APEC Capacity Building Workshop on APEC's Goals of Doubling the Renewable Energy Share in the Energy Mix and Reducing Energy Intensity

Workshop Summary

APEC Energy Working Group

February 2024

Asia-Pacific
Economic Cooperation

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1 Background

The Asia-Pacific Economic Cooperation (APEC) Capacity Building Workshop on APEC's Goals of Doubling the Renewable Energy Share and Reducing Energy Intensity took place on 29-30 December 2022. In 2011, APEC Leaders committed to reducing aggregate energy intensity by 45% by 2035 (using 2005 as the base year). In 2014, they also agreed to double the share of renewable energy in APEC's energy mix by 2030 (compared to 2010 levels). Moreover, most APEC members have announced their carbon-neutral goals. Hong Kong, China (HKC) organized this workshop in collaboration with the Expert Group on Energy Efficiency and Conservation (EGEE&C) and the Expert Group on New and Renewable Energy Technologies (EGNRET) to:

- report and project progress on APEC regional goals,
- promote effective energy intensity reduction and renewable energy policies and best practices,
- highlight new energy efficiency (EE) and renewable energy (RE) policies and frameworks that help accelerate progress towards achieving APEC's climate goals.

The outcome of this workshop will serve as a reference for members to set their respective energy efficiency (EE) and renewable energy (RE) targets, policy framework, and roadmap to achieve APEC's goals and carbon neutrality.

2 Objective

The workshop aimed to enhance the capacity of APEC members and promote collaboration among the APEC Energy Working Group (EWG), APEC fora, and external partners (including intergovernmental organisations, private companies, think tanks, and non-governmental organisations). The objectives were:

(1) to achieve APEC's regional goals of increasing renewable energy and reducing energy intensity, and
(2) to strengthen the cooperation for carbon neutrality.

The workshop covered topics such as:

- global climate action and the APERC's Energy Demand and Supply Outlook,
- successful energy efficiency policies and initiatives in APEC,
- successful renewable energy policies and initiatives in APEC, and
- emerging low-carbon technologies and economic instruments.

3 Workshop Summary

3.1 Opening Remarks of Workshop

Presenter: Mr TSE Chin-wan, Secretary for Environment and Ecology, Hong Kong, China

APEC member economies consume 60% of the world's energy. As the region develops and urbanizes, consumption will increase. APEC aims to reduce energy intensity by 45% by 2035 compared to 2005 levels. HKC has already reduced energy intensity by over 30%, but more needs to be done. HKC's goals are to achieve carbon neutrality before 2050, and to reduce the total carbon emissions from the 2005 level by half before 2035. To this end, HKC will tackle the carbon emissions problem at source through its four major decarbonisation strategies, namely (1) Net Zero electricity generation, (2) energy saving at green builders, (3) green transport, and (4) waste reduction.

Hong Kong, China's local electricity generation contributes two-thirds of its carbon emissions. HKC is reducing coal use and replacing it with low-carbon and zero-carbon energy. HKC aims to increase the share of renewable energy in electricity generation to 10% by 2035 and gradually to 15% by 2050. HKC is also exploring the feasibility of hydrogen blending. Energy-saving in buildings is crucial since they account for 90% of electricity consumption and over 60% of carbon emissions. The government aims to improve the energy performance of government buildings by 6% by 2024-25 and promote district cooling systems.

Public participation is essential for energy conservation. Energy labels are mandatory for prescribed products to inform consumers of their energy efficiency. HKC plans to expand the scope of labelling to include more household appliances, increasing coverage from 50% to 80%. To strengthen coordination and promote decarbonization, an Office of Climate Change and Carbon Neutrality will be established to formulate strategies, policies, and action plans for tackling climate change and achieving carbon neutrality. Dialogues with stakeholders will be held to develop innovative decarbonization ideas. The Council for Sustainable Development will become the new Council for Carbon Neutrality and Sustainable Development, providing advice on decarbonization strategies, and promoting the participation by different community sectors.

Building a carbon-neutral future requires the efforts of every sector and economy in the region. Participants in the workshop were encouraged to take advantage of the occasion.

3.2 Project Summary of Day 1 Presentations

Presenter: Ms Elaine YIP, Project Officer, Engineer of Electrical and Mechanical Services Department, Hong Kong, China

This workshop was the first collaboration between APEC's expert groups on Energy Efficiency and Conservation (EGEEC) and New and Renewable Energy Technologies (EGNRET).

The two half-day workshops consist of four sessions, covering:

(1) highlights of the global climate action and the APERC's Energy Demand and Supply Outlook,
(2) key drivers of the successful policies and initiatives in energy efficiency in APEC,
(3) key drivers of the successful policies and initiatives in renewables in APEC, and
(4) emerging low-carbon technologies and economic instruments.

The 27th session of the Conference of the Parties (COP27) to the United Nations Framework Convention on Climate Change took place in Egypt in mid-November 2022. During the event, the importance of energy transition in addressing climate change was emphasized. The focus on hydrogen, particularly green hydrogen, continued from COP26 to COP27 with discussions on unlocking its potential.

3.3 Session 1: Highlights of the Global Climate Action and the APERC's Energy Demand and Supply Outlook

Sharing 1-1: Highlights of the global climate action – COP27

Presenter: Dr William Chung, Associate Professor, City University of Hong Kong, Hong Kong, China

During COP27, energy issues for climate change adaptation and mitigation were a concern. While waiting for the official results, the materials presented here were related to energy issues published on the COP27 official website.

Green hydrogen has the potential to industrialize Africa sustainably and increase GDP by 6 to 12% in six key economies. These economies, members of the Africa Green Hydrogen Alliance (Egypt, Kenya, Mauritania, Morocco, Namibia, and South Africa), have identified commercial opportunities, job creation, top export markets, and investment needs. With abundant wind and solar energy resources, these economies can competitively produce green hydrogen and related products like ammonia to meet domestic demand and export to priority markets like the European Union; Japan; and Korea.

Investment in fossil fuels must be rapidly phased out to avoid disastrous consequences. The international community, including the International Energy Agency (IEA) and the High-Level Expert Group on Net Zero, recognizes that expanding fossil fuels is incompatible with the Paris Agreement's climate targets. Transitioning to renewable energy can provide 100% access to the world's population through solar and wind power alone, with an estimated cost of USD450 billion annually until 2030. However, the world is set to spend USD570 billion per year on new oil and gas during the same period.

The electricity sector is a significant contributor to global emissions, accounting for 25% of all GHG emissions. The good news is that there is a growing shift to renewables in this sector, reaching over 29% globally. COP27 is an opportunity to move from commitments to action and implementation, particularly in Africa and Asia, ensuring a just and equitable energy transition.

In the transport sector, leaders in the maritime industry and green hydrogen have agreed on ambitious targets to achieve zero emissions in global shipping by 2050. Ten organizations have signed a Joint Statement on Green Hydrogen and Green Shipping, committing to adopting green hydrogen-based fuels rapidly. They call on policymakers for support in achieving these targets as the shipping sector's emissions are expected to grow to 50% of global greenhouse gas emissions by 2050 without intervention.

The Breakthrough Agenda is a plan to speed up the process of reducing carbon emissions in five important sectors. Governments from economies that make up more than half of the world's economy have created a 12-month action plan to make clean technologies more affordable and accessible worldwide. As part of this plan, these economies have set out sector-specific "Priority Actions" to reduce emissions in power, transportation, and steel industries, as well as increase the production of low-emission hydrogen and promote sustainable agriculture. These measures aim to lower energy costs, decrease emissions quickly, and improve food security for billions of people around the world. The Priority Actions include agreements to:

- Develop common definitions for low-emission and near-zero emission steel, hydrogen, and sustainable batteries to ensure credibility and transparency in directing investments, procurement, and trade.
- Establish a common target date to phase out polluting cars and vehicles, in line with the Paris Agreement. The dates of 2040 globally and 2035 in leading markets will be announced by economies, businesses, and cities on Solutions Day.

- Utilize private and public procurement and infrastructure spending to stimulate global demand for green industrial goods.
- Strengthen financial and technological assistance to developing economies and emerging markets to support their transitions, including the creation of a dedicated industry transition program under the Climate Investment Funds.
- Promote investment in agriculture research, development, and demonstration (RD&D) to address challenges related to food insecurity, climate change, and environmental degradation.

From an investor's perspective, there are some issues related to carbon credits and the energy transition that need to be addressed. One issue is the imbalance between rich and poor, which the Just Climate Transition idea aims to address. Carbon markets can help, but there are challenges. The process of accrediting and validating carbon projects is complex and costly, especially for start-ups. Choosing the right carbon offset standard also requires careful planning. Cash flow and liquidity can be difficult for businesses using carbon credits to lower prices. They must wait for at least a year after selling the product to receive revenue from carbon credits. Companies often enter pre-financing agreements to bridge this gap. Finding buyers at desirable prices is another challenge, as most transactions occur through brokers. Transparency in the carbon markets is lacking, although efforts are being made to improve it. Buyers should prioritize quality over price for maximum impact. High-quality credits are additional, permanent, accurately estimated, not claimed by others, and don't cause harm. Supporting efforts to improve the overall quality of carbon credits and companies that benefit local communities is important.

COP27's results related to energy were criticized by Alok Sharma, the COP26 President. He expressed disappointment in the lack of clear commitments to peaking emissions before 2025, phasing out coal, and phasing out all fossil fuels. He emphasized the need for stronger actions to limit global warming to 1.5 degrees Celsius.

Sharing 1-2: Milestones to a cost-effective way to transport renewable electricity via hydrogen trade

Presenter: Mr Dolf Gielen, Director of the IRENA Innovation and Technology Centre

Global hydrogen demand in 2050 is estimated to increase significantly. Currently around 120 million tons of hydrogen are produced yearly, but only 2% of hydrogen production is clean, with 1% being green and produced from water electrolysis, and 1% being blue, produced from fossil fuels with CO_2 capture and storage.

To meet future demand, hydrogen production needs to grow four to six-fold, reaching between 500 and 800 million tons by 2050. Green hydrogen is expected to become the dominant form of production in the next 30 years, accounting for 12% to 22% of total final energy demand.

Affordable hydrogen production relies on the cost of renewable electricity and electrolysers. The target cost for hydrogen production is around USD1.50 per kilogram. Electrolyser costs are expected to halve by 2030.

There are more than 500 hydrogen projects in development, more investments are needed to close the gap between projects and investment decisions. Europe, North America, Latin America, and the MENA region are key regions for hydrogen development.

Discussions were held on hydrogen trade routes, plans, and agreements. The Middle East, North Africa, and sub-Saharan Africa have significant potential for hydrogen technology and production. The total global potential is more than ten times the current global energy usage. Due to variations in potential and production costs, significant trade is expected. IRENA analysis suggests that around a quarter of hydrogen will be traded, with Europe and East Asia as importers and worldwide exporters emerging.

Transportation cost efficiency for hydrogen (H2) is a concern. Pipelines are considered the most cost-effective mode of transportation, accounting for about half of international trade. The other half will be shipped via oceans, with ammonia being the leading form of transportation due to its higher energy efficiency and lower cost. Additionally, the ammonia trade has already been well-established. Apart from the ammonia trade, there is anticipated future trade of clean or green hydrogen commodities such as methanol and synthetic fuels.

The majority of hydrogen derivatives are shipped globally. It is estimated that clean hydrogen production worldwide will reach around 60 million tons by 2030, accounting for approximately half of all hydrogen production. Africa, India, the Middle East, Latin America, the Rest of Asia, and the CIS will emerge as producers, with the Middle East and CIS predominantly producing blue hydrogen, while Africa and Latin America primarily produce green hydrogen. North America and China will also see significant growth in hydrogen production.

As mentioned earlier, ammonia will be the main form of hydrogen trade, but there will also be the trade of hydrogen-based commodities. Short-term ammonia will play a crucial role, as it can serve as a hydrogen energy carrier and is already an important commodity used in various industries, such as nitrogen fertilizers, methanol production, chemical feedstock, and synthetic kerosene for jet fuel. Ammonia will have a significant market, especially with upcoming policy regulations mandating their use. The decarbonization of the iron and steel industry is another critical market that requires large amounts of hydrogen for direct emissions reduction.

The expected demand for ammonia until 2050 is projected to grow three-and-a-half-fold from present levels, driven by its use as a shipping fuel and a hydrogen carrier for ocean-going trade. Ammonia serves as an early market opportunity for green hydrogen use, with numerous renewable ammonia projects currently underway. There are also ongoing commercial decisions for these projects, indicating solid development of renewable ammonia production.

