APEC Workshop on Promoting Energy Efficiency in the Manufacturing Sector

Summary Report

APEC Energy Working Group

September 2025

Asia-Pacific
Economic Cooperation

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APEC WORKSHOP ON PROMOTING ENERGY EFFICIENCY IN THE MANUFACTURING SECTOR

19 – 20 June 2025

Summary Report

I. INTRODUCTION

On 19 and 20 June 2025, the APEC Workshop on Promoting Energy Efficiency in the Manufacturing Sector, initiated by Viet Nam and co-sponsored by Hong Kong, China; Indonesia; Japan; Chinese Taipei; Thailand; and United States was held in Ha Noi, Viet Nam. Speakers and participants came from global organizations and research institutions and representatives from APEC member economies' relevant Ministries and government's agencies, companies and business associations that relates to energy and/or manufacturing in APEC economies and across the APEC region.

The Workshop aimed to help economies and stakeholders to share information, experiences on promoting energy efficiency in manufacturing industry as well as to provide recommendations on enhancing energy efficiency in this industry.

II. BACKGROUND

According to a report by UN Intergovernment Panel on Climate Change (IPCC), the increase in greenhouse gas emissions is creating the world climate change[1]. The average global temperature will increase by 1.5 Celcius degree as early as 2030 which leads to intensified desertification, reduced food production, increased sea levels and extreme climatic events . In this context, industrial manufacturing is the largest end-use sector (more than 30% of the total) in terms of both final energy demand and greenhouse gas emissions[2]. Not mentioning the great impact of manufacturing industry on environment, manufacturing industry plays an important role in the global economy. Manufacturing sector also plays an important role in the development of one economy. It supports both economic and social developments and also influences every aspect of people's life.

[1] Causes and Effects of Climate Change | United Nations
[2] https://www.sciencedirect.com/science/article/abs/pii/S0959652619331464

Energy efficiency is the use of less energy to perform the same task or produce the same result. Energy efficiency is an important topic in manufacturing. With rising energy costs and increasing environmental concerns, manufacturers are looking for ways to reduce energy consumption and improve their sustainability. Energy efficiency not only helps reduce energy costs but also contributes to a cleaner environment and a more sustainable future. Energy efficiency plays an important role when measuring the environmental impact of manufacturing industry.

In APEC, energy efficiency is a popular topic. For many years, APEC economies have been sharing experiences in developing policies regarding energy efficiency. This project is also a chance for APEC economies continue to share experiences, policies regarding energy efficiency in the region, especially in manufacturing industry. Improving energy efficiency in manufacturing industry has significant environmental benefits. There are many ways to improve the energy efficiency in manufacturing industry.

This project aims to hold a 2-full day Workshop in Viet Nam in 2024 that helps APEC and non – APEC economies and stakeholders to share about the experiences and good practices on how to promote energy efficiency in manufacturing industry.

III. OPENING REMARKS

In the opening remarks, Mr Nguyen Anh Tuan (Vice President, Energy Association, Viet Nam) highlighted that according to the International Energy Agency (IEA), about 33% of total energy consumption in 2023 will be consumed by industry sector, of which manufacturing accounts for 76% and is one of the largest sources of greenhouse gas emissions. With rising energy costs and growing concerns about the environment, manufacturers are looking for ways to reduce energy consumption and emissions. Applying energy-saving and efficient energy use measures not only helps businesses reduce production costs, improve competitiveness, contribute to environmental protection, build a green business image and sustainably develop.

Mr Tuan mentioned that in APEC, energy efficiency is an important topic that receives attention from all members. A concrete example is that in 2012 in Vladivostok, Russia, APEC Economic Leaders agreed to set a collective goal of reducing APEC' aggregate energy intensity by 45% by 2035 compared to 2005 levels. This goal is part of a joint effort to enhance energy security, promote sustainable development and transition to a low-carbon economy, and is currently coordinated by the APEC Experts Group on Energy Efficiency and Conservation (EGEEC).

The EGEEC recognized that realizing the collective goal of reducing APEC's aggregate energy intensity in the APEC region, especially in developing economies, is facing many challenges. Some common challenges include: high initial investment costs, lack of advanced technology, insufficient awareness of benefits and policy barriers. This reality requires strengthening international cooperation, through APEC - an idea incubator, APEC economies maintain activities to share experiences, technology and financial support to promote energy-saving solutions, reduce waste and emissions in the production process.

With that meaning, the Workshop is the contribution of the Government of Viet Nam to the collective APEC effort in implementing the Just Energy Transition Initiative and aiming to achieve the common goal of the APEC region: to double the share of modern renewables in the energy mix by 2030 (relative to the numbers from 2010) as instructed by APEC Economic Leaders. The Workshop is also expected to discuss and propose feasible and applicable initiatives, recommendations and policy solutions for APEC cooperation in the coming time.

IV. KEY ISSUES

1. OVERVIEW ON ENERGY NEEDS IN THE MANUFACTURING SECTOR

The speaker in the Session was Dr Surles Surles, Consultant, Hawaii Natural Energy Institute, United States.

- Dr Surles's presentation focused on the evolving landscape of industrial energy efficiency in the United States, with an emphasis on the impact of shifting political administrations and technological advancements. He discussed how the U.S. energy policy, often inconsistent due to changes in leadership, creates confusion globally. While renewable energy sources like solar and wind are growing, the federal government's approach fluctuates depending on the president's priorities. Notably, the previous administration focused on climate change and carbon emission reductions, whereas the current administration is more concerned with reducing fossil fuel dependency in industries beyond electricity production, such as petroleum refining.
- One emerging factor influencing energy demands is the rapid rise of artificial intelligence (AI), which significantly increases electricity needs. However, AI also contributes to improving efficiency in industrial operations. Dr Surles emphasized the importance of addressing process heat in addition to electricity generation, citing the Department of Energy's past focus on industries with high

heating needs like chemicals and steel. He contrasted this with the current administration's priorities, noting how policies around solar, wind, electric vehicles, and hydrogen technologies are shifting, with less focus on hydrogen due to its current limitations.

- Dr Surles also highlighted the importance of state-level policies, particularly in California, where consistent investment in energy efficiency has resulted in substantial reductions in electricity use. He argued that while federal policies may be inconsistent, states have more flexibility and can implement long-term strategies. For a sustainable future, he advocates for an integrated approach, incorporating AI, machine learning, and local efforts, while working closely with plant managers who are key to identifying practical solutions and improving industrial energy efficiency.

2. OPPORTUNITIES IN PROMOTING ENERGY EFFICIENCY IN THE MANUFACTURING SECTOR

There were two speakers in the Session: Dr Pan Tze-Chin, Deputy Division Director, Industrial Technology Research Institute, Chinese Taipei and Mr Vu Quang Dang, Independent Energy Consultant, Viet Nam.

- Dr Pan Tze-Chin discussed strategies for improving energy efficiency in Chinese Taipei's industrial sector. He noted that while GDP has increased by 37% over the past decade, overall energy demand has declined—demonstrating a successful decoupling of economic growth from energy consumption. The industrial sector currently accounts for approximately 38% of GDP, with the electronics industry contributing 52% by 2023, which is less energy-intensive compared to traditional industries like paper manufacturing. Dr Pan identified three key opportunities for energy savings: first, among large industrial consumers; second, within six energy-intensive industries; and third, in utility systems such as chilled water and compressed air, where mature technologies are readily available to improve efficiency. To promote energy efficiency, Chinese Taipei has implemented a suite of regulatory measures, including Minimum Energy Performance Standards (MEPS), mandatory energy audits, and energy efficiency labeling. The government also offers financial incentives for energy-saving initiatives, such as subsidies for high-efficiency motor replacements and waste heat recovery systems. In parallel, renewable energy deployment and energy storage are being actively promoted. Large electricity consumers are now required to either install renewable energy facilities or

procure renewable electricity. Looking ahead, Dr Pan stressed the importance of future policy changes and the growing global focus on Environmental, Social, and Governance (ESG) practices. He advocated for a systems-thinking approach to energy efficiency—focusing on optimizing entire industrial systems rather than isolated equipment upgrades. Digital tools, such as Energy Management Information Systems (EMIS), will be instrumental in supporting this transformation. However, success will depend not only on technology, but also on a mindset shift and long-term investment. Overall, Dr Pan's presentation emphasized the integration of policy, incentives, and systemic optimization as the foundation for achieving sustainable industrial energy efficiency in Chinese Taipei.

