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APEC Symposium on the Holistic Approach of Decarbonization towards Carbon Neutrality

APEC Energy Working Group

February 2023

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Economic Cooperation

APEC Symposium on the Holistic Approach of Decarbonization towards Carbon Neutrality

SUMMARY REPORT

APEC Energy Working Group

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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. 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 symposium as an APEC project under the auspices of Japan's Ministry of Economy, Trade and Industry (METI).

2. Objective

The symposium was held to demonstrate the importance of the holistic approach of decarbonization in pursuit of carbon neutrality. It was intended to enhance the capacity of APEC economies to pursue decarbonization towards carbon neutrality.

3. Symposium Description

APEC Symposium on the Holistic Approach of Decarbonization towards Carbon Neutrality was held online on August 30th and 31st, 2021. The two-day symposium consisted of the following three 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**

The agenda and presentation materials are included in the Appendices.

4. Symposium Session Summary

4-1. Opening Session

4-1-1. Opening Remarks

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

Dr. Irie welcomed all participants. The objective of the symposium was then introduced: to demonstrate the importance of a holistic approach to decarbonization in pursuit of carbon neutrality. Dr. Irie emphasized that various pragmatic and sustainable decarbonization pathways, that reflect the different circumstances of each economy, are essential for achieving each economy's energy transition. The importance of sharing knowledge and experience among member economies to facilitate these transitions was also mentioned. The opening remarks were concluded after the introduction of the two-day agenda.

4-1-2. Keynote Speech: Necessity of the Holistic Approach of Decarbonization towards Carbon

Neutrality in the APEC Region

Mr. Shinichi Kihara, Deputy Commissioner for International Affairs, Agency for Natural Resources and Energy (ANRE), Ministry of Economy, Trade and Industry (METI), Japan

Mr. Kihara emphasized the necessity of each economy's work to reduce CO2 emissions given the increasing rate of extreme weather events around the world. Mr. Kihara then introduced Japan's commitment towards carbon neutrality by 2050, to reduce its GHG emissions by 46% in 2030 from 2013 level, and Japan's "Green Growth Strategies". While energy demand in APEC economies will continue to grow, it is important to simultaneously reduce CO2 emissions in a safe and affordable manner. As circumstances differ among economies, there are many paths towards carbon neutrality.: Introducing renewable energies, improving energy efficiency, introducing both smart grids and energy storage, and switching to cleaner fuels are all effective options on any pathway. In the future, the utilization of hydrogen and ammonia, CCUS, and nuclear power will also become realistic options. Mr. Kihara also mentioned "Asia Energy Transition Initiative (AETI)". In that initiative, Japan committed to support each economy's effort in decarbonization in the ASEAN region with five concrete actions. Finally, the upcoming "Tokyo Beyond Zero Week" conference was introduced.

4-2 Potential of Decarbonization towards Carbon Neutrality in the APEC Region

Mr. Takahiko Tagami, Senior Coordinator, The Institute of Energy Economics, Japan (IEEJ)

Mr. Takahiko Tagami (Senior Coordinator, IEEJ) presented "Potential of Decarbonization towards Carbon Neutrality in the APEC Region."

The IEEJ Outlook, of which results are utilized to estimate CO2 emission reduction potential in the APEC region, covers 19 APEC member economies other than Peru and Papua New Guinea. This analysis defines CO2 emission reduction potential as the difference between the "Reference Scenario" (the scenario in which past trends, such as economic and social structures and technology evolution, will continue) and the "Circular Carbon Economy/4R Scenario" (the scenario in which powerful energy and environmental policies result in success to the extent possible and decarbonization technologies using fossil fuels are introduced to the likely extent determined by the IEEJ's expertise).

The breakdown of the CO2 emission reduction potential of 10.3Gt by technical field shows that renewable energy has the highest potential at 3.2Gt, accounting for 31.1% of the total. Increased energy conservation is 3.1Gt (30.4% of the total). Hydrogen/ammonia technologies are 2.4Gt (23.3% of the total). CCUS technologies are 1.1Gt (10.2% of the total). Nuclear power in the APEC region is the lowest at 0.5Gt (5.0% of the total).

The breakdown of the CO2 emission reduction potential by economy shows that China has the highest potential of 4.9Gt, accounting for 47.2% of the entire APEC region. The United States follows China at

1.9Gt (18.8% of the total), followed by Indonesia (0.7Gt, 6.7% of the total) and Russia (0.5Gt, 5.2% of the total).

CO2 emission reduction potential by technology is as follows:

- Efficiency: In 2050, China is expected to account for the largest share in total APEC CO2 emission reduction at 40%, followed by the United States (22%), Indonesia (8%) and Russia (7%).
- Renewables: The largest contribution to emission reduction potentials in the APEC region (3,137 Mt) comes from China (1,734 Mt), followed by the US (755 Mt).
- Hydrogen: APEC economies will introduce hydrogen, with the largest volume of demand from China, the United States and Republic of Korea.
- CCUS: The largest contribution to emission reduction potentials come from China (459 million tons), followed by Indonesia (183 Mt), the United States (130 Mt) and Russia (122 Mt).
- Nuclear: China has the largest emission reduction potential, with 190 Mt in 2050, followed by Viet Nam with 79 Mt, Japan with 51 Mt, and the United States with 50 Mt.

Q: Chinese Taipei, Republic of Korea and Hong Kong, China have larger shares of CO2 emission reduction potential by hydrogen than other economies. Are there any reasons behind this?
A: Chinese Taipei, Republic of Korea and Hong Kong, China are major energy importing economies in the APEC region. Therefore, they have larger potentials to reduce CO2 emission reductions by using hydrogen and ammonia than other economies.

4-3. Hydrogen and Ammonia including infrastructure issues

4-3-1. Clean Hydrogen (by Video)

Dr. Sunita Satyapal, Director, Hydrogen and Fuel Cell Technologies Office, Office of Energy Efficiency and Renewable Energy (EERE), and DOE Hydrogen Program Coordinator, Department of Energy, USA

The United States has set goals to have a carbon pollution-free power sector by 2035 and a net-zero economy by no later than 2050. Multiple pathways are being explored to reach those goals and hydrogen will play an important role in them. The US Department of Energy (DOE) Hydrogen Program supports research, development, demonstration, and deployment (RDD&D) efforts to accelerate clean hydrogen RDD&D across sectors. The DOE Hydrogen Program includes participation from multiple DOE offices, and released a coordinated Hydrogen Program Plan in November 2020 providing a strategic framework to advance the domestic production, transport, storage, and use of clean hydrogen across different sectors of the economy.

Current hydrogen production in the United States is approximately 10 million tonnes, primarily through steam methane reforming using natural gas, and there are over 172 MW of polymer electrolyte membrane-based electrolyzers installed. Scenarios show potential for a 5X growth in hydrogen production from current levels, across various applications. Hydrogen is also considered an enabler for renewable energy and long duration energy storage. For example, if 10 million additional tonnes of hydrogen were to be produced today, this would roughly double the current wind and solar deployment in the U.S.

Within HFTO, many initiatives exist to address different areas of the hydrogen value chain. Deploying hydrogen at commercial scale and at low cost is a key challenge. The H2@Scale initiative aims to enable commercial scale hydrogen production and consumption to support deep decarbonization, economic growth and environmental justice objectives. The program contains funding for various stages of RDD&D.

In June 2021, the U.S. Department of Energy launched the Hydrogen Energy Earthshot initiative with the objective of producing 1 kg of clean hydrogen at 1 U.S. dollar in 1 decade (" 1 1 1"). The Hydrogen Shot is open to different pathways for producing clean hydrogen such as electrolysis, thermal conversion with carbon capture and storage, and other advanced pathways such as advanced water splitting, biological approaches and more. In addition to Hydrogen Shot, the Program is focusing on hydrogen distribution and storage, fuel cells (such as for trucks as well as stationary applications), and end uses including industrial (e.g., steel manufacturing), ammonia production, and energy storage.

4-3-2. Ammonia

Mr. Shigeru Muraki, Representative Director, Clean Fuel Ammonia Association, Japan

Transporting and utilizing hydrogen are important parts of the hydrogen value chain. Ammonia is proposed as a way of storing hydrogen in a liquid form, allowing for easier transportation and ready utilization in end-use applications, such as power generation. Ammonia has many appealing properties: it can be directly combusted without producing CO2 emissions; a large commercial supply chain exists with clear cost structures; safety standards exist and are practiced in several industries; and it can be effectively used to transport hydrogen using marine transportation.

Ammonia as a hydrogen carrier is in the early stages of demonstration. Japan and other economies in northeast Asia are test-beds for developing blue and green ammonia value chains. 1 GW coal power plant demonstration is currently being conducted. Depending on the result, the company will soon make a final decision on using ammonia in their boilers from around 2027, which marks the start of the commercialization of ammonia in coal boilers. For reference, 1 GW coal plant co-firing with 20% ammonia will require 0.5 million tons of ammonia per year. Demand of 0.5-1 million tons per year is expected around 2027, and then ammonia will expand to other uses, such as industrial furnaces and marine engines.

The Clean Fuel Ammonia initiative is a phased implementation plan. Phase I includes mixed combustion in coal power generation as a first step to entering the energy market. At the same time, the development of ammonia supply infrastructure is required. Japan needs to develop the infrastructure to accommodate large ammonia carriers. The goals of phase II are to have ammonia single-fuel combustion in both coal power plants and advanced combined-cycle gas turbines and to expand ammonia-coal cofiring in existing coal power assets across Asia.

Potential sources of blue and green ammonia are from the United Arab Emirates, Oman, Saudi Arabia, Australia, New Zealand, Chile, Canada, the United States and Russia. Japan, in particular, has potential to promote investment by Japanese companies to develop the value chain and provide financing for projects and reduce costs with long-term supply security.

Q&A for all presenters and discussion

Q: (to Mr. Muraki) Are there any recommendations for other APEC economies that are considering hydorgen in their decarbonization plans? Should they prioritize some sectors as parts of the value chain?

A (Mr. Muraki): Japan and Korea announced hydrogen strategies. Some APEC economies are looking at hydrogen as a clean energy option. However, renewable energy resources are not well located in the APEC region, which would require imports of clean carbon hydrogen in the regions with green hydrogen resources or with natural gas and CCS capacities. That is also another incentive for the development of hydrogen energy carriers. Korea is looking into ammonia as a hydrogen energy carriers, and Singapore is looking into ammonia as bunker fuel. Economies should consider how to practically develop the hydrogen economy using hydrogen energy carriers.

Q: (to Mr. Muraki) Could you briefly explain some of the safety issues surrounding ammonia's use as an energy carrier, perhaps in transport or power generation applications?

A (Mr. Muraki): Safety standards are established in chemical and power industries and practically executed. We will review those safety standards for wider applications, but safety will not be a hurdle for the use of fuel ammonia.

Hydrogen and ammonia will complement each other. Ammonia is the cheapest way to introduce hydrogen into the energy market. Ammonia can create a sizeable market for hydrogen energy carriers and that can enhance the cost reductions of hydrogen production from both natural gas and renewables. Ammonia will open the door for the hydrogen economy, and then ammonia and other types of hydrogen will come into the market depending on the requirements.

4-4. Energy Saving

4-4-1. Energy Efficiency of Buildings

Mr. Tadafumi Nishimura, Senior Engineer, Technology Innovation Center, ZEB Energy Management Group, Daikin Corp, Japan

Mr. Nishimura presented two pilot projects of DAIKIN, an air-conditioner manufacturer, that test their commercially available products and technologies on zero-emission building (ZEB) office buildings.: One ZEB tests a newly-built, large-size Technology and Innovation Center (TIC) and the other a small-size retrofit system. In both cases, most systems (HVAC, lighting) were commercially available products. DAIKIN introduced individual control systems for both temperature and humidity, rather than the conventional combined system. The individual control system allows for better efficiency, especially in lower load ranges. In the retrofit building project, natural ventilation, outer air cooling, and sensor-controlled LED lighting system are used in addition to the individual temperature and humidity control systems. The most impactful retrofit variable is the choice of air conditioning capacity, which if accurate, avoids frequent fluctuations in operational activity during lower load times, when efficiency tends to be less. This retrofit project improved efficiency by replacing a 191hp capacity system with a much smaller 123hp system.

Mr. Nishimura stresses the importance of optimizing the operation by continuously monitoring air conditioning loads and comparing these measurements to the design simulations, both with and without the technological improvements.. This continuous optimization of the system adds extra energy savings that will improve make ZEB Ready building to Nearly ZEB.

4-4-2. Demand Side Energy Management

Mr. Steven Schiller, Lawrence Berkeley National Laboratory (LBNL), USA

Mr. Schiller summarized the importance of demand-side energy efficiency as a cost-effective means of reducing consumers' energy cost burden (particularly for the disadvantaged and low-income households and businesses), improving energy system reliability and resilience, supporting economic development, and addressing energy security. However, the focus of his presentation was on the importance of "Demand Flexibility" for supporting the cost-effective decarbonization of the energy sector by reducing the amount of capital investment required for new generation, transmission and distribution capacity as well by accommodating the variable patterns of renewable sources. The latter is true because with demand-side management, building and industrial energy loads can follow the patterns of variable generation via Demand Flexibility. Thus, to support decarbonization, simple saving energy is not enough, energy has to be saved at the *Right Time* and *Right Place*. Efficient, demand flexible buildings can use time and location sensitive distributed energy resources, with smart controls, for "Load Shedding," "Load Shifting," "Load Pattern Modulation," and "Site Generation." Such buildings are regarded as Grid-Interactive Efficiency Building (GEB) with benefits for the economy, utilities, consumers, and society as a whole. Mr. Schiller concluded his presentation with suggestions for actions APEC Economies can take to advance efficiency and demand flexibility in gathering information and identifying opportunities, taking early actions, and establishing demand management programs for buildings and industrial facilities.

Q&A for all presenters and discussion
(Moderator) Any advice for APEC economies on energy efficiency toward carbon neutrality?
(Mr. Nishimura) An actual measurement of building performance is very important.
(Mr. Schiller) Energy stakeholders should genuinely commit to using demand-side management as an essential resource in the long run in order to support market transformation and technology diffusion.

(Moderator) What about the additional cost of ZEB or the cost of energy efficiency improvement?
(Mr. Nishimura) The upfront cost of a retrofit is one of the barriers. Understanding the total cost, the upfront investment, and the energy saving thereafter is the key.

(Moderator) Give us a keyword for the challenge on the uncertainty of energy efficiency.
(Mr. Nishimura) Cost Efficiency
(Mr. Schiller) Managing risks and uncertainty – efficiency and demand flexibility are high potential, low risk means for addressing the risks, and known impacts, of climate change to APEC economies.

4-5. Renewables Energy in the power sector.

This session focused on the role that renewable energy, specifically wind, solar and geothermal, could play in future APEC energy systems.

4-5-1. Wind Power in the APEC region (including offshore): Experience of Chinese Taipei

Mr. Ssu-yuan Hu, Manager of Wind Power Program, Green Energy & Environment Research Laboratories (GEL), Industrial Technology Research Institute, Chinese Taipei

The potential for future offshore resources in APEC is significant and is expected to grow particularly in China, the United States, Chinese Taipei, the Republic of Korea, Japan and Viet Nam. In Chinese Taipei, the potential for onshore wind is limited and new capacity due to resource and land-use constraints. Offshore wind offers the area for further wind development. Chinese Taipei's development plan has three phases (demonstration, economies of scale, and pipeline for sustainable domestic market). The first phase is underway with the demonstration-scale offshore wind farms and international engagement. The second phase is focused on developing the planning process and infrastructure for large-scale deployment, including site identification for offshore wind turbines as well as manufacturing and interconnection facilities. The final phase is the upscaling of offshore wind infrastructure. The upscaling will be coupled with environmental monitoring and engagement with stakeholders, such as fisheries groups, to ensure that the expansion is sustainable. Between 2026 and 2035, the development plan sees 1.5 GW of offshore wind capacity added per year.

4-5-2. Solar Power in the APEC region

Ms. Charuwan Phipatana-phuttapanta, Senior Professional Scientist, Solar Energy Development Division, Department of Alternative Energy Development and Efficiency (DEDE) Ministry of Energy, Thailand

Ms. Phipatana-phuttapanta outlined Thailand's policies supporting the development of solar energy. Thailand is publishing various roadmaps targeting renewable energy. The current target is a 30% share of final energy consumption by 2037. Each iteration of the renewable energy master plan published by the government of Thailand has significantly enhanced the share of solar. The original target was 500 MW by 2022, the current goal is 12,139 MW of solar by 2037. Currently, almost 3 GW of solar is connected to the grid, and the share of renewable energy in final energy is 16.4%. Solar is supported through a feed-in tariff with different rates for different sectors, such as household, educational institutions and agricultural systems used for pumping water. There is also investment support, with tax incentives, from the Thailand Board of Investment and policy support for growing self-consumption. The presentation concluded by highlighting Thailand's activities that supported carbon neutrality. These acts include increasing the share of RE and the use of electric vehicles. Other policies include zero waste landfills and smart farming initiatives, as well as the use of carbon capture and storage and hydrogen technologies.

4-5-3. Geothermal Power in the APEC region

Mr. Harris, Director of Geothermal, Directorate General of New, Renewable Energy and Energy Conservation (DGNREEC), Ministry of Energy and Mineral Resources (MEMR), Indonesia

Mr Harris highlighted Indonesia's international commitments to reducing emissions intensity and plans for net-zero emissions in 2060 and their NDC's, underscoring the need to supply accessible, affordable energy and the desire to enhance clean technology such as renewable energy. One such technology is geothermal power. Indonesia has significant geothermal resources of up to 23 GW. However, there is only 2.2 GW currently installed. Other economies with substantial potential include the US, the Philippines, New Zealand and Mexico. However, there are some challenges to geothermal development, including financial risks, environmental issues accessing resources in protected areas, social issues affecting communities around plants. Indonesia is targeting expanding geothermal capacity significantly in the coming years targeting 9.3 GW of capacity by 2035. Government policy supports this through supporting data gathering drilling programs, funding support, joint development, supporting resource optimisation expanding existing plants.

4-6. Issues for Electricity Security: To Cope with Increasing Intermittent Renewables Power Sources

Increasing the share of wind and solar energy sources in the power grid is a key method for decarbonizing an economy's power sector. Unfortunately, wind turbines and photovoltaic panels provide variable and intermittent power depending on weather conditions. This session of the Symposium focused on addressing the challenges associated with ensuring electrical grid stability while increasing the share of variable and intermittent renewable energy sources in an economy's power sector.

4-6-1. Grid Infrastructure in Indonesia

Mr. Wanhar, Director for Electricity Technical and Environment, Directorate General of Electricity, Ministry of Energy and Mineral Resources of Indonesia, Indonesia

The Indonesian government regulates electricity supply, while state-owned enterprises and private companies produce electrical power. PLN as a state-owned enterprise is given first priority in electricity supply. Electricity policy has five goals: Sufficiency, Reliability, Sustainability, Affordability, and Equality.

Indonesia has various goals across its electricity supply chain. Generation is targeting 23% new and renewable energy (NRE) by 2025; it also plans to target the utilization of more domestic primary energy sources and in the longer term, implement both clean-coal and nuclear technology. Expansions of electricity access and the deployment of a smart grid are to start in 2020.

As per June, 2021 the domestic power installed capacity around 73,4 GW, electrification ratio around 99.3% and interm of energy mix of PLN's power generation, which consists of Coal 63.5%; Gas 18.7%; Geothermal 5.6%; Hydro 7.6%; other RE 0.4%; and Fuel Oil (including biofuel) 4.2%.

The Government of Indonesia is committing to reduce Greenhouse Gas (GHG) emissions by 29% from Business as Usual (BaU), or by 41% with international assistance, by 2030.

There are many long-term challenges facing the Indonesian electrical utility sector as it embarks on an energy transition to implement its roadmap to achieving NZE by 2060, while electricity demand grows 5-fold, or 1400 TWh, over current levels by 2050. These include:

- high penetration and Integration of Variable RE,
- grid modernization through smart grid implementation and distributed energy resource implementation,
- market development & investment in RE, grid modernization, and electric mobility transformation through electric vehicle
- subsidy reallocation (fossil fuel subsidy shifting).

Indonesia is considering two scenarios to achieve Net Zero. Scenario 1: retire coal-fired and gas power plant according to the current life/contract: No additional coal-fired power plants, with additional capacity after 2030 only coming from hydrogen, the use of BESS (battery energy storage system), and VRE. RE-based power plants starting in 2035 are dominated by VRE in the form of Solar, followed by Wind and Tidal. Nuclear energy starts producing by 2045, and increasing to 35 GW in 2060. Geothermal utilization is maximized up to 75% of resources.

Scenario 2: same as Scenario 1, with the following differences: CCS/CCUS technology decarbonizes coal and gas power plants (after 2040) and IGCC development. CCS-equipped IGCC starts in 2050, which will decrease nuclear's share.

Transmission and interconnection development:

- Develop inter islands connections like Sumatera Java, Bali Lombok.

- Support the ASEAN Power Grid cooperation.

- Grid operation: Amendment of Grid Code to cover intermittent RE development.

- Smart Grid concept for Indonesia to cover Prosumer (consumer generate own electricity) and Smarter Consumer (use electricity more efficient with more smart devices). Now developing Smart Grid in Java Bali, with enhance Metering infrastructure.

- Indonesia has 9 small-scale and control center smart grid pilot projects.

- Indonesia supports the EV development by regulating the development of charging stations and battery exchange stations (now have 166 charging stations). By 2030, 254 181 electric cars and 24 720 charging stations, 805 000 electric motorized vehicles and 67 000 battery swab stations.

4-6-2. Power Storage

Dr. Douglas J. Arent, Executive Director, Strategic Public Private Partnerships, National Renewable Energy Laboratory (NREL), USA

NREL is located in Colorado and focuses on renewable energy (RE) and Energy Efficiency. NREL has almost 900 partnerships with industry, academia and government, a $500 million annual budget and $1.2 billion in domestic economic impacts. NREL's capabilities in energy storage include research, modelling, deployment models, grid integration, system design and research facilities. Research encompasses decision support, impact analysis, application, storage system design and optimization, and component analysis. NREL identifies benefits of system flexibility: employing a combination of technologies (RE, storage, grid) to respond to change demand and supply.

There are four phases of storage deployment (sequential or overlap and uncertainty): operating reserves, peaking capacity, diurnal capacity, and energy time shifting, multiday to seasonal capacity and energy time shifting. Storage can provide: not only energy, but also capacity, stability, ancillary services.

Cost trends in lithium-ion battery (LIB) packs show decreasing battery costs. LIB costs declined 89% from 2010 to 2020 and are expected to decline an additional 33% by 2024 according to Bloomberg New Energy Finance. NREL's storage futures study concludes that dramatic growth in grid energy storage is the least cost option for ensuring grid stability and reliability under all scenarios.

4-6-3. Electricity Security in regards to Clean Energy Transitions

Ms. Randi Kristiansen, Economics and Financial Analyst, Clean Electricity, Renewable Integration and Security of Electricity Unit, International Energy Agency (IEA)

The power sector landscape is changing dramatically away from traditional power sector systems. The traditional power system is centralized, exhibits high stability, is centrally controlled with one way flows of communication. It is a closed network with few devices. The new power system that is emerging will be more decentralized and include more variable generation. Inertia may decrease, there will in most cases be multiple actors/competitive markets, two-way power and communication flows and many devices. It will be designed to adjust to the effects of changing climate patterns on power demand.

In the new system, economies will see a significant retirement of fossil fuel dispatchable plants in electricity system mix, while carbon dispatchable sources like nuclear and hydro lag behind. RE penetration will increase the requirements for flexibility in the system. Thermal (gas/coal) power plants will continue for some time especially in the APEC region to provide the bulk of flexibility needs, along with interconnection, but the use of batteries and demand side response will increase.
Reliability measuring will require new methods, stochastic methods provide a much more detailed picture, and supply and the contribution of different types of resources to adequacy under different scenarios.

The new power grid will be increasingly digital with interconnected networks and smart grids. The new power systems will provide many benefits for electricity customers and the clean energy transitions: improved generation and transmission efficiency, enhanced grid stability, improved demand response and forecasting.

However, digitalization comes with cybersecurity risks. Some events have already occurred, and the threat of cyberattack is growing. Policymakers need to enhance cyber resilience: strengthen institutions (set appropriate responsibilities), identify risks, manage, and mitigate risk, monitor progress, enhance respond and recover mechanism. Implementation strategies should be tailored to mandatory regulation approaches (specific standards) and framework-based (common criteria).

In conclusion, the approach to electricity security will change with the clean energy transitions. Diversification of technology and location are critical enablers. New aspects will arise due to the more decentralized systems, but secure clean energy transitions are achievable in the APEC region, but context specific policies must be implemented, and collaboration between power systems can enable further cost effectiveness.

4-7. Keynote Speech: The role of Carbon Capture Coupled to Dedicated and Reliable Storage in

Helping to Meet Net-Zero Carbon Emissions Goals (by video)

Dr. Jennifer Wilcox, Acting Assistant Secretary for Fossil Energy, Department of Energy (DOE), USA

As "climate change" has become a "climate crisis", cutting emission by 50% by 2030, producing 100% clean electricity by 2035, and achieving a net-zero carbon economy by 2050 are becoming more urgent in the United States. Technology approaches like CCS, carbon dioxide removal (CDR) will play an enormously important role over the next decade. Every sector requires attention: energy, manufacturing, transportation, the entire economy. Given that fossil fuels continue to play a key role in the Unites States and around the world, their decarbonization is critical. CCS provides us with the opportunity to use fossil assets responsively. The United States would like to expand the potential of CCS to include carbon capture not just from the power sector but also industrial sectors like cement and steel production. There is also significant potential that carbon capture can have for advancing a low cost and low carbon hydrogen economy through decarbonization of fossil-based hydrogen production. Coupled to carbon capture, dedicated and reliable CO2 storage is critical to meeting climate goals. As carbon removal directly from the atmosphere is more costly than point-source carbon capture, CDR should only be used to offset the truly hard-to-abate sectors like agriculture, shipping, and aviation. Achieving a net-zero, clean energy economy requires collaboration across government, industry, academia and across economies.

4-8. CCUS in the APEC region

4-8-1. CCUS in the APEC region: An expert view from Australia

Mr. Alex Zapantis, General Manager, Global CCS Institute, Australia

There are increasing numbers of operational CCS projects in APEC. Many future projects will not be reliant on utilisation (such as enhanced oil recovery) to be economically viable. Almost all climate/energy scenarios with decarbonisation ambitions will require CCS.

One quarter of industry emissions are attributed to unavoidable chemical reactions (process emissions), emphasising large role for CCS to decarbonise industry. Global facility age for steel and chemical facilities is young, particularly in Asia. Widespread retrofits of these facilities will be required to meet Paris, and other climate, commitments.

There are heroic assumptions for rapid movement away from thermal coal fired power plants. Even with optimistic assumptions of lower utilisation and early retirements, significant proportion of these units will remain operational for multiple decades and require CCS for climate ambitions to be met.

Current hydrogen production is almost solely grey hydrogen (fossil fuel derived with no CCS). Electrolysis powered by renewable energy (green hydrogen) and Hydrogen produced from fossil fuels with CCS (blue hydrogen) will need to scale up 500 times between now and 2050 to meet global demand with (close to) no emissions.

Blue hydrogen has significant advantages in most locations compared to green hydrogen right now (cost advantage, space saving, and lower burden on electricity grids). There are many opportunities for CCS hubs in APEC, exploiting viable geography and fostering economic growth, development, and jobs.

4-8-2. CCUS in the APEC region: An expert view from Indonesia
Dr Mohammad Rachmat Sule, Associate Professor, Institut Teknologi Bandung, Indonesia

Indonesia has large potential to develop CCS to enhance productivity of current oil and gas wells, while complementing expanding fleet of coal-fired power plants. The Indonesian government sees large role for CCUS to assist local and global decarbonisation efforts.

The Gundih CCS pilot project has demonstrated the economic case for EGR (Enhanced Gas Recovery) technologies, though shortest payback periods and greatest profitability are reliant on carbon credits.

CCS in Indonesia will improve environment, lead to additional revenue flows (EOR and EGR), and provides possibility to sell carbon credits. There is large potential to establish regional CO2 hubs/sinks, that Indonesia can leverage for economic growth potential.

Q&A for presenters and discussion
Q: The recent IEA Net Zero publication does not rely on a large role for CCS. Do you see this as reflective of the reality for CCS?
A (Mr Zapantis): There is still large potential for CCS even in scenarios that rely more heavily on other decarbonisation methods.

Q: Has the Gundih CCS project been successful at promoting CCS projects in Indonesia?
A (Dr Sule): Projects such as Gundih will benefit from international capital flows and provide continued justification for Indonesia’s coal fired power fleet.

Q: What challenges are there to monitoring captured emissions? And are earthquakes a concern for storage of emissions?
A (Mr Zapantis): Instituting a reputable global body to track captured emissions will be more of a management challenge than technical challenge. Monitoring captured carbon dioxide is already undertaken to high precision. Captured CO2 is robust to frequent earthquakes and seismic activity as demonstrated by the Tomakomai project in Japan. CO2 located deep in the earth’s crust is a liquid and

not prone to escape.

Q: Is the challenging operational environment for Boundary Dam and Petra Nova indicative of the viability of CCS technologies?
A (Mr Zapantis): Boundary Dam and Petra Nova both encountered large challenges to their success, but this is not indicative of future projects. CCS is no different to any other large industrial technology, some facilities will experience operational or commercial difficulties from time to time.

4-9. Nuclear Energy in the APEC region

4-9-1. Nuclear Energy in the APEC region: An expert view from Korea

Dr. Chae Young Lim, Research Director, Korea Atomic Energy Research Institute (KAERI), Korea

Korea has ambitious GHG emission reduction targets. The government has published energy transition policy. In October 2020, the president Moon Jae-in pledged 2050 carbon neutrality. According to their plan, Korea will increase renewable energy to 57-71% of total power generation by 2050, while reducing nuclear energy to 6-7%. The use of nuclear power plants will continue until the lifetime of units end, but no lifetime extension is planned.

However, Korea is also researching SMR development and its potential as a transitional technology for decarbonization and emerging option to contribute to carbon neutrality. Its rapid ramp-up ability can harmonized with renewable energy and serve as a replacement for aging coal fired power plants. A survey of projections illustrate a global SMR market between 65-85GW by 2035. There are over 70 concepts of SMR under development across the world, including in Korea. They are developing SMART reactor and innovative SMR (iSMR) technologies. The projected construction cost of iSMR is less than 4,000 USD per kW. Several Korean industries, including marine transport, are interested in iSMR. Develops can improve competitiveness by communicating with regulators and tailoring a new business model to reduce the risk to investors. At the same time, government support and scaling up the supply chain are also important.

4-9-2. Nuclear Energy in the APEC region: An expert view from Southeast Asia

Dr. Philip Andrews-Speed, Senior Principal Fellow, The Energy Studies Institute, National University of Singapore, Singapore

In ASEAN, 5 economies have research reactors and one of these has an experimental advanced reactor, but others have no active involvement in nuclear energy. These 5 economies are cooperating with IAEA or developed economies and are assessing the option to deploy SMRs and other advanced reactors. At the ASEAN level there are networks to share information on regulation and technology. The US, Canada, Japan and China are cooperating with ASEAN Centre for Energy (ACE) mainly in capacity building. The ASEAN Plan of Action for 2021-2025 give its priority to capacity building and public communication. But as for power deployment, the 5th Outlook of ACE says nuclear will have 0.2-0.5% share of total primary energy production by 2040, but in the recent 6th Outlook, there is no mention for nuclear energy. Therefore, the speaker thinks that nuclear energy will not become a major energy source by 2040.

Q&A for all presenters and discussion

Q: (to Dr. Lim) Will Korean government allow to construct SMRs despite its nuclear policy?

A: It is not sure. But the presidential election will be held next year, and so the policy of the next government will be important.

Q: (to both speakers) SMR is small-scaled, and so it cannot have the economics of scale. Will it be possible to gain economic competitiveness?

A (Dr. Lim): I think it is possible in the future. Certainly, it sacrifices economics of scale, but it has other advantages to the conventional reactors. Technology innovation would change the situation.

A (Dr. Andrews-Speed): The key is to manufacture large quantities. But the question is who would construct the first reactor? This is a “chicken and egg” problem.

C (Dr. Lim): We have a positive signal from the market. For example, many customers show their interest in NuScale project. They are seeing SMR as a promising business.

Q: (to both speakers) SMR is not a new technology, but it has been developed since 1980s. Why do you think SMR has not been commercialized so far?

A (Dr. Lim): At that time, nuclear vendors didn’t need SMRs, but the situation is changed. Now small power plants are easier to build than conventional large reactors.

A (Dr. Andrews-Speed): Currently, EPR in Europe is experiencing cost overruns, and both governments and people have come to think nuclear energy is expensive. This has made financing difficult. Now we are on a new path.

Q: (to Dr. Andrews-Speed) What is the role of the international networks in ASEAN?

A: They are exchanging information and ideas. I don’t think these networks are currently having a major impact, but such effort is important.

4-10. Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables

4-10-1. Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables: A view of a private financial institution

Mr. Masayuki Fujiki, Solution Products Division, MUFG Bank, Ltd., Japan

Mr. Fujiki introduced MUFG Bank's business activities regarding project finance and its global presence in the project finance field. Sustainable debt including green bond, social bond etc. has been increasing in the recent years. Various guidelines for transition finance have been developed in the past few years. MUFG Bank participated in some of these activities. In IEA's Net Zero Emissions scenario, natural gas is projected to be a dominant source of power supply until 2030. Power generated by unabated natural gas and global supply of natural gas will decrease after 2030. To support transition finance in Asia, as LNG is a fossil fuel, a framework that has global consensus is needed. Also, each economy should establish a clear roadmap or strategy to achieve carbon neutrality. Transition projects should be incorporated into these roadmaps and strategies. Although there are a variety of risks in LNG related finance, these risks can be mitigated by various methodologies.

4-10-2. Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables: A view of a government financial institution (by video)

Ms. Kazuko Sakuma, Director General, Oil and Gas Finance Department, Energy and Natural Resources Finance Group, Japan Bank for International Cooperation (JBIC), Japan

This June, JBIC announced its medium-term business plan; a key focus area was to "Address global issues toward realizing sustainable development for the global economy and society".
JBIC has also announced several action plans that respond to the need for energy transformation towards the realization of a decarbonized society. These action plans cover areas including "Green Finance" and "Transition Finance" to support developing economies progress towards a decarbonized society. This separation acknowledges that economies must balance the stable supply of energy and achieve sustainable economic growth, but it will also be necessary to take a realistic and phased approach in energy transition by considering each economy's current energy mix and renewable energy potential. It will require mobilizing a variety of methods, each having regard to individual circumstances and affordability. Not only renewables but gas-fired thermal power generation, which has a low CO2 emission on relative terms, would be indispensable for a more realistic energy transition. In this context, LNG is an indispensable energy resource during the transition period toward decarbonization in the future. Fuels like ammonia and hydrogen are also expected to be utilized for mixed combustion. Challenge is to build up the overall supply chain to make the cost more affordable. Ms. Sakuma emphasized the importance of not taking a unified approach but to consider the circumstances and features of the specific regions and to take a holistic approach to move towards carbon neutrality. JBIC is willing to support such an approach with its Green Finance and Transition Finance.

Q&A for all presenters and discussion
Q: (to Mr. Fujiki) Aside from LNG, how do you consider financing transition energy sources such as biomass and cofired generation?

A: (Mr. Fujiki) It is very difficult to define what transition finance is. Some may mention financing cofired generation is transition finance while others may insist that it is just extending the lifetime of an old-style generation. At this moment it is challenging to finance greenfield coal-fired power generation.

Q: (to Mr. Fujiki) How is carbon capture (CCUS) viewed from a financing and risk perspective?
A: (Mr. Fujiki) Financing carbon capture (CCUS) could be considered as one of transition finance. In order to do so, again, it should be clearly included into the roadmap or framework. The private sector should carefully review a framework, roadmap, guideline, and strategy in each CCUS project in each economy.

Q: (to Mr. Fujiki) How will guidelines for transition finance change the behaviors of financial institutions?
A: (Mr. Fujiki) There are various guidelines in the world (e.g., the United States. EU, and developing economies in Asia). Guidelines have huge impact on behaviors of financial institutions. It is challenging to establish a proper guidelines as it should not be too vague or too detail.

Q: (to Mr. Fujiki) There are many risks regarding LNG project finance. What are the benefits of participating in LNG project finance for private financial institutions in addition to returns from investments?
A: (Mr. Fujiki) Participating in these projects is to contribute financially. Also, regarding risks, there are many parties and risks can be mitigated. Therefore, although the tenor is longer, the project finance is more secure than corporate finance.

4-11. Panel Discussion: How to Pursue Carbon Neutrality while Strengthening Energy Security and Resiliency in the Asia Pacific Region

4-11-1. Report from ABAC Sustainability Working Group

Mr. Takashi Imamura, Executive Officer and General Manager of Research Institute, Marubeni Corporation; ABAC Sustainability Working Group

In ABAC’s view, for the APEC economies to achieve carbon neutrality, a major shift in energy policies will be necessary. Trade and investment in renewable energy as well as low emission technologies are important to achieve both carbon neutrality and energy resilience. By sharing technologies, best practices, and successful businesses with each other, the whole APEC economies will benefit. Regarding renewable energy, ABAC recommends developing an APEC framework for trade and investment in renewable energy to achieve carbon neutrality and energy resilience. ABAC also recommends developing suitable policy for each economy while acknowledging the differences among economies. Mr. Imamura shared ideas on proposals for 2022. A realistic energy policy to achieve carbon neutrality should be formulated. The policy should be promoting the transition to carbon neutrality while incorporating energy resilience. It also should be practical and reflecting the diversity of APEC economies. In addition, it is important for APEC economies to cooperate with each other in developing and utilizing the technology including CSS, hydrogen, ammonia and synthetic fuels and related systems.