The Breakthrough Agenda Report highlights the importance of international cooperation for hydrogen in this decade. Recommendations include developing durable demand to support near-term investments in low-carbon and renewable hydrogen supply, implementing rigorous emission standards, investing in research and development to accelerate hydrogen applications, ensuring adequate financing across the value chain, preparing ports and transportation infrastructure for handling hydrogen and its derivatives, and harmonizing standards and certification systems for global market development.

Currently, there are around ten different standards and certification systems for clean and renewable hydrogen worldwide, which vary in terms of emissions thresholds, production processes, types, and pathways. Efforts are underway to harmonize these systems to facilitate global market development, with IRENA actively engaging with financing institutions like the World Bank to support green hydrogen projects and expedite their deployment.

Sharing 1-3: Key Messages from the APEC Energy Demand and Supply Outlook 8th Edition

Presenter: Mr Thanan Marukatat, Research Fellows, APERC

Mr Marukatat discussed two scenarios in the APEC Energy Demand and Supply Outlook. The Reference scenario (REF) reflects current policies and trends, while the Carbon Neutrality scenario (CN) explores hypothetical decarbonization pathways. The REF scenario serves as a baseline for comparison, while the CN scenario focuses on additional energy sector transformations to support decarbonization objectives. Both scenarios have their definitions, purposes, key assumptions, and limitations outlined in a table.

The APEC population is expected to increase in the short term, reaching a peak of around 3.2 billion between 2030 and 2040 before declining. The GDP of the APEC region is projected to grow significantly, driven by key economies like China and Southeast Asia, reaching USD150 trillion in 2050.

Results show that energy demand decouples from economic activity, meaning that despite population and GDP growth, total energy demand in the REF scenario does not increase significantly. In the CN scenario, APEC puts more effort into reducing energy demand, leading to a nearly one-quarter decrease by 2050 compared to the REF scenario. However, fossil fuels still play a significant role in both scenarios.

Electricity demand is met increasingly by wind and solar generation due to the transition towards electrification. Natural gas continues to substitute for coal and provides services to the electric grid. Coal, gas, and nuclear are projected to have significant shares in the reference case, while modern renewables, especially wind and solar, will increase significantly in the future. In the CN scenario, there will be a greater increase in wind and solar generation, along with a decline in coal and gas and the anticipated use of CO2 emissions absorption technology.

APEC aims to achieve dual energy goals: final energy intensity reduction and increased share of modern renewables. Projections show that APEC can meet these goals ahead of schedule. In terms of CO2 emissions reductions, APEC-wide emissions will decline by 14% in the REF scenario and 67% in the CN scenario by 2050.

Energy and emissions intensity improvements contribute to CO2 emissions reductions, with lower energy intensity delivering most of the reductions in both scenarios. The combination of growing GDP and energy intensity results in higher CO2 emissions, while the CN scenario further reduces emissions through energy and emissions intensity reductions.

Oil and gas security remains a concern in the CN scenario, with China being a net oil importer throughout the projection. The United States and Russia remain net exporters of oil. For natural gas, China, Northeast Asia, and Southeast Asia are projected to be net gas importers. Efforts to discourage oil and gas investment may affect supply elasticity and energy security.

The reliability of the electric grid is a challenge due to increased reliance on wind and solar generation. Intermittent generation from wind and solar sources can pose reliability issues and increase costs. This challenge needs to be addressed by APEC member economies.

In summary, Mr. Marukatat highlighted several key points: energy demand decoupling from economic growth, increased efficiency and electrification reducing demand, growth in wind and solar generation, the continued use of fossil fuels, progress towards APEC's energy goals, the importance of energy and emissions intensity reductions, concerns about oil and gas security in the CN scenario, and challenges related to electric grid reliability with increased wind and solar power generation.

3.4 Session 2: Key Drivers of the Successful Policies and Initiatives in Energy Efficiency in APEC

Sharing 2-1: Energy Efficient Mobility Systems

Presenters: Ms Sanjini Nanayakkara, Project Manager, NREL, the United States;
Venu Graikapati and Joshua Sperling, Senior Researchers, Centre for Integrated Mobility Sciences, NREL, the United States

The National Renewable Energy Lab (NREL) is funded and operated by the U.S. DOE. It focuses on sustainable transportation, including bioenergy vehicles and hydrogen technologies. The Centre for Integrated Mobility Sciences (CIMS) has a tool called Transportation Systems to measure mobility energy productivity.

Currently, the transportation system relies heavily on one energy source and carrier. While there is growth in light-duty electric vehicles (E.V.s) in the United States, they only account for 2% of vehicle sales and 59% of transportation GHG emissions. To achieve an 80% reduction in GHG emissions, other sectors like medium and heavy-duty vehicles and aviation need to be targeted.

To decarbonize transportation, a whole system-integration approach is needed. CIMS considers electrification, hydrogen, grid, and building integration when assessing electric vehicle charging across sectors.

Decarbonizing transportation involves both supply and demand. CIMS aims to understand how people can meet mobility needs and adopt technologies. Factors like socio-demographics, affordability, location, access to job opportunities, shopping, food, education, and various transportation choices are considered. Human behaviour plays a significant role in transportation decisions, making it complex. CIMS developed the Mobility-Energy-Productivity (MEP) Metric Tool to measure performance.

The MEP quantifies the quality of mobility in a location. Access to goods, services, and employment that improve quality of life is crucial in transportation. The MPE measures access efficiency. They reviewed existing metrics like Walk score, Bike score, and Transit score, but found them limited. The goal was to combine access through various modes of transportation. The CIMS also considered socio-demographic factors as different groups may have different access levels.

To calculate the MEP score, the CIMS determines the number of opportunities reachable within a set travel time using different modes. Users can input a location and query the road network to see how far they can reach in 10, 20, 30, or 40 minutes using modes like Walk, Bike, Transit, and Drive. Then, the CIMS intersects this boundary with a land use layer to quantify reachable job, retail, school, religious, and healthcare opportunities.

For each mode and travel time, the CIMS calculates unique queries to reduce opportunity measures based on time, energy, and cost. Modes with more efficient measures receive higher weighting. For example, if Drive reaches 100 opportunities from a location while Bike only reaches 50 within 10 minutes, Drive gets a higher time rating. Similarly, if both modes reach 100 opportunities, Bike receives better weighting due to energy efficiency. The same applies to cost efficiency. The MEP score combines all these weightings to provide a unique metric for each location.

The MEP score is calculated at a square kilometre pixel resolution, which means that each square kilometre in a city gets a unique value. For example, downtown Denver has MEP scores as high as 350, indicating excellent access using various efficient modes of transportation. On the other hand, places like Castle Pines or the Pinery have MEP scores close to zero, meaning poor access from those locations.

The Overall MEP score combines four modes and six activity types. Each mode and activity type can be analyzed individually. For example, comparing the Overall MEP and Transit MEP scores in Denver shows that Transit mode has less time, energy, and cost-efficient access. This is due to constraints like schedules and routes.

Looking at specific activities, like Healthcare, the MEP score can be calculated for different modes (Drive, Bike, Walk, Transit). Downtown Denver has decent healthcare opportunities, while suburbs like Superior or Indian Hills have relatively sparse access.

The Transit MEP has access to all opportunities using transit, while the Healthcare MEP has access to healthcare opportunities using all modes. Users can also explore further to see the level of access they have to healthcare opportunities using only one mode, such as transit. There are a total of 24 different combinations of four modes in six activity types. Therefore, there are

24 different metrics that are combined to create the overall map MEP. It is easy to extract any specific layer and examine the MEP score for a particular mode and activity.

The MEP metric has been developed for about five years and has been used by various entities to aid decision-making and assess infrastructural investments. It helps compare the impact of different investments on time, energy, and cost-efficient access.

The MEP tool is versatile, connecting technology or infrastructural investments to real-world impacts. It is one of the few tools that represent access efficiency across multiple modes in a single framework.

The MEP metric can analyze the impact of factors like time efficiency, energy efficiency, cost efficiency, land use changes, mode share, and wait times for on-demand services or transit frequency. It provides information on how these factors affect overall access efficiency.

Users can access MEP scores for various U.S. cities through an online dashboard, and there are plans to expand MEP calculations to locations outside the U.S.

To decarbonize transportation systems, we need to consider complex integrated approaches that take into account human behaviour. The CIMS is adapting NREL tools for different economies, using local data to gain insights into decarbonization strategies. APEC projects also focus on peer learning and knowledge sharing. Learning from regional leaders is crucial to increasing ambition and making progress in climate action at a regional level.

Sharing 2-2: From the Top 1000 Programme to the Top 10000 Industrial Energy Conservation Programme

Presenters: Dr Meng Liu, Associate Professor, China National Institute of Standardization, China.

China, the largest consumer of energy, has reduced its energy intensity by about 34% between 2007 and 2017. However, it still faces several challenges including limited energy resources, environmental pollution, low energy efficiency, and the need for energy security due to high dependence on imported crude oil.

To address these challenges, China implemented the Top 1000 program in 2006 to promote energy conservation in the top 1000 energy-consuming plants across various industries. This program aimed to achieve a target energy saving of 100 million tons of coal equivalent (tce) by 2010.

To achieve this, China established an accountability system, set up a leadership team, appointed energy managers, and implemented energy auditing and conservation plans. Energy retrofitting projects were accelerated, and the application of energy-saving technologies and measures was promoted. Energy conservation laws and standards were also strengthened, and an incentive mechanism was created.

The implementation of the Top 1000 program resulted in total energy savings of 150 million tce, surpassing the target of 100 million tce. Key sectors such as thermal power, aluminium oxide, ethylene, caustic soda, crude oil processing, electrolytic aluminium, and cement achieved significant improvements in energy efficiency during this period.

Why did China implement the Top 10000 programme? It was launched in 2011 to help conserve energy in the top 10000 plants and energy users. These users accounted for 60% of China's total energy consumption in 2010, and the goal was to save 250 million tce by 2015.

The programme included measures such as setting energy conservation targets, establishing an energy management system, submitting regular energy consumption reports, conducting energy audits, implementing energy retrofitting projects, promoting energy-saving technologies, and strengthening energy-saving policies and incentives.

By the end of the programme, China exceeded its target, saving 330 million tce. During the 13th FYP period (2016-2020), China achieved an average annual economic increase rate of 5.7% and an average annual increase in energy consumption of 2.8%, resulting in savings of over 650 million tce and an 18.8% reduction in CO2 emission intensity. The energy intensity of the industrial users covered by the Top 10000 programme was reduced by 36.2% compared to 2012, equivalent to an annual reduction of 4.9%.

China implemented two mandatory industrial energy conservation standards systems as part of the Top 10000 programme. These standards required the energy intensity of the Top 10000 plants to meet a specific threshold value. Another system focused on energy efficiency standards.

To support the implementation of these mandatory standards, China developed voluntary territory-wide standards systems for energy management, optimization, technology, benchmarking, evaluation, metering, audit, and performance contracting.

The energy intensity standards consisted of three types of energy intensity (EI) values: threshold EI value, entry EI value, and leading EI value. Existing plants had to meet the threshold EI value or face phasing out. New plants had to exceed the entry EI value. The leading EI value aimed to encourage the entire industry to improve energy intensity. This value was based on international standards.

Energy efficiency (EE) standards were used to phase out inefficient equipment. These standards labelled the energy consumption of equipment in plants. China developed around 400 territory-wide Energy Efficiency Standards, including 112 mandatory energy intensity standards for sectors such as iron, steel, non-ferrous metals, coal, electric power, petrochemistry, chemical engineering, building materials, paper making, and textile. Additionally, there were 75 other energy efficiency standards for industrial equipment like electric motors, pumps, compressors, industrial fans, industrial boilers, and power transformers. From 2005 to 2020, these standards and labels saved over 2500 billion kWh of energy.

The success of the Top 1000 and 10000 programme relies on leadership commitment, energy efficiency targets mandated by law, a performance appraisal system for local government, a comprehensive polity framework, and ministry coordination. China learned that data is costly and they still need to collect sufficient high-quality data. Additionally, China faces a shortage of professionals and conducts only a limited number of policy evaluations. It is important for China to identify effective measures for each policy.

