APEC Symposium on Bioenergy

APEC 3rd Sectoral Symposium for Energy Transition

APEC Energy Working Group

February 2026

Asia-Pacific
Economic Cooperation

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II. Abbreviations and terms

AEDP	Alternative Energy Development Plan
APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
ASTM	American Society for Testing and Materials
ATJ	Alcohol-to-Jet
AZEC	Asia Zero Emission Community
BCG	Bio-Circular-Green
BHD	bio-hydrogenated diesel
BRT	Bus Rapid Transit
CAAS	Civil Aviation Authority of Singapore
CDMO	Contract Development and Manufacturing Organization
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CPO	Crude Palm Oil
DEDE	Department of Alternative Energy Development and Efficiency
DOE	Department of Energy
EGAT	Electricity Generating Authority of Thailand
eSAF	electro-fuel-based SAF
EV	Electric Vehicle
EWG	Energy Working Group
FAA	Federal Aviation Administration
GEF	Global Environment Facility
GWP	Global Wildlife Program
GX	Green Transformation
HEFA	Hydroprocessed Esters and Fatty Acids
HVO	hydrotreated vegetable oil
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
IPPs	Independent Power Producers
ISCC	International Sustainability and Carbon Certification
KEEI	Korea Energy Economics Institute
METI	Ministry of Economy, Trade and Industry
NDC	Nationally Determined Contribution
NREP	National Renewable Energy Program
PEIT	Petroleum and Energy Institute of Thailand
PFAD	Palm Fatty Acid Distillate
RBD PO	Refined, Bleached and Deodorized Palm Oil

RDF	Refuse-Derived Fuel
RFNBO	Renewable Fuels of Non-Biological Origin
SAF	Sustainable Aviation Fuel
SAF	Sustainable Aviation Fuel
SPPs	Small Power Producers
UCO	used cooking oil
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WCO	Waste Cooking Oil

III. Background

About energy transitions, there is no "single best solution" for achieving carbon neutrality, as each economy has different economic and social structures, and geographical situations. We strongly believe that various, pragmatic, and sustainable energy transitions that reflect the different circumstances of each economy, are essential. To achieve such energy transitions, sharing knowledge and experience among members is important.

IV. Objective

The objective is to hold a symposium to follow up "APEC Sectoral Symposia on the Holistic Approach of Decarbonization for Energy Transition" (EWG 03 2022S) held in 2021, and to organize the third Sectoral Symposium on Bioenergy in collaboration with the Ministry of Energy, Thailand.

The first and second sectoral symposia were "APEC Symposium on Pursuing Decarbonization of Fossil Fuels" in 2023 and "APEC Symposium on Promoting Energy Efficiency and Energy Management Systems" in 2024 respectively.

Ⅴ. Outcome

The symposium in person was held in Khon Kaen, Thailand on 3 December, 2024. 57 participants from 13 APEC economies (Australia; China; Hong Kong, China; Indonesia; Japan; Korea; Malaysia; Papua New Guinea; The Philippines; Singapore; Chinese Taipei; Thailand and Viet Nam) attended the symposium.

The speakers were invited from a wide range of government, private sector, academic, and research institutions. The participants were government officials involved in formulating policies, programs, and measures for decarbonization of fossil fuel use, energy efficiency and energy management systems and bioenergy. The In-person symposium facilitated an active exchange to share expertise, best practices and insights on the topics among participants, including "Biodiesel and Bioethanol", "Synthetic Biofuels" and "Decarbonization in Power Sector by Biomass and Biohydrogen".

The Symposium participants visited Mitr Phol Sugar and Ethanol Plants on 4 December 2024. Mitr Phol was ranked as the 4th largest sugar producer in the world in 2023, and 2nd in 2018. The complex is a fully integrated facility comprising a sugar mill, ethanol plant, biomass power plant, and fertilizer plant.

The Participants learned fundamental knowledge, related policies and initiatives in the meeting, and then they experienced the application and practical case in the site and maximized the advantage of the in-person event.

Ⅵ. Symposium Summary

1. Welcome Remarks

Mr Waranon Chansiri, Executive Director, Ministry of Energy, Thailand

Mr Chansiri welcomed all attendees, including Mr Siriwat Pinijpanich, Vice Governor of Khon Kaen Province, Dr Kazutomo Irie, President of the Asia Pacific Energy Research Centre, and Mr Shan Weiguo, the incoming Chair of the APEC Energy Working Group. He spoke on behalf of the Ministry of Energy, Thailand, and expressed appreciation for the opportunity to co-organize the symposium with the Asia Pacific Energy Research Centre through the APEC Energy Working Group framework.

He introduced the energy context of Khon Kaen Province, emphasizing its capacity to produce electricity from various sources such as combined cycle power plants, hydropower, biomass, solar, and waste. He also highlighted Khon Kaen's potential to advance bioenergy development, with an ethanol production capacity of approximately 590,000 liters per day from sugarcane and cassava. This effort supports both decarbonization and economic growth in the local agricultural sector.

He reiterated Thailand’s commitment to APEC collective goal of doubling the share of renewable energy by 2030, relative to 2010 levels. Thailand aims to contribute by pursuing carbon neutrality by 2050 and continuing its active role in APEC energy cooperation mechanisms.

He emphasized that the symposium would serve as a valuable platform for exchanging ideas, discussing opportunities and challenges in biofuel development, and strengthening collaboration among APEC economies.

He also encouraged participants to enjoy the city of Khon Kaen, which plays a significant role in Thailand's renewable energy landscape.

In closing, he expressed gratitude to the Vice Governor of Khon Kaen Province and the Khon Kaen Energy Provincial Office for their support in hosting the symposium.

He then invited Mr Siriwat Pinijpanich, Vice Governor of Khon Kaen Province, to deliver his welcome remarks.

2. Opening Remarks

Mr Siriwat Pinijpanich, the Vice Governor of Khon Kaen Province, Thailand

Mr Siriwat Pinijpanich welcomed the participants and experts and delegates from APEC member economies, and expressed his pleasure in hosting the APEC Energy Working Group meeting in Khon Kaen Province. He expressed his acknowledgement in the importance of this event, which was the third event of the APEC energy symposium series.

Mr Pinijpanich introduced Khon Kaen as an important economic center located in the northeastern region of Thailand. The province plays a significant role due to its strategic location and natural resources. He welcomed all delegates from the APEC economies and emphasized Khon Kaen's rich offering of tourism attractions, domestic parks, and diverse sources of energy. These resources include on-shore natural gas resources, solar energy, water, and bioenergy from agricultural byproducts, all of which contribute to the region's potential in renewable energy development.

He expressed his sincere belief that the cooperation fostered through the third sectorial symposium in bioenergy by APEC Energy Working Group would contribute meaningfully to energy development initiatives in Khon Kaen over the course of the two-day program. He underscored the importance of sharing knowledge, advancing technology, and improving ecosystem management among APEC members to support energy transition in APEC member economies towards a more sustainable energy future.

Mr Pinijpanich concluded by thanking all participants for attending and showing respect for Khon Kaen Province. He expressed hope that the event would serve as a valuable platform for the exchange of ideas and experiences, and wished all attendees an enjoyable and enriching visit.

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

Dr Kazutomo Irie welcomed distinguished guests and participants from APEC economies. He introduced himself as President of the Asia Pacific Energy Research Centre and noted the significance of this symposium on bioenergy.

He explained that this event builds upon the previous virtual symposium held in August 2021, which focused on a holistic approach to achieving carbon neutrality. Dr Irie stressed that no single pathway can achieve carbon neutrality due to the diverse economic and geographic circumstances of each APEC economy. He emphasized the importance of knowledge exchange to support inclusive and practical transitions. He introduced the context of the current event as part of a series of sector-focused symposia. The first focused on decarbonizing fossil fuels and was held in Kobe, Japan, in October 2023. The second focused on promoting energy efficiency and energy management system and was held in Tokyo in January 2024. Key findings from both were presented at the APEC Energy Transition Workshop in Nanjing, China, in May 2024.

This third symposium, organized in collaboration with the Ministry of Energy of Thailand, aligns with Thailand's Bio Circular Green Economy initiative. It aims to promote increased use of bioenergy through policy dialogue and technological exchange.

He outlined the symposium agenda. It would begin with a keynote address from the Japanese Ministry of Economy, Trade and Industry, followed by a scene-setting presentation from an APERC colleague. The day would include three expert sessions covering biodiesel and bioethanol in the morning, and synthetic biofuels, biomass, and biohydrogen in the power sector in the afternoon. He also noted that a networking reception would be held in the evening, and a site visit would take place the next morning.

He concluded by thanking all participants for their contributions and invited Mr Yoshiomi Yoshino from the Ministry of Economy, Trade and Industry of Japan to deliver the keynote address via video message.

3. Keynote Speech

Mr Yoshiomi Yoshino, Director for International Policy on Carbon Neutrality, Ministry of Economy, Trade and Industry, Japan

Following the opening remarks by Dr Kazutomo Irie, the keynote address was delivered via video message by Mr Yoshiomi Yoshino, Director for International Policy on Carbon Neutrality at the Agency for Natural Resources and Energy, under the Ministry of Economy, Trade and Industry (METI), Japan.

Mr Yoshino began by warmly welcoming all participants to the symposium and extended his remarks on behalf of METI. He emphasized the evolving nature of the global energy landscape, citing both the urgency of climate change and the volatility brought about by recent energy crises. He noted that many economies, including Thailand, have set ambitious climate targets. Specifically, Thailand has announced its commitment to achieving carbon neutrality by 2050 and net zero greenhouse gas emissions by 2065.

Addressing the broader challenges, Mr Yoshino pointed out that the energy crisis has caused instability in energy supply and elevated prices worldwide. This situation, he explained, highlights the critical importance of ensuring energy security as a foundational element of any society and economy. A balanced approach is necessary, one that harmonizes energy security, economic growth, and climate action.

Mr Yoshino then outlined three key principles that Japan believes are essential to a successful global energy transition:

1. One Goal, Various Pathways

He stressed that each economy has its own unique energy conditions, shaped by factors such as geography and industrial structure. Therefore, while the shared goal of net zero emissions is important, it is equally essential to recognize and respect the diversity of transition pathways suited to different domestic contexts.

2. Promotion of Innovation

Japan is undergoing a wide-ranging transformation of its economy, society, and industrial systems with the goal of achieving both carbon neutrality and economic growth by 2050. This transition is known as the Green Transformation (GX).

Mr Yoshino shared that Japan anticipates over JPY150 trillion (approximately USD1 trillion) of investment in GX over the next decade. To support this, the Japanese government plans to provide JPY20 trillion (approximately USD140 billion) in upfront investment. This will be supported through the issuance of GX Economic Transition Bonds. These funds will help accelerate the development of innovative technologies, including offshore wind, next-generation solar, hydrogen, and ammonia energy solutions.

3. Providing Solutions Globally

Mr Yoshino stated that achieving decarbonization globally requires cooperation among all economies, whether developed or developing, producers or consumers. Despite contributing only 3% of global carbon dioxide emissions, Japan is committed to contributing to reductions in the remaining 97% by sharing technologies, financing options, and expertise.

One such effort includes the Asia Zero Emission Community (AZEC) platform, through which Japan collaborates with ASEAN economies to simultaneously pursue decarbonization, economic development, and energy security. Additionally, Japan intends to share its knowledge and experiences with other APEC economies through both APEC initiatives and bilateral frameworks.

Shifting to the focus of the symposium—bioenergy—Mr Yoshino introduced some of Japan's current initiatives in this area. In biomass power generation, projects are underway to convert sources such as seaweed sludge, food waste, and livestock waste (such as cow dung) into methane gas, which is then used to generate electricity and heat. Japan has set a goal of reaching 8GW of biomass power generation capacity by 2030. As of March of this year, 7.5GW have already been achieved.

In terms of biofuels, Japan is actively encouraging the use of bioethanol derived from feedstocks like corn and sugarcane for use in passenger vehicles, either mixed with gasoline or as a complete substitute. At the local government level, biodiesel is being promoted by refining waste cooking oil and mixing it with diesel fuel. This biodiesel is then used in public transport vehicles such as buses and municipal service vehicles like street cleaners.

In aviation and maritime transport, Japan is preparing to meet new international decarbonization standards. For aviation, in particular, the economy has set a goal of replacing 10% of conventional jet fuel with Sustainable Aviation Fuel (SAF) by 2030. Policies and regulatory systems are currently being developed to support this transition.

To further reduce emissions in the fuel sector, Japan also emphasizes the potential of synthetic fuels, such as e-fuels and e-methane, as well as expanded adoption of existing biofuels.

Mr Yoshino concluded by expressing his sincere hope that the symposium would serve as a meaningful platform for APEC economies to exchange knowledge, formulate new policies, and accelerate progress toward carbon neutrality.

He thanked participants for their attention and reaffirmed Japan's commitment to supporting regional and global decarbonization efforts.

4. Scene Setting: "Outlook for Bioenergy in APEC: Two Scenarios"

Mr Glen Sweetnam, Senior Vice President, APERC

Mr Glen Sweetnam, Senior Vice President of the Asia Pacific Energy Research Centre, delivered a scene setting presentation at the symposium. He began by expressing appreciation to the province of Khon Kaen for hosting the event and to the Ministry of Energy of Thailand for co-organizing the symposium. He emphasized the importance of the meeting and shared his hope that participants would gain valuable insights into the potential of bioenergy in achieving decarbonization.

In his introduction, Mr Sweetnam explained that his presentation aimed to provide context on how APERC views bioenergy, how it is incorporated into their energy outlook, and what challenges and opportunities lie ahead. He stated that this overview would help frame the expert discussions planned for the rest of the symposium.

He noted that APERC produces an energy outlook every three years, with the next edition scheduled for release in October 2025. The preparation of this outlook involves collaboration with all twenty-one APEC member economies to develop energy use projections, including those for bioenergy.

Mr Sweetnam highlighted one of the major strengths of bioenergy. Through the process of photosynthesis, plants absorb carbon dioxide from the atmosphere. When these plants are later used for energy, the carbon dioxide released is effectively balanced out by the carbon previously absorbed. This makes bioenergy a potentially carbon-neutral energy source. However, despite this benefit, bioenergy still plays a relatively small role in APEC energy system. He posed the question of whether technological innovation could help scale bioenergy for greater impact.

To provide clarity, he outlined the energy system structure used in APERC analysis. Primary energy supply includes fossil fuels, nuclear energy, and biomass. This supply can either be used directly in sectors such as industry and residential, or transformed into electricity, heat, or refined fuels. Bioenergy enters the system in multiple ways, which makes it complex to track and evaluate accurately.

Reviewing historical data from 2000 to 2021, Mr Sweetnam pointed out that biomass and biofuels have played a limited role in APEC primary energy supply. In 2021, biomass accounted for 2.5% and biofuels for 0.7%. Though both have experienced growth, it has been from a small base.

Electricity generation from biomass increased from 63TWh to 201TWh between 2000 and 2021. However, even with this growth, biomass accounted for only 1.1% of total electricity generation in APEC. Regarding final energy consumption, biomass represented 4% and biofuels 2%, primarily used in the industrial and residential sectors. The transport sector was the major consumer of liquid biofuels.

Mr Sweetnam further explained that while bio-gasoline experienced rapid growth, it plateaued around 2010 at approximately 5% of liquid fuels. Biodiesel, on the other hand, continued to grow and reached a 6% share in 2021. Southeast Asia, in particular, showed significant uptake due to its large biomass resources such as palm oil. In this region, biodiesel accounts for 18% of biofuel supply.

He introduced two future scenarios: the reference case and the target case. The reference case assumes continuation of current policies. Under this scenario, bioenergy use remains relatively flat. The target case assumes implementation of each economy's stated decarbonization goals. In this case, biomass use nearly doubles by 2060. However, the share of biofuels declines due to increasing electrification of the transport sector.

In terms of electricity generation, biomass plays a more significant role in the target case. It could reach almost 25% of renewable electricity generation by 2060. However, its share of total electricity generation is projected to remain modest, increasing only to 2.3% in the target case, compared to 1.1% in the reference case.

Biofuels are expected to remain important in Southeast Asia. Blending rates for biodiesel and biogasoline are projected to rise to 18% and 12% respectively under the reference case. In the target scenario, they could reach 55% for biodiesel and 25% for biogasoline. Mr Sweetnam explained that electrification will reduce the need for biofuels in road transport, but in marine and aviation sectors where electrification is more difficult, biofuels can play a larger role. Biodiesel could account for 30% of marine fuel in the target case, and biokerosene could reach 50% of aviation fuel.

He then addressed a key challenge facing bioenergy. Despite its environmental benefits, bioenergy has low energy density. Fossil fuels like diesel and gasoline provide around 40megajoules per liter, while ethanol offers about half that amount. Solid biomass sources such as wood pellets and charcoal have even lower energy density, making them expensive to transport and process. This characteristic limits the scalability of bioenergy unless new technologies reduce these economic barriers.

To illustrate this, Mr Sweetnam presented a chart showing the energy density and specific energy of various fuels. Fossil fuels ranked highest, followed by ethanol, then solid biomass, and finally lithium-ion batteries. He emphasized that while bioenergy is viable in specific conditions, such as regions with plentiful biomass, it is not yet suitable for widespread use without further innovation.

He also noted that bioenergy feedstocks often have competing uses, such as food production, which adds cost. Gathering and processing biomass can be labor-intensive and energy-intensive. The conversion of cellulose to liquid fuels, though promising, is not yet commercially viable.

In conclusion, Mr Sweetnam stated that until technological breakthroughs occur, policies and subsidies will be needed to support the expansion of bioenergy. He stressed that there are contexts in which bioenergy is already practical and beneficial. He expressed his hope that the symposium would help identify those areas and stimulate innovation that could make bioenergy a more competitive and scalable solution in the future.

5. Session 1. “Biodiesel and Bioethanol: Opportunities & Challenges and Recent Developments”

Session Moderator:
Dr Ruengsak Thitiratsakul, Petroleum and Energy Institute of Thailand (PEIT)

Session1-1
"Thailand Latest Policy to Promote Bioenergy"
Dr Natikorn Prakobboon, Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand

Dr Natikorn Prakobboon began his presentation by greeting the audience and introducing himself as an engineer at the Biofuel Development Bureau, under the Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. He expressed his gratitude for the opportunity to speak and introduced the topic of Thailand's latest biofuel promotion policy, emphasizing its timeliness and importance in addressing global energy challenges.

He explained that Thailand is ranked seventh globally in both ethanol production and consumption, with most domestically produced ethanol used as transport fuel in gasohol blends. Molasses and cassava are the primary feedstocks. He presented an overview of Thailand's ethanol production facilities, highlighting 28 plants with a total capacity of 6.7 million liters per day. These included 11 plants using molasses (2.8 million liters per day), 2 hybrid plants using sugarcane juice or molasses (0.83 million liters per day), 5 hybrid plants using cassava and molasses (1.05 million liters per day), and 10 cassava-based plants (2.09 million liters per day).

Dr Natikorn noted that over the past four years, ethanol production in Thailand relied approximately 70% on molasses and 30% on cassava, though this ratio fluctuates based on raw material prices. He reviewed ethanol consumption trends, stating that prior to the COVID-19 pandemic, Thailand consumed 4.4 million liters per day. The pandemic led to a decline in travel and ethanol usage, dropping to 4.1 million liters per day in 2020 and 3.85 million liters per day in 2022, with a projected further decrease to 3.41 million liters per day by year-end.

He identified two major challenges to ethanol: the planned termination of the Oil Fund subsidy by the end of 2026, and the rise of electric vehicles under the 30@30 policy, which targets 30% electric vehicle production by 2030. These trends could reduce gasoline consumption to 17 million liters per day, half the current level in 2037.

To address future demand scenarios, the government developed two projections: if E20 remains the primary fuel, ethanol demand would be 3.2 million liters per day; if E10 dominates, demand would drop to 1.52 million liters per day. With production capacity at 6.7 million liters per day, he discussed options for surplus management.

Dr Natikorn explained that during the COVID-19 pandemic, ethanol producers were temporarily allowed to manufacture pharmaceutical-grade sanitizers. Around 81 million liters of ethanol were used for this purpose. Thailand has also exported ethanol to several economies, including Ethiopia; Hong Kong, China; Japan; and the Philippines, albeit in limited volumes. Export requires case-by-case approval from the Excise Department.

He outlined potential solutions for adapting the ethanol industry: producing ethanol-based bioplastics, which reduce emissions and are aligned with Thailand's BCG (Bio-Circular-Green) economy model; expanding pharmaceutical and chemical applications; and producing Sustainable Aviation Fuel (SAF) using Alcohol-to-Jet (ATJ) technology. Thailand plans to mandate a 2% SAF blend in jet fuel by 2027, pending cabinet approval. He noted that export restrictions may be relaxed to establish Thailand as a regional ethanol trading hub.

Dr Natikorn then transitioned to biodiesel development. He presented data on 15 biodiesel plants in Thailand with a combined capacity of 11.96 million liters per day, using raw materials such as CPO, RBD PO, palm stearin, and PFAD. The largest producer, Global Green Chemical, has a capacity of 1.2 million liters per day.

He reviewed biodiesel consumption trends and blending ratios. Diesel consumption has grown steadily since 2011, reaching 67 million liters per day in 2024. Biodiesel consumption increased with higher blending ratios (B10) but declined during 2020-2022 due to the pandemic. It rose again to 4.39 million liters per day by 2024. Blending ratios have evolved from B3 to B20, with B7 Euro5 introduced in May 2024. However, due to rising palm oil prices, the blend was temporarily reduced to B5 in November 2024.

He listed challenges for biodiesel: the same issues affecting ethanol (Oil Fund termination and EV expansion), Euro5 emission standards limiting biodiesel blends to 7%, and high palm oil production costs caused by low yield and extraction efficiency. These factors impact the competitiveness of Thai biodiesel.

Dr Natikorn emphasized the need for innovation and diversification in the biodiesel industry. Solutions include increasing palm oil yield, developing high-quality oil palm standards, and promoting alternative high-value products such as BHD (bio-hydrogenated diesel), SAF, and bio-based transformer oils.

He concluded with future projections. Under AEDP 2024, diesel consumption is expected to fall from 67 million liters per day in 2024 to 35 million liters per day in 2037. Biodiesel use is projected to decline from 6.5 million liters per day in 2022 to 2.46 million liters per day by 2037. He noted the importance of stable supply chain management, palm oil price control, and high-quality raw materials.

Dr Natikorn ended by summarizing Thailand's strategy to support high-value palm oil products to enhance competitiveness and sustainability, contributing to the broader goals of energy transition and environmental improvement.

Session1-2

“Bioenergy in Chinese Taipei and Asia”

Dr Chia-Chi Chang, Taiwan Bio-energy Technology Development Association, Chinese Taipei

The second speaker was Dr Chia-Chi Chang. He holds a bachelor’s degree from the Department of

Environmental Engineering and Science from Feng Chia University, a master's degree in civil engineering from the same university, and a PhD in Environmental Engineering from Taiwan University. Since 2009, Dr Chang has held multiple roles across universities and research institutes, including senior research fellow, postdoctoral fellow, and project manager. His areas of expertise include bioengineering, energy, waste-to-fuel conversion, water treatment, and resource recovery. Dr Chang presented on the topic of bioenergy in Chinese Taipei and Asia.

Dr Chang began by expressing his honor in sharing Chinese Taipei's experience with biofuel, acknowledging upfront that their liquid biofuel policy failed ten years ago. He stated that currently, only a small amount of liquid biofuel is used at a few gasoline stations, essentially for symbolic purposes. He aimed to share this story as a lesson.

He highlighted the long history of bioenergy usage throughout human civilization. Despite technological advancements, 60% of global biomass is still used inefficiently for basic applications such as illumination, household heating, or cooking. The development of modern bioenergy has enabled the production of heat, fuels, and electricity. Dr Chang's focus was on liquid biofuels including bio-alcohol, biodiesel, sustainable aviation fuel (SAF), and hydrotreated vegetable oil (HVO).

Dr Chang noted that there has been little technological innovation in biofuel production in recent decades. Most current technologies, such as gasification and the Fischer–Tropsch process, date back to World War II. The primary challenge remains securing sufficient feedstock. Although the market has shifted its focus from biodiesel to SAF and HVO, the feedstock remains the same.

He stressed that reviving biofuel usage in Chinese Taipei would be difficult, as existing suppliers have already adapted to other pathways. Liquid biofuels, mainly used in transportation, face growing competition from electric vehicles.

Chinese Taipei has committed to achieving net-zero emissions by 2050. Every five years, new targets are set under the Global Greenhouse Gases Reduction and Management Act. Currently, Chinese Taipei is in the second phase, aiming to reduce carbon dioxide emissions by 10% by the end of 2025. However, fossil fuels still dominate energy consumption, and the use of biofuel remains minimal.

Currently, only 14 gasoline stations offer E3 ethanol blends. A few factories use biofuel derived from plankton oil, representing less than 1% of energy consumption. Most renewable energy development focuses on the power sector. Chinese Taipei has also shut down two nuclear plants in recent years, further complicating the renewable energy transition. Bioenergy remains underrepresented.

Dr Chang stated that his association is the only one in Chinese Taipei actively promoting bioenergy, a cause that he finds increasingly discouraging. He remains hopeful that net-zero goals may provide new momentum.

In the transportation sector, Chinese Taipei emitted 60.5 million tons of carbon dioxide in 2020. By 2030, this must be reduced to 27 to 28 million tons. The government's primary strategy is to replace fossil fuel-powered vehicles with electric vehicles, rather than expanding biofuel use, due to negative past experiences with biodiesel.

Biodiesel development began in 1998 with a pilot project using soybean oil. In 2006, a partnership between the EPA, industry, and energy departments focused on converting waste cooking oil into biodiesel. Benefits included waste reduction and reduced carbon and pollutant emissions.

The first commercial biodiesel plant using raw feedstock opened in 2004. A second plant using waste cooking oil began operations in 2006 and remains the only one operating today. The government launched a four-stage plan starting in 2006. In the first phase, over 400 buses and garbage trucks used biodiesel. In the second phase (2007–2008), biodiesel supply systems were established in Chiayi and Taoyuan. The third phase introduced a B1 policy, blending 1% biodiesel into commercial diesel, followed by B2 blending in the fourth phase (post-2010).

Despite these efforts, biodiesel blending was suspended in May 2014, limiting biodiesel use to industrial boilers. At its peak, biodiesel production reached 100,000 kiloliters annually. After the program's termination, the waste cooking oil supply chain adapted independently. Of the 25,000 tons of used oil collected annually, 30 to 40% is exported, while 60 to 70% is used domestically by the single remaining producer.

This producer buys waste cooking oil at high prices from fast-food chains, making production costs higher than diesel. Despite subsidies, domestic gasoline remains very cheap. For instance, the price is less than USD1 per liter, making it difficult for biodiesel to compete.

Due to price disadvantages, producers export biodiesel to Europe. However, some domestic users, such as McDonald's, still use 100% biodiesel (B100) for transport. This fixed supply chain presents challenges for reintroducing biodiesel use without significant government subsidies.

Turning to bioethanol, the government initially piloted E3 gasoline in Taipei and Kaohsiung at 14 stations through international cooperation with US organizations. The price was lower than petrol, but consumer misconceptions about engine performance led to poor adoption.

Dr Chang emphasized that this experience underscored the importance of public education. He mentioned a recent MoU between CPC and the US Grains Council to provide E10 gasoline beginning next year. However, the high transportation costs of imported ethanol pose a challenge, making the plan financially unfeasible.

A domestic initiative launched in 2010 to encourage the cultivation of energy crops also failed due to unstable climate conditions and uncompetitive crop pricing.

In conclusion, Dr Chang reflected on Chinese Taipei's history with biofuel, which began over 20 years ago. At one point, large volumes of biodiesel, bio-alcohol, palm kernel shells, and wood pellets were used or imported. However, since the termination of the biodiesel program in 2014 and the COVID-19 pandemic, bioenergy usage has declined.

He expressed regret over the decline, noting that Chinese Taipei is perhaps the only economy in the region where bioenergy usage is decreasing. Despite his efforts, he feels that more should have been done.

Subsidy-driven demand from the EU has further complicated domestic use of waste cooking oil for biodiesel or SAF, as foreign buyers offer higher prices. CPC and Formosa Petrochemical have recently launched SAF projects using domestic waste cooking oil, but securing sufficient feedstock remains a major challenge.

Dr Chang concluded by stating that the government's decision a decade ago to abandon biofuel use was a mistake. Restarting the program is now even more difficult. Although he could not share any successful examples from Chinese Taipei, he welcomed suggestions for reviving the initiative.

Session1-3

"Malaysia's Biofuel Partnership Program"

Mr Norizal Khushairi bin Mohamad Zamri, Head of National Project & Technical Advisor for Global Wildlife Program (GWP) Malaysia. UNDP Malaysia

Dr Ruengsak Thitiratsakul expressed appreciation for the previous speaker's presentation and informed the audience that questions would be addressed during the Q&A session following the third presenter.

He introduced Mr Norizal Khushairi bin Mohamad Zamri, the Head of National Project & Technical

Advisor for Global Wildlife Program. Mr Norizal has been involved in domestic, regional, and local programs and budgets across federal and regional agencies, including the Iskandar Malaysia and East Coast Economic Region corridors. He currently leads the implementation of the GEF7 Global Wildlife Program in Malaysia, focusing on enhancing institutional and local capacities to combat wildlife crime and protect iconic wildlife species.

Mr Norizal was previously the Head of the National Project for GEF-5's Green Technology Application for the Development of Low Carbon Cities in Malaysia, a collaboration between the Sustainable Energy Development Authority, Ministry of Environment and Water, and the UN Development Program. He was invited to present on the Malaysia Biofuel Partnership Program.

Mr Norizal greeted the audience and thanked them for their attention. He stated that instead of presenting theoretical data or complex figures, he would share practical experiences from Malaysia's partnership program involving the UNDP, the Government of Malaysia, the GEF, and the Sustainable Energy Development Authority. He outlined that the five-year project targeted five major cities in Malaysia, addressing pollution and GHG emissions, particularly in the transport sector. Funding came from the GEF, with co-financing from the Malaysian government.

The project focused on three key components: policy development to incentivize and support stakeholders, awareness creation and capacity building, and technological investment. The central initiative was the implementation of B100 biodiesel. Mr Norizal highlighted the challenge of engaging stakeholders such as Scania, Petronas, biodiesel suppliers, and public transport operators. Securing their participation was itself a success, demonstrating mid- and long-term benefits beyond current B10, B20, or B30 mandates. In Malaysia, B20 is the standard for public transportation.

He noted that these stakeholders collaborated on bus routes connecting neighborhoods to MRT stations. Another major challenge was supplying B100 biodiesel due to inadequate infrastructure. Petronas addressed this using its mobile fueling facility, ROVR, to supply buses with biodiesel at the MRT Depot in Kajang, Selangor.

Mr Norizal shared that multinational companies like Shell and Scania had piloted their own B100 biodiesel programs for road tankers, indicating private sector support for government initiatives. According to project data, B100 reduced carbon emissions by up to 70%, particularly in heavy vehicles like buses. He also mentioned that vehicle manufacturers such as Scania and Volvo already had B100-ready equipment, and that implementation challenges were mainly behavioral, related to drivers.

He emphasized the potential for significant value chain impact if major palm oil-producing economies like Colombia; Indonesia; and Malaysia adopted B100 extensively. However, he acknowledged concerns regarding food security due to increased palm oil demand.

Malaysia, he said, had a solid documentation and policy foundation. The National Low Carbon Cities Masterplan, launched in 2022, involved 154 local authorities. It promoted low carbon vehicle engines and other environmentally focused recommendations. The National Energy Transition Roadmap, also launched in 2022, emphasized green mobility and land transport. This roadmap supported the adoption of biodiesel, including B1 blends, and encouraged federal support systems.

He stated that the roadmap had included a B30 blend amendment. However, cities and industry participants in the Low Carbon Cities program believed Malaysia was ready to exceed the earlier B20 mandate. One option under consideration was a biodiesel-based Bus Rapid Transit (BRT) system in Iskandar Malaysia. Although electrification was the primary focus, biodiesel remained a viable alternative.

Mr Norizal concluded by thanking the audience and welcoming questions after his presentation.

Q&A Session Summary

Question:

- A participant asked about the cost of importing bioethanol to Chinese Taipei and proposed potential future cooperation with Thailand.

Answer: Dr Chia-Chi Chang

- Uncertain of the specific cost from the USA.
- Offered to introduce relevant officials from Hong Kong, China, to facilitate future collaboration with Thailand.
- Open to future imports from Thailand as part of carbon reduction efforts.

Question: Mr Glen Sweetnam

- Highlighted the complexity of the biofuel ecosystem.
- Pointed out unintended consequences of government policy (e.g., market distortions, supply-demand mismatches).
- Asked whether Southeast Asian economies should promote regional biofuel trade and reduce regulatory barriers.

Answer: Dr Natikorn Prakobboon

- Thailand has abundant raw materials (sugarcane, molasses, cassava, palm oil).
- Biofuel use may decline due to EV adoption and the "30@30" policy.
- High production costs limit Thailand's export competitiveness.
- Emphasized that Thailand's biofuel is non-GMO and farmer-sourced, providing environmental advantages.

