Asia-Pacific Economic Cooperation

Advancing Free Trade for Asia-Pacific **Prosperity**

APEC TECHNOLOGY EMPOWERS LOW CARBON ACTION (TELCA)

Best Practice Report

APEC Policy Partnership on Science, Technology and Innovation

November 2024

Asia-Pacific
Economic Cooperation

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List of Acronyms

APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
BEEO	Building Energy Efficiency Ordinance
CCUS	Carbon Capture, Utilization, and Storage
EAF	Electric Arc Furnace
EGEDA	Expert Group on Energy Data Analysis
EV	Electric Vehicle
GHG	Greenhouse Gas
HVAC	High-efficiency Heating, Ventilation, and Air Conditioning
HVAL	High Volume Low Speed
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JETP	Just Energy Transition Partnership
PPP	Public-Private Partnership
R&D	Research and Development
SMR	Small Modular Reactor
TELCA	Technology Empowers Low Carbon Action
TRL	Technology Readiness Level

Glossary

Carbon Capture, Utilization, and Storage (CCUS)	A technology aimed at reducing carbon dioxide emissions by capturing CO_2 from industrial processes or power plants, utilizing it in products like building materials, or storing it underground in geological formations.
Electric Vehicles	Vehicles powered by electric motors, using energy stored in batteries or fuel cells instead of gasoline or diesel.
Greenhouse Gas (GHG)	Gases that trap heat in the Earth's atmosphere, leading to global warming and climate change. Major greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.
Just Transition	A framework for ensuring that the shift to a sustainable economy is fair and inclusive. It emphasizes the protection of workers' rights, the creation of quality jobs, and equal access to opportunities as economies move away from fossil fuels. Just Transition also addresses the social, economic, and environmental challenges faced by vulnerable and underrepresented groups, including women, rural communities, and individuals in industries impacted by the shift to sustainable practices.
Low-Carbon Technology	Technologies designed to reduce carbon emissions across various sectors, including energy, transportation, and industry. These technologies aim to minimize the carbon footprint by enhancing energy efficiency, transitioning to renewable energy sources, and implementing carbon capture methods.
Sectoral Carbon Emissions	The carbon dioxide (CO_2) and other greenhouse gas emissions released by specific economic sectors, such as energy, transportation, agriculture, industry, and waste.
Technology Readiness Level	A method for assessing the maturity of a particular technology through nine levels, ranging from basic principles (TRL 1) to a fully developed and operational technology in real-world conditions (TRL 9).
Urban Waste Characterization	The process of analyzing and categorizing waste generated in urban areas to better understand its composition and develop appropriate management strategies.
Vulnerable Groups	Communities that are disproportionately affected by the negative impacts of climate change or other social issues, such as women, children, the elderly, low-income households, indigenous peoples, and rural communities.

Acknowledgments

The APEC Technology Empowers Low Carbon Action (TELCA) report has been made possible through the collaboration, expertise, and dedication of many individuals and organizations. We would like to extend our sincere gratitude to everyone who contributed to the development of this important work.

Firstly, we would like to thank the APEC economies for their active participation and invaluable insights. The contributions from representatives of Australia; Canda; Chile; China; Hong Kong, China; Indonesia; Japan; Republic of Korea; Malaysia; Mexico; Peru; The Philippines; Russia; Singapore; Thailand; The United States; and Viet Nam, have been instrumental in shaping this report, bringing together a diverse range of perspectives on sustainable development and low-carbon technologies.

We are particularly grateful to the APEC Secretariat Policy Support Unit for their guidance, support, and expert knowledge in fostering dialogue on sustainability and climate action within the APEC region.

Our heartfelt appreciation goes to Dr Jieni Guo, Secretary General of the Beijing International Exchange Association and Project Overseer, along with her dedicated team, for organizing the APEC TELCA project, which served as the foundation for much of the content in this report. Their logistical and organizational support made the event a great success, facilitating rich exchanges of ideas and best practices.

Special thanks are due to the experts, policymakers, and industry leaders who participated in interviews and roundtable discussions. Your insights have provided depth and clarity to the report's findings, helping to identify critical barriers and opportunities in the transition to a low-carbon economy.

Finally, we express our appreciation to the startups, innovators, and technology providers who shared their groundbreaking work in low-carbon technologies. Your creativity and determination are paving the way for a more sustainable and energy-efficient future.

On a personal note, I would like to extend my deepest thanks to my family for their unwavering support throughout this journey, especially to my parents Han Zongyu and Chen Jilan. I regret that I have not been able to spend as much time with them as I would have liked due to my work commitments. I hope to make it up to them soon by planning a special trip together, as they deserve nothing less for all their love and patience. Your support has been my strength, and I look forward to creating more memories with you.

I would also like to take a moment to acknowledge myself. This journey has not only been about professional achievements but also about personal growth. I have learned valuable lessons along the way and have gained a deeper understanding of my role in driving change. As I look ahead, I see this report as another milestone in my life and a reminder to continue striving for progress. Our commitment to digital inclusion and gender equality remains steadfast, as these two key agendas are at the heart of our company's mission and my personal passion. I look forward to further advancing these causes, both within APEC and globally.

Together, we hope this report will serve as a valuable resource for policymakers, businesses, and stakeholders across APEC as we continue our collective journey toward a low-carbon, sustainable future.

Thank you all for your dedication, passion, and commitment to advancing the goals of the APEC TELCA initiative.

EXECUTIVE SUMMARY

The APEC TELCA research report delivers an in-depth analysis of innovative low-carbon technologies across key sectors – electricity and heat generation, transport, industry, buildings, and individual actions - within the Asia-Pacific Economic Cooperation (APEC) economies. This report utilizes a robust methodology including literature reviews, case studies, and expert interviews to extract actionable insights, practical policies, and assess the effectiveness of these technologies in promoting sustainability and economic growth.

The research initiates with an in-depth review of sectoral carbon emissions based on the International Energy Agency's (IEA) data, focusing on identifying the most pressing sectors both globally and within APEC economies. Through expert interviews across various economies, the report explores the challenges and opportunities in adopting low-carbon technologies, providing a deeper understanding of how different regions are navigating their transition to a low-carbon future.

The report also examines key technologies targeting the highest emitters within these sectors, offering valuable insights into the practical applications of these technologies to reduce carbon emissions.

The report concludes with tailored policy recommendations and the APEC TELCA Principles aimed at enhancing the adoption of green technologies across APEC economies. These recommendations and principles are aimed at fostering a collaborative approach to environmental challenges, ensuring that sustainability is integrated into the fabric of economic development strategies within the APEC region. In which, it underscores the importance of a Just Transition, ensuring that the shift to low-carbon technologies is fair and inclusive, particularly for underrepresented and vulnerable groups. This focus on equality is essential to ensuring that all communities benefit from the transition to a sustainable future.

1

INTRODUCTION

The APEC TELCA project is a strategic initiative designed to leverage innovative low-carbon technologies across key sectors within the APEC economies to foster sustainable development and address the urgent challenges of climate change. The project's primary goal is to catalyze the shift towards low-carbon economies, thereby enhancing environmental sustainability, economic stability, and social well-being throughout the region.

Climate change represents a critical threat to global ecosystems and human populations, particularly within the APEC region which faces unique vulnerabilities due to its geographical and economic diversity. Addressing this global issue through the adoption of low-carbon technologies is essential for mitigating environmental impacts such as increased pollution and greenhouse gas (GHG) emissions. Such technologies not only help in reducing carbon footprints but also play a crucial role in enhancing economic resilience by fostering new industries and reducing dependency on fossil fuels.

The proactive exploration and promotion of technologies to reduce emission by the project is crucial for ensuring sustainable development. This initiative supports the global transition towards energy systems that are not only environmentally viable, but also economically and socially beneficial. By effectively implementing the insights derived from this project, APEC economies can pave the way for a sustainable future, demonstrating global leadership in tackling the climate change issue.

The primary purpose of the project was to identify, evaluate, and promote the adoption of low-carbon technologies that can significantly reduce carbon emissions and enhance energy efficiency. The key research objectives included:

· *Identifying the most pressing industries in APEC economies for carbon reduction.*

· *Identifying and assessing the effective technologies in key sectors.*

· *Introducing effective government policies to support technological innovation and enhance environmental sustainability.*

· *Compiling best practices and lessons learned.*

· *Producing policy recommendations and the APEC TELCA Principles.*

The project explored the following four critical questions to guide its research and outputs:

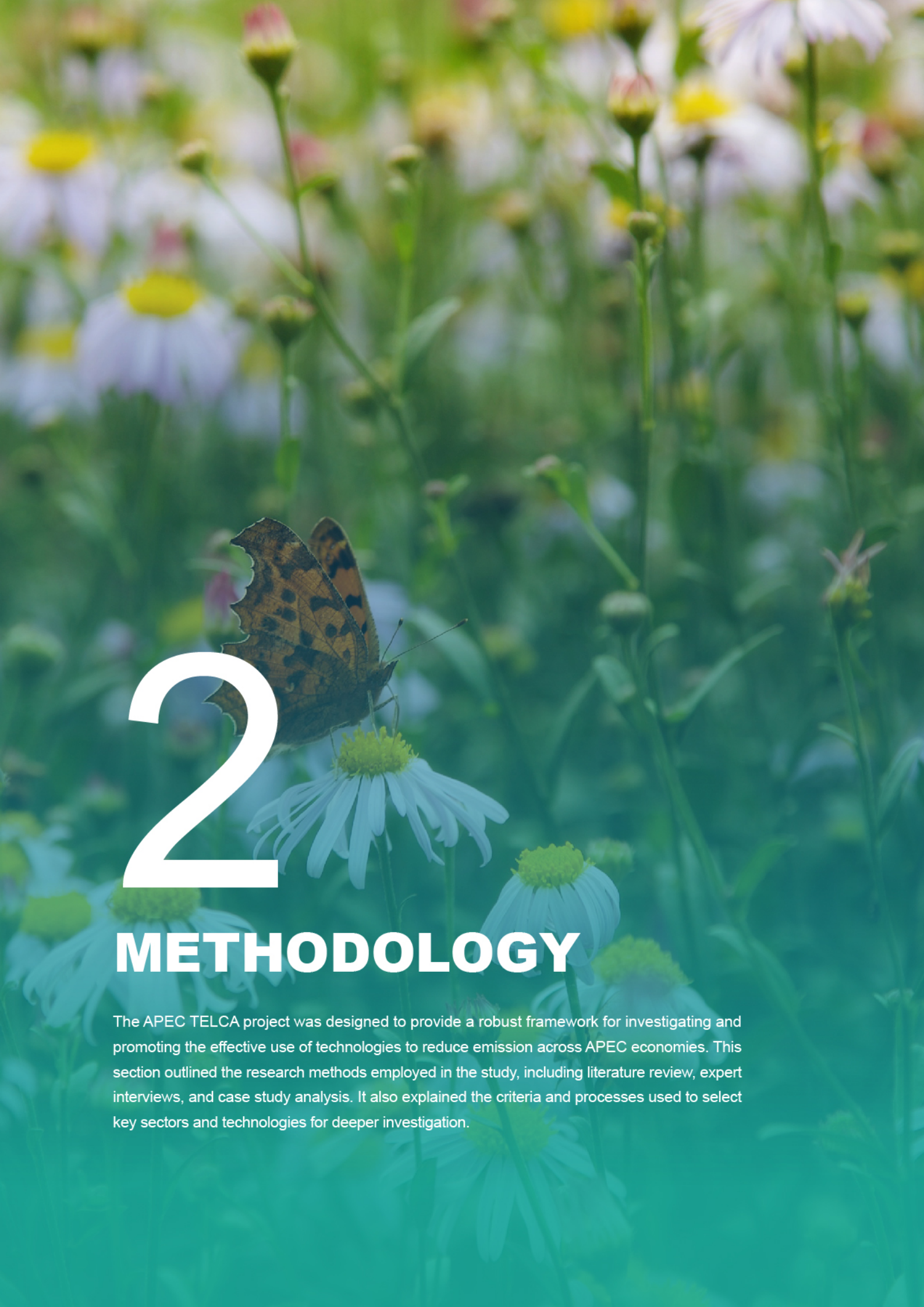
· *Which sectors are the most pressing for carbon reduction both globally and within APEC?*