- Mr Vu Quang Dang's presentation focused on energy efficiency and decarbonization in Viet Nam's cement sector, emphasizing that optimizing energy consumption—not just reducing it—leads to cost savings and increased profits. He highlighted the two primary strategies for reducing carbon emissions: improving energy efficiency and sourcing more sustainable materials and fuels. Mr Dang pointed to government initiatives like Decision 1266, which aims for a reduction in energy consumption to 730 kcal per ton of cement by 2030, from the current 800 kcal per ton, demonstrating the sector's potential for significant energy savings. A key strategy for achieving these reductions is the use of alternative fuels, such as biomass or solid waste, to replace coal. Although the Vietnamese government targets a 15% substitution rate, the current rate stands at only 4%. Mr Dang also emphasized the importance of waste heat recovery, with a mandate for cement factories exceeding certain production capacities to install systems by 2025. This technology captures waste heat from production processes and converts it into electricity for self-consumption. As of now, 330 MW of waste heat recovery capacity is already operational or under construction in Viet Nam. Mr Dang argued that adopting energy-efficient practices can bring several benefits to cement companies, including reduced fuel and production costs, higher profits, and participation in carbon trading. Despite challenges like limited alternative fuel adoption and the need for investment in equipment, the long-term profitability is clear, especially with rising electricity prices. He concluded by emphasizing the importance of operational improvements and government support to drive the Vietnamese cement sector toward a more sustainable and efficient future, aligning with broader domestic climate goals.

3. PROMOTING ENERGY EFFICIENCY IN THE MANUFACTURING SECTOR

There were three speakers in the Session: Dr Cao Dongyuan, Professor, University of Science and Technology Beijing, China; Ms Jenjira Gulpanich, Engineer, Professional Level, Department of Alternative Energy Development and Efficiency, Thailand; Dr Nguyen Ngoc Hung, Director, Energy Economics Department, Institute of Energy, Viet Nam.

- Dr Cao Dongyuan's presentation stressed that achieving energy efficiency in the manufacturing sector requires a systemic, holistic approach that goes beyond adopting new technologies. It involves a comprehensive assessment of an organization's operations, addressing technological, structural, and policy-related factors that affect energy consumption. While technological innovations are crucial, the presentation emphasized that policies must incentivize energy conservation and guide manufacturers toward sustainable practices. Effective regulatory frameworks, support systems, and continuous monitoring are key to driving sustainable operations. Drawing from research in China, Dr Cao identified three main drivers for energy efficiency: the adoption of advanced technologies, the shift towards service-oriented industries that consume less energy, and the integration of clean energy sources. However, the path to energy efficiency is fraught with challenges, including high investment costs, limited access to financing, management issues, inconsistent regulations, and external factors such as geopolitical risks. These barriers can be overcome through strategic interventions like digitization, AI-powered maintenance, innovative financial instruments, and coordinated policies. Dr Cao's presentation emphasized the importance of government policies and consumer choices in fostering energy efficiency. By offering tax incentives, promoting clean energy, and raising public awareness, governments can create powerful incentives for businesses and consumers to adopt energy-efficient practices. In conclusion, Dr Cao advocated for a collaborative, multi-dimensional approach to energy efficiency, highlighting the need for innovation, policy support, and industry cooperation to unlock the full potential of sustainable growth in manufacturing.

- Ms Jenjira Gulpanich's presentation delved into the challenges and opportunities surrounding energy efficiency in the manufacturing sector, focusing on the barriers that prevent progress and the strategies needed to overcome them. Ms Jenjira emphasized that obstacles are not always obvious and often stem from

internal resistance or ingrained habits. The importance of energy efficiency goes beyond cost savings, offering benefits like improved competitiveness, enhanced energy security, and a reduction in greenhouse gas emissions. However, achieving widespread adoption remains hindered by financial barriers, a lack of awareness and technical expertise, and policy gaps. The presentation identified financial constraints as a major obstacle, with high upfront costs for energy-efficient technologies often putting them out of reach for small and medium-sized enterprises (SMEs). Additionally, limited access to financing and uncertainty around return on investment make it difficult for manufacturers to commit to energy upgrades. Even with adequate financial resources, a lack of awareness and skilled personnel to implement and manage energy efficiency measures, as well as unreliable data, pose significant challenges. Furthermore, inconsistent government policies, weak incentives, and the absence of mandatory standards further exacerbate the problem. Acknowledging the diverse challenges across the Asia-Pacific region, the presentation recognized that the issues vary from one economy to another, with developed economies facing barriers in convincing small businesses to replace outdated equipment, and rapidly developing economies struggling with access to affordable technologies. Additionally, gender considerations are important, as women entrepreneurs often face greater difficulties accessing resources and information. To overcome these barriers, Ms Jenjira called for a collaborative effort from governments, industries, and financial institutions, with stronger policies, better financial support, more training, and an inclusive approach to workforce engagement. Ultimately, promoting energy efficiency is framed not only as an environmental necessity but also as a strategic economic opportunity with significant potential for sustainable growth.

- Dr Nguyen Ngoc Hung's presentation focused on Viet Nam's energy landscape and strategies for enhancing energy efficiency in its industrial sector. He began by outlining Viet Nam's rapid growth from 2010 to 2022, with significant increases in GDP, population, and urbanization, leading to a sharp rise in energy demand. By 2015, Viet Nam shifted from being a net energy exporter to a net energy importer, with imports accounting for a significant portion of its primary energy supply, primarily coal. The industrial sector, particularly iron and steel production and cement manufacturing, accounts for a large share of energy consumption, with these sectors together representing 40% of the economy's total final energy demand. The presentation highlighted energy audits and expert surveys to identify key energy efficiency measures that can bring substantial benefits, including significant reductions in greenhouse gas emissions. Despite

the cost-effectiveness of these measures, with short payback periods and the potential to reduce reliance on coal and electricity, several barriers persist. These include financial constraints, a lack of awareness and technical expertise, and gaps in policy and regulations. Dr Hung emphasized the importance of addressing these obstacles through strategic interventions to promote energy efficiency. A cost-benefit analysis of five major energy efficiency measures reveals their potential for significant impact, including reducing emissions by approximately 575 million tons. However, Dr Hung acknowledged that overcoming existing barriers remains a critical challenge. The need for further exploration and action to implement these strategies effectively is underscored, with a focus on developing policies, improving awareness, and overcoming financial and technical hurdles.

4. ENHANCING INNOVATION AND FINANCE TO PROMOTE ENERGY EFFICIENCY IN THE MANUFACTURING SECTOR

There were 3 speakers in the Session: Dr Pan Tze-Chin, Deputy Division Director, Industrial Technology Research Institute (ITRI), Chinese Taipei; Mr Arthit Vechakij, Vice Chairman, Renewable Energy Industry Club - Energy Efficiency and Grid Modernization, The Federation of Thai Industries, Thailand and Mr Vu Quang Dang, Independent Energy Consultant, Viet Nam.

- Dr Pan Tze-Chin's presentation focused on advancing innovation to promote energy efficiency in Chinese Taipei's industrial sector. He began by emphasizing the importance of accurately measuring current energy consumption as a foundation for identifying energy-saving opportunities. He noted that traditional power meter installations face several challenges, including (i) complex wiring requirements, (ii) limited physical installation space, and (iii) the need to shut down power during installation. To address these issues, the Industrial Technology Research Institute (ITRI) developed the Power Tab sensor—a compact, non-contact power sensing device that eliminates the need for intrusive wiring and minimizes disruptions to production. This sensor enables real-time monitoring of energy metrics, feeding directly into ITRI's intelligent energy management system, iAuto. The iAuto system leverages AI-powered analytics to optimize energy consumption across various industrial processes. It operates in four primary domains: environmental management, preventive maintenance, intelligent manufacturing, and utility control. Dr Pan illustrated these functions through practical case studies, such as optimizing chilled water systems,

improving energy efficiency in wastewater treatment, and enhancing process control in textile dyeing operations. He concluded by highlighting the critical role of data transparency in effective energy management. Technologies like the iAuto system, he argued, not only reduce installation costs but also provide a robust platform for continuous performance optimization. By integrating real-time monitoring, artificial intelligence, and predictive modeling, iAuto presents a holistic solution to industrial energy challenges, enabling smarter and more efficient operations.

