Energy Bhd. The project will produce GH2 from hydroelectric power in Sarawak, and the hydrogen will be used domestically and exported to Korea.
- The H2biscus project, which is a joint venture between Sarawak Energy Bhd and the Malaysian GH2 Corporation. The project will produce GH2 from solar power in Sarawak, and the hydrogen will be used domestically and exported to Singapore.

The Malaysian government has set a goal of becoming a major player in the global GH2 market. The government has developed a Hydrogen Economy and Technology Roadmap, which outlines the economy's plans for the development of the GH2 industry. The roadmap aims to make Malaysia a major producer and exporter of GH2 by 2030.

The development of the GH2 industry in Malaysia has the potential to create jobs, boost the economy, and help the economy reduce its carbon emissions. It is an exciting time for the GH2 industry in Malaysia, and the economy is well-positioned to become a major player in the global market.

5.0 ASPIRATION POST SEMINAR: ROUNDTABLE DISCUSSION

Roundtable Discussions for APEC Green Hydrogen Advocacy were conducted in conjunction with the Seminar conducted. The Roundtable Discussion have been concluded and summarised (Figure 5).

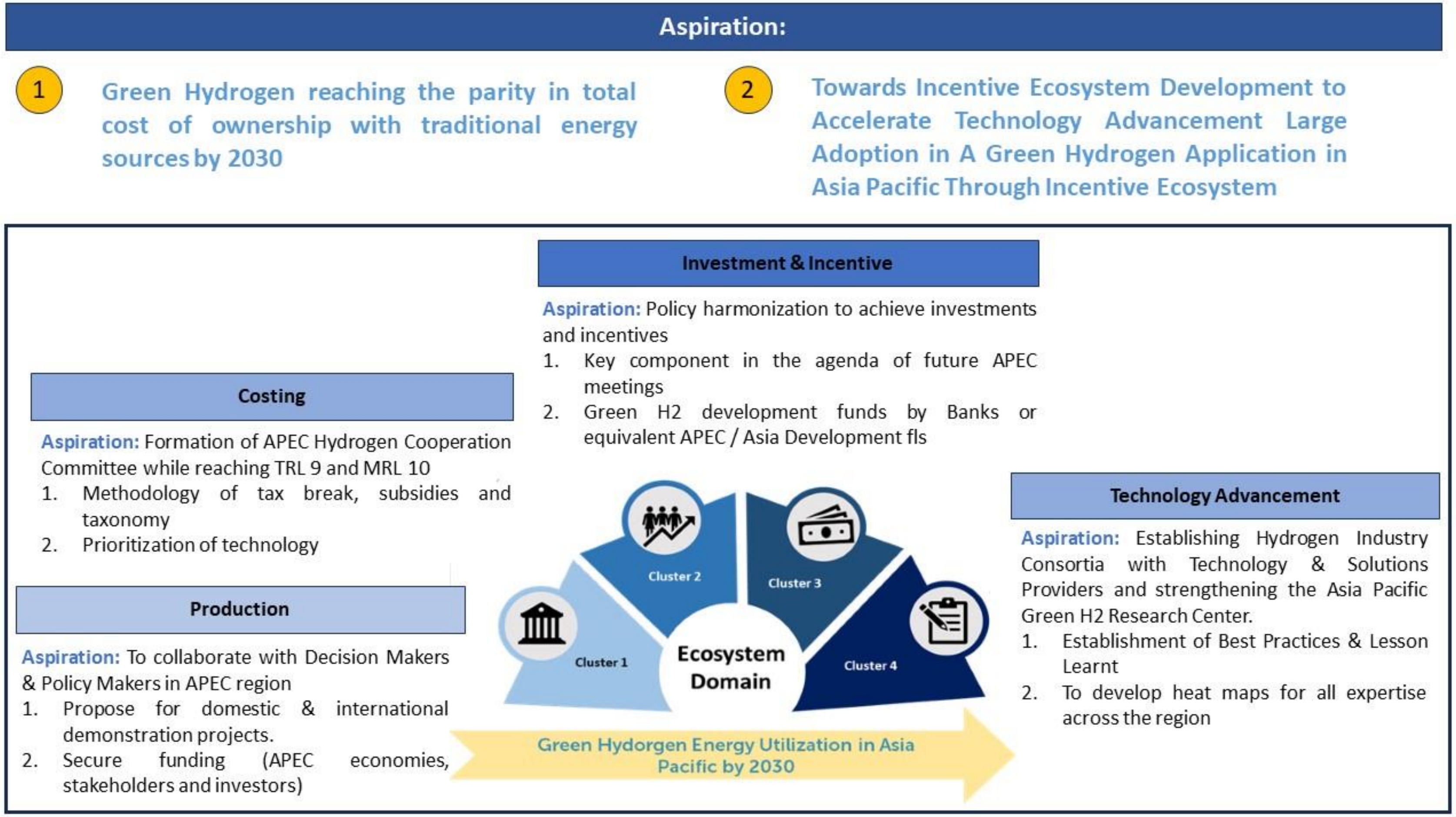


Figure 5.0: RTD summarise mind map.

5.1 List of Group Members

Lead Facilitator: Prof Ts Dr Shahrina Md Nordin

Group 1:

Facilitators:

1) Dr Chai Yee Ho - Malaysia
2) Dr Muhammad Raza Ul Mustafa - Malaysia

Members:

1) Mr Denis Deryushkin – The Russian Federation
