APEC Sectoral Symposia on the Holistic Approach of Decarbonization for Energy Transition

APEC Energy Working Group

June 2024

Asia-Pacific
Economic Cooperation

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Economic Cooperation

APEC Sectoral Symposia on the Holistic Approach of Decarbonization for Energy Transition

APEC Symposium on Pursuing Decarbonization of Fossil Fuels
11-12 October 2023
Kobe City, Hyogo, Japan

APEC Symposium on Promoting Energy Efficiency and Energy Management System
23-24 January 2024
Tokyo, Japan

APEC Energy Working Group

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Asia-Pacific Energy Research Centre (APERC)
11F, 1-13-1 Kachidoki, Chuo-ku
Tokyo 104-0054
Japan

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

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1. Background

In energy transitions, there is no “single best solution” for achieving carbon neutrality or “net-zero”, as each APEC economy has different economic and social structures, and geographical situations. Asia Pacific Energy Research Centre (APERC) strongly believes that various, pragmatic and sustainable decarbonization pathways, that reflect the different circumstances of each economy, are essential to achieving the energy transitions.

To facilitate these transitions, it is beneficial to share knowledge and experience among member economies. For that purpose, APERC organized the symposia as an APEC project under the auspices of Japan’s Ministry of Economy, Trade and Industry (METI).

2. Objectives

Our objective is to provide vital information on decarbonization of fossil fuel use and energy efficiency and energy management system, and to share experience and insights on these issues so that voluntary and engaged APEC economies will be better prepared to realize various, pragmatic, and sustainable energy transitions while pursuing decarbonization towards carbon neutrality.

3. Symposium Methodology

The two in-person sectoral symposia were held as a follow-up to the APEC Symposium on Holistic Approaches to Decarbonization Towards Carbon Neutrality in 2021 to further discuss two issues, which are important elements of that holistic approach. One is the decarbonization of fossil fuel use including Hydrogen, Ammonia and Carbon Capture, Usage and Storage (CCUS), and the other is energy efficiency and energy management system.

Date	Theme	Place
11 and 12 October 2023	Pursuing Decarbonization of Fossil Fuels	Kobe City, Hyogo Prefecture, Japan
23 and 24 January 2024	Promoting Energy Efficiency and Energy Management System	Tokyo, Japan

The symposia invited speakers from a wide range of experts, including government, private company, academia, and research institutions, to share their knowledge and experience through the theme presentations and discussions:

・Evaluation of Current Status and How to Promote Development and Deployment on Hydrogen, Fuel Ammonia, CCUS, and Direct Carbon Capture (DAC).
・Energy Efficiency in Building, Transport, : Current Situation and Room for further improvement.
・Energy Efficiency in Industry: Additional Potential for Achieving Carbon Neutrality in APEC.
・Energy Management System and Smart City: Current Situation and Room for further improvement.

4. Participating Economies and Organizations

A total of 114 individuals attended the two symposia, including speakers and participants from 17 APEC economies and one non-member economy: Australia; Canada; Chile; China; Hong Kong, China; Indonesia; Japan; Korea; Malaysia; New Zealand; Papua New Guinea; the Philippines; Singapore; Chinese Taipei; Thailand; the US; Viet Nam and Portugal.

- Government officials from energy agencies involved in formulating policies, programs and measures for various, pragmatic and sustainable energy transitions and decarbonization: Department of Climate Change, Energy, the Environment and Water (Australia), Ministry of Energy (Chile), National Energy Administration (China), Electrical and Mechanical Services Department, Government of the Hong Kong, China, Ministry of Energy and Mineral Resources (Indonesia), Ministry of Economy, Trade and Industry (Japan), Ministry of Trade, Industry and Energy (Korea), Ministry of Natural Resources, Environment and Climate Change (Malaysia), Ministry of Energy Transition and Public Utilities (Malaysia), Energy Commission of Malaysia, Ministry of Business, Innovation and Employment (New Zealand), National Energy Authority (Papua New Guinea), Department of Energy (the Philippines), Ministry of Economic Affairs (Chinese Taipei), Ministry of Energy (Thailand), Department of Energy (the US) , and Ministry of Industry and Trade (Viet Nam).

Symposium on Pursuing Decarbonization of Fossil Fuels in Kobe

- Representatives of clean energy solution company, integrated engineering and contractor, engineering manufacturer, power generation company, steel manufacturer implementing decarbonization technologies and measures: Carbon Engineering (Canada), Chiyoda Corporation (Japan), Kawasaki Heavy Industries, Ltd (Japan), JERA Co, Inc (Japan), Kobe Steel, Ltd (Japan) and Gentari Hydrogen Sdn Bhd (Malaysia).

- Research institutes and academia, and others involved in R&D activities for CCUS and DAC technologies, as well as other research activities: CO2CRC Limited (Australia), Chinese Society for Environmental Sciences (China), PetroChina Planning and Engineering Institute (China), National Research and Innovation Agency (BRIN) (Indonesia), Institute of Applied Energy (Japan), Research Institute of Innovative Technology for the Earth (Japan), University of Tokyo (Japan), Institute of Energy Economics, Japan, Argonne National Laboratory (the US), European Maritime Safety Agency (Portugal) , and Asia Pacific Energy Research Centre.
- Representatives of relevant organization with interest in the topic: The Global CCS Institute (Japan), and Department New Energy and Industrial Technology Development Organization (Japan).

Symposium on Promoting Energy Efficiency and Energy Management System
in Tokyo

- Representative of EV provider charging infrastructure: Green EV Charge Sdn Bhd (Malaysia)
- Research institutes and academia involved in energy efficiency and energy management system, as well as other research activities: Commonwealth Scientific and Industrial Research Organisation (Australia), China National Institute of Standardization (China), Universitas Gadjah Mada (Indonesia), Japan Automobile Manufacturers Association, Inc (Japan), Energy Conservation Center, Japan, Institute of Energy Economics, Japan, Korea Energy Economics Institute (Korea), University of the Philippines, National University of Singapore, Industrial Technology Research Institute (Chinese Taipei), and Institute of Regional Sustainable Development (Viet Nam).

5. Description

APEC Symposium on Pursuing Decarbonization of Fossil Fuels was held on 11 and 12 October 2023 in Kobe City, Hyogo, Japan. The two-day symposium consisted of the following four parts:

I) **Opening Session** included opening remarks and keynote speech.

II) **Presentations and Panel Discussions** on various topics regarding carbon neutrality from experts and related Q&A.

III) **Closing Remarks**
IV) **Site Visits:** Kawasaki Heavy Industries, Ltd, Kobe Steel, Ltd, and Mitsubishi Heavy Industries, Ltd Takasago Machinery Works

APEC Symposium on Promoting Energy Efficiency and Energy Management System was held on 23 and 24 January 2024 in Shinagawa, Tokyo. The two-day symposium consisted of the following four parts:
I) **Opening Session** included opening remarks and keynote speech.
II) **Presentations** on various topics regarding energy efficiency and energy management system from experts and related Q&A.
III) **Closing Remarks**
IV) **Site Visit (Half a day)**: Tokyo Denki University

The agenda and presentation materials are included in the Appendices.

6. Summary of Symposium

6-1. Pursuing Decarbonization of Fossil Fuels (Kobe)

6-1-1. Session 1: Opening Session

a) Opening Remarks

Dr Kazutomo Irie (President, Asia Pacific Energy Research Centre (APERC))

Key points

・Welcomed participants and explained the background & objectives of the symposium.
・Emphasized the importance of the energy transition and decarbonization of fossil fuels and sharing knowledge and experiences among APEC economies.

Summary

Dr Irie welcomed all participants and explained the background and objectives of the symposium. This symposium aims to follow up on the APEC Symposium on Holistic Approach of Decarbonization towards Carbon Neutrality held online in August of 2021 which highlighted the importance of holistic approach to decarbonization in path carbon neutrality.

In energy transition there is no single best solution for achieving carbon neutrality or net zero as each APEC economy has different economic and social structure, and geographically situations.

Emphasized that various pragmatic and sustainable decarbonization pathways which reflect the different the circumstances of each economy essential to achieving successful energy transitions to facilitate these transitions it is beneficial to share knowledge, experience among member economies.

As a holistic approach inevitably covers various issues, a series of sectorial symposium is necessary to deepen our understanding in each sector.

APERC intend to start the sectorial symposium series last year but extend it because of the COVID-19 pandemic ring out. As a first topic of the symposium series, picked up decarbonization fossil fuels.

b) Keynote Speech: Necessity of Decarbonization of Fossil Fuels for Carbon Neutrality

Ms Reiko Eda (Director for Natural Resources and Energy Research, International Affairs Division, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), Japan)

Key points

・Highlighted the common goals of net zero emissions through various pathways according to circumstances of each economy and the need to utilize all kind of technologies energy sources including energy conservation, renewable energy, hydrogen, ammonia, nuclear power, CCUS, and carbon recycling.

・Described Japan’s aims to invest approximately USD1 trillion in green transformation over the next 10 years in both public and private sectors, including green transformation (GX) economic transition bonds.

・Emphasized Japan’s plan to contribute to decarbonization of Asian economies under the Asia Zero Emissions Community (AZEC) platform.

Summary

Ms Eda explained that facing the un-precedented energy crisis, we are expected to combat climate change and to promote energy security while also growing our economies, and it is important to aim common goals of net zero emissions through various pathways according to circumstances each economy. Emphasized that importance of utilizing all kind of technologies energy sources including energy conservation, renewable energy, hydrogen, ammonia, nuclear power, CCUS, and carbon recycling. Japan introduced GX economic transition bonds, which will provide bold upfront investment of JPY20 trillion, equivalent to USD140 billion in the innovations

needed to decarbonize their economy. Through this, the Japanese government will promote energy conservation, development of floating offshore wind power, Perovskite solar cells, and innovative technologies for hydrogen reduction steel making. Japan aims to invest JPY150 trillion, equivalent to USD1 trillion in the GX sector over the next 10 years in both public and private sectors including the use of economic transition bonds.
Japan is working with other Asian economies to decarbonize Asia under the Asia Zero Emissions Community (AZEC) platform. The AZEC Public-Private invest forum announced the 28MOUs in a wide range of decarbonization sectors, including renewable energy, biomass, hydrogen, ammonia, and LNG. In this way, Japan hopes to take the leading role to contribute decarbonization not only domestically but for the entire APEC region.

6-1-2. Session 2: Hydrogen

a) Energy Transition and Green Hydrogen in Chile

Mr Alex Santander Guerra (Head of Division, Energy and Environmental Policy and Studies Division, Ministry of Energy, Chile)

Key points

・With its abundant renewable resources Chile positions itself as future green hydrogen exporter.
・The Chilean Government is working on the Green Hydrogen Action Plan 2023-2030 which is planned for release in November 2023

Summary

To achieve the CN (Carbon Neutrality) goal by 2050, Chile has released several mid-term (2030) policies and has set mid-term goals, such as 80% renewable electricity by 2030, 2GW energy storage by 2030, etc. Given the economy's abundant renewable resources, solar in the north and wind in the south, Chile has positioned itself as a major green hydrogen supplier in the future. Green hydrogen will also play a significant role in local energy supply, expected to contribute 24% of Chile's greenhouse gas emissions reduction by 2050.
To facilitate the economy's green hydrogen development, the Chilean government has developed and published the National Green Hydrogen Strategy in 2020, in which there are several goals such as 5GW electrolyzer capacity by 2025 and 25GW by 2030, green hydrogen production cost lower than USD1.5/kg by 2030, etc. The Green Hydrogen

Strategy has two action plan windows, Action Plan 2020-2023, and Action Plan 2023-2030. In Chile green hydrogen policies are overseen by an Inter-Ministerial Council, chaired by the Ministry of Energy and involves several public agencies that related to green hydrogen project development. The latest green hydrogen policy development in Chile is drafting of the Green Hydrogen Action Plan 2023-2030, which also involves consultation through citizen workshops, interaction with groups from different political backgrounds, as well as getting feedback from private companies. The preliminary version of the Green Hydrogen Action Plan 2023-2030 is supposed to be released in November 2023, and after the public consultation process the action plan will be finalized within the first quarter of 2024.

b) Gentari's Venture into Hydrogen Production Projects in Malaysia and Overseas
Mr Awadh Asyraf Bin Supri (Head of Marketing & Sales, Far East & Australia
Gentari Hydrogen Sdn Bhd, Malaysia)

Key points

・Gentari, the clean energy solutions arm of PETRONAS, focuses on clean energy with a global target of renewable energy (30-40GW) and Hydrogen (up to 1.2 million tons) as well as Green Mobility (10% market share in select markets) by 2030.

・The company is developing mainly export-scale clean hydrogen projects (including hydrogen carriers, such as ammonia) in Canada; India; Malaysia, and is looking to grow its business in Australia; Chile; Europe; the US; and Oman while cooperating with various Japanese companies.

Summary

Gentari, though is a subsidiary of Petronas, is an independent entity focuses fully on clean energy. The company is targeting 30-40GW renewable energy portfolio and up to 1.2 tons per year clean hydrogen production by 2030. The Malaysian Government has released the Hydrogen Economy and Technology Roadmap in October 2023. Gentari is developing both blue and green hydrogen and ammonia in Malaysia utilizing existing facilities and infrastructures. The company also has clean hydrogen and ammonia project development in Canada and India. Gentari sees Australia; Chile; and the US as promising clean hydrogen suppliers in the future.

Gentari has several cooperation with Japanese companies, for example, joint studies with IHI Corporation for ammonia co-firing and with ENEOS for MCH in West Malaysia, blue ammonia project development with Itochu Corporation in Canada, and e-methane projects with Tokyo Gas and Osaka Gas separately in East Malaysia. Key learnings from the company's business activities include: importance of government support mechanisms at the early stage, strategic partnerships over the entire supply chain to improve economic factors, roadmap with practical deployment plans.

c) Development of Global Supply Chain by LOHC-MCH method

Mr Yuji Chishima (Group Leader of Business Development, Hydrogen Business Department, Chiyoda Corporation, Japan)

Key points

・The major advantage of using Methylcyclohexane（MCH) as hydrogen carrier is that existing infrastructure and logistic facilities can be utilized.

・Chiyoda has started R&D on Liquid Organic Hydrogen Carriers (LOHC)-MCH system since 2002 and has a hydrogen supply chain demonstration project of Brunei Darussalam and Japan and other projects in Rotterdam Port.

Summary

There are several carriers for long distance hydrogen transportation. Each carrier has its advantages and disadvantages. Chiyoda's SPERA technology uses LOHC-MCH as hydrogen carrier. Chiyoda has started R&D on LOHC-MCH system since 2002. The LOHC-MCH system includes hydrogenation process at the production side, which is synthesis of MCH with hydrogen and toluene, and dehydrogenation process at the demand side, which is taking hydrogen out from MCH. The toluene from the dehydrogenation process can be transported back to the production side and be reused. Chiyoda's key proprietary technology is the development of catalyst used in the dehydrogenation process.

MCH's property is similar to gasoline and can be shipped using existing tankers. Regulations for the handling of MCH is already in place. Chiyoda is a central member in the Advanced Hydrogen Energy Chain and Association for Technology Development (AHEAD) and the international hydrogen supply chain demonstration project, shipping hydrogen from Brunei Darussalam to Japan using MCH system. First cargo of the project has arrived in Japan. Chiyoda is also taking out R&Ds to further reduce the cost and carbon footprint of the MCH system, including direct MCH synthesis at the production end, and integration of dehydrogenation with applications that generate heat such as gas turbine, Direct Reduced Iron (DRI), or Solid Oxide Fuel Cell (SOFC) to utilize the recycled heat from the application. Besides the AHEAD demonstration project, Chiyoda is also working on hydrogen transportation using MCH system in Singapore and Europe (Port of Rotterdam) etc.

d) Towards the Realization of International Liquefied Hydrogen Supply Chain

Mr Shintaro Onishi (Senior Staff Officer, Section 3, Business Development Department, Project Group, Hydrogen Strategy Division, Kawasaki Heavy Industries, Ltd, Japan)

Key points

- Kawasaki Heavy Industries focuses on using liquefied hydrogen as a hydrogen transportation carrier and has a liquefied hydrogen supply chain demonstration project between Australia and Japan.
- The company plans to start the first commercial liquefied hydrogen supply chain by 2030 and scaling up the supply facilities is the main challenge.

Summary

Kawasaki Heavy Industries (KHI) has developed technologies over the entire hydrogen supply chain, from hydrogen production, to transportation, storage, and utilization. For hydrogen transportation and storage, KHI focuses on liquefied hydrogen, utilizing the company's long-time experience on LNG. KHI is a major member of the Australia-Japan liquefied hydrogen transportation pilot project (HySTRA (CO2-free Hydrogen Energy Supply-chain Technology Research Association)). Under the pilot project, a prototype of liquefied hydrogen ship has been built and has carried liquefied hydrogen from Australia to Japan. At the receiving terminal at Kobe in Japan facilities such as liquefied hydrogen loading arms and storage tank have been built.

For the next stage, scaling up the facilities is the main challenge and main task for liquefied hydrogen supply. KHI, together with its partners, is working on building commercial scale liquefied hydrogen supply chain and has been supported from the government's Green Innovation Fund for key technology development. The company plans to start the first commercial liquefied hydrogen supply chain by 2030 and once the feasibility and economic viability is proved, building more supply chains in the future.

e) Analysis of Current and Future Hydrogen Production and Utilization in the United States

Dr Amgad Elgowainy (Senior Scientist, Distinguished Fellow, and Group Leader, Energy Systems and Infrastructure Analysis, Argonne National Laboratory, the US)

Key points

・Hydrogen (grey) production in the US is about 10 million tons per year. Most of the US's hydrogen production and usage is in the Gulf region.

・ Argonne's hydrogen carbon footprint assessment model finds out that hydrogen produced from electrolysis using renewable electricity has the lowest carbon intensity from well-to-gate.

・Results from the economic evaluation model suggest that for the hydrogen applications to be competitive, hydrogen supply cost need to be USD1-2/kg-H2.

Summary

Hydrogen (grey) production in the US nowadays is about 10 million tons per year, most of which is used for oil refinery and ammonia production. Approximately half of hydrogen production is in the Gulf area of the US. Under the Bipartisan Infrastructure Law, several clean hydrogen hubs are to be selected and government will provide subsidies for hydrogen supply chain development at the hubs. Production of hydrogen in the hubs including not only renewable hydrogen but also fossil-fuel based hydrogen with CCS and hydrogen from nuclear power. Benchmark for clean hydrogen in the US is less than 4kg-CO2/kg-H2. In 2022, the Inflation Reduction Law gives clean hydrogen producers up to USD3/kg-H2 incentive for hydrogen carbon intensity below 0.45kg-CO2/kg-H2. Argonne's the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model is used to quantify the carbon intensity and therefore the credit for clean hydrogen production.

With Department of Energy (DOE)'s support, Argonne has developed the Life Cycle Assessment (LCA) model since 1995. The model covers the whole hydrogen value chain. On the production side, electrolysis with renewable electricity has the lowest carbon intensity. For domestic hydrogen delivery, hydrogen tube trailer and liquid hydrogen trucks are considered in the model. Argonne's technoeconomic models, including Hydrogen Delivery Scenario Analysis Model (HDSAM), also evaluated cost of hydrogen supply chain and various end use applications, including fuel cell vehicles, hydrogen refueling stations, ammonia production, e-methanol synthesis, and other e-fuels from Fischer-Tropsch (FT) process, steel production using DRI technology, etc. The modeling results suggest that for the hydrogen applications to be competitive, hydrogen supply cost need to be USD1-2/kg-H2. USD1/kg-H2, which is also consistent with the near-term and long-term price targets set by the DOE's Hydrogen Shot program.

f) Q&A and Discussions

Key points

- The idea of a hub is basically to co-locate supply and demand in a single region at scale. At present most hub likely activities will be in ammonia sector.
- Utilization of existing infrastructure is important to bring down hydrogen supply costs.
- Government support at the early stage is necessary to scale up the market.
- Although there is no price index for hydrogen and synthetic fuels, there are some players working on price index development.
- Government support to push forward Chile's green hydrogen projects includes bringing public land for use and coordinating territorial planning in the northern part of Chile.
- While recognizing the importance of equipment embodied emissions in hydrogen supply, most of the current assessment methodologies are well-to-gate evaluation. There are challenges to data availability and consistency of boundaries for all fuels to cover the embodied emissions for the entire global supply chain.

Summary

Q (to all): When I think of a hydrogen hub, I'm thinking that may be a location where we can start to observe the prices of hydrogen produced from different sources with different carbon contents behind it. Could you talk a little bit about if we were interested in observing the price of hydrogen and various other fuels and carriers like MCH, methanol and ammonia, and what is the best way to do that (transport hydrogen)?

A (Dr. Amgad Elgowainy): The idea of a hub is basically to co-locate supply and demand in the same region at scale. And like you mentioned, we already have a major hydrogen hub in Texas just by nature because a lot of refining capacities are located there. But as we develop a new value chain for hydrogen across other regions outside the Gulf area in the US, we need to do several things. We need clean hydrogen supply, we need market scaling up, and then we need infrastructure to connect them. That is why we have incentives for clean hydrogen production. And the market scaling up is a big question. Where are the off takers for clean hydrogen? We are now at the early stage of market scaling up and we see a lot of these are going to ammonia. It is natural because we already have infrastructure for ammonia delivery across longer distance at a bigger scale and because of potential of export to other regions. We see a lot of interest in the Sustainable Aviation Fuel (SAF), because this is really an area where there is global pressure for decarbonization. And then we see the vehicle market, which will take some time to develop. But it is coming around. We see some applications in power sector too. Today there is no market price for hydrogen. We can google and know prices for natural gas or oil or even ammonia. There is nothing like that for hydrogen. We are looking forward to a mechanism that can tell hydrogen prices with different carbon intensities.

A (Mr Shintaro Onishi): As for the liquefied hydrogen, currently its cost is considered to be higher than that of existing fossil fuels such as LNG. However, as in the case of LNG, in the future, we have the potential to significantly reduce the price by scaling up the demand. 2030 is still the early stage of market scaling up, but for 2040 or 2050 if utilization of liquefied hydrogen scales up, we can anticipate cost-effectiveness. To scaling up the market, it is essential to collaborate with partners from various fields, as the company’s efforts alone may not be sufficient.

A (Mr Yuji Chishima): Now new infrastructure will be required basically to establish the global supply chain of hydrogen. But to bring the cost down, it will be very important to utilize existing infrastructures. In that sense, in the port area especially, there are lots of existing infrastructures which can be utilized. How we can utilize such existing infrastructures is a very important point. It should be the same for ammonia and MCH and other carriers. Instead of new infrastructure construction, utilization of existing ones can bring down the cost.

A (Mr Awadh Asyraf Bin Supri): While my colleagues (other panelists) have spoken about liquefied hydrogen and MCH, a bit of comment on ammonia. Ammonia is in a bit of a different situation as compared to the other hydrogen carriers. Ammonia has an existing market. The market size is around 200 million tons per year, and of which about 10% or 20 million tons are being traded internationally. But the question is, is this market price the right market price for the new landscape (low carbon ammonia)? Probably not, because the current ammonia market primarily serves the fertilizer market, which has its own supply and demand dynamics. But there are some learnings from the buildup of this market price that we can adopt in the future market pricing for low carbon ammonia and hydrogen. And I think on the business and publication side, we've seen some movements, some learnings that we take from also the LNG industry. In the LNG industry, we have *the Japan Korea Marker, the JKM*, which is published by Platts. Similar concepts are being proposed and being developed for low carbon ammonia, but we need to take away the supply-demand dynamics for the fertilizer segment rather to apply it on the new upcoming segments such as power or the bunkering segments.

Q (to Mr Alex Santander Guerra): I'm referring to the many projects that you currently have in Chile. You've got several projects already under operation in Chile and also a very ambitious target towards 2030. The question that I have is a bit of a reality check in terms of how do you see that upscaling and the actual production of hydrogen over the next seven years?

A (Mr Alex Santander Guerra): We are creating conditions for green hydrogen projects. As a government, we are creating the conditions in infrastructure, mainly ports, routes, and other ones, for example, government-owned companies develop and own the infrastructure, which is open for use by the private companies. In the case of the north of Chile, we are supporting different projects, creating conditions to bring public lands for use, and coordinating all territorial plannings and aspects related with green hydrogen projects.

Q (to Dr Amgad Elgowainy): The carbon intensity you have shown for hydrogen produced from wind or solar was zero. What I'm getting from that figure is that this is not a life cycle analysis, this is just the carbon intensity for hydrogen production. The debate that we have in Australia and globally is like, what is the actual carbon intensity if we include the life cycle analysis or the embedded carbon emissions for the production of the materials. If you have any figures, that would be nice.

A (Dr Amgad Elgowainy): What I showed was strictly conforming to the definition of well-to-gate in the US. These carbon intensity numbers are for well-to-gate, and they do not include embodied emissions. If you look at what is the embodied emission in electrolyzer, we need to track the supply chain to manufacture the electrolyzer, all of that, and then spreading it over the lifetime of the electrolyzer. It is around 70g-CO2/kg-H2. It is relatively small, but the bigger one is solar PV. Most of the solar PV panels come from China, which are more carbon intensive. So, for solar, it is about 35g-CO2/kWh and if multiplied by 60-65kWh/kg-H2 for electrolyzers, it will be about 2kg-CO2/kg-H2. For wind, it is about 0.5kg-CO2/kg-H2. To cover the embodied emissions, there are two difficulties. First, we need to track the supply chain coming to the US, which is difficult due to lack of comprehensive relevant data. And different economies have different numbers because of different supply chains. Second, can we cover the entire supply chain and can we be consistent? For example, if we do that for gas supply chain, we need to cover platforms, onshore, offshore, and processing plants, pipelines, and so on. What we do in the International Partnership for the Hydrogen Economy (IPHE) is that we excluded the embodied emissions also though we think that something needs to be done about embodied emissions. And in the ISO LCA , we put a language there that embodied emissions is key and should be included for information purposes. Lack of data, consistent system boundary, and also regulatory framework sometimes restrict us on what we present about embodied emissions.

6-1-3. Session 3: Fuel Ammonia

a) Fuel Ammonia Production from Fossil Fuels

Mr Yoshikazu Kobayashi (Executive Analyst, New Energy System Group, Clean Energy Unit, The Institute of Energy Economics, Japan)

Key points

・Low carbon ammonia from natural gas is likely to be more cost competitive than ammonia from electrolyzed hydrogen. Lowering carbon intensity on a well-to-gate basis is the major challenge.

・Most of the planned fuel ammonia projects are at the feasibility study stage and policy supports for the demand side will be required to realize active hydrogen trade.

Summary

Mr Kobayashi made a presentation on fuel ammonia produced from fossil fuels. He emphasized that, despite the skepticism against fuel ammonia produced from fossil fuel as less clean, G7 leaders' communique made this year confirmed that low carbon hydrogen and ammonia produced from fossil fuel as an effective means of decarbonization. He explained lowering carbon intensity on well-to-gate basis will be a major challenge for fuel ammonia based on fossil fuels and introduced several technological efforts for such intensity improvement. He also noted that most of the currently planned fuel ammonia projects are still at feasibility study stage and more policy supports toward the demand side will be required to realize active hydrogen trade.

b) Fuel Ammonia Power Generation and Building Supply Chain

Mr Najib Rahman Sabory (General Manager, Decarbonization Promotion Section, Planning Division, JERA Co, Inc, Japan)

Key points

・JERA aims to commence 20% co-firing within FY 2030, and 50% co-firing after 2030.

・Plans to apply its expertise of ammonia utilization aboard and partners with foreign firms in Bangladesh; Indonesia; Malaysia; the Philippines; and Thailand.

Summary

Mr Sabory made a presentation about JERA's decarbonization strategy and the role of fuel ammonia in the strategy. He elaborated the company's investment projects in the entire value chain of fuel ammonia from production, transportation, and utilization at power plants both in Japan and abroad. He explained that JERA aims to commence 20% co-firing within FY 2030, and 50% co-firing after 2030. JERA, according to his presentation, will adopt zero-emission thermal power generation by utilizing hydrogen/ammonia single firing as of 2050. JERA also plans to apply its expertise of ammonia utilization aboard and partners with foreign firms in Bangladesh; Indonesia; Malaysia; the Philippines; and Thailand.

c) EMSA Study Potential of Ammonia as Fuel in Shipping

Mr Sergio Alda (Senior Project Officer, Sustainability, European Maritime Safety Agency (EMSA), Portugal)

Key points

・The International shipping industry would need substantially reducing its GHG emissions to achieve net zero GHG emission by or around 2050 and green ammonia has potential as a zero-carbon fuel for maritime.

・However, several challenges need addressing: safety issues, controlling NOx and N2O, and cost reduction.

Summary

Mr Alda made a presentation on the Agency's recent study on potential use of ammonia as a maritime fuel. He noted the international shipping industry will also need to substantially reduce its GHG emissions to achieve the IMO targets and contribute to achieving carbon neutrality by 2050 in the EU, and green ammonia is being explored as one of several alternatives to support decarbonizing the industry. Ammonia has several advantages such as availability of existing infrastructure and absence of CO2 emissions from its combustion onboard, yet he pointed out several challenges for its commercial use in marine engines, such as safety issues, need of controlling NOx and N2O, and need to reduce the cost gap with other alternatives.

d) Q&A and Discussions

Key points

- Ammonia-co-firing has low technological risks compared to CCS at coal-fired power plants. Japan will not be able to find sufficient domestic storage capacity and utilizing storage abroad may be an option, but it may emit additional CO2 in transporting CO2. Ammonia co-firing, on the other hand, is an established technologies and effectively reduce the CO2 emission in Japan.
- Potential pricing mechanism of fuel ammonia is uncertain. Ammonia already has an international market as a feedstock for fertilizer production, but clean ammonia price will reflect carbon intensity, tax benefits for production, certification by third-party organization, and energy security.
- If a hydrogen carrier is used for fuel cells, it may not be appropriate due to the low purity of cracked hydrogen from ammonia. For combustion as a fuel for boilers or turbines, ammonia is currently the most cost competitive.
- Ammonia will be used soon because it is more technologically matured with existing infrastructure. In the long run, other hydrogen carriers could enjoy the benefits of economies of scale and learning curve effect as their production will grow.

Summary

Q (to Mr Najib Rahman Sabory): Which is more economically attractive option: CCUS application at a power plant in Japan or utilizing ammonia as a co-firing or single-firing fuel?

A (Mr Najib Rahman Sabory): Ammonia-co-firing has a low uncertainty compared to CCS application to coal-fired power plant. In case Japan is not able to find sufficient storage capacity within Japan, utilizing storage in overseas may be an option, but it may still emit additional CO2 in transporting CO2 abroad. Moreover, the CCS application in coal power plants might also require each power plant to be modified and retrofitted with additional infrastructure, which will result additional operation cost in coal power plants. So, there are technical and economical disadvantages to capturing and storing CO2 in coal power plants in Japan. Ammonia co-firing, on the other hand, is an established technologies and effectively reduce the CO2 emission in Japan. Ammonia co-firing is a more preferred option.

Q (to Mr Sergio Alda): How will fuel ammonia be priced? What is a likely benchmark for fuel ammonia?

A (Mr Sergio Alda): It is very difficult to tell. Ammonia already has an international market as a feedstock for fertilizer production, but clean ammonia as decarbonization fuel for shipping will reflect some other factors such as carbon intensity regulations and carbon market pricing, tax benefits for production, competition with other sectors. Consideration of energy security element may also be reflected. All of these factors will affect the final price of fuel ammonia, and it is not easy to tell based on what kind of benchmark the price will be set.

Q (to Mr Yoshikazu Kobayashi): What factors affect the end users' choice of hydrogen carrier?

A (Mr Yoshikazu Kobayashi): It depends on the purpose of the use. If it is utilized for fuel cell, the purity of cracked hydrogen from ammonia will be relatively low and will not be appropriate. But if it is just combusted as a fuel for boiler or turbine, ammonia is currently the most cost competitive.

A (Mr Sergio Alda): It also depends on the time horizon. Ammonia may be used in the near future because it is more technologically mature and has an existing infrastructure. In the long run, other hydrogen carriers may have more benefits of economies of scale and could also become more economically attractive.

6-1-4. Session 4: Carbon Capture, Utilization and Storage (CCUS)

a) CCUS in Japan

Dr Kenta Asahina (Mineral and Natural Resources Division, Natural Resources and Fuel Department, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), Japan)

Key points

- Japan published its annual storage capacity target of 120 to 240 million tons by 2050 and need to start its first commercial CCS operation by 2030 to find enough storage capacity and scale up the operation.
- Japan has already selected seven CCS projects as potential commercialized projects. Swift implementation of feasibility study for those projects are needed to start the

storage operation by 2030.

Summary

Dr Asahina made a presentation about the Japanese government's policies on CCS. He introduced the historical development of CCS in Japan from 2000 and explained the current long-term CCUS roadmap that was released in March 2023. To achieve an annual storage capacity of 120 to 240 million tons by 2050, Japan will start the CCS business by 2030. He explained that the Japanese government has selected seven advanced CCS projects to establish various business models with different combinations of CO2 sources, transportation methods, and CO2 storage areas. He also added that the Japanese government is also working to demonstrate maritime CO2 transportation by ship next year.

b) CCUS in Australia

Dr Matthias Raab (Chief Executive Officer, Executive, CO2CRC Limited, Australia)

Key points

・Australian upstream operations have reached a crossover point where the cost of emitting CO2 exceeds the cost of CCS, stimulated by several factors, including 2050 net-zero targets set by most companies. A further income stream for CCS operators would be the CO2 utilization through enhanced oil recovery for a long time in many projects.

・There are no real technical barriers to CCS operation in Australia. CCS is an essential technology and needs to be adopted on an unprecedented scale for Australia to reach its legislated 2030 and 2050 targets.

Summary

Dr Raab presented the current status of Australian CCS project development. He suggested that Australian gas reached a crossover point where, for projects onshore and offshore, the cost of emitting CO2 exceeds the cost of CCS. He noted that several factors stimulated this crossing over. The first one is that most companies have had their own 2050 net-zero targets. The second one is that CCS can be utilized for enhanced oil recovery for a long time in many projects. He claimed that there are no real technical barriers exist for CCS operations. He emphasized that CCS is an essential technology and needs to be adopted on an unprecedented scale.

c) Carbon Capture, Utilization and Storage in China

Prof Jiutian Zhang (Green Development Institute, Beijing Normal University, Secretary General, China CCUS Association of Chinese Society for Environmental Sciences, China)

Key points

- CCUS is a very important decarbonization solution for China's energy transition and achievement of its carbon neutrality goal before 2060 and will play an important role in keeping the power system at zero emission as well as for the industry sector to realize carbon dioxide removal.
- More than 100 CCS projects in different stages are developed. Major challenges are to reduce costs with innovation and develop good business models.

Summary

Professor Zhang made a presentation on the CCUS operations in China. He contended that CCUS is very important for China's energy transition and achievement of its carbon neutrality goal before 2060. To secure a robust power system, he argued, CCUS will play an important role in keeping the power system at zero emission. CCUS is also very important in decarbonizing the industry sector and realizing negative emissions potentials. Without CCUS, he claimed, China cannot reach the goal of carbon neutrality. In China, a growing number of CCUS demonstration projects are being developed, and the number has already exceeded 100. CCS will be broadly adopted in various sectors from the oil and gas, power, steel, chemical, to cement sectors. He suggested that the main task of CCS technology development is to reduce costs, and developing good business models will bring more CCS potential in the future.

d) CCUS in ASEAN: Recent Developments in Indonesia

Dr Usman Pasarai (Senior Researcher, Research Center for Process and Manufacture Technology, National Research and Innovation Agency (BRIN), Indonesia)

Key points

- CCUS will play a critical role in achieving carbon neutrality in Southeast Asia (SEA), CO2 capture in SEA will have to reach 35 million tons in 2030 and exceed 200 million tons in 2050 to achieve the Paris Agreement.
- Indonesia is an active promoter of CCS in SEA. Most of 15 CCUS initiatives in

Indonesia at varied development stages will be on stream before 2030. Indonesia has relevant laws and regulations on greenhouse gas emissions, carbon tax, carbon trading and upstream oil & gas business activities.

Summary

Dr Pasarai presented the CCUS developments in ASEAN and Indonesia. He referred to the estimate made by the International Energy Agency (IEA) that, in order to remain in line with the Paris Agreement, CO2 capture in SEA will have to reach 35Mt in 2030 and exceed 200Mt in 2050. He introduced that, currently, there are 15 CCS/CCUS initiatives in Indonesia at varied development stages, and most of the projects will be on stream before 2030. He assesses the CO2 storage potential of saline aquifers in Indonesia at around 650Gt and assesses the storage capacity of depleted oil and gas fields in Indonesia at 12Gt. He explained that Indonesia has relevant laws and regulations on greenhouse gas emissions, carbon tax, and carbon trading and performance-based payment. The Indonesian government recently issued dedicated regulations on implementing CCUS in the upstream oil and gas business activities.

e) Q&A and Discussions

Key points

- Emissions trading, or any other type of carbon pricing system, may help business actors conduct CCS operations by reducing their emissions and gaining reduction credits for sale. The carbon pricing system sometimes becomes very complicated. It should be designed as simple as possible.
- Technological development is needed to reduce costs further, particularly in the carbon-capturing process. Financing will be a major challenge because few CCS projects have been conducted in Asia. Social acceptance is another challenge. Close dialogue and transparent information sharing with the local community are necessary. A legal framework to limit the responsibility of businesses is important to reduce business risks.
- Because the success of CCS largely depends on the government's support, whether the government is supportive of CCS or not greatly affects the progress of CCS projects. Stable policy and regulatory environments are required to smoothly realize CCS projects, which must operate for many decades to amortize costs.
- It was agreed that CCUS collaboration in APEC is essential, starting from knowledge sharing among economies. Sharing best practices in safety practices in operation, legal and regulatory framework to incentivize business, and intergovernmental

dialogue and agreement for international CCS operations will facilitate CCS projects in the APEC region.

Summary

Q (to Dr Kenta Asahina): What is the legal basis for CCS operations in Japan?

A (Dr Kenta Asahina): The Japanese government is currently preparing for the legal basis for CCS in Japan and try to legislate next fiscal year.

Q (to Prof Jiutian Zhang): China has an emissions trading system for the power sector, but not for the industrial sector. Do you think that emission trading in broad sectors may become an incentive to promote CCUS?

A (Prof Jiutian Zhang): Emissions from industrial sources such as steel and cement are not covered in the existing carbon market system in China. China may work to include CCS to the existing carbon market mechanism.

Q (to Dr Matthias Raab): Australia has a domestic carbon crediting system. What is the status of methodological development for CCS in the system?

A (Dr Matthias Raab): The clean energy regulator in Australia has developed a method for CCS. In the methodology, CCS facilities are eligible to obtain Australian carbon credit units, the price of which is set at a minimum of AUD26. However, the method is redundant to the newly introduced safeguard mechanism because, in the safeguard mechanism, an existing CCS project is no longer eligible for carbon credits.

Q (to Dr Usman Pasarai): Why will the Enhanced Gas Recovery (EGR) project be the first CCS project in Indonesia?

A (Dr Usman Pasarai): All of the relevant parties, from the Indonesian government to oil and gas operators, made commitments to the projects. A major reason is that the required costs for CCS will be covered by the revenues from the enhanced gas production.

Q (to all): What do you think of CCU projects?

A (Dr Matthias Raab): Currently, most CCU projects are enhanced oil recovery in the US. The conversion of captured carbon into useful products is not at the commercial stage, and there is an issue with how quickly the scale-up and cost reduction will be realized.

Q (to all): What is the cost of storage today and in the future?

A (Dr Matthias Raab): The pure storage cost in an Australian onshore project were stated by the operator to be below AUD30 per ton of CO2. The cost for other projects vary depending on the availability of existing infrastructure.

A (Prof Jiutian Zhang): The marginal storage cost will be competitive with other emissions mitigation technologies in the future. Renewable power could be expanded to a very large scale, but the resources such as suitable land will be increasingly scarce, and the cost of renewable energy will become higher.

A (Dr Matthias Raab): The share of capturing cost out of the whole value chain, on average, is 65 to 70%. The cost of capture varies also depending on the purity of CO2 of captured gas.

Q Will carbon-neutral energies potentially become new game changers?

A (Dr Matthias Raab): The key point is, what is the dependency on the world on fossil fuel going forward? The four material pillars of our society are fertilizer, steel, cement, and plastics. CCS is mainly looking for electricity generation. However, that is only 27% of the whole energy equation. CCS needs to be adopted to decarbonize such material sectors.

Q (to Dr Matthias Raab): What is the current situation of the Australian government regarding willingness to promote CCS?

A (Dr Matthias Raab): The government will not financially support the oil and gas industry to start their CCS project. The newly introduced safeguard mechanism will require faster actions within the next five years than the industry can achieve because the CCS projects take much longer to build.

Q (to Dr Matthias Raab): In Australia, how onshore and offshore regulations for CCS operations are designed and implemented?

A (Dr Matthias Raab): All offshore projects are governed by the Federal Offshore Greenhouse Gas Act. In addition to the federal law, most states in Australia have onshore legislation. The Australian government is currently revising its offshore regulations to streamline the regulatory framework.

6-1-5. Session 5: Direct Carbon Capture (DAC)

a) Research and Development for DAC in Japan

Prof Kenji Yamaji, President (Research Institute of Innovative Technology for the Earth, Japan)

Key points

- The DAC projects by New Energy and Industrial Technology Development Organization, Japan are pursued under the government initiative named "Moonshot" to realize human well-being and various DAC technologies are developed to capture low-concentration CO_2 in the atmosphere.
- Realizing low-cost and high-efficiency DAC system should be given a high priority in the initiative. Various new technologies are also developed such as synthetic fuel to bring additional values to DAC.

Summary

Professor Yamaji overviewed the DAC technology development projects in Japan. The projects are being pursued under a larger government initiative named "Moonshot." He explained that there are nine Moonshot goals to realize human well-being and DAC technology development is included in the Goal No.4, realization of sustainable resource circulation to recover the global environment by 2050. In this initiative, various DAC technologies are being developed to capture low-concentration CO_2 in the atmosphere to realize low-cost and high-efficiency DAC system. In addition to DAC technologies, he suggested, various new technologies are being developed to convert captured CO_2 into valuables.

b) Commercial-scale Direct Air Capture

Mr Adam Baylin-Stern (Director, Policy and Engagement, Carbon Engineering, Canada)

Key points

- When a large-scale project under construction in West Texas in the US by Carbon Engineering comes online, the project is designed to capture up to half a megaton of CO2 per year, which is expected to be the largest DAC project in the world when it comes online in 2025, and helping to demonstrate DAC commercially and on climate-relevant scale.
- Direct Air Capture, especially combined with underground storage, is ultimately an environmental service, and it is necessary for governments to help create the market for such service and to support accelerators for early projects.

Summary

Mr Baylin-Stern briefed the audience on his company's DAC projects in this presentation. He explained that, because CO2 is dilute in the atmosphere, a large quantity of air has to be mobilized to capture CO2 at commercial scale. The company uses a process based on technologies that have industrial precedents and which are widely available across the world and couples them with the company's proprietary configurations. He noted that a large-scale project is now under construction in West Texas in the US, and once it comes online, the project is designed to capture up to half a megaton of CO2 per year. He stated that DAC technology enables important decarbonization solutions such as carbon dioxide removal (CDR) as well as sustainable aviation fuel (SAF) utilizing captured CO2 combined with hydrogen. He contended that Direct Air Capture, especially when combined with underground storage, is ultimately an environmental service, and it is necessary for governments to help create the market for such service and to provide accelerators for early projects.

c) Q&A and Discussions

Key points

- Currently DAC projects are only conducted on a small scale. But a project pursued by 1PointFive, using Carbon Engineering DAC technology, may become a game changer with a mega-ton scale DAC operation. Japan's R&D project is currently early stage but they intend to scale up and continue collecting date for life cycle assessment.
- Life cycle CO2 emissions including capital goods (infrastructure) was discussed, however, they are found to be a minor part. Energy inputs to DACCS operation are important emissions factors in determining net removal from the process, including full

accounting of lifecycle emissions associated with the use of natural gas and electricity.

- Preferred conditions for DAC operation include availability of high quality geologic reservoirs, land availability, and low-cost, low-carbon electricity. There was interest in cryogenic CO2 capture technology as a getting high-pressure carbon dioxide.
- Importance of policy framework, e.g. incentive and credits trading, were also discussed. Credit obtained from high integrity removal pathways such as Direct Air Capture with Carbon Storage (DACCS) are increasingly recognized as having a higher climate value than avoidance/reduction credits.
- Both downstream pathways of utilization and storage were noted as highly important. In Japan's project, main focus is DAC proses but including utilization, and it will be assisted of the utilization carbon recycling or usage of carbon recovered. On the other hand, the cost of hydrogen is a key influence on the economics to produce synthetic fuels as a utilization option.

Summary

Q: What is the current number that your existing facility can capture per day?

A (Mr Adam Baylin-Stern): The nameplate design capacity of the Carbon Engineering Innovation Center in British Columbia, Canada is about 1,000 tons of CO2 per year, or a few tons per day.

A (Prof. Kenji Yamaji): Japan just started research and development of DAC, so we are in very early stage. The Dr Kodama's project which RITE is participating is very small plants, it's about 5kg per day of carbon dioxide captured from the air. And we are collecting various data, we are now counting life cycle assessments it a really net reductions with that scale, it is probably input of energy greenhouse gas is more than the removal from atmosphere. But by scaling up, we are planning to several hundred kg per day other vent plant. And in case probably we can get more data, and cost is concerned. We are not in stage evaluate commercial scale.

Q (to Mr Adam Baylin-Stern): In life cycle analysis, do you have an estimate of carbon penalty?

A (Mr Adam Baylin-Stern): Penalty in terms of lifecycle analysis exists, and it's essential to minimize it, and ensure that it is fully accounted for within net removal of a facility. The lifetime of the project extends multi-decade, and the material impact is very minor. In

mitigating the carbon penalty, energy usage in the upstream sector is the key.
Q (to Mr Adam Baylin-Stern): What are the most important economic conditions needed for Direct Air Capture?

A (Mr Adam Baylin-Stern): There is a set of factors. If DAC is combined with underground storage, quality and availability of geologic reservoirs are an important factor. Solid regulatory environments and the availability of low-carbon energy inputs, particularly low-carbon and affordable electricity, are another key factor.

Q: DAC uses a large land per unit of CO2 captured. Do you see in the future that land footprint to be more optimized?

A (Mr Adam Baylin-Stern): Because DAC can be used as an option for negative emissions, it is a relatively land-efficient carbon removal technology. It is nonetheless true that DAC needs large facilities. The best way to achieve cost-effective deployment is to prioritize development in places with large sites available.

Q (to Prof Kenji Yamaji): I would like to know details of cryogenic CO2 capture.

A (Prof Kenji Yamaji): Cryogenic CO2 capture is a technology that uses cold energy from liquefied natural gas. Although the technology can get very high-pressure carbon dioxide, there are several problems. Controlling water vapor is technologically challenging, and location of the facility is limited to near liquefied natural gas facility.

Q (to Prof Kenji Yamaji): Presentation material seems to imply the DAC cost can be reduced to around USD60 per ton of CO2. Is this a realistic estimate?

A (Prof Kenji Yamaji): The number in the slide is illustrative. The assessment is cited from the analysis made by the report of Innovation for Cool Earth Forum (ICEF). If it currently USD800 per ton, they can be reducing USD100 per ton. Reduce the cost realized carbon neutrality. In that sense, I call it backstop technology.

Q: It seems there are two DAC options: one with underground storage and another with use of captured carbon. Which should we choose?

A (Prof Kenji Yamaji): Moonshot goal No 4 is realization sustainable resource circulation to recover global environment by 2050. Resource circulation is mentioned in Moonshot goal No 4 of objective and we add utilization parts to the DAC project. But main focus is the DAC process. There are many developments business challenge or utilization recovered carbon dioxide not only recovered from the atmosphere but recovered before emitted to the atmosphere. In addition to that, some parts of DAC project of Moonshot goal No 4, part of the utilization, may be assist of the utilization carbon recycling or usage of carbon recovered.

A (Mr Baylin-Stern): Ultimately, achieving carbon neutrality will require both options. The choice to pursue any given pathway will ultimately be influenced by the setting of policy priorities and by the emergence of strong business cases based on DAC.

6-1-6. Session 6: Closing Remarks

Dr Kazutomo Irie, President, Asia Pacific Energy Research Centre (APERC)

Dr Irie was very appreciative to all the speakers, moderators, and active participants. He concluded this symposium was rich and multifaceted contents, and informative and encouraging for those who are persuading decarbonization ultimately toward carbon neutrality. Dr Irie stated that APERC will continue move forward with the APEC sectoral symposium and APERC was planning to organize the second symposium on energy efficiency in January 2024 in Tokyo.

6-1-7. Site Visits - Day2 (12 October)

Participants were divided into three groups and visited one of the facilities on the list:
Total 51 individuals attended the site visit programs.

Kawasaki Heavy Industries 9:20-12:00

Kawasaki Heavy Industries promotes the development of its original technologies in the four-phase process of hydrogen: production, transportation, storage, and utilization.
Kobe LH2 Terminal (Hy touch Kobe) is the world's first liquefied hydrogen receiving terminal. It accommodates a 2,500m3 volume spherical liquefied hydrogen storage tank as well as other equipment including a loading arm system specially designed for transferring liquefied hydrogen between land land-based facilities and ships. Co - generation system (CGS) with one MW class hydrogen gas turbine has been installed in city area (Kobe Port Island). Demonstrating power and heat derived from hydrogen to community. Achieved the world's first heat and power supply in city area using gas turbine CGS fueled 100% hydrogen.

Kobe Steel, Ltd (KOBELCO） 10:00-12:30

Kobe Steel, Ltd is expanding the utilization of hydrogen at various industries including their Group companies to contribute to the transition to decarbonization. During the transition period until a large amount of economical green hydrogen becomes available, they think it is important to promote the use of liquid hydrogen in combination with the hydrogen produced by water electrolysis using small-scale renewable energy power generation. They believe that KOBELCO's hybrid-type hydrogen gas supply system will be a key to successful decarbonization.

Mitsubishi Heavy Industries (MHI) -Takasago Machinery Works 10:00-12:30

Mitsubishi Heavy industries has launched the world's first integrated validation facility from hydrogen production to power generation (Takasago Hydrogen Park) in September 2023. Takasago Hydrogen Park is divided into sections according to three hydrogen-related functions: hydrogen production, storage, and utilization.

MHI Group is pursuing the energy transitions as an engine for corporate growth based on its declaration of "MISSION NET ZERO", targeting carbon neutrality by 2040.

6-2. Promoting Energy Efficiency and Energy Management System (Tokyo)

6-2-1. Session 1: Opening Session

a) Opening Remarks

Dr Kazutomo Irie (President, Asia Pacific Energy Research Centre (APERC))

Key points

・ Welcomed participants and explained the background and objectives of the Symposium.

・Emphasized the importance of the energy transition, energy efficiency, and sharing knowledge and experiences among APEC economies.

Summary

Dr Irie welcomed all invited speakers and active participants. Dr Irie explained the objective of the symposium was follow up the APEC symposium on Holistic approach of Decarbonization towards Carbon Neutrality held online in August 2021. As a second follow up symposium, picked up energy efficiency and energy management system.

Dr Irie emphasized that in energy transition there was no single best solution for achieving carbon neutrality or net zero as each APEC economy has different economic and social structure, and geographical situations. Various pragmatic and sustainable decarbonization pathways that reflect the different the circumstances of each economy are essential to achieving successful energy transitions. Sharing knowledge and experiences among member economies is beneficial, and a sectoral symposium is necessary to enhance our understanding of each sector. This symposium topic included energy efficiency in building, energy efficiency in transport, energy efficiency in industry and energy management systems and smart city.

b) Keynote Speech: The Evolution of Energy Efficiency Policy to Support Clean Energy Transition in Japan

Mr Hideyuki Umeda (Director for International Policy on Carbon Neutrality, Agency for Natural Resources and Energy (ANRE), Ministry of Economy, Trade and Industry (METI), Japan)

Key points

- Emphasized that Japan needs to reduce 62 million kL in final energy consumption in FY 2030, which will be achieved by improvement of energy efficiency and expansion of non-fossil energy.
- Concluded Japan's demand-side policies support clean energy transition. Japan will keep contributing to energy efficiency and decarbonization in APEC region by sharing its experience and policies.

Summary

Mr Umeda described Japan's performance in energy efficiency during the past decades and the need to reduce 62 million kL in final energy consumption in FY 2030, which will be achieved by improvement of energy efficiency and expansion of non-fossil energy. He then gave an overview of Japan's demand-side policies, including regulations which are stated in the Act on Rationalizing Energy Use and Shifting to Non-fossil Energy, and incentives in which energy conservation subsidies package is provided. Finally, Mr. Umeda concluded that Japan's demand-side policies have moved toward supporting clean energy transition, and Japan will keep contributing to the energy efficiency and decarbonization in the APEC region through its knowledge, experience, and policies in this regard.

c) Keynote Speech: The Key to an Energy Resilient APEC: Energy Efficiency and

Energy Management

Dr Meng Liu (Chair, APEC Expert Group on Energy Efficiency and Conservation (EGEEC) and, Deputy Chief, Division of Resources and Environment, China National Institute of Standardization, China)

Key points

・Recommended an increased focus on evaluating the cost-effectiveness of energy efficiency policies.

・Emphasized the importance of collecting and reporting energy efficiency data.

Summary

Dr Meng Liu appreciated joining the symposium as a member of the APEC Expert Group on Energy Efficiency and Conservation (EGEEC). He remarked that energy efficiency has been widely accepted as a critical solution to achieve sustainable development. Global focus on energy efficiency remains steady fast. The estimated 2023 rate of progress in energy intensity was set to fall back to below longer-term trends, to 1.3% from a stronger 2% last year. The global trend of energy efficiency will continuously increase.

APEC economies represent over 38% of the global population and 56% of global economic activity. The role APEC plays in the global energy market is indispensable. It accounts for 56% of world energy demand, 58% of world energy supply, and 68% of world electricity generation. APEC accounts for 60% of global CO2 emissions.

The energy goal of APEC is to improve energy intensity by at least 45% by 2035 compared to 2005 levels. As of 2020, APEC-wide final energy intensity has improved 26% leaving an additional 19% improvement needed to meet the goal.

There are four important key sectors and areas regarding energy efficiency: industry, transport, building, and regulations and standards.

Regarding industry, it is important to deploy high efficient equipment. This also requires accelerated energy system integration and optimization. Moreover, expanding engagement in energy management activities such as PDCA is needed. As we are facing the technological age, integrating industry with emerging technology such as IoT, AI, etc is significant to improve energy efficiency.

On the transport sector, green, decarbonization, and smart transport are the main keywords.

On building, global experience shows the improvement in the green building codes. Multiple energy supply and demand are required to develop an integrated district energy system. It could be cost-effective and efficient as well.

Regulations and standards are important to continue the eco-system.

Standards can be divided as four categories: Minimum energy performance standards (MEPS), Energy management system standards (EnMS), Supporting energy conservation standards for MEPS and EnMS, and Standards for energy efficiency and conservation market mechanism.

The ISO 50001 (EnMS) system is based on a process of monitoring, targeting, and implementing energy saving measures in a cycle of continuous improvement. As of 2023, 23 ISO standards were released. In 2022, the number of ISO 50001 certificates issued worldwide grew by almost 30% to 28,000.

The key to success in achieving energy efficiency, leadership commitment, energy efficiency target, policy framework, and coordination of stakeholders are needed.

There are complicated correlations between energy efficient improvement and emission reduction. Therefore, coordinated improvement between these two indicators. Furthermore, integration among different technologies, energy, and systems, especially smart technologies is important. He also suggested the importance of cost-effective evaluation of policies and continuous improvement of the policy portfolio (regulations and standards). Last but not least, capacity building for collecting quantitative/qualitative data and international collaboration to share a good practice/experience can contribute to more sustainable economies.

6-2-2. Session 2: Energy Efficiency in Building

a) Improving Energy Efficiency in Buildings in Hong Kong, China

Mr Wallace Leung (Chief Engineer, Energy Efficiency B, Electrical and Mechanical Services Department, Government of Hong Kong, China)

Key points

・Buildings account for about 90% of electricity consumption and 60% of carbon emissions in Hong Kong, China. The reduction targets of 30-40% and 20-30% were set for electricity consumption in commercial and residential buildings, respectively, by 2050, using the operational conditions of 2015 as the comparison basis. Hong Kong, China's energy intensity has decreased by 33.3% from 2005 to 2021.

・The major regulatory approach is implemented by 1) Ordinance on energy efficiency and energy audit of buildings, 2) Mandatory Energy Labelling for appliances covering 80% of residential consumption, and 3) Building Regulation for energy efficiency of building envelope of commercial buildings and hotels.

Summary

There are around 46,000 buildings in Hong Kong, China, which account for about 90% of total electricity consumption and for around 60% of carbon emissions. Hong Kong, China set the targets of 30-40% and 20-30% reduction of electricity consumption in commercial and residential buildings, respectively, by 2050, compared to operational conditions of 2015. The major regulatory approach of energy efficiency policies in Hong Kong, China is implemented through 1) Buildings Energy Efficiency Ordinance which stipulates minimum energy efficiency and energy audit for building services installation of buildings, 2) Mandatory Energy Efficiency Labelling for appliances which covers around 80% of energy consumption in residential buildings, and 3) Building (Energy Efficiency) Regulation which governs the energy efficiency of building envelope of commercial buildings and hotels. The governmental buildings have taken the lead to carry out energy saving retrofit and retro-commissioning and share the experience with the private sector.

Hong Kong, China also implemented Energy Saving Initiatives such as helping energy saving in schools and NGO venues, and smart meters are expected to be installed for all electricity utilities' customers by the end of 2025. Besides, finance subsidies are provided through the Scheme of Control Agreement signed between the government and the two power companies, the Integrated Building Rehabilitation Assistance Scheme by Urban Renewal Authority, and accelerated deduction under profit tax, facilitating the improvement of energy efficiency in buildings.

Hong Kong, China has improved its performance in energy intensity by 33.3% from 2005 to 2021. Hong Kong, China's energy efficiency in buildings is on the right track and will continue to do so.

b) Modeling the US buildings energy efficiency

Ms Courtney Sourmehi (Industry Economist, Energy Information Administration, U.S. Department of Energy, the US)

Key points

- The National Energy Modeling System (NEMS) *Annual Energy Outlook 2023 Reference case* projects that electricity will be the fastest growing energy source in buildings in the US through 2050. The drivers of this growth include stable and declining electricity prices, the relative efficiency of electric appliances and continued population shifts to warmer regions.

・ In the residential and commercial sectors, higher equipment efficiencies and compliance with building codes extend ongoing declines in energy intensity.

・Despite growth in heat pump adoption, natural gas continues to be the leading source for space heating for single-family homes.

Summary

The National Energy Modeling System (NEMS) is used to project energy markets out to 2050. Residential and commercial energy consumption projections by fuel through 2050 show electricity is the fastest growing energy source in buildings in the US. Thanks in part to energy efficiency, floorspace and housing stocks expand at a faster rate than energy consumption over the next 30 years. Natural gas remains the dominant source of space heating in the US.

In the residential and commercial sectors, higher equipment efficiencies and compliance with building codes extend ongoing declines in energy intensity. Changes in the buildings fuel mix reduce energy-related CO2 emissions, which decline faster in buildings than any other end-use sector. The drivers of building electrification in the US include the relative efficiency of electric appliances, a continued population shift to warmer regions, which is projected to increase demand for air-conditioning.

The Inflation Reduction Act of 2022 extended and expanded investment tax credits for residential and commercial distributed generation and combined heat and power cogeneration.

Regarding residential equipment shares, despite historical growth in heat pump adoption in single-family new-construction, we project natural gas will continue to be the biggest source for space heating in the US in the context of stable gas prices, given current laws and regulations. The average stock efficiency of natural gas-fired equipment increases over time and continues to compete with electric equipment.

c) Energy Efficiency of Buildings in Australia

Dr Subbu Sethuvenkatraman (Research Group Leader, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia)

Key points

・Sixty percent of building energy use is through electricity and buildings account for 18% of total emissions in Australia.

・Digitalization of buildings involves connecting the buildings and getting access to all data in a cost-effective way, and then delivering benefits through analytics.

・The pathway for decarbonization is achieved by a combination of energy efficiency measures supported by policies and technology changes with digitalization, and high uptake of renewable energy resources.

Summary

Buildings make up of about 18% total emissions in Australia, and nearly 60% of building energy use is through electricity. Australia has high uptake of Distributed Energy Resources (DER), where one in every three households is likely to have rooftop solar by 2050.

Australia’s energy efficiency policies for buildings have been implemented through National Energy Performance Strategy, Trajectory for low emission buildings, Sector wide decarbonization plans, National Construction Code (NCC), and Greenhouse and Energy Minimum Standards (GEMS) for appliances. As the data presents, the policies successfully improved the emission intensity in office buildings.

Regarding decarbonization of Australian built environment sector, there are ongoing policy improvements. For the residential buildings, from 2023, requirements for thermal performance for new homes has been increased from six to seven stars; and for commercial buildings, usage-based rating system (NABERS) successfully improved efficiency.

There are emerging opportunities that drive changes in Australia. Switching from gas heating to heat pumps, gas/electric boiler to heat pumps, and self-consuming facilitate electrification and decarbonization. Some of the trends regarding digitalization are moves such as installing smart meters and the sensors for monitoring and control. Access to data is valuable for consumers to participate in the market.

Take an example of Australian buildings which are undergoing a digitalization journey. First, we need to connect the buildings (“digital ready”) and get access to all data in a cost-effective way. Second, we need to deliver benefits through analytics (both operational and energy cost). We connect different sources, such as Building Management System (BMS) and IoT sensors, to a data platform for analytics.

For decarbonization of the Australian building sector, the modeling shows we should be able to reduce emissions from buildings to reach at least 2% of 2020 level emissions by 2050. The pathway is going to be supported by a combination of energy efficiency measures supported by policies and technology changes that enable digitalization and high uptake of renewable energy resources which are going to be available to the building sector.

d) Japan's Path for Carbon Neutrality and the Role of Energy Efficiency in Buildings

Dr Naoko Doi (Senior Research Director, Assistant Director, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ))

Key points

・Promoting the introduction of zero energy buildings, energy efficiency renovation of stock buildings, and efforts in operational energy efficiency improvement are the keys in the building sector.

・In the second supplementary budget for households in FY2023, a total of JPY421.5 billion are being provided for the energy efficiency of residential sector.

・Japan's evolving energy efficiency policies include promoting carbon neutrality of water heaters, demand response ready appliances, and consumers' engagement which would requires the electric/gas retailers to set energy saving targets.

Summary

Japan amended its energy conservation law. It was made to include "non-fossil fuels" on top of fossil fuels for energy efficiency improvement in April 2022. Demand response is also included as the energy efficiency concept. Promoting the introduction of zero energy buildings, energy efficiency renovation of stock buildings, and efforts in operational energy efficiency improvement are the keys in the building sector.

The Japanese government set a comprehensive approach to mobilizing JPY150 trillion of public-private investment for green transformation (GX). In the second supplementary budget for FY2023, for households, a total of JPY421.5 billion are being provided for the energy efficiency of residential sector.

According to the estimation, if all the newly built residential houses are ZEH from 2021, its share will reach 28.7% by 2050, while around 70% are existing stock buildings. Hence, the results show the needs for additional measures such as (1) operational energy efficiency improvement, (2) strengthening of energy efficiency renovation for existing stocks, and (3) promotion of ZEH in apartment buildings.

Japan's evolving energy efficiency policies areas includes promoting carbon neutrality of water heaters, demand response ready appliances, and consumers' engagement which would requires the electric/gas retailers to set energy saving targets.

Tokyo Metropolitan Government set the goal of reducing CO2 emissions by half, compared to 2000 emission level, by 2030. Among the measures to achieve this goal,

the Top-level Business Entity Certification System, which has been implemented for years, is utilized to facilitate the energy efficiency of building sector.

e) Q&A and Discussions

Key points

・In the US, EIA is looking to create an even more accessible open-source version of the National Energy Modeling System. From a building's perspective, they will take a deep look into how they can more robustly represent nuances in policy development.

・The government of Hong Kong, China takes the lead by showing the commitment to the private sector through implementing energy saving targets, energy audit, retro-commissioning, etc in government facilities. The government merits achievements of private buildings to the society, provides technical advice to SMEs and encourages them to apply the finance subsidy for energy saving retrofit.

・Data is the primary basis for continuous commissioning or tuning in Australia. Starting with basic instrumentation or monitoring is going to be important.
Data driven Measurement and Verification (M&V) provided will be a major motivator for people to participate in energy efficiency schemes and benefit from them.

・The Energy Conversion Law in Japan has been amended to include non-fossil energy. All energy sources, including all fossil fuels and renewables need to be regulated. The regulated industry and commercial sectors must report the annual fuels consumption aside from the fossil fuels.

Summary

Q (to Ms Courtney Sourmehi): What are you most excited about modeling in buildings as EIA updates NEMS this year, and why?

A (Ms Courtney Sourmehi): We are actually looking to create an open-source version of the National Energy Modeling System. Now our model is currently open and available to the public, but it can be expensive to run because you have to procure certain subscriptions that we cannot provide based on our subscription agreements with third party vendors. But we are looking to build a version of NEMS that is even more accessible. The general public could access NEMS via GitHub, to use and to do their own modeling to test our assumptions. We have also undertaken project Blue Sky, an initiative to develop the next generation energy systems model.
From a building's perspective, I am interested in looking at how we can add an income

dimension to better model income-targeted programs that save energy. One important facet of building energy efficiency modeling is weatherization upgrades. There are new funds from the Inflation Reduction Act that are intended to support weatherization programs. Some programs specifically target low-income homes as well as tribal areas in the US. Income-targeted programs are difficult to model, at our current level of geographic granularity. It is really difficult to estimate those kinds of impacts. We are going to take a really deep look into how we can more robustly represent these latest policy developments.