· *What are the current technologies being implemented to reduce carbon emissions in the key sectors?*

· *How do governments in APEC economies formulate and implement policies to support the sustainable development? Particularly in promoting the adoption and scaling of technologies for carbon reduction.*

· *What are the barriers (e.g., financial, regulatory, cultural) and facilitators (e.g., incentives, education, infrastructure) to technology adoption in these key sectors?*

By focusing on key five sectors, including electricity and heat generation, transport, buildings, industry, and individual actions, the APEC TELCA sought to develop a comprehensive understanding of how these technologies can be integrated effectively. The project encompassed extensive research activities, including literature reviews, expert interviews, and case studies, aimed at compiling actionable data that will inform policy development and strategic decision-making.



2 METHODOLOGY

The APEC TELCA project was designed to provide a robust framework for investigating and promoting the effective use of technologies to reduce emission across APEC economies. This section outlined the research methods employed in the study, including literature review, expert interviews, and case study analysis. It also explained the criteria and processes used to select key sectors and technologies for deeper investigation.

2.1 Literature Review

The research began with a thorough review of existing literature focused on the decarbonization of pressing sectors at both the global and APEC levels. This included examining the policies of key APEC economies and their impacts on carbon emissions within these sectors, as well as exploring the role of specific technologies in reducing emissions. The literature review covered academic papers, industry reports, APEC reports, policy documents, and other relevant publications.

The selection of research articles involved using specific search queries and keywords related to the research questions. Identified articles were then screened based on their relevance to the inclusion and exclusion criteria through title and abstract screening.

The main objectives of the literature review were not only to identify gaps in existing research but also to provide a contextual backdrop for the project's subsequent phases. The process focused on the key research questions:

· *Which sectors are the most pressing for carbon reduction both globally and within APEC?*

· *What are the current technologies being implemented to reduce carbon emissions in the key sectors?*

· *How do governments in APEC economies formulate and implement policies to support the sustainable development? Particularly in promoting the adoption and scaling of technologies for carbon reduction.*

· *What are the barriers (e.g., financial, regulatory, cultural) and facilitators (e.g., incentives, education, infrastructure) to technology adoption in these key sectors?*

Key industries were identified in this phase, guided by the IEA's data and research on sectoral carbon emissions. The analysis focused on pinpointing the top emitters within each sector, followed by categorizing and evaluating technologies that specifically target and reduce these high emissions. This approach ensures that the selected technologies are directly aligned with addressing the most significant sources of carbon emissions in each industry.

2.2 Expert Interviews

Semi-structured interviews were conducted with eight experts from six APEC economies. These interviews aimed to gather qualitative insights into the landscape, trends, opportunities, and obstacles associated with the adoption of technologies, and policy development of key APEC economies.

Experts included policymakers, industry leaders, academics, and representatives from the public and private sectors. The selection of experts was based on their expertise and experience in fostering sustainable development through policy, research, and technological innovation.

The interviews involved seventeen tailored questions for the public and private sectors, respectively. The interviews explored open-ended questions to gather in-depth information on the key trends, challenges and opportunities, as well as the strategies and technologies.

A thematic analysis was employed to analyze the interviews. This method involved coding the interview transcripts to identify recurring themes and patterns across different responses. Key themes such as barriers to technology adoption, policy impacts, and innovative practices were systematically identified and categorized. By

organizing the data into these themes, the analysis provided deeper insights into the shared challenges and opportunities faced by APEC economies in reducing carbon emissions through technology adoption.

2.3 Case Study Analysis

Twenty case studies in the five sectors from nine APEC economies were selected and meticulously analyzed to demonstrate real-world applications and the impacts of technologies in reducing emissions. These case studies showcased successful implementations and the practical challenges of integrating these technologies. Analysis of these cases helped identify best practices, barriers to implementation, and measurable outcomes.

Technologies were chosen based on their proven ability to reduce carbon emissions and their alignment with the identified key industries. The selection process also considered the technology's maturity (Technology Readiness Level or TRL), cost-effectiveness, and potential for broader implementation across multiple APEC economies.

3

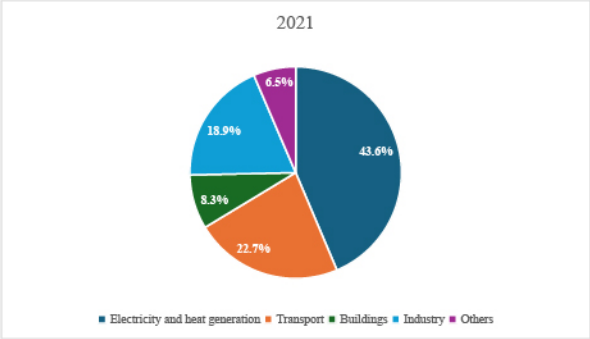
LITERATURE REVIEW

This literature review systematically explores the decarbonization efforts in key sectors both globally and within APEC economies, emphasizing the most pressing areas for carbon reduction. The review begins by identifying the primary sectors contributing to global and regional emissions in APEC, guided by the IEA's research. Following this, the review delves into the policies implemented by key APEC economies, examining their impacts on carbon emissions within these sectors. The final section introduces specific technologies that contribute to reducing emissions in the identified key sectors. By translating policy needs and sectoral challenges into actionable technological solutions, this review offers practical insights for stakeholders looking to advance sustainable practices within the APEC region.

3.1 Most Pressing Sectors' Decarbonization at Global and APEC Level

Globally, the electricity and heat generation, remains the largest source of GHG emissions, accounting for 43.6% of global emissions in 2021 (IEA, 2024). This is followed by the transport sector, responsible for 22.7% of emissions, and the industrial sector, contributing 18.9%. The building sector, though smaller in comparison, still represents a significant 8.3% of global emissions. Notably, GHG emissions in the industry, buildings, and transport sectors continued to grow, driven by an increase in the global demand for products and services (IPCC, 2022).

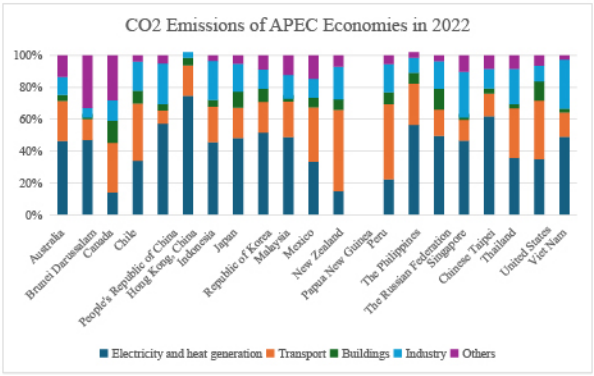
While others including emissions from agriculture and forestry, fishing, other energy industry own use, and other final consumption not elsewhere specified, accounted for 6.5% of global emissions.



Our World in Data (Ritchie, 2020) also showed similar rankings in a global level in 2020, the biggest contributor is the electricity and heat, following by transport, manufacturing and construction, agriculture, fugitive emissions, industry, and buildings.

In the APEC region, these trends are similar, according to IEA's data in 2022. Electricity and heat generation dominate emissions due to the reliance on fossil fuels. The industry sector, especially ineconomies with significant manufacturing bases, remains a major source of emissions. This trend is consistent across both developed and developing economies, though the scale varies.

The transport sector in APEC is also a growing contributor, driven by increased vehicle ownership, urbanization, and expanding transportation networks in developing economies. The buildings sector, as economies develop, there is a noticeable increase in emissions from this sector due to rapid urbanization, the expansion of infrastructure, and higher energy demands in residential and non-residential buildings.

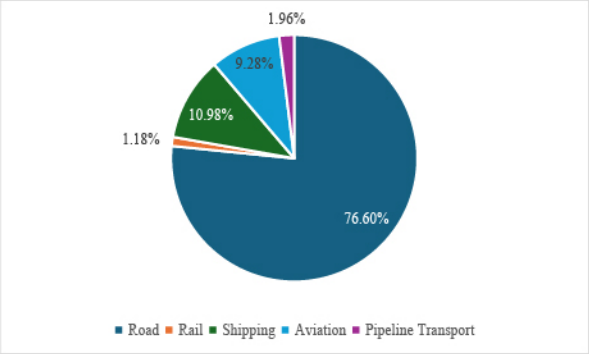


Among the key sectors, the electricity and heat generation sector's emissions are primarily from the burning of coal, oil, and natural gas (IPCC, 2022). In 2022, emissions from coal-fired electricity and heat generation in the global level increased by 2.1%, continuing to make coal the predominant contributor to emissions within this sector (IEA, 2022).

This trend is reflected in the APEC region as well. According to the data of the APEC Expert Group on Energy Data Analysis (EGEDA, 2023) in 2021, coal share of the total primary energy supply reached 34.6%, followed by oil (27.4%), gas (23.9%), renewables (8.3%), and others (5.8%).

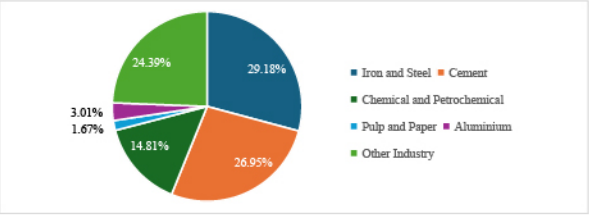
In the transport sector, road transportation primarily

reliant on petroleum, accounts for the majority of emissions (IEA, 2022; Moran & del Rio Gonzalez, 2007). Its' emissions accounted for 76.60% of the total energy consumption by the transportation sector in 2021 (IEA, 2022) and even 81% in Chapman's study (2007). It followed by the shipping industry (10.98%), aviation industry (9.28%), and others (IEA, 2022). A similar pattern is observed in APEC economies, where road transportation remains dominant in the market (APEC, 2023).