Sharing 2-3: The Japanese policy and strategy in the building sector towards "Carbon Neutrality"

Presenters: Mr Kyohei Horiguchi, Assistant Director, Energy Efficiency Division, Energy Efficiency and Renewable Energy Department, Agency for Natural Resources and Energy, Ministry of Economy Trade and Industry, Japan

Japan is taking various measures to achieve the 2050 carbon-neutral goal. These include promoting energy efficiency and increasing the use of non-fossil energy sources. Regulatory measures like the Act on the Rational Energy Use and Shifting to Non-fossil Energy and the Act on the Improvement of Energy Consumption Performance of Buildings (hereafter Building Energy Efficiency Act) are being reviewed and strengthened. Supportive measures are based on subsidies, including net Zero Energy Building/House (ZEB/ZEH), tax incentives, etc.

To facilitate the transition to cleaner energy sources, Japan is focusing on expanding the use of non-fossil energy on the supply side and optimizing demand based on electricity supply and surplus power from renewables. Private power generation and device control for grid stabilization are also being utilized.

In the 6th Strategic Energy Plan (hereafter the 6th Plan), Japan aims to reduce final energy consumption by 62 million kl by 2030 through energy efficiency improvements. This includes a target of saving 13.5 million kl in the commercial sector, including buildings.

The ZEB definition was established in 2015. The 6th Plan requires new housing and buildings built after 2030 to meet ZEH/ZEB efficiency standards. For ZEB, buildings need to limit loads, use natural energy, utilize energy efficiently through high-efficient equipment systems, and create energy through solar PV systems.

ZEB is classified as (Net)ZEB, Nearly ZEB, ZEB Ready, or ZEB Oriented based on the reduction from a reference primary energy consumption as below.
(Net)ZEB: 100% or more energy consumption reduction with energy saving and introducing renewable energy
Nearly ZEB: 75% or more energy consumption reduction with energy saving and introducing renewable energy
ZEB Ready: 50% or more energy saving
ZEB Oriented: 30% or 40% or more energy saving depending on application and certain conditions

Despite increasing numbers, ZEB buildings still account for only around 0.4% of total non-residential buildings in 2021.

The Ministry of Economy, Trade and Industry (METI) supports achieving ZEB in collaboration with the Ministry of the Environment (MOE), based on their respective responsibilities depending on the size of the building.

Realizing ZEB in large-scale buildings using existing energy efficiency technologies is challenging. METI supports this by demonstrating "Web Program unevaluated technologies" with high energy efficiency potential in subsidized projects. The Web Program calculates energy consumption efficiency. The unevaluated technologies include 15 technologies with high energy efficiency potential published by The Society of Heating, Air-Conditioning and Sanitary Engineers of Japan. These technologies include CO2-controlled outside air amount control, natural ventilation system, advanced air conditioning pump control, advanced air conditioning fan control, etc.

To promote ZEB business, design, construction, and consulting companies registered as ZEB Planners offer consultation services to building owners. ZEB Leading Owners, who are registered building owners, need to disclose information about themselves, ZEB targets, actual results, and introduction plans for ZEB projects. As of September 2022, there are 449 ZEB Planners and 318 ZEB Leading Owners.

ZEB Leading Owners are required to showcase examples of ZEB to encourage other building owners to adopt ZEB practices. This includes increasing the number of reference cases, raising awareness about the benefits of ZEBs, and promoting best practices.

The Building Energy Efficiency Act, which governs energy consumption in buildings, was amended in June 2022 to make energy efficiency requirements mandatory for all scales of non-residential buildings. This amendment aims to meet the 2030 target outlined in the 6th Plan.

To achieve carbon neutrality by 2050, it is crucial to prioritize energy efficiency. The 6th Plan sets a political target of achieving 13.5 million kl of energy savings in the commercial sector, including buildings, by 2030. Additionally, the 6th Plan introduces a new target that requires new buildings constructed after 2030 to meet the ZEB efficiency standards. To promote ZEB, Japan implements measures such as subsidies for ZEB projects, awareness campaigns, and gradually tightening regulations on energy efficiency in collaboration with relevant ministries and agencies.

Sharing 2-4: Drivers for Enhancing Energy Efficiency of Commercial Buildings

Presenters: Ms Ada Fung, Director of the World Green Building Council (World GBC) and the Hong Kong Green Building Council (HKGBC) of Hong Kong, China

The Government of Hong Kong, China aims to decarbonize by 2050. Buildings and activities within buildings are responsible for 90% of total electricity consumption and 60% of greenhouse gas emissions in HKC. In order to address the urgent climate change situation, the government has set a policy to achieve carbon neutrality by 2050.

The Hong Kong Green Building Council (HKGBC) launched the Advancing Net Zero (ANZ) campaign in November 2019. The campaign promotes Net Zero practices in the building and construction sector, with the goal of becoming a role model for similar cities.

The HKGBC has established five strategies for 2020-2021. These include setting targets, providing certification, fostering competition, organizing international conferences, and supporting research.

Commercial buildings in HKC typically consume around 65% of total energy. To address this, the HKGBC launched the ANZ Ideas Competition in 2020. The competition aimed to reduce energy consumption in commercial buildings and involved six supporting partners and 45 supporting organizations.

With these supporting partners and organizations, HKGBC organized the ANZ Ideas Competition with the following aims:

1. Inspire professionals to develop net zero ideas and solutions.
2. Build a Knowledge Bank of net zero ideas and solutions for the industry.
3. Accelerate the adoption of net zero ideas and solutions.
4. Review building regulations and codes that may hinder net zero ideas and solutions.
5. Encourage industry professionals to prioritize decarbonizing building portfolios.

The HKGBC organized the competition with a team of five for the organizing committee, nine for the technical committee, eight for the jury panel, six for the advisory team, and three for the independent team. The principal partner of the HKGBC is a property company that provides real historical data and encourages industry participation.

The ANZ Ideas Competition focused on three areas: Zero Carbon and Ultra Energy-Efficient, Embodied Carbon, and Healthy and Sustainable. These areas align with themes set by the World Green Building Council.

Strategies in the Zero Carbon and Ultra Energy-Efficient area include passive and active strategies, fit-out/user strategies, renewable energy, and energy/carbon management. The Embodied Carbon area aims to reduce carbon emissions throughout a building's life cycle through design efficiency, buildability, adaptability, durability, deconstruction and decommissioning, and material reuse and recycling. The Healthy and Sustainable area prioritizes occupant comfort (thermal comfort, daylight, acoustics, ventilation, air quality, safety) with low energy consumption.

The ANZ Ideas Competition was launched globally through webinars, with a focus on participants from HKC. The HKGBC organized the International Conference on ANZ and later shared the competition through an E-book. The E-book includes different sections such as conference highlights, organization details, and the significance of the competition. The most important part of the E-book is the collection of all the "ideas harvested" during the competition.

The HKGBC has achieved a significant milestone by gathering a wealth of ideas for ANZ. Moving forward, they plan to bring some of these ideas to life in the coming years. While some ideas are practical and scalable, others may require further research and regulatory adjustments.

In summary, the ideas include passive design, structural efficiency, radiant cooling, integrated facades, flexible office spaces, high-rise greenery, mindset and behaviour changes, renewable energy, AI/IoT utilization, energy/carbon management, and wellness.

The yearbook captures ideas and processes that can:

- Help HKC's building sector become carbon neutral
- Speed up the adoption and development of low/zero carbon designs and technologies in the building industry
- Encourage innovative ideas and solutions for reducing carbon emissions
- Evaluate current regulations and codes of practice.

3.5 Project Summary of Day 2 presentations

Presenter: Ms Elaine YIP, Project Officer, Engineer of Electrical and Mechanical Services Department, Hong Kong, China

In the APEC region, APEC leaders have set goals to reduce energy intensity and double renewable energy to address climate change. The main drivers for reducing energy intensity by 45% by 2035, based on 2005 levels, have been discussed in three sectors.

For transportation, it is recommended to adopt electric vehicles and new energy sources. Speakers emphasize that individual transportation decisions greatly impact carbon dioxide emissions.

In the industrial sector, implementing energy-efficient projects and promoting the use of energy-saving technology can be accelerated through energy metering, statistics systems, and regular energy audits.

Energy efficiency regulations are crucial for the building sector. New constructions are actively encouraged to aim for net zero or zero energy design, while existing buildings may require additional efforts.

The doubling of renewable energy in the APEC Energy mix is another goal. This involves doubling the share of renewables in power generation by 2030 compared to the 2010 level. Renewables are essential for transitioning to clean energy and mitigating climate change. The deployment of renewables in power, heat, and transport sectors is key to limiting global temperature rise. Green hydrogen, emission-free building heating, and electric vehicles require an integrated approach utilizing all renewable energy technologies.

According to the Renewable Energy Market Update Outlook for 2022 and 2023, renewable capacity is expected to increase by over 8% in 2022 compared to the previous year, reaching 300 gigawatts. Solar and wind energy will contribute significantly to this capacity increase, with solar PV accounting for 60% and offshore wind doubling in capacity compared to 2020.

3.6 Session 3: Key Drivers of the Successful Policies and Initiatives in Renewables in APEC

Sharing 3-1: Evolution of the Regulatory Energy Policies in Solar Energy in Chile

Presenter: Mr Danilo Jara Aguilera, Head of Regulation Support Unit, Renewable Energy and Energy Efficiency Division, Ministry of Energy, Chile

Chile's geographical location poses challenges for its energy development. While the economy has renewable potential in the north and south, the demand is concentrated in the central region. To overcome this, Chile must find ways to transport energy from the north and south to the central region.

Chile is committed to transitioning to 100% renewable energy and has updated its energy policy accordingly. It aims to achieve carbon neutrality by 2050, making it the only APEC member with such a commitment. The energy sector, which accounts for 73% of GHG emissions, needs significant efforts to reduce emissions.

Chile has set 18 goals for the carbon-free energy sector, including emissions-free energy, universal access to energy, sustainable cities, and sustainable transport.

The transition to a carbon-free future is an urgent goal for Chile. The economy aims to achieve 100% zero-emission electricity production by 2050 and 80% by 2030. It also aims for a 60% reduction in GHG emissions by 2050, a carbon price of USD35/tCO2e, 100% electrification of new vehicles and public transportation by 2035, and 6GWs of storage by 2050.

Decarbonizing the electrical system is particularly challenging due to Chile's geographic properties. The economy has three separate electrical systems that are not interconnected, making it difficult to transfer energy from the north and south to the central region where the demand is highest.

Despite having renewable power capacities, over 40% of Chile's generation capacity still relies on fossil fuels.

Chile has a renewable potential of around 1,800GW, including 509GW of Concentrating Solar Power, 1,180GW of solar PV, 191GW of onshore wind turbines, and 6GW of hydropower. This exceeds the current power demand by 70 times, highlighting its significant renewable potential.

Chile's renewable future looks promising, with renewables becoming the main focus in the energy sector. The central and northern regions have competitive costs for renewables. In 2020, solar PV cost around USD20-25/MWh in the north and around USD25/MWh in the central region. The southern region has a competitive wind power potential at approximately USD36/MWh.

The north of Chile has the highest solar radiation on the planet, with a capacity factor of 35% for mono-facial PV with one-axis tracking. Solar generation in the central region is more competitive than fossil fuel generation. The renewable potential is conveniently located near consumption centres, gas networks, port logistics centres, and valleys. In terms of wind power, the strong winds in the extreme south provide land-based turbines with capacity factors over 60%, equivalent to offshore turbines in other economies.

Renewable energy, particularly solar and wind power, has seen increased participation in Chile's energy sector. Currently, around 60% of Chile's renewable capacity comes from solar and wind power, surpassing the historical contribution of hydropower. This percentage is expected to continue growing.

Chile also focuses on increasing the participation of distributed energy resources. Large-scale distributed energy projects with an average capacity of around 10MW have already reached around 2GW of installed capacity. Additionally, there are approximately 15,000 small-scale distributed projects with a total capacity of around 150MW throughout Chile. This sector is expected to experience significant growth in the coming years.

Chile is a leader in renewable energy, surpassing China and the United States in integration.

They believe that while reaching 100% renewables is important, the percentage of renewable energy already in use is significant.

Chile has approximately 78 power plant projects, 15 transmission projects, and one green hydrogen project currently being built. These projects require an investment of around USD5.9 billion.

As of October 2022, Chile had numerous projects undergoing environmental evaluation. The table below provides details on the evaluation status, capacity, and investment scale of these projects, demonstrating a dynamic and significant investment scenario:

	Evaluation status		
Project type	Admitted	Under evaluation	Approved
Solar PV	9 projects	95	4
	USD999 million	12,228	242
	925MW	11,759	326
Grid	1 project	17	4
	USD13 million	731	12

Chile is particularly interested in developing renewable energy storage systems. They already have 51 storage system projects with a total capacity of around 6GW, focused mainly on solar power (approximately 4GW). Renewable energy storage systems are an increasingly important area that must be included in the future energy mix.