Q (to Mr Wallace Leung): How do government buildings take the lead to encourage the private sector to improve energy efficiency? Are there any subsidies or incentives given and how do you measure the achievements?

A (Mr Wallace Leung): First, the government takes the lead by showing the commitment of government facilities to the private. Government buildings have a duty to save minimum 5% of energy in every five years since 2003. The current target is up to 6%. The central government allocates funding to drive the Energy Savings Initiative to achieve this target, through energy audit, retro-commissioning, energy saving retrofit, and install renewable energy system.
To promote the movement to the private buildings, the government, for example, will recognize the buildings which have done a good job, showing their achievement to the society through third parties' building certification schemes.
For other building stocks, largely owned by small and medium enterprise, the government would encourage them especially in retro-commissioning, because normally they do not have enough resources. We provide technical advice with them or encourage them to apply for the finance subsidy for energy audit, retro-commissioning and energy saving retrofit. That's what we do to encourage building energy efficiency.

Q (to Mr Wallace Leung): Retro-commissioning is important for the existing building stocks. Could you please explain more regarding this?

A (Mr Wallace Leung): The government normally did not allocate funding directly to the building owners to carry out energy saving works, but we have incentives and finance subsidy schemes to drive energy efficiency improvement works.
In Hong Kong, China, the power companies have set up funding schemes to subsidize the Energy Savings Initiative. Now, they provide free energy audit service, retro-

commissioning service as well as to subsidized part of the funding of the capital cost investment for some energy saving retrofitting works. We use these financial subsidies to drive the energy saving works.
But for some specific groups of buildings, for example, schools and some NGOs, we set up special schemes to help them save energy. For example, we help them to replace the LED lighting and variable speed air conditioners in their venues as part of the community programs. We put this as a showcase for the society.

Q (to Dr Subbu Sethuvenkatraman): How to improve energy efficiency by adopting retro-commissioning with digitalization technology in your introduced case?

A (Dr Subbu Sethuvenkatraman): Digitalization underpins the energy efficiency upgrades that you might want to do with very low cost. Data is the primary basis for continuous commissioning or tuning.
Based on our digitalization experience with commercial buildings, the primary data sources building tests start with installation of smart meters. The uptake of smart meters in building varies very widely. Perhaps at the higher end of the spectrum, premium buildings or buildings in major cities would probably have some form of digital infrastructure. The biggest challenge is medium and small sized buildings which do not have access to expensive upgrades and people who do not even have building management systems. How do they monitor and improve efficiency? That's why we believe the data platform that we have created, and we are trying to make it as open data platform for the public good where people can actually provide all the data and the data can be used by contractors or service providers to implement energy efficiency upgrades scheme. Starting with basic instrumentation or monitoring is going to be really important. The other aspect is having reliable tools like measurement and verification. The fundamental challenge with all policy implementation is that you do not have a baseline. If you do not have a baseline, how do you make sure the improvement that has happened? It is important if you're gathering data on a continuous basis. If you're able to provide data driven M&V services, that is going to be a major motivator for people to actually participate in energy efficiency schemes and benefit from them.

Q (to Dr Naoko Doi): How to promote electrification and non-fossil fuels in Japan?

A (Dr Naoko Doi): The Energy Conversion Law has been amended to include non-fossil energy, so all energies including all fossil fuels, renewables and other non-fossil fuels, need to be regulated. The industry sector and commercial sector regulated by this law have to report the annual consumption of fuels aside from the fossil fuels. Non-fossil fuels need to be utilized efficiently, including variable renewable energies.

6-2-3. Session 3: Energy Efficiency in Transport

a) Improving Energy Efficiency in Transport Sector of Singapore

Professor Qiang Meng (Department of Civil and Environmental Engineering (CEE), National University of Singapore)

Key points

・On the land transportation, the Singapore government is committed to reduce peak land transport emissions from the 2016 peak by 80% by or around 2050 mid-century through a holistic vehicle electrification plan.

・On the maritime industry, each container ship requires tugboats. Therefore, electric tugboats and optimal tugboat scheduling are needed to save energy.

・On the aviation industry, Changi Airport is upgrading its lighting and chilling systems to enhance energy efficiency of airport operations. The airport will step up its solar deployment on terminal buildings.

Summary

Singapore is a small city with a high population density. Although the airport is the second busiest in Asia and PSA Corporation is ranked number two in terms of container throughput worldwide, it is livable and sustainable city.

Singapore has an extra-developed road network which takes up 12% of the total land area. More than 60% (around one million vehicles) are private and rental cars. The car ownership rate is kept around 11% due to implementing Certificate of Entitlement (COE) management. On the other hand, two-thirds of daily individual travel trips are overtaken by buses and MRTs. About 1,000 vessels in Singapore water areas and one vessel leaves or enters every two-three minutes. 298,000 aircraft movements were recorded from January to November 2023.

Singapore works towards reducing its greenhouse gas emissions by using less carbon-intensive fuels, and by improving energy efficiency. A whole-of-government approach has been adopted to implement measures to improve energy efficiency and reduce the energy use of various sectors. Government agencies actively promote energy efficiency in five sectors through legislation, incentives, public education, etc.

Approximately 2.5 million tons of oil equivalent of primary energy were consumed in 2020 by the transport sector in Singapore（https://www.statista.com/statistics/973029/singapore-transport-related-energy-consumption/). Electricity consumption of transport was 2,899.7GWh in 2022 ranked in the third place (www.ema.gov.sg).

The Singapore government passed the Energy Conservation Act in 2012. Under this Act, regulation for Energy Management Practices for Transport Facility Operators was enforced in 2013.

The Singapore government is committed to reduce peak land transport emissions from the 2016 peak by 80% by or around 2050 mid-century through a holistic vehicle electrification plan.

Although the Singapore government proposes several incentive schemes to purchase EVs, the price is high than that in other economies.

The Land Transport Master Plan 2040 envisions a land transportation system that is convenient, well-connected, and fast.

SBS Transit Ltd has already adopted strategies to reduce energy consumption. Also, SMRT Corporation Ltd is also taking the initiative that will reduce Heating, Ventilation and Air-Conditioning (HVAC) energy consumption through predictive AI to adjust setpoints, while maintaining commuter comfort.

On the maritime industry, each container ship requires tugboats. Therefore, electric tugboats and optimal tugboat scheduling in order to save energy are needed.

On aviation Changi Airport is upgrading its lighting and chilling systems to enhance energy efficiency of airport operations. Moreover, the airport will be stepping up its solar deployment on terminal buildings.

b) Improving Energy Efficiency in Transport in Malaysia

Mr Huzaimi Nor Bin Omar (Chief Operating Officer, ChargeEV, Green EV Charge Sdn Bhd, Malaysia)

Key points

- National Energy Transition Roadmap (NETR) 2023-2050 was launched, focusing on carbon emission reduction towards realizing the Net Carbon Emission 2050.
- Manufacturing incentives and voluntary energy efficient vehicle labeling schemes are implemented. Electric vehicles take center stage as the primary focus that EV penetration is expected to be 15% by 2030, 38% by 2040, and 80% by 2050.
- National EV Taskforce (NEVTF) and National EV Steering Committee (NEVSC) look

at the progress of EVs.

Summary

Regarding policy push for energy efficiency transport in Malaysia, Low Carbon Mobility Blueprint (LCMB) 2021-2030 is the first holistic policy document on land transport. The transportation sector is the highest contributor to emissions (20-29%) and final energy consumption (27%). As of last year, 33 million vehicles, 46% of which belong to passenger vehicles and motorcycles. Also, vehicle sales reached the highest (719,000s vehicles) last year. Moreover, the National Energy Transition Roadmap (NETR) 2023-2050 has been launched recently. NETR focused on carbon emission reduction towards realizing the Net Carbon Emission 2050.

Various initiatives are taken. First, manufacturing incentives and voluntary energy efficient vehicle labeling schemes are implemented. Second, launched in 2022, electric vehicles take center stage as the primary focus that EV penetration is expected to be 15% by 2030, 38% by 2040, and 80% by 2050. Finally, the National EV Taskforce (NEVTF) and the National EV Steering Committee (NEVSC) look at the progress of EVs. Due to these initiatives, EV market is growing in Malaysia. However, only 1.8% EV penetration rate in 2023.

He introduced YINSON Greentech which is aiming to accelerate the transition towards a net zero world.

c) Improving Energy Efficiency in Transport in the Philippines

Dr Noriel Christopher Tiglao (National College of Public Administration and Governance (NCPAG), University of the Philippines)

Key points

- In 2015, the transport sector contributed to 34% of the total Philippines greenhouse gas emissions, with road transport accounting for 80% of those emissions.
- Based on the transportation modeling, expansion of mass transit network is the single policy scenario that contributed to a higher overall reduction in petroleum and alternative fuel consumption levels.
- The Comprehensive Roadmap for the Electric Vehicle Industry has four components: EVs and charging stations, manufacturing component, research and development, and human resource development.

Summary

Dr Noriel Christopher Tiglao made a presentation on Energy Efficiency in Transport in the Philippines.

In the Philippines, the total final energy consumption (TFEC) increased from 18.61Mtoe in 1990 to 32.224Mtoe in 2016, increasing annually by 2.8%. The TFEC of the transportation sector had increased by an average of 5.5% per year. In the 1990s, the residential sector had the largest share of TFEC whereas the transportation sector ranked second. From 2000 to 2016, the transportation sector occupied the largest share of total final energy consumption, with an average share of 34.2%. The road transportation mode consistently had the largest share, followed by the water transportation and air transportation mode. The rail transportation mode has little demand for energy, but this would change in the future. Diesel consistently had the largest share, followed by gasoline. The transportation sector is highly dependent on fossil fuels and it will remain as the highest energy consuming sector.

In the Philippines, the transportation sector is the largest source of air pollution and energy-related GHG emissions. In 2015, transport GHG emissions contributed to 34% of the total Philippines GHG emissions, with road transport accounting for 80% of those emissions. Similarly, 74% of air pollutants come from transport sources. Here. the transport sector in the Philippines is energy-intensive and contributed about 35.6MtCO2e and 27.4MtCO2e of emissions in 2019 and 2020, respectively.

In April 2021, the Philippines submitted its NDC. The Philippines commits to a projected GHG emissions reduction and avoidance of 75%, of which 2.71% is unconditional. Data from the Department of Transportation indicates that from a baseline of 24.02MtCO2e in 2010, the GHG contribution from the transport sector is projected to grow to 87.10MtCO2e in 2030 and 166.07MtCO2e in 2040. Based on initial calculations, transport projects can contribute to a GHG reduction of 10.03MtCO2e in 2030 and 14.23MtCO2e in 2040. Notably, rail has the largest contribution to GHG reduction at 6.79%.

Based on the transportation modeling, the expansion of the mass transit network is the single policy scenario that contributed to a higher overall reduction in petroleum and alternative fuel consumption levels. This is followed by the vehicle restraint (TDM) policy. The motor vehicle inspection system did not contribute to a significant reduction in fuel consumption.

The Electric Vehicle Industry Development Act (EVIDA) ensures the Philippines's energy security and independence by reducing reliance on imported fuel for the transport sector and provides an enabling environment for the development and adoption of EVs and EV charging stations.

The Comprehensive Roadmap for the Electric Vehicle Industry (CREVI) refers to a National Development Plan for the EV industry which has four components: EVs and charging stations, manufacturing component, research and development, and human resource development.

National Energy Efficiency and Conservation Plan (NEECP) is a comprehensive framework and plan that institutionalizes energy efficiency and conservation in the domestic across key sectors. It forecasted that the Philippines's energy mix in 2040 will appear like the energy mix to date, with a strong emphasis on oil products. This is due, in part, to the predicted continued demand for diesel and petrol from the transportation sector. While there have been programs to test electric vehicles and the use of natural gas in public transport, these have been limited.

The Philippine Energy Labelling Programs (PELP) is the development and rollout of energy performance requirements. Eco-driving has the potential to reduce fuel consumption. The observed engine fuel rate for eco-driving reduces by 41% compared to aggressive driving.

Two strategies come out: Transport Vehicles Fuel Economy Labeling Program (VFELP) needs cooperation between the private sector as well as the government agency. At the same time, research and development require co-create programs for incentivizing fuel efficiency and emission reduction. Public transport is key to keeping management and competition standards.

d) Achievement and Potential of Multi-Pathway Approach in Road Transport Sector -Japan's Experience

Mr Takao Aiba (Vice Chairperson of Environmental Policy Subcommittee, and Chairperson of International Climate Change Policy Expert Group, Japan Automobile Manufacturers Association, Inc, (JAMA))

<u>Key points</u>

・Japan has reduced 23% of CO_2 emissions from the road transport sector, comparing with 9% in the US and 3 % in Germany and the Netherlands.

・ An integrated approach is essential. There are four pillars: 1) automobile manufacturers should provide more fuel-efficient vehicles, 2) fuel suppliers should provide diversified fuel supply, 3) users/customers should select environmentally friendly cars, and 4) governments should enforce traffic flow improvement.

・Study findings of the JAMA's scenario-based analysis show that there is potential not only for 100% BEVs, but also for a wide variety of electrified vehicles including HEVs and PHEVs and the use of Carbon-Neutral Fuel (CNF) for global CO_2 emissions reduction in road transport to be in line with the IPCC's 2050 1.5-degree climate scenarios.

Summary

Mr Takao Aiba made a presentation on achievement and potential of multi-pathway approach in road transport sector.

Japan Automobile Manufacturers Association, Inc (JAMA) is a non-profit industry association comprising Japan's 14 manufacturers of passenger cars, trucks, buses, and motorcycles. JAMA member companies are making efforts towards carbon neutrality by 2050 by developing technologies to further reduce automotive CO_2 emissions. Technology-neutral stance is important, which means a diversity of options is crucial to achieving carbon neutrality. Many pathways exist toward carbon neutrality.

Japan has reduced 23% of CO_2 emissions from the road transport sector. This is indispensable when it comes to 9% increase in the US, 3% increase in Germany, and 3% increase in the Netherlands. It could be said that Japan is the leader in emission reduction in the transportation sector.

An integrated approach is essential. There are four pillars: automobile manufacturers should provide more fuel-efficient vehicles, fuel suppliers should provide diversified fuel supply, users/customers should select environmentally friendly cars, and governments should enforce traffic flow improvement. By implementing an integrated approach Japan is steadily reducing CO_2 emissions from 2000.

Study findings of the JAMA’s scenario-based analysis show that the supply of Carbon-Neutral Fuel (CNF), which comprises of biofuel and synthetic fuel, could take a crucial role. These pathways are recognized in the G7 communique and the Global Stocktake at COP28.

To sum up, Japan has been a leader in CO_2 emission reduction in the road transportation sector among G7 members through the Integrated Approach. Particularly expanding line up of electrified vehicles suitable for regional circumstances, which is in line with the range of pathways’ concept, has improved energy efficiency. Based on the quantitative scenario analysis, JAMA believes that there is potential not only for 100% BEVs, but also for a wide variety of electrified vehicles including HEVs and PHEVs and the use of CNF for global CO_2 emissions reduction in road transport to be in line with the IPCC's 2050 1.5-degree climate scenarios.

e) Q&A and Discussions

Key points

- In Singapore, the government is also concerned about the impact of EV charging demand on the capacity of grid. A smart charging strategy is also important. The highest EV charging demand at HDB could be after 6pm.
- Malaysia tries to understand the demand for generation and distribution on the grid. Currently initiatives on EVs are integrated. Malaysia understands there is huge potential for energy storage.
- In the Philippines monitoring enforcement and evaluation are key things. Moreover, there is a need to work with the private sector for reporting. Co-production and co-creation approaches are needed for stronger stakeholder cooperation and improving collaborative governance.
- In Japan the fuel economy standards using the top-runner approach set a very high target to reduce CO2 emissions. Backed by government incentives, the share of HEVs grew dramatically, which contributed to improving fuel economy in Japan.

Summary

Q: What is the impact on the electricity grid? How do different economies deal with the electricity grid?

A (Mr Huzaimi Nor Bin Omar): Currently initiatives on EVs are integrated. As mentioned, all stakeholders are involved in task forces. During the EV projection, Malaysia tries to understand the demand for generation and distribution on the grid. The number of EVs is primitive now but he forecasted that regulation would come soon. Technologies such as energy storage systems are taken into carefully. Malaysia understands there is huge potential for energy storage as well.

A (Prof Qiang Meng): The majority of people in Singapore are living in the government house. When the government designed the building, they already had electricity. However, in the future, demand will grow. Therefore, the government is concerned about the impact of EV charging demand on the capacity of the grid. A smart charging strategy is also important. The highest charging demand is after six pm. The government might need a sub-system of the grid.

A (Dr Noriel Christopher Tiglao): In the Philippines the issues are not only grid supply, but island matters. In order to ensure better energy for an island, the government tries to set strict targets on shares of renewable energy.

A (Mr Takao Aiba): Depending on the charging situation, people want to reduce charging time. If people use quick charging systems, charging time will be reduced, but the impact on the grid increases. The city is fine with this situation, but in the rural area is not so easy.

Q (To Dr Noriel Christopher Tiglao): The Energy Conservation Law was amended so that 50,000KWh of power should be reported back to the government. How will the government implement this reporting system?

A (Dr Noriel Christopher Tiglao): Monitoring enforcement and evaluation are key things. He believes that there is a need to work with the private sector for reporting. Co-production and co-creation approaches should be widely explored for improving collaborative governance.

Q (To Mr Takao Aiba): What are the main factors according to the CO2 reduction in the Japanese case?

A (Mr Takao Aiba): The fuel economy standard using the top-runner approach, setting a very high target, has been effective. Backed up by the government's economic incentive support, from the end of 2000s the share of HEV grew dramatically, which contributed to improving the fuel economy in Japan. Moreover, small cars/kei-cars account for 30-40% in Japan which features the Japanese market.

Q (To Professor Qiang Meng): On slide 10 why is tax on EVs higher than conventional cars? Why does the government treat EVs negatively?

A: I got the information from the website. Will double-check. But I assume that road tax will be decided by the power of cars.

Q (To Mr Takao Aiba): Do you consider the production costs of fuels?

A (Mr Takao Aiba): The production costs of synthetic fuel are important. 60% or two-thirds of its costs are green hydrogen. If green hydrogen costs are reduced, so is synthetic fuel. Brazil has a capacity for biofuel. The production costs depend on the environmental factors of production.

6-2-4. Session 4: Energy Efficiency in Industry

a) Improving Energy Efficiency in Industry in Chinese Taipei

Dr Tze-Chin Pan (Deputy Division Director, Energy Policy and Planning Division, Green Energy and Environment Research Laboratories, Industrial Technology Research Institute, Chinese Taipei)

Key points

- Considering that the growth rate of electricity consumption in the industrial sector dramatically exceeds that of energy demand, Chinese Taipei focuses on improving efficiency in electricity usage.
- Designated factories in Chinese Taipei are faced with a mandatory target of saving electricity by 1%, which means that the total energy saved from 2015 to 2024 should exceed the total electricity consumption by 1%.
- This target is currently under discussion regarding the potential strengthening of future targets to also encompass reductions in fossil fuel usage or setting more ambitious targets.

Summary

Chinese Taipei's energy and economic trends in recent decades were observed that while the GDP growth significantly outpaced the total energy demand from 2010-2022, the contribution of the industrial sector to the GDP rose markedly during this period, accounting for 40% of the total output of our economy. Despite this, the energy consumption in the industry remained relatively constant.

The rapid expansion of Chinese Taipei's electronics manufacturing industry, including semiconductors manufacturing industry, is believed to have caused this phenomenon. The energy intensity of the electronics manufacturing industry is significantly lower than that of heavy industries. For example, in Chinese Taipei, the energy intensity of the paper industry is about 16 times that of electronics manufacturing industry. Considering that the growth rate of electricity consumption in the industrial sector dramatically exceeds that of energy demand, the policy focus in Chinese Taipei is centered on improving efficiency in power usage.

A pivotal element of Chinese Taipei's policy framework is the designation of large energy users who are subject to regulatory requirements aimed at driving continuous performance improvements. The designation thresholds consider factors such as fossil fuel consumption volumes or electricity contract capacity. Factories that are designated are required to appoint energy management officers who must obtain certification from government to oversee compliance.

These factories are also mandated to undergo energy audits conducted by energy management officers and report comprehensive consumption data to authorities annually. This reporting system enables authorities to monitor trends, identify priority sectors and technologies, and inform the development of new policies based on insights gleaned from aggregated industry data.

Designated factories in Chinese Taipei are faced with a mandatory target of electricity saving by 1%, which means that the total energy saved from 2015 to 2024 should exceed the total electricity consumption by 1%. However, discussions are currently underway regarding the potential strengthening of future targets to also encompass reductions in fossil fuel usage or setting more ambitious goals for the largest energy consumers.

Subsidy programs serve to complement regulatory measures by incentivizing the replacement of outdated equipment with more efficient models. Additional performance-based incentives are available for projects that can exceed energy savings thresholds of 10% or more.

Looking ahead, Chinese Taipei's new energy-saving strategy will focus on deploying emerging efficiency-boosting technologies and transitioning demonstration projects to wider adoption.

b) Improving Energy Efficiency in Industry in Korea

Mr Minkyu Kim (Associate Research Fellow, Department of Energy Demand and Policy Analysis, Korea Energy Economics Institute (KEEI), Korea)

Key points

- Under the Korea's voluntary energy efficiency targets program, the government collaborates with about 30 significant energy-intensive corporations, which account for over 60% of industrial energy usage.
- Those corporations pledge to annual improvement targets for their energy intensity with a partnership agreement with the authorities.
- The Korean LEEN initiative (Learning Energy Efficiency Networks) fosters innovation and facilitates knowledge-sharing among small and medium-sized companies, through workshops, diagnostic services, and other collaborative activities.

<u>Summary</u>

The manufacturing industry in Korea, which constitutes over 27% of the Gross Domestic Product (GDP), serves as the economic backbone of the economy. This sector is also responsible for over 50% of the economy’s energy consumption.

Given the industry's critical role in both the economic and environmental spheres, enhancing efficiency is prioritized to bolster decarbonization targets and fortify energy security. The energy intensity of Korea, a metric that gauges the energy efficiency of its economy, surpasses that of numerous major economies and is improving at a relatively slower pace on average.

Under the aegis of Korea's voluntary energy efficiency targets program (KEEP 30 ; Korea Energy Efficiency Partnership 30), the government collaborates closely with about 30 significant energy-intensive corporations, which collectively account for over 60% of industrial energy usage. Firms participating in this program pledge to annual improvement targets for their energy intensity, facilitated through a partnership agreement with the authorities.

Incentives such as support for technology development or tax benefits are subsequently provided, contingent on regular performance evaluations. The Korean LEEN initiative (Learning Energy Efficiency Networks) augments this approach by instituting regional networks designed to foster innovation and facilitate knowledge-sharing among small and medium-sized enterprises, through mechanisms such as workshops, diagnostic services, and other collaborative activities.

c) Improving Energy Efficiency in Industry in Thailand

Mr Wisaruth Maethasith (Engineer, Professional Level, Energy Regulation and Conservation Division, Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand)

<u>Key points</u>

・The key policy measures targeted at the industrial sector encompass mandatory energy management standards for designated high energy usage factories and buildings.

・The designated facilities are obligated to appoint energy managers, implement management systems, and submit annual compliance reports to be verified by independent auditors.

・Thailand provides financial incentives such as equipment subsidies, which cover upper 30% of project costs for energy efficiency upgrades that meet the stipulated payback criteria.

Summary

Thailand’s National Energy Efficiency Plan, which aspires to achieve a 36% reduction in energy intensity by the year 2037, relative to the levels recorded in 2010. Given that the manufacturing sector has emerged as the predominant energy consumer at the economy’s level, enhancements in industrial energy efficiency are deemed indispensable for the realization of this ambitious, economy-wide objective.

Under Thailand's plan, the key policy measures targeted at the industrial sector encompass mandatory energy management standards for designated high energy usage factories and buildings. The designation thresholds consider factors such as annual electricity consumption volumes. Facilities that have been designated are obligated to appoint energy managers, implement management systems, and submit annual compliance reports, which are to be verified by independent auditors.

In addition to the regulatory requirements, Thailand provides financial incentives such as equipment subsidies, which cover upper 30% of project costs for energy efficiency upgrades that meet the stipulated payback criteria. Tax incentives are also in place to encourage investments in energy efficiency.

Furthermore, Thailand is at the forefront of pioneering approaches to harness greater private sector investment in energy efficiency. This is achieved by bundling standardized factory project opportunities into investable financial products, which are certified based on projected savings and returns. The aim of this initiative is to amplify the impacts of energy efficiency by private sector.

d) Improving Energy Efficiency in Industry in Japan

Mr Akira Ishihara (Special Adviser, International Cooperation Division, the Energy Conservation Center, Japan (ECCJ))

Key points

・Considering the revisions to Japan's Energy Conservation Act, new strategies have been devised with the objective of promoting a transition in energy usage away from fossil fuels.

・Benchmark targets, which were previously applicable only to the most energy-intensive industries, have been expanded to additional sub-sectors within both the industry and commercial buildings.

・Overall, Japan's experience emphasizes the importance of integrated policy packages that combine clear economy-wide objectives with tailored support measures, suited to the varying circumstances of industries and company sizes.

Summary

Despite an overall decrease in the industry's energy consumption in Japan, achieving further reductions would necessitate multilateral approaches, given the diverse circumstances across sectors.

The substantial gains of the past were largely attributed to the implementation of the best available technologies, such as combined heat and power systems and heat recovery. These technologies have now been widely adopted, indicating that the scope for incremental improvements solely through individual technologies might be limited.

Considering the revisions to Japan's Energy Conservation Act, new strategies have been devised with the objective of promoting a transition in energy usage away from fossil fuels. Benchmark targets, which were previously applicable only to the most energy-intensive industries, have been expanded to encompass additional sub-sectors within both the industry and commercial buildings.

Companies bear the responsibility of establishing internal efficiency and decarbonization targets and plans, adhering to the guidelines set forth by the government. Moreover, the government also delineates actual economy-wide reduction objectives that companies strive to collectively achieve.

Energy audits persist in playing a crucial role in driving performance improvements. Local platforms have been instituted to bolster information sharing and provide support for small and medium-sized enterprises that might lack in-house expertise. These audits consider optimization opportunities across various stages, ranging from minor retrofits to large-scale investments.

Looking towards the future, several technologies have high potential to improve the industries energy intensities. Heat pumps, for instance, are witnessing broader application in the industry owing to technical advancements, offering not only efficiency benefits but also a pathway for transitioning to lower-carbon electricity. The coordination of multiple efficient systems is demonstrating growing implementation, as evidenced by the integrated energy hub for an industrial park.

Digitalization also paves the way for new opportunities to visualize and optimize entire production processes. Overall, Japan's experience accentuates the importance of integrated policy packages that amalgamate clear economy-wide objectives with tailored support measures, suited to the varying circumstances of industries and company sizes.

e) Q&A and Discussions

Key points

- The existence of a target is necessary for the progress of energy conservation. The existence of a target allows more efficient use of economic subsidies, leading to efficient energy conservation.
- Improving awareness of the effects of energy conservation is important for promoting energy conservation. A lack of accurate information on the economy and effects of energy conservation leads to a lack of awareness, hindering energy conservation. Therefore, government intervention is necessary.
- Differences in judgment criteria between management and operational workers can be a factor hindering energy conservation. Even if the workers feel energy efficiency deterioration of the equipment, the management may hesitate to make new investments for equipment. Third-party perspectives are needed.
- There is a need to address cases where energy conservation investments are not made due to lack of knowledge of energy conservation for investment decision-makers. Workers should provide information to decision-makers.

Summary

Q (to Dr Tze-Chin Pan): Dr. Pan mentioned that Chinese Taipei has a policy of reducing electricity consumption by 1% every year, and currently, a review of this policy is being considered. In the discussions for the review, will renewable energy be included as a target in addition to fossil fuels?

A (Dr Tze-Chin Pan): Including renewable energy as a target could be one option. On the other hand, it could also be considered to raise the original target of reducing electricity consumption by 1% itself. Either way, the direction is still under discussion at present.

Q (to Mr Minkyu Kim): What kind of incentives are given in the voluntary energy efficiency improvement program in the industrial sector of Korea?

A (Mr Minkyu Kim): The government evaluates the progress of energy conservation, and depending on the level of evaluation, incentives including economic ones such as tax benefits are given.

Q (to Mr Wisaruth Maethasith): In the system of reporting energy consumption in Thailand, is it mandatory for companies to set energy conservation targets?

A (Mr Wisaruth Maethasith): In Thailand, companies are required to set energy conservation targets, but there is no specification of numerical targets or the types of energy to be targeted.

Q (to Mr Akira Ishihara): Since the goal of companies is to maximize profits, especially in small and medium-sized enterprises, it is likely that they would prioritize investment towards business expansion over energy-saving investment. How should this be addressed?

A (Mr Akira Ishihara): In small and medium-sized enterprises, there is a lack of knowledge and key persons regarding energy conservation. Therefore, in small and medium-sized enterprises, energy audits and analysis of energy-saving potential are important, and government support for these is necessary.

Q (to all presenter): Energy conservation brings benefits to companies and is expected to progress based on market principles. In this context, is there a significance for the government to implement energy conservation policies?

A (Dr Tze-Chin Pan): There could be cases where energy conservation investments are not made because those who make investment decisions or workers who should provide information to decision-makers do not have knowledge of energy conservation. Also, there could be cases where energy conservation is not performed due to financial constraints. Energy conservation policies are necessary to address such cases.

A (Mr Wisaruth Maethasith): Differences in judgment criteria between management and the field can also be a factor hindering energy conservation. Even if the field feels the deterioration of energy efficiency of the equipment, the management may hesitate to make new investments for equipment that is financially operational. To address such problems, the opinion of a third party would be necessary.

A (Mr Akira Ishihara): The existence of a target is also necessary for the progress of energy conservation. There are targets for the government and companies, and the existence of each target allows for more efficient use of economic subsidies and efficient energy conservation. This is the same for not only energy conservation but also climate change.

A (Mr Minkyu Kim): Improving awareness of the effects of energy conservation is also important for promoting energy conservation. In Korea, the awareness of the importance of energy conservation is high, but there are cases where support for energy conservation is small compared to government support for renewable energy. This is due to a lack of accurate information on the economy and effects of energy conservation, leading to a lack of awareness. From this perspective, the importance of energy conservation should be appealed to society.

6-2-5. Session 5:Energy Management System and Smart City

a) APEC Low-Carbon Model Town (LCMT) Project

Mr Minh Tran (Deputy Head, Environment and Regional Sustainability Department, Institute of Regional Sustainable Development, Viet Nam)

Key points

- “Da Lat” was selected as the case studies to prevent emissions caused by incineration of solid waste and to contribute to generation of electricity for local consumption.
- Introduction of EVs leads to reduction of dependence on fossil fuel run vehicles and GHG emission. Modal shift leads to reduce road congestion and provide added attraction to tourists. Energy management systems can help reduce energy by up to 20% when installed.

Summary

The aim of the APEC Low-Carbon Model Town (LCMT) project is to conduct feasibility studies on low-carbon development and develop low-carbon visions for cities based on international best practices.

Low carbon intervention is conducted in pre-selected assessment areas, town structures and buildings, transportation, untapped energy, multi-energy and area energy system, renewable and energy management system, overall city. There are three sources of funding for interventions, multi-lateral funding agencies, government funding, private sector entrepreneurs and post-workshop consultation to be undertaken to gather data to facilitate assessment in feasibility study.

Case studies of regions “Da Lat” resembling operating scenario had been selected and they provide some learnings. Potential to prevent emissions caused by incineration of >160MT of solid waste and contribute to generation of electricity for local consumption. Introduction of EVs leads reduction of dependence on fossil fuel run vehicles and reduce GHG emission. Modal shift also leads reduce road congestion and provide added attraction to tourists. Implementation of Green Building Standards increase energy requirement in buildings and reduce GHG emissions. Introduction of ride sharing options and improving public transport system reduce requirement of fossil fuel vehicles and provide business opportunities for locals. Energy consumption in buildings expected to increase by 10% CAGR (Compound Average Growth Rate) between 2010 & 2030 under existing conditions. Energy Management System can help reduce energy by up to 20% when installed.

b) Energy Management System and Smart Cities: Current Situation and its Future in the Philippines

Mr Felix William Fuentebella (Undersecretary, Office of Undersecretary, Department of Energy, the Philippines)

Key points

・The Philippines energy plan 2023-2050 shows Renewable Energy (RE) share in power generation to be 35% by 2030 and 50% by 2050. The plan implements an energy management system among designated establishments, an energy management program by government, and efficiency guidelines for buildings design.

・The Smart and Green Grid Plan (SGGP) forms part of the Philippines Energy Transition Program. The aggressive RE targets require the timely expansion of the transmission system to integrate and manage the additional RE capacity to come online from 2024 to 2040.

Summary

The future energy scenario in the Philippines include five points, energy saving, power generation mix, emerging technologies, ICT, energy resiliency. And there are three energy strategic framework as access to affordable energy, reliability and resiliency and clean and sustainable energy.

In the Philippines energy plan 2023-2050, reference is 35% Renewable Energy (RE) share in power generation mix by 2030 and 50% RE by 2030-2050. There are some plans for energy efficiency and conservation act such as Implementation of Energy management system among designated establishments, government energy

management program and guidelines on energy conserving design of buildings. And fiscal incentives and energy efficiency excellence awards is valid.
The smart grid visions of smart power generation, smart utility and smart home and cities are conducted to ensure the seamless integration of additional renewable energy capacity to the grid in the coming years. The Smart and Green Grid Plan would serve as the basis for the transmission development plan.
The Smart and Green Grid Plan (SGGP) forms part of the Philippines Energy Transition Program and will complement the Philippines energy plan 2023-2050. The aggressive RE targets require the timely development of smart and green transmission system to integrate and manage the additional RE capacity expected to come online from 2024 to 2040.

c) Implementation of Energy Management System on Campus Buildings in Indonesia

Dr Sentagi Sesotya Utami (Associate Professor, Engineering Physics, Faculty of Engineering, Universitas Gadjah Mada (UGM), Indonesia)

Key points

- In Indonesia, the Integrated Smart and Green Building (INSGREEB) in campus building is installed.
- INSGREEB started in 2012, focusing on integrating building physics and acoustics using smart instrumentation and systems, and adapted to COVID-19 conditions. The innovation continues with a new paradigm "Healthy, but still energy efficient" from 2020.

Summary

In Indonesia the Integrated Smart and Green Building (INSGREEB) in campus building is installed. INSGREEB starts in 2012 and focus on integrating building physics and acoustics using smart instrumentation and systems and adapted to COVID-19 conditions, the innovation continues with a new paradigm "Healthy, but still energy efficient" from 2020.
Carbon emission in Indonesia, distribution of CO_2 emissions by Building increase from 29% in 2011 to 36% in 2021. So, to set Green Building Goal is important. Green Building Goals have four aspects. Human development and mastery of science and technology, sustainable economic development, equitable development, strengthening Indonesia's resilience and governance are valid and they are pillars of Indonesian development for 2045.

Smart building system includes nine principles, Automatization, Connected and Integrated, Energy Management Implemented, Cyber Security Applied, Use of Artificial Intelligence, User Satisfaction, Flexible, Ongoing Monitoring, Inclusive. About Automatization, Lighting automation, Thermal and Indoor Air Quality (IAQ), Control Algorithm is applied. About User Satisfaction, the platform adapts and prioritizes the building occupant's needs in terms of safety, health, comfort, accessibility, security while improving life quality and increasing productivity is the key to achieve occupant satisfaction.

d) Q&A and Discussions

<u>Key points</u>

・Energy management systems can be implemented effectively at the institution, city, and economy-wide level.

・Artificial intelligence (AI) software has great potential but is far from being realized. Future efforts should focus on using AI to meet human needs for energy services more efficiently, which requires better measurement systems.

<u>Summary</u>

Q: If technology such as AI makes growing energy consumption much faster than other uses of energy? And also, technology makes agriculture, which is currently small, become much more important in terms of energy use?

A (Mr Minh Tran): As far as data centers are concerned, we seem on for example, in our office, if we digitalize our entire system, we save on space. So basically, it's a behavior shift of the entire world. So, no problem with that.
On the agricultural side, if we come up with a better design for energy, transit session markets, it can be captured because what we are measuring there are emissions. The energy transition market is still being developed globally.

A (Dr Sentagi Sesotya Utami): I believe that the technology of computers and data centers is very advanced now. We had to send off apple11 with the size of computer room. Now we can say that just one touch screen, something like that to send out our launcher or Apollo11. It still exists now. This is just an example that you know technology can adapt with the use of energy itself.

A (Mr Felix William Fuentebella): The smart city or smart technology enables the solution.

Q: Is there any thinking around managing energy use from air conditioning due to reducing humidity?

A: (Dr. Sentagi Sesotya Utami): In order to move out the humidity the most effective way is actually through air exchange. If we have an air exchange, we have the potential of having natural ventilation that would be very green. That is what we want to have in our green buildings to avoid using a lot of mechanical systems.

6-2-6. Session 6: Closing Remarks

Dr Kazutomo Irie, President, Asia Pacific Energy Research Centre (APERC)

Dr Irie was very appreciative to all the speakers, moderators, and active participants. He concluded this symposium was rich and multi-faceted contents, and informative and encouraging for those who are persuading decarbonization ultimately toward carbon neutrality. Dr Irie stated that APERC will continue move forward with the APEC sectoral symposium and APERC was planning to organise the third symposium on bioenergy in approximately October 2024 in Thailand in cooperation with the Thai ministry of energy. And he introduced the sixth 2024 ESCI Energy Smart Communities initiative best practices Awards Program hosted by Chinese Taipei.

6-2-7. Site Visit - Day2 (24 January)

Tokyo Denki University 10:00-12:00

Fifty-one individuals attended Tokyo Denki University site visit.

Tokyo Denki University (TDU) is an integrated science and engineering university founded in 1907 (formerly Denki School). TDU Senju Campus is engaged in a variety of CO_2 reduction initiatives. They adopt vertical installed huge Thermal Capsule, Air-flow window with Retro-reflective film, Breeze air conditioning system, and energy-saving operation coordination with monitoring system for calculate the number of people in the room. They also provide real-time monitoring of electricity consumption, CO_2 emissions, and water usage. These initiatives are unique and have had a significant effect on reducing electricity consumption and CO_2 emissions.

7. Symposium Analysis

APEC Symposium on Pursuing Decarbonization of Fossil Fuels on 11 and 12 October 2023 in Kobe City, Hyogo, Japan.

In the symposium, including speakers, participants, and organizers, more than 60 individuals participated. 26 attendees completed the evaluation survey.

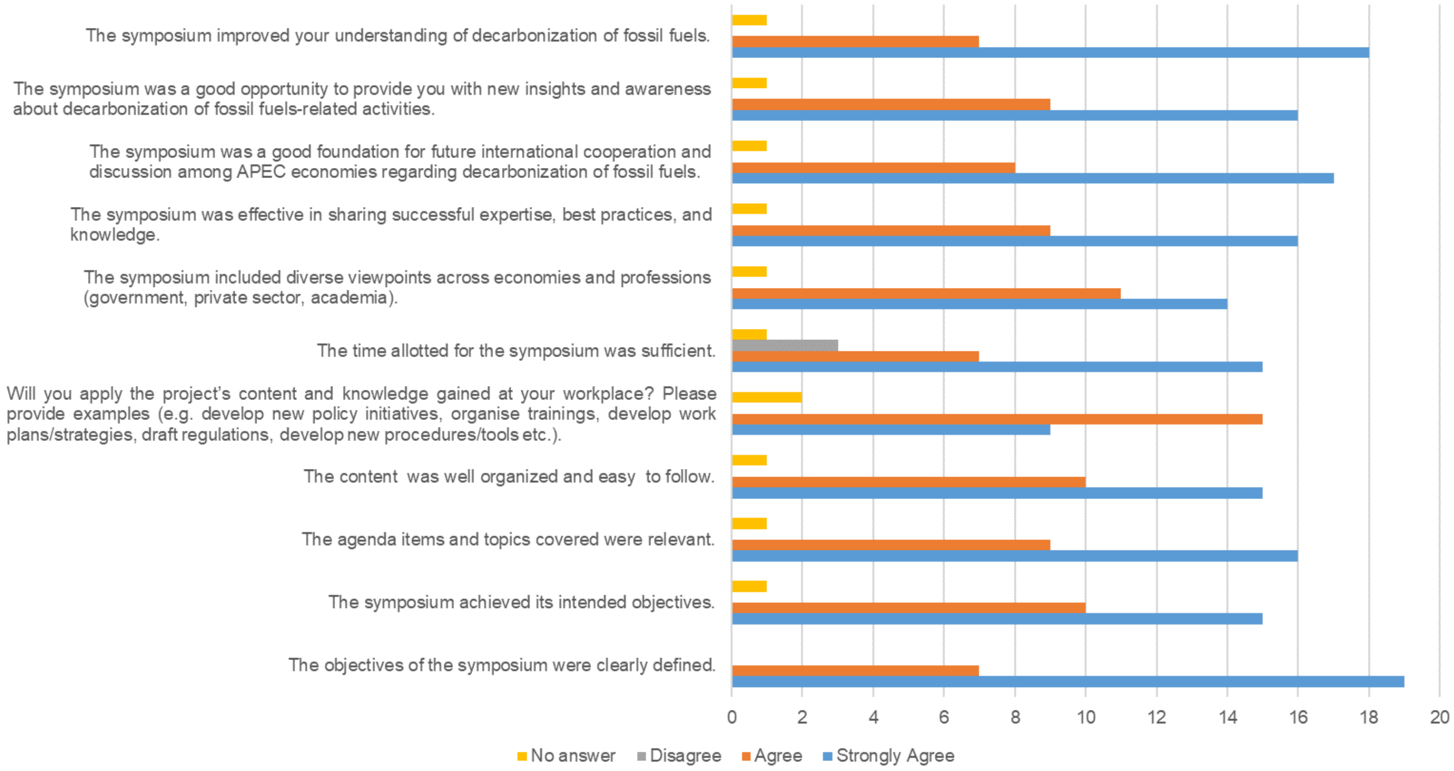


Figure 1. APEC Project Evaluation Survey on Fossil Fuels

According to the survey results shown in Figure 1, most respondent thought that the objectives in the symposium were clearly defined and easily understood.

In general, the survey results support the notion that it achieved the intended objectives. Some respondent thought that the presentations were a bit compressed in time and needed more time to get more details. Some request more sessions focus on decarbonization of fossil fuels other than renewable energies.

APEC Symposium on Promoting Energy Efficiency and Energy Management System on 23 and 24 January, 2024 in Shinagawa, Tokyo.

In the symposium, including speakers, participants, and organizers, more than 60 individuals participated. 25 attendees completed the evaluation survey.

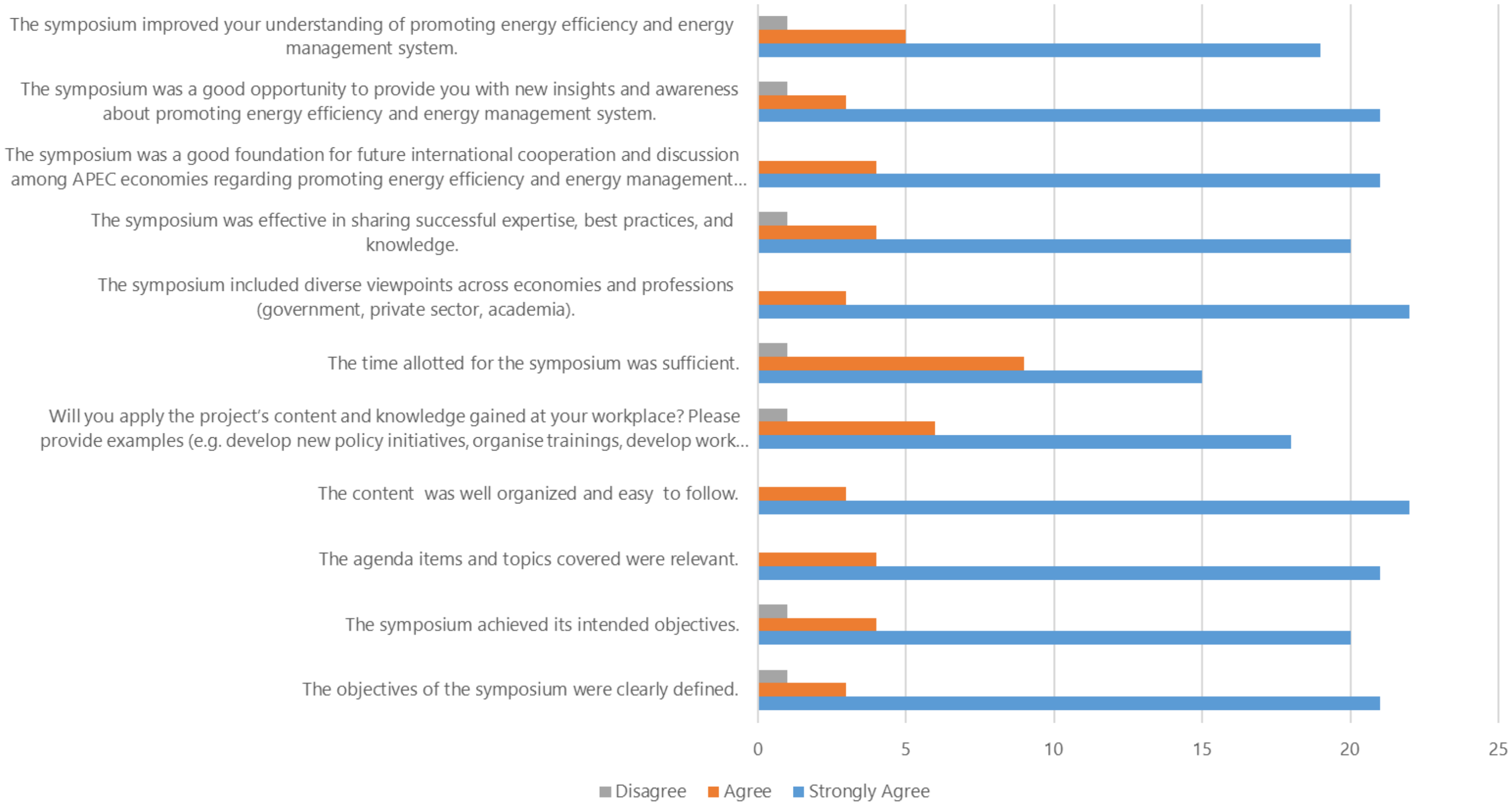


Figure 2. APEC Project Evaluation Survey on Fossil Fuels

According to the survey results shown in Figure 2, most respondent thought that the agenda items and topics covered were relevant and the content was well organized and easy to follow. The symposium included diverse viewpoints across economies and professions. The symposium was a good foundation for future international cooperation and discussion among APEC economies. Some respondent thought that this type of symposium should be a two-day event to allow more time for the Q&A. For reasons unknown, one person shows a negative reaction for applying the project's content and knowledge gained at his/her workplace.

The participation rate of female speakers should be increased.

8. Appendix

8-1. Agenda

APEC Symposium on Pursuing Decarbonization of Fossil Fuels
11-12 October 2023 in Kobe City, Hyogo, Japan

Venue: Banquet hall "Kairaku" on the B1 Floor, Kobe Portopia Hotel

(JST)	**Wednesday, 11 October** MC: Prof Mayumi Matsumoto, Visiting Associate Professor, Special Division of Environmental and Energy Sciences, Komaba Organization for Educational Excellence (KOMEX), the University of Tokyo, Japan
08:30-09:00	**Registration**
09:00-09:20	**1. Opening Session**
09:00-09:05	**1-1 Opening Remarks** Dr Kazutomo Irie, President, Asia Pacific Energy Research Centre (APERC)
09:05-09:20	**1-2 Keynote Speech:** **Necessity of Decarbonization of Fossil Fuels for Carbon Neutrality** Ms Reiko Eda, Director for Natural Resources and Energy Research, International Affairs Division, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), Japan
09:20-11:20	**2. Hydrogen:** **Evaluation of Current Status and How to Promote Development and Deployment** Moderator: Ms Sichao Kan, Senior Researcher, New Energy System Group, Clean Energy Unit, Institute of Energy Economics, Japan (IEEJ)
09:20-09:40	**2-1 Production of Hydrogen I** Mr Alex Santander Guerra, Head of Division, Energy and Environmental Policy and Studies Division, Ministry of Energy, Chile
09:40-10:00	**2-2 Production of Hydrogen II** Mr Awadh Asyraf Bin Supri, Head of Marketing & Sales, Far East & Australia Gentari Hydrogen Sdn. Bhd., Malaysia
10:00-10:20	**2-3 Transportation of Hydrogen** Mr Yuji Chishima, Group Leader of Business Development, Hydrogen Business Department, Chiyoda Corporation, Japan
10:20-10:40	**2-4 Transportation of Hydrogen (Liquefied Hydrogen)** Mr Shintaro Onishi, Senior Staff Officer, Section 3, Business Development Department, Project Group, Hydrogen Strategy Division, Kawasaki Heavy Industries, Ltd., Japan
10:40-11:00	**2-5 Hydrogen Utilization** Dr Amgad Elgowainy, Senior Scientist, Distinguished Fellow, and Group Leader, Energy Systems and Infrastructure Analysis, Argonne National Laboratory, the United States
11:00-11:20	**Q&A for all presenters and discussion**
11:20-11:35	**Coffee Break**

11:35-12:55	**3. Fuel Ammonia:** **Evaluation of Current Status and How to Promote Development and Deployment** Moderator: Mr Mathew Charles Horne, Senior Researcher, Asia Pacific Energy Research Centre (APERC)
11:35-11:55	**3-1 Production of Fuel Ammonia from Fossil Fuels** Mr Yoshikazu Kobayashi, Executive Analyst, New Energy System Group, Clean Energy Unit, The Institute of Energy Economics, Japan
11:55-12:15	**3-2 Fuel Ammonia for Power Generation** Mr Najib Rahman Sabory, General Manager, Decarbonization Promotion Section, Planning Division, JERA Co., Inc., Japan
12:15-12:35	**3-3 Ammonia as Fuel in Shipping** Mr Sergio Alda, Senior Project Officer, Sustainability, European Maritime Safety Agency (EMSA), Portugal
12:35-12:55	***Q&A for all presenters and discussion***
12:55-14:10	**Lunch Break Banquet hall "Kairaku" on the B1 Floor**
14:10-16:00	**4. Carbon Capture, Utilization and Storage (CCUS):** **Evaluation of Current Status and How to Promote Development and Deployment** Moderator: Dr Atsushi Kurosawa, Director, Global Environment Program, Research and Development Division, Institute of Applied Energy (IAE), Japan
14:10-14:30	**4-1 CCUS in Japan** Dr Kenta Asahina, Mineral and Natural Resources Division, Natural Resources and Fuel Department, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI) , Japan
14:30-14:50	**4-2 CCUS in Australia** Dr Matthias Raab, Chief Executive Officer, Executive, CO2CRC Limited, Australia
14:50-15:10	**4-3 CCUS in China** Prof Jiutian Zhang, Green Development Institute, Beijing Normal University, Secretary General, China CCUS Association of Chinese Society for Environmental Sciences, China
15:10-15:30	**4-4 CCUS in ASEAN** Dr Usman Pasarai, Senior Researcher, Research Center for Process and Manufacture Technology, National Research and Innovation Agency (BRIN), Indonesia
15:30-16:00	**Q&A for all presenters and discussion**
16:00-16:15	**Coffee Break**
16:15-16:55	**5. Direct Carbon Capture (DAC):** **Evaluation of Current Status and How to Promote Development and Deployment** Moderator: Mr Glen E. Sweetnam, Senior Vice President, Asia Pacific Energy Research Centre (APERC)
16:15-16:35	**5-1 R&D for DAC in Japan** Prof Kenji Yamaji, President, Research Institute of Innovative Technology for the Earth, Japan
16:35-16:55	**5-2 R&D/commercialization for DAC in North America** Mr Adam Baylin-Stern, Director, Policy and Engagement, Carbon Engineering, Canada
16:55-17:15	**Q&A for all presenters and discussion**

17:15-17:20	**6. Closing Remarks** Dr Kazutomo Irie, President, Asia Pacific Energy Research Centre (APERC)
18:00-	**Reception Banquet hall "Kairaku" on the B1 Floor**
(JST)	**Thursday, 12 October**
	Site Visit

APEC Symposium on

Promoting Energy Efficiency and Energy Management System

23-24 January 2024 in Tokyo, Japan

Venue: Banquet room “RUBY 34” on the 34th Floor, Shinagawa Prince Hotel

(JST)	**Tuesday, 23 January 2024** MC: Professor Mayumi Matsumoto, Visiting Associate Professor, Special Division of Environmental and Energy Sciences, Komaba Organization for Educational Excellence (KOMEX), the University of Tokyo, Japan
08:30-09:00	**Registration**
09:00-09:35	**1. Opening Session**
09:00-09:05	**1-1 Opening Remarks** Dr Kazutomo Irie, President, Asia Pacific Energy Research Centre (APERC)
09:05-09:20	**1-2 Keynote Speech:** Mr Hideyuki Umeda, Director for International Policy on Carbon Neutrality, Agency for Natural Resources and Energy (ANRE), Ministry of Economy, Trade and Industry (METI), Japan
09:20-09:35	**1-3 Keynote Speech:** Dr Meng Liu, Chair, APEC Expert Group on Energy Efficiency and Conservation (EGEEC) and, Deputy Chief, Division of Resources and Environment, China National Institute of Standardization, China
09:35-09:45	**Group Photo**
09:45-11:05	**2. Energy Efficiency in Building: Current Situation and Room for further improvement** Moderator: Mr Ting-Jui Sun, Senior Researcher, APERC
09:45-10:00	**2-1 Improving Energy Efficiency in Buildings in Hong Kong, China** Mr Wallace Leung, Chief Engineer, Energy Efficiency B, Electrical and Mechanical Services Department, Government of Hong Kong, China
10:00-10:15	**2-2 Modeling US buildings energy efficiency** Ms Courtney Sourmehi, Industry Economist, Energy Information Administration, U.S. Department of Energy, the US
10:15-10:30	**2-3 Energy Efficiency of Buildings in Australia** Dr Subbu Sethuvenkatraman, Research Group Leader, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
10:30-10:45	**2-4 Japan’s Path for Carbon Neutrality and the Role of Energy Efficiency in Buildings** Dr Naoko Doi, Senior Research Director, Assistant Director, Climate Change and Energy Efficiency Unit, The Institute of Energy Economics, Japan (IEEJ)
10:45-11:05	***Q&A* for all presenters and discussion**
11:05-11:20	**Coffee Break**
11:20-12:40	**3. Energy Efficiency in Transport: Current Situation and Room for further improvement** Moderator: Mr Finbar Maunsell, Assistant Researcher, APERC

11:20-11:35	**3-1 Improving Energy Efficiency in Transport Sector of Singapore** Professor Qiang Meng, Department of Civil and Environmental Engineering (CEE), National University of Singapore
11:35-11:50	**3-2 Improving Energy Efficiency in Transport in Malaysia** Mr Huzaimi Nor Bin Omar, Chief Operating Officer, ChargeEV, Green EV Charge Sdn Bhd, Malaysia
11:50-12:05	**3-3 Improving Energy Efficiency in Transport in the Philippines** Dr Noriel Christopher Tiglao, National College of Public Administration and Governance (NCPAG) , University of the Philippines
12:05-12:20	**3-4 Achievement and Potential of Multi-Pathway Approach in Road Transport Sector -Japan's Experience** Mr Takao Aiba, Vice chairperson of Environmental Policy Subcommittee, and Chairperson of International Climate Change Policy Expert Group, Japan Automobile Manufacturers Association, Inc., (JAMA), Japan
12:20-12:40	***Q&A* for all presenters and discussion**
12:40-13:55	**Lunch Break**
13:55-15:15	**4.Energy Efficiency in Industry: Additional Potential for Achieving Carbon Neutrality in APEC** Moderator: Mr Mathew Horne, Senior Researcher, APERC
13:55-14:10	**4-1 Improving Energy Efficiency in Industry in Chinese Taipei** Dr Tze-Chin Pan, Deputy Division Director, Energy Policy and Planning Division, Green Energy and Environment Research Laboratories, Industrial Technology Research Institute, Chinese Taipei
14:10-14:25	**4-2 Improving Energy Efficiency in Industry in Korea** Mr Minkyu Kim, Associate Research Fellow, Department of Energy Demand and Policy Analysis, Korea Energy Economics Institute (KEEI), Korea
14:25-14:40	**4-3 Improving Energy Efficiency in Industry in Thailand** Mr Wisaruth Maethasith, Engineer, Professional Level, Energy Regulation and Conservation Division, Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand
14:40-14:55	**4-4 Improving Energy Efficiency in Industry in Japan** Mr Akira Ishihara, Special Adviser, International Cooperation Division, the Energy Conservation Center, Japan (ECCJ)
14:55-15:15	***Q&A* for all presenters and discussion**
15:15-15:30	**Coffee Break**
15:30-16:35	**5. Energy Management System and Smart City: Current Situation and Room for further improvement** Moderator: Mr Glen Sweetnam, Senior Vice President, APERC
15:30-15:45	**5-1 APEC Low-Carbon Model Town (LCMT) Project** Mr Minh Tran, Deputy Head, Environment and Regional Sustainability Department, Institute of Regional Sustainable Development, Viet Nam
15:45-16:00	**5-2 Energy Management System and Smart Cities: Current Situation and its Future in the Philippines** Mr Felix William Fuentebella, Undersecretary, Office of Undersecretary, Department of Energy, the Philippines
16:00-16:15	**5-3 Implementation of Energy Management System on Campus Buildings in Indonesia** Dr Sentagi Sesotya Utami, Associate Professor, Engineering Physics, Faculty of Engineering, Universitas Gadjah Mada (UGM), Indonesia
16:15-16:35	**Q&A for all presenters and discussion**

16:35-16:40	**6. Closing**
16:35-16:40	**6-1 Closing Remarks** Dr Kazutomo Irie, President, Asia Pacific Energy Research Centre (APERC)
17:30-	**Reception:** **Banquet room “AQUAMARINE 32” on the 32nd Floor**
(JST)	**Wednesday, 24 January 2024**
10:00-12:00	**Site Visit (half a day)：Tokyo Denki University**

8-2. Presentation Materials

1. APEC Symposium on Pursuing Decarbonization of Fossil Fuels

1-1. Keynote Speech: Necessity of Decarbonization of Fossil Fuels for Carbon Neutrality

1-2. Energy Transition and Green Hydrogen in Chile

1-3. Development of Global Supply Chain by LOHC-MCH method

1-4. Towards the Realization of International Liquefied Hydrogen Supply Chain

1-5. Analysis of Current and Future Hydrogen Production and Utilization in the United States

1-6. Fuel Ammonia Production from Fossil Fuels

1-7. Fuel Ammonia Power Generation and Building Supply Chain

1-8. EMSA study Potential of Ammonia as Fuel in Shipping

1-9. CCUS in Japan

1-10. CCUS in Australia

1-11. CCUS in ASEAN: Recent Developments in Indonesia

1-12. Research and Development for DAC in Japan

1-13. Commercial-scale Direct Air Capture

2. APEC Symposium on Promoting Energy Efficiency and Energy Management System

2-1. Keynote Speech: The Evolution of Energy Efficiency Policy to Support Clean Energy Transition in Japan

2-2. Keynote Speech: The Key to an Energy Resilient APEC: Energy Efficiency and Energy Management

2-3. Improving Energy Efficiency in Buildings in Hong Kong, China

2-4. Modeling the US buildings energy efficiency

2-5. Energy Efficiency of Buildings in Australia

2-6. Japan’s Path for Carbon Neutrality and the Role of Energy Efficiency in Buildings

2-7. Improving Energy Efficiency in Transport in Malaysia

2-8. Improving Energy Efficiency in Transport in the Philippines

2-9. Achievement and potential of multi-pathway approach in road transport sector - Japan's experience

2-10. Improving Energy Efficiency in Industry in Chinese Taipei

2-11. Improving Energy Efficiency in Industry in Thailand

2-12. Improving Energy Efficiency in Industry in Japan

2-13. Energy Management System and Smart Cities: Current Situation and its Future in the Philippines

2-14. Implementation of Energy Management System on Campus Buildings in Indonesia

METI

APEC Symposium on Pursuing Decarbonization of Fossil Fuels – October 11, 2023

Necessity of Decarbonization of Fossil Fuels for Carbon Neutrality

Reiko Eda
Agency for Natural Resources and Energy, Japan
EGCFE Chair

Climate Change

Trilemma

Economic Growth   Security

2

Energy transition through various pathways and innovation

3

G7

G7 Climate, Energy, and Environment Ministerial, 15-16 April, Sapporo

G7 Leaders' Summit
19-21 May, Hiroshima

4

Basic Policy for Realization of GX(Green Transformation)

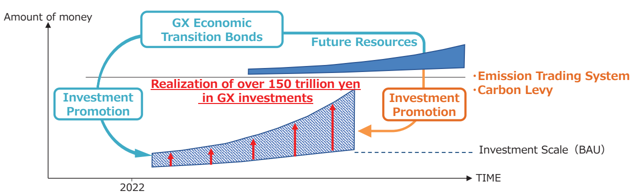
To rebuild a stable supply of energy, measures including promoting drastic shift to decarbonized power sources will be taken.

- **Renewable Energy**: To expand the introduction of renewable energy, **a grid development plan** has been established. **Investment in the next 10 years will be 8 times** as much as that in the past 10 years.
- **Nuclear power**: **Replacement** of reactors decided to be decommissioned with next generation innovative reactors. **Review of operating period** (40 years + 20-year extension + shutdown period such as inspection)

Government support will be provided for **upfront investment of 20 trillion yen** to achieve carbon neutrality by 2050 while strengthening industrial competitiveness and realizing economic growth, **aiming for more than 150 trillion yen of public and private investment over the next 10 years.**

To promote the GX investment as described above, a **"Growth Oriented Carbon Pricing Concept"** will be embodied and implemented as soon as possible.

① **Government support for bold upfront investment** by issuing **"GX Economic Transition Bonds"** (20 trillion yen over the next 10 years)
② **Introduction of carbon pricing to give incentives for GX investment**
(1) Full-scale operation of **emissions trading system** in high emission industries [**from FY2026**].
+ Allowance auctioning is phased in gradually to **power generation companies** [**from FY2033**]
(2) Introduction of a **carbon levy** on fossil fuel importers [**from FY2028**]
③ Strengthen financial support through public-private partnership



5

Highlight of the 2023 Basic Hydrogen Strategy

- To introduce hydrogen having well regard to the **S+3E** principles (**S**afety, **E**nergy security, **E**conomic efficiency, **E**nvironmental compatibility) and industry competitiveness.
- The scope of strategy includes hydrogen and its derivatives such as ammonia, synthetic methane, synthetic fuels, etc., taking into consideration of the challenges and timelines surrounding these products.

Basic Strategy

Expanding Supply

(a) A new volume target at **12 Mt/p.a. by 2040.**
(b) Leading to low-carbon hydrogen by introducing:
① **carbon intensity-based criteria**, not "colour" based;
② guiding regulatory requirements.
(c) Promote domestic production and supply chain. Target share of **electrolysers** (domestic and overseas) that involve Japanese element (including parts and materials) **by 2030 is set around at 15GW.**
(c) Strengthen relationships with exporting countries, develop transportation technologies and expand financing capabilities.

Creating Demand

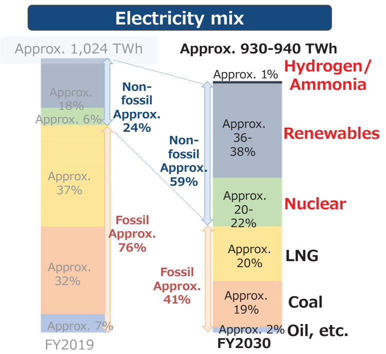
(a) **Power generation**
A wide range of use in power sector, including co-firing and single-firing.
(b) **Fuel cells**
Deploy FC stack technology in a variety of applications such as commercial vehicles, rolling stocks, vessels, heavy-duties, agri machinery as well as use for decarbonising ports and airports.
(c) **Industrial use**
Heat use such as boilers and other equipment in the hard-to-abate factories. Develop technologies to utilise as raw material in the fields of steel and chemicals.
(d) **Home use**
Promote high performance and low-cost residential FC.

To introduce various support schemes with a view to setting up large-scale, resilient supply chains:
a. **Producer support scheme (price gap subsidy)**
b. **Cluster development support**

Others:
①Promote regional use and consumption and engage local governments ②Assist innovative R&D
③Cross-border cooperation for standardisation and other activities ④Raise public awareness and acceptance

6

Strategic Energy Plan -Policy responses for 2030-



- **Maximum introduction of renewables as primary power sources**.
- **Further pursuit of thorough energy efficiency**
- **Restart of nuclear power plants with safety as a top priority**.
- On the major premise of **ensuring energy security**, **thermal power** in the electricity mix **will be lowered as much as possible.**
- **Innovation** in the thermal power by means of **hydrogen /ammonia - fired power generation and CCUS/Carbon Recycling** will be pursued.