Answer: Dr Chia-Chi Chang

- Feedstock competition shifts with trends (e.g., SAF vs biodiesel).
- Supports global carbon reduction rather than isolated local efforts.
- Encourages exports from Chinese Taipei when domestic support is insufficient.
- Raised ethical concerns over excessive use of cooking oil as feedstock.
- Warned that many "green" projects lack feasibility studies.

Answer: Mr Norizal Khushairi bin Mohamad Zamri

- Stressed the importance of industry readiness and mandates.
- Malaysia's B20/B30 policies exist but scaling requires political will.
- Called for regional cooperation in Southeast Asia to align efforts and reduce inefficiencies.

Question:

- How can second-generation biofuels (non-food biomass) help reduce dependence on feedstock?
- What role do community-scale biomass/biogas projects play in Thailand's energy transition?

Answer: Dr Natikorn Prakobboon

- Thailand has not widely adopted second-generation biofuels due to sufficient first-generation feedstock (only 10% of cassava used for ethanol).
- Second-generation technologies are more expensive due to additional processing steps.
- Community-scale bioenergy is important but requires localized incentives and technical support.

Answer: Dr Chia-Chi Chang

- The distinction between first- and second-generation biofuels is semantic, not functional.
- Second-generation fuels (e.g., ethanol from cellulose) have lower energy efficiency.
- Bioenergy should be application-specific—diesel-type vs alcohol-type fuels serve different purposes.
- Feedstock management is the most critical factor.

Question:

- How does Chinese Taipei collect WCO, especially from households?

Answer: Dr Chia-Chi Chang

- Restaurants are regulated by the EPA and must report usage and WCO output.
- Household collection is minimal and inefficient; most is unsuitable for biodiesel due to high water content.
- Current reuse is mainly for fertilizer, not biofuel.

Question:

- Why is CPC promoting ethanol in Chinese Taipei despite low public adoption of E3?

Answer: Dr Chia-Chi Chang

- Candidly stated: "Someone wants to sell it."
- Suggested that external pressure from suppliers (e.g., U.S. bioethanol interests) may have influenced policy.

Closing Remarks by Moderator: Dr Ruengsak Thitiratsakul

- Emphasized the potential of biofuels (biodiesel and ethanol) as renewable energy sources.
- Highlighted the need to address feedstock, cost, and technical challenges.
- Stressed the importance of R&D and consistent government policy to ensure sustainable adoption.

6. Session 2. "Synthetic Biofuels: Opportunities & Challenges and Recent Developments"

Session Moderator:
Mr Thanan Marukatat, Research Fellow, APERC

Session2-1
"SAF initiatives and potential: Thailand case"
Mr Kittiphong Limsuwannarot, Chief Executive Officer and President, BBGI Plc. Thailand

Mr Kittiphong Limsuwannarot began his presentation by outlining Thailand's strategic direction in Sustainable Aviation Fuel (SAF). He emphasized the economy's efforts to transition from conventional fuels to low-carbon alternatives, and the crucial role of BBGI and Bangchak Corporation in this transformation.

Mr Kittiphong explained that BBGI is Thailand's foremost integrated biofuel producer and operates as a key subsidiary of Bangchak Corporation. He highlighted the group's successful diversification over four decades from petroleum to green energy and bio-based sectors. BBGI, he noted, is now a leader in both traditional biofuels and emerging fields such as synthetic biology.

He pointed out that Thailand's agricultural strength forms the foundation for its biofuel strategy. According to Mr Kittiphong, Thailand ranks among the top global producers of palm oil, sugarcane, and cassava. These crops are being utilized to generate value-added bio-products while supporting domestic energy security through reduced oil imports.

As Mr Kittiphong stated, biofuels like palm biodiesel and sugarcane ethanol contribute significantly to reducing greenhouse gas emissions. He referenced IEA data showing GHG reductions of up to 84% for palm biodiesel and up to 74% for sugarcane ethanol. He underscored that SAF, depending on the pathway, could reduce emissions by as much as 94%.

Mr Kittiphong described the SAF production technologies in detail, noting the ASTM-certified pathways: HEFA (Hydroprocessed Esters and Fatty Acids), AtJ (Alcohol-to-Jet), and Gas-FT (Fischer-Tropsch). He stated that while HEFA is currently the most mature, other pathways are gaining interest due to their flexibility in feedstock use.

He elaborated on Thailand's SAF policy, explaining that the government plans to implement a blending mandate starting at 2% in 2027, increasing to 3% by 2030, and reaching 5–8% by 2033. Mr Kittiphong noted that HEFA will be the initial pathway due to its maturity, with AtJ anticipated in later phases.

According to Mr Kittiphong, one of the key challenges in SAF deployment is its high production cost, which is currently 2–5 times more than fossil jet fuel. He added that feedstock availability and scale-up capacity are also pressing concerns. Nevertheless, Thailand's strong agricultural base positions it well for future SAF growth.

Mr Kittiphong shared details of BBGI ongoing construction of Thailand's first SAF production facility. The plant, located within Bangchak's refinery, uses used cooking oil (UCO) as its primary feedstock. He reported a total investment of THB8.5 billion, with 77% completion as of October 2024. The plant aims to start operations in Q2 2025 and will have a daily capacity of 1 million liters.

In addition, Mr Kittiphong discussed BBGI expansion into synthetic biology. He explained that the company is developing a CDMO (Contract Development and Manufacturing Organization) platform to produce high-value products, including enzymes, collagen, and functional proteins, enhancing Thailand's bioeconomy footprint.

To conclude, Mr Kittiphong highlighted Thailand's commitment to international aviation decarbonization through its participation in ICAO CORSIA framework. He emphasized that global SAF demand is expected to rise dramatically, reaching 2.1 million barrels per day by 2050, and that BBGI aims to position Thailand as a regional SAF leader.

Session2-2
"SAF and e-fuels"
Mr Chua Wei Jun, Biofuels Analyst, S & P Global Commodity Insights, Singapore

Mr Chua Wei Jun began his presentation by addressing the current dominance of the HEFA-SAF production pathway. He stated that while HEFA is the most widely adopted method today, it will not be sufficient to meet global SAF demand by 2050. As the industry progresses toward 2030, 2040, and 2050, he highlighted the growing importance of ATJ (Alcohol-to-Jet) and eSAF (electro-fuel-based SAF) technologies to close the demand gap.

He elaborated on the process of producing eSAF, which primarily involves green hydrogen derived from renewable energy or nuclear sources. This hydrogen is produced by electrolyzing water. Mr Chua emphasized that capturing carbon is equally critical. Carbon sources include industrial emissions such as flue gas from steel or refinery plants, or carbon captured directly from the air. In the EU, eSAF is also referred to as RFNBO (Renewable Fuels of Non-Biological Origin).

Mr Chua outlined three main eSAF production pathways: converting captured carbon into e-methanol or e-ethanol followed by Methanol-to-Jet or Ethanol-to-Jet conversion, and producing syngas followed by Fischer-Tropsch synthesis to yield SAF. He stressed that these technologies are currently limited by their high cost and technological immaturity.

He pointed out that eSAF offers several advantages. It is not constrained by feedstock availability like HEFA, has a high GHG reduction potential of up to 99%, and is compatible with existing fuel infrastructure. However, Mr Chua noted that high production costs remain a major barrier. eSAF is currently three to five times more expensive than fossil jet fuel. While policy and regulation may help lower costs, uncertainty in policy implementation remains a challenge.

Mr Chua also explained the technical limitations. Unlike HEFA and ATJ, eSAF production is still in its early stages, with most facilities operating at pilot scale. High capital expenditures and limited investor interest further impede progress. Project financing remains a significant hurdle for scaling eSAF technologies.

He then presented data on global eSAF demand. According to EU policy forecasts, 16 million tons of eSAF will be needed by 2050. However, current infrastructure, particularly for green hydrogen production, falls short of meeting this target. The EU is only on track to produce around 6 million tons, highlighting a substantial gap that must be bridged by reducing green hydrogen costs.

Mr Chua emphasized the role of policy in driving investment. He showed that most eSAF projects are concentrated in the EU, where strong policy frameworks exist. In Asia-Pacific, Australia and China have begun to include green hydrogen and e-fuel production in their energy strategies. Policy clarity and incentives are key to maturing the eSAF market.

He summarized the primary risks facing e-fuel development: policy uncertainty, technical scalability, and financing constraints. Mr Chua noted that while the EU is expected to lead in the short term due to robust policies and existing projects, the United States and Middle East could follow due to hydrogen production incentives and low hydrogen costs. Australia and China are expected to lead within the Asia-Pacific region.

Lastly, Mr Chua discussed private sector commitments. He shared examples of offtake agreements signed by airlines and corporations in the EU and US to support eSAF production. However, such agreements are still rare in regions where supply chains are less developed.

Mr Chua concluded his presentation by reiterating the importance of coordinated policy, investment, and technological development to scale up eSAF and meet future aviation decarbonization targets.

Session2-3

“Biofuels and SAF in Korea”

Dr Hyunyoung Oh, Associate Research Fellow, Korea Energy Economics Institute (KEEI), Korea

Dr Hyunyoung Oh began her presentation by greeting the audience. She introduced herself as a researcher at KEEI and mentioned that while the government used to be their coworker, it now functions as their client. She explained that in Korea, the Renewable Fuel Standard is the central policy governing biofuels. A mandate for biodiesel has been in place since 2015, starting at 2.5%, with plans to increase it to 5% by 2030. She shared that the current blending rate mirrors the mandated rate, indicating that companies only produce biodiesel in the amounts required to meet this regulation and do not go beyond it.

Dr Oh pointed out that one of the major issues in Korea is the limited domestic availability of feedstock. Increasing the blending rate would require companies to import all their feedstock, which is a significant challenge. Industry associations have expressed that this constraint makes it difficult to raise the blending mandate any further.

She also highlighted the opposition from NGOs in Korea, noting that many of them are against the use of biofuels. These organizations tend to focus on the idea of combustion and generally oppose anything that involves burning, regardless of practical realities. As a result, the adoption of biofuels in Korea remains limited. However, the government continues to show strong interest in expanding biofuel use and seeks new opportunities to promote it.

Earlier this year, the government revised the Alternative Fuels Act to categorize fuels into three fixed sectors: biofuels, e-fuels, and others. This restructuring reflects the government’s intention to promote development across all three sectors.

Dr Oh described the government’s experimental efforts in bio-marine fuels, which include both inland and maritime testing. The fuels being tested are biodiesel and bio-heavy fuel oil. A pilot study was conducted involving international ships using a 30% biodiesel blend. Currently, the government is working on establishing quality standards for bio-heavy fuel oil and biodiesel intended for use in ships.

She presented the domestic SAF supply strategy. The initial policy idea, announced in October 2022, stemmed from her research developed in consultation with policymakers. Dr Oh explained that the motivation for this policy came from the European Union’s Refuel EU initiative. When the proposal was published, the Korean government sought to understand its implications and develop a corresponding domestic policy. Dr Oh worked with the government to interpret Refuel EU and drafted a report in 2021, which served as the foundation for the resulting policy and the 2024 version of the domestic supply expansion strategy.

As a result of these efforts, the Korean government has introduced a mandatory SAF blending ratio for international flights, beginning with a 1% mandate in 2027. Dr Oh noted that this figure was chosen to allow for testing related to safety and to provide time to develop a long-term expansion plan, particularly because of Korea's limited domestic feedstock supply. The year 2027 is regarded as a pilot phase, with the aim to increase the blending ratio to approximately 5% shortly after 2030.

She further explained the coordination efforts between the government, the petroleum industry, and the airline industry. Meetings have been held with all stakeholders, including Dr. Oh herself. However, airlines, as SAF buyers, were cautious in the discussions, citing high costs and concerns over potential ticket price increases. In contrast, petroleum companies have shown strong interest in the strategy and are actively working toward producing SAF domestically.

Currently, discussions are ongoing to determine an appropriate SAF blending ratio for Korea. A major challenge lies in drafting specific laws, including those related to penalties, flexible regulations, and mechanisms to stabilize prices in case of spikes. Feedstock remains a critical concern. Consequently, the government is exploring e-fuels as a potential solution. However, Korea has limited available land for solar photovoltaic and wind power installations, both of which are essential for producing e-fuels. Therefore, e-fuel production is not expected to commence until around 2035. The plan is to begin with HEFA-SAF, particularly co-processing methods.

Petroleum companies such as S-Oil and SK Energy are currently working on SAF production and have already obtained certifications from CORSIA and ISCC.

Dr Oh concluded by discussing the development of Korea's SAF blending roadmap. She referred to a roadmap provided by Bloomberg but commented that its targets—exceeding 60 or 70% blending by 2050—are unrealistic for Korea. Instead, she suggested that a 50% target by 2050 is more feasible. The development of specific SAF mandates is currently in progress, with her direct involvement.

Session2-4
"SAF and e-fuels"
Dr Nuwong Chollacoop, Low Carbon Energy Research Group Director, National Energy Technology Center (ENTEC), Thailand

Mr Thanan Marukatat introduced Dr Nuwong Chollacoop from Thailand, who has worked in the biofuels field for over two decades. Dr Nuwong began by thanking APERC for organizing the event and shared his appreciation for having an opportunity to speak on bioenergy, noting that many current discussions focus on electric vehicles and hydrogen rather than biofuels.

Dr Nuwong provided a summary of Thailand's climate goals. He referenced Thailand's first Nationally Determined Contribution (NDC) from COP21, aiming for CO2 reductions by 2025. He explained that by COP27, Thailand had committed to carbon neutrality by 2050 and net-zero emissions by 2065. The updated NDC increased the reduction target from 30% to 40%. Thailand currently has around 18-20% renewable energy, but it aims for at least 50% by 2050. He emphasized the importance of achieving this without compromising industrial competitiveness.

Dr Nuwong then discussed his recent assignment from April to focus on SAF and e-fuels. He explained that while SAF is a popular topic, e-fuels are more challenging and less developed in Thailand. He highlighted the need to explore hydrogen-based SAF (eSAF) and Power-to-Liquid (PtL) technologies. He noted that HEFA (Hydroprocessed Esters and Fatty Acids) is the current mainstream SAF technology, while alcohol-based and e-fuel-based pathways are emerging.

He referred to mandates in the European Union for blending eSAF and noted Germany's PtL roadmap. In Thailand, companies like Bangchak are producing HEFA SAF, and others such as Mitr Phol are exploring Alcohol-to-Jet technology. Dr Nuwong mentioned that Thai airlines, including both domestic and international carriers, are beginning to engage with SAF, and the higher cost of SAF is a concern for adoption.

He described his regional involvement through ASEAN and cooperation with the United States, including grants from the Federal Aviation Administration (FAA) and the Hawaii Natural Energy Institute (HNEI). He described initiatives such as workshops and policy discussions held in Bangkok, Thailand and Bali, Indonesia. He highlighted the differences in aviation fuel usage across ASEAN economies, noting that Thailand has 80% international and 20% domestic consumption, while Indonesia has a 60:40 split.

Dr Nuwong explained that Pertamina in Indonesia produces SAF using palm oil through various methods, and although ISCC does not accept palm oil due to sustainability concerns, Indonesia continues using it for domestic flights, which are not subject to international sustainability standards.

He stated that future workshops will continue rotating among ASEAN economies and that funding remains a significant barrier to SAF implementation. Feedstock availability is another issue, as current SAF producers may consume most used cooking oil (UCO). Infrastructure challenges include managing compliance between domestic and international aviation requirements.

He highlighted the importance of R&D, particularly in developing new feedstocks, and described how current drafts of Thailand's Oil Plan and Alternative Energy Development Plan (AEDP) both support SAF. He emphasized that Thailand follows EU trends but may delay implementation to avoid passing high costs to consumers. He explained the SAF development mechanism in Thailand, which is structured under the Thailand Climate Change Committee and its subcommittee on climate policy.

Dr Nuwong mentioned that Thailand is also studying ISCC 14 sustainability criteria and working with the Federation of Thai Industries (FTI) to gather accurate CO2 emission data for ethanol, palm oil, and UCO in the Thai context.

On the topic of e-fuels, he noted that his research organization supports hydrogen as a key component. He mentioned the different carbon intensities of hydrogen and that although much of the e-fuel research is proprietary, feasibility studies are underway.

He also described ongoing biogas projects in Thailand, where agricultural residues and animal manure are used to produce methane, which can be reformed into hydrogen. He highlighted projects by companies such as Toyota and CP Group, aiming to capture methane from waste and convert it into usable energy.

He concluded by describing biogas treatment and scaling projects designed to create a waste-to-energy ecosystem. These initiatives aim to support hydrogen production for future e-fuel use. He ended his presentation by thanking the audience.

Q&A Session Summary

Question:

- How can SAF (Sustainable Aviation Fuel) development be moved into actionable progress?
- Referred to Dr Nuwong’s emphasis on expanding feedstock processing and securing supply chains.
- Asked how governments and industries can work together to reduce SAF/e-fuel production costs while ensuring scalability and sustainability.
- Specific follow-up questions:

    - Can investments in green hydrogen reduce production costs?
    - What lessons can be learned from Korea's certification process under ICAO CORSIA?
    - Should partnerships or subsidies be established to support SAF infrastructure?

Answer: Dr Nuwong Chollacoop

- Economies of scale are essential to lowering SAF costs.
- Governments should stimulate demand so private investors will supply accordingly.
- Alcohol-to-jet pathways are more expensive but offer cleaner potential and greater availability.
- Transition mechanisms must be carefully designed to manage costs and implement CO_2 reduction strategies.

Answer: Mr Kittiphong Limsuwannarot

- Investment decisions vary significantly across companies.
- Example: Bangchak invested USD300 million in SAF, benefiting from existing hydrogen resources; standalone SAF plants cost 50–80% more.
- SAF is viewed as a high-value product, unlike commodity biofuels.
- Large investment requirements are a major barrier; economic justification depends on long-term internal business perspectives.

Answer: Dr Hyunyoung Oh

- Airlines are hesitant due to SAF (high cost).
- Korea may establish a SAF support scheme funded through environmental charges added to airfares—allowing money to flow from consumers to airlines and then to fuel producers.

Answer: Another Male Participant

- Compared SAF to Thailand's bioplastics: consumers support sustainability in principle but resist paying more.
- Biofuel oversupply in Thailand resulted from overly optimistic demand forecasts.
- While SAF is more expensive, airline passengers may accept price increases due to convenience and willingness to pay.
- Unlike biofuels, SAF costs can be more easily passed on to consumers through airlines.

Answer: Mr Chua Wei Jun

- The main cost driver for SAF is used cooking oil collection, accounting for 70–80% of total cost.
- Government models:
    - EU: Passes cost to consumers, minimal subsidies.
    - Singapore: Central procurement and a SAF levy on passengers via CAAS.
- Advocated for a fair, transparent pricing mechanism to prevent vendor price inconsistencies.
- Airlines are interested in SAF but need clarity and consistency in pricing.

Question: Mr Glen Sweetnam

- Are blending limits for SAF technical or cost-driven?

Answer: Multiple Participants

- Biodiesel blending in cars is technically limited but policy-driven.
- SAF currently has an ASTM limit of 50% due to aromatic content.
- Future technologies like methanol-to-jet could enable 100% SAF.
- Initial blends of 1–2% are used to introduce higher costs gradually and test logistics.
- SAF pricing will eventually be compared against carbon tax levels to justify economic feasibility.

Question:

- Which feedstock is cheapest among HEFA, ATJ, and used cooking oil?

Answer: Mr Chua Wei Jun

- Used cooking oil is currently the cheapest feedstock.
- Palm oil is expensive due to market conditions and has a lower GHG reduction score.
- The industry is beginning to focus on cost of abatement, not just SAF type, to evaluate carbon reduction effectiveness.

Closing Remarks by Moderator: Mr Thanan Marukatat

- The moderator thanked all speakers and highlighted the depth and relevance of the discussion.
- Applause acknowledged shared insights on SAF implementation, policy, economics, and technical pathways.

7. Session 3. "Decarbonization in Power Sector by Biomass and Biohydrogen"

Session Moderator:
Mr Glen Sweetnam, Senior Vice President, APERC

Session3-1

"Biofuel : Co-firing Application and Pathway to Sustainable Decarbonization in Mae Moh Smart City"

Ms Ornnicha Phalino, Chief of Fuel Development Department, Fuel Engineering Division, Electricity Generating Authority of Thailand (EGAT), Thailand

Ms Ornnicha Phalino began by expressing appreciation to the APEC Symposium organizers for providing a platform to share knowledge and innovation. Representing EGAT, she presented a biofuel profiling application and a pathway to sustainable decarbonization in the Mae Moh Smart City, outlining EGAT commitment to a low-carbon and sustainable energy future for Thailand.

She explained that as a signatory of the Paris Agreement, Thailand is committed to reducing carbon emissions and transitioning to a low-carbon economy. This includes achieving a 30% to 40% reduction in greenhouse gas emissions by 2030, reaching carbon neutrality by 2050, and net-zero emissions by 2065.

Under Thailand's National Energy Plan, the government targets 50% renewable energy, 30% energy efficiency improvement, and 30% electric vehicle penetration by 2030. EGAT aligns its work with this domestic strategy by following a "Triple S" approach:

- Source transformation: EGAT is increasing the use of renewable energy and modernizing power plants with technologies like hydro-floating solar hybrids combined with battery energy storage systems.
- Sink co-creation: EGAT is exploring carbon capture, utilization, and storage technologies; promoting greenhouse gas reduction mechanisms; and supporting electric vehicle infrastructure, including EV charging stations
- Support measures mechanism: Building strong support mechanisms to ensure the transition is feasible and effective.

Thailand's total electricity generation capacity is about 34,300MW, with EGAT operating power plants contributing around 16,200MW. EGAT also procures electricity from Independent Power Producers (IPPs), Small Power Producers (SPPs), and through imports from Laos and Malaysia.

EGAT focuses on maintaining a balanced and sustainable energy mix by investing in hydropower, floating solar, pumped storage hydropower, battery storage, and wind turbines. Additionally, EGAT is exploring other renewable energy sources like biomass and hydrogen to strengthen energy security and diversify the clean energy portfolio.

Electricity is generated by 53 EGAT-operated power plants. These include 3 thermal power plants, 6 combined-cycle plants, 30 hydropower plants, and 10 renewable energy plants (including wind, solar, and pumped storage hydropower). She focused specifically on the Mae Moh Power Plant in Northern Thailand, which operates coal-fired units (Unit 8–14) with a capacity of 2,455MW. This plant supplies electricity to Lampang, Chiang Mai, Lamphun, and Mae Hong Son provinces, supporting economic growth in the northern region. The cost of electricity generation at Mae Moh is less than THB2 per unit, which helps reduce the average electricity cost for consumers.

She emphasized that decarbonization remains a major challenge and identified renewable energy as a promising alternative to fossil fuels. EGAT is studying biomass integration into its operations as a path toward sustainable decarbonization, starting with 5% biomass co-firing in 2026, increasing to 15%, and eventually reaching 100% biomass usage.

For context, she provided the following comparison: a 300MW coal plant requires 1.69 million tons of lignite and emits 2.1 million tons of CO_2. Switching to 5% biomass would reduce coal consumption by 80,000 tons and cut CO_2 emissions by 100,000 tons annually. A full switch to 100% biomass would require 1.3 million tons of biomass and would result in zero CO_2 emissions from coal, demonstrating the environmental benefits and the importance of a sustainable biomass supply chain to meet carbon neutrality goals.

Initial findings indicate that less than 5% biomass co-firing requires no major modification to existing equipment, helping minimize development costs. New infrastructure required includes biomass unloading areas, storage domes, conveyor systems, and biomass mixing stations. EGAT plans to implement 5% co-firing at three power units, generating approximately 60MW of green electricity and requiring about 260,000 tons of biomass pellets annually.

She described EGAT three strategies for sourcing sustainable biomass:

1. Growing trees – Partnering with organizations to cultivate fast-growing tree species.
2. Agricultural residues – Purchasing crop residues from local communities to reduce open burning and increase rural income.
3. Wood pellets – Procuring high-quality pellets from reliable partners that meet international sustainability standards and avoid deforestation.

The biomass initiative delivers several benefits:

- Environmental – Reducing carbon emissions and converting waste into energy.
- Economic – Generating income for farmers, creating jobs, and supporting local economies.
- Energy security – Ensuring stable and renewable energy supplies.
- Community engagement – Strengthening rural communities and fostering collaboration.
- Policy alignment – Supporting Thailand's renewable energy goals and global climate targets.

In conclusion, Ms Ornnicha Phalino emphasized the success factors for biomass implementation at Mae Moh Smart City: a reliable biomass supply, technological feasibility for integration, economic viability, measurable CO_2 reduction, strong community engagement, and policy and regulatory support. EGAT is committed to transforming Mae Moh into a clean energy hub and realizing its Smart City vision as part of Thailand's sustainable energy future.

Session3-2
"Biohydrogen"
Ms Alice Li, Senior Technical Consultant, DR Biomass Development (HK) Limited, Hong Kong, China

Ms Alice Li welcomed everyone and introduced her presentation titled "Exploration and Experience of Bioenergy." She outlined four key parts in her presentation, beginning with the development and trends in bioenergy.

Ms Li opened by addressing why biomass utilization is important and how it can be converted into bioenergy. She noted that bioenergy is the fourth largest energy source and a critical tool for decarbonization during the energy transition. With the current global challenges such as the energy crisis, ecological degradation, and food shortages, all stemming from fossil fuel combustion, she emphasized the value of biomass as an alternative.

She defined biomass as including plants, agricultural waste, and food waste, and described how converting this biomass into bioenergy forms such as biodiesel, bioethanol, renewable electricity, biomethane, and renewable methanol could help address energy and ecological issues while promoting food security.

Ms Li then explained the current development status of bioenergy across different regions. She used a chart to show how economies utilize different biomass sources. For example, the EU primarily uses silage for biogas and biomethane, the US uses corn for bioethanol, and Brazil uses sugarcane. In contrast, China uses abandoned crop straw to generate renewable electricity, focusing on non-food biomass. Biodiesel is also widely used globally.

Next, Ms Li discussed various conversion technologies for turning biomass into bioenergy, including direct combustion, gasification, anaerobic fermentation, and pyrolysis. She expressed a preference for anaerobic fermentation due to its biological breakdown of biomass in oxygen-free environments. She explained that the choice of technology depends on the raw material and regional characteristics but cautioned that land usage must prioritize food over energy.

She illustrated the anaerobic fermentation process through a diagram, highlighting an industrial biogas plant at the center. Various biomass inputs such as crop straw (dry), manure (wet), food and kitchen waste, and industrial wastewater are used. The plant produces biogas, bioresidue, and slurry. Biogas can be separated into biomethane and CO2, with biomethane further processed into liquefied biomethane. The CO2 can be combined with green hydrogen, derived from water electrolysis using renewable energy, to produce renewable methanol (e-methanol). The process can also support sustainable aviation fuel (SAF) production.

Ms Li then moved to her second section on bioenergy manufacturing, starting with biomass collection, transportation, and storage. She shared images of large-scale straw collection, manure transport, and wastewater storage in China. She emphasized the role of an intelligent online platform in managing these operations.

She discussed biomass crushing and pretreatment to improve efficiency and flexibility. She showcased a multifunctional automatic crushing system and a high-efficiency pretreatment system, including components like automatic unpacking, straw shaving, and rollers. She explained that post-pretreatment, two fermentation options exist: semi-dry anaerobic fermentation, suitable for dry biomass in North China and North America, and wet fermentation, used in South China and South Asia.

Ms Li elaborated on the post-fermentation processes, including drying biogas residue and high-temperature gasification to produce syngas, which can be upgraded into renewable methanol and SAF.

She also mentioned the application of biogas slurry in integrated water and fertilizer systems. She stressed that biogas, when fully utilized, can yield diverse energy products and reduce fossil fuel dependency.

She described biogas separation and purification equipment. From this equipment, biomethane and carbon dioxide are obtained. The biomethane can then be upgraded to liquefied biomethane. In addition, when renewable electricity is used to carry out the water electrolysis process and produce green hydrogen, this hydrogen can be combined with the carbon dioxide captured from the equipment to produce e-methanol, and even SAF.

Ms Li offered development suggestions for the Asia-Pacific region. She noted that the region has rich biomass resources and great potential for anaerobic fermentation technologies. Economies like Hong Kong, China and Singapore are developing supply chains for green methanol and SAF.

She outlined Hong Kong, China's strategic plan to become a leading green maritime fuel bunkering center. She cited recent government policy speeches and an action plan released in November that detail the development of SAF and green fuel supply chains. The plan includes establishing Hong Kong, China as a green fuel trading center and creating a roadmap for a zero-carbon, multi-fuel strategy.

Finally, Ms Li presented case studies from DR Biomass. Headquartered in Hong Kong, China, DR Biomass focuses on bioenergy production through anaerobic fermentation. The company operates five biogas plants in North China and one in the South. Its goal is to innovate sustainable bioenergy technologies and recycle agricultural waste.

She shared details of a project in South China that has operated at high capacity for three years, processing 190,000 tons of organic waste from 11 biomass types. She emphasized the model's applicability to the Asia-Pacific region.

She also discussed a unique project in North China that uses dry corn stalk as the sole biomass source in extremely cold conditions. DR Biomass developed original technology to ensure stable full-load production. This project is currently the only one in the world that uses dry straw exclusively to produce biogas on a large scale.

She concluded by stating that regions rich in biomass can achieve large-scale bioenergy production using DR Biomass's anaerobic fermentation technology.

Session3-3

"Contribution to Carbon Neutral Society by Biomass use in Coal-fired Boiler"

- "Introduction of Idemitsu Green Energy Pellet" -

Mr Naotsugu Otani, Deputy General Manager, Environment & Biomass, Coal and Energy Solution Department, Idemitsu Kosan Co., Ltd., Japan

Mr Naotsugu Otani expressed his gratitude for the opportunity to speak at the symposium and introduced Idemitsu's business activities related to carbon neutrality. He clarified that although Idemitsu is not a power sector company, it is an energy company involved in supplying coal and biomass to power companies in Japan. His presentation focused on solid biomass fuel, specifically 'black pellet,' as a coal replacement.

Mr Otani provided a brief history of Idemitsu, noting that the company was founded by Sazo Idemitsu and has over 110 years of history. Located a 10-minute walk from Tokyo Station, the company has a 30% share in Japan's petroleum market and holds the top market share for jet fuel. He mentioned colleagues who work on fuel supply for airlines such as JAL and ANA.

He explained that while Idemitsu has been involved in coal business for over 40 years, over 90% of its profits still come from fossil fuels, necessitating a transition toward carbon neutrality. The company's resource business segment, where Mr Otani works, sells approximately 12 million tons of coal annually, which is about 10% of Japan's total thermal coal usage.

Mr Otani noted that Idemitsu manages the coal supply chain from Australian mines to Japanese customers. Previously, Idemitsu operated four coal mines in Australia and held minor equity in two Indonesian mines, but now only operates one mine in New South Wales. The company also has a unique coal-focused laboratory in Japan, which is now expanding its research to include biomass and ammonia.

Mr Otani emphasized that Idemitsu is pursuing an environmentally friendly coal business by extracting high-grade coal with high calorific value and low ash content, and by offering technical consulting for coal handling and combustion. He mentioned a product named ULTY, which reduces boiler fuel consumption by approximately 1% and is already installed in over 100 units.

Turning to the core of his presentation, Mr Otani discussed the use of black pellet for biomass co-firing in coal boilers. He presented a table comparing typical biomass fuels and highlighted black pellet as the most efficient and realistic option for use in pulverized boilers. Unlike other fuels or ammonia, black pellet requires minimal modifications to existing coal facilities.

He showed an image demonstrating black pellet's waterproof property, which allows for outdoor storage without silos, unlike white pellets. He summarized three main advantages of black pellet: higher calorific value, better grindability for pulverized boilers, and waterproof characteristics. These properties enable black pellet to be handled similarly to coal.

Mr Otani explained the production process of black pellet, stating that their first commercial plant in Viet Nam uses a method that transforms white pellet into black pellet within 30 minutes using gas generated from the process itself, without requiring fossil fuels.

He described the co-firing test process, where black pellet is mixed with coal and processed through the usual coal handling system. It took two weeks to achieve 20% co-firing at an existing plant. He noted that similar tests have been successfully conducted at 20 power plants and factories, with positive feedback.

The first commercial black pellet plant is located in Qui Nhon, Viet Nam, and will begin operations by the end of the month. It is one of Southeast Asia's largest commercial black pellet plants. Mr Otani acknowledged delays due to technical challenges, permit issues, and COVID-19, but expressed satisfaction in completing the plant.

The product is named Idemitsu Green Energy Pellet to avoid negative connotations of the word "black." The plant employs seven Japanese and around 150 local staff. Japanese coal users have shown strong interest in the product, and the plant will begin producing 120,000 tons annually.

Mr Otani stated that Idemitsu is seeking business partners in Southeast Asia to supply woody agricultural residues to increase production. Although the first plant’s output is limited compared to their coal sales, the goal is to reach 3 million tons of black pellet annually. He mentioned that relying solely on woody biomass is limiting, and thus they are exploring agricultural residues and grass plantations such as sorghum in Australia and empty fruit bunches in Malaysia.

He introduced the Japan Black Pellet Forum, organized by Idemitsu, which has members consuming 75 million tons of coal annually. The forum targets 20% to 30% replacement of coal with black pellet by 2030.