Chile aims to decarbonize its energy sector by phasing out coal-fired turbines by 2030, ten years earlier than originally planned. This requires an additional 5.5GW of coal-fire capacity to be phased out, with a total of 24.5GW of new renewables needed. The storage of renewable energy is crucial for converting unstable generation processes into more manageable ones.
Chile’s next steps for renewable energy development include:

- Publishing a fast decarbonization strategy
- Implementing a law on renewable energy that establishes new energy quotas
- Enacting an energy transition law to improve transmission expansion and address issues with the marginalist market
- Modernizing the adequacy market, such as through equity market neutral policies
- Promoting the aggressive penetration of distributed energy resources, aiming for 10-20% of total renewables.

Sharing 3-2 Drivers and Policies of Wind Energy Growth – from Onshore to Offshore

Presenter: Dr Chung-Hsien Chen, Director, Energy Technology Division, Bureau of Energy, Ministry of Economic Affairs, Chinese Taipei

Chinese Taipei faces several challenges in its energy sector, including heavy dependence on imported energy, high reliance on fossil fuels, and an isolated power grid system. These issues impact power stability and energy security, which are crucial for the semiconductor industry and information communications technology development. To address these challenges, Chinese Taipei has set targets to increase green energy and reduce coal usage by 2025.

Chinese Taipei aims to increase the share of LNG in its energy mix from 31.4% in 2015 to 50% in 2025, while renewables are targeted to increase from 4.1% to 20%. Coal usage is planned to decrease from 44.6% to less than 30%, and nuclear power will be phased out by 2025. The goal is to have 29.4GW of installed renewable energy capacity by 2025.

To achieve these goals, Chinese Taipei aims to have 29.4GW of installed renewable energy capacity by 2025, with an interim target of 13,167MW capacity by 2022. The primary focus will be on solar power and wind power. Chinese Taipei also plans to develop solar PV on agricultural land in a balanced manner, according to Dr Chen.

Chinese Taipei's plan to reach net-zero emissions in 2050 is illustrated in the table below:

		2019	2050
Non-electricity	Industrial, Manufacturing, Commercial and residential buildings	86.6MtCO_2e	8.7MtCO_2e
	Transportation	35MtCO_2e	3.3MtCO_2e
	Non-energy	26.4MtCO_2e	10.5MtCO_2e
			Hydrogen, bioenergy
Electricity	Electricity	139MtCO_2e	0MtCO_2e Electrification (increased demand > 50%); Decarbonized electricity Renewables 60 – 70% Hydrogen 9 – 12% Gas + CCUS 20 – 27%

Pumped storage 1%

Carbon sinks	Forest	21.4MtCO_2e	22.5MtCO_2e
Net Emissions		265.5MtCO_2e	40.2MtCO_2e (net CCUS)

The main strategy is to timely introduce advanced technologies to increase the use of zero-carbon energy. It is expected that renewables will contribute 60-70% of electricity in 2050, with over 50% of energy demand being electrified.

In terms of onshore wind power, Chinese Taipei plans to have 886MW of installed capacity by 2025. However, there have been concerns from residents regarding the impact of wind turbines on their health and Feng Shui. To address these concerns, Chinese Taipei has increased the distance between residences and wind turbines to 500meters and avoided installing wind power in certain protected areas.

Due to limited space and concerns about typhoons and earthquakes, Chinese Taipei is shifting its focus to offshore wind power. A three-phase strategy has been implemented, including a demonstration incentive program, zone planning for capacity building, and zonal development for offshore wind farms. The capacity target for offshore wind power is set at 5.6GW by 2025, 20.6GW by 2035, and 40-55GW by 2050.

Phase 1 is a program to incentivize pioneers in the offshore wind power sector. Phase 2 focuses on planning and capacity building, with the goal of expanding offshore wind farm capacities. Phase 3, known as zonal development, provides guidelines for offshore wind power development. The capacity targets for Phase 3 are 5.6GW by 2025, 20.6GW by 2035, and 40-55GW by 2050.

Chinese Taipei initiated the Phase 1 demo incentive program in 2012, which proved successful. By 2021, two commercial offshore wind farms with a capacity of 237.2MW were commissioned as part of Phase 1.

Phase 2, also known as Zones of Potential, builds upon the lessons learned from Phase 1. Chinese Taipei aims to attract companies from Europe, the United States, and Asia to develop the offshore wind power market. The capacity target for Phase 2 is approximately 5.6GW by 2025.

Currently under construction, Phase 2’s capacity target of 5.5GW is divided into two parts. The first part (3,836MW) involves a company selection process to encourage technology and investment in the offshore wind power sector. This process will take place from 2020 to 2024.

The second part (1,664MW) involves an auction process where companies with lower feeding prices will be selected. The expected feeding price is around US cents 8 per kWh. The auction process will occur in 2025.

Phase 3, zonal development, consists of two stages: Stage 1 (2026-2031) and Stage 2 (2032-2035), with capacity targets of 9GW and 6GW respectively. On average, 1.5GW of offshore wind power will be developed each year during Phase 3.

Stage 1 of Phase 3 will consist of three selection rounds, as shown below.

Phase 3: Stage 1 (2026 – 2031)			
Round	1	2	3
Year	2026 – 2027	2028 – 2029	2029 - 2031
Capacity allocation	3GW	3GW	3GW
Selection year	2022 Q4	2023	2024

The selection mechanism of Rounds 2 and 3 might be adjusted based on the result of Round 1.

The selection process for offshore wind projects is ongoing, with companies from Europe, the United States, and Asia expected to participate. It is divided into two parts: one for company selection and the other for a competitive auction process. The goal is to attract investments and technologies into Chinese Taipei's offshore wind power sector.

In addition to offshore wind power, Chinese Taipei is also considering floating offshore wind farms. The target is to have a single wind farm of 50MW with a total planned capacity of 100MW.

Overall, Chinese Taipei aims to achieve its energy transition goals by increasing the use of green energy, reducing reliance on imported energy, and promoting self-generated energy.

Sharing 3-3 Floating solar power plant development policy in achieving NDC and NZE targets

Presenter: Mr Praptono Adhi Sulistomo, Director of Various New and Renewable Energy, Directorate General of New, Renewable Energy and Energy Conservation, Ministry of Energy and Mineral Resources, Indonesia

Indonesia's G20 Presidency in November 2022 focused on three main issues, including the transition to sustainable energy. The G20 agreed on the Bali Compact, a document outlining principles for accelerating the energy transition. Mr Sulistomo highlighted three key energy transitions: ensuring energy accessibility, advancing clean technologies, and improving energy financing.

Despite having a significant potential for clean technologies, such as renewable energy (NRE), Indonesia currently only utilizes 0.3% of its total NRE potential. To move away from fossil fuels, Indonesia aims to gradually increase the percentage of renewables in its energy mix.

Indonesia hopes to increase electricity consumption to create more demand for NRE. However, one challenge is the spread of renewable energy potential and demand, particularly in the economy's five large islands. Indonesia aims to double its NRE energy mix from 12.2% in 2021 to 23% by 2025.

Reducing emissions from the energy sector is another challenge for Indonesia in the short term. The economy aims to achieve net zero emissions by 2060 through the gradual replacement of retiring coal-fired power plants with solar PV and wind power plants, as well as accelerating NRE development.

Solar PV plays a crucial role in Indonesia's energy transition, and it is included in the economy's electricity plan. Indonesia aims to retire some coal-fired power plants by 2060.

Indonesia has significant potential for developing the solar PV industry, including rooftop solar, large-scale solar power plants, and floating solar power plants. The economy plans to target an additional capacity of 20.9GW of NRE, with solar PV contributing more than 4.68GW by 2030.

The recent breakthrough Presidential Regulation No. 112/2022 addresses the challenges of procurement and compensation for renewable energy development, including solar PV. Indonesia is also drafting a new renewable energy law to further support the energy transition.

The Cirata Floating PV project, the largest floating PV in ASEAN, is currently ongoing, with a capacity of 145MW. Indonesia plans to replicate similar floating solar PV projects, such as the Saguling and Singkarak projects. The details of these two MoU are shown below.

	Saguling	Singkarak
Capacity	60MWac	50MWac
Location	Saguling Reservoir	Singkarak Lake
COD	2024 - 2025	2025
Area	1.69% of reservoir surface	0.33% of Lake surface

Collaborations with companies like Amazon and ACWA Power are further enhancing solar PV development in Indonesia. PT PLN (Persero) and three solar PV producers are also planning to build Southeast Asia's largest solar panel factory.

Sharing 3-4: Drivers and policies for enhanced geothermal systems growth

Presenter: Ms Lauren Boyd, Acting Office Director, Enhanced Geothermal Systems Program Manager, U.S. Department of Energy, Geothermal Technologies Office.

Geothermal Energy has immense potential as a renewable power source in the US. The depth of the geothermal system determines the amount of heat available, ranging from low to high temperatures. This heat can be utilized in various applications, including geothermal heat pumps for heating and cooling homes, direct-use applications in industries like greenhouse warming and brewing beer, and power production at high temperatures.

Geothermal energy offers several advantages. It is clean, reliable, and can be used in industrial, commercial, and residential sectors. It helps reduce CO2 emissions and creates job opportunities in the clean energy sector. Geothermal power plants operate 24/7 with a 90% capacity factor, more electricity compared to conventional plants. Geothermal also requires less land and space than other energy technologies.

In the US, geothermal power plants are considered a reliable and flexible energy source. They can generate power continuously and adjust their output as needed. This is valuable for utilities trying to balance fluctuations in renewable energy generation.

Geothermal energy also requires less land and space compared to other technologies. There is a vast amount of heat available in the Earth's crust, estimated to meet global energy needs for millions of years.

Internationally, geothermal power generation has been increasing, with around 15,000MW installed by the end of 2021. Many economies are also developing their geothermal resources.

To meet global energy demands and reduce emissions, enhanced geothermal systems (EGS) are necessary. These systems tap into deeper heat sources in the subsurface. The Department of Energy conducted a study called GeoVision to explore the potential of geothermal energy in the US, considering technology development, cost reduction, and non-technical barriers.

By 2050, geothermal could contribute over 60GWe of power generation to the US, compared to around 4GWe in 2020. EGS would play a significant role in this increase. The study also suggests that around 23% of the heating and cooling market could be served by geothermal energy by 2050.

The widespread adoption of geothermal heat pumps is expected to grow from 2 million installations to at least 28 million by 2050, resulting in substantial CO_2 emissions reductions.

EGS are crucial for achieving the target of 60GWe power production. They allow the utilization of stranded heat in the subsurface.

Conventional geothermal systems occur naturally where there is heat, water, and permeability. EGS replicate and enhance these natural systems by injecting fluid into the subsurface to create pathways for heat extraction.

The success of EGS depends on maximizing the exposure of fluid water to the hot reservoir rock. By engineering a human-made version of natural geothermal systems, enhanced geothermal technology can unlock the full potential of geothermal energy.

However, the EGS science and technology face challenges. No EGS are currently deployed globally. To access deep heat resources, geoscience and engineering challenges must be addressed. Deep wells are needed to reach the hot rock. For higher temperature resources, even deeper drilling, between 4,000 to 12,000feet, is necessary to create artificial reservoirs. Understanding these deep environments is a challenge.

Extreme conditions and the harshness of the environment also pose obstacles to the development of enhanced geothermal systems. Temperatures can reach 200 to 500°C, similar to Venus' surface temperature. Reservoir rocks are in an extremely harsh environment.

Furthermore, the rocks are very hard, making drilling through igneous and metamorphic rocks more challenging compared to sedimentary rocks often found in oil and gas exploration . The equipment used for resource extraction undergoes significant stress. The rocks have low permeability and contain corrosive fluids naturally.

There is limited data available about subsurface environments at depths of 12,000feet. The oil and gas industry drills thousands of wells annually, while the geothermal sector drills only 10 to 20 in the United States. Lack of data collection opportunities hinders progress. Consequently, some necessary tools for characterizing, monitoring, and creating reservoirs are not yet available. Existing tools need adaptation for higher temperature environments, caustic brines, and hard rocks.

EGS is not a new concept and was initially developed as hot, dry rock in the 1970s with the Fenton Hill project in New Mexico. Although there have been about 18 global projects, they have had limited commercial success until recently. However, advancements in technology, learnings from research programs worldwide, and shifts in philosophy associated with the shale revolution and high-performance computing have brought EGS close to becoming commercially viable, especially with adequate funding from public and private partners.