7

13th APEC Energy Ministerial Meeting 15-16 August, Seattle

- The first Energy Ministerial Meeting in eight years.
- Participants held discussions mainly on three issues:
  [i] Power Sector Decarbonization
  [ii] Accelerating Methane Abatement
  [iii] Supporting a Just Energy Transition
- The Chair's statement was compiled.
- Inclusion of the phrase **"various pathways"**

APEC Asia-Pacific Economic Cooperation

8

AZEC Ministerial Meeting

- On 4 March 2023, METI hosted **Asia Zero Emissions Community (AZEC) Ministerial Meeting**.
- Minister Nishimura, Minister of Economy, Trade and Industry of Japan, who chaired the meeting, made remarks on **the importance of decarbonization in Asia, AZEC concept, and Japan's specific efforts**.

Participating economies (in alphabetical order)
Australia, Brunei Darussalam, Cambodia, Indonesia, Japan, Laos Malaysia, the Philippines, Singapore Thailand, Viet Nam
Participating international organizations (in alphabetical order)
Economic Research Institute for ASEAN and East Asia (ERIA)
International Energy Agency (IEA)

Policies to promote clean fossil energy in APEC (1)

Economies	Programs/Policies	Goal
United States	The Inflation Reduction Act, which is intended to promote alternative fuels	• Extension of Tax Credits for Biodiesel and Renewable Diesel • Extension of Tax Credit for Alternative Fuels • Extension of Second-Generation Biofuel Incentives • Clean Fuel Production Credit
Canada	Federal and provincial regulations to reduce methane emissions (fugitives, venting and flaring) in the oil and gas sector	Achieve methane reduction targets: 40 to 45% below 2012 levels by 2025 and 75% below 2012 levels by 2030.
Canada	Carbon price rising to 130 USD per tonne by 2030, up from 50 USD now	Affect business decisions and consumer behavior to investment in CCUS, biofuels, renewables and low-carbon energy carriers.
Canada	Clean fuel standard (liquid fuels)	Reduce carbon intensity of gasoline, diesel by 15% below 2016 levels by 2030.
Canada	Fund CCUS research; CCUS investment tax credits for eligible equipment	Encourage decarbonization research and investment.
Canada	Hydrogen Strategy	Set out short-, mid- and long-term goals for developing a hydrogen industry in Canada. No specific policy support thus far.
Canada	Provincial renewable natural gas (RNG) blending mandates (e.g., landfill methane)	B.C. mandating a 15% RNG blend by 2030. Quebec mandating a 5% blend by 2025 and 10% by 2030.

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Policies to promote clean fossil energy in APEC (2)

Economies	Programs/Policies	Goal
Singapore	National Hydrogen Strategy	Establishes five activities to foster the development of hydrogen technologies and the global hydrogen supply chain.
Singapore	Fund research into emerging low-carbon alternatives	Fund studies and demonstration projects to research and foster the development of low-carbon hydrogen CCUS projects.
Singapore	Carbon price rising from 4 USD per tonne now to 35 to 60 USD per tonne in 2030	Affect business decisions and consumer behavior to investment in CCUS, biofuels, renewables and low-carbon energy carriers.
Australia	Australia's National Hydrogen Strategy	Designed to establish Australia's hydrogen industry as a major global player by 2030.
Australia	Emissions Reduction Fund (ERF)	The government will purchase lowest cost abatement (in the form of Australian carbon credit units (ACCUs)).
China	Action Plan for Carbon Dioxide Peaking Before 2030	• Promote advanced bio-liquid fuels, sustainable aviation fuels, and other alternatives. • Improve the energy efficiency of end-use fuel products.

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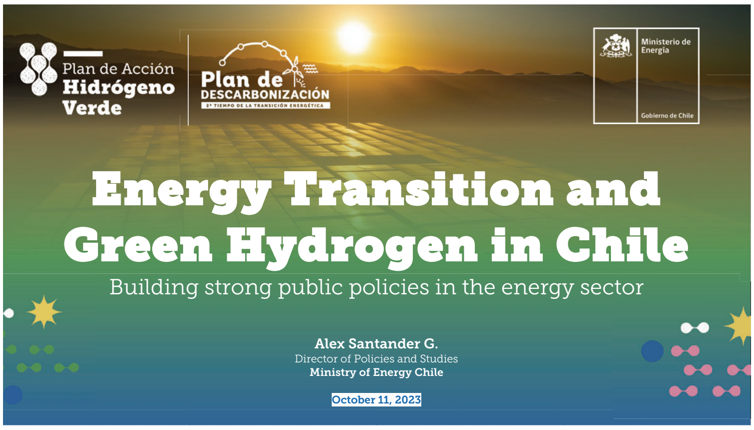
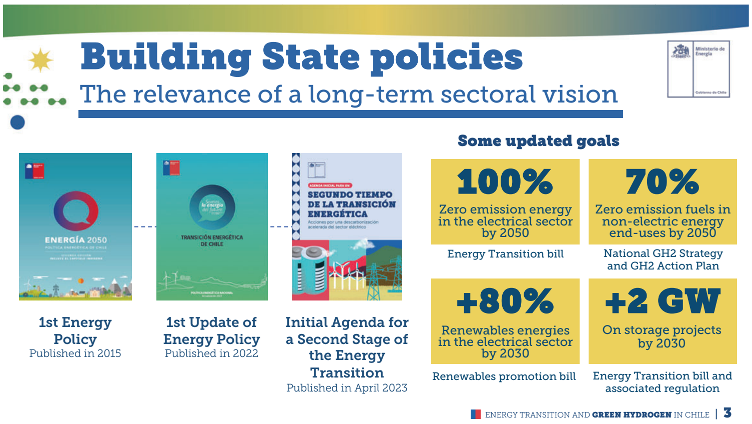
Policies to promote clean fossil energy in APEC (3)

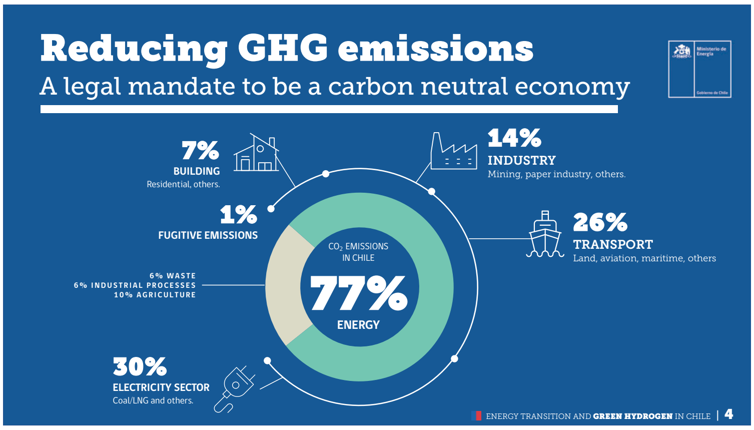
Economies	Programs/Policies	Goal
Thailand	The Thailand Board of Investment's Investment Promotion Packages (notification no. Sor. 7/2564)(Nov 2021)	Natural gas separation plants and petrochemical production facilities implementing CCUS will be granted 8-year corporate income tax exemption.
Thailand	Biofuel blending mandate (introduced in 2007)	• E20 as the primary gasohol by 2037. • Biodiesel blend rate is adjusted based on domestic supplies and energy prices.
Korea	Eco-friendly Biofuel Development Measures (Oct 2022)	Expand domestic biofuels by adopting marine biofuel by 2025, sustainable aviation fuel by 2026 and raising its 2030 biofuels blending mandate in the diesel pool.
Japan	2050 Carbon Neutral and 2030 Climate Goal	• Reduce greenhouse gas emissions to net-zero by 2050 . • Reduce its GHG emissions by 46 percent in FY 2030 from its FY 2013 levels. • National Hydrogen Policy
Japan	Basic Policy for Realization of GX(Green Transformation)	• "GX Economic Transition Bonds" (20 trillion yen over the next 10 years) • Introduction of carbon pricing to give incentives for GX investment • Strengthen financial support through public-private partnership

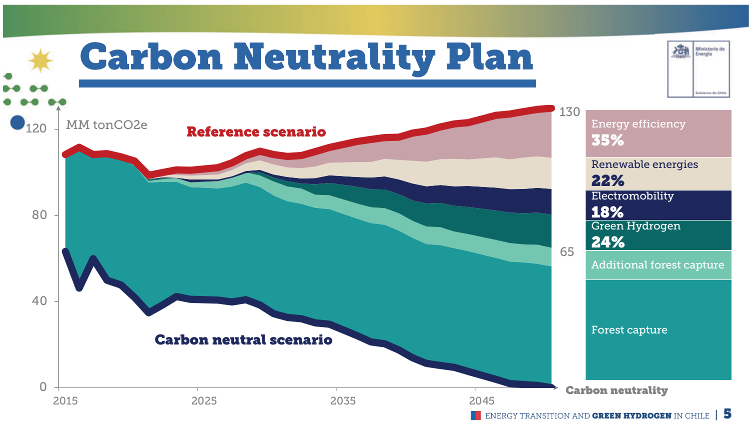
12

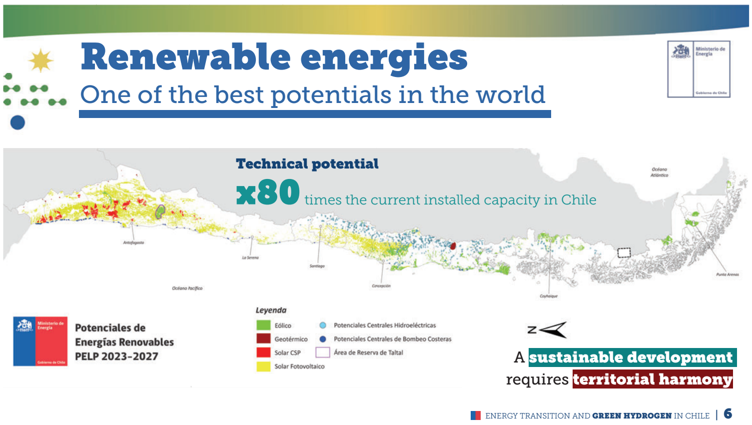
1-2. Energy Transition and Green Hydrogen in Chile

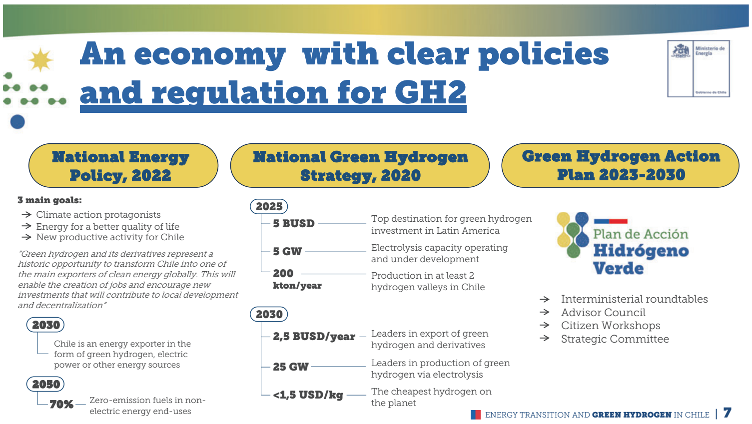




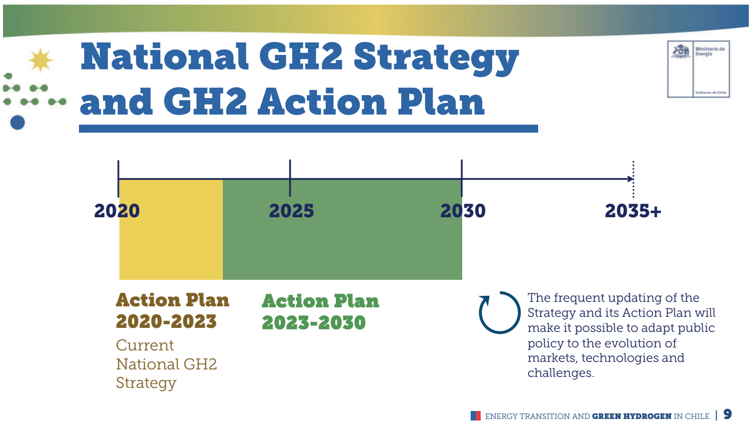


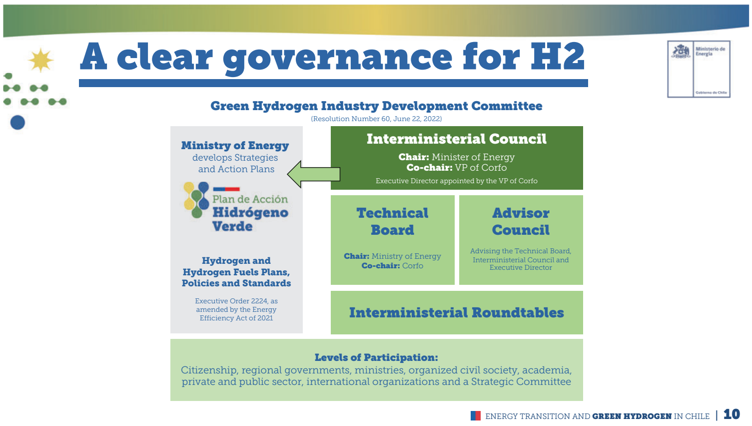




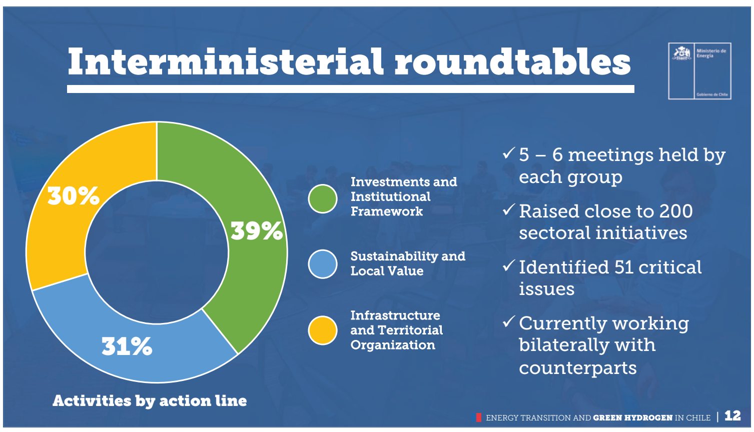

An economy with clear policies and regulation for GH2
Ministerio de Energía
Gobierno de Chile
National Energy Policy, 2022
National Green Hydrogen Strategy, 2020
Green Hydrogen Action Plan 2023-2030
3 main goals:
→ Climate action protagonists
→ Energy for a better quality of life
→ New productive activity for Chile
"Green hydrogen and its derivatives represent a historic opportunity to transform Chile into one of the main exporters of clean energy globally. This will enable the creation of jobs and encourage new investments that will contribute to local development and decentralization"
2030
Chile is an energy exporter in the form of green hydrogen, electric power or other energy sources
2050
70% — Zero-emission fuels in non-electric energy end-uses
2025
5 BUSD — Top destination for green hydrogen investment in Latin America
5 GW — Electrolysis capacity operating and under development
200 kton/year — Production in at least 2 hydrogen valleys in Chile
2030
2,5 BUSD/year — Leaders in export of green hydrogen and derivatives
25 GW — Leaders in production of green hydrogen via electrolysis
<1,5 USD/kg — The cheapest hydrogen on the planet
Plan de Acción Hidrógeno Verde
→ Interministerial roundtables
→ Advisor Council
→ Citizen Workshops
→ Strategic Committee
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 7

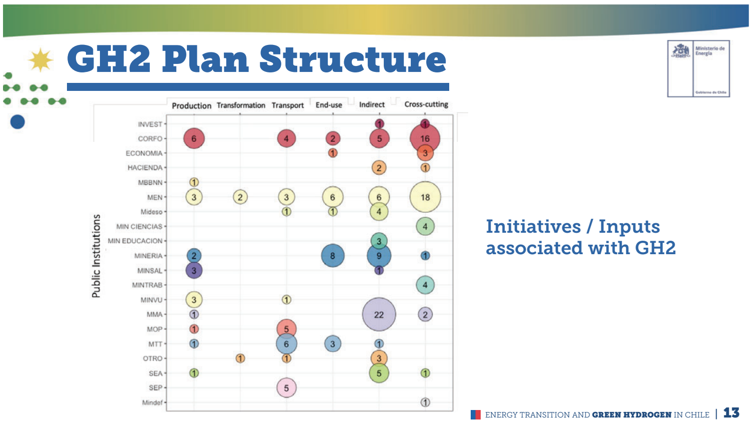

National GH2 Strategy
Ministerio de Energía
Gobierno de Chile
Mission-oriented policy
Efficient route to a zero-emission economy
Our pillars
These pillars, born from the participation of multiple public and private actors, establish a coherent framework under which efforts to develop green hydrogen in Chile will be deployed.
Balanced use of resources and territory
Green Hydrogen as an engine for local development
New clean export economy
International openness
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 8


National GH2 Strategy and GH2 Action Plan
Ministerio de Energía
Gobierno de Chile
2020
2025
2030
2035+
Action Plan 2020-2023
Current National GH2 Strategy
Action Plan 2023-2030
The frequent updating of the Strategy and its Action Plan will make it possible to adapt public policy to the evolution of markets, technologies and challenges.
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 9

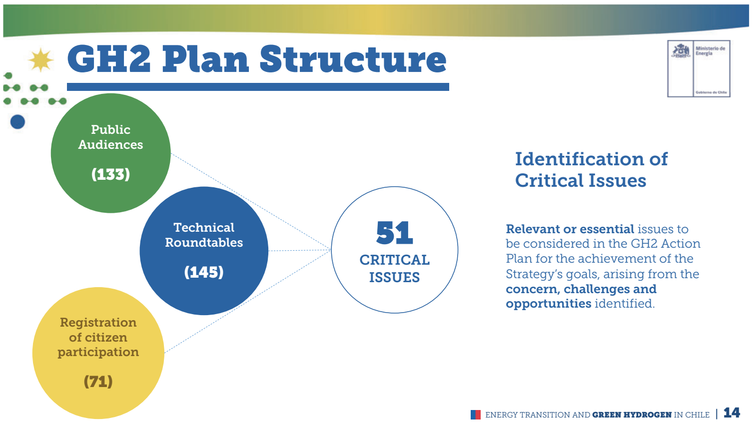

A clear governance for H2
Ministerio de Energía
Gobierno de Chile
Green Hydrogen Industry Development Committee
(Resolution Number 60, June 22, 2022)
Ministry of Energy develops Strategies and Action Plans
Plan de Acción Hidrógeno Verde
Hydrogen and Hydrogen Fuels Plans, Policies and Standards
Executive Order 2224, as amended by the Energy Efficiency Act of 2021
Interministerial Council
Chair: Minister of Energy
Co-chair: VP of Corfo
Executive Director appointed by the VP of Corfo
Technical Board
Chair: Ministry of Energy
Co-chair: Corfo
Advisor Council
Advising the Technical Board, Interministerial Council and Executive Director
Interministerial Roundtables
Levels of Participation:
Citizenship, regional governments, ministries, organized civil society, academia, private and public sector, international organizations and a Strategic Committee
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 10


GH2 Action Plan 2023-2030
Ministerio de Energía
Gobierno de Chile
Advisor Council
GH2 Interministerial Committee
Strategic Committee
Results of the discussion
Inputs and topics for discussion
Inputs and topics for discussion
Strategic guidelines
Interministerial Roundtables
GH2 Interministerial Committee
Elaboration of the Plan
Plan de Acción Hidrógeno Verde
Results
Inputs and topics for discussion
Public Consultation
Citizen Workshops
Participatory process
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 11

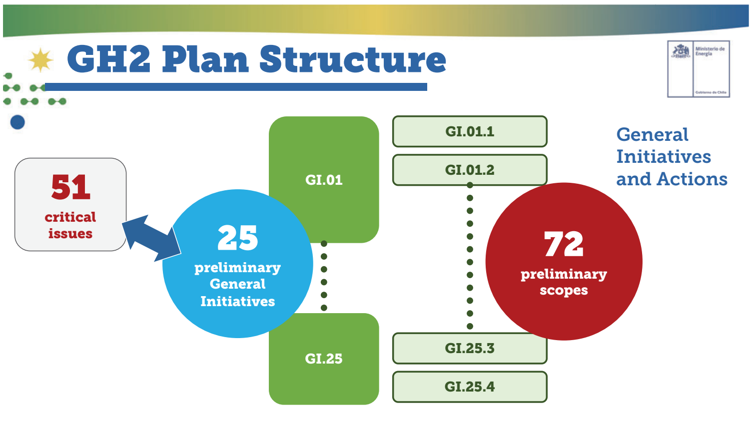

Interministerial roundtables
30%
39%
31%
Activities by action line
Investments and Institutional Framework
Sustainability and Local Value
Infrastructure and Territorial Organization
✓ 5 – 6 meetings held by each group
✓ Raised close to 200 sectoral initiatives
✓ Identified 51 critical issues
✓ Currently working bilaterally with counterparts
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 12



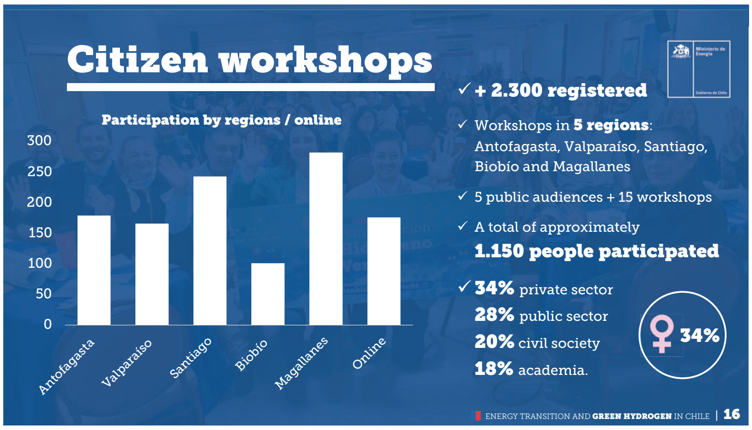
GH2 Plan Structure
Production
Transformation
Transport
End-use
Indirect
Cross-cutting
Public Institutions
INVEST
CORFO
ECONOMIA
HACIENDA
MBBNN
MEN
Mideso
MIN CIENCIAS
MIN EDUCACION
MINERIA
MINSAL
MINTRAB
MINVU
MMA
MOP
MTT
OTRO
SEA
SEP
Mindef
Initiatives / Inputs associated with GH2
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 13



GH2 Plan Structure
Public Audiences (133)
Technical Roundtables (145)
Registration of citizen participation (71)
51 CRITICAL ISSUES
Identification of Critical Issues
Relevant or essential issues to be considered in the GH2 Action Plan for the achievement of the Strategy's goals, arising from the concern, challenges and opportunities identified.
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 14



GH2 Plan Structure
51 critical issues
25 preliminary General Initiatives
GI.01
GI.25
GI.01.1
GI.01.2
GI.25.3
GI.25.4
72 preliminary scopes
General Initiatives and Actions



Citizen workshops
Participation by regions / online
300
250
200
150
100
50
0
Antofagasta
Valparaíso
Santiago
Biobío
Magallanes
Online
✓ + 2.300 registered
✓ Workshops in 5 regions: Antofagasta, Valparaíso, Santiago, Biobío and Magallanes
✓ 5 public audiences + 15 workshops
✓ A total of approximately 1.150 people participated
✓ 34% private sector
28% public sector
20% civil society
18% academia.
34%
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 16

A GH2 Action Plan with a State Vision
STRATEGIC COMMITTEE
Strategic Committee aims to provide strategic and policy orientations, with broad consensus among participants, to constitute a high-level framework for the Green Hydrogen Action Plan and build a political discourse that communicates, domestically and globally, the hydrogen guidelines.
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 17

Strategic Committee progress
Sustainability Dimension
✓ Industry is developing in a unique window of opportunity
✓ Pillar for domestic economic growth
✓ High international environmental standards
✓ Contribution to local development and quality of life improvement for local communities
International Dimension
✓ International openness
✓ Diversification of players
✓ Compliance with international trade rules
✓ Promotion of innovation and technology transfer
✓ Green corridors
✓ Certification with sustainability standards
3 other dimensions are being worked on
1. Economic
2. Human capital
3. Communities
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 18

The option Chile is taking

Our economy is signed several instruments that seek promoting cooperation for the development of the hydrogen industry.

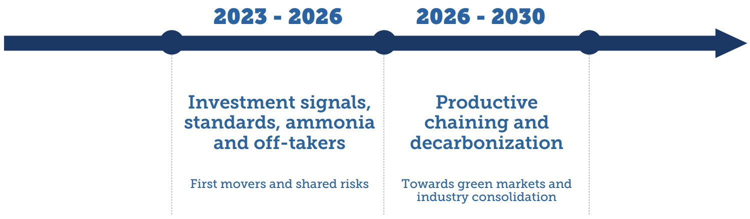
To position ourselves internationally, we require investment in critical internal infrastructure, such as transmission lines, ports, roads, pipelines, connectivity, etc.

Leverage international collaboration for the economy's interests: attract investments, promote innovation and technology transfer, training, etc.

Chile must maintain its openness and investment diversification policy to avoid the vulnerability of concentration of actors.

- **33** FTA-network of trade agreements
- **9** Joint statements and cooperation agreement
- **7** MoU
- **2** MoC

Time windows for action this decade



Time windows for action this decade

Energy cost
Institutional strengthening
Permitting
Tax and financial incentives
Public environmental baselines
Enabling infrastructure (desalination plants, ports, eletrolyzers, CCS and DAC, electrical lines)
Regulations path (i.e. ammonia as fuel)
Standards
International positioning
Promotion to local demand
Voluntary agreements
Demand aggregation
Governance

Territorial planning
Updating norms
Law requirements
Certification
Electrical conversion and use in isolated areas
Public information and participation
Human capital
Green markets
Performance indicators (environmental, life quality, etc)

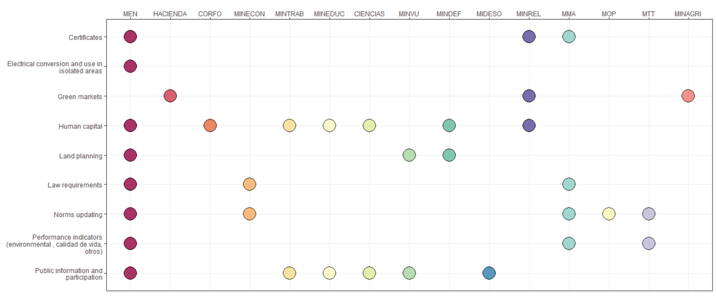
Key actions

1st time window

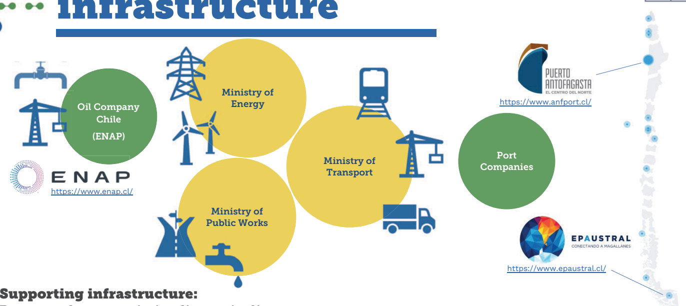
Investment signals, standards, ammonia and off-takers

2nd time window

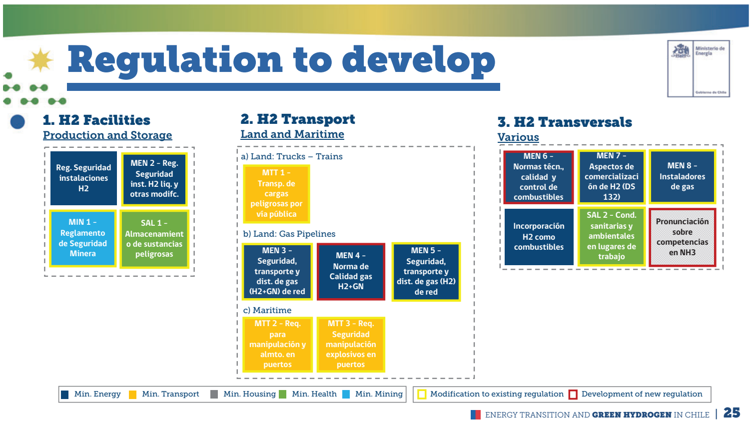
Productive chaining and decarbonization

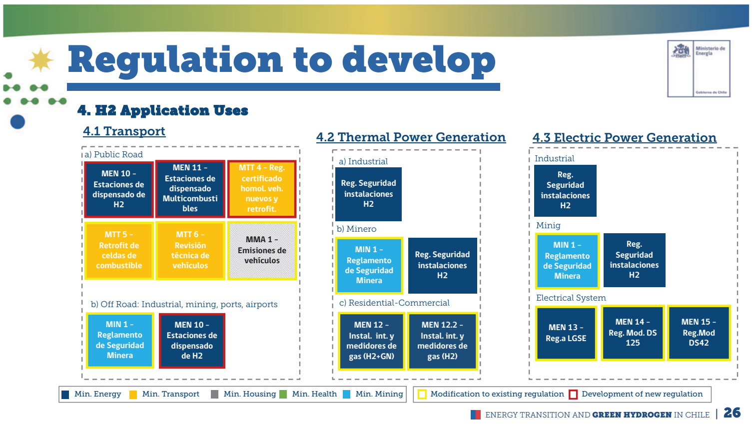


Enabler and shared infrastructure

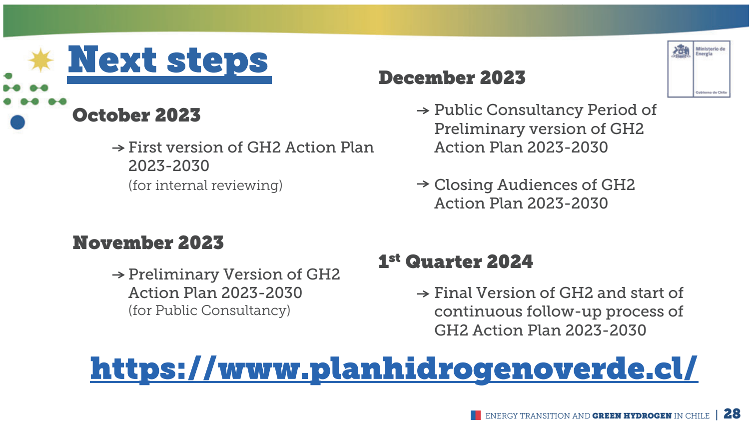


Supporting infrastructure:
Ports, roads, transmission lines, pipelines, etc.


Regulation to develop
1. H2 Facilities
Production and Storage
Reg. Seguridad instalaciones H2
MEN 2 – Reg. Seguridad inst. H2 liq. y otras modifc.
MIN 1 - Reglamento de Seguridad Minera
SAL 1 - Almacenamiento de sustancias peligrosas
2. H2 Transport
Land and Maritime
a) Land: Trucks – Trains
MTT 1 - Transp. de cargas peligrosas por vía pública
b) Land: Gas Pipelines
MEN 3 - Seguridad, transporte y dist. de gas (H2+GN) de red
MEN 4 - Norma de Calidad gas H2+GN
MEN 5 - Seguridad, transporte y dist. de gas (H2) de red
c) Maritime
MTT 2 - Req. para manipulación y almto. en puertos
MTT 3 - Req. Seguridad manipulación explosivos en puertos
3. H2 Transversals
Various
MEN 6 - Normas técn., calidad y control de combustibles
MEN 7 - Aspectos de comercialización de H2 (DS 132)
MEN 8 - Instaladores de gas
Incorporación H2 como combustibles
SAL 2 - Cond. sanitarias y ambientales en lugares de trabajo
Pronunciación sobre competencias en NH3
Min. Energy
Min. Transport
Min. Housing
Min. Health
Min. Mining
Modification to existing regulation
Development of new regulation
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 25

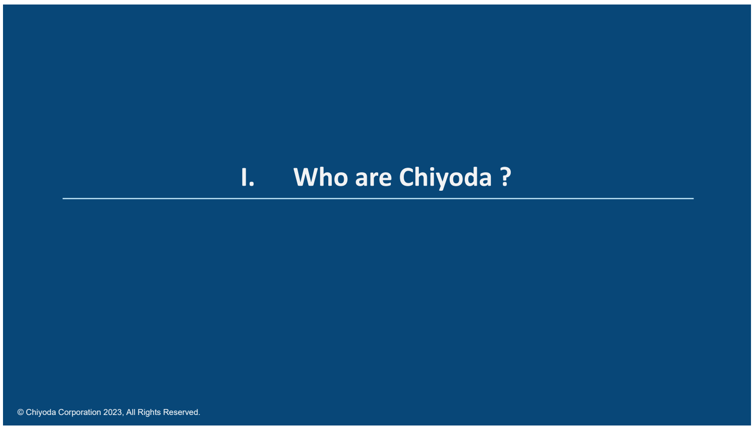

Regulation to develop
4. H2 Application Uses
4.1 Transport
a) Public Road
MEN 10 - Estaciones de dispensado de H2
MEN 11 - Estaciones de dispensado Multicombustibles
MTT 4 - Reg. certificado homol. veh. nuevos y retrofit.
MTT 5 - Retrofit de celdas de combustible
MTT 6 - Revisión técnica de vehículos
MMA 1 - Emisiones de vehículos
b) Off Road: Industrial, mining, ports, airports
MIN 1 - Reglamento de Seguridad Minera
MEN 10 - Estaciones de dispensado de H2
4.2 Thermal Power Generation
a) Industrial
Reg. Seguridad instalaciones H2
b) Minero
MIN 1 - Reglamento de Seguridad Minera
Reg. Seguridad instalaciones H2
c) Residential-Commercial
MEN 12 - Instal. int. y medidores de gas (H2+GN)
MEN 12.2 - Instal. int. y medidores de gas (H2)
4.3 Electric Power Generation
Industrial
Reg. Seguridad instalaciones H2
Minig
MIN 1 - Reglamento de Seguridad Minera
Reg. Seguridad instalaciones H2
Electrical System
MEN 13 - Reg.a LGSE
MEN 14 - Reg. Mod. DS 125
MEN 15 - Reg.Mod DS42
Min. Energy
Min. Transport
Min. Housing
Min. Health
Min. Mining
Modification to existing regulation
Development of new regulation
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 26

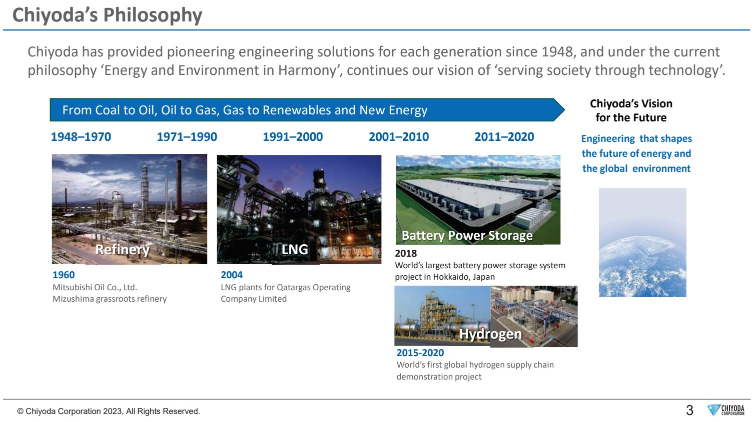

Projects under development
1 AES "Green Ammonia"
2 HyEx
3 Paracelsus
4 H2 Solar Project
5 Pauna Greener Future
6 Hydra
7 ACH – MRP Project
8 AMER project
9 Quintero Bay H2 Hub
10 Hypro Aconcagua
11 H2 for Forklifts in retail
12 Las Tortolas project
13 Green Steel project
14 HDF Project
15 HNH Energy
16 H2 Magallanes
17 Faro del Sur
18 Llaquedona
19 Haru Oni
20 Magallanic Winds
21 Gente Grande
H2 Valley
Pre-fid
Development
Operation
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 27

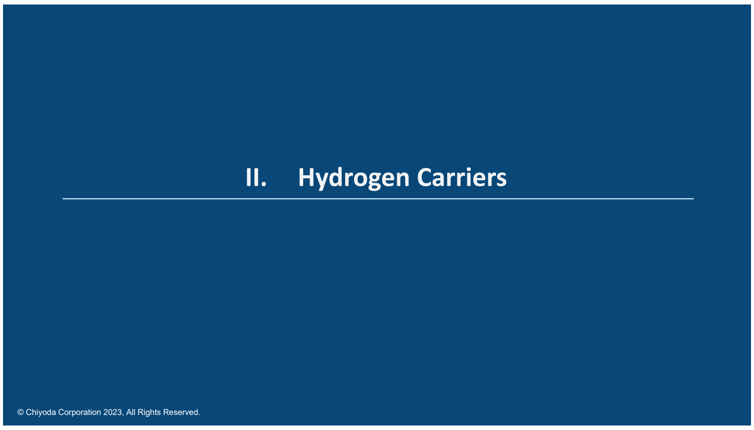

Next steps
October 2023
→ First version of GH2 Action Plan 2023-2030
(for internal reviewing)
November 2023
→ Preliminary Version of GH2 Action Plan 2023-2030
(for Public Consultancy)
December 2023
→ Public Consultancy Period of Preliminary version of GH2 Action Plan 2023-2030
→ Closing Audiences of GH2 Action Plan 2023-2030
1st Quarter 2024
→ Final Version of GH2 and start of continuous follow-up process of GH2 Action Plan 2023-2030
https://www.planhidrogenoverde.cl/
ENERGY TRANSITION AND GREEN HYDROGEN IN CHILE | 28

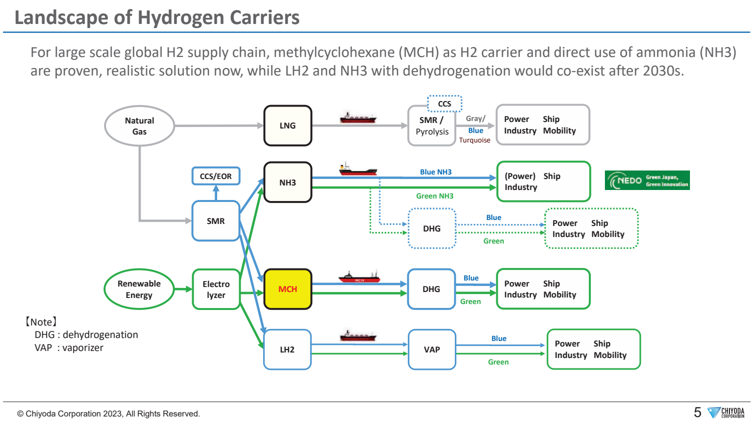

Plan de Acción Hidrógeno Verde
Ministerio de Energía
Gobierno de Chile

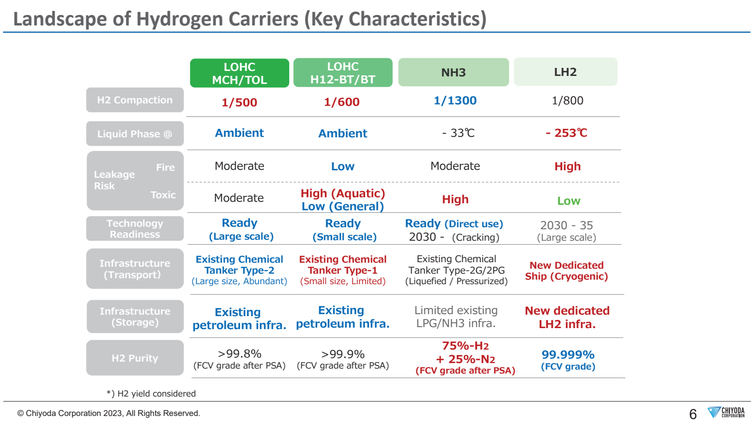
1-3. Development of Global Supply Chain by LOHC-MCH method









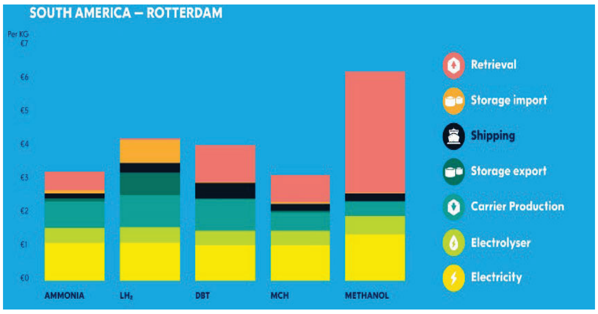

Landscape of Hydrogen Carriers (Key Characteristics)

		LOHC MCH/TOL	LOHC H12-BT/BT	NH3	LH2
H2 Compaction		1/500	1/600	1/1300	1/800
Liquid Phase @		Ambient	Ambient	- 33℃	- 253℃
Leakage Risk	Fire	Moderate	Low	Moderate	High
	Toxic	Moderate	High (Aquatic) Low (General)	High	Low
Technology Readiness		Ready (Large scale)	Ready (Small scale)	Ready (Direct use) 2030 - (Cracking)	2030 - 35 (Large scale)
Infrastructure (Transport)		Existing Chemical Tanker Type-2 (Large size, Abundant)	Existing Chemical Tanker Type-1 (Small size, Limited)	Existing Chemical Tanker Type-2G/2PG (Liquefied / Pressurized)	New Dedicated Ship (Cryogenic)
Infrastructure (Storage)		Existing petroleum infra.	Existing petroleum infra.	Limited existing LPG/NH3 infra.	New dedicated LH2 infra.
H2 Purity		>99.8% (FCV grade after PSA)	>99.9% (FCV grade after PSA)	75%-H2 + 25%-N2 (FCV grade after PSA)	99.999% (FCV grade)

*) H2 yield considered

 6

Landscape of Hydrogen Carriers (Economic Comparison)



(Source) Keynote speech Allard Castelein, CEO Port of Rotterdam Authority, at the 2nd World Hydrogen Summit [2021]

Landscape of Hydrogen Carriers (Safety Assessment)

	NFPA Diamond	NFPA (Health)	NFPA (Flammability)	DOT (Hazard Label) IMDG Class	GESAMP (Aquatic Toxicity/ Biodegradability)	IMO Safety (Ship)
TOL	3 / 2 / 0	2 Can cause temporary incapacitation or residual injury	3 Can be ignited at ambient conditions	DOT: Flammable Liquid IMDG: Class 3 Flammable Liquids	Acute Toxicity: 3 (Moderately toxic) Chronic Toxicity: 0 (Negligible) Biodegradability: Readily	IMO Ship Type-3 (least danger) Ambient liquid No boil-off
MCH	3 / 1 / 0	1 Can cause significant irritation	3 Can be ignited at ambient conditions	DOT: Flammable Liquid IMDG: Class 3 Flammable Liquids	Acute Toxicity: 3 (Moderately toxic) Chronic Toxicity: 1 (Low) Biodegradability: Not readily	IMO Ship Type-2 (less danger) Ambient liquid No boil-off
LH2	4 / 3 / 0	3 Can cause serious or permanent injury	4 Burns readily. Rapidly or completely vaporizes at ambient pressure & temperature	DOT: Flammable Gas IMDG: Class 2 Refrig. Liquified Gas	No aquatic impact	IMO Ship Type-2G (less danger) -253° C High boil-off
NH3	1 / 3 / 0	3 Can cause serious or permanent injury	1 Must be preheated before ignition can occur	DOT: Non-Flammable Gas Inhalation Hazard Poison Gas Corrosive IMDG: Class 2 Refrig. Liq. Gas, Toxic Gas	Acute Toxicity: 3 (Moderately toxic) Chronic Toxicity: 2 (Moderate) Biodegradability: Readily	IMO Ship Type-1G (more danger) -33° C Moderate boil-off

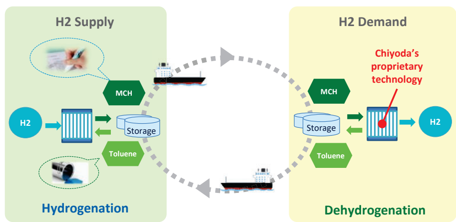
DOT : US Department of Transport, IMDG: International Maritime Dangerous Goods
GESAMP: Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

III. What is the SPERA Hydrogen^{TM} Technology

MCH Technology (SPERA Hydrogen^{TM}) at a Glance

Chiyoda's SPERA Hydrogen technology uses MCH as the hydrogen carrier in a LOHC (*) system, enabling the safe, efficient and commercially viable storage and transportation of hydrogen on a global scale.

LOHC：Liquid Organic Hydrogen Carrier



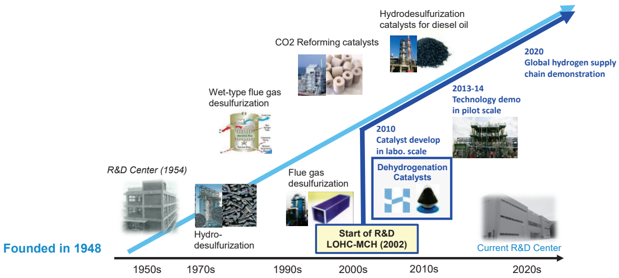
*MCH: Methylcyclohexane LOHC: Liquid Organic Hydrogen Carrier

Key Features

1. **Easy to Handle**: SPERA Hydrogen, a stable liquid at ambient temperature and pressure, is as easy to handle as petroleum, and suitable for long term storage and long distance transportation.
2. **Existing Infrastructure:** Possible to repurpose, utilize existing petroleum transportation and storage facility (tanks, tanker, pipeline, tank lorry, etc.), standard and regulation, to minimize investment for H2 infrastructure.
3. **Safe with Lower risk:** Safe transportation and storage that is equivalent level to petroleum products, that has already been managed in the society for long term.
4. **Circular System:** H2 is cycled from/to water, and Toluene as H2 carrier (LOHC) are recycled, and heat can be effectively cycled with value added, to develop efficient /sustainable H2 system.

History of Technology Development

Chiyoda commenced R&D of the MCH system in 2002 and developed its proprietary dehydrogenation catalyst on a laboratory scale in 2010 – a significant step forward towards a hydrogen economy and a low carbon society.



1st Global Hydrogen Supply Chain Demonstration

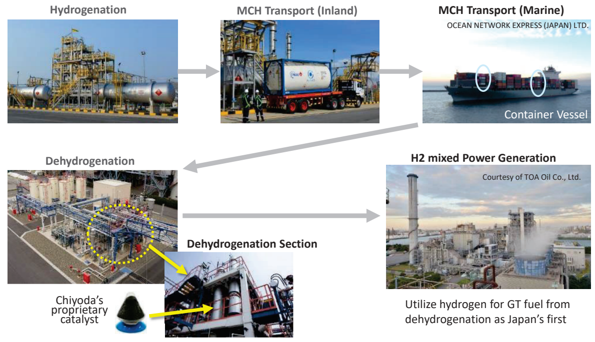
In December 2020, AHEAD successfully completed the worlds first 'Global Hydrogen Supply Chain Demonstration Project', an important milestone for the construction of an international hydrogen supply chain.

Description	
Scale	210 tons/year at facility scale (Maximum)
Duration	2020
Hydrogen Supply	Brunei Darussalam (Hydrogen production)
Hydrogen Demand	Kawasaki City, Japan (Fuel for gas turbine power plant)
Transportation	ISO tank containers (Container ship/truck)
Business Scheme	Established by AHEAD Funded project by NEDO**

* Advanced Hydrogen Energy Chain Association for Technology Development (Chiyoda, Mitsubishi Corporation, Mitsui & Co., Nippon Yusen Kabushiki Kaisha)
** New Energy and Industrial Technology Development Organization : National research and development agency that creates innovation by promoting technological development necessary for realization of a sustainable society

(Reference) https://www.chiyodacorp.com/media/210202_e.pdf

1st Global Hydrogen Supply Chain Demonstration (Photos)



2nd Global Hydrogen Supply Chain Demonstration (Tanker Transportation)

AHEAD has achieved a world's first milestone of transporting hydrogen, in the form of MCH, and this achievement demonstrates the viable long-term storage and transportation of hydrogen in the form of MCH by tanker on a global scale.

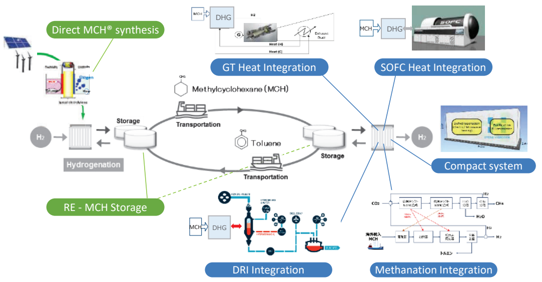
- AHEAD manufactured MCH in Brunei Darussalam, for transportation to an ENEOS petroleum refinery in Japan.
- For supplying MCH to the ENEOS refinery, this ENEOS's demonstration project supported by CROS*1 has been conducting.
- The first chemical tanker arrived at the refineries receiving facility on 4 February 2022, and the MCH was fed into the refinery.

*1 CROS : Consortium for Resilient Oil Supply System

(Reference) https://www.chiyodacorp.com/media/20220208_E_R1.pdf

Further MCH Technology Development

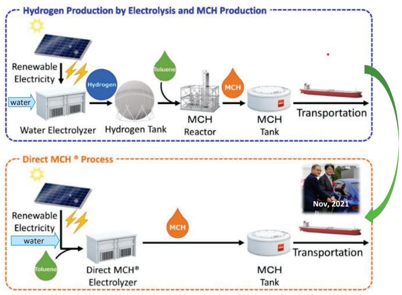
Chiyoda is further developing technologies and system integration from upstream to downstream to optimize and reduce total H2 value chain cost.



Further MCH Technology Development : Direct MCH® Synthesis

Direct MCH® Synthesis technology has been developed at laboratory scale in 2019, successfully fill the green hydrogen by Direct MCH to FCEV in 2021, and is under scaling up stage toward commercialization around 2030.

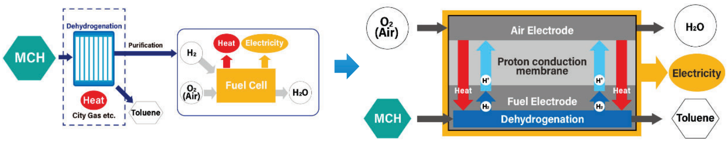
- **Existing Technology (Electrolysis + MCH)**
  - Hydrogen is produced by water electrolyzer, and hydrogen is converted to MCH by hydrogenation process (MCH Reactor).
  - Hydrogen gas tanks and MCH reactor are required for this technology.
- **New Technology (Direct MCH® synthesis)**
  - MCH is directly produced from renewable electricity, water and toluene, not through hydrogen production.
  - Hydrogen gas tanks and MCH reactor are NOT required for this technology.



Further MCH Technology Development : MCH Direct Fuel Cell

" New Fuel Cell System (MCH Direct Fuel Cell) " that use MCH as a fuel is under R&D phase.

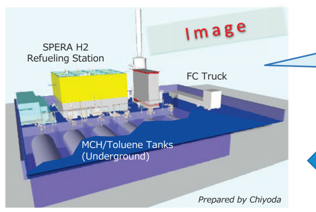
- Develop new medium-temperature fuel cell that is operated under temperature range for dehydrogenation (below 400 deg-C)
- Realize high efficiency energy conversion system with excellent heat balance and cost balance.



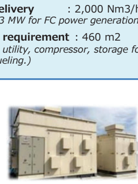
Further MCH Technology Development : SPERA Hydrogen Refueling Station

Smaller size dehydrogenation package for H2 distributed demand, such as refueling station, has been demonstrated in 2018, and is under optimization stage to realize downsizing and automation.

	H2 Supply (Nm³/h)	H2 volume (kg/truck)	Number of Trucks (truck/hour)	Number of dispenser (set)
For FC truck	2,000	100	2	1



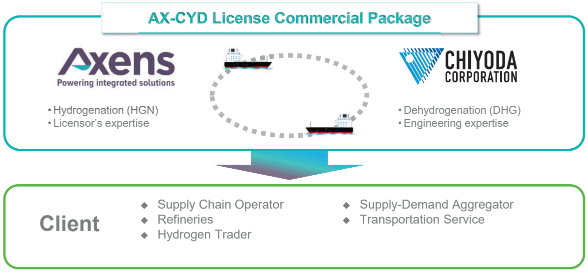
- **H2 delivery** : 2,000 Nm3/h (= 3.3 MW for FC power generation)
- **Land requirement** : 460 m2 (incl. utility, compressor, storage for refueling.)



NEDO Pilot Project (2016 – 18)

MCH Hydrogen Value Chain Collaboration

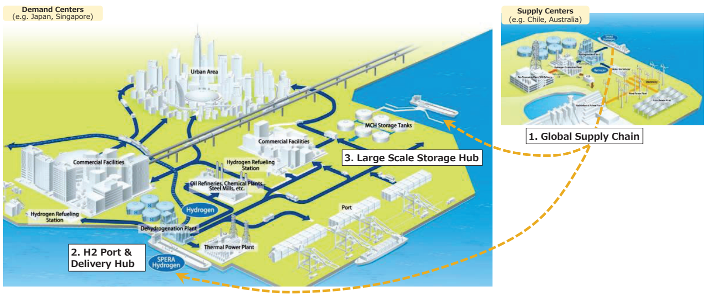
Chiyoda and Axens has concluded Joint Commercial Cooperation Agreement on Nov. 2022, that bring strong synergies allowing fast track approach for MCH supply chain implementation with single point of contract.



IV. Ongoing SPERA Hydrogen^{TM} Project

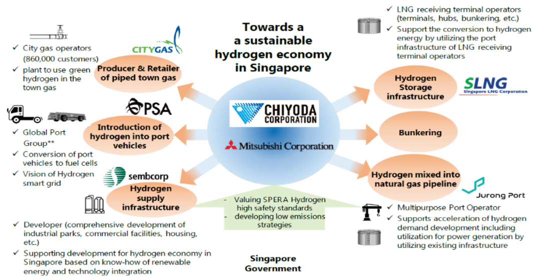
SPERA Hydrogen Use Case

There are 3 major use cases (Global Supply Chain / H2 Port & Delivery Hub / Large Scale Storage) by using MCH Technology, to seamlessly link between global hydrogen supply chain, storage and domestic distribution.



1. Global H2 Supply Chain Projects : Singapore Hydrogen Project

The Singapore government announced its Long-Term Low-Emissions Development Strategy (LEDS) in 2020, aiming to halve peak emissions by 2050. Chiyoda and Mitsubishi signed an MOU with 5 Singaporean companies on March 2020 to conduct feasibility studies for a H2 import value chain using SPERA Hydrogen in cooperation with the government.

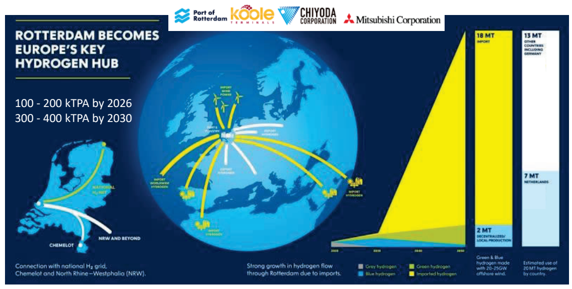


1. Global H2 Supply Chain Projects : Singapore Hydrogen Project

To achieve net zero in Singapore by 2050, Singapore and Japanese companies strongly collaborate with government support, to develop global H2 supply chain by MCH, toward the operation start in 2026.

1. Global H2 Supply Chain Projects : European Hydrogen Project (Rotterdam)

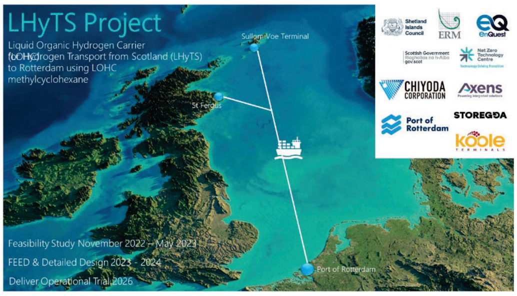
The Port of Rotterdam (POR) released its Hydrogen Master Plan in May 2020, aiming to become the H2 import hub of NW-EU by importing 20 MTPA of H2 by 2050. PoR, Koole Terminals, Mitsubishi and Chiyoda signed an MOU in July 2021 to jointly study importing H2 on an international scale using SPERA Hydrogen



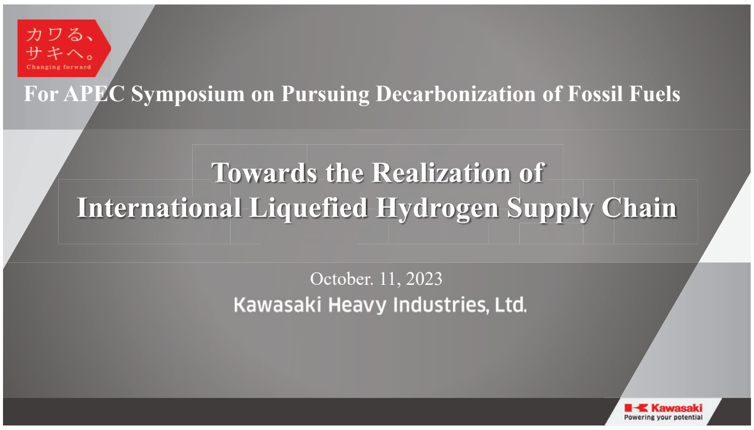
(Reference) https://www.portofrotterdam.com/sites/default/files/2021-06/hydrogen-economy-in-rotterdam-handout.pdf
https://www.chiyodacorp.com/media/20210730_E.pdf

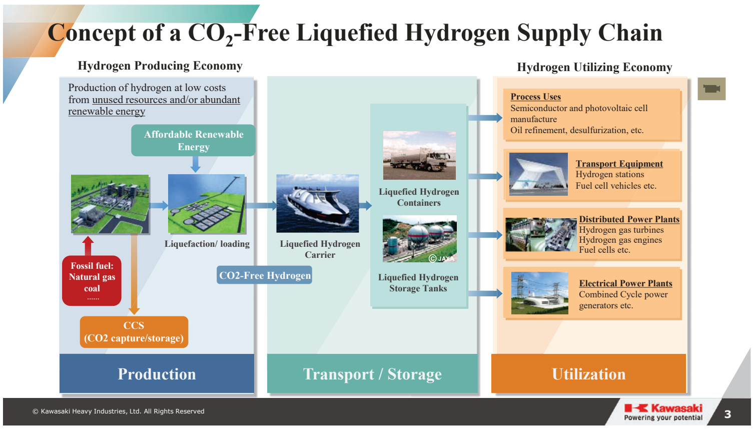
1. Global H2 Supply Chain Projects : European Hydrogen Project (LHyTS Project)

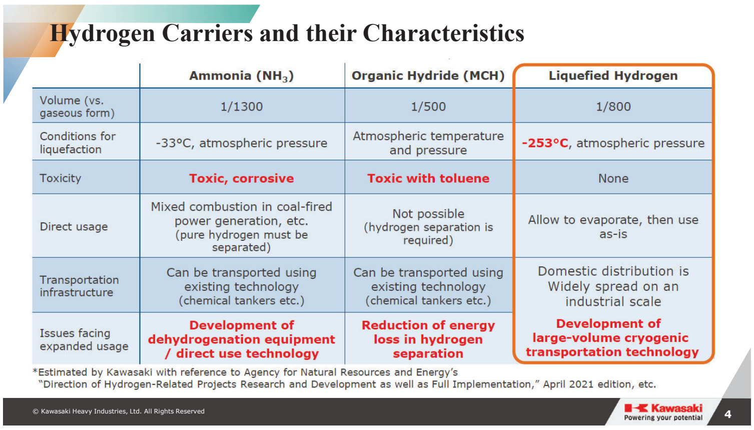
The LHyTS project (10 organizations) seeks to demonstrate that LOHC in the form of MCH can be successfully transported at scale, providing an export route to the Port of Rotterdam and other European destinations.



Thank you !

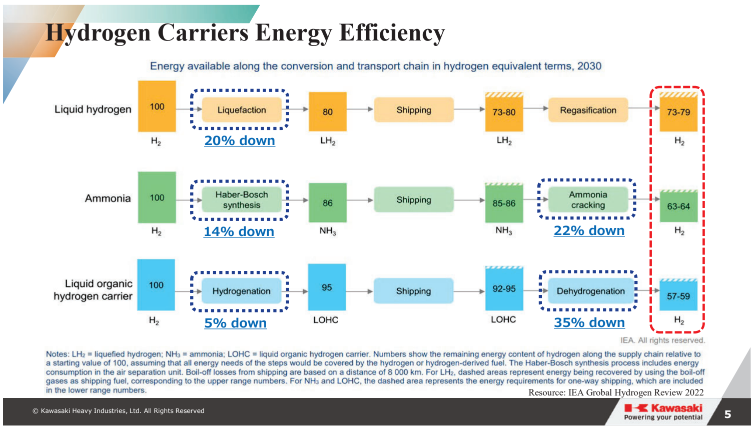


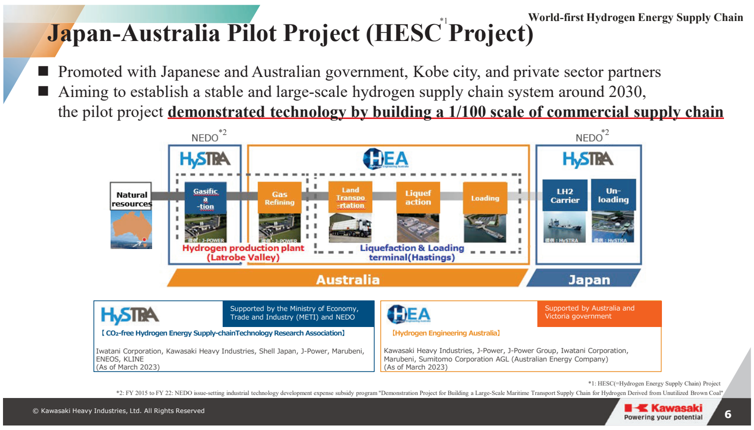


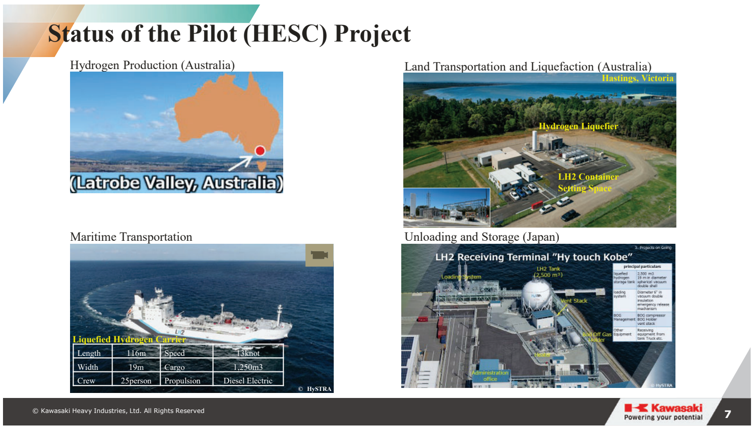


	Ammonia (NH_3)	Organic Hydride (MCH)	Liquefied Hydrogen
Volume (vs. gaseous form)	1/1300	1/500	1/800
Conditions for liquefaction	-33°C, atmospheric pressure	Atmospheric temperature and pressure	-253°C, atmospheric pressure
Toxicity	Toxic, corrosive	Toxic with toluene	None
Direct usage	Mixed combustion in coal-fired power generation, etc. (pure hydrogen must be separated)	Not possible (hydrogen separation is required)	Allow to evaporate, then use as-is
Transportation infrastructure	Can be transported using existing technology (chemical tankers etc.)	Can be transported using existing technology (chemical tankers etc.)	Domestic distribution is Widely spread on an industrial scale
Issues facing expanded usage	Development of dehydrogenation equipment / direct use technology	Reduction of energy loss in hydrogen separation	Development of large-volume cryogenic transportation technology

*Estimated by Kawasaki with reference to Agency for Natural Resources and Energy's "Direction of Hydrogen-Related Projects Research and Development as well as Full Implementation," April 2021 edition, etc.