4-11-2. Report from ERIA on Decarbonization Scenarios for ASEAN

Dr. Han Phoumin, Senior Energy Economist, Energy Unit, Economic Research Institute for ASEAN and East Asia (ERIA)

The energy demand in ASEAN economies is expected to continue to increase with the rapid economic growth. Currently, fossil fuels make up almost 80% of the primary energy mix in the ASEAN region. VRE resources are unevenly distributed across regions. For example, ASEAN economies have relatively scarce wind resources and abundant solar PV resources. Regarding power generation costs (LOCE), VRE costs except for solar PV will be still higher than coal in 2050. When the VRE share increases, two challenges will arise. The first is that with a greater supply of electricity generated by solar PV and wind, wholesale electricity prices go below LCOEs and prevent further deployment of VRE facilities. The second is that solar and wind power generation can be extremely limited depending on the day. To solve this problem, energy storage capacity would be required. Regarding hydropower, it is also unevenly distributed in ASEAN region. Therefore, international grid expansion can maximize the utilization of hydro resources. Currently, ERIA and IEEJ are developing a model. It calculates the least cost power generation mix with different carbon prices for ASEAN region in 2050. Without carbon prices, coal-fired and gas-fired power generations are dominant. However, as carbon prices go up, low-carbon technologies become dominant. Modelling also shows that to achieve net zero by 2060, various technologies including renewables, nuclear, CCS, and imported hydrogen and ammonia will be necessary. In this case, renewables become main power resources. In order to achieve carbon neutrality, it is essential to reduce the cost of decarbonization technologies.

4-11-3. Panel Discussion on Energy Security

Moderator, Dr. Ken Koyama (Senior Managing Director, Chief Economist, IEEJ) opened the panel discussion by asking each panelist to comment on energy security with regards to carbon neutrality ambitions. **Dr. Han Phoumin** (Senior Energy Economist, Energy Unit, ERIA) begun by saying that any energy transition without consideration for energy security presents large risks, especially for the ASEAN region. He stressed that any energy transition should be well-designed in terms of energy infrastructure, and that using coal or natural gas in a ‘clean’ manner would be key for the APEC region.

Mr. Takeshi Soda (Director, Oil and Natural Gas Division, ANRE, METI, Japan) mentioned 3E+S as the basis of energy policy in Japan which places both energy security and environmental protection as core pillars, which is important for any move to a more carbon neutral society. **Dr. Twarath Sutabutr**

(Inspector-General, Ministry of Energy, Thailand) highlighted that carbon neutrality and energy security is a trade-off, especially in an economy like Thailand. The trade-off involves: 1) domestic development or imported supply of clean energy, 2) planning based on existing or emerging and unproven technologies, and 3) market transformation based on quick and disruptive or gradual transition.

Dr. Ken Vincent (Director, Office of Asian Affairs, DOE, USA) commented that energy security remains paramount to all of us and raised three new energy security issues: 1) resiliency benefits of cross-border electricity flows as we introduce more variable renewable energy into the market, 2) when electrifying the vehicle fleet gathers pace, the supply risk for transport and the power sector will intersect, and 3) market concentration in solar cells, batteries, and critical minerals is much more severe than in the oil market.

When asked about the **major risk for electricity security of supply**, **Dr. Vincent** again emphasized resiliency of the system. He elaborated about the need for appropriate system design that manages extreme weather events, cyberattacks, and incorporates sufficient storage capability. **Dr. Twarath** emphasized the large growth in electricity demand (especially in the transportation sector), and the importance of ensuring existing gas-fired power plants accommodate this growth while meeting carbon neutrality ambitions. Grid interconnections between economies will be helpful in this context.

Mr. Soda highlighted LNG would be important as an adjustable backup power resource, that can minimize blackout risks thanks to flexible operation. **Dr. Phoumin** emphasized that any policies to incorporate renewables must be balanced with delivering energy at an affordable price, especially in the ASEAN region.

To the second question—**the role of natural gas/LNG as a transitional or backup energy source in the context of a move to carbon neutrality?**—**Mr. Soda** again pointed out the importance of LNG as an adjustable power source to balance renewable intermittency. He also stressed that natural gas provides the raw materials for hydrogen and ammonia. Considering this importance, additional efforts to reduce greenhouse gas emissions in the LNG supply chain are required.

Dr. Twarath mentioned that LNG and natural gas will be used as a transition fuel for the coming three decades to anchor and stabilize renewables. He noted that continued investment in the natural gas supply chain is required in the context of reducing emissions. **Dr. Vincent** expressed his gratitude to hear others committed to reducing the carbon footprint of the entire LNG value chain. However, he flagged that focusing on any one energy source too much can cause problems. **Dr. Phoumin** stressed the importance of infrastructure to support the energy transition; a stable market for natural gas is needed to facilitate a transition that is reliant on natural gas.

Dr. Koyama wrapped up the session by highlighting that Japan, USA, and ASEAN economies have already been successful at enhancing energy security, but that continued and enhanced efforts are required, including increased international cooperation.

4-11-4. Panel Discussion on Energy Resiliency

Moderator, Mr. Hiroki Kudo (Board Member, IEEJ) opened the panel discussion, mentioning the critical need to build energy systems that are resilient to ever-increasing natural and socioeconomic threats (for example, cyber security) in the ASEAN region. Following the August 2020 endorsement of the APEC Energy Resiliency Principles, which lays out voluntary norms and measures, APEC leaders declared their intentions to collaborate on energy resiliency. The Energy Resiliency Guidelines are currently being formulated as a follow-up initiative.

In his initial comments, **Mr. Takashi Imamura** (Executive Officer and General Manager of Research Institute, Marubeni Corporation; ABAC Sustainability Working Group) pointed out that while renewables are an important solution for achieving carbon neutrality (CN), energy resiliency and CN need to be balanced, and thus stressed the importance of "transition." **Mr. Hiroshi Hasegawa** (Director, Energy Supply and Demand Policy Office, Ministry of Economy, Trade and Industry (METI), Japan) highlighted the different member economy circumstances across the APEC region. Japan is ready to cooperate with other APEC economies in pursuing diversified energy supply and demand structures and enhancing energy resiliency in their respective contexts.

From the perspective of a developing economy, **Mr. Alexander Lopez** (Undersecretary, Department of Energy, the Philippines) flagged that climate change impacts continue to threaten energy infrastructure, placing parts of the Philippines in a vicious cycle of energy poverty and significant economic costs. Strategies geared toward CN can be further enhanced while addressing the shared challenges of energy resiliency. **Mr. Dan Ton** (Program Manager, Office of Electricity, Department of Energy, USA) explained that the Office of Electricity drives the modernization of the grid, ensuring a secure, resilient, reliable and flexible electricity system, with a focus on not only technological innovation, but also institutional support and alignment with the market as a whole.

Asked **what the risks were for energy resiliency of APEC economies in the process towards carbon neutrality, Mr. Imamura** identified the risk of undermining energy resiliency by compromising energy supply diversification. Given the important role of fossil fuels in the energy resiliency of APEC economies, the concept of energy transition should not be lost in the drive towards CN. **Mr. Hasegawa** stressed the importance of the order in which policy initiatives are taken and welcomed discussions on designing policy initiatives toward CN. **Mr. Lopez** pointed out that decarbonization efforts centered on increasing renewables expose the power sector to risk of reduced reliability. He also flagged the need for APEC to address the impact of climate change in the context of energy resiliency. **Mr. Ton** highlighted the importance of addressing energy resiliency by accounting for linked infrastructures, including energy, transport, communications, and water.

To the second question—**what actions should APEC take to promote energy resiliency enhancement in each APEC economy?**—**Mr. Imamura** showcased the potential for cooperation on multiple initiatives (such as those for storage technologies) that contribute to enhancing energy resiliency in accordance with regional circumstances. **Mr. Hasegawa** emphasized the importance of cooperation among stakeholders and private sector initiatives outside APEC, as well as sharing experiences among economies and stakeholders, as important actions to be taken. **Mr. Lopez** recommended developing sustainable financing and insurance mechanisms to address evolving supply and demand needs, conducting impact and vulnerability assessments of old and new energy systems and infrastructure, and sharing knowledge and experience. **Mr. Ton** stressed that given the diversity across APEC economies, information-sharing on key activities that support energy resiliency would be valuable, citing the benefits of microgrids in the U.S.

Mr. Kudo wrapped up the session by reiterating the importance of stakeholder cooperation amongst multiple levels of government, energy suppliers, consumers, and the financial sector. This cooperation will lead to a better understanding of any risks, and enhance energy resiliency action across different time frames. He encouraged stakeholders to harness the upcoming APEC Energy Resiliency Guidelines, maintaining a good balance between energy resiliency enhancement and climate change impact reduction.

4-12. Closing Remarks

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

Dr. Irie stated that the two-day symposium was informative and encouraging for institutions, companies, and economies that are pursuing decarbonization goals, including highly ambitious carbon neutrality goals. He was very appreciative of all those who attended and thanked those individuals who took the time to make presentations and discuss issues in panel sessions. Dr. Irie concluded the symposium by reiterating APERC's commitment to facilitating cooperation amongst APEC member economies on energy issues, including decarbonization and carbon neutrality.

5. Symposium Analysis

Including speakers and organizers, more than 180 individuals registered to participate in the symposium. 27 attendees completed the evaluation survey.

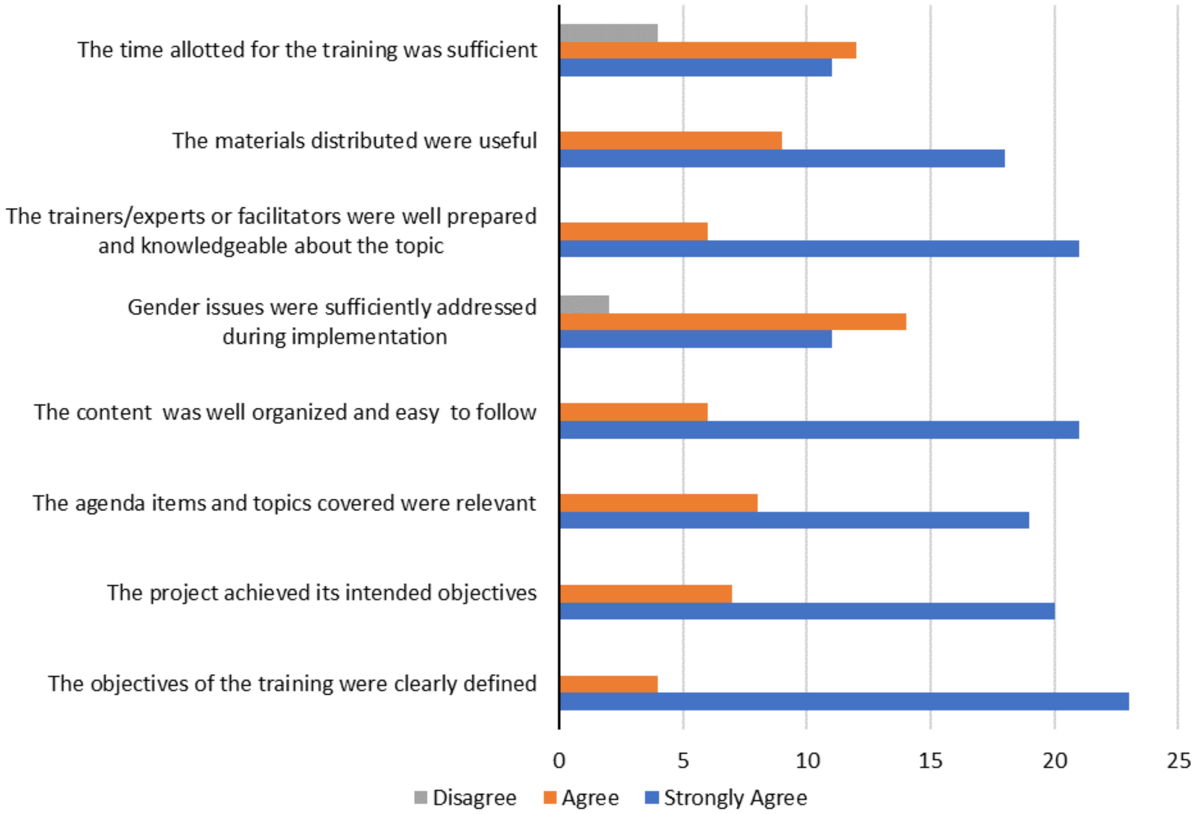


Figure 1. Summary of APEC Project Evaluation Survey

According to the survey results shown in Figure 1, most respondents thought that the objectives were clearly defined and had been achieved. Most respondents also thought that the agenda items and topics covered were relevant and that the content was well organized and easy to follow. Some survey respondents believed that more time was needed for questions and answers. In general, the survey results support the notion that it achieved the intended objectives.

6. Appendix 1: Agenda

(JST)	***Monday, August 30*** MC: Ms. Reiko Chiyoya, Researcher, Asia Pacific Energy Research Centre (APERC)
08:30-09:00	Registration
	1-1. Opening Session
09:00-09:05	*1-1-1. Opening Remarks* - **Dr. Kazutomo Irie**, President, Asia Pacific Energy Research Centre (APERC)
09:05-09:15	*1-1-2. Keynote Speech: Necessity of the Holistic Approach of Decarbonization towards Carbon Neutrality in the APEC Region* **Mr. Shinichi Kihara**, Deputy Commissioner for International Affairs, Agency for Natural Resources and Energy (ANRE), Ministry of Economy, Trade and Industry (METI), Japan
09:15-09:30	**1-2. Potential of Decarbonization towards Carbon Neutrality in the APEC Region** - **Mr. Takahiko Tagami**, Senior Coordinator, The Institute of Energy Economics, Japan (IEEJ)
	1-3. Hydrogen and Ammonia including infrastructure issues - Moderator: **Dr. David Wogan,** Assistant Vice President, APERC
09:30-09:45	*1-3-1. Clean Hydrogen (by Video)* - **Dr. Sunita Satyapal**, Director of Hydrogen and Fuel Cell Technologies Office, the Office of Energy Efficiency and Renewable Energy (EERE), Department of Energy, USA
09:45-10:00	*1-3-2. Ammonia* - **Mr. Shigeru Muraki**, Representative Director, Clean Fuel Ammonia Association, Japan
10:00-10:10	*Q&A for all presenters and discussion*
	1-4. Energy Saving - Moderator: **Dr. Naoko Doi**, Senior Economist, IEEJ
10:10-10:25	*1-4-1. Energy Efficiency of Buildings* - **Mr. Tadafumi Nishimura**, Senior Engineer, Technology Innovation

	Center, ZEB Energy Management Group, Daikin Corp, Japan
10:25-10:40	*1-4-2. Demand Side Energy Management* - **Mr. Steve Schiller**, Visiting Scientist/Senior Advisor, Electricity Markets and Policy (EMP) Department, Lawrence Berkeley National Laboratory, USA
10:40-10:50	*Q&A for all presenters and discussion*
	1-5. Renewable Energy Power - Moderator: **Mr. Hugh Marshall-Tate**, Researcher, APERC
10:50-11:05	*1-5-1. Wind Power in the APEC region (including offshore): Experience of Chinese Taipei* - **Mr. Ssu-yuan Hu**, Manager of Wind Power Program, Green Energy & Environment Research Laboratories (GEL), Industrial Technology Research Institute, Chinese Taipei
11:05-11:20	*1-5-2. Solar Power in the APEC region* - **Ms. Charuwan Phipatana-phuttapanta**, Senior Professional Scientist, Solar Energy Development Division, Department of Alternative Energy Development and Efficiency (DEDE) Ministry of Energy, Thailand
11:20-11:35	*1-5-3.Geothermal Power in the APEC region* - **Mr. Harris**, Director of Geothermal, Directorate General of New, Renewable Energy and Energy Conservation (DGNREEC), Ministry of Energy and Mineral Resources (MEMR), Indonesia
11:35-11:50	*Q&A for all presenters and discussion*
	1-6. Issues for Electricity Security: To Cope with Increasing Intermittent Renewables Power Sources - Moderator: **Mr. Glen Sweetnam**, Senior Vice President, APERC
11:50-12:05	*1-6-1.Grid Infrastructure in Indonesia* - **Mr. Wanhar,** Director for Electricity Technical and Environment, Directorate General of Electricity, Ministry of Energy and Mineral Resources of Indonesia, Indonesia
12:05-12:20	*1-6-2. Power Storage* - **Dr. Douglas J. Arent**, Executive Director, Strategic Public Private

	Partnerships, National Renewable Energy Laboratory, USA
12:20-12:35	*1-6-3. Electricity Security in regards to Clean Energy Transitions* - **Ms. Randi Kristiansen**, Economics and Financial Analyst, Clean Electricity Renewable Integration and Security of Electricity Unit, International Energy Agency (IEA)
12:35-12:45	*Q&A for all presenters and discussion*

(JST)	***Tuesday, August 31*** MC: Ms. Reiko Chiyoya, Researcher, APERC
08:30-09:00	Registration
09:00-09:10	**2-1.** *Keynote Speech: Keynote Speech: The role of Carbon Capture Coupled to Dedicated and Reliable Storage in Helping to Meet Net-Zero Carbon Emissions Goals (by video)* - **Dr. Jennifer Wilcox**, Acting Assistant Secretary for Fossil Energy, Department of Energy (DOE), USA
	2-2. CCUS in the APEC region - Moderator: **Mr. Mathew Horne,** Researcher, APERC
09:10-09:25	*2-2-1. CCUS in the APEC region: An expert view from Australia* - **Mr. Alex Zapantis**, General Manager - Commercial, Global CCS Institute (GCCSI), Australia
09:25-09:40	*2-2-2. CCUS in the APEC region: An expert view from Indonesia* - **Dr. Mohammad Rachmat Sule**, Associate Professor in Faculty of Mining and Petroleum Engineering, Department of Geophysical Engineering, Institut Teknologi Bandung, Indonesia
09:40-09:50	*Q&A for all presenters and discussion*
	2-3. Nuclear Energy in the APEC region - Moderator: **Ms. Tomoko Murakami**, Senior Economist, IEEJ
09:50-10:05	*2-3-1 Nuclear Energy in the APEC region: An exper view from Korea* - **Dr. Chae Young Lim**, Research Director, Korea Atomic Energy Research Institute (KAERI), Korea
10:05-10:20	*2-3-2. Nuclear Energy in the APEC region: An expert view from Southeast Asia*

	- **Dr. Philip Andrews-Speed**, Senior Principal Fellow, The Energy Studies Institute, National University of Singapore, Singapore
10:20-10:30	*Q&A for all presenters and discussion*
	2-4. Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables - Moderator: **Ms. Reiko Chiyoya**, Researcher, APERC
10:30-10:45	*2-4-1. Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables: A view of a private financial institution* - **Mr. Masayuki Fujiki,** Solution Products Division, MUFG Bank, Ltd.
10:45-11:00	*2-4-2. Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables: A view of a government financial institution (by video)* - **Ms. Kazuko Sakuma**, Director General, Oil and Gas Finance Department, Energy and Natural Resources Finance Group, Japan Bank for International Cooperation (JBIC), Japan
11:00-11:10	*Q&A for all presenters and discussion*
	2-5. Panel Discussion: How to Pursue Carbon Neutrality while Strengthening Energy Security and Resiliency in the Asia Pacific Region - Moderator: **Ms. Reiko Chiyoya**, Researcher, APERC
11:10-11:20	*2-5-1. Report from ABAC Sustainability Working Group* - **Mr. Takashi Imamura**, Executive Officer and General Manager of Research Institute, Marubeni Corporation; ABAC Sustainability Working Group
11:20-11:30	*2-5-2. Report from ERIA on Decarbonization Scenarioos for ASEAN* - **Dr. Han Phoumin**, Senior Energy Economist, Energy Unit, Economic Research Institute for ASEAN and East Asia (ERIA)
11:30-12:00	*2-5-3. Panel Discussion on Energy Security* - Moderator: **Dr. Ken Koyama**, Senior Managing Director, Chief Economist, IEEJ - **Dr. Han Phoumin**, Senior Energy Economist, Energy Unit, ERIA - **Mr. Takeshi Soda**, Director, Oil and Natural Gas Division, ANRE, METI, Japan - **Dr. Twarath Sutabutr,** Inspector-General, Ministry of Energy,

	Thailand - **Dr. Ken Vincent**, Director, Office of Asian Affairs, DOE, USA
12:00-12:30	*2-5-4. Panel Discussion on Energy Resiliency* - Moderator: **Mr. Hiroki Kudo**, Board Member, Director, IEEJ - **Mr. Takashi Imamura**, Executive Officer and General Manager of Research Institute, Marubeni Corporation; ABAC Sustainability Working Group - **Mr. Hiroshi Hasegawa**, Director, Energy Supply and Demand Policy Office, ANRE, METI, Japan - **Mr. Alexander Lopez**, Undersecretary, Department of Energy, The Philippines - **Mr. Dan Ton**, Program Manager, Office of Electricity, DOE, USA
12:30-12:40	*Q&A for all presenters and discussion*
12:40-12:45	**2-6.** *Closing Remarks* - **Dr. Kazutomo Irie**, President, APERC

7. Appendix 2: Presentation Materials

Keynote Speech: Necessity of the Holistic Approach of Decarbonization towards Carbon Neutrality in the APEC Region

METI Ministry of Economy, Trade and Industry

Necessity of the Holistic Approach of Decarbonization toward Carbon Neutrality in the APEC Region

30,August, 2021

Shinichi KIHARA
Agency for Natural Resources and Energy
Ministry of Economy, Trade and Industry, Japan

2050 Carbon-Neutral Declaration and 2030 Climate Goal

- In October 2020, Prime Minister Suga declared that **by 2050 Japan will aim to reduce greenhouse gas emissions to net-zero,** that is, to realise a carbon-neutral, decarbonised society.
- At Leaders Summit on Climate in April 2021, Prime Minister Suga announced that **Japan aims to reduce its GHG emissions by 46 percent in FY 2030 from its FY 2013 levels**.

Prime Minister's remarks at Leaders Summit on Climate

Japan aims to reduce its greenhouse gas emissions by 46 percent in fiscal year 2030 from its fiscal year 2013 levels, setting an ambitious target which is aligned with the long-term goal of achieving net-zero by 2050.

Furthermore, **Japan will continue strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50 percent**.

Green Growth Strategy

- **Launched in December, 2020, updated in June 2021**
- **The strategy is an Industrial policy**
- **Covers Electricity, Industry, Transport, Service/household areas**
- **Sets ambitious goals (Roadmaps) to induce companies' investment and fully support the private sector's efforts**
  → Supported by Government's Finance, Tax, Regulatory reform
- **Includes action plans for 14 growing industrial sectors and cross sectoral policy tools**

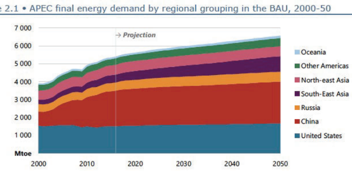
14 Growth Sectors

Energy	Transport/Manufacturing	Home/ Office
Offshore wind power Wind turbines, parts, floating wind turbines	Mobility and battery EV (electric vehicle), FCV (fuel cell vehicle), next generation batteries	Housing and building, Next generation PV (perovskite solar cell)
Ammonia fuel Combustion burner (as fuel in transition period to hydrogen-powered society)	Semiconductor and ICT Data centers, energy-saving semiconductors (demand-side efficiency)	Lifestyle-related industry Local decarbonization business
Hydrogen Turbines for power generation, hydrogen reduction steel-making, carrier ships, water electrolyzers	Maritime Fuel-cell ships, electric propulsion ships, gas-fueled ships	Resource circulation Biomaterials, recycled materials, waste power generation
Nuclear power SMR (Small Modular Reactor), nuclear power for hydrogen production	Logistics, people flow and infrastructure Smart transportation, drones for logistics, fuel-cell construction machinery	
	Foods, agriculture, forestry and fisheries Smart-agriculture, wooden skyscrapers, blue carbon	
	Aviation Hybrid electric, Hydrogen-powered, Aircraft	
	Carbon Recycling Concrete, biofuel, plastic materials	

Energy supply and demand situation in the APEC region

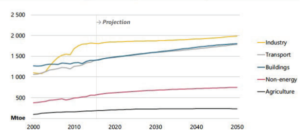
Key points from APEC Energy and Demand Outlook 7th Edition (2019)

Figure 2.1 • APEC final energy demand by regional grouping in the BAU, 2000-50



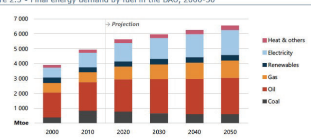
Sources: APERC analysis and IEA (2018a).

Figure 2.2 • APEC final energy demand by sector in the BAU, 2000-50



Sources: APERC analysis and IEA (2018a).

Figure 2.3 • Final energy demand by fuel in the BAU, 2000-50

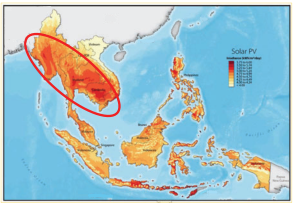


Sources: APERC analysis and IEA (2018a).

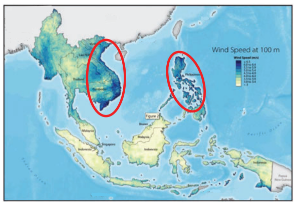
Renewable energy potentials in ASEAN economies

- In ASEAN economies, **renewable energy resource potentials are unevenly distributed**.
- There are only a limited number of regions where renewable energy can be introduced at low costs.

<Solar resource potentials in ASEAN economies>



<Wind resource potentials in ASEAN economies>



・LCOE (Levelized Cost of Energy), which doesn't include integration costs, such as battery costs or grid costs etc.

Source: Lee Nathan et al.(2020), EXPLORING RENEWABLE ENERGY OPPORTUNITIES IN SELECT SOUTHEAST ASIAN COUNTRIES (modified by METI)

Asia Energy Transition Initiative (AETI)

- Japan announced "**Asia Energy Transition Initiative (AETI)**" in **the Special Meeting of ASEAN Ministers on Energy and Minister of Economy, Trade and Industry of Japan** on June 21, 2021
- This initiative includes a variety of support for the realisation of various and pragmatic energy transitions in Asia, and each country welcomed it at the meeting.

1. **Support drawing roadmaps for energy transitions**
2. **Presentation and promotion of the concept of Asia Transition Finance**
3. **US$10 billion financial support for renewable energy, energy efficiency, LNG, CCUS and other projects**
4. **Technology development and deployment, utilizing the achievement of Green Innovation fund**
   (e.g.) Offshore wind, Fuel-ammonia, Hydrogen etc.
5. **Human resource development, knowledge sharing and rule-making on decarbonisation technologies**
   - Capacity building of decarbonisation technologies for 1,000 people in Asian economies
   - Workshops and Seminars on energy transitions
   - Asia CCUS network

Announcement of AETI by Minister Kajiyama at Japan-ASEAN Business Week Opening Session

Tokyo Beyond-Zero Week 2021

- Japan has been aiming at improving the competitiveness of new industries toward **a virtuous cycle of environment and growth** through the achievement of "**Environmental Innovation for Beyond-Zero**", which is an approach to establishing innovative technologies which not only allow carbon neutral efforts to become possible worldwide, but also to realize the "Beyond-Zero" initiative for retroactively reducing carbon dioxide (CO_2) emissions in accordance with the stock-based approach, and publicly implementing the technologies.

Oct. 4th (Mon.) the 1st Asia Green Growth Partnership Ministerial Meeting
the 3rd International Conference on Carbon Recycling
the 4th Hydrogen Economical Ministerial Meeting

5th (Tue.) the 10th LNG Consumer-Producer Conference
the 3rd TCFD Summit

6th (Wed.) the 1st International Conference on Fuel Ammonia
the 8th ICEF (Oct. 6th-7th)

8th (Fri.) the 3rd RD20 (Leaders' Session)

Thank you for your attention.

Potential of Decarbonization towards Carbon Neutrality in the APEC Region

IEE JAPAN

Potential of Decarbonization towards Carbon Neutrality in the APEC Region

August 2021

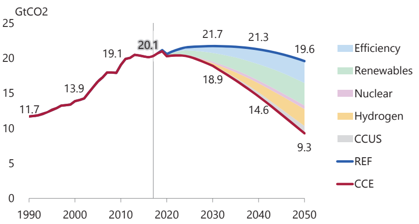
Takahiko Tagami
Senior Coordinator
The Institute of Energy Economics, Japan

The IEEJ Outlook and CO_2 emission reduction potential

- **The IEEJ Outlook**, which results are utilized to estimate CO2 emission reduction potential in the APEC region, covers 19 APEC member economies other than Peru and Papua New Guinea.

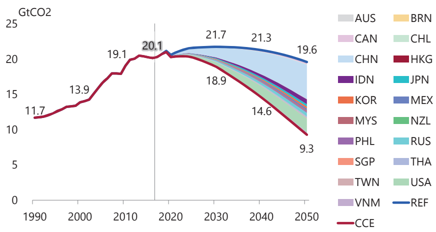
- This analysis defines **CO_2 emission reduction potential** as **the difference between**
  - the "**Reference Scenario**" (the scenario in which past trends, such as economic and social structures and technology evolution, will continue) and
  - the "**Circular Carbon Economy/4R Scenario**" (the scenario in which powerful energy and environmental policies result in success to the extent possible and decarbonization technologies using fossil fuels are introduced to the likely extent determined by the IEEJ's expertise).

CO_2 emission reduction potential (by technical field)



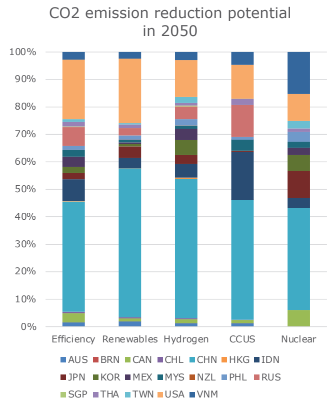
- The breakdown of the CO_2 emission reduction potential of 10.3Gt by technical field shows that **renewable energy** have the highest potential at **3.2Gt**, accounting for 31.1% of the total. **Increased energy conservatio**n are **3.1Gt** (30.4% of the total). **Hydrogen/ammonia technologies** are **2.4Gt** (23.3% of the total). **CCUS technologies** is **1.1Gt** (10.2% of the total). **Nuclear power** in the APEC region is the lowest at **0.5Gt** (5.0% of the total).

CO_2 emission reduction potential (by economy)



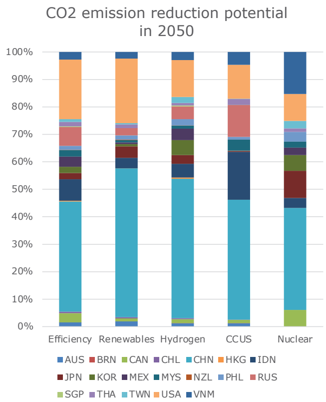
- The breakdown of the CO_2 emission reduction potential by economy shows that **China** has the highest potential at **4.9Gt**, accounting for 47.2% of the entire APEC region. **The United States of America** follows China at **1.9Gt** (18.8% of the total). Following China and the United States of America are **Indonesia** (**0.7Gt**, 6.7% of the total) and **Russia** (**0.5Gt**, 5.2% of the total).

CO_2 emission reduction potential by technology/economy (1/2)



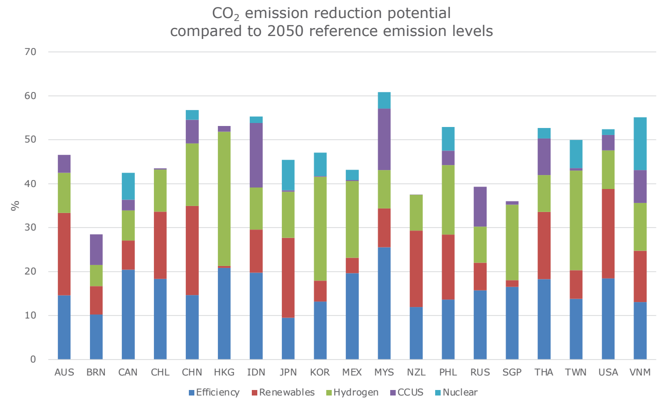
- **Efficiency**: In 2050, **China** is expected to account for the largest share in total APEC CO_2 emission reduction at 40%, followed by **USA** (22%), **Indonesia** (8%) and **Russia** (7%).
- **Renewables**: The largest contribution to emission reduction potentials in the APEC region (3,137 $MtCO_2e$) comes from **China** (1,734 $MtCO_2e$), followed by **the US** (755 $MtCO_2e$).

CO_2 emission reduction potential by technology/economy (2/2)



- **Hydrogen**: APEC economies will introduce hydrogen, with the largest volume of demand from **China**, **US** and **Republic of Korea**.
- **CCUS**: The largest contribution to emission reduction potentials come from **China** (459 million tons), followed by **Indonesia** (183 million tons), **US** (130 million tons) and **Russia** (122 million tons).
- **Nuclear**: **China** has the largest emission reduction potential, with 190 million tons in 2050, followed by **Viet Nam** with 79 million tons, **Japan** with 51 million tons, and **the U.S.** with 50 million tons.

CO_2 emission reduction potential by economy/technology



Clean Hydrogen (by Video)

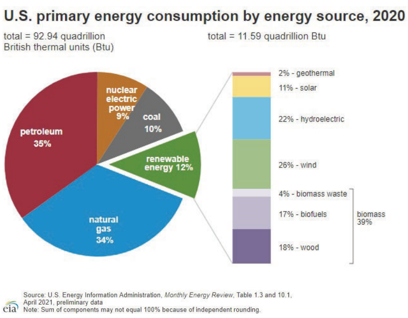
U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

U.S. Department of Energy's Hydrogen and Fuel Cell Perspectives

Dr. Sunita Satyapal, Hydrogen and Fuel Cell Technologies Office Director and DOE Hydrogen Program Coordinator

August 2021

U.S. Energy Landscape and Key Goals



Administration Goals include:

- Net zero emissions economy by 2050
- 100% carbon-pollution-free electric sector by 2035

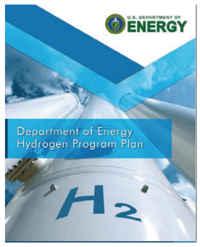
Priorities: Ensure benefits to all Americans, focus on jobs, EJ40: 40% of benefits in disadvantaged communities

EJ: Environmental Justice

The U.S. DOE Hydrogen Program

U.S. DEPARTMENT OF ENERGY

Hydrogen is one part of a broad portfolio of activities



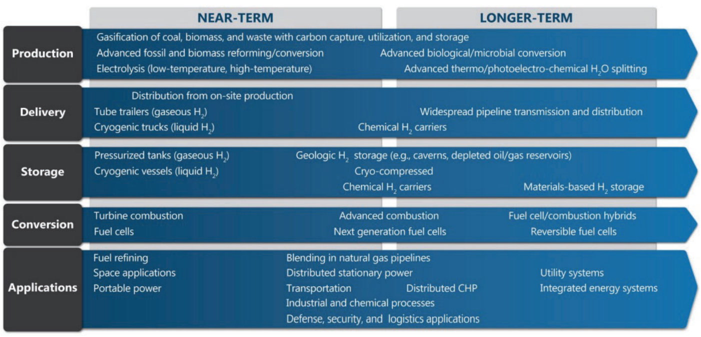
www.hydrogen.energy.gov

Examples of Key DOE Hydrogen Program Targets

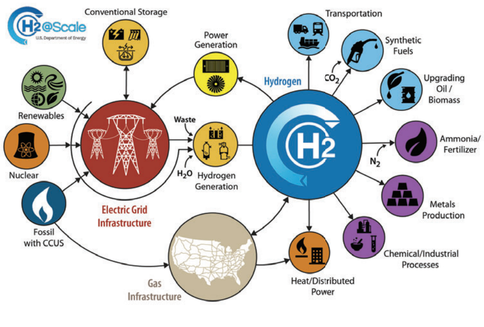
DOE targets are application-specific and developed with stakeholder input to enable competitiveness with incumbent and emerging technologies. These targets guide the R&D community and inform the Program's portfolio of activities. Examples include:

- $2/kg for hydrogen production and $2/kg for delivery and dispensing for transportation applications
- $1/kg hydrogen for industrial and stationary power generation applications
- Fuel cell system cost of $80/kW with 25,000-hour durability for long-haul heavy-duty trucks
- On-board vehicular hydrogen storage at $8/kWh, 2.2 kWh/kg, and 1.7kWh/l
- Electrolyzer capital cost of $300/kW, 80,000 hour durability, and 65% system efficiency
- Fuel cell system cost of $900/kW and 40,000 hour durability for fuel-flexible stationary high-temperature fuel cells

Comprehensive Strategy Across the Hydrogen Value Chain



H2@Scale: Deep Decarbonization, Economic Growth, Jobs



- 10 MMT of H_2/yr produced today with scenarios for 2-5X growth.
- +10 MMT H_2 would ~ double today's solar or wind deployment
- Industry study shows potential for $140B in revenue, 700K jobs by 2030. 16% GHG reduction. Analysis underway (export, etc.)