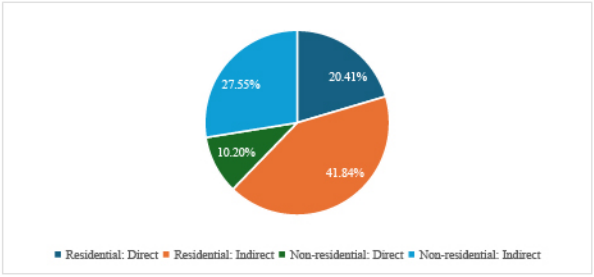


Many economies' emissions' reduction was realized in the electricity and heat sector, industry and buildings, while in many cases transport emissions have increased since economies reached their overall emissions peak (Climate Transparency 2021; Lamb et al. 2021a).

In the industry sector, the top three emitters worldwide in 2022 were iron and steel, cement, and chemicals and petrochemicals, with these industries leading in GHG emissions (IEA, 2022). In the APEC region, chemicals and petrochemicals, iron and steel, and non-metallic minerals were the three largest energy-consuming and GHG emissions subsectors (APEC, 2019).



For the buildings sector in 2022, indirect emissions, from the energy required for electricity and heat generation to supply residential and non-residential buildings, were the largest contributors. Additionally, direct emissions from residential buildings (e.g. gas used for cooking and space heating, and heat pumps) surpassed those from non-residential buildings, highlighting the significant impact of household energy use on overall emissions (IEA, 2022).



Reducing carbon emissions cannot be achieved without the active participation of individuals. According to the IEA (2021), individual actions play a critical role in driving demand for energy-related goods and services, and behavioral changes can significantly contribute to a sustainable future. By adopting energy-efficient habits and improving material efficiency, IEA estimated that around 8% of global emissions could be reduced.

Individuals can contribute to energy savings and carbon reduction in various ways. This includes making investments such as installing solar panels or purchasing energy-efficient appliances, adjusting daily habits like optimizing air conditioning use, and switching to suppliers that offer green electricity (Niamir and Filatova, 2017).

In summary, the electricity and heat generation, transport, industrial, and building sectors stand out as the most pressing contributors to global and APEC level CO2 emissions. The dominance of fossil fuels, particularly coal, in electricity and heat

production, along with the significant emissions from road transport and key industrial processes, underscores the critical need for targeted decarbonization strategies. Addressing these sectors is essential for APEC economies to meet their climate goals and foster sustainable economic growth, with individual actions also playing a vital role in driving down emissions.

3.2 Governmental Policies Supporting Decarbonization

As of 2023, 19 APEC economies have committed to achieving carbon neutrality by 2050 or 2060, implementing various policies to support carbon reduction and the adoption of low-carbon technologies. These policies often include incentives like subsidies and tax breaks to encourage transformation and green technology uptake.

For instance, China outlined the strategic plan for advancing green, low-carbon, and high-quality development (The State Council of the People's Republic of China, 2024). Key areas of focus included optimizing domestic land and resource development, transforming industrial structures, promoting green energy and transportation, and encouraging green consumption. The policy aimed for significant progress by 2030, with the goal of achieving a green, low-carbon economic system by 2035. The document also emphasized the importance of international cooperation, legal support, and the integration of digital technologies in driving this transformation.

3.2.1 Electricity and Heat Generation

Across APEC economies, policies have been actively targeting the decarbonization of the electricity and heat generation sector, which is the largest source of GHG emissions (Asia Pacific Energy Research Centre, 2024).

China's Energy Plan and Renewable Energy Law aimed to increase the share of non-fossil fuels and promote renewable energy through incentives such as feed-in tariffs. This has led to a gradual decline in coal's share of electricity production and a significant rise in renewable energy, especially in the past decade. As of June 2024, this shift resulted in wind and solar energy collectively surpassing coal in capacity, marking a milestone in China's energy transition, according to China's National Energy Administration (NEA).

The USA announced a historic USD20 billion in awards as part of the Environmental Protection Agency's Greenhouse Gas Reduction Fund (The White House, 2024). These funds aimed to expand access to clean energy and climate solutions for the industry sector, focusing on low-income and disadvantaged communities. Similarly, Japan's Strategic Energy Plan and Feed-in Tariff System focused on integrating renewable energy into the grid, reducing dependence on fossil fuels. The Republic of Korea's Renewable Energy 3020 Implementation Plan also aimed to boost the share of renewables, with substantial investments in solar and wind power infrastructure. In 2023, Viet Nam introduced the National Energy Master Plan (NEMP) for 2021-2030, with a vision extending to 2050. The NEMP sets forth a comprehensive strategy to secure energy supplies and promote

sustainable economic growth. Key targets include enhancing energy security, reducing carbon emissions by 17–26% by 2030 and approximately 90% by 2050, and significantly increasing the share of renewable energy to 15–20% by 2030 and 80–85% by 2050. These policies are essential in accelerating the transition to cleaner energy systems across the region.

3.2.2 Transport

The transport sector is a major and expanding source of emissions across APEC economies, prompting various policies aimed at promoting low-carbon transportation. For example, China; Japan; and Republic of Korea have introduced subsidies and incentives to accelerate the adoption of electric vehicles (EVs) and the development of EV infrastructure.

Thailand rolled out the EV incentives from 2024 to 2027 to boost EV adoption and manufacturing. Incentives included subsidies of THB50,000 to THB100,000 (~USD1,450 – USD3,000) for EVs, reduced excise tax from 8% to 2%, and a customs tax reduction of up to 40%. Singapore's Green Plan 2030 included targets to increase public transport usage and promote cleaner vehicles, such as hybrids and EVs. Further, this economy's EV Early Adoption Incentive provided a 45% reduction in the Additional Registration Fee (ARF) for electric vehicle owners, capped at USD11,500, tax rebates of up to USD3,800 for some EVs, and a 34% reduction in road tax for electric and hybrid vehicles. These policies reflected a broader trend within APEC economies to reduce transport emissions by transitioning to cleaner, more efficient technologies.

3.2.3 Industry

The industry sector, particularly in economies with large manufacturing bases, is another major contributor to emissions. China's industrial policies emphasized energy efficiency improvements and the adoption of clean technologies in heavy industries like steel, cement, and chemicals. According to the State Council of the People's Republic of China (2024), it aimed to promote the green and low-carbon transformation and upgrading of traditional industries, including “Vigorously promote the green and low-carbon transformation of industries such as steel, nonferrous metals, petrochemicals, chemicals, building materials, papermaking, printing and dyeing, promote energy-saving, low-carbon and clean production technology and equipment, and promote the updating and upgrading of process flows. Optimize the scale and layout of production capacity, continuously update binding standards such as land, environment, energy efficiency, water efficiency and carbon emissions, lead the optimization and upgrading of traditional industries with the improvement of standards, and establish and improve the capacity withdrawal mechanism. Reasonably raise the resource and environmental access thresholds for new construction, renovation and expansion projects, and resolutely curb the blind launch of high-energy-consuming, high-emission and low-level projects.”

The USA announced a historic USD6 billion investment to transform the industrial sector by funding 33 projects across various high-emission industries like steel, cement, and chemicals (U.S.A. Department of Energy, 2023). The sector contributed newly one-third of the economy's overall GHG emissions. This initiative aimed to significantly reduce greenhouse gas emissions,

strengthen domestic manufacturing, and create tens of thousands of jobs, particularly in disadvantaged communities. These projects were expected to cut over 14 million metric tons of CO2 annually, equivalent to the emissions from 3 million gasoline-powered cars. Japan's Strategic Energy Plan also included measures to decarbonize its industrial sector through technological innovation and energy conservation. Republic of Korea's focused on the Renewable Energy 3020 Implementation Plan similarly includes initiatives to reduce emissions from industrial processes by promoting energy efficiency and low-carbon technologies.

3.2.4 Buildings

APEC economies are increasingly focusing on the building sector to reduce emissions through policies that promote energy efficiency and sustainable building practices. Hong Kong, China's Building Energy Efficiency Ordinance (BEEO) mandated energy-saving measures in commercial buildings, while Singapore's Green Plan 2030 set ambitious targets for reducing energy consumption in buildings through improved efficiency and increased use of renewable energy.

Canada's 2022 Budget allocated CAD150 million (~USD110 million) to develop the Canada Green Buildings Strategy and launch the Codes Acceleration Fund (Natural Resources Canada, 2023). Building on this, Budget 2024 will invest an additional CAD903.5 million (USD670 million) into the strategy, focusing on reducing building emissions and lowering home energy bills. This will be achieved by supporting energy-efficient retrofits, enhancing building codes, and promoting home energy labeling. These policies are critical in addressing the growing emissions from the building sector, particularly in rapidly urbanizing economies.

3.2.5 Individual Action

Individual actions are recognized as vital in the overall effort to reduce carbon emissions. The Environmental Protection Departmentof Hong Kong,China,developed the GREEN@COMMUNITY recycling network (2024), which includes Recycling Stations, Stores, and Spots across all 18 districts. The network had around 380 public collection points for various recyclables like paper, plastics, and glass. To encourage participation, the GREEN$ Electronic Participation Incentive Scheme allowed the public to earn points through the GREEN$ app or smart card by recycling, which can be redeemed for gift items. Additionally, environmental education and promotional activities were organized to promote a green lifestyle.

In Japan and Republic of Korea, government initiatives encouraged households to adopt energy-efficient appliances and renewable energy solutions such as rooftop solar panels. Singapore's policies also included public awareness campaigns to promote energy-saving behaviors and the adoption of green technologies at the individual level. These efforts are complemented by incentives and programs designed to make sustainable choices more accessible to the general public.

3.3 Technologies for Key Sectors

The decarbonization of key sectors such as electricity and heat generation, transport, industry, buildings, and individual actions is crucial for achieving global climate goals. Each of these sectors contributes significantly to global GHG emissions, and various technologies have been developed to mitigate their impact.

However, the deployment of these technologies is accompanied by several challenges, including high costs, infrastructural limitations, and the need for supportive regulatory frameworks.

This literature review explores the current state of technologies in each sector, highlighting their potential and the obstacles to their widespread adoption.

3.3.1 Electricity and Heat Generation

The sector is the largest contributor to global GHG emissions, making it a critical focus for decarbonization efforts (IEA, 2023). Multiple technologies have been implemented and developed to reduce carbon emissions. Wind and solar are the most prominent renewable energy sources (Viviescas, etc., 2019). They have seen significant growth due to technological advancements that have reduced costs and improved efficiency.