- Mr Arthit Vechakij's presentation focused on the urgent need to address global warming and accelerate the transition to low-carbon solutions, emphasizing the missed target of limiting global temperature rise to 1.5°C. He highlighted the challenges faced by Thailand in promoting renewable energy and energy efficiency, including outdated laws and regulations that hinder progress. He also noted that customers, particularly younger generations, are increasingly demanding low-carbon products and are willing to pay more for them, underscoring the growing global trend toward sustainability. To achieve a low-carbon future, Mr Vechakij advocated for integrating Renewable Energy 100 and emphasized the importance of a transition that supports business survival. He pointed out Thailand's struggle with limited third-party access to the electricity grid, which is a major barrier to progress, and stressed the need for supportive climate policies such as the awaited Climate Act. The presentation also highlighted potential areas for intervention, including water treatment and greener energy solutions, particularly solar PV and Battery Energy Storage Systems (BESS), which can significantly reduce energy tariffs and promote sustainable energy generation. Mr Vechakij concluded by discussing the role of Energy Service Companies (ESCOs) in Thailand, emphasizing their ability to conduct energy audits, implement green energy solutions, and provide measurement and verification to ensure proper carbon management. The "Share Savings" business model for ESCOs allows companies to invest in energy efficiency improvements and profit from them while reducing carbon emissions. This integrated approach offers a pathway for Thailand to transition to a low-carbon economy through local actions, enabling policies, and strategic partnerships.

- Mr Vu Quang Dang's presentation focused on the Energy Efficiency in the industrial sector in Viet Nam. He began by outlining the key benefits of energy efficiency: reducing energy costs, conserving finite resources, mitigating environmental impacts, and fostering sustainable economic growth. ESCO

model, according to Mr Dang, are specialized entities that provide a comprehensive range of energy services, including energy audits, project design, and implementation. A key feature of the ESCO model is the Energy Performance Contract (EPC), where the ESCO invests in energy-efficient equipment, and the energy savings are shared between the ESCO and the client, creating a win-win situation. To illustrate the effectiveness of the ESCO model, Mr. Dang presented a practical example: a company spending USD10 on energy could reduce this to USD6 through ESCO intervention, realizing a USD4 saving. The savings would then be split between the company and the ESCO, with the specific allocation depending on the negotiated EPC terms. Mr. Dang highlighted several advantages of the ESCO model, including no upfront investment for companies, guaranteed reductions in energy costs, access to advanced technologies, and shared project risks. However, he also acknowledged barriers such as long-term commitments, dependence on external ESCO suppliers, and potential disputes over savings allocation. Mr Dang then explored the main applications of the ESCO model in the industrial sector, focusing on industrial system upgrades, solar energy deployment, and building infrastructure improvements. Of these, industrial system optimization, solar energy integration, and building infrastructure enhancements offer the greatest potential for energy savings. To demonstrate the model's success, Mr Dang shared a case study from Viet Nam, where a solar water heating system was installed at the Can Tho Seafood Processing Company, resulting in significant energy savings. However, he pointed out the challenges that hinder broader adoption, including regulatory constraints and VAT imposition. To unlock the full potential of the ESCO model in Viet Nam, Mr Dang called for a clear legal framework, financial support mechanisms, updated regulations, and improved dispute resolution systems. He concluded by urging industrial facilities to embrace ESCO projects, either independently or in collaboration with ESCOs, to achieve substantial energy savings and promote sustainable practices.

5. CASE STUDIES IN SOME APEC MEMBER ECONOMIES

There were 4 speakers in this Session: Dr Wang Peng, Vice Director, Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, China; Dr Surles Surles, Consultant, Hawaii Natural Energy Institute, the United States; Ms Jenjira Gulpanich, Engineer, Professional Level, Department of Alternative Energy Development and Efficiency, Thailand and Mr Phung Quoc Huy, Senior Researcher, Asia Pacific Energy Research Centre (APERC).

- Dr Wang Peng's presentation outlined Guangdong province's approach to energy efficiency and carbon management within China's climate goals. He emphasized the urgent need to address climate change, citing evidence of a warming planet. As China's economic powerhouse, Guangdong faces the challenge of balancing economic growth with reducing its carbon footprint, especially as other provinces advance economically. The central issue is decoupling economic growth from energy consumption, given China's reliance on fossil fuels. Dr Wang outlined an ambitious goal for Guangdong to shift from 80% fossil fuel dependence to 80% renewable energy by 2060. This transition requires deep reforms across energy and societal sectors. Integrating both fossil fuels and renewables while ensuring system reliability and reducing carbon emissions is crucial. Guangdong's challenges include pressure of the middle-to-late stage of industrialization, high fuel import dependence, and energy-intensive industries. However, the province also benefits from a growing clean energy sector and potential for offshore wind power. The province's "1+1+N" policy framework addresses these issues: the overarching goal of carbon neutrality by 2060, a clear timeline, and specific actions such as promoting low-carbon lifestyles, investing in renewables, and establishing carbon markets. Dr Wang acknowledged the tensions between economic development and carbon reduction. Energy-intensive industries are sensitive to energy and carbon costs, potentially affecting employment and industrial stability. However, he was optimistic about leveraging digital energy management technologies and establishing platforms for carbon emissions calculation. These measures, along with a green credit system, offer sustainable solutions. In conclusion, Dr Wang emphasized the global inevitability of a low-carbon transition. He called for strict governance, innovation in energy efficiency, renewable energy investment, carbon trading markets, and digital technologies to accelerate Guangdong's progress. He also stressed the importance of international collaboration and partnerships to overcome the challenges of building a greener future.

- Dr Surles presented a case study on Stanford University's district heating and cooling system, highlighting its significant energy efficiency improvements. The university began implementing major changes in 2011, with the approval of a new central energy facility. In 2018, the system was further optimized for day-ahead management, making the operation more energy-efficient. Stanford has aggressively developed solar energy both on-site and off-site. These efforts have contributed to a 78% reduction in greenhouse gas emissions since 2006. By leveraging solar energy, the campus has reduced its emissions by 45%, thanks to importing electricity during low-demand, solar-heavy times of the day. The university's energy efficiency also translates into financial benefits. Stanford

actively participates in California's complex wholesale electricity market, which operates on a time-of-use pricing structure. During the day, when solar energy is abundant, electricity prices are low. Stanford takes advantage of this, buying energy during cheap periods and storing it for use when prices peak in the evening. To optimize energy use, Stanford developed an in-house software system that allows the campus to manage energy capacity and predict demand response events. The software helps Stanford reduce energy costs by making smart decisions on how much power to bid into capacity programs each month. The system also helps the university operate efficiently, even during periods of high demand, by managing thermal storage. Since adopting this system, Stanford has reduced its annual peak load by 10%, saving around USD750,000 annually. The university also receives USD600,000 annually in capacity payments from California's demand response programs. These savings demonstrate how efficient management of resources can result in financial gain. Dr Surles emphasized the importance of close collaboration between the software developers and the operational staff. This approach ensures that the software works effectively and aligns with real-world operational needs. He concluded by highlighting the success of Stanford's energy system innovation, which has reduced energy consumption, water use, and fossil fuel dependence, saving over USD400 million in total since its inception in the 1990s. The Stanford case study shows how energy efficiency improvements, supported by innovative software, can lead to significant savings and environmental benefits. This approach is a model for other large organizations aiming to improve energy efficiency and reduce emissions