Mr Otani concluded by emphasizing that Idemitsu Green Energy Pellet is a realistic and efficient solution for reducing CO2 emissions. He reiterated the plan to expand production to 3 million tons and noted the alignment with Sustainable Development Goals (SDGs). He thanked the audience for their attention.

Session3-4

“Decarbonization in Power Sector by Biomass and Biohydrogen in the Philippines”

Ms Anna Mikko G. Realo, Officer-in-Charge, Biomass Energy Management Division, Renewable Energy Management Bureau, Department of Energy (DOE), the Philippines

Ms Realo began her presentation by expressing her gratitude to APEC and the Ministry of Energy of Thailand for organizing the symposium and providing her with the opportunity to present on the topic of decarbonization in the power sector through biomass in the Philippines.

She explained that the Philippines has enacted two landmark legislations to promote the development and utilization of bioenergy: Republic Act 9367, known as the Biofuels Act of 2006, and Republic Act 9513, known as the Renewable Energy Act of 2008. Both pieces of legislation share common objectives, including ensuring energy security, reducing dependency on imported fossil fuels, and protecting the environment by mitigating toxic emissions such as greenhouse gases.

In alignment with the Renewable Energy Act, the Department of Energy in the Philippines developed the National Renewable Energy Program (NREP), which outlines the policies and initiatives necessary to accelerate the deployment of renewable energy in the economy. This program spans from 2020 to

2040 and targets a 35% renewable energy share in the power generation mix by 2030, increasing to 50% by 2040. The overarching goal is to transition away from fossil fuels and establish renewable energy as the primary source of power.

She provided an update on the development and utilization of biomass energy for power generation in the Philippines. Citing a USAID resource assessment study, Ms Realo stated that the econoomy has a biomass power generation potential of approximately 4,449MW. If fully harnessed, this potential could result in a reduction of approximately 17 million tons of carbon dioxide emissions. Currently, however, only 591MW are under commercial operation, which accounts for just 13% of the economy's total biomass potential capacity. This indicates a substantial amount of untapped potential.

The biomass industry in the Philippines has grown since the enactment of the Renewable Energy Act, with 591MW of new capacity added and now operating commercially. A significant increase in installations occurred in 2019, driven by the feed-in tariff system that guarantees a fixed rate per kilowatt-hour for electricity generated from eligible biomass facilities. The investment value of these projects is estimated at approximately 38.10 billion pesos or USD1.8 billion, with an associated reduction of 2.2 million tons of CO2 equivalent emissions recorded between 2019 and 2022.

According to the 2023 power statistics report, coal remains dominant in the power mix, accounting for approximately 62%, while renewable energy contributes around 22%. Biomass has a 1.19% share, generating roughly 1,409GWh and avoiding about 0.56 million tons of CO2 emissions.

Ms Realo shared data on registered biomass projects categorized by feedstock. The total installed capacity of biomass power plants, including both grid-connected and self-use systems, is approximately 774.67MW. Of this, 182MW are allocated for own-use or self-consumption. Biomass feedstocks include bagasse, rice husk, biogas, cocoa waste, municipal solid waste, Napier grass, empty fruit bunches, and sugarcane trash.

Currently, there are 37 biomass power generation projects in commercial operation and 18 for own-use applications. Additionally, two projects are dedicated to non-power applications such as refuse-derived fuel production and thermal energy generation.

She presented the four-point strategy of the Philippines' Department of Energy for energy transition, which aligns with global efforts to decarbonize the power sector. One of the strategic priorities is to accelerate the deployment of renewable energy projects and clean energy technologies. The objective is to reach 35% renewable energy in electricity generation by 2030 and 50% by 2040.

To support this transition, there is also a need to modernize and expand the economy's transmission systems to accommodate increased renewable energy capacity. Offshore wind technology is being considered a frontrunner in achieving the NREP targets. Infrastructure development, such as port facilities for offshore wind and other marine energy projects, is therefore prioritized. The Department also advocates for the voluntary early decommissioning and repurposing of existing coal-fired power plants, with biomass co-firing seen as a viable alternative. This entails modifying existing coal boilers to use biomass either exclusively or alongside coal.

She included updates on waste-to-energy initiatives, which are part of the Biomass Energy for Power sector. According to Section 30 of the Renewable Energy Act, the Department supports the adoption of waste-to-energy technologies, provided that toxic emissions are controlled through advanced emission capture and monitoring systems.

As of October 2024, twelve waste-to-energy projects are registered with the Department, using various technologies including combustion, gasification, landfill methane capture, anaerobic digestion, RDF production, and briquette manufacturing. The total capacity includes 149MW of electricity generation, 650 metric tons per day of RDF production, and 30 metric tons per day of briquette production. Of the twelve projects, six are operational, while the remaining six are under development. Letters of intent submitted to the Department indicate an additional 229MW of potential capacity.

She presented a breakdown of the twelve waste-to-energy projects registered with the Department. Six projects are operational, including two utilizing landfill methane capture with a combined capacity of 9.69MW, three producing 650 metric tons of RDF per day, and one producing 30 metric tons of briquettes per day.

She mentioned that a Waste-to-Energy bill is currently pending in the Philippines' Congress. Both chambers have draft versions of the bill, which is one of the administration's legislative priorities. Final plenary deliberation is awaited.

Ms Realo identified several challenges facing the expansion of biomass energy in the Philippines. One major challenge is the availability of biomass feedstock. Agricultural residues, forest residues, and dedicated energy crops are often seasonal, affecting consistency and supply reliability. Feedstock such as rice husk, sugarcane bagasse, and coconut shells fluctuate with harvest cycles, disrupting power plant operations. Furthermore, competition for feedstock from other industries, such as for animal feed or fertilizer, creates supply constraints.

She added that biomass resources are often widely dispersed, complicating collection and increasing transportation costs. The lack of centralized collection points and efficient transport infrastructure further hinders logistics. Once collected, biomass feedstock requires proper storage to maintain quality and avoid spoilage or contamination. Without adequate storage facilities, feedstock can degrade, losing energy content and reducing power generation efficiency. Inadequate storage also heightens the risk of seasonal supply imbalance.

She also highlighted the perceived financial risks associated with biomass projects, particularly concerning feedstock availability. Financial institutions and investors often hesitate to support such projects due to these uncertainties.

As a way forward, she proposed strategies such as diversifying feedstock sources and conducting comprehensive resource mapping. Diversifying the types of biomass used can mitigate disruptions caused by seasonal availability. Resource mapping can help identify where and how much biomass is available and determine competing uses, enabling more informed decisions on prioritizing biomass for energy without affecting other sectors.

Lastly, she emphasized the importance of building the capacity of financial institutions and exploring opportunities for green financing.

In her concluding remarks, Ms Realo stated that the Philippines has significant untapped biomass energy potential, with only around 30% of the estimated 4,449MW currently being utilized. Harnessing this potential can significantly enhance energy security, support rural development, and help achieve renewable energy goals. However, overcoming challenges related to feedstock supply, infrastructure, and financing will require strategic investment and policy support. With the right backing, biomass can become a substantial contributor to the econoomy's renewable energy portfolio and a crucial element in global decarbonization and clean energy transition efforts.

Q&A Session Summary

Question: Mr Glen Sweetnam

- Bioenergy is often not financially viable without support—how much government assistance do the projects from China; Japan; the Philippines; and Thailand require?
- Are these projects viable independently, or do they depend on concessional financing, subsidies, or regulations?
- Can these models be scaled effectively?

Answer: Ms Ornnicha Phalino

- Thailand is still evaluating biomass electricity pricing to match domestic electricity rates.
- Biomass electricity increases cost slightly (0.0024 Baht/kWh), which may be acceptable.
- Approval depends on competitiveness with gas-fired power.
- Carbon tax on lignite and community compensation could further improve viability.
- If competitive pricing and carbon costs are addressed, government approval is likely.

Answer: Ms Alice Li

- Bioenergy receives substantial government support in China for energy and environmental reasons.
- Government assists in collecting biomass (dry straw) from farmers to prevent open burning.
- Offers reimbursements and preferential electricity pricing for biomass power.
- Company plans to expand to methanol production, which is technically more challenging.
- Ongoing policy support exists for biomethanol from both the central government and the Hong Kong, China government as part of decarbonization strategy.

Answer: Mr Naotsugu Otani

- Black pellets cost USD300/ton, while Australian coal is less than half that price.
- Coal users in Japan receive limited subsidies, prompting lobbying efforts.
- Need to balance subsidies with regulations such as Japan's Energy Saving Law.
- Believes market entry for black pellets is possible using both regulatory incentives and economic measures.

Answer: Ms Anna Mikko G. Realo

- Government incentives include:
  - Fiscal: 10-year duty-free importation, 7-year income tax holiday (extendable to 21 years), reduced corporate tax (10% after holiday), VAT exemptions.
  - Non-fiscal: Renewable Portfolio Standard requiring utilities to source renewables (raised to 2.5%), and former feed-in tariff guaranteeing fixed pricing.
- New Green Energy Auction Program replaces feed-in tariff, offering an assured market.
- Additional benefits: exemption from government sharing fees, full foreign ownership allowed for biomass projects.

Answer: Mr Glen Sweetnam

- Noted that projected global biomass growth is only 100% over 40 years.
- Based on panel insights, suggested higher real-world growth potential.
- Proposed follow-up with panelists to refine economy-level projections.

Question: Participant from Papua New Guinea

- Can other players participate in the Philippines' power generation market?
- Are feed-in tariff rates different across technologies?

Answer: Ms Anna Mikko G. Realo

- Feed-in tariff rates vary by technology.
- Feed-in tariff system is now closed, replaced by the Green Energy Auction Program.
- Electricity pricing is regulated by the Energy Regulatory Commission, not the Department of Energy.

Question: Dr Kazutomo Irie

- Does biomass co-firing affect coal ash disposal and exhaust gas quality?

Answer: Mr Naotsugu Otani

- Biomass produces less ash, reducing total ash volume.
- Ash composition changes, making it unsuitable for certain uses like cement.
- More long-term operational data is needed, as the commercial plant has just begun operations.

Comment: Male Participant

- Flexibility in power systems is essential for integrating renewables.
- Coal-to-biomass co-firing is a promising approach.
- China is adapting coal plants for flexible, low-carbon energy integration.
- Praised the Philippines and Japanese presentations for technical and policy insights.

Closing Remarks by Moderator: Mr Glen Sweetnam

- Thanked all speakers for their valuable insights.
- Highlighted the practical lessons for scaling biomass.
- Session concluded with audience applause.

8. Closing Remarks

Dr Kazutomo Irie, President, APERC

At the end of the meeting of the APEC Symposium on Bioenergy, Dr Kazutomo Irie extended his deepest appreciation to all the speakers, moderators, and active participants on behalf of the Asia Pacific Energy Research Centre, APERC, and the Ministry of Energy of Thailand, the symposium organizer. He noted that it was beyond his capacity to summarize the rich and multifaceted contents of the one-day meeting. However, he stated that the meeting was as informative and encouraging for those pursuing decarbonization, ultimately aiming for carbon neutrality, as he had hoped it would be when the symposium series was first proposed.

He announced that the participants would visit a bioethanol plant the following day to gain firsthand knowledge of bioenergy production. He expressed his gratitude to Mitr Phol Biofuel Company Limited for accepting the site visit. He thanked everyone once again for their kind participation and contributions. He then declared that this part of the symposium meeting was adjourned.

9. Site Visit

The Mitr Phol Sugar and Ethanol Plants in Phu Khiew were selected as the site visit location. Mitr Phol was ranked as the 4th largest sugar producer in the world in 2023, and 2nd in 2018. The complex is a fully integrated facility comprising a sugar mill, ethanol plant, biomass power plant, and fertilizer plant.

Approximately 40 guests were welcomed and gathered in the Phu Lan Kha Room. After the welcome speech by Mr Thanyavee Pongsricharoensuk, Managing Director of the Ethanol Business, four presentations were delivered, providing an overview of Mitr Phol Phu Khiew Park, as follows:

- Presentation on the Mitr Phol Group and Mitr Phol Phu Khiew Park introductory video
- Presentation on the Sugarcane Farm, Sugar Factory, and Electricity Business
- Presentation on the Ethanol Business
- Presentation on the Mitr Phol Innovation and Research Center, followed by a Q&A session

After the presentations, participants joined a site tour, followed by lunch. Participants experienced practical applications and case studies at a cutting-edge site. The site visit was essential for participants to deepen their understanding.

Ⅶ. Appendix A: Agenda

"APEC Symposium on Bioenergy"
- APEC 3rd Sectoral Symposium for Energy Transition -
Agenda

Date: 3-4 December 2024
Venue: Orchid Ballroom (2F), Pullman Khon Kaen Raja Orchid Hotel, Khon Kaen, Thailand
Format: In-person meeting

Day 1: 3 December 2024
Symposium

9:00 - 9:30	**Registration**

9:30 - 10:15	**Welcome Speech:** **-Mr Waranon Chansiri**, Executive Director, Ministry of Energy, Thailand **Opening Remarks:** **-Mr Siriwat Pinijpanich, the Vice Governor of Khon Kaen Province, Thailand** **Opening Remarks:** **-Dr Kazutomo Irie**, President, Asia Pacific Energy Research Centre (APERC)
10:15 - 10:25	**Keynote Speech:** -**Mr Yoshiomi Yoshino,** Director for International Policy on Carbon Neutrality, Ministry of Economy, Trade and Industry, Japan
10:25 - 10:40	**Scene Setting:** "Outlook for Bioenergy in APEC: Two Scenarios" -**Mr Glen Sweetnam**, Senior Vice President, APERC
10:40 - 10:55	**Group photo**
	Coffee break
Session 1. "Biodiesel and Bioethanol: Opportunities & Challenges and Recent Developments" • Biodiesel • Bioethanol	
10:55 - 12:05 (70 min) 15 min/speaker	Session Moderator: -**Dr Ruengsak Thitiratsakul**, Petroleum and Energy Institute of Thailand (PEIT)
	"Thailand Latest Policy to Promote Bioenergy"-**Dr Natikorn Prakobboon**, Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy, Thailand
	"Bioenergy in Chinese Taipei and Asia" -**Dr Chia-Chi Chang**, Taiwan Bio-energy Technology Development Association, Chinese Taipei
	"Malaysia's Biofuel Partnership Program" – **Mr Norizal Khushairi bin Mohamad Zamri**, Head of National Project & Technical Advisor for Global Wildlife Program (GWP) Malaysia. UNDP Malaysia
12:05 - 12:25	Discussion and Q&A
12:25 - 13:35 (70 min)	**Lunch** (Room: Chat Tan: 1F)

Session 2. "Synthetic Biofuels: Opportunities & Challenges and Recent Developments" • Sustainable Aviation Fuel: SAF • E-fuel	
13:35 – 14:45 (70 min) 15 min/speaker	Session Moderator: -**Mr Thanan Marukatat**, Research Fellow, APERC
	"SAF initiatives and potential: Thailand case" **-Mr Kittiphong Limsuwannarot,** Chief Executive Officer and President, BBGI Plc. Thailand

	“SAF and e-fuels” -**Mr Chua Wei Jun**, Biofuels Analyst, S & P Global Commodity Insights, Singapore
	“Biofuels and SAF in Korea” - **Dr Hyunyoung Oh**, Associate Research Fellow, Korea Energy Economics Institute (KEEI), Korea
	“SAF and e-fuels” – **Dr Nuwong Chollacoop**, Research Group Director, National Energy Technology Center, Thailand
14:45 – 15:05	Discussion and Q&A
15:05 – 15:20	Coffee break

Session 3. “Decarbonization in Power Sector by Biomass and Biohydrogen”	
15:20 – 16:30 (70 min) 15 min/speaker	Session Moderator: -**Mr Glen Sweetnam,** Senior Vice President, APERC
	“Biofuel : Co-firing Application and Pathway to Sustainable Decarbonization in Mae Moh Smart City" -**Ms Ornnicha Phalino,** Chief of Fuel Development Department, Fuel Engineering Division, Electricity Generating Authority of Thailand (EGAT), Thailand
	“Biohydrogen” -**Ms Alice Li**, Senior Technical Consultant, DR Biomass Development (HK) Limited, Hong Kong, China
	“Contribution to Carbon Neutral Society by Biomass use in Coal-fired Boiler” - “Introduction of Idemitsu Green Energy Pellet” - **Mr Naotsugu Otani**, Deputy General Manager, Environment & Biomass, Coal and Energy Solution Department, Idemitsu Kosan Co., Ltd., Japan
	“Decarbonization in Power Sector by Biomass and Biohydrogen in the Philippines” -**Ms Anna Mikko G. Realo**, Officer-in-Charge, Biomass Energy Management Division, Renewable Energy Management Bureau, Department of Energy (DOE), The Philippines
16:30 – 16:50	Discussion and Q&A
16:50 – 16:55	**Closing Remarks** **Dr Kazutomo Irie**, President, APERC

Day 1: 3 December 2024

Reception Dinner

18:00– 20:00	**Reception Dinner** (See Na Nuan Cafe)

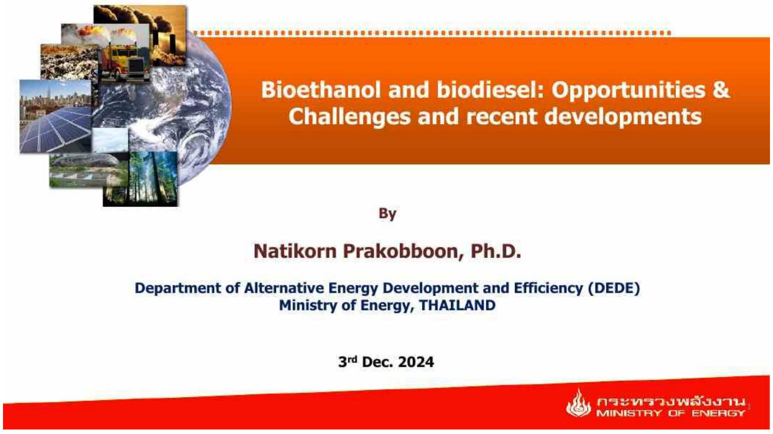
Day 2: 4 December 2024

Site Visit

8:15 –13:30	Site Visit: Mitr Phol Biofuel Co., Ltd.

Ⅷ. Appendix B: Symposium Presentations

Session1-1 "Thailand Latest Policy to Promote Bioenergy"
Dr Natikorn Prakobboon



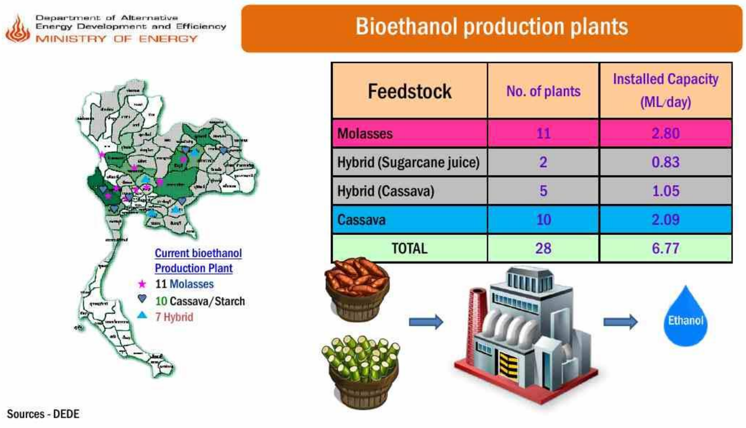
Bioethanol and biodiesel: Opportunities & Challenges and recent developments

By

Natikorn Prakobboon, Ph.D.

Department of Alternative Energy Development and Efficiency (DEDE)
Ministry of Energy, THAILAND

3rd Dec. 2024



Bioethanol production plants

Feedstock	No. of plants	Installed Capacity (ML/day)
Molasses	11	2.80
Hybrid (Sugarcane juice)	2	0.83
Hybrid (Cassava)	5	1.05
Cassava	10	2.09
TOTAL	28	6.77

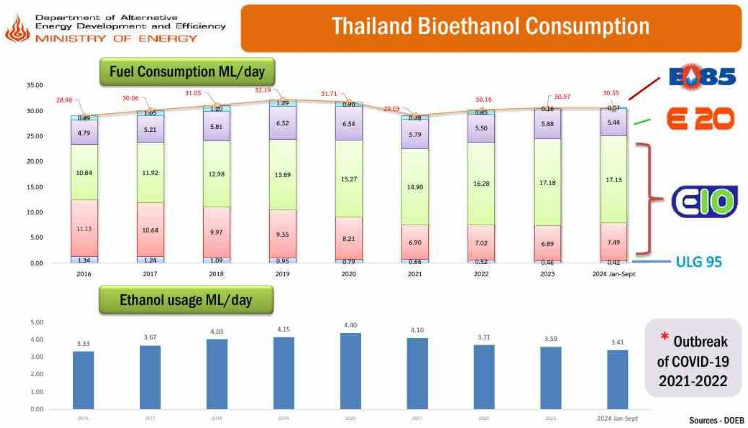
Sources - DEDE

Bioethanol production

Feedstock	Year	Installed capacity (ML/day)	Actual production (ML/day)	%
Molasses	2020	3.88	2.65	68
	2021	4.59	2.27	62
	2022	4.59	2.64	63
	2023	4.59	2.39	67
Cassava	2020	2.09	1.39	32
	2021	2.32	1.37	38
	2022	2.32	1.45	37
	2023	2.32	1.19	33

Remarks: 1. This is the average bioethanol production in each year.
2. In 2023, the available data is only from Jan to July.

Sources – DOEB, Compiled by DEDE



Thailand Bioethanol Consumption

* Outbreak of COVID-19 2021-2022

Sources - DOEB

Big challenges

Oil fund

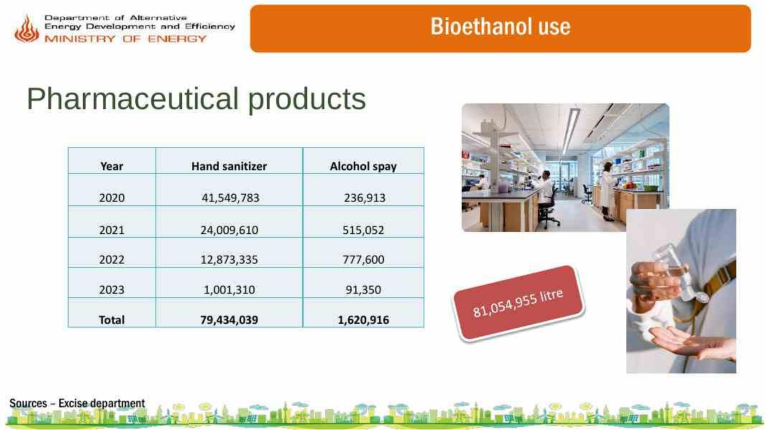
The Oil Fund of Thailand has been established to stabilize domestic fuel prices and promoted biofuel recently.

Electric vehicles

The 30@30 policy stipulates that Thailand must boost manufacturing capacity of zero-emission vehicles, or EVs, by 30% by 2030.

(Draft) AEDP2024

Sources – Department of energy business (DOEB)



Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

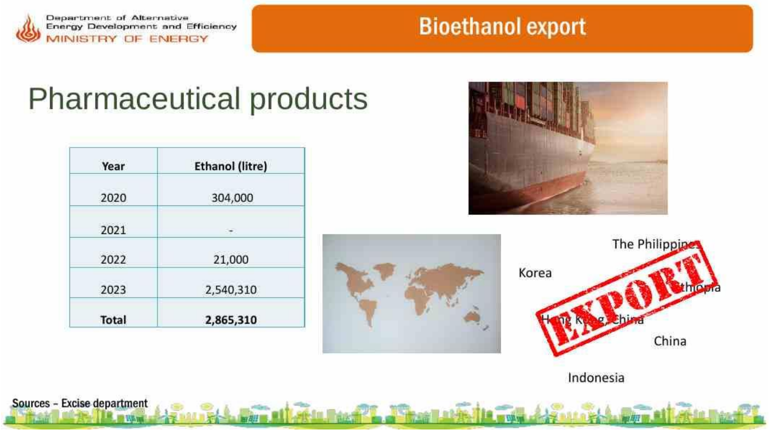
Bioethanol use

Pharmaceutical products

Year	Hand sanitizer	Alcohol spay
2020	41,549,783	236,913
2021	24,009,610	515,052
2022	12,873,335	777,600
2023	1,001,310	91,350
Total	79,434,039	1,620,916

81,054,955 litre

Sources – Excise department



Department of Alternative Energy Development and Efficiency
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Bioethanol export

Pharmaceutical products

Year	Ethanol (litre)
2020	304,000
2021	-
2022	21,000
2023	2,540,310
Total	2,865,310

Sources – Excise department

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

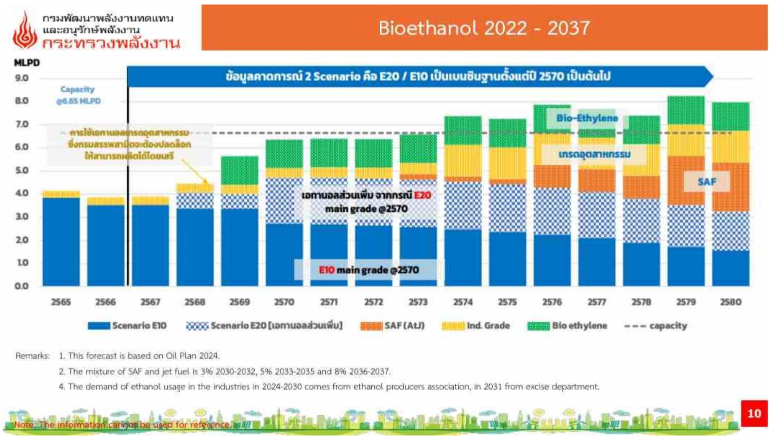
Bioethanol future

Pharmaceutical products
- Isopropyl alcohol

SAF
- Ethanol to jet

Bio plastics
- Bio PE (Bio Poly Ethylene)

Export

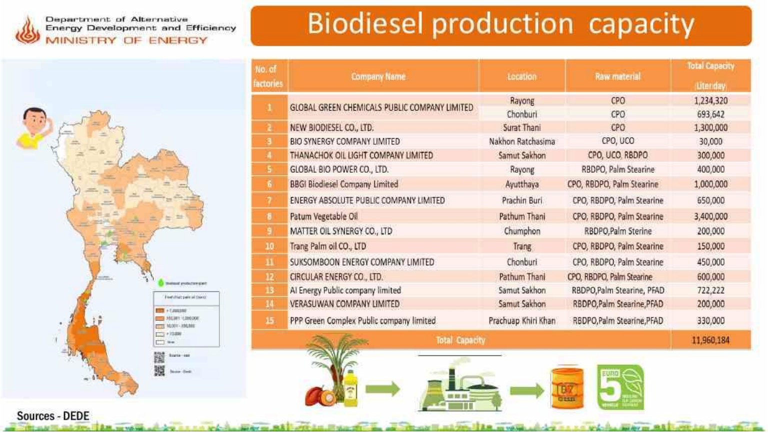


กรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงาน
กระทรวงพลังงาน

Bioethanol 2022 - 2037

Remarks:
1. This forecast is based on Oil Plan 2024.
2. The mixture of SAF and jet fuel is 3% 2030-2032, 5% 2033-2035 and 8% 2036-2037.
4. The demand of ethanol usage in the industries in 2024-2030 comes from ethanol producers association, in 2031 from excise department.

Note: The information cannot be used for reference.

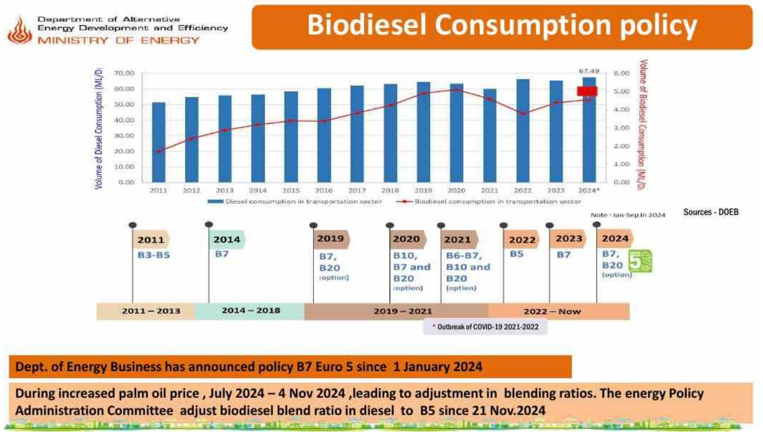


Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

Biodiesel production capacity

No. of factories	Company Name	Location	Raw material	Total Capacity (Liter/day)
1	GLOBAL GREEN CHEMICALS PUBLIC COMPANY LIMITED	Rayong	CPO	1,234,320
		Chonburi	CPO	693,642
2	NEW BIODIESEL CO., LTD.	Surat Thani	CPO	1,300,000
3	BIO SYNERGY COMPANY LIMITED	Nakhon Ratchasima	CPO, UCO	30,000
4	THANACHOK OIL LIGHT COMPANY LIMITED	Samut Sakhon	CPO, UCO, RBDPO	300,000
5	GLOBAL BIO POWER CO., LTD.	Rayong	RBDPO, Palm Stearine	400,000
6	BBGI Biodiesel Company Limited	Ayutthaya	CPO, RBDPO, Palm Stearine	1,000,000
7	ENERGY ABSOLUTE PUBLIC COMPANY LIMITED	Prachin Buri	CPO, RBDPO, Palm Stearine	650,000
8	Patum Vegetable Oil	Pathum Thani	CPO, RBDPO, Palm Stearine	3,400,000
9	MATTER OIL SYNERGY CO., LTD	Chumphon	RBDPO,Palm Sterine	200,000
10	Trang Palm oil CO., LTD	Trang	CPO, RBDPO, Palm Stearine	150,000
11	SUKSOMBOON ENERGY COMPANY LIMITED	Chonburi	CPO, RBDPO, Palm Stearine	450,000
12	CIRCULAR ENERGY CO., LTD.	Pathum Thani	CPO, RBDPO, Palm Stearine	600,000
13	AI Energy Public company limited	Samut Sakhon	RBDPO,Palm Stearine, PFAD	722,222
14	VERASUWAN COMPANY LIMITED	Samut Sakhon	RBDPO,Palm Stearine,PFAD	200,000
15	PPP Green Complex Public company limited	Prachuap Khiri Khan	RBDPO,Palm Stearine,PFAD	330,000
Total Capacity				11,960,184

Sources - DEDE



Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

Biodiesel Consumption policy

Note : Jan-Sep in 2024

Sources - DOEB

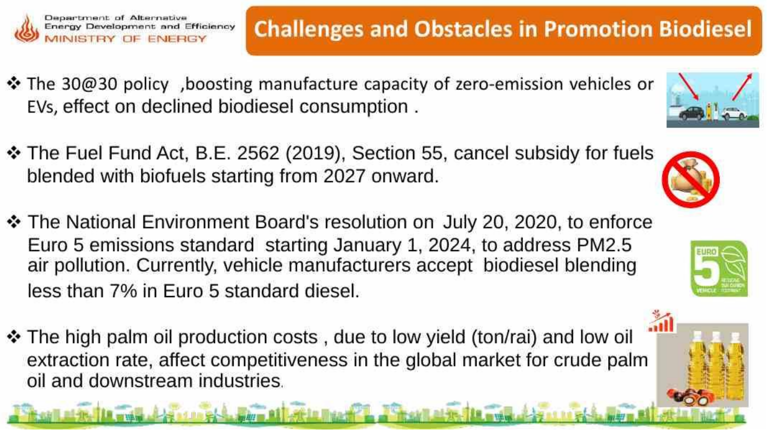
- 2011: B3-B5
- 2014: B7
- 2019: B7, B20 (option)
- 2020: B10, B7 and B20 (option)
- 2021: B6-B7, B10 and B20 (option)
- 2022: B5
- 2023: B7
- 2024: B7, B20 (option)

2011 – 2013 | 2014 – 2018 | 2019 – 2021 | 2022 – Now

* Outbreak of COVID-19 2021-2022

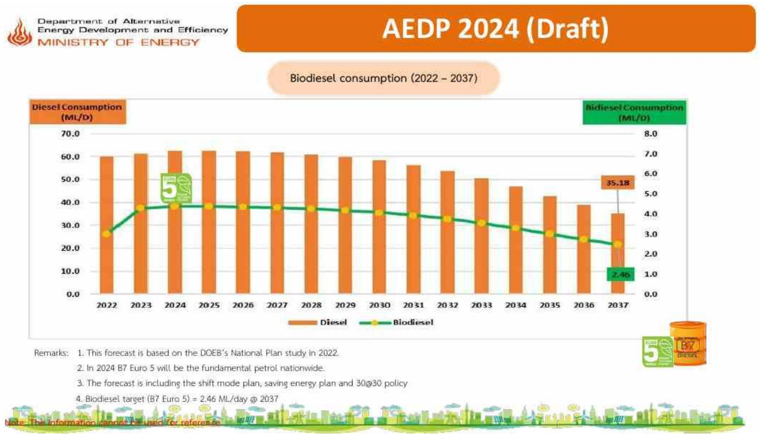
Dept. of Energy Business has announced policy B7 Euro 5 since 1 January 2024

During increased palm oil price , July 2024 – 4 Nov 2024 ,leading to adjustment in blending ratios. The energy Policy Administration Committee adjust biodiesel blend ratio in diesel to B5 since 21 Nov.2024



Challenges and Obstacles in Promotion Biodiesel

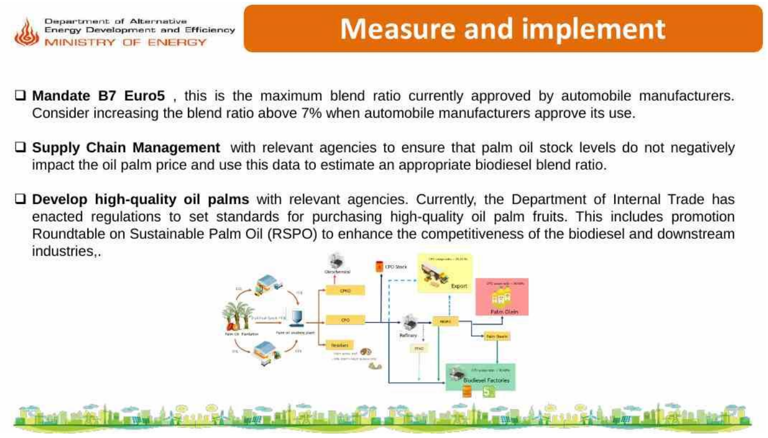
- ❖ The 30@30 policy ,boosting manufacture capacity of zero-emission vehicles or EVs, effect on declined biodiesel consumption .
- ❖ The Fuel Fund Act, B.E. 2562 (2019), Section 55, cancel subsidy for fuels blended with biofuels starting from 2027 onward.
- ❖ The National Environment Board's resolution on July 20, 2020, to enforce Euro 5 emissions standard starting January 1, 2024, to address PM2.5 air pollution. Currently, vehicle manufacturers accept biodiesel blending less than 7% in Euro 5 standard diesel.
- ❖ The high palm oil production costs , due to low yield (ton/rai) and low oil extraction rate, affect competitiveness in the global market for crude palm oil and downstream industries.