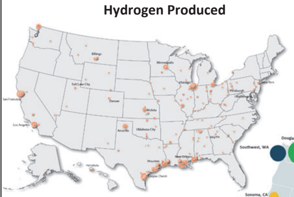
Snapshot of Hydrogen and Fuel Cell Applications in the U.S.

Examples of Applications Deployed

- >500MW Backup Power
- >40,000 Forklifts
- >172 MW PEM* Electrolyzers
- >60 Fuel Cell Buses
- >45 H_2 Retail Stations
- ~11,000 Fuel Cell Cars

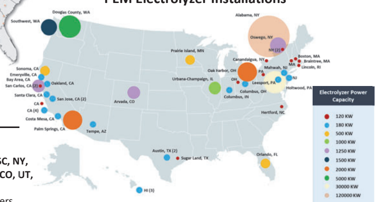
* Polymer electrolyte membrane

Hydrogen Produced



- 10 million metric tons produced annually
- More than 1,600 miles of H_2 pipeline
- World's largest H_2 storage cavern

PEM Electrolyzer Installations



Hydrogen Stations Plans Across States

California	Northeast	HI, OH, SC, NY, CT, MA, CO, UT, TX, MI
200 Stations Planned California Fuel Cell Partnership Goal	12 – 20 Stations Planned	And Others

Current and under construction installations over 120 kW as of Jun. 2021
* Source: Arjona, et al, DOE HFTO Program Record, June 2021

President Biden and Energy Secretary Granholm at Climate Summit

"…I've asked the Secretary of Energy to speed the development of critical technologies to tackle the climate crisis. No single technology is the answer on its own because every sector requires innovation to meet this moment."

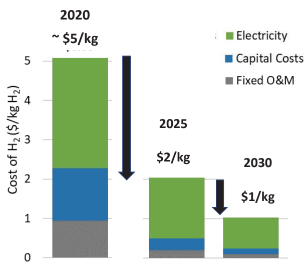
President Joseph R. Biden
April 23, 2021

Launch of Hydrogen Energy Earthshot
First of the Energy Earthshots
June 7, 2021
at DOE Hydrogen Program Annual Merit Review

Secretary Jennifer Granholm
June 7, 2021

Examples of pathways to "1 1 1"

Example: Cost of Clean H_2 from Electrolysis



One of several pathways

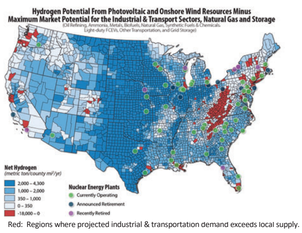
- Reduce electricity cost from >$50/MWh to
  - $30/MWh (2025)
  - $20/MWh (2030)
- Reduce capital cost >80%
- Reduce operating & maintenance cost >90%

All pathways for clean hydrogen included: Thermal conversion with CCS, advanced water splitting, biological approaches, etc.

2020 Baseline: PEM low volume capital cost ~$1,500/kW, electricity at $50/MWh. Need less than $300/kW by 2025, less than $150/kW by 2030 (at scale)

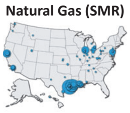
Stakeholder Engagement, Production and End-Use Collocation and Environmental Justice to Drive Activities

Renewables

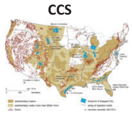


Red: Regions where projected industrial & transportation demand exceeds local supply.

Natural Gas (SMR)



CCS



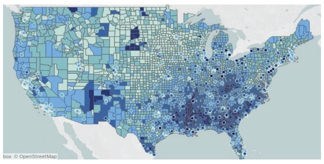
- Hydrogen Shot Summit and Stakeholder Engagement Planned Aug 31-Sept 1
- Request for Information on Key Topics Issued

DOE Request of Information covered key themes:

- Production, Resources, Infrastructure
- End Users, Cost, Value Proposition
- Co-location potential
- Emissions Reduction Potential
- DEI, Jobs, EJ
- Science & Innovation Needs and Challenges

DEI: Diversity, Equity and Inclusion
EJ: Environmental Justice

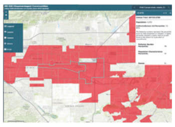
Focus on Benefits in Underserved & Disadvantaged Communities



New index ranks America's 100 most disadvantaged communities | University of Michigan News (umich.edu)

Funding Opportunities will encourage broader engagement, demonstrating benefits, including DEI (minorities, gender equity, etc.)

Example: DOE project with CTE for UPS Fuel Cell Delivery Vans



Trucks will be demonstrated in Ontario, CA- disadvantaged community

Goal: Demonstrate 15 fuel cell trucks (up to 125-mile range)

Project impact per year: Savings of

- **285 metric tons of CO_{2e}**
- **280,000 grams of criteria pollutants**
- **56,000 gallons of diesel**

**in honor of Bob Rose, founder of US Fuel Cell Council*

"No one can whistle a symphony. It takes a whole orchestra to play it."

- H. Luccock

Examples of International Collaborations

iea

CLEAN ENERGY MINISTERIAL — Advancing Clean Energy Together

HYDROGEN INITIATIVE — AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

MISSION INNOVATION

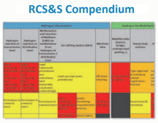
CLEAN HYDROGEN MISSION

PRHYDE — PRESLHY

IPHE — The International Partnership for Hydrogen and Fuel Cells in the Economy — Enabling the global adoption of hydrogen and fuel cells in the economy — www.iphe.net

Regulations, Codes, Standards, Safety and Education & Outreach Working Groups

RCS&S Compendium

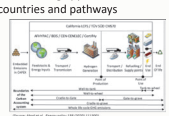


- Reports, workshops, safety sharing
- Assessing gaps
- Education, student engagement, compiling country info

Task Force to facilitate international trade of H_2

H_2 Production Analysis (H2PA)

- Developing a common analytical framework to determine emissions footprint for H_2
- Harmonizing approach across countries and pathways



Center for Hydrogen Safety

Global Center for Hydrogen Safety established to share best practices, training resources and information

High Priority: Lessons learned and best practices on safety

Encourage membership (industry, govt, universities, labs) to join CHS

CENTER FOR Hydrogen SAFETY 水素安全センター — Connecting a Global Community

www.aiche.org/CHS

IPHE — Hydrogen Council — AIChE — Pacific Northwest NATIONAL LABORATORY — hySafe

Over 60 partners: government, industry, universities and more

Access to >110 countries, 60,000 members

Resources, Events and Ways to Stay Connected

Annual Merit Review

Week of June 6, 2022
www.hydrogen.energy.gov
Projects posted online

Oct 8 - Hydrogen and Fuel Cells Day

- Held on hydrogen's very own atomic weight-day

1 — 1.008 — H — Hydrogen

Early career network

- Run by students, postdocs
- Over 10 countries

IPHE — International Partnership for Hydrogen and Fuel Cells in the Economy

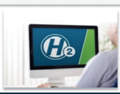
Stephanie Azubike, Chair

Priya Buddhavarapu, Co-Chair

iphe.net/early-career-chapter

Free Online Resources Available at energy.gov/eere/fuelcells

INCREASE YOUR H_2IQ — **Join Monthly** H2IQ Hour Webinars — **Download** H2IQ For Free



Visit H2tools.Org For Hydrogen Safety And Lessons Learned
https://h2tools.org/

Join our team as a Hydrogen Technologies Fellow!
Apply at www.zintellect.com

Sign up to receive hydrogen and fuel cell updates
www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-newsletter

Thank you

Sunita Satyapal
Director, Hydrogen and Fuel Cell Technologies Office
Coordinator, DOE Hydrogen Program
U.S. Department of Energy

www.energy.gov/fuelcells
www.hydrogen.energy.gov

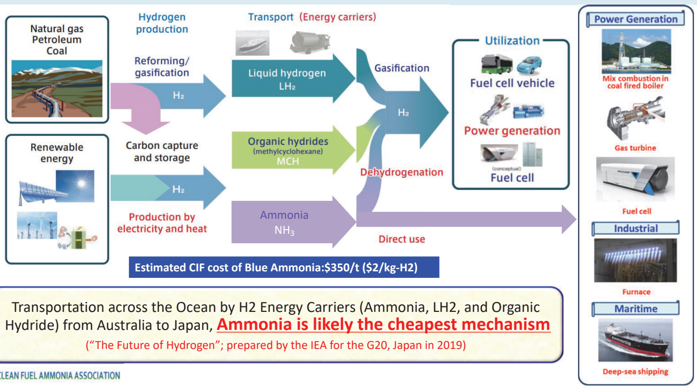
Ammonia

Implementation Plan of Clean Fuel Ammonia Value Chain

APEC Symposium Holistic Approach of Decarbonization towards Carbon Neutrality
August 30, 2021

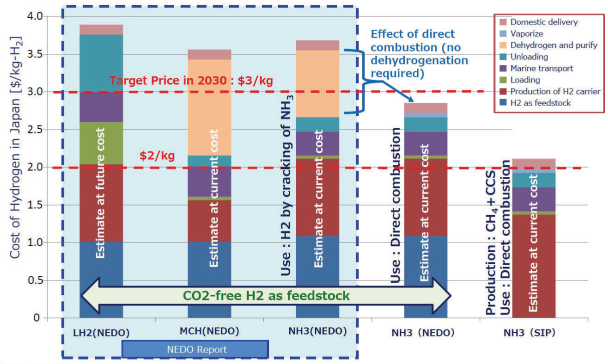
Shigeru Muraki
Representative Director, Clean Fuel Ammonia Association

Hydrogen Energy Carrier



Transportation across the Ocean by H2 Energy Carriers (Ammonia, LH2, and Organic Hydride) from Australia to Japan, **Ammonia is likely the cheapest mechanism**
("The Future of Hydrogen"; prepared by the IEA for the G20, Japan in 2019)

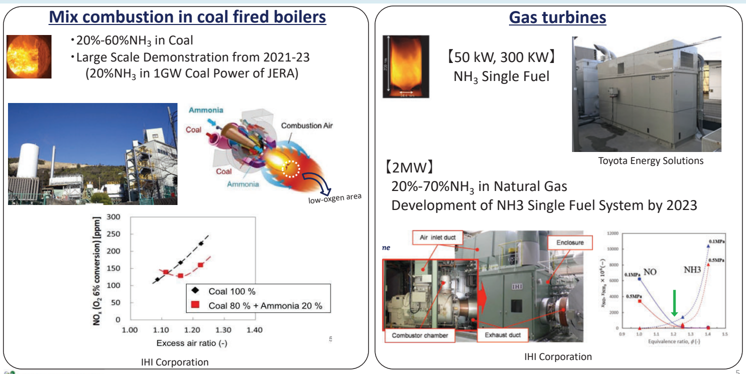
Cost Comparison of Hydrogen Carriers



Why Ammonia

- Directly combusted without CO_2 emissions.
- Largest H_2 content among 3 carriers and most efficient in marine transportation.
  (NH_3 121kg-H_2/m³ liquid , LH_2 71kg-H_2/m³ , MCH 47kg-H_2/m³)
- Large commercial supply chain is established, and cost structure is clear.
  (Global production: 200 million tons, International trade: 20 million tons)
- NOx emissions can be controlled by technologies.
  (Air-fuel ratio , Two staged combustion etc.)
- Technologies are becoming ready for commercial use.
- Safety standards are practically used in chemical and power industries.
- Primary markets are controlled facilities with trained operators such as power plant, industrial factories and data centers.

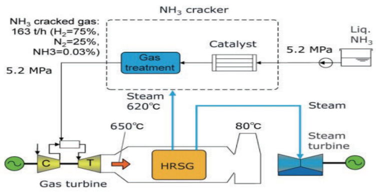
Key Technologies of Ammonia Utilization in the Energy Market



Key Technologies of Ammonia Utilization in the Energy Market

Advanced Combined Cycle Gas Turbines

Decomposition of NH_3 using part of exhaust heat and H_2 is supplied to turbine.
Efficiency is equivalent to CH_4.



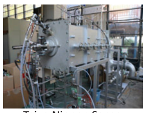
Mitsubishi Heavy Industries Engineering / Mitsubishi Power

SOFC

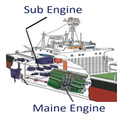
10kW
～200kW


IHI Corporation

Industrial Furnaces

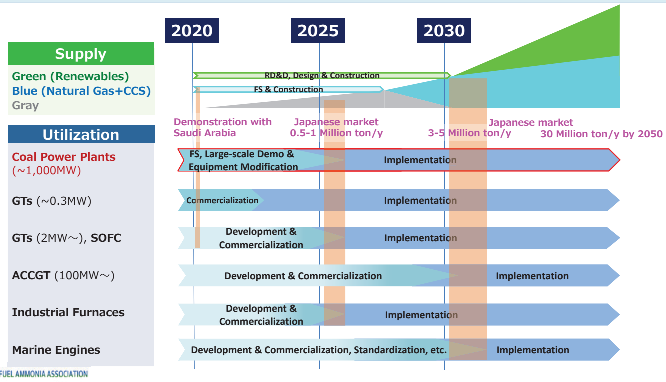

Taiyo Nippon Sanso

Marine Diesel Engine



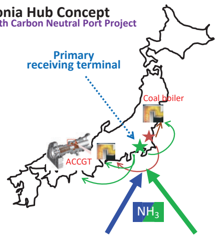
JFE Engineering / National Institute of Maritime, Port and Aviation Technology

Roadmap of Fuel Ammonia Value Chain



Implementation Plan of Clean Fuel Ammonia Value Chain

Ammonia Hub Concept
Collaborate with Carbon Neutral Port Project



Natural Gas +CCS/EOR (Blue) Renewables (Green)

Australia, USA, Middle East

Phase Ⅰ

- Mixed combustion in coal power generation
- Development of ammonia supply infrastructure
  (Primary receiving terminal + domestic delivery system)
- Establishment of supply chain (mainly from Australia and USA)

Phase Ⅱ

- Increase of fuel ammonia co-firing ratio in coal power generation
- Mixed combustion in natural gas ACCGT

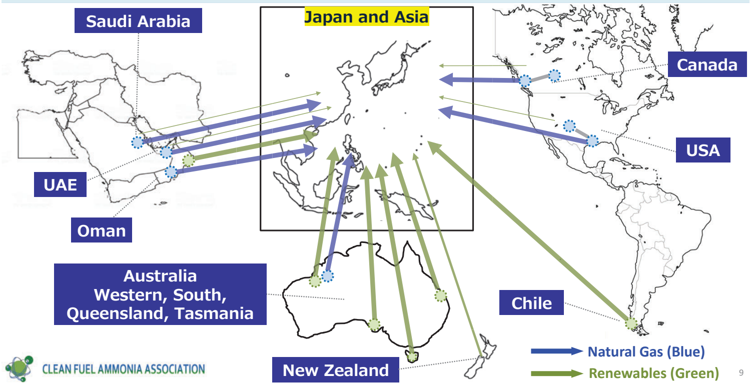
Distributed power (small & medium GTs, SOFC)
Industrial Furnaces
Marine Engine
＜C-free Power Generation＞

- Ammonia single fuel combustion in coal power plants
- Ammonia ACCGT
- Expansion of mix combustion in coal power generation in Asia

(ACCGT：Advanced Combined Cycle Gas Turbine)

2050 Demand in Japan, more than 30M Tons
CO2 reduction more than 60M Tons

Potential Supplies of Blue and Green Ammonia



Public-Private Council on Fuel Ammonia Introduction

Established : October 2020 under Natural Resources and Fuel Department of METI
Interim Report : February 2021

1．Objectives

Identifying issues for expanding the use of fuel ammonia, and sharing the roles and timelines of the public and private sectors in solving these issues, with the aim of promoting a unified approach.

2．Members

Public sector	Private sector
Natural Resources and Fuel Department, Agency for Natural Resources and Energy, METI	IHI Corporation
Japan Oil, Gas and Metals National Corporation (JOGMEC)	JERA Co., Inc.
Japan Bank for International Cooperation (JBIC)	Electric Power Development Co., Ltd. (J-POWER)
Nippon Export and Investment Insurance (NEXI)	JGC HOLDINGS CORPORATION
	Nippon Yusen Kabushiki Kaisha (NYK Line)
(Observers)	Marubeni Corporation
Material Industries Division, Manufacturing Industries Bureau, METI	MITSUBISHI HEAVY INDUSTRIES, LTD.
Ports and Harbours Bureau, Ministry of Land, Infrastructure, Transport and Tourism	Mitsubishi Corporation
Maritime Bureau, Ministry of Land, Infrastructure, Transport and Tourism	The Institute of Energy Economics, Japan (IEEJ)
	Clean Fuel Ammonia Association (CFAA)

Public-Private Council on Fuel Ammonia Introduction

Outline of Interim Report

- Promotion of involvements by Japanese companies in Clean Fuel Ammonia Value Chain from production, transportation, storage, utilization to finance for cost reductions and mid to long term supply security
- Contribution to the decarbonization of the world and Asia where thermal power generation will continue to be significant portion of power supply.
- Expected demand in Japan is 3MMtons in 2030, 30MMtons in 2050 and 100MMtons for global supply chain by Japanese companies in 2050.
- Targeted price by 2030 is upper 10yen range per Nm3 hydrogen equivalent (upper $1 range per kg).
- Development of technologies for ammonia GTs, CHPs, industrial furnaces, marine diesel engines, low cost and high efficiency production and CCS.
- Establishment of international standards and criteria.

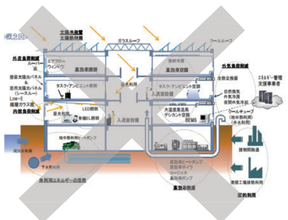
Energy Efficiency of Buildings

Energy Efficiency of Buildings
～DAIKIN Zero Energy Building～

Realizing General purpose ZEB with office building

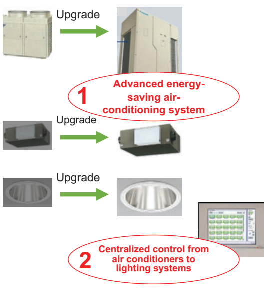
General-purpose ZEB that Daikin strives for

General ZEB



Generally, to achieve ZEB, various type of technologies are required to be installed like improvement of air-conditioning, lighting and envelope performance and natural energy use. So the ZEB cannot be common.

Daikin strives to achieve general-purpose ZEB



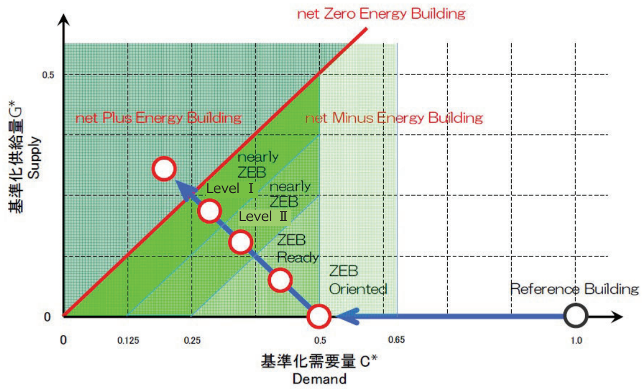
+

3 Select the optimum capacity

+

Less construction

（For Reference）Definition of ZEB



DAIKIN ZEB achievements

Newly built large size building
“Technology Innovation Center”

Location	: Settsu,Osaka
Application	: Office/Lab
Structure/ Floors	: S/SRC　-1+6 P2
Total floor area	: 47,911.86 ㎡
Completion	: Nov. 2015

LEED FACTS
Platinum
85/110

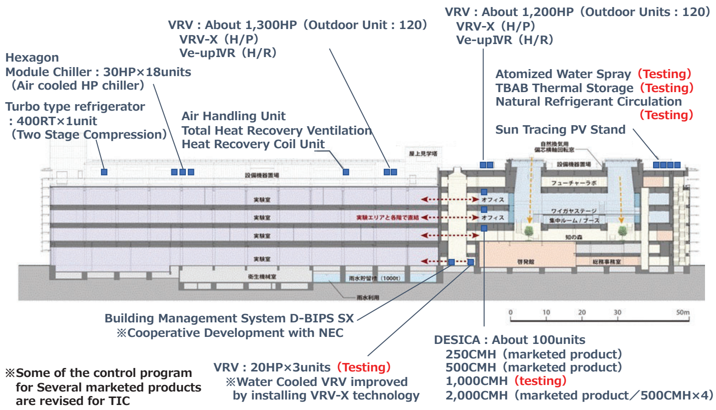
Achieved “Nearly　ZEB ” by actual results

Renovation of small-to-medium sized building:
Daikin Industries Fukuoka Building

Location	: Hakata, Fukuoka
Type of building	: Office building
Structure/ Story	: Steel construction 4 stories above ground, 1-story penthouse
Total floor area	: 2,620 m^2
Renovation	: May 2017

Recognized as “ZEB Ready” by Building-Housing Energy-efficiency Labeling System (BELS)

Installed Daikin’s Product and Testing Machines



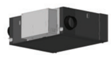
Temperature and Humidity Individual Control System

Improve energy saving by individually controlling temperature and humidity

Commercial multi Air Conditioner「VRV QX」

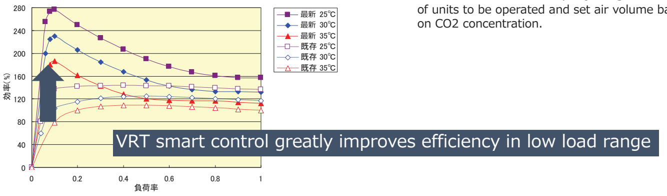
・Temperature treatment aims to achive high energy saving
・Realizing high efficiency in low range by changing evaporation temperature according to required capacity

Humidity control fresh air treatment unit「DESICA」



・**Humidity control**
Control humidity through humidity sensor

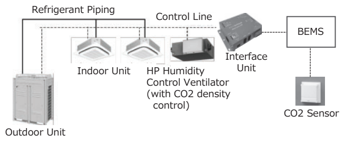
・**CO2 concentration control**
Reduce ventilation load by adjusting the number of units to be operated and set air volume based on CO2 concentration.



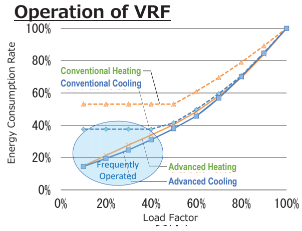
Temperature and Humidity Individual Control System

Feature of the System

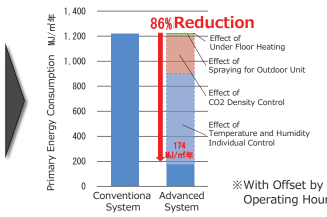
・By the refrigerant pressure optimal control, the performance in partial load operation is greatly improved.
・In combination with the HP humidity control ventilator, the system can realize the temperature and humidity individual control.
⇒▲86% of Energy Reduced



Performance in Partial Load Operation of VRF



Energy Reduction Effect of VRF



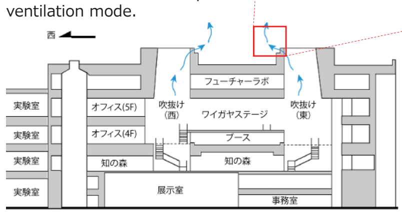
※With Offset by the Operating Hours

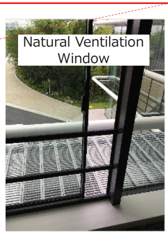
Natural Ventilation and Outdoor Air Cooling

【In Natural Ventilation Mode】

When the natural ventilation is effective, the LED on the office ceiling is lit.

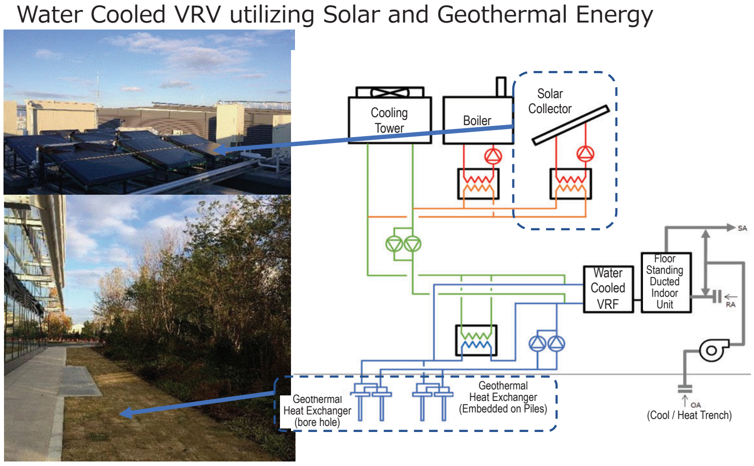
As the office users open the windows, the natural ventilation is utilized
・Improve user's energy consciousness
・Adjustment of IAQ by users own hands
Adopting the automatic selection among
Natural ventilation →Outdoor air cooling →Hybrid cooling
VRV can reduce the unevenness of temperature in the natural ventilation mode.





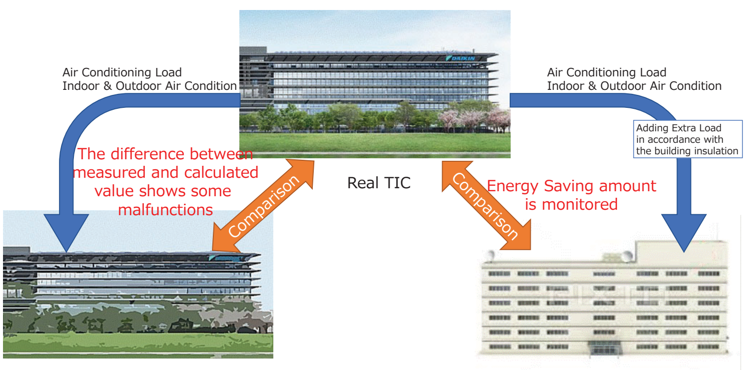
Solar and Geothermal Air Conditioner

Water Cooled VRV utilizing Solar and Geothermal Energy

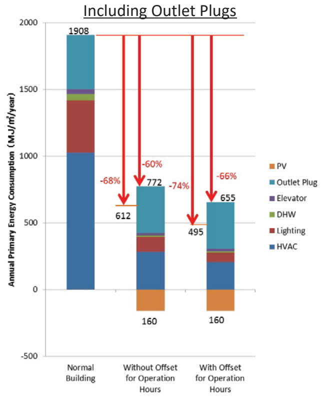


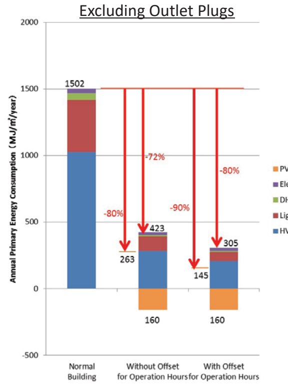
Performance Monitoring (Commissioning)

【Energy Consumption Prediction and Monitoring of Energy Saving Effect by Utilizing Cyber Physical System】



Measured Energy Consumption





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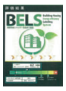


ZEB planning of Fukuoka Building

Set ZEB target

On-site survey / Check existing drawings

<Target> **Achieve Nearly ZEB by upgrading systems**
Achieve “ZEB ready” by design, and “Nearly ZEB” by operation and energy creation
Select a capacity of air conditioner based on the actual operation data (air network data)

Temporary system design

Lighting
- Change illuminance
- Study installation of sensors and schedule timers, etc.

Ventilation
- Check ventilation air volume
- Study installation of total heat exchanger/DESICA
- Study installation of CO2 sensors, humidity sensors, etc.

Air-conditioning
- Check actual operation data
- Load calculation
- **Select optimum capacity**, etc.

・・・・

Enter each change of setting into the online program for calculation

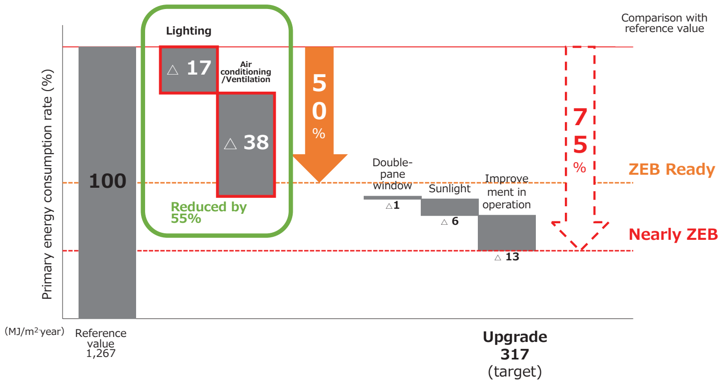
NO — ZEB target — OK

Finalize systems and equipment models

＊ “Online program”・・・Calculation assistance program offered by Building Research Institute. It is used to **calculate the primary energy consumption according to the Act on Improvement of Energy Consumption Performance of Buildings.**

Daikin Industries Fukuoka Building:
Reduction of primary energy consumption by design

Achieved “ZEB Ready” in air conditioning, ventilation and lighting



Equipment Profile of Daikin Fukuoka Building

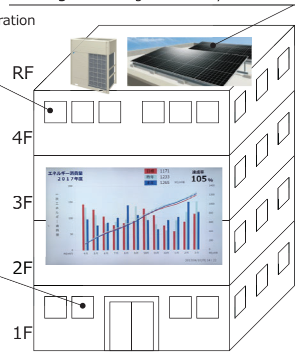
① Air conditioner : **VRV QX** VRV-SMART control
Ventilation : **DESICA** ON/OFF control by CO2 concentration

② Lighting : LED dimming system（**DALI** control）
Energy saving control by illuminance sensor and human sensor.

③Select optimum capacity by **Remote monitoring** system.

④ Improvement in operation : **Cool/hot space**

⑤ **Sunlight Power** generation system（20.8kW）



① VRV+DESICA system

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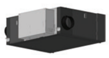
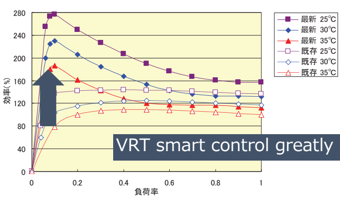


- **Humidity control**
  Control humidity through humidity sensor
- **CO2 concentration control**
  Reduce ventilation load by adjusting the number of units to be operated and set air volume based on CO2 concentration.



VRT smart control greatly improves efficiency in low load range

② LED dimming system

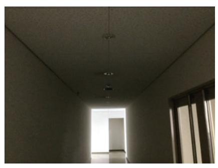
Control illuminance of LED with illuminance sensor

Daytime

Night

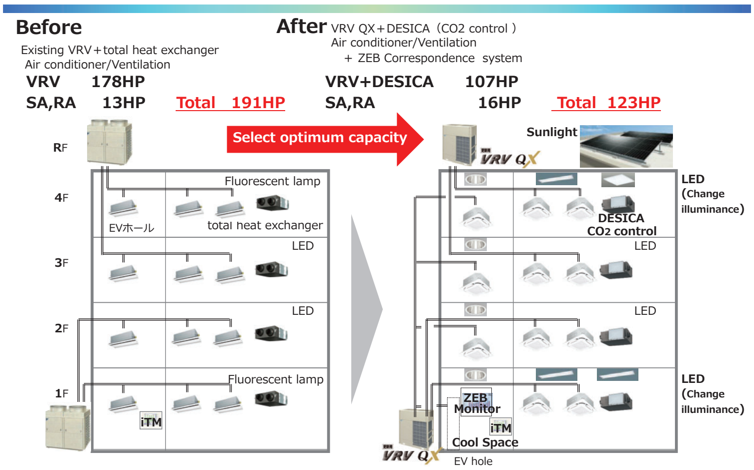
Light goes off when there is no human presence (Common areas)

When a person is present



When no presence

③ Select optimum capacity by remote monitoring system

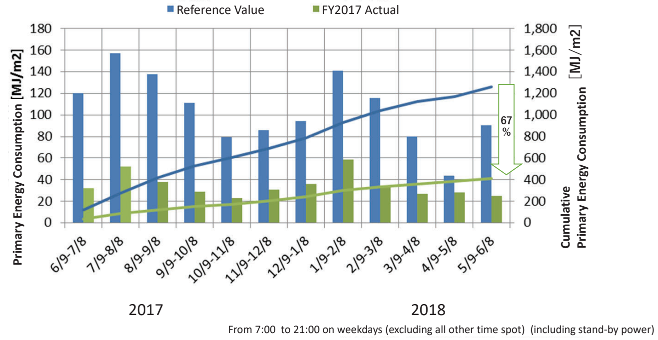


Measured Energy Consumption

Actual Primary Energy Consumption

As a result of whole year (2017. Jun ~ 2018.May) measurement,

energy consumption is reduced by **67%** compared with reference building

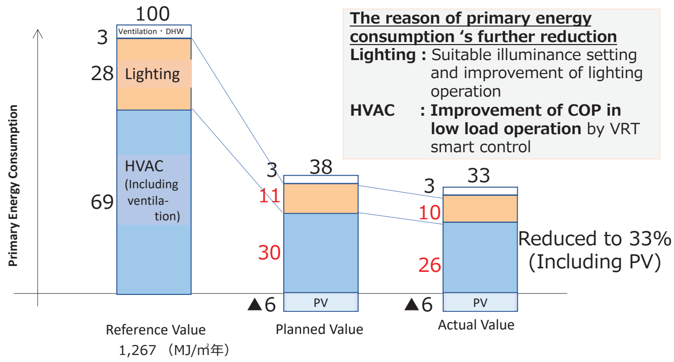


Measured Energy Consumption

Actual Primary Energy Consumption

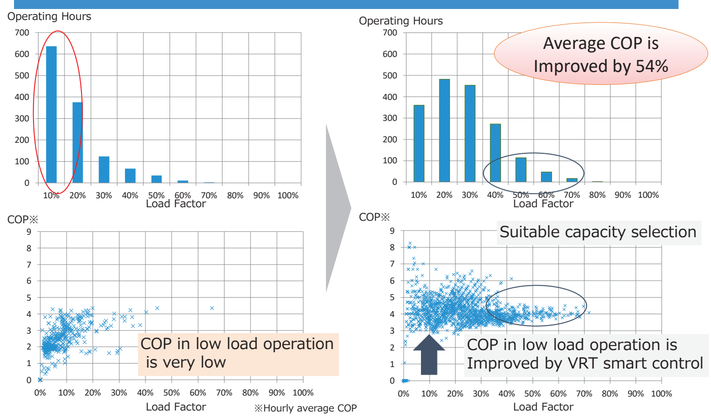
Planned energy conservation is by 62%. But the actual energy conservation is by 67%.

Temperature and Humidity individual control was more effective than expected.



Measured Operating Condition

Comparison of the operating data before and after the renewal



BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY
U.S. DEPARTMENT OF ENERGY

Demand Side Energy Management

Steven R. Schiller
Senior Advisor/Guest Scientist - Affiliate
Electricity Markets and Policy Department - https://emp.lbl.gov/

APEC Symposium on the Holistic Approach of Decarbonization Towards Carbon Neutrality
30-31 August 2021
Tokyo, Japan

ENERGY TECHNOLOGIES AREA | ENERGY ANALYSIS AND ENVIRONMENTAL IMPACTS DIVISION

Demand Side Energy Management

Acknowledgements

- Many government agencies, utilities, contractors, researchers and others are investigating how best to implement demand side energy management for its multiple benefits, which include:
  - Reducing consumers' energy cost burden – particularly for the disadvantaged, low income households and businesses
  - Improving energy system reliability and resilience
  - Reducing the environmental impact of energy consumption
  - Improving energy security
  - And - *Supporting the cost-effective decarbonization of the energy sector*
- In particular I want to acknowledge the work of my colleagues at:
  - U.S. Department of Energy's Office of Energy Efficiency and Renewables and its Building Technologies Office - https://www.energy.gov/eere/office-energy-efficiency-renewable-energy
  - Lawrence Berkeley National Laboratory - https://energyanalysis.lbl.gov and https://buildings.lbl.gov

First Step of Energy Management – Use Energy Efficiently

Within the U.S. Economy it has been estimated that

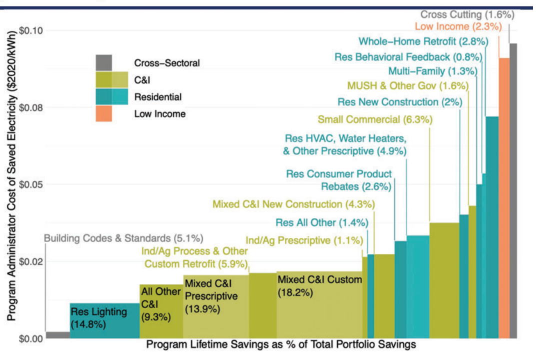
- There are over 2,000,000 energy efficiency jobs
- Without the energy efficiency investments made since 1980, energy consumption and emissions would have been 60% higher
- Appliance and equipment standards have helped deliver up to 80% in energy savings since 1980, often while improving size, capacity, and performance of such devices
- Energy efficiency is responsible for half the carbon dioxide emissions reductions in the power sector relative to 2005

Source: Energy Efficiency Impact Report, 2020, https://energyefficiencyimpact.org/about/

And…Energy Efficiency Is Very Cost Effective

Composite cost curve for energy savings from electric efficiency programs (2010-2018)

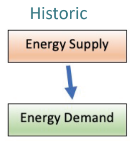
The levelized program administrator cost for saving energy in the U.S. Economy for 2018 programs was 2.4¢/kWh.



