

Realising Asia Zero Emission Community

Strategic Research
Programmes and
Multi-Stakeholder
Engagement

ERIA Asia Zero Emission Center
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Background





Background

The global pursuit of carbon neutrality has brought significant attention to Asia, a region that contributes more than half of the world's emissions. As the engine of the global economy, Asia, particularly the Association of Southeast Asian Nations (ASEAN) region, faces the challenge of balancing rapid economic growth with the urgent need to decarbonise. This challenge is exacerbated by factors such as rapid urbanisation, population surges, and increasing disposable incomes, all of which drive up energy demand.

In response to these challenges, the Asia Zero Emission Community (AZEC) was inaugurated by 11 partner countries in 2023. This community aims to achieve carbon neutrality/net-zero emissions through practical energy transitions tailored to each country's unique circumstances in Asia. AZEC promotes cooperation under the concept of 'one goal, various pathways,' recognising the diverse industrial structures, social contexts, geographies, and developmental stages of its partner countries. AZEC's approach is centred on simultaneously achieving a triple breakthrough: decarbonisation, economic growth, and energy security. This holistic strategy acknowledges the need for a paradigm shift towards both established and novel clean technologies across sectors.

In August 2024, inspired by the aspirations of AZEC to shape a sustainable future in Asia, the Economic Research Institute for ASEAN and East Asia (ERIA) will launch the Asia Zero Emission Center (the Center) as a platform to share information, conduct studies on policies and projects, and help AZEC partner countries develop vision, roadmaps, or policies towards decarbonisation to promote energy transitions.

This paper presents a comprehensive overview of the strategic research programmes and activities planned by the Center to facilitate the region's transition to a low-carbon future. It begins by summarising the past research in the field of decarbonisation, establishing a foundation for understanding the Center's proposed activities. By synthesising regional projections with existing studies, this paper aims to offer a clear roadmap of the Center's role in advancing Asia's sustainable energy future.



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Overview of ERIA's Past Research on Decarbonisation

2.1 The Decarbonisation Outlook of ASEAN

The global effort to combat climate change gained significant momentum with the adoption of the Paris Agreement in 2015. This legally binding international treaty aims to limit the global average temperature increase to well below 2°C above pre-industrial levels, with efforts to cap it at 1.5°C. Many nations have pledged to achieve net-zero emissions by mid-century, announcing their carbon neutral scenarios for 2050–2060 during recent United Nations Climate Change Conferences.

However, recent global events have introduced new complexities. The coronavirus disease (COVID-19) pandemic brought significant uncertainties, and the Russia–Ukraine war led to a surge in global oil and gas prices. These price fluctuations, exacerbated by escalating Middle East conflicts and tensions between the United States and China, have raised concerns about global energy security and may potentially discourage the transition from coal to natural gas in fossil fuel-dependent regions.

AZEC, primarily comprising ASEAN countries, faces unique challenges in this transition. These developing economies rely heavily on fossil fuels to drive high economic growth. In 2019, ASEAN's final energy demand reached 448 million tonnes of oil equivalent (Mtoe), with oil dominating at 47%, followed by electricity (21%), coal (12%), and natural gas (10%).

The total primary energy supply (TPES) in the region was 661 Mtoe in 2019, dominated by oil consumption of 218.5 Mtoe, followed by coal at 192 Mtoe. In power generation, a significant shift from oil to natural gas and coal has occurred since 1990. By 2019, coal accounted for 43% and natural gas for 34% of the region's electricity production, while hydropower contributed 14.5%.