- Ms Jenjira's presentation highlighted three case studies: the Energy Conservation Promotion Fund (ENCON Fund) of Thailand, the Energy Efficiency Directive (EED), and the Top Runner Program of Japan. The ENCON Fund of Thailand, a key initiative designed to promote energy efficiency and reduce energy consumption across the economy. The ENCON Fund was established under the Energy Conservation Promotion Act and is funded primarily through a tax on fossil fuels, specifically oil, generating around THB7 billion annually. This tax-based funding model ensures a steady financial stream for energy efficiency projects, with the fund's goal being to support projects that reduce energy consumption, improve industrial energy efficiency, and encourage the use of renewable energy. In addition to project funding, the ENCON Fund also invests in public awareness campaigns, training, and research to encourage energy conservation across the economy. The fund focuses heavily on projects with public benefits, particularly those targeting remote and underserved areas. This approach has led to significant advancements in Thailand's energy

landscape, especially within the manufacturing sector, where companies receive grants, low-interest loans, and tax incentives to implement energy-saving technologies. The fund's flexibility and ability to tailor financial solutions to different sectors, from government bodies to private companies, has been crucial in fostering energy-efficient practices. The ENCON Fund serves as a powerful model for other economies looking to set up similar domestic climate or energy conservation programs. It demonstrates how taxation on fossil fuels can be used as a sustainable source of financing for energy projects, while its adaptive management ensures that the fund remains responsive to the evolving energy sector and economic conditions. Furthermore, the involvement of both external experts and government officials in the fund's management ensures effective governance, risk management, and transparency. Overall, the ENCON Fund stands out as a successful example of how well-designed financial tools, adaptive strategies, and strong governance can create a sustainable and impactful energy conservation program. The Energy Efficiency Directive (EED) is a key EU policy aimed at improving energy efficiency across member states to help achieve the bloc's climate target of reducing greenhouse gas emissions by at least 55% by 2030. Initially adopted in 2012 and revised in 2018 and 2023, the latest update strengthens the directive by making several previously voluntary measures—such as energy audits and EMS for large companies—mandatory due to earlier compliance gaps. Beyond regulatory obligations, the EED brings significant economic benefits, including cost reductions, increased competitiveness, and improved profitability for businesses. It also supports environmental stewardship through carbon footprint reduction and progress toward sustainability goals. Additionally, the directive encourages innovation and the adoption of efficient technologies, while enhancing energy resilience by reducing exposure to volatile energy prices. The Top Runner Program, launched by Japan's Ministry of Economy, Trade and Industry (METI) in 1998, is a key part of the revised Energy Conservation Law aimed at improving the energy efficiency of appliances, vehicles, and other end-use products. It was introduced to replace earlier mandatory standards from the 1980s, which proved ineffective due to infrequent updates and industry-driven negotiations. The Top Runner approach sets mandatory energy efficiency standards based on the performance of the most efficient products currently on the market—the "top runners." These realistic and flexible targets are developed in consultation with industry stakeholders. A government-led labelling system highlights compliant products to consumers. Today, the program covers 23 product groups across residential, commercial, and transport sectors and has successfully led to significant improvements in Japan's overall energy efficiency.

- Mr Phung Quoc Huy's presentation focused on the urgent need to decarbonize coal-fired power generation, which is a critical issue due to the significant carbon emissions from the power sector. Coal-fired power plants account for 79% of total carbon emissions from the power sector as of 2023, and several economies, including China; Indonesia; Malaysia; and Viet Nam, still rely heavily on coal for power generation, with coal contributing between 40-60% of their electricity output. Moreover, the relatively young age of existing power fleets, especially in Asian economies, means that these plants are likely to operate for many more years, necessitating urgent efforts to reduce their carbon emissions. As economies set net-zero targets, decarbonizing the power sector becomes essential to meeting those goals. There are four main approaches to decarbonizing coal-fired power plants: improving thermal efficiency, co-firing with biomass, co-firing with ammonia, and carbon capture, utilization, and storage (CCUS). Improving thermal efficiency is one of the most immediate and practical solutions. This involves enhancing the conversion of coal's energy content into electricity, which reduces the amount of coal burned and lowers carbon emissions. Technologies like supercritical and ultra-supercritical plants, as well as integrated gasification combined cycle (IGCC), offer efficiency improvements. For example, IGCC technology achieves 46-50% efficiency, compared to the 38% of subcritical plants, and reduces carbon intensity by up to 15%. However, these technologies face challenges such as high initial investment costs and compatibility issues with existing infrastructure. Co-firing with biomass, where coal is burned alongside carbon-neutral fuels like biomass, can also reduce emissions depending on the biomass-to-coal ratio. Economies like Indonesia; Japan; and Korea are already implementing this solution, but concerns about biomass supply and deforestation persist, as seen in Indonesia's challenge of securing sufficient biomass by 2030. Another potential solution is coal-firing with ammonia, which has been tested with promising results in Japan; Korea; and Thailand. In Japan, a 20% coal-firing rate with ammonia has successfully reduced carbon dioxide emissions by 20%, demonstrating the potential of this technology. However, ammonia coal-firing is still in its early stages and faces challenges related to scalability, cost, and resource availability. Finally, carbon capture, utilization, and storage (CCUS) is a critical technology for reducing carbon emissions from coal-fired power generation. While the global deployment of CCUS is still limited, several economies, including China; Japan; and the US, are investing in its development. Each economy adopts a combination of strategies based on its energy policies and resources. While improving efficiency and adopting coal-firing technologies are the most feasible approaches in the short term, achieving net-zero emissions in power generation will require a mix of these strategies tailored to each economy's circumstances.

6. DISCUSSIONS

- The speakers and participants discussed the status of energy efficiency in manufacturing, particularly focusing on California, Hawaii, and broader US energy policy. A participant sought clarification on the geographical scope of the electricity data presented, probing whether it represented the entire United States or focused primarily on California. The US speaker emphasized that despite the federal administration's stance, individual states were actively pursuing their own agendas in energy and sustainability. He highlighted that the states tended to have more consistent long-term plans and underscored the flexibility inherent in the US federal system, enabling the states like California and Hawaii to set the ambitious goal of 100 percent renewable energy.
- In the case of California, the US speaker highlighted the efforts to attract energy industries when improving energy efficiency and reducing the state's carbon footprint at the same time. Furthermore, the importance of shifting the focus from “electricity alone” to “process heat and waste heat recovery” was stressed, suggesting this approach offered significant cost savings and potential revenue generation, especially within California's regulatory framework. Therefore, continued work on areas of importance at the state level was essential.
- One participant expressed optimism about the energy transition and greenhouse gas emission reduction, observing that the US had independent carbon reduction policies. He then inquired why green energy was easier than before, and whether this change stemmed from political, technological, or economic factors.
- The US speaker stated that the advancement of renewable energy was influenced by diverse factors. Notably, renewable energy, particularly at the utility scale, was becoming cost-competitive against such traditional sources as natural gas even without incentives. This made continued progress inevitable, regardless of federal policies. In Hawaii, the situation was unique because old, inefficient oil-fired plants were being retired. While the state prioritized solar and wind energy and energy storage, it would likely need some "solid" capacity, potentially from cleaner natural gas plants, which still drastically reduced emissions compared to the old infrastructure. California with its access to geothermal, biomass and hydropower resources, was better positioned to achieve the 100 percent renewable energy target.
- After that the possibility of California abandoning its carbon neutrality goal by 2050 was discussed. The US speaker explained that while California's overall carbon-neutral target remained, a new federal law challenged the state's plan to ban the sale of fossil-fueled vehicles by 2030, which was a key component of that target. The subsequent legal dispute over the state rights might reach the Supreme Court. Furthermore, he expressed doubt that California would fully

achieve its goals due to existing infrastructure limitations and the lack of mature technologies in certain carbon-intensive industries like cement and petroleum. This also applied to Hawaii, due to problems in the state's grid and stability, which had not been fixed. While significant progress was expected, a full realization of carbon neutrality was deemed unlikely.