2) Ms Bui Thi Hong Van – Viet Nam
3) Professor Ir Dr Haslenda Hashim FASc - Malaysia
4) Ms Fan Li - China
5) Dr Ma Fanhua - China
6) Dr Muhammad Abdul Kholiq - Indonesia
7) Dr Yusrizam Bin Sharifuddin - Malaysia
8) Mr David Lujan Tantarico - Peru
9) Dr Ronaldo P. Parreno Jr. - The Republic of the Philippines
10) Dr Rujira Jitrwung - Thailand
11) Dr Anita Ramli - Malaysia
12) Dr Liew Peng Yen - Malaysia
13) Ms Nur Suraya - Malaysia
14) Dr Amjad Shamim - Malaysia
15) Ts. Muhtar bin Suhaili - Malaysia
16) Ts Dr Rozetta Dolah - Malaysia
17) Mr Abdul Hadi Mat Som - Malaysia
18) Mr Teoh Phi Li – Malaysia
19) Ts Muhammad Shafiq Bin Shahrul Amar - Malaysia

Group 2:

Facilitators:

1) Dr Suriati Sufian - Malaysia
2) Dr Amjad Shamim - Malaysia

Members:

1) Prof Ricardo Vega Viveros - Chile
2) Prof Rocio Salas - Peru
3) Dr Kai Xu - China
4) Dr Zhigang Liu - China
5) Dr Rezal Khairi Ahmad - Malaysia
6) Mr Mohamad Azreen Firdaus bin Abd Aziz - Malaysia
7) Dr Tania Pena Baca - Peru
8) Mr Nonilo A. Pena - The Republic of the Philippines
9) Dr Piya Parnphumeesup - Thailand
10) Dr Lim Jun Wei - Malaysia
11) Dr Nik Abdul Hadi - Malaysia
12) Mr Amir Ariff Fadzil - Malaysia
13) Ts. Dr. Mohd Fadhzir Ahmad Kamaroddin - Malaysia
14) Dr Roshafima Rasit Ali - Malaysia
15) Mr Ridzuan bin Ali - Malaysia
16) Mr Fuaat @ Fuaad bin Mohamed Nawawi - Malaysia
17) Ms Teng Yu He - Malaysia
18) Ms Chan Foh Ching - Malaysia
19) Ir Lalchand Gulabrai FASc - Malaysia

5.2 "How do you see the Green Hydrogen Energy Utilization in Asia Pacific by 2030?"