AEDP 2024 (Draft)

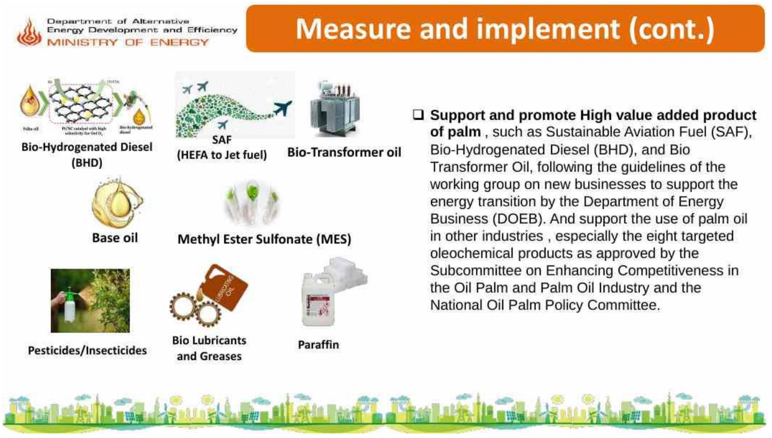
Remarks: 1. This forecast is based on the DOEB's National Plan study in 2022.
2. In 2024 B7 Euro 5 will be the fundamental petrol nationwide.
3. The forecast is including the shift mode plan, saving energy plan and 30@30 policy
4. Biodiesel target (B7 Euro 5) = 2.46 ML/day @ 2037

Note: The information cannot be used for reference



Measure and implement

- ❑ **Mandate B7 Euro5** , this is the maximum blend ratio currently approved by automobile manufacturers. Consider increasing the blend ratio above 7% when automobile manufacturers approve its use.
- ❑ **Supply Chain Management** with relevant agencies to ensure that palm oil stock levels do not negatively impact the oil palm price and use this data to estimate an appropriate biodiesel blend ratio.
- ❑ **Develop high-quality oil palms** with relevant agencies. Currently, the Department of Internal Trade has enacted regulations to set standards for purchasing high-quality oil palm fruits. This includes promotion Roundtable on Sustainable Palm Oil (RSPO) to enhance the competitiveness of the biodiesel and downstream industries,.



Measure and implement (cont.)

- ❑ **Support and promote High value added product of palm** , such as Sustainable Aviation Fuel (SAF), Bio-Hydrogenated Diesel (BHD), and Bio Transformer Oil, following the guidelines of the working group on new businesses to support the energy transition by the Department of Energy Business (DOEB). And support the use of palm oil in other industries , especially the eight targeted oleochemical products as approved by the Subcommittee on Enhancing Competitiveness in the Oil Palm and Palm Oil Industry and the National Oil Palm Policy Committee.

THANK YOU FOR YOUR KIND ATTENTION

E-mail : Natikorn_p@dede.go.th

Session1-2 “Bioenergy in Chinese Taipei and Asia”
Dr Chia-Chi Chang

Asia Pacific Energy Research Centre (APERC)

APEC Symposium on Bioenergy
- APEC 3rd Sectoral Symposium for Energy Transition

Development and Current Situation of Bio-fuel in Chinese Taipei

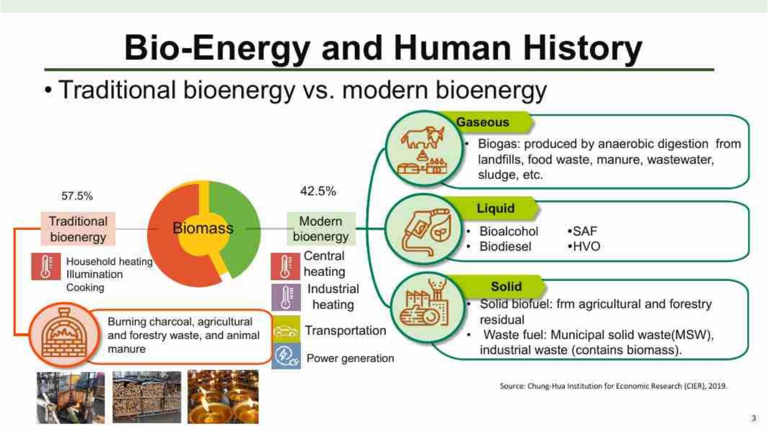
Dr. Chia-Chi Chang

Taiwan Bio-energy Technology Development Association

Dec, 3th, 2024

OUTLINE

- **Introduction**
- Renewable Energy Policy in Chinese Taipei
- Development and Current Situation of Biofuels in Chinese Taipei
- Conclusions



Bio-Energy and Human History

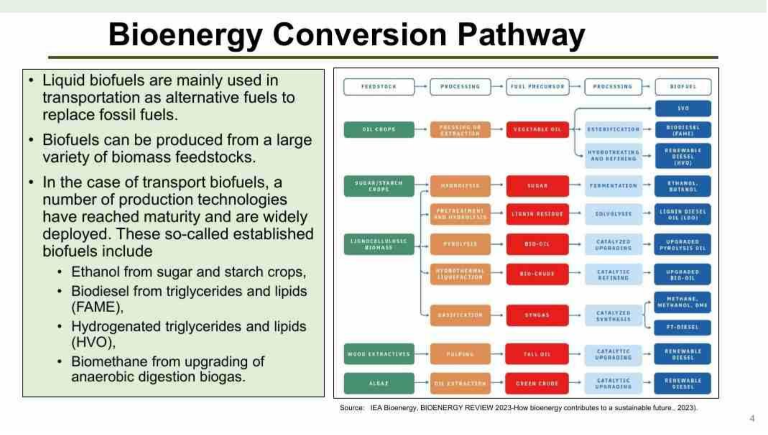
- Traditional bioenergy vs. modern bioenergy

Gaseous
- Biogas: produced by anaerobic digestion from landfills, food waste, manure, wastewater, sludge, etc.

Liquid
- Bioalcohol •SAF
- Biodiesel •HVO

Solid
- Solid biofuel: frm agricultural and forestry residual
- Waste fuel: Municipal solid waste(MSW), industrial waste (contains biomass).

Source: Chung-Hua Institution for Economic Research (CIER), 2019.



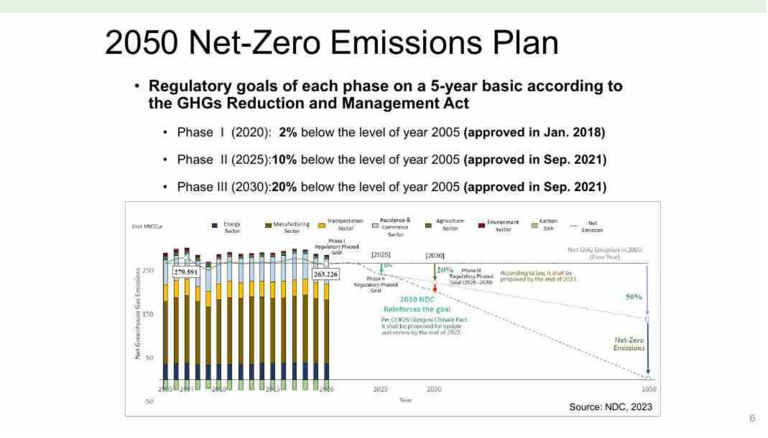
Bioenergy Conversion Pathway

- Liquid biofuels are mainly used in transportation as alternative fuels to replace fossil fuels.
- Biofuels can be produced from a large variety of biomass feedstocks.
- In the case of transport biofuels, a number of production technologies have reached maturity and are widely deployed. These so-called established biofuels include
  - Ethanol from sugar and starch crops,
  - Biodiesel from triglycerides and lipids (FAME),
  - Hydrogenated triglycerides and lipids (HVO),
  - Biomethane from upgrading of anaerobic digestion biogas.

Source: IEA Bioenergy, BIOENERGY REVIEW 2023-How bioenergy contributes to a sustainable future., 2023).

OUTLINE

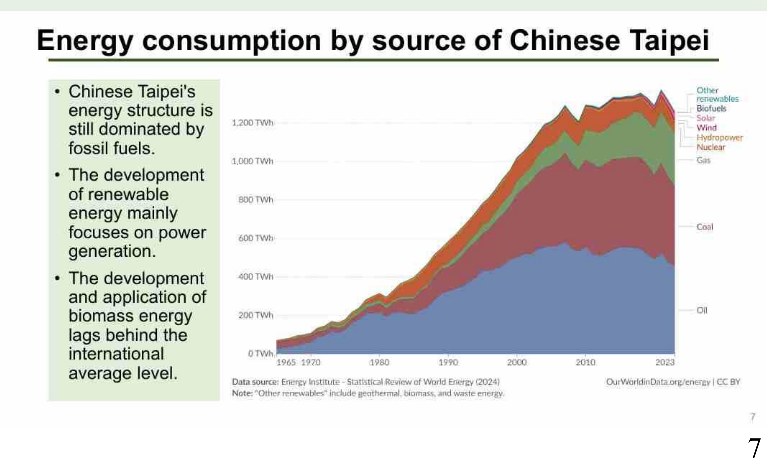
- Introduction
- **Renewable Energy Policy in Chinese Taipei**
- Development and Current Situation of Biofuels in Chinese Taipei
- Conclusions



2050 Net-Zero Emissions Plan

- **Regulatory goals of each phase on a 5-year basic according to the GHGs Reduction and Management Act**
  - Phase Ⅰ (2020): **2%** below the level of year 2005 **(approved in Jan. 2018)**
  - Phase Ⅱ (2025):**10%** below the level of year 2005 **(approved in Sep. 2021)**
  - Phase III (2030):**20%** below the level of year 2005 **(approved in Sep. 2021)**

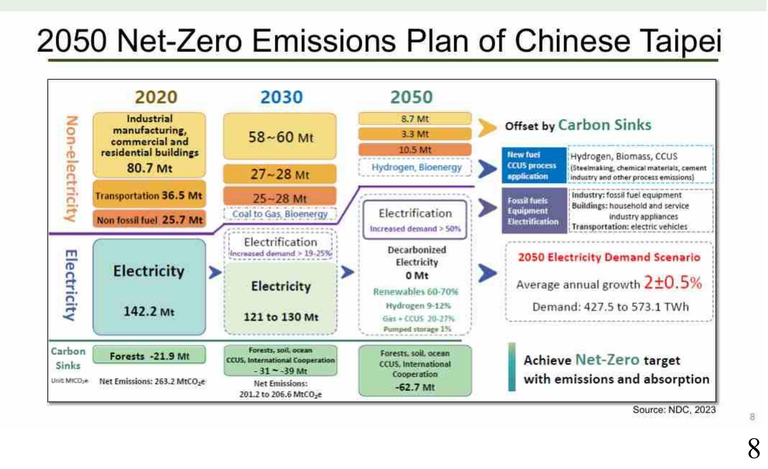
Source: NDC, 2023



Energy consumption by source of Chinese Taipei

- Chinese Taipei's energy structure is still dominated by fossil fuels.
- The development of renewable energy mainly focuses on power generation.
- The development and application of biomass energy lags behind the international average level.

Data source: Energy Institute - Statistical Review of World Energy (2024)
Note: "Other renewables" include geothermal, biomass, and waste energy.
OurWorldinData.org/energy | CC BY



2050 Net-Zero Emissions Plan of Chinese Taipei

2020
2030
2050

Non-electricity
Industrial manufacturing, commercial and residential buildings 80.7 Mt
Transportation 36.5 Mt
Non fossil fuel 25.7 Mt
58~60 Mt
27~28 Mt
25~28 Mt
Coal to Gas, Bioenergy
8.7 Mt
3.3 Mt
10.5 Mt
Hydrogen, Bioenergy

Electricity
Electricity 142.2 Mt
Electrification
Increased demand > 19-25%
Electricity 121 to 130 Mt
Electrification
Increased demand > 50%
Decarbonized Electricity 0 Mt
Renewables 60-70%
Hydrogen 9-12%
Gas + CCUS 20-27%
Pumped storage 1%

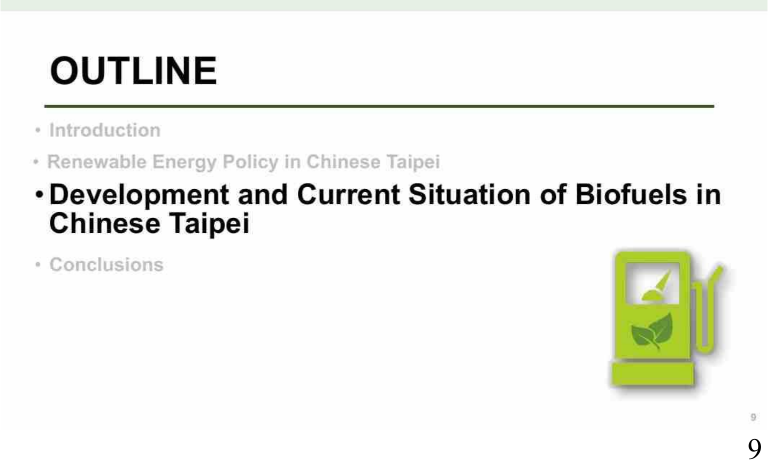
Carbon Sinks
Unit: MtCO₂e
Forests -21.9 Mt
Net Emissions: 263.2 MtCO₂e
Forests, soil, ocean CCUS, International Cooperation - 31 ~ -39 Mt
Net Emissions: 201.2 to 206.6 MtCO₂e
Forests, soil, ocean CCUS, International Cooperation -62.7 Mt

Offset by Carbon Sinks
New fuel CCUS process application
Hydrogen, Biomass, CCUS (Steelmaking, chemical materials, cement industry and other process emissions)
Fossil fuels Equipment Electrification
Industry: fossil fuel equipment
Buildings: household and service industry appliances
Transportation: electric vehicles

2050 Electricity Demand Scenario
Average annual growth 2±0.5%
Demand: 427.5 to 573.1 TWh

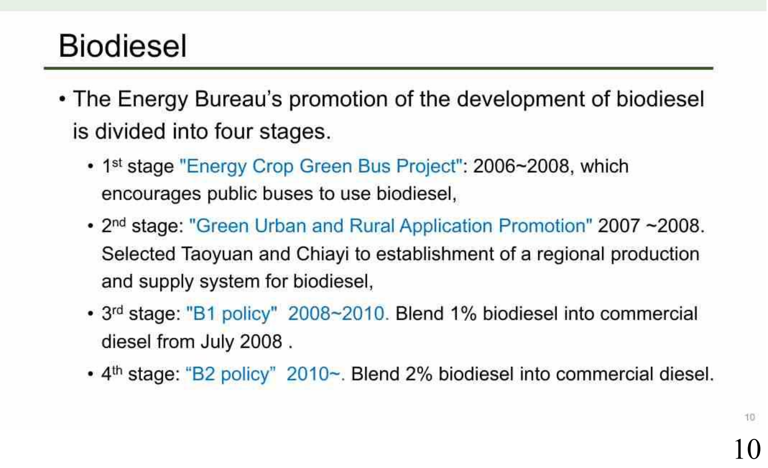
Achieve Net-Zero target with emissions and absorption

Source: NDC, 2023



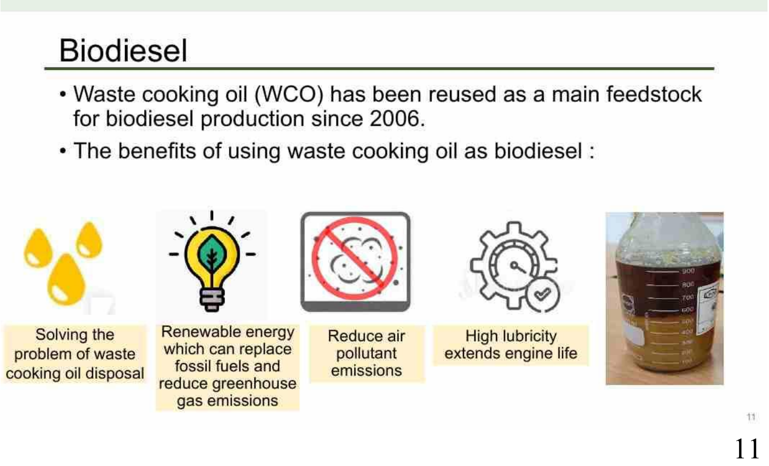
OUTLINE

- Introduction
- Renewable Energy Policy in Chinese Taipei
- **Development and Current Situation of Biofuels in Chinese Taipei**
- Conclusions



Biodiesel

- The Energy Bureau's promotion of the development of biodiesel is divided into four stages.
  - 1st stage "Energy Crop Green Bus Project": 2006~2008, which encourages public buses to use biodiesel,
  - 2nd stage: "Green Urban and Rural Application Promotion" 2007 ~2008. Selected Taoyuan and Chiayi to establishment of a regional production and supply system for biodiesel,
  - 3rd stage: "B1 policy" 2008~2010. Blend 1% biodiesel into commercial diesel from July 2008 .
  - 4th stage: "B2 policy" 2010~. Blend 2% biodiesel into commercial diesel.



Biodiesel

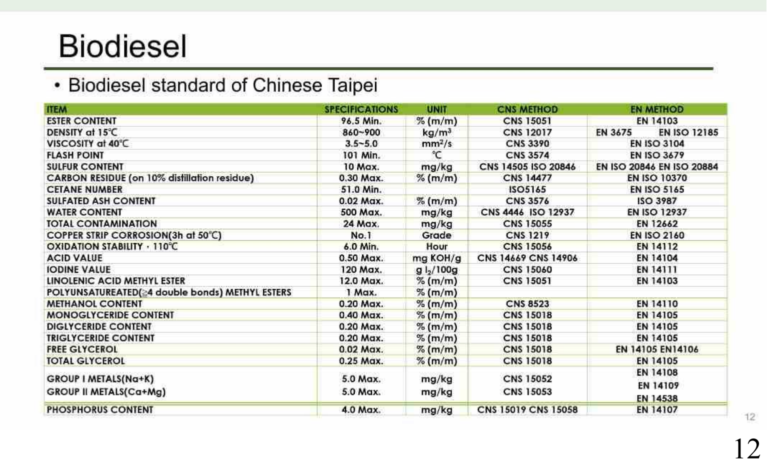
- Waste cooking oil (WCO) has been reused as a main feedstock for biodiesel production since 2006.
- The benefits of using waste cooking oil as biodiesel :

Solving the problem of waste cooking oil disposal

Renewable energy which can replace fossil fuels and reduce greenhouse gas emissions

Reduce air pollutant emissions

High lubricity extends engine life



Biodiesel

- Biodiesel standard of Chinese Taipei

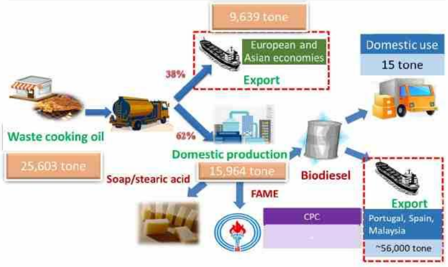
ITEM	SPECIFICATIONS	UNIT	CNS METHOD	EN METHOD
ESTER CONTENT	96.5 Min.	% (m/m)	CNS 15051	EN 14103
DENSITY at 15℃	860~900	kg/m³	CNS 12017	EN 3675 EN ISO 12185
VISCOSITY at 40℃	3.5~5.0	mm²/s	CNS 3390	EN ISO 3104
FLASH POINT	101 Min.	℃	CNS 3574	EN ISO 3679
SULFUR CONTENT	10 Max.	mg/kg	CNS 14505 ISO 20846	EN ISO 20846 EN ISO 20884
CARBON RESIDUE (on 10% distillation residue)	0.30 Max.	% (m/m)	CNS 14477	EN ISO 10370
CETANE NUMBER	51.0 Min.		ISO5165	EN ISO 5165
SULFATED ASH CONTENT	0.02 Max.	% (m/m)	CNS 3576	ISO 3987
WATER CONTENT	500 Max.	mg/kg	CNS 4446 ISO 12937	EN ISO 12937
TOTAL CONTAMINATION	24 Max.	mg/kg	CNS 15055	EN 12662
COPPER STRIP CORROSION(3h at 50℃)	No.1	Grade	CNS 1219	EN ISO 2160
OXIDATION STABILITY · 110℃	6.0 Min.	Hour	CNS 15056	EN 14112
ACID VALUE	0.50 Max.	mg KOH/g	CNS 14669 CNS 14906	EN 14104
IODINE VALUE	120 Max.	g I_2/100g	CNS 15060	EN 14111
LINOLENIC ACID METHYL ESTER	12.0 Max.	% (m/m)	CNS 15051	EN 14103
POLYUNSATUREATED(≥4 double bonds) METHYL ESTERS	1 Max.	% (m/m)		
METHANOL CONTENT	0.20 Max.	% (m/m)	CNS 8523	EN 14110
MONOGLYCERIDE CONTENT	0.40 Max.	% (m/m)	CNS 15018	EN 14105
DIGLYCERIDE CONTENT	0.20 Max.	% (m/m)	CNS 15018	EN 14105
TRIGLYCERIDE CONTENT	0.20 Max.	% (m/m)	CNS 15018	EN 14105
FREE GLYCEROL	0.02 Max.	% (m/m)	CNS 15018	EN 14105 EN14106
TOTAL GLYCEROL	0.25 Max.	% (m/m)	CNS 15018	EN 14105
GROUP I METALS(Na+K)	5.0 Max.	mg/kg	CNS 15052	EN 14108 EN 14109
GROUP II METALS(Ca+Mg)	5.0 Max.	mg/kg	CNS 15053	EN 14538
PHOSPHORUS CONTENT	4.0 Max.	mg/kg	CNS 15019 CNS 15058	EN 14107

Biodiesel

- The supply amounts of biodiesel indicated a soaring growth from 1,029 kiloliters in 2006 to 96,373 kiloliters in 2013.
- However, the users have complained about some issues, including fuel tank and filter clogging/plugging, ignition delay.
- The government thus temporarily terminated the biodiesel blends (B2) promotion policy in May 2014.

Biodiesel

- In order to continuously support WCO recycling, the vast majority of biodiesel by domestic production was exported to European (e.g., Spain) and Asian economies (e.g., Korea).



Bioethanol

- The policy for promoting the use of bioethanol and its domestic production plan started from 2007.
- Limited gas stations in the metropolitan cities (8 gas stations in Taipei City and 6 gas stations in Kaohsiung city) provided E3 gasohol for all vehicles by subsidizing a discount rate at NT $1.0–2.0 per liter.
- Due to no ethanol plants currently operating, the bioethanol in the E3 gasohol was completely imported.
- Through the signing of a MOU between CPC and the US Grains Council, the government will provide E10 starting from 2025 to achieve carbon reduction goals.

Source: news.u-car.com.tw, 2007

OUTLINE

- Introduction
- Renewable Energy Policy in Chinese Taipei
- Development and Current Situation of Biofuels in Chinese Taipei
- **Conclusions**

Conclusions

- The lack of enthusiasm in promoting biomass energy policies has led to the slow development of biomass energy.
- Compared with fossil fuels, the cost of biofuels is higher. Economic subsidies are needed to promote effectively.
- The EU economics' subsidy policy for WCO-based biodiesel has increased the demand for WCO, resulting in large-scale exports of WCO and soaring purchase prices.
- The new 2050 net-zero policy will help re-examine bioenergy policies and promote the development of biofuels.
- Supply and price are the main obstacles to the future development of biofuels.

THE END

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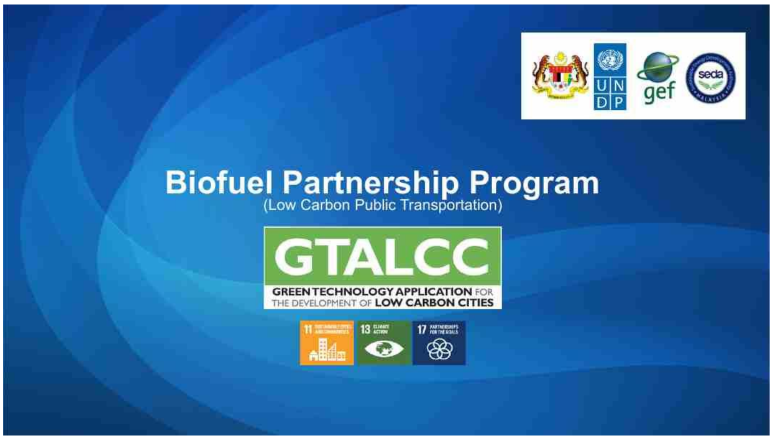
Session1-3 “Malaysia's Biofuel Partnership Program”

Mr Norizal Khushairi bin Mohamad Zamri

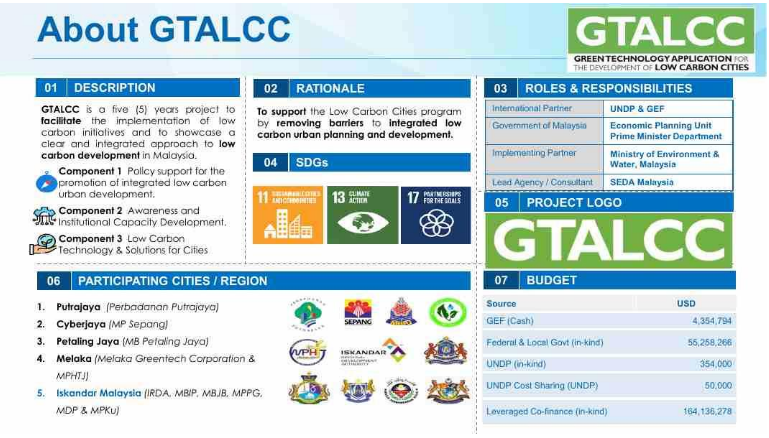


Biofuel Partnership Program

(Low Carbon Public Transportation)

GTALCC

GREEN TECHNOLOGY APPLICATION FOR THE DEVELOPMENT OF LOW CARBON CITIES



About GTALCC

GTALCC GREEN TECHNOLOGY APPLICATION FOR THE DEVELOPMENT OF LOW CARBON CITIES

01 DESCRIPTION

GTALCC is a five (5) years project to **facilitate** the implementation of low carbon initiatives and to showcase a clear and integrated approach to **low carbon development** in Malaysia.

Component 1 Policy support for the promotion of integrated low carbon urban development.

Component 2 Awareness and Institutional Capacity Development.

Component 3 Low Carbon Technology & Solutions for Cities

02 RATIONALE

To support the Low Carbon Cities program by **removing barriers** to **integrated low carbon urban planning and development.**

04 SDGs

03 ROLES & RESPONSIBILITIES

International Partner	**UNDP & GEF**
Government of Malaysia	**Economic Planning Unit Prime Minister Department**
Implementing Partner	**Ministry of Environment & Water, Malaysia**
Lead Agency / Consultant	**SEDA Malaysia**

05 PROJECT LOGO

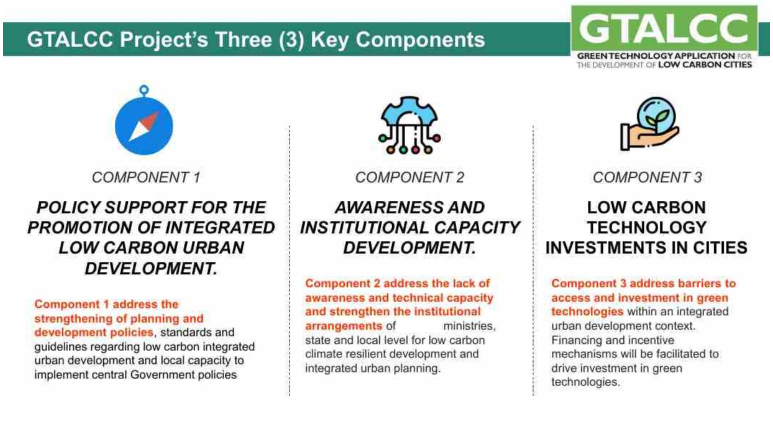
GTALCC

06 PARTICIPATING CITIES / REGION

1. **Putrajaya** *(Perbadanan Putrajaya)*
2. **Cyberjaya** *(MP Sepang)*
3. **Petaling Jaya** *(MB Petaling Jaya)*
4. **Melaka** *(Melaka Greentech Corporation & MPHTJ)*
5. **Iskandar Malaysia** *(IRDA, MBIP, MBJB, MPPG, MDP & MPKu)*

07 BUDGET

Source	USD
GEF (Cash)	4,354,794
Federal & Local Govt (in-kind)	55,258,266
UNDP (in-kind)	354,000
UNDP Cost Sharing (UNDP)	50,000
Leveraged Co-finance (in-kind)	164,136,278



GTALCC Project's Three (3) Key Components

COMPONENT 1

POLICY SUPPORT FOR THE PROMOTION OF INTEGRATED LOW CARBON URBAN DEVELOPMENT.

Component 1 address the strengthening of planning and development policies, standards and guidelines regarding low carbon integrated urban development and local capacity to implement central Government policies

COMPONENT 2

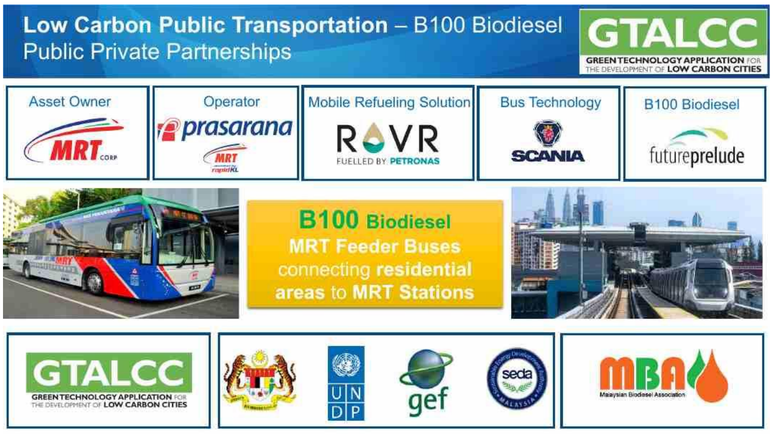
AWARENESS AND INSTITUTIONAL CAPACITY DEVELOPMENT.

Component 2 address the lack of awareness and technical capacity and strengthen the institutional arrangements of ministries, state and local level for low carbon climate resilient development and integrated urban planning.

COMPONENT 3

LOW CARBON TECHNOLOGY INVESTMENTS IN CITIES

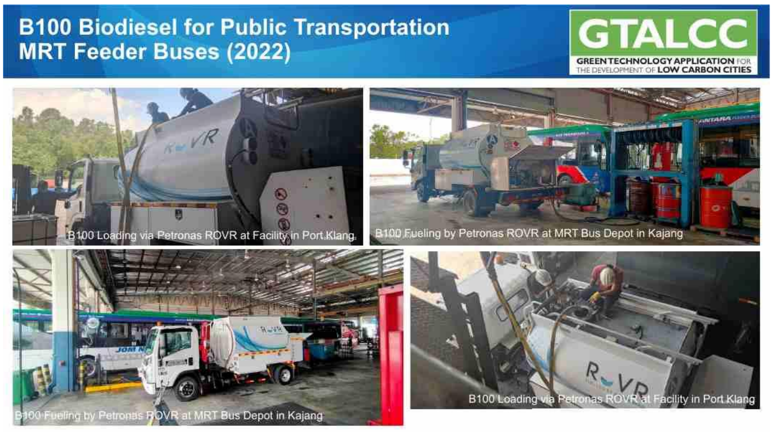
Component 3 address barriers to access and investment in green technologies within an integrated urban development context. Financing and incentive mechanisms will be facilitated to drive investment in green technologies.