- The speaker from Chinese Taipei expressed concerns about whether the current energy efficiency regulations and incentives are sufficient, particularly for the economy's energy-intensive industries. He specifically pointed out that balancing industrial automation with reduced energy consumption remains a significant challenge. He expressed hope that the industry will strengthen the use of digital energy management tools to enhance overall energy efficiency and help mitigate the growth in electricity consumption.
- The Chinese Taipei speaker outlined a multi-pronged approach that combined regulatory mandates with market forces and a shift in strategic thinking. Factories exceeding a contract capacity threshold of 5,000 kW must source at least 10 percent of their energy from renewable sources. They could be flexible in selection of the procurement methods, including on-site generation and energy storage solutions. Additionally, new industrial park users are required to allocate 20% to 30% of their rooftop area for solar panel installations.
- The speaker from Chinese Taipei emphasized that rising pressure from global supply chains and growing ESG awareness are becoming more influential than government regulations in driving industrial change. He highlighted a strategic shift from focusing solely on high-efficiency individual facilities to adopting a more integrated, system-level approach. While high-efficiency equipment plays an important role, he noted that it does not guarantee overall system efficiency. Instead, energy management should prioritize coordination across multiple facilities. He identified Energy Management Information Systems (EMIS) as a key enabler of future savings and recommended that companies first plan their system architecture, then gradually implement EMIS in major energy-consuming operations based on available resources and capabilities.
- A question was raised about the cement industry and initiatives involving Refuse-Derived Fuel (RDF) in Viet Nam. It was related to the viability of sustainable business models for RDF implementation and the feasibility of conducting a cost-benefit analysis. Highlighting the potential financial risks associated with adopting RDF, the participant asked about investment incentives for businesses, specifically seeking clarity on potential support from the Vietnamese government and the expected return on investment (ROI) for such ventures.
- The Vietnamese speaker explained the landscape of RDF adoption in Viet Nam's cement sector by outlining the popular business models, economic

considerations and existing barriers. He noted that currently two primary business models were observed. First, companies could purchase RDF from external suppliers to co-process with coal. This practice had been adopted by about ten companies. Second, companies can directly invest in RDF production facilities to process solid waste and utilize the product in their clinker production. This model had been employed by around five companies, most of which were located in Ho Chi Minh City and Kien Giang province. However, he emphasized that the RDF market in Viet Nam remained small and underdeveloped, making it difficult for companies to secure large volumes of RDF.

- The Vietnamese speaker explained the economic viability of RDF, highlighting that RDF became more economically attractive when the price of coal exceeded USD93 per ton. In addition, cement manufacturers in Viet Nam adopted RDF as a way to meet client requirements for carbon-low cement rather than for its financial benefit. A few other factors also impacted cement manufacturers' implementation of RDF, including RDF business models, expertise in the Industrial Development Fund (IDF), environmental compliance and the lack of government incentives. Furthermore, the complex regulatory environment, particularly concerning the environmental permits for changes to production lines when using RDF, presented a significant hurdle. Lastly, a shift in donor funding towards waste-to-energy projects, particularly in larger cities, was being observed. The Vietnamese speakers concluded with the observation that promoting RDF enabled Viet Nam to simultaneously save energy and protect the environment.
- A participant asked about the specific reward and penalty mechanisms associated with energy efficiency targets for large energy users in Chinese Taipei. He also expressed interest in the Waste Heat Recovery (WHR) technology, which had yet to be implemented in Indonesia's cement industry.
- In response, the Chinese Taipei speaker clarified that while there were regulations to promote energy efficiency, penalties for non-compliance were currently limited to approximately USD1,000. Despite that, the authorities were working intensively to amend the Energy Administration Act toward increasing the penalty amount. It could be increased to at much as USD10,000 in the future although this remained under discussion. At the same time he noted that direct financial incentives for compliance had not been put in place. However, companies could apply for subsidies to support energy efficiency initiatives and participate in a benchmarked energy-saving award program.
- Answering the question about the Waste Heat Recovery technology, the Vietnamese speaker explained that the payback period was highly dependent on the electricity prices and the specific technology deployed. Based on calculations within Viet Nam, a typical payback period ranged from five to six years. WHR

was becoming more popular in Viet Nam. It was often implemented based on Engineering, Procurement, and Construction (EPC) contracts, which typically took only one year to complete. The costs were around 1.6 million per megawatt. The Organic Ranking Cycle (ORC) technology was now widely used. In addition to the cement sector, application of the WHR technology was feasible in many industries such as the steel industry.

- The speakers and the participants discussed the challenges of attracting investor contributions towards energy efficiency due to the high upfront costs, focusing on identifying benefits for investors and promotion strategies for governments to incentivize investment in this sector. The question was raised by an Indonesian participant.
- The Chinese speaker highlighted the importance of collaboration among governments, factories, and investors to decrease energy consumption. Drawing on China's experience, she explained the use of a "consume tax," shifting the taxation point from the manufacturing sector to the consumers. This approach encouraged the consumers to choose more energy-efficient options, with higher taxes applied to less efficient choices like gasoline-powered cars. She also suggested that governments should consider offering tax incentives to manufacturing companies that adopted environmentally friendly practices, utilized clean equipment, and invested in new technologies and materials that enhanced energy efficiency.
- The Chinese speaker also referred to the crucial role of Energy Management Companies (EMCs). They contracted with manufacturing companies and made promises about decreasing energy efficiency. These companies took responsibility for using high-cost equipment and decreasing consumption with their expertise in return for payment.
- The moderator from Viet Nam highlighted the importance of tax policies, particularly shifting the tax burden from producers to consumers, and the value of contracts to apply efficiency energies and directly benefit firms.
- The speaker from Thailand shared that the economy utilized subsidy programs, providing 10-20 percent to designated industries and 30 percent to Small and Medium-sized Enterprises (SMEs) to replace older equipment with new, energy-efficient alternatives, along with energy-efficient labeling schemes.
- A moderator from Viet Nam highlighted insights gained from recent APEC workshops, noting the importance of both "push" factors like regulations and "pull" factors such as eco-friendly digitalization and green transformation. These were driven by net-zero goals, stringent market requirements, and a growing need for firms to adapt and transform traditional industrial zones to meet evolving demands, particularly in developed economies.

- The Chinese speaker emphasized the significant contribution of energy efficiency to the reduction of global energy consumption and GHG emission. Drawing upon China's development over the past 30 years, he highlighted the power of government policies as a primary driver for energy efficiency, arguing that it was often more effective than relying solely on market mechanisms. China set energy-saving targets, which were decomposed to different levels of government and individual factories. This strategy was discussed in-depth by the speaker, explaining associated penalties imposed for non-compliance. While acknowledging the challenges involved, he pointed out the opportunities created by strict energy efficiency standards. He referred to the research which showed that such standards could induce the development of energy-efficient industries.
- Experiences of technology transfer from Japan; Korea; and other economies were mentioned, and the opportunities for further experience sharing among Southeast Asian economies were emphasized.
- The potential for newly industrialized economies to leverage backward advantages through a focus on system-level energy savings was also noted by the Chinese speaker, employing digital technologies and AI to optimize energy use across different equipment, facilities, and product lines. Fully automated "dark factories" were highlighted as an example of advanced technology by the speaker, representing a means by which energy efficiency could be significantly improved, potentially by 30-50 percent.
- The speakers and participants exchanged perspectives on the relative importance of government policies versus private investment in effectively promoting energy efficiency.
- The Chinese speaker emphasized the critical role of government policies and regulations, stating that government targets and associated penalties were paramount. Drawing on China's experiences over the past 30-40 years of economic reforms, she suggested that these experiences could be valuable for other economies, and that APEC provided a useful forum for knowledge sharing and communication.
- The Thailand speaker expressed strong agreement with the previous comments, noting that Thailand had implemented numerous measures to promote energy efficiency, stressing the importance of consistent monitoring and evaluation, which were often neglected. She mentioned that Thailand had subsidy schemes to support energy efficiency investment, particularly given that many factories could not afford the full upfront costs of new equipment.
- Learning and sharing experiences among APEC economies were emphasized as an effective measurement.