Group 1

Regulatory Framework	**Financial & Costing**	**Social Acceptance**	**Hydrogen Industry**	**Partnership**
▪ Safety Regulations ▪ Technological Standards ▪ Technological Management	▪ Methodology for Tax breaks and Subsidies ▪ Fiscal and Non-Fiscal intervention ▪ Unified Taxonomy ▪ ESG ▪ CAPEX	▪ Communication Education Plan Awareness (CEPA) - Impactful Communication Plan to the public/stakeholders/financiers ▪ Raising awareness ▪ Conferences ▪ Readiness to embrace Green Hydrogen.	▪ Hydrogen Volume ▪ Technological Readiness Level (TRL/MRL=BRL) ▪ Creation for market demand for GH ▪ Energy Mix ▪ Mode of transportation	▪ Database of projects ▪ Creation of Educational Programs ▪ International Pilot/ Demonstration Projects
Aspiration	**Green Hydrogen reaching the parity in total cost of ownership with traditional energy sources by 2030**			

Group 2

Technology Advancement	**User Demand Market Production**	**Investment & Incentive**	**Social Profitability**	**Infrastructure Readiness**	**Partnership**
▪ Disruptive Technology excluding Electrolysis, Biomass, Biogasss Utilization ▪ Refining Decarbonisation using H2 ▪ Hydrogen Fuel Cell use technologies	▪ RE power for Green Hydrogen Production ▪ H2 use in Gas Power Plants ▪ 5% of H2 ICE & Fuel Cell Vehicles ▪ H2 Based electricity (for remote Communities) ▪ H2 Blending NG for Gas Turbines ▪ Wind & Solar to generate H2 ▪ Green H2 Steel Production ▪ Green H2 for Power Generation ▪ Thermal Applications in industry	▪ Cost Competitive H2 Production ▪ Incentives ▪ Subsidies ▪ Research Grants ▪ Tax Exemptions .	▪ Socioeconomic Benefits Metrics ▪ Policies ▪ Public Awareness ▪ Public Acceptance ▪ Environmental Social & Governance (ESG) ▪ Future-ready Education	▪ H2 pipeline below 20% ▪ Transport Ammonia Mining Sector	▪ Hydrogen Technical Codes and Standards Standardization ▪ Technology & Knowledge Transfer through Strategic Procurement Processes
Aspiration	**Towards Incentive Ecosystem Development to Accelerate Technology Advancement Large Adoption in A Green Hydrogen Application in Asia Pacific Through Incentive Ecosystem**				

5.3 End-State Aspirations, Key Success Factors & Measures

Consolidated Aspiration:

Adoption of Green Hydrogen in a Large Application in Asia Pacific through Economic Ecosystem by 2030.

The following summarises the discussion from Groups 1 and 2 on end-state aspiration statement which must be meaningful, desired and achievable. The description in the tables below also outline key success factors.

Group 1

End-State Aspiration Statement- Meaningful, Desired & Achievable	
Green Hydrogen reaching parity in total cost of ownership with traditional energy sources by 2030	
Key Success Factors (How to Measure?)	
TCO metrics for various sectors: metallurgy, power generation, transportation	Reducing the LCOH by 30% (USD5/kg) by 2030 (Green Hydrogen)
Building Energy Index (BEI)	Reducing the BEI to 45 and below by 2030
Green Hydrogen Production in APEC Region	10 million tons of Green Hydrogen in the APEC region in new industries (metallurgy, power generation, transportation), annual production & consumption by 2030
Publication of 5 documents for hydrogen industry, approved by APEC economies.	Hydrogen Footprint, Taxonomy, Safety requirements, Universal Technological Standards, Management

Theme 1	Green Hydrogen Production in APEC Region (10 million ton by 2030)	
Key Strategies (How)	To collaborate with Decision Makers & Policy Makers in APEC regions	To establish a Center of Excellence for APEC members (Research and Development)
Initiatives	1. Propose for domestic & international Demonstration projects. 2. Secure funding (APEC economies, Stakeholders, Investors)	1. Creation of more IP 2. Formation of APEC R&D Cooperation committee
Key Success Factors	Successful production of Green Hydrogen as targeted	

Theme 2	Reducing LCOH by USD5/kg by 2030 (Green Hydrogen			
Key Strategies (How)	Formation of APEC Hydrogen Cooperation Committee		Reaching TRL of 9 and MRL of 10	
Initiatives	Methodology of Tax Breaks and Subsidies	Taxonomy	Prioritization of technology	Development of Joint Pilot projects
Key Success Factors	People, financing, and technology			