The United States is experiencing commercial growth in the development of enhanced geothermal systems. The Department of Energy's Geothermal Technologies Office (GTO) sponsored multiple demonstration projects in the past, including successful ones in Newberry Volcano Brady's Hot Springs, Desert Peak, The Geysers, and Raft River.. One notable project is the Frontier Observatory for Research in Geothermal Energy (FORGE), a large-scale field laboratory focused on developing EGS and sharing knowledge with other economies interested in this technology.

FORGE is the flagship effort of GTO, with a budget of over USD200 million since 2014. It serves as a collaborative laboratory for testing and advancing breakthroughs in enhanced geothermal energy systems. The goal is to create efficient and effective human-made reservoirs that can operate for long periods. The project involves close collaboration with the Energy Geoscience Institute at the University of Utah.

In addition to the drilling of six wells, GTO has achieved significant milestones, such as drilling one of the fastest geothermal wells in granitic rock and stimulating the reservoir. All data collected from the site is publicly available on GTO's website. The initiative also offers competitive research and development funding of around USD50 million every few years to universities, companies, and National Laboratories.

The Energy Earthshots initiative by the Department of Energy aims to achieve major R&D breakthroughs within the next decade to address climate change goals. GTO's target is a bold 90% reduction in the cost of deep EGS by 2035, with a goal of reaching an average cost of

USD45 per megawatt hour. This reduction would have a significant impact on the United States, as analyzed through robust analysis.

The current geothermal capacity in the United States is 3.7GW out of a global capacity of 15GW. Most of this development is concentrated in a few western regions. However, by 2050, there is potential for growth across the economy if technology barriers are overcome.

There are opportunities for deployment in states like California, Nevada, Utah, and New Mexico, where there has been traditional development. These states have the best resources and expanding them makes sense. Additionally, there are exciting development opportunities in the Eastern States, specifically Virginia, West Virginia, and Pennsylvania, with around 4GW of deployment.

Significant geothermal development is also happening in the Sun Belt states (Texas, Louisiana, Arizona, Arkansas, and Mississippi).

Technological improvements in EGS enable heating and cooling. The GTO's analysis predicts significant growth in the heating and cooling sector, benefiting around 45 million households in the U.S.

The geographic diversity of EGS presents an exciting opportunity for a transition from the oil and gas industry to clean renewable geothermal power. This is especially relevant due to the co-location of oil and gas resources with the new geothermal development in the Sun Belt.

Ms Boyd emphasized the importance of technology innovation in achieving the goal of a 26-fold increase in a geothermal generation to 60GW or more in the U.S. Technological advancements improve understanding of the subsurface, reduce risks, and provide access to previously untapped resources. Ultimately, successful technological innovation will drive the growth of geothermal power worldwide.

3.7 Session 4: Emerging Low-Carbon Technologies and Economic Instruments

Sharing 4-1: Floating PV Power Plant Technology

Presenter: Mr Albert Park, Director of Communication, Hanwha Q CELLS, Korea

Floating solar PV is gaining attention in Asia, particularly in economies like Korea and

Singapore where available land for large-scale solar farms is limited. Examples of successful projects include Thailand's hybrid hydro-solar farm on the Sirindhorn dam, Singapore's plant on Tengeh Reservoir, and India's planned plant in Madhya Pradesh's Khandwa.

Floating projects have advantages such as easier connection to the power grid, the potential to restrict algae blooms, and increased efficiency due to water cooling. However, they are more costly compared to land-based installations, with a price difference of around 18%.

In Korea, where land regulations and local opposition make utility-scale projects challenging, floating solar PV is increasingly popular. It offers water-reservoir owners an additional revenue stream while reducing evaporation.

Korea's government has set a less aggressive renewable energy target for 2030 but remains committed to the direction of increasing renewable energy installations. Korean companies are also joining the global RE100 campaign to transition to renewable energy.

The Saemanguen project is one of Korea's major floating solar PV projects, with a planned capacity of 2.1GW and a total investment of KRW4.6 trillion.

The Korean government supports floating PV through the Renewable Energy Portfolio Standard (RPS) system and assigns higher weights to Renewable Energy Certificates (REC) for floating solar PV projects, providing them with additional benefits compared to land-based projects.

Two successful cases in Korea are the Hapcheon Dam and Goheung Lake floating solar PV systems. The Hapcheon Dam system generates 41MW and features an innovative design resembling plum blossoms. The Goheung Lake system generates 63MW and symbolizes the launch of the Naro-1 space vehicle.

These projects demonstrate how floating solar PV can overcome local resistance and harmonize different stakeholders' interests. Korea has higher quality standards for floating PV modules, leading to the development of specialized products that enhance safety and reliability.

Floating PV systems effectively utilize idle water surface areas and have a 10% higher energy production output compared to land-based systems due to reduced shading effects.

Sharing 4-2: Clean Fuel Ammonia for Energy Carrier

Presenter: Dr Toshiyuki Suda, Program Director for Carbon Solution, Corporate Strategy Headquarters, IHI Corporation, Japan

The advantages of ammonia as an energy carrier, particularly in achieving carbon neutrality, were discussed. While hydrogen is an ideal energy carrier, it is challenging to transport and store. Therefore, the Government of Japan is seeking an alternative energy carrier for hydrogen, and there are three options: liquid hydrogen, organic hydrides, and ammonia. Among these, ammonia has several advantages. It has a high hydrogen density, making transportation and infrastructure costs more efficient. Ammonia is also easily liquefied and already widely used as a stock or fertilizer globally. Additionally, ammonia can be directly used as fuel for gas turbines or boilers.

IHI Corporation (IHI) is working to improve the value chain for ammonia production, transportation, and utilization. Their goal is to provide advanced ammonia utilization technology and affordable prices to customers striving for carbon neutrality. The production of ammonia can be achieved through renewable energy sources, such as hydropower. These efforts are supported by the Government of Japan.

IHI is also developing infrastructure for ammonia storage, including a large ammonia receiving terminal to support a larger supply chain. Utilization technology for ammonia includes using it directly for power generation, with measures in place to reduce NOx emissions. IHI has demonstrated the effectiveness of ammonia co-firing technology in commercial-scale power plants and aims to achieve a 20% co-firing rate in a 1,000MW coal-fired turbine by 2024. Additionally, IHI has developed a smaller gas turbine that runs on 100% ammonia with no CO2 emissions.

To calculate the CO2 footprint, IHI collaborates with various companies in Japan to create platforms that collect operational information from power stations and equipment. This allows customers to see the total reduction in CO2 emissions achieved through the use of ammonia.

Some Asian economies, such as Indonesia; Malaysia; and Singapore are actively working on adopting ammonia-based technology in coal-fired power plants. Indonesia was the first to use ammonia in a commercial gas turbine in Asia, demonstrating its potential for achieving carbon neutrality in the region.

In Malaysia, IHI is collaborating with two firms on ammonia production and its use in coal-fired power plants. They are also working with a Japanese power company to expand the use of ammonia-fired technology in Malaysia.

Indonesia already has an operational ammonia co-fired power facility, with IHI collaborating with the gas-fired PLN Gresik Steam Power Plant. This technology has proven successful and is the first of its kind in Southeast Asia, indicating its readiness for commercial use.

In Singapore, IHI is collaborating with Sembcorp to develop an ammonia supply chain. There are also several similar projects using ammonia in the maritime sector. The aim is to create a large ammonia market, which would lead to lower costs. Expanding ammonia utilization in Asia and globally is therefore crucial.

In summary, IHI aims to build a carbon-free energy network utilizing ammonia as an energy carrier. This comprehensive network includes the production of ammonia from natural gas or renewable sources, transportation through pipelines and tankers, and utilization in various sectors such as power generation and industry. The ultimate goal is to help achieve carbon neutrality in a cost-effective and efficient manner.

Sharing 4-3: Development of China’s Emission Trading System (ETS)

Presenter: Dr Meng Liu, Deputy Chief of Energy Group, Sub-institute of Resources and Environment, China National Institute of Standardization, China

China incorporated carbon intensity reduction into its economic and social development plans since the 12th Five-year Plan period (2011-2015), setting binding targets. By 2030, China aims to peak carbon dioxide emissions. In 2019, China achieved its 2020 climate action target ahead of schedule. The 14th Five-Year Plan (2021-2025) includes a binding target to reduce carbon intensity by 18% from 2020 to 2025. China also announced new targets for carbon neutrality before 2060.

Since October 2011, seven provinces and municipalities have been piloting carbon emissions trading projects. These projects have launched seven local-level pilot carbon markets, covering key emissions companies in industries such as power, steel, and cement. By September 2021, the total trading volume of these pilot carbon markets reached 495 million tonnes of carbon dioxide equivalent.

China’s carbon market was launched on July 16, 2021, with online trading starting. The market follows the “1 + N” policy framework, with “1” referring to the long-term approach to combating climate change and "N" representing specific implementation plans for key areas and sectors.

The carbon emission trading market in China consists of four subsystems: data reporting, registration, emission transaction, and trading settlement. The ETS mechanism framework operates based on five mechanisms: emissions gap, allocation, verification, settlement, and transaction.

Participants in the market include emitters from industries covered by the system and those with annual emissions of at least 26,000 tons of CO2 equivalent. Emitters must apply for participation and can exit the market if their emissions remain below the threshold for two consecutive years.

China started its carbon market by trading in the power generation industry due to its high energy consumption and emissions. The industry has a strong capacity for energy management and environmental protection. The market has already covered 186 power plants and three power grid companies.

The allocation of emissions quotas is determined by local environment governing bodies based on production data and standardized calculations. The total quota in China is determined by summing up the quotas from all provinces.

The trading process involves registered emitters using their allocated quotas for transactions through negotiated transfer or bidding. Trading agencies ensure risk control, and settlements are done among agencies and participants.

Rules for emission transactions include membership management, risk control, punishment of illegal acts, information management, and investor management.

Verification of emissions is critical for the market's design and operation. It can be entrusted to verification bodies funded by the government and emitters involved in the market. Verification must follow registered plans, ensuring data quality and accuracy.

Settlements involve completing the settlement of last year's emissions under supervision. Settlements can be achieved through actual emission reduction, purchasing quota allocation, or purchasing carbon credits.

Offsetting allows organizations covered by the market to partially offset their emissions through

GHG reduction projects not involved in the market. The offset percentage must be less than 5% of the total emission quota.

In the first compliance period of China's emission trading market, 2,162 power generation companies participated, representing 4.5 billion tonnes of carbon dioxide emissions.

Looking ahead, China aims to align the total emissions allocation with its decarbonization goals. Laws and regulations will be developed to support the emissions trading market and expand its coverage to other industries. The transition from free allocation to compensated allocation will be considered. China will also develop a harmonized carbon verification system that aligns with international standards using digital technologies like blockchain algorithms.

Sharing 4-4: Development of Carbon Markets

Presenter: Mr Rui Yun Gan, Senior Manager (Global Partnerships). National Climate Change Secretariat, Strategy Group, Prime Minister's Office, Singapore

Carbon credits are non-physical commodities that can be carbon allowances or carbon offsets. They are typically issued by certification or standard bodies. Carbon credits are mainly used by firms that want to reduce their carbon footprint. Allowances represent the right to emit greenhouse gases, while offsets represent a claim on the reduction or removal of greenhouse gas emissions. The following table details the carbon allowance and carbon offset.

	Carbon allowance	Carbon offset
Definition	A permit to emit greenhouse gases One unit represents the right to emit 1 tonne of CO2	A claim on reduction or removal of greenhouse gas emissions One unit represents a claim to 1 tonne of CO2 equivalent reduced/avoided/stored or removed from the atmosphere
Issued by	Member economy governments that have Emissions Trading Schemes (ETS) /Cap and Trade (CAT) Schemes	Certification/Standard bodies based on eligible emissions reduction projects
Used by	Firms in ETS/CAT schemes	Firms that want to reduce their carbon footprint
How it works	Allowances are allocated or auctioned. Companies trade the allowances in secondary	Projects generate offsets, which are sold to companies to meet emissions compliance obligations or for voluntary

	markets.	CSR purposes
Examples	Allowances in ETS in the EU, California/Quebec, Korea, China	Offsets from Clean Development Mechanism (CDM), Japan's Joint Crediting Mechanism (JCM), Gold Standard, Verra

Allowances are issued by member economy governments with emissions trading schemes, while offsets are issued by certification/standard bodies based on eligible emissions reduction projects. Carbon credits can be bought and sold in secondary markets. Some examples of carbon credits include allowances in emissions trading schemes in various economies and offsets from projects like the Clean Development Mechanism and the Gold Standard.