Low Carbon Public Transportation – B100 Biodiesel Public Private Partnerships

Asset Owner	Operator	Mobile Refueling Solution	Bus Technology	B100 Biodiesel

B100 Biodiesel
MRT Feeder Buses
connecting residential areas to MRT Stations



B100 Biodiesel for Public Transportation MRT Feeder Buses (2022)

B100 Loading via Petronas ROVR at Facility in Port Klang

B100 Fueling by Petronas ROVR at MRT Bus Depot in Kajang

B100 Fueling by Petronas ROVR at MRT Bus Depot in Kajang

B100 Loading via Petronas ROVR at Facility in Port Klang

Other B100 Biodiesel Project – Road Tankers

Scania with B100 Biodiesel from Shell proven to be suitable for KPD operations and to reduce CO2 emissions

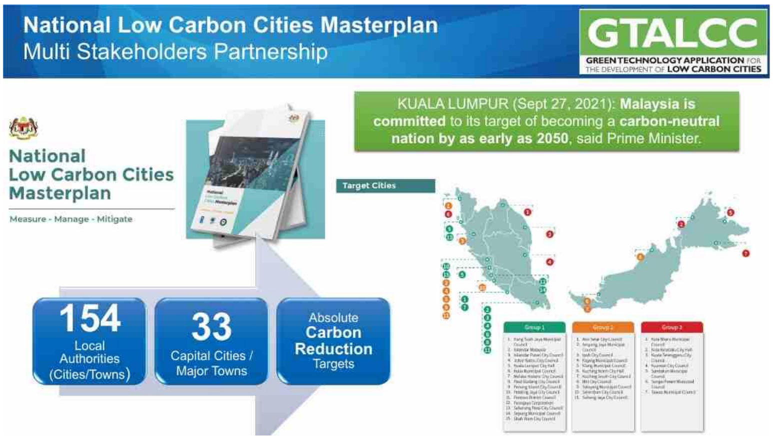
Back in November 2023, Scania (Malaysia) Sdn Bhd (Scania) and Shell Malaysia Trading Sdn Bhd (Shell) launched the pilot test of the first pair of Scania road tankers, operated by Konsortium Port Dickson Sdn Bhd (KPD), running solely on B100 Biodiesel. After several months of trial, the results are:

- Confirmed to be reducing carbon emissions by up to 70 percent
- Suitable for heavy haulage with adjustment in driving behaviour
- No issues with the truck if the vehicle is equipped accordingly
- Suitable alternative, considering locally made product
- Positive impact on major parts of the supply chain

Source Credit: Scania.com.my & Shell Malaysia

Photo Credit: paultan.org

Photo Credit: paultan.org



National Low Carbon Cities Masterplan
Multi Stakeholders Partnership

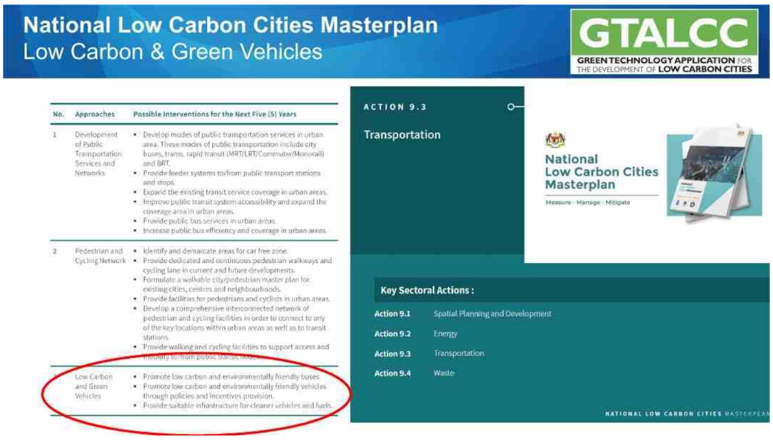
National Low Carbon Cities Masterplan
Measure - Manage - Mitigate

KUALA LUMPUR (Sept 27, 2021): **Malaysia is committed** to its target of becoming a **carbon-neutral nation by as early as 2050**, said Prime Minister.

154 Local Authorities (Cities/Towns)

33 Capital Cities / Major Towns

Absolute **Carbon Reduction** Targets



National Low Carbon Cities Masterplan
Low Carbon & Green Vehicles

No.	Approaches	Possible Interventions for the Next Five (5) Years
1	Development of Public Transportation Services and Networks	• Develop modes of public transportation services in urban area. These modes of public transportation include city buses, trams, rapid transit (MRT/LRT/Commuter/Monorail) and BRT. • Provide feeder systems to/from public transport stations and stops. • Expand the existing transit service coverage in urban areas. • Improve public transit system accessibility and expand the coverage area in urban areas. • Provide public bus services in urban areas. • Increase public bus efficiency and coverage in urban areas.
2	Pedestrian and Cycling Network	• Identify and demarcate areas for car free zone. • Provide dedicated and continuous pedestrian walkways and cycling lane in current and future developments. • Formulate a walkable city/pedestrian master plan for existing cities, centres and neighbourhoods. • Provide facilities for pedestrians and cyclists in urban areas. • Develop a comprehensive interconnected network of pedestrian and cycling facilities in order to connect to any of the key locations within urban areas as well as to transit stations. • Provide walking and cycling facilities to support access and mobility to/from public transit nodes.
	Low Carbon and Green Vehicles	• Promote low carbon and environmentally friendly buses. • Promote low carbon and environmentally friendly vehicles through policies and incentives provision. • Provide suitable infrastructure for cleaner vehicles and fuels.

ACTION 9.3

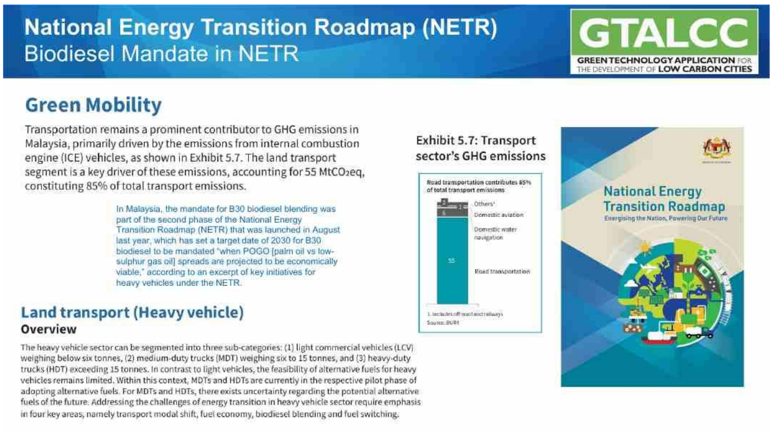
Transportation

National Low Carbon Cities Masterplan
Measure · Manage · Mitigate

Key Sectoral Actions :

Action 9.1	Spatial Planning and Development
Action 9.2	Energy
Action 9.3	Transportation
Action 9.4	Waste

NATIONAL LOW CARBON CITIES MASTERPLAN



National Energy Transition Roadmap (NETR)
Biodiesel Mandate in NETR

Green Mobility

Transportation remains a prominent contributor to GHG emissions in Malaysia, primarily driven by the emissions from internal combustion engine (ICE) vehicles, as shown in Exhibit 5.7. The land transport segment is a key driver of these emissions, accounting for 55 $MtCO_2eq$, constituting 85% of total transport emissions.

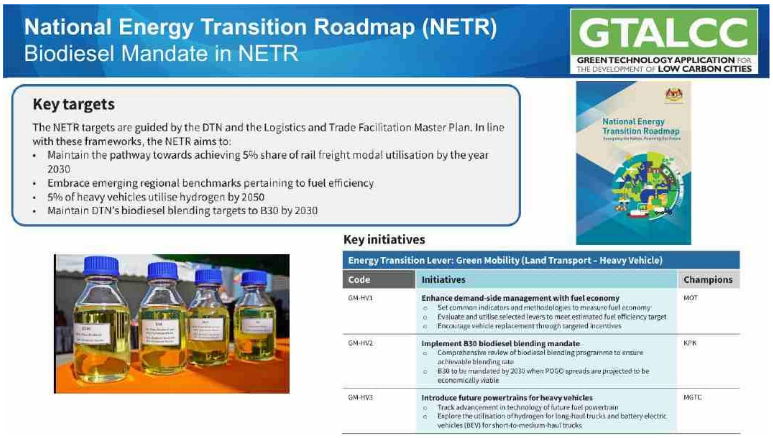
In Malaysia, the mandate for B30 biodiesel blending was part of the second phase of the National Energy Transition Roadmap (NETR) that was launched in August last year, which has set a target date of 2030 for B30 biodiesel to be mandated "when POGO [palm oil vs low-sulphur gas oil] spreads are projected to be economically viable," according to an excerpt of key initiatives for heavy vehicles under the NETR.

Land transport (Heavy vehicle)

Overview

The heavy vehicle sector can be segmented into three sub-categories: (1) light commercial vehicles (LCV) weighing below six tonnes, (2) medium-duty trucks (MDT) weighing six to 15 tonnes, and (3) heavy-duty trucks (HDT) exceeding 15 tonnes. In contrast to light vehicles, the feasibility of alternative fuels for heavy vehicles remains limited. Within this context, MDTs and HDTs are currently in the respective pilot phase of adopting alternative fuels. For MDTs and HDTs, there exists uncertainty regarding the potential alternative fuels of the future. Addressing the challenges of energy transition in heavy vehicle sector require emphasis in four key areas, namely transport modal shift, fuel economy, biodiesel blending and fuel switching.

Exhibit 5.7: Transport sector's GHG emissions



National Energy Transition Roadmap (NETR)
Biodiesel Mandate in NETR

Key targets

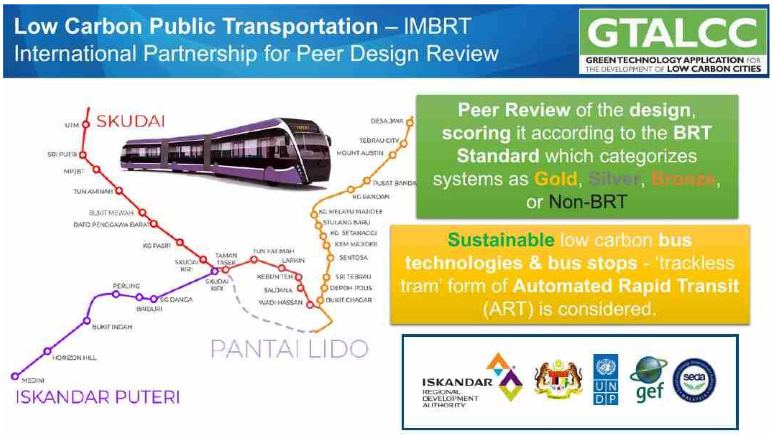
The NETR targets are guided by the DTN and the Logistics and Trade Facilitation Master Plan. In line with these frameworks, the NETR aims to:

- Maintain the pathway towards achieving 5% share of rail freight modal utilisation by the year 2030
- Embrace emerging regional benchmarks pertaining to fuel efficiency
- 5% of heavy vehicles utilise hydrogen by 2050
- Maintain DTN's biodiesel blending targets to B30 by 2030

Key initiatives

Energy Transition Lever: Green Mobility (Land Transport – Heavy Vehicle)

Code	Initiatives	Champions
GM-HV1	**Enhance demand-side management with fuel economy** ○ Set common indicators and methodologies to measure fuel economy ○ Evaluate and utilise selected levers to meet estimated fuel efficiency target ○ Encourage vehicle replacement through targeted incentives	MOT
GM-HV2	**Implement B30 biodiesel blending mandate** ○ Comprehensive review of biodiesel blending programme to ensure achievable blending rate ○ B30 to be mandated by 2030 when POGO spreads are projected to be economically viable	KPK
GM-HV3	**Introduce future powertrains for heavy vehicles** ○ Track advancement in technology of future fuel powertrain ○ Explore the utilisation of hydrogen for long-haul trucks and battery electric vehicles (BEV) for short-to-medium-haul trucks	MGTC



Low Carbon Public Transportation – IMBRT
International Partnership for Peer Design Review

Peer Review of the **design**, **scoring** it according to the **BRT Standard** which categorizes systems as **Gold**, **Silver**, **Bronze**, or Non-BRT

Sustainable low carbon **bus technologies & bus stops** - 'trackless tram' form of **Automated Rapid Transit** (ART) is considered.

Thank You

Session2-2 “SAF and e-fuels”
Mr Chua Wei Jun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Global SAF and e-SAF development

APEC Symposium on Bioenergy
Chua Wei Jun, Biofuels Analyst

3rd December 2024

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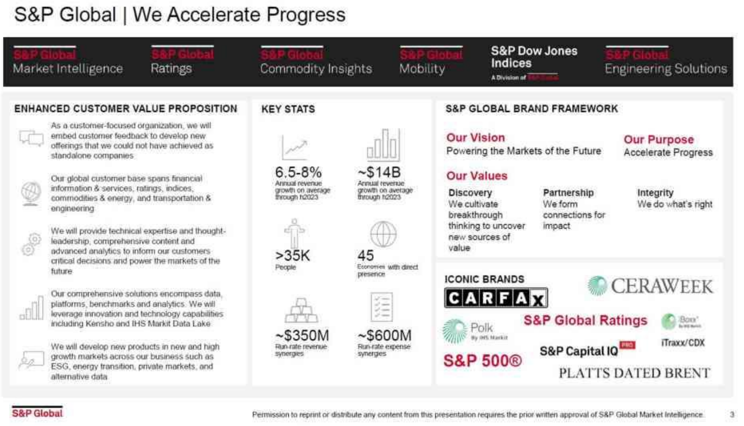
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KEY STATS

6.5-8% Annual revenue growth on average through h2023

~$14B Annual revenue growth on average through h2023

>35K People

45 Economies with direct presence

~$350M Run-rate revenue synergies

~$600M Run-rate expense synergies

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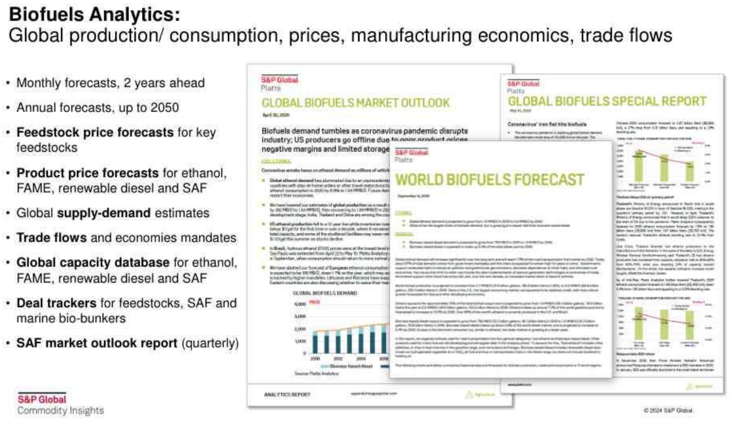
Biofuels Analytics:
Global production/ consumption, prices, manufacturing economics, trade flows

- Monthly forecasts, 2 years ahead
- Annual forecasts, up to 2050
- **Feedstock price forecasts** for key feedstocks
- **Product price forecasts** for ethanol, FAME, renewable diesel and SAF
- Global **supply-demand** estimates
- **Trade flows** and economies mandates
- **Global capacity database** for ethanol, FAME, renewable diesel and SAF
- **Deal trackers** for feedstocks, SAF and marine bio-bunkers
- **SAF market outlook report** (quarterly)

S&P Global Platts GLOBAL BIOFUELS MARKET OUTLOOK

Biofuels demand tumbles as coronavirus pandemic disrupts industry; US producers go offline due to poor product prices, negative margins and limited storage

S&P Global Platts WORLD BIOFUELS FORECAST

S&P Global Platts GLOBAL BIOFUELS SPECIAL REPORT

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Policies and Initiatives

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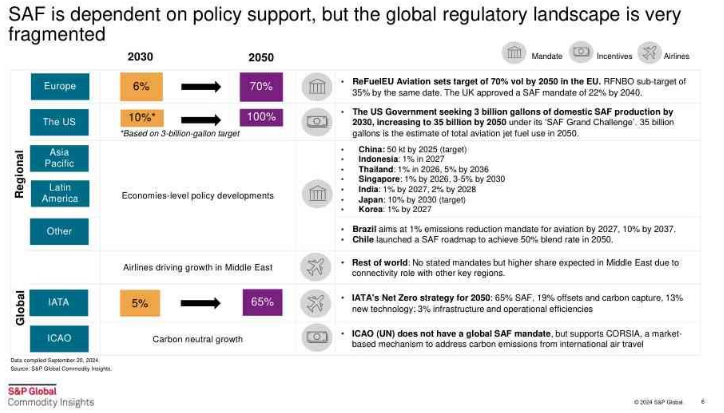
SAF is dependent on policy support, but the global regulatory landscape is very fragmented

Mandate | Incentives | Airlines

		2030	2050		
Regional	Europe	6%	70%	Mandate	**ReFuelEU Aviation sets target of 70% vol by 2050 in the EU.** RFNBO sub-target of 35% by the same date. The UK approved a SAF mandate of 22% by 2040.
	The US	10%*	100%	Incentives	**The US Government seeking 3 billion gallons of domestic SAF production by 2030, increasing to 35 billion by 2050** under its 'SAF Grand Challenge'. 35 billion gallons is the estimate of total aviation jet fuel use in 2050.
	Asia Pacific	Economies-level policy developments		Mandate	**China:** 50 kt by 2025 (target) **Indonesia**: 1% in 2027 **Thailand**: 1% in 2026, 5% by 2036 **Singapore**: 1% by 2026, 3-5% by 2030 **India**: 1% by 2027, 2% by 2028 **Japan**: 10% by 2030 (target) **Korea**: 1% by 2027
	Latin America				**Brazil** aims at 1% emissions reduction mandate for aviation by 2027, 10% by 2037. **Chile** launched a SAF roadmap to achieve 50% blend rate in 2050.
	Other	Airlines driving growth in Middle East		Airlines	**Rest of world**: No stated mandates but higher share expected in Middle East due to connectivity role with other key regions.
Global	IATA	5%	65%	Airlines	**IATA's Net Zero strategy for 2050**: 65% SAF, 19% offsets and carbon capture, 13% new technology; 3% infrastructure and operational efficiencies
	ICAO	Carbon neutral growth		Incentives	**ICAO (UN) does not have a global SAF mandate**, but supports CORSIA, a market-based mechanism to address carbon emissions from international air travel

*Based on 3-billion-gallon target

Data compiled September 20, 2024.
Source: S&P Global Commodity Insights.

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CORSIA - developed by ICAO, is designed to deal with international aviation emissions which are not governed by UN climate framework

Source: ICAO, ICCT, S&P Global Commodity Insights

ICAO: International Civil Aviation Authority. CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation

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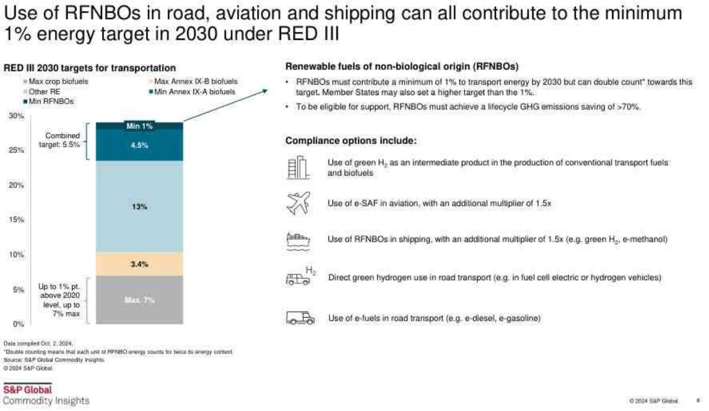


Use of RFNBOs in road, aviation and shipping can all contribute to the minimum 1% energy target in 2030 under RED III

RED III 2030 targets for transportation

Renewable fuels of non-biological origin (RFNBOs)

- RFNBOs must contribute a minimum of 1% to transport energy by 2030 but can double count* towards this target. Member States may also set a higher target than the 1%.
- To be eligible for support, RFNBOs must achieve a lifecycle GHG emissions saving of >70%.

Compliance options include:

Use of green H_2 as an intermediate product in the production of conventional transport fuels and biofuels

Use of e-SAF in aviation, with an additional multiplier of 1.5x

Use of RFNBOs in shipping, with an additional multiplier of 1.5x (e.g. green H_2, e-methanol)

Direct green hydrogen use in road transport (e.g. in fuel cell electric or hydrogen vehicles)

Use of e-fuels in road transport (e.g. e-diesel, e-gasoline)

Data compiled Oct. 2, 2024.
*Double counting means that each unit of RFNBO energy counts for twice its energy content.
Source: S&P Global Commodity Insights.

ReFuelEU sets long-term targets for SAF use in the EU, including a sub-target for synthetic aviation fuels

Background

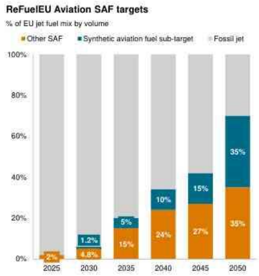
- ReFuelEU Aviation was adopted by the EU in September 2023 and aims to reduce the GHG emissions from the aviation sector by increasing demand for SAF.

Targets and coverage

- Commencing in 2025, aviation fuel suppliers must increase the minimum volume of SAF supplied in total aviation fuel, starting at 2% and growing to 70% by 2050. This includes a synthetic aviation fuel sub-target, increasing from 1.2% in 2030 to 35% in 2050.
- ReFuelEU applies to aviation fuel suppliers supplying jet fuel at EU airports, EU airports with over 800,000 in passenger traffic, and aircraft operators at EU airports.
- Aircraft operators must uplift over 90% of their yearly aviation fuel required at EU airports to avoid anti-competitive fuel tinkering at locations with lower fuel prices.

Implementation

- ReFuelEU sets a penalty for non-compliance at not less than twice the yearly average price differential of conventional fuel and applicable SAF type, multiplied by the shortfall quantity. Member States must develop a specific methodology for the penalty calculation by 2024 end.
- During a flexibility period from Jan 2025 to Dec 2034, fuel suppliers may meet targets by supplying the min. SAF share as an average of total fuel supplied at EU airports for that period.
- As of October 2024, the European Commission is assessing whether a book-and-claim system should be implemented to help facilitate the supply and uptake of SAF.



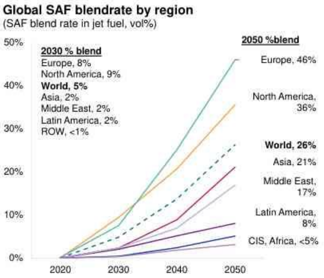
ReFuelEU Aviation SAF targets

% of EU jet fuel mix by volume

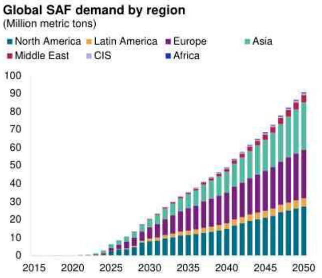
Data compiled Oct. 2, 2024.
Source: S&P Global Commodity Insights.

SAF Fundamentals

As the aviation sector has no scalable alternative to decarbonize, SAF demand is expected to see significant growth in demand compared to other biofuels



Global SAF blendrate by region
(SAF blend rate in jet fuel, vol%)



Global SAF demand by region
(Million metric tons)

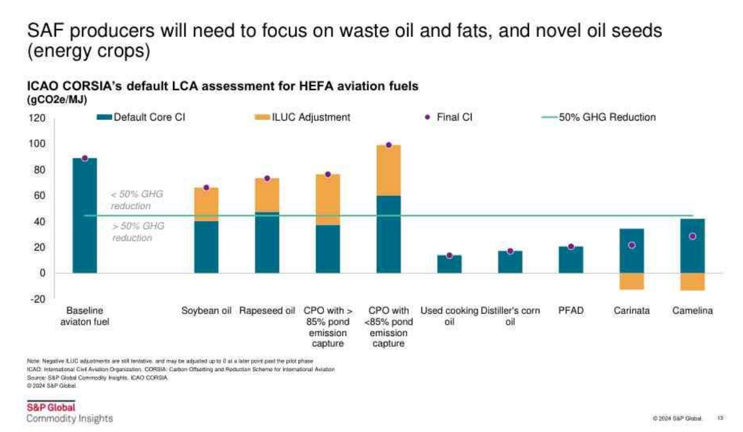
Data compiled July 31, 2024.
Source: S&P Global Commodity Insights.

Feedstocks and technologies used to produce SAF

Sustainable aviation fuels feedstocks and pathways

1st Gen – Crop	Edible oil crops	Palm oil, Soybean oil, Sunflower oil, Rapeseed/Canola oil	HEFA-SPK	20-45% CI reduction
	Edible sugars	Sugarcane, maize/corn, sugar beet	ATJ-SPK	
2nd Gen – Advanced / waste	Waste lipids	Tall oil, Palm Oil Mill Effluent (POME), Palm Fatty Acid Distillate (PFAD), Used Cooking Oil (UCO), Animal Fat (Tallow)	HEFA-SPK	45-90% CI reduction
	Energy crops	Oil trees: Jatropha, Pongamia, Oil cover crops: Camelina, Carinata, Pennycress, Cellulosic cover crops: Switchgrass, Miscanthus, Reed	Oil: HEFA Cellulosic: ATJ	
	Ag residues	Straw, sugarcane bagasse, corn stover, cereal residues	ATJ-SPK	
	Forestry residues	Roundwood, sawdust, woodchip, sawmill slabs, logging leftovers, stemwood residues	FT-SPK	
	Biogenic compounds	Municipal waste streams (biogenic portion), algae, sewage sludge	HEFA-SPK	
3rd Gen – RFNBO / eFuels	Non-biomass	CO_2 from DAC, Green H_2	PTL-SPK	90-99% CI reduction
	Recycled carbon fuels	Fossil share of reusable plastic waste Industrial waste gas :CO_2 from CCS, Other (such as flue gas from steel production)	FT-SPK	

HEFA: Hydroprocessed Ester Fatty Acids, ATJ: Alcohol-to-Jet, FT: Fischer Tropsch, PTL: Power-to-liquid, SPK: Synthetic Paraffinic Kerosene, RFNBO: Renewable Fuels of Non-Biological Origin
Source: S&P Global Commodity Insights.



SAF producers will need to focus on waste oil and fats, and novel oil seeds (energy crops)

ICAO CORSIA's default LCA assessment for HEFA aviation fuels
(gCO2e/MJ)

Note: Negative ILUC adjustments are still tentative, and may be adjusted up to 0 at a later point past the pilot phase
ICAO: International Civil Aviation Organization. CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation
Source: S&P Global Commodity Insights, ICAO CORSIA
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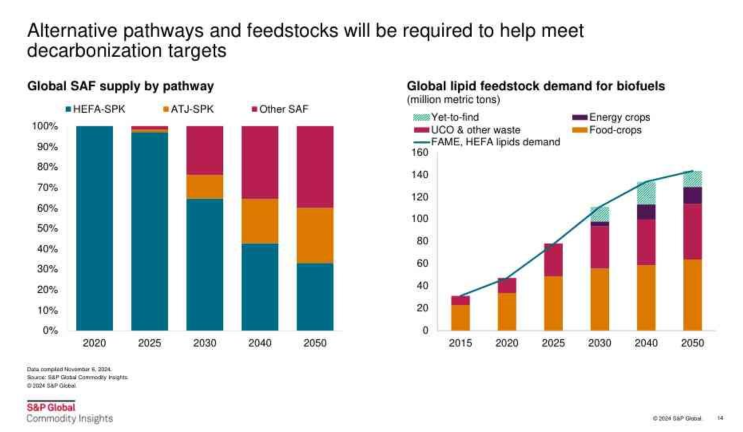

Alternative pathways and feedstocks will be required to help meet decarbonization targets

Global SAF supply by pathway

Global lipid feedstock demand for biofuels
(million metric tons)

Data compiled November 6, 2024.
Source: S&P Global Commodity Insights.
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e-SAF Technology

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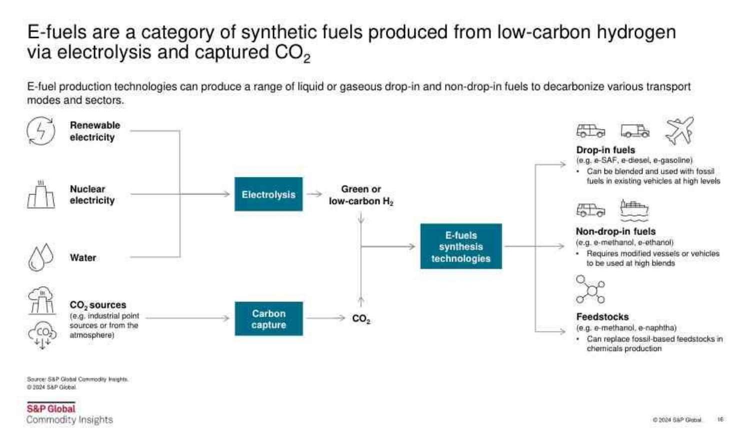

E-fuels are a category of synthetic fuels produced from low-carbon hydrogen via electrolysis and captured CO_2

E-fuel production technologies can produce a range of liquid or gaseous drop-in and non-drop-in fuels to decarbonize various transport modes and sectors.

Drop-in fuels
(e.g. e-SAF, e-diesel, e-gasoline)
- Can be blended and used with fossil fuels in existing vehicles at high levels

Non-drop-in fuels
(e.g. e-methanol, e-ethanol)
- Requires modified vessels or vehicles to be used at high blends

Feedstocks
(e.g. e-methanol, e-naphtha)
- Can replace fossil-based feedstocks in chemicals production

Source: S&P Global Commodity Insights.
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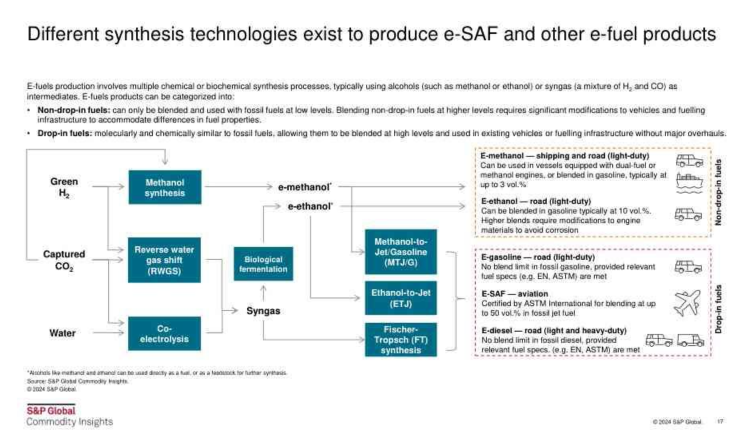

Different synthesis technologies exist to produce e-SAF and other e-fuel products

E-fuels production involves multiple chemical or biochemical synthesis processes, typically using alcohols (such as methanol or ethanol) or syngas (a mixture of H_2 and CO) as intermediates. E-fuels products can be categorized into:

- **Non-drop-in fuels:** can only be blended and used with fossil fuels at low levels. Blending non-drop-in fuels at higher levels requires significant modifications to vehicles and fuelling infrastructure to accommodate differences in fuel properties.
- **Drop-in fuels:** molecularly and chemically similar to fossil fuels, allowing them to be blended at high levels and used in existing vehicles or fuelling infrastructure without major overhauls.

E-methanol — shipping and road (light-duty)
Can be used in vessels equipped with dual-fuel or methanol engines, or blended in gasoline, typically at up to 3 vol.%

E-ethanol — road (light-duty)
Can be blended in gasoline typically at 10 vol.%. Higher blends require modifications to engine materials to avoid corrosion

E-gasoline — road (light-duty)
No blend limit in fossil gasoline, provided relevant fuel specs (e.g. EN, ASTM) are met

E-SAF — aviation
Certified by ASTM International for blending at up to 50 vol.% in fossil jet fuel

E-diesel — road (light and heavy-duty)
No blend limit in fossil diesel, provided relevant fuel specs. (e.g. EN, ASTM) are met

*Alcohols like methanol and ethanol can be used directly as a fuel, or as a feedstock for further synthesis.
Source: S&P Global Commodity Insights.
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E-fuels are attracting interest as they face fewer feedstock constraints than biofuels, but commercial barriers still exist to scale-up

Opportunities

Minimal physical feedstock constraints. The potential of renewable energy and CO_2 sources (e.g. from the atmosphere) are abundant, meaning there are technically no limitations on scaling up e-fuels supply.

High GHG saving potential. CO_2 is emitted when e-fuels are combusted, but as CO_2 is also used in their production, their use is considered carbon neutral. On a lifecycle basis, GHG savings can be up to 90% vs. fossil fuels, depending on sources of feedstock and energy used and any CCS.

Compatibility with existing fuel value chains. Many e-fuels are 'drop-in' fuels, which are chemically/molecularly similar to fossil fuels. This allows them to be used in existing vehicles and fuel infrastructure at high blends without major overhauls.