Group 2

End-State Aspiration Statement- Meaningful, Desired & Achievable	
Adoption of Green Hydrogen in A Large Application in the Asia Pacific Through Economic Ecosystem by 2030 This sentence may need revision	
Key Success Factors (How to Measure?)	
Demand & Supply	Green Hydrogen Production: 500 tones per day
Competitive Electricity Tariff/Levelised Cost of Hydrogen	USD0.04/kWh (with incentive) / USD1/kgH2
Common Standards Compliance Among APEC members	Practicing ISO

Theme 1	Investment & Incentive			
Key Strategies (How)	Policy Harmonization to achieve investments and incentives			
Initiatives	Key component in the agenda of future APEC meetings	Government/ developmental / commercial financial institution to promote Green H2-based projects	Green H2 development funds by Banks or Equivalent APEC/Asian Development FIs	Fiscal & Non-fiscal incentives
Key Success Factors	1. APEC H2 Roadmap as a foundation of policy for APEC members 2. 5% of group revenue generated from Green H2 in APEC region			

Theme 2	Technology Advancement			
Key Strategies (How)	Forming Hydrogen Industry Consortia with Technology & Solutions Providers		Reinforcing/empowering existing capabilities as Asia Pacific Research Centre on Green H2	
Initiatives	Applied Research, Commercialisation to accelerate Technology Adaption	Establishment of Best Practices & Lessons Learnt	To develop heat maps for all expertise across the region	Consolidating expertise and capacity building
Key Success Factors	1. Active participation by 50% of APEC members 2. Establish Regional Data Bank on Technology Advancements 3. Adoption and implementation of technologies developed			

5.4 Implementation Plans

The successful implementation of the project to enhance GH2 capacity and advocacy within the APEC region requires a well-structured and coordinated approach. The following implementation plan outlines key steps and actions to be taken:

5.4.1 Stakeholder Engagement:

i. Identify relevant stakeholders, including government agencies, industry players, academia, and NGOs, involved in the GH2 sector within the APEC region.

ii. Establish communication channels and conduct regular consultations to gather input, insights, and feedback from stakeholders.

iii. Organize workshops, seminars, and conferences to facilitate knowledge exchange, collaboration, and strategic planning among stakeholders.

5.4.2 Research and Analysis:

i. Conduct comprehensive research on the Green Hydrogen sector, focusing on technological advancements, policy frameworks, market trends, and best practices from APEC economies and global case studies.

ii. Analyse the effects of incentives on technological innovations within the new energy vehicle ecosystem to understand their impact on GH2 adoption.

iii. Identify barriers, challenges, and opportunities for GH2 development in APEC economies through data collection, surveys, and analysis.

5.4.3 Capacity Building Programs:

i. Develop and implement capacity building programs tailored to the specific needs of APEC economies. These programs may include training workshops, technical assistance, and knowledge-sharing platforms.

ii. Collaborate with academic institutions, research organizations, and industry experts to provide specialized training on GH2 technologies, project development, and policy implementation.

iii. Facilitate partnerships between educational institutions and industry players to foster research and talent development in the GH2 sector.

5.4.4 Policy Advocacy:

i. Advocate for supportive policies and regulatory frameworks at the domestic and regional levels to facilitate the development and deployment of GH2 technologies.

ii. Engage with policymakers, government agencies, and international organizations to provide evidence-based recommendations on policy incentives, standards, and regulations.

iii. Highlight the economic, environmental, and social benefits of GH2 to encourage policy support and promote GH2 as a viable solution for achieving carbon neutrality.

5.4.5 Monitoring and Evaluation:

i. Establish a robust monitoring and evaluation framework to track the progress, effectiveness, and impact of the projects.

ii. Define key performance indicators (KPIs) to assess the achievement of project objectives and targets.

iii. Regularly review and analyse project outcomes, gather feedback from stakeholders, and make necessary adjustments to the implementation plans based on evaluation results.