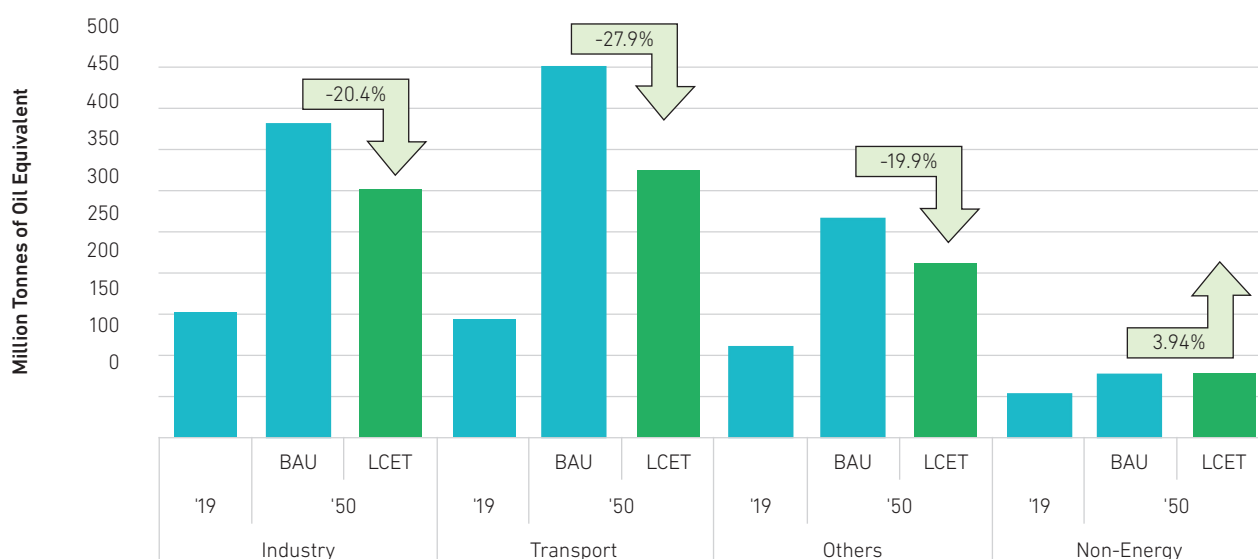
ERIA has developed a biennial energy outlook, analysing energy savings and the potential for reduction in carbon dioxide (CO₂) emissions in the East Asia Summit region. The aim is to provide a platform to enable the countries to collaborate on energy and to build capacity in energy modelling and policy development.

Under the Business-as-Usual (BAU) scenario in the latest energy outlook, final energy demand in ASEAN is projected to grow by 3.1% annually from 2019 to 2050. By mid-century, the transport sector is expected to account for nearly 39% of energy consumed, while oil is anticipated to maintain its dominance at 47%. The TPES is also projected to grow at 3.1% per year. By 2050, oil is expected to make up about 32% of the TPES, followed by coal at 29% and natural gas at 22.5%.

In contrast, the low-carbon energy transition (LCET) scenario aims to achieve carbon neutrality by 2050 or beyond. This ambitious scenario combines more efficient technologies, higher contributions from renewable energy, and the introduction of advanced technologies such as carbon capture, utilisation, and storage (CCUS).

Under the LCET scenario, final energy demand in ASEAN is projected to be almost 22% lower than BAU by 2050, with significant reductions in fossil fuel consumption. The transport sector's energy use is expected to decrease by 28% compared to BAU (Figure 1). The consumption of oil is expected to decrease by more than 53%, coal by 29%, and natural gas by around 25%. Notably, the use of hydrogen and ammonia is expected to increase significantly, particularly in power generation.

Figure 1. Total Final Energy Demand in ASEAN by Sector, Business-as-Usual and Low-Carbon Energy Transition, 2019–2050
[million tonnes of oil equivalent]



BAU = business-as-usual; LCET = low-carbon energy transition.

Note: 'Others' covers subsectors such as residential, agriculture, services, and commerce.