Flexibility in product slates. E-fuels technologies can produce a range of drop-in and non-drop-in fuels, which can be used to decarbonize multiple transport modes and sectors.

Challenges

High production costs. E-fuels currently cost several times more to produce than fossil fuels and biofuels. This is mainly driven by the high cost of green hydrogen production, as well as the CAPEX of e-fuels technologies and equipment. In the absence of policy support, costs will remain uncompetitive.

Policy and regulatory uncertainty. Whilst policy support for e-fuels is growing in the EU, UK and the US, there remains some uncertainty in how specific legislation will be implemented and the associated impact on e-fuels markets.

Technical challenges. Most e-fuel technologies are still at a pilot or demonstration stage today, with challenges in integrating multiple early-stage conversion technologies together to achieve stable and efficient production.

Challenges with project financing. Owing to policy uncertainty, technology risks and high upfront CAPEX, investors have been slow to provide financing for e-fuels projects, the majority of which have not reached FID.

Source: S&P Global Commodity Insights.
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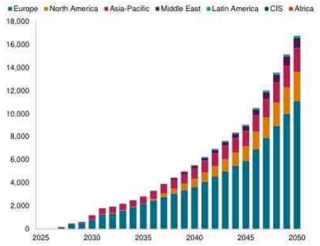
SAF Fundamentals

Global e-SAF demand could reach almost 17 MMt per year by 2050. European markets account for 66% of demand in 2050, driven by mandates

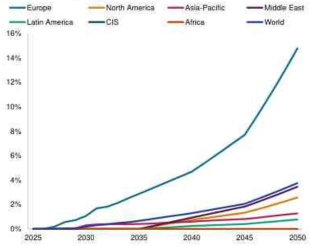
Global e-SAF demand outlook

(Thousand metric tons per year)



Global e-SAF blend rate outlook

(Vol.% blend rate in jet fuel pool)

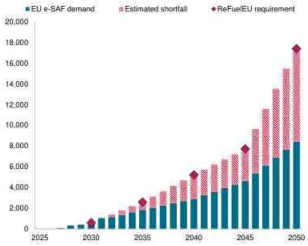


Data compiled Oct. 2, 2024.
CIS = Commonwealth of Independent States.
Source: S&P Global Commodity Insights.

In the base case, the EU falls far behind long-term targets under ReFuelEU due to the high cost and limited availability of e-SAF

EU e-SAF demand outlook vs. ReFuelEU

(Thousand metric tons per year)



- E-SAF demand in the base case is forecasted for each market based on its track record in meeting past mandates, its current position on climate and renewable fuels policy, and the availability of e-SAF supply.
- From 2030, the EU is expected to fall behind the e-SAF sub-targets in ReFuelEU. By 2040, we forecast a shortfall quantity of 2.3 million metric tons (MMt) per year and by 2050, this reaches nearly 9 MMt per year.
- This is due to the limited availability of e-SAF at global level, with supply unable to scale sufficiently quickly to meet demand. The supply of green hydrogen and CO_2 (biogenic or DAC) is expected to be sufficient to meet mandated volumes.
- Rather, e-SAF supply is likely constrained by high production costs, which inhibits the large-scale investment needed to significantly ramp-up production. Investment in projects has been limited to date, resulting in no major projects in Europe reaching FID.
- In the long term, we expect e-fuel production costs to reduce significantly – potentially by up to 60% between 2025 and 2050 in some locations (e.g. the US Gulf Coast, Middle East and parts of Europe). However, costs will remain uncompetitive with HEFA and fossil jet fuel without further support*.
- Higher e-SAF blending will require levers on both the supply and demand side. Further production cost reduction, driven primarily by falling LCOH and CAPEX of e-fuels plants, as well as stronger policy and market support will both be important for making e-SAF more competitive.

Data compiled Oct. 2, 2024.
*See the 'Overview of E-fuels Technology & Policies' report for high-level commentary on e-fuel production economics.
Source: S&P Global Commodity Insights.

The majority of announced e-SAF projects so far are in Europe, but there are also large projects planned in North America and Asia-Pacific

Global e-SAF projects

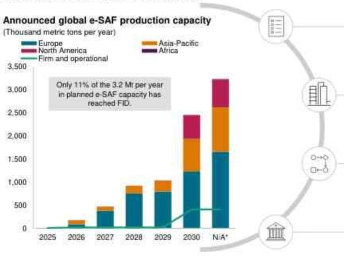
Data compiled Oct. 2, 2024.
Source: S&P Global Commodity Insights. ID 2074486.

The e-SAF sector is currently facing several headwinds, with the majority of planned projects yet to reach FID

Challenges with e-fuels development

Announced global e-SAF production capacity

(Thousand metric tons per year)



Only 11% of the 3.2 Mt per year in planned e-SAF capacity has reached FID.

Policy and market uncertainty

While policy support is growing for e-SAF/e-fuels in the EU, UK and the US, there remains uncertainty in how key policies such as ReFuelEU will be implemented (e.g. the level of support and penalties). This is currently resulting in a lack of clarity on the market value and business model of e-SAF.

Technology risks

Most e-fuel pathways are at a low level of technological maturity today, with facilities operating at pilot or demonstration scale. There remain technical risks associated with integrating multiple conversion technologies in a single process at full industrial scale.

Reliance on other key value chains

E-fuel production requires a source of green hydrogen and captured CO_2. While electrolysis and CO_2 capture technologies are mature, we have yet to see projects and supply chains develop to the level required for large-scale e-fuel production.

Project financing

Owing to policy uncertainty, technology risks and high upfront CAPEX, investors have been slow to provide finance for projects. Progressing projects to FID may require greater policy certainty and public funding and incentives to derisk private investment.

Data compiled Oct. 2, 2024.
*N/A = Not available (includes projects with no start-date publicly announced).
The above data is available in the E-fuel Capacities Database on Platts Connect.
Source: S&P Global Commodity Insights.

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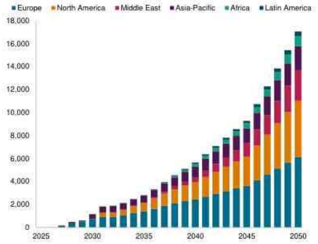
e-SAF production will scale to meet demand as technologies mature/costs decrease, with the US, Middle East and Nordic economies the most competitive regions

- The key drivers of e-SAF production will be:
  - **Location of existing and planned capacity**
  - **Policy support, mandates and government funding/incentives**
  - **Availability and cost of green hydrogen and captured CO_2**
  - **Cost of capital and economy risk**
  - **Strategic location and trade routes**
- **Europe:** dominates short-term production due to existence of strong policy support and existing announced projects. The share of production decreases longer term as other regions become more cost-competitive.
- **North America:** due to a high supply of green hydrogen and CO_2 at low cost, the US becomes the most competitive economy for production.
- **Middle East:** a low LCOH combined with established crude and refined product value chains mean the Middle East becomes a key e-SAF producer and the second-largest regional exporter in the long term.
- **Asia-Pacific:** Australia and China dominate production. Both already have planned large e-fuel projects which aim to service key Asia-Pacific markets.

Global e-SAF production outlook

(Thousand metric tons per year)



Data compiled Oct. 2, 2024.
Source: S&P Global Commodity Insights.

Private Commitments

Key e-SAF investments and agreements (1/2)

Investor/Buyer	Target/Seller	Deal type	Announced	Offtake volume (if applicable)	Duration	Start	Background
American Airlines	Prometheus Fuels	Offtake agreement	2021	Up to 30 kt in total (10 million gal)	–	–	Non-binding agreement to purchase e-SAF from future Prometheus Fuel facilities. American Airlines has a net-zero target for 2050.
United Airlines	Dimensional Energy	Equity investment /offtake agreement	2022	At least 871 kt (300 million gal)	20 years	2030	Equity investment made by United Airlines in the US-based start-up, including a commercial commitment to e-SAF offtake from 2030.
DCC Shell Aviation Denmark	Arcadia eFuels	Offtake agreement	2022	~55 kt per year (18 million gal)	–	2028	Agreement for the offtake of all e-SAF produced at Arcadia's first facility in Vordingborg, Denmark, scheduled for commissioning in 2028.
United Airlines Ventures	-	Investment fund	2023	–	–	2023	United Airlines Ventures (UAV) launched the Sustainable Flight Fund to invest in SAF start-ups, worth over £200 million in capital. Participation from over 22 corporates, including banks, airlines, software companies and technology licensors.
Icelandair	IdunnH2	MoU	2023	Up to 45 kt in total (14.8 million gal)	–	2028	MoU for the offtake of e-SAF from 2028 onwards from IdunnH2's planned project in Iceland. Icelandair has a 50% carbon emissions reduction target for 2030, and net-zero target for 2050.
Norwegian Air	Norsk e-Fuel	Equity investment	2023	7 kt per year, rising to 29 kt per year (2.3, rising to 9.5 m. gal)	–	2028	Norwegian became a shareholder in Norsk e-Fuel with an investment of up to $6 million, to co-develop the Mosjoen plant in Norway, planned from 2028.

Data compiled Oct. 2, 2024.
Source: S&P Global Commodity Insights.

Key e-SAF investments and agreements (2/2)

Investor/Buyer	Target/Seller	Deal type	Announced	Offtake volume (if applicable)	Duration	Start	Background
United Airlines Ventures	OXCCU	Equity investment	2023	–	–	–	UAV made an undisclosed investment in UK e-SAF start-up OXCCU, who raised $22 million in Series A. A demonstration project is planned in the UK from 2026.
Microsoft	Dimensional Energy	Equity investment	2023	Undisclosed	–	2028+	Microsoft invested an undisclosed amount in the US e-fuels start-up Dimensional Energy, who raised $20 million in Series A. Microsoft will offtake e-SAF from Dimensional's planned project in New York state.
Amazon	Infinium	Equity investment/ offtake agreement	2023	Undisclosed	–	–	Amazon had previously invested in Infinium from their Climate Pledge Fund in 2021. Further offtake agreement announced for e-diesel from Infinium's Texas facilities.
Alaska Airlines, Shopify	Twelve	Offtake agreement	2024	Undisclosed	–	2026	Both companies to purchase e-SAF from the US start-up Twelve, beginning with volumes from a planned demonstration facility in Washington, the US.
Etihad Airways	Twelve	MoU	2023	–	–	–	MoU to collaborate on advanced production and use of Twelve's e-SAF in Etihad's network, starting with an international demonstration flight.
Cathay Pacific	SPIC	Strategic partnership/MoU	2024	Undisclosed	–	2026+	MoU signed for the purchase of e-SAF from four SPIC e-SAF projects in China, each with a capacity of 50-100 kt/year. Expected commissioning from 2026 onwards.
International Airline Group	Twelve	Offtake agreement	2024	785 kt in total (260 million gal)	14 years	2026	IAG to purchase one-third of its 2030 SAF target, to be supplied from Twelve's demonstration project in Washington and future projects.

Data compiled Oct. 2, 2024.
Source: S&P Global Commodity Insights.

Contact us

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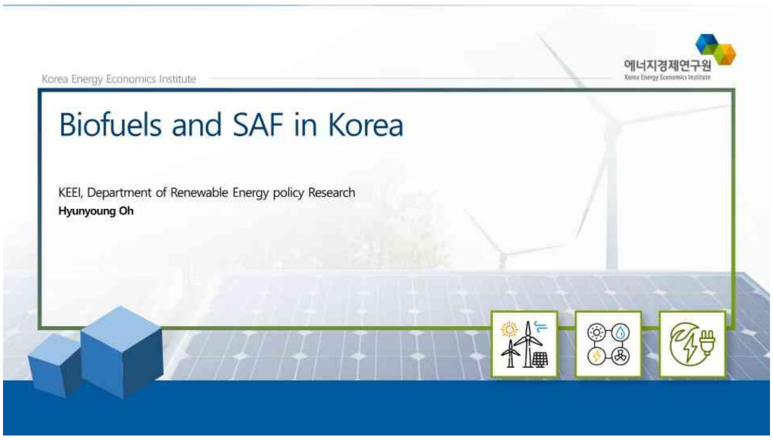
www.spglobal.com/en/enterprize/about/contact-us.html
www.spglobal.com/commodityinsights

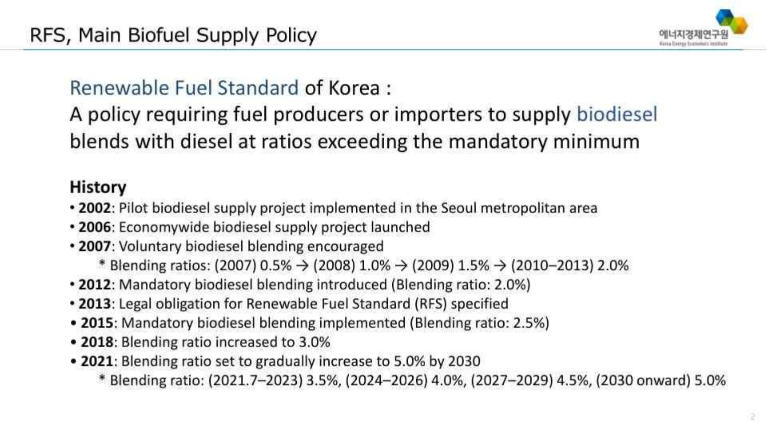
Session2-3 “Biofuels and SAF in Korea”
Dr Hyunyoung Oh



Korea Energy Economics Institute

Biofuels and SAF in Korea

KEEI, Department of Renewable Energy policy Research
Hyunyoung Oh

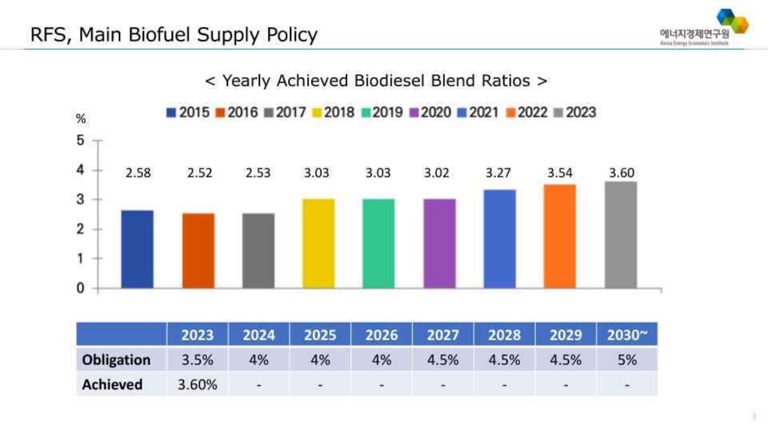


RFS, Main Biofuel Supply Policy

Renewable Fuel Standard of Korea :
A policy requiring fuel producers or importers to supply biodiesel blends with diesel at ratios exceeding the mandatory minimum

History

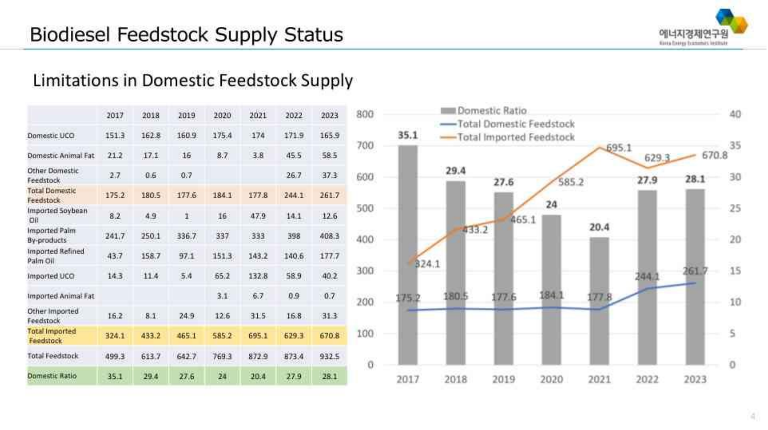
- **2002**: Pilot biodiesel supply project implemented in the Seoul metropolitan area
- **2006**: Economywide biodiesel supply project launched
- **2007**: Voluntary biodiesel blending encouraged
  - * Blending ratios: (2007) 0.5% → (2008) 1.0% → (2009) 1.5% → (2010–2013) 2.0%
- **2012**: Mandatory biodiesel blending introduced (Blending ratio: 2.0%)
- **2013**: Legal obligation for Renewable Fuel Standard (RFS) specified
- **2015**: Mandatory biodiesel blending implemented (Blending ratio: 2.5%)
- **2018**: Blending ratio increased to 3.0%
- **2021**: Blending ratio set to gradually increase to 5.0% by 2030
  - * Blending ratio: (2021.7–2023) 3.5%, (2024–2026) 4.0%, (2027–2029) 4.5%, (2030 onward) 5.0%



RFS, Main Biofuel Supply Policy

< Yearly Achieved Biodiesel Blend Ratios >

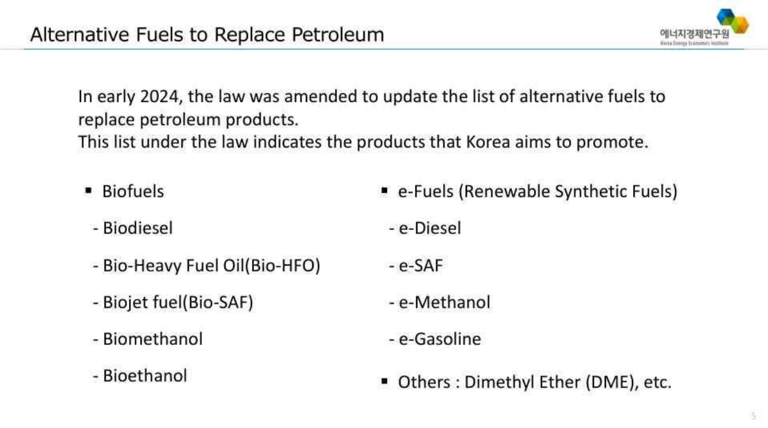
	2023	2024	2025	2026	2027	2028	2029	2030~
Obligation	3.5%	4%	4%	4%	4.5%	4.5%	4.5%	5%
Achieved	3.60%	-	-	-	-	-	-	-



Biodiesel Feedstock Supply Status

Limitations in Domestic Feedstock Supply

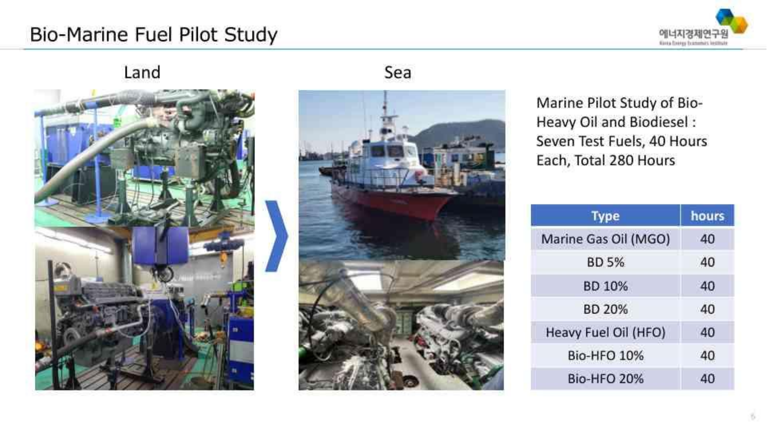
	2017	2018	2019	2020	2021	2022	2023
Domestic UCO	151.3	162.8	160.9	175.4	174	171.9	165.9
Domestic Animal Fat	21.2	17.1	16	8.7	3.8	45.5	58.5
Other Domestic Feedstock	2.7	0.6	0.7			26.7	37.3
Total Domestic Feedstock	175.2	180.5	177.6	184.1	177.8	244.1	261.7
Imported Soybean Oil	8.2	4.9	1	16	47.9	14.1	12.6
Imported Palm By-products	241.7	250.1	336.7	337	333	398	408.3
Imported Refined Palm Oil	43.7	158.7	97.1	151.3	143.2	140.6	177.7
Imported UCO	14.3	11.4	5.4	65.2	132.8	58.9	40.2
Imported Animal Fat				3.1	6.7	0.9	0.7
Other Imported Feedstock	16.2	8.1	24.9	12.6	31.5	16.8	31.3
Total Imported Feedstock	324.1	433.2	465.1	585.2	695.1	629.3	670.8
Total Feedstock	499.3	613.7	642.7	769.3	872.9	873.4	932.5
Domestic Ratio	35.1	29.4	27.6	24	20.4	27.9	28.1



Alternative Fuels to Replace Petroleum

In early 2024, the law was amended to update the list of alternative fuels to replace petroleum products.
This list under the law indicates the products that Korea aims to promote.

- Biofuels
  - Biodiesel
  - Bio-Heavy Fuel Oil(Bio-HFO)
  - Biojet fuel(Bio-SAF)
  - Biomethanol
  - Bioethanol
- e-Fuels (Renewable Synthetic Fuels)
  - e-Diesel
  - e-SAF
  - e-Methanol
  - e-Gasoline
- Others : Dimethyl Ether (DME), etc.



Bio-Marine Fuel Pilot Study

Marine Pilot Study of Bio-Heavy Oil and Biodiesel : Seven Test Fuels, 40 Hours Each, Total 280 Hours

Type	hours
Marine Gas Oil (MGO)	40
BD 5%	40
BD 10%	40
BD 20%	40
Heavy Fuel Oil (HFO)	40
Bio-HFO 10%	40
Bio-HFO 20%	40

Bio-Marine Fuel Pilot Study

Marine Pilot Study of Biofuel for International Ships: HFO(70%) + BD(30%)

→Supply of 5,100 MT of Marine Biofuel Meeting ISO 8217 RMG380 Standards
- Completion of 6 Voyages with No Abnormalities Observed in Applied Ships.
- Comprehensive Data Collected on 32 Performance Metrics, Including Main Engine and Generator Safety, Performance, and Defect Analysis.

Direction for Establishing Quality Standards

- Extensive Data Secured on Biodiesel Quality and Performance. Proposed to Apply Automotive Biodiesel Standards if No Significant Changes in Feedstock or Manufacturing Processes Occur.
- Due to the Characteristics of Bio-Heavy Oil, High Acid Number and Metal Content May Cause Fuel System Corrosion, Filter Blockages, and Reduced Engine Performance. Currently Reviewing Draft Quality Standards Based on ISO 8217.
- Plans to Establish Performance Evaluation Standards for Marine Bio-Heavy Oil, Including 100% Bio-Heavy Oil and Blended Fuels (e.g., 30%), Through Performance and Emission Tests.

SAF Supply Policy

In October 2022, the 'Green Biofuel Expansion Plan' introduced the first strategy for SAF supply.

"Bio-jet fuel and bio-marine fuel, not yet commercialized domestically, are undergoing demonstration projects to enable swift adoption in Korea (targeting 2026 for bio-jet fuel and 2025 for bio-marine fuel). To establish a legal framework for new biofuels, research studies will be completed this year, followed by legislative amendments starting next year."

Announced in July 2023 : "Demonstration studies on bio-jet fuel and bio-marine fuel, involving both production and demand sectors, to commence in the second half of 2023."

SAF Expansion Strategy 2024

Policy Announcement Dedicated to SAF(2024.8.30.)

The Ministry of Trade, Industry and Energy (MOTIE) and the Ministry of Land, Infrastructure, and Transport (MOLIT) jointly announced the "Sustainable Aviation Fuel (SAF) Expansion Strategy" to reduce carbon emissions from international aviation and create new industries at Incheon International Airport Terminal 2 on Friday, August 30, with officials from the oil and aviation industries in attendance.

SAF Expansion Strategy 2024

Commencement of SAF Commercial Refueling Operations (from 2024)

Starting August 30, 2024, domestic airlines will begin regularly scheduled international flights refueled with domestically produced SAF certified by the ICAO at Korean airports.
Airlines will independently determine the routes, duration, and SAF blending ratios, while refueling will proceed through purchase agreements with domestic refiners.

< Domestic Airlines Participating in SAF Commercial Refueling Operations in 2024 >
- **Korean Air (from Aug. 30, 2024):** Incheon → Haneda, refueling once weekly with 1% SAF blend.
- **T'way Air (from Sep. 2, 2024):** Incheon → Kumamoto, refueling once weekly with 1% SAF blend.
- **Asiana Airlines (from Sep. 7, 2024):** Incheon → Haneda, refueling once weekly with 1% SAF blend.
- **Eastar Jet (from Oct. 2024):** Incheon → Kansai, refueling once weekly with 1% SAF blend.
- **Jeju Air (from Q4 2024):** Incheon → Fukuoka, refueling once weekly with 1% SAF blend.
- **Jin Air (from Q4 2024):** Incheon → Kitakyushu, refueling once weekly with 1% SAF blend.

With this initiative for commercial refueling operations using SAF, Korea will be listed on the ICAO website as the 20th economy worldwide to implement SAF refueling.

SAF Expansion Strategy 2024

Promoting Voluntary SAF Utilization through Public-Private Collaboration (~2026)

To expand the use of SAF domestically, an "MOU for the Commercial Use of SAF" was signed on August 30 between the Ministry of Trade, Industry and Energy (MOTIE), the Ministry of Land, Infrastructure and Transport (MOLIT), Korean domestic airlines, domestic oil refiners, Incheon International Airport Corporation, and Korea Airports Corporation.

Participating domestic airlines include nine companies: Korean Air, Asiana Airlines, Jeju Air, Jin Air, Eastar Jet, T'way Air, Air Busan, Air Premia, and Aero K. Participating domestic oil refiners include five companies: SK Energy, GS Caltex, S-Oil, HD Hyundai Oilbank, and Hanwha TotalEnergies.
MOLIT and Incheon International Airport Corporation plan to provide various incentives to promote SAF usage and establish an eco-friendly aviation hub. Proposed measures include "increasing allocation points for international air traffic rights" and "supporting SAF-powered flights at Incheon Airport."

SAF Expansion Strategy 2024

Mandatory SAF Blending for International Flights from 2027

The Ministry of Trade, Industry and Energy (MOTIE) and the Ministry of Land, Infrastructure and Transport (MOLIT) plan to mandate the blending of SAF at approximately 1% for all international flights departing from Korea starting in 2027.

This initiative follows the International Civil Aviation Organization (ICAO)'s enforcement of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) as a mandatory regulation for all 193 member economies, signaling strengthened carbon regulations in international aviation.

To minimize the impact of SAF usage mandates on airlines' carbon reduction costs and ticket prices, MOLIT is considering several measures, including improving the allocation method for international air traffic rights, introducing a tentative "Aviation Carbon Mileage System"(to be studied in 2025), and reducing airport facility fees. These efforts aim to support airlines in adapting to the mandatory SAF requirements while promoting eco-friendly aviation.

SAF Expansion Strategy 2024

Investment Support for Expanding Domestic SAF Production

The government is actively promoting initiatives to expand domestic SAF production. Key measures include:

Designation as New Growth and Core Technology

- Incentives are being planned to alleviate the burden of high SAF production costs in the future.

Regulatory Reforms to Broaden Feedstock Range

- Active regulatory reforms are underway to expand the range of SAF feedstocks.
- Upon confirmation of new domestic SAF production facility investments, a dedicated task force (TF) will be established with the participation of relevant ministries, local governments, and industries to provide concentrated support for permits and approvals.

Advancing SAF Production Technologies with Diverse Feedstocks

- In addition to used cooking oil, the primary SAF feedstock, the government will:
    - Collaborate on investigating overseas bioresources such as animal fats and palm byproducts, which can be utilized with current technologies.
    - Support domestic companies in conducting SAF production demonstrations and quality verifications for desired feedstocks.
- Develop next-generation feedstock technologies, such as:
    - Microalgae.
    - Green hydrogen.
- Strengthen the capability to supply raw materials for SAF production.

Formulating SAF Mandate Policy

Key Considerations for SAF Mandate Policy

- **Fines for Non-Compliance**
    - Evaluate new fines or adopt an RFS level
    - *Example: The EU imposes fines equivalent to at least twice the cost difference between SAF and fossil fuels.*
- **Flexibility Regulations**
    - Consider mechanisms such as depositing excess SAF quantities or deferring shortfalls.
    - *Example: Norway allows fuel suppliers with SAF quantities exceeding the mandate to transfer the surplus to other suppliers.*
    - *Example: The UK permits fuel suppliers to trade compliance certificates and use surplus certificates to meet up to 25% of the following year's requirements.*
- **Price Stabilization Measures**
    - Explore the need for public sector strategic SAF procurement to stabilize prices.
- **Feedstock Supply Measures**
    - Analyze the current distribution of HEFA SAF feedstocks used for biodiesel production.
    - Develop strategies to secure additional SAF feedstocks domestically and internationally.
    - Assess and establish feedstock allocation strategies between SAF and biodiesel production.

Trends in SAF Production by Korean Refiners

S-OIL : First Korean Refinery with ISCC CORSIA Certification

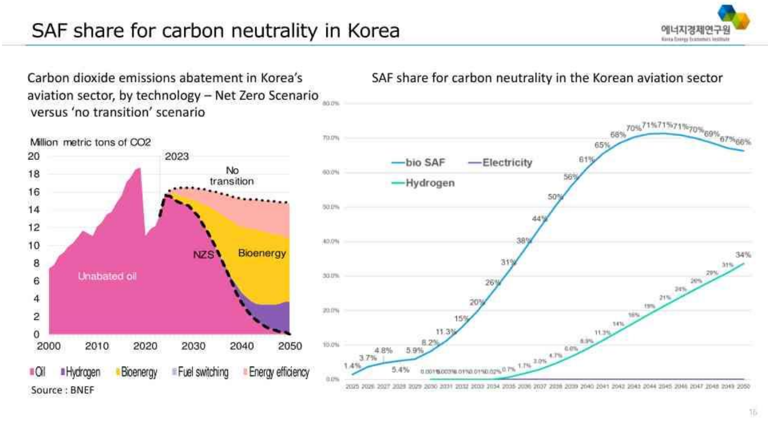
- Certified to produce SAF under the CORSIA scheme (2024.04).
- Additional certifications:
    - **ISCC EU**: Complies with EU Renewable Energy Directive (RED) for low-carbon fuels.
    - **ISCC PLUS**: Recognizes eco-friendly products for voluntary markets.
- Production Highlights

- Processing bio-feedstocks (e.g., used cooking oil, palm fatty acid distillates)
- SAF reduces greenhouse gas emissions by up to **90%** compared to traditional jet fuel.
- Supports decarbonization efforts in the global aviation industry.

SK Energy Establishes Korea's First Dedicated Production Line for SAF

SK Energy has set up the first dedicated production line for SAF in Korea, utilizing the co-processing method.
The company is set to begin commercial production in October 2024.
The facility processes bio-based feedstocks such as used cooking oil and animal fats to continuously produce SAF and other low-carbon products.
In June, SK Energy obtained multiple certifications to enable SAF sales, including ISCC CORSIA, ISCC EU, and ISCC PLUS. These certifications ensure compliance with international standards for sustainability and carbon reduction in the aviation sector.

SAF share for carbon neutrality in Korea



Carbon dioxide emissions abatement in Korea's aviation sector, by technology – Net Zero Scenario versus 'no transition' scenario

Source : BNEF

SAF share for carbon neutrality in the Korean aviation sector

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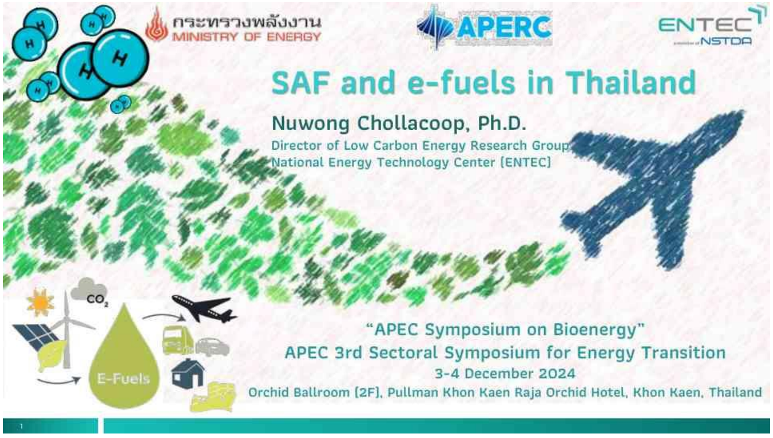
Korea Energy Economics Institute

Thank you!