By following this implementation plan, the project will effectively enhance capacity building and advocacy for GH2 in the APEC region, driving sustainable growth, reducing carbon emissions, and contributing to the transition towards a carbon-neutral future. Regular monitoring, evaluation, and adaptation of the plan will ensure its successful implementation and desired outcomes.

6.0 SUMMARY AND RECOMMENDATIONS

The project aimed to enhance capacity building and advocacy for GH2 within the APEC region, aligning with global sustainability goals and the transition towards a net-zero emissions economy. By addressing key challenges and engaging multiple stakeholders, the project seeks to promote the adoption of GH2 technologies and policies, fostering inclusive sustainable growth and reducing carbon emissions. The implementation plan outlines steps for effective project coordination, stakeholder engagement, research, capacity building, policy advocacy, knowledge dissemination, and monitoring.

Recommendations:

a. Strengthen Collaboration:

Foster strong collaboration among APEC economies, academia, industry players, and policymakers. Encourage knowledge exchange, sharing of best practices, and joint initiatives to accelerate GH2 development across the region.

b. Policy Support:

Advocate for supportive policies and regulatory frameworks that incentivize GH2 adoption and create a favorable market environment. Encourage APEC economies to implement feed-in-tariffs, carbon pricing, and financial support mechanisms to drive investment in GH2 technologies.

c. Technology Advancement:

Promote research and development efforts to improve the efficiency and cost-effectiveness of GH2 technologies. Facilitate partnerships between research institutions, industry experts, and technology providers to accelerate technological advancements in GH2 production, storage, and distribution.

d. Capacity Building:

Develop tailored capacity building programs to address the specific needs of APEC economies. Provide training, technical assistance, and knowledge-sharing platforms to enhance expertise in GH2 technologies, project development, and policy implementation.

e. Public Awareness:

Launch comprehensive awareness campaigns to educate the public about the benefits and potential of GH2. Highlight the role of GH2 in achieving net-zero emissions and its positive impact on economic growth, job creation, and environmental sustainability.

f. Financing Support:

Explore funding opportunities, public-private partnerships, and investment frameworks to support GH2 projects and infrastructure development. Encourage financial institutions to provide favourable financing options and incentives for GH2 initiatives.

g. Monitoring and Evaluation:

Establish a robust monitoring and evaluation framework to assess the progress and impact of the project. Regularly review project outcomes, gather stakeholder feedback, and make necessary adjustments to ensure its effectiveness.

By implementing these recommendations, the project can effectively enhance capacity building and advocacy for GH2 within the APEC region, contributing to the transition towards a cleaner and more sustainable future. The project's success will depend on close collaboration among stakeholders, supportive policies, technological advancements, and effective communication to build a strong foundation for GH2 development.

Conclusions

The purpose of our project was to enhance capacity building on GH2 technologies, production and value chain enhancement through advocacy for acceleration towards actionable strategic planning and recommendations. The development and adoption of GH2 presents significant opportunities for inclusive sustainable growth and the achievement of net-zero emissions goals within the Asia-Pacific Economic Cooperation (APEC) region. This project to enhance GH2 capacity building and advocacy through structured engagements and research is crucial in addressing the existing gaps and challenges in the sector.

By effectively coordinating stakeholders, conducting in-depth research, implementing capacity building programs, advocating for supportive policies, and promoting knowledge dissemination, the project aims to accelerate the development and adoption of GH2 technologies across APEC economies.

While challenges such as high production costs, infrastructure development, technological advancements, policy frameworks, public acceptance, and scalability exist, they can be overcome through collaborative efforts and targeted actions. The project's implementation plan provides a roadmap for addressing these challenges and maximizing the potential of GH2 in the region.

By following the recommended strategies, including strengthening collaboration, advocating for supportive policies, advancing technology, building capacity, raising public awareness, and ensuring effective monitoring and evaluation, the project can achieve its objectives and deliver positive outcomes for the APEC region.

Ultimately, the successful implementation of this project will position APEC economies as leaders in the GH2sector, promoting inclusive sustainable growth, addressing climate change, and contributing to the global transition towards a net-zero emissions economy.