Produced via electrolysis using renewable energy, green hydrogen is a versatile energy carrier that can be used for electricity generation, heating, and as a fuel for transportation (Vidas & Rui, 2021). Hydrogen fuel cells, which convert hydrogen into electricity, offer a promising solution for reducing carbon emissions in the electricity and heat generation sector. The main methods of producing hydrogen include hydrocarbon reforming, thermochemical biomass processes, biological biomass processes, and water splitting (Vidas & Rui, 2021). However, the development of cost-effective and efficient electrolyzes, along with the establishment of infrastructure for hydrogen production, storage, and distribution, are critical for the large-scale adoption of hydrogen energy (Olabi, etc., 2021).

Nuclear energy also provides a low-carbon alternative to fossil fuels. Advanced reactor designs, such as Small Modular Reactors (SMRs), are being developed to enhance safety, reduce costs, and provide flexible power generation (Michaelson & Jiang, 2021). Nuclear fusion, though still in experimental stages, holds the promise of providing nearly limitless, low-carbon energy. However, public perception, safety concerns, waste disposal, and high capital costs remain significant barriers to the expansion of nuclear energy (Goodfellow, Williams, & Azapagic, 2011).

3.3.2 Transport

The transport sector is a significant contributor to global carbon emissions, and addressing this requires the deployment of innovative technologies and strategies. The primary focus areas for reducing emissions include the development and adoption of EVs in the road transportation, advancements in public transportation, and logistics optimization.

One of the main technologies for the transport companies are utilizing is by transitioning to electric and hybrid vehicles (APEC, 2023). The deployment of EVs is supported by advancements in battery technology, such as lithium-ion batteries, which have seen significant improvements in energy density, charging speed, and cost reduction. Companies such as Tesla, Rivian, and Ford are leading the way in producing electric trucks, which can haul heavy loads while emitting low emissions. However, challenges remain, including the underdevelopment of fast-charging networks, which limits the convenience and widespread adoption of EVs compared to conventional vehicles.

Enhancing public transportation systems and promoting shared mobility options are crucial for reducing the overall carbon footprint of the transport sector (APEC, 2023; Gordon, 2023). Electrification of public buses, trains, and other mass transit systems significantly reduces emissions per passenger-kilometer. Additionally, the development of shared mobility platforms, such as ride-hailing services, bike-sharing, and carpooling, can reduce the number of vehicles on the road, thereby lowering emissions (APEC, 2023). Nonetheless, the success of these initiatives depends on cultural shifts towards accepting shared mobility over personal vehicles. Furthermore, developing the necessary infrastructure, such as charging stations for electric buses and bike-sharing networks, requires substantial capital investment.

Improving the efficiency of logistics and supply chain operations is another critical area for reducing carbon emissions (Marchi & Simone, 2017). Technologies such as advancedtelematics, route optimization software,and the use of autonomous vehicles can minimize fuel consumption and emissions by ensuring that goods are transported in the most efficient manner possible. However, the implementation of autonomous vehicle technology is still in its developmental stages, facing regulatory, safety, and public acceptance challenges. Additionally, integrating advanced logistics technologies across fragmented supply chains can be complex and costly. The effective use of telematics and optimization software also raises concerns regarding data privacy and security, given the vast amounts of data required (McDonnell, etc., 2021).

3.3.3 Industry

The industrial sector is a major contributor to global GHG emissions, making emission reduction efforts in this area crucial for achieving climate goals. Various technologies are being developed and implemented to reduce these emissions effectively.

Energy efficiency remains the most effective strategies for reducing carbon emissions in the sector. Key improvements include upgrading equipment, optimizing processes, and implementing energy management systems. For instance, in steel production, energy-efficient technologies such as continuous casting and advanced furnace designs are employed to lower energy consumption (Wang, etc., 2020). In cement manufacturing, methods like pre-calcination and waste heat recovery systems have significantly reduced emissions (Nikolakopoulos, 2024). However, the high initial costs and long payback periods can deter investment, while a lack of technical expertise in

certain regions may limit the effectiveness of these technologies.

Carbon Capture, Utilization, and Storage (CCUS) technology is critical for industries where direct emissions reduction is challenging, such as steel, cement, and chemicals (Olabi, 2022). CCUS involves capturing CO2 emissions from industrial processes, transporting them to storage sites, and either utilizing or permanently storing them. It is particularly important in cement production due to the emissions generated during limestone calcination. Nevertheless, the high costs and energy requirements associated with CCUS, along with limited infrastructure for CO2 transport and storage, make it less economically viable at present.

Alternative processes could be another option. In steel production, the direct reduction of iron using hydrogen instead of carbon is being explored as a low-emission alternative. When combined with electric arc furnaces powered by renewable energy, this method can significantly reduce emissions in steel manufacturing (Ren, etc., 2021). The cement industry is also focusing on alternative binders like geopolymer cements, which produce lower CO2 emissions than traditional Portland cement (Das, etc., 2022). However, the development and commercialization of these new materials and processes require substantial research and investment. Additionally, market acceptance of alternative materials can be slow, especially in industries with stringent product standards.

3.3.4 Buildings

The buildings sector is a significant contributor to global carbon emissions. To mitigate this impact, various technologies have been developed and deployed to reduce emissions associated with building construction, operation, and maintenance.

Energy efficiency is the most straightforward and cost-effective strategy to reduce carbon emissions in buildings. Technologies like advanced insulation materials, energy-efficient windows, and high-efficiency heating, ventilation, and air conditioning (HVAC) systems are critical in minimizing energy consumption (Dadzie, 2022). Smart building technologies, including automated lighting and thermostat controls, further enhance energy efficiency by optimizing energy use based on occupancy and environmental conditions (Shah, etc., 2019). However, the high upfront costs of energy-efficient materials and systems can hinder widespread adoption. Retrofitting existing buildings is particularly challenging and costly, especially in older structures. The lack of incentives and supportive regulatory frameworks in some regions further complicates the implementation of energy efficiency measures.

The other is using sustainable and low-carbon building materials, such as cross-laminated timber (CLT), recycled steel, and low-carbon concrete (Korra, 2021). They can significantly reduce the carbon footprint of building construction. Green roofs and walls, which incorporate vegetation into the building design, also contribute to carbon sequestration and provide insulation benefits. Despite their environmental advantages, green building materials often face higher costs compared to conventional materials. Additionally, the limited availability and variability in the quality of these materials can affect their performance and

market acceptance.

3.3.5 Individual Actions

Individual actions are increasingly recognized as vital contributors to reducing carbon emissions. While large-scale industrial and governmental interventions are crucial, personal choices and behaviors also play a significant role in mitigating climate change. Various technologies are being developed and adopted to facilitate these actions, focusing on energy efficiency, sustainable consumption, and waste reduction.

Technologies that enhance energy efficiency in homes and personal transportation are among the most effective ways for individuals to reduce their carbon footprint (Dubois, etc., 2019). These include energy-efficient appliances, smart home systems, and EVs discussed previously. Modern energy-efficient appliances such as refrigerators, washing machines, and air conditioners consume significantly less energy than their older counterparts. The adoption of these appliances can substantially reduce household energy consumption and associated emissions. The main challenge is the higher upfront cost of energy-efficient models, which can deter individuals from purchasing them, especially in low-income households.

Sustainable consumption is another option, involving making choices that reduce the carbon footprint of daily activities, such as diet, clothing, and travel (Vita, etc., 2019). Technologies that support sustainable consumption include carbon footprint calculators, food waste apps, and digital platforms promoting sustainable products.

4

INTERVIEW FINDINGS

Based on the expert interviews conducted with Andree Marcel Henriquez Aravena (Executive Director, Technology Centre for the Circular Economy of the Northern Chilean Macrozone, Chile), Emmanuel A. San Andres (Senior Analyst, Policy Support Unit at APEC Secretariat, Singapore), Maria Del Pilar Medina Ortega (Head of Business Development, Perú Sostenible, Peru), Melanie Colburn (Director of Innovation and Research, U.S. Green Building Council in the USA), Pipo Reiser (General Manager and Co-founder of Sinba in Peru), Ruth Rain Cespedes (Global Women's Network for the Energy Transition in Chile), Wan Mohd Hirwani Wan Hussain (Director, Center for Innovation and Technology Transfer, Universiti Kebangsaan Malaysia, Malaysia), and Wenjuan Dong (Associate Researcher of Institute of Climate Change and Sustainable Development in Tsinghua University in China), several key insights regarding the policy development, adoption and impact of low-carbon technologies across various sectors in the APEC region.

Here was a detailed summary of these findings:

4.1 Policy Landscape

- Policy initiatives and support: Wenjuan noted specific policies targeting the reduction of carbon emissions in heavy industries through subsidies and tax incentives for adopting green technologies. Ruth added the importance of sector-specific initiatives in Chile, focusing on photovoltaic industries and hydrogen production. Maria highlighted the challenges of implementing policies in Peru, noting the significant gap between policy creation and implementation due to political instability and institutional distrust. Melanie discussed the importance of setting clear definitions and benchmarks for carbon neutral buildings as part of policy support, referencing recent work with the White House to establish a definition for carbon neutral buildings in the USA. Emmanuel emphasized the need for complementary policies to support the electrification of land transport and promote the use of public transit systems, smart city infrastructure, and last-mile solutions to reduce reliance on private vehicles.
- Regulatory frameworks: Discussions highlighted a gap in regulatory frameworks necessary to support the full lifecycle of implementing low-carbon solutions, such as procurement, maintenance, and end-of-life recycling, with Ruth noting challenges in adapting these frameworks to support new technologies like hydrogen. Maria emphasized the importance of the Action Plan on Business and Human Rights in Peru as a well-grounded and effective policy, particularly in engaging the private sector in sustainable practices. Melanie emphasized the development and enforcement of building performance standards, particularly in the USA, which can significantly impact carbon emissions from buildings.
- International cooperation: Emphasized as crucial for scaling up the implementation of low-carbon technologies, with diplomatic and trade relations among member economies facilitating the sharing of best practices and technology transfer. Andree highlighted the role of the circular economy as a facilitator for technology transfer and scaling, collaborating internationally to enhance the adoption of circular economy technologies.

4.2 Trends and Opportunities

- Innovation: Pipo showcased his company's use of circular economy principles to convert waste into resources, demonstrating innovative waste management contributing to sustainability. Andree shared insights on their efforts in repurposing waste from mining and solar industries in Chile, integrating technology to enhance waste processing and repurposing efficiencies. Melanie highlighted the importance of integrating AI and machine learning in building systems to optimize energy use and automate building operations, emphasizing USGBC' s focus on smart building technologies for enhancing building efficiency and sustainability.
- Technological integration: Wenjuan and Ruth discussed the integration of advanced technologies such

as AI and machine learning to enhance efficiency in processes like recycling and energy production, marking a trend towards technology-driven sustainability. Maria added that in Peru, large companies, especially in mining and fisheries, are leading the way in implementing advanced technologies for water management and biodiversity conservation, although challenges remain in scaling these technologies to smaller operations.