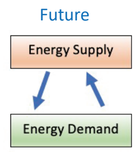
Source: **Still the One: Efficiency Remains a Cost-Effective Electricity Resource**
https://eta-publications.lbl.gov/sites/default/files/cose_cspd_analysis_2021_final_v2.pdf

Demand Side Energy Management – More Than Energy Efficiency

- Historically, conservation and energy efficiency have been used to primarily reduce the amount and cost of energy that consumers needed and thus the amount of energy provided by power plants, natural gas and fuel oil pipelines, biomass sources, etc.
  - Primary benefits include reduced fuel costs, reduced pollution and improved energy security
  - However, our energy supply system still followed the patterns of consumption



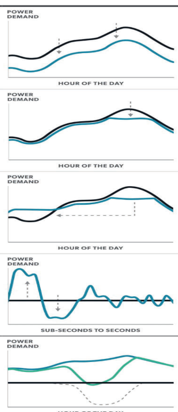
- With increased variable, renewable generation, the role of the demand side is changing and cost-effectively achieving a decarbonized energy system, particularly in the electricity sector, requires the consumption of energy to be coordinated with the supply side – i.e., *demand side energy management*
  - Primary benefits are same as efficiency but also focused on *improved grid reliability and resilience while reducing the amount and thus cost for generation, transmission and distribution infrastructure – reducing capacity costs*
  - And, now the demand can follow the patterns of generation via ***Demand Flexibility***



Demand Flexibility	Capability to adjust energy consumption across different timescales

What Is Demand Side Energy Management – Demand Flexibility

Behind the Meter Resources



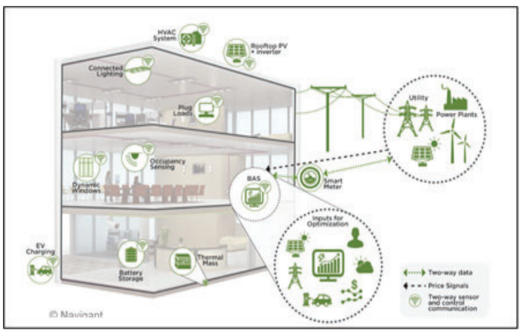
	LOAD IMPACT	EXAMPLE MEASURE	EXAMPLE BENEFIT
Efficiency		Building has an insulated, tight envelope and an efficient HVAC system to reduce heating/cooling energy needs	Reduced costs of burning fuel to satisfy energy demand, and reduced emissions associated with lower fuel use
Shed Load		Building dims lighting system by a preset amount in response to grid signals while maintaining occupant visual comfort levels	Reduced investment in generation and transmission capacity due to lower peak demand
Shift Load		Connected water heaters pre-heat water during off-peak periods in response to grid signals	Reduced energy costs due to shifting consumption to cheaper hours of the day; avoided curtailment of renewables during off-peak periods
Modulate		Batteries and inverters autonomously modulate power draw to help maintain grid frequency or control system voltage	Reduced ancillary services costs, improved integration of variable generation resources (e.g., wind, solar)
Generate		Rooftop solar PV exports electricity to the grid	Reduced T&D losses due to on-site consumption; avoided need for grid-scale generation

Source: A National Roadmap for Grid-Interactive Efficient Building, U.S. Department of Energy, May 2021, https://eta-publications.lbl.gov/sites/default/files/a_national_roadmap_for_gebs_-_final_20210517.pdf

Demand Flexibility via Grid-interactive Efficient Buildings (and Industry)

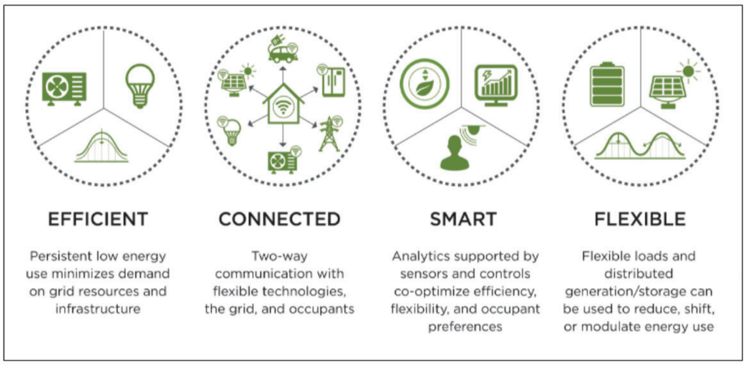
Grid-interactive Efficient Building (GEB)	An energy-efficient building that uses smart technologies and on-site DERs to provide demand flexibility while co-optimizing for energy cost, grid services, and occupant needs and preferences in a continuous and integrated way

- *DER* – A resource sited close to customers that can provide all or some of their immediate power needs and/or can be used by the utility system to either reduce demand or provide supply to satisfy the energy, capacity, or ancillary service needs of the grid
- *Smart technologies for energy management* - **Advanced controls,** sensors and analytics used to manage DERs. **GEBs are characterized by their use of these technologies.**



Source: https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings

Characteristics of Demand Flexible Buildings and Facilities



From: A National Roadmap for Grid-Interactive Efficient Building, U.S. Department of Energy, May 2021, https://eta-publications.lbl.gov/sites/default/files/a_national_roadmap_for_gebs_-_final_20210517.pdf

Examples of Demand Flexibility Systems

- Controls: building energy management systems, industrial controls, stand-alone controls (e.g., thermostats) - control the energy use of lighting, refrigeration, motors (e.g., water pumping, ventilation fans), space and heating and cooling systems, water heaters, etc. - *Demand Response*
- Energy storage: batteries, thermal storage, etc.
- Generators: photovoltaic systems
- Managed electric vehicle charging – and vehicle to grid
- Combinations of the above

Why Demand Flexibility is Essential for Decarbonization

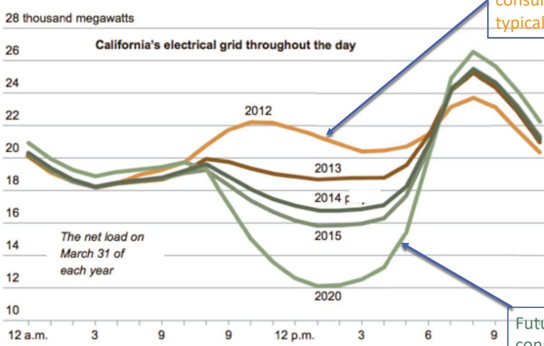
- Decarbonization efforts on the supply side (e.g., switching from coal to wind) are not enough – it requires coordinated resources on the supply and demand side
  - A challenge of renewable energy is how to integrate these variable resources into the grid
  - Variability causes periods of over and undersupply

- Thus, simply saving energy isn't enough – energy has to be saved **at the right times and right places**
- Demand flexibility focuses on time- and location-sensitive load shedding and shifting - using a diverse set of solutions including efficiency, electrification, demand response, storage and on-site generation.

See Active Efficiency Collaborative: https://activeefficiency.org

Demand Flexibility Supports Renewables Integration – the Duck Curve

Past: net electricity consumption during typical day



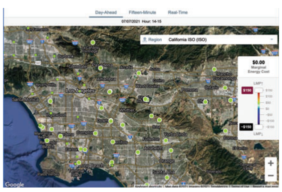
In California, 191 GWh of renewables were curtailed in April 2019

Future: net electricity consumption during times with significant solar generation

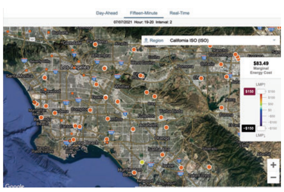
The Time and Location of Efficiency Impacts Matter

Green Dots ~50 USD/MWh Red Dots ~ 100 USD/MWh

July 7th - from 2-3pm



July 7th - from 7-8pm



California Independent System Operator – Los Angeles, California Area

Summary of Demand Flexibility Benefits

- **Helps meet multiple economy-wide policy goals:**
  - **Supports decarbonization**
  - Other energy-related goals, e.g., resilience for critical infrastructure
- **Reduces stress on grid by addressing:**
  - Growth in peak demand
  - Infrastructure constraints for T&D
  - Impact of variable renewable generation
  - **Electrification of space and water heating, industrial processes and transportation**
- **For consumers** —improves building performance, increases asset value, and provide more control over energy use and costs
- **For society** — jobs, energy security, and environmental and public health benefits

Benefit	Utility System	Building Owners/Occupants
Reduced utility operation & maintenance costs	✓	-
Reduced generation capacity costs	✓	-
Reduced energy generation costs	✓	-
Reduced T&D costs	✓	-
Reduced T&D losses	✓	-
Reduced ancillary services costs	✓	-
Reduced environmental compliance costs	✓	-
Increased resilience	✓	✓
Increased DER integration	✓	✓
Improved power quality	-	✓
Reduced owner/occupant utility bills	-	✓
Increased owner/occupant satisfaction	-	✓
Increased owner/occupant flexibility and choice	-	✓

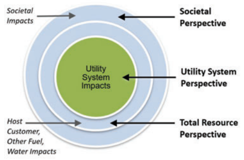
Source: State and Local Energy Efficiency Action Network. (2020). *Grid-Interactive Efficient Buildings: An Introduction for State and Local Governments.* https://eta-publications.lbl.gov/sites/default/files/bto-see-action-gebs-intro-20200415.pdf

Assessing Potential & Assessing Performance

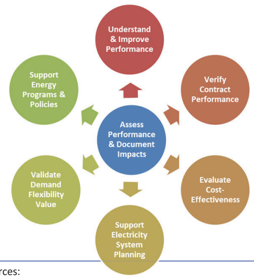
Potential Assessment

Comparing benefits and costs of alternative resource options to determine whether the benefits exceed the costs over the lifetime of the program or project.   Options:

- Modeling:
  - Integrated Resource Planning
  - Benefit Cost Analyses
- Competitive bidding processes/auctions to compare with other resource options



Measurement and Verification



Resources:

- *Performance Assessments of Demand Flexibility from Grid-Interactive Efficient Buildings: Issues and Considerations.* https://emp.lbl.gov/publications/performance-assessments-demand
- *National Standard Practice Manual For Benefit-Cost Analysis of Distributed Energy Resources* *https://www.nationalenergyscreeningproject.org/national-standard-practice-manual/*

The Potential and the Barriers

Potential – U.S. Economy Example

By 2030, according to one estimate, the United States will have nearly 200 gigawatts (GW) of cost-effective load flexibility potential, equal to 20% of estimated U.S. peak load - with savings for consumers from avoiding utility system costs estimated at $15 billion annually.

Hledik, R., A. Faruqui, T. Lee, and J. Higham. 2019. The Brattle Group. "The National Potential for Load Flexibility: Value and Market Potential Through 2030." https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_-_final.pdf.

Barriers

- Front-end investment requirements
- Principal agent problem (property owner/tenant)
- Lack of information and understanding of benefits (and risks)
- Transaction costs
- Lack of knowledgeable contractors, suppliers, etc.
- Uncertainty in documenting benefits
- Lack of mechanisms for incenting consumers

Actions APEC Economies Can Take to Advance Demand Flexibility

- **Gather Information and Identify Opportunities**
  - Catalog opportunities
  - Prepare integrated resource plans with demand side options
  - Assess cost-effectiveness with full assessment of costs and benefits
  - Establish metrics and set goals
- **Early actions**
  - Work with regulators, utilities and grid operators to establish value (e.g., $/kWh) for demand management services provided by buildings and industry
  - Provide consumer education and workforce education and training
  - Lead by example - pilot projects/demonstrations – share results
  - Establish data collection and measurement verification standards
  - Improve utility metering infrastructure– improve access to real time data
  - Address data access, interoperability, cyber security and privacy through standards
- **Establish demand management programs for buildings and industrial facilities**
  - Time of use interruptible service energy tariffs
  - Financial incentives for energy users – utility and third-party aggregator programs
  - Low income consumer programs to support most-vulnerable and address equity
  - Establish building energy codes and appliance standards – demand flexibility ready buildings and equipment

Conclusion

The road to a decarbonized energy infrastructure requires demand side energy management, including demand flexibility, resources.

These resources can be plentiful and low-cost solutions, but to reach the scale needed to have widespread impact, it must be treated as a true resource and allowed equal access to markets like other energy resources.

BERKELEY LAB

ASSESSING DEMAND FLEXIBILITY

Thank You

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Wind Power in the APEC region (including offshore): Experience of Chinese Taipei

Wind Power in the APEC Region & Experience of Chinese Taipei

Dr. Ssu-yuan Hu
Green Energy and Environment Laboratories
Industrial Technology Research Institute

2020 Status of Wind Power in APEC Region

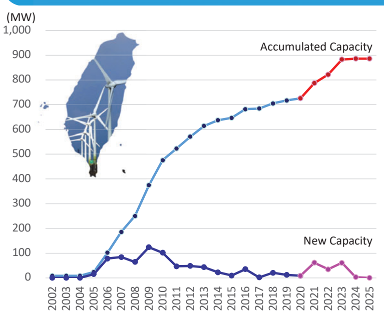
Country / Region	Onshore (MW) new	Onshore (MW) total	Offshore (MW) new	Offshore (MW) total	Total (MW)
China	48,940	278,324	3,060	9,996	288,320
the United States	16,193	122,275	12	42	122,317
Canada	165	13,577	0	0	13,577
Australia	1,097	7,296	0	0	7,296
Mexico	574	6,789	0	0	6,789
Japan	551	4,373	0	65	4,438
Chile	684	2,829	0	0	2,829
Republic of Korea	100	1,515	60	136	1,651
Thailand	0	1,538	0	0	1,538
Russia	843	945	0	0	945
Chinese Taipei	6	726	0	128	854
New Zealand	95	784	0	0	784
Viet Nam	125	513	0	99	612
the Philippines	0	427	0	0	427
Peru	0	376	0	0	376
Indonesia	0	154	0	0	154

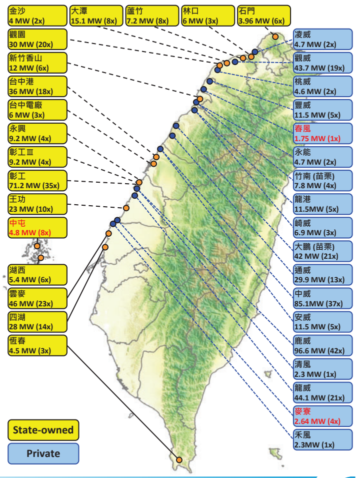
Ref. "Global Wind Report 2021," GWEC
"Global Offshore Wind Report 2020," GWEC
"Renewable Capacity Statistics 2021," IRENA

Offshore in 2030

- **China:** 52 GW
- **the United States:** 23 GW
- **Chinese Taipei:** 13 GW
- **Republic of Korea:** 7.9 GW
- **Japan:** 7.4 GW
- **Viet Nam:** 5.2 GW

Status of Onshore Wind in Chinese Taipei





Accumulated Onshore Capacity

- **2015:** 646.69 MW
- **2020:** 725.71 MW
- **2025:** 886 MW (estimated)

Phases of Promotion for Offshore Wind

DIP

- Offshore Demonstration Incentive Program (示範獎勵)
  - Incentives for Pioneers
  - Subsidy for 2 Demonstration Wind Farms

ZAP

- Directions of Zone Application for Planning (潛力場址)
  - Economies of Scale
  - Environmental Information of 36 Zones of Potential (ZoP)

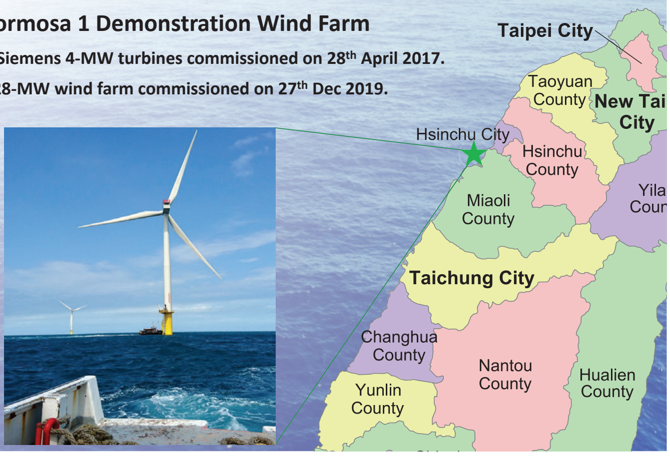
ZD

- Offshore Zonal Development (區塊開發)
  - Pipeline and Sustainability
  - Strategic Environmental Assessment (SEA)

Phase 1: DIP - Formosa I

Formosa 1 Demonstration Wind Farm

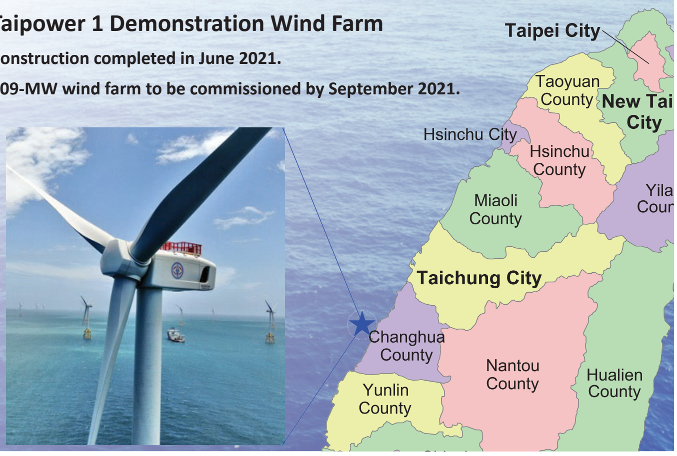
- **2 Siemens 4-MW turbines commissioned on 28th April 2017.**
- **128-MW wind farm commissioned on 27th Dec 2019.**



Phase 1: DIP - Taipower I

Taipower 1 Demonstration Wind Farm

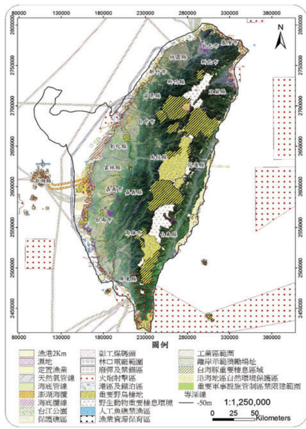
- **Construction completed in June 2021.**
- **109-MW wind farm to be commissioned by September 2021.**



Phase 1: DIP - International Attention & Cooperation

Phase 2: ZAP - Strategic Environmental Assessment

- 34 items of evaluation in 8 categories
  - Environmental Assimilative Capacity
  - Natural Ecology and Landscape
  - Civil Health and Safety
  - Utilization of Land Resources
  - Water Resource System and Its Usage
  - Cultural Heritage
  - International Environmental Agreements
  - Social Economy
- Consultation Meetings
  - SEA Report approved by EPA on 1st May 2017
  - 36 ZoP were then reduced or adjusted based on the results of SEA consultation.



Phase 2: ZAP - Grid Allocation

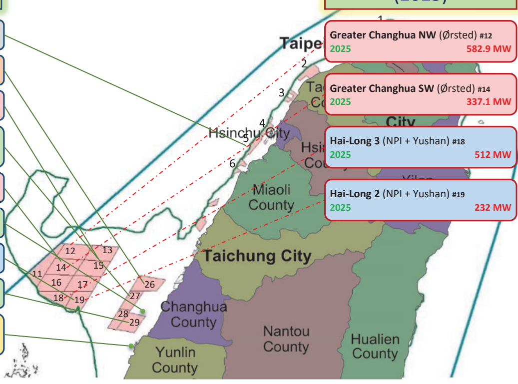
Selection
3,836 MW
(2020 ~ 2024)

Total 5.5 GW

Auction
1,664 MW
(2025)

Selection project	Year	Capacity
Formosa II (Swancor + Macquarie+JERA) #5-6	2020	378 MW
Taipower Phase II #26	2024	300 MW
Greater Changhua SE (Ørsted) #15	2021	605.2 MW
Chang-Fang (CIP) #27	2021	100 MW
	2023	452 MW
Greater Changhua SW (Ørsted) #14	2021	294.8 MW
Xi-Dao (CIP)	2024	48 MW
Hai-Long 2 (NPI + Yushan) #19	2024	300 MW
Chung-Neng (CSC+CIP) #29	2024	300 MW
Yun-Neng (wpd)	2020	360 MW
	2021	348 MW

Auction project	Year	Capacity
Greater Changhua NW (Ørsted) #12	2025	582.9 MW
Greater Changhua SW (Ørsted) #14	2025	337.1 MW
Hai-Long 3 (NPI + Yushan) #18	2025	512 MW
Hai-Long 2 (NPI + Yushan) #19	2025	232 MW



Phase 2: ZAP - Inter-ministerial Negotiation

Executive Yuan (cabinet)
Office of Energy and Carbon Reduction (OECR)
Inter-ministerial negotiation

- **Environmental Protection Administration** (EPA) — Environmental Impact Assessment
- **Ministry of Interior** (MOI) Construction and Planning Agency (CPA) — Permission of the Coast
- **Ministry of Interior** (MOI) Dept. of Land Administration — Permission of Sea Cables
- **Ministry of National Defense** (MND) — Military Restricted Area
- **Ministry of Finance** (MOF) National Property Administration (NPA) — Land Lease
- **Ministry of Culture** (MOC) Bureau of Cultural Heritage (BOCH) — Underwater Heritage
- **Ministry of Transportation and Communications** (MOTC) Maritime Port Bureau (MPB) — Ship and Navigational Safety

Ministry of Economic Affairs (MOEA)
Single Service Window for Wind Power
- Keep tracks of administrative progress
- Eliminate obstacles of application

Phase 2: ZAP - Infrastructure

Ports & Grids

Assembly quayside

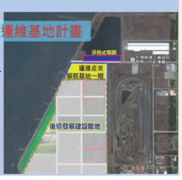
- Quay 2, 5A, 5B & 36 of Taichung Harbor are reserved for dedicated use.

Foundation quayside

- "Industrial Innovation Park of Marine Technology" of Hsinda Harbor.

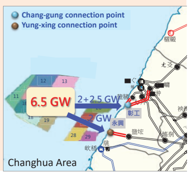
O&M quayside

- Changhua County Government is constructing O&M quays in Changhua Fishery Port (in the vicinity of Changhua Industrial Park).

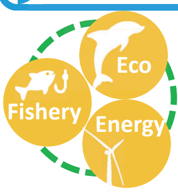


Grid enhancement

- 10.7 GW reserved for 2025
  - Existing: 3.5 GW
  - Chuanghua: 6.5 GW
  - Taoyuan: 640 MW



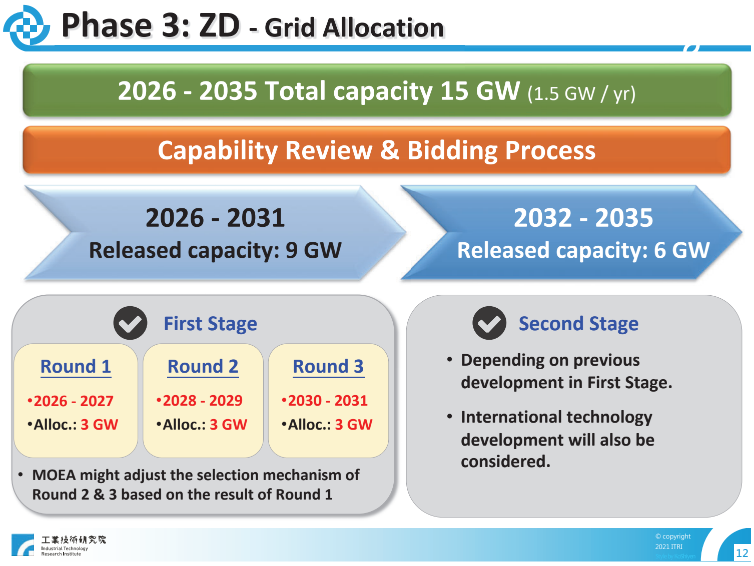
Phase 3: ZD - Eco-coexistence

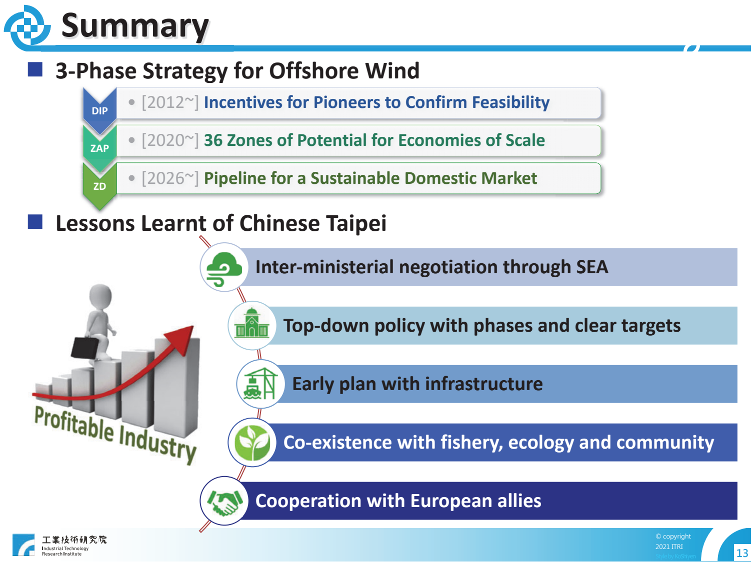


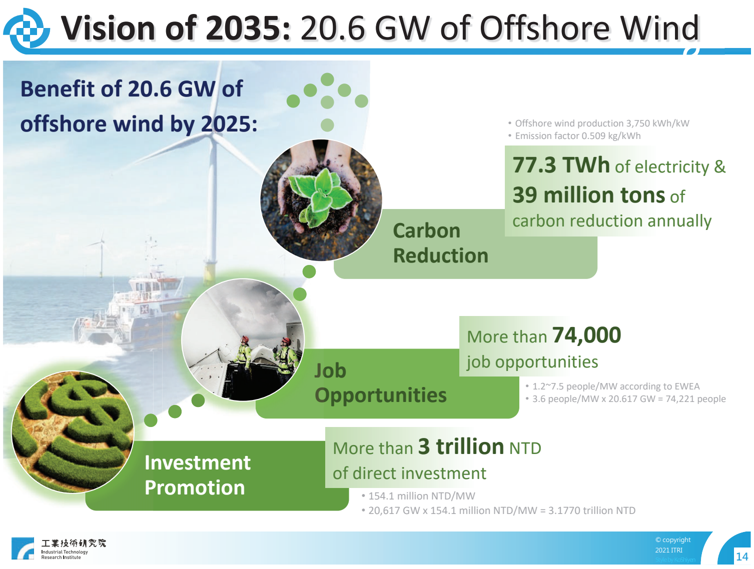
Pre-development
EIA
Stakeholders
(e.g. Fishery group, NGO)
SEA · Communication

Construction
Environmental Monitoring
Mitigation Measures
Key Issues · Supervision

Operation
Co-existence
Sustainability
Cooperation · MPA





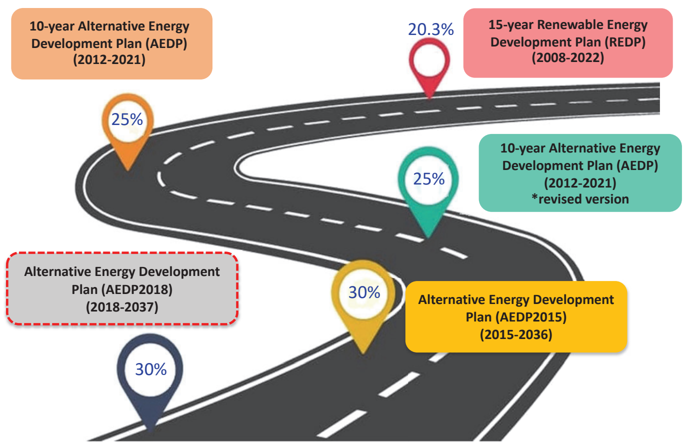


Solar Power in the APEC region

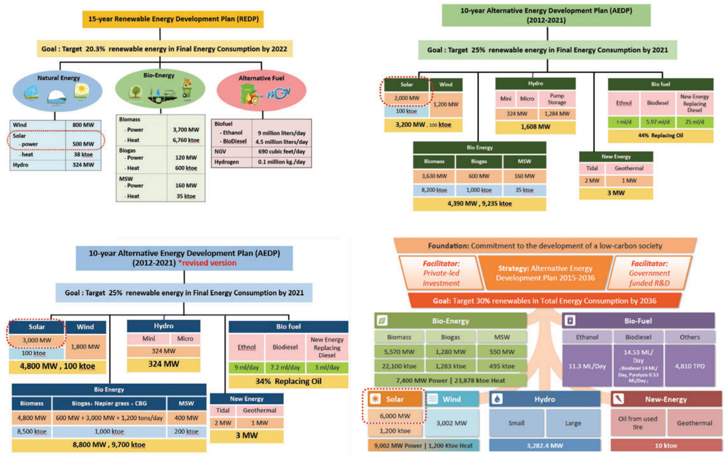
Outlines

- The history of RE roadmap in Thailand
- Solar PV policy : Status Update
- Supporting schemes and Opportunities
- Thailand Key Activities to Carbon Neutrality

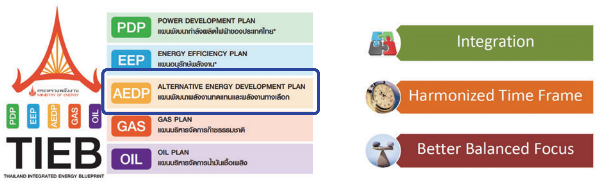
The history of RE roadmap



Solar power target in RE master plans



The current masterplan : TIEB / AEDP2018



Alternative Energy Development Plan (AEDP2018) (2018-2037)

Goal : Target 30% renewable energy in Final Energy Consumption by 2037

Electricity	Target (MW)
MSW	900
Industrial waste	75
Biomass	5,790
Biogas (waste water/waste)	565
Small hydro	308
Large Hydro	2,920
Biogas (energy crop)	1,000
Wind	2,989
Solar	12,139
Floating Solar	2,725
Total	29,411

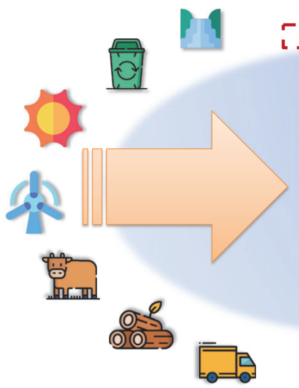
Heat	Target (ktoe)
MSW	495
Biomass	23,000
Biogass	1,283
Solar	100
Biomethane	2,023
Total	26,901

Biofuel	Target	
	Ml/day	ktoe
Ethanol	7.50	1,396
Biodiesel	8.00	2,517
Pyrolysis	0.53	171
Total	16.03	4,085

National Energy Plan's direction

- Increase electricity generation from renewable sources for more than half of total production for the new power plants
- Shift the energy consumption in transportation sector to Green Energy according to the "EV 30@30 Policy"
- Enhance energy performance for more than 30% by accelerate the advance energy technology and innovation
- Restructure energy business/energy regulatory to be in line with 4D1E policy in order to cope with energy transition.

Solar PV policy : Status Update

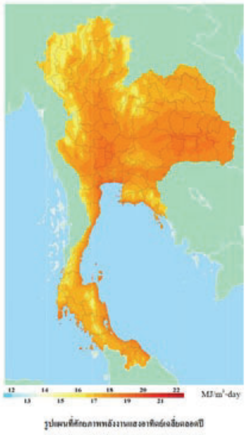


RE	Current status	Target by 2037
Electricity (MW)		
1. Solar	2,983	12,139
2. Wind	1,103	2,989
3. Small Hydropower	188	308
4. Biomass	3,410	5,790
5. Biogas	260	1,565
6. Waste to Energy	315	975
7. Large Hydropower	2,920	2,920
8. Floating Solar		2,725
Total (MW)	11,369	29,411
Heat (ktoe)		
1. Solar	10	100
2. Biomass	7,770	23,000
3. Biogas	634	1,283
4. Biomethane	-	2,023
5. Waste to Energy	111	495
Total (ktoe)	8,525	26,901
Biofuels (million liters/day)		
1. Ethanol	4.45	7.50 (1,396 ktoe)
2. Biodiesel	4.90	8.00 (2,517 ktoe)
% share of RE	16.4%	30%

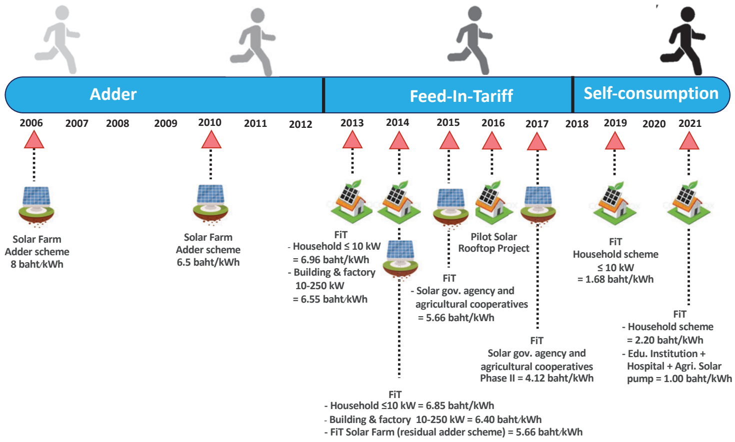
Solar potential

The latest Solar map ver.2017

- Average solar irradiance 17.6 MJ/m²-day
- Maximum : 18-20 MJ/m²-d
- Solar map developed by DEDE using satellite images and ground station measurement (38 Stations)



Milestones of Solar Energy



Current schemes implementation

Household Solar rooftop scheme

To reduce electricity bill in household sector

- Target = 50 kWp of each years
- Installed capacity < 10 kWp
- Power purchasing rate = 2.20 THB
- Purchasing period for 10 years

Solar rooftop Scheme for Edu. Institution / Hospital / Solar pump for agriculture

To reduce electricity Bill

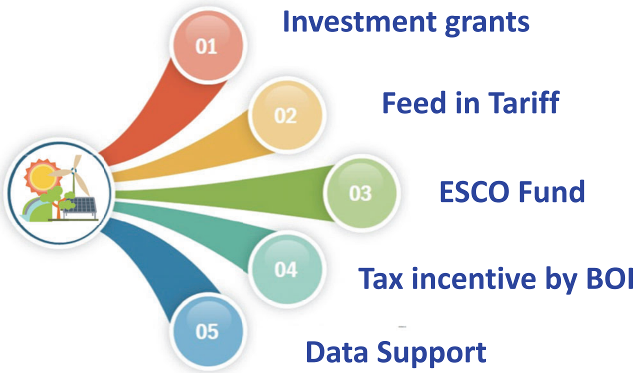
Educational institution

Hospital

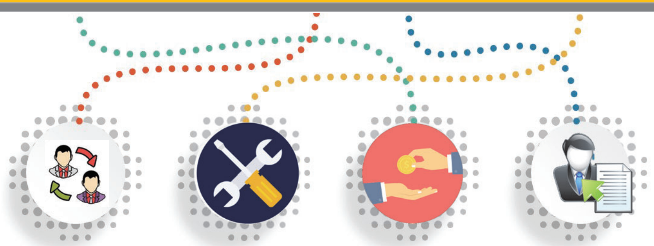
Solar pump for agriculture

- Target = 50 kWp for 1st year
- Installation cap. between 10 kWp to 200 kWp
- Power purchasing rate = 1.00 THB
- Purchasing period for 10 years

Supporting measures



Opportunities



Solar PV market in Thailand is still very active

More opportunities for PV self-consumption and as tool for energy efficiency

Still-strong support from BOI for PV supply chain

Innovative technologies will be a key in solar PV industry

Thailand Key Activities to Carbon Neutrality

Energy and Transportation Sector	#1: Increase power generation from RE and low carbon fuel #2: Increase share of domestic use EV
Waste management Sector	#3: Zero waste to landfill according to BCG Model
Industrial process and product use sector	#4: Use of low carbon products and services
Agricultural Sector	#5: Moving toward zero burning and smart farming through BCG Model and digital technology
Forest and land use sector	#6: Capture, storage, utilize and hydrogen technology

Thank you for your attention

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

Charuwan Phipatana-phuttapanta
Solar Energy Development Division

Visit us at : http://www.dede.go.th

Geothermal Power in the APEC region

MINISTRY OF ENERGY & MINERAL RESOURCES
REPUBLIC OF INDONESIA

Geothermal Power Development in Indonesia

Harris
Director of Geothermal

APEC Symposium on the Holistic Approach of Decarbonization towards Carbon Neutrality

30th August 2021

Energy Sector Commitment On Net Zero Emission

UNFCCC - COP21, December 2015

Leaders Summit on Climate, 22 April 2021

National Commitments 2021-2030:

A. The mandate of Law No. 16/2016 on Ratification of the Paris Agreement: **reducing GHG emissions by 29%** (self-effort) or **41%** (with international assistance) by 2030 according to NDC;

B. The energy sector reduces GHG by **314–398 million tons of CO2** in 2030, through **the development of renewable energy, implementation of energy efficiency, energy conservation, as well as the application of clean energy technology**.

National Commitments 2021-2050

A. Implement concrete actions on climate change through a moratorium on forest and peat land conversion to reduce forest fires by 82%;

B. Encouraging **green development** through the development of a **Green Industrial Park** covering an area of 12,500 hectares in North Kalimantan;

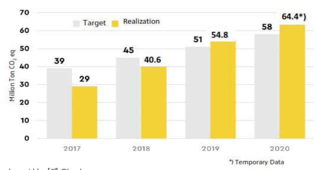
C. Unlock investment in the energy transition through **the development of biofuels, lithium battery industry, and electric vehicles.**

Indonesia's NDC & RE Development Target

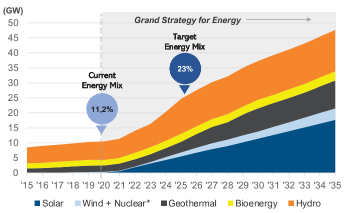
No	Sector	GHG Emission 2010 (Million Ton CO_2e)	GHG Emission in 2030 (Million Ton CO_2e)			Reduction (Million Ton CO_2e)	
			BaU	CM1	CM2	CM1	CM2
1	Energy	453.2	1,669	1,335	1,271	314	398
2	Waste	88	296	285	270	11	26
3	IPPU	36	69.6	66.85	66.35	2.75	3.25
4	Agriculture	110.5	119.66	110.39	115.86	9	4
5	Forest	647	714	217	64	497	650
	Total	**1,334**	**2,869**	**2,034**	**1,787**	**834**	**1,081**

38%

Scenario Notes:
CM1: self effort
CM2: Had international assistance
CM: Counter Measure



*) Temporary Data



Currently, Indonesia is developing a **Long Term Strategy towards Carbon Neutrality** where Indonesia's energy **demand will peak at 2040** and reach **Net Zero in 2060** (or sooner with International assistance).