Status of the Pilot (HESC) Project
Hydrogen Production (Australia)
(Latrobe Valley, Australia)
Land Transportation and Liquefaction (Australia)
Hastings, Victoria
Hydrogen Liquefier
LH2 Container Setting Space
Maritime Transportation
Liquefied Hydrogen Carrier
Length 116m Speed 13knot
Width 19m Cargo 1,250m3
Crew 25person Propulsion Diesel Electric
Unloading and Storage (Japan)
LH2 Receiving Terminal "Hy touch Kobe"
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World's First International Shipping of Liquefied Hydrogen
World's first demonstration of hydrogen transport and cargo handling by liquefied hydrogen carrier
First voyage from Japan to Australia (Dec. 24, 2021)
"Suiso Frontier" Australia arrival ceremony (Jan. 21, 2022)
Japan-Australia Pilot Project Completed (Apr. 9, 2022)
At the ceremony to complete the demonstration of the Japan-Australia hydrogen supply chain
Prime Minister Kishida attended the meeting.
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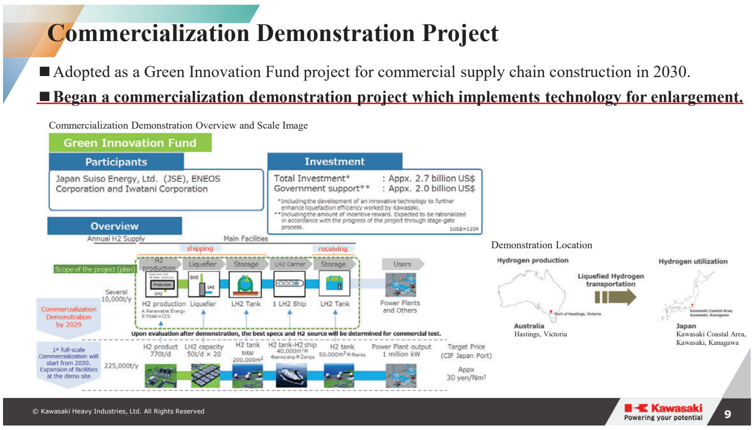
Commercialization Demonstration Project
Adopted as a Green Innovation Fund project for commercial supply chain construction in 2030.
Began a commercialization demonstration project which implements technology for enlargement.
Commercialization Demonstration Overview and Scale Image
Green Innovation Fund
Participants
Japan Suiso Energy, Ltd. (JSE), ENEOS Corporation and Iwatani Corporation
Investment
Total Investment* : Appx. 2.7 billion US$
Government support** : Appx. 2.0 billion US$
Overview
Demonstration Location
Hydrogen production
Liquefied Hydrogen transportation
Hydrogen utilization
Australia Hastings, Victoria
Japan Kawasaki Coastal Area, Kawasaki, Kanagawa
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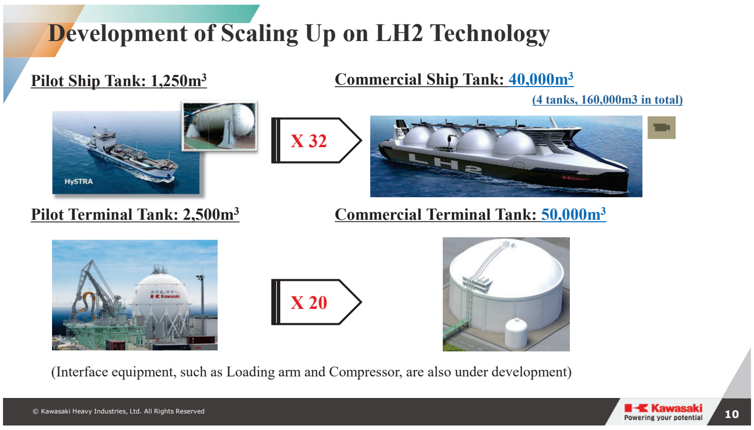
Development of Scaling Up on LH2 Technology
Pilot Ship Tank: 1,250m3
Commercial Ship Tank: 40,000m3
(4 tanks, 160,000m3 in total)
X 32
Pilot Terminal Tank: 2,500m3
Commercial Terminal Tank: 50,000m3
X 20
(Interface equipment, such as Loading arm and Compressor, are also under development)
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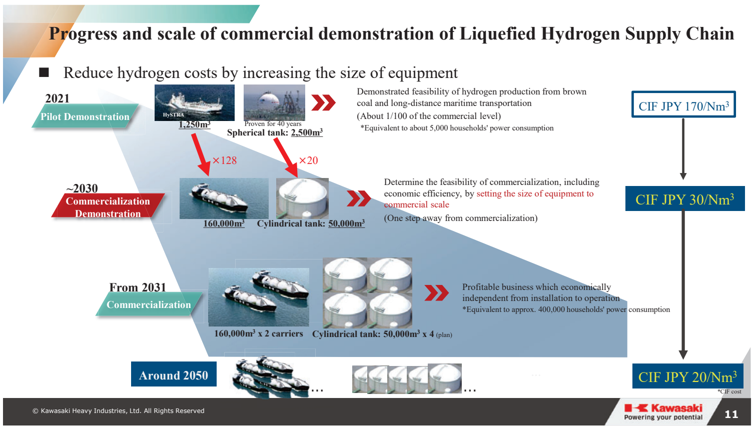
Progress and scale of commercial demonstration of Liquefied Hydrogen Supply Chain
Reduce hydrogen costs by increasing the size of equipment
2021
Pilot Demonstration
1,250m3
Spherical tank: 2,500m3
Demonstrated feasibility of hydrogen production from brown coal and long-distance maritime transportation
(About 1/100 of the commercial level)
CIF JPY 170/Nm3
×128
×20
~2030
Commercialization Demonstration
160,000m3
Cylindrical tank: 50,000m3
Determine the feasibility of commercialization, including economic efficiency, by setting the size of equipment to commercial scale
(One step away from commercialization)
CIF JPY 30/Nm3
From 2031
Commercialization
160,000m3 x 2 carriers
Cylindrical tank: 50,000m3 x 4
Profitable business which economically independent from installation to operation
Around 2050
CIF JPY 20/Nm3
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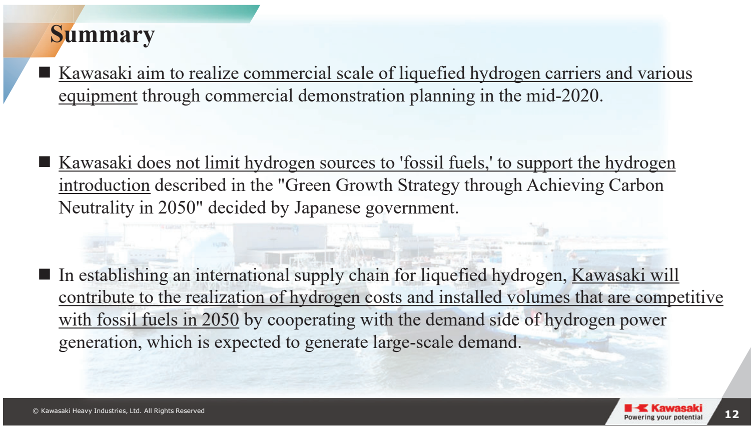
Summary
Kawasaki aim to realize commercial scale of liquefied hydrogen carriers and various equipment through commercial demonstration planning in the mid-2020.
Kawasaki does not limit hydrogen sources to 'fossil fuels,' to support the hydrogen introduction described in the "Green Growth Strategy through Achieving Carbon Neutrality in 2050" decided by Japanese government.
In establishing an international supply chain for liquefied hydrogen, Kawasaki will contribute to the realization of hydrogen costs and installed volumes that are competitive with fossil fuels in 2050 by cooperating with the demand side of hydrogen power generation, which is expected to generate large-scale demand.
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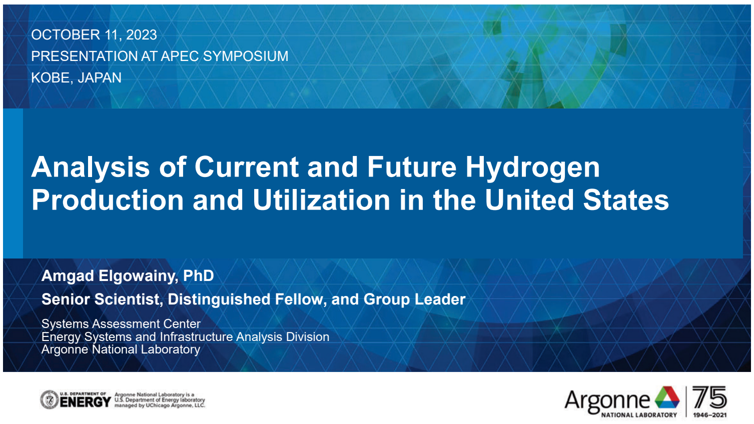
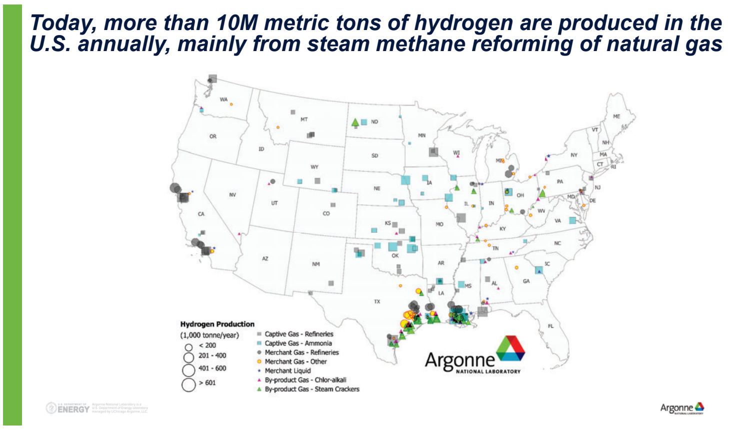
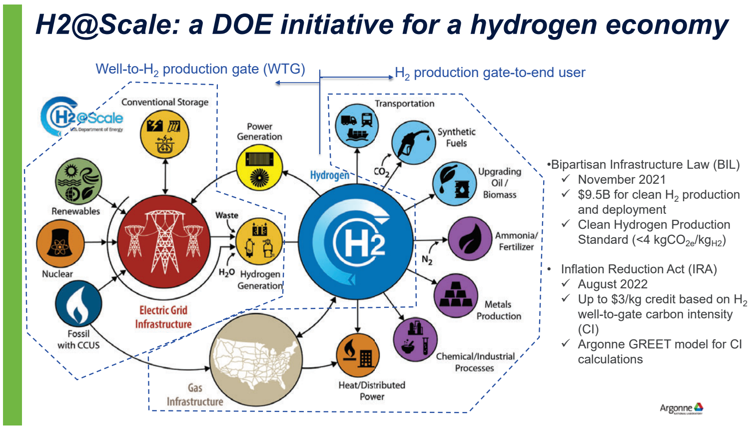
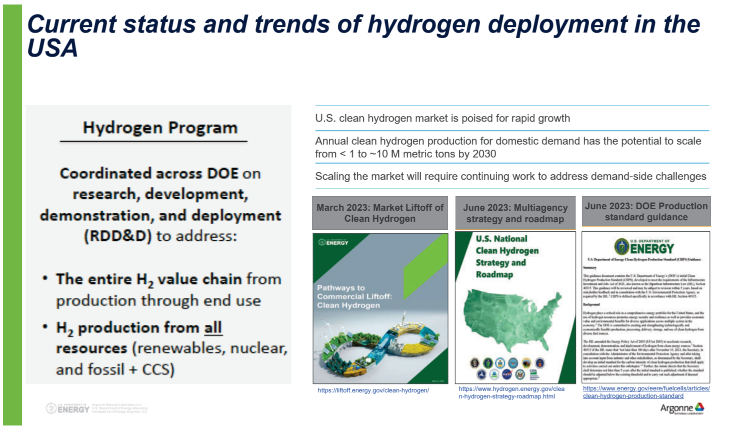
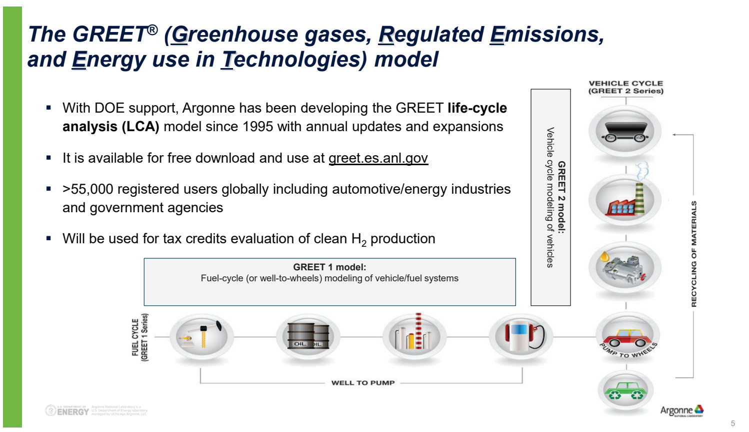
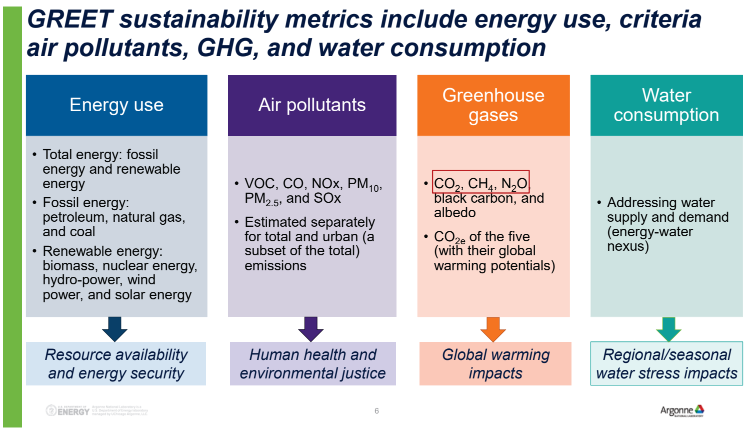

OCTOBER 11, 2023
PRESENTATION AT APEC SYMPOSIUM
KOBE, JAPAN
Analysis of Current and Future Hydrogen Production and Utilization in the United States
Amgad Elgowainy, PhD
Senior Scientist, Distinguished Fellow, and Group Leader
Systems Assessment Center
Energy Systems and Infrastructure Analysis Division
Argonne National Laboratory
ENERGY
Argonne NATIONAL LABORATORY
75
1946–2021

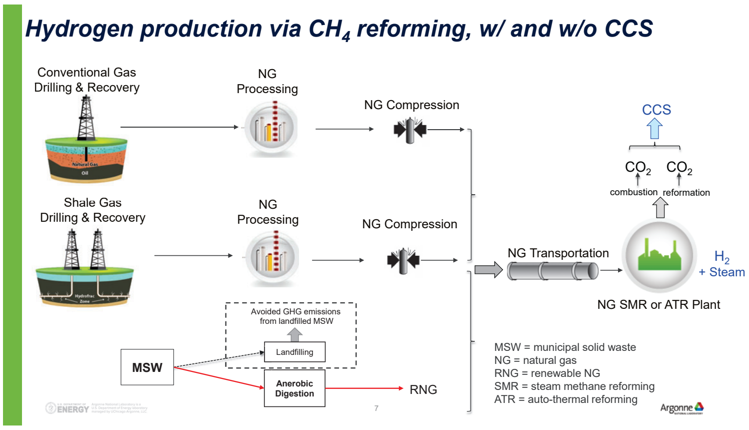

Today, more than 10M metric tons of hydrogen are produced in the U.S. annually, mainly from steam methane reforming of natural gas
Hydrogen Production
(1,000 tonne/year)
< 200
201 - 400
401 - 600
> 601
Captive Gas - Refineries
Captive Gas - Ammonia
Merchant Gas - Refineries
Merchant Gas - Other
Merchant Liquid
By-product Gas - Chlor-alkali
By-product Gas - Steam Crackers
Argonne NATIONAL LABORATORY

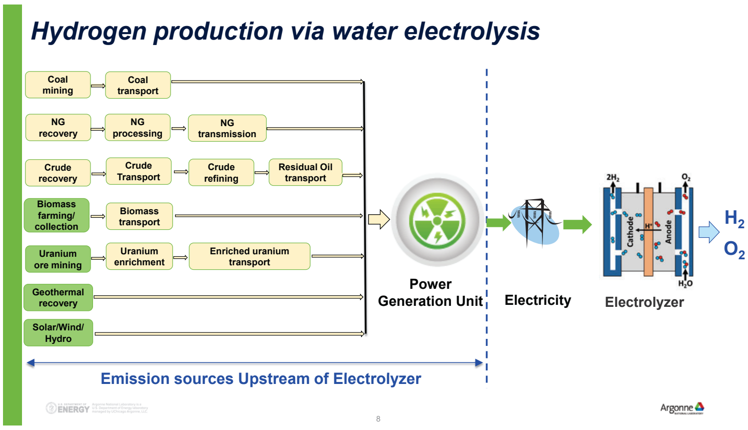

H2@Scale: a DOE initiative for a hydrogen economy
Well-to-H2 production gate (WTG)
H2 production gate-to-end user
H2@Scale
Conventional Storage
Power Generation
Transportation
Synthetic Fuels
Hydrogen
CO2
Upgrading Oil / Biomass
Renewables
Waste
Ammonia/ Fertilizer
H2
Nuclear
H2O
Hydrogen Generation
N2
Metals Production
Electric Grid Infrastructure
Fossil with CCUS
Chemical/Industrial Processes
Gas Infrastructure
Heat/Distributed Power
•Bipartisan Infrastructure Law (BIL)
✓ November 2021
✓ $9.5B for clean H2 production and deployment
✓ Clean Hydrogen Production Standard (<4 kgCO2e/kgH2)
• Inflation Reduction Act (IRA)
✓ August 2022
✓ Up to $3/kg credit based on H2 well-to-gate carbon intensity (CI)
✓ Argonne GREET model for CI calculations
Argonne

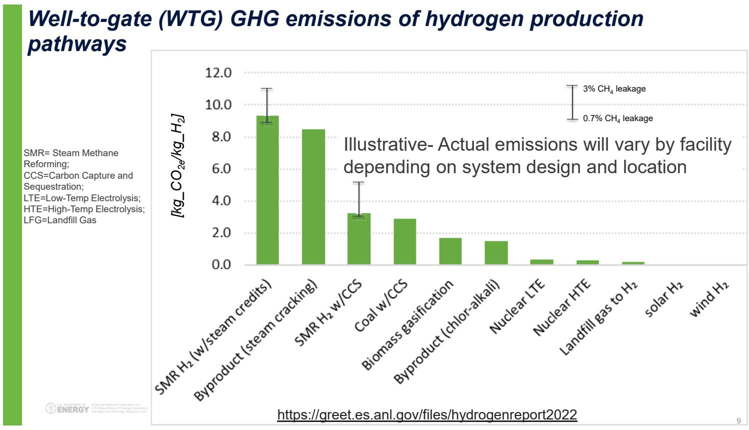

Current status and trends of hydrogen deployment in the USA
Hydrogen Program
Coordinated across DOE on research, development, demonstration, and deployment (RDD&D) to address:
• The entire H2 value chain from production through end use
• H2 production from all resources (renewables, nuclear, and fossil + CCS)
U.S. clean hydrogen market is poised for rapid growth
Annual clean hydrogen production for domestic demand has the potential to scale from < 1 to ~10 M metric tons by 2030
Scaling the market will require continuing work to address demand-side challenges
March 2023: Market Liftoff of Clean Hydrogen
June 2023: Multiagency strategy and roadmap
June 2023: DOE Production standard guidance
Pathways to Commercial Liftoff: Clean Hydrogen
U.S. National Clean Hydrogen Strategy and Roadmap
ENERGY
https://liftoff.energy.gov/clean-hydrogen/
https://www.hydrogen.energy.gov/clean-hydrogen-strategy-roadmap.html
https://www.energy.gov/eere/fuelcells/articles/clean-hydrogen-production-standard
Argonne

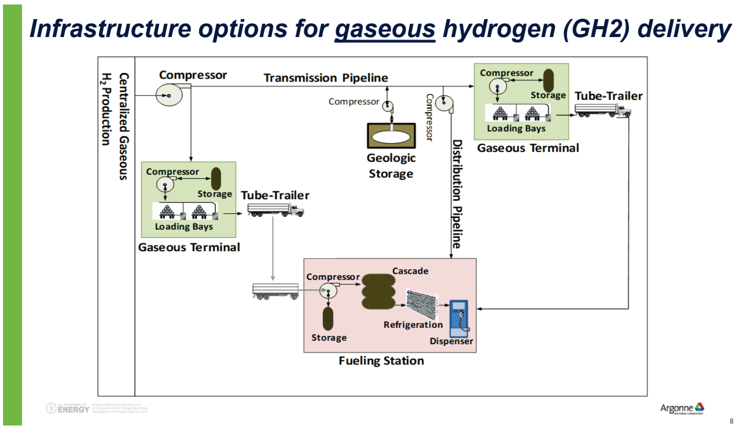

The GREET® (Greenhouse gases, Regulated Emissions, and Energy use in Technologies) model
▪ With DOE support, Argonne has been developing the GREET life-cycle analysis (LCA) model since 1995 with annual updates and expansions
▪ It is available for free download and use at greet.es.anl.gov
▪ >55,000 registered users globally including automotive/energy industries and government agencies
▪ Will be used for tax credits evaluation of clean H2 production
VEHICLE CYCLE (GREET 2 Series)
GREET 2 model: Vehicle cycle modeling of vehicles
GREET 1 model: Fuel-cycle (or well-to-wheels) modeling of vehicle/fuel systems
RECYCLING OF MATERIALS
FUEL CYCLE (GREET 1 Series)
PUMP TO WHEELS
WELL TO PUMP
Argonne

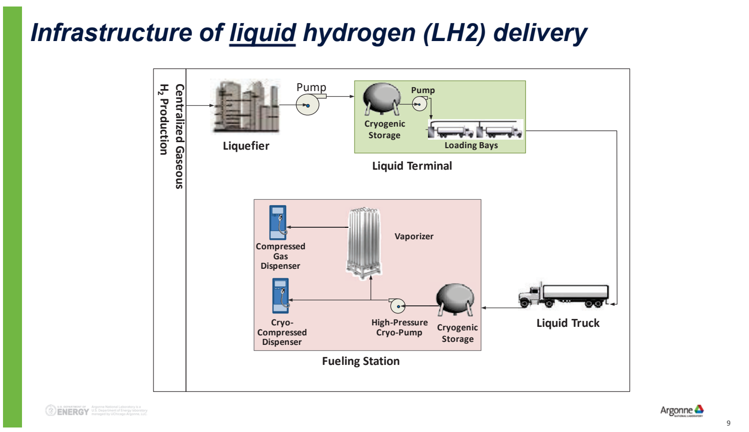

GREET sustainability metrics include energy use, criteria air pollutants, GHG, and water consumption
Energy use
• Total energy: fossil energy and renewable energy
• Fossil energy: petroleum, natural gas, and coal
• Renewable energy: biomass, nuclear energy, hydro-power, wind power, and solar energy
Resource availability and energy security
Air pollutants
• VOC, CO, NOx, PM10, PM2.5, and SOx
• Estimated separately for total and urban (a subset of the total) emissions
Human health and environmental justice
Greenhouse gases
• CO2, CH4, N2O black carbon, and albedo
• CO2e of the five (with their global warming potentials)
Global warming impacts
Water consumption
• Addressing water supply and demand (energy-water nexus)
Regional/seasonal water stress impacts
Argonne

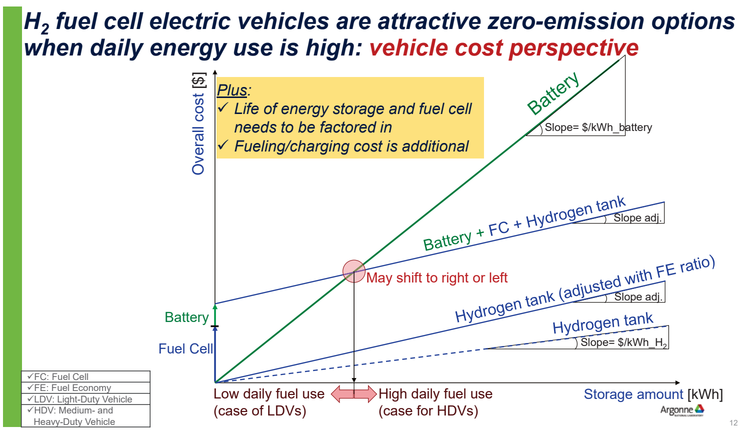

Hydrogen production via CH4 reforming, w/ and w/o CCS
Conventional Gas Drilling & Recovery
NG Processing
NG Compression
Shale Gas Drilling & Recovery
NG Processing
NG Compression
CCS
CO2 CO2
combustion reformation
NG Transportation
H2 + Steam
NG SMR or ATR Plant
Avoided GHG emissions from landfilled MSW
Landfilling
MSW
Anaerobic Digestion
RNG
MSW = municipal solid waste
NG = natural gas
RNG = renewable NG
SMR = steam methane reforming
ATR = auto-thermal reforming


Hydrogen production via water electrolysis
Coal mining
Coal transport
NG recovery
NG processing
NG transmission
Crude recovery
Crude Transport
Crude refining
Residual Oil transport
Biomass farming/ collection
Biomass transport
Uranium ore mining
Uranium enrichment
Enriched uranium transport
Geothermal recovery
Solar/Wind/ Hydro
Power Generation Unit
Electricity
Electrolyzer
H2
O2
Emission sources Upstream of Electrolyzer


Well-to-gate (WTG) GHG emissions of hydrogen production pathways
SMR= Steam Methane Reforming;
CCS=Carbon Capture and Sequestration;
LTE=Low-Temp Electrolysis;
HTE=High-Temp Electrolysis;
LFG=Landfill Gas
[kg_CO2e/kg_H2]
12.0
10.0
8.0
6.0
4.0
2.0
0.0
3% CH4 leakage
0.7% CH4 leakage
Illustrative- Actual emissions will vary by facility depending on system design and location
SMR H2 (w/steam credits)
Byproduct (steam cracking)
SMR H2 w/CCS
Coal w/CCS
Biomass gasification
Byproduct (chlor-alkali)
Nuclear LTE
Nuclear HTE
Landfill gas to H2
solar H2
wind H2
https://greet.es.anl.gov/files/hydrogenreport2022


Infrastructure options for gaseous hydrogen (GH2) delivery
H2 Production
Centralized Gaseous
Compressor
Transmission Pipeline
Compressor
Compressor
Geologic Storage
Distribution Pipeline
Compressor
Storage
Tube-Trailer
Loading Bays
Gaseous Terminal
Compressor
Storage
Tube-Trailer
Loading Bays
Gaseous Terminal
Compressor
Cascade
Storage
Refrigeration
Dispenser
Fueling Station

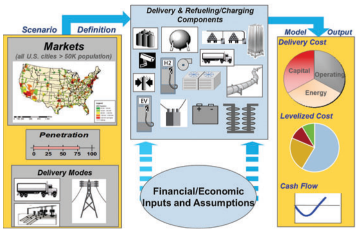

Infrastructure of liquid hydrogen (LH2) delivery
H2 Production
Centralized Gaseous
Liquefier
Pump
Pump
Cryogenic Storage
Loading Bays
Liquid Terminal
Compressed Gas Dispenser
Vaporizer
Cryo-Compressed Dispenser
High-Pressure Cryo-Pump
Cryogenic Storage
Fueling Station
Liquid Truck


H2 fuel cell electric vehicles are attractive zero-emission options when daily energy use is high: vehicle cost perspective
Overall cost [$]
Plus:
✓ Life of energy storage and fuel cell needs to be factored in
✓ Fueling/charging cost is additional
Battery
Slope= $/kWh_battery
Battery + FC + Hydrogen tank
Slope adj.
May shift to right or left
Hydrogen tank (adjusted with FE ratio)
Slope adj.
Hydrogen tank
Slope= $/kWh_H2
Battery
Fuel Cell
Low daily fuel use (case of LDVs)
High daily fuel use (case for HDVs)
Storage amount [kWh]
✓FC: Fuel Cell
✓FE: Fuel Economy
✓LDV: Light-Duty Vehicle
✓HDV: Medium- and Heavy-Duty Vehicle

Hydrogen Delivery Scenario Analysis suite of Models (HDSAM)

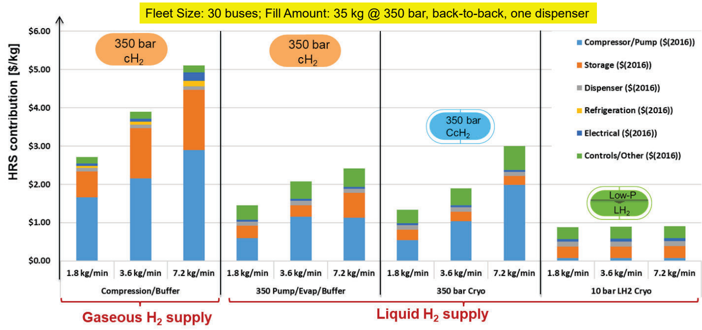
Argonne's HDSAM and its derivatives evaluate the economic performance and market acceptance of hydrogen delivery technologies and fueling infrastructure for FCEVs

- Publicly available with >5,000 users, including major gas and energy companies, in more than 25 economies
- Supported by U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) since 2004



https://hdsam.es.anl.gov/

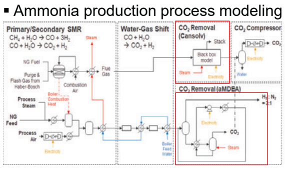
H_2 supply form and onboard storage technology strongly impact H_2 refueling station (HRS) cost



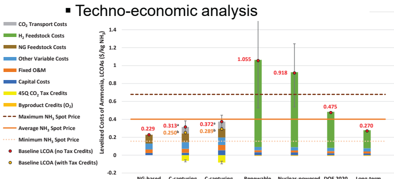
- Cost of H_2 delivered to the station is additional

Ammonia as fertilizer, fuel and H_2 carrier

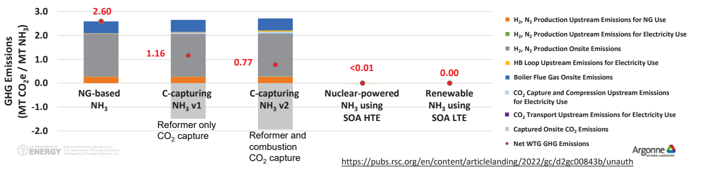
- Ammonia production process modeling



- Techno-economic analysis



- Well-to-gate emissions

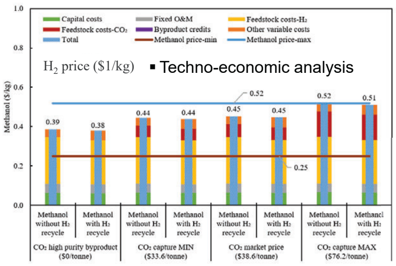


https://pubs.rsc.org/en/content/articlelanding/2022/gc/d2gc00843b/unauth

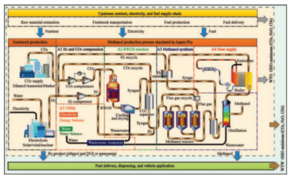
e-methanol as chemical, fuel, H_2 carrier

- Methanol can be synthesized by using CO_2 and H_2 via RWGS and methanol reaction
- CO_2 + H_2→ syngas→ methanol

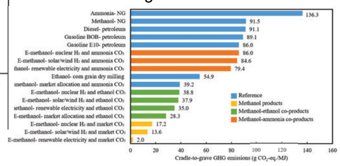
- Techno-economic analysis



- Conversion process modeling



- Well-to-gate GHG emissions

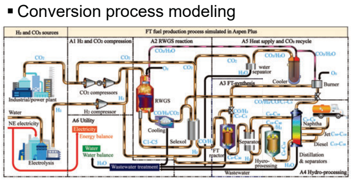


https://pubs.acs.org/doi/10.1021/acs.est.0c08237

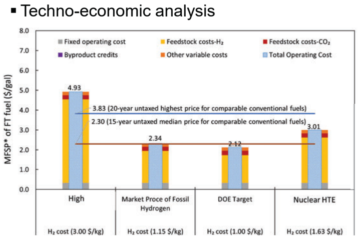
E-fuels via Fischer-Tropsch (FT) process using H_2 + CO_2

- FT fuels can be synthesized by using CO_2 and H_2 via RWGS and FT reaction
- CO_2 + H_2→ syngas→ FT fuels

- Conversion process modeling

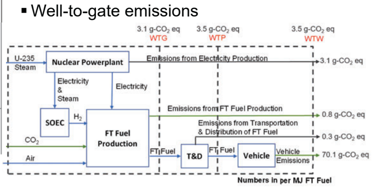


- Techno-economic analysis



*MFSP=minimum fuel selling price

- Well-to-gate emissions

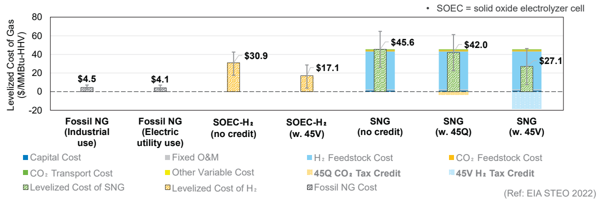


https://www.osti.gov/biblio/1868524

SNG Production Cost – w/ and w/o IRA Tax Credits

- SOEC = solid oxide electrolyzer cell

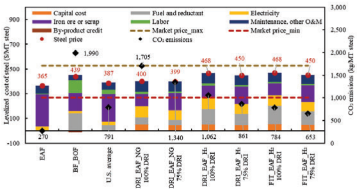
- Ethanol-CO_2 supply

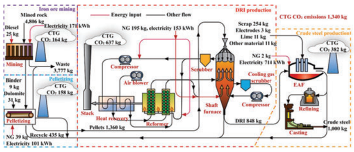


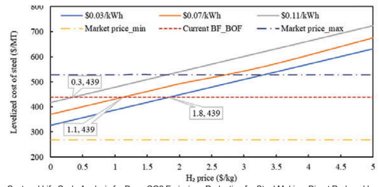
(Ref: EIA STEO 2022)

TEA Parameter	Unit	Low-Cost Value	Baseline Value	High-Cost Value	Reference
Nuclear electricity price	¢/kWh	3	**7**	11	DOE 2020 Record
SOEC-H_2 price (no credit)	\$/kg-H_2	2.4	**4.2**	5.7	DOE 2020 Record
SOEC-H_2 price (with 45V PTC)	\$/kg-H_2	0.5	**2.3**	3.9	This work
Ethanol-CO_2 price	\$/MT-CO_2	17.7 (minimum)	**25.2 (weighted average)**	33.4 (maximum)	This work and NETL, 2014
CO_2 transport distance	mi	50	**100**	500	This work
Byproduct steam	-	Export	**No export**	No export	This work

Steel production using hydrogen in DRI technology







- NG=$3.7/GJ, Elec =$0.07/kWh, H_2=$1.3/kg
- The production cost with DRI-NG-EAF is similar with that of BF-BOF
- DRI-H_2 is more costly, and sensitive to H_2 price
- For DRI-H_2 steel to reach price parity with market price, H_2 cost needs to be $1-2/kg H_2
- IRA 45V incentivize DRI with H_2

Cost and Life Cycle Analysis for Deep CO2 Emissions Reduction for Steel Making: Direct Reduced Iron Technologies - Zang - steel research international - Wiley Online Library

Argonne

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Acknowledgment

Hydrogen TEA and LCA at Argonne have been supported by DOE's Office of Energy Efficiency and Renewable Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) for over two decades

ENERGY

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Thank You!

aelgowainy@anl.gov

Our models, tutorials and publications are available at:
https://greet.es.anl.gov/
https://hdsam.es.anl.gov/

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1

Fuel Ammonia Production from fossil fuels

APEC Symposium on Pursuing Decarbonization of Fossil Fuels
October 11, 2023

Yoshikazu (Yoshi) Kobayashi
The Institute of Energy Economics, Japan (IEEJ)

2

Different sources, different uses

- Hydrogen can be produced from both fossil fuels and zero-emission electricity, which makes it a preferred energy not only for climate action but also for energy security.

Grey hydrogen
- Fossil fuel-based hydrogen (SMR, ATR)

Blue hydrogen
- Fossil fuel-based hydrogen with CCUS

Turquoise hydrogen
- Natural gas with pyrolysis

Green hydrogen
- Renewable energy-based hydrogen (Electrolysis)

Pink (or purple) hydrogen
- Nuclear-based hydrogen (Electrolysis, High-temperature reactor)

Hydrogen

Industrial gas
- Oil refining, Semiconductor, etc.

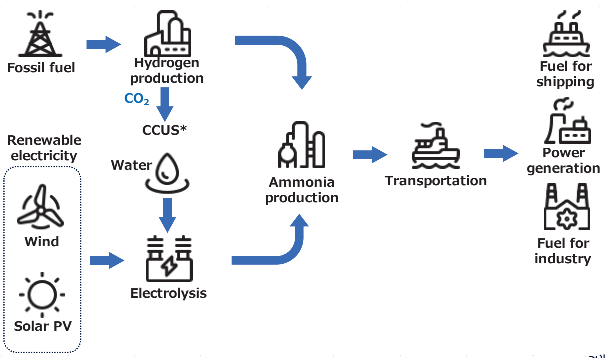
Zero-emission energy
- Transportation (FCV for land transportation; Hydrogen derivatives for maritime shipping; Synthetic fuel for aviation fuel)
- Industry (Fuel for high temperature; Reduction agent for steel making)
- Building (Hydrogen or synthetic fuel for heating and cooking)
- Power generation (Co-firing/Single-firing of ammonia and hydrogen)

Energy Storage
- Storage of surplus electricity generated from variable (intermittent) renewable energy

3

Fuel ammonia supply chain

- Ammonia is produced from hydrogen, which can be produced from various sources.
- In most cases, hydrogen and ammonia are produced in an integrated manner.

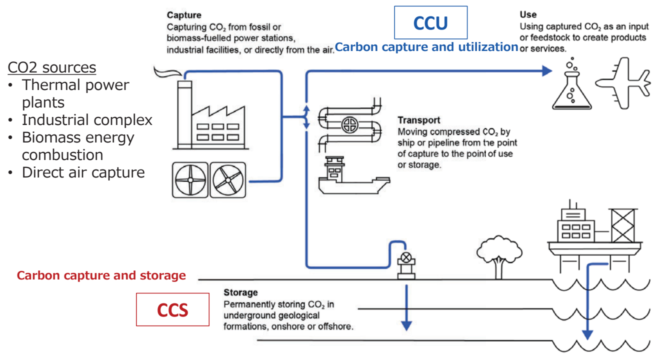


 Source: IEEJ

4

What is CCUS?

- CCUS = Carbon Capture, Utilization and Storage.
- Key technology to make the existing fossil fuel-based hydrogen technology clean enough.



 Source: IEEJ

5

Importance of low-carbon ammonia

- Low-carbon ammonia (=ammonia produced from fossil fuels" is clearly re recognized as an effective means for decarbonization by G7 leaders this year.

> We recognize that low-carbon and renewable hydrogen and its derivatives such as ammonia should be developed and used, if this can be aligned with a 1.5 °C pathway, where they are impactful as effective emission reduction tools to advance decarbonization across sectors and industries, notably in hard-to-abate sectors in industry and transportation, while avoiding N_2O as a GHG and NO_x as air pollutant.
>
> --- *G7 Hiroshima Leaders' Communiqué*, Paragraph 25

 Source: Ministry of Foreign Affairs of Japan

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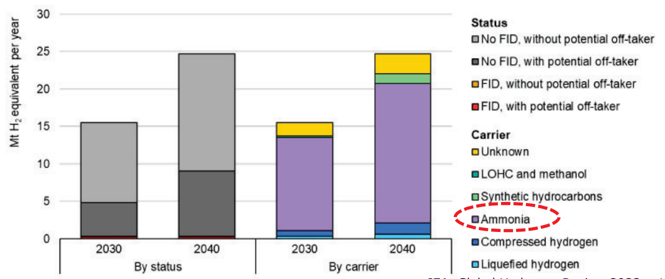
Ammonia's role for hydrogen trade

- 80% of hydrogen export project currently planned will utilize ammonia as its carrier.
- Some of the exported ammonia will be directly utilized without cracking.

Figure 4.1 Low-emission hydrogen trade by status and by carrier based on announced projects, 2030-2040

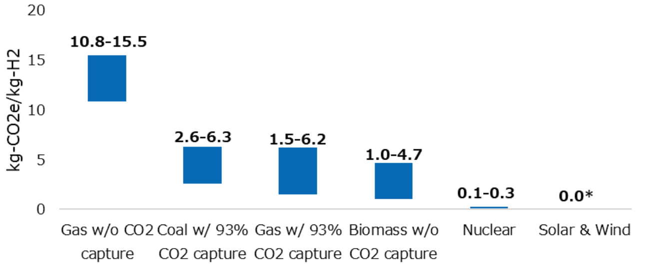


 IEA, Global Hydrogen Review 2023, p102

Not color but carbon intensity

- Different feedstocks of hydrogen/ammonia have different level of carbon intensity.
- Carbon footprint per unit of production (= carbon intensity) needs to be lowered to zero in the long run.

Carbon intensity of different types of hydrogen



*Life cycle carbon intensity including the manufacturing process of hydrogen production facilities may go up to 0.9-2.5kg-CO2e/kg-H2 in case of solar and 0.4-0.8kg-CO2e/kg-H2 in case of wind.
Source: IEA (2023), Towards Hydrogen Definitions based on Their Emissions Intensity, pp39-43

How clean is clean enough?

- Several governments / organizations published threshold of carbon intensity for low carbon or clean hydrogen.
- The amount of subsidy or tax benefit may change subject to the level of carbon intensity.

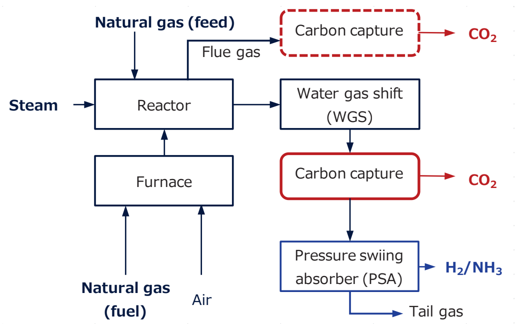
Carbon intensity condition for clean hydrogen

Standard	Carbon intensity (kg-CO2e/kg-H2)	Boundary
RED/RFNBO (EU)	3.4	Life cycle
EU taxonomy (EU)	3.0	Life cycle
Low Carbon Hydrogen Standard (UK)	2.4	Well to gate
Clean Hydrogen Production Standard	4.0	Well to gate
Inflation Reduction Act (US)	0-4	Life cycle (well to gate)
Japan Hydrogen Strategy	3.4	Well to gate
CertifHy Low Carbon (Industry)	60% reduction	Well to gate

Blue hydrogen/ammonia: SMR route

- Most of the existing ammonia production plants adopt steam-methane reforming (SMR) process to produce hydrogen as a feedstock of ammonia.
- Matured technologies with very low technological risks.
- Productions costs can be lowered by scale up.

Simplified flow of SMR process

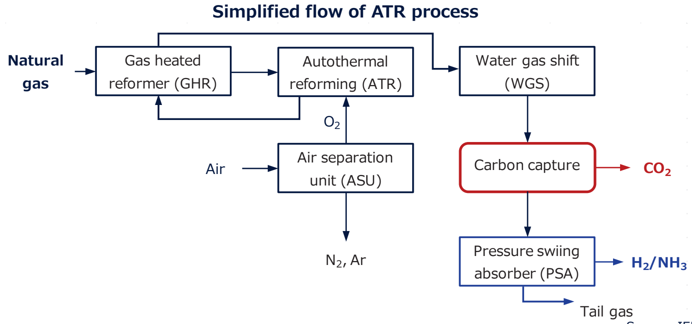


Source: Author

Blue hydrogen/ammonia: ATR route

- Auto thermal reforming process (ATR) uses oxygen and steam or carbon dioxide to partially oxidize the feedstock natural gas. Because of the oxidation, the reaction is exothermic.
- Larger volume of CO2 can be captured easily compared to SMR because ATR needs less energy inputs for the process.

Simplified flow of ATR process

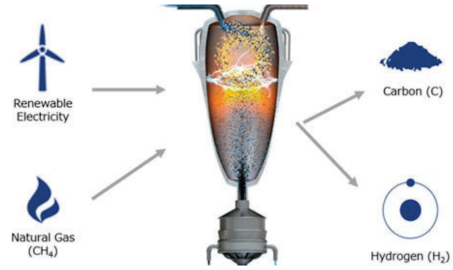


Source: IEEJ

Turquoise hydrogen/ammonia

- Turquoise hydrogen is hydrogen produced from natural gas with pyrolysis process.
- The process does not emit carbon dioxide but carbon; how to monetize the produced carbon is a big challenge for the process.
- Turquoise hydrogen can be of course utilized to produce ammonia

$$CH_4 \Rightarrow C + 2H_2$$

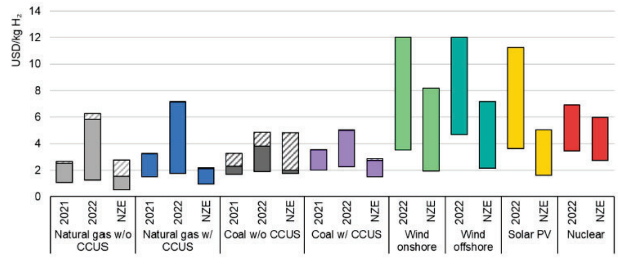


Source: Mitsubishi Heavy Industries

Production cost of hydrogen

- Low carbon hydrogen produced from fossil fuel is likely to maintain cost competitiveness against hydrogen produced by electrolysis by renewable electricity.
- The effects of the recent hike of natural gas and renewable electricity generation cost on the hydrogen / ammonia production cost remain to be seen.

Figure 3.11 Levelised cost of hydrogen production by technology in 2021, 2022 and in the Net Zero Emissions by 2050 Scenario in 2030

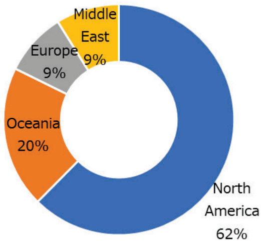


Source: IEA, Hydrogen Projects Database

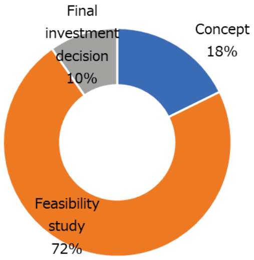
Projects for fossil fuel-based ammonia

- According to IEA's database, currently 12 million tons of ammonia production projects are currently planned.
- More than half of the planned projects are in North America (mostly in the US).
- 90% of the planned capacities are still at either conceptual or feasibility study phase. Policy supports may be needed to accelerate the development.

Fossil fuel-based ammonia projects by region



Fossil fuel-based ammonia projects by status

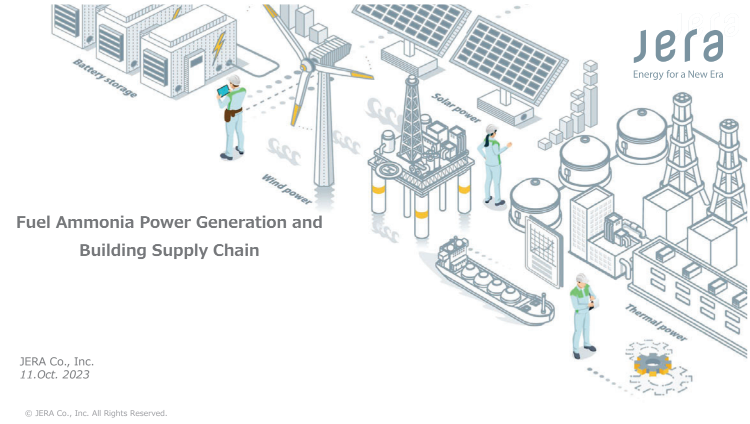


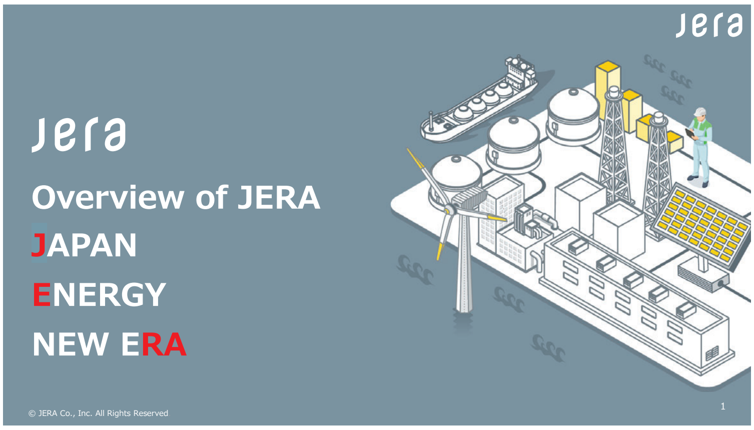
Source: IEA, Hydrogen Projects Database

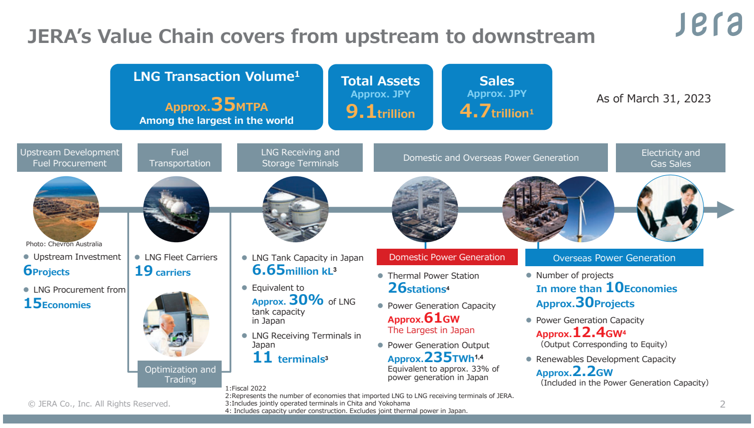
Summary

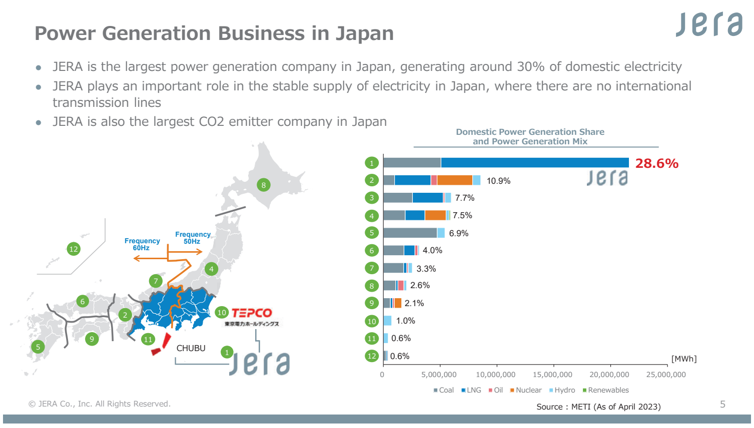
- **While hydrogen and ammonia can be produced from various feedstock and inputs, low carbon hydrogen produced from fossil fuel was confirmed as an effective means for decarbonization by the G7 summit leaders.**
- **Carbon intensity of fossil fuel-based ammonia will be lowered in the long run to realize carbon neutrality.**
- **Low carbon hydrogen produced from fossil fuel is likely to be more cost competitive than hydrogen produced by electrolysis by renewable electricity.**
- **Most of the projects for low carbon hydrogen produced from fossil fuels are still at feasibility study stage. Policy supports may be needed to accelerate the development.**

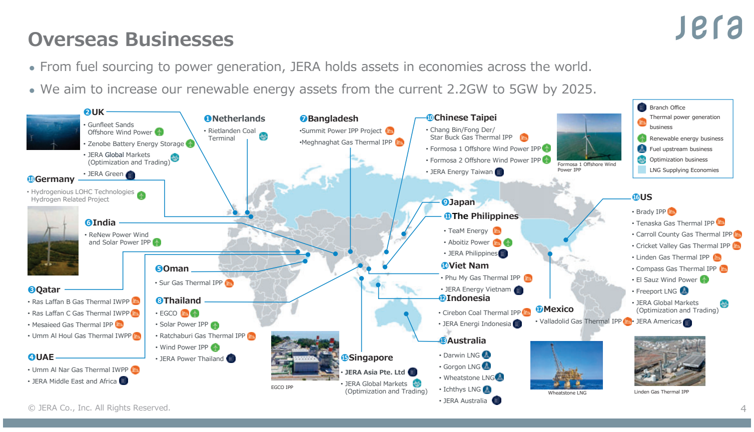
1-7. Fuel Ammonia Power Generation and Building Supply Chain

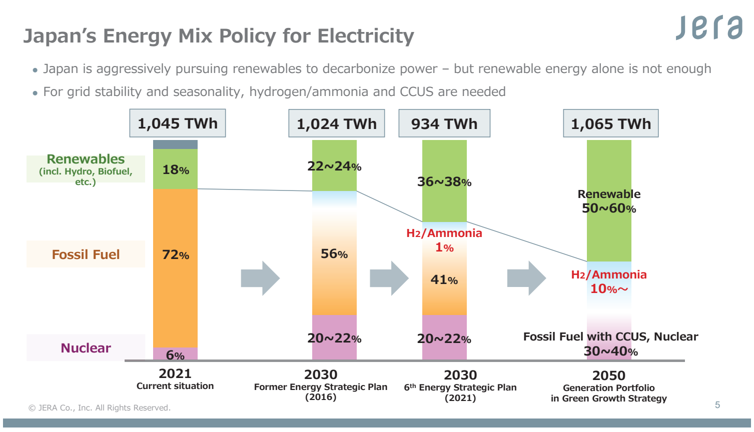


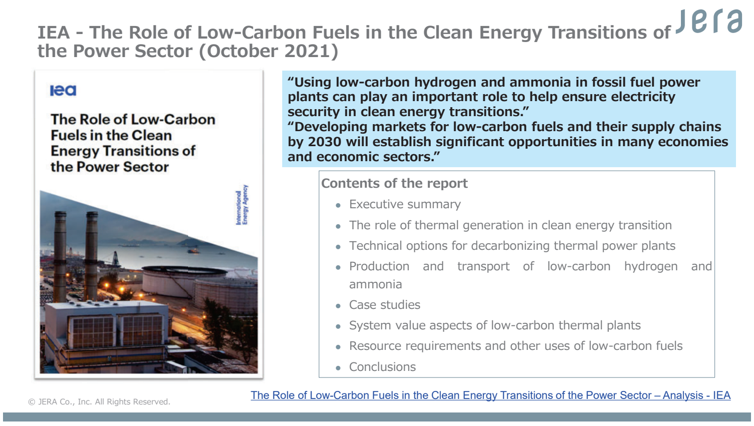











IEA - The Role of Low-Carbon Fuels in the Clean Energy Transitions of the Power Sector (October 2021)
jera
iea
The Role of Low-Carbon Fuels in the Clean Energy Transitions of the Power Sector
"Using low-carbon hydrogen and ammonia in fossil fuel power plants can play an important role to help ensure electricity security in clean energy transitions."
"Developing markets for low-carbon fuels and their supply chains by 2030 will establish significant opportunities in many economies and economic sectors."
Contents of the report
Executive summary
The role of thermal generation in clean energy transition
Technical options for decarbonizing thermal power plants
Production and transport of low-carbon hydrogen and ammonia
Case studies
System value aspects of low-carbon thermal plants
Resource requirements and other uses of low-carbon fuels
Conclusions
The Role of Low-Carbon Fuels in the Clean Energy Transitions of the Power Sector – Analysis - IEA
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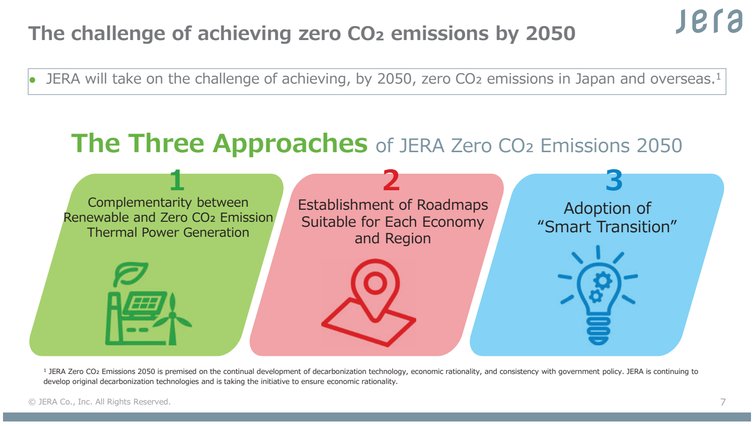
The challenge of achieving zero CO2 emissions by 2050
jera
JERA will take on the challenge of achieving, by 2050, zero CO2 emissions in Japan and overseas.1
The Three Approaches of JERA Zero CO2 Emissions 2050
1
Complementarity between Renewable and Zero CO2 Emission Thermal Power Generation
2
Establishment of Roadmaps Suitable for Each Economy and Region
3
Adoption of "Smart Transition"
1 JERA Zero CO2 Emissions 2050 is premised on the continual development of decarbonization technology, economic rationality, and consistency with government policy. JERA is continuing to develop original decarbonization technologies and is taking the initiative to ensure economic rationality.
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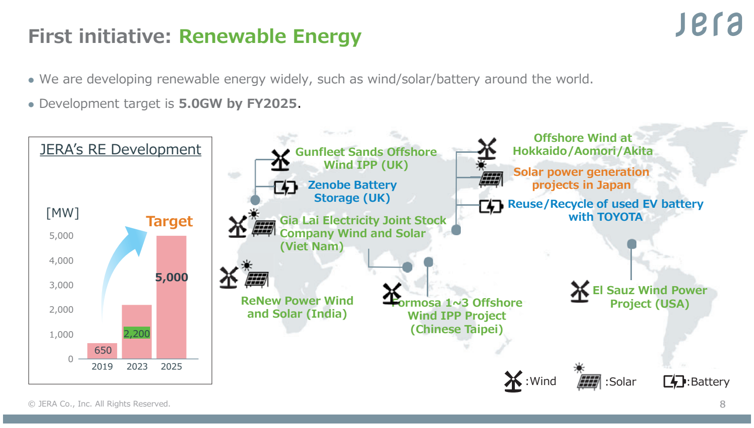
First initiative: Renewable Energy
jera
We are developing renewable energy widely, such as wind/solar/battery around the world.
Development target is 5.0GW by FY2025.
JERA's RE Development
[MW]
Target
5,000
4,000
3,000
2,000
1,000
0
650
2,200
5,000
2019
2023
2025
Gunfleet Sands Offshore Wind IPP (UK)
Zenobe Battery Storage (UK)
Gia Lai Electricity Joint Stock Company Wind and Solar (Viet Nam)
ReNew Power Wind and Solar (India)
Formosa 1~3 Offshore Wind IPP Project (Chinese Taipei)
Offshore Wind at Hokkaido/Aomori/Akita
Solar power generation projects in Japan
Reuse/Recycle of used EV battery with TOYOTA
El Sauz Wind Power Project (USA)
:Wind
:Solar
:Battery
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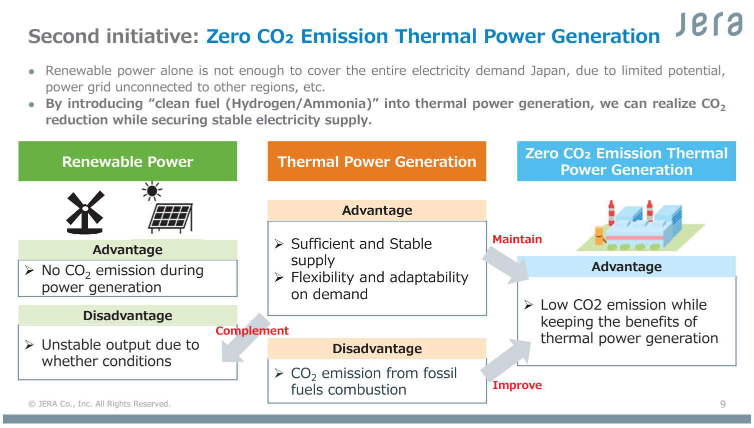
8


Second initiative: Zero CO2 Emission Thermal Power Generation
jera
Renewable power alone is not enough to cover the entire electricity demand Japan, due to limited potential, power grid unconnected to other regions, etc.
By introducing "clean fuel (Hydrogen/Ammonia)" into thermal power generation, we can realize CO2 reduction while securing stable electricity supply.
Renewable Power
Advantage
No CO2 emission during power generation
Disadvantage
Unstable output due to whether conditions
Thermal Power Generation
Advantage
Sufficient and Stable supply
Flexibility and adaptability on demand
Disadvantage
CO2 emission from fossil fuels combustion
Complement
Maintain
Improve
Zero CO2 Emission Thermal Power Generation
Advantage
Low CO2 emission while keeping the benefits of thermal power generation
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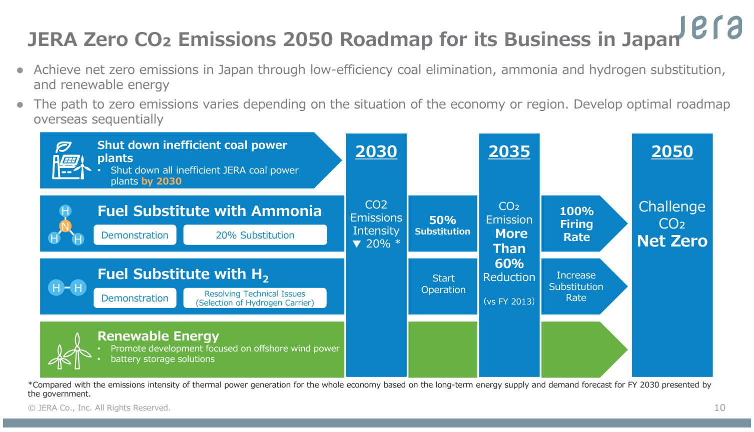
9


JERA Zero CO2 Emissions 2050 Roadmap for its Business in Japan
jera
Achieve net zero emissions in Japan through low-efficiency coal elimination, ammonia and hydrogen substitution, and renewable energy
The path to zero emissions varies depending on the situation of the economy or region. Develop optimal roadmap overseas sequentially
Shut down inefficient coal power plants
Shut down all inefficient JERA coal power plants by 2030
Fuel Substitute with Ammonia
Demonstration
20% Substitution
Fuel Substitute with H2
Demonstration
Resolving Technical Issues (Selection of Hydrogen Carrier)
Renewable Energy
Promote development focused on offshore wind power battery storage solutions
2030
CO2 Emissions Intensity ▼20% *
50% Substitution
Start Operation
2035
CO2 Emission More Than 60% Reduction (vs FY 2013)
100% Firing Rate
Increase Substitution Rate
2050
Challenge CO2 Net Zero
*Compared with the emissions intensity of thermal power generation for the whole economy based on the long-term energy supply and demand forecast for FY 2030 presented by the government.
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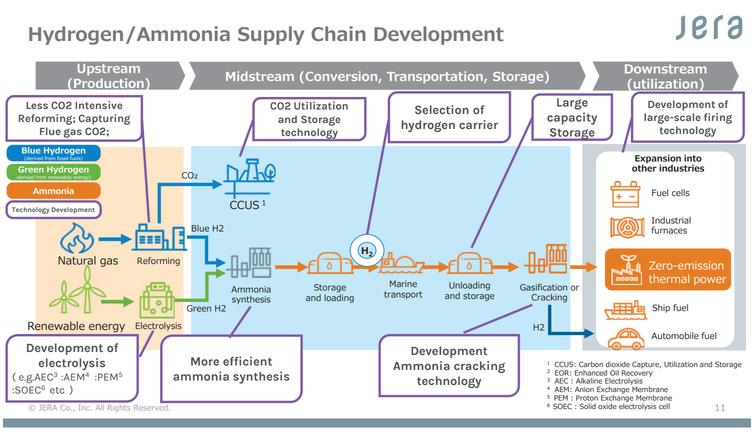
Hydrogen/Ammonia Supply Chain Development
jera
Upstream (Production)
Midstream (Conversion, Transportation, Storage)
Downstream (utilization)
Less CO2 Intensive Reforming; Capturing Flue gas CO2;
CO2 Utilization and Storage technology
Selection of hydrogen carrier
Large capacity Storage
Development of large-scale firing technology
Blue Hydrogen
Green Hydrogen
Ammonia
Technology Development
CO2
CCUS 1
Blue H2
Natural gas
Reforming
Green H2
Renewable energy
Electrolysis
Ammonia synthesis
Storage and loading
Marine transport
Unloading and storage
Gasification or Cracking
H2
Expansion into other industries
Fuel cells
Industrial furnaces
Zero-emission thermal power
Ship fuel
Automobile fuel
Development of electrolysis
(e.g.AEC3 :AEM4 :PEM5 :SOEC6 etc)
More efficient ammonia synthesis
Development Ammonia cracking technology
1 CCUS: Carbon dioxide Capture, Utilization and Storage
2 EOR: Enhanced Oil Recovery
3 AEC : Alkaline Electrolysis
4 AEM: Anion Exchange Membrane
5 PEM : Proton Exchange Membrane
6 SOEC : Solid oxide electrolysis cell
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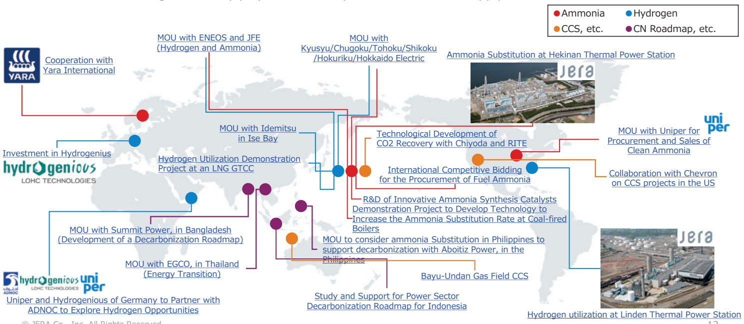
11

Initiatives to Establish Hydrogen and Ammonia Supply Chain

- JERA is collaborating with many players to develop a low-carbon fuel supply chain.



Initiatives to Establish Hydrogen and Ammonia Supply Chain cont…

Production → Procurement → Shipping → Receiving/ Storage → Generation

Cooperation in Upstream Area

- JERA has conducted an international competitive bidding process for the procurement of fuel ammonia. (2022.2-)
- In Jan 2023, JERA has executed MOUs with CFI and Yara, as a result of bid for development and sales of clean ammonia.

Number of bids sent	Approx. 30 companies
Duration	Long term from FY2027 into 2040s
Quantity	Up to 500,000 t/year
Delivery	FOB
Others	- CO_2 is not generated during ammonia production, or captured and stored. - JERA has the opportunity to participate in ammonia production projects.