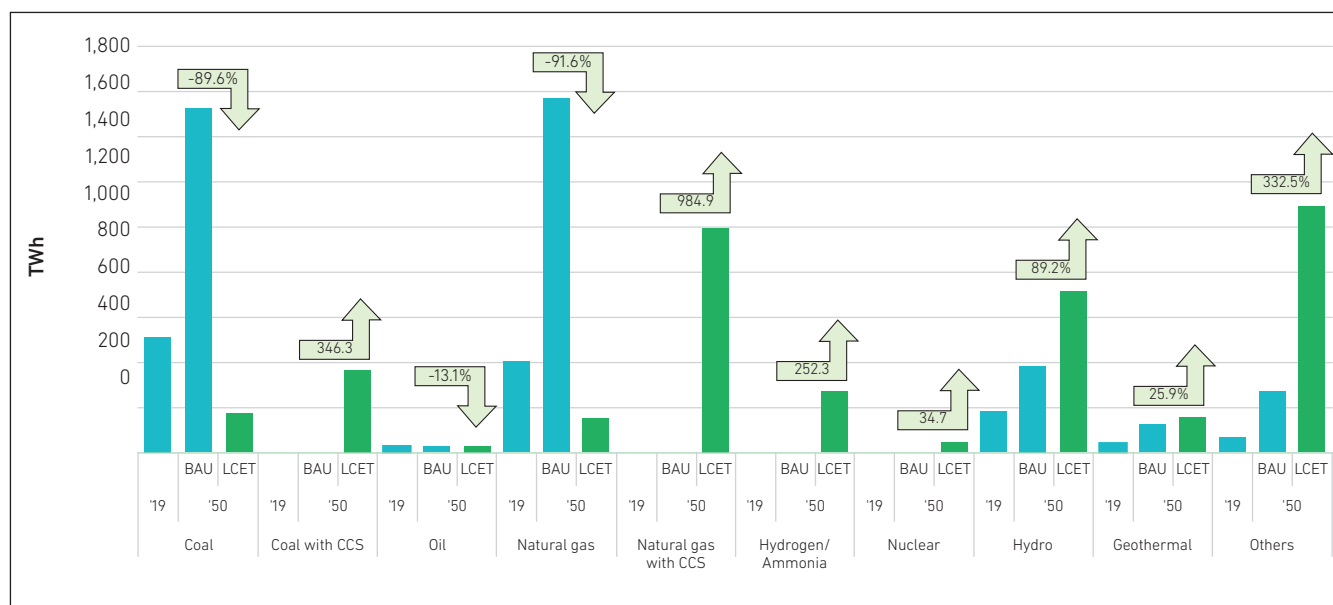
Source: Energy Outlook and Energy Saving Potential in East Asia, 2023.

Primary energy supply in ASEAN under the LCET scenario will decrease by approximately 20% in 2050 relative to the BAU scenario. The most significant reduction will come from coal (63% drop from BAU), followed by oil (53% drop from BAU) and natural gas (30% drop from BAU). In contrast, geothermal power generation will rise by 43% relative to BAU, and other renewable sources will more than double.

In the power sector, electricity generation in ASEAN under the LCET scenario would reach around 3,848 terawatt hours (TWh) by 2050, similar to BAU. However, the generation mix would be significantly different. Both coal-fired and gas-fired electricity production would drop by about 90% compared to BAU. Other renewable sources are expected to nearly triple their electricity

generation. Coal and gas power plants with carbon capture and storage (CCS) are projected to produce 346 TWh and 985 TWh, respectively. Hydrogen and ammonia power generation is expected to contribute 252 TWh by 2050 (Figure 2).

Figure 2. Electricity Generation in ASEAN by Source, Business-as-Usual and Low-Carbon Energy Transition 2019–2050
[terawatt hours]



BAU = business-as-usual; CCS = carbon capture and storage; Hydro = hydropower; LCET = low-carbon energy transition; TWh = terawatt hour.

Note: 'Others' covers wind, solar, and biomass sources.

Source: Energy Outlook and Energy Saving Potential in East Asia, 2023.

The impact on carbon emissions is substantial. In the BAU scenario, carbon emissions from energy consumption in ASEAN are projected to increase from 425 million tonnes of carbon (Mt-C) in 2019 to approximately 1,177 Mt-C in 2050. However, under the LCET scenario, emissions would decrease to 301 Mt-C by 2050, which is 29% less than 2019 LCET emissions and 74% less than the BAU scenario.

To achieve carbon neutrality in the ASEAN region, several key strategies have been identified through the analysis above. These include improving energy efficiency and increasing electrification, expanding variable renewable energy (VRE), and diversifying power sources to include hydro, geothermal, biomass, and nuclear power. Additionally, implementing CO₂-free hydrogen, CCS, and negative-emission technologies is crucial. The transition from coal to natural gas in the power sector, along with the introduction of more efficient turbines and co-firing with hydrogen or ammonia in existing fossil fuel power plants, are also important steps.