4.3 Barriers to Adoption

- Economic and regulatory challenges: Melanie and Pipo discussed the economic and regulatory challenges in the USA and Peru hindering the adoption of sustainable practices. Ruth also mentioned the financial and regulatory adjustments needed in Chile to fully support emerging technologies. Maria further noted that Peru's political instability hinder the effective implementation of sustainability policies, despite the existence of strategies and initiatives.
- Lack of financial resources: A common barrier across economies, as noted by several experts, is the insufficient financial resources to implement action plans for sustainability, even when robust policies and action plans are in place. This lack of funding affects the deployment of new technologies, the development of infrastructure, and the capacity to support large-scale adoption of low-carbon initiatives, especially in developing economies.
- Technological and infrastructure limitations: Highlighted by Wenjuan as a significant barrier, especially in energy-intensive industries where advanced technologies are not yet cost-effective or fully developed. Maria emphasized the issue of connectivity in Peru, particularly in rural and Amazon regions, which hampers the implementation of technology-driven sustainability initiatives.

4.4 Strategies and Technologies Promoting Sustainability

- Leveraging local strengths: Pipo emphasized the importance of aligning sustainability initiatives with local economic activities, like agriculture and mining, to enhance economic sustainability in Peru. Ruth also stressed integrating new technologies with traditional industries to maximize impact. Maria added that large-scale mining companies in Peru are successfully integrating advanced technologies for water management and biodiversity conservation, which could serve as models for other sectors.
- Focus on mature technologies: Wenjuan advocated for the adoption of established technologies like smart grids, which are crucial for their affordability and impact, complemented by Ruth's push for innovative applications in traditional sectors.

4.5 Governmental Support and Policy Implementation

- Strong policy enforcement: Experts agreed on the necessity of not only devising effective policies but also ensuring their rigorous enforcement to guarantee the implementation of sustainability practices, especially in sectors with significant pollution and waste management challenges. Maria highlighted the challenges in Peru, where despite the presence of policies like the Peru Strategy on Climate Change, the lack of effective implementation due to corruption and political instability remains a significant barrier However, she pointed out the positive impact of the Economy's Plan on Human Rights for Companies, which has seen better implementation and collaboration with the private sector. Melanie discussed the role of USGBC in advocating for stronger government policies and standards to support sustainable building practices, including efforts to define and enforce building performance standards at the economy's level.

  Emmanuel highlighted the importance of ensuring a Just Transition in the shift to low-carbon technologies. This involves not only the adoption of new technologies but also providing social protections and reskilling opportunities for workers affected by these changes, particularly those in vulnerable positions. .

These insights provided a comprehensive understanding of the complex interplay between technology, policy, and industry practices in advancing low-carbon technologies within the APEC region. They highlighted the importance of contextual and localized strategies that align with economic and environmental goals for effective sustainability transitions.

5 BEST PRACTICE FINDINGS

5.1 Electricity and Heat Generation

Company Name: LONGi
Company Size: : Large
Member Economy: China

Technology: High-efficiency monocrystalline solar cells and modules

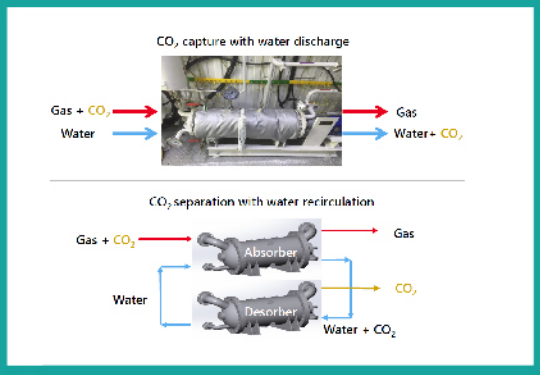
Contribution to Sustainability: LONGi's commitment to sustainability is evident through its continuous innovation in solar technology, aiming to make solar power more efficient, affordable, and accessible worldwide. Their products significantly reduce carbon footprints by enhancing the performance and reducing the cost of solar installations, contributing to the global transition towards renewable energy sources.

▲ Complex Mountain PV Power Station in Guizhou, China

Company Name: Start-Catalyst
Company Size: SME
Member Economy: Russia

Technology: CO2 Capture & Separation from any raw material using new type of equipment

Contribution to Sustainability: Start-Catalyst developed heat and mass transfer horizontal apparatus which in 1 stage can provide separation of mechanical impurities, gas cooling and release of up to 100% of CO2 in gaseous state. Technology involves removing CO2 by physical absorption. Decarbonization chemistry ensures 100% selectivity, absence of hydrocarbons in absorbent and possibility of using water (including seawater). Compared to known technologies, proposed solution has such key advantages as no requirements for gas preparation, low operating pressure, no pressure loss, no destruction of absorbent. Simplicity of technology and small volume of equipment provide a significant reduction in capital and operating costs for Decarbonization of any raw material (gas, oil, emissions).



Company Name: Hitachi Energy
Company Size: Large
Member Economy: Japan

Technology: Power quality solutions, grid edge technologies, and integration of renewable energy sources

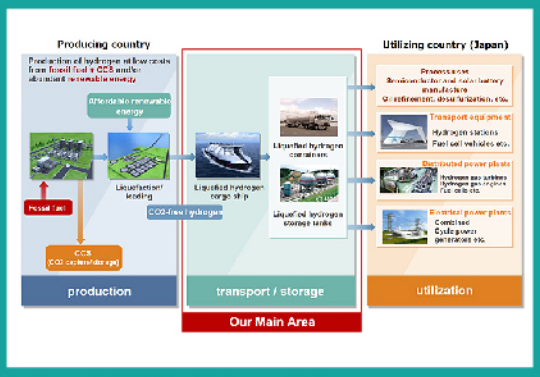
Contribution to Sustainability: Hitachi Energy plays a critical role in transforming the global energy landscape by driving the adoption of renewable energy and improving energy management systems. Their innovations not only support the transition towards a more sustainable energy future but also help in reducing carbon footprints across various industries. They contribute to the resilience and sustainability of energy infrastructures worldwide, ensuring a more efficient and reliable supply of clean energy.

▲ Hitachi Energy Gas-insulated switchgear

Company Name: Kawasaki Heavy Industries
Company Size: Large
Member Economy: Japan

Technology: Liquefied hydrogen supply chain

Contribution to Sustainability: Kawasaki Heavy Industries has been a pioneer in developing the world' s first liquefied hydrogen carrier ship, the "Suiso Frontier," which plays a crucial role in establishing an international hydrogen supply chain, particularly between Australia and Japan. This initiative is part of a broader strategy to create a hydrogen-based society and achieve carbon neutrality by reducing dependence on traditional fossil fuels.

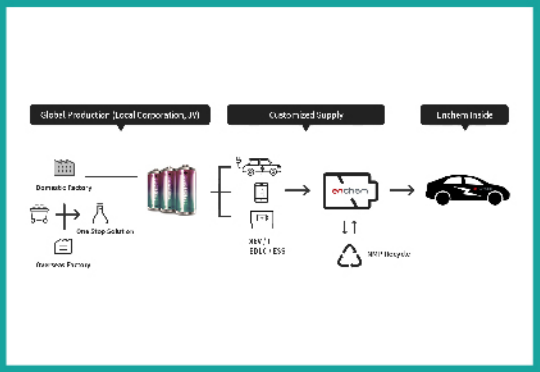


▲ Concept of CO2-free Hydrogen Chains

Company Name: EnChem
Company Size: SME
Member Economy: The Republic of Korea

Technology: Advanced energy storage solutions and electrolyte technologies for lithium-ion batteries

Contribution to Sustainability: EnChem's innovative technologies focus on enhancing the efficiency and lifespan of lithium-ion batteries, which are pivotal for the renewable energy sector. Their advancements in electrolyte solutions improve battery performance and safety, contributing to more reliable and sustainable energy storage options. This technology supports the broader adoption of renewable energy sources, aiding Republic of Korea's transition towards a more sustainable energy landscape.



5.2 Transport

Company Name: Hyzon Motors
Company Size: SME
Member Economy: Australia

Technology: Hydrogen fuel cell technology for commercial vehicles

Contribution to Sustainability: Hyzon Motors is committed to advancing hydrogen fuel cell technology, targeting heavy and commercial vehicles to reduce emissions significantly. Their technology provides a viable alternative to diesel engines, promoting carbon neutral transportation solutions, particularly for trucks and buses, thus contributing to cleaner air and a reduction in greenhouse gas emissions.

▲ Hyzon's Prime Mover, a heavy-duty commercial truck.

Company Name: SW/TCH Maritime
Company Size: SME
Member Economy: USA

Technology: Electric propulsion systems for maritime transport

Contribution to Sustainability: SW/TCH Maritime develops electric ferries and other marine vessels that operate without fossil fuels. Their initiatives aim to transform maritime transportation into a more sustainable industry by eliminating emissions, reducing noise, and lowering operational costs, which benefits urban waterways and impacts global efforts to combat marine pollution.

▲ Carbon neutral maritime vessel powered by hydrogen fuel cell.

Company Name: BYD Co Ltd
Company Size: Large
Member Economy: China

Technology: Electric vehicles, battery technologies, and monorail systems

Contribution to Sustainability: BYD Co Ltd is a leader in the global shift towards sustainable transportation with its extensive range of electric vehicles, including buses, cars, and monorails. Their technology helps reduce urban pollution, decreases reliance on fossil fuels, and supports infrastructure for sustainable urban development, significantly impacting efforts to achieve carbon neutrality.

▲ Shell worked with BYD to open its largest EV charging station globally in Shenzhen, China.

Company Name: Proterra
Company Size: SME
Member Economy: USA

Technology: Electric buses and charging infrastructure

Contribution to Sustainability: Proterra is at the forefront of manufacturing electric buses and developing electric charging systems. Their technology supports public transit authorities in reducing operational costs and carbon footprints. Proterra's buses offer an environmentally friendly alternative to traditional diesel buses, which is crucial for reducing greenhouse gas emissions and improving air quality in urban settings.

▲ Proterra's new line of fleet charging units enables charging of up to 20 transit buses simultaneously.

5.3 Industry

Company Name: Fortera
Company Size: SME
Member Economy: USA

Technology: ReCarb technology, Carbon capture

Contribution to Sustainability: Fortera is revolutionizing the cement industry with its innovative ReCarb technology. This process integrates with existing cement production facilities to capture CO2 emissions and convert them into a mineral form, thereby producing low-carbon cement. Fortera's technology reduces the carbon footprint of cement production by up to 70% per ton, aligning with global efforts to mitigate climate change and promoting sustainability in the construction industry. The company's scalable solution has already attracted significant investment, facilitating the broader deployment of low-carbon cement technologies globally.

▲ Fortera's ReCarb cement plant process heats up the race to neutrality.