APPENDIX I: Poster

APPENDIX II: Tentative

Day	Time	Procedure	Location	Remarks
29 May 2023 (Day 1)	8.15am – 9.00am	Registration		Permata Sapura Lobby – Access Card CAPE Lobby – Event materials, Tagging,
	9.00am – 9.40am	**Opening Session of UTP-APEC GH2 Seminar**		1) Welcoming Speech: **Professor Ts. Dr Mohamed Ibrahim Bin Abdul Mutalib,** Vice Chancellor Universiti Teknologi PETRONAS 2) Opening Speech: **YBhg. Datuk Ts. Dr. Hj. Aminuddin Bin Hassim**, Secretary General of MOSTI 3) Video presentation on GH2 4) Project Overseer Speech: **AP Ts. Dr. Shahrina Md Nordin** Director of Institute of Self-Sustainable Building, Universiti Teknologi PETRONAS
	9.40am – 11.30am	**The Role of Hydrogen in Energy Transition: Strategies and Policies**		Speaker 1 **Mr. Denish Deryushkin**

				Head of Russian National Hydrogen Union, The Russian Federation
	11.30am – 11.45am	Morning Tea Break		Tea/coffee with snacks
	11.45am – 12.45pm	**Green H2 inclusion in Global Energy Mix**		Speaker 2 **Ms. Bui Thi Hong Van** Managing Director of Angelin Energy, Viet Nam
	12.45pm – 2.30pm	Lunch		
	2.30pm – 4.30pm	**Forum: Developing and Growing Hydrogen Value Propositions**		Forum speakers: **1.Mr Denis Deryushkin** Head of Russian National Hydrogen Union, The Russian Federation **2.Ms. Bui Thi Hong Van** Managing Director of Angelin Energy, Viet Nam Moderator: **Professor Shameem Rafik Galea** President of Malaysian Association of Applied Linguistics (MAAL)
	4.30pm	Hi-tea		Tea/coffee with snacks
End of Day 1				

<table>
<tr><td rowspan="8">30 May 2023

(Day 2)</td><td>8.15am</td><td>Registration</td><td rowspan="8">CAPE</td><td>Permata Sapura Lobby</td></tr>
<tr><td>9.00am – 11.00am</td><td>GH2: The Fuel of The Future</td><td>Speaker 3

Prof Ricardo Vega Viveros

Professor at Universidad de Santiago de Chile (USACH)

Chile</td></tr>
<tr><td>11.00am</td><td>Morning Tea Break</td><td>Tea/coffee with snacks</td></tr>
<tr><td>11.30am – 12.30pm</td><td>Women Leaders in the Energy Sector: Perspectives on GH2</td><td>Speaker 4

Prof Rocio Salas

Professor at Universidad Nacional de Ingeniería (UNI) Perú.

Project Manager, Women in GH2

Peru</td></tr>
<tr><td>12.30pm</td><td>Lunch</td><td></td></tr>
<tr><td>2.30pm – 4.30pm</td><td>Forum: Regional Roadmap needed through 2030 to meet the targets for clean, affordable energy SDG 7, towards net-zero emissions by 2050</td><td>Forum speakers:

1. Prof Ricardo Vega Viveros

Professor at Universidad de Santiago de Chile (USACH)

Chile

2. Prof Rocio Salas

Professor at Universidad Nacional de Ingeniería (UNI) Perú.

Project Manager, Women in GH2

Peru

Moderator:

Professor Shameem Rafik Galea

President of Malaysian Association of Applied Linguistics (MAAL)</td></tr>
<tr><td>4.30pm</td><td>Hi-tea</td><td>Tea/coffee with snacks</td></tr>
<tr><td colspan="5">End of Day 2</td></tr>
</table>