In addition to this research, recent studies have estimated the cost-optimal deployment of energy technologies to achieve carbon neutrality by 2050/2060 in ASEAN. The results indicate that energy efficiency and electrification are essential strategies, with VRE highlighted as a major contributor

due to its potential in the region. The region also needs to diversify its power sources and various carbon-free technologies to achieve carbon neutrality.

Despite the potential for deep decarbonisation, several challenges remain. Economic hurdles include rising mitigation costs and energy prices while carbon-free technologies are still expensive. The varying availability of low-carbon energy sources and technologies across countries as well as the feasibility of using them, pose another challenge. Geographical and climate limitations affect the potential of certain renewable energy sources. Additionally, external factors such as global events and geopolitical tensions can hinder the realisation of net-zero emissions goals. The continuous growth in energy demand due to high economic and population growth projected up to 2050/2060 further complicates the transition.

Related Publications

Energy Outlook and Energy Saving Potential in East Asia 2023
Decarbonisation of ASEAN Energy System: Optimum Technology Selection Model Analysis up to 2060- updated 2023

2.2 Power Generation

The ASEAN region has been the focus of significant research regarding energy integration and renewable energy adoption. Two key areas of research under this theme are the ASEAN Power Grid (APG) initiative and the integration of renewable energy sources in electricity system.

ASEAN Power Grid (APG)

The APG initiative, proposed in the ASEAN Vision 2020 in 1997, has been a focal point of research due to its potential benefits and challenges. Studies have highlighted the APG's role in optimising the utilisation of diverse energy resources across the ASEAN region, promoting economic development, and enhancing energy security.

The past research underscores the critical importance of regional cooperation to develop and manage shared energy resources. The economic benefits of cross-border power trade are significant, leading to optimised use of energy resources, cost reduction, and power sector development. Moreover, studies indicate that the APG has the potential to reduce greenhouse gas (GHG) emissions, contributing to environmental sustainability.

The Lao PDR–Thailand–Malaysia–Singapore Power Integration Project has been identified as a 'pathfinder' project, demonstrating the feasibility of multilateral power trading within ASEAN. However, research also highlights significant challenges, particularly in harmonising technical

standards, regulatory frameworks, and market rules amongst countries with diverse development levels and energy policies.

Studies emphasise the importance of preparing for and integrating new technologies such as renewable energy sources, energy storage, smart grids, hydrogen-based energy, ultra-high voltage transmission, and artificial intelligence for grid management. The potential of hydrogen as a complementary energy source is recognised, especially for hard-to-electrify sectors, supporting the carbon neutrality agenda and complementing APG development.

Related Publications

- Power Generation and Cross-border Grid Planning for the Integrated ASEAN Electricity Market: A Dynamic Linear Programming Model (ERIA Discussion Paper 2012-15)
- Investing in Power Grid Interconnection in East Asia (ERIA Research Project Report 2013, No.26)
- Infrastructure Investment for Power Trade and Transmission in ASEAN+2: Costs, Benefits, Long-Term Contracts, and Prioritised Development (ERIA Discussion Paper 2014-21)
- Financing Renewable Energy Development in East Asia Summit Countries: A Primer of Effective Policy Instruments (ERIA Research Project Report 2014, No.27)
- A Review on Institutional Framework, Principles, and Key Elements for Integrated Electricity Market: Implications for ASEAN (ERIA Discussion Paper 2016-26)
- Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning Institution (ERIA Research Project Report 2018, No.25)
- Study on the Formation of the ASEAN Power Grid Transmission System Operator Institution (ERIA Research Project Report 2018, No.24)

Electricity Generation from Renewables

Research on renewable energy integration in ASEAN countries has been driven by the need to reduce the region's carbon footprint, enhance environmental sustainability, stimulate economic growth, and enhance energy security.

Studies have identified numerous challenges to increasing the share of VRE in the region. These range from issues with the capacity and robustness of the power grid to energy storage requirements and market mechanism readiness. The sector also grapples with a lack of financing, underdeveloped localised supply chains, insufficient infrastructure, and a lack of harmonised policies and regulatory frameworks across ASEAN countries.

Research findings highlight several critical areas in the renewable energy landscape of ASEAN countries. Regarding financing, studies underscore that lack of proper and sufficient funding remains a key constraint. Effective strategies to address this include supportive policies that enhance project revenue and reduce risks, innovative business models for distributed generation, and the development of financial instruments such as green bonds.