Energy Transition Towards NZE

Fossil Fuel

Renewable Energy

Availability, Accessibility, Affordability, Sustainability & Competitiveness

Fossil Fuel + Clean Technology (CCT, CCUS) + Net Sink

Green Energy

NRE Acceleration:
- Primary Energy Substitution (Biofuels, Cofiring, RDF/SRF)
- Fossil Energy Conversion.
- Additional Capacity of NRE Power Plant, focus on Solar PV.
  - **Hydro** (incl. pumped storage)
  - **Wind** (on-shore and off-shore)
  - **Biomass & Waste**
  - **Geothermal** (Gov't Drilling, small-scale)
  - **Ocean Energy**
- Non-Electricity / Non-Biofuels (Briquette, Biogas, CBG).

+

- **Electric Vehicle**
- **Nuclear** (incl. SMR's)
- **Battery**
- **Hydrogen**

+

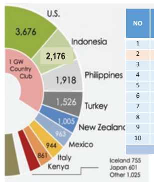
Smart Energy, Smart Grid, Energy Conservation

- Energy Independence
- Energy Security
- Sustainable Development
- Low Carbon & Climate Resilience

Geothermal Power Potential

No	Island	Number of Location	Resource (MW)					Total	Installed Capasity (MW)
			Spekulatif	Hipotetis	Reserve				
					Possible	Probable	Proven		
1	Sumatera	101	2,276	1,551	3,594	976	1,120	9,517	789.4
2	Jawa	75	1,259	1,191	3,403	377	1,820	8,050	1.253.8
3	Bali	6	70	21	104	110	30	335	0
4	Nusa Tenggara	34	225	148	892	121	12,5	1,398,5	12.5
5	Kalimantan	14	151	18	6	0	0	175	0
6	Sulawesi	91	1,365	343	1,063	180	120	3,071	120
7	Maluku	33	560	91	485	6	2	1,144	0
8	Papua	3	75	0	0	0	0	75	0
	Total	357	5,891	3,363	9,547	1,770	3,014.5	23,765.5	2,175.7
					14.421,5				
			23,765.5						

Indonesia's National Standard 60 09:2017
Geological Agency MEMR, 2020



NO	COUNTRY	RESOURCES (MW)	INSTALLED CAPACITY (MW)
1	United States	30,000	3,676
2	Indonesia	23,765.5	2,175.7
3	Philippines	4,000	1,918
4	Turkey	4,500	1,526
5	New Zealand	3,650	1,005
6	Mexico	4,600	963
7	Italy	3,270	944
8	Kenya	15,000	861
9	Iceland	5,800	755
10	Japan	23,400	601
	TOTAL	118,185.5	15,390.7

* Other countries development: **1025 MW**

Source: ThinGeoEnergy, 2020 with Modification

1. Indonesia is blessed with enormous geothermal resources (23.76 GW)
2. Most of the power plants are still focused on Java-Bali system (70% of total generators).
3. PLN's electricity system is currently over-supplied. Covid-19 pandemic reduces the electricity demand significantly from the projection as estimated in RUEN and the previous RUPTL 2019-2028.

Note:
Additional 45 MW geothermal capacity of Sorik Marapi Unit 2 is installed on July 28th, 2021

Main Challenges

Some of geothermal **prospect areas** are located in **Conservation Area & Global Heritages Area**

Geothermal business is considered high risk, causing not all financial institutions are interested in providing funding primarily before feasibility study

Cost Efficiency to achieve competitive geothermal tariff

Social Issues occur in some geothermal plants & nearby

The abundant resources in some areas meet **low demand of electricity**

In case of Java-Bali system, the electricity supply is over

Indonesia's Regulatory Framework for Geothermal Development

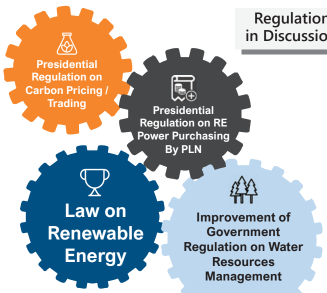
1 Law
- Law No.30/2007 on Energy
- Law No.21/2014 on Geothermal
- Law No.11/2020 on Job Creation

2 Government Regulation (GR)
- GR 79/2014 on National Energy Policy
- GR 7/2007 on Geothermal for Indirect Use
- GR 28/2016 on Amount and Procedure for Geothermal Production Bonuses
- GR 5/2021 on Risk-based Licensing
- GR 22/2021 & GR 23/2021 on Environment & Forestry management

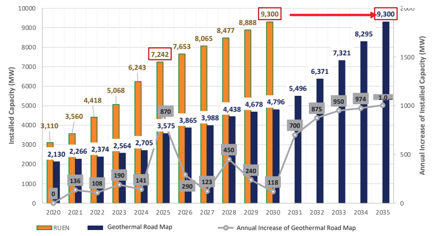
3 Presidential Regulation (PR)
- PR 56/2018 jo. 3/2016 on Acceleration of National Strategic Projects
- PR 14/2017 jo 4/2016 on Acceleration of Electricity Infrastructure Development
- PR 22 / 2017 on General Plan of National Energy

4 MEMR Regulation

Regulations in Discussion



Geothermal Development Program 2020-2035



*The road map is adjusted in RUPTL discussion in order to consider the effect of Covid-19 pandemic to electricity demand

GHG Mitigation from Geothermal Projects (Million Ton CO2e/year)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Annual Increase	0,00	0.91	0.72	1.27	0.94	5.83	1.94	0.82	3.02	1.61	0.79	4.69	5.86	6.37	6.53	6.73
Cumulative Mitigation	14.27	15.18	15.91	17.18	18.12	23.95	25.90	26.72	29.74	31.35	32.14	36.83	42.69	49.06	55.58	62.32

1. ***Government Drilling***:
   - In order to improve the quality of data before an area is offered to a business entity, MEMR through c.q Geological Agency will conduct geothermal exploration drilling in 20 WKP with a development plan of 683 MW.
   - Collaboration with MoF by assigning 2 WKP to PT SMI with a 60 MW development plan.
2. **Providing Funding Access: PISP** (Pembiayaan Infrastruktur Sektor Panas Bumi) and **GREM** (*Geothermal Resource Risk Mitigation*) to support the development of geothermal projects in Indonesia
3. **SOE synergy** on geothermal development:
   - Joint development between PT PLN (Persero) and PT Geo Dipa Energi (Persero) for Candradimuka field with a 40 MW development plan.
   - Joint development between PT PLN (Persero) and PT Pertamina for several WKP with a development plan of approximately 100 MW.
4. **Optimalization of resources** in productive WKP by developing expansion and small-scale power plants (Salak Binary 15 MW, Dieng Small Scale 10 MW, etc.).

Geothermal Funding & Incentives in Indonesia

Geothermal Infrastructure Funding Schemes:

1. Private Development
2. State Owned Companies
3. Joint Operation Contract – State Owned & Private Companies
4. State Budget
   Support funding facilities

Funding / Facility for Geothermal:
- PISP (Geothermal Sector Infrastructure Financing)
- GEUDP (Geothermal Exploration Upstream Development Project)
- GREM (Geothermal Resource Risk Mitigation)

Other Funding / Facilities:
SDG Indonesia One and Subsidized Loans through PT SMI
Green Bond /Sukuk

Incentives

Fiscal Incentives for Geothermal projects:
- **Tax Allowance (or) – MoF Decree 96/2020**
  - 30% Reduction of Income Tax for 6 years for the minimum investment of 100 billions rupiahs
  - Accelerated amortization
- **Tax Holiday – MoF Decree 130/2020**
  Income tax relief in the initial project deployment, duration depends on the amount of investment (min. 550 Billion Rupiahs)
- **Import Duty Facilitation – Mof Decree 218/2019**
  Import duty tax relief for 2 year project deployment
- **Land & Building Tax – MoF Decree 172/2016**
  Land & building tax relief up to 100% during exploration stage
- **Exploration by the Government**
  Reduction of exploration risks in the potential areas before offering to the developers, in order to increase the tariff competitiveness

Government Geothermal Exploration Program 2020-2024

Resource classification according to Indonesia National Standard Number 6009 of 2017

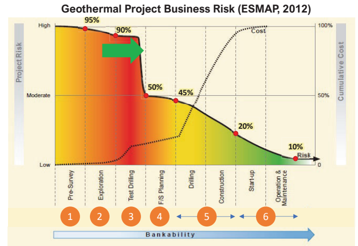
RESOURCES CLASSIFICATION				
SPECULATIVE	HYPOTHETIC	RESERVES		
		POSSIBLE	PROBABLE	PROVEN
Geology & geochemistry	Geology, Geochemstry and geophysics (3G)	3G and / or temperature gradient	3G and / or temperature gradient and ≥ 1 exploration well	3G and / or temperature gradient and ≥ 3 exploration well

Detailed resource data

GOVERNMENT GEOTHERMAL EXPLORATION PROGRAM

✓ In accordance with SNI 6009/2017 exploration drilling is required to **improve reserves classification from possible reserves to probable reserves** by obtaining the following data and information:
- **Confirmation of the conceptual model of the geothermal system by drilling through clay cap until reaching reservoir zone.**
- **Direct measurement of reservoir temperature.**
- **Direct measurement of reservoir fluid and / or production test data.**

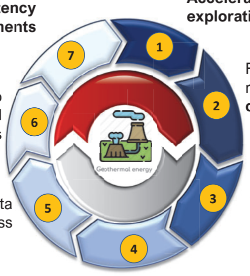
Geothermal Project Business Risk (ESMAP, 2012)



"The **exploration/test-drilling phase can be considered as the riskiest parts** of geothermal project. It needs **much more capital investment** while still **fraught with uncertainty**." (ESMAP, 2012)

Therefore, **Government will carefully face this riskiest parts** in order to **reduce the uncertainty and the business risk**, while in the same time **increase the competitiveness** of geothermal projects.

Government Efforts



Personnel **competency developments**

Acceleration on government exploration drilling execution

Facilitating with other ministries related **the water utilization in conservation forest** areas

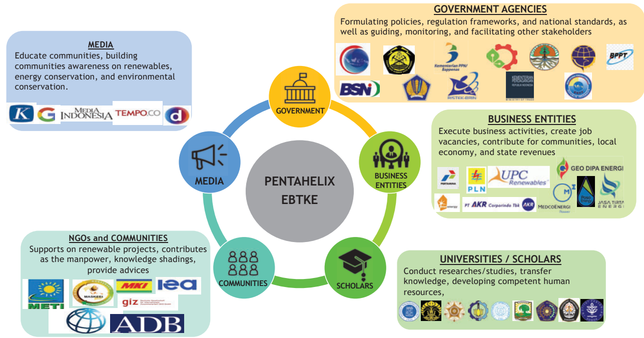
Completing **regulation frameworks for direct-use** applications

Knowledge sharing, public discussions and public hearings to **mitigate social issues**

Providing better geothermal data and information access

Collaborating with other ministries to **provide incentives and financial supports** for geothermal projects

Collaboration Opportunities



Closing

1. Indonesia is committed to achieve 23% renewable penetration on the National Energy Mix by 25% and to achieve 29-41% GHG reduction by 2030. Diversification among energy sources (including among renewables) is very important to maintain energy security.
2. The regulation frameworks in geothermal industry is relatively comprehensive. However, Government continues to develop further policies to follow the latest energy sector condition and support geothermal development projects.
3. All stakeholders in geothermal industry must collaborate to increase the competitiveness of geothermal projects.

Goal 7:
Ensure access to affordable, reliable, sustainable and modern energy for all.

Thank You

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Grid Infrastructure in Indonesia

Directorate General of Electricity
Ministry of Energy and Mineral Resources
Republic of Indonesia

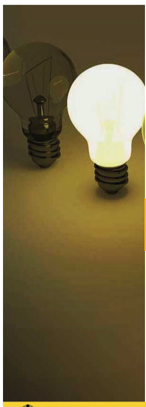
Grid Infrastructure in Indonesia

Rida Mulyana
Director General of Electricity

Ministry Energy and Mineral Resources

Jakarta, 30 August 2021

OUTLINE



1 Electricity Policy

MANAGEMENT OF ELECTRICITY SUPPLY IN INDONESIA

(Law No. 30/2009 on Electricity & Law No. 11/2020 on Job Creation)

AUTHORIZATION

STATE

GOVERNMENT
REGIONAL GOVERNMENT

- Regulation, policy, standard
- RUKN, RUKD, IUPTL, Op. License, Tariff, and Business Area
- Provides funding for:
  - Low income society
  - Development of electricity supply infrastructure in undeveloped regions
  - Development of electricity in remote and border areas
  - Development of rural electricity

BUSINESS

ELECTRICITY BUSINESS LICENSE HOLDER (IUPTL)

STATE-OWNED ENTERPRISE* | REGION-OWNED ENTERPRISE** | PRIVATE ENTITIES** | COOPERATIVES** | SELF-RELIANT COMMUNITIES**

* : First Priority ; ** : Given the opportunity as integrated electricity business license organizer for not electrified areas

Article 11 of Law 30/2009 in conjunction with Law 11/2020 on Job Creation

1. The electricity supply business for public can be performed by State-Owned Enterprises (SOEs), Regional-Owned Enterprises (ROEs), Private Enterprises, Cooperatives and Non-Government Organizations (NGO).
2. State-owned enterprises as referred in article (1) is given the first priority to execute the electricity supply business for the public

Article 3 President Decree No. 4/2016 on Acceleration of Electricity Infrastructure Development

1. The government has assigned PT PLN (Persero) to carry out the acceleration of electricity infrastructure
2. Supervision for the implementation of acceleration of electricity infrastructure by PT PLN (Persero) as referred in article (1) is conducted by the minister in energy and mineral resources sector.

5 K OF ELECTRICITY

In the electricity sector, Government of Indonesia defined our policy in a term called "5K of Electricity".

1 **SUFFICIENCY** (Kecukupan)
Implementation of National Electricity Demand and Planning

2 **RELIABILITY** (Keandalan)
Utilization of technology (sensors) in power plants for efficiency

3 **SUSTAINABILITY** (Keberlanjutan)
Use of EBT / Installation of PLTS in Power Plants

4 **AFFORDABILITY** (Keterjangkauan)
Striving for competitive electricity prices, so that community rates are affordable

5 **EQUALITY** (Keadilan)
Equitable access to electricity is manifested in an increase in the electrification ratio for household

POLICY DIRECTION FOR ELECTRICITY SUPPLY DEVELOPMENT

GUARANTEE THE AVAILABILITY OF ELECTRICITY

SUFFICIENT | GOOD QUALITY | AFFORDABLE PRICE

GENERATION
- **Minimum share of RE 23% by 2025.**
- Diesel generation is only for emergency and temporary power supplies such as crisis areas.
- GTPP/CC/GE/CCGE platform.
- CFPP uses Clean Coal Technology (CCT).
- Utilization of local primary energy sources.
- The use of nuclear energy is in line with National Energy Policy (KEN).

TRANSMISSION
- Dispatching electricity to business and industrial centers (Special Economic Zones, Tourism and Industrial Zones).
- HVDC transmission for long distance power evacuation (point to point / inter-island).

SUBSTATION
- At least 1 substation for each district/city.
- The addition transformer of the substation if the load capacity of transformer has reached about 70%.
- Development of Gas Insulated Switchgear (GIS) for limited land.
- Reducing losses and rehabilitation of old network.

RURAL ELECTRICITY AND SMART GRID
- Expansion of access to electricity in remote and scattered areas.
- In 2020 smart grids is began to be implemented in Java-Bali.

Source: National Electricity Master Plan 2019 - 2038

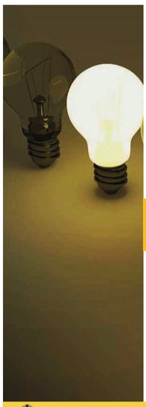
INDONESIAN GOVERNMENT COMMITMENT

UNFCCC – COP 21, December 2015

Leaders Summit on Climate, 22 April 2021

National Commitments
- ❑ The Mandat of Law No 16/2016 on Ratification of Paris *Agreement* : Reducing GHG emissions by 29% (self-effort) or 41% (with international assistance) by 2030 according to NDC
- ❑ The energy sector reduces GHG emissions by 314 - 398 million tons of CO_2 by 2030, through the development of renewable energy, the application of energy conservation, clean energy technology, fuel switching and post-mining reclamation

National Commitment
- ❑ Implement concrete actions on climate change through a moratorium on forest and peat land conservation to reduce forest fires by 82%
- ❑ Encouraging green development through the development of a Green Industrial Park covering an area of 12.500 hectares in North Kalimantan
- ❑ Unlock investment in the energy transition through **the development of biofuels, lithium battery industry, and electric vehicles**

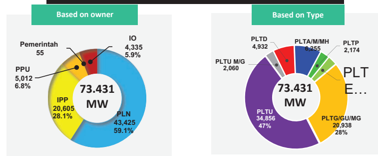


2

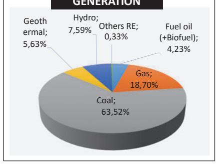
Status of National Electricity

STATUS OF NATIONAL ELECTRICITY (STATUS OF JUNE 2021)

INSTALLED CAPACITY OF NATIONAL POWER GENERATION



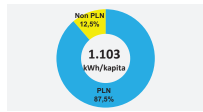
ENERGY MIX OF PLN'S POWER GENERATION



TRANSMISSION AND DISTRIBUTION

Transmission	62.440 kms
Substation	151.698 MVA
Distribution	1.013.217 kms
Distribution Substation	62.345.606 MVA

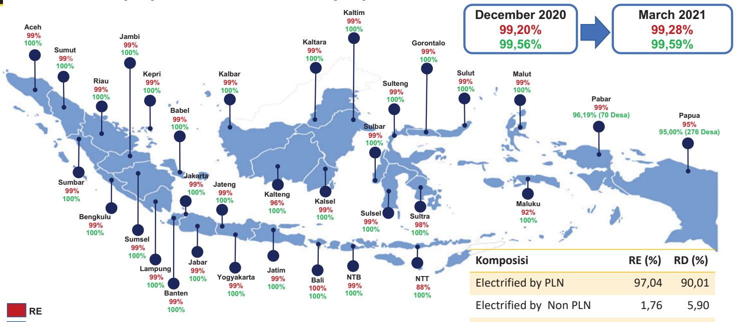
NATIONAL ELECTRICITY CONSUMPTION



- IPP: *Independent Power Producer*
- PPU (Private Power Utility) is a holder of a business area other than PLN
- IO non BBM is the holder of an Operating Permit with a generator that uses fuel other than BBM

HOUSEHOLD (RE) AND RURAL AREAS (RD) ELECTRIFICATION RATIO

December 2020	March 2021
99,20%	99,28%
99,56%	99,59%

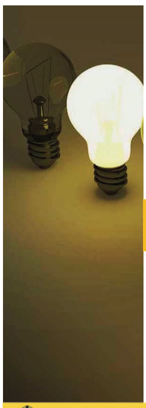


Household not yet electrified : 542.124 RT
Villages not yet electrified : 346 villages

Komposisi	RE (%)	RD (%)
Electrified by PLN	97,04	90,01
Electrified by Non PLN	1,76	5,90
Electrified by LTSHE	0,48	3,68
Not yet electrified	0,72	0,41

CHALLENGES IN THE ELECTRICITY UTILITY SECTOR

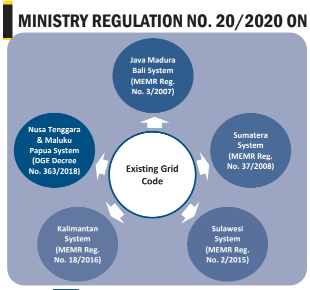
- Energy Transition Plan And Roadmap Implementation To Achieve Net Zero Emission 2060
- High Penetration & Integration Of Variable Renewable Energy
- **Grid Modernization Through Smart Grid Implementation & Distributed Energy Resource Implementation**
- Market Development & Investment In The Renewable Energy, Grid Modernization And Electric Mobility Transformation Through Electric Vehicle
- Subsidy Realocation



4

Grid Codes Development For Renewable Energy Integration

MINISTRY REGULATION NO. 20/2020 ON POWER SYSTEM GRID RULES (GRID CODE)



Regulation haven't been accomodated in MEMR Reg. on Grid Code

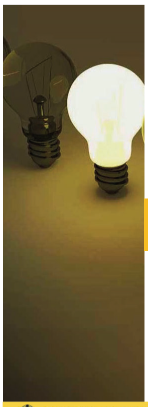
- MEMR Reg. No. 01/2015 **(power wheeling)**
- MEMR Reg. No. 01/2017 **(parallel operation)**
- MEMR Reg. No. 19/2017 ***(excess power)***
- MEMR Reg. No. 50/2017 jo. MEMR Reg. No. 53/2018 **(RE generation)**

IMPROVEMENT & SIMPLIFICATION

MEMR Regulation No. 20/2020 on Power System Grid Rules (Grid Code)

REVISION BACKGROUND

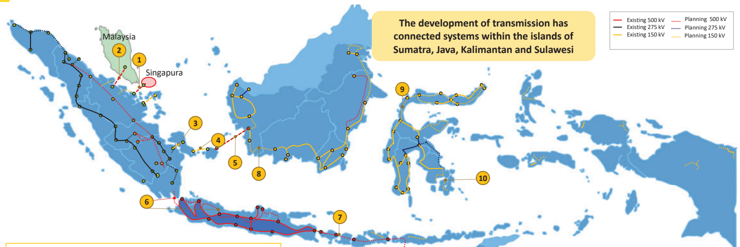
- Updates on regulatory developments
- Encouraging the use of New Renewable Energy (NRE) power plants, specifically intermittent in an electric power system while maintaining system reliability
- The enforcements of electric power system network rules (grid code) by all users
- Investigation of non-compliance by network users impacting system reliability
- Update on the technology related to the operational pattern and the stabilization of power supply system with good quality and reliability
- Merging the power system network rules to 1 (one) rule governing all existing electrical system



5

Smart Grid in Indonesia

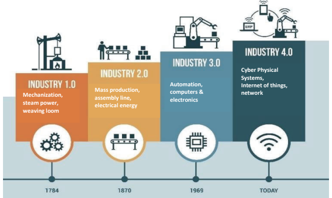
Transmission and Interconnection Development

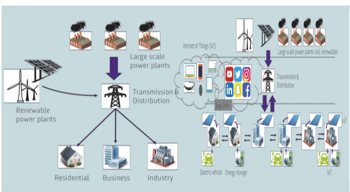


1. Sumatra-Singapore interconnection (including Sumatra-Bintan interconnection), supports the APG cooperation framework, further studies are needed;
2. 500 kV Sumatra-Malaysia Interconnection (2030), supporting the APG cooperation framework;
3. 150 kV Sumatra-Bangka Interconnection (2022);
4. 150 kV Bangka-Belitung Interconnection (included in DRUPTL narrative, further study required);
5. Belitung-Kalimantan interconnection (included in the DRUPTL narrative, further study is needed as part of the Nusantara Supergrid program);
6. 500 kV Sumatra-Java Interconnection (included in the DRUPTL narrative, further study is needed because it considers supply and demand);
7. 150 kV Bali-Lombok Interconnection (included in the DRUPTL narrative, further studies are needed to support the Java-Nusa Tenggara interconnection plan)
8. 150 kV Kalimantan Interconnect (2023)
9. 150 kV Sulbagut-Sulbagsel Interconnection (Tambu-Bangkir COD 2027, proposed DJK 2024 adjusted for Tambu-Tawaeli section)
10. 150 kV Baubau-Sulbagsel Interconnection (included in DRUPTL narrative, further study needed)

SMART GRID CONCEPT

Industry 4.0 → Electricity 4.0





- **Prosumer :** Consumer who can generate, store, and sell electricity to providers or fellow consumers, including electricity from rooftop solar PV and battery electric vehicles.
- **Consumer is getting smarter** to utilize electricity as efficient as possible, supported by smart equipment (*smart meters, digital infrastructure*, dan *smart devices*).

SMART GRID DEVELOPMENT IN JAVA AND BALI (2020)

1. Spread Advanced Metering Infrastructure (AMI) to one million customers in Jakarta (Step Early); **(On Going)**
2. Application Digital Substation **(On Going):**
   1) Sepatan II: 4 Line Bay, 1 Bus Couple, 3 Transformer Bay and 20 kV Cubicle,
   2) Teluk Naga II: 2 Line Bay, 1 Bus Couple, 2 Transformer Bay and 20 kV Cubicle;
3. Analysis Prediction on Generator Electricity **(On Going):**
   1) Remote Engineering, Monitoring, Diagnostic & Optimization Centre (REMDOC) phase 2 at PJB,
   2) Reliability Efficiency Optimization Centre (REOC) at Indonesia Power;
4. Blockchain Pilot Project - Phase 1 (PLN Research Institute work same with Chaintope, Japan); **(Still Pending)**
5. Platform e-mobility Electric Vehicle (EV) Charging Station (SPKLU) in three cities.
   *) Ministerial Regulation MEMR No. 13/2020 **(On Going)**

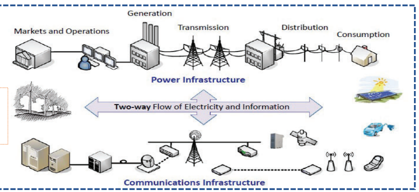
SMART GRID DEVELOPMENT (SMALL SCALE AND CONTROL CENTER)

Pilot Project Smart Grid in Indonesia *(Small Scale)*

1. Smart Grid Project Batam
2. Smart Grid Project Kandur Riau
3. Smart Grid Project Karawang
4. Smart Grid EMS Jakarta
5. Smart Grid Karimunjawa
6. Smart Grid Project Bali
7. Micro Grid Sumba
8. Smart Micro Grid Wini Project
9. Smart Grid Nemberala Project

SMART GRID

Smart Grid
"Integration, Automation and 2-way Communication"

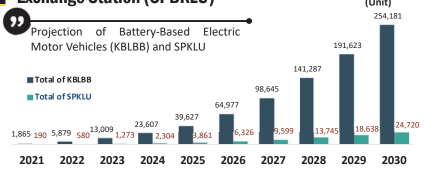


Pilot Project at Control Center

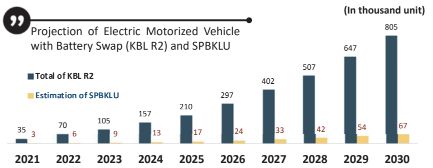
a. Cawang, Jakarta
b. Jawa *Control Center* (JCC) Gandul, P2B, Depok
c. Cirata *Hydro Electric Power Plant* (HEPP) *Smart Control Project*, Jawa Barat
d. *Regional Control Center* (RCC) Cigareleng, Jabar
e. RCC Ungaran, Jawa Tengah
f. RCC Waru, Jawa Timur
g. RCC Bali

Projection of Public Electric Vehicle Charging Station (SPKLU) & Public Electric Vehicle Battery Exchange Station (SPBKLU)

Projection of Battery-Based Electric Motor Vehicles (KBLBB) and SPKLU

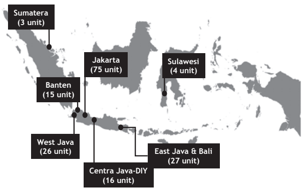


Projection of Electric Motorized Vehicle with Battery Swap (KBL R2) and SPBKLU



Source: PT PLN (Persero)

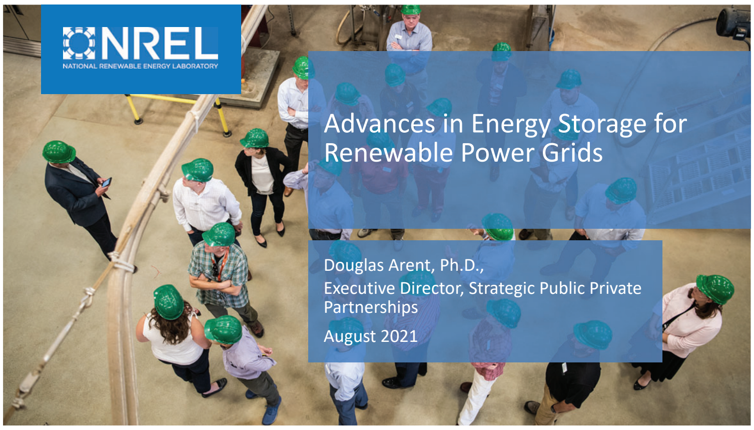
Distribution of SPKLU & Charging Stations in Indonesia

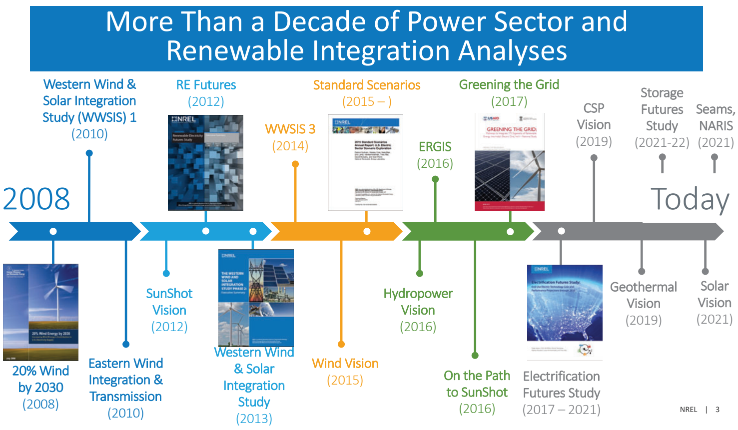


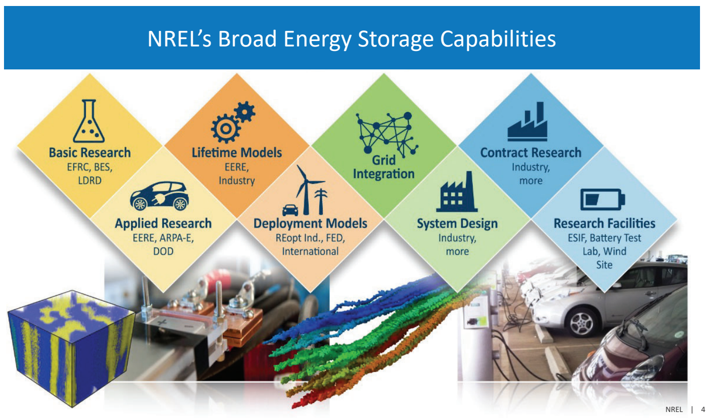
Until July 2021, 166 SPKLU units and Charging Stations have been built in 135 locations at:

- Oil and Gas Station
- Office
- Hotel
- Shopping Centre
- Parking area

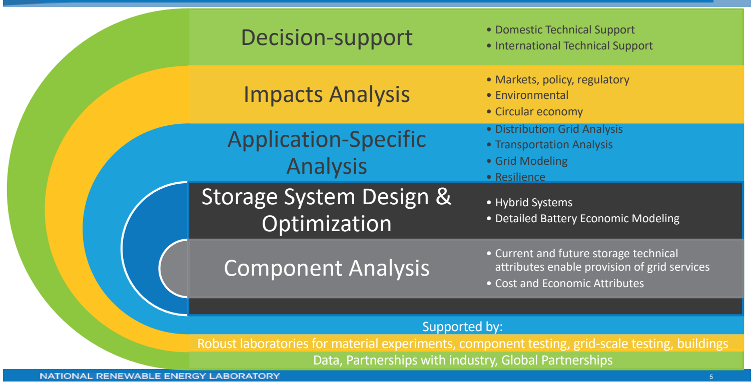
Power Storage

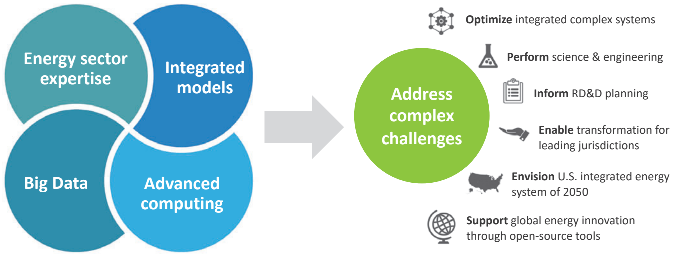






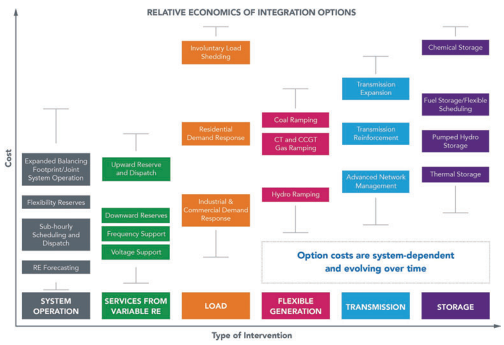
Storage analysis broad areas of research





Accelerate global energy system transformation through comprehensive, rigorous, and scalable computing and analysis
... to inform research, planning, investment, and policy.

Early Studies Identified Strategies to Integrate RE: A Focus on System Flexibility



Flexibility: The ability of a power system to respond to change in demand and supply

The Four Phases of Storage Deployment

Phase	Primary Service	National Potential in Each Phase	Duration	Response Speed
Deployment prior to 2010	Peaking capacity, energy time shifting and operating reserves	23 GW of pumped hydro storage	Mostly 8–12 hr	Varies
1	Operating reserves	<30 GW	<1 hr	Milliseconds to seconds
2	Peaking capacity	30–100 GW, strongly linked to PV deployment	2–6 hr	Minutes
3	Diurnal capacity and energy time shifting	100+ GW. Depends on both on Phase 2 and deployment of variable generation resources	4–12 hr	Minutes
4	Multiday to seasonal capacity and energy time shifting	Zero to more than 250 GW	Days to months	Minutes

While the Phases are roughly sequential there is considerable overlap and uncertainty!

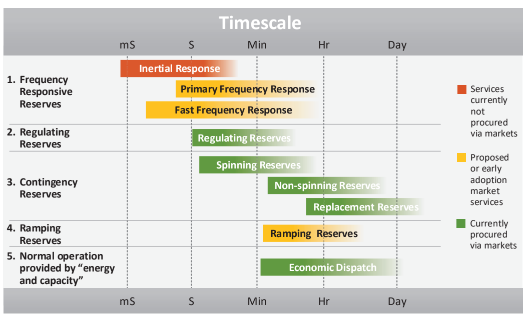
Denholm, Paul, Wesley Cole, A. Will Frazier, Kara Podkaminer, and Nate Blair. 2021. *The Four Phases of Storage Deployment: A Framework for the Expanding Role of Storage in the U.S. Power System*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-77480.

Services

Four Major Categories of Bulk Power System Storage Services

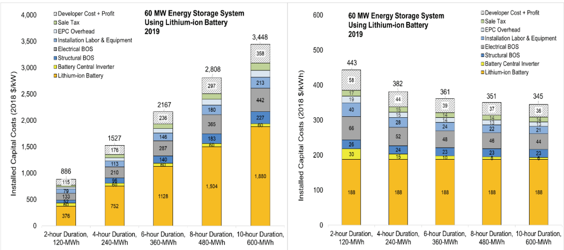
Service	Description
Capacity	Firm capacity
Energy	Energy shifting/dispatch efficiency/avoided curtailment
Transmission	Avoided capacity, congestion relief
Ancillary services	Operating reserves, voltage support

Reserve Types



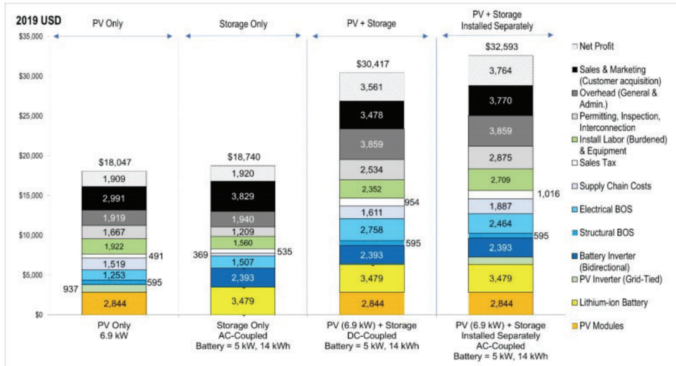
Current Utility-Scale Battery Costs

- Based on methodology used in NREL PV and BESS cost benchmarking study*
- Developed costs for 2/4/6/8/10-hour duration storage using NREL Utility-Scale BESS bottom up cost model
- Note the "2-D" nature of BESS costs, differences between $/kWh (energy) and $/kW (power) basis, at total and component level

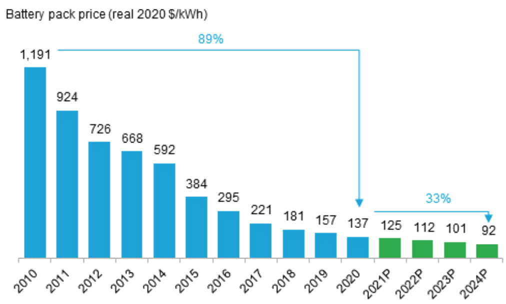


Feldman, David, Vignesh Ramasamy, Ran Fu, Ashwin Ramdas, Jal Desai, and Robert Margolis. 2021. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2020. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-77324. https://www.nrel.gov/docs/fy21osti/77324.pdf.