The life cycle of carbon credits involves implementing mitigation activities to reduce or remove carbon emissions, verifying and validating the emission reductions and removals, issuing corresponding carbon credits, and selling them to buyers or the market. The revenue generated from selling carbon credits can support further mitigation activities.

Article 6 of the Paris Agreement sets a framework for carbon markets to advance global climate ambition. Under this framework, there are two articles: Article 6.2 and Article 6.4. Article 6.2 allows member economies to trade emission reductions and removals through bilateral or multilateral agreements. Article 6.4 is a centralized sustainable development mechanism that issues credits using approved methodologies. Its benefits include:

- Yield sustainable development economic co-benefits;
- Unlock mitigation potential to meet future and more ambitious climate targets; and
- Meet advanced climate targets cost-effectively.

Some key features of Article 6 include corresponding adjustments to prevent double counting of emissions, restrictions on the international transfer of certain units, and financial contributions to adaptation and cancellation of units, for example:

- 5% of carbon credits will go towards an adaptation fund for developing economies;
- 2% will be cancelled at issuance to increase overall emission cuts;

High environmental integrity principles are important for carbon credits, including independent verification, permanence, additionality, and strong governance. Various initiatives and programs are developing standards for the quality and use of carbon credits. The Integrity Council, Gold Standard, VERRA, and the Voluntary Carbon Markets Integrity Initiative are examples of these initiatives. The Science Based Targets initiative helps define credible target-setting for corporates.

The Climate Action Data Trust is a global platform that links and harmonizes carbon credit data to enhance transparency and reduce double-counting risks across different carbon markets. It will be launched in December 2022 in Singapore.

It is important to ensure high environmental integrity in carbon markets to support global climate action and ambition. Although Article 6 does not govern voluntary carbon markets, it may influence them and potentially align them with compliance markets.

3.8 Closing Remarks of Workshop

Mr Kei-Ming Barry Chu, Project Overseer and Deputy Lead Shepherd of the Energy Working Group delivered the closing remarks.

APEC projects are vital activities of the APEC Energy Working Group that helps translate policy directions of APEC member economies, leaders, and ministers into action and create tangible benefits for people in the Asia Pacific region.

Mr Chu thanked all the speakers and moderators for their fruitful exchange on successful energy intensity reduction, renewable energy policies, low-carbon technologies, and economic instruments to combat climate challenges.

Mr Chu encouraged participants to actively take part in future APEC projects and workshops. This workshop by HKC has provided a platform for promoting energy-efficient and sustainable energy development, leading economies towards a brighter and greener future.

4 Summary of Discussion

Session 1 – Highlights of Global Climate Action and APERC's Energy Demand and Supply Outlook

Moderator: Ms Jovian Cheung, Project Manager, Senior Engineer of Electrical and Mechanical Services Department, Hong Kong, China

Q1. In the COP27, hydrogen and ammonia are highlighted. Do you have any suggestions on how APEC can collaborate with international organizations to address the green hydrogen in our agenda? Could you give us some suggestions?

Dr Chung: I may consider why not the APEC forms a kind of green hydrogen alliance to collaborate with some international organizations. From the study of Africa's area, we learned that the result was quite positive, no matter whether the region had rich renewable resources or not. Green hydrogen is a good initiative for economies to help each other through collaborations by forming alliances. It would be very positive if we could have similar alliances. I have checked the APEC energy data for the year 2016. The final energy consumption of the domestic transport sector was around 26% of the total energy consumption, which is quite significant. We can get together to promote green hydrogen to this sector by allying.

Q2. How does the Covid-19 pandemic affect the projections for meeting the two APEC energy goals?

Mr Marukatat: We have always been asked this question. Unfortunately, we completed the Outlook just before the pandemic started. We try to reflect the preliminary pandemic effect. Our Demand and Supply Outlook is a little dip around 2019, and we plan to do it during the next Outlook study, the 9th Edition. We have started in January 2022, and we will reflect more on the effect of the pandemic and the Russian-Ukraine crisis on the energy projection. In the last few years, all our member economies are facing Covid-19, climate changes, and issues in the APEC region. I hope we can still meet our two goals, including the reference and carbon utility scenarios.

Q3. Should APEC come with the definitions of green hydrogen as mentioned by IRENA? What is the impact of modern renewable energy in APEC? Can we have some green hydrogen definitions and energy supply and demand analysis?

Mr Marukatat: In APEC, we are still discussing the “colour” of hydrogen. We hope there will be a more precise definition, but we will take care of those definitions again in our next round of Outlook. Dr Chung mentioned that energy transition had been addressed in the COP27.

Q4. The United States will be the APEC host for 2023. They have highlighted just energy transitions, which are very important to our APEC member economies. Could you give us some suggestions regarding the promotion of the energy transition and what you have mentioned in the COP27? What is your insight, and how can we accelerate an energy transition?

Dr Chung: I remember that COP27 has emphasized the definitions of green energy and green technologies. A clear definition of green energy and related technologies can help speed up the energy transition. In APEC, when we had *modern renewable energy* discussions among our member economies, it took us a certain time to finalize the definitions. After that, the individual economies can apply the same definition to their works and measure the results on the same scale. I believe it is crucial to derive standard definitions of green ammonia or green hydrogens among the APEC member economies. In this way, everyone can use the same standards to pursue their plans with the same target measures. As we see in IRENA's presentation, there are different standards of green hydrogen, and we do not know which one to adopt. Eventually, individual member economies may not be able to measure their achievements. Without a clear definition, we won't have a common target to pursue.

Session 2 – Key Drivers of the Successful Policies and Initiatives in Energy Efficiency in APEC

Moderator: Mr V. Y. Ek Chin, APEC EGEEC Chair

Q1. The capacity building of every energy management in various economies and sectors will be quite different. We may learn from each other. For the transportation sector, the speaker mentioned quantifying human behaviour. The speaker mentioned implementing Top 1000 to Top 10000 programmes for the industrial sector. Could we learn some best practices for the building sector from the above transportation and industrial sectors?

Ms Fung: I think the building sector, as we have identified, HKC's commercial buildings is the Big Spenders. Hence, we should tackle this sector first. From the ideas generated for the existing buildings, I have also mentioned the Ideas Harvested, which can be applied in these areas. For example, changing people's mindsets and behaviour is always true. Still, in the other aspects, like if you can reduce energy consumption on air conditioning by pre-drying the outdoor air, it is just a simple initiative that can help a lot. I think, in our Ideas Harvested, there are a lot of things that we can learn from each other. It is nice to brainstorm with everyone to see what we can do and how we can do it.

The other important thing is to adopt passive design first. By passive design, we can reduce air conditioning and lighting load. This can be done more efficiently for new buildings. However, for existing buildings, we can try to work it out as well.

Q2. How did China promote the Top 10000 programme based on the success of the Top 1000 one? For the Top 1000 programme, many of the companies are large-scale companies. However, those companies in the Top 10000 programme can be medium-scale or even small-scale companies other than those large-scale ones. These small and medium-scale companies may have different approaches to tackling energy efficiency problems. Can you share how to promote the success of the Top 10000 programme to these smaller companies?

Dr Liu: When we designed the Top 1000 programme, China's large-scale plants used low-efficient equipment, which was 40 or 50 years old. There were coal-fired boilers still running and emitting black smoke. These kinds of large-scale plants were included in the Top 1000 programme.

Hence, in the Top 1000 programme, we aimed to phase out low-efficient equipment as quickly as possible. After five years, we found that we had not made an outstanding achievement. It was because many of the workers were engineers in the plants. Most had no idea (or few ideas) about the energy conservation concept. Then, we conducted capacity-building activities. When the workers and engineers were well-educated and well-trained with modern energy conservation concepts and knowledge, we went to the Top 10000. The Top 10000 was to improve the average efficiency towards the excellent level.

Then, we introduced advanced technology processes and ideas into the industrial sector, such as digital and information technology. We demonstrated how these advanced technologies could contribute to energy conservation. The well-educated and well-trained workers could then use them to improve the efficiency of their plants up to the advanced international level.

Q3. Numerous effective policies and initiatives to reduce the energy consumption of commercial buildings are widely adopted within the APEC region. What challenges and opportunities will we face to reduce energy consumption in commercial buildings?

Mr Fung: People would be the biggest challenge to us. If we can all move forward, we should not wait for the government's regulations to come. We should not wait for others to tell us what to do. Developers and owners should drive more demand for Net Zero buildings and Neutral Carbon buildings. Professionals should also get together to do it voluntarily without waiting to be asked.

Hence, this is the challenge that the mindset of people does not change and just waits for policies and regulations to come. Then everything will be passive. We should advocate for each other to move faster to involve people in every sector: governments, developers, professionals, and the public.

At the ANZ Ideas Competition, developers are starting to move forward.

For listed companies, there are requirements on ESG disclosure. This may be an incentive for these companies to move faster. I think this is an area that motivates developers. How to motivate professionals is a question that I am always keen to know. After the Ideas Competition, we created a rippling effect across the professionals.

The Ideas Competition has been cited as a valuable method because we have demonstrated how a successful competition can generate publicity, promote civic education to the public, and elevate the business profile of all those who participated. They all share their experiences on Facebook, LinkedIn, and whatever.

We cascade the message and can accelerate the adoption of these new initiatives across the industry. That is what I am hoping for. However, what about the next generation? How to motivate 30 students, for example? How can professors also work faster with us, and more research into the areas are being carried out? These are the opportunities that I can see for everyone to educate the younger generations, including secondary school and primary school kids.

Q4. What are the challenges when implementing the Top 10000 or Top 1000 initiatives in different geological zones? They have different climate, weather, and environmental constraints and financial concerns. You have also mentioned that many APEC member economies have different constraints. How can the experience of different geological zones in China help?

Dr Liu: China has a vast land area and different regions with different geological difficulties and financial situations. For geological constraints, for example, our chosen industrial boilers are very efficient and run well in Shanghai and Beijing. However, when we use them in Tibet, low efficiency is expected due to the high altitude and low pressure. Hence, we release a catalogue listing different high-efficient technology and equipment for the users to choose from. They can pick the right ones to improve their efficiency according to the local criteria.

On the other hand, when companies develop boilers or equipment to elevate efficiency standards for factories, we will fully consider the geological problems with composition factors and the efficiency calculations for different regions.

Most of the regions in China have geological or financial difficulties. There are also developing areas that are not that rich, impoverished, and lacking infrastructure. Usually, we will provide adjustment and capacity buildings because most of the workers and staff in the plants of these regions are not as well-educated and trained as workers in Guangdong, Shanghai, or Beijing. On the other hand, diversity in capacity building is difficult owing to financial constraints. These regions do not have enough money. To them, capacity building is an expensive activity.

The Government of China thus allocates funding to them from public finance to help them modernize their plants with high-energy-efficiency equipment.

To alleviate the financial burden of the Government of China, we also introduce appropriate market mechanisms to help them solve the financial problem, for example, as I mentioned in my presentation, energy performance contract (EPC). Hence, we can attract investment from the public sector. On the other hand, most investors from the private sector are very interested in this EPC because there is usually a significant improvement gap between the existing low-efficiency and the new high-efficiency equipment. This significant improvement gap can help the investors make more money from the energy efficiency improvement contracts. Consequently, both public and private investors are interested in the EPC in the developing regions in China.

Session 3 – Key Drivers of the Successful Policies and Initiatives in Renewables in APEC
Moderator: Dr Tom Lee, APEC EGNRET Past Chair

Q1. What are the most challenging issues of grid integration as renewable energy and the penetration increase in Chile? Also, Chile has a considerable renewable energy potential of around 70 times the energy demand. Is there any plan to export renewable energy, such as green hydrogen or ammonia?

Mr Aguilera: Regarding the first question, we are facing critical challenges regarding renewal integration. In the past, we focused on reaching maximum penetration with the lowest possible cost. However, we did not consider the importance of flexibility and the necessity to incorporate a certain amount of renewable. The existing transmission system can manage the variability of renewables, from wind and solar power, up to 30%. But over this 30%, we face a new and vital challenge. We are having problems with congestion in the transmission system because the existing transmission lines are not being developed as fast as we expected. Hence, we are trying to speed up that process. We now have centralized planning in transmission, but the transmission system is privately owned by some companies, which need to follow a plan that the Energy Commission sets. However, that process is too slow.

Consequently, we are having transmission congestion, and we expect to be in that situation until 2029. There will be a new HVDC electric power transmission system that is under construction and to be ready by then. This HVDC faces a problem with the marginal cost. We see zero marginal costs in specific periods of the day, so it is an important issue. That is why we have now established a special commission to address the problem. Trying to find a fast solution is the most critical and challenging mission we face.