Energy storage emerges as another crucial factor in the findings. The intermittent nature of renewable energy sources necessitates significant storage capacity to fully absorb and utilise this

energy. Research emphasises the importance of developing appropriate supportive policies to boost both the financing and the market mechanisms for remunerating energy storage capacities.

Studies also highlight the complementary role of hydrogen in the renewable energy landscape. Low-carbon hydrogen and its derivatives are emerging as important options for large-scale energy storage for electricity from renewables. Moreover, these energy carriers can support the decarbonisation of various key sectors in the economy.

The research to date emphasises the interconnected nature of renewable energy integration and power grid development in ASEAN countries. It underscores the need for a holistic approach that addresses financing, technological challenges, infrastructure development, and policy harmonisation. The research consistently points to the importance of regional cooperation and innovative solutions to overcome barriers and maximise the potential of renewable energy in the region.

Related Publications

- Electricity Futures in the Greater Mekong Subregion: Towards Sustainability, Inclusive Development, and Conflict Resolution (ERIA Research Project Report 2017, No.08)
- Study of Renewable Energy Potential and Its Effective Usage in East Asia Summit Countries (ERIA Research Project Report 2017, No.09)
- The Economics and Risks of Power Systems with High Shares of Renewable Energies (ERIA Research Project Report 2021, No.13)
- Renewable Energy Transition in South Asia: Role of Regional Energy Trade (ERIA Research Project Report 2023, No.10)
- Green Finance and Renewable Energy in ASEAN and East Asia (2023)
- Large-Scale Development of Renewables in the ASEAN (2024)

2.3 Electrification of Transport and Electric Mobility in ASEAN

ERIA's research has highlighted the complex interplay between electric vehicle (EV) adoption and its impacts on energy systems, carbon emissions, and economies within the ASEAN region. These studies have emphasised the need for an approach to sustainability assessment in electric mobility, considering not only on-road emissions but the entire lifecycle of EVs.

One of the key areas of research has been on policy measures to support wider EV penetration. ERIA's studies have indicated that a combination of financial and non-financial incentives is necessary for successful EV adoption. While reducing total ownership costs through subsidies and tax relaxations is important, support to enable the industry to reduce production costs and accelerate the development of charging infrastructure is equally crucial. The results also suggest that while EVs may have higher upfront costs, they can potentially offer lower total ownership costs over the vehicle's lifetime, depending on local conditions and policies.

ERIA researchers also underline the importance of country-specific EV penetration roadmaps. The impacts of EV penetration on the economy, energy systems, and climate change vary considerably amongst ASEAN countries. Factors such as the types of EVs being adopted, the existing configuration of the vehicle stock, the energy mix used in the power generation sector, and the characteristics of local industries all play a role in shaping these impacts.

The effect of EV penetration on employment, related industries, and the potential for fostering domestic EV and battery industries have also been examined. These analyses suggest that the transition to electric mobility could create new economic opportunities but could also pose challenges for existing industries.

Lastly, ERIA's ongoing research activities have begun to address the sustainability of the entire EV lifecycle, including manufacturing, supply chain, and the mining of critical minerals. These studies highlight the need for responsible sourcing of materials and sustainable end-of-life management for EVs and their batteries.

Overall, past and current ERIA research on electrification of transport and electric mobility in ASEAN presents a complex picture of challenges and opportunities. It emphasises the need for nuanced, country-specific approaches that consider the broader implications for energy systems, economies, and long-term sustainability. As the region continues to pursue electric mobility, ongoing research will be crucial to guide policy decisions and maximise the benefits of this transition.

Related Publications

- An Analysis of Alternative Vehicles' Potential and Implications for Energy Supply Industries in Indonesia (ERIA Research Project Report 2017, No.15)
- Study on Electric Vehicle Penetrations' Influence on 3Es in ASEAN (ERIA Research Project Report 2019, No.06)
- The Influence on Energy and the Economy of Electrified Vehicle Penetration in ASEAN (ERIA Research Project Report 2020, No.14)
- Study on Policies and Infrastructure Development for the Wider Penetration of Electrified Vehicles in ASEAN Countries (ERIA Research Project Report 2022, No.18)