Session2-4 “SAF and e-fuels”
Dr Nuwong Chollacoop



กระทรวงพลังงาน MINISTRY OF ENERGY

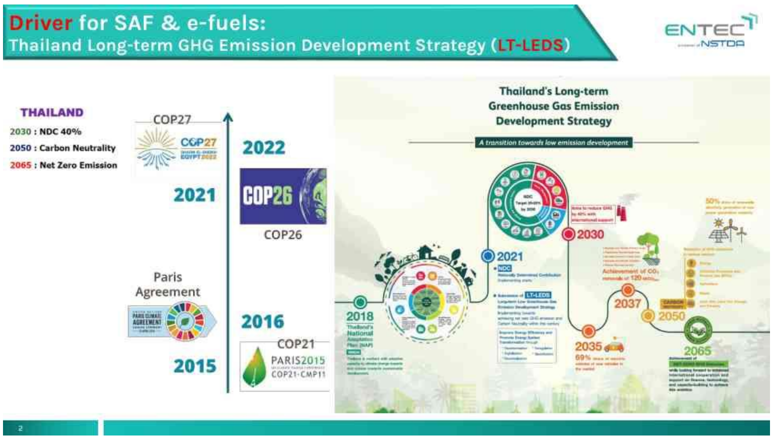
APERC

ENTEC NSTDA

SAF and e-fuels in Thailand

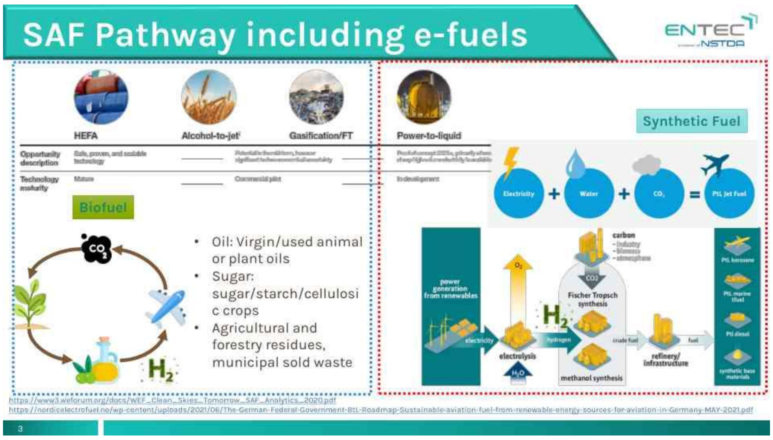
Nuwong Chollacoop, Ph.D.
Director of Low Carbon Energy Research Group
National Energy Technology Center (ENTEC)

“APEC Symposium on Bioenergy”
APEC 3rd Sectoral Symposium for Energy Transition
3-4 December 2024
Orchid Ballroom (2F), Pullman Khon Kaen Raja Orchid Hotel, Khon Kaen, Thailand



Driver for SAF & e-fuels:
Thailand Long-term GHG Emission Development Strategy (LT-LEDS)

THAILAND
2030 : NDC 40%
2050 : Carbon Neutrality
2065 : Net Zero Emission



SAF Pathway including e-fuels

- Oil: Virgin/used animal or plant oils
- Sugar: sugar/starch/cellulosic crops
- Agricultural and forestry residues, municipal sold waste

https://www3.weforum.org/docs/WEF_Clean_Skies_Tomorrow_SAF_Analytics_2020.pdf
https://nordicelectrofuel.no/wp-content/uploads/2021/06/The-German-Federal-Government-BtL-Roadmap-Sustainable-aviation-fuel-from-renewable-energy-sources-for-aviation-in-Germany-MAY-2021.pdf

SAF activities in Thailand

SAF activities from private sectors in Thailand
- Bangchak
- PTT Groups
- BAFS
- Mitrphol,
- Thai Airways

1st ASEAN Workshop

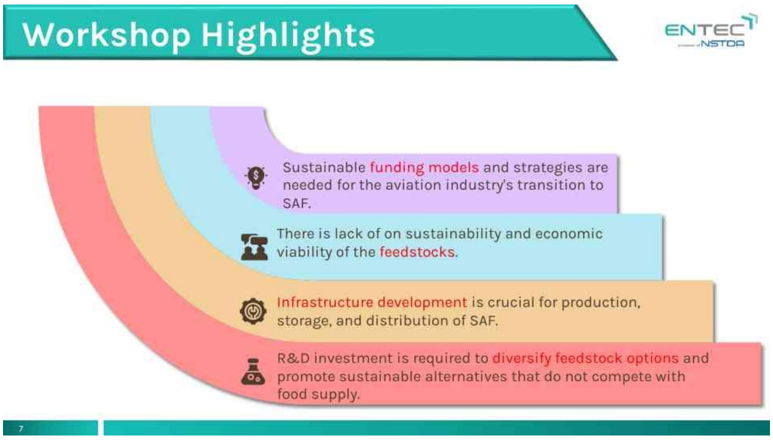
A stakeholder consultation workshop was used as a mean to develop SAF strategies in ASEAN economies.

The workshop, held in Bangkok, Thailand in May 2023, was attended by
- Policy makers
- Regulators
- Academic and research institutes
- Private sector

2nd ASEAN Workshop

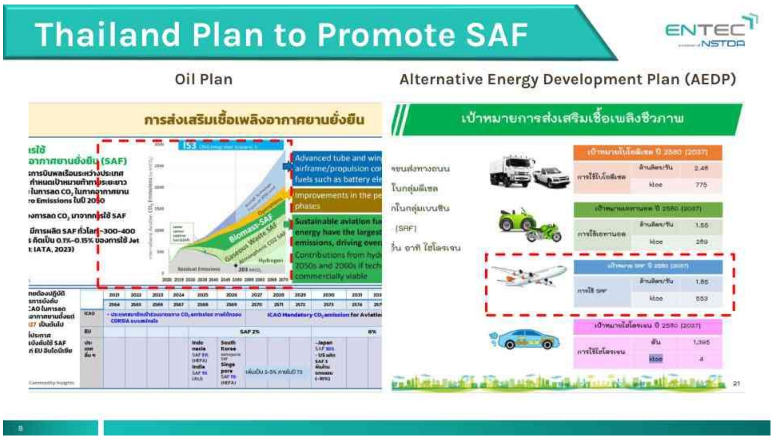
To advance a common goal of SAF value chain development

The workshop, held in Bali, Indonesia in July 2024, was attended by
- Policy makers
- Regulators
- Academic and research institutes
- Private sector
- Airline



Workshop Highlights

- Sustainable funding models and strategies are needed for the aviation industry's transition to SAF.
- There is lack of on sustainability and economic viability of the feedstocks.
- Infrastructure development is crucial for production, storage, and distribution of SAF.
- R&D investment is required to diversify feedstock options and promote sustainable alternatives that do not compete with food supply.



Thailand Plan to Promote SAF

Oil Plan

การส่งเสริมเชื้อเพลิงอากาศยานยั่งยืน

Alternative Energy Development Plan (AEDP)

เป้าหมายการส่งเสริมเชื้อเพลิงชีวภาพ

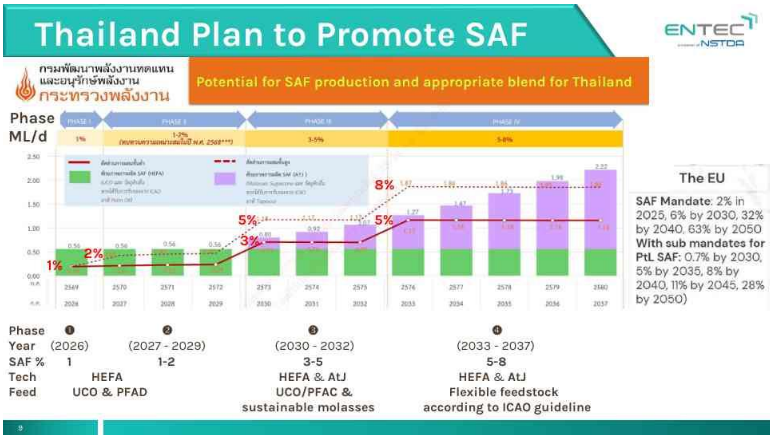
เป้าหมายไบโอดีเซล ปี 2580 (2037)		
การใช้ไบโอดีเซล	ล้านลิตร/วัน	2.46
	ktoe	775

เป้าหมายเอทานอล ปี 2580 (2037)		
การใช้เอทานอล	ล้านลิตร/วัน	1.55
	ktoe	289

เป้าหมาย SAF ปี 2580 (2037)		
การใช้ SAF	ล้านลิตร/วัน	1.86
	ktoe	553

เป้าหมายไฮโดรเจน ปี 2580 (2037)		
การใช้ไฮโดรเจน	ตัน	1,395
	ktoe	4

21



Thailand Plan to Promote SAF

กรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงาน
กระทรวงพลังงาน

Potential for SAF production and appropriate blend for Thailand

The EU

SAF Mandate: 2% in 2025, 6% by 2030, 32% by 2040, 63% by 2050
With sub mandates for PtL SAF: 0.7% by 2030, 5% by 2035, 8% by 2040, 11% by 2045, 28% by 2050)

Phase	❶	❷	❸	❹
Year	(2026)	(2027 - 2029)	(2030 - 2032)	(2033 - 2037)
SAF %	1	1-2	3-5	5-8
Tech	HEFA		HEFA & AtJ	HEFA & AtJ
Feed	UCO & PFAD		UCO/PFAC & sustainable molasses	Flexible feedstock according to ICAO guideline

Thailand Committee for SAF (draft)

กรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงาน
กระทรวงพลังงาน

Mechanism to drive SAF

SAF Policy Working Group under Thailand Climate Change Committee and Sub-Committee on Plan & Policy

แต่งตั้งคณะทำงานจัดทำนโยบายการส่งเสริม SAF ภายใต้คณะกรรมการนโยบายการเปลี่ยนแปลงสภาพภูมิอากาศแห่งชาติ และคณะอนุกรรมการการเปลี่ยนแปลงสภาพภูมิอากาศ ด้านการบูรณาการนโยบายและแผน

Thailand Climate Change Committee and Sub-Committee on Plan & Policy

คณะกรรมการนโยบายการเปลี่ยนแปลงสภาพภูมิอากาศแห่งชาติ (กนภ.)

ประธาน: นรม. หรือ รนม. ที่ได้รับมอบหมาย
รองประธาน: รมว.ทส.
เลขานุการ: อธิบดีกรมการเปลี่ยนแปลงสภาพภูมิอากาศและสิ่งแวดล้อม

Thailand Climate Change Sub-Committee on Plan & Policy

คณะอนุกรรมการการเปลี่ยนแปลงสภาพภูมิอากาศ ด้านการบูรณาการนโยบายและแผน

ประธาน: ปลัด ทส.

SAF Policy Working Group

แต่งตั้ง

คณะทำงานจัดทำนโยบายการส่งเสริมเชื้อเพลิงอากาศยานยั่งยืน

หน้าที่และอำนาจ:
- นำเสนอเป้าหมายและแนวทางส่งเสริมการใช้ SAF ของประเทศ
- จัดทำแผนการดำเนินงานเพื่อส่งเสริมการผลิตและการใช้ SAF จากวัตถุดิบทางการเกษตรของประเทศ
- นำเสนอนโยบายเพื่อสนับสนุนการใช้ SAF อาทิ มาตรการทางภาษี
- พิจารณาแนวทางการรายงานข้อมูลการลดก๊าซเรือนกระจกจากการใช้ SAF ภายใต้ NDC

ประธาน: อธิบดีกรมการเปลี่ยนแปลงสภาพภูมิอากาศและสิ่งแวดล้อม
รองประธาน: อธิบดีกรมธุรกิจพลังงาน
เลขานุการ:
(1) ผู้แทนกรมเปลี่ยนแปลงสภาพภูมิอากาศและสิ่งแวดล้อม
(2) ผู้แทนกรมธุรกิจพลังงาน
(3) ผู้แทนกรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงาน
คณะทำงาน อาทิ กพท. กค. กษ. กค. อว. อบก. สภาอุตสาหกรรมฯ

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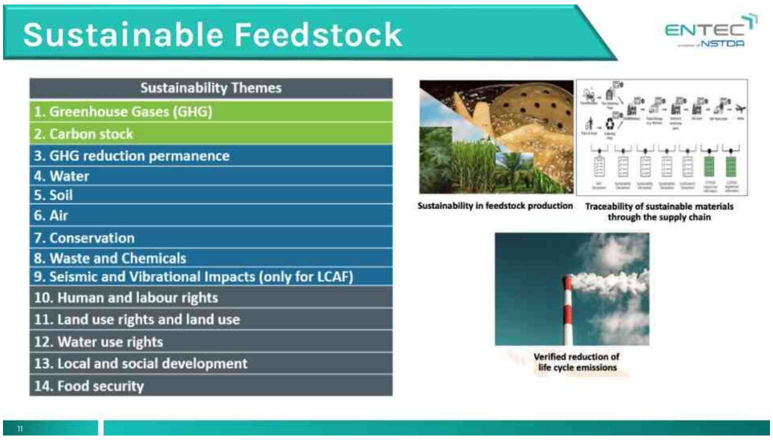


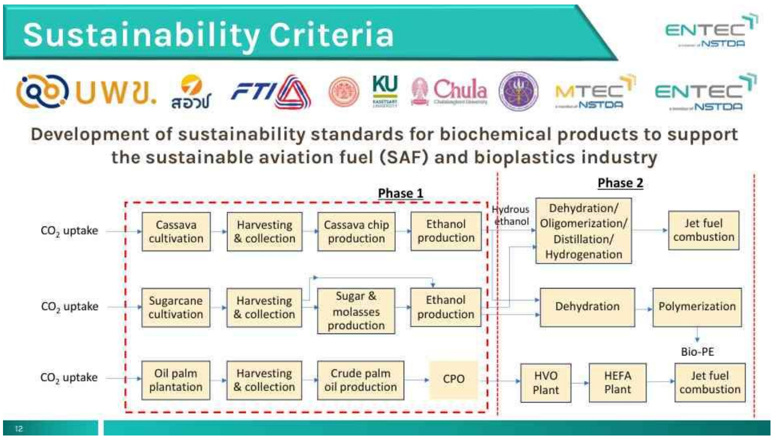
Sustainable Feedstock

Sustainability Themes
1. Greenhouse Gases (GHG)
2. Carbon stock
3. GHG reduction permanence
4. Water
5. Soil
6. Air
7. Conservation
8. Waste and Chemicals
9. Seismic and Vibrational Impacts (only for LCAF)
10. Human and labour rights
11. Land use rights and land use
12. Water use rights
13. Local and social development
14. Food security

Sustainability in feedstock production

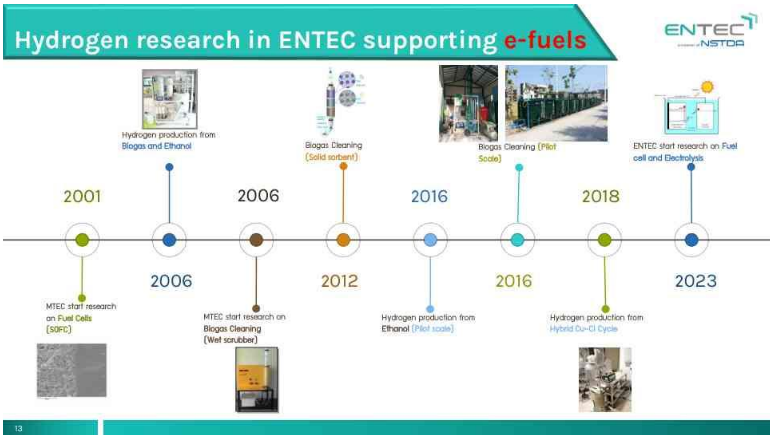
Traceability of sustainable materials through the supply chain

Verified reduction of life cycle emissions



Sustainability Criteria

Development of sustainability standards for biochemical products to support the sustainable aviation fuel (SAF) and bioplastics industry



Hydrogen research in ENTEC supporting e-fuels

2001
MTEC start research on Fuel Cells (SOFC)

2006
Hydrogen production from Biogas and Ethanol

2006
MTEC start research on Biogas Cleaning (Wet scrubber)

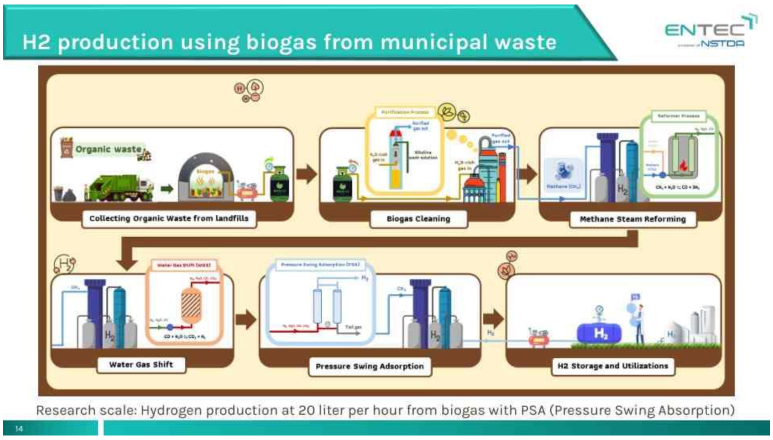
2012
Biogas Cleaning (Solid sorbent)

2016
Hydrogen production from Ethanol (Pilot scale)

2016
Biogas Cleaning (Pilot Scale)

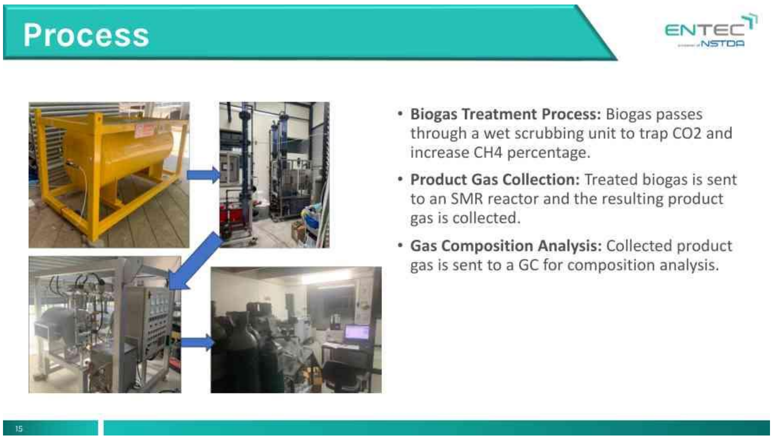
2018
Hydrogen production from Hybrid Cu-Cl Cycle

2023
ENTEC start research on Fuel cell and Electrolysis



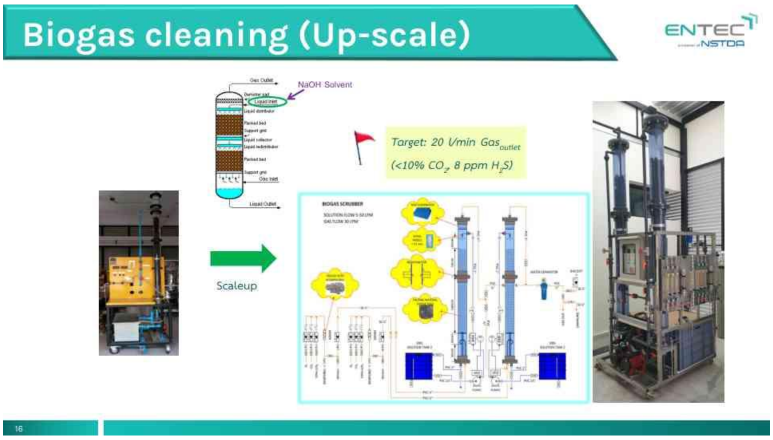
H2 production using biogas from municipal waste

Research scale: Hydrogen production at 20 liter per hour from biogas with PSA (Pressure Swing Absorption)



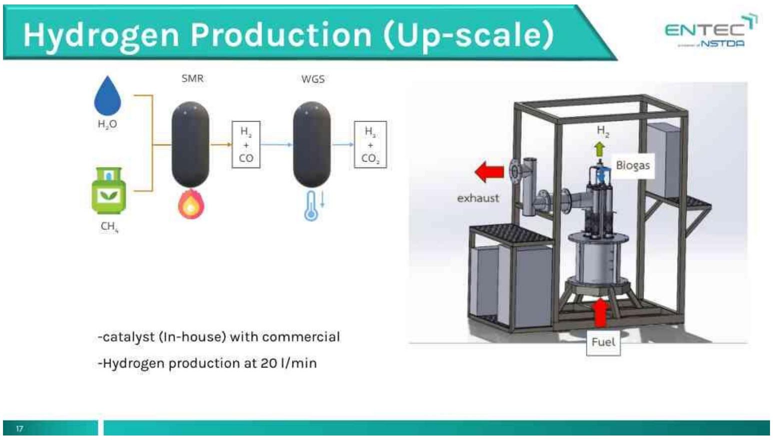
Process

- **Biogas Treatment Process:** Biogas passes through a wet scrubbing unit to trap CO2 and increase CH4 percentage.
- **Product Gas Collection:** Treated biogas is sent to an SMR reactor and the resulting product gas is collected.
- **Gas Composition Analysis:** Collected product gas is sent to a GC for composition analysis.



Biogas cleaning (Up-scale)

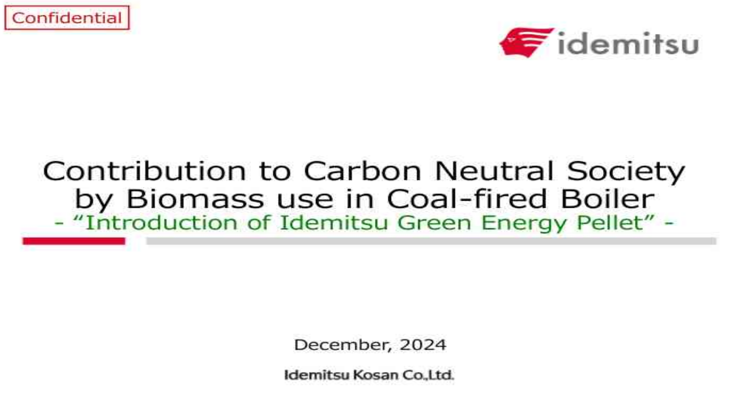
Target: 20 l/min Gas_{outlet}
(<10% CO_2, 8 ppm H_2S)



Hydrogen Production (Up-scale)

-catalyst (In-house) with commercial
-Hydrogen production at 20 l/min

Session3-3 “Green Energy Pellets in Viet Nam”
Mr Naotsugu Otani



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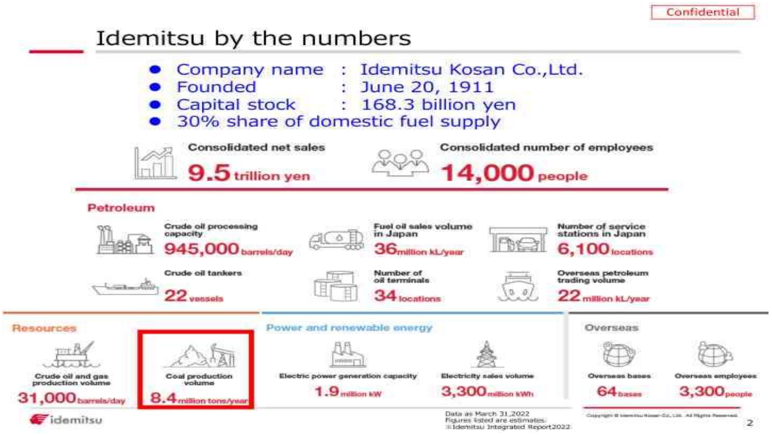
Contribution to Carbon Neutral Society by Biomass use in Coal-fired Boiler
- “Introduction of Idemitsu Green Energy Pellet” -

December, 2024

Idemitsu Kosan Co.,Ltd.

1



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Idemitsu by the numbers

- Company name : Idemitsu Kosan Co.,Ltd.
- Founded : June 20, 1911
- Capital stock : 168.3 billion yen
- 30% share of domestic fuel supply

Consolidated net sales 9.5 trillion yen

Consolidated number of employees 14,000 people

Petroleum

Crude oil processing capacity 945,000 barrels/day

Fuel oil sales volume in Japan 36 million kL/year

Number of service stations in Japan 6,100 locations

Crude oil tankers 22 vessels

Number of oil terminals 34 locations

Overseas petroleum trading volume 22 million kL/year

Resources

Crude oil and gas production volume 31,000 barrels/day

Coal production volume 8.4 million tons/year

Power and renewable energy

Electric power generation capacity 1.9 million kW

Electricity sales volume 3,300 million kWh

Overseas

Overseas bases 64 bases

Overseas employees 3,300 people

Data as March 31,2022
Figures listed are estimates.
※Idemitsu Integrated Report2022

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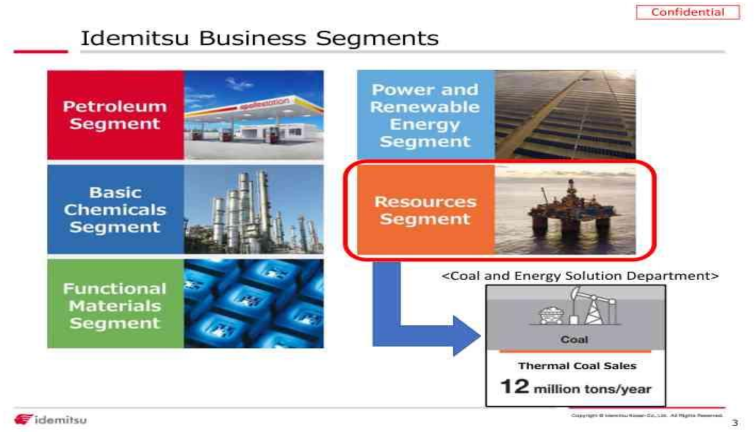

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Idemitsu Business Segments

Petroleum Segment

Basic Chemicals Segment

Functional Materials Segment

Power and Renewable Energy Segment

Resources Segment

<Coal and Energy Solution Department>

Coal

Thermal Coal Sales
12 million tons/year

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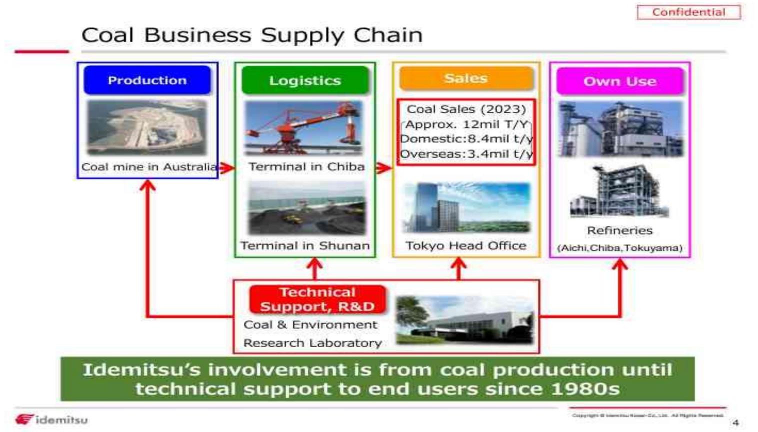

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Coal Business Supply Chain

Production
Coal mine in Australia

Logistics
Terminal in Chiba
Terminal in Shunan

Sales
Coal Sales (2023)
Approx. 12mil T/Y
Domestic:8.4mil t/y
Overseas:3.4mil t/y
Tokyo Head Office

Own Use
Refineries
(Aichi,Chiba,Tokuyama)

Technical Support, R&D
Coal & Environment Research Laboratory

Idemitsu’s involvement is from coal production until technical support to end users since 1980s

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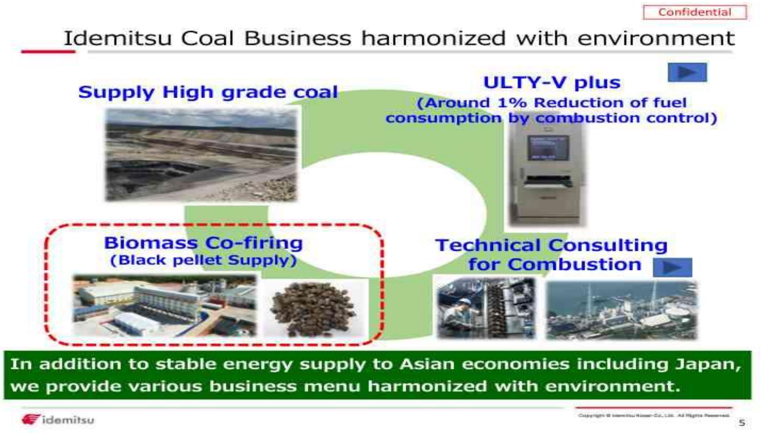

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Idemitsu Coal Business harmonized with environment

Supply High grade coal

ULTY-V plus
(Around 1% Reduction of fuel consumption by combustion control)

Biomass Co-firing
(Black pellet Supply)

Technical Consulting for Combustion

In addition to stable energy supply to Asian economies including Japan, we provide various business menu harmonized with environment.

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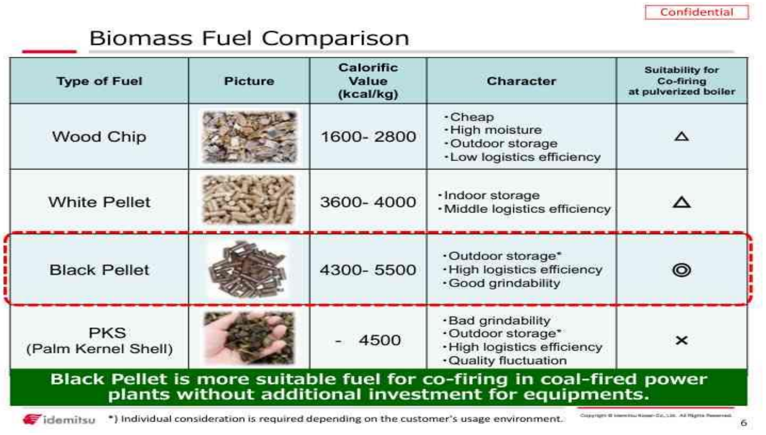

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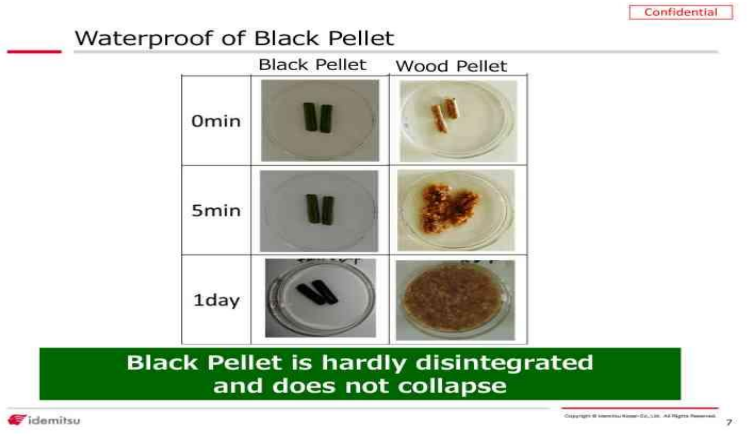
Biomass Fuel Comparison

Type of Fuel	Picture	Calorific Value (kcal/kg)	Character	Suitability for Co-firing at pulverized boiler
Wood Chip		1600- 2800	･Cheap ･High moisture ･Outdoor storage ･Low logistics efficiency	△
White Pellet		3600- 4000	･Indoor storage ･Middle logistics efficiency	△
Black Pellet		4300- 5500	･Outdoor storage* ･High logistics efficiency ･Good grindability	◎
PKS (Palm Kernel Shell)		- 4500	･Bad grindability ･Outdoor storage* ･High logistics efficiency ･Quality fluctuation	×

Black Pellet is more suitable fuel for co-firing in coal-fired power plants without additional investment for equipments.

idemitsu *) Individual consideration is required depending on the customer’s usage environment.

6



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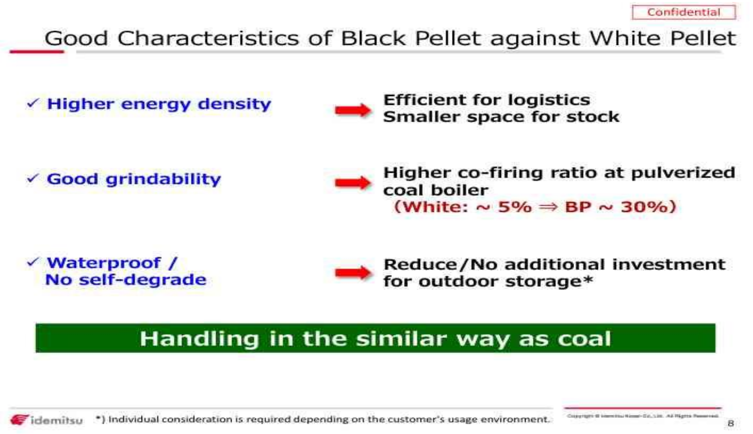
Waterproof of Black Pellet

Black Pellet is hardly disintegrated and does not collapse

7



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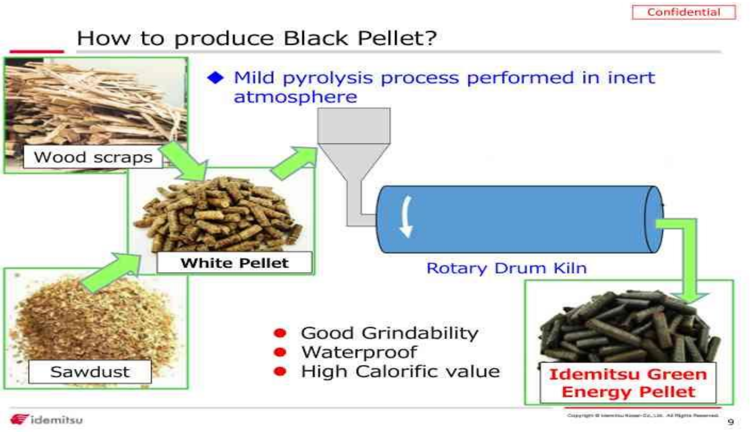
Good Characteristics of Black Pellet against White Pellet

- ✓ **Higher energy density** → **Efficient for logistics Smaller space for stock**
- ✓ **Good grindability** → **Higher co-firing ratio at pulverized coal boiler (White: ~ 5% ⇒ BP ~ 30%)**
- ✓ **Waterproof / No self-degrade** → **Reduce/No additional investment for outdoor storage***

Handling in the similar way as coal

*) Individual consideration is required depending on the customer's usage environment.