Company Name: Cemex
Company Size: Large
Member Economy: Mexico

Technology: Lower-carbon concrete, sustainable building materials

Contribution to Sustainability: Cemex is a leading supplier of cement and other building materials that has committed to reducing carbon emissions across its operations. The company has developed lower-carbon concrete products that enable significant reductions in CO2 emissions compared to traditional concrete. Cemex's initiatives include optimizing energy use, sourcing alternative fuels, and employing advanced manufacturing processes. These efforts contribute to a more sustainable construction sector by providing eco-efficient solutions that meet the growing demand for green building materials.

▲ Cemex's Vertua lower-carbon concrete helped to build Terminal 2 at Puerto Vallarta International Airport in Mexico.

Company Name: Nippon Steel
Company Size: Large
Member Economy: Japan

Technology: Hydrogen reduction steelmaking

Contribution to Sustainability: Nippon Steel is pioneering the transition to sustainable steel production with its innovative hydrogen reduction technology. This method replaces traditional coal in the iron reduction process with hydrogen, significantly cutting CO2 emissions by up to 33% in initial tests. As part of Japan' s Green Innovation Fund, Nippon Steel aims to fully commercialize this technology by 2030, with plans to achieve carbon neutrality across its steel production processes by 2050. This breakthrough not only represents a major step forward in reducing the environmental impact of the steel industry but also sets a global benchmark for sustainable practices in heavy industries.

▲ Hydrogen utilization in steelmaking at Nippon Steel's Kimitsu Steel Works, Japan.

Company Name: Primetals Technologies
Company Size: Large
Member Economy: Japan

Technology: EAF Quantum and EAF Ultimate Electric Arc Furnace Technologies

Contribution to Sustainability: Primetals Technologies is at the forefront of sustainable steel production, providing advanced energy-efficient solutions in electric arc furnaces (EAF). Their EAF Quantum technology significantly reduces energy consumption by optimizing scrap preheating and heat transfer, achieving energy use as low as 280 kWh/t of steel produced. Additionally, the EAF Ultimate offers high productivity with shorter tap-to-tap times and improved performance, contributing to a lower carbon footprint in steel manufacturing. These innovations are key to minimizing the environmental impact of steel production, aligning with global efforts to achieve more sustainable industrial practices.

▲ EAF Ultimate

5.4 Buildings

Company Name: Big Ass Fans
Company Size: SME
Member Economy: USA

Technology: High volume low speed (HVLS) fans

Contribution to Sustainability: Their HVLS fans are used in large commercial and industrial settings to improve air circulation and energy efficiency, reducing the need for heating and air conditioning, thus contributing significantly to energy conservation and reducing carbon footprint.

▲ Big Ass Fans' HVLS fan was applied in a warehouse, improving air circulation and energy efficiency.

Company Name: EcoWindows
Company Size: SME
Member Economy: Canada

Technology: High-efficiency windows and glazing

Contribution to Sustainability: EcoWindows provides advanced window solutions that significantly improve the thermal efficiency of buildings. Their technology helps reduce energy consumption for heating and cooling, which is critical in Canada's varied climate, leading to lower greenhouse gas emissions and enhanced comfort for occupants.

Company Name: Weimob
Company Size: SME
Member Economy: China

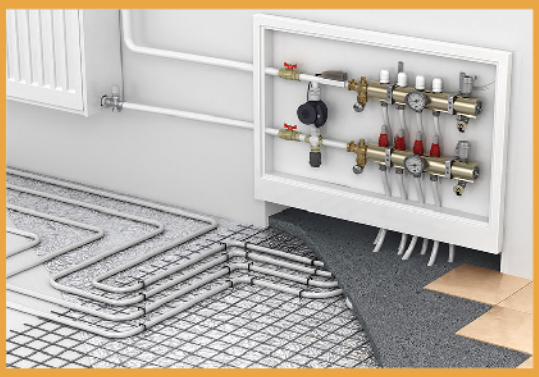
Technology: Low-carbon building solutions

Contribution to Sustainability: The Weimob Headquarters building in Shanghai, China is a model of sustainable building design, integrating both passive and active technologies to significantly reduce carbon emissions. It was awarded the "Low-Carbon Building" demonstration project certification by the China Association of Building Energy Efficiency. The project features advanced shading, optimized natural lighting and ventilation, and high-performance thermal insulation, alongside a fully electrified air conditioning system and extensive use of renewable energy (solar photovoltaic and solar thermal). These innovations have resulted in a carbon emission intensity of 27.73 kgCO2/m² and a carbon reduction rate of 32.60%, setting a benchmark for low-carbon buildings in the region.

Company Name: SmartHeat
Company Size: SME
Member Economy: Australia

Technology: Geothermal heating systems

Contribution to Sustainability: SmartHeat specializes in the installation of geothermal heating solutions for buildings, leveraging Australia' s rich geothermal resources. This technology provides a reliable and sustainable heat source, significantly reducing the carbon emissions associated with traditional heating methods.



▲ SmartHeat's hydronic heating.

5.5 Individual Actions

Company Name: Meituan
Company Size: Large
Member Economy: China

Technology: Bike-sharing platform

Contribution to Sustainability: Meituan' s bike-sharing technology has significantly contributed to sustainability efforts in urban China. By facilitating the widespread use of bicycles, Meituan has helped reduce carbon dioxide emissions by 436,500 tonnes over the past year, as reported ahead of World Cycling Day. This reduction is particularly impactful in densely populated urban areas like Beijing, where Meituan bike users logged a total of 850 million km, equivalent to a reduction of 41,100 tonnes of carbon dioxide. The technology promotes not only environmental benefits but also health and mobility improvements for its users, aligning with China's green transportation goals. Additionally, the increased demand for bicycles has influenced production, with China seeing rises in both traditional bicycle and e-bicycle manufacturing, further supporting the sustainable transportation industry.

▲ The carbon reduction of a Meituan electric motorcycle and a Meituan bicycle are 558 kg and 214 kg in the entire life cycle, respectively.

Company Name: Nanoleaf
Location: Canada

Technology: Energy-efficient LED lighting and smart home solutions

Contribution to Sustainability: Nanoleaf, a pioneer in the smart lighting industry, has revolutionized how homes and businesses manage energy consumption. Their energy-efficient LED lighting products, known for their modular design and smart functionality, significantly reduce energy usage by adapting to user preferences and environmental conditions. Nanoleaf's smart home solutions, integrated with voice assistants and mobile apps, allow users to optimize lighting schedules, further minimizing unnecessary energy consumption. By enabling consumers to personalize their lighting while cutting down on energy use, Nanoleaf helps reduce carbon emissions, contributing to sustainability goals.

Company Name: Fairtrade Network of Asia & Pacific Producers (NAPP)

Company Size: Large

Member Economy: Regional (Asia & Pacific)

Technology: Certification and support systems for fair trade practices

Contribution to Sustainability and the Industry: Fairtrade NAPP champions sustainable development by enforcing fair trade standards in agriculture and textiles. They ensure fair compensation and safe working conditions for producers while promoting environmentally sustainable practices. This reduces inequality, enhances livelihoods, and supports sustainable business models. Consumers benefit by purchasing ethically sourced products that contribute to positive social impacts and sustainable development goals.

Company Name: TCL Electronics

Company Size: Large

Member Economy: China

Technology: A-20% Energy Class Washing Machines with BLDC Inverter Motor Technology

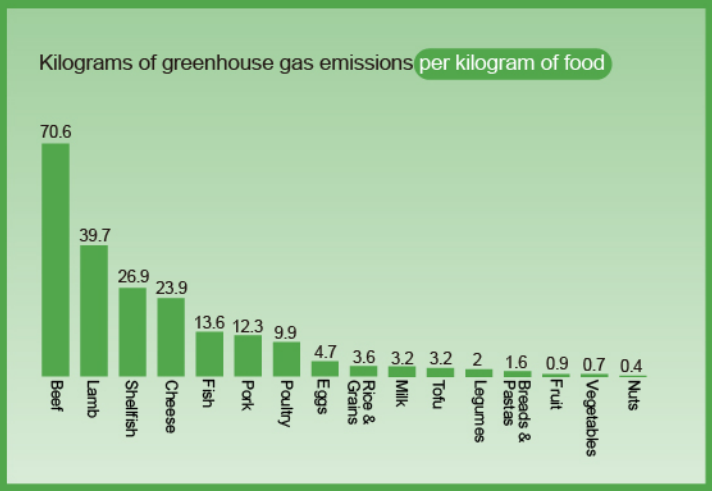
Contribution to Sustainability and the Industry: With the rise in energy prices, it is also and above all the electricity bill of people that is growing. TCL's technology means people don't have to choose between performance, environment, and economy. New TCL F3 and P3 Series are the products perfectly adapted to today's consumers and concerns. TCL's A-Energy Class washing machines incorporate advanced technologies to enhance energy efficiency and reduce environmental impact. TCL's A-20% Energy Class washing machines incorporate advanced technologies to enhance energy efficiency and reduce environmental impact. The BLDC Inverter Motor optimizes the machine' s performance, allowing for quieter operation and longer lifespan while using less energy. The machines also feature an auto weight system that adjusts water consumption based on the load, significantly lowering unnecessary water usage. Additional features like the steam wash program contribute to better hygiene and overall sustainability, promoting environmentally responsible laundry practices.

▲ TCL new A-Energy Class washing machines: products that are good for environment and budget.

Company Name: Huawei Spicy Hot Pot Restaurant
Company Size: Micro
Member Economy: China

Technology: No, but providing low-carbon diets

Contribution to Sustainability: Who says going green has to be complicated? At Huawei's Spicy Hot Pot Restaurant in Shenzhen, sustainability is served up in a delicious, low-tech way. With a menu packed with low-carbon vegetarian options, the restaurant champions the idea that you don't need fancy gadgets to make a difference—just a fork and a healthy appetite! Given that about a third of all human-caused greenhouse gas emissions are linked to food, Huawei encourages diners to reduce their carbon footprints with their "Low-Carbon Diet" offerings, in a good price. Plant-based foods not only use less energy, land, and water but also come with a side of lower emissions compared to their animal-based counterparts. And for those who shy away from the heat, don' t worry! They' ve got non-spicy options, so you can enjoy a healthy, eco-friendly meal without breaking a sweat. Just remember, a balanced diet is still key!



▲ Source: https://www.un.org/en/climatechange/science/climate-issues/food

6

SEMINAR SUMMARY REPORT

6.1 Seminar Description

Topic: Seminar on APEC Technology Empowers Low Carbon Action (TELCA)

Date: September 2-4, 2024

Location: Beijing Friendship Hotel, Beijing, China

The APEC TELCA Seminar, held from September 2-4, 2024, in Beijing, China, brought together over 30 representatives from 11 APEC member economies, including experts from the public and private sectors, policymakers, startups, and international organizations. The event was aimed at advancing low-carbon technologies and policies in APEC, fostering collaboration and sharing best practices to address the challenges posed by climate change.

Over the course of three days, participants engaged in keynote presentations, panel discussions, capacity-building sessions, startup showcases, and site visits to two low-carbon facilities. The seminar emphasized the importance of innovative low-carbon technologies, sustainable policies, and the critical role of public-private partnerships in promoting a low-carbon economy across the region.