The electricity and its marginal market do not have high renewable penetration, and the transmission expansion is not going as fast as we needed. We are conducting some studies. For example, now we are constructing specific lines to reach our renewable potential. Hence, we are building the line before the renewable productions are ready. We are sending a signal to the investors to start investing in those places.

Regarding the second question, green hydrogen is one of our top priorities in the energy policy now. We plan to develop a substantial hydrogen industry, so we take some actions to make it a reality. For example, we established a green hydrogen strategy and published it on the Ministry of Energy website. In that strategy, we expect an essential penetration of hydrogen in the next year, for example. By 2030, we expect to invest around USD50 billion in the industry with a corresponding renewable capacity of 40 gigawatts. Hydrogen is an essential priority for us. For example, in the South, we have a significant wind power potential, and we want to develop the hydrogen industry there. It is because we can supply green energy to the process and produce 100% green hydrogen.

Q2. Chinese Taipei has a law regulating the distance between residential areas and wind turbines. This distance has been changed from 250 meters to 500 meters. What are the rationales or logic behind it, and what are the impacts on the industry? Are there any technical difficulties?

Dr Chen: I think the distance between residents and turbines doubled from 250 meters to 500 meters is not a result of the rationale argument. In Chinese Taipei, we have strong resistance from the residents if they know that there are/will be larger turbines near their living places. The people have diverse opinions, but it seems doubling the distance is a good compromise. I'm not aware of any whistle call, signal, information, or evaluation on the topic. Anyhow, people do not like the turbine being too close, especially for the noise it makes.

Q3. What is the capacity factor for floating solar PV systems? Are there any big differences between rooftop and land-based solar PV systems?

Mr Sulistomo: The capacity factor is not that good enough. In practice, it is just around 11 to 30%. In some places, the capacity factor can reach 70%. It is satisfactory because Indonesia has many different areas. Some areas with extensive radiation, like Sumba Island, can have a 70% capacity factor, while some areas with not-so-good radiation, like Java Island, have around 12% in practice. However, there will still be a 70% capacity factor for some areas on Java Island.

Session 4 – Emerging Low-Carbon Technologies and Economic Instruments

Moderator: Ms Jovian Cheung, Project Manager, Senior Engineer of Electrical and Mechanical Services Department, Hong Kong, China

Q1. We learned that there were a lot of floating solar PV developments in Korea. Besides RPS, how does the government's policy support and encourage more stakeholders to participate in the floating solar PV development projects?

Mr Park: About subsidies, I have already explained the RPS system and one of the suitable custom subsidy systems. But at the same time, the economics of the floating PV has improved significantly.

I would like to explain why the cost of floating solar PV is 1.5 times higher than that of conventional land-based solar PV.

Floating solar PV can provide 10 to 20% more electricity than the ground one and can get 1.2 to 1.6 times RPS subsidies as compared to ground PV. Moreover, we need to pay 1.5 times more to build floating solar PV than the conventional land-based one. The RPS system has already covered the additional 50% of costs. As a result, we can get more electricity from floating solar PV, and thus the project development can readily meet its breakeven point under RPS.

However, one of the most important concerns is that usually, in the case of RPS, when the electricity players sell the RPC in the market, they have to go through auctions. There are risks that the processes may not be able to get government approvals. That is why it is agreed that the electricity players can construct RPS as an independent auction, not a common one. And this is the best option available for the players.

Moreover, the prices of the PV plant materials such as PV modules, inverters, and NOS have been declining yearly, especially the cultivating modules, which have dropped 20 to 30% in ten years. Some people think that the price may even go below 50%. If the price goes down sharply, it may pass the penalty level and trigger non-compliance. The RPS has significantly brought the price of PV plant material down.

Q2. If ammonia is used directly in power generation, are there any dioxide emissions from the process?

Dr Suda: The emission of NOx during the use of ammonia in power generation is one of the issues to be addressed. It is 100ppm, higher than the natural gas turbine, which emits only 30 or 40ppm. Since the emission is well below the 1000ppm level, it can be reduced by using a CR de-NOx Unit (NOx scrubbing technology) to meet the emission regulations if needed. A co-fired power plant is already at the same level as 100% coal. Hence, we don't have to change the CR de-NOx system and can still satisfy the regulations. We also try to reduce it more so to adapt it to the existing gas turbine in the GTCC system can be easier.

Q3. It was mentioned that an existing power generation facility had been converted to 100% ammonia. Can the speaker share the details of the existing facilities and the conversion process?

Dr Suda: The converted power generation facility was a natural gas turbine. We didn’t need to change the compressor and the turbine. We only changed the combustor to use ammonia pumped from the added ammonia supply unit. Then, we can reduce CO_2 emissions to zero.

Q4. Please explain why China is running local emission trading systems.

Dr LIU: We have developed emission trading systems at a local level for the past ten years. It is a pilot initiative. It is used to prepare ourselves for the launch of China’s ETS. ETS is new to almost all economies. We do not have relevant experiences. That is why we start running local ETSs before we launch the nationwide one. We can then accumulate sufficient data and learn enough to build a much larger operation. This is the basic idea around these local markets.

Q5. Singapore will launch Climate Action Data Trust. Can the speaker introduce more about this Trust and how to participate?

Mr Gan: Climate Action Data Trust is a joint effort by Singapore, the World Bank, and the International Emissions Trading Association. What the Trust does is to help bring all the disaggregated, decentralized data from various standard credit registries together onto a single platform. It will form a beta data layer with aggregated information that market participants can assess. This layer will help improve market transparency and avoid double counting in terms of double claiming, double issuance, and double using. Consequently, we will be confident that carbon credits are credible and properly accounted for when they are used and issued.

How to participate in this scheme? You can either be a private sector player or a government. You can use the data that will be available on the platform. You can use it to check against specific claims and credits that have been used or issued. If you have a carbon credit registry, you can join this Climate Action Data Trust to contribute your data to enhance the accountability of the international carbon markets. I think there will be more information coming out soon.

Q6. Singapore has two credit focuses targeting suppliers of credits as well as users of credits. Can the speaker share with us how this framework is set up and how it works?

Mr Gan: For this initiative, I would like to clarify that they are international initiatives, not from Singapore. In Singapore, we intend to guide carbon credits users toward using high-quality carbon credits through our carbon tax system. We announced that we will raise our carbon tax from 2024 onwards to SGD25 per tonne, with a view of reaching SGD50 to 80 per tonne by the end of the decade. We will also allow companies to offset up to 5% of their taxable emissions using eligible carbon credits. Through this, we are sending out a message that the company should only use Article 6 complied credit units that are really measurable. I believe it will help guide the market towards the use of high-quality carbon credits. That is our approach, but notwithstanding, we will not actively influence what the voluntary carbon market should do. It will definitely encourage mitigation actions and promote global climate action and ambition.

Q7. Bilateral cooperation is vital, in particular in the ammonia Industries. IHI had signed a couple of MOUs in Asia to build bilateral cooperation. Can the corresponding speaker share with us more about how to set up these MOUs and their relation to your ammonia network?

Dr Suda: The purpose of the MOUs is to understand and realize the advantages of ammonia for carbon neutrality. The whole initiative is like a kind of feasibility study, and the first step is to find out how much ammonia can contribute to carbon neutrality. There are many concerns, one of which is the price of ammonia. Compared with liquid hydrogen, ammonia is much cheaper. However, if it is compared with the existing fossil fuels, ammonia is very expensive. We must think about developing a system to reduce the ammonia price. I mean, using technologies can help reduce the price of ammonia, but some kind of government support is required to lower the electricity price of ammonia-fired turbines to the consumers. It is a combination of technologies and pricing mechanisms. Our first step is to understand how much ammonia is required to reduce CO_2 emissions in the corresponding APEC member economies. We also need to combine the entire supply chain of ammonia covering Asia and may extend to the Middle East as well.

Q8. China has already implemented ETS for more than five years. Can the corresponding speaker share the major challenges of developing the ETS in China?

Dr Liu: I believe that ETS is new to all of us. We have to build up everything from scratch. The first thing is the policies and regulations. These are critical to sustain the development of the ETS. Designing them is a huge challenge. So far, we are still amidst the development and perfecting of the laws and policies for the new ETS in China.

On the other hand, I see the market as like a swimming pool. Water flows into and out of it, and we need to maintain sufficient water levels to attract swimmers. With this analogy, China's new emission trading market needs enough funding to maintain its operation. Moreover, we need to keep excellent money flowing into and out of the market. In short, attracting enough good-quality participants with their financial contributions is the major challenge.

I also believe that when we put products and services into the market, we need the ability to deliver different categories of products and services for the different demand segments. Since China is still in the early stage of ETS development, we do not have many categories of carbon emission permit products. We can start with quota allocation, but we need to diversify our carbon emission permit offerings. We also need to build our ETS financing systems to attract more funding to join the emission trading market.

5 Conclusion

There are two energy-related goals that the APEC member economies have agreed to meet as a collective. The two goals are (1) to improve energy intensity by 45% in 2035 as compared to 2005 and (2) to double the share of modern renewables in the energy mix by 2030 compared to 2010.

This workshop was to build the capacity of the APEC member economies to achieve these two goals and to strengthen regional cooperation to attain carbon neutrality. A group of speakers from the APEC member economies and international organisations were invited to share their successful experiences and cases in the workshop.

There were four sessions in the workshop. In Session 1, two analyses conducted by IRENA on hydrogen energy development and APERC’s energy demand and supply outlooks provided a glimpse into the most recent energy policy development. The hydrogen and ammonia energy were addressed in COP27. Renewable resources in the APEC region were segregated. Some member economies had rich resources while some others had very limited. The APEC member economics might consider forming a kind of green hydrogen alliance to trade and collaborate with international organizations to promote green hydrogen. Moreover, there was no clear definition of green hydrogen, as discussed by the IRENA's reports. A clear definition of green energy, green hydrogen, and related green technologies could help speed up the energy transition.

In Session 2, the U.S. Energy Efficient Mobility Systems for the transport sector, China's Top 1000 and Top 10000 programmes for the industrial sector, Japan's Zero Energy Building/House policies for residential buildings, and the Ideas Harvested for enhancing energy efficiency of commercial buildings by the Green Building Council of HKC were presented. It was suggested that the governments should run some competition campaigns and activities to collect "ideas harvested" from the public. These "ideas harvested" could be employed in various energy sectors. On the other hand, diverse capacity buildings were essential in the transition of the Top 1000 to the Top 10000 in China, owing to the differences in geological and financial difficulties among different regions of China. Similar situations could be found in APEC as different member economies had different geological and financial difficulties. It was suggested that different types of energy-efficient equipment could be used accordingly to overcome geological difficulties. Financial difficulties could be alleviated by using EPC in developing regions.

In Session 3, presentations on the solar energy policies in Chile, offshore wind energy development in Chinese Taipei, the floating solar energy policies in Indonesia, and the enhanced geothermal systems in the U.S. were given. The variability of solar and wind power might affect the reliability of the existing transmission system. The development pace of the transmission system had to match the renewables. Using renewable energy for green hydrogen or ammonia could be an option. On the other hand, while developing the floating solar PV systems, there were big differences in capacity factors in a different area, from 30% to 70%, which should be considered. Further studies of Enhanced geothermal systems were needed.

In Session 4, the floating PV power plant technology in Korea, the clean fuel ammonia for energy carriers in Japan, China's emission trading system (ETS), and the development of carbon markets in Singapore were discussed. In the floating PV power development, it was learned that the name and outlook (the distribution of the individual floating PV modules) of a power plant should be harmonized with local history or belief in order to alleviate the residents' resistance. Another green technology discussed was the use of ammonia in power generation. By modifying the combustor of the existing (natural) gas-fired turbine and connecting it to a simple ammonia supply unit, the existing turbine could be changed to an ammonia-fired one for carbon-free operation. The success of commercializing green ammonia applications was highly dependent on the ammonia supply chain development. A small amount of NOx emissions in using ammonia in power generation became negligible after the use of NOx scrubbing technologies.

On the other hand, to develop an emission trading system (ETS), it was recommended that the system should be deployed in the fossil fuel energy-intensive sectors first, like power plants. For developing voluntary ETS, data quality was vital. The Climate Action Data Trust would bring all the disaggregated decentralized data from various standard credit registries together onto a single platform. It would help improve the emission data's credibility and ensure that there was no double counting in terms of double claiming, double issuance, and double using.