8



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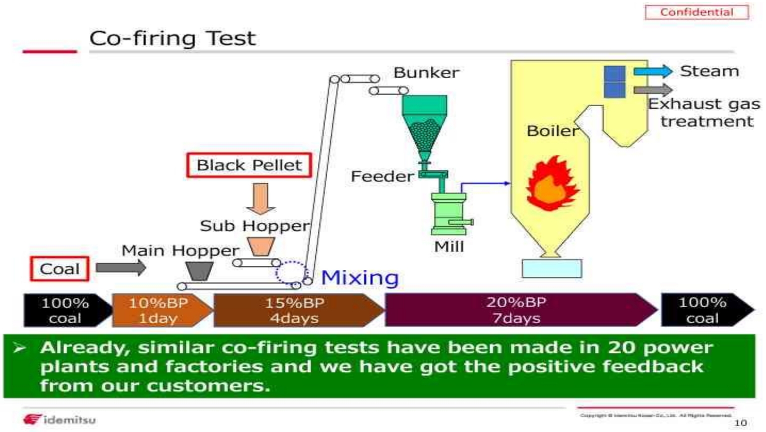
How to produce Black Pellet?

◆ Mild pyrolysis process performed in inert atmosphere

- ● Good Grindability
- ● Waterproof
- ● High Calorific value

9



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Co-firing Test

➢ **Already, similar co-firing tests have been made in 20 power plants and factories and we have got the positive feedback from our customers.**

10

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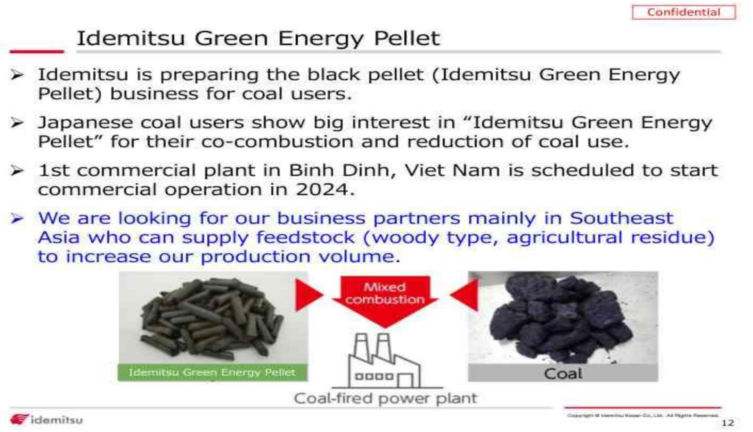
1st Commercial Plant in Viet Nam

- **Producer : Idemitsu Green Energy Viet Nam**
- **Location : Binh Dinh**
- **Feedstock : Acacia**
- **Capacity : 120,000t/year**
- **Technology : Rotary kiln**
- **Status : Commercialized in end of 2024**
- **Product : "Idemitsu Green Energy Pellet"**

11



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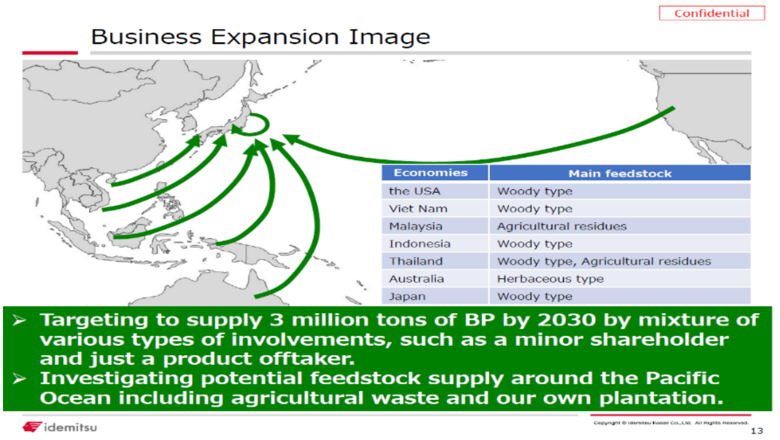
Idemitsu Green Energy Pellet

- ➢ Idemitsu is preparing the black pellet (Idemitsu Green Energy Pellet) business for coal users.
- ➢ Japanese coal users show big interest in "Idemitsu Green Energy Pellet" for their co-combustion and reduction of coal use.
- ➢ 1st commercial plant in Binh Dinh, Viet Nam is scheduled to start commercial operation in 2024.
- ➢ We are looking for our business partners mainly in Southeast Asia who can supply feedstock (woody type, agricultural residue) to increase our production volume.

12



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Business Expansion Image

Economies	Main feedstock
the USA	Woody type
Viet Nam	Woody type
Malaysia	Agricultural residues
Indonesia	Woody type
Thailand	Woody type, Agricultural residues
Australia	Herbaceous type
Japan	Woody type

- **Targeting to supply 3 million tons of BP by 2030 by mixture of various types of involvements, such as a minor shareholder and just a product offtaker.**
- **Investigating potential feedstock supply around the Pacific Ocean including agricultural waste and our own plantation.**

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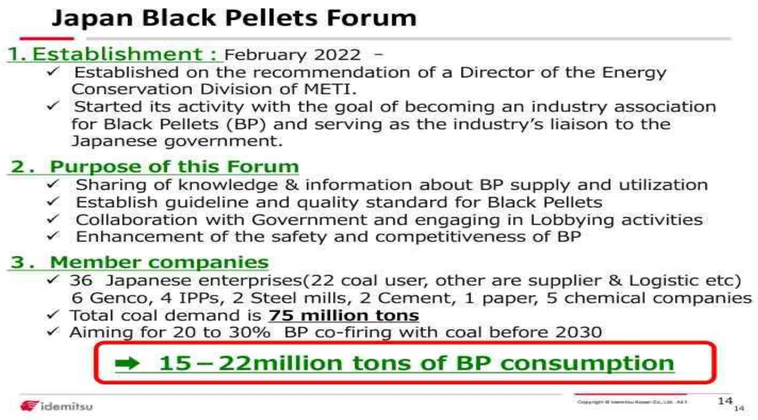

Japan Black Pellets Forum

1. Establishment : February 2022 –
   - ✓ Established on the recommendation of a Director of the Energy Conservation Division of METI.
   - ✓ Started its activity with the goal of becoming an industry association for Black Pellets (BP) and serving as the industry's liaison to the Japanese government.
2. Purpose of this Forum
   - ✓ Sharing of knowledge & information about BP supply and utilization
   - ✓ Establish guideline and quality standard for Black Pellets
   - ✓ Collaboration with Government and engaging in Lobbying activities
   - ✓ Enhancement of the safety and competitiveness of BP
3. Member companies
   - ✓ 36 Japanese enterprises(22 coal user, other are supplier & Logistic etc) 6 Genco, 4 IPPs, 2 Steel mills, 2 Cement, 1 paper, 5 chemical companies
   - ✓ Total coal demand is **75 million tons**
   - ✓ Aiming for 20 to 30% BP co-firing with coal before 2030

➡ 15－22million tons of BP consumption

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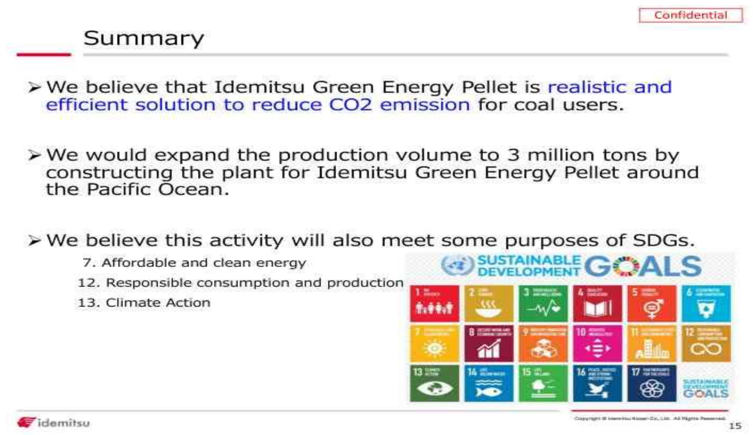

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Summary

- We believe that Idemitsu Green Energy Pellet is realistic and efficient solution to reduce CO2 emission for coal users.
- We would expand the production volume to 3 million tons by constructing the plant for Idemitsu Green Energy Pellet around the Pacific Ocean.
- We believe this activity will also meet some purposes of SDGs.
  - 7. Affordable and clean energy
  - 12. Responsible consumption and production
  - 13. Climate Action

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Idemitsu Coal & Environment Research Laboratory

- Highly efficient Coal Combustion Technology
  - ･Combustion Simulation
  - ･Coal Evaluation System
- Dust handling, Feedstock Management
- Environment Technology Products
- Biomass Co-firing technology

As a unique private research institute specialized for coal in Japan, we are working on the technical consulting to help solving our customers' technical issues and environmental problem and developing various kinds of technical products for promoting highly efficient coal utilization and environmental protection.

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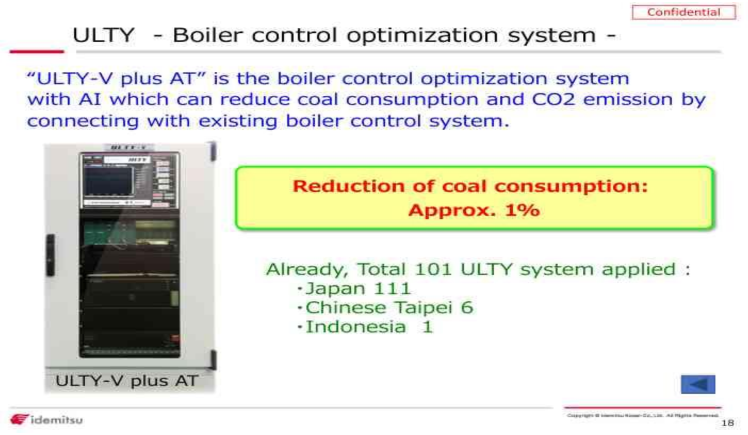

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ULTY - Boiler control optimization system -

"ULTY-V plus AT" is the boiler control optimization system with AI which can reduce coal consumption and CO2 emission by connecting with existing boiler control system.

Reduction of coal consumption: Approx. 1%

Already, Total 101 ULTY system applied :
- ･Japan 111
- ･Chinese Taipei 6
- ･Indonesia 1

ULTY-V plus AT

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Session3-4 “Decarbonization in Power Sector by Biomass and Biohydrogen in the Philippines”

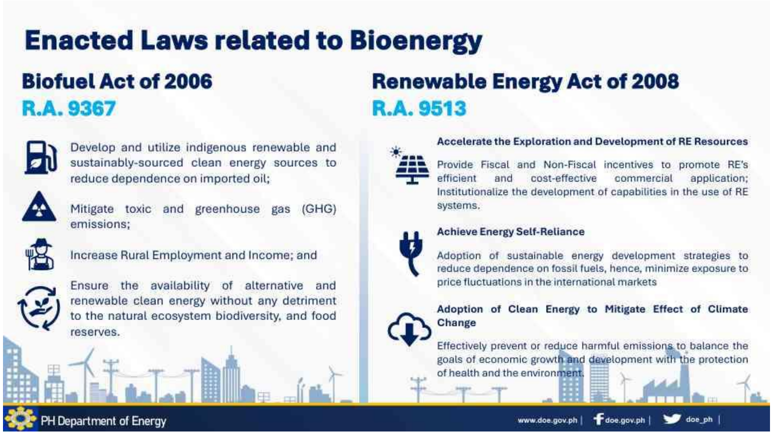
Ms Anna Mikko G. Realo

DECARBONIZATION IN POWER SECTOR BY BIOMASS IN THE PHILIPPINES

APEC 3rd Sectoral Symposium
for Energy Transition
03 December 2024

Khon Kaen, Thailand

ANNA MIKKO G. REALO
OIC – Chief, Biomass Energy Management Division
Renewable Energy Management Bureau
The Philippine Department of Energy



Enacted Laws related to Bioenergy

Biofuel Act of 2006
R.A. 9367

- Develop and utilize indigenous renewable and sustainably-sourced clean energy sources to reduce dependence on imported oil;
- Mitigate toxic and greenhouse gas (GHG) emissions;
- Increase Rural Employment and Income; and
- Ensure the availability of alternative and renewable clean energy without any detriment to the natural ecosystem biodiversity, and food reserves.

Renewable Energy Act of 2008
R.A. 9513

Accelerate the Exploration and Development of RE Resources

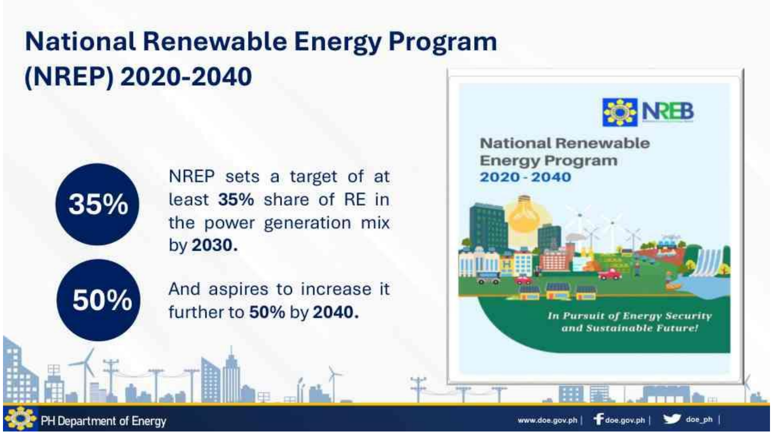
Provide Fiscal and Non-Fiscal incentives to promote RE's efficient and cost-effective commercial application; Institutionalize the development of capabilities in the use of RE systems.

Achieve Energy Self-Reliance

Adoption of sustainable energy development strategies to reduce dependence on fossil fuels, hence, minimize exposure to price fluctuations in the international markets

Adoption of Clean Energy to Mitigate Effect of Climate Change

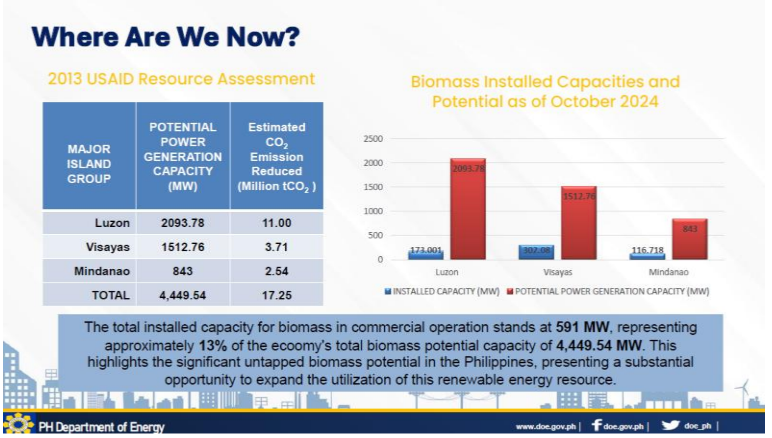
Effectively prevent or reduce harmful emissions to balance the goals of economic growth and development with the protection of health and the environment.



National Renewable Energy Program (NREP) 2020-2040

35% NREP sets a target of at least **35%** share of RE in the power generation mix by **2030.**

50% And aspires to increase it further to **50%** by **2040.**



Where Are We Now?

2013 USAID Resource Assessment

MAJOR ISLAND GROUP	POTENTIAL POWER GENERATION CAPACITY (MW)	Estimated CO_2 Emission Reduced (Million tCO_2)
Luzon	2093.78	11.00
Visayas	1512.76	3.71
Mindanao	843	2.54
TOTAL	4,449.54	17.25

Biomass Installed Capacities and Potential as of October 2024

The total installed capacity for biomass in commercial operation stands at **591 MW**, representing approximately **13%** of the ecoomy's total biomass potential capacity of **4,449.54 MW**. This highlights the significant untapped biomass potential in the Philippines, presenting a substantial opportunity to expand the utilization of this renewable energy resource.

Biomass Decarbonization Initiatives

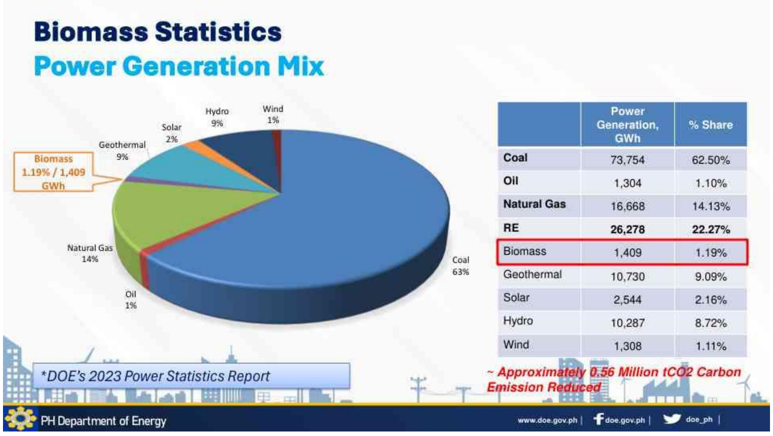
1. Biomass to Energy Projects

under the RE Act, 2009-2022

591.799 MW of additional RE Capacity Installations since the effectivity of the RE Law in 2009

PhP 38.10 Billion Cost of investments

2.2 Million t-CO_2 Equivalent GHG Emission Avoidance



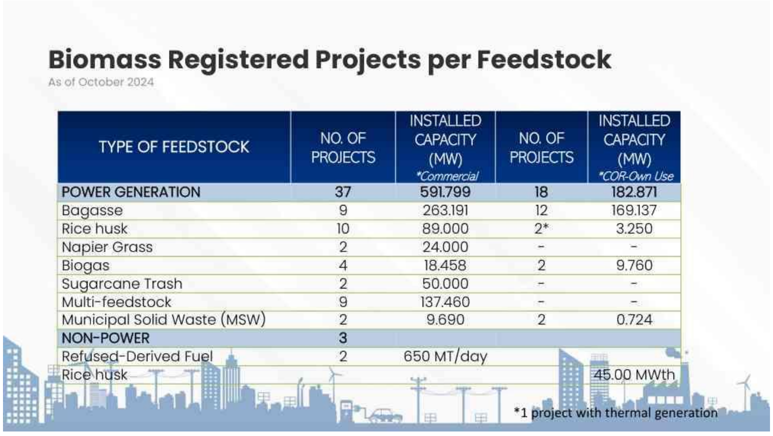
Biomass Statistics

Power Generation Mix

	Power Generation, GWh	% Share
Coal	73,754	62.50%
Oil	1,304	1.10%
Natural Gas	16,668	14.13%
RE	**26,278**	**22.27%**
Biomass	1,409	1.19%
Geothermal	10,730	9.09%
Solar	2,544	2.16%
Hydro	10,287	8.72%
Wind	1,308	1.11%

*DOE's 2023 Power Statistics Report

~ Approximately 0.56 Million tCO2 Carbon Emission Reduced

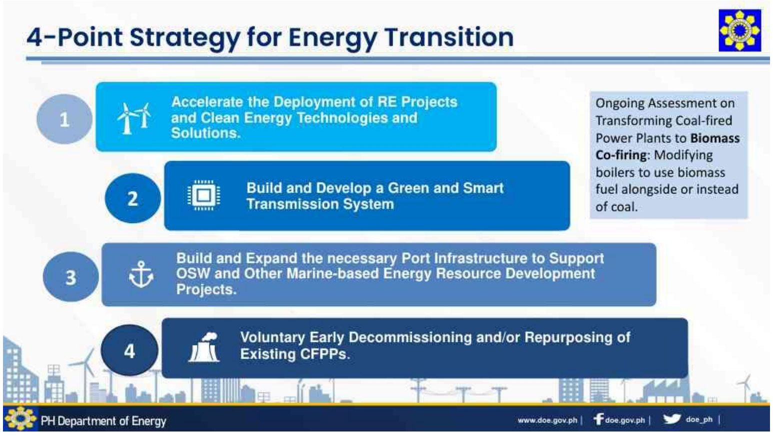


Biomass Registered Projects per Feedstock

As of October 2024

TYPE OF FEEDSTOCK	NO. OF PROJECTS	INSTALLED CAPACITY (MW) *Commercial	NO. OF PROJECTS	INSTALLED CAPACITY (MW) *COR-Own Use
POWER GENERATION	**37**	**591.799**	**18**	**182.871**
Bagasse	9	263.191	12	169.137
Rice husk	10	89.000	2*	3.250
Napier Grass	2	24.000	-	-
Biogas	4	18.458	2	9.760
Sugarcane Trash	2	50.000	-	-
Multi-feedstock	9	137.460	-	-
Municipal Solid Waste (MSW)	2	9.690	2	0.724
NON-POWER	**3**			
Refused-Derived Fuel	2	650 MT/day		
Rice husk				45.00 MWth

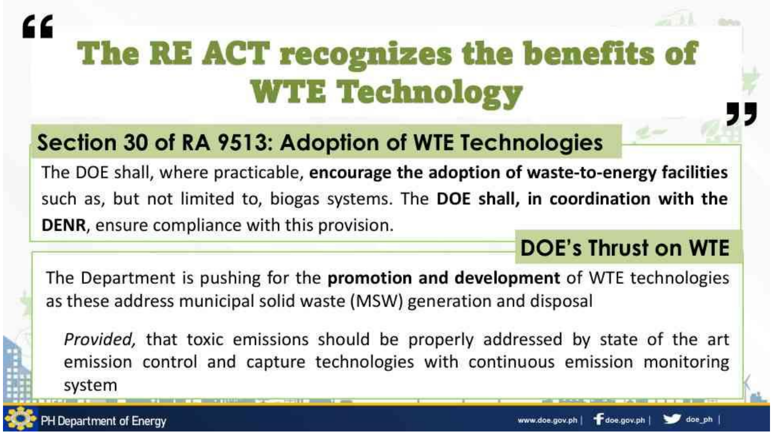
*1 project with thermal generation



4-Point Strategy for Energy Transition

1. Accelerate the Deployment of RE Projects and Clean Energy Technologies and Solutions.
2. Build and Develop a Green and Smart Transmission System
3. Build and Expand the necessary Port Infrastructure to Support OSW and Other Marine-based Energy Resource Development Projects.
4. Voluntary Early Decommissioning and/or Repurposing of Existing CFPPs.

Ongoing Assessment on Transforming Coal-fired Power Plants to **Biomass Co-firing**: Modifying boilers to use biomass fuel alongside or instead of coal.



"The RE ACT recognizes the benefits of WTE Technology"

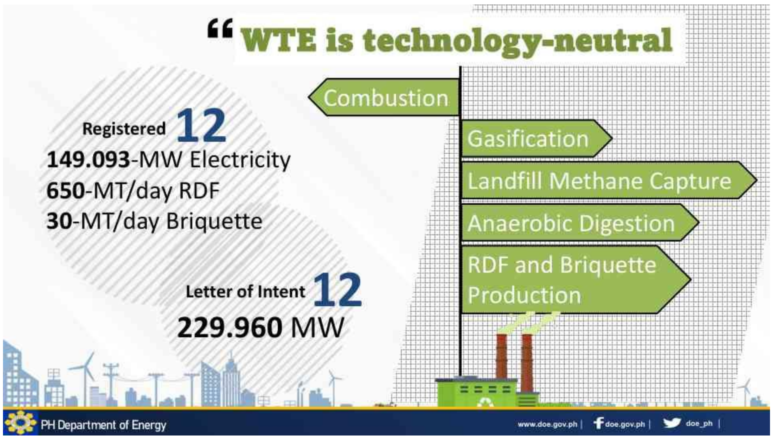
Section 30 of RA 9513: Adoption of WTE Technologies

The DOE shall, where practicable, **encourage the adoption of waste-to-energy facilities** such as, but not limited to, biogas systems. The **DOE shall, in coordination with the DENR**, ensure compliance with this provision.

DOE's Thrust on WTE

The Department is pushing for the **promotion and development** of WTE technologies as these address municipal solid waste (MSW) generation and disposal

Provided, that toxic emissions should be properly addressed by state of the art emission control and capture technologies with continuous emission monitoring system



"WTE is technology-neutral

Registered **12**

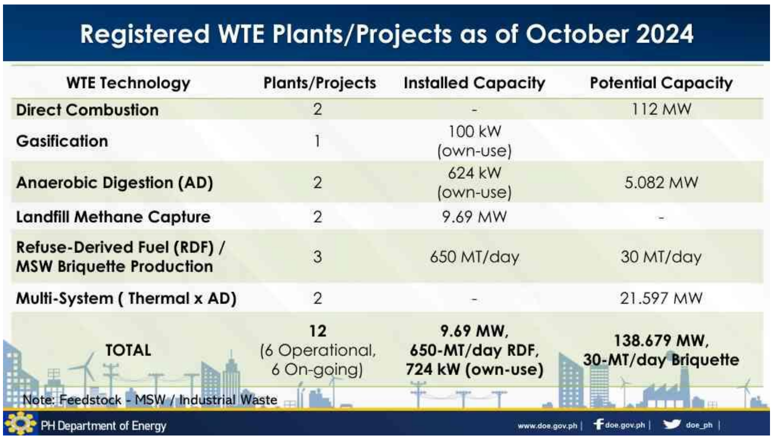
149.093-MW Electricity

650-MT/day RDF

30-MT/day Briquette

Letter of Intent **12**

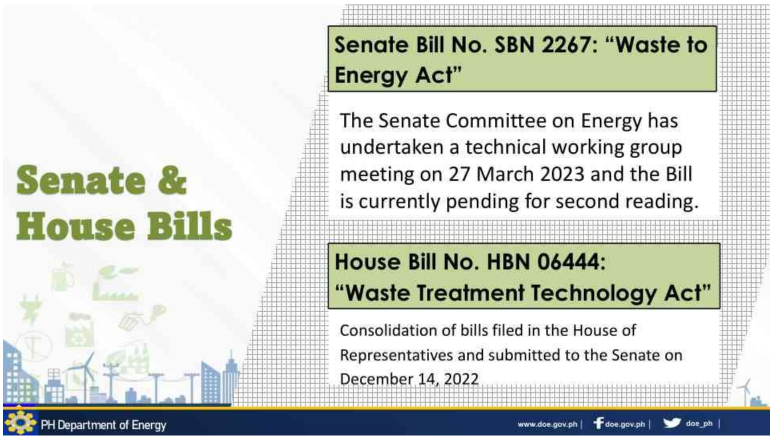
229.960 MW



Registered WTE Plants/Projects as of October 2024

WTE Technology	Plants/Projects	Installed Capacity	Potential Capacity
Direct Combustion	2	-	112 MW
Gasification	1	100 kW (own-use)	
Anaerobic Digestion (AD)	2	624 kW (own-use)	5.082 MW
Landfill Methane Capture	2	9.69 MW	-
Refuse-Derived Fuel (RDF) / MSW Briquette Production	3	650 MT/day	30 MT/day
Multi-System (Thermal x AD)	2	-	21.597 MW
TOTAL	**12** (6 Operational, 6 On-going)	**9.69 MW, 650-MT/day RDF, 724 kW (own-use)**	**138.679 MW, 30-MT/day Briquette**

Note: Feedstock - MSW / Industrial Waste



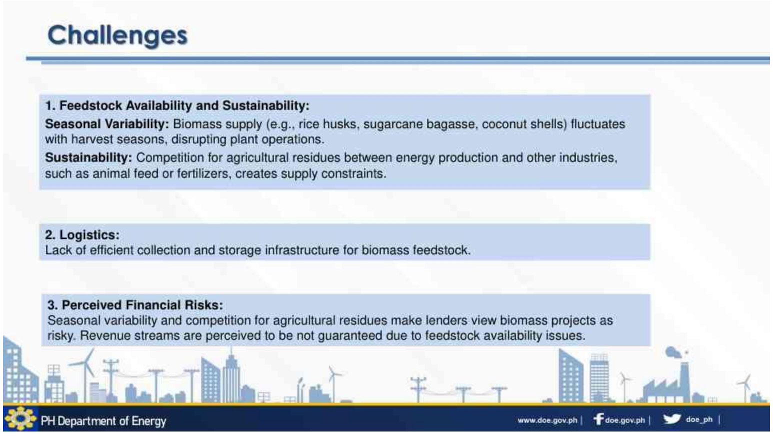
Senate & House Bills

Senate Bill No. SBN 2267: "Waste to Energy Act"

The Senate Committee on Energy has undertaken a technical working group meeting on 27 March 2023 and the Bill is currently pending for second reading.

House Bill No. HBN 06444: "Waste Treatment Technology Act"

Consolidation of bills filed in the House of Representatives and submitted to the Senate on December 14, 2022



Challenges

1. Feedstock Availability and Sustainability:
Seasonal Variability: Biomass supply (e.g., rice husks, sugarcane bagasse, coconut shells) fluctuates with harvest seasons, disrupting plant operations.
Sustainability: Competition for agricultural residues between energy production and other industries, such as animal feed or fertilizers, creates supply constraints.

2. Logistics:
Lack of efficient collection and storage infrastructure for biomass feedstock.

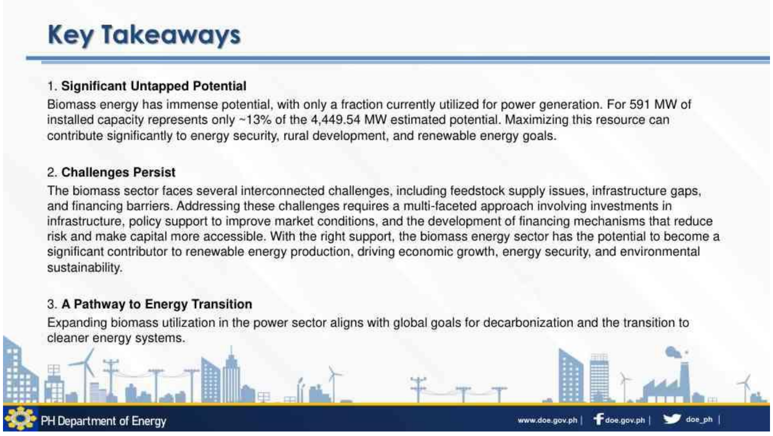
3. Perceived Financial Risks:
Seasonal variability and competition for agricultural residues make lenders view biomass projects as risky. Revenue streams are perceived to be not guaranteed due to feedstock availability issues.

Ways Forward

1. Diversify Feedstock Sources: Use multiple types of biomass to ensure a continuous supply even during off-seasons for specific crops.
Resource Mapping: Conduct studies to determine the availability and competing uses of agricultural residues. This will help prioritize where residues can be allocated for maximum economic and environmental benefit.

2. Biomass Hub and Cooperatives:
Create strategically located collection and aggregation centers near biomass sources to minimize transport distances and costs. Encourage the formation of cooperatives.

3. Updating of Biomass Potential, Resource Mapping. Capacity Building for Financial Institutions, and Access to Green Financing

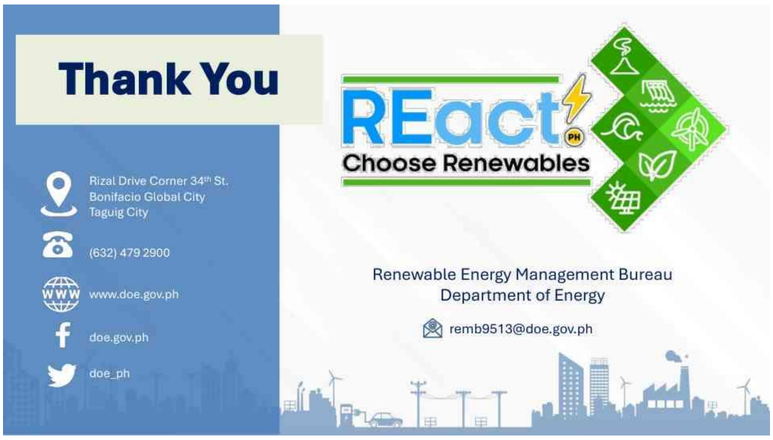


Key Takeaways

1. **Significant Untapped Potential**
Biomass energy has immense potential, with only a fraction currently utilized for power generation. For 591 MW of installed capacity represents only ~13% of the 4,449.54 MW estimated potential. Maximizing this resource can contribute significantly to energy security, rural development, and renewable energy goals.

2. **Challenges Persist**
The biomass sector faces several interconnected challenges, including feedstock supply issues, infrastructure gaps, and financing barriers. Addressing these challenges requires a multi-faceted approach involving investments in infrastructure, policy support to improve market conditions, and the development of financing mechanisms that reduce risk and make capital more accessible. With the right support, the biomass energy sector has the potential to become a significant contributor to renewable energy production, driving economic growth, energy security, and environmental sustainability.

3. **A Pathway to Energy Transition**
Expanding biomass utilization in the power sector aligns with global goals for decarbonization and the transition to cleaner energy systems.



Thank You

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