6.2 Summary of Presentations & Discussions

The seminar opened with welcoming remarks from Jieni Guo, Secretary General of the Beijing International Exchange Association and the Project Overseer. She highlighted the significance of regional cooperation in achieving low-carbon objectives and emphasized the need for technology-driven solutions to advance sustainability across APEC economies.

Policymakers, researchers, and international experts shared their insights on strategies and technologies aimed at promoting a low-carbon transition in the Asia-Pacific region.

· China's Goals on Carbon Peaking and Carbon Neutrality

Ying Chen from the Chinese Academy of Social Sciences presented China's roadmap towards achieving carbon peaking by 2030 and carbon neutrality by 2060. She discussed the importance of comprehensive policies, investments in renewable energy, and advancements in green technologies to meet these ambitious targets.

· Carbon Neutral Actions of Viet Nam

Thi Thanh Ha Nguyen from Viet Nam's Ministry of Science and Technology shared Viet Nam's actions and policies to achieve carbon neutrality. Key measures included promoting renewable energy, strengthening energy efficiency, and aligning the economy' s strategies with international climate commitments.

· Policy Paths Toward Low-Emission Multimodal Transportation in APEC Glacer Niño Vasquez from

the APEC Secretariat outlined the critical role of multimodal transportation in reducing carbon emissions across APEC economies. His presentation emphasized the importance of policy frameworks that support sustainable transport systems, while leveraging technology to minimize emissions.

· Green Transformation in Tajikistan

Parvin Muminov from the UNDP Tajikistan provided insights into how the economy is adopting green technologies in water management, energy production, and agriculture. He underscored the importance of international cooperation in building infrastructure that supports green growth in Central Asia.

· Decarbonization in Mexico

Vicente Ugalde Saldaña from the College of Mexico discussed the economy's decarbonization strategies, particularly in heavy industries and public policies aimed at reducing greenhouse gas emissions. He emphasized the need for more effective implementation of existing policies and stronger incentives for the adoption of low-carbon technologies.

Innovation, inclusivity, and international collaboration were the key themes of discussions during the seminar. Participants actively debated how these themes could be integrated into low-carbon policies and practices across APEC economies:

· Innovation in Low-Carbon Technologies

Experts from the private sector and academia showcased groundbreaking innovations such as renewable energy solutions, smart grids, AI-based optimization for energy efficiency, and the development of carbon-neutral technologies. These presentations demonstrated how technological advancements can drive sustainable development and reduce emissions.

· Inclusivity and Vulnerable Groups

Inclusivity emerged as a core theme throughout the seminar. Participants agreed that the transition to low-carbon economies must address the needs of vulnerable groups, such as women, rural communities, and individuals with disabilities. Co-creating policies that provide equal access to green technologies and ensure participation from marginalized groups was deemed essential for achieving long-term sustainability.

· Public-Private Partnerships (PPP) for Low Carbon Development

A key discussion focused on the role of PPP in accelerating the adoption of low-carbon technologies. Speakers stressed that successful PPPs require close collaboration between governments, private companies, and financial institutions to finance and implement sustainable infrastructure projects, particularly in areas like renewable energy and green transportation.

· Women's Role in Low Carbon and Energy Transition

In a dedicated session, panelists from Chile; Viet Nam; and Peru discussed the contributions of women to low-carbon and energy transition efforts. They highlighted initiatives led by women that focused on clean energy adoption, energy efficiency, and capacity building in communities, stressing the importance of gender equality in achieving sustainable development.

· Supply and Demand in Low-Carbon Technologies

Speakers emphasized the importance of bridging the gap between the supply and demand of low-carbon technologies. Several participants noted that investments in technology often lack a clear connection to market needs, leading to wasted resources. Better alignment between supply and market demand, particularly through public-private collaboration, is essential to ensure technologies are widely adopted.

· Political Decision-Making and Policy Implementation

Some speakers, particularly those from Latin America, highlighted the challenges of political decision-making in the context of low-carbon transitions. They stressed that innovation and policy development must go hand-in-hand with strong governance and decision-making frameworks, noting the difficulties posed by institutional crises and lack of investment in R&D.

· Environmental Impact of Clean Technologies

The issue of waste management in clean technologies, particularly the disposal of electronic components, was raised. Speakers called for more attention to the environmental impacts of green technologies, emphasizing that their life cycle must be carefully managed to avoid future waste problems.

· International Collaboration

The need for enhanced international cooperation to tackle climate change was emphasized throughout the seminar. Participants called for greater efforts in knowledge sharing, technology transfer, and joint research initiatives to address the challenges faced by both developed and developing economies in the APEC region. The discussions reiterated that addressing climate change requires collective action from all economies, and APEC serves as an ideal platform for fostering such collaboration.

The seminar concluded with visits to leading low-carbon facilities in Beijing, where participants had the opportunity to see cutting-edge logistics technologies and green building innovations in action. These site visits further illustrated the potential of integrating technology into sustainable urban development and supply chain operations, reinforcing the themes of the seminar:

· Zhongguancun Xisanqi (BBMG) Sci-Tech Park showcased innovations in green building technologies and smart city solutions aimed at reducing carbon emissions and promoting sustainable urban development.

· JD's Beijing Asia No.1 Logistics Fulfillment Center demonstrated cutting-edge logistics technologies, emphasizing the role of automation and digitalization in reducing carbon footprints in the supply chain.

6.3 Key Takeaways

The seminar's discussions and presentations generated a wealth of insights, culminating in four major takeaways that can guide future efforts toward achieving a low-carbon economy in the APEC region.

These key themes emphasize the importance of collaboration, innovation, policy alignment, and inclusivity as critical drivers of success. By addressing these areas, APEC economies can better align their efforts to combat climate change, promote sustainable development, and ensure that the benefits of the low-carbon transition are shared equally across all sectors of society.

The following points summarize the foundational lessons learned during the seminar, providing a roadmap for future action.

· Collaboration is Essential: The seminar reinforced the need for collaboration across economies and sectors. Public-private partnerships, knowledge sharing, and cross-border cooperation were identified as critical components for advancing low-carbon technologies in the region.

· Innovation Drives Sustainability: Presentations highlighted the importance of leveraging technology and innovation to achieve sustainability goals. Startups and businesses play a pivotal role in developing and deploying solutions that reduce emissions and promote a circular economy.

· Regional Policy Alignment: Policy alignment across APEC economies is necessary to ensure that low-carbon technologies can scale. Participants emphasized the need for clear policies, incentives, and regulatory frameworks to support the adoption of sustainable technologies.

· Just Transition is Key: The importance of ensuring that the low-carbon transition is inclusive given to vulnerable groups, including women, rural communities, and low-income economies, to ensure equal access to opportunities and benefits.

7

POLICY RECOMMENDATIONS AND APEC TELCA PRINCIPLES

To guide APEC economies towards more sustainable and environmentally friendly practices, this section presents targeted policy recommendations and outlines the APEC TELCA Principles.

6.1Policy Recommendations

The recommendations are crafted to enhance the integration of low-carbon technologies across various industries, supported by strategic, regulatory, and collaborative frameworks.

- Strategic Planning and Action Plans: Governments should establish clear policies and detailed action plans to achieve APEC climate targets, with a particular focus on developing and adhering to a comprehensive technology roadmap. Regular reviews and updates should be conducted to ensure progress remains on track and adjustments are made as necessary. Further, these plans should include specific strategies for capacity building and support for women and other vulnerable groups to ensure they are not left behind in the transition to a low-carbon economy.

- Infrastructure Development: Transitioning to a low-carbon economy requires substantial new infrastructure and significant modifications to existing assets. Governments must play a central role in planning, financing, and regulating the development of critical infrastructure, including electricity networks, EV charging stations, and transportation systems. This will ensure that the necessary support systems are in place to enable widespread adoption of low-carbon technologies.

- Research and Development (R&D) Support: Governments should provide robust and sustained support for R&D activities focused on emerging low-carbon technologies, recognizing that bringing new technologies to market typically requires significant time and resources. Support mechanisms should include grants, tax incentives, public-private partnerships, and funding for pilot projects to accelerate the commercialization of innovative technologies. Additionally, R&D investments should be targeted towards technologies that specifically benefit low-income and vulnerable communities, such as affordable clean energy solutions, off-grid technologies, and decentralized energy systems.

- Incentives for Innovation: Governments are encouraged to implement a combination of fiscal incentives, such as tax breaks, subsidies, and grants, along with public funding initiatives to stimulate the adoption and innovation of low-carbon technologies. These financial incentives will drive corporate and public sector investment in sustainable practices and technological advancements.

- PPPs: Partnership between the public and private sectors shall be encouraged to leverage resources, expertise, and innovation. It can accelerate the development and implementation of low-carbon technologies and infrastructure projects.

- Public Awareness and Education: Governments should prioritize public education and awareness programs to increase knowledge and uptake of sustainable practices and green skills among citizens, particularly for vulnerable groups.

- International Cooperation: Governments must advocate for stronger international cooperation and agreements to scale low-carbon technologies and set regional standards across APEC economies. This includes facilitating knowledge transfer, sharing technologies and best practices, capacity building, and providing technical and financial support to lower-income economies for the deployment of new technologies.

- R&D and Patenting: Clean energy R&D and patenting have been concentrated in a few key economies. To address this, governments should establish a regional fund for clean energy R&D, promote open access to patents for low-income economies, encourage open-source innovation models, and incentivize the sharing of intellectual property related to low-carbon technologies.

6.2 APEC TELCA Principles

The APEC TELCA Principles, derived from extensive research, discussions, and findings, provide a framework for APEC member economies to take concerted action toward addressing climate change and promoting a low-carbon future. These principles emphasize collaboration, innovation, and inclusivity, ensuring that all communities, especially vulnerable and under-represented groups, benefit from the low-carbon transition.

The TELCA Principles advocate for the creation of a clear technological roadmap, the promotion of a just and equal transition, and the wide-scale adoption of sustainable technologies. Furthermore, they emphasize the importance of tracking progress, continuous improvement, and accountability through data-driven approaches. Below are the ten APEC TELCA Principles:

1. Technological Pathway for APEC Targets: Establish and implement a clear technology roadmap across APEC economies that outlines the necessary steps and technologies to reduce aggregate energy intensity by 45% by 2035 and achieve carbon neutrality by 2050. This roadmap should integrate sustainability goals into all business operations and governmental policies, providing specific milestones and technological advancements required to meet these targets. It should also address the gaps between supply and demand in low-carbon technologies, ensuring their efficient deployment.

2. Just Transition: Ensure that the shift to low-carbon technologies is fair and inclusive, with a particular focus on women and girls, under-represented, and vulnerable groups. This includes aligning technological solutions with local economic activities to promote both environmental and economic sustainability, ensuring that no one is left behind in the transition.