Current Distributed-Scale Battery Costs



Recent Cost Trends in LIB pack costs



Source: BNEF (2020)

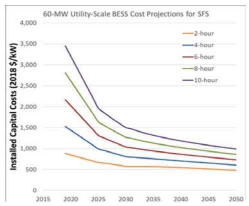
Storage Futures Study

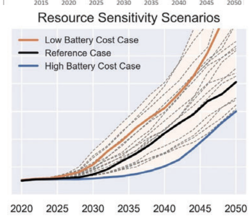
NREL is analyzing the rapidly increasing role of energy storage in the electrical grid through 2050.

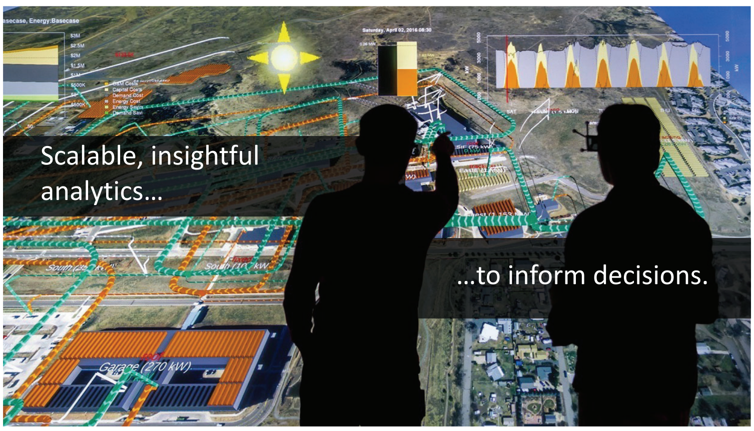
- "Four Phases" - theoretical framework driving storage deployment
- Techno-Economic Analysis of Storage Technologies
- Deep dive on future costs of distributed and grid batteries
- Various cost-driven grid scenarios to 2050
- Distributed PV + storage adoption analysis
- Grid operational modeling of high-levels of storage

One Key Conclusion: Under all scenarios, dramatic growth in grid energy storage is the least cost option.

https://www.nrel.gov/analysis/storage-futures.html







Thank you!

www.nrel.gov
www.nrel.gov/analysis/storage-futures.html
www.21stcenturypower.org
https://greeningthegrid.org/
www.globalpst.org
www.jisea.org
https://cleanenergysolutions.org/

Electricity Security in regards to Clean Energy Transitions

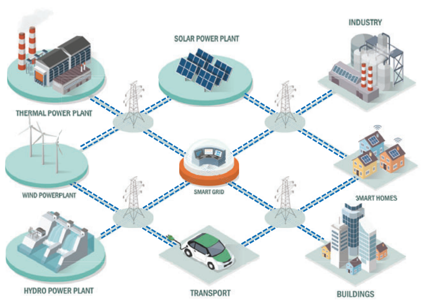
International Energy Agency

Electricity security and clean energy transitions

Randi Kristiansen

31 August 2021

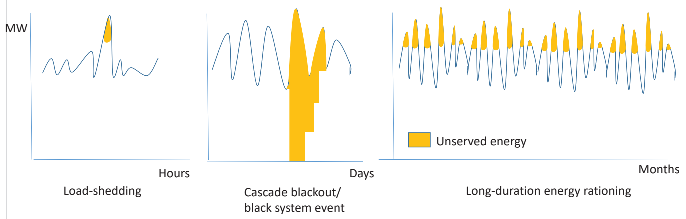
The power sector landscape is changing dramatically



Traditional system
Centralised / dispatchable
High inertia and stability
Central planning
One way flows of energy and communication
Closed networks, few devices

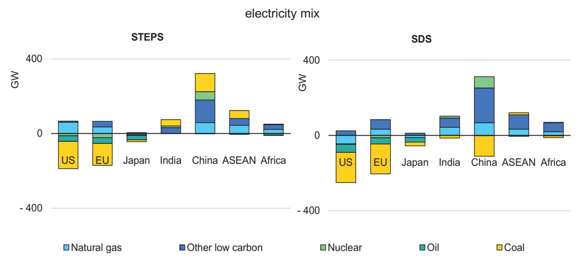
New system
Decentralised / variable generation
Low system inertia from rotating machines
Multiple actors / competitive markets
Two way flows of energy and communication
Open networks and many devices
Changing climate patterns

Under this circumstances is necessary to understand what changes are needed to keep security of supply



Different types of supply interruptions, form duration and depth to long lasting interruptions.

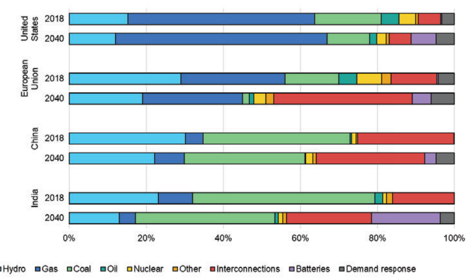
Large amounts of dispatchable capacity, used to balance the system, is being retired in advanced economies



Advanced economies will see a large retirement of fossil fuel dispatchable plants, while low carbon dispatchable sources, like nuclear and hydro, lag behind

Flexibility will increasingly be provided by non-thermal sources

Sources of flexibility by region in STEPS



Thermal power plants continue to provide the bulk of flexibility needs, along with interconnections, but use of batteries and demand-side response is rising fast

Measuring Reliability will require new methods

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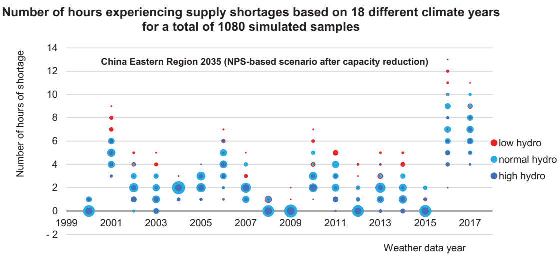
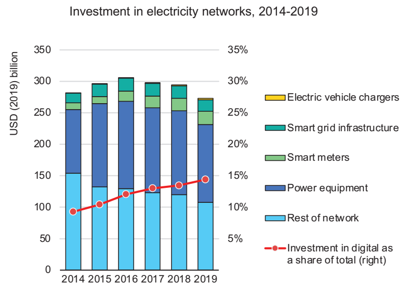
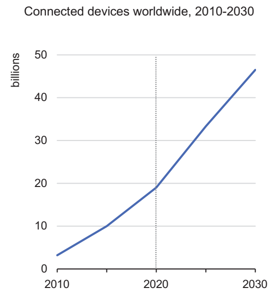


Stochastic methods provide a much more detailed picture of the risks for power systems accounting for weather-dependent factors affecting both demand and supply - and the contribution of different types of resources to adequacy under different scenarios

The electricity system is increasingly digitalising…

iea





…bringing many benefits for electricity and clean energy transitions

iea

Generation	Transmission & distribution	Consumers and DERs
• Improved efficiency • Predictive maintenance • Reduced downtime • Lifetime extension • Renewables forecasting	• Improved efficiency of assets and wider system operations • Predictive maintenance • Reduced downtime with faster fault localisation • Lifetime extension • Grid stability monitoring • Enhanced local flexibility options	• Demand response, including vehicle-to-grid (V2G) • Demand forecasting • Energy management • Smart buildings

But digitalisation comes with risks to cybersecurity

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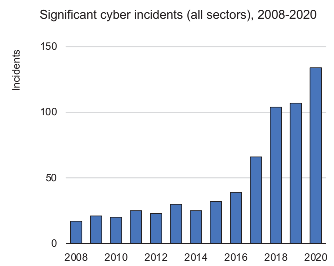

Note: Significant incidents are defined as cyber-attacks on government agencies, defense and high tech companies, or economic crimes with losses of more than a million dollars.
Source: Center for Strategic and International Studies (2020), Significant Cyber Incidents.

Selected electricity-related cyber incidents in 2020

- Supply chain cyberattack on IT service provider
- Ransomware attack on market operator in the UK
- Ransomware attack on Canadian utility
- Ransomware attack on Portuguese utility
- Intrusion of internal information exchange platform of European TSO association
- Ransomware attack on US equipment vendor

The threat of cyberattack is substantial and growing, and threat actors are becoming increasingly sophisticated at carrying out attacks – both in their ability to identify vulnerabilities and their destructive capabilities.

Policy makers are central to enhancing cyber resilience

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- **Institutionalise:** set appropriate responsibilities and incentives for relevant organisations within their jurisdiction.
- **Identify risks:** ensure that operators of critical electricity infrastructure identify, assess and communicate critical risks.
- **Manage and mitigate risk:** collaborate with industry to improve readiness across the entire electricity system-value chain.
- **Monitor progress:** ensure mechanisms and tools are in place to evaluate and monitor risks and preparedness, and track progress over time.
- **Respond and recover:** enhance the response and recovery mechanisms of electricity sector stakeholders.

Tailoring policy and regulatory approaches

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The regulatory spectrum for ensuring cybersecurity – the balance between prescription and outcome

Requirements to meet specific standards ensures:
+ minimum level across networks
+ streamlined monitoring for compliance
- but regulations can lag behind technology changes and focus more on compliance rather than risk

Establishing common criteria across networks allows:
+ customised approaches to achieve desired outcome
+ focus on outcomes to adapt to evolving risks
- but variable speed and level of cyber resilience risks weak link or contagion

Implementation strategies should be tailored to national contexts while considering the global nature of risks

Conclusion

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- The approach to electricity security will **change** with the clean energy transitions
- **Diversification of technology and location** are key enablers of a secure clean energy transition
- New aspects will arise due to the more decentralised nature of the power system, such as considerations for cyber resilience and **new policies** will have to be implemented
- **Secure clean energy transitions are achievable** also in APEC region, but context specific policies must be implemented and collaboration between power systems can enable further cost effectiveness

The IEA's participation in this event was made possible through the Clean Energy Transitions in Emerging Economies programme has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 952363.

CCUS in the APEC region: An expert view from Australia

CARBON CAPTURE & STORAGE & DECARBONISATION OF THE APEC REGION

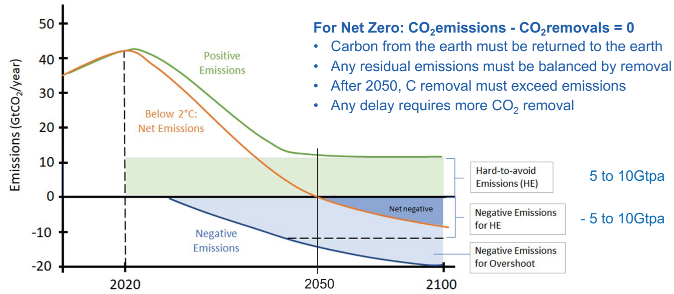
Symposium on the Holistic Approach of Decarbonisation Towards Carbon Neutrality

30-31 August 2021

Alex Zapantis, General Manager Commercial

GLOBAL CCS INSTITUTE

TO STABILISE AT 1.5°C: NET ZERO BY 2050 AND NET NEGATIVE EMISSION AFTER 2050



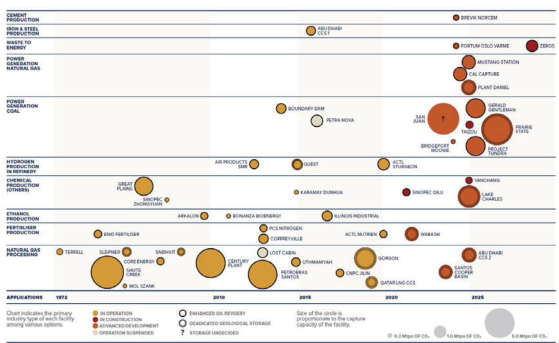
For Net Zero: CO_2emissions - CO_2removals = 0

- Carbon from the earth must be returned to the earth
- Any residual emissions must be balanced by removal
- After 2050, C removal must exceed emissions
- Any delay requires more CO_2 removal

Source: J. Wilcox et al 2020

COMMERCIAL CCS FACILITIES IN OPERATION, CONSTRUCTION AND ADVANCED DEVELOPMENT (MAY 2021)

- 26 operating
- 4 in construction.
- 14 in FEED studies.

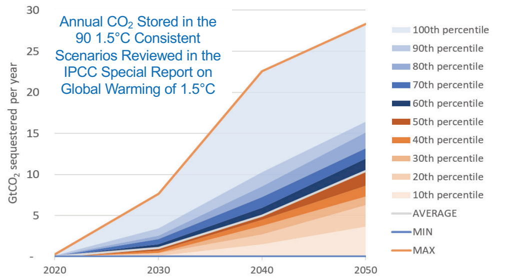


C MANAGEMENT POTENTIAL: >1000GtCO_2 THIS CENTURY

Almost all scenarios required CCS

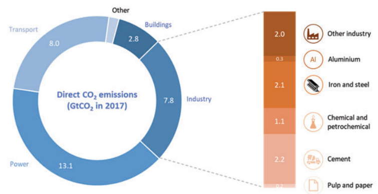
3 of 4 Illustrative Pathways required 348Gt to 1,218Gt CO_2 to be stored this century.

The 4th Illustrative Pathway required final energy demand to reduce by one third by 2050 compared to 2010.



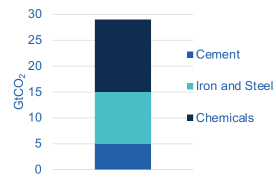
Source: GCCSI analysis of IIASA 1.5C Scenario Explorer

CCS PLAYS AN IMPORTANT ROLE IN INDUSTRY



Global Direct CO_2 Emissions from Industry in 2017

- Approximately 1.9Bt are process emissions



CCS Emission Reduction between 2017 and 2060

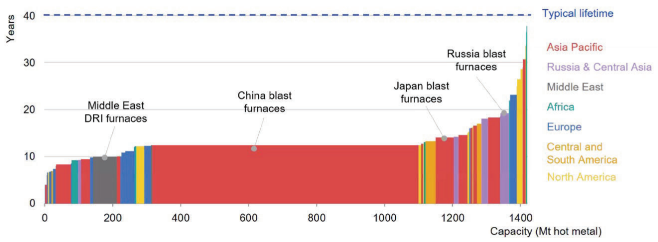
- CCS must deliver 29Bt abatement in industry to meet Paris Agreement objectives

Source: GCCSI analysis of IEA Data

Source: IEA, 2019, Transforming Industry through CCS

CCS IS NEEDED FOR EXISTING INDUSTRIAL FACILITIES

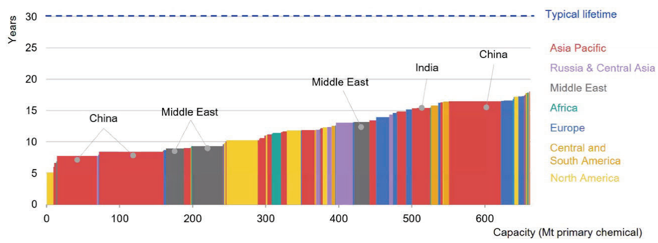
Age profile of primary steelmaking from iron ore (mostly blast furnaces)



Source: IEA, 2020

CCS IS NEEDED FOR EXISTING INDUSTRIAL FACILITIES

Age profile of primary chemical production facilities



Source: IEA, 2020

CCS PLAYS AN IMPORTANT ROLE IN POWER; eg Coal

Assumed in Modelling

Coal utilisation reduces by ~60% to 80% by 2030 compared to 2010

IPCC Illustrative Pathway to 1.5 degrees C	Pathway 1	Pathway 2	Pathway 3	Pathway 4
Reduction in primary energy from coal in 2030 compared to 2010	-78%	-61%	-75%	-59%
Reduction in primary energy from coal in 2050 compared to 2010	-97%	-77%	-73%	-97%

Actual

Coal utilisation is growing

- ~2000GW operating
- Over 500GW new capacity expected before 2030
- Over 200GW new capacity under construction
- Economic life of 40-50 years
- Considering only operating and under construction, and assuming early retirements and low capacity factors reduce emissions from this fleet to half of what is expected, approximately 85Gt of CO_2 must be captured and stored between 2030 and 2050 to achieve a 1.5 degree outcome.

Source: IPCC, 2018, Global Warming of 1.5 degrees C; Summary for Policy Makers

Source: GCCSI analysis of Cui et al, 2019, Quantifying operational lifetimes for coal power plants under the Paris Goals, Nature Communications 10:4759

CLEAN HYDROGEN PRODUCTION MUST SCALE UP

H_2 Production in 2020

Total production:120Mtpa

Grey H_2
Fossil origin, no CCS: 97%
Chlor-Alkali bi-product: 2%

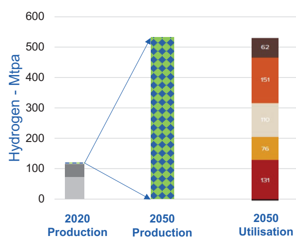
Clean H_2
Fossil origin with CCS or renewable powered electrolysis: 1%

H_2 Production in 2050

Total production:530Mtpa

100% Clean H_2 (Mixture of Green and Blue H_2)

Potential abatement:
6GtCO_2



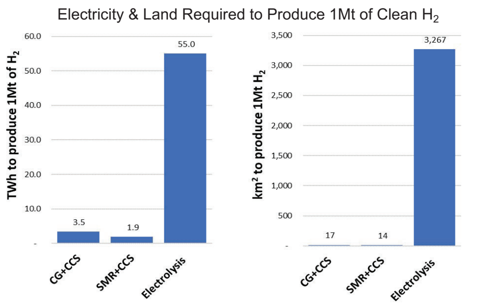
Sources: Adapted from Hydrogen Council (2017), Hydrogen scaling up, A sustainable pathway for the global energy transition, Global CCS Institute CO_2RE Database, IEA (2019), 'The Future of Hydrogen for G20. Seizing today's opportunities', Report prepared by the IEA for the G20.

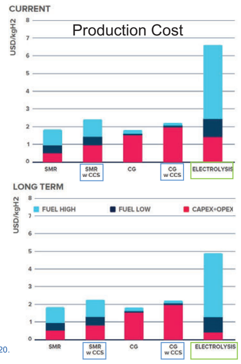
BLUE H_2 PRODUCTION IS MATURE & AVAILABLE AT SCALE NOW

Facility	H_2 Production (tonnes/day)	H_2 Production Process	Operational Commencement
Blue hydrogen			
Enid Fertiliser	200 (in syngas)	Methane reformation	1982
Great Plains Synfuel	1,300 (in syngas)	Coal gasification	2000
Air Products	500	Methane reformation	2013
Coffeyville	200	Petroleum coke gasification	2013
Quest	900	Methane reformation	2015
Alberta Carbon Trunk Line - Sturgeon	240	Asphaltene residue gasification	2020
Alberta Carbon Trunk Line - Agrium	800	Methane reformation	2020
Sinopec Qilu	100 (estimated)	Coal/Coke gasification	2021 (planned)
Green hydrogen			
Trondheim	0.3	Electrolysis; Solar	2017
Fukushima (largest operating)	2.4	Electrolysis; Solar	2020
NEOM	650	Electrolysis; Wind + Solar	2025 (planned)
AREH	4800	Electrolysis; Wind + Solar	Possible after 2028

Source: Global CCS Institute 2021: Friedmann et al., 2020: Renew Economy 2020

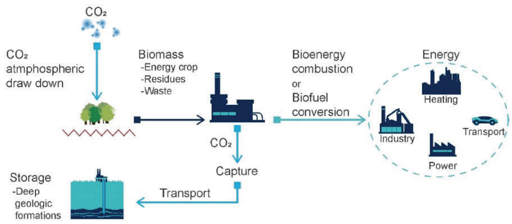
BLUE H2 HAS COST AND RESOURCE ADVANTAGES





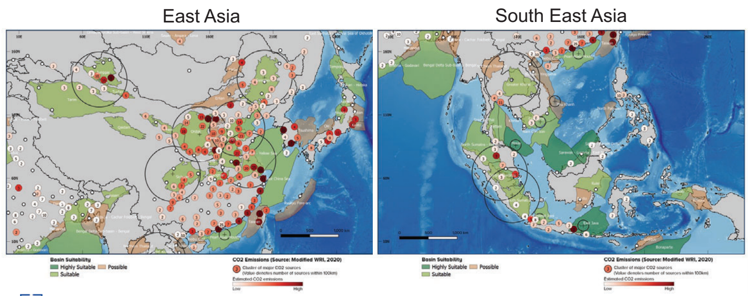
Source: Cost adapted from IEA 2020.

BIOENERGY WITH CCS (BECCS) – NEGATIVE EMISSIONS



- Bioethanol produces "pure" CO_2 – CO_2 capture is very low cost (e.g. ADM Decatur Plant which is operating & Summit Carbon Solutions Network of 31 bioethanol plants)
- Waste to Energy (e.g.Fortum Oslo Varme & Zeros both in development) and Biomass (e.g Drax in development) have capture costs similar to coal power generation

MANY POTENTIAL CCS HUBS IN APEC REGION



CONCLUSION

- CCS is one of many technologies that are essential for decarbonizing the Asia Pacific region
- CCS has broad application across industries, to enable clean hydrogen production at meaningful scale and in the power sector
- There are many opportunities for CCS hubs to create low-emission industrial hubs, protecting and creating high value jobs
- A stronger business case for investment is required to accelerate deployment

THANK YOU

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CCUS in the APEC region: An expert view from Indonesia

APEC Asia-Pacific Economic Cooperation

APEC Symposium on the Holistic Approach to Decarbonization towards Carbon Neutrality
30 – 31 August 2021

CCUS in the APEC Region: Indonesian View

Dr. Mohammad Rachmat Sule
*Study Program of Geophysical Engineering & Geothermal Engineering, Institut Teknologi Bandung
*Manager of National Center of Excellence for CCS/CCUS
*Manager of Center for CO_2 and Flared Gas Utilization, Institut Teknologi Bandung

INDONESIA CENTER OF EXCELLENCE CARBON CAPTURE STORAGE · Center for CO_2 & Flared Gas Utilization · skkmigas · RISTEKDIKTI · PUSAT UNGGULAN IPTEKS PERGURUAN TINGGI INDONESIA

Why CCUS Implementation is needed in Indonesia?

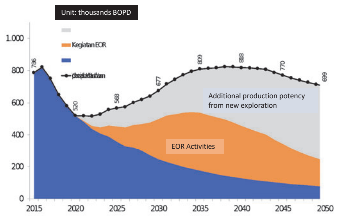
INDONESIA's Commitment on Climate Change

COP-21 in Paris (2015):
29% emissions reduction from BAU by 2030 and 41% with international support scenario

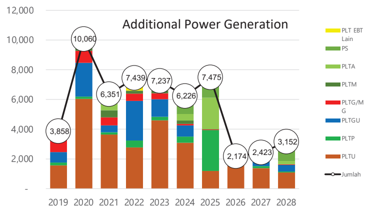
In order to increase the contribution of carbon reduction from Energy Sector:
Implement CCS and CCUS in Indonesia!

Indonesia has big potential for capturing and utilizing CO_2

- Many new proven gas fields are yet to be produced, many with high CO2 content
- Many oil and gas fields in natural depletion phase, need tertiary recovery (EOR/EGR)
- Significant role of coal power plant in electricity mix
  (total coal fired power plant in 2019: 26.5 GW), potential to be integrated with oil and gas CCUS projects

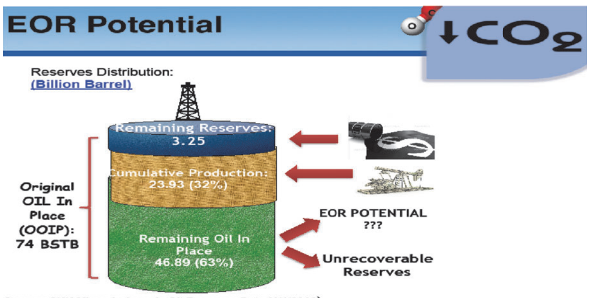


RUEN, 2017



PLN, 2019

www.esdm.go.id · Kementerian Energi dan Sumber Daya Mineral · @KementerianESDM · @kesdm · Kementerian ESDM



Source: SKK Migas Indonesia Oil Reserves Data (1/1/2014)

- Unfortunately, CCS and CCUS implementations are not included yet in Indonesian NDC as the tool that could reduce the GHG emissions, because when NDC is constructed in 2016, we thought that these kinds of technologies are too expensive to be implemented in Indonesia
- The concept of CO_2-injection implementation in the form of CO2-EOR or CO_2-EGR are introduced by National CoE for CCS, CCUS and Flared Gas Utilization since the end of 2019, when the preparation of the Gundih CCS project is revised to be the Gundih CCUS project

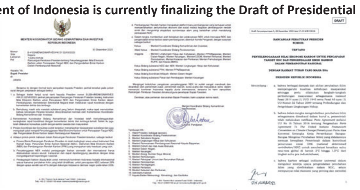
Just Fresh from the oven (Nov - 2020)

Minister of EMR Reiterates Commitment to Use of Cleaner Fuels in East Asia Energy Forum

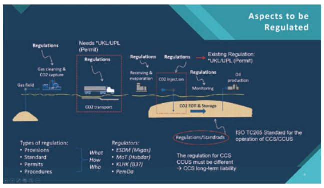
Arifin also emphasized that development of Carbon Capture, Utilization, and Storage (CCUS) is vital to reduce CO2 emissions. "CCUS is currently a key issue at the global level relating to reduction of CO2 emissions and reuse of the same to increase oil recovery in depleted oil fields," said Arifin.

In closing, Arifin invited all stakeholders to collaborate in enhancing CCUS capacity and use. According to him, it is necessary to strengthen the framework for public-private cooperation by creating a sustainable platform for accelerated implementation of CCUS, identification of investment opportunities, and improvement of business environment as well as dissemination of policies, regulations, and best practices. "Indonesia welcomes all parties to join us in developing CCUS in order to achieve the commitment to sustainable energy", Arifin concluded. (IY)

Besides that, the Government of Indonesia is currently finalizing the Draft of Presidential Decree on Carbon Pricing



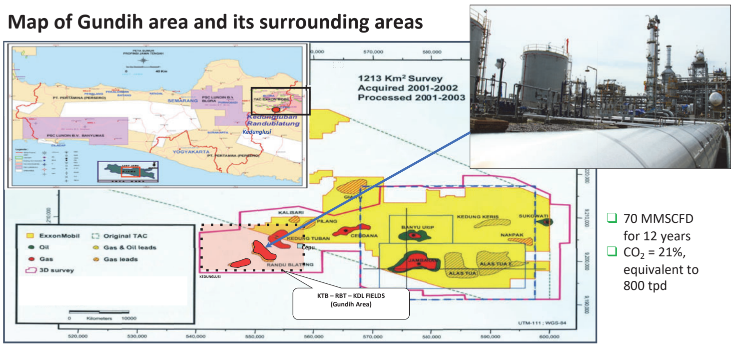
Current Status of CCUS Regulation in Indonesia



What we have learnt from Gundih CCUS Studies?

Latest Status of Gundih Project: Shifting from CCS Pilot Project to CCUS (CO_2-EGR) Project

Map of Gundih area and its surrounding areas

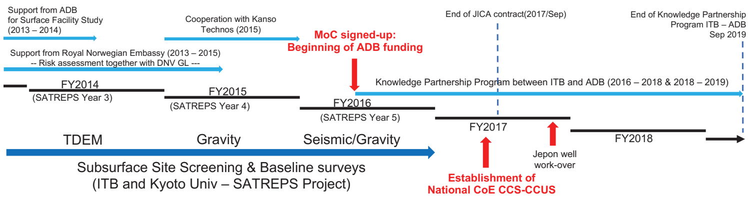


- 70 MMSCFD for 12 years
- CO_2 = 21%, equivalent to 800 tpd

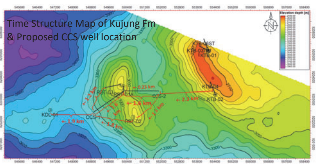
Historical Gundih CCS Pilot Project (2012 – 2019)

Contributors:

SATREPS project (2012-2017), ADB TA (2013 – 2014), Royal Norwegian Embassy (2013 – 2015), Kanso Technos (2015) and Knowledge Partnership Program ITB and ADB (2016 – 2019)

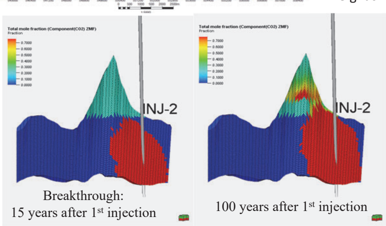


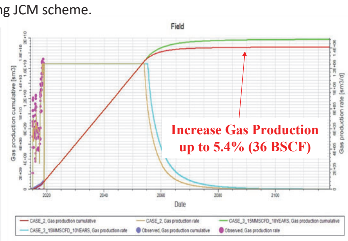
NEW Scenario of CCUS Project in GUNDIH AREA (Starting from 2019)



Currently Gundih CPP releases 800 tpd of CO_2. If all of available CO_2 is injected to Kedungtuban structure:

- 3 mio of CO_2 will be reduced for 10 years injection time.
- Incremental gas production (80% CH_4) of 36 BSCF for 10 years, equivalent to approx. USD 100 - 120 mio.
- The Capex for 10 years CO_2 injection = USD 49 mio, total OPEX = USD 20 mio
- Offering participation of foreign institutions for injecting CO_2, e.g. using JCM scheme.



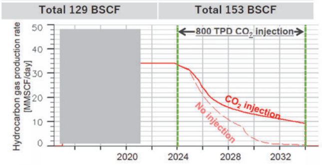


2020 Study Results and Way Forward

Subsurface Study on KTB

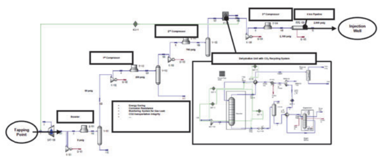
Feasible CO_2 injection, Positive EGR impact, but apparent uncertainties

Hydrocarbon Gas Production	
No Injection Case	CO_2 Injection Case
Total 129 BSCF	Total 153 BSCF



Facility Study for 800 TPD-CO_2 Injection

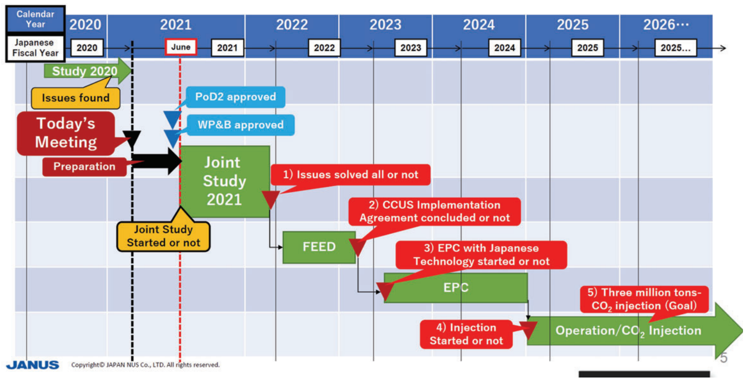
- Facility desined
- Cost estimated (max. -80 million USD of CAPEX)
- No consideration of site-specific issue



Follow up:

- Need further studies to be equivalent to Pre-FEED study, to be conducted from March 2021 – Feb/March 2022.
- Pertamina assigns a task force to work together with CoE CCS/CCUS at ITB, Japanese research team, and DG Oil and Gas in finalizing this Pre-FEED document by Feb/Mar 2022.

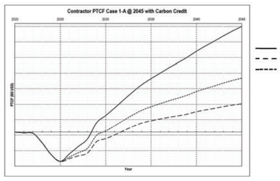
Expected Schedule toward Gundih CCUS Implementation



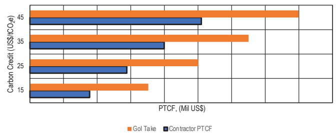
Economical Motivation of CCUS Implementation in Indonesia (the study was conducted by CoE ITB in 2021)

Make oil and gas fields more environmentally friendly & they give economic benefit e.g. from incremental production

--- A Study from an Indonesian EGR Project Plant: Analysis on Carbon Credit Sensitivity for Project Economics ---



Carbon Credit Sensitivity-EGR Implementation in a field in Indonesia



Assumptions: Injection of CO_2 starts in 2026 & all CO_2- credit could be sold

Estimated Project pay out time for
- Carbon Credit 15 US$/t$CO_2$e : Q1 2032
- Carbon Credit 25 US$/t$CO_2$e : Q4 2030
- Carbon Credit 35 US$/t$CO_2$e : Q2 2029

- PTCF Comparison for project 35 US$ carbon credit is 1.6 times as profitable as the project with 25 US$ carbon credit and 2.4 times more profitable compared to the project with 15 US$ carbon credit.

- Based on the calculation, carbon credit is able to reduce operating expenditure to zero, therefore increasing profit for both contractor and the Government of Indonesia.

References of Carbon Pricing Around the World:
- EU ETS : 25 US$/t$CO_2$e (50-60 US$/tCO_2e in 2022)
- Hitachi: 46.7 US$/t$CO_2$e
- Iceland Carbon Tax: 31.3 US$/t$CO_2$e
- Beijing Pilot ETS: 10.4 US$/t$CO_2$e

The Uniqueness of CCUS Implementation in Indonesia

1. It makes the environment in the vicinity of energy facilities cleaner, because a large portion the produced GHG emission is injected underground.
2. It gives an opportunity for both the government of Indonesia and the oil and gas companies to receive additional income from incremental hydrocarbon production.
3. It creates an opportunity to receive more economic benefit from selling carbon credits.

BP secures enhanced gas recovery PoD

Wednesday, August 18 2021 - 11:05AM WIB
By Alexander Ginting

Upstream oil, gas authority SKK Migas announced on Tuesday that it has approved Enhanced Gas Recovery (EGR) Plan of Development (PoD) of Ubadari and Vorwata fields located within BP-operated Berau, Muturi and Wiriagar PSCs in West Papua.

Based on the PoD, Ubadari and Vorwata EGR will produce 1,269 BCF and 3.77 million barrels of condensate until the PSCs' contracts expire in 2035. According to SKK Migas, Ubadari is targeted to come onstream in the third quarter of 2026, followed by Vorwata in 2027. Investment required to develop the fields is estimated at US$ 2.041 billion.

Gas produced from the fields will support Tangguh Train-3, which is slated to start production next year with a capacity of 3.8 million ton per annum. Tangguh currently operates two trains with a capacity of 3.8 MTPA each.

Read also: BP Indonesia plans US$4 billion fresh investment

SKK Migas said that the fields' development will utilize Carbon capture, Utilization and Storage (CCUS) to support enhanced gas recovery and at the same time reduce the fields' carbon footprint.

According to SKK Migas, Tangguh Train-1 and 2 currently release 5 million tons of CO2 annually and will increase to 8 MTPA without CCUS application with the operations of Train-3. CCUS application will cut CO2 release by 45 percent, SKK Migas said.

The Tangguh LNG is developed by a consortium of international companies, led by BP (37% stake), CNOOC (17%), and Mitsubishi Corporation (16.3%). Smaller partners include the Japanese companies Nippon Energy, Kanematsu, Sumitomo, and Nissho Iwai. Production began in June 2009.

Editing by Reiner Simanjuntak

Note: - CCUS activities in a oil and gas block could be as part of field development scenario, thus could be proposed in the POD proposal.
- CCS/CCUS activities should be part of oil and gas operations, thus CAPEX-OPEX will become oil and gas operation cost, which is integrated to the field economic.