	8.15am – 9.00am	Registration		Permata Sapura Lobby
	9.00am – 10.00am	**Sharing session of research work findings**		**Dr Amjad Shamim** Senior lecturer Universiti Teknologi PETRONAS
	10.00 am – 10.15 am	Morning Tea Break		Tea/coffee with snacks
31 May 2023 (Day 3)	10.15am – 12.00pm	**GH2 & CO2 methanation for decarbonising industry**	CAPE	Speaker 5 **Professor Ir Dr Haslenda Hashim FASc** Professor Chemical Engineering/Chair Resource Sustainability Research Alliance Faculty of Engineering Universiti Teknologi Malaysia
	12.00pm – 1.00 pm	**Mastering Green & Clean Hydrogen**		Speaker 6 **Dr Rezal Khairi Ahmad** Chief Executive Officer NanoMalaysia Berhad
	1.00pm – 2.15pm	Lunch		
	2.15pm – 3.15pm	Roundtable Discussion 1 **Aspiration on Green H2 in APEC economies: Best Practices, Key Success Factors & Challenges**		The roundtable discussion will be amongst the participants facilitated by PO. **AP Ts. Dr. Shahrina Md Nordin** Director of Institute of Self-Sustainable Building, Universiti Teknologi PETRONAS
	3.15pm – 4.15pm	Roundtable Discussion 2		

		GH2 as the Fuel of the Future: Key Strategies across the multi-sectors sharing session (15 minutes) **Ms Fan Li** Institute of Engineering Thermophysics (IET), Chinese Academy of Sciences		
	4.15pm – 4.45pm	Stakeholder Management: **Strategic Communications on GH2 Advocacy**		
	4.45 pm – 5.00 pm	Closing by Project Overseer (PO)		**AP Ts. Dr. Shahrina Md Nordin** Director of Institute of Self-Sustainable Building, Universiti Teknologi PETRONAS
	5.00 pm	Hi-tea & Wrap-up		Tea/coffee with snacks
End of Day 3				

APPENDIX III: Event Flow

APPENDIX IV: Photo during Seminar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Speaker's Profile
Prof Ricardo Vega Viveros
Professor at Universidad de Santiago de Chile
(USACH), Chile
Ricardo Vega Viveros is a Chilean chemical engineer and professor at the Universidad de Santiago de Chile (USACH), where he serves as the Director of the Hydrogen Economy Centre. With a PhD in Chemical Engineering from the University of Cambridge, he has a strong academic background. His research focuses on hydrogen production, storage, and transportation, leading to the publication of over 100 papers in reputable journals. In 2016, he received the prestigious Chilean National Prize for Exact Sciences. He is a prominent advocate for the development of a hydrogen economy in Chile, leveraging the country's abundant renewable energy resources. He actively contributes to public policy discussions as a member of the Chilean Hydrogen Council and an advisor to the Chilean government on hydrogen policy. His expertise extends beyond academia, as he influences key decision-making processes and collaborates with peers across Latin America. His significant contributions and commitment to a clean and sustainable energy future make him a highly respected and accomplished scholar in the field of hydrogen energy.
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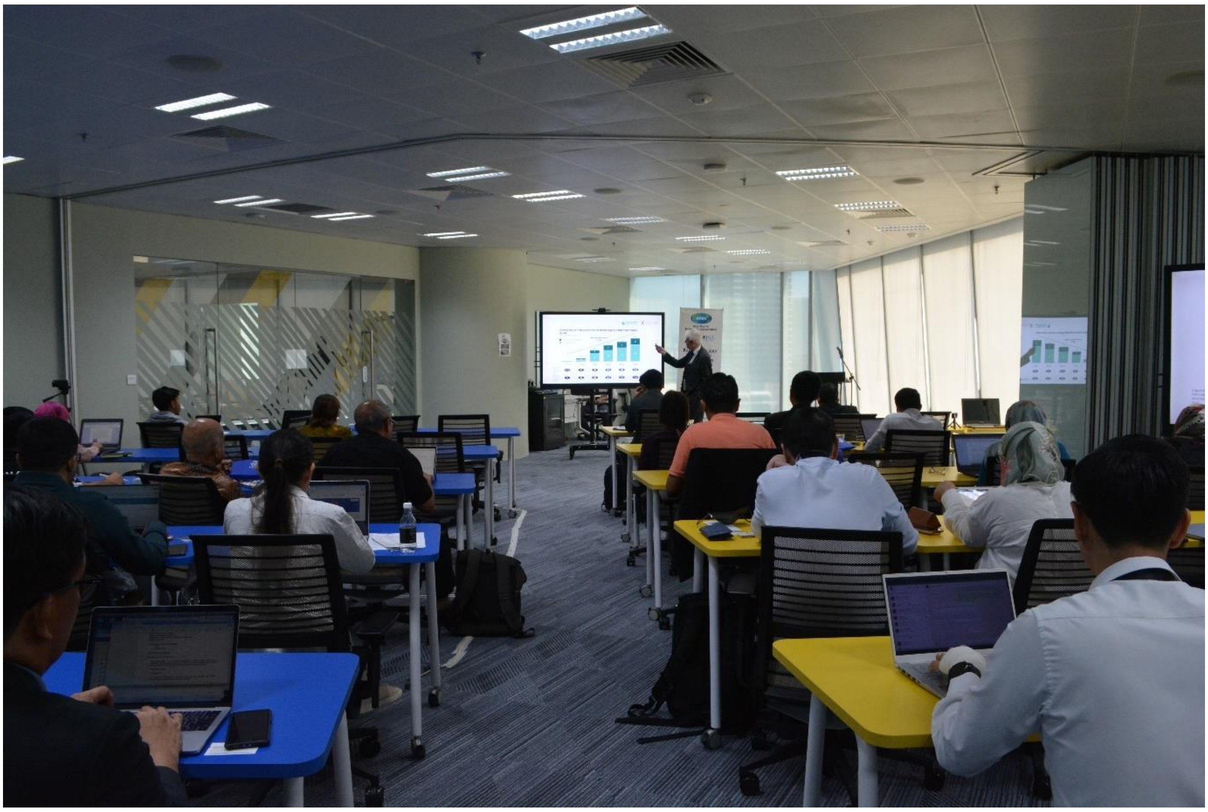
29TH-31ST MAY 2023
VENUE:




8 KEY FACTORS* TO SUCCES IN LAC REGION
*Source: Retrieved from H2LAC.org https://h2lac.org/publicaciones/infografia-sobre-el-estado-del-hidrogeno-verde-en-america-latina-y-el-caribe/
1. Global energy transition: There is a global momentum to achieve an accelerated energy transition that favors all decarbonization technologies in the energy, industrial and transport sectors.
2. Decarbonization industries: Hydrogen can help decarbonize industries where electrification does not have technical capacity to do so. Industrial Decarbonization Roadmap is a MUST.
3. Unified ecosystem: Hydrogen, unlike any other energy vector, makes it possible to directly link the sectors of electric power, gas, transport and industry by using the same molecule.
4. Costs trending down:
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29TH-31ST MA
VENUE:
(CAPE),
KUALA LUMPUR
CAPE


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Asia-Pacific Economic Cooperation
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PAVING THE WAY FOR GREEN HYDROGEN IN ADVANCING CIRCULAR


Roadmap
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UTP
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PAVING THE WAY FOR GREEN HYDROGEN IN ADVANCING CIRCULAR ECONOMY:
STAKEHOLDER MANAGEMENT FOR CAPACITY BUILDING AND STRATEGIC COMMUNICATIONS FOR ADVOCACY


NANOMALAYSIA
MASTERING GREEN AND CLEAN HYDROGEN:
THE MALAYSIAN APPROACH
PAVING THE WAY FOR GREEN HYDROGEN IN ADVANCING CIRCULAR ECONOMY FORUM
by Dr Rezal Khairi Ahmad, CEO of NanoMalaysia
31 May 2023


Background of the Project
Objective
Start Date
Project Completion Date
Data Collection
Seminar
Data analysis and synthesis
Final report
APEC
Asia-Pacific Economic Cooperation
UTP
ISB
PAVING THE WAY FOR GREEN HYDROGEN IN ADVANCING CIRCULAR ECONOMY:
STAKEHOLDER MANAGEMENT FOR CAPACITY BUILDING AND STRATEGIC COMMUNICATIONS FOR ADVOCACY
29TH-31ST MAY 2023
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