3. Technology & Practice Collaboration: Foster strong collaboration between APEC economies to exchange technological advancements and best practices. Such partnerships are key to accelerating the implementation of low-carbon solutions across the region. PPP should also play a central role, ensuring that technological development is driven by both market needs and public policy frameworks.

4. Equality and Accessibility: Ensure equal access to the benefits of low carbon technologies, with special attention to under-represented groups, developing economies in APEC. This approach ensures that all communities can participate in and benefit from these innovations, reducing disparities and fostering inclusivity.

5. Empowerment through Green Skills: Develop capacity-building programs and a comprehensive roadmap for reskilling and upskilling the workforce, ensuring individuals are equipped with the green skills necessary to thrive in a low-carbon economy. These programs should address gaps in education and training, focusing on the needs of vulnerable communities to empower them as active participants in the green economy.

6. Interoperable Technology Integration: Promote the integration and alignment of low-carbon technologies across sectors and APEC economies to ensure they are interoperable and can work together efficiently. Standardization and harmonization of technological frameworks can help streamline adoption and create a consistent, region-wide approach.

7. Green Procurement: Advocate for strong green procurement policies within government and the private sector. By promoting the procurement of sustainable technologies, APEC economies can create a market for green innovations, stimulating demand and encouraging further technological development. This approach should also include incentivizing green

procurement practices in the private sector to broaden impact.

8. International Trade and Investment: Recognize the role of international trade and investment in accelerating the adoption of low-carbon technologies. Avoiding barriers like tariffs on green technologies (e.g., EVs) can help expedite the deployment of clean tech across borders. APEC economies should work together to create favorable conditions for the cross-border flow of green technologies, fostering innovation and reducing costs through global cooperation.

9. Track and Benchmark: Implement a robust system for tracking and benchmarking the progress of low-carbon technologies across APEC economies. This principle emphasizes the need for regular monitoring and evaluation, using standardized metrics to ensure that the region remains on track to meet its climate targets. By continuously measuring the outcomes of low-carbon initiatives, economies can identify areas for improvement and adjust policies accordingly.

10. Responsible Environmental Action: Encourage a shift in mindset toward environmental responsibility, urging individuals and businesses to take ownership of their carbon footprints. Rather than relying solely on incentives, this principle calls for promoting environmental actions as part of a collective moral responsibility. APEC economies should create public awareness campaigns that highlight the importance of personal and corporate responsibility in achieving a sustainable future.

8 CONCLUSIONS

The APEC TELCA initiative has made significant strides in fostering collaboration, innovation, and inclusivity across APEC economies to address the pressing challenge of climate change. Through extensive discussions, expert insights, and real-world case studies, the project has demonstrated that advancing low-carbon technologies is not only a necessity but also an opportunity for sustainable economic growth and development.

Key themes emerged throughout the seminar, highlighting the critical role of collaboration between public and private sectors, the need for clear policy roadmaps, and the importance of technological innovation. The seminar also underscored the essential principle of inclusivity, ensuring that the transition to a low-carbon economy benefits all communities, particularly vulnerable and underrepresented groups such as women, rural populations, and individuals with disabilities.

The research conducted as part of the project aimed to provide a comprehensive analysis of the current state of low-carbon technologies and their integration across APEC economies. It focused on identifying key barriers, opportunities, and best practices in promoting sustainable development. Through a blend of qualitative and quantitative approaches, the research offered valuable insights into policy frameworks, technology deployment, and public-private partnerships, helping to shape the APEC TELCA Principles and policy recommendations. Moreover, our research emphasized the importance of tailoring solutions to the diverse economic and technological realities across the APEC region, ensuring that the benefits of the low-carbon transition are shared equally.

The case studies offered practical examples of how APEC economies are innovating and adopting low-carbon technologies. These real-world examples demonstrated the effectiveness of renewable energy initiatives, smart grids, waste management systems, and public-private partnerships in addressing climate change. By examining successful projects from various economies, the case studies illustrated how targeted investments, strong policy frameworks, and collaborative efforts can result in measurable environmental and economic benefits. These case studies not only provided inspiration for other APEC economies but also served as proof that sustainable development is achievable through focused and innovative approaches.

The APEC TELCA Principles and policy recommendations established in this report offer APEC economies a comprehensive framework for achieving their climate targets, driving technological advancements, and promoting sustainable practices. By focusing on strategic planning, infrastructure development, research and development, and public-private partnerships, APEC economies can lead the way in the global effort to mitigate climate change.

While the APEC TELCA project provides a strong foundation for low-carbon transitions, we acknowledge the limitations of our research. Due to the diversity of APEC economies in terms of economic development, technology readiness, and policy frameworks, some recommendations may face challenges in uniform application. Additionally, the rapidly evolving nature of low-carbon technologies and policy environments may require continuous adaptation and further research to keep pace with emerging trends and innovations. These limitations highlight the need for ongoing dialogue, flexibility, and knowledge sharing among APEC economies as they work toward their climate goals.

Looking ahead, the success of the APEC TELCA initiative will depend on continued commitment and collaboration across APEC economies. Governments, businesses, and civil society must work together to ensure that low-carbon technologies are accessible, scalable, and aligned with the broader goals of environmental sustainability and social equality. Through collective action, APEC can play a pivotal role in building a resilient, low-carbon future for the region and beyond.

Appendix: Seminar Agenda

September 2 (Monday)	
09:30-09:35	**Moderator Introduction** Jieni Guo, China Secretary General, Beijing International Exchange Association
09:35-09:45	**Welcome Remarks** Keqin Dong, China Director, Division of Multilateral Cooperation, Ministry of Science and Technology, China
09:45-10:05	**China's Goals on Carbon Peaking and Carbon Neutrality: Policies and Actions** Ying Chen, China Researcher & Deputy Director, Research Center for Sustainable Development, Chinese Academy of Social Sciences
10:05-10:25	**Carbon Neutral Actions of Viet Nam** Thi Thanh Ha Nguyen, Viet Nam Deputy Chief, Department of Social, Natural and Human, Ministry of Science and Technology of Viet Nam
10:25-10:40	**Tea Break**
10:40-11:00	**Policy Paths toward Low-emission Multimodal Transportation in APEC** Glacer Niño Vasquez, The Philippines Researcher, Policy Support Unit, APEC Secretariat
11:00-11:20	**Green Transformation in Tajikistan: Promoting Green Technologies for Sustainable Development** Parvin Muminov, Tajikistan Project Manager a.i., IWRM, Climate Change, Energy and Environment, UNDP
11:20-11:40	**The Place of Decarbonization in Public Policies in Mexico** Vicente Ugalde Saldaña, Mexico Research Professor and Secretary General, Center for Demographic, Urban and Environmental Studies (CEDUA), The College of Mexico
11:40-14:00	**Lunch Break**

14:00-15:00	**Policy Panel Discussion: Supporting Policies for Low Carbon and Sustainable Development of the Asian Pacific Region** Moderator: Wan Mohd Hirwani Bin Wan Hussain Kampanart Silva, Thailand Researcher, Renewable Energy and Energy Efficiency Research Team, National Energy Technology Center Yanto Rochmayanto, Indonesia Senior Researcher, National Research and Innovation Agency (BRIN) Nam Vinh Dinh, Viet Nam Official, Department of Technology Appraisal, Examination and Assessment, Ministry of Science and Technology of Viet Nam Nurual Asyikin Bt Kamaruzaman, Malaysia Assistant Director, National Nanotechnology Centre, Ministry of Science, Technology and Innovation (MOSTI)
15:00-15:30	**Tea Break**
15:30-16:30	**Capacity Building Discussion: Public-Private Partnership for Low Carbon Development** Moderator: Andree Marcel Henriquez Aravena Vasilii Petrechenko, Russia General Manager, Moscow State University Science Park Queenie Riva Nombrado Rojo, The Philippines Executive Director, Ethanol Producers Association of the Philippines (EPAP) Wan Mohd Hirwani Bin Wan Hussain, Malaysia Director, Center for Innovation and Technology Transfer, Universiti Kebangsaan Malaysia

16:30-17:30	**Capacity Building Discussion: Women's Endeavors for Low Carbon & Energy Transition** Moderator: Bing Han Ruth Patricia Rain Céspedes, Chile Mentor, Mujeres Empresarias Thi Ngoan Nghiem, Viet Nam Energy Advisor, GIZ Viet Nam Maria Del Pilar Medina Ortega, Peru Head of Business Development, Perú Sostenible
17:30-17:40	**Wrap up on Day 1** Philip Carlo Reiser Von Gaudecker, Peru Cofounder & Director, Sinba

September 3 (Tuesday)	
09:30-09:40	**Moderator Introduction** Jieni Guo,China Secretary General, Beijing International Exchange Association
09:40-10:00	**Circular Economy in Chile: Technological Practice and Experience** Andree Marcel Henriquez Aravena, Chile Executive Director, Technology Centre for the Circular Economy of the Northern Chilean Macrozone
10:20-10:40	**Tea Break**
10:40-11:00	**Towards Greenovation: Advancing Climate Technology Cooperation** Han Na Kang, Republic of Korea Researcher, National Institute of Green Technology
11:00-11:30	**Best Case Study Report Release & Discussion** Bing Han, Hong Kong, China Founder & Partner, Union Communications Hong Kong

11:30-14:00	**Lunch Break**
14:00-15:40	Startups Roadshow & Experts' Sharing Session Moderator: Parvin Muminov Sawal Hamid Bin Md Ali, Malaysia Professor, Universiti Kebangsaan Malaysia Aleksei Tiurin, Russia Executive Director, Start-Catalyst LLC Sakayong Pattanavekin, Thailand CEO, CERO Philip Carlo Reiser Von Gaudecker, Peru Cofounder & Director, Sinba Adil Bin Mohd Salleh, Malaysia Senior Strategy Associate, NanoMalaysia Berhad Marco Antonio Gusukuma Higa, Peru Professor, Pontificia Universidad Católica del Perú Luis Antonio Izquierdo Horna, Peru Researcher & Professor, Pontificia Universidad Católica del Perú Himma Firdaus, Indonesia Senior Researcher, Research Center for Testing Technology and Standards, Research Organization for Energy and Manufacture, National Research and Innovation Agency (BRIN) Yot Boontongkong, Thailand Researcher, Environment Research Group, National Metal and Materials Technology Center (MTEC), National Science and Technology Development Agency (NSTDA)
15:40-16:00	**Tea Break**
16:00-17:00	TELCA Principle Discussion Moderator: Vicente Ugalde Saldaña

17:00-17:15	**Wrap up of Day 2** Maria Del Pilar Medina Ortega, Peru Head of Business Development, Perú Sostenible

September 4 (Wednesday)	
AM Session	Site Visit: Zhongguancun Xisanqi (BBMG) Sci-Tech Park in Haidian District, Beijing, China
PM Session	JD's Beijing Asia No.1 Logistics Fulfillment Center, Beijing, China

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