- A question was raised about the latest technologies applied in China, specifically seeking insights into advanced AI and metering systems used for energy audits. The Chinese speaker confirmed that energy audits were a highly effective and cost-efficient strategy to identify energy-saving potential. Such a diagnosis could be done by inviting many experts and energy saving technology equipment suppliers, and research and development actors.
- China's first energy audit was supported by the World Bank and developed economies. While such a task faced a big challenge, governmental support in collaboration with non-governmental organizations (NGOs) or energy associations could facilitate greater capacity building. Furthermore, the speaker highlighted that China's manufacturers did not possess the requisite expertise and know-how, despite their desire to perform energy audits for business incentives.
- Adding to this point, another Chinese speaker mentioned that different standards existed among different provinces in China. To counter this, for energy audits, there should be a unified standard.
- A question was raised about whether there were any considerations regarding the utilization of heat pumps or electric boilers in Viet Nam, particularly in the context of low electricity prices and low carbon emissions.
- The speaker from Viet Nam confirmed that heat pumps and electric boilers were indeed mentioned within the extensive list of researched solutions. However, at the time of his research, these solutions were less frequently recommended as the technology was not as advanced as it is today. The speaker emphasized that the research list encompassed various types of heat pumps, electric furnaces, boilers, and other boiler types, with the objective to initially select the most important solutions and potentially expand the list in the future.
- A question was raised about the practical application of the LEAP model in assisting the Vietnamese government with establishing quantifiable energy efficiency policy targets, emphasizing the model's role in informing policymaking decisions.
- The discussion extended to the potential for optimizing energy efficiency in Viet Nam's planned industrial parks. The Chinese speaker proposed exploring a combined supply-side and demand-side approach during park development, particularly focusing on shared resources to maximize efficiency across clustered industries.
- The Vietnamese speaker clarified that various tools, including LEAP and TIMES models, were used to advise the Ministry of Industry and Trade in setting energy efficiency targets. The Vietnamese Energy Efficiency Program (VNEEP3) had set targets for reducing energy consumption by 5-7 percent this year and 8-10 percent by 2030.

- He agreed on the importance of industrial parks (IPs) and the increasing trend of manufacturers moving to IPs to benefit from common infrastructure.
- The industrial park market, especially in the North of Viet Nam, was experiencing high demand. The speaker emphasized that the initial design stage of industrial parks played a crucial role in achieving energy efficiency. Strategies such as utilizing efficient boilers and modern pipelines, and shared air compression, allowed for economic scale advantages and also affirmed that the standard for setting industrial parks played a very important role in promoting energy efficiency.
- The concept of eco-industrial parks and industrial symbiosis was highlighted by a participant from Viet Nam as a valuable approach for enhancing energy efficiency and promoting circular economy principles. Industrial symbiosis, characterized by the exchange of materials, energy, water, and byproducts between firms, led to resource interdependence. However, she mentioned that challenges arose in coordinating these relationships due to waste production variability and potential requirements for waste treatment, potentially increasing transaction costs. To mitigate these challenges, companies might opt for internal waste reuse or selling waste on the open market, which reduced firm interdependence and coordination needs. The governance of industrial symbiosis systems often involved a centralized authority, which might face challenges in managing complex inter-firm interactions.

V. RECOMMENDATIONS

During the final session, there were two panelists in this Session: Dr Surles Surles, Consultant, Hawaii Natural Energy Institute, the United States; and Mr Arthit Vechakij, Vice Chairman, Renewable Energy Industry Club - Energy Efficiency and Grid Modernization, The Federation of Thai Industries, Thailand.

- Dr Surles's remarks highlighted the broader, strategic considerations surrounding energy efficiency and decarbonization in the manufacturing sector. He emphasized that while discussions often focus on improving energy efficiency from an economic standpoint, the environmental and domestic security dimensions are equally important. Reducing the demand for raw materials through energy-efficient technologies not only benefits the environment but can also enhance energy security, which is vital from a geopolitical perspective. He also noted that the meeting participants were largely in agreement about the challenges in scaling energy-efficient technologies. These included the need for consistent government policies, the importance of

lifecycle cost considerations (where initial costs often deter investment in energy-efficient technologies despite their long-term benefits), and the critical role of finance. He pointed out that many companies, especially in the U.S., are driven by short-term goals like quarterly earnings, which often conflict with the long-term investments required to address carbon emissions. Dr Surles outlined several key recommendations, including the need for governments to establish clear standards and regulations that foster consistency across sectors and economies. These standards should include incentives such as subsidies, loan guarantees, or tax adjustments to address the financial barriers many companies face when adopting energy-efficient technologies. He also stressed the importance of improving data collection, monitoring, and auditing, with a focus on continuous testing and information gathering. In terms of practical measures, he pointed out that facility managers often have the best insights into where improvements in efficiency can be made. However, solutions must avoid being overly academic or ideologically driven, ensuring they are applicable to real-world manufacturing environments. The participants were also in agreement on key technological approaches, particularly thermal management and waste heat recovery, which are seen as low-hanging fruit for improving energy efficiency in industrial settings. Dr Surles also introduced some forward-thinking ideas, including the potential of circular economies and technologies like waste-to-fuel systems and battery recycling. Additionally, the adoption of advanced demand-side management and data-driven methods, including AI, was highlighted as a way to optimize manufacturing efficiency and reduce fossil fuel use. He further emphasized that improvements in energy efficiency would lower costs, raise productivity, and enhance shareholder value, while also benefiting the environment by reducing emissions. Finally, he stressed the importance of international collaboration and public-private partnerships, noting that the path forward must integrate both technological advancements and policy innovations.

- Mr Arthit Vechakij emphasized the critical importance of a systematic, long-term approach to energy efficiency, focusing on several key stages in the process. These stages range from energy audits and board approval for investments to the actual implementation of energy efficiency measures. However, he noted that a key factor often overlooked is the operation and maintenance phase. Many energy efficiency projects fail over time because of inadequate knowledge on how to sustain and operate the measures effectively. To address this, he recommended the adoption of continuous improvement models to ensure sustained success. According to Mr Vechakij, energy efficiency is not just a short-term goal but requires long-term commitment, with a focus on continuous improvement across all levels of the organization. He further highlighted the

urgent need for businesses, especially in Thailand, to reduce carbon emissions to remain competitive in the global market. In Thailand, he used the phrase "do it or die" to underscore the gravity of the situation, emphasizing that businesses must align with global sustainability targets or risk being left behind. This is where government support becomes crucial. Drawing from examples like China and Chinese Taipei, Mr Vechakij pointed out that governments must play a facilitative role in supporting the private sector to drive energy efficiency. However, he also stressed that the private sector must excel in financing, implementing, and maintaining energy-efficient systems to ensure long-term sustainability. Lastly, Mr Vechakij discussed the importance of encouraging investor interest in energy efficiency at the enterprise level. He advocated for systematic energy efficiency plans that integrate new technologies such as AI and digitalization to enhance productivity and reduce energy consumption. Policymakers, he said, should integrate energy efficiency into industrial policies, ensuring that energy security is also taken into account. He also touched on the critical issue of financing, noting that there is a gap between the financial institutions offering green transition funds and the enterprises that need them. Bridging this gap requires more effective communication channels, clearer guidelines, and better collaboration between the private sector and financial institutions. In conclusion, Mr Vechakij emphasized that while energy efficiency is essential for the long-term success of businesses and economies, it requires coordinated efforts from both the public and private sectors to achieve meaningful results.

Participants also shared a range of recommendations and domestic experiences related to improving energy efficiency through technological, financial, institutional, and policy reforms.

Technological and Infrastructure Solutions:

- The participants emphasized the need for upgrading and improving energy-related equipment to enhance efficiency and reduce waste. Technological innovation, such as AI-based tools for energy analysis, should be encouraged.
- Investment in infrastructure—including roads, energy transmission grids, and communication systems—was highlighted as a foundational requirement. Adjustments to the domestic grid and load balancing mechanisms were mentioned as necessary steps to support energy transition.
- Data collection and analysis emerged as a critical input for policymaking. Some economies, such as Chile, have taken the lead in gathering and analyzing data to identify which strategies are effective.