According to the APERC's results, the two goals were going to be achieved as per projection. In COP26, economies were invited to come forward with more ambitious 2030 emissions reduction targets, aiming to reach net zero by the middle of the century. The APEC member economies stated their COP26 Net-zero targets in different years (2050 or 2060). They were recommended to move forward to speed up the energy transition to carbon-neutral energy systems by developing regional emission trading systems and clean energy supply chains.

Appendix A – Agenda

Day 1 Workshop on 29 November 2022 08:30-12:10 (GMT+8)

HKC Time (GMT+8)	Sessions
09:00 - 09:05	**Welcome**
09:05 - 09:10	**Opening Remarks** Mr Tso Chin-wan, Secretary for Environment and Ecology, Hong Kong, China
09:10 - 09:15	**Photo Taking**
09:15 - 09:20	**Project Summary** Ms Elaine Yip, Project Officer, Engineer of Electrical and Mechanical Services Department, Hong Kong, China
Session 1: Highlight Of Global Climate Action And APERC's Energy Demand And Supply Outlook Moderator: Ms Jovian Cheung, Project Manager, Senior Engineer of Electrical and Mechanical Services Department, Hong Kong, China	
09:20 - 09:40	**Highlights Of Global Climate Action – COP27** Dr William Chung, Associate Professor, Department of Management Sciences, City University of Hong Kong, Hong Kong, China
09:40 - 10:00	**Milestones To Cost-Effective Way To Transport Renewable Electricity Via Hydrogen Trade** Mr Dolf Gielen, Director of the IRENA Innovation and Technology Centre
10:00 - 10:20	**Key messages from the APEC Energy Demand and Supply Outlook 8th Edition** Mr Thanan Marukatat, Research Fellow, APERC
10:20 - 10:40	**Q&A**
10:40 - 10:50	Break
Session 2: Key Drivers Of The Successful Policies And Initiatives In Energy Efficiency In APEC Moderator: Mr VY Ek Chin, APEC EGEEC Chair	
10:50 - 11:05	**Energy Efficient Mobility Systems** Dr Sanjini Nanayakkara, Project Manager, Integrated Decision Support Group, National Renewable Energy Laboratory, USA.
11:05 - 11:20	**From Top 1,000 Industrial Energy Conservation Programme And Thereafter** Dr Liu Meng, Deputy Chief of Energy Group, Sub-institute of Resources

	and Environment, China National Institute of Standardization, China
11:20 - 11:35	**The Japanese policy and strategy in the building sector towards "Carbon Neutrality"** Mr Kyohei Horiguchi, Assistant Director, Energy Efficiency Division, Energy Efficiency and Renewable Energy Department Agency For Natural Resources and Energy (ANRE), Trade and Industry (METI), Japan
11:35 - 11:50	**Drivers For Enhancing Energy Efficiency Of Commercial Buildings** Ms Ada Fung, Director of the World Green Building Council (WorldGBC) and the Hong Kong Green Building Council (HKGBC), Hong Kong, China
11:50 - 12:10	**Q&A**

Day 2 Workshop on 30 November 2022 08:30-12:10 (GMT+8)

HKC Time (GMT+8)	Sessions
09:00 - 09:05	**Welcome**
09:05 - 09:10	**Project Summary** Ms Elaine Yip, Project Officer, Engineer of Electrical and Mechanical Services Department, Hong Kong, China
Session 3: Key Drivers Of The Successful Policies And Initiatives In Renewables In APEC Moderator: Dr Tom LEE , APEC EGNRET Past-Chair	
09:10 - 09:25	**Evolution Of The Regulatory Energy Policies In Solar Energy In Chile** Mr Danilo Jara Aguilera, Head of the Regulatory Support Unit, Sustainable Energy Division, Ministry of Energy, Chile
09:25 - 09:40	**Drivers And Policies Of Wind Energy Growth – From Onshore To Offshore** Dr Chen Chung-Hsien, Director, Energy Technology Division, Bureau of Energy, Ministry of Economic Affairs, Chinese Taipei
09:40 - 09:55	**Drivers and Policies for Floating Solar Energy Growth** Mr Praptono Adhi Sulistomo, Investment and Cooperation Coordinator in the Directorate General of New Renewable Energy and Energy Conservation, Ministry of Energy and Mineral Resources
09:55 - 10:10	**Drivers And Policies For Enhanced Geothermal Systems Growth** Ms Lauren Boyd, Acting Director of DOE's Geothermal Technologies Office, USA

10:10 - 10:30	**Q&A**
10:30 - 10:40	**Break**
Session 4: Emerging Low-Carbon Technologies And Economic Instruments Moderator: Ms Jovian CHEUNG, Project Manager, Senior Engineer of Electrical and Mechanical Services Department, Hong Kong, China	
10:40 - 10:55	**Floating PV Power Plant Technology** Mr Albert Park, Director of Communication, Hanwha Q CELLS, Korea
10:55 - 11:10	**Green Ammonia For Energy Storage And Co-Firing Technology** Dr Toshiyuki Suda, Program Director for Carbon Solution, Corporate Strategy Headquarters, IHI Corporation, Japan
11:10 - 11:25	**Development Of China's Emission Trading System** Dr Liu Meng, Deputy Chief of Energy Group, Sub-institute of Resources and Environment, China National Institute of Standardization, China
11:25 - 11:40	**Development Of Carbon Market** Mr Rui Yun Gan, Senior Manager (Global Partnerships), National Climate Change Secretariat, Strategy Group, Prime Minister's Office, Singapore
11:40 - 12:00	**Q&A**
12:00 - 12:05	**Photo Taking**
12:05 - 12:10	**Closing Remarks** Mr Chu Kei-Ming, Barry, Project Overseer

Appendix B – Participant List

Name	Economies / Organisation	Gender
1. Ms Bryna BAMBERRY	Australia	F
2. Ms Sarah SHERIDAN	Australia	F
3. Mr Danilo Jara AGUILERA	Chile	M
4. Dr Meng LIU	China	M
5. Mr Kei Ming, Barry CHU	Hong Kong, China	M
6. Ms Jovian CHEUNG	Hong Kong, China	F
7. Ms Wai Ling YIP	Hong Kong, China	F
8. Mr Ronvin KWAN	Hong Kong, China	M
9. Mr Kwok Ho LAU	Hong Kong, China	M
10. Mr Ka Wai TAM	Hong Kong, China	M
11. Ms Shing Nok YUEN	Hong Kong, China	F
12. Ms Ada Yin-Suen, BBS FUNG	Hong Kong, China	F
13. Dr William CHUNG	Hong Kong, China	M
14. Ms Joanie FOK	Hong Kong, China	F
15. Ms Jaime CHIM	Hong Kong, China	F
16. Mr John LAM	Hong Kong, China	M
17. Mr Ka-Ming, Kelvin CHOW	Hong Kong, China	M
18. Mr Lok-Ting, Terry HO	Hong Kong, China	M
19. Mr Wai Ming KWAN	Hong Kong, China	M
20. Ms Pui Yu, Top LAM	Hong Kong, China	F
21. Ms Boon-Ki, Janica LEE	Hong Kong, China	F
22. Ms Wing-Tak, Ada SO	Hong Kong, China	F
23. Mr Hon-Wing, Steve WONG	Hong Kong, China	M
24. Mr Chi-Hung, Victor YEUNG	Hong Kong, China	M
25. Mr Leo CHAN	Hong Kong, China	M
26. Ms Caterina CHOI	Hong Kong, China	F
27. Mr Rodney IP	Hong Kong, China	M
28. Ms Emily WONG	Hong Kong, China	F
29. Mr Jimmy YAM	Hong Kong, China	M
30. Mr Cary CHAN	Hong Kong, China	M
31. Ms Fiona CHAN	Hong Kong, China	F
32. Ms Karen CHEUNG	Hong Kong, China	F
33. Mr Tw FUNG	Hong Kong, China	M

34.	Mr Paul SAT	Hong Kong, China	M
35.	Mr Chi Shing LEUNG	Hong Kong, China	M
36.	Mr Freddy LI	Hong Kong, China	M
37.	Mr Michael YEUNG	Hong Kong, China	M
38.	Mr Steven CHAN	Hong Kong, China	M
39.	Mr Ivan WAN	Hong Kong, China	M
40.	Mr Kenneth CHAN	Hong Kong, China	M
41.	Mr Martin WAN	Hong Kong, China	M
42.	Mr Gary MOK	Hong Kong, China	M
43.	Ms Athena CHAN	Hong Kong, China	F
44.	Mr Chris TING	Hong Kong, China	M
45.	Mr Tony LAM	Hong Kong, China	M
46.	Mr Garrick SZE	Hong Kong, China	M
47.	Ms Deasy Kurniawati MISNA	Indonesia	F
48.	Mr Raden Waluyo Jati SOEMOWIDAGDO	Indonesia	M
49.	Mr Praptono Adhi SULISTOMO	Indonesia	M
50.	Ms Yosi Dwi Tantri Ani	Indonesia	M
51.	Ms Reiko EDA	Japan	F
52.	Mr Daisuke HAYAMIZU	Japan	M
53.	Mr Kyohei HORIGUCHI	Japan	M
54.	Dr Toshiyuki SUDA	Japan	M
55.	Mr Albert Park	Korea	M
56.	Mr Muhammad IDHAM	Malaysia	M
57.	Mr Saiful Hakim Abdul RAHMAN	Malaysia	M
58.	Dr Ivy YAP	Malaysia	F
59.	Mr Walter ANGEL	Mexico	M
60.	Mr Heberto BARRIOS	Mexico	M
61.	Mr Dave Angelo CABALTEJA	The Philippines	F
62.	Mr Robert DOLOJAN	The Philippines	M
63.	Mr Michael G. FLORIA	The Philippines	M
64.	Ms Diana Christine GABITO	The Philippines	F
65.	Ms Criscel L. GALANG	The Philippines	F
66.	Ms Sienna Mae HORTALEZA	The Philippines	F
67.	Mrs Ron-Rod D. MADERA	The Philippines	F
68.	Ms Lilibeth MORALES	The Philippines	F
69.	Ms Ma. Angelica Eunice PERALTA	The Philippines	F

70.	Ms Marietta QUEJADA	The Philippines	F
71.	Mr Allan D. RABE	The Philippines	M
72.	Mr Kristam U. SABTURANI	The Philippines	M
73.	Mr Raymond SAMSON	The Philippines	M
74.	Mr Jayser D. TAN	The Philippines	M
75.	Ms Joice Gianne VICENTE	The Philippines	F
76.	Mr Danilo VIVAR	The Philippines	M
77.	Mr Arnulfo M. ZABALA	The Philippines	M
78.	Mr Rui Yun GAN	Singapore	M
79.	Ms Latha GANESH	Singapore	F
80.	Mr Lucius TAN	Singapore	M
81.	Dr Chung-Hsien CHEN	Chinese Taipei	M
82.	Ms Shu Wen JANG	Chinese Taipei	F
83.	Dr Chi-Wen LIAO	Chinese Taipei	M
84.	Ms Joy MAO	Chinese Taipei	F
85.	Ms Lynn Wan-Ling WANG	Chinese Taipei	F
86.	Dr Wannapa BUANGAM	Thailand	F
87.	Mr Warote CHAINTARAWONG	Thailand	M
88.	Ms Sutthasini GLAWGITIGUL	Thailand	F
89.	Mr Chatchai KARUNA	Thailand	M
90.	Ms Sukanya NANTA	Thailand	F
91.	Dr Chonticha SAHUB	Thailand	F
92.	Mrs Munlika SOMPRANON	Thailand	F
93.	Dr Anupong SUKEE	Thailand	M
94.	Dr Pachara VACHARAPANICH	Thailand	M
95.	Dr Pongpan VORASAYAN	Thailand	M
96.	Mr Cary BLOYD	United States	M
97.	Ms Lauren BOYD	United States	F
98.	Mr Ron CHERRY	United States	M
99.	Dr Sanjini NANAYAKKARA	United States	F
100.	Ms Kate SELLEY	United States	F
101.	Mr Hoang Van TAM	Viet Nam	M
102.	Dr Manuel HEREDIA	APERC	M
103.	Mr Alexander IZHBULDIN	APERC	M
104.	Mr Thanan MARUKATAT	APERC	M
105.	Mr Ek Chin VY	EGEEC	M
106.	Mr Steivan DEFILLA	APSEC	M

107. Mr Chun Yin LI	EGEEC	M
108. Dr Tom LEE	EGNRET	M
109. Dr Tarcy Sih-Ting JHOU	EGNRET	F
110. Mr Dolf GIELEN	IRENA	M