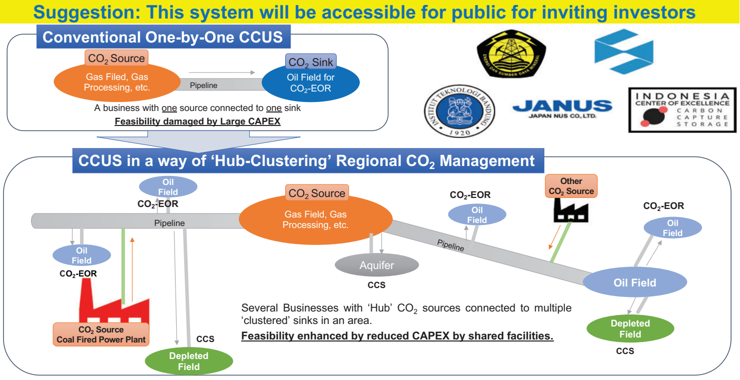
Proposal:
Development of CO2-source-sink match GIS system and providing the system as public domain for attracting investors

INDONESIA CENTER OF EXCELLENCE CARBON CAPTURE STORAGE

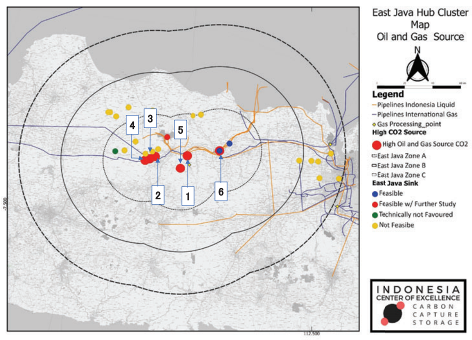
INDONESIA CENTER OF EXCELLENCE FOR CCS

Development of CO_2-Source-Sink GIS System for Indonesia

Suggestion: This system will be accessible for public for inviting investors



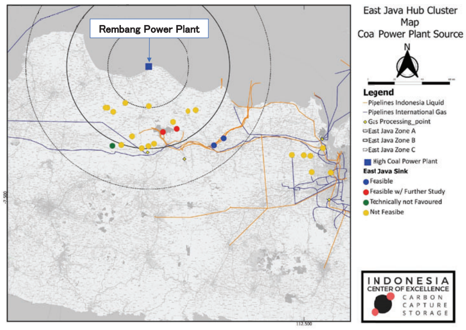
Potential CO_2 Source in East Java from Gas Fields



Potential Fields:
1. Banyu Urip
2. Kedung Tuban
3. Randu Blatung
4. Kedung Lusi
5. Tiung Biru
6. Sukowati

Estimated CO_2 Potential: 180 MMSCFD eq. to 10,000 tpd (Muslim et al, 2013; Hartono et al, 2017)

Potential CO_2 Source in East Java from Coal



Potential Source:
Rembang Power Plant (PLTU Rembang)

Power Generation: 300 MW

Estimated CO_2 Potential:
>2 million tonnes of CO_2 per annual

Challenge:
No existing pipeline from Rembang PP to potential sinks

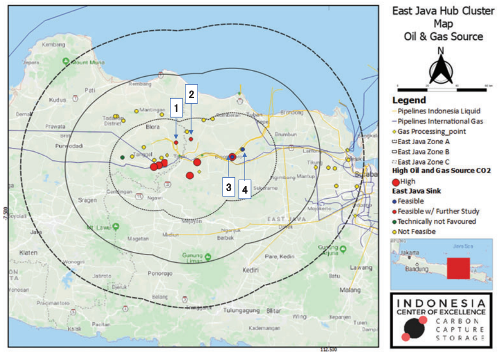
Potential CO_2 Sink- East Java

Potential Sink Fields:

1. Ledok Field (Old Field, very high uncertainty)
2. Kawengan Field (Old field, production approx. 1250 BOPD)
3. Sukowati Field (Most possible candidate, already on PERTAMINA's EOR Roadmap, production approx., 10,000 BOPD)
4. Mudi Field (possible candidate, production approx. 9,500 BOPD)

Estimated CO_2 Sequestered:
9650 tonnes per day

Estimated additional oil recovery:
4000-7000 BOPD



Potential CO_2 Source in South Sumatera

CO_2 Source from Oil & Gas

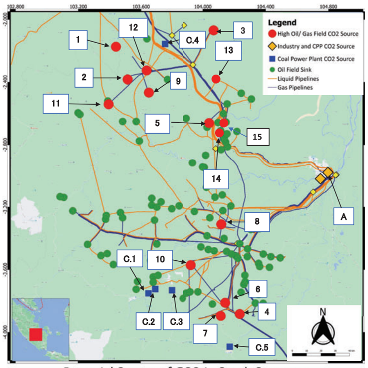
No	Field Name	Operator
1	Bungin 1	ConocoPhillips (South Jambi) Ltd
2	Dayung	ConocoPhillips (Grissik) Ltd
3	Gelam	ConocoPhillips (Grissik) Ltd~PT Pertamina/Talisman (Jambi Merang) Ltd
4	Kuang	PT Pertamina EP
5	Letang	ConocoPhillips (Grissik) Ltd
6	Pagardewa	PT Pertamina EP
7	Prabumenang	PT Pertamina EP
8	Raja	PT Pertamina EP
9	Sambar 1	ConocoPhillips (Grissik) Ltd
10	Singa (Medco)	PT Medco E&P Lematang
11	Suban	ConocoPhillips (Grissik) Ltd
12	Sumpal	ConocoPhillips (Grissik) Ltd
13	Bentayan	PT Pertamina EP
14	Tanjung Laban	PT Pertamina EP
15	Ramba	PT Pertamina EP

CO_2 Source from Industry

No	Industry Category	Company
A	Petrochemical	PT Pupuk Sriwidjaja

CO_2 Source from Power Plant

No	Coal Power Plant	Owner
C.1	Keban Agung	PT Priamanaya Energi
C.2	PLTU Banjarsari	PT Bukit Pembangkit Innovative
C.3	Bukit Asam #2	PT PLN (Persero) Pembangkitan Sumatera Bagian Selatan
C.4	Sumsel-5	PT DSSP Power
C.5	Baturaja	PT Bakti Yudha Nugraha Power



Potential Source of CO2 in South Sumatera
Source Category: Gas Field, PLTU, Industry

Potential CO_2 Source in East Kalimantan

CO_2 Source from Oil & Gas

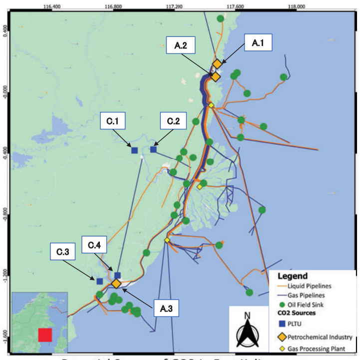
No	Field Name	Operator
No Data		

CO_2 Source from Industry

No	Industry Category	Company
A.1	Petrochemicals	PT Pupuk Kalimantan Timur
A.2	LNG Plant	PT. Badak NGL
A.3	Refinery	PT. Pertamina (RU V)

CO_2 Source from Power Plant

No	Coal Power Plant	Owner
C.1	PLTU Senoni	PT Kalimantan Powerindo
C.2	PLTU CFK	PT PT Cahaya Fajar Kaltim
C.3	PLTU Teluk Balikpapan	PT PLN (Persero) Pembangkitan dan Penyaluran Kalimantan
C.4a	PT Kariangau Power	PT Kariangau Power



Potential Source of CO2 in East Kalimantan
Source Category: Gas Field, PLTU, Industry

Upcoming and Next Proposed Cooperation

March 19, 2021

Japan Oil, Gas and Metals National Corporation

Mitsubishi Corporation

Signing of Memorandum of Understanding regarding CCS Joint Study for Clean Fuel Ammonia Production in Indonesia

Signing ceremony

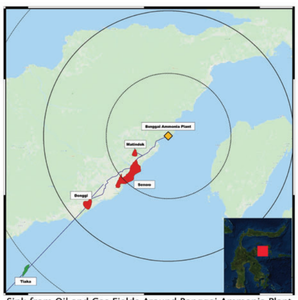
Japan Oil, Gas and Metals National Corporation (JOGMEC), Mitsubishi Corporation (MC), Bandung Institute of Technology (ITB), a national university in the Republic of Indonesia, and PT Panca Amara Utama (PAU) have agreed to conduct a joint study on carbon capture and storage (CCS) and carbon dioxide utilization for clean fuel ammonia production in Central Sulawesi, the Republic of Indonesia. The four parties have signed a Memorandum of Understanding (MOU).

Ammonia is being used worldwide as raw material for fertilizers/plastics/chemicals. Expectation for ammonia to become a next generation clean energy source is growing because ammonia does not emit carbon dioxide when burnt; transportation methods have been established with existing infrastructure; and due to its high hydrogen content.

Under the MOU, the four parties will jointly conduct a CCS feasibility study near PAU's ammonia plant in Luwuk, Central Sulawesi, and the Donggi-Senoro LNG plant in the same province which is being led by MC as the largest shareholder. Mitsubishi Gas Chemical Company, Inc., which also indirectly invests in PAU together with Mitsubishi Corporation, has expressed its interests to cooperate in this joint study. Going forward, the companies concerned will formulate the necessary work processes including project composition; data accumulation of candidate storage formations; simulations; analysis and evaluations.

Through this joint study, we will make effort to contribute towards realizing a decarbonized society and securing stable energy supply for Japan by pursuing the feasibility of clean fuel ammonia production from utilization of existing ammonia plant and CCS treatment of carbon dioxide generated during the production phase.

No ID	FIELD_NAME	OPR_CURR	PROD_STAT	GN_HC_TYPE	FLD_SQKM
1	Senoro	JOB Pertamina-Medco E&P Tomori Sulawesi (JOB PMTS)	Producing	Oil & Gas Fields	56.9
2	Tiaka	JOB Pertamina-Medco E&P Tomori Sulawesi (JOB PMTS)	Temporarily shut-in	Oil & Gas Fields	6.9
3	Donggi	PT Pertamina EP	Producing	Gas Fields	14.1
4	Matindok	PT Pertamina EP	Producing	Gas Fields	5.92



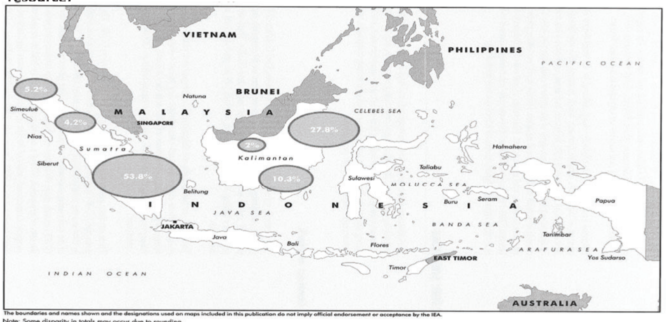
Sink from Oil and Gas Fields Around Banggai Ammonia Plant
Central Sulawesi

INDONESIA CENTER OF EXCELLENCE CARBON CAPTURE STORAGE

Legend
Banggai Ammonia Plant
Liquid Pipelines
Gas Pipelines
Fields_Structure
Gas
Oil
Cluster C (90 km)
Cluster A (30 km)
Cluster B (60 km)

Indonesia is a Coal Economy

Distribution of coal (ca. 18,7 billon tonnes as reserve and 90 billion tonnes as potentioan resource)



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.
Note: Some disparity in totals may occur due to rounding.
Source: Ministry of Energy and Mineral Resources.

CO_2 Sources from Main Energy Sectors in Indonesia

<u>Indonesian target</u> for GHG emission reduction **<u>from energy sector</u>** from 2020 – 2030 (20 years): ~ 400 Mt of CO_2.

<u>Some facts</u> about CO_2 – injection plans from some sites in Indonesia:

- Cumulative total CO_2 that could be injected in Gundih field for 10 years ~ <u>3 Mt</u> of CO_2
- Cumulative total CO_2 that could be injected in Tangguh field for 10 years **~ <u>32 Mt</u> of CO_2**
- Cumulative CO_2 that could be produced from main oil and gas fields in Eastern Java (incl. Gundih, Banyu Urip, Sukowati, & JTB) for 10 years **~ <u>35 Mt</u> of CO_2**
- Potential of CO_2 to be injected from Banggai Ammonia Plant (Central Sulawesi) for 10 years **~ <u>10 Mt</u> of CO_2**
- Potential of pure CO_2 injection from DME Project in Tanjung Enim – South Sumatra for 10 years (from coal gasification) ~ <u>40 Mt</u> of CO_2 (there will be another 25 Mt of CO_2 for 10 years from boiler incl. impurities)
    - ⇒ Potential of GHG reduction from those above planned projects (10 years): **~ <u>117 Mt</u> of CO_2** (29% of GHG emission reduction target from energy sector)

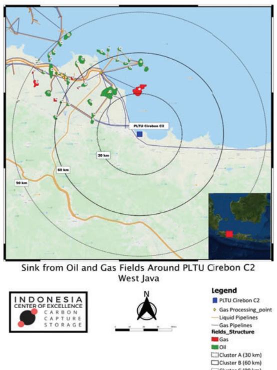
If we add the potential of CO2 produced from coal-fired power plant:

- CO_2 released from PLTU Cirebon (650 MW, 80% capacity factor) **~ <u>4.5 Mt</u>** of CO_2 per year (Note: 1 MWh ~ 0.9 ton of CO_2)
- CO_2 released from all Coal-fired power plants in Indonesia (totally 35 GW, 80% capacity factor) **~ <u>250 Mt</u>** of CO_2 per year

⇒ Thus, CCUS can play an important role in Indonesia, since there are a lot of CO_2 sources from energy sector, but their locations are close enough to depleted oil reservoirs and coal mining, so that CO_2-EOR, CO_2-EGR and ECBM can perhaps be carried out economically in Indonesia.

CO2 from Coal Fired Power Plant, Connected to Oil and Gas fields (CCUS)

Photo of Coal-fired power plant near Cirebon (West Java), currently the installed capacity is 650 MW and the production of flared CO2 is about 4 mio. Tonnes per year. In 2022, unit-2 will be on stream with additional capacity of 1,000 MW.

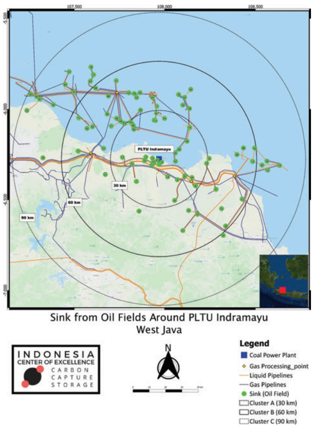


Sink from Oil and Gas Fields Around PLTU Cirebon C2
West Java

Around 40 km from this power plant, there several oil and gas fields, e.g. Jatibarang field. Potential for future CCUS Project?

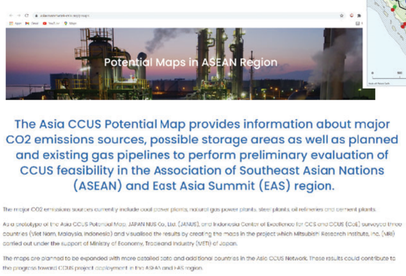
PLTU Indramayu (290 MW), and the list of sinks are as follow:

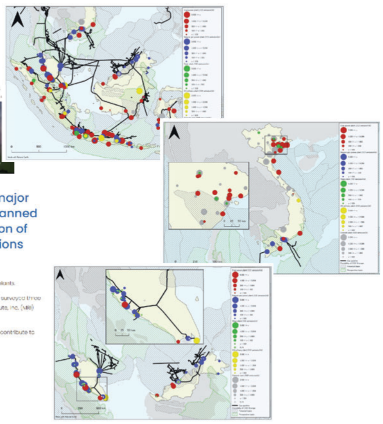
No ID	FIELD_NAME	Operator	PROD_STAT	GN_HC_TYPE
1	Karang Enggal	PT Pertamina EP	Producing	Oil & Gas Fields
2	Jati Asri	PT Pertamina EP	Producing	Oil & Gas Fields
3	Jati Sinta	PT Pertamina EP	Producing	Oil & Gas Fields
4	Kandang Haur Timur	PT Pertamina EP	Producing	Oil & Gas Fields
6	Cemara Barat	PT Pertamina EP	Producing	Oil & Gas Fields
7	Pegaden	PT Pertamina EP	Producing	Oil & Gas Fields
8	Cemara Selatan	PT Pertamina EP	Producing	Oil & Gas Fields
10	Kandang Haur Barat	PT Pertamina EP	Temporarily shut-in	Oil & Gas Fields
13	Bojongraong	PT Pertamina EP	Producing	Oil & Gas Fields
20	Gantar	PT Pertamina EP	Producing	Oil & Gas Fields
21	Pamanukan Selatan	PT Pertamina EP	Producing	Oil & Gas Fields
22	Waled Utara	PT Pertamina EP	Producing	Oil & Gas Fields
24	Cemara Timur	PT Pertamina EP	Producing	Oil & Gas Fields
26	Melandong	PT Pertamina EP	Producing	Oil & Gas Fields
28	Karang Baru	PT Pertamina EP	Producing	Oil & Gas Fields
29	Tegal Taman	PT Pertamina EP	Producing	Oil Fields
31	Karang Baru Barat	PT Pertamina EP	Temporarily shut-in	Oil & Gas Fields
32	Karang Tunggal	PT Pertamina EP	Temporarily shut-in	Oil & Gas Fields
34	Jati Keling	PT Pertamina EP	Producing	Oil & Gas Fields
40	Arjuna FS	PT Pertamina Hulu Energi ONWJ Ltd	Temporarily shut-in	Oil & Gas Fields
42	Arjuna U	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
45	Arjuna FF	PT Pertamina Hulu Energi ONWJ Ltd	Temporarily shut-in	Oil & Gas Fields
47	Arjuna FZ	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
54	Arjuna ESR	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
55	Arjuna ESS	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
56	Arjuna FSW	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
66	Arjuna ES	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
75	Arjuna EST	PT Pertamina Hulu Energi ONWJ Ltd	Temporarily shut-in	Oil & Gas Fields
79	Arjuna F	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
85	Arjuna UB	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields
86	Arjuna UY	PT Pertamina Hulu Energi ONWJ Ltd	Producing	Oil & Gas Fields



Sink from Oil Fields Around PLTU Indramayu
West Java

Asia CCUS Network





THANK YOU

http://ccs-coe.fttm.itb.ac.id/

http://ccs-gundih.fttm.itb.ac.id/

Nuclear Energy in the APEC region: An expert view from Korea

Disclaimer

The opinions expressed in this presentation are that of the author. They do not purport to reflect the opinions or views of KAERI.

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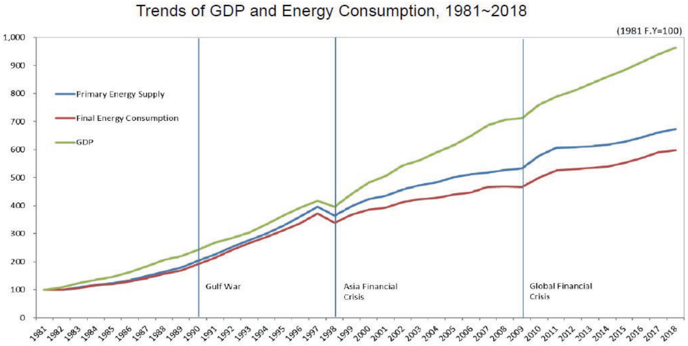
KAERI

01 Background : Economy & Energy in Republic of Korea

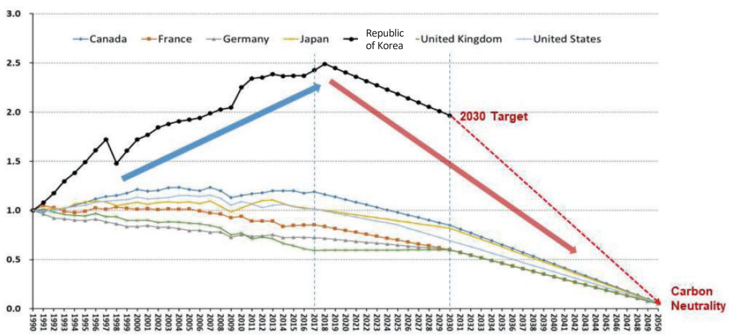
Trends of GDP and Energy Consumption, 1981~2018



Source : The role of the power sector for 2050 carbon neutrality in Korea, Jaekyu Lim, KAIF2021

» Greenhouse Gas emission in 2018 : 728 Mton-CO2eq

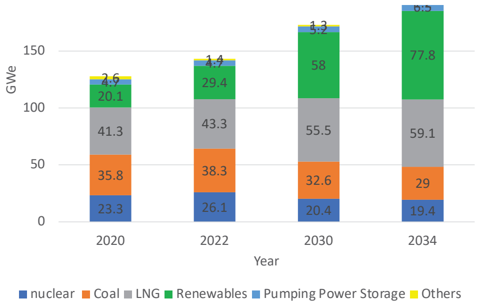
02 GHG Reduction for 2050 Carbon Neutrality



Source : The role of the power sector for 2050 carbon neutrality in Korea, Jaekyu Lim, KAIF2021

03 Energy Transition Policy (2017~)

- Aggressive Increase of Renewables
- Rapid Decrease of Coal-fired Power Plants
- Stepwise Phase-out of Nuclear Power Plants, but Support Exporting Nuclear Power Plants



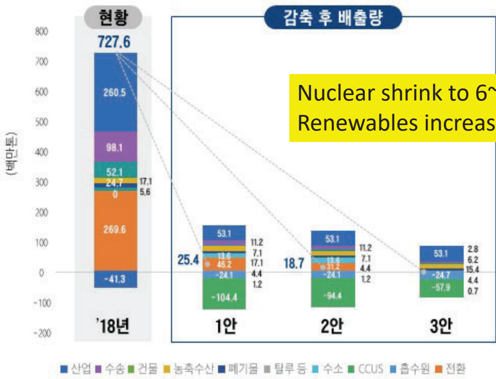
Source : 9th Basic Plan on Supply & Demand of Electricity, MOCIE, 2020

04 Pledge of 2050 Carbon Neutrality

- Pledge of 2050 Carbon Neutrality of ROK by President Moon Jae-in (2020.10)
- Development of Scenarios for 2050 Carbon Neutrality (by 2021.6) & Development of strategies for each sector (by 2021.12)

05 Draft Scenario of Carbon Neutrality

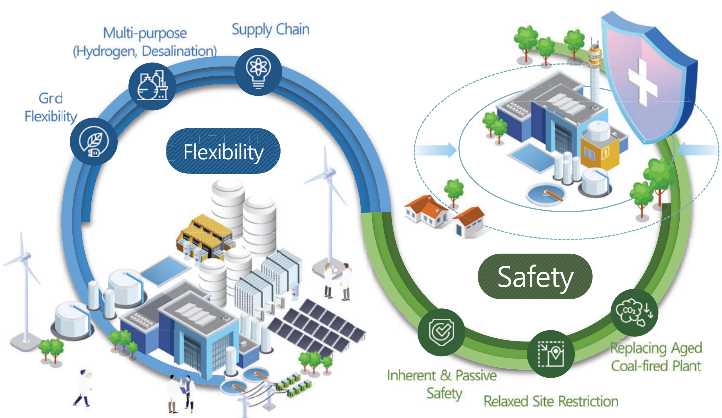
- Presidential Committee on Carbon Neutrality announced 3 proposed scenarios to achieve net zero carbon emissions by 2050



CONTENTS

KAERI

06 Why SMR?



07 SMR Market Prospect

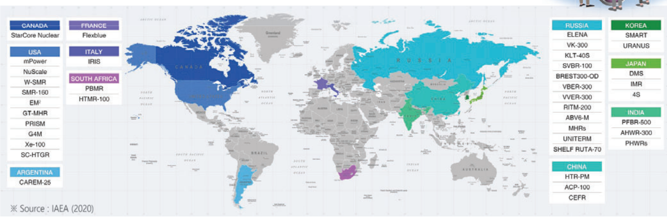
65~85GW new installation by 2035

※ Source : Small Modular Reactors – once in a lifetime opportunity for the UK (2017)

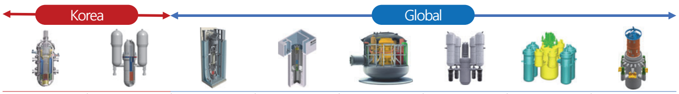
※ Source : Canadian SMR Roadmap: Economic and Finance Working Group Report (2018)

08 Status of SMR Development

Over 70 concepts of SMR are under development



Korea | Global

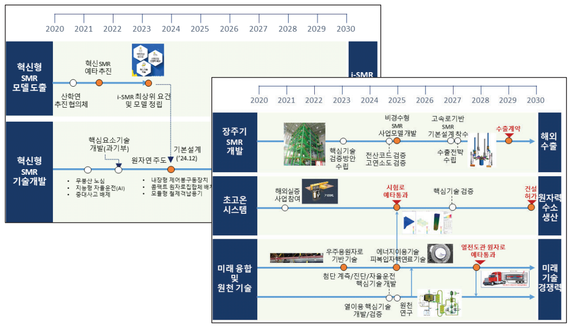


SMART	BANDI-60S	NuScale	BWRX-300	NuWard	UK SMR	KLT-40S	ACP100
KAERI	KEPCO-ENC	NuScale(USA)	GE-Hitachi(USA)	EDF(Fr)	Rolls-Royce(UK)	OKBM(Ru)	CNNC(China)

09 Future Reactor Development Plan

» Atomic Energy Promotion Committee accepted the Plan for future reactor development (Dec. 2020.)

◆ Roadmap to develop SMR & Gen-IV



10 Innovative SMR development Forum in NA

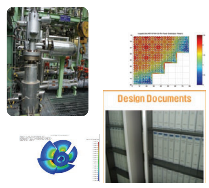
» **The Bipartisan Forum established under Science, Technology & IT Standing Committee of National Assembly**

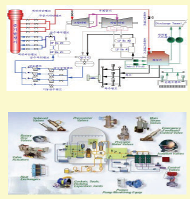
◆ 1st Forum held 14th of April, 2021
  - ◆ 11 members of NA including chairman and executive secretaries of the standing committee

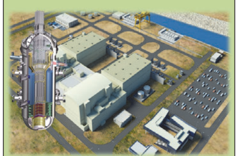
◆ 2 task force teams will be working on
  - ◆ the revision of Nuclear Safety Law and Regulations
  - ◆ Prepare governmental support to promote SMR development

11 SMR Development in Korea: SMART(2)

Technology Development	Joint Development	Commercialization
ROK	ROK & KSA	K.A.CARE & EPC
SMART Development	Pre-Project Engineering	FOAK Plant Construction
SMART Standard Design Technology Validation Licensing Safety Enhancement for Post Fukushima Action Plan	FOAK Eng. Design, 365MWth HCB on K.A.CARE Experts Prepare PSAR, Vendor Survey	2 FOAK Plants Construction Licensing (CP, OL), Operation
1997 ~ 2014	2015 ~ 2018	5~6 yr

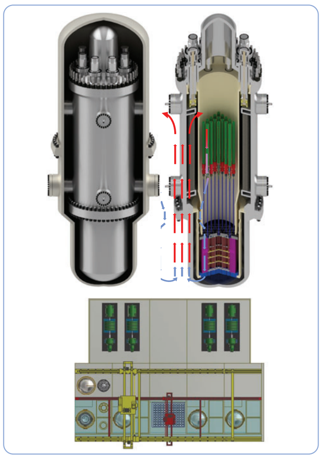






12 SMR Development in Korea: iSMR(1)

Development Goal

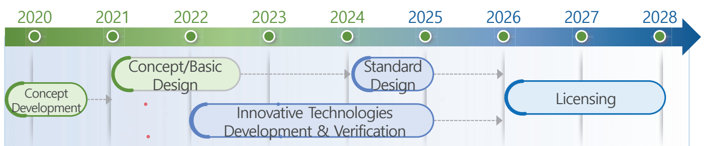


13 SMR Development in Korea: iSMR(2)

Key Targets

- 170 MWe, 4 Reactors
- Cost: <4,000 USD/kW
- CDF: <10-9/yr
- Cons.Period: < 24months
- No. Operators: 3 persons /4 Rx

Milestone



Nuclear Energy in the APEC region: An expert view from Southeast Asia

Outlook for nuclear power by 2050

- Uncertain, probably not major source of power
  - Potential for SMRs
  - Multiple potential vendors
- Constraints:
  - Political commitment:
    - Perceived high cost cf renewables
    - Public perception of risk
  - No IAEA safety guidelines for licensing & regulating SMRs
  - No large-scale SMR deployment elsewhere

Action at Country Level (1)

Country	Research reactor(s)	NPP	Status
Indonesia	3	HTGR planned	Advanced, but no decision
Malaysia	1	-	Advanced, but suspended
The Philippines	1 (shutdown)	1 Mothballed	Reinvigorated
Thailand	1	-	Advanced, but no decision
Viet Nam	1	-	Advanced, but postponed
Brunei Darussalam	-	-	*Not a priority*
Cambodia	-	-	*Future option*
Laos	-	-	*Not a priority*
Myanmar	-	-	*Not a priority*
Singapore	-	-	*Future option*

Action at Country Level (2)

- International Treaties
- IAEA missions, advice, training
- External partners:
  - Russia, China, Japan, Republic of Korea, the USA, Canada
- Focus has changed from conventional, large-scale reactors to include SMR's and GIV reactors
- COVID-19 seems to have slowed momentum

Action at ASEAN Level (1)
Treaty & Networks

- Southeast Asia Nuclear-Weapon-Free Zone Treaty (SEANWFZ, 1995)
  - SEANFZ Commission
- Nuclear Energy Cooperation Sub-Sector Network (2008)
- ASEAN Network of Regulatory Bodies on Atomic Energy (ASEANTOM, 2013)
- Network on Nuclear Power Safety Research (2018)

Action at ASEAN Level (2):
ASEAN Centre for Energy

- External cooperation (mainly capacity building):
  - Canada Nuclear Radiological Programme Administrative Support
  - Japan Atomic Energy Agency
  - US Department of Energy
  - China
- Webinars
- Reports

Action at ASEAN Level (3)
Current priorities

- ASEAN Plan of Action for 2021-2025:
  - Capacity building in nuclear science & technology for power generation
  - Assess potential for nuclear power to support energy transition and resilience
  - Public communication and awareness
  - Improve capacity in policy, regulation and technology relating to emerging technologies (eg SMRs)

Action at ASEAN Level (4):
Nuclear power in the energy mix

- ASEAN Centre for Energy, 5th ASEAN Energy Outlook (2017)
  - Nuclear: 0.2-0.5% of total primary energy by 2040
- International Energy Agency, ASEAN Energy Outlook (2019)
  - 2-3 GW of nuclear by 2040
- ASEAN Centre for Energy, 6th ASEAN Energy Outlook (2020)
  - No mention of nuclear by 2040

Outlook for nuclear power by 2050

- Uncertain, probably not major source of power
  - Potential for SMRs
  - Multiple potential vendors
- Constraints:
  - Political commitment:
    - Perceived high cost of renewables
    - Public perception of risk
  - No IAEA safety guidelines for licensing & regulating SMRs
  - No large-scale deployment elsewhere

Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables: A view of a private financial institution

For Discussion Purpose Only

Transition Finance

Including Finance for LNG as a Transitional Fossil Fuel and Back Up for Intermittent Renewables

Aug 31st, 2021

MUFG Bank, Ltd.
A member of MUFG, a global financial group

MUFG

MUFG's Global Presence in Project Finance

Play a significant role in project finance globally

MUFG Bank and Project Finance

- MUFG Bank has been engaged in and committed to project finance since the 1980s
- MUFG was awarded Global Bank of the Year in 2011, 2013, 2015, 2016 and 2018 from Project Finance International (PFI) Magazine
- MUFG won Global Bond House of the Year in 2017 and 2019 from PFI
- MUFG was ranked Global No1 in MLA League Table of PFI Magazine eight years in a row from 2012 to 2019
- MUFG was ranked Global No 2 in Clean Energy & Energy Smart Technology League Table by Bloomberg (as below)

Our Global Presence

- Approx. 360 PF Professionals Across 8 Offices
- Global Coverage (as of April 2021):
  - New York (39 professionals)
  - Los Angeles (28)
  - London (125)
  - Frankfurt (4)
  - Singapore (39)
  - Hong Kong, China (12)
  - Sydney / Melbourne (41)
  - Tokyo (75)

MLA ranking for Clean Energy & Energy Smart Technology

Rank	Arranger	Amount (USD million)	Share	No. of Deals
1	SMBC	3,758	6.2%	68
2	MUFG	3,106	5.1%	62
3	Santander	3,039	5.0%	61
4	BNP Paribas	2,837	4.7%	49
5	Societe Generale	2,446	4.0%	57
6	Rabobank	2,301	3.8%	61
7	Mizuho	2,042	3.4%	40
8	Credit Agricole	1,770	2.9%	37
9	Caixa Bank	1,282	2.1%	23
10	ING	1,262	2.1%	30

(Source) Asset Finance Lead Arranger Ranking 2020 by Bloomberg

PFI AWARDS 2011 · PFI AWARDS 2013 · PFI AWARDS 2015 · PFI AWARDS 2016 · PFI AWARDS 2018

Global Bank of the Year

MUFG

PFI AWARDS 2017 · PFI AWARDS 2019

Global Bond House of the Year

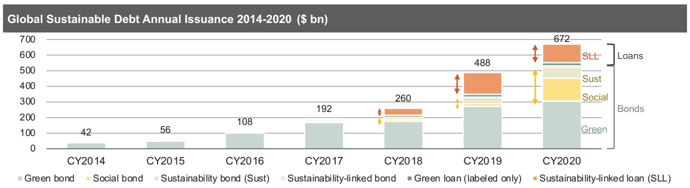
MUFG

MUFG

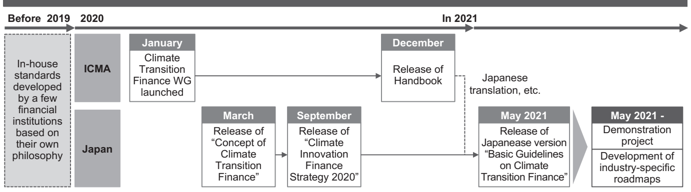
New Trends in Sustainable Finance

Developments in transition finance guidelines

Global Sustainable Debt Annual Issuance 2014-2020 ($ bn)



Guidelines on Transition Finance



(Source) Compiled based on Bloomberg NEF and the information on an article by Mizuho Research & Technologies, Ltd. from Nikkei ESG (February 2021 ed.)

MUFG

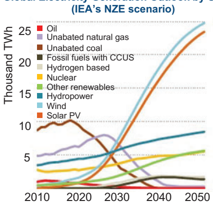
LNG and Transition Finance in Asia

Need a framework for transition finance

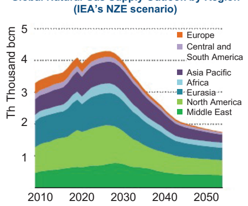
- **In IEA's Net Zero Emissions by 2050 scenario (NZE), natural gas continues to be one of the dominant sources in the power supply until 2030.**
- **Declines in power generated by unabated natural gas and global supply of natural gas after 2030.**
- **Under NZE scenario, declines in natural gas demand slow after 2040, and more than half of natural gas use globally in 2050 is to produce hydrogen in facilities with CCUS.**

LNG in the Electricity Sector and Supply Outlook in Net Zero Emission (NZE) Scenario

Global Electricity Generation Outlook by Source (IEA's NZE scenario)



Global Natural Gas Supply Outlook by Region (IEA's NZE scenario)



In order to support transition finance particularly in Asia…

- Need a framework to support transition finance in Asia
- Such framework should gain global consensus
- Each economy to establish a clear roadmap/strategy to achieve carbon neutral
- Transition projects need to be clearly incorporated into the roadmap/strategy

(Source) International Energy Agency (2021) "Net Zero by 2050 A Roadmap for the Global Energy Sector"

Typical Risks of Project Finance

Viewpoints from private financial institutions in case of LNG related project finance

Typical Project Risks

Key Risks		Mitigants
Sponsor Risk	■ Equity funding shortfall ■ Poor management of the Project ■ Sponsors to walk away	■ Financial strength and expertise of sponsors to execute the Project with good understanding of LNG ■ Strategic importance of the Project to sponsors and share maintenance commitment
Construction Risk	■ Delay and cost overrun	■ Turnkey EPC contract with experienced and financially strong contractors ■ Adequate schedule and budget with appropriate level of contingency and sufficient buffer to sunset date ■ Acceptable testing and commissioning regime under project documents
Technology Risk	■ Technical failures during construction and operation ■ Technology to become obsolete	■ Proven and tested technology ■ Technological competitive advantage over life of Project
Operating Risk	■ Poor operating performance	■ Experienced and financially acceptable operator with adequate staffing plan
Offtaker / Cashflow / Market Risks	■ Non-payment by offtakers ■ Revenue reduction due to internal and external issues (including force majeure)	■ Credit strength of offtakers and strategic importance of the Project to offtakers ■ Project underpinned by underlying demand and supply of LNG / power ■ Reasonable risk allocation (e.g. force majeure, termination events)
Feedstock Risk	■ Depletion of gas field ■ Supplier's failure to procure LNG ■ Mismatch between PPA and LNG supply contract	■ 1P+2P gas reserve covering debt service ■ LNG supplier's long term capability to procure LNG ■ Limited mismatch between LNG supply contract and offtake contract (particularly alignment of power dispatch volume and LNG supply volume)
Interface Risk	■ Poor performance of one asset affecting another during construction and operation in the case of multiple assets (with regas and power assets)	■ Alignment of interest of sponsors / lenders with substantially identical sponsors / lenders across assets and cross collateralization across assets (in the case of multiple assets)
Social & Environment al Risk	■ Adverse social and environmental impact ■ Reputational damage	■ Environmental and social compliance ■ Project consistent with energy transition plans of sponsors / offtakers / country
Country Risk	■ Expropriation, transfer & conversion restrictions, political violence, non-payment by government entities	■ Government support and guarantee ■ Long term importance / benefit of the Project to host country ■ ECA cover

〒100-8388 東京都 千代田区 丸の内 2-7-1

株式会社 三菱UFJ銀行 ソリューションプロダクツ部

当行が契約している指定紛争解決機関　一般社団法人 全国銀行協会

連絡先 全国銀行協会相談室

- ■ 電話番号：0570-017109 または 03-5252-3772
- ■ 受付時間：月～金曜日9:00～17:00（祝日、12/31～1/3等を除く）

Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables: A view of a government financial institution (by video)

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Supporting Your Global Challenges

JBIC

Transition Finance including finance for LNG as a transitional fossil fuel and back-up for intermittent renewables: A view of a government financial institution

SAKUMA Kazuko

Director General, Oil and Gas Finance Department

Japan Bank for International Cooperation (JBIC)

August 2021

Agenda

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JBIC

JBIC Overview

JBIC Overview

Brief Profile

Name	Japan Bank for International Cooperation (JBIC)
Established	Apr 1, 2012
Governor	Tadashi Maeda
*Capital**	(100% Government-owned): JPY 1,883bil (USD 17.1bil)
*Total Assets**	JPY 17,337bil (USD 157.6bil)
*Net Assets**	JPY 3,114bil (USD 28.3bil)
Number of Employees	636

Overseas Offices (17 offices)

* Figures as of March 31, 2020
※ JPY110/USD

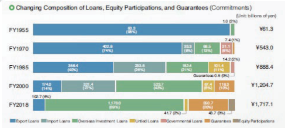
Tadashi Maeda / Governor

Government-owned financial institution

Japan Bank for International Cooperation (JBIC) is a policy-based financial institution wholly owned by the Japanese government.