Cooperation in Shipping Area

- JERA has signed MOU with "NYK" and "MOL" to cooperate in transporting fuel ammonia. (2022.11)

MOU covers :

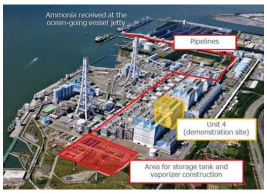
- ✓ Developing fuel-ammonia carriers suitable for domestic thermal power plants and receiving stations
- ✓ Building a fuel ammonia transportation and receiving system
- ✓ Installing and operating propulsion engines that use ammonia as ship fuel
- ✓ Working with related parties to foster the formation of rules related to the reception of fuel ammonia

Initiatives to Establish Hydrogen and Ammonia Supply Chain cont…

Production → Procurement → Shipping → Receiving/ Storage → Generation

Demonstration for Ammonia Substitution

- Small-scale ammonia substitution test has been completed. (2022.7)
- Preparations are underway to conduct a large-scale 20% substitution demonstration in FY2023.



Collaboration with Utilities

- JERA has signed MOU with 6 Japanese utility companies to consider collaboration aimed at the adoption of hydrogen and ammonia as fuel for power generation.

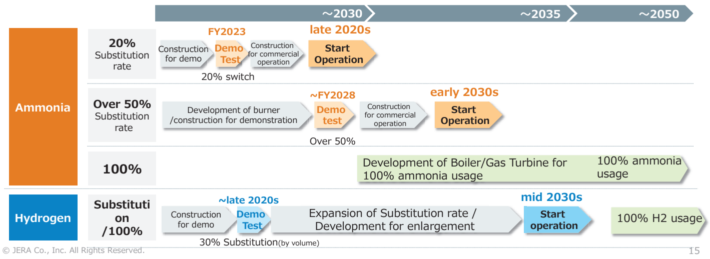
MOU covers :

- Joint procurement to reduce LCF costs
- To establish transportation and storage methods for LCF
- Working to gain policy support and to develop rules related to LCF
- Exchanging opinions and considering collaborative projects regarding the introduction of LCF in Japan

KYUSHU ELECTRIC POWER CO.,INC. Energia 北陸電力 YONDEN Tohoku Electric Power ほくでん

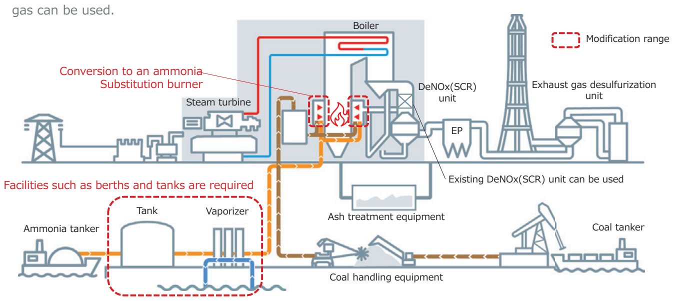
JERA's Zero Emissions Technologies' Development Timeline

- **20% ammonia generation Demonstration test** will start **by FY2023.** Demonstration test of **ammonia generation over 50%** will conduct **by FY2028 at Hekinan and other Power Plants**.
- After the demo tests, commercial operation will start at the power plants.



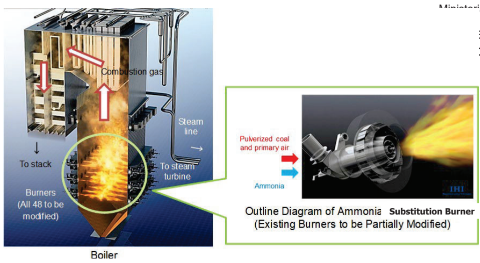
Outline of required modification for Ammonia

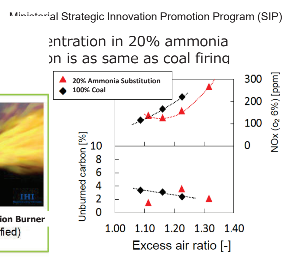
- JERA makes modification works for Ammonia in Hekinan Unit 4
- Small modification is required, but the most of existing facility and DeNOx(SCR) unit for treatment of exhaust gas can be used.



Development of Ammonia Substitution technology

- A challenge of using ammonia in a blended fuel is controlling NOx emissions
- JERA's demonstration test program will use modified burners that inject ammonia at the center of a stream of pulverized coal and air



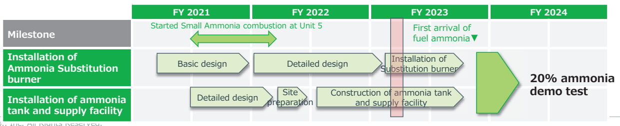


The Demonstration Test for Ammonia Generation (FY 2021-FY 2024)

NEDO project "R&D and Demonstration of Technologies for Ammonia Substitution Thermal Power Generation"	
Companies	**JERA and IHI**
Place	**Hekinan Thermal Power Station** (1,000MW) in Aichi prefecture, Japan
Contents	- Installation of Ammonia Substitution burner & supply facility - **20% coal as fuel will be replaced by ammonia.**
Ammonia Consumption	**30,000 to 40,000 tons** during the test

NEDO: New Energy and Industrial Technology Development Organization

Schedule of the demonstration



Procurement of Fuel Ammonia

- JERA conducted an international competitive bidding for the procurement of fuel ammonia.

Main T&Cs	Number of bids RFP sent	Approx. 30 companies
	Contract duration	**FY2027~2040's Long term**
	Quantity	Max. **500,000 ton/year**
	Delivery	FOB
	Others	• In principle, CO2 is not generated during ammonia production, or is collected and stored. • JERA's opportunity to participate in the ammonia production projects

- In January 2023, JERA has executed MOUs with **Yara** and **CFI**, as a result of bid process, for potential collaboration for the joint project development and sales & purchase of clean ammonia. **The joint development of 1 million mtpa blue ammonia project in US.**

JERA's efforts to support Asia's Energy Transition

Indonesia - Nov 2021
・JERA concluded an agreement with JICA regarding a "Data Collection Survey on Power Sector in Indonesia for Decarbonization."

Thailand - January 2023
- MOU signed with EGCO for collaboration on decarbonization initiatives
- MOU signed with multiple parties for conducting feasibility study for ammonia Substitution at the BLCP thermal power station

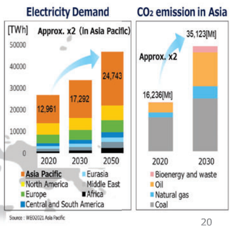
Thailand - May 2023
MOU signed with PTT to
- Study on the construction of hydrogen and ammonia supply chain in Thailand
- Evaluation of the feasibility of ammonia cracking technology supplying hydrogen
- Development of hydrogen/ammonia production business assuming supply to Thailand

Singapore - August 2022
- MOU with MHI and Jurong Port to jointly explore establishing 100% ammonia fired power plant combined with bunkering operations in Singapore

The Philippines - February 2023
- MOU signed under witness of President Marcos to consider ammonia Substitution in Philippines to support decarbonization

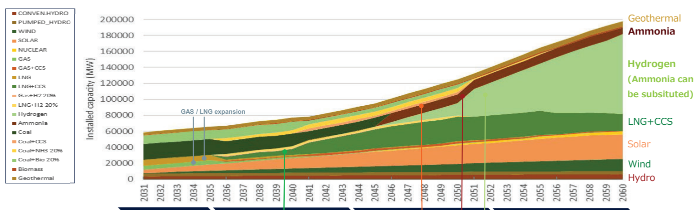
Bangladesh - April 2022
- Signed of MOU for Cooperation on Decarbonization Roadmap
- Acquired 22% of shares of Summit Power, the largest IPP in Bangladesh

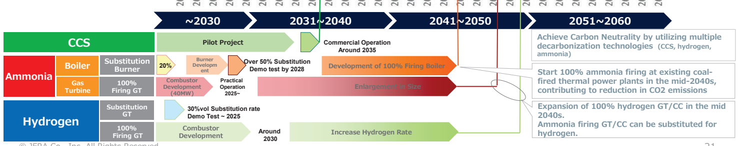
Malaysia - October 2022
- MOU with IHI for collaboration towards expansion of ammonia in Malaysia's energy sector to support decarbonization



Study for Zero Emission Thermal Power Development Timeline

"Data Collection Survey on Power Sector in Indonesia for Decarbonization"(2021.11)

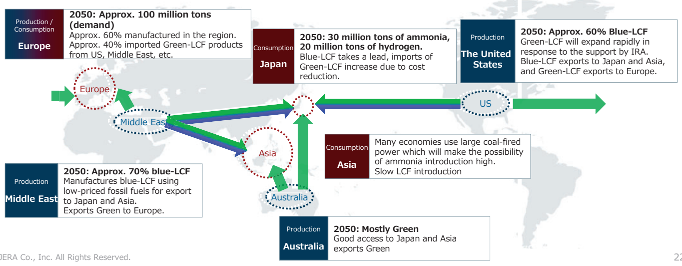




https://openjicareport.jica.go.jp/670/670/670_108_1000047527.html

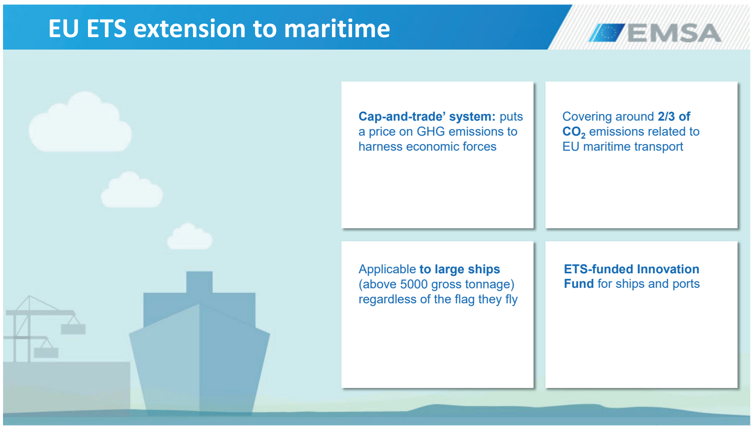
Green & Blue Hydrogen/Ammonia flow projection for 2050

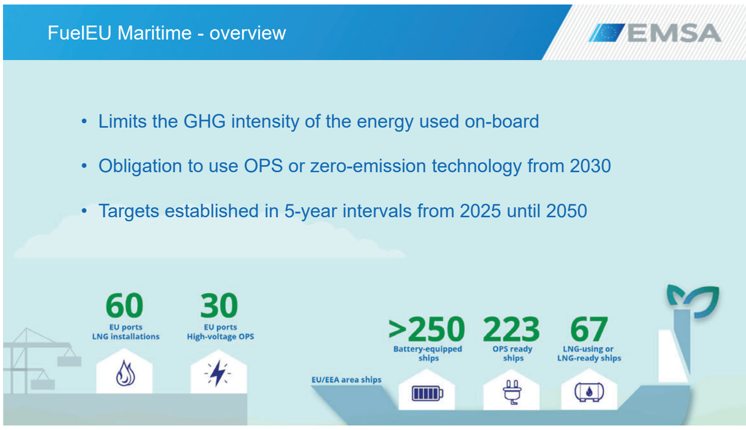
Due to the current mechanism and cost, two commercial flows will occurr simultaneously:
Blue-Hydrogen/Ammonia (LCF) : U.S./Middle East to Japan/Korea
Green-Hydrogen/Ammonia (LCF) : U.S./Middle East to Europe
The cost of Green-LCF will go down, and the commercial flow of Green-LCF and Blue-LCF will mix and optimize the global commercial flow.

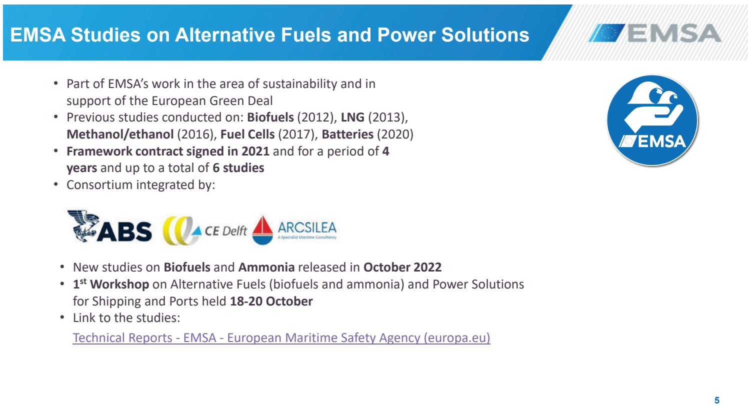


Thank you for your attention!

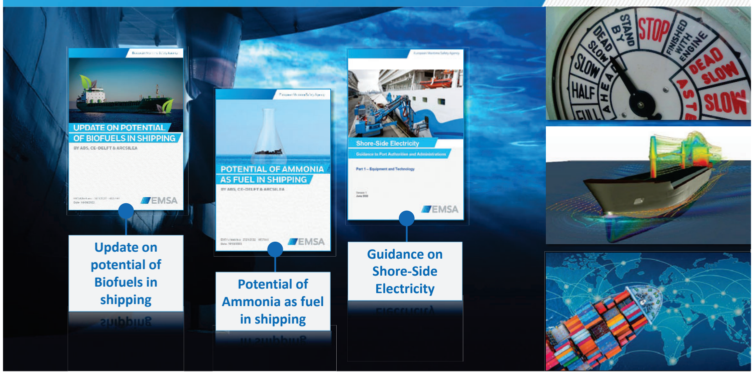
1-8. EMSA study Potential of Ammonia as Fuel in Shipping





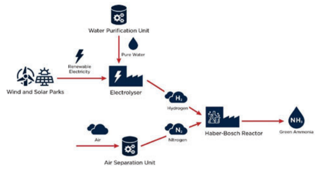


Studies released



Availability and Scalability

HB is the most mature process



Process Type	Expected Efficiency [up to]
Pathway 1 Electrolysis and Haber-Bosch synthesis	~72%
Pathway 2 Direct solar hydrogen production	9% [up 70%]
Pathway 3 Biogenic hydrogen production	~57%
Pathway 4 Non-thermal plasma synthesis	12-37% [up to 45%]
Pathway 5 Electrochemical ammonia synthesis	14-62% [up to 90%]

Grey NH3 Production

235
Mtons/year
2019

Green NH3 Announced

>133
Mtons/year
*annouced blue and green ammonia production

What are the challenges?

- Many sectors will have demand for green or blue ammonia.
- Green electricity will also be in high demand
- Demand depends on policy, many of which are not yet confirmed
- Green production needs to be efficient, utlized at maximum capacity and this poses challenges:
  - Location, pipelines, access to ports
  - Connection to grid (sustainable?)
  - Potentially oversized

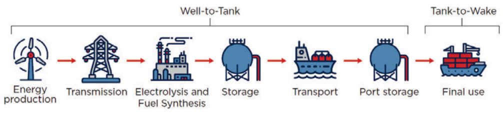
8

Sustainability

The challenge is green electricity
- Certification mechanisms
- If connected to the grid, need to ensure the source of that energy
- Transportation, if not decarbonised, may lead to increased footprint

Engine still under development
- NOx & N2O slip uncertain
- Pilot fuel usage

Pollutant	HFO, MGO	LNG	Ammonia (combusted in engines)
SO_2 and metals	Present	Not present	Not present
Carbon monoxide and hydrocarbons	Present	Present or increased	Not present
VOCs and PAHs	Present	Reduced	Not present
NO_x **	Needs SCR for Emission Control Area	Otto engines meet Emission Control Area without SCR	Needs SCR for Emission Control Area
Direct particulate matter	Present	Reduced	Reduced
Ammonia (NH_3) ***	Low	Not present	Unknown
N_2O	Present	Present	Present or increased****
CH_4	Low	Present at Otto engines	Not present
CO_2*****	Present	Present	Not present



9

Sustainability (2)

Other Environmental Impacts (production)

- Production of hydrogen requires pure, deionized water. The amount of (fresh) water can increase water scarcity. Desalination and rejection of brines can be detrimental to ocean biodiversity and marine life;
- Generating green electricity will require land (solar or onshore wind);
- Production of Solar should avoid using land used for crops;
- Inland transportation has been ongoing for many decades. Accidents happened and handling of ammonia is known;
- Ammonia spills can be harmful for marine life, need for further evaluation.

Where Solar ?

- Western Australia
- Northern Chile
- Parts of China and US
- Northeast Brazil
- Northern Africa

Where Wind ?

- Avoid land used for crops (Australia, Chile, etc)
- Using offshore may be an option in Western Europe and USA

10

Sustainability (3)

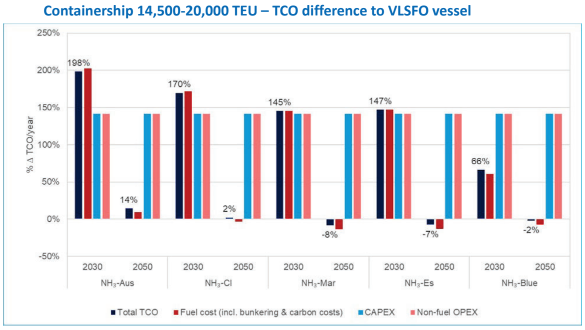
Other Environmental Impacts (bunkering/onboard)

- Ammonia spills may cause more sever harm:
  - Ammonia dissolves partly into water (towards an equilibrium of NH3, NH4+ and NH3 (g))
  - At pH of 8, NH3(aq) ranges from 0.8% to 7.4% (higher pH, higher percentages)
  - Toxicity depends on bio-sphere, from 17 mg/L to 510 mg/L in toxicity limit for Ammonia exposure
- Ammonia spills may be a threat to the marine life, also quality of the water, nutrients on the water, stimulate noxious blooms of algae.
- Stricter safety for bunkering or when vessel enter and leave ports (similar to LNG, but for different reasons)

11

Total Cost Ownership (TCO) - Ammonia fuelled vessel

Containership 14,500-20,000 TEU – TCO difference to VLSFO vessel



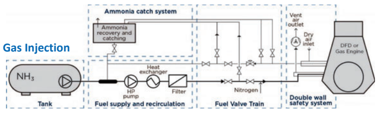
12

Suitablility

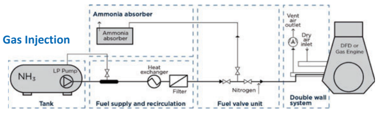
What is needed ?

1. Tanks, either Type A or Type C
2. Ammonia supply pumps
   I. High pressure ~ 80 bar
   II. Low pressure~ 5-15 bar
3. Temperature control
4. Filters
5. Double block and bleed
6. Vent system incl. a collection & treatment system for ammonia vapor
7. Double wall pipe system

High Pressure Gas Injection



Low Pressure Gas Injection



Conclusions

Ammonia as a fuel is likely to take place. It presents a series of advantages and is a promising fuel:

- Known and well-estabilished production process
- Naturally carbon-free, although attention is to be given to NOx, N2O and Pilot fuel and trully green production pathways
- It is known to shipping as a cargo (IGC covers it), and poses many challenges to be used as a fuel
- There are challenges to overcome to handle its corrosivity and toxicity: bunkering, engine, fuel supply systems.
- However, it has been used for many decades and there is substantial knowledge available

Main challenges:

- Ensure availability of green energy and competition with other sectors
- High costs associated with green ammonia production
- Safety and Regulations concerns: need to accelerate awareness and regulatory framework developments
- Need more knowledge on spillage and other environmental aspects
- IMO Guidelines to be ready by 2025

European Maritime Safety Agency

Thank you for your attention

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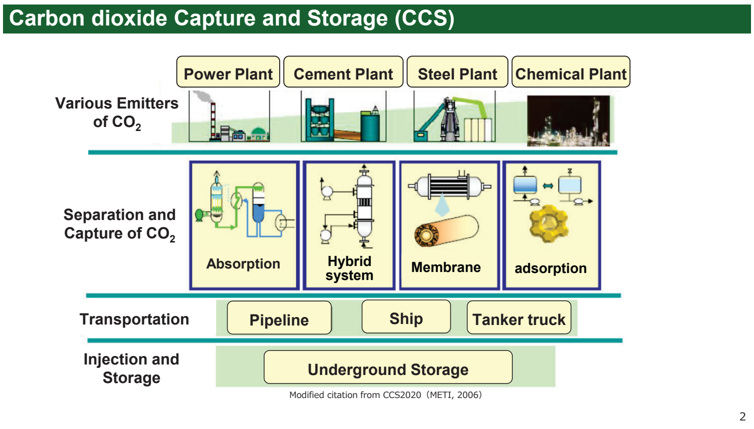
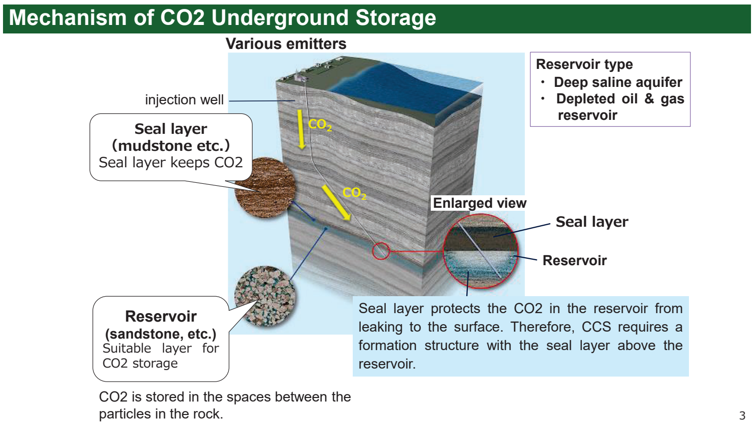
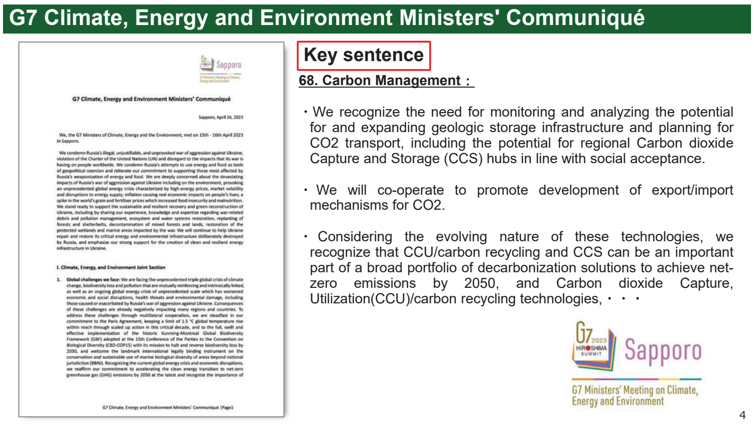
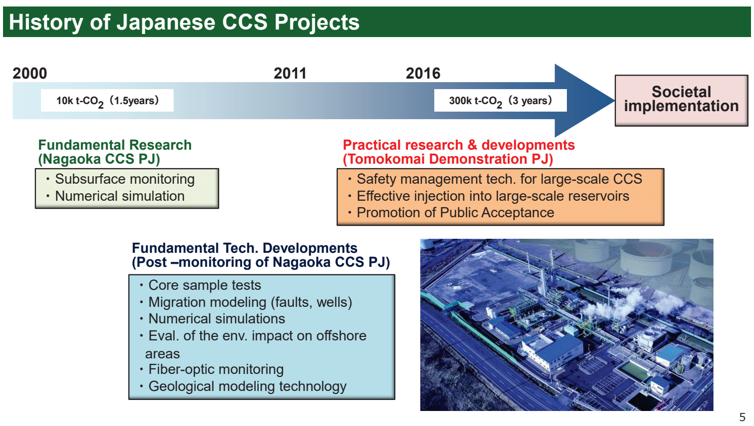
emsa.europa.eu/newsroom/connect


METI
Ministry of Economy, Trade and Industry
CCUS in Japan
Kenta Asahina
CCS policy office, METI, Japan
CO2-BLUE


Carbon dioxide Capture and Storage (CCS)
Power Plant
Cement Plant
Steel Plant
Chemical Plant
Various Emitters of CO_2
Separation and Capture of CO_2
Absorption
Hybrid system
Membrane
adsorption
Transportation
Pipeline
Ship
Tanker truck
Injection and Storage
Underground Storage
Modified citation from CCS2020 (METI, 2006)
2


Mechanism of CO2 Underground Storage
Various emitters
injection well
Seal layer (mudstone etc.)
Seal layer keeps CO2
CO_2
CO_2
Reservoir type
・ Deep saline aquifer
・ Depleted oil & gas reservoir
Enlarged view
Seal layer
Reservoir
Reservoir (sandstone, etc.)
Suitable layer for CO2 storage
Seal layer protects the CO2 in the reservoir from leaking to the surface. Therefore, CCS requires a formation structure with the seal layer above the reservoir.
CO2 is stored in the spaces between the particles in the rock.
3


G7 Climate, Energy and Environment Ministers' Communiqué
G7 Climate, Energy and Environment Ministers' Communiqué
Key sentence
68. Carbon Management :
・We recognize the need for monitoring and analyzing the potential for and expanding geologic storage infrastructure and planning for CO2 transport, including the potential for regional Carbon dioxide Capture and Storage (CCS) hubs in line with social acceptance.
・We will co-operate to promote development of export/import mechanisms for CO2.
・Considering the evolving nature of these technologies, we recognize that CCU/carbon recycling and CCS can be an important part of a broad portfolio of decarbonization solutions to achieve net-zero emissions by 2050, and Carbon dioxide Capture, Utilization(CCU)/carbon recycling technologies, ・・・
G7 2023 HIROSHIMA SUMMIT
Sapporo
G7 Ministers' Meeting on Climate, Energy and Environment
4


History of Japanese CCS Projects
2000
2011
2016
10k t-CO_2 (1.5years)
300k t-CO_2 (3 years)
Societal implementation
Fundamental Research (Nagaoka CCS PJ)
・Subsurface monitoring
・Numerical simulation
Practical research & developments (Tomokomai Demonstration PJ)
・Safety management tech. for large-scale CCS
・Effective injection into large-scale reservoirs
・Promotion of Public Acceptance
Fundamental Tech. Developments (Post –monitoring of Nagaoka CCS PJ)
・Core sample tests
・Migration modeling (faults, wells)
・Numerical simulations
・Eval. of the env. impact on offshore areas
・Fiber-optic monitoring
・Geological modeling technology
5


Japan's Long-Term Roadmap

Japan's Long-Term Roadmap

[Basic principles]

To implement CCS systematically and rationally to promote the sound development of CCS business in Japan with minimal social costs, thereby contributing to the sound development of Japan's economy and industry, securing a stable energy supply, and the achievement of carbon neutrality.

[Objectives]

A business environment for commencement shall be prepared by 2030, involving cost reduction, public understanding, overseas CCS promotion, and CCS Business Act legislation, **based on the rough estimation of enabling CO_2 storage of about 120 to 240 million tons as of 2050, and full-scale CCS business shall deploy after 2030**.

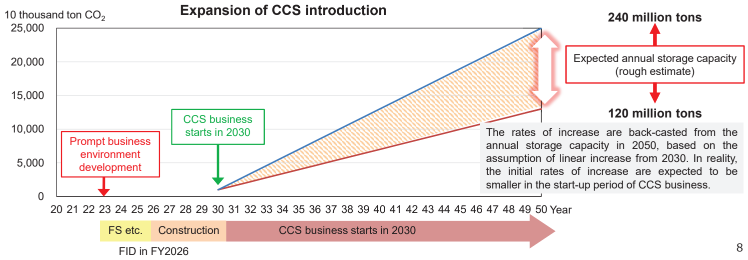
[Specific actions]

(1) Government support for CCS business
(2) Efforts for reducing CCS costs
(3) Promotion of public understanding of CCS business
(4) Promotion of overseas CCS business
(5) Examination for the development of the CCS Business Act (tentative name)
(6) Formulation and review of the CCS Action Plan

7

The necessity of developing business environment toward the start of CCS business by 2030

- Based on IEA trial calculation, **estimated annual storage capacity of Japan's CCS can be roughly estimated at 120 to 240 million tons in 2050** (about 10-20% of current emissions). Supposing CCS is introduced in 2030, the annual storage capacity needs to increase by 6–12 million tons every year during the 20 years until 2050.
- **There are concerns that postponing the introduction of CCS in 2030 will make it difficult to secure the annual storage capacity necessary to achieve 2050 Carbon Neutrality.**



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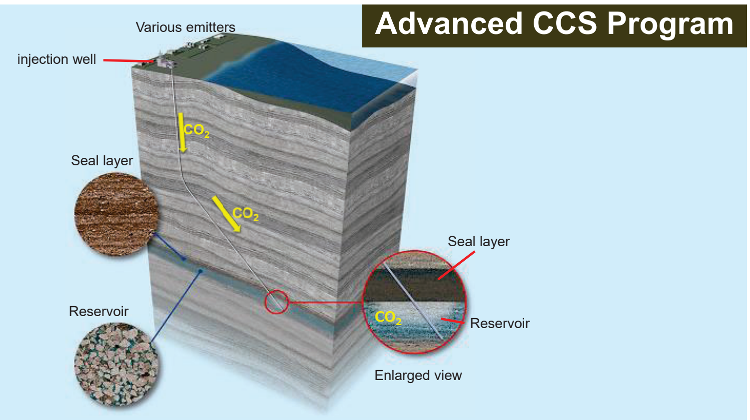
Advanced CCS Program



Purpose of advanced CCS program

- To secure annual storage of 120-240 million tons of CO2 by 2050, A business model for CCS that can cross-sectoral should be established at an early stage. Thus, Japanese government selected "Advanced CCS projects" led by operators and will actively support them.
- This supporting program will establish various CCS business models by supporting projects with different combinations of CO2 source, transportation methods and CO2 storage areas. Furthermore, it aims to secure 6-12 million tons of CO2 storage per year by 2030.
- This year, this program will provide support for the analysis of this geologic data and feasibility study.

Possible types of CO2 source, transport methods, and CO2 storage areas

CO2 sources	Transport methods	CO2 storage areas
Thermal power plant Steel plant Chemical plant Cement plant Paper plant Hydrogen plant etc.	Pipeline Ship	Onshore Near shore Offshore

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Overviews of Selected Advanced CCS Projects

- On June 6, Seven CCS projects was selected as Advanced CCS project (including two oversea export projects) which was considered CO2 source, transportation methods, storage areas.
- Selected project target a wide range of industries such as electric pawer, oil refineries, steel, chemical, pulp/paper, and cement, and capture CO2 emitted from various regions in Japan.
- The total estimated annual storage of CO2 in 2030 is about 13 million tons (including 30% exported overseas).

Storage areas	CO2 Sources	Transportation methods	Types of storage site
①Tomakomai Area CCS JAPEX, Idemitsu Kosan, Hokkaido Electric power	Oil refinery, electric power plant	Pipeline	Onshore depleted gas fields and/or Near shore
②Tohoku region west coast CCS ITOCHU Corp., Nippon Steel, Taiheiyo Cement, Mitsubishi Heavy Industries, ITOCHU Oil Exploration, INPEX, Taisei Corp.	Steel plant, Cement plant	Ship, Pipeline	Near shore
③East Niigata Aria CCS JAPEX, Tohoku electric power, Mitsubishi Gas Chemical Company, Hokuetsu Co, Nomura Research Institute.	Chemical plant, Paper plant, electric power plant	Pipeline	Onshore depleted gas fields ～ Near Shore
④Metropolitan Aria CCS INPEX, Nippon Steel, Kanto Natural Gas Development	Steel plant, others	Pipeline	Near Shore
⑤Northern to Western Offshore CCS ENEOS、JX Nippon Oil & Gas Exploration、J-Power	Oil refinery, electric power plant	Ship, Pipeline	Offshore
⑥Offshore Malay CCS Mitsui & Co.	Oil refinery, Chemical plant, others	Ship, Pipeline	Oversea project (Malaysia)
⑦Oceania Mitsubishi Corp., Nippon Steel, ExxonMobil	Steel plant, others	Ship, Pipeline	Oversea project（Oceania）

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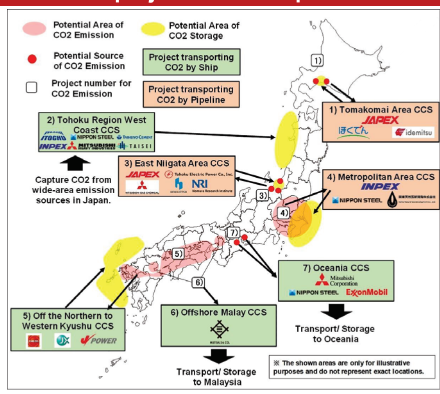
Locations of the selected projects and companies



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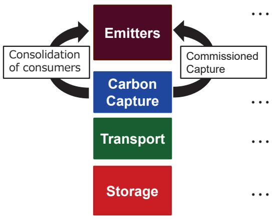
Lessons from Advanced CCS Program

- T & S companies requires several hundreds million dollars and high technologies to install. The number of potential entrants would be limited.
- In order to install Carbon Capture process and transportation, "Aggregator" for emitters is necessary to foster by promoting outsourcing. Some public utilities companies to think to enter.
- In CCS, quantities of CO2 to transport would be more than 100 times. Primary transport would be pipelines and shipping would fill the regional gap.

CCS System and its challenges



・・・ In Japan there are around 7,500 factories to consume more than energy equivalent to 3,000kl annually
・Large class facilities : couples of 100k – million ton
・Middle class facilities : couples of 10k – 100k ton
・Small class facilities : ～ couples of 10 K ton

・・・ "Aggregation business" to covers Carbon Capture needs
- Covering potential users and accept outsourcing of capture

・・・ Smooth installation of pipelines and liquified shipping
Pipelines are required to cover the general requirement

・・・ Expansion of its capacity and sustainable discovery of potential

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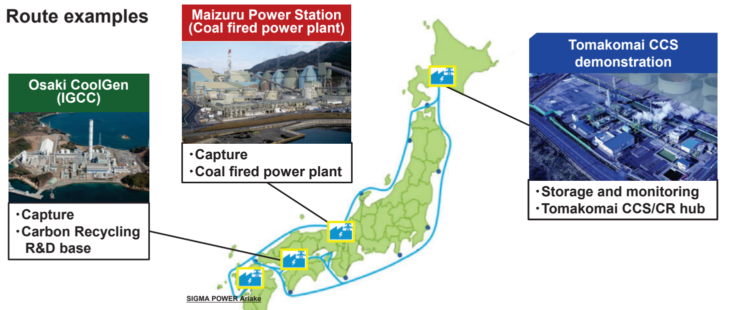
Liquefied CO2 Shipping Demonstration Project

A demonstration project for long-haul transportation from emission sources to places suitable for storage will be carried out to establish liquefied CO2 shipping techniques.

Liquefied CO2 Shipping Demonstration Project

In the hub and cluster plan for CCS, liquefied CO2 ship transportation is an important technology for transporting CO2 which is captured at distant emission sources.

Route examples



Demonstration transportation of CO2 will start in 2024

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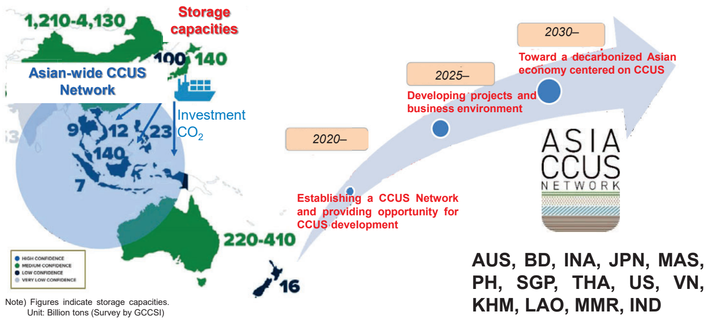
Building Asian-wide CCUS Network

In June 2021, **the Asia CCUS Network (ACN), an international industry-academia-government platform, was established as part of AETI**. **It aims to share knowledge and develop a business environment for CCUS utilization throughout Asia** where large-scale CO_2 storage potential is expected.



Note) Figures indicate storage capacities.
Unit: Billion tons (Survey by GCCSI)

AUS, BD, INA, JPN, MAS, PH, SGP, THA, US, VN, KHM, LAO, MMR, IND

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Japan's contribution toward CCS value chain

- Japan is the only economy that has various technology related to the CCS value chain, such as CO2 capture, transport and storage.

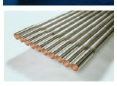
CO2 capture

[Engineering]
MITSUBISHI HEAVY INDUSTRIES — Global No.1 Provider for exhausted gases (70% of global market) and Provided for Petra Nova
NIPPON STEEL ENGINEERING — Provided for Steel Makers and Coal-fired power plants.
CHIYODA CORPORATION — Delivered PCC facility as EPC contractor, New technology development under NEDO project

Liquefied CO2 transport ship

[Engineering]
MITSUBISHI HEAVY INDUSTRIES — Low Temperature Low Pressure First mover in the world
[Shipping Company]
MOL Mitsui O.S.K. Lines — Invested in Larvik Shipping
K LINE — Provides for Northern Lights

CO2 pipeline



[Manufacturing]
NIPPON STEEL — Provides Seamless Pipe for CO2 Injection well of Northern Lights
[Engineering]
JFE Engineering Corporation
NIPPON STEEL ENGINEERING

Storage/Total engineering

[Engineering]
JGC — Designed "Tomakomai" Demonstration PJ
CHIYODA CORPORATION — Delivered CCS facilities for LNG plants in Qatar

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CCUS in Australia

Enabling industrial-scale emission abatement in the Asia Pacific

Dr Matthias Raab
Chief Executive Officer

APEC conference, Kobe, Japan
11 October 2023

Economic relationship between Australia & Japan

- Japan is Australia's third-largest trading partner, with 2-way goods and services trade valued at A$66.3 billion.
- Australia's major exports to Japan are **natural resources, including gas, coal, iron ore, copper and aluminium**
- In 2022, Australia supplied:
  - **43 per cent of Japan's LNG and**
  - **66 per cent per cent of coal**
- Australia and Japan have a deeply connected energy relationship and joint responsibility to decarbonise the energy sectors. CCS plays a vital role in this.

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CO2CRC is a world leader in applied CCUS research

We do research and commercially relevant demonstrations in CCUS applications.

We build and operate first of a kind plant and equipment.

We develop industry led technology options to accelerate commercial deployment.

We own and operate the Otway International Test Centre in South-West Victoria, Australia.

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Global collaboration between industry and academia

Trained over 60 PhDs

Published more than 450 peer-reviewed journal papers

Between 40 – 180 researchers participating in our research program at any one time

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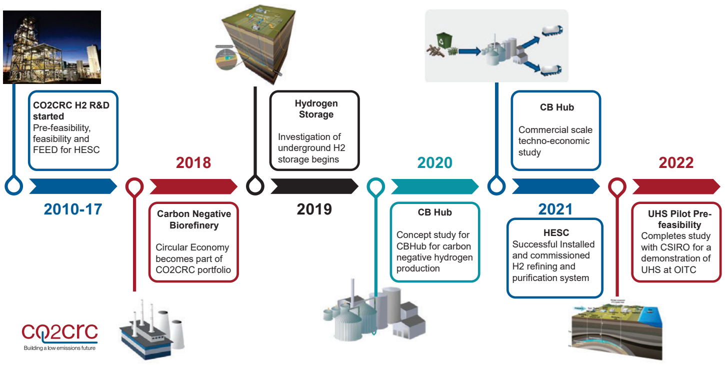
Hydrogen Research at CO2CRC



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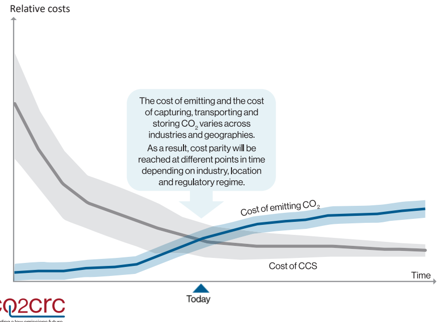
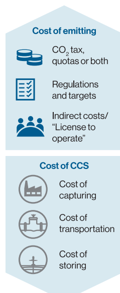
Recognising economic value of CCS

Cost of emitting CO_2 vs cost of CCS





Modified after Rystad Energy and analysis

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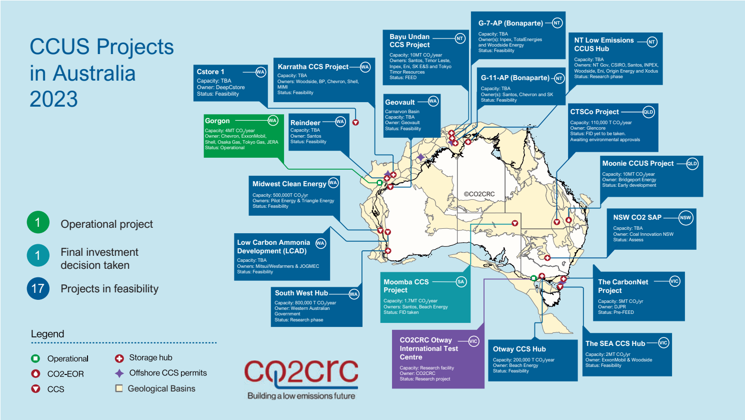
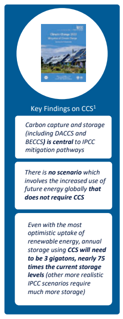


Carbon Capture & Storage is Necessary

- ✓ Carbon capture and storage (CCS) is necessary for the global emissions reduction targets to be met according to the IPCC, IEA and DOE
- ✓ CCS is safe, reliable and permanent; CCS has been in operation for decades, with multiple case studies of success
- ✓ There are no technical barriers that exist to prevent the required rollout of CCS
- ✓ CCS is a key enabler for a future hydrogen economy
- ✓ So… CCS IS necessary, but not everywhere is suitable for CCS
- ✓ Offshore Australia has vast potential for geological carbon storage, something that our major trading partners lack (London Protocol)



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[1]Soure: IPCC's Working Group III's (WGIII) Contribution to the Sixth Assessment Report, https://report.ipcc.ch/ar6wg3/

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Global Total Primary Energy Supply in the Net Zero (NZE) Scenario

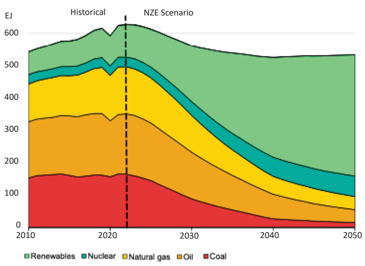

Figure modified after IEA Energy Technologies Perspectives 2023

NZE Scenario – sets out a pathway to stabilize global average temperatures at 1.5°C above pre-industrial levels. This scenario achieves global net zero energy sector CO2 emissions by 2050 without relying on emissions reductions from outside the energy sector (i.e. land clearing).

"Carbon capture, utilisation and storage (CCUS) plays an increasingly important role: CO_2 capture grows from around 0.04 Gt in 2021 to 1.2 Gt in 2030 and 6.2 Gt in 2050, with industry and fuel transformation sectors accounting for more than 40%, direct air capture (DAC) for around 5%, and power and heat generation for the rest by then."

IEA, *Energy Technologies Perspectives 2023*

The role of CCS will be significantly larger if the decline of fossil fuels is slower

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How Do We Get to Net Zero and What are the Challenges?

- We need to rollout multiple CCS projects with large-scale storage (multi-Mt/a) around and across Australia
- This roll-out needs to be done quickly to meet Net Zero
- However, the current project cycle takes ~9 years due to cumbersome regulatory processes, which only allows for three full project cycles between now and 2050
- How many large (>4Mt/a) CCS projects are in place or being planned?
  - How many are needed to meet Net Zero?

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Existing and Planned Large Australian CCS Projects/Hubs

- By 2032, if all of the projects below are online, we could potentially have up to **31 to 35 Mtpa** stored in these projects:
  - SEA CCS (2 Mt/a)
  - CarbonNet (6 Mt/a)
  - Moomba (1.7 Mt/a; soon to store)
  - Gorgon (1.7-4 Mt/a; storing now))
  - Bonaparte (G-7-AP) (10Mt/a)
  - Bayu-Undan (10Mt/a)
- This is quite optimistic, and most of these projects will not store CO_2 before 2030

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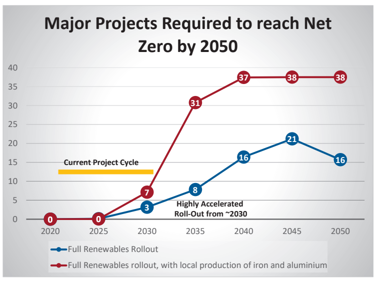
Number of Major Projects (>4Mtpa) to get to Net Zero



Data from Net Zero Australia Report 2023

- The longer the delay, *the more complex and difficult is the Net Zero challenge*
- Blue line is most optimistic, *red line is realistic*
- The average required number of projects is between ~20 and 40 from 2045, with 40 being more realistic; *majority of the projects will be required from 2032 after existing project cycle*
- Regulatory delay results directly in emissions that are higher than otherwise possible – *it really does matter*

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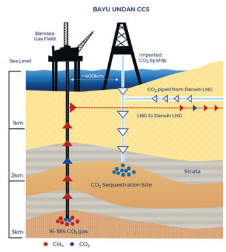
Summary

- To get to Net Zero, CCS is essential and will require a major project roll-out, which will have to accelerate dramatically after the current project cycle ends in ~2032
- To deliver on Net Zero, CCS projects will require a greatly accelerated regulatory process so that the project cycle can be shortened from the existing 9 years
- **CO2CRC leads** the **CCS Regulatory Affairs Task Force** and is working with industry and government to provide the required improvements in government regulation and allow companies to deliver on their Net Zero commitments

The Barossa / Darwin LNG / Bayu-Undan Project

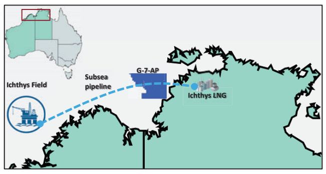


- The Barossa Gas Field has high (16-18%) concentrations of naturally occurring CO_2
- Gas produced from the Barossa Gas Field will be **transported via pipeline** to Darwin LNG
- The Darwin LNG facility will separate the Methane (CH_4) from the CO_2
- The CO_2 will be transported via Pipeline from Darwin LNG to the **Bayu-Undan depleted gas field** and injected into the reservoir for permanent geological storage

The Barossa / Darwin LNG / Bayu-Undan Project

- This project will involve repurposing the Bayu-Undan offshore facilities reservoir (located in Timor Leste waters) into a geological CO_2 storage hub (BU CCS) with a maximum capacity of 10 MTPA+
- New CO_2 transport and import facilities will be required
- Because Bayu-Undan is located in Timor-Leste, moving CO_2 from Australia to Timor-Leste will trigger the London Protocol

Ichthys Project



- Ichthys LNG is expected to produce up to 9.3 million tons of LNG and 1.65 million tons of LPG per annum, and more than 100,000 barrels of condensate per day at peak.
- The Ichthys Field is estimated to contain more than 12 trillion cubic feet of gas and 500 million barrels of condensate.
- The Brewster Formation has 8% CO_2 and the Plover Formation has approximately 17%. So it will ramp up once the switch to the Plover produces, but that is a long time from now.
- CCS will be essential to ensure Ichthys meets the requirements of the Safeguard Mechanism.

In Summary

- CCS is a proven suite of technologies
- Elements of a robust storage site:
  - Trapping, compression, seal and storage formation, no adverse impacts
- CCS is mandatory for future LNG

Collaboration to accelerate CCUS technology advancements

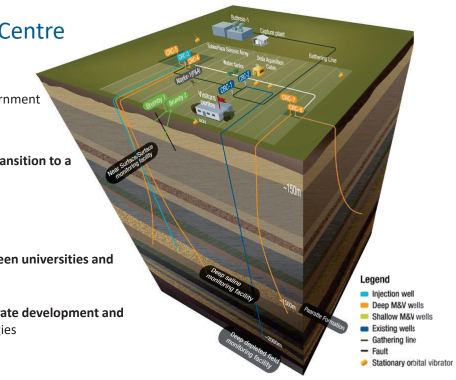
- Australia, Japan and Korea have ambitious 2030 emission reduction targets, CCUS is a key technology
- Development of **offshore CO_2 monitoring techniques**
- Execution of **field trials** at CO2CRC's Otway International Test Centre for improving CO_2 injection
- Progress **transboundary CCS** projects between Korea, Japan and Australia
- Development of **carbon credit methodology** for transboundary CCS
- Review of **domestic and international legal challenges** for transboundary CCS projects

Breakthrough technologies

Otway International Test Centre

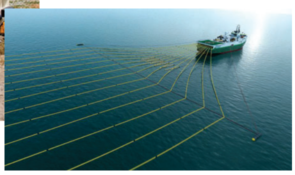
Key Success Factors

- **At scale investment** - Long term Government and Industry funding
- Focused on **accelerating Australia's transition to a low emissions future**
- **Industry led Research**
- Well-established **collaboration between universities and industry**, domestically and globally
- **Globally unique** test centre to accelerate development and **commercial deployment** of technologies



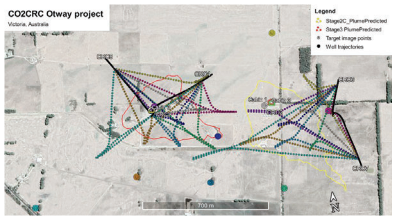
A paradigm shift in subsurface monitoring

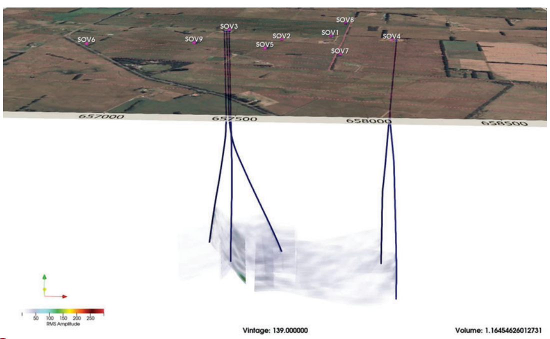
In order to see, the industry needed:



Risk based monitoring through downhole seismic and SOV/DAS

- The system was configured to provide a new image of the plume every 2 days.
- It first detected the gas plume on the 2nd day of injection with ~300 tonnes.





Summary

- Australia has a golden opportunity for global CCS leadership
- The CCS industry can move faster than government can approve projects
- Legislated targets are at odds with the industry's ability to get project approvals
- To achieve 43% of emission reduction by 2030, we will need 50% reduction in permitting time
- Permitting will determine the pace to net-zero
- Delays are deadly – a lack of urgency will force the status quo in emissions and deter investment
- Australia can create many win-win situations with Japan.

International Educational Opportunities in CCS

- **CO2CRC Education**: Essentials to detailed technical specialist level; bespoke courses can be tailored to individual needs
- **CO2CRC Symposium**: Shaping the Next Decade of CCS
  - 20-23rd November
  - Learn more about Australian CCS projects, CCS technology and the regulatory and policy landscape locally and globally
- CO2Tech: proposal reviews through to detailed technical evaluations

CO2Tech
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CO2CRC acknowledges and appreciates the strong relationships it has with industry, community, government, research organisations, and agencies in Australia and around the world

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BRIN #INOVASI INDONESIA

APEC Asia-Pacific Economic Cooperation

CCUS IN ASEAN: RECENT DEVELOPMENETS IN INDONESIA

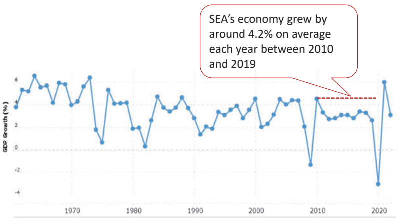
DR. USMAN PASARAI
OCTOBER 11, 2023

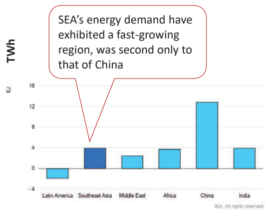
Outline

- Context 3
- Role of CCUS in NZE 5
- Recent CCUS/CCS development in Indonesia 6

Economic and energy trends

Southeast Asia is a major engine of global economic growth and energy demand



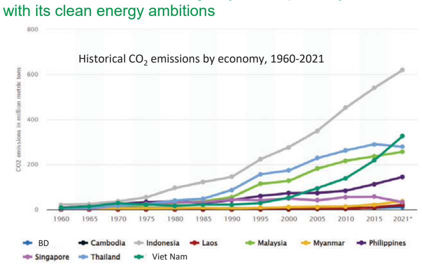


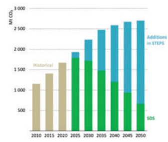
- As the economy and population have grown, total energy supply expanded by around 80% between 2000 and 2020.
- Power generation has almost tripled over the past two decades, driven by a sixfold increase in coal-fired generation, which accounted for more than 40% of total generation in 2020.
- As a result of the fossil-driven energy demand growth, CO2 emissions increased from 0.7 Gt in 2000 to over 1.6 Gt in 2020.

Source: Southeast Asia Energy Outlook, IEA (2022); https://www.macrotrends.net/countries/WLD/world/gdp-growth-rate (2023)

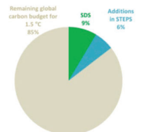
CO_2 emissions trends

Southeast Asia is still a long way off the pathway consistent with its clean energy ambitions





Cumulative CO_2 emissions between 2020 and 2050 is around 75 Gt in STEPS, and 45 Gt in SDS



Cumulative CO_2 emissions in SEA to 2050 and the remaining global carbon budget for 1.5°C

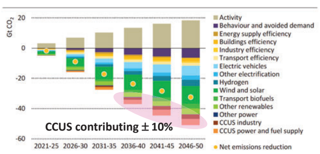
- In 2050, Southeast Asia comprises around 8% of the world's population and global GDP.
- Achieving net zero emissions will rely on support to ensure the deployment of key technologies and infrastructure for the SDS and NZE Scenarios.

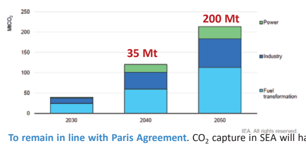
Source: Statista (2023); : Southeast Asia Energy Outlook, IEA (2022)

Role of CCUS in NZE pathways

CCUS technologies will play in putting the world on a path to NZE, contributing more than 10% of cumulative emission reduction globally by 2050

Average annual CO_2 reduction from 2020 in the NZE

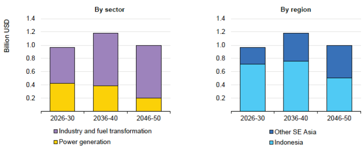




To remain in line with Paris Agreement. CO_2 capture in SEA will have to reach 35 Mt CO2 in 2030 and to exceed 200 Mt in 2050.

This includes lower-cost opportunities in industry, fuel supply sectors, and retrofitting of coal power plants.

Indonesia accounts for around 80% of SEA's projected CCUS investment in 2030, reflecting the size of its economic and the reative advanced state of CCUS development in this economy.

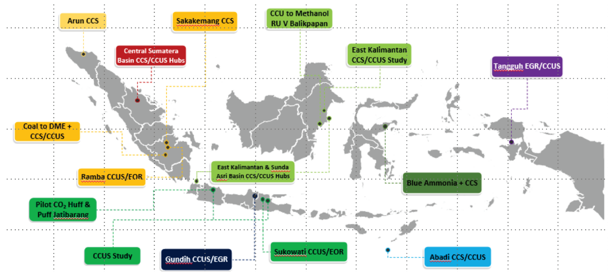


The role for CCUS spans virtually all parts of the global energy system including heavy industry, low-carbon hydrogen production, power generation, carbon removal, and as a source of CO2 for synthetic fuels.

Source: Net Zero by 2050, IEA (2021), CCUS Opportunities in SEA, IEA (2021)

CCUS/CCS projects in Indonesia @August 2022

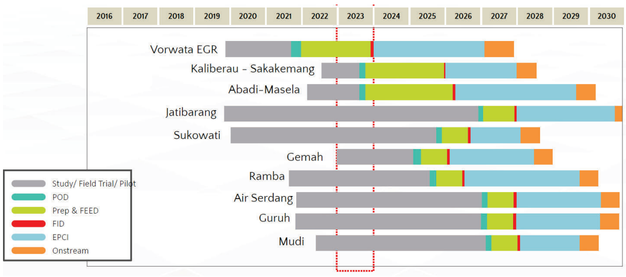
15 CCS/CCUS activities in Indonesia are still in the study/ preparation stage, but most are targeted for onstream before 2030



Source: DJMIGAS, MEMR (2022)

On going CCUS projects

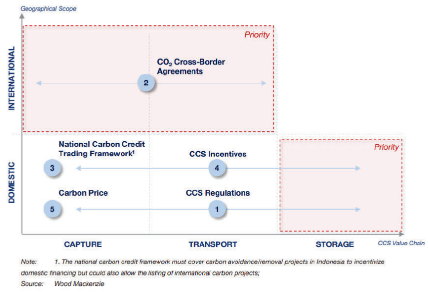
in the Indonesia's upstream oil & gas business



Source: IOG 4.0 SKKMIGAS (2023)

Strategic priorities for CCUS in Indonesia/SEA

Identify and develop onshore and offshore CO_2 storage resources



"CO2 Cross border agreement is required for transporting CO2 among countries as stated in Paris Protocol"

"To determine the technical aspect and profit sharing framework for Saline Aquifer Blocks"

Source: The Indonesia CCS Center (2023)

CO_2 storage potential

One of the first steps to evaluate regional CCUS options is to identify and estimate the storage potential of suitable geological formations

NO	EVALUATOR	YEAR	BASINS	FORMATIONS	CO_2 STORAGE (Giga Tones)
1	LEMIGAS – ADB	2013	South Sumatra	Talang Akar, Lahat	7.4
				Batu Raja, Lower Telisa	0.2
2	LEMIGAS – World Bank	2015	South Sumatra	Talang Akar	3.7 (P50)
				Batu raja	
				Lemat	
			North West Java	Talang Akar	4.9 (P50)
				Batu raja	
3	Yunyue Elita Li et al. (Exxon Mobil, Univ. of Singapore, Australia)	2022	South Sumatra		13 – 23
			North Sumatra		5 - 8
			Kutai		32 - 67
4	Ryoko Setoguchi (JOCMEC)	2023	North West Java	Parigi, Massive/Main, Batu Raja, Talanng Akar	69 (Best Case)
			East Java		
			North Sumatra	Upper Benio, Sihapas, Telisa, Batu Raja, Pematang	56 (Best Case
			Central Sumatra		
			South Sumatra		
5	ERIA - BRIN - MEMR	On going study	Includes 20 Production Basins	30 Formations, 1071 oil & gas fields	> 650 Gt in Saline Aquifers; > 12 Gt in O&G fields

Source: BRIN – MEMR - ERIA (2023)

Policies and regulations

Recent government policies will provide a boost to the CCUS development in Indonesia

- **Law Number 16 of 20016** concerning Ratification of the Paris Agreement to the UNFCCC. Ratification of this agreement is expected to increase international cooperation to implement climate change mitigation and adaptation actions with the support of funding, technology, transfer as well as transparency mechanisms and sustainable governance.
- **Law Number 7 of 2021** concerning Harmonized Taxation. This law regulates carbon tax.
- **Presidential Regulation Number 98 of 2021** "on Implementation of Carbon Economic Value to Achieve Nationally Determined Contribution Target and Control of Greenhouse Gas Emissions in National Development."

  Implementation of Carbon Economic Value. This regulation stipulates the implementation of **carbon trading**, **levies on carbon emission**, and **performance-based payment** for reducing carbon emission.
- **Minister of Environment and Forestry Regulation Number 21 of 2022** on the Guidelines of carbon Economic Value Implementation.
- **Minister of Energy and Mineral Resources Regulation Number 2 of 2023** on the Implementation of Carbon Capture and Storage, as well as Carbon Capture, Utilization and Storage in Upstream Oil and Gas Business Activities.
- **Financial Services Authority (OJK) Regulation no. 4 of 2023** concerning Carbon Trading through the Carbon Exchange.

Policies and regulations

Regulations have been established

Regime	CCUS-Specific Framework Act	CCUS Regulatory Authorities	CCUS Acreage Licensing Programme	CCUS Permitting Process	CCUS Project Terms & Obligations	CCUS Liability	Carbon Credit System	CCUS Tax Incentives	Other support for CCUS
Alberta Canada	✔ Well developed	✔ Well developed	✔ Well developed	✔ Well developed	✔ Fairly developed	✔ Well developed	✔ Well developed	✔ Well developed	✔ Well developed
Australia	✔ Well developed	✔ Well developed	✔ Well developed	✔ Well developed	✔ Fairly developed	✔ Well developed	✔ Well developed	✘ Initial development/absent	✔ Well developed
Indonesia	✔ Fairly developed	✔ Fairly developed	✘ Initial development/absent	✔ Fairly developed	✔ Fairly developed	✔ Fairly developed	✘ Initial development/absent	✘ Initial development/absent	✘ Initial development/absent

Source: S&P Global Commodity Insights

✔ Well developed ✔ Fairly developed ✘ Initial development/absent

Source: IOG 4.0 SKKMIGAS (2023)

Research and Development for DAC in Japan

Kenji Yamaji
Program Director for Moonshot Goal No. 4
President, Research Institute of Innovative Technology for the Earth (RITE)

APEC Symposium on
Pursuing Decarbonation of Fossil Fuels
Session 5. Direct （Air） Carbon Capture (DAC)

October 11, 2023
KOBE PORTPIA HOTEL @Kobe City, Hyogo, Japan

1

Recent Development for Carbon Neutrality in Japan

2015/12：Paris Agreement adopted at COP21
2018/10：Special Report of IPCC for 1.5°C (Carbon Neutrality by 2050)
2020/10：Japan announced 2050 Carbon Neutrality
2020/12：Japan decided Green Growth Strategy (updated June, 2021)

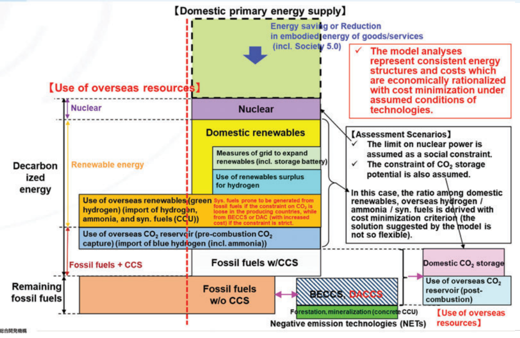
2021/04：Climate Summit by US President Biden
Japan announced a new 2030 Target (46% reduction)

2021/10：Japan decided 6th Strategic Energy Plan
2021/11：COP26 in UK

2022/02：Russian invasion of Ukraine started
2022/11：COP27 in Egypt
2023/02 : Japan decided Basic Policy for GX (Green Transformation)

2

Image of Primary Energy in Japan for Net Zero Emissions (by Keigo Akimoto, RITE)



3

Implications of RITE 2050CN Scenario Analysis Results

- Various measures such as Energy Conservation, Renewables, Nuclear, CCUS, Hydrogen/Ammonia, NETs(Negative Emission Technologies) are mobilized to realize Carbon Neutrality. Nuclear is used to the level of the upper constraint in the optimal solution.
- Electrification and decarbonization of electricity are commonly required in all scenarios for Carbon Neutrality while costs of electricity increase. Electricity of 100% renewables further increases the cost, thus suppress the electrification of final demands in the optimal solution.
- Hydrogen and zero-emission synfuels are used in non-electric demand sectors. NETs are used to offset the emissions from the hard-to-abate sectors for realizing Carbon Neutrality.
- DAC (Direct Capture of CO_2 in Air) is commonly used in all scenarios to realize Carbon Neutrality. Scale of the utilization of recovered CO_2 is limited. CO_2 storage capacities abroad are used as well as the domestic storage capacities for Carbon Neutrality in Japan.
- Super smart society (Society 5.0) promotes circular/sharing economies leading substantial energy/material reductions, thus to explore a new perspective to realize a huge energy conservation with low costs.

4

Moonshot Goals

Goals

To realize "Human Well-being",
9 Moonshot goals were decided in the area of society, environment, and economics.

Goal 4 ：**Realization of sustainable resource circulation to recover the global environment by 2050.**
Started in 2020 as the first group of MS Goals

5

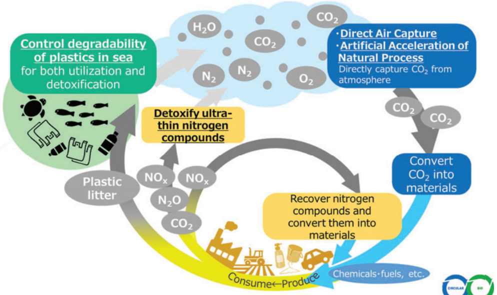
The concept of Moonshot Goal No. 4

6

Moonshot R&D Program

Moonshot Goal 4 Realization of sustainable resource circulation to recover the global environment by 2050

- **About:**
To develop radical solutions for difficult societal challenge, the Government of Japan set 9 inspiring and ambitious goals (Moonshot Goals) for challenging R&D. NEDO is pursuing ambitious R&D activities to achieve Moonshot Goal 4. This program began in 2020 and will last up to 10 years.
- **Program Director:**
Dr. YAMAJI Kenji
President, Director-General of the Research Institute of Innovative Technology for the Earth (RITE)



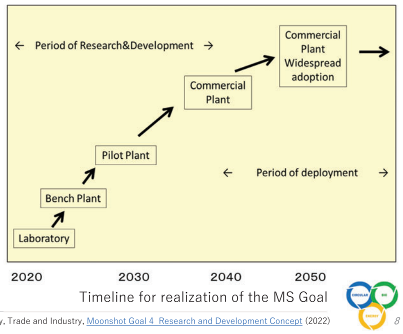
Target of Moonshot Goal 4

Outcome target (2050): The Cool Earth & The Clean Earth

Realization of sustainable resource circulation to recover the global environment. Commercial plants or products utilizing circulation technology will be deployed globally.

Output target (2030): Cool Earth

Development of circulation technology on a pilot scale for reducing greenhouse gases, that is also **effective in terms of life cycle assessment** (LCA).