Financing and Market-Based Mechanisms:

- Mobilizing capital is crucial. Participants proposed leveraging domestic funds and concessional loans to help businesses access the resources needed for equipment upgrades.
- Beyond government support, private capital and market mechanisms must play a role. Public-private partnerships and green venture capital were cited as promising tools.
- Viet Nam proposed conducting energy audits and using the results to attract venture capital investments in new technologies.
- Delegates acknowledged the importance of commercial funding sources, particularly in promoting scalable and sustainable solutions.

Policy and Institutional Support:

- The participants from Chile and Thailand highlighted the importance of clear, detailed policy frameworks. Thailand highlighted the role of energy management systems (EMS) and presented successful examples such as the ESCO models.
- The Indonesian participant talked about the lack of incentive programs for energy efficiency and suggested the need for labeling schemes and fiscal incentives.
- The Chinese Taipei participant shared experience in collecting energy consumption data—especially electricity and gas—while acknowledging challenges in tracking coal consumption and imports.
- Discussions also addressed carbon trading. Viet Nam was noted for having a strong carbon exchange mechanism. The participants raised questions about carbon pricing methodologies and defining carbon credit types.
- The Thailand speaker clarified that in Thailand business-to-business (B2B) Engineering, Procurement, and Construction (EPC) contracts did not require special legislation, as long as they complied with the internationally recognized Measurement and Verification (MRV) protocols accepted by both the ESCO and the customers. However, in the cases where private ESCOs had a contract with the government, certain amendments to laws and regulations, particularly regarding budgeting and procurement, were necessary to accommodate long-term performance guarantees. Currently, the World Bank was supporting Thailand in implementation of ESCO projects in the public sector, which had faced challenges for over 15 years. It was expected that the issue would be resolved this year.

Human Capital and Capacity Building:

- Several economies highlighted the need for investment in training and capacity building not only for government officials but also for enterprises and local communities. Training programs must equip businesses with skills to adjust their operations post-support.
- The establishment of a dedicated team of energy experts was seen as essential to support implementation and ongoing adaptation.

Socioeconomic and Cross-Economy Considerations:

- Attention was drawn to the development gap between economies, and the need to consider income disparities within economies when designing energy efficiency programs.
- Inclusive energy planning should ensure that benefits are equitably distributed, particularly in disadvantaged or rural areas.
- The Chinese participant suggested focusing on energy-intensive sectors such as the cement industry, where targeted interventions could yield significant results.

VI. CONCLUSIONS

In her closing remarks, Ms Pham Quynh Mai (Viet Nam's Senior Official to APEC) observed that the Workshop's participants have had great opportunities for sharing overview of energy needs in the manufacturing sector; opportunities and challenges in promoting energy efficiency in the manufacturing sector; enhancing innovation and finance to promote energy efficiency; sharing experiences and case studies from some APEC member economies; as well as discussing and developing practical recommendations to accelerate energy efficiency in the manufacturing sector.

Through the sharing and discussion of speakers/ experts and floor interventions on policies, best practices, case studies and experiences from member economies during 2 days, a number of key findings and recommendations have been highlighted which might include, but not limited to the followings:

1. **Awareness and education**: It is essential to launch campaigns and raise public awareness and education on the importance and benefits of pursuing and practicing energy efficiency in the manufacturing sector.
2. **Promoting R&D and collaboration**: We must continue to promote research and development, investment, and public-private partnerships through appropriate mechanisms, policies, incentives, and support programs. Collaboration among governments, research institutions, and enterprises as well as international cooperation is vital to support manufacturers to promote energy efficiency (for

example: introduce advanced technologies and participate in the formulation of global standards, etc.,).

3. **Capacity building**: Strengthening capacity and providing technical support are important to help manufacturers improve their understanding and promote the adoption of energy efficiency in an effective and efficient manner.
4. **Access to finance**: Facilitating access to financial resources, such as bank loans, investment capital, energy efficiency credit, green bonds, energy management contract (EMC) model etc., which is critical for manufacturing enterprises to develop and practice energy efficiency;
5. **APEC's role**: APEC should play an active role in promoting sustainable growth in general and sustainable, renewable and efficient energy in particular. This includes fostering cooperation, sharing knowledge, and supporting networking and experience-sharing among member economies.

Mr Pham hoped that each and every member economy's participants could have gained valuable insights and are now better equipped to contribute to the shared goal of green and sustainable growth—tailored to your specific domestic contexts and long-term development strategies.

By hosting this Workshop, Viet Nam wishes to join and strongly support APEC's common efforts in pursuing green economy, sustainable and inclusive growth and development.

VII. ANNEX 1: PRE-WORKSHOP SURVEY RESULTS

1. What are the benefits of promoting energy efficiency in the manufacturing sector?

China

The benefits of improving energy efficiency in the manufacturing industry are numerous. The core advantages include reducing costs, enhancing competitiveness, conserving energy and reducing emissions, and also promoting technological innovation.

Indonesia

Promoting energy efficiency in the manufacturing sector yields significant benefits across economic, environmental, and energy security aspects. Often referred to as the "first fuel," energy efficiency prioritizes using less energy to achieve the same or better outcomes. Some key advantages for the manufacturing sector include:

a. Reduced operational costs: Lower energy consumption leads to substantial savings on utility bills for manufacturers, directly improving their profitability and competitiveness.

b. Reduced greenhouse gas emissions: By decreasing the demand for fossil fuels, the primary source of these emissions, lower energy consumption helps companies and the economy meet climate change mitigation targets. Furthermore, companies can potentially generate additional revenue by selling these emission reductions on the carbon market. Reduced emissions also contribute to a cleaner environment and improved public health.

c. Enhanced energy resilience: A more energy-efficient manufacturing sector becomes more resilient to the volatility of energy prices and disruptions in supply.

In conclusion, promoting energy efficiency is a crucial strategy for a more sustainable and economically sound manufacturing sector.

Papua New Guinea

- Energy efficiency reduces costs, improves competitiveness, and ensures regulatory compliance in manufacturing.
- Upgrading equipment and using renewable energy are key strategies for reducing energy waste.

- Carbon accounting tools streamline emissions reporting, empower data-driven energy efficiency initiatives, and drive meaningful sustainability improvements.

Viet Nam

Promoting energy efficiency in manufacturing offers significant advantages, including:

Economic Benefits:

- Reduced Operational Costs
- Increased Competitiveness
- Accelerated Payback Period

Environmental Benefits:

- Reduced Environmental Impact
- Sustainability Enhancement

Other Benefits:

- Compliance with Regulations
- Improved Productivity
- Enhanced Safety

2. What are the challenges when promoting energy efficiency in the manufacturing sector?

China

Improving energy efficiency in the manufacturing sector is a systemic challenge that requires a multifaceted approach, including technological upgrades, financial support, policy optimization, enhanced awareness, and structural reforms.

Indonesia

Promoting energy efficiency in the manufacturing sector, while offering numerous benefits, faces several challenges, including:

a. High initial investment cost.

b. Lack of awareness and engagement from companies.

c. Lack of technology and technical expertise.

d. Data and measurement challenges.

e. Lack of supportive regulations.

Papua New Guinea

- Outdated Domestic Technical Standards which is not inline with the current Technology.
- Costings and Affordability.
- No proper Testing and Reporting.

Viet Nam

Promoting energy efficiency in Viet Nam's manufacturing sector faces several challenges, including:

- **High Upfront Investment Costs:**

Many energy-saving technologies and projects require significant initial investments, which can be a barrier for businesses, especially small and medium-sized enterprises (SMEs).

- **Lack of Awareness:**

There's a need to raise awareness about the benefits of energy efficiency and the availability of solutions.

- **Technological and Infrastructure Gaps:**

Access to advanced energy-saving technologies and the necessary infrastructure to support their implementation may be limited in certain regions.

- **Lack of Skilled Workforce:**

A skilled workforce capable of designing, implementing, and maintaining energy efficiency projects is crucial, but this is a challenge in some sectors.