Policy-based finance

JBIC provides policy-based finance with a mission of contributing to the sound development of Japan, the international economy and society as a whole.



Missions of JBIC

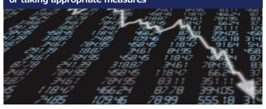
◆ JBIC is a policy-based financial institution wholly owned by the Japanese government which conducts lending, investment, and guarantee operations in the following four fields

①Promoting the overseas development and securement of resources which are important for Japan

②Maintaining and improving the international competitiveness of Japanese industries

③Promoting the overseas business having the purpose of preserving the global environment

④Preventing disruptions to international financial order or taking appropriate measures



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Fourth Medium-term Business Plan (FY2021–FY2023)

Direction of the Business

In FY2020, economic activities faced an unprecedented degree of restrictions due to the COVID-19 pandemic. Amidst expectations of strong recovery of the global economy after such a year, the international community is confronted by these common challenges: (1) exploring the way toward sustainable growth and development that achieves balance between the economy, society, and the environment; (2) acceleration of energy transition toward the realization of a decarbonized society; (3) responding to industrial and social transformation due to advancement in digitization. Taking these challenges into consideration, JBIC has set out the following objectives, from the perspective of policy-based finance. These objectives have been incorporated as action plans into the Fourth Medium-term Business Plan. JBIC is fully committed to the achievement of the plan.

Challenges faced by the global economy and society

- Sharing of sustainable development goals
- Addressing climate change and energy transition
- Investment demand in sustainable infrastructure
- Slow-down of global economy brought about by the COVID-19 pandemic
- Rapid digitization of industry and society
- Increasingly complex, geopolitical risks

JBIC's Objectives

- With a view to achieving the SDGs and realizing a decarbonized society, address global issues such as the formation of ecosystems that deploy decarbonized innovation created by Japanese companies, and effective energy transformation in the host country and resolution of social issues
- Offer proactive support for the overseas businesses of Japanese companies that are developing new global alliances with a view to realizing digital transformation and are reviewing and optimizing global supply chains
- While keeping in mind the needs of the host country and awareness of international cooperation, promote strategic initiatives to promote investment in quality infrastructure that gives consideration to openness, transparency, economic viability, and debt sustainability
- Exert the risk-assuming function, as well as policy-based finance functions that address the damage caused by the prolonged COVID-19 pandemic, create post-COVID new business opportunities overseas, and facilitate mobilization of private capital

Key Focus Areas

JBIC's corporate philosophy is, "Positioned at the crossroads of global business opportunities, JBIC is opening new venues to the future for the Japanese and global economy." Under this philosophy, it has established the medium- to long-term vision, "To serve as a 'navigator' to build a brighter future with Japanese power in an uncharted global situation," which defines what JBIC wishes to become over the next 10 years. Based on this vision, the Fourth Medium-term Business Plan sets out six key focus areas based on the theme "navigator in an era of transformation," in the context of objectives such as the realization of the SDGs and a decarbonized society, and the irreversible advancements in energy transformation and digital transformation. Seventeen action plans have been positioned under these six key focus areas, and JBIC is committed to achieving these action plans in coming years.

JBIC Medium- to Long-term Vision
To serve as a "navigator" to build a brighter future with Japanese power in an uncharted global situation

Fourth Medium-term Business Plan: Navigator in an era of transformation (JBIC Compass 2.0)		
	Key Focus Areas (Business)	1. Address global issues toward realizing sustainable development for the global economy and society.
		2. Support the strengthening of the international competitiveness of Japan's industries in the era of industrial and social transformation.
		3. Propel strategic initiatives to promote quality infrastructure projects overseas.
		4 Execute policy-based finance functions that are adapted to changes in the economic situation.
	Key Focus Areas (Organization)	5. Develop a business structure that can adapt to changes in the external environment.
		6. Manage the organization efficiently in order to respond to the "new normal."

Action Plans (Business)

JBIC

Key Focus Area 1	Address global issues toward realizing sustainable development for the global economy and society.

Action Plan (1) **Respond to energy transformation toward the realization of a decarbonized society.**

- To contribute toward the creation of a new ecosystem, with a view to reducing greenhouse gases worldwide and realizing decarbonization in Japan, support efforts to reduce greenhouse gases and popularize green innovation by financing projects in fields such as renewable energy and energy savings, smart energy (power storage technology, etc.), green mobility, smart cities, and promotion of the production, transportation, and utilization of hydrogen (Green finance)
- While working to engage host countries to make the shift toward sustainable energy, provide support for initiatives toward **global energy transition** by financing projects in areas such as **energy conversion**, **CCUS/carbon recycling**, **ammonia and hydrogen co-combustion**, in order to contribute toward expanding businesses that help to reduce environmental burden (Transition finance)

Action Plan (2) **Support projects that contribute toward resolving social issues.**

- To contribute toward efforts aimed at resolving social issues in host countries and realize sustainable growth, such as efforts to improve health, welfare and hygiene, create employment, and develop sustainable cities and living spaces, provide support for projects that assist resolving social issues in the host countries. These include the development and enhancement of the medical care environment (infectious disease countermeasures, hospital and medical equipment), access to basic infrastructure (water and sewage services, rural electrification and distributed power systems, information communications), development of the living environment (urban development and disaster prevention, public transport), improvement in the hygiene environment (waste disposal, reuse and recycling, countermeasures for marine plastic waste), and food safety and sustainable food systems (food value chains) (Social impact finance)

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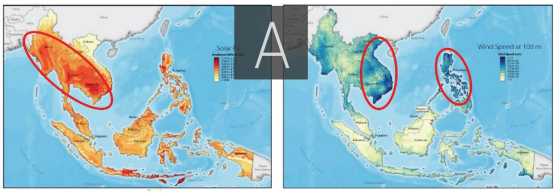
Realistic Energy Transition in Asia Pacific

1 Renewable Energy Potentials in ASEAN Countries

JBIC

- In ASEAN countries, **renewable energy resource potentials are unevenly distributed**.
- There are only a limited number of regions where renewable energy can be introduced at low costs.

<Solar resource potentials in ASEAN countries> <Wind resource potentials in ASEAN countries>



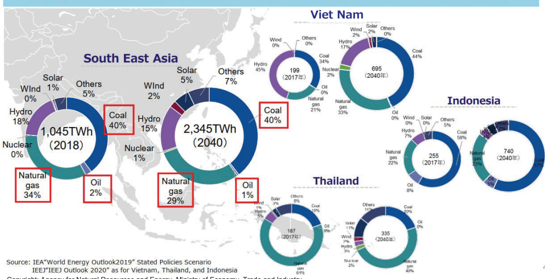
・LCOE (Levelized Cost of Energy), which doesn't include integration costs, such as battery costs or grid costs etc.

Source: Lee Nathan et al.(2020), EXPLORING RENEWABLE ENERGY OPPORTUNITIES IN SELECT SOUTHEAST ASIAN COUNTRIES

2 Importance of Natural Gas in ASEAN Countries

JBIC

- In the Asia-Pacific region, **IEA expects that fossil fuels will still be an important source of supply**, even if a rapid shift to renewable energy occurs.
- Especially in Southeast Asia, where the access to electricity is still insufficient, **the proportion of coal and natural gas will remain almost unchanged**.

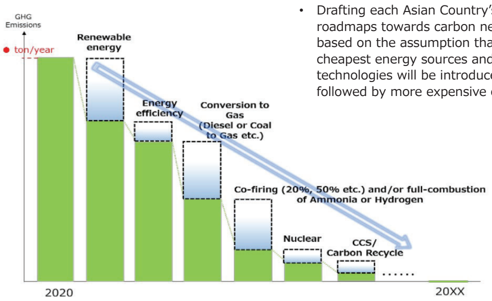


Source: IEA"World Energy Outlook2019" Stated Policies Scenario
IEEJ"IEEJ Outlook 2020" as for Vietnam, Thailand, and Indonesia

3 Utilization of Gas Ammonia or Hydrogen in Existing Facilities

JBIC

<Image of achieving net-zero scenarios in Asia>



- Drafting each Asian Country's roadmaps towards carbon neutrality based on the assumption that the cheapest energy sources and technologies will be introduced first, followed by more expensive ones.

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JBIC's Commitment for Energy Transition in Asia Pacific

1 Policy Dialogue with Host Countries' Government

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JBIC Governor discussed with PM and CEC Chairman for Energy Transition in Viet Nam

Proposal to the Government of Viet Nam and CPV (May 2019)

① Transition from coal to gas-fired power and renewable energy
② Introducing technologies with low environmental impact for coal-fired power

Poliburo Resolution No.55 "National Energy Development Strategy to 2030" (Feb 2020)

① Emphasis on gas-fired and renewable energy
② Coal-fired power's ratio to be adjusted appropriately, and prioritize the introduction of advanced, high-efficiency technology

PM Phuc (then) and JBIC Governor Maeda (May 2019)

CEC Chairman Binh (then) and JBIC Governor Maeda (May 2019)

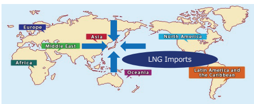
2 Finance Solution for LNG Value Chain

JBIC

2 Finance Solution for LNG Value Chain (concept)

JBIC

Before

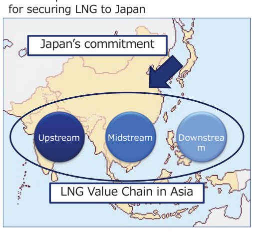


▲Primarily focusing on projects which directly contribute to securing LNG to Japan

Japan's aims to focus on LNG Value Chain in Asia

1) **To create a thick and matured LNG market enabling Japan to ensure stable supply of LNG**
2) **To support realistic and sustainable energy transition in Asia**

▼Development of LNG Value Chain in Asia for securing LNG to Japan



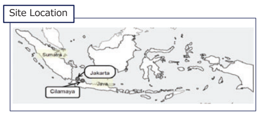
Now

3 Finance Record: Jawa 1 Gas to Power Project (Indonesia)

JBIC

Project outline	・IPP capacity: 1,760 MW ・FSRU capacity: 170,000㎥ ・PPA: 25 years
Project site	Cilamaya, West Java Province, Indonesia
Sponsors	Marubeni Corporation, Sojitz Corporation, Mitsui O.S.K. Lines, Ltd.("MOL"), PT. Pertamina (Persero), etc.
Signing date	October 18, 2018
JBIC loan amount	USD604 million (co-financing amount: USD1,312 million)

Site Location



Project Diagram

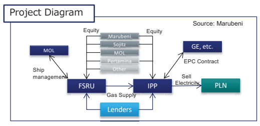
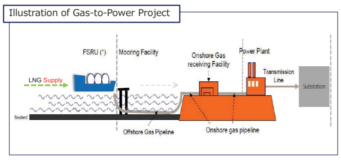


Illustration of Gas-to-Power Project



Characteristics

- **First project financing for Gas-to-power project in Asia**
- Support for economic growth through stable energy supply in the country

3 Finance Record: Meghnaghat Natural Gas-Fired Combined Cycle Power Plant Project (Bangladesh)

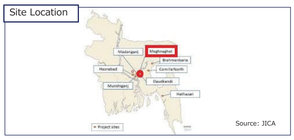
JBIC

Project outline	・Project to build, own and operate a natural gas-fired combined cycle power plant ・Power generation capacity: 718MW ・PPA: 22 years
Project site	Meghnaghat, located some 40 km southeast of the capital Dhaka, Bangladesh
Sponsors	JERA Co., Inc. and Reliance Power Limited.
Signing date	July 30, 2020
JBIC loan amount	USD265 million (co-financing amount: USD642 million)

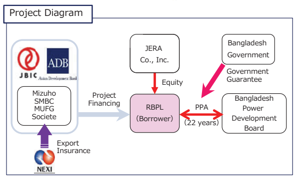
Characteristics

- **First IPP project in Bangladesh where a Japanese company is participating**
- JBIC's first project financing extended to Bangladesh
- Support for economic growth through stable energy in the country

Site Location

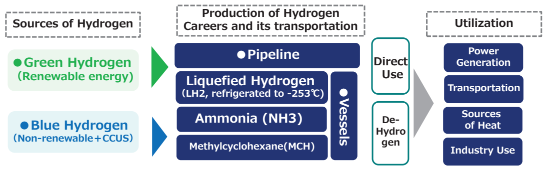


Project Diagram



4 Support for Hydrogen / Ammonia Supply Chain

JBIC



Similar areas in which JBIC has ever had financing experiences		
• Development of gas field and coal mine • Steam-methane reforming • CCS / CCUS • Renewable energy power generation	• LNG production (liquefaction of CH4, refrigerated to -162° C) • Ammonia production • LNG careers • Oil and gas pipelines	• LNG receiving terminals • Thermal power generation (gas and coal fired power plant) • Hydrogen stations • Gas distribution • Iron manufacturing • Oil refining
Areas in which JBIC has not experienced financing so far		
• Water electrolysis	• LH2 production (liquefaction of H2, refrigerated to -253° C) • Hydrogen careers	• Hydrogen receiving terminals

Thank you for your kind attention.

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JAPAN BANK FOR INTERNATIONAL COOPERATION

Report from ABAC Sustainability Working Group

APEC Business Advisory Council

Report from ABAC Sustainability Working Group

Takashi Imamura
Executive Officer and GM of Research Institute, Marubeni Corporation
ABAC Sustainability Working Group

ASIA PACIFIC ENERGY RESEARCH CENTRE
APEC SYMPOSIUM ON THE HOLISTIC APPROACH OF DECARBONIZATION TOWARDS CARBON NEUTRALITY (ONLINE)
August 31, 2021

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ABAC Views on Renewable Energy

ABAC REPORT TO APEC MINISTERS RESPONSIBLE FOR TRADE
MAY 2021 "PEOPLE, PLACE AND PROSPERITY – TĀNGATA, TAIAO ME TE TAURIKURA"

1. APEC economies will not be able to meet Paris Agreement commitments
2. Major shift in energy policies are necessary to move towards carbon neutrality
3. Trade and investment in renewable energy and low emissions technologies are key to achieving carbon neutrality and energy resilience
4. APEC should build consensus on approaches to the challenge of reducing emissions, through cooperation to promote such trade and investment in renewable energy
5. Economies will transition according to domestic objectives and resources, but the whole APEC region will benefit from addressing the challenges of reducing emissions by sharing technologies, best practices, and successful business models

ABAC Recommendations on Renewable Energy

ABAC REPORT TO APEC MINISTERS RESPONSIBLE FOR TRADE
MAY 2021 "PEOPLE, PLACE AND PROSPERITY – TĀNGATA, TAIAO ME TE TAURIKURA"

1. Develop an APEC framework for trade and investment in renewable energy, to assist and encourage all APEC economies to achieve carbon neutrality and energy resilience through development of policies which will accelerate the adoption of renewable energy and low emissions technologies
2. Develop suitable policy measures to best assist each economy to achieve low carbon energy and eventual neutrality, promoting innovative technology development, enhancing energy resilience and continued sustainable economic growth, while acknowledging the vast differences between economies, in geographical constraints, and stages of development, including available infrastructure.

➡ Setting the goal of carbon neutrality, while recognizing the importance of energy resiliency and the differences between economies

Report from ERIA on Decarbonization Scenarios for ASEAN

APEC Symposium on the Holistic Approach of Decarbonization towards Carbon Neutrality organised by APERC on August 31st , 2021

Decarbonization Scenarios towards Carbon Neutrality in ASEAN: Methodology and Expected Results

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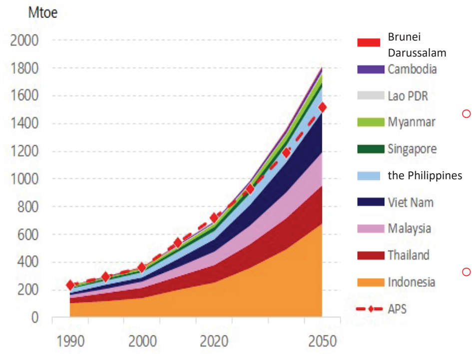
Rapid Growth in Energy Demand & the Energy Landscape



- In line with rapid economic growth, energy demand in ASEAN countries are expected to expand sharply towards 2050 and later.
- Even in the APS (Alternative Policy Scenario), which includes ambitious energy-saving targets, ASEAN's primary energy demand grows 2.2 times by 2050.
- At current energy system, fossil fuels (oil, coal, and natural gas) make up almost 80% of the primary energy mix for ASEAN region.

Distributed VRE Resources

Solar Europe

ASEAN

Source:
Global Solar Atlas

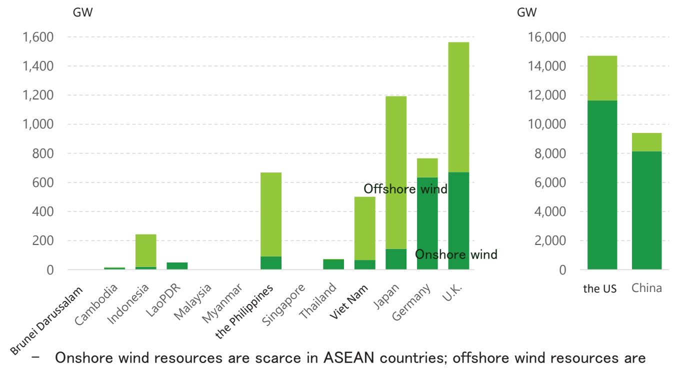
Wind Europe

ASEAN

Source:
Global Wind Atlas

- **VRE resources differ significantly across regions.** While wind power resources are abundant in Europe, ASEAN countries see relatively scarce resources except for those in specific areas in Viet Nam and the Philippines.

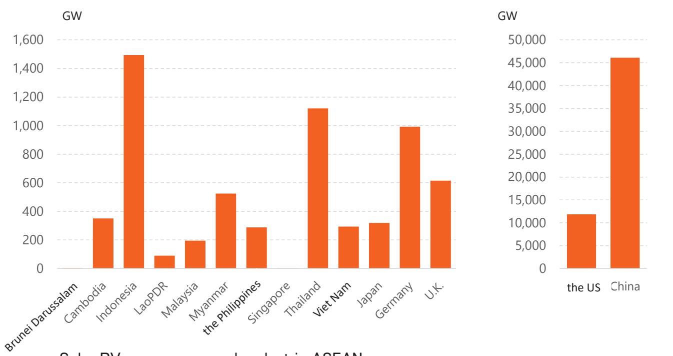
Estimated Wind Resources



- Onshore wind resources are scarce in ASEAN countries; offshore wind resources are present only in the Philippines, Viet Nam, and Indonesia, although they are not as abundant as in countries in other regions.

(Sources) IEEJ estimate using geographic information system (GIS) data

Estimated Solar PV Resources



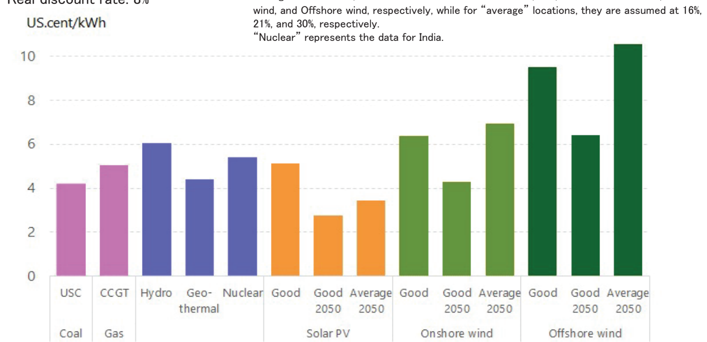
- Solar PV resources are abundant in ASEAN.
- We should note, however, that large-scale deployment of solar PV may lead to intrinsic difficulties as described later.

(Sources) IEEJ estimate using geographic information system (GIS) data

Comparison of Power Generation Costs (LCOE)

Real discount rate: 8%

For "good" locations, the load factors are assumed at 21%, 36%, and 51% for solar PV, Onshore wind, and Offshore wind, respectively, while for "average" locations, they are assumed at 16%, 21%, and 30%, respectively.
"Nuclear" represents the data for India.



- Levelized cost of electricity (LCOE) refers to the average power generation cost per one unit of generation. Because of the low fossil fuel prices, VRE costs are still higher than coal power generation, although solar PV may be cheaper than coal in 2050.

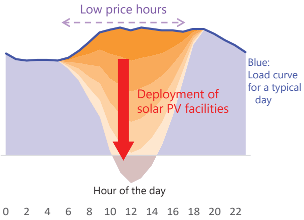
(Sources) Estimated based on "Technology Data for Indonesian Power Sector," IEA, "World Energy Outlook 2020," and other sources

Challenges associated with high shares of VRE: Cannibalization effect

With large deployment of solar PV power generating facilities,

– Massive electricity is supplied with very low marginal costs, during the daytime on a sunny day.

– Wholesale electricity prices take very low values during those hours.



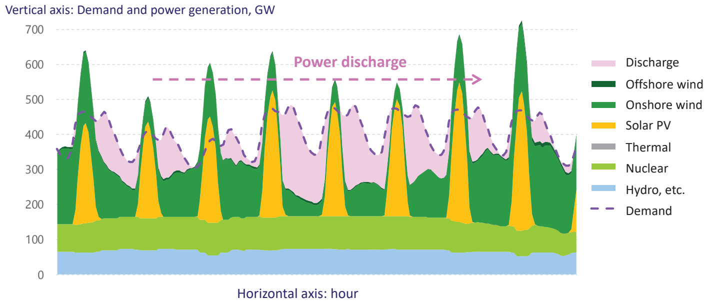
Under such situations,

– As solar PV facilities only generate electricity during low-price hours, *"market values" of solar power facilities decline* significantly in line with solar power deployment.

– If the "value" falls below the LCOE, further deployment of solar PV facilities becomes difficult.

– Similar situations also take place, although in a somewhat milder manner, for large deployment of wind power facilities.

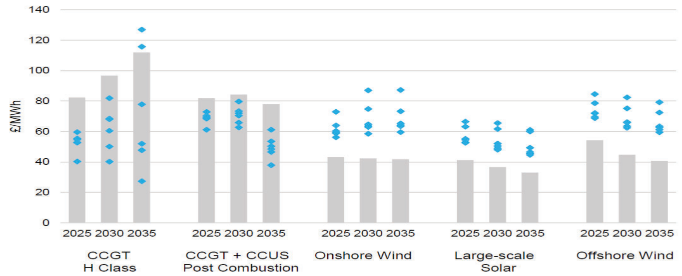
Challenges associated with high shares of VRE: Risk of supply disruption



・ **Windless and sunless periods**, also known as **dark doldrums**, in which wind and solar power output is exceptionally small for several days, can take place once or twice in a year. The above figure illustrates an extreme case with zero thermal power generation during these periods, in which massive power discharge is required to meet the demand.

・ To achieve very high shares of VRE, it would be required implement energy storage capacities large enough to meet electricity demands.

Marginal Costs of Power Sources: An example

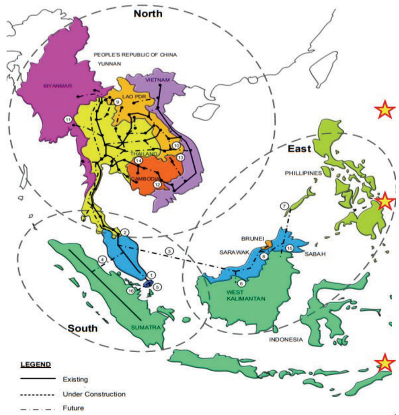


・ Because of the changes in electricity market caused by high penetration of variable renewable energies, the marginal costs of power sources can vary significantly from LCOE; the effective cost of solar PV can be considerably higher than the LCOE, because of the intermittency.

・ U.K. Department for Business, Energy Industrial Strategy (BEIS) estimates that although the LCOE of CCGT is expected to be higher than that of VRE, the "enhanced levelized cost" of CCGT can be lower than that of VRE, depending on the energy mix in which they exist. These effects can only be estimated with detailed mathematical models with a high temporal resolution.

(Source) BEIS, Electricity Generation Costs 2020.

Power Grid Interconnection and Hydro Resources



– Hydropower resources are distributed unevenly in the ASEAN region; international grid expansion can maximize the use of the hydro resources.

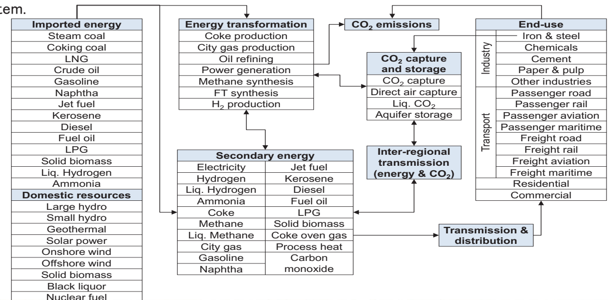
– Thus, international cooperation is important for decarbonization in ASEAN.

(Source) HAPAU, 2015

ERIA-IEEJ-UTokyo Energy System Model

– This study uses an ASEAN version of IEEJ–NE linear programming model, originally developed by the University of Tokyo, and currently under development by ERIA and IEEJ, that simulates the cost–optimal deployment of energy technologies under technical constraints

– It encompasses the total energy system including energy transformation (power generation) and energy demand (industry, transport, residential, and commercial) sectors with high time resolution (up to 8,760 time slices with an hourly resolution), to simulate the effect of VRE penetration on the energy system.



Regional divisions 10 ASEAN member countries

Time period 2017 – 2070 with representative years of 2017, 2030, 2040, 2050, 2060 and 2070

Objective function Discounted total energy system cost for ASEAN

Discount rate 8%

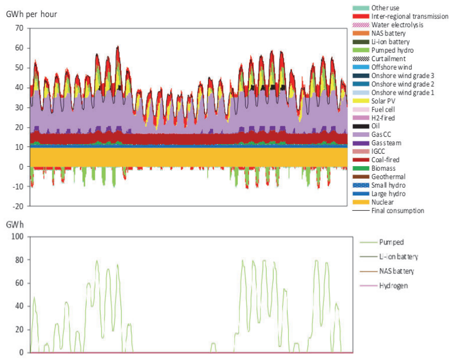
Temporal resolution 8760 time slices per year for electricity supple and demand balance

End-use sectors Energy service demand is obtained from IEEJ Outlook

Industry - Iron & Steel, Cement, Chemicals, Paper & pulp, Other industries
Transport - Passenger LDV, Bus & truck, Rail, Aviation, Navigation, Other transport
Residential - Space cooling, Water heating, Kitchen, Other residential
Commercial - Space cooling, Refrigerator, Office appliances, Other commercial
Other - agricultural and other energy demand

- Temporally disaggregated (8760 time slices per year) to capture the variability of renewable energy and system integration cost
- Co-firing at both existing and newly installed power plants are explicitly modeled

Modeled technologies	
Coal-fired	Geothermal
Coal-Ammonia co-firing (20%)	Solar PV
	Onshore wind
IGCC	Offshore wind
Gas-fired	Biomass-fired
Gas combined	Nuclear
Gas-Hydrogen co-firing (H_2 20%, 40%, 60%, 80%)	Hydrogen-fired
	Ammonia-fired
	Pumped hydro
	Li-ion battery
Hydro	H_2 tank



Technologies Assumed for the Study

Technologies assumed in prior models

– Energy saving/efficiency improvement
– Fuel switching/electrification
– Renewables (Wind, solar PV, hydro, geothermal, biomass, etc.)
– Energy storage systems (Batteries, pumped hydro)
– Nuclear (LWR)

New technologies assumed for the study

– Secondary energy carriers (Hydrogen, ammonia, etc.)
– Carbon recycling (Synthetic methane, synthetic fuels, etc.)
– CO_2 transportation
– Negative emission technologies (Direct air capture with CCS, biomass with CCS)

Tentative Calculation for the Power Sector

– Calculate the "optimal" (=least cost) 2050 power generation mix for the 10 ASEAN countries, with different carbon prices from 0 to 500 USD/tCO_2.

– Tentative LCOE Assumptions are:

Coal: 4.1 cent/kWh
Gas: 4.3 cent/kWh
Gas with CCS: 6.8 cent/kWh
Hydrogen: 11.7 cent/kWh
Nuclear: 5.7 cent/kWh

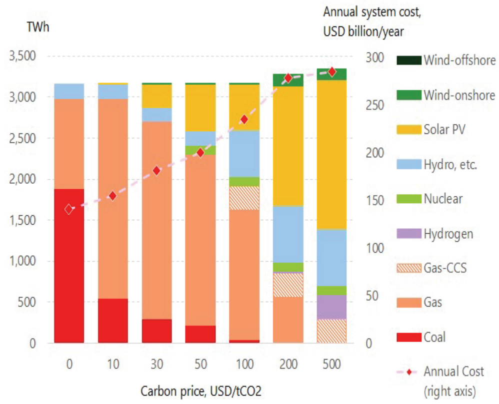
Solar PV: 4.0 cent/kWh
Onshore wind: 7.1 cent/kWh
Offshore wind: 9.6 cent/kWh
Hydro: 6.0 cent/kWh

– Other assumptions include:

– Availability of CCS is limited to 100 MtCO_2 annually.

– New nuclear power construction is limited to 16 GW.

Tentative Calculation: Power Generation Mix and Total System Cost (total of 10 countries)



Without carbon prices coal–fired and natural gas–fired power generation is dominant.

However, with higher carbon prices, low–carbon technologies such as hydro, nuclear, CCS, and hydrogen are introduced, despite the large differences in the LCOE of the technologies.

Decarbonization Scenarios (Cases- setting)

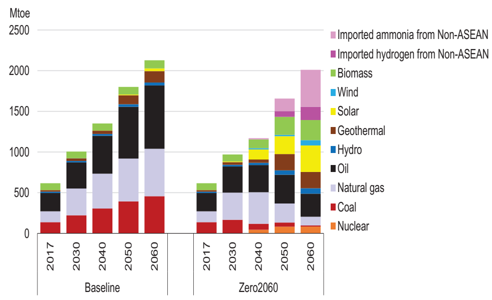
Case 1 – *Reg2050*: CO_2 regulation for ASEAN, net zero by 2050

Case 2 – *Reg2060*: CO_2 regulation for ASEAN, net zero by 2060

Case 3 – *Reg2070*: CO_2 regulation for ASEAN, net zero by 2070

Case 4 – *RegCntry*: CO_2 regulation by country

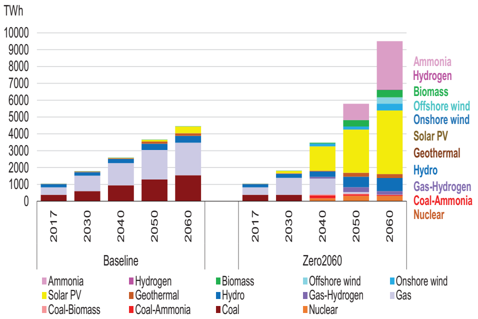
Primary Energy Supply-Preliminary Results



- A wide range of technologies, including renewables, nuclear, CCS and import of hydrogen and ammonia, are necessary for deep decarbonization.

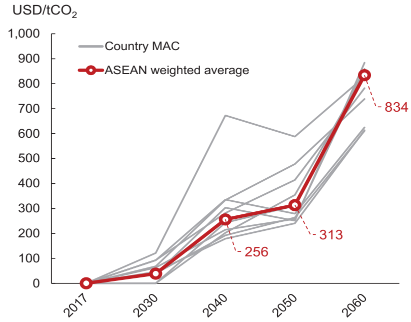
- Share of these technologies collectively reach 80% of primary energy supply in 2060 in the Zero2060.

Power Generation in ASEAN-Preliminary Results



- Renewables become the main power source in the Zero2060, accounting for 63% in 2060.
- Hydrogen and ammonia, including co-firing, could also be a part of the power generation mix.

Marginal Abatement Cost of Decarbonization Scenarios (Under calculation)

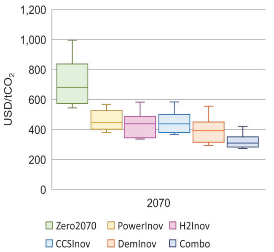


- Marginal abatement cost (MAC), which reflects the intensity of decarbonization policy measures, and is a proxy for carbon prices, can rise rapidly after 2050 and to 834 USD/tCO2 in 2060.

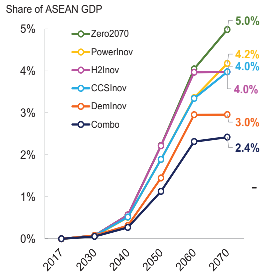
– Note that *the results are tentative and under scrutiny.*

Reducing the cost of decarbonization technologies

Marginal CO2 abatement cost (MAC)



Additional annual cost



- In order to achieve carbon neutrality, it is essential to reduce the cost of decarbonization technologies, such as battery, CCUS and hydrogen.
- If the cost of 4 technologies is reduced, the cost of reducing the marginal abatement cost of CO2 will drop to approximately $300 in 2070.

<Technological Innovation>

○Power innovation…Cost reduction of battery and international grid extension.
○CCS innovation…Cost reduction of DAC, and CO2 storage capacity expands.
○Hydrogen innovation…Cost reduction of hydrogen production and consumption.
○Demand-side innovation…Cost reduction of demand-side technologies.
○Combo…All four innovation has been achieved.

– Note that *the results are tentative and under scrutiny.*

Conclusion and way forward

- Decarbonization pathways are different across regions. The achievement of very ambitious carbon reduction targets in ASEAN may face problems different from that in other regions, such as limited wind resources. Thus, **developing regional decarbonization scenarios based on quantitative analyses will be important for future policy making**.
- The consideration of "decarbonization technology mix," which exploits all the technologies that are available now, and that will be available in the future, would be important from a practical point of view. In addition, **We should also be aware that even with advanced technologies, the tremendous costs associated with very ambitious targets may soar into the future.**
- In this context, **development of innovative technologies through cooperation among advanced countries and regional cooperation**, such as the development of an international power grid in the Mekong region and the establishment of hydrogen/ammonia value chain, **will be a "key"**.

Panel Discussion on Energy Security

Carbon Neutrality and Energy Security : From **Thailand's** Policy Point of View

Dr. Twarath Sutabutr
Chief Inspector-General
Ministry of Energy, Royal Thai Government

Carbon Neutrality and Energy Security

Policy Considerations ➔ Trade off:

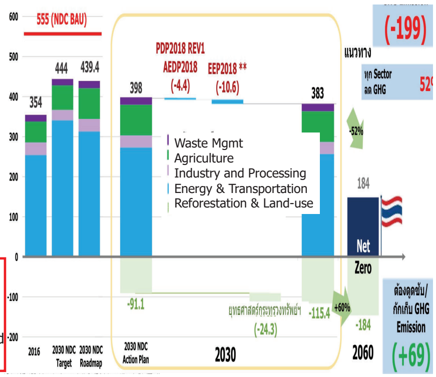
1. "Domestic development" or "Imported supply" of Clean Energy?
2. Planning based on "Existing" or "Emerging & Unproven Technologies"
3. Market transformation based on "Quick & Disruptive" or "Gradually Progressive"

Status Quo and Existing Plans

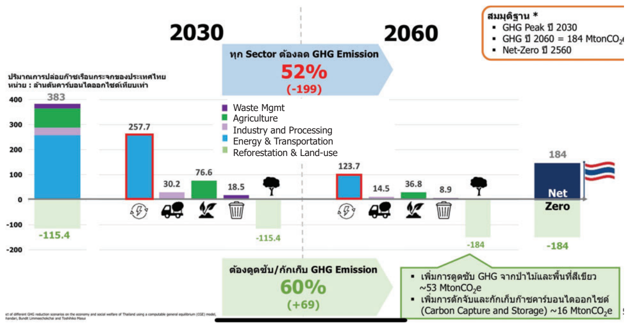
Thailand

- Emitted 354 m.ton of GHG @2016 (our NDC baseline)
- Had submitted NDC targets and developed a comprehensive roadmap where the projection pointed to the level of emission at 444 m.ton at 2030 (vs. 555 of BAU case)
- Additional efforts ➔ revised plans:
  - MoNRE's reforestation revised plan will increase carbon sinks capabilities from 91.1 to 115.4 m.ton in 2030
  - MoEN's integrated energy blueprint (PDP/AEDP/EEP) 2018 will further reduce the emission by 15 m.ton by 2030

- Now planning with assumptions:
  - Peak year @2030
  - Net-Zero year @2060
- The remain of 199 m.ton of GHG or 52% need to be mitigated further



Thailand needs to cut 52%(from its peak level)of GHG from 2030➔ 2060



Thailand needs to cut 52%(from its peak level)of GHG from 2030➔ 2060

Policy Considerations ➔	**➔ What are we considering….**
1. "Domestic development" or "Imported supply" of Clean Energy?	1.1 More imported power from neighboring countries via ASEAN Power Grid 1.2 More RE development domestically with focus on Solar & Biofuels
2. Planning based on "Existing" or "Emerging & Unproven Technologies"	Both….. 2.1 Advanced EE in Industries & Smart Cities 2.2 Anticipating more carbon sink technologies esp. CCUS 2.3 Anticipating Hydrogen to mix with Natural Gas 2.4 Next-Gen Biofuels for jet fuels
3. Market transformation based on "Quick & Disruptive" or "Gradually Progressing"	Both…… 3.1 Biomass pallet (ala Reforestation) replacing coal in industries 3.2 EVs gradually replacing ICE vehicles

Thank you