Timeline for realization of the MS Goal

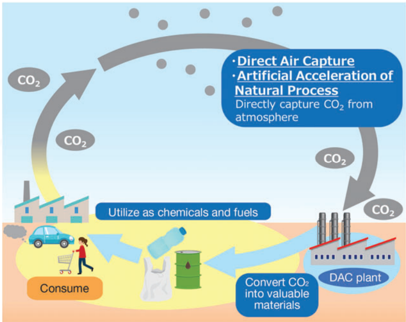
Ministry of Economy, Trade and Industry, Moonshot Goal 4 Research and Development Concept (2022)

Outline of DAC-U projects

Development of Technologies to Recover CO_2 and Convert Them into Valuable Materials

In this program, various technologies to realize direct air capture (DAC) are being developed to capture low-concentration (around 0.04%) CO_2 that diffuses into the atmosphere, with the aim of **commercializing low-cost, high-efficiency DAC technologies**.

In addition to DAC technologies, various new technologies are being developed to convert captured CO_2 into valuable.

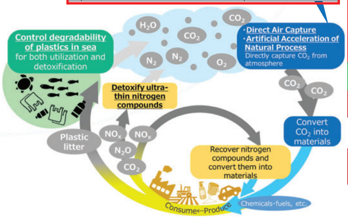


Outline of DAC-U projects

Chemical engineering
Mineralization
Biomass

Cool Earth Development of technologies to recover greenhouse gases ("GHGs") and convert them into valuable materials

	R&D Projects	Project Managers
1	Development of highly efficient direct air capture (DAC) and carbon recycling technologies	Dr. KODAMA Akio, Kanazawa University
2	Integrated Electrochemical Systems for Scalable CO2 Conversion to Chemical Feedstocks	Dr. SUGIYAMA Masakazu, The University of Tokyo
3	C4S Research and Development Project	Dr. NOGUCHI Takafumi, The University of Tokyo
4	Research and development toward saving energy for direct air capture with available cold energy	Dr. NORINAGA Koyo, Nagoya University
5	Development of Combined Carbon Capture and Conversion (quad-C) modules targeting low carbon dioxide concentration gases for balancing the global carbon budget	Dr. FUKUSHIMA Yasuhiro, Tohoku University
6	Development of Global CO2 Recycling Technology towards "Beyond-Zero" Emission	Dr. FUJIKAWA Shigenori, Kyushu University
7	Redesign of Macroalgae for Highly Efficient CO2 Fixation by Functional Modifications and Their Product Generation	Dr. UEDA Mitsuyoshi, Kyoto University
8	Advanced Enhanced Rock Weathering (A-ERW) Technology Actively Combined With Site Characteristics	Dr. NAKAGAKI Takao, Waseda University
9	Development of Next-generation CO2 -fixing Plant Through the Gene Optimization, Distant Hybrid, and Microbial Symbiosis	Dr. MITSUDA Nobutaka, National Institute of Advanced Industrial Science and Technology (AIST)
10	Feasibility Study of Enhanced Mineralization Based on LCA/TEA Platform	Dr. MORIMOTO Shinichirou, National Institute of Advanced Industrial Science and Technology (AIST)
11	Agrobiotechnological Direct Air Capture Towards Carbon Circulation Society	Dr. YANO Masahiro, National Agriculture and Food Research Organization (NARO)

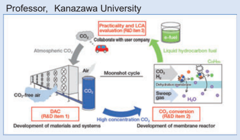


Outline of DAC-U projects (Chemical engineering)

PM


Development of highly efficient Direct Air Capture (DAC) and carbon recycling technologies

Dr. KODAMA Akio
Professor, Kanazawa University



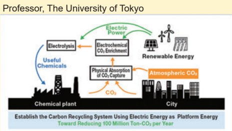
POINT
- Development of innovative **amine-loaded CO_2 solid sorbent**
- CO_2 capture and enrichment process using less energy than conventional technologies

Implementing organizations: Kanazawa University, Research Institute of Innovative Technology for the Earth (RITE)

PM


Integrated Electrochemical Systems for Scalable CO_2 Conversion to Chemical Feedstocks

Dr. SUGIYAMA Masakazu
Professor, The University of Tokyo



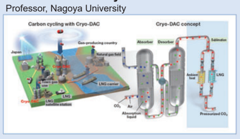
POINT
- Creation of a system fore CO_2 enrichment and reduction to chemical feedstocks by **electro-chemical process** using renewable electricity
- Flexible system that allows for small-scale Distributed deployment

Implementing organizations: The University of Tokyo, Osaka University, RIKEN, Ube Industries, Ltd., Shimizu Corporation, Chiyoda Corporation, Furukawa Electric Co., Ltd.

PM


Research and development toward saving energy for Direct Air Capture with available cold energy

Dr. NORINAGA Koyo
Professor, Nagoya University



POINT
- Direct capture of atmospheric CO_2 by employing Unused cold energy from **liquefied natural gas (LNG)**
- Pressure swing recovery of CO_2 by the CO_2 sublimation while operating both absorber and desorber at room temperature

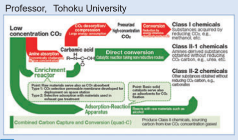
Implementing organizations: Nagoya University, Toho Gas Co., Ltd., Tokyo University of Science

Outline of DAC-U projects (Chemical engineering)

PM


Development of Combined Carbon Capture and Conversion (quad-C) modules targeting low carbon dioxide concentration gases for balancing the global carbon budget

Dr. FUKUSHIMA Yasuhiro
Professor, Tohoku University



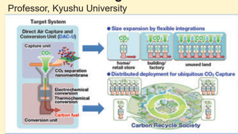
POINT
- Creation of streamlined reaction system, termed "quad-C", by directly **linking CO_2 fixation and conversion**
- Takes energy-efficient conversion routes without Carbon reduction

Implementing organizations: Tohoku University, Osaka Metropolitan University, Renaissance Energy Research Corporation

PM

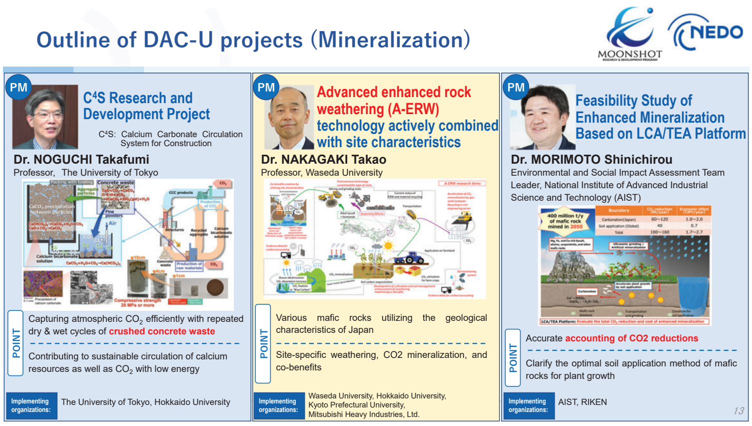

Development of Global CO_2 Recycling Technology towards "Beyond-Zero" Emission

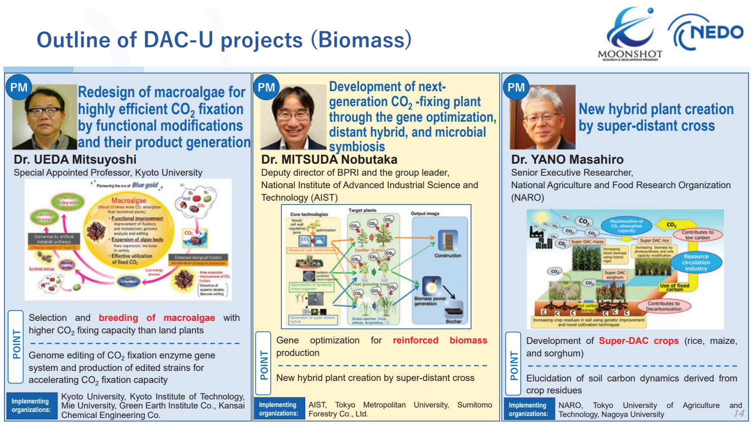
Dr. FUJIKAWA Shigenori
Professor, Kyushu University

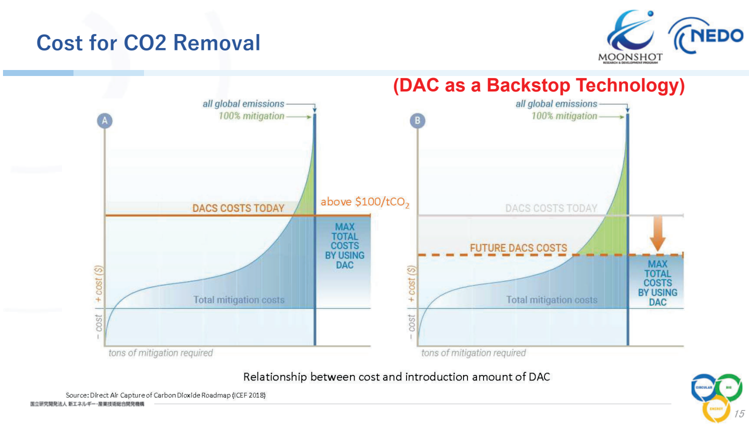


POINT
- Development of CO_2 capture using innovative **separation nano-membranes** with unparalleled CO_2 permeability
- Scalable system for use in small-sized homes and medium-sized buildings

Implementing organizations: Kyushu University, Kumamoto University, Hokkaido University

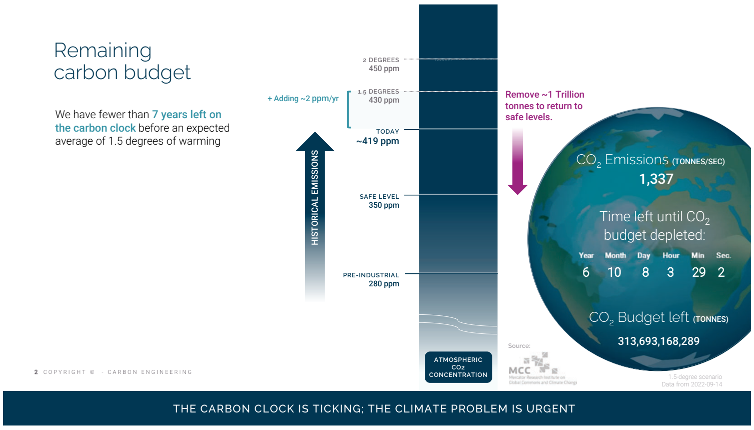

Outline of DAC-U projects (Mineralization)
MOONSHOT
NEDO
PM
C4S Research and Development Project
C4S: Calcium Carbonate Circulation System for Construction
Dr. NOGUCHI Takafumi
Professor, The University of Tokyo
POINT
Capturing atmospheric CO2 efficiently with repeated dry & wet cycles of crushed concrete waste
Contributing to sustainable circulation of calcium resources as well as CO2 with low energy
Implementing organizations: The University of Tokyo, Hokkaido University
PM
Advanced enhanced rock weathering (A-ERW) technology actively combined with site characteristics
Dr. NAKAGAKI Takao
Professor, Waseda University
POINT
Various mafic rocks utilizing the geological characteristics of Japan
Site-specific weathering, CO2 mineralization, and co-benefits
Implementing organizations: Waseda University, Hokkaido University, Kyoto Prefectural University, Mitsubishi Heavy Industries, Ltd.
PM
Feasibility Study of Enhanced Mineralization Based on LCA/TEA Platform
Dr. MORIMOTO Shinichirou
Environmental and Social Impact Assessment Team Leader, National Institute of Advanced Industrial Science and Technology (AIST)
POINT
Accurate accounting of CO2 reductions
Clarify the optimal soil application method of mafic rocks for plant growth
Implementing organizations: AIST, RIKEN
13

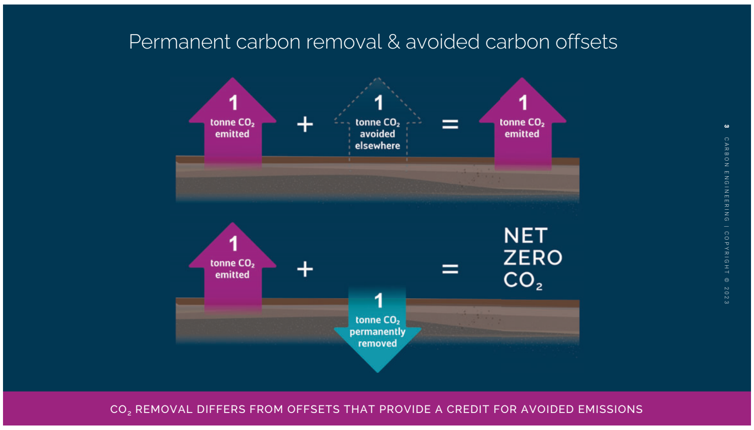

Outline of DAC-U projects (Biomass)
MOONSHOT
NEDO
PM
Redesign of macroalgae for highly efficient CO2 fixation by functional modifications and their product generation
Dr. UEDA Mitsuyoshi
Special Appointed Professor, Kyoto University
POINT
Selection and breeding of macroalgae with higher CO2 fixing capacity than land plants
Genome editing of CO2 fixation enzyme gene system and production of edited strains for accelerating CO2 fixation capacity
Implementing organizations: Kyoto University, Kyoto Institute of Technology, Mie University, Green Earth Institute Co., Kansai Chemical Engineering Co.
PM
Development of next-generation CO2 -fixing plant through the gene optimization, distant hybrid, and microbial symbiosis
Dr. MITSUDA Nobutaka
Deputy director of BPRI and the group leader, National Institute of Advanced Industrial Science and Technology (AIST)
POINT
Gene optimization for reinforced biomass production
New hybrid plant creation by super-distant cross
Implementing organizations: AIST, Tokyo Metropolitan University, Sumitomo Forestry Co., Ltd.
PM
New hybrid plant creation by super-distant cross
Dr. YANO Masahiro
Senior Executive Researcher, National Agriculture and Food Research Organization (NARO)
POINT
Development of Super-DAC crops (rice, maize, and sorghum)
Elucidation of soil carbon dynamics derived from crop residues
Implementing organizations: NARO, Tokyo University of Agriculture and Technology, Nagoya University
14

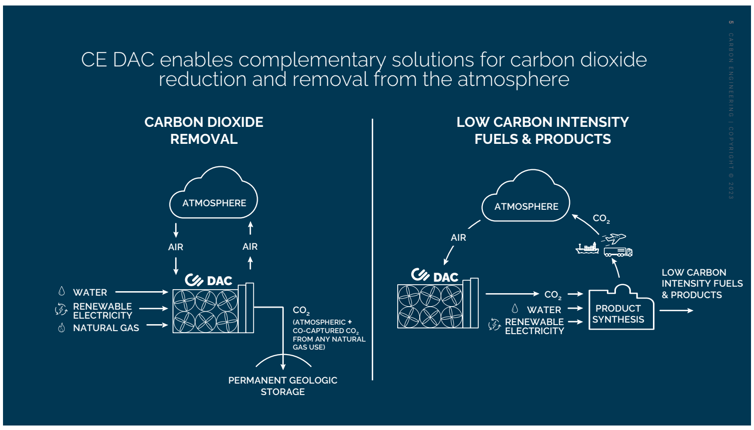

Cost for CO2 Removal
MOONSHOT
NEDO
(DAC as a Backstop Technology)
A
all global emissions
100% mitigation
DACS COSTS TODAY
above $100/tCO2
MAX TOTAL COSTS BY USING DAC
Total mitigation costs
- cost | + cost ($)
tons of mitigation required
B
all global emissions
100% mitigation
DACS COSTS TODAY
FUTURE DACS COSTS
MAX TOTAL COSTS BY USING DAC
Total mitigation costs
- cost | + cost ($)
tons of mitigation required
Relationship between cost and introduction amount of DAC
Source: Direct Air Capture of Carbon Dioxide Roadmap (ICEF 2018)
15

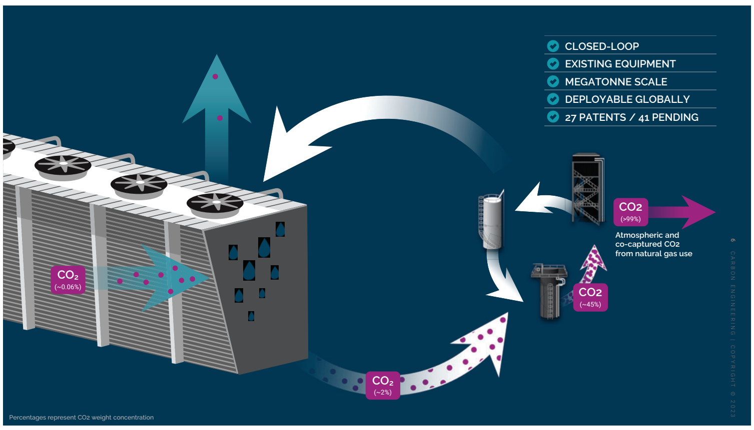

ご清聴ありがとうございました
Thanks for your attention
公益財団法人 地球環境産業技術研究機構 (RITE)
Research Institute of Innovative Technology for the Earth
16

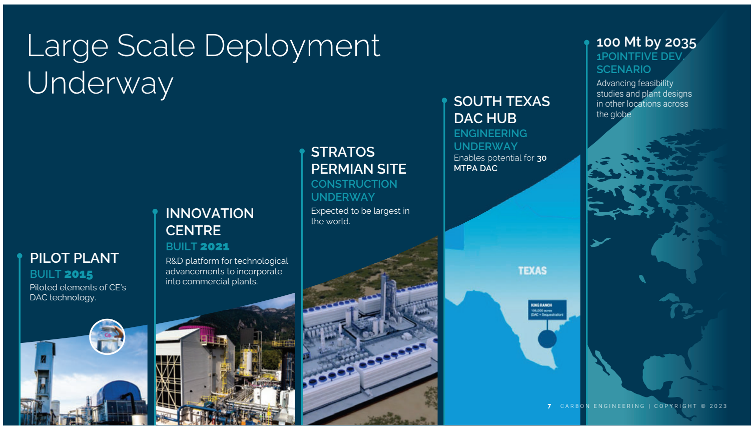
1-13. Commercial-scale Direct Air Capture





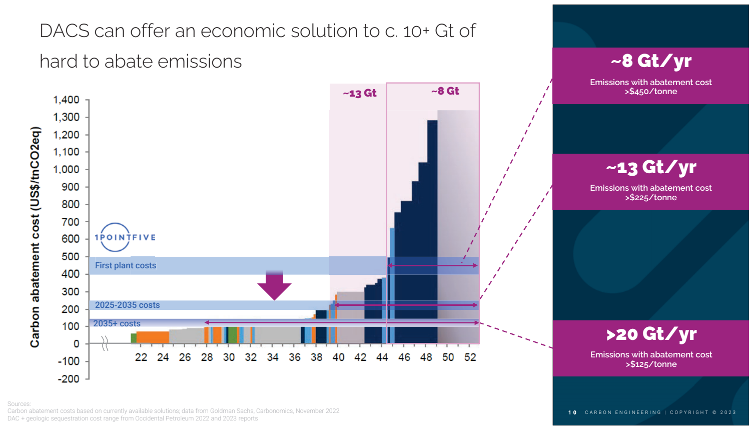





Large Scale Deployment Underway
PILOT PLANT
BUILT 2015
Piloted elements of CE's DAC technology.
INNOVATION CENTRE
BUILT 2021
R&D platform for technological advancements to incorporate into commercial plants.
STRATOS PERMIAN SITE
CONSTRUCTION UNDERWAY
Expected to be largest in the world.
SOUTH TEXAS DAC HUB
ENGINEERING UNDERWAY
Enables potential for 30 MTPA DAC
100 Mt by 2035
1POINTFIVE DEV. SCENARIO
Advancing feasibility studies and plant designs in other locations across the globe
TEXAS
7 CARBON ENGINEERING | COPYRIGHT © 2023


CE Innovation Centre
Squamish, BC, Canada
Built 2021
Validation plant for pre-commercial testing of equipment (run-replace-run), ~1,000 t/y capacity
Extensive facilities for lab and bench scale testing
Lab, bench, and fully-integrated demonstration testing


STRATOS
Permian Basin, Texas, US
Expected to capture 500kt/year once fully complete
Site prep and early construction started Q4 2022
Operations targeting mid-2025
CANADA
MEXICO
9 CARBON ENGINEERING | COPYRIGHT © 2023
STRATOS, THE FIRST COMMERCIAL SCALE DAC PLANT TO USE CE TECH, IS UNDER CONSTRUCTION BY 1POINTFIVE


DACS can offer an economic solution to c. 10+ Gt of hard to abate emissions
Carbon abatement cost (US$/tnCO2eq)
~13 Gt
~8 Gt
1POINTFIVE
First plant costs
2025-2035 costs
2035+ costs
~8 Gt/yr
Emissions with abatement cost >$450/tonne
~13 Gt/yr
Emissions with abatement cost >$225/tonne
>20 Gt/yr
Emissions with abatement cost >$125/tonne
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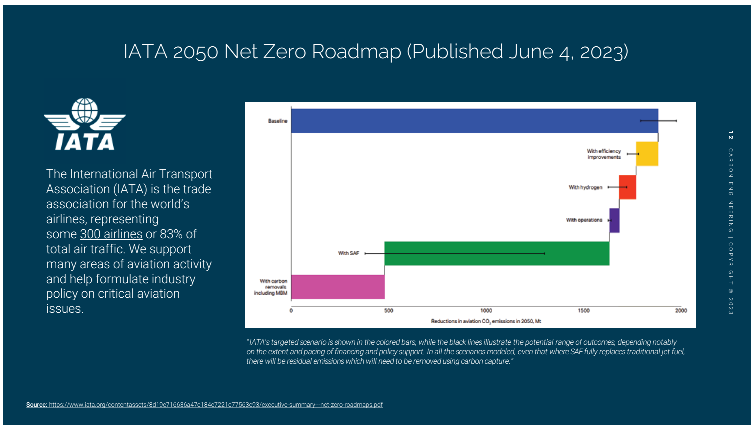
A solution for hard to abate transportation sectors
DAC enables complementary solutions for reduction and removal
1 Durable Carbon Dioxide Removal (CDR)
1POINTFIVE
DAC by Carbon Engineering
2 Sustainable Aviation Fuel (SAF)
Produced through CE's AIR TO FUELS™ process.
CE's fuel (right) compared to conventional diesel (left)
BOTH options are considered equal in existing and emerging high-integrity transportation decarbonization compliance markets like the pioneering California LCFS (and WA/BC LCFS policies)


IATA 2050 Net Zero Roadmap (Published June 4, 2023)
IATA
The International Air Transport Association (IATA) is the trade association for the world's airlines, representing some 300 airlines or 83% of total air traffic. We support many areas of aviation activity and help formulate industry policy on critical aviation issues.
Baseline
With efficiency improvements
With hydrogen
With operations
With SAF
With carbon removals including MBM
Reductions in aviation CO2 emissions in 2050, Mt
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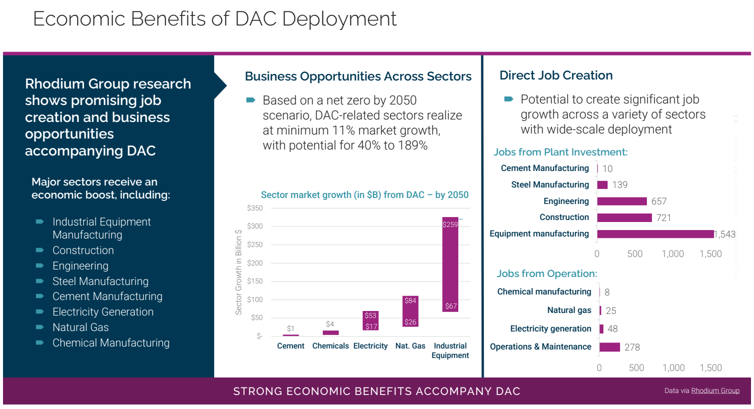
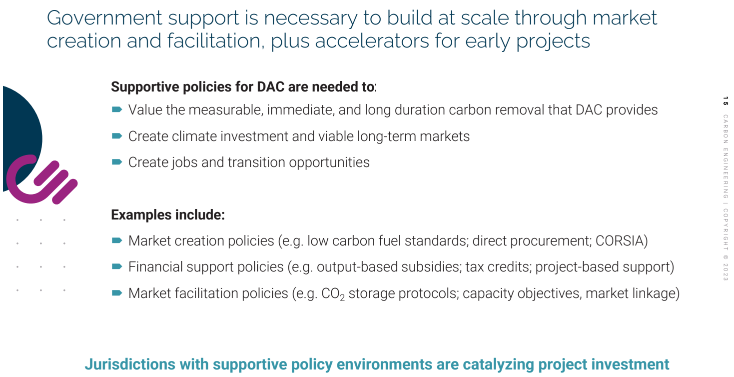
Over the last 18 months, aviation partners have joined CE/1P5 to accelerate DAC
1 March 2022
Airbus pre-purchased 400,000 tonnes of CDR from 1PointFive
2 July 2022
Airbus announced a CDR collaboration with seven other airlines (and airline groups) at the Farnborough airshow
3 November 2022
Carbon Engineering announced significant R&D investments by Airbus and Air Canada
4 August 2023
All Nippon Airways announced the pre-purchase of 30,000 tonnes of CDR from 1PointFive, becoming the first airline to directly purchase CDR.
AIRBUS
1POINTFIVE
AIR CANADA
AIRFRANCE KLM
Lufthansa
easyJet
LATAM
virgin atlantic
IAG
AIRBUS
AIR CANADA
ANA
Direct Air Carbon Capture & Storage
1 million tonnes


Economic Benefits of DAC Deployment
Rhodium Group research shows promising job creation and business opportunities accompanying DAC
Major sectors receive an economic boost, including:
Industrial Equipment Manufacturing
Construction
Engineering
Steel Manufacturing
Cement Manufacturing
Electricity Generation
Natural Gas
Chemical Manufacturing
Business Opportunities Across Sectors
Based on a net zero by 2050 scenario, DAC-related sectors realize at minimum 11% market growth, with potential for 40% to 189%
Sector market growth (in $B) from DAC – by 2050
Sector Growth in Billion $
$350
$300
$250
$200
$150
$100
$50
$-
$1
$4
$53
$17
$84
$26
$259
$67
Cement
Chemicals
Electricity
Nat. Gas
Industrial Equipment
Direct Job Creation
Potential to create significant job growth across a variety of sectors with wide-scale deployment
Jobs from Plant Investment:
Cement Manufacturing 10
Steel Manufacturing 139
Engineering 657
Construction 721
Equipment manufacturing 1,543
0
500
1,000
1,500
Jobs from Operation:
Chemical manufacturing 8
Natural gas 25
Electricity generation 48
Operations & Maintenance 278
0
500
1,000
1,500
STRONG ECONOMIC BENEFITS ACCOMPANY DAC
Data via Rhodium Group


Government support is necessary to build at scale through market creation and facilitation, plus accelerators for early projects
Supportive policies for DAC are needed to:
Value the measurable, immediate, and long duration carbon removal that DAC provides
Create climate investment and viable long-term markets
Create jobs and transition opportunities
Examples include:
Market creation policies (e.g. low carbon fuel standards; direct procurement; CORSIA)
Financial support policies (e.g. output-based subsidies; tax credits; project-based support)
Market facilitation policies (e.g. CO_2 storage protocols; capacity objectives, market linkage)
Jurisdictions with supportive policy environments are catalyzing project investment


MORE INFORMATION CAN BE FOUND AT:
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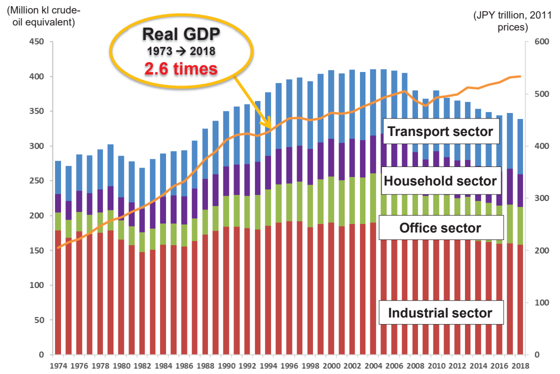
METI Ministry of Economy, Trade and Industry

The Evolution of Energy Efficiency Policy to Support Clean Energy Transition in Japan

January 2024
Ministry of Economy, Trade and Industry (METI), Japan

Trends in final energy consumption

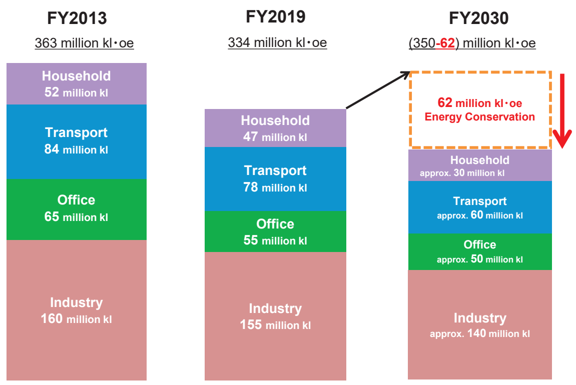
➔ Real GDP is up 2.6 times since the oil crisis in 1970s, while final energy consumption is up 1.2 times.



Final energy consumption	
Total	1973 → 2018 1.2 times
Transport	1973 → 2018 1.7 times
Household	1973 → 2018 1.9 times
Office	1973 → 2018 2.1 times
Industry	1973 → 2018 0.8 times

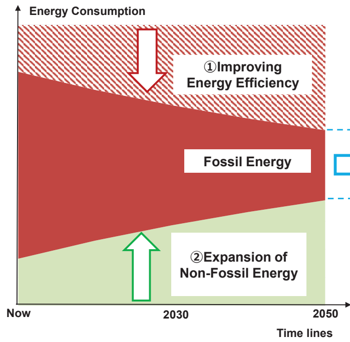
1

The policy target of energy conservation



2

The Evolution of Energy Efficiency Policy to Support Clean Energy Transition



<Improving Energy Efficiency>
[Industry]
・Expansion and revision of Industrial and Business Benchmarking
・Support for development, practical application, and introduction of energy efficiency technologies
[Building]
・Expanding ZEB/ZEH, reviewing building energy efficiency standards
・Reviewing and strengthening the Top Runner Program for equipment and building materials
[Transport]
・Reviewing system, improving logistics Efficiency

Necessary technologies in the future: CCS, DACCS, BECCS, etc.

<Expansion of Non-Fossil Energy>
・Expand introduction of non-fossil energy such as renewable energy for self-consumption and hydrogen etc. (i.e., upgrading of demand)
・Optimization of demand according to electricity supply and demand conditions, including use of surplus renewable energy
・Utilization of on-site power generation and equipment control to stabilize the grid, etc.

3

The Overview of Demand-side Policies: Regulation and Incentives

Regulation

Energy Conservation Act
(the Act on Rationalizing Energy Use and Shifting to Non-fossil Energy)

- Reporting obligation for large-scale enterprises
- Requirement to achieve energy efficiency criteria for manufacturers (called "Top Runner Program")

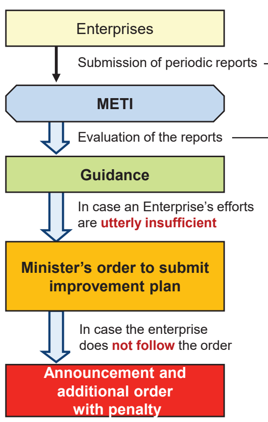
Incentives

Energy Conservation Subsidies Package (2022/2023)

- Replacing inefficient facilities
- Experts' advice for SMEs
- Insulation retrofitting and residential water heater (heat pumps)

4

Energy Conservation Act: (1) Reporting obligation for large-scale enterprises



○The amount of fossil energy consumption
○The amount of non-fossil energy consumption
○The plan of energy conservation and shift to non-fossil energy

Evaluation

○**Non-binding target**
・Reduction of specific energy consumption by 1% or more on an annual average basis, etc.

○**Benchmark index/Target levels**
(only for applicable sectors*)
Target level: Level met by the best operators in each industry

* Manufacture of steel, power supply, manufacture of cement, manufacture of paper, petroleum refinery, and manufacture of chemicals

○As the result,
- Achievers are evaluated as excellent (S-class) businesses.
- For large companies, the acquisition of S-Class is required for subsidies.

5

Energy Conservation Act: (1) Reporting obligation for large-scale enterprises

1979.

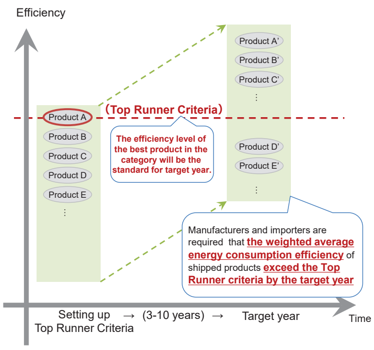
The Act on Rationalizing Energy Use

2022.

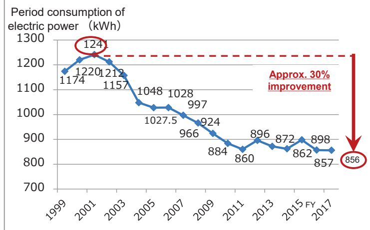
The Act on Rationalizing Energy Use and Shifting to Non-fossil Energy

Energy Conservation Act: (2) Requirement for Manufacturers

How Top Runner Program Works



The Outcome Example: Air-conditioners



- Trends in simple averages for air-conditioners (Cooling capacity 2.8kW (14.6 - 21.9m²))
- The period consumption of electric power is based on JIS C 9612:2005

Source: Energy efficiency performance catalogs of each FY (summer, winter)

Incentives: Energy Conservation Subsidies Package

		Dec. 2022	Dec. 2023
Businesses	Replacing inefficient facilities	500 billion JPY = 3.4 billion USD (the amount of next 3 years)	700 billion JPY = 4.8 billion USD (the amount of next 3 years)
Businesses	Experts' advice for SMEs	2 billion JPY = 14 million USD	2.1 billion JPY = 14 million USD
Households	Insulation Retrofitting / Residential Water Heater	280 billion JPY = 1.9 billion USD	420 billion JPY = 2.9 billion USD

＊Amount assuming JPY145.0 per USD

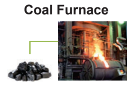
Incentives: (1) Replacing inefficient facilities

Type 1: Energy efficiency improvement throughout the plant or building

Improvement Rate: **10%** or Reduction of Energy Consumption **700kloe**

New **Type 2: Select facilities from the list**
***Specialized for Electrification and Fuel Switching**

Coal Furnace



Electric Furnace

*Facilities example

Type 3: Select facilities from the list

Heat Pumps

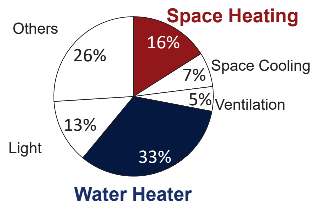
Air Conditioner

Motors

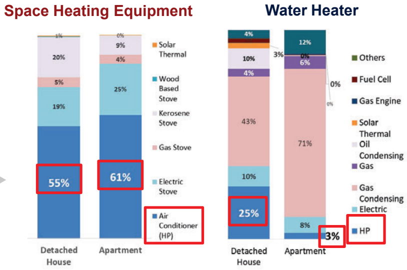
*Facilities example

Incentives: (2) Residential Water Heater

Household Energy Consumption



- While central-heating system (with water heater) is the main system of space heating in Europe, individual-heating system (with air conditioner) is the main system of space heating in Japan.
- Japan people habitually take a bath, so water heater occupies 33% of the household energy consumption.



*each graph shows warmer climate case

Incentives: (2) Residential Water Heater

	Subsidy for Owners (2022)	Subsidy for Owners (2023)
① Heat Pump Water Heater	50,000 Yen/unit	100,000 Yen/unit
② Hybrid Water Heater	50,000 Yen/unit	130,000 Yen/unit
③ Residential Fuel Cell	150,000 Yen/unit	200,000 Yen/unit

① Heat Pump Water Heater

Source: Panasonic

② Hybrid Water Heater

Source: Rinnai

③ Residential Fuel Cell

Source: Aisin Corp.

*Subsidy amount depends on the additional function (e.g. DR-Ready). Described is the main example of amount.

G7 Communiqué: "Energy Efficiency First" and Developing demand side policies

G7 Hiroshima Leaders' Communiqué

Energy - 25.
"Through our experience in coping with past and current energy crises, we highlight the importance of **enhanced energy efficiency and savings as the "first fuel"**, and of **developing demand side energy policies**."

G7 Climate, Energy and Environment Ministers' Communiqué

63. Energy efficiency.
・・・We underline the need for '**energy efficiency first**' to be recognized as a driving principle for our actions to ensure that energy efficiency and energy savings are duly taken into consideration in policy, planning and investment decisions. We also note that **energy efficiency regulations**, such as vehicle fuel efficiency regulations, building codes, minimum energy performance standards, energy performance certificates, and energy reporting systems for large scale consumers continue to gain momentum. **These measures will leverage further efforts to decarbonize energy demand**, with strategic approaches including electrification, fuel switching, grid flexibility, digitalization of energy demand information and disclosure of energy and climate related information. ・・・

End of Document

The APEC Symposium on Promoting Energy Efficiency and Energy Management System

The Key to an Energy Resilient APEC: Energy Efficiency and Energy Management

Dr. LIU Meng
Chair, APEC EGEEC
China National Institute of Standardization

23 January 2024, Tokyo Japan

Multiple benefits of energy efficiency

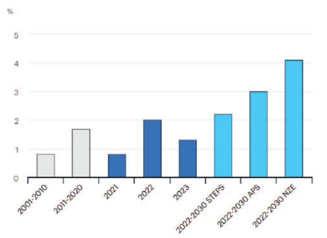
Source: International Energy Agency

Asia-Pacific Economic Cooperation
The APEC Expert Group on Energy Efficiency & Conservation (EGEEC)

Global overview

- **Steadyfast**: Global focus on energy efficiency remains steadyfast.
- **Slowdown**:The estimated 2023 rate of progress in energy intensity is set to fall back to below longer-term trends, to 1.3% from a 2% in 2022. which largely reflects an increase in energy demand of 1.7% in 2023, compared with 1.3% in 2022.
- **Trend:** the global trend of continously increasing in EE will not be changed.

（Note: Energy intensity is defined as the amount of primary energy used to produce a given amount of economic output or GDP）



Annual primary energy intensity improvement, 2001-2023, and by scenario, 2022-2030

(Source: International Energy Agency)

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The APEC Expert Group on Energy Efficiency & Conservation (EGEEC)

Importance of energy cooperation in APEC region

- APEC economies represent over 38 percent of the global population and 56 percent of global economic activity, with strong economic trade ties throughout the world.
- The role APEC plays in the global energy market is indispensable. It accounts for 56 percent of world energy demand, 58 percent of world energy supply, and 68 percent of world electricity generation. APEC accounts for 60 percent of global CO_2 emissions.

(Source: APEC Energy Demand and Supply Outlook (8th Edition), by APERC)

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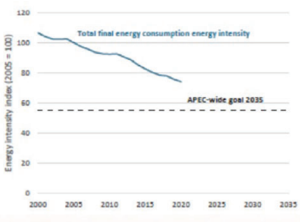
The APEC Expert Group on Energy Efficiency & Conservation (EGEEC)

Importance of energy cooperation in APEC region

- APEC energy goals,
  - ➢ to improve energy intensity by at least 45 percent by 2035 compared to 2005 levels;
  - ➢ to double the share of modern renewables in the energy mix by 2030, relative to the numbers from 2010.
- As of 2020,APEC-wide final energy intensity has improved 26% leaving an additional 19% improvement needed to meet the goal.



APEC total final energy consumption intensity index,2000-2020
(Source: APEC EGADA)

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EE(energy efficiency) in key sectors and areas

- Industry
- Transport
- Buildings
- Regulations and standards
- …

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EE activities in key sectors and areas

- Industry
  - Using high efficient equipment.
    - ✓ Widely deployment+efficient operation
  - Accelerating system integration and optimization
    - ✓ 1+1>2
  - Expanding engagement in energy management activities.
    - ✓ PDCA
  - Integrating with the emerging tech such as IoT, AI, etc
    - ✓ Data and information empower the efficiency

EE activities in key sectors and areas

- Transport
  - Green transportation system
    - ✓ Vehicles – Deploying more green vehicles and developing electrified railways.
    - ✓ Infrastructure – Building up the charging and swap battery networks, hydrogen refilling stations.
  - Decarbonization and efficiency of the existing transport system
    - ✓ Improving the EE standards for fossil-fuel vehicle
  - Smart transportation system
    - ✓ Integrating with the emerging tech such as IoT, AI, etc

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EE activities in key sectors and areas

- Buildings
  - Improving the green building codes.
  - Optimize the energy supply in building.
    - ✓ Distributed energy resources (Renewable energy such as solar energy, biomass, heat pump, geothermal energy,etc.)
    - ✓ Integrated District Energy System, IDES (power, heating and cooling,etc.)
  - Accelerating construction of low energy consumption buildings.
  - Promoting energy-saving retrofitting for the existing buildings.

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EE activities in key sectors and areas

- Regulations and standards
  - Laws and supporting policies.
    - ✓ Laws for EE&C
    - ✓ Supporting policies for EE&C related finance, tax and pricing
  - Standards.
    - ✓ Minimum energy performance standards (MEPS)
    - ✓ Energy management system standards (EnMS)
    - ✓ Supporting energy conservation standards for MEPS and EnMS
    - ✓ Standards for EE&C market mechanism

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International standards for EnMS and energy savings

- ISO/TC301 (***Energy management*** and energy savings)

- The ISO 50001 (EnMS) system is based on a process of monitoring, targeting and implementing energy saving measures in a cycle of continuous improvement.
- As of 2023, 23 ISO standards released, 6 ISO standards under development.
- In 2022, the number of ISO 50001 certificates issued worldwide grew by almost 30% to 28000.

(Sources: ISO Survey 2022 of certifications, www.iso.org)

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International standards for EnMS and energy savings

- ISO/TC301 (***Energy management*** and energy savings)

Source: www.iso.org

Intention	Standard title
General requirements	ISO 50001:2018 Energy management systems — Requirements with guidance for use
Energy audits	ISO 50002:2014 Energy audits — Requirements with guidance for use
Energy audits	ISO 50003:2021 Energy management systems — Requirements for bodies providing audit and certification of energy management systems
Implementation of EnMS	ISO 50004:2020 Energy management systems — Guidance for the implementation, maintenance and improvement of an ISO 50001 energy management system
Implementation of EnMS	ISO 50005:2021 Energy management systems — Guidelines for a phased implementation
Implementation of EnMS	ISO 50009:2021 Energy management systems — Guidance for implementing a common energy management system in multiple organizations
Implementation of EnMS	ISO/PAS 50010:2023 Energy management and energy savings — Guidance for net zero energy in operations using an ISO 50001 energy management system
Performance of EnMS	ISO 50006:2023 Energy management systems — Evaluating energy performance using energy performance indicators and energy baselines
Performance of EnMS	ISO/TS 50011:2023 Energy management systems — Assessing energy management using ISO 50001:2018

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The APEC Expert Group on Energy Efficiency & Conservation (EGEEC)

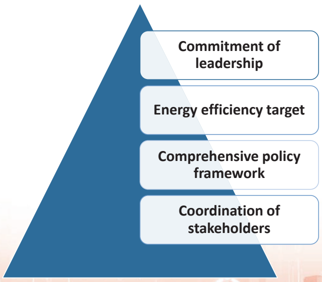
International standards for EnMS and energy savings

- ISO/TC301 (Energy management and ***energy savings***)

Source: www.iso.org

Intention	Standard title
Terms	ISO/IEC 13273-1:2015 Energy efficiency and renewable energy sources — Common international terminology — Part 1: Energy efficiency
Terms	ISO/IEC 13273-2:2015 Energy efficiency and renewable energy sources — Common international terminology — Part 2: Renewable energy sources
General methods	ISO 17743:2016 Energy savings — Definition of a methodological framework applicable to calculation and reporting on energy savings
General methods	ISO 50046:2019 General methods for predicting energy savings
Region level	ISO 17742:2015 Energy efficiency and savings calculation for countries, regions and cities
Region level	ISO 50049:2020 Calculation methods for energy efficiency and energy consumption variations at country, region and city levels
Organization level	ISO 50047:2016 Energy savings — Determination of energy savings in organizations
Project level	ISO 17741:2016 General technical rules for measurement, calculation and verification of energy savings of projects
Energy performance	ISO/TS 50008:2018 Energy management and energy savings — Building energy data management for energy performance — Guidance for a systemic data exchange approach
Energy performance	ISO 50015:2014 Energy management systems — Measurement and verification of energy performance of organizations — General principles and guidance
Energy performance	ISO 50021:2019 Energy management and energy savings — General guidelines for selecting energy savings evaluators
Energy performance	ISO 50045:2019 Technical guidelines for the evaluation of energy savings of thermal power plants
Financial performance	ISO/TS 50044:2019 Energy saving projects (EnSPs) — Guidelines for economic and financial evaluation
Energy Services	ISO 50007:2017 Energy services — Guidelines for the assessment and improvement of the energy service to users

Key to success



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Suggestions

- Efficiency
  - Energy efficiency → coordinated improvement in EE and emission reduction
  - Individual equipment efficiency → System efficiency improvement
  - Rated/designed efficiency →Operational efficiency improvement
- Integration
  - Technology integration: energy technologies, energy tech + non energy tech
  - Energy integration: clean and renewables energy mix
  - System integration: energy systems, energy sys + non energy sys

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Suggestions

- Policy
  - Cost-effective evaluation of policies
  - Continuous improvement of the policy portfolio (regulations and standards)
- Capacity building
  - Basic data and database
  - International collaboration

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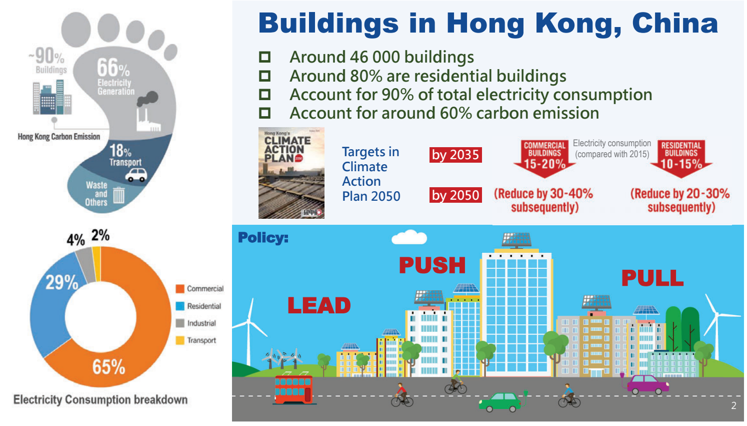
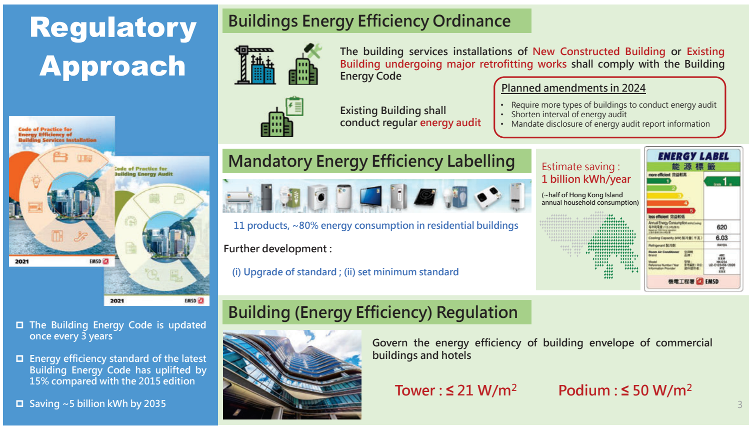
THANK YOU

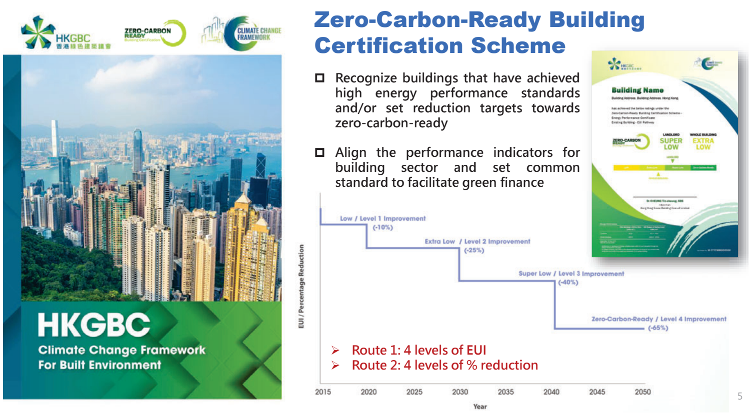
Dr. LIU Meng
liumeng@cnis.ac.cn

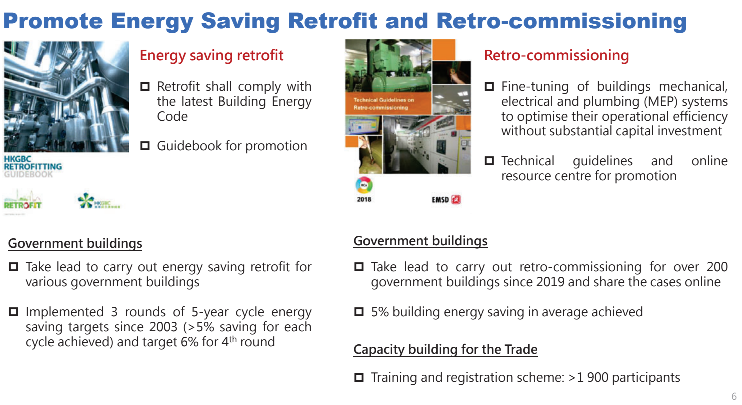
Asia-Pacific Economic Cooperation
The APEC Expert Group on Energy Efficiency & Conservation (EGEEC)

2-3. Improving Energy Efficiency in Buildings in Hong Kong, China









Examples of Energy Saving Initiatives

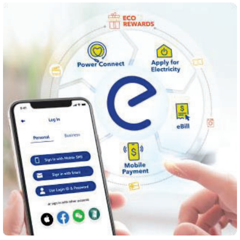
Existing Schools

Government to carry out energy saving retrofit works for non-governmental schools

Existing NGO Venues

Government to carry out energy audit and energy saving retrofit works for welfare NGOs

Smart Power Meters

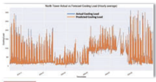


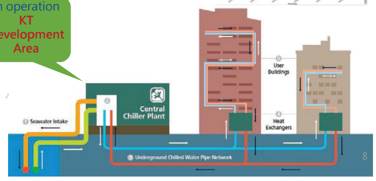
- The two power companies started installing smart meters for all customers for target completion in 2025
- Read data for past 14 months and hourly data for past 90 days
- Alerts for unusual consumption pattern

7

District Cooling Systems

Energy optimization control by artificial intelligent





- Total cooling capacity > 460 MW
- Chilled water distribution pipe > 60 km
- Estimated saving ~ 140 million kWh/year

8

Finance Subsidy

Promoting energy efficiency and conservation through the Scheme of Control Agreements signed between the Government and the two power companies

- Subsidy energy-saving retrofitting works, retro-commissioning and smart technology projects to enhance energy efficiency in communal areas of private buildings
- Target to save 60 million kWh per year

Building Rehabilitation Assistance Scheme by Urban Renewal Authority

- Subsidy energy-saving equipment replacement during building repair works in communal areas of private buildings

Accelerated deduction under profit tax

- For new or existing buildings that have achieved BEAM Plus certification, capital expenditure incurred in the installation of energy efficient building installations registered under an Energy Efficiency Registration Scheme for Buildings is eligible for accelerated deduction under profits tax

9

Community Promotion and Education on Energy Saving

10

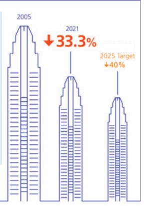
Energy Data Monitoring

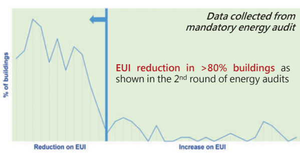
Hong Kong, China's Energy Intensity Target

The Government has set target to reduce the energy intensity by 40% by 2025, using 2005 as base year.

Hong Kong, China's energy intensity has decreased by 33.3% from 2005 to 2021

Data collected from annual energy end-use survey





Feed-in-Tariff for renewable energy systems

Application increased for 300 times (i.e. from 60 to 18 000) since the launch in 2018

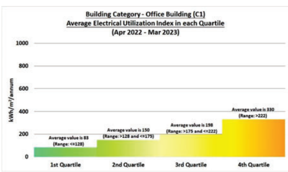
solar power system total

120

million kWh/year

Online Building EUI Benchmarking Tool

Based on real consumption data of 500 sample commercial buildings



Benchmark data for commercial buildings

5 category

15%

EUI reduction From 2015 to 2022

11

Modeling the US buildings energy efficiency

How technological change affects the US energy use through 2050

APERC Energy Efficiency Workshop
Courtney Sourmehi, Industry Economist
January 23, 2024 | Tokyo, Japan

U.S. Energy Information Administration | Independent Statistics and Analysis | www.eia.gov

About EIA

The U.S. Energy Information Administration (EIA) is the statistical and analytical agency within the U.S. Department of Energy. EIA collects, analyzes, and disseminates **independent and impartial** energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment.

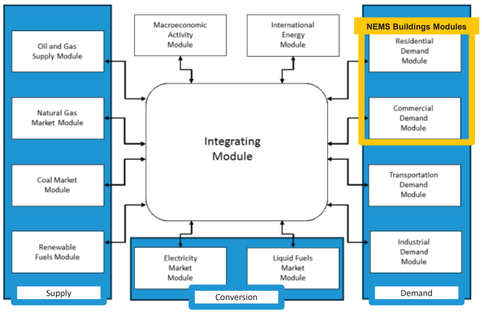
Energy efficiency

– Energy services provided per unit of energy consumption (e.g., COP), improvement driven by technological change

– In the National Energy Modeling System (NEMS): Measured at the end-use technology level, enabling projections of economy-wide changes through 2050

EIA.gov: Buildings energy data and modeling resources

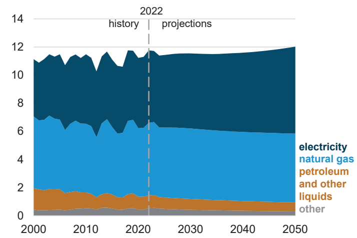
National Energy Modeling System (NEMS) structure



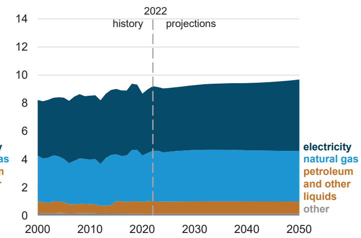
Data source: U.S. Energy Information Administration, *The National Energy Modeling System: An Overview* (2023)

Energy consumption does not keep pace with increases in housing and floorspace due to the role of energy efficiency

Residential delivered energy consumption by fuel
AEO2023 Reference case, quadrillion British thermal units



Commercial delivered energy consumption by fuel
AEO2023 Reference case, quadrillion British thermal units

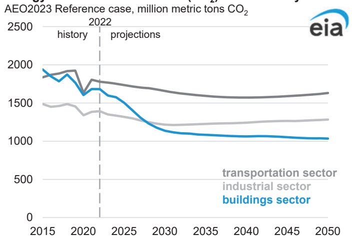


Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023 Reference case (AEO2023)

Energy-related CO2 emissions fall across all AEO2023 cases because of increased electrification and higher equipment efficiencies

- In the residential and commercial sectors, higher equipment efficiencies and compliance with building codes extend ongoing declines in energy intensity
- Changes in the buildings fuel mix reduce energy-related CO_2 emissions, which decline faster in buildings than any other end-use sector

Energy-related carbon dioxide (CO_2) emissions by sector
AEO2023 Reference case, million metric tons CO_2

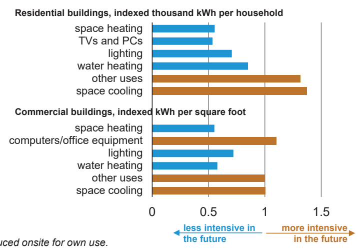


Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023 Reference case (AEO2023)
Note: Figure includes emissions associated with electric power generation. Electric power sector emissions are distributed to each end-use sector according to their share of electricity consumption.

Drivers of building electrification in the United States

- Relative efficiency of electric appliances
- Declining cost of onsite electricity generation (for example, solar photovoltaics)
- Utility energy efficiency rebates
- Stable to declining electricity prices
- Continued population shifts to warmer regions

Buildings electricity intensity by end use and sector in 2050, relative to 2022 levels
AEO2023 Reference case, kilowatthours (kWh) indexed to 2022



Note: Intensities reflect both purchased electricity and electricity produced onsite for own use.

Legislation and policy assumptions: Inflation Reduction Act

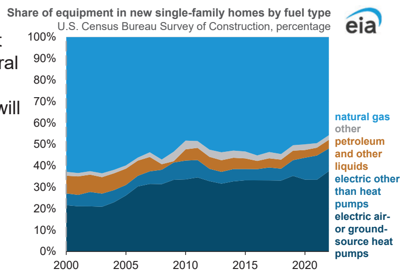
Extend and modify energy credit (IRS 48)	Extend, modify new energy efficient home credit (IRS 45L)	Extend, modify non-business energy property credit (IRS 25C)	Extend *Modified Accelerated Cost Recovery System* (IRS 167)
renewables and combined heat and power investment **tax credits** (ITC)	newly constructed, high efficiency residential housing packages **tax credits**	residential energy efficiency **tax credits**	commercial qualified facilities, qualified property, grid improvement property **cost recovery**

Inflation Reduction Act: Ongoing work

Home Owner Managing Energy Savings (HOMES) rebates	High-Efficiency Electric Home Rebate Program	Assistance for Latest and Zero Building Energy Code Adoption	Energy efficient commercial buildings deduction (IRS 179D)
investigate whole-home **retrofit savings potential**	investigate qualification criteria and estimate **share of eligible homes** and **equipment**	investigate potential for **increases in** regional building **energy code adoption**	investigate potential impact on **building code compliance** in new construction, heating and cooling use

Residential single-family new-construction equipment shares

- Despite historical growth in heat pump adoption, we project natural gas-fired heating equipment, including furnaces and boilers, will account for the largest share of energy consumption for space heating through 2050
- The average stock efficiency of natural gas-fired equipment increases over time



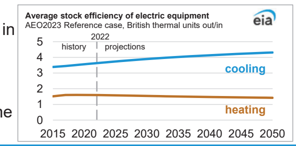
Data source: U.S. Census Bureau Survey of Construction (SOC), 2000 – 2022 SOC microdata files

Buildings technological improvement in NEMS

1. **Building technology reports** represent the *average* cost and performance of installed equipment in buildings

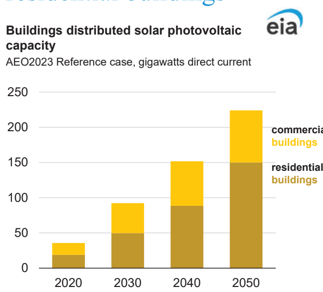
efficiency	capcst	maintcst	subcst	life	yintro	ylast	techname
3.20	380.21	3.13	0.00	14.40	2013	2062	comm_GSHP-heat 2017 current standard
3.70	396.88	3.13	0.00	14.40	2033	2062	comm_GSHP-heat 2017 typical
			194.90	14.40	2020	2022	comm_GSHP-heat 2020 typ 26% ITC
			284.51	14.40	2020	2022	comm_GSHP-heat 2020 mid 26% ITC
			292.33	14.40	2020	2022	comm_GSHP-heat 2020 high 26% ITC
			210.70	14.40	2023	2032	comm_GSHP-heat 2023 typ 30% ITC
		13	300.81	14.40	2023	2032	comm_GSHP-heat 2023 mid 30% ITC
		13	309.23	14.40	2023	2032	comm_GSHP-heat 2023 high 30% ITC

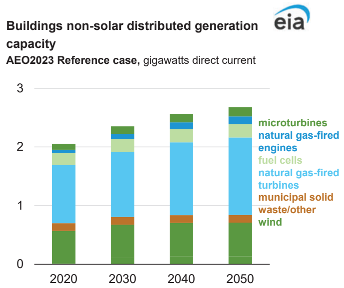
2. Model uses **technology menus** to select optimal equipment based on energy service requirements, consumer behavior rules, cost and performance **considerations**
3. **Technologies *compete*** to meet service demand in each US census division and building type
4. NEMS projects **average stock** and **purchased stock efficiency**, by end use and region, over time



Additional data

The US distributed generation capacity in commercial and residential buildings





Note: Excludes utility-scale electricity generation.

Commercial Ground-Source Heat Pumps

Example from technology report

Final

Return to Table of Contents

DATA	2012	2018	2022			2030		2040		2050	
	Installed Base	Installed Base	Current Standard	Typical	High	Typical	High	Typical	High	Typical	High
Typical Capacity (kBtu/h)	48	48	48	48	48	48	48	48	48	48	48
COP (Heating)[1]	3.1	3.7	3.2	3.5	3.6	3.5	3.6	3.5	3.6	3.5	3.6
EER (Cooling)[2]	12.7	17.4	14.1	17.0	21.6	17.0	21.6	17.0	21.6	17.0	21.6
Average Life (y)	8	8	8	8	8	8	8	8	8	8	8
	21	21	21	21	21	21	21	21	21	21	21
Retail Equipment Cost (2022$)	10,470	6,470	5,590	6,470	7,880	6,470	7,880	6,470	7,880	6,470	7,880
Total Installed Cost (2022$)	19,760	18,230	17,350	18,230	19,650	18,230	19,650	18,230	19,650	18,230	19,650
	44,820	26,520	25,580	26,520	27,880	26,520	27,880	26,520	27,880	26,520	27,880
Total Installed Cost (2022$/kBtu/h)	673	466	447	466	495	466	495	466	495	466	495
Annual Maintenance Cost (2022$)	180	180	180	180	180	180	180	180	180	180	180
Annual Maintenance Cost (2022$/kBtu/h)	4	4	4	4	4	4	4	4	4	4	4

1. COP values listed are assessed at a "ground loop" test condition, which is representative of closed loop GSHP operating conditions. However, DOE sets standards at a "water loop" test condition. The AHRI directory lists COP ratings at both sets of test conditions and is used to convert between them where necessary.
2. EER values listed are assessed at a full-load "ground loop" test condition, which is representative of closed loop GSHP operating conditions. However, DOE sets standards at a full-load "water loop" test condition. The AHRI directory lists EER ratings at all sets of test conditions and is used to convert between them where necessary.

Note:
Residential and commercial GSHPs are very similar - the main difference in data presented is the different capacity (3-ton vs. 4-ton) and slightly higher installation costs for commercial GSHP. DOE does not distinguish between residential and commercial units in its regulations.