3. In your opinion, what strategies do you think are the key for enhancing energy efficiency in manufacturing sector? (Please choose 1-2 options)

Option	Responses (%)
A. Energy audits and assessments	90
B. Process optimization	4
C. Equipment upgrades	6
D. Implementation of renewable energy	0

sources	
E. Energy management systems (EMS)	90

4. Please share some policies/ laws/ regulations that your economy is applying to promote energy efficiency in the manufacturing sector.

China

1.Industrial Energy Efficiency Improvement Action Plan（2022）

2.Energy Efficiency Advanced Level, Energy-Saving Level, and Access Level for Key Energy-Consuming Products and Equipment（2024）

Indonesia

Several regulations in Indonesia aim to promote energy efficiency in the manufacturing sector, including:

a. Law No. 30 of 2007 concerning Energy: This law serves as the primary legal basis for domestic energy management, encompassing energy conservation and efficiency efforts across all stages of energy sector, including the industrial sector.

b. Government Regulation No. 33 of 2023 concerning Energy Conservation: This regulation governs the implementation of energy conservation in both the energy supply and energy demand sectors. One of the mechanisms for implementing energy conservation in the industrial sector, including manufacturing, is the mandatory implementation of energy management for industries that use energy sources and/or energy equal to or greater than 4,000 tons of oil equivalent (TOE) per year.

c. Regulation of the Minister of Energy and Mineral Resources No. 8 of 2025 concerning Energy Management: This regulation is a derivative regulation of Government Regulation No. 33 of 2023 and details energy management. It covers energy management activities, the development of energy efficiency programs, audits, financing, incentives and disincentives, and the application of carbon economic value.

d. Regulations from the Minister of Industry of the Republic of Indonesia concerning Green Industry Standards for each type of industry: These regulations also support the implementation of energy efficiency in respective industrial sectors, including: the Flat Steel Industry (Regulation of the Minister of Industry No. 45 of 2024) and the Portland Cement Industry (Regulation of the Minister of Industry No. 26 of 2018).

Papua New Guinea

In Papua New Guinea, the regulation of electrical appliances and equipment is primarily governed by various laws and standards aimed at ensuring safety, efficiency, and compliance with domestic standards.

Domestic Energy Authority (NEA) Act 2021

APPROVAL OF ELECTRICAL APPLIANCES.

1. For the purposes of Section 108 of the NEA Act, the Regulator may grant

a. A certificate of suitability in Form 2 of Schedule I in respect of an electrical appliance; or

b. A certificate of approval in Form 3 of Schedule I in respect of a prescribed electrical appliance, that it is satisfied has passed the requisite examination and tests and conforms to the relevant published publication.

2. The Regulator may, by notice in the Domestic Gazette, approve a minimum safety standard in a published specification for an electrical appliance notwithstanding that the standard is a modification or variation of a published specification relating to the appliance, and may grant a certificate of suitability or a certificate of approval for such an electrical appliance if it is satisfied that it is satisfactory for the purpose for which it is intended to be used.

3. Each a certificate of suitability or certificate of approval shall be numbered in a manner determined by the Regulator.

Viet Nam

Viet Nam is actively promoting energy efficiency in its manufacturing sector through a combination of policy initiatives, financial incentives, and technological advancements.

Some of key policies and initiatives include:

a. The Viet Nam Domestic Energy Efficiency Programme (VNEEP):

This program, with its current iteration (VNEEP3) running from 2019 to 2030, sets targets for energy savings and efficiency improvements in various sectors, including manufacturing.

b. VSUEE (Viet Nam Scaling Up Energy Efficiency Project):

This project, funded by the Green Climate Fund (GCF), provides credit guarantees and financial support to energy-efficient enterprises, encouraging investment in energy-saving technologies and practices.

c. Financial Incentives:

The government provides various incentives, such as exemptions from land use and rental fees, to attract investment in energy-efficient projects and renewable energy sources.

d. Promoting Renewable Energy:

Viet Nam is actively promoting renewable energy sources, including rooftop solar power and wind power, to reduce reliance on fossil fuels and increase the share of clean energy in the power mix.

e. Technical Support and Capacity Building:

The Ministry of Industry and Trade (MoIT) and its partners provide technical assistance and capacity-building programs to help manufacturers implement energy efficiency measures and adopt best practices.

f. Energy Audits and Management Systems:

Encouraging manufacturers to conduct energy audits and implement energy management systems (EMS) helps identify areas for improvement and optimize energy consumption.

g. Promoting Excess and Waste Heat Recovery:

Encouraging the recovery and utilization of excess and waste heat in industrial processes can significantly reduce energy consumption and generate additional power.

h. Amendments to the Law on Economical and Efficient Use of Energy:

The government is working on amending the law to update provisions and ensure it aligns with current challenges and goals, including achieving net-zero emissions by 2050.

5. If possible, please share a case study/ case studies where a company in manufacturing sector successfully promoting/applying energy efficiency in your economy.

China

Beijing Yanjing Brewery Co., Ltd. has implemented the renewal and reconstruction of its beer bottle filling production lines as part of an energy system optimisation and energy-saving technology reconstruction project.

The construction site is located at No. 9 Shuanghe Road in the Shunyi District, Beijing, where four old glass bottle filling production lines are being replaced with two new, high-efficiency ones. These new production lines improve thermal efficiency and reduce steam usage by increasing heat recycling and minimising heat dissipation. Through the energy-saving technological transformation, the project can achieve annual energy savings of 2,225 tonnes of standard coal.

Indonesia

One notable success story in the implementation of energy efficiency through energy management within the manufacturing sector is exemplified by PT Chang

Shin. PT Chang Shin is a footwear manufacturing industry located in West Java, Indonesia.

Over a three-year improvement period, PT Chang Shin achieved a significant energy performance improvement of 13%. The total energy cost savings realized amounted to USD808,382, with a relatively modest cost of USD488,697 for implementing the Energy Management System (EnMS). During this improvement period, the factory also contributed to a substantial CO2eq emission reduction of 7,565 metric tons.

Several key activities were undertaken by PT Chang Shin, including efficient machine control implementation, installation of an oxygen controller for the boiler, rigorous inspection to reduce air compressor leakage from 25% to 10%, installation and maintenance of air preheater performance for boiler efficiency enhancement, installation of insulation between hot and cold stations to minimize heat loss, and the replacement of inefficient motors with more efficient IE3 motors.

In recognition of its successful energy management implementation, PT Chang Shin was also awarded Winner at the Clean Energy Ministerial (CEM) 2024.

Papua New Guinea

In the case of PNG, most of the Electrical Appliances and Equipment are important from other economies especially China. The NEA as the Regulator have established its Regulatory Framework for Importers and Suppliers to comply by making sure they are tested, and quality verified before issuance of Certificate of Approval by the Regulator.

Viet Nam

Several Vietnamese manufacturing companies have successfully implemented energy-efficient practices, leading to significant cost savings and reduced environmental impact. Examples include: Saigon Dairy Factory (Vinamilk), Thang Nam Forestry Joint Stock Company, and SCM Metal Viet Nam Co., Ltd., each utilizing various energy-saving strategies. These case studies highlight the effectiveness of proactive solutions and investments in energy-saving initiatives.

a. Saigon Dairy Factory (Vinamilk):

- Proactive Energy Efficiency:

Vinamilk has become a leading example of energy efficiency through proactive solutions and investments in energy-saving initiatives.

- Focus on Efficiency:

The company's focus on energy-efficient equipment, optimized processes, and employee training has resulted in substantial energy consumption reductions.

b. Thang Nam Forestry Joint Stock Company:

- Comprehensive Energy-Saving Measures:

Thang Nam has implemented a range of energy-saving measures, including optimizing machinery and processes, improving lighting, and utilizing renewable energy sources.

- Reduced Energy Consumption:

As a result of these efforts, Thang Nam has significantly reduced energy consumption per unit of product, demonstrating the practical impact of energy efficiency.

c. SCM Metal Viet Nam Co., Ltd.:

- Inverter Installation:

SCM Metal has seen positive results from installing inverters for its furnace, leading to improved efficiency and reduced energy consumption.

- Specific Savings:

The installation of inverters resulted in measurable cost savings and reduced energy waste.