Data source: U.S. Energy Information Administration *https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf*

View our data online

- Interactive graphs available as part of our online data table browser

  www.eia.gov/outlooks/aeo/data/browser

- Excel spreadsheets for Reference and side cases

  www.eia.gov/outlooks/aeo/tables_ref.php

  www.eia.gov/outlooks/aeo/tables_side_xls.php

For more information

U.S. Energy Information Administration homepage | www.eia.gov

Buildings Working Group materials | www.eia.gov/outlooks/aeo/workinggroup/buildings

Today in Energy | www.eia.gov/todayinenergy

Annual Energy Outlook | www.eia.gov/aeo

Short-Term Energy Outlook | www.eia.gov/steo

State Energy Data System | www.eia.gov/state/seds

Monthly Energy Review | www.eia.gov/mer

Residential Energy Consumption Survey | www.eia.gov/recs

Commercial Building Energy Consumption Survey | www.eia.gov/cbecs

International Energy Portal | www.eia.gov/international

Energy Efficiency of Buildings in Australia

Dr. Subbu Sethuvenkatraman
Jan 24

Australia's National Science Agency

CSIRO

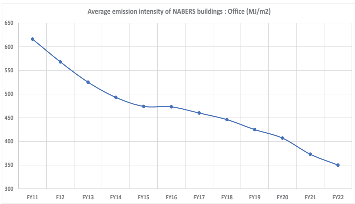
Energy use in buildings : Australia

- 86% Australian population live in cities
- Buildings make up of about 18% total emissions
- Nearly 60% of building energy use is through electricity
- High uptake of Distributed Energy Resources (DER). One in every three households likely to have rooftop solar by 2050

CSIRO

Energy use in buildings : Australia

- National Energy Performance Strategy (2015, 2024)
- Trajectory for low emission buildings (2019,2024)
- Sector wide decarbonisation plans (2023)
- National Construction Code (NCC), Greenhouse and Energy minimum Standards (GEMS) for appliances



Policies with successful implementation history

CSIRO

Decarbonisation of Australian built environment sector

➢ Residential buildings :

- From 2023 : Increased requirements for thermal performance (6 to 7)
- Whole of home rating to incorporate efficiency of appliances
- Household energy upgrade fund

➢ Commercial buildings :

- Usage based rating system (NABERS) : highly successful in improving efficiency
- Commercial Building Disclosure (CBD) program requires energy efficiency information to be provided during sale or lease
- Energy efficiency in government operations : Government buildings to lead by example

CSIRO

Drivers for energy efficiency

➢ As a consumer

- Reduce energy bills
- Climate resilient
- Health and comfort

➢ Technology/policy

- Net zero
- Electrification
- Distributed generation + storage
- Consumers becoming prosumers

CSIRO

Emerging Opportunities

➢ Electrification & Decarbonisation

- Switch from gas heating to heat pumps
- Gas /electric boiler to heat pumps
- Self consume : use onsite generation and storage

➢ Digitalisation

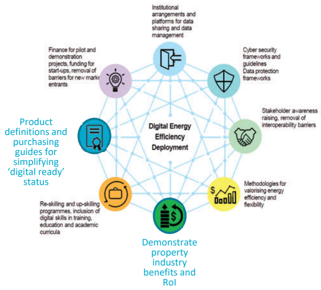
- Smart meters, sensors for monitoring and control
- Optimal control, management, preventive maintenance
- Participate in the electricity market

CSIRO

Digitalisation journey: Australian experience

Two step process :

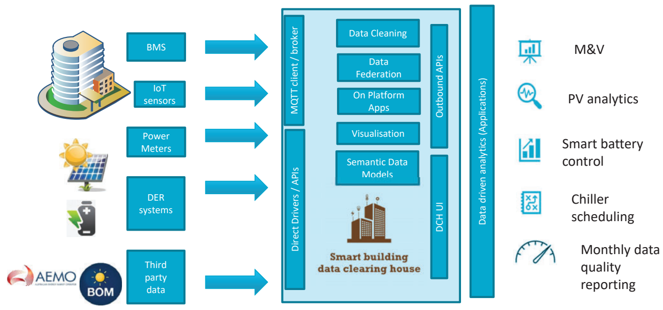
- Connecting the buildings ("digital ready") and getting access to all data in a cost effective way
- Delivering benefits through analytics (both operational and energy cost)



Source : RACE CRC B2 Industry 4.0 Opportunity Assessment

CSIRO

Digitalisation journey: Australian experience



100+ buildings : office buildings, mixed use, schools, hospitals

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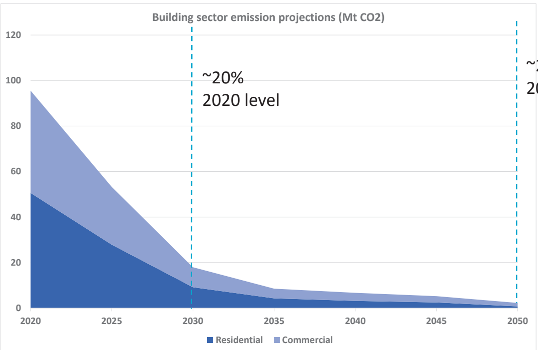
Pathway for decarbonisation of building sector



Brinsmead et al (2023) : Pathways to Net Zero Emissions – An Australian Perspective on Rapid Decarbonisation, CSIRO, Australia

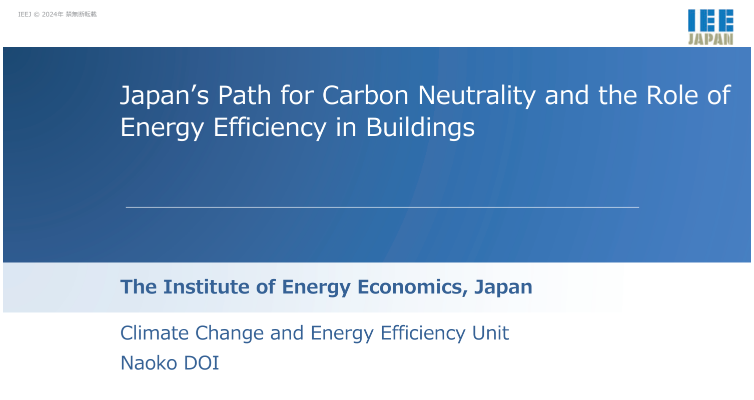
CSIRO

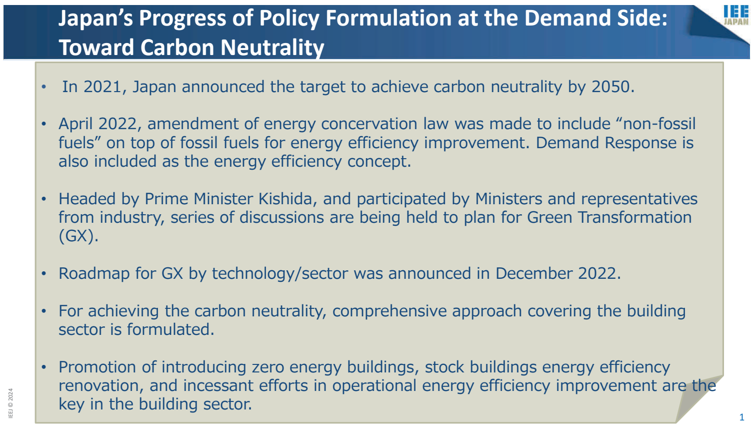
Thank you

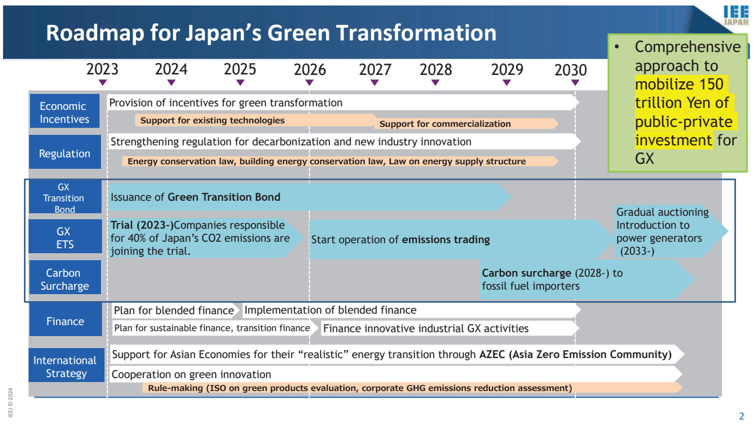
Dr. Subbu Sethuvenkatraman,
Subbu.sethuvenkatraman@csiro.au
+61 416 528 314

Australia's National Science Agency

CSIRO


IEE JAPAN
Japan's Path for Carbon Neutrality and the Role of Energy Efficiency in Buildings
The Institute of Energy Economics, Japan
Climate Change and Energy Efficiency Unit
Naoko DOI


Japan's Progress of Policy Formulation at the Demand Side: Toward Carbon Neutrality
• In 2021, Japan announced the target to achieve carbon neutrality by 2050.
• April 2022, amendment of energy concervation law was made to include "non-fossil fuels" on top of fossil fuels for energy efficiency improvement. Demand Response is also included as the energy efficiency concept.
• Headed by Prime Minister Kishida, and participated by Ministers and representatives from industry, series of discussions are being held to plan for Green Transformation (GX).
• Roadmap for GX by technology/sector was announced in December 2022.
• For achieving the carbon neutrality, comprehensive approach covering the building sector is formulated.
• Promotion of introducing zero energy buildings, stock buildings energy efficiency renovation, and incessant efforts in operational energy efficiency improvement are the key in the building sector.
IEEJ © 2024
1


Roadmap for Japan's Green Transformation
2023
2024
2025
2026
2027
2028
2029
2030
• Comprehensive approach to mobilize 150 trillion Yen of public-private investment for GX
Economic Incentives
Provision of incentives for green transformation
Support for existing technologies
Support for commercialization
Regulation
Strengthening regulation for decarbonization and new industry innovation
Energy conservation law, building energy conservation law, Law on energy supply structure
GX Transition Bond
Issuance of Green Transition Bond
GX ETS
Trial (2023-)Companies responsible for 40% of Japan's CO2 emissions are joining the trial.
Start operation of emissions trading
Gradual auctioning Introduction to power generators (2033-)
Carbon Surcharge
Carbon surcharge (2028-) to fossil fuel importers
Finance
Plan for blended finance
Implementation of blended finance
Plan for sustainable finance, transition finance
Finance innovative industrial GX activities
International Strategy
Support for Asian Economies for their "realistic" energy transition through AZEC (Asia Zero Emission Community)
Cooperation on green innovation
Rule-making (ISO on green products evaluation, corporate GHG emissions reduction assessment)
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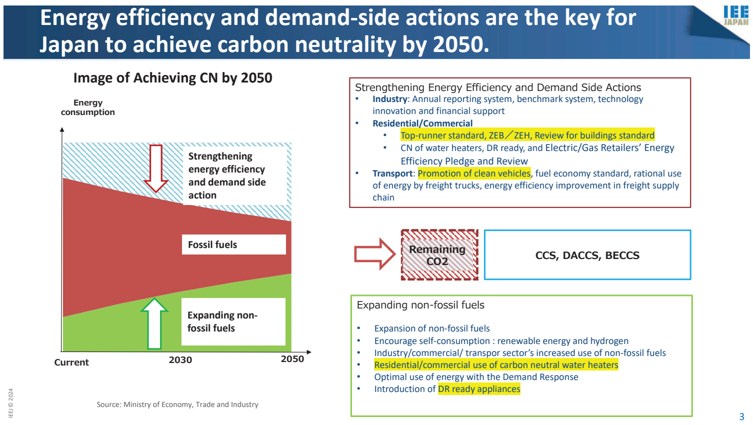
2


Energy efficiency and demand-side actions are the key for Japan to achieve carbon neutrality by 2050.
Image of Achieving CN by 2050
Energy consumption
Strengthening energy efficiency and demand side action
Fossil fuels
Expanding non-fossil fuels
Current
2030
2050
Source: Ministry of Economy, Trade and Industry
Strengthening Energy Efficiency and Demand Side Actions
• Industry: Annual reporting system, benchmark system, technology innovation and financial support
• Residential/Commercial
• Top-runner standard, ZEB／ZEH, Review for buildings standard
• CN of water heaters, DR ready, and Electric/Gas Retailers' Energy Efficiency Pledge and Review
• Transport: Promotion of clean vehicles, fuel economy standard, rational use of energy by freight trucks, energy efficiency improvement in freight supply chain
Remaining CO2
CCS, DACCS, BECCS
Expanding non-fossil fuels
• Expansion of non-fossil fuels
• Encourage self-consumption : renewable energy and hydrogen
• Industry/commercial/ transpor sector's increased use of non-fossil fuels
• Residential/commercial use of carbon neutral water heaters
• Optimal use of energy with the Demand Response
• Introduction of DR ready appliances
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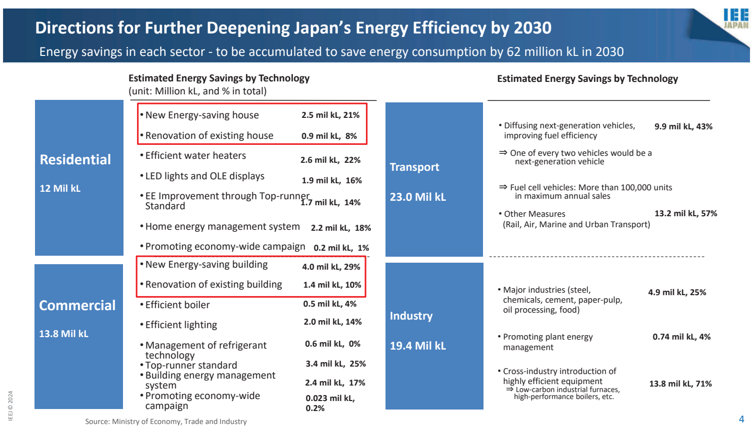
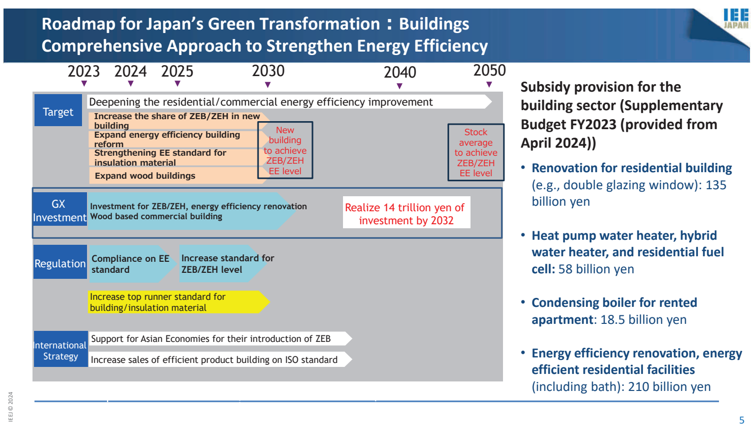
3


Directions for Further Deepening Japan's Energy Efficiency by 2030
Energy savings in each sector - to be accumulated to save energy consumption by 62 million kL in 2030
Estimated Energy Savings by Technology
(unit: Million kL, and % in total)
Residential
12 Mil kL
• New Energy-saving house 2.5 mil kL, 21%
• Renovation of existing house 0.9 mil kL, 8%
• Efficient water heaters 2.6 mil kL, 22%
• LED lights and OLE displays 1.9 mil kL, 16%
• EE Improvement through Top-runner Standard 1.7 mil kL, 14%
• Home energy management system 2.2 mil kL, 18%
• Promoting economy-wide campaign 0.2 mil kL, 1%
Commercial
13.8 Mil kL
• New Energy-saving building 4.0 mil kL, 29%
• Renovation of existing building 1.4 mil kL, 10%
• Efficient boiler 0.5 mil kL, 4%
• Efficient lighting 2.0 mil kL, 14%
• Management of refrigerant technology 0.6 mil kL, 0%
• Top-runner standard 3.4 mil kL, 25%
• Building energy management system 2.4 mil kL, 17%
• Promoting economy-wide campaign 0.023 mil kL, 0.2%
Estimated Energy Savings by Technology
Transport
23.0 Mil kL
• Diffusing next-generation vehicles, improving fuel efficiency 9.9 mil kL, 43%
⇒ One of every two vehicles would be a next-generation vehicle
⇒ Fuel cell vehicles: More than 100,000 units in maximum annual sales
• Other Measures (Rail, Air, Marine and Urban Transport) 13.2 mil kL, 57%
Industry
19.4 Mil kL
• Major industries (steel, chemicals, cement, paper-pulp, oil processing, food) 4.9 mil kL, 25%
• Promoting plant energy management 0.74 mil kL, 4%
• Cross-industry introduction of highly efficient equipment 13.8 mil kL, 71%
⇒ Low-carbon industrial furnaces, high-performance boilers, etc.
Source: Ministry of Economy, Trade and Industry
IEEJ © 2024
4


Roadmap for Japan's Green Transformation：Buildings
Comprehensive Approach to Strengthen Energy Efficiency
2023
2024
2025
2030
2040
2050
Target
Deepening the residential/commercial energy efficiency improvement
Increase the share of ZEB/ZEH in new building
Expand energy efficiency building reform
Strengthening EE standard for insulation material
Expand wood buildings
New building to achieve ZEB/ZEH EE level
Stock average to achieve ZEB/ZEH EE level
GX Investment
Investment for ZEB/ZEH, energy efficiency renovation
Wood based commercial building
Realize 14 trillion yen of investment by 2032
Regulation
Compliance on EE standard
Increase standard for ZEB/ZEH level
Increase top runner standard for building/insulation material
International Strategy
Support for Asian Economies for their introduction of ZEB
Increase sales of efficient product building on ISO standard
Subsidy provision for the building sector (Supplementary Budget FY2023 (provided from April 2024))
• Renovation for residential building (e.g., double glazing window): 135 billion yen
• Heat pump water heater, hybrid water heater, and residential fuel cell: 58 billion yen
• Condensing boiler for rented apartment: 18.5 billion yen
• Energy efficiency renovation, energy efficient residential facilities (including bath): 210 billion yen
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5

Government Support and the Private Sector Business Expansion

In the second supplementary budget for FY2023, for households, a total of 421.5 billion yen are being provided for the energy efficiency of residential sector.

	Subsidy for Owners
Heat Pump Water Heater	• **100,000 Yen/unit**
Hybrid Water Heater	• **130,000 Yen/unit**
Residential Fuel Cell	• **200,000 Yen/unit**

Heat Pump Water Heater

Source: Panasonic

Hybrid Water Heater

Source: Rinnai

Residential Fuel Cell

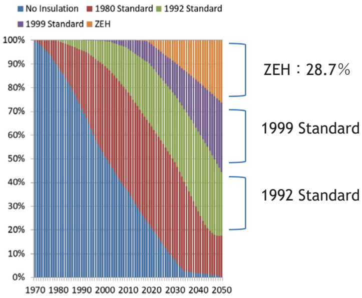
Source: Aisin Corp.

Overseas HP Production and Investment for Plant Expansion

Daikin Corp.	• European market entry from 2006, and from 2019 maintain **the top share in pump-type heating (air conditioners).** • Invest more than 40 billion yen in 2022, and decided to establish a new plant for pump-type heaters in Poland
Panasonic	• Started production of Residential heat pumps for Europe in the Czech Republic from 2018 • The company announced plans to **more than triple its production capacity, Invest 45 billion yen by 2023 to 2025**
Mitsubishi Electric.	• In 2016, as a production base for Europe and Turkey, Established a factory in West Turkey. • **Announcement of Total investment of 15 billion yen in 2021 and 2022 (including new factory construction)**

Estimated Distribution of Stock: Residential Buildings in Japan

Distribution of Residential Building Stock by Energy Efficiency Standard



- An estimation is being made to consider the potential share of Zero Energy House in 2050.
- If all the newly built residential houses are ZEH from 2021, its share will reach 28.7% by 2050.
- This results show the needs for additional measures such as (1) operational energy efficiency improvement, (2) strengthening of energy efficiency renovation for existing stocks, and (3) promotion of ZEH in apartment buildings.

Source: Author's Estimation.

Japan's evolving energy efficiency policies areas

2022 Amendment of the Energy Conservation Act

Expanding Use of Non-fossil fuels — **Non-fossil Fuel Target for Industry Sub-Sectors and Transport**
- Cement, paper and pulp, petrochemical, iron and steel, and automobile manufactures, and transport business entities are required to meet non-fossil fuel target by 2030.
- In addition to the five industries, **each business subject to periodic reporting has set a "target for transition to non-fossil energy".**

Demand Response — **Demand Response Implementation by Large-scale Energy Users**
- Those entities required to report annual energy consumption to the Ministry are encouraged to report the number of frequency that they implement DR (both turn up demand and turn down demand.

2023-2024 Energy Efficiency Subcommittee Discussion Policy Areas

Residential Water Heaters — **Carbon Neutrality of Water Heaters**
- Along with the boilers' energy efficiency improvement, it is being planned to require manufactures to change the product configuration by increasing the share of water heaters that can contribute to carbon neutrality (heat pump, hybrid heat pump, and hydrogen combustion water heater).

Appliances — **Demand Response Ready Appliances**
- It is being planned to introduce the DR ready requirements for appliances. Careful considerations are being made to determine the appliances for DR ready, consider cost transfer mechanisms, and estimate the benefits and costs. Creation of market environment induces implementation of demand response is also under consideration.

Consumers' Engagement — **Electric/Gas Retailers' Energy Efficiency Pledge and Review**
- To increase consumers' engagement on energy efficiency, electric/gas retailers would be required to set energy savings target at the demand side, which will be reviewed by government.

Source: Ministry of Economy, Trade and Industry (2023). "Energy Efficiency Subcommittee: Interim Report"
https://www.meti.go.jp/shingikai/enecho/shoene_shinene/sho_energy/pdf/20230726_2.pdf

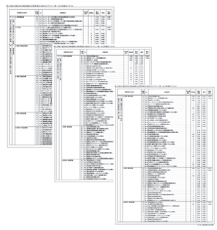
Tokyo Cap-and-Trade Program : Top Level Certification System

Example of Top Level Certified Buildings

Sky tree

Tokyo midtown

Documentation to follow detailed check list for energy savings/CO2 emissions reduction

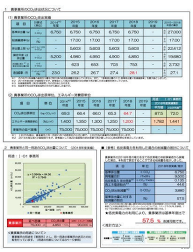


The Top-level Business Entity Certification System:
- Mechanism that reduces the reduction obligation rate of a business entity with excellent specified global warming countermeasure business entity

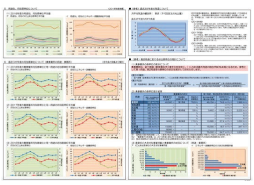
The emissions reduction obligation rate:
- Large-scale businesses in Tokyo is imposed GHG emissions reduction rate of 27% or 25% (fiscal years 2020-2024) .

Tokyo Cap-and-Trade Program : Buildings' Energy Savings Score Card

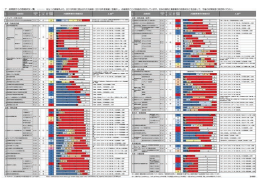
Score card – current status



Score card – trends



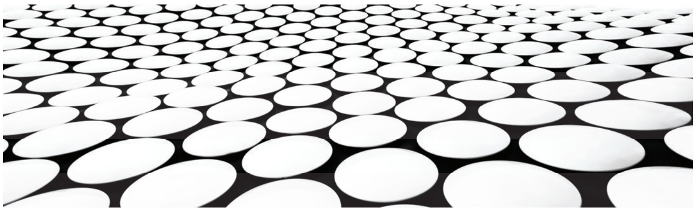
Score card – check list



2-7. Improving Energy Efficiency in Transport in Malaysia

SESSION 3-2 "IMPROVING ENERGY EFFICIENCY IN TRANSPORT IN MALAYSIA"

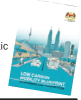
BY HUZAIMI NOR OMAR



POLICY PUSH FOR ENERGY EFFICIENCY (TRANSPORT) IN MALAYSIA

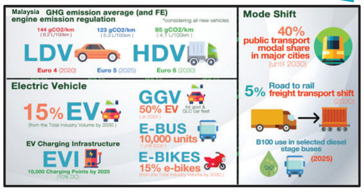
LCMB 2021-30

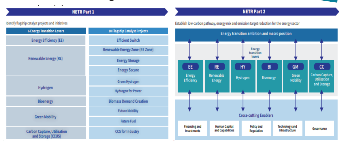
1. Low Carbon Mobility Blueprint 2021-30 is the 1st holistic policy document on Land Transport of Malaysia.
2. Focus is on energy savings which also resulting on carbon emission reduction and cost savings.



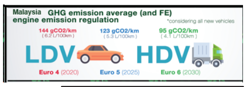
NETR 2023-50

1. National Energy Transition Roadmap latest policy document launched
2. NETR focus is on carbon emission reduction towards realizing the Net Carbon Emission 2050

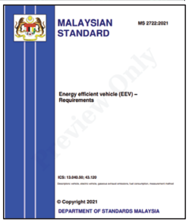




STOCK TAKE – VARIOUS INITIATIVES (GOVERNMENT)



Manufacturing incentives



Implementation of Energy Efficient Vehicles

Voluntary Energy Efficient Vehicle (EEV) Labelling Scheme

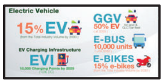
Kerb Weight (kg)	Fuel Consumption Limits (L/100km)
<800	4.5
801-1000	5.0
1001-1250	6.0
1251-1400	6.5
1401-1550	7.0
1551-1800	9.5
1801-2050	11.0
2051-2350	11.5
2351-2500	12.0
2501-2750	13.5
2751-3000	14.7
3001-3250	16.0
3251-3500	17.2

On the other hand, electric vehicles (EVs) are automatically regarded as EEVs.

STOCK TAKE – VARIOUS INITIATIVES (GOVERNMENT)

- ✓ Electric Vehicles taking center stage as the primary incentives focus
- ✓ Continuous and evolving target for EV penetration

LCMB 2030

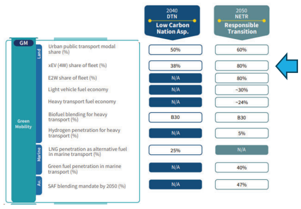


National Energy Policy 2022-2040

38% of EV penetration at 2040

National Energy Transition Roadmap 2050

*80% xEV penetration at 2050



STOCK TAKE – VARIOUS INITIATIVES ON EV (GOVERNMENT)

National EV Taskforce (NEVTF) and National EV Steering Committee (NEVSC)

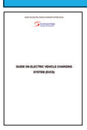
Both chaired by Ministry of Investment & Trade. To accelerate EV charging infrastructure and EV adoption in Malaysia

- Key ministries only → NEVSC
- Ministries, Government Agencies, Association and Corporate → NEVTF

Incentives on EV

- Full exemption of import duty, excise duty and sales tax on locally assembled EV or CKD until 2027
- Full exemption of import duty and excise duty on CBU EV until 2025
- 100% Road tax exemption until 2025
- Individual income tax relief for EV Charging from 2024 to 2027
- RM2,400 cash rebates for e-motorcycle
- Company tax deduction up to RM300k for non-commercial EV leasing (2023 – 2027)

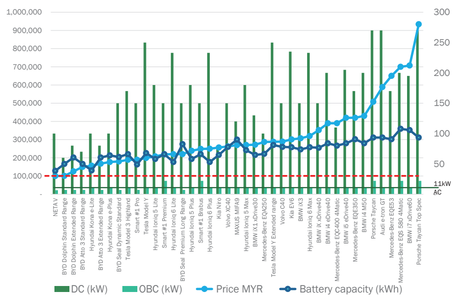
Regulatory reinforcement



Requirement of EVCS Distribution License by Energy Commission started April 2023

Requirement to comply to Planning Guideline of EV Charging Bay inclusive of fire hazard guidelines in enforcement from October 2023

EV MARKET ARE GROWING IN MALAYSIA



- ✓ Various models are available, and more are being introduced
- ✓ No EV below RM100k. Below this threshold require local assembly EV.
- ✓ 1.8% EV penetration rate for 2023. Expecting growing rate.

Hydrogen (FCEV) are on trial, mostly in Sarawak

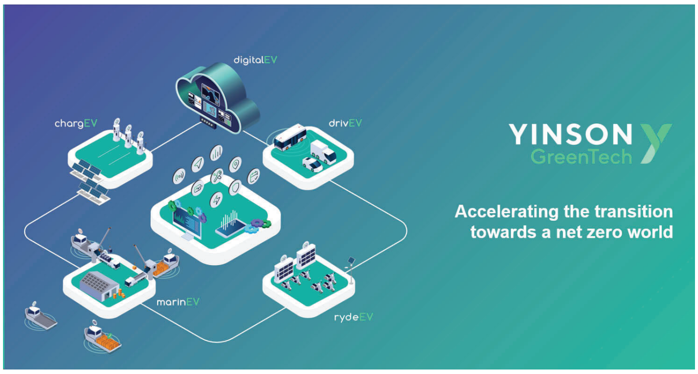
Automated Rapid Transit (ART) on trial at Kuching since 2023

Premier of Sarawak driving Toyota Mirai as part of trial

3 Free H2 bus and 3 Hyundai Nexo as corporate fleet in operation in Kuching since 2020

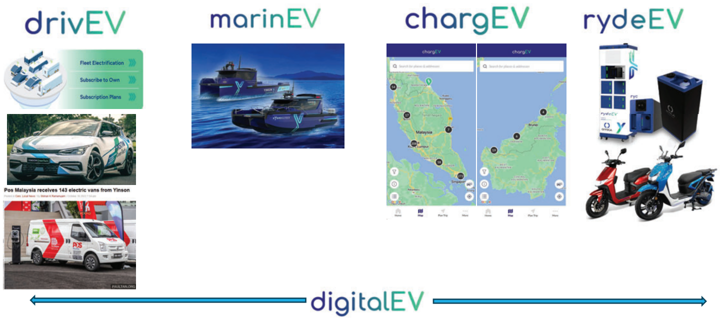
Sarawak to produce larger scale green hydrogen in 2027.

STOCK TAKE – VARIOUS INITIATIVES (PRIVATE)



STOCK TAKE – VARIOUS INITIATIVES (PRIVATE)

Yinson Greentech leading private EV initiatives in Malaysia



Thank you

Huzaimi Nor Omar
+6011 1662 2392
huzaimi.omar@yinson.com

APEC Symposium on Promoting Energy Efficiency and Energy Management System, 23-24 January 2024, Tokyo, Japan
Hosted by the Asia Pacific Energy Research Centre (APERC)

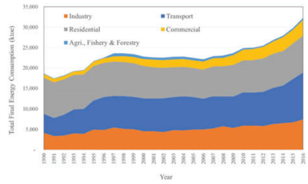
Improving Energy Efficiency in Transport in The Philippines

Noriel Christopher C. Tiglao, Dr. Eng
Professor, University of the Philippines National College of Public Administration and Governance
nctiglao@up.edu.ph

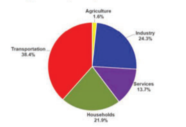
Session 3 "Improving Energy Efficiency in Transport - The use, challenges and future of urban transportation

Total Energy Consumption

- According to the Philippines Department of Energy's Compendium of Philippine Energy Statistics and Information
  - The total final energy consumption (TFEC) increased from 18.619 Mtoe in 1990 to 32.224 Mtoe in 2016 increasing annually by 2.8%
  - The TFEC of the transportation sector had increased by an average of 5.5% per year
  - In the 1990s, the residential sector had the largest share of TFEC where the transportation sector ranked second. From 2000 to 2016, the transportation sector occupied the largest share of total final energy consumption, with an average share of 34.2%
  - The TFEC of the transportation sector increased from 4.685 Mtoe in 1990 to 11.425 Mtoe in 2016



Energy Consumption by Sector



Total Final Energy Consumption by Sectoral Share (2018-2040)

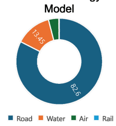
Sources: Department of Energy (2018). Compendium of Philippine Energy Statistics and Information. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/energy_statistics/doe_compendium_energy_statistics.pdf
National Energy Efficiency and Conservation Plan and Roadmap 2023-2050. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2023-05-0018-NEECP-and-Roadmap-2023-2050.pdf

2

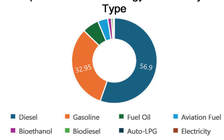
Transport Sector Energy Consumption

- The road transportation mode consistently had the largest share ranging from 77.0% to 88.2%, followed by the water transportation mode (~7.2% to 19.7%), followed by the domestic air transportation mode (~1.9% to 5.9%), and the lastly followed by the rail transportation mode (~0.03% to 0.23%)
- Diesel consistently had the largest share ranging from 53.0% to 60.8% followed by gasoline (~29.6% to 36.3%), followed by fuel oil (~1.7% to 11.2%), followed by aviation fuel (~1.9% to 5.9%, followed by bioethanol with an average share of 1.4%, and the bottom three with less than 1% share, biodiesel (0.7%), Auto-LPG (0.4%) and electricity (0.08%)
- The transportation sector is highly dependent on fossil fuels and it will remain as the highest energy consuming sector with a 35.6% average share across the entire planning horizon, and accounting for the bulk of the increase (38.1%) in total final energy consumption levels between 2015 and 2030

Transportation Sector Energy Demand by Model



Transportation Sector Energy Demand by Fuel Type



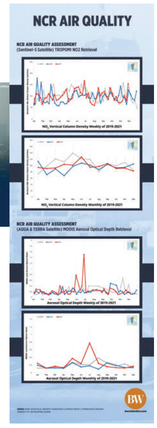
Department of Energy (2016). Philippine Energy Plan 2016-2030. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/pep/2016-2030_pep.pdf

3

Air Quality and Climate Impacts

- In the Philippines, the transportation sector is the largest source of air pollution and energy-related greenhouse gas (GHG) emissions.
- In 2015, transport GHG emissions contributed to 34% of the total Philippines GHG emissions, with road transport accounting for 80% of those emissions
- The DENR reports that 74% of air pollutants come from transport sources (e.g., cars, motorcycles, trucks, and buses). Transport sources account for 83.09% of NOx (0.40 Mt) and 37.73% of PM (0.29 Mt) of pollutants in Metro Manila
- The transport sector in the Philippines is energy-intensive and contributed about 35.6 metric tons of carbon dioxide equivalent (MtCO2e) and 27.4 MtCO2e of emissions in 2019 and 2020, respectively. Moreover, the price volatility of oil products and fears of fuel shortages, in addition to continued fuel dependence, pose a burden on our energy security, the economy, and the public

Sept 2023 smog in Metro Manila due to vehicular traffic



Source: TRANSfer Philippines. (2015, September 14). Philippines: Jeepney + NAMA (Nationally Appropriate Mitigation Actions). http://www.transferproject.org/projects/transfer-partner-countries/philippines/

Low Carbon Transport Development

- In April 2021, the Philippines submitted its Nationally Determined Contribution (NDC) in accordance to the Paris Agreement
  - The Philippines "commits to a projected GHG emissions reduction and avoidance of 75%, of which 2.71% is unconditional and 72.29% is conditional, representing the country's ambition for GHG mitigation for the period 2020 to 2030 for the sectors of agriculture, wastes, industry, transport, and energy"
  - This commitment is referenced against a projected business as usual (BAU) cumulative economy-wide emission of 3,340.3 MtCO2e for the same period
- Data from the Department of Transportation indicates that from a baseline of 24.02 MtCO2e in 2010, the GHG contribution from the transport sector (combined road, rail, air, water) is projected to grow to 87.10 MtCO2e (in 2030) and 166.07 MtCO2e (in 2040) under the BAU scenario
  - Based on initial calculations, transport projects can contribute to a GHG reduction of 10.03 MtCO2e in 2030 and 14.34 MtCO2e in 2040, which are equivalent, respectively, to 11.51% and 8.63% GHG reduction from the BAU.
  - Disaggregating the total by projects, rail has the largest contribution to GHG reduction at 6.79% (2030) and 4.23% (2040), followed by Public Utility Vehicle (PUV) Modernization Program at 2.91% (2030) and 2.75% (2040)

Source: UNFCC (2021). "Nationally Determined Contribution Communicated to the UNFCCC on 15 April 2021 – Republic of the Philippines." https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Philippines%20First/Philippines%20-%20NDC.pdf

5

The Philippines NDC Projects

Nationally Determined Contribution (NDC) Project	Project Cost (PHP Billion)	GHG Reduction in MtCO2e (relative to 2040)	GHG reduction to project cost ratio (MtCO2e/Php trillion)	Government Budget (PHP Billion) *significant only	Implementing agency / company
North-South Commuter Rail	777.55	1.13	1.45	–	Department of Transportation
Philippine National Railways – South Long Haul	175.318	0.58	3.31	–	Department of Transportation
Metro Manila Subway Project	356.974	0.65	1.82	–	Department of Transportation
LRT 1 Extension	64.915	0.75	11.55	–	Light Rail Transit Authority Department of Transportation
LRT 2 Extension	19.62	0.85	43.32	10.12	Department of Transportation
MRT 7	74.5	0.11	1.48	–	San Miguel Holdings Corporation (SMHC)
Mindanao Railway – Phase 1	82	0.34	4.15	–	Department of Transportation
BRT – Quezon Avenue and Cebu	21.8	1.01	46.33	–	Department of Transportation
PUVMP – Jeepney Modernization	400*	4.57	11.43	30.6	Department of Transportation

Source: Sunio, V., & Mendejar, J. (2022). Financing low-carbon transport transition in the Philippines: Mapping financing sources, gaps and directionality of innovation. Transportation Research Interdisciplinary Perspectives, 14, 100590. https://doi.org/10.1016/j.trip.2022.100590

6

Assessing Sustainable Transport Measures

- Vergel & Tiglao (2013) estimated fuel consumption and air pollutant emissions for baseline and transportation policy scenarios in 2010 and 2015 using fuel consumption factors from local studies
  - The expansion of the mass transit network is the single policy scenario that contributed to higher overall reduction in petroleum and alternative fuel consumption levels. This is followed by the vehicle restraint (TDM) policy. The implementation of all-CNG bus policy contributed to the significant reduction of diesel fuel consumption. The public utility buses consumed the largest share (28%) of diesel fuel consumed in Metro Manila in 2010. The MVIS policy did not contribute to significant reduction in fuel consumption.

Change in Fossil Fuel and Alternative Fuel Consumption of Each Scenario Compared to Baseline

Scenario	Reduction in Daily Fuel Consumption				
	Diesel	Gasoline	LPG	CNG	CME
4-Stroke TC	0%	-1%	0%	0%	0%
MVIS	-3%	-3%	-5%	-5%	-3%
TDM	-6%	-10%	-11%	0%	-6%
Bikeways	0%	0%	0%	0%	0%
Mass Transit	-13%	-13%	-14%	-11%	-13%
CNG	-28%	0%	0%	high	-28%

Fuel Economy

Vehicle Type	Fuel Type	FCF (li/km)	Fuel Economy (km/li)	Source
passenger car	gasoline	0.133	7.50	DOE
passenger car	diesel	0.102	9.79	MMUTIS
utility vehicle	gasoline	0.133	7.50	DOE
utility vehicle	diesel	0.176	5.69	
motorcycle	gasoline	0.034	29.29	
truck	diesel	0.224	4.47	MMUTIS)
taxi	gasoline	0.133	7.50	
taxi	LPG	0.144	6.94	DOE
tricycle (2-stroke)	gasoline	0.041	24.41	Biona et al. (2007)
tricycle (4-stroke)	gasoline	0.034	29.29	
jeepney	diesel (B1)	0.176	5.69	UPD-COE (2009)
bus	diesel (B2)	0.375	2.67	DOTC-MMPTPSS (2010)
AUV	diesel (B2)	0.173	5.77	DOTC-MMPTS (2007)
jeepney	LPG	0.298	3.36	
bus	LPG	0.635	1.58	
bus	CNG*	0.326	3.07	

Source: Vergel, K.B.N., Tiglao, N.C.C. (2013). Estimation of emissions and fuel consumption of sustainable transport measures in Metro Manila. Philippine Engineering Journal. Volume XXXIV, Number 1, pp. 31–46. Retrieved from http://journals.upd.edu.ph/ index.php/pej/article/view/3797

Comprehensive Roadmap for the Electric Vehicle Industry (CREVI)

- The Electric Vehicle Industry Development Act (EVIDA) became law on April 15, 2022, as Republic Act 11697, which mandates the creation of CREVI
  - A Law that "ensures the country's energy security and independence by reducing reliance on imported fuel for the transport sector" and provides an enabling environment for the development and adoption of EVs and EV charging stations
  - Includes fiscal and non-fiscal incentives
- "The CREVI refers to a national development plan for the EV industry with an annual work plan to accelerate the development, commercialization, and utilization of EVs in the country comprised of the following four (4) components":
  - EVs and charging stations component;
  - Manufacturing component that gives emphasis on EV for public transport in addition to EV for individual use;
  - Research and development (R&D) component that generates Science and Technology (S&T) based policies and local technologies for commercialization; and
  - Human resource development component which includes skills and capacity building of needed personnel to support the development of the EV industry

Source: EVIDA and its Implementing Rules and Regulations (IRR), https://lawphil.net/statutes/repacts/ra2022/ra_11697_2022.html
https://www.doe.gov.ph/laws-and-issuances/implementing-rules-and-regulations-republic-act-ra-no-11697

National Energy Efficiency and Conservation Plan (NEECP)

- "A comprehensive framework and plan that institutionalizes energy efficiency and conservation in the country across key sectors of the economy in accordance with the EEC Act"
  - "Section 4(z) of the EEC Act stipulates that the NEECP shall set out the governance structure, and programs for energy efficiency and conservation with defined national targets, feasible strategies, and regular monitoring and evaluation. The plan is also required to be regularly reviewed and revised by DOE"
  - "The DOE has forecasted that the country's energy mix in 2040 will appear like the energy mix to date, with a strong emphasis on oil products (50%). This is due, in part, to the predicted continued demand for diesel and petrol from the transportation sector. While there have been programs to test electric vehicles and the use of natural gas in public transport, these have been limited. The limited infrastructure and regulatory barriers in place mean that it may be several years before the use of electric vehicles can be effectively scaled up"
  - Under the Clean Energy Scenario (CES) of the Philippine Energy Plan 2018-2040 , there will be a 10% penetration rate for EVs for road transport by 2040"

Sector	Programs	Short Term Emissions Savings (2023 – 2024)	Medium Term Emissions Savings (2025 – 2028)	Long Term Emissions Savings (2029 – 2050)
Transport	Fuel Efficiency Standards	-	-	-
	10% EV penetration by 2040	-	-	116.54 Mt CO2e 8.22%

Sources: Philippines Republic Act No. 11285 - An Act Institutionalizing Energy Efficiency and Conservation, Enhancing The Efficient Use Of Energy, And Granting Incentives To Energy Efficiency And Conservation Projects
National Energy Efficiency and Conservation Plan and Roadmap 2023-2050. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2023-05-0018-NEECP-and-Roadmap-2023-2050.pdf

Improving Fuel Efficiency in Transport

- The Philippine Energy Labelling Programs (PELP) is a large program that has been undergoing phase-by-phase implementation since 2020
  - The development and rollout of energy performance requirements beyond the appliances sector remains a high priority for the DOE. These include technologies and industrial devices such as motors, and possibly transformers, which is widespread in use and energy consuming
  - Minimum fuel efficiency ratings and labelling for vehicles also fall under the PELP
  - The updated Roadmap highlights the necessary actions to expand the PELP product/technology coverage, through the conduct of market assessment studies, establishing and harmonizing standards in collaboration with experts and ASEAN economies respectively.
  - Supporting measures to the PELP include a robust online registration system, a Monitoring, Verification and Evaluation (MV&E) framework
- Incentivizing Eco-Driving on Busway operations
  - Literature points out that through the practice of eco-driving, fuel consumption can be reduced by 25%. Eco-driving can be measured by determining that the vehicle would operate at optimal fuel efficiency, or within the green area, through the estimation of parameters including speed, speed variation, acceleration/deceleration, and the continuous improvement through the use of real time data.
  - Based on on-road observation of bus operations on the EDSA Busway, the observed Engine Fuel Rate for Aggressive Driving is 22.03 Liter/Hr while Eco-Driving is 13.03 Liter/Hr, a 41% reduction
  - Eco-drivers when in motion and maintaining a cruising speed for an hour with at least 1,000 RPM can save up to 8.217 liters of fuel, compared to driving more aggressively.

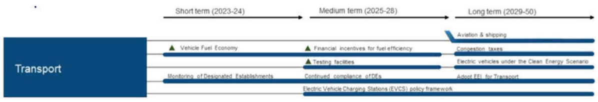
Telematics IoT device and *SafeTravelPH* crowdsourcing app

EDSA Busway

Source: National Energy Efficiency and Conservation Plan and Roadmap 2023-2050. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2023-05-0018-NEECP-and-Roadmap-2023-2050.pdf
Tiglao, N. C., Ng, A. C., Tacderas, M. A., & Tolentino, N. J. (2023). Crowdsourcing, digital Co-production and collaborative governance for modernizing local public transport services: The exemplar of general Santos City, Philippines. Research in Transportation Economics, 100, 101328. https://doi.org/10.1016/j.retrec.2023.101328

Philippine Transport Vehicles Fuel Economy Labeling Program (VFELP)

- With the expansion and amendment of the PELP coverage as indicated in DC2022-11-0035 and the requirement for fuel economy performance labelling under Section 17 of the EEC Act, the government's initiative on energy efficiency and conservation policies for the Transport Sector entails the development of the Philippine Transport Vehicles Fuel Economy Labeling Program
  - The program covers the fuel economy performance rating for the transport sector which will initially cover road transport vehicles
  - Requires that transport vehicle manufacturers, importers, distributors, dealers, and rebuilders shall comply with the vehicle fuel economy labeling requirements set by the DOE with the assistance of the DOTr, DENR, and other concerned agencies (EEC under Section 17, Section 2 of DC2020-10-0023, Sections 58 and 60 of DC2019-11-0014)
  - DOE will develop the necessary technical requirements, including but not limited to, implementing guidelines, vehicle fuel economy performance testing guidelines, and minimum energy performance for transport vehicles



Source: National Energy Efficiency and Conservation Plan and Roadmap 2023-2050. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2023-05-0018-NEECP-and-Roadmap-2023-2050.pdf

Key Strategies

- Transport Vehicles Fuel Economy Labeling Program (VFELP)
  - The Short-Term (2023-2024) strategic action includes the development of a Monitoring, Verification and Enforcement (MVE) framework
  - The Medium-Term (2025-2028) actions will establish financial incentives for fuel efficiency and the establishment of Electric Vehicles Charging Stations (EVCS) policy framework
    - "The emerging EV technology presents opportunities for improving energy efficiency in the transportation sector in support of the government's energy independence agenda." "There is a need to consolidate and harmonize all existing issuances to ensure the safe, efficient operations and system reliability and to accelerate investments in EVCs in the country"
    - In terms of vehicle testing, dedicated testing facilities will be established that are aligned with ASEAN standards
  - The Long-Term (2029-2050) actions will include energy efficiency programs beyond road transport (passenger and cargo ships, aviation fuels), congestion taxes, and continued institutionalization of the Energy Efficiency Index (EEI) across the sector
- Research and Development
  - Co-create programs for incentivizing fuel efficiency and emission reduction
  - Public transport monitoring and evaluation tools for government uses
  - Professionalizing fleet management through training programs and development of tools for asset management
  - Upgrade Competency Standards to include eco-driving as a core competency, and improve knowledge of drivers and operators on transport sector's environmental footprint

Source: National Energy Efficiency and Conservation Plan and Roadmap 2023-2050. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/issuances/dc2023-05-0018-NEECP-and-Roadmap-2023-2050.pdf

Maraming Salamat Po!

13

APEC Symposium on Promoting Energy Efficiency and Energy Management System

Achievement and potential of multi-pathway approach in road transport sector - Japan's experience -

23rd January, 2024
Takao Aiba
Japan Automobile Manufacturers Association (JAMA)
Chair, the International Climate Change Policy Expert Group

 1

Who We Are?

■JAMA (**J**apan **A**utomobile **M**anufacturers **A**ssociation, Inc.) is a non-profit industry **association comprising Japan's 14 manufacturers** of passenger cars, trucks, buses and motorcycles.

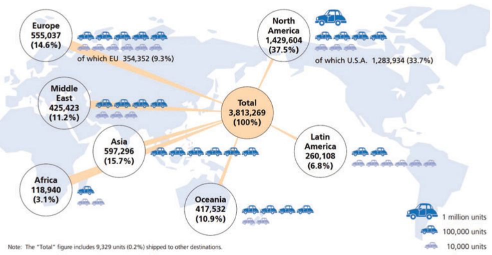
Established	April 3, 1967
Our Objective	• To promote the sound development of the automobile industry and contribute to social and economic welfare.
Our Activities	• Conducts studies and surveys related to automobile production, distribution, trade and use. • Assists in the rationalization of automobile production, and helps establish policy for the development, improvement and promotion of production technology. • Establishes and promotes policies related to automobile trade and worldwide exchange. • Carries out other activities involved in meeting its organizational objectives.
Member Companies	• Daihatsu Motor Co., Ltd. • Honda Motor Co., Ltd. • Kawasaki Motors, Ltd. • Mitsubishi Motors Corporation • Nissan Motor Co., Ltd. • Suzuki Motor Corporation • UD Trucks Corporation • Hino Motors, Ltd. • Isuzu Motors Limited • Mazda Motor Corporation • Mitsubishi Fuso Truck & Bus Corporation • Subaru Corporation • Toyota Motor Corporation • Yamaha Motor Co., Ltd.

 2

Who We Are?

■Member companies **produce and export motor vehicles worldwide.**

Motor Vehicle Exports By Destination In 2022

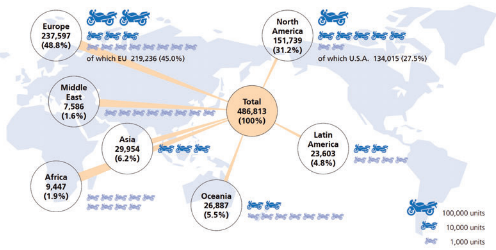


 3

Who We Are?

■Member companies **produce and export motorcycles worldwide.**

Motorcycle Exports By Destination In 2022



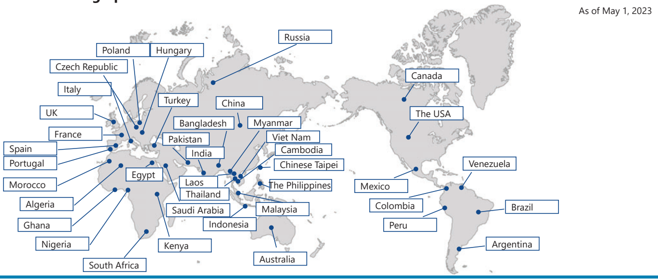
 4

Who We Are?

■Member companies **produce and export vehicles worldwide.**

Geographical Distribution of JAMA Members` Overseas Production Bases

As of May 1, 2023



 5

JAMA stance on Carbon Neutrality

JAMA member companies are making maximum efforts towards Carbon Neutrality by 2050.

JAMA Stance

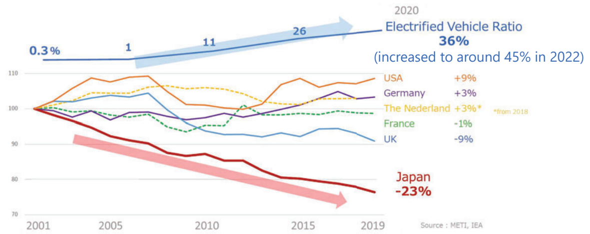
JAMA member companies, together with their global stakeholders, are **making maximum efforts towards carbon neutrality by 2050 by developing technologies to further reduce automotive CO_2 emissions** so that they can provide optimal choices for consumers in economies/regions worldwide.

- The goal is carbon neutrality (CN).
  Approaches to achieving CN should be technology-neutral.
  ➡ **A diversity of options is crucial to achieving our goals.**
- There are optimal pathways to CN for individual economies.

 6

CO2 emissions from road transport sector in Japan

■Japanese auto makers has been contributing in reducing CO2 emissions from road transport sector mainly through its **effort to improve fuel efficiency by expanding lineup of electrified vehicles.**



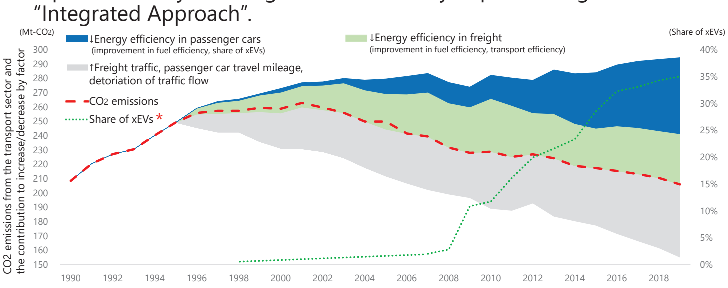
Concept of an "Integrated Approach"

Integrated Approach with 4 pillars

- ① Increasing Fuel-Efficient vehicles by Automobile Manufacturers
- ② Diversified Fuel Supply by Fuel Suppliers
- ③ Efficient Vehicle Use by Vehicle Users
- ④ Traffic Flow Improvement by Governments

CO2 emissions reduction by "Integrated Approach"

■Japan is steadily reducing CO2 emissions by implementing an "Integrated Approach".



*xEVs are electrified vehicle (HEVs, BEVs, PHEVs, FCEVs)

Sourse: KEIDANREN (Japan Business Federation) carbon neutrality action plan

Transitioning to Carbon Neutrality by 2050 (A Scenario-Based Analysis)

1. Purpose of using scenarios

   To understand, based on quantitative assessments, possible pathways to be pursued towards carbon neutrality in automotive transport by 2050.

2. Data applied

   New-vehicle sales data, in-use vehicle fleet data, energy/fuel mix data, vehicle fuel efficiency data, vehicle kilometers travelled annually, etc.

3. Scenario parameters

*FC: Fuel consumption

2050 Scenario Designation & Definition		BEV/FCEV Share of New Passenger Vehicle Sales			2050 Projected CNF Share in Automotive Fuel Mix [2020 FC*-Based]
		Worldwide	Japan, North America, Europe etc.	ASEAN economies	
0	BAU[1]	BAU	←	←	←
1	CNF (Wide use of CNF)	40%	50%	25%	30% approx.
2	BEV75 (Wide EV adoption)	75%	100%	50%	20% approx.
3	NZE (100% BEVs/FCEVs) from IEA[2] NZE[3] scenario	100%	100%	100%	7% (biofuel only)

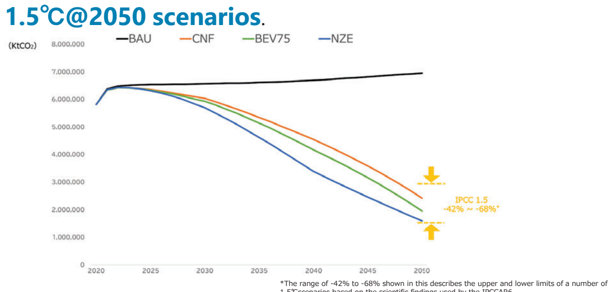
[1] BAU: Business as usual
[2] IEA : International Energy Agency
[3] NZE : Net Zero Emissions by 2050

Summary of Study Findings

Context	CO_2 Emission Levels in 2050
Worldwide	• **Findings show that the study's three scenarios (excluding the BAU scenario) demonstrate the potential for global CO_2 emissions reduction in automotive transport to be in line with the IPCC*'s 2050 1.5ºC climate scenarios.** *IPCC: Intergovernmental Panel on Climate Change • The IEA's NZE scenario is premised on one pathway towards carbon neutrality, but the JAMA study confirms that there are **other pathways, comprising a wide variety of electrified vehicles including HEVs and PHEVs and** the use of **carbon-neutral fuel (CNF).**
ASEAN	• **In many ASEAN economies**, vehicle sales volumes are expected to rise significantly. • If the amount of CNF in the automotive fuel mix in 2050 can be increased to a level equivalent to 40% (approx.) of global automotive fuel consumption in 2020, it will be **possible for CO_2 emissions** in ASEAN economies **to be in line with the IPCC's 1.5 climate scenarios for 2050.**
Japan	• The study's three scenarios demonstrate the **potential** in Japan **for carbon neutrality in automotive transport by 2050.** • **To that end**, however, **in addition to decarbonized electricity**, the supply of **carbon-neutral fuels for in-use vehicle fleets will be necessary.**

CO_2 Emissions Worldwide 2020-2050, by Scenario

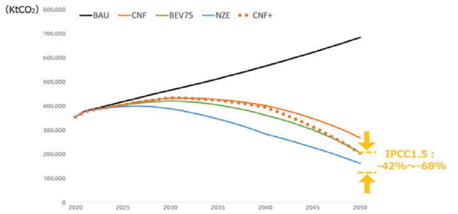
■In all three scenarios, CO_2 emissions worldwide are **in line with the IPCC's 1.5℃@2050 scenarios.**



*The range of -42% to -68% shown in this describes the upper and lower limits of a number of 1.5℃scenarios based on the scientific findings used by the IPCCAR6.

CO_2 Emissions ASEAN 2020-2050, by Scenario

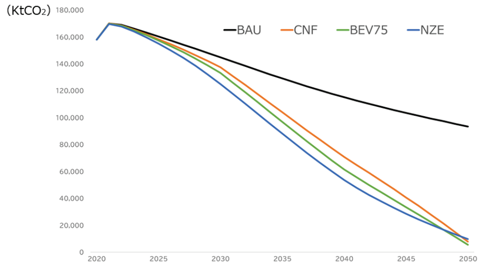
- **1.25 increase in carbon-neutral fuel supply** compared to the CNF scenario will make it possible for CO_2 emissions **in ASEAN economies to be in line with the IPCC's 1.5 scenarios for 2050.**



Note: The CNF+ scenario assumes that CNF supply is 1.25 times greater than in the CNF scenario, has a 40% (approx.) instead of 30% share (approx.) in the fuel mix and that most of the increase will be supplied to Africa, the Middle East, India, and ASEAN where the supply of decarbonized energy is a major challenge.

CO_2 Emissions Japan 2020-2050, by Scenario

- In all the scenarios, **CO_2 emission levels are close to carbon neutrality**.



Initiative in G7 members

- **G7 Leaders recognized the importance** of reducing GHG emissions from the global fleet and "**the range of pathways**" for **keeping a limit of 1.5℃ within reach.**

> other entities through decarbonization solutions. We welcome the progress of the Industrial Decarbonization Agenda (IDA) that decided to start working on implementation of the new Global Data Collection Framework for steel production and product emissions. We reaffirm our commitment to a highly decarbonized road sector by 2030, and recognize the importance of reducing GHG emissions from the global fleet and the range of pathways to approach this goal in line with trajectories required for keeping a limit of 1.5°C within reach. We are committed to the goal of achieving net-zero emissions in the road sector by 2050. In this context, we highlight the various actions that each of us is taking to decarbonize our vehicle fleet, including such domestic policies that are designed to achieve 100 percent or the overwhelming penetration of sales of light duty vehicles (LDVs) as zero emission vehicles (ZEV) by 2035 and beyond; to achieve 100 percent electrified vehicles in new passenger car sales by 2035; to promote associated infrastructure and sustainable carbon-neutral fuels including sustainable bio- and synthetic fuels. We note the opportunities that these policies offer to contribute to a highly decarbonized road sector, including progressing towards a share of over 50 percent of zero emission LDVs sold globally by 2030. Considering the findings of the International Energy Agency (IEA)'s Energy

Source: "G7 Hiroshima Leaders' Communiqué", Ministry of Foreign Affairs of Japan

The Global Stocktake at COP28, Dubai

- The first **"Global Stocktake"** on how economies can accelerate action to meet the goals of the **Paris Agreement** was conducted.
- In the agreement document, the importance of **"range of pathways"** was mentioned.

> 28. *Further recognizes* the need for deep, rapid and sustained reductions in greenhouse gas emissions in line with 1.5 °C pathways and *calls on* Parties to contribute to the following global efforts, in a nationally determined manner, taking into account the Paris Agreement and their different national circumstances, pathways and approaches:
>
> (g) Accelerating the reduction of emissions from road transport on a range of pathways, including through development of infrastructure and rapid deployment of zero- and low-emission vehicles;

https://unfccc.int/sites/default/files/resource/cma5_auv_4_gst.pdf

Summary of our presentation

- ✓ Japan **has been a leader of CO_2 emission reduction in road transport sector among G7 members** through
  - **"Integrated Approach"** consist of **4 pillars.**
  - **Expanding lineup** of electrified vehicles **suitable for regional circumstances**, which is in line with **"the range of pathways," key concept of G7 and COP28 agreement**.
- ✓ Based on the quantitative scenario analysis, JAMA believe that there is potential **not only for 100% BEVs**, but also for **a wide variety of electrified vehicles including HEVs and PHEVs and the use of carbon-neutral fuel (CNF)** for global CO_2 emissions reduction in road transport **to be in line with the IPCC's 2050 1.5℃ climate scenarios**.

工業技術研究院
Industrial Technology Research Institute

Improving Energy Efficiency in Industry in Chinese Taipei

Dr. PAN, Tze-Chin

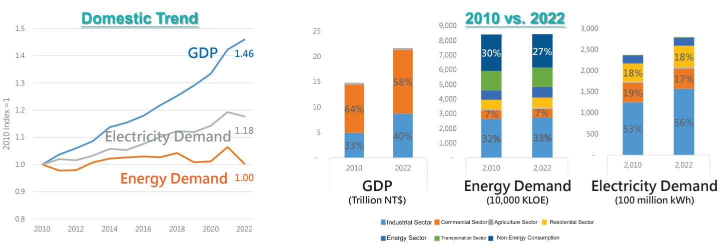
Deputy Division Director, Energy Policy and Planning Division, Green Energy and Environment Research Laboratories (GEL), Industrial Technology Research Institute (ITRI).

2024/01/23

1. **Energy Demand in Chinese Taipei**
2. Energy Efficiency Policies for Industrial Sector
3. 2050 Net-Zero Strategy: "Strategic Plan of Energy Saving"
4. Conclusion

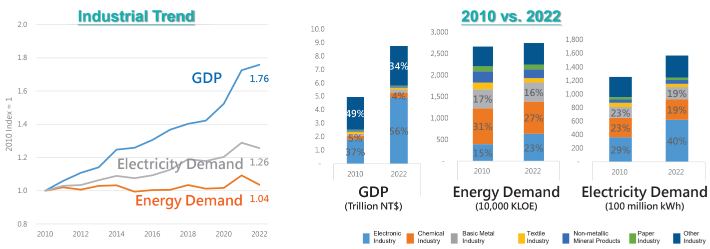
1-1. Domestic Trend in Economy and Energy

- Chinese Taipei's GDP is growing rapidly, leading to increased electricity demand, while total energy consumption remains stable.
- The industrial sector's share of GDP, energy usage, and electricity consumption has significantly increased.



1-2. Industrial Trend in Economy and Energy

- Industrial GDP growth surpasses electricity and energy use.
- Electronic Industry shows marked increases in GDP contribution, energy consumption, and electricity usage ratios.



1. Energy Demand in Chinese Taipei
2. **Energy Efficiency Policies for Industrial Sector**
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2-1. Energy Efficiency for Equipment and Appliances

- **Minimum Energy Performance Standard (MEPS)**

Equipment and Appliances	Issued Date	Energy Efficiency Improving (%)
Fan	2024/7/1	7~10
Rotodynamic pump	2023/1/1	5~8
Air compressor	2021/1/1	5~7
Water chilling packages using the vapor compression cycle	2020/7/1	2
Low-voltage three-phase squirrel-cage high-efficiency induction motors	2016/7/1	2~3 (IE3)

- **Energy Efficiency Ranking Labeling**

Water Chilling Packages		COP								
		3rd			2nd			1st		
		< 528 kW	≧ 528 kW < 1758 kW	≧ 1758 kW	< 528 kW	≧ 528 kW < 1758 kW	≧ 1758 kW	< 528 kW	≧ 528 kW < 1758 kW	≧ 1758 kW
Water-Cooled	Displacement	4.45	4.90	5.50	4.80	5.30	5.90	5.15	5.70	6.35
	Centrifugal	5.00	5.55	6.10	5.40	5.95	6.60	5.80	6.40	7.10
Air-Cooled			2.79			3.00			3.20	

Air Compressors	3rd	2nd	1st
Proportional loss factor	d = -5 ~ 0	d = 0 ~ 5	Above d = 5

2-2. Energy Audit Reporting Scheme

- **Large Energy User** (LEUs): The energy user whose energy consumption meets the level stipulated by the Ministry of Economic Affairs, shall establish its own **energy audit system** and set objectives for energy conservation and execution.
- There are **3,500 industrial LEUs**, and they consumed about **75%** of industrial energy consumption

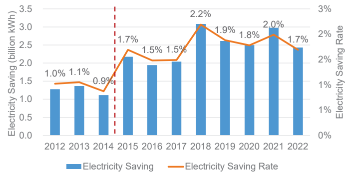
Energy Form	Basis for energy use	Mandatory Obligation
Electricity	Contract capacity **> 800kW**	1. Set energy management officer. 2. Report the energy audit and energy conservation plan annually.
Fuel oil	> 6,000 KL/y	
Natural gas	> 10,000,000m^3/y	
Coal	> 6,000 Ton/y	

2-3. Electricity Saving by 1%

- The government mandated a target of 1% electricity saving for LEUs:
  Annual average electricity saving (Si) from 2015 to 2024 must exceed 1% of the annual average total electricity consumption (Ci).

$$Annual\ average\ electricity\ saving\ rate = \frac{\sum_{2015}^{2024} S_i}{(\sum_{2015}^{2024} C_i + \sum_{2015}^{2024} S_i)} \geq 1\%$$

- Electricity saving from one energy efficiency measure will be counted only in one year.
- If the LEUs' annual average saving rate less than 1% in 2024, the LEUs will be penalized by the government.



2-4. Regulations for Six Energy Intensive Industries

Industry	Start date	Regulation for Energy Efficiency
Cement	2015.1.1	Maximum allowed specific energy consumption (SEC)* for different manufacturing systems
Iron & Steel	2015.1.1	• Blast furnace must install a blast furnace gas top pressure recovery turbine • Maximum temperature and oxygen concentration in the flue outlet
Pulp & Paper	2015.1.1	Maximum allowed specific energy consumption (SEC)* for different paper types
Chemical	2015.1.1	Maximum temperature and oxygen concentration in the outlets of the furnace, cracker, and thermal oil boiler.
Electronic	2015.11.1	Operation condition for chiller, fan, and desiccant air dryer
Textile	2016.1.1	• Limit of temperature difference between inlet and exit water in chiller; • Maximum temperature and oxygen concentration in flue outlet of coal stoke

*Energy consumptions per product

2.5 Energy Efficiency Subsidies for Industrial Sector

Type	Name	Applicant Eligibility	Subsidy Item	Grant Amount
Equipment -Based	**Motor-Driven Equipment Subsidy**	All companies	Government provide a list of high efficiency equipment, including IE4 motor, air compressor, fan, and pump.	• **IE4 Motor**: 700 NT$/kW (≒ 22.4 USD/kW) • **Air Compressor**: 700~5,000 NT$/kW (≒ 22.4~160 USD/kW) • **Fan**: 2,000~2,400 NT$/kW (≒ 64~76.8 USD/kW) • **Pump**: 2,000~4500 NT$/kW(≒ 64~144 USD/kW) (dependent on different capacity and model)
Project -Based*	**Energy Saving Performance Subsidy**	Companies (Contract Capacity over 100 kW)	Energy-saving project with more than a 10% improvement in energy efficiency	• Subsidy 20% of project total expenditure** • Subsidy ceiling is NT$5 million (160,000 USD).
	Waste Heat Recovery Subsidy	Companies (Contract Capacity over 100 kW)	Energy saving project with waste heat recycle	• Subsidy 30% of expenditure of waste heat recycle equipment • Subsidy ceiling is NT$5 million (160,000 USD).

* The subsidy program has a fixed total budget, and each application competes with others. The review committee determines the priority order of applications.
** If applicant is small-medium enterprises, the subsidy rate is 30%.
*** NT$1 ≒ 4.55 ¥ ≒ USD 0.032

1. Energy Demand in Chinese Taipei
2. Energy Efficiency Policies for Industrial Sector
3. **2050 Net-Zero Strategy: "Strategic Plan of Energy Saving"**
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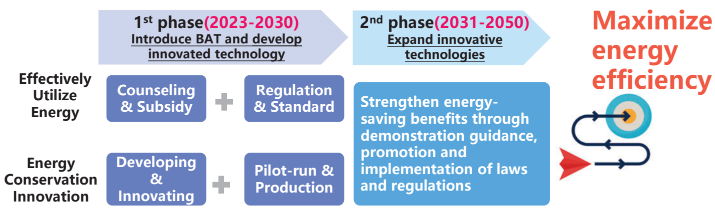
3-1. Phases of Strategic Plan

Chinese Taipei's "**Energy Saving Strategic Plan**" consists of two phases:



3-2. Plan Targets and Path (Phase 1)

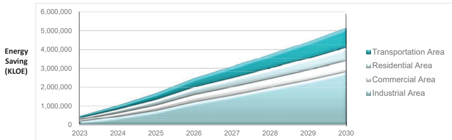
- **Target：** Maximizing Energy Efficiency through the efforts of public and private sectors.
- **Path：** "Energy Saving Strategic Plan" covers energy saving programs in industrial, commercial, residential, transportation sectors, and advanced technology research.

2025

- Gradually replace process equipment
- Large energy users (50% of the energy usage) is included in ISO 50001
- 700 new green buildings per year
- HVAC-R equipment to be the 1st energy-efficacy level
- Residential buildings efficiency increased by 5%
- Retail lamps 100% use LED.
- Include 2.5 tons+ light-duty trucks energy efficiency management

2030

- Implement high efficiency, low emission equipment
- 60% of the energy consumption of large energy users is included in ISO 50001
- 800 new green buildings per year
- New public buildings to be efficiency level 1 or ZEB.
- 30% of commercial large energy users adopt efficiency level 1 HVAC-R equipment. 100% lightings in commercial buildings use LED.
- Residential building envelope efficiency increased by 10%
- MEPS of AC and refrigerator reach level 3
- Energy efficiency of new cars increased by 30%



Industrial energy saving	• Improving **manufacturing processes** • **Counselling** on energy-saving measures • Raise corporate **energy-saving target** and efficiency improvement
Commercial energy saving	• Improve equipment operation efficiency or behavior • Low-carbon transformation of business • Green buildings
Residential energy saving	• Improve efficiency of new/existing buildings • Improve efficiency of home appliances • Social advocacy and communication
Transportation energy saving	• Expand the scope of vehicle energy efficiency management • Change fleet driving behavior • Strengthen the vehicle energy efficiency classification system
Advanced energy saving technology	• Develop innovative manufacturing processes • Develop high efficiency equipment • Develop and promote energy management system

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4. **Conclusion**

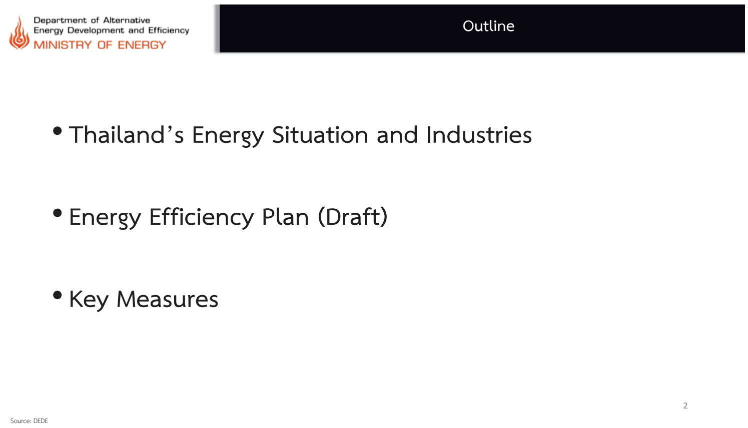
Conclusion

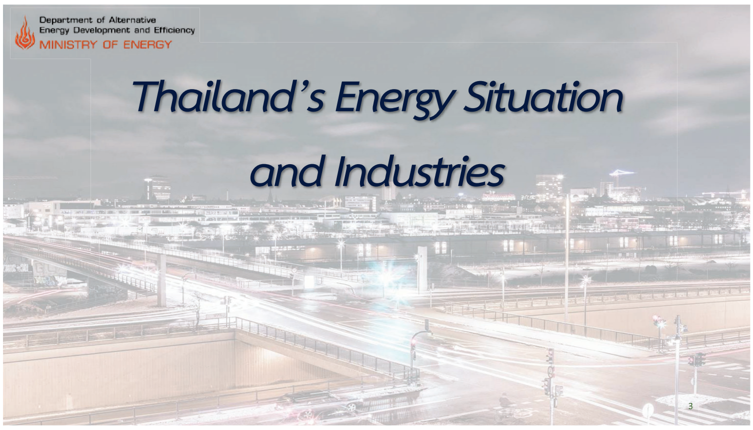
- The **industrial sector** in Chinese Taipei consumes **33%** of the total energy, a significantly higher share than other sectors.
- To enhance industrial energy efficiency, Chinese Taipei is implementing the following measures:

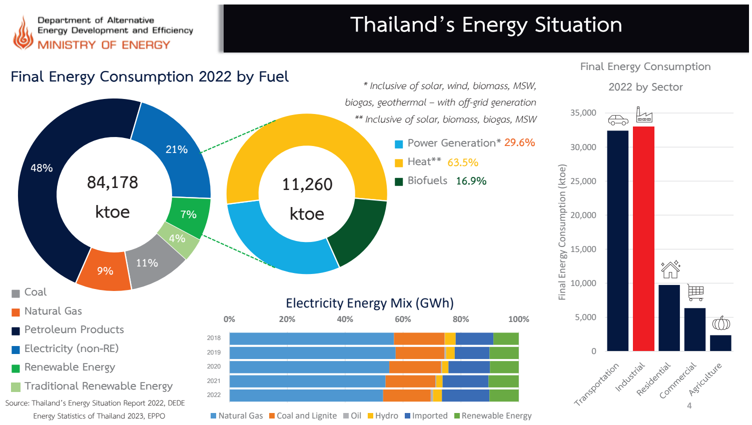
Equipment	Large Energy Users	Incentives
• MEPS	• Energy Audit Reporting Scheme	• Motor-Driven Equipment Subsidy
• Energy Efficiency Ranking Labeling	• Mandatory 1% Electricity Saving Target	• Energy Saving Performance Subsidy
	• Regulations for Six Energy Intensive Industries	• Waste Heat Recovery Subsidy

- To achieve the **2050 Net-Zero**, Chinese Taipei has devised the "**Strategic Plan of Energy Saving**".

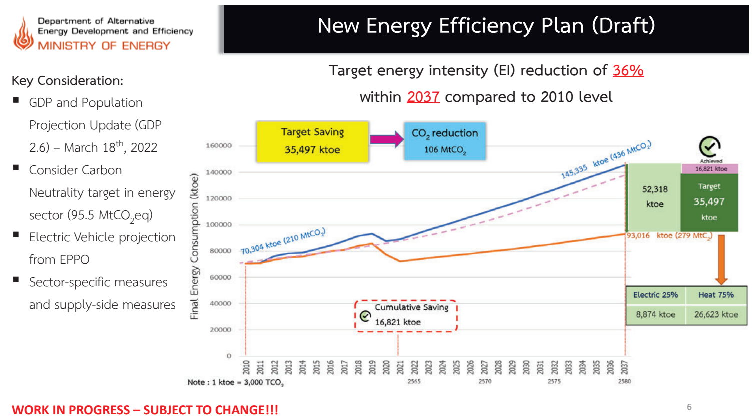

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
Improving Energy Efficiency in Industry in Thailand
Mr.Wisaruth Maethasith
Department of Alternative Energy Development and Efficiency
APEC Sectoral Symposia on the Holistic Approach of Decarbonization for Energy Transition
23 January 2024
กระทรวงพลังงาน
MINISTRY OF ENERGY
1


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
Outline
• Thailand's Energy Situation and Industries
• Energy Efficiency Plan (Draft)
• Key Measures
Source: DEDE
2


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
Thailand's Energy Situation and Industries
3


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
Thailand's Energy Situation
Final Energy Consumption 2022 by Fuel
* Inclusive of solar, wind, biomass, MSW, biogas, geothermal – with off-grid generation
** Inclusive of solar, biomass, biogas, MSW
84,178 ktoe
48%
21%
7%
4%
11%
9%
11,260 ktoe
Power Generation* 29.6%
Heat** 63.5%
Biofuels 16.9%
Coal
Natural Gas
Petroleum Products
Electricity (non-RE)
Renewable Energy
Traditional Renewable Energy
Source: Thailand's Energy Situation Report 2022, DEDE
Energy Statistics of Thailand 2023, EPPO
Electricity Energy Mix (GWh)
0% 20% 40% 60% 80% 100%
2018 2019 2020 2021 2022
Natural Gas Coal and Lignite Oil Hydro Imported Renewable Energy
Final Energy Consumption 2022 by Sector
Final Energy Consumption (ktoe)
35,000 30,000 25,000 20,000 15,000 10,000 5,000 0
Transportation Industrial Residential Commercial Agriculture
4


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
Energy Efficiency Plan (Draft)
5


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
New Energy Efficiency Plan (Draft)
Key Consideration:
GDP and Population Projection Update (GDP 2.6) – March 18th, 2022
Consider Carbon Neutrality target in energy sector (95.5 MtCO2eq)
Electric Vehicle projection from EPPO
Sector-specific measures and supply-side measures
Target energy intensity (EI) reduction of 36% within 2037 compared to 2010 level
Target Saving 35,497 ktoe
CO2 reduction 106 MtCO2
Final Energy Consumption (ktoe)
70,504 ktoe (210 MtCO2)
145,335 ktoe (436 MtCO2)
93,016 ktoe (279 MtCO2)
52,318 ktoe
Target 35,497 ktoe
Achieved 16,821 ktoe
Cumulative Saving 16,821 ktoe
Electric 25% Heat 75%
8,874 ktoe 26,623 ktoe
Note : 1 ktoe = 3,000 TCO2
WORK IN PROGRESS – SUBJECT TO CHANGE!!!
6

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New Energy Efficiency Plan (Draft) – cont.

Energy efficiency measures target by energy types: 2022 - 2037

Unit: ktoe

	Compulsory	Voluntary	Total	%
Electricity	3,822	5,051	8,874	25
Thermal	7,058	19,565	26,623	75
Total	10,880	24,617	35,497	100

Energy efficiency measures target by economic sectors: 2022 - 2037

Unit: ktoe

Sector	Compulsory		Voluntary		Total	%
	Elec.	Thermal	Elec.	Thermal		
1. Industrial	1,590	4,610	2,300	3,922	12,423	35
2. Commercial	1,700	32.	1,328	488	3,549	10
3. Residential	117	-	1,461	196	1,774	5
4. Agricultural	50	-	147	512	709	2
5. Transportation		1,650	-	15,538	17,03	48
Total	3,458	6,293	5,238	20,657	35,497	100

WORK IN PROGRESS – SUBJECT TO CHANGE!!!

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

Key measures – Industrial and Commercial Sector

15,973 ktoe

Compulsory	Voluntary	Complementary
• Energy management standards in designated factories and buildings • Enforcement of factory and building energy codes	• Energy efficiency standards and labelling for equipment • Financial Incentives - Direct subsidy (Subsidy, 80:20) - Loans (Soft loan, ESCO Fund) - Tax incentive - Credit Guarantee Mechanism • Promoting innovations (IOT, Smart Factory, Smart Building, Big Data) • Promoting energy efficiency in equipment utilizing renewable energy (Biomass boiler, Biomass furnace, Generator, Solar Heat) • Energy efficiency for the supply side	• Human Resource Development • Public awareness • Research and Development of technologies and innovations

WORK IN PROGRESS – SUBJECT TO CHANGE!!!

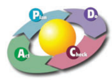
Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

1. Energy Management System

Classification of designated factories/buildings

Current status (as of January 1st 2024):
6,473 designated factories
3,324 designated buildings
9,797 in total

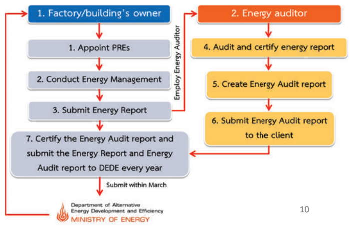
Criteria	Designated Factories/Buildings	
	Group 1	Group 2
Installed electric meter (total)	Between 1000 – 3000 kW	More than 3000 kW
Installed transformers (total)	Between 1,175 – 3,530 kVA	More than 3,530 kVA
Total annual energy consumption	Between 20 – 60 TJ/year	More than 60 TJ/year



Legal responsibilities of designated factories/buildings

1. Appoint Person Responsible for Energy (PRE)
   - At least 1 PRE for Group 1 – (C-PRE/S-PRE)
   - At least 2 PREs for group 2, in which one must be senior PREs (S-PRE).

2. Conduct energy management system as described in regulation and submit an annual report to DEDE every March.



C-PRE: Convention PRE, S-PRE: Senior PRE

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

2. Financial Incentive - Subsidy Program 20 – 80

Measure Overview
- Subsidize equipment and machinery replacement (with approved high-efficiency ones) or innovative energy-efficient equipment
- Subsidize for equipment and installation cost
  - **20%** for Designated buildings and factories when replacing with efficient equipment and machinery
  - **30%** for Designated buildings and factories when replacing with efficient equipment and machinery with approved innovative technologies
  - **30%** for non-designated buildings and factories, community enterprise, start-ups, or agriculturers
- **Supports up to 3 million baht per applicant**
- **Payback period no longer than 7 years**

Examples measures

- ❖ **Installing variable speed motors used with the machine.**
- ❖ **Replacement air compressors, high efficiency**
- ❖ **To improve the power factor.**
- ❖ **Replacing high-performance electric motor**
- ❖ **Insulation**
- ❖ **The use of heat pumps**

For further information

https://bit.ly/3bZLmnI

Source: DEDE

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

2. Financial Incentive – Board of Investment

Smart and Sustainable Industry

Applicable Projects*
- ❖ Energy-efficient equipment replacement
- ❖ Equipment replacement to utilize renewable energy
- ❖ GHG Reduction project (must be certified by TGO**)
- ❖ Environmental impact reduction project

Benefits
- ❖ Exemption on import duty on machinery
- ❖ 3-year corporate income tax (CIT) exemption – 50% of the investment cost

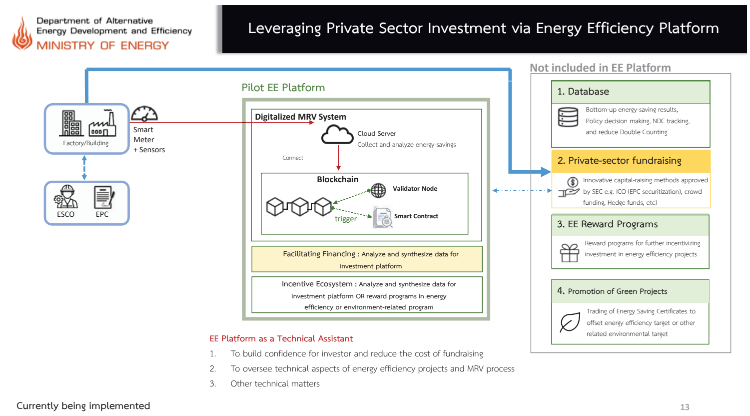
Energy Service Companies (ESCO)
- ❖ Provide turnkey solutions for energy efficiency project
- ❖ Project implemented can be in the form of guaranteed saving, shared saving, or chauffrage

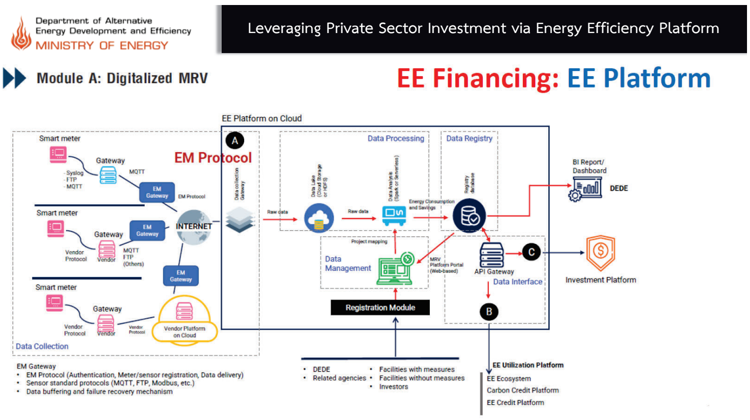
Benefits
- ❖ Exemption on import duty on machinery
- ❖ 8-year corporate income tax (CIT) exemption – no CIT exemption cap

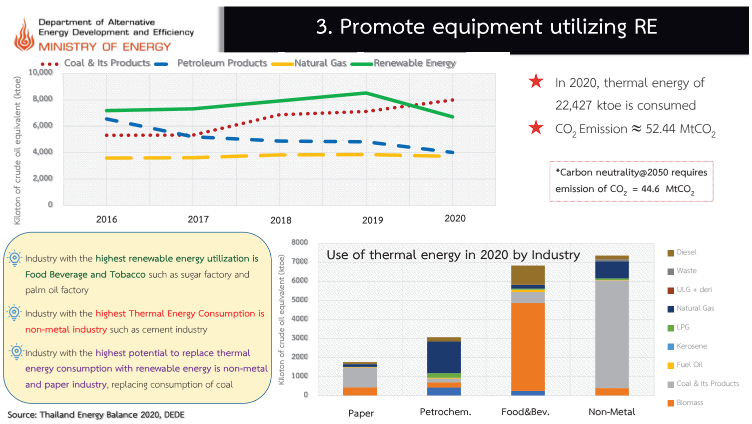
THAILAND BOARD OF INVESTMENT

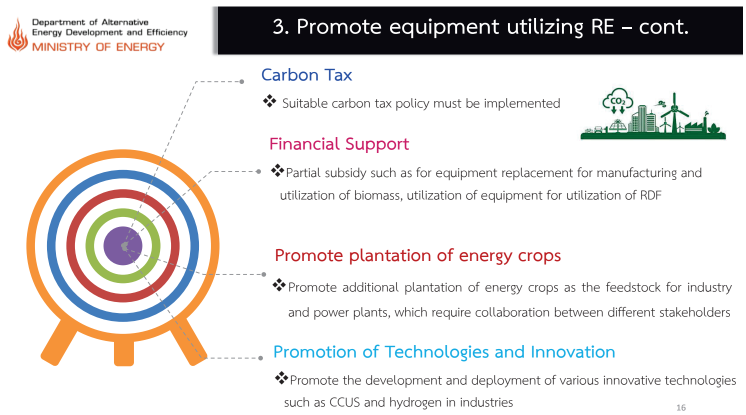
For further information

*At least 1M Baht in investment (or 500k Baht for SME)
**Thai Greenhouse Gas Organization


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
Leveraging Private Sector Investment via Energy Efficiency Platform
Pilot EE Platform
Not included in EE Platform
Factory/Building
Smart Meter + Sensors
ESCO
EPC
Digitalized MRV System
Cloud Server
Collect and analyze energy-savings
Connect
Blockchain
Validator Node
trigger
Smart Contract
Facilitating Financing : Analyze and synthesize data for investment platform
Incentive Ecosystem : Analyze and synthesize data for investment platform OR reward programs in energy efficiency or environment-related program
1. Database
Bottom-up energy-saving results, Policy decision making, NDC tracking, and reduce Double Counting
2. Private-sector fundraising
Innovative capital-raising methods approved by SEC e.g. ICO (EPC securitization), crowd funding, Hedge funds, etc)
3. EE Reward Programs
Reward programs for further incentivizing investment in energy efficiency projects
4. Promotion of Green Projects
Trading of Energy Saving Certificates to offset energy efficiency target or other related environmental target
EE Platform as a Technical Assistant
1. To build confidence for investor and reduce the cost of fundraising
2. To oversee technical aspects of energy efficiency projects and MRV process
3. Other technical matters
Currently being implemented
13


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
Leveraging Private Sector Investment via Energy Efficiency Platform
Module A: Digitalized MRV
EE Financing: EE Platform
EE Platform on Cloud
Smart meter
Gateway
EM Protocol
Data Processing
Data Registry
INTERNET
Data Management
Registration Module
API Gateway
Data Interface
BI Report/ Dashboard
DEDE
Investment Platform
Data Collection
Vendor Platform on Cloud
EM Gateway
• EM Protocol (Authentication, Meter/sensor registration, Data delivery)
• Sensor standard protocols (MQTT, FTP, Modbus, etc.)
• Data buffering and failure recovery mechanism
• DEDE
• Related agencies
• Facilities with measures
• Facilities without measures
• Investors
EE Utilization Platform
EE Ecosystem
Carbon Credit Platform
EE Credit Platform


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
3. Promote equipment utilizing RE
Coal & Its Products
Petroleum Products
Natural Gas
Renewable Energy
Kiloton of crude oil equivalent (ktoe)
10,000
8,000
6,000
4,000
2,000
0
2016
2017
2018
2019
2020
In 2020, thermal energy of 22,427 ktoe is consumed
CO2 Emission ≈ 52.44 MtCO2
*Carbon neutrality@2050 requires emission of CO2 = 44.6 MtCO2
Industry with the highest renewable energy utilization is Food Beverage and Tobacco such as sugar factory and palm oil factory
Industry with the highest Thermal Energy Consumption is non-metal industry such as cement industry
Industry with the highest potential to replace thermal energy consumption with renewable energy is non-metal and paper industry, replacing consumption of coal
Use of thermal energy in 2020 by Industry
Kiloton of crude oil equivalent (ktoe)
8000
7000
6000
5000
4000
3000
2000
1000
0
Paper
Petrochem.
Food&Bev.
Non-Metal
Diesel
Waste
ULG + deri
Natural Gas
LPG
Kerosene
Fuel Oil
Coal & Its Products
Biomass
Source: Thailand Energy Balance 2020, DEDE


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY
3. Promote equipment utilizing RE – cont.
Carbon Tax
Suitable carbon tax policy must be implemented
Financial Support
Partial subsidy such as for equipment replacement for manufacturing and utilization of biomass, utilization of equipment for utilization of RDF
Promote plantation of energy crops
Promote additional plantation of energy crops as the feedstock for industry and power plants, which require collaboration between different stakeholders
Promotion of Technologies and Innovation
Promote the development and deployment of various innovative technologies such as CCUS and hydrogen in industries
16


Thank You
For further information, please contact email: wisaruth_m@dede.go.th
17

APEC Symposium on Promoting Energy Efficiency and Energy Management System

Improving Energy Efficiency in Industry in Japan

Jan 23, 2024

Akira Ishihara
The Energy Conservation Center, Japan

1

Energy efficiency trend

and the situations in industry

2

Situations of industry for energy efficiency and low carbon

Measures in industry, as in other sectors, continue to be important to achieve low carbon. While electrification and the expansion of renewable electricity are important directions for transport, household and business sectors, industry further needs multilateral approaches such as process efficiency, efficient use of heat and electricity, and non-fossil energy sources.

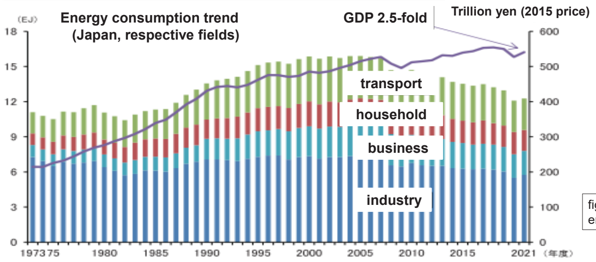
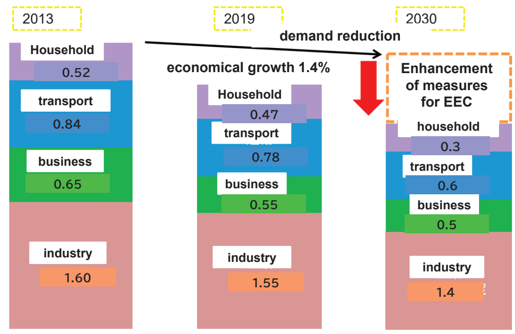


fig: Annual report on energy 2023 (Gov)

3

Medium period energy efficiency plan (Japan)

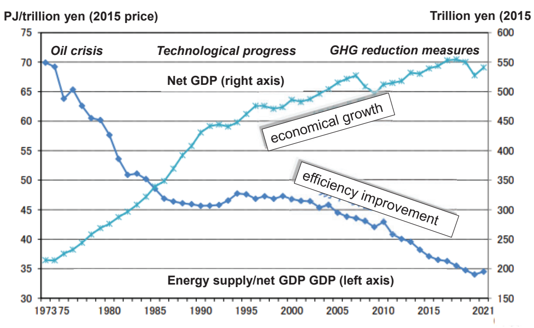


unit 100million-kL (crude oil equiv.)

Source: 6th Strategic energy plan

4

Trends of energy efficiency



Energy efficiency is improving in a long trend. It should be enhanced further.

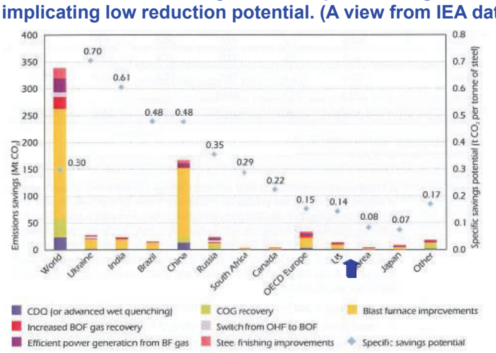
The horizontal trend seen is 1990s might be influenced by the addition of equipment and process for environment and quality.

fig: Annual report on energy 2023 (Gov)

5

CO_2 reduction potential reference (iron and steel)

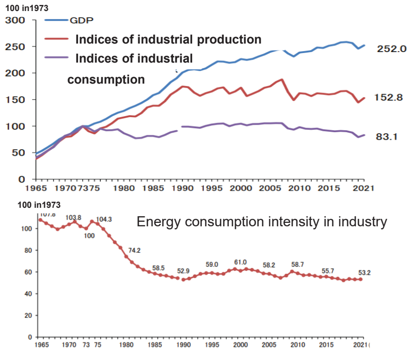
Best available technologies are adopted in a high level in Japan, implicating low reduction potential. (A view from IEA data in the past.)



Worldwide Trends in Energy Use and Efficiency (IEA, 2008) p32
CO_2 reduction potential in iron and steel in 2005 based on best available technology.

6

Trends of energy efficiency (industry)

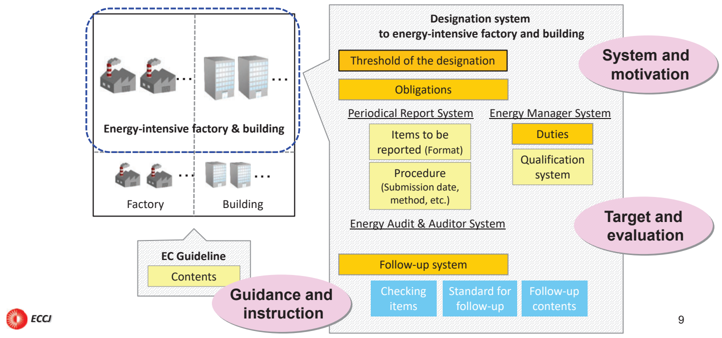


The trend in industry is similar as the whole field trend, but recent progress ratio is not so large, which seem to be under the influence of low reduction potential. Multilateral measures are needed.

fig: Annual report on energy 2023 (Gov)

Methodologies to promote energy efficiency in industry

Total EM System as a fundamental methodology



Transition to non-fossil energy in EC Act

expansion of target of policies in EC Act toward carbon neutrality (amendment in 2022) red letters: newly introduced concept in EC Act

Rational use of energy (energy efficiency and conservation)

Transition to non-fossil energy

Optimization of the demand for electricity (demand response in both of increasing and decreasing)

(definition)
Expansion of kind of energies regulated in EC Act
to non-fossil fuel
non-fossil electricity
non-fossil heat

Approaches for higher energy efficiency and low carbon (in industry)

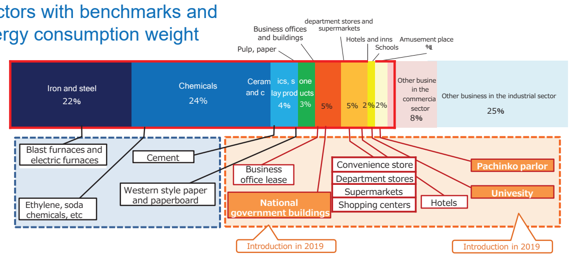
Subsets	Policy and management
Energy intensive (material) subsectors	Benchmark on energy efficiency Non-fossil ratio target Cooperation between factories
Large scale businesses	Carbon target management
Small and medium businesses	Energy audit and implementation (government support)
Electricity system	Use of renewable energy Use of non fossil fuels Optimization of electricity use Non-fossil certificate

Technology and system background
Production technologies
Heat process technologies
Heat pumps and efficient thermal utility
Cogeneration technologies
EMS and production control system
Established energy efficient devices
Electricity use optimization (demand-side measures to electrification)
Non-fossil fuel technologies
On site renewable energy

Subsector approach (benchmark in EC Act)

The benchmark system in EC Act has been established for energy intensive and material subsectors in industry and focused subsectors in buildings and non-industry business.

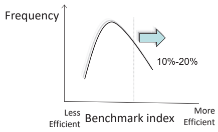
subsectors with benchmarks and the energy consumption weight



advantages and setting of the value

Advantages of the benchmark target;
・raising motivation to pursue a realizable target
・useful in the evaluation process as a fair target.

Benchmark value is set as the top 10%-20% business operators to satisfy, which is a kind of top runner.



examples of industry benchmark indices and value

Source: EC Guideline (METI)

Business operation	Benchmark indices	Aimed level
Steel manufacturer using blast furnaces	Energy consumption per basic unit quantity of crude steel.	≦0.531kl/t
Ordinary steel manufacturer using electric furnace	Sum of unit consumption (energy consumption per unit quantity of crude steel) of upper processes and unit consumption (energy consumption per unit rolled metal quantity) of lower processes. Modification by out-of-fire refining is applied to upper processes, and modification by kind of product is applied to lower processes.	≦0.150kl/t
Cement manufacturer	Sum of energy consumption of the following processes; raw material, calcination, finishing, and also shipping and other, divided by the production amounts or shipping amount of the respective processes.	≦3,739MJ/t
Paperboard manufacturer	Energy consumption in paperboard manufacturing processes per paperboard production amount. Modification by production of specific products is applied.	≦4,944MJ/t
Petrochemical basic product manufacturer	Energy consumption in the production of ethylene and the like products divided by the production volume of ethylene and ethylene related components of the like products.	≦11.9GJ/t
Soda chemical manufacturer	Sum of energy consumption in electrolysis processes divided by the weight of caustic soda derived from electrolytic tanks, and the steam heat consumption in condensation processes divided by the weight of liquid caustic soda.	≦3.22GJ/t

Non-fossil target system

Indices

- Non-fossil electricity ratio (non fossil electricity account to total electricity account)
- Non-fossil energy index
  indices separately defined for several subsectors
  with expected value levels
- Indices related to non-fossil energy adopted by business operators (not mandatory)

recommendation of actions

Business operators

- Target setting
- Planning
- Action
- Report

14

Energy audit in Japan

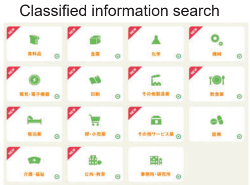
Supports for small and medium businesses

Energy Audit by METI project
ECCJ has conducted more than 15,000 free energy audits since 1978. Recently, the main target is small & medium factory/building.

Further support by local platforms

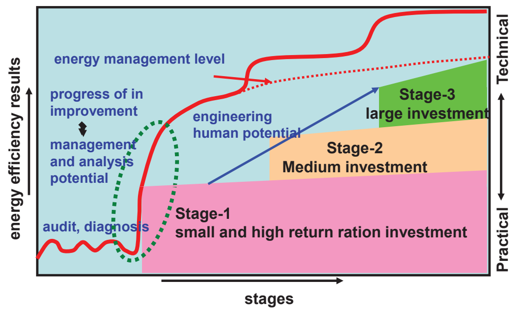
ECCJ Web information on site audit reports

Classified information search



15

site-oriented improvement promotion scheme



16

16

A case study

Management in a large business

Corresponding SDGs

Basic Philosophy	**Reducing environmental footprint** **as a high priority environmental strategy together with developing sustainable products, and sustainable and responsible procurement**
Current activity (problems and measures)	**Promotion of field/site based energy conservation** **Measurement and visualization** **→ To review efficiency of the production method and line** **Power consumption prediction system** **Input: production plan, actual power consumptions, meteorological data** **Output: prediction of power consumption and solar generation** **→ To establish standard production plan based on the weather conditions** **Enhancement of motivation** **Reporting on EE actions directly to higher managements** **System to allow energy data to any member anytime** **(results) 10% reduction of energy consumption/CO2 emission**

Technical trends and development

The case of iron and steel industry

Technological Development

process innovation (CC, CAPL, PCI, CMC, expansion use of EF) → ferro cokes COURCE50

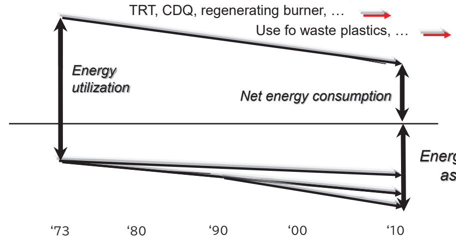
process improvement (hot charge, thermal control, …) →

efficient use of byproduct gas, combined cycle, … →

TRT, CDQ, regenerating burner, … →

Use fo waste plastics, … →

Development for future: innovative reduction performance



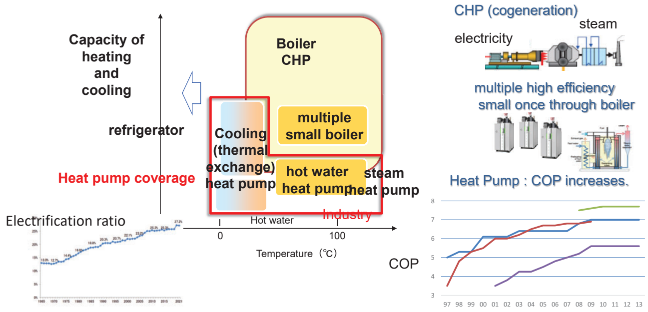
The commitment for a low-carbon society
Eco Process
Eco Solution
Eco Producs

18

Made using information by Japan Iron and Steel Federation

Review on Technologies

Heating facility and heat pump

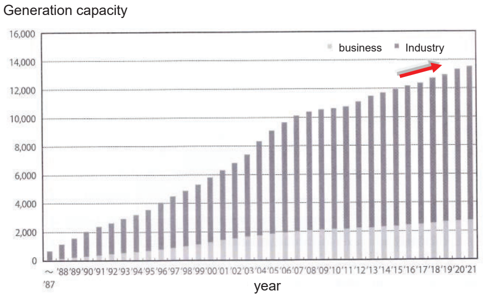


coefficient of performance (COP)= output energy (heat transfer) / input energy

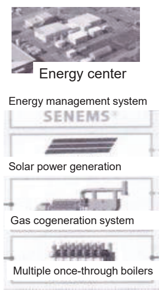
Cogeneration

Source: "Energy Conservation" (ECCJ) Mar 2022 and Dec 2022

Accumulated implementation volume of cogeneration in Japan (industry and business)

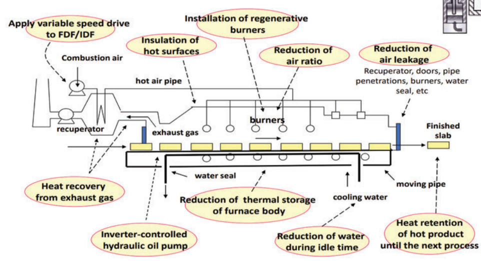


A case of application (Kiyohara industry area, Tochigi pref., Japan)

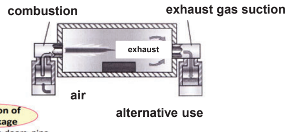


Industrial furnace

Application of recent technologies for higher efficiency including regenerative burner systems



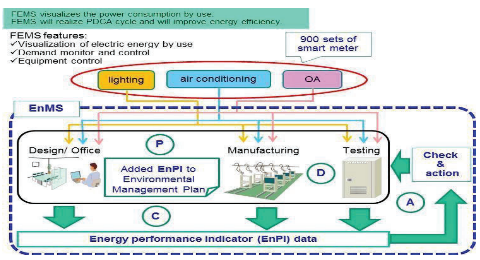
Regenerative burner



Technological study for future
possibility of use of non-fossil energy resource

FEMS and optimization

FEMS: management and visualization



Source of figure: Hitachi, Omika Works
"EMWG leadership awards document in public"

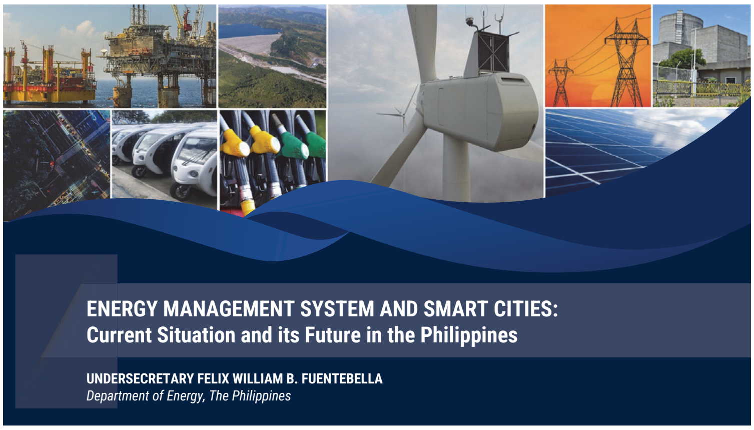
Optimization of production energy

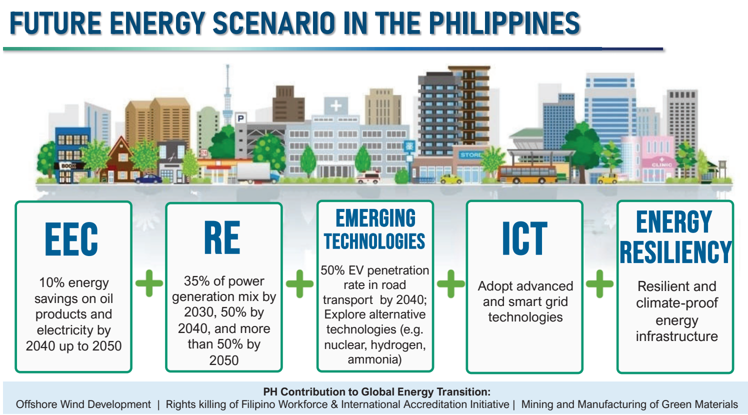
- Measurement and energy visualization
- Flexible fabrication by compact equipment and arrangement
- Minimum consumption control according to production demand
- Renkei (cooperative) control

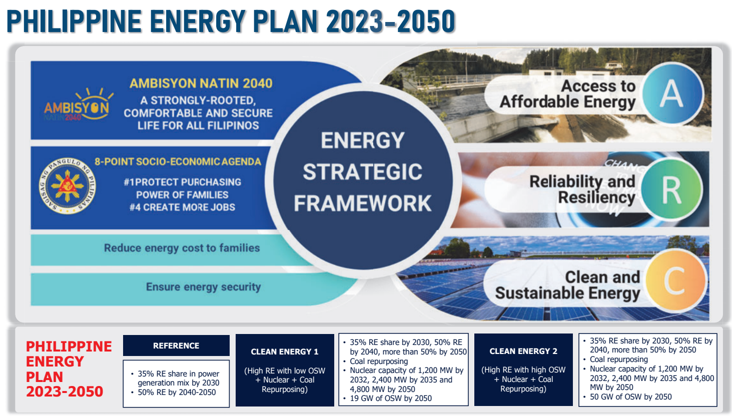
Source: "Energy Conservation" (ECCJ) Dec. 2023

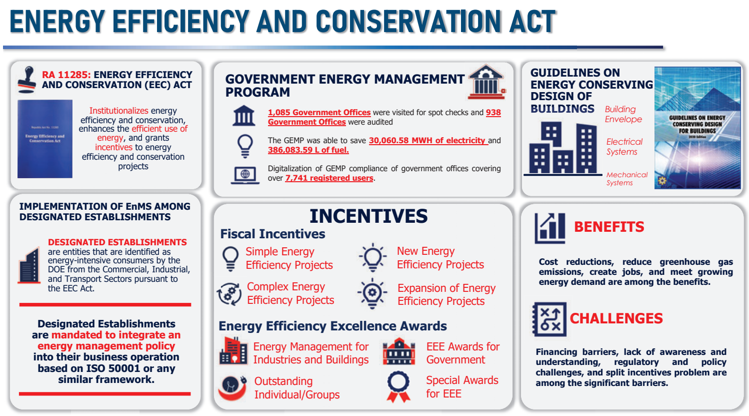
conclusion

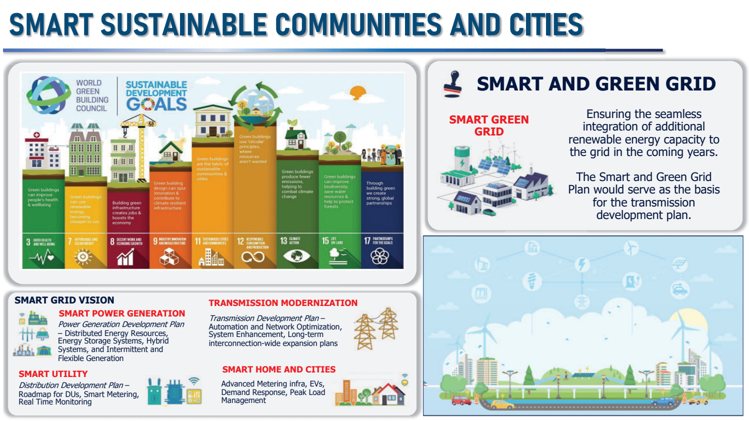
(1) The energy efficiency of Japan's Industry has been improved by technologies such as heat recovery. Currently, it is also improving but not rapidly. It is necessary to promote multilateral measures of policy and technology.
(2) EC Act (amendment) will promote energy conservation, conversion to non-fossil energy, and optimal use of electricity.
(3) Measures appropriate to respective fields or businesses, should be taken; such as energy audits for small and medium-sized businesses, carbon emission reduction targets for large businesses, energy efficiency benchmark target values for subsectors, etc.
(4) The efficiency of thermal systems should be raised by expanding heat pumps, cogenerations, high-efficiency boilers and combustion systems. Also, technologies for the use of non-fossil energy is important.
(5) It is expected that FEMS including visualization, effective production planning, and control for the entire production process, will be useful.

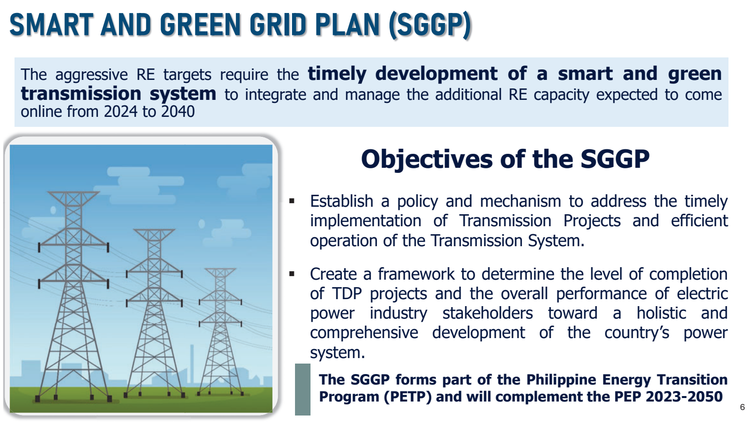

ENERGY MANAGEMENT SYSTEM AND SMART CITIES:
Current Situation and its Future in the Philippines
UNDERSECRETARY FELIX WILLIAM B. FUENTEBELLA
Department of Energy, The Philippines


FUTURE ENERGY SCENARIO IN THE PHILIPPINES
EEC
10% energy savings on oil products and electricity by 2040 up to 2050
RE
35% of power generation mix by 2030, 50% by 2040, and more than 50% by 2050
EMERGING TECHNOLOGIES
50% EV penetration rate in road transport by 2040; Explore alternative technologies (e.g. nuclear, hydrogen, ammonia)
ICT
Adopt advanced and smart grid technologies
ENERGY RESILIENCY
Resilient and climate-proof energy infrastructure
PH Contribution to Global Energy Transition:
Offshore Wind Development | Rights killing of Filipino Workforce & International Accreditation Initiative | Mining and Manufacturing of Green Materials


PHILIPPINE ENERGY PLAN 2023-2050
AMBISYON NATIN 2040
A STRONGLY-ROOTED, COMFORTABLE AND SECURE LIFE FOR ALL FILIPINOS
8-POINT SOCIO-ECONOMIC AGENDA
#1 PROTECT PURCHASING POWER OF FAMILIES
#4 CREATE MORE JOBS
Reduce energy cost to families
Ensure energy security
ENERGY STRATEGIC FRAMEWORK
Access to Affordable Energy
Reliability and Resiliency
Clean and Sustainable Energy
PHILIPPINE ENERGY PLAN 2023-2050
REFERENCE
35% RE share in power generation mix by 2030
50% RE by 2040-2050
CLEAN ENERGY 1
(High RE with low OSW + Nuclear + Coal Repurposing)
35% RE share by 2030, 50% RE by 2040, more than 50% by 2050
Coal repurposing
Nuclear capacity of 1,200 MW by 2032, 2,400 MW by 2035 and 4,800 MW by 2050
19 GW of OSW by 2050
CLEAN ENERGY 2
(High RE with high OSW + Nuclear + Coal Repurposing)
35% RE share by 2030, 50% RE by 2040, more than 50% by 2050
Coal repurposing
Nuclear capacity of 1,200 MW by 2032, 2,400 MW by 2035 and 4,800 MW by 2050
50 GW of OSW by 2050


ENERGY EFFICIENCY AND CONSERVATION ACT
RA 11285: ENERGY EFFICIENCY AND CONSERVATION (EEC) ACT
Institutionalizes energy efficiency and conservation, enhances the efficient use of energy, and grants incentives to energy efficiency and conservation projects
GOVERNMENT ENERGY MANAGEMENT PROGRAM
1,085 Government Offices were visited for spot checks and 938 Government Offices were audited
The GEMP was able to save 30,060.58 MWH of electricity and 386,083.59 L of fuel.
Digitalization of GEMP compliance of government offices covering over 7,741 registered users.
GUIDELINES ON ENERGY CONSERVING DESIGN OF BUILDINGS
Building Envelope
Electrical Systems
Mechanical Systems
IMPLEMENTATION OF EnMS AMONG DESIGNATED ESTABLISHMENTS
DESIGNATED ESTABLISHMENTS are entities that are identified as energy-intensive consumers by the DOE from the Commercial, Industrial, and Transport Sectors pursuant to the EEC Act.
Designated Establishments are mandated to integrate an energy management policy into their business operation based on ISO 50001 or any similar framework.
INCENTIVES
Fiscal Incentives
Simple Energy Efficiency Projects
New Energy Efficiency Projects
Complex Energy Efficiency Projects
Expansion of Energy Efficiency Projects
Energy Efficiency Excellence Awards
Energy Management for Industries and Buildings
EEE Awards for Government
Outstanding Individual/Groups
Special Awards for EEE
BENEFITS
Cost reductions, reduce greenhouse gas emissions, create jobs, and meet growing energy demand are among the benefits.
CHALLENGES
Financing barriers, lack of awareness and understanding, regulatory and policy challenges, and split incentives problem are among the significant barriers.


SMART SUSTAINABLE COMMUNITIES AND CITIES
WORLD GREEN BUILDING COUNCIL
SUSTAINABLE DEVELOPMENT GOALS
SMART AND GREEN GRID
SMART GREEN GRID
Ensuring the seamless integration of additional renewable energy capacity to the grid in the coming years.
The Smart and Green Grid Plan would serve as the basis for the transmission development plan.
SMART GRID VISION
SMART POWER GENERATION
Power Generation Development Plan – Distributed Energy Resources, Energy Storage Systems, Hybrid Systems, and Intermittent and Flexible Generation
TRANSMISSION MODERNIZATION
Transmission Development Plan – Automation and Network Optimization, System Enhancement, Long-term interconnection-wide expansion plans
SMART UTILITY
Distribution Development Plan – Roadmap for DUs, Smart Metering, Real Time Monitoring
SMART HOME AND CITIES
Advanced Metering infra, EVs, Demand Response, Peak Load Management


SMART AND GREEN GRID PLAN (SGGP)
The aggressive RE targets require the timely development of a smart and green transmission system to integrate and manage the additional RE capacity expected to come online from 2024 to 2040
Objectives of the SGGP
Establish a policy and mechanism to address the timely implementation of Transmission Projects and efficient operation of the Transmission System.
Create a framework to determine the level of completion of TDP projects and the overall performance of electric power industry stakeholders toward a holistic and comprehensive development of the country's power system.
The SGGP forms part of the Philippine Energy Transition Program (PETP) and will complement the PEP 2023-2050
6


DOE Information
Campaign Activities
Thank you!
Rizal Drive Corner 34th Street Bonifacio Global City Taguig City
(02) 8479-2900
www.doe.gov.ph
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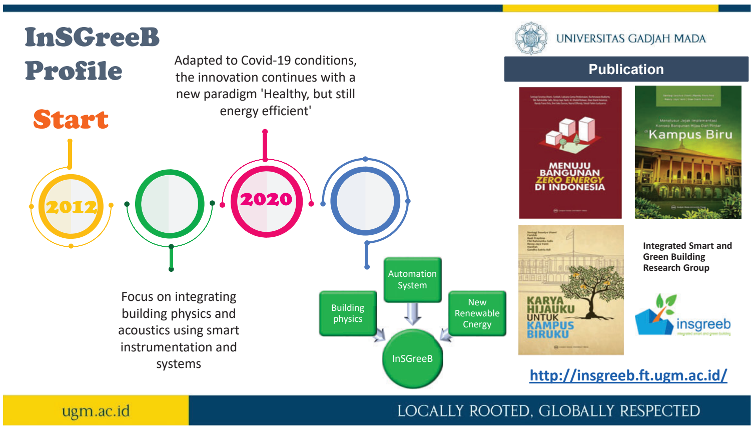
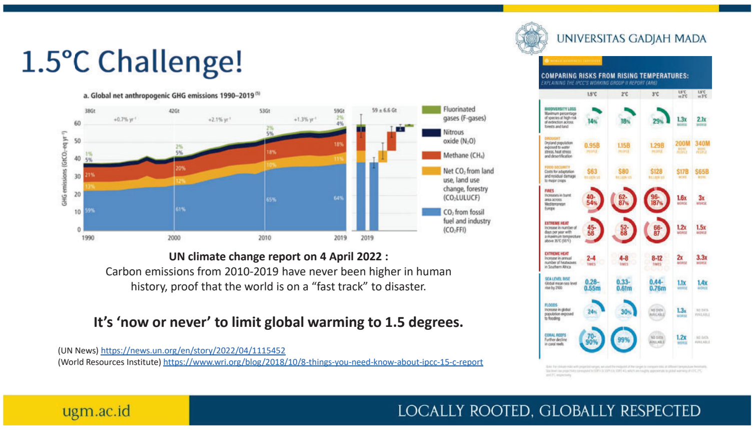
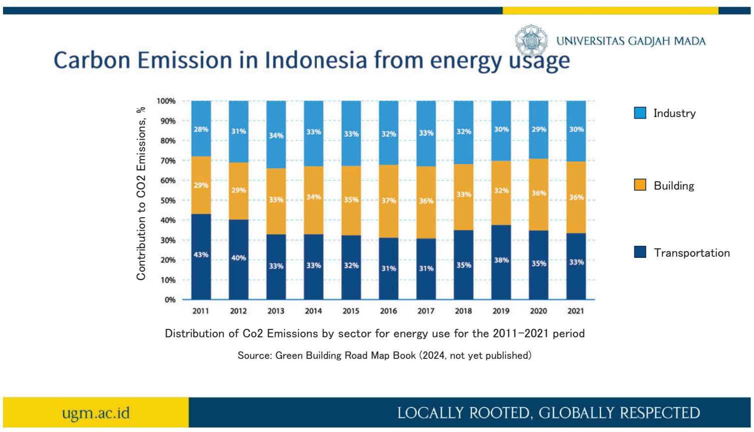
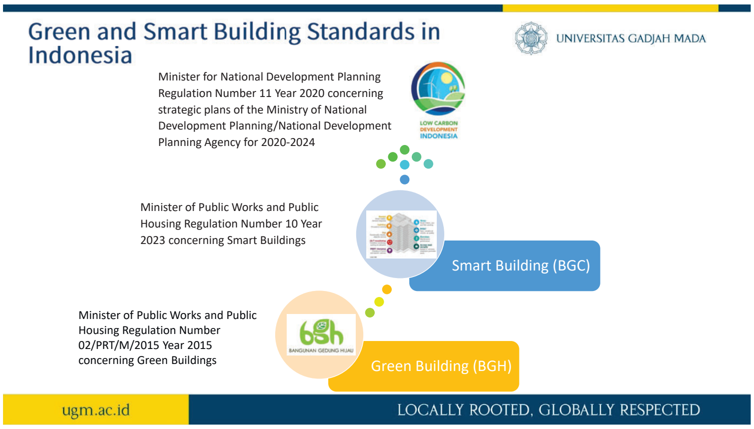
DOEgovph

2-14. Implementation of Energy Management System on Campus Buildings in Indonesia








Green and Smart Building Standards in Indonesia
UNIVERSITAS GADJAH MADA
Minister for National Development Planning Regulation Number 11 Year 2020 concerning strategic plans of the Ministry of National Development Planning/National Development Planning Agency for 2020-2024
LOW CARBON DEVELOPMENT INDONESIA
Minister of Public Works and Public Housing Regulation Number 10 Year 2023 concerning Smart Buildings
Smart Building (BGC)
Minister of Public Works and Public Housing Regulation Number 02/PRT/M/2015 Year 2015 concerning Green Buildings
Green Building (BGH)
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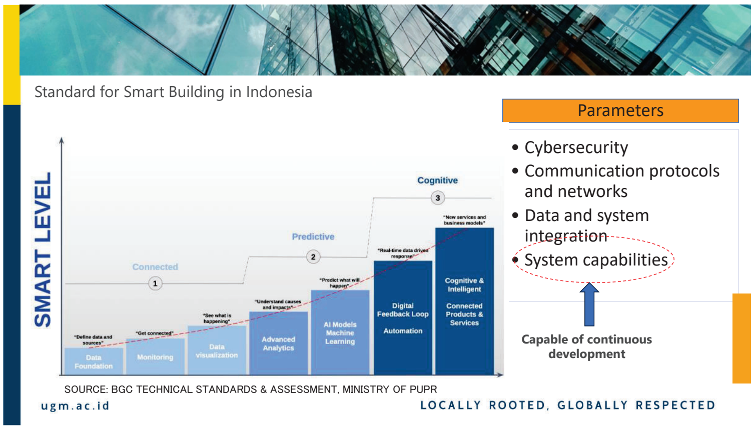
Standard for Smart Building in Indonesia
SMART LEVEL
Connected
Predictive
Cognitive
Data Foundation
Monitoring
Data visualization
Advanced Analytics
AI Models Machine Learning
Automation
Digital Feedback Loop
Cognitive & Intelligent
Connected Products & Services
Parameters
• Cybersecurity
• Communication protocols and networks
• Data and system integration
• System capabilities
Capable of continuous development
SOURCE: BGC TECHNICAL STANDARDS & ASSESSMENT, MINISTRY OF PUPR
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Lessons-Learned in UGM
PIU
1. LLC (Law Learning Center)
2. IFFLC (Integrated Forest Farming Learning Center)
3. ASLC (Animal Science Learning Center)
4. AGLC (Agrotropica Learning Center)
5. FRC (Field Research Center)
6. TILC (Teaching Industry Learning Center)
7. DLC (Dental Learning Center)
8. APSLC (Advanced Pharmaceutical Sciences Learning Center)
9. SGLC (Smart and Green Learning Center)
10. ERIC (Engineering Research Innovation Center)
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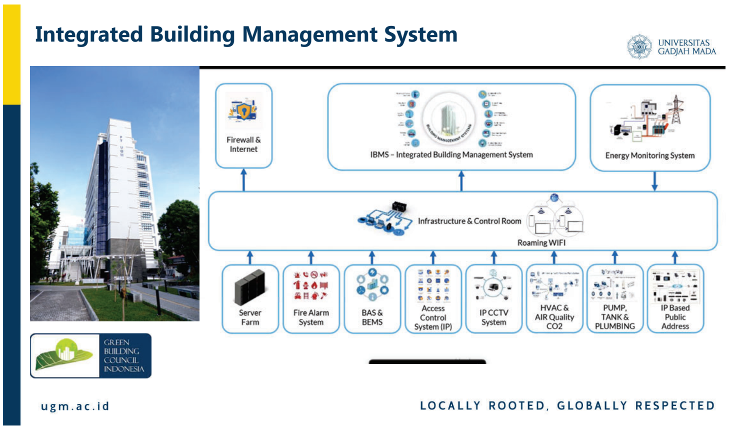
Integrated Building Management System
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Firewall & Internet
IBMS – Integrated Building Management System
Energy Monitoring System
Infrastructure & Control Room
Roaming WIFI
Server Farm
Fire Alarm System
BAS & BEMS
Access Control System (IP)
IP CCTV System
HVAC & AIR Quality CO2
PUMP, TANK & PLUMBING
IP Based Public Address
GREEN BUILDING COUNCIL INDONESIA
ugm.ac.id
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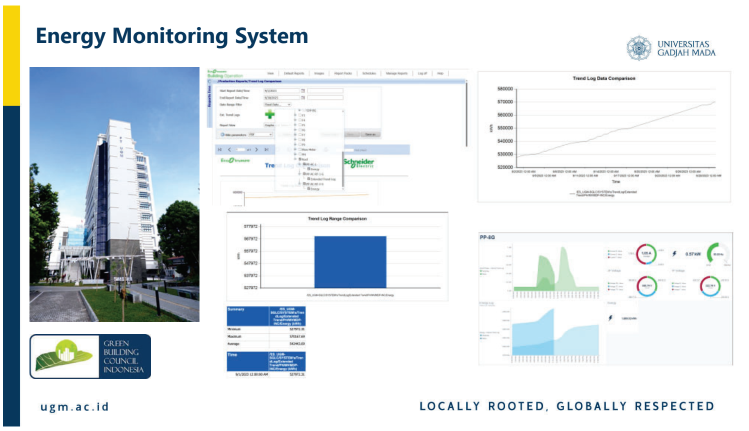
Energy Monitoring System
UNIVERSITAS GADJAH MADA
Trend Log Data Comparison
Trend Log Range Comparison
GREEN BUILDING COUNCIL INDONESIA
ugm.ac.id
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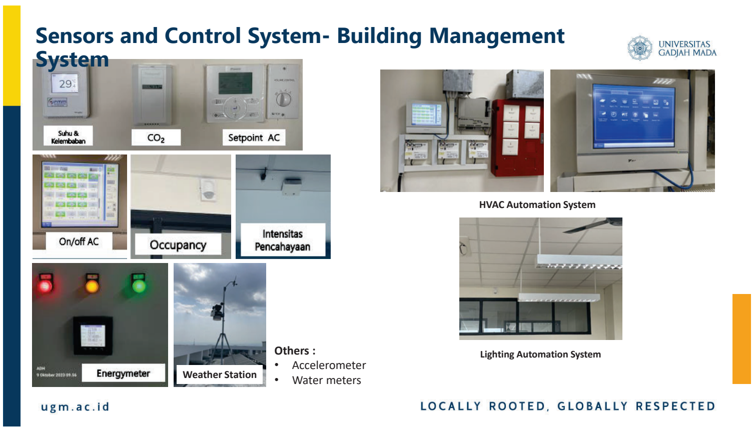
Sensors and Control System- Building Management System
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Suhu & Kelembaban
CO2
Setpoint AC
On/off AC
Occupancy
Intensitas Pencahayaan
Energymeter
Weather Station
Others :
• Accelerometer
• Water meters
HVAC Automation System
Lighting Automation System
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9 Principles of Smart Building System

- Automatization
- User Satisfaction
- Flexible
- Connected and Integrated
- Use of Artificial Intelligence
- Ongoing Monitoring
- Energy Management implemented
- Cyber Security applied
- Inclusive

Source: Technical Standard on BGC and Assessment Guideline, Ministry of Public Work PUPR

Automatization — Lighting automation

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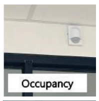
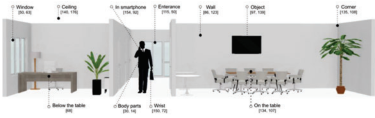
Purpose of automatization:
To monitor, arrange, and control all the building systems intended for an optimal and efficient operation that is responsive to the occupant's needs

Method and Tools for measurement:
- The sensor's reading must be valid in characterizing the phenomenon of the occupant's activity areas
- Efficient, easy in utilization, and does not agitate occupants
- Depends on sensor's selection and placement





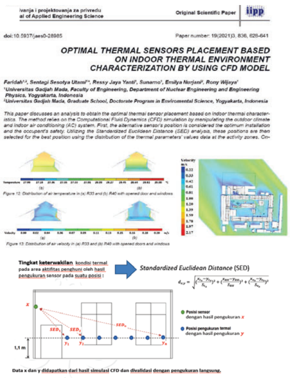
Common problem in sensor's selection and placement:
- The use of occupancy sensors to detect movement with PIR. Most are installed near the ceiling in areas where movements are difficult to detect.
- Most readings from the light intensity sensors do not conform with occupants' visual perception since measurement are at the work plane heights, meanwhile the sensors are on the ceiling.

Wael Alsafery, Omer Rana, and Charith Perera. 2023. Sensing within Smart Buildings: A Survey. ACM Comput. Surv. 55, July 2023.

Automatization — Thermal and IAQ

Purpose of automatization:
To monitor, arrange, and control all the building systems intended for an optimal and efficient operation that is responsive to the occupant's needs

Thermal Sensors Placement Requirements :
- The sensor's reading must be valid in characterizing the phenomenon of the occupant's activity areas
- The sensor's readings should comply with occupants' thermal comfort perception. Measurements should be around head heights and for sitting position at 1,1 m height.



Automatization

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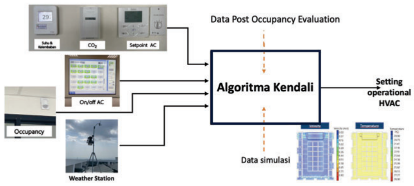
Purpose of automatization:
To monitor, arrange, and control all the building systems intended for an optimal and efficient operation that is responsive to the occupant's needs

HVAC automation system
❖ The VRV system are controlled automatically based on a **fixed schedule** for an entire year.

Control Algorithm requirements :
- Complies with the occupants' thermal comfort needs.
- Includes environmental variables (climate, occupants' behavior, and activity patterns) to accommodate dynamic response.
- The responsive system is only possible if the control algorithm integrates with the sensors.



Automatization — Data required for **Control Algorithm**

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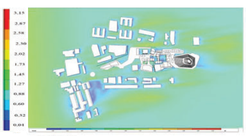
Purpose of automatization:
To monitor, arrange, and control all the building systems intended for an optimal and efficient operation that is responsive to the occupant's needs

CFD Simulation for Natural Ventilation Availability

Gelanggang Inovasi dan Kreativitas UGM



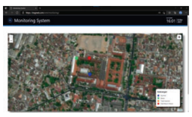
Ketinggian 1.3 m

Post Occupancy Evaluation (POE)

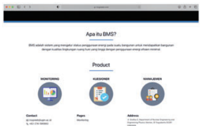
❖ **Manual POE**

Mengukur data lingkungan yang memapar

Membagikan kuesioner untuk data respon subyektif

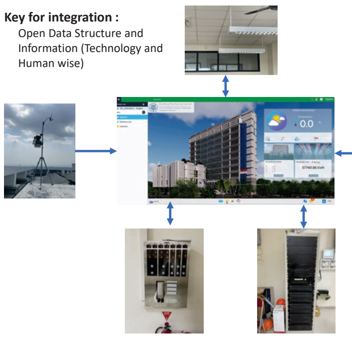


❖ **Smart POE**



Connected and Integrated

Key for integration :
Open Data Structure and Information (Technology and Human wise)



Cyber-security Applied

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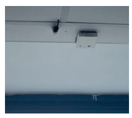
Key for a secured system :
Regulation, technology, and culture readiness



Use of AI

Purpose for implementation :
To collect, analyze, and utilize the data to create a system that is well connected and integrated

Users Satisfaction

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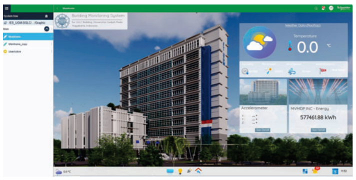
Key to achieve occupant satisfaction:
The Platform adapts and prioritizes the building occupant's needs in terms of safety, health, comfort, accessibility, security while improving life quality and increasing productivity

- Upper layer : HMI, User monitoring and control
- Middle layer : Data processing and Database
- Bottom layer : Sensors, controllers, and actuators



ISO 9241-11:2018 : Ergonomics of human-system interaction

Questions :
- How would the 'business model' be?
- Who would be involved?
- What kind of information will be delivered?
- What kind of technology should be applied?

Features :
- A user-friendly HMI (for operators, engineers, building managers).
- System security
- Data Logging
- Control Algorithm
- Remote connectivity

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Thank you

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