2.4 Energy Efficiency and Conservation in ASEAN

Recent studies have highlighted a complex landscape of energy efficiency and conservation (EEC) in the ASEAN region, particularly focusing on the paradoxical trend of improving energy efficiency alongside worsening carbon intensity in countries with large populations and economies. Research conducted by ERIA has shed light on this phenomenon, examining four key countries – Indonesia, Malaysia, the Philippines, and Viet Nam – which account for approximately 90% of total energy supply and CO₂ emissions in ASEAN. The studies reveal that factors contributing to worsening carbon intensity vary by country. In Indonesia and Viet Nam, the primary causes are the low efficiency of coal-fired power generation and increasing coal consumption in manufacturing industries, while in the Philippines and Malaysia, the main factor is rising energy consumption in the road sector due to motorisation.

The research emphasises the role of energy efficiency indicators in promoting and monitoring a country's EEC programmes. ERIA's research has contributed to this field by developing and measuring energy efficiency indicators for the commercial and industrial sectors, with a case study for the Philippines. In this respect, these indicators suggest potential for energy savings compared to neighbouring countries such as Singapore and Malaysia, indicating opportunities for targeted interventions to improve energy efficiency in these sectors.

Several studies have focused on the economic aspects of EEC investments. Notably, that ASEAN can expect \$15.4 billion in annual net benefits and a very high (30%) internal rate of return from EEC investment over the next 20 years. However, the research also highlights the challenge of substantial upfront investment, which may necessitate financial assistance and policy interventions.

Research on the transport sector has revealed insights into the relationship between infrastructure development and energy efficiency. A study focused on Da Nang City, Viet Nam, found that a 10-year delay in developing public transport systems could increase oil consumption

by 5% by 2030. This finding points to the importance of timely infrastructure development to improve energy efficiency.

The research shows that the issues are complicated, offering both challenges and opportunities. It emphasises the need for a multifaceted approach to achieve sustainable development that incorporates not only technological solutions but also policy interventions, financial mechanisms, and behavioural changes. It highlights the potential for significant economic benefits from energy efficiency investments, while also revealing the challenges in implementing these solutions, particularly in the face of rapid urbanisation and industrialisation.

Related Publications

- Addressing Energy Efficiency in the Transport Sector through Traffic Improvement (ERIA Research Project Report 2016, No.04)
- Cost Effectiveness of the Energy Efficiency and Conservation Policy in the Association of Southeast Asian Nations (ERIA Research Project Report 2018, No.14)
- Assess EE&C Indicators and Policies to Ensure a Low Carbon Development Path (ERIA Research Project Report 2023, No.13)
- Conducting Energy Consumption Survey and Establishing Energy Efficiency Indicators for the Industrial and Commercial Sectors of the Philippines (ERIA Research Project Report 2023, No.15)

2.5 Cross-sectoral Themes

Future Clean Energy (Hydrogen, Ammonia, Other Power-to-X)

ERIA's research has shed light on the potential of hydrogen as a key player in the future clean energy landscape of ASEAN. This comprehensive study explores various aspects of hydrogen development in the region, including demand projections, supply sources, production economics, and strategic roadmaps.

The research on hydrogen use in ASEAN reveals a growing trend, with demand as feedstock primarily concentrated in the industrial sector. Hydrogen consumption increased from 3.270 million tonnes per annum in 2015 to 3.745 million tonnes per annum in 2021, with projected annual growth rates of 2.34% to 3.94% from 2020–2050, depending on climate ambitions. The highly climate ambitious scenarios from the study show a significant increase toward mid-century of low-emission hydrogen use to produce not only industrial commodities but also to produce ammonia fuels and e-methanol to be used in power generation and transport sectors.

On the supply side, promising sources for hydrogen production in the East Asia and ASEAN region include flared gas, low-rank coal, and hydropower. An innovative approach involving electricity curtailment from renewable sources could generate 4.23 to 8.96 million tonnes of hydrogen annually by 2050, effectively utilising excess renewable energy in the ASEAN region.

The cost-effectiveness of hydrogen production is heavily dependent on feedstock prices and production efficiency. While gas reforming is currently the most economical method, the study notes that the falling cost of renewable hydrogen production could soon be a game-changer. Demand potential to use hydrogen and energy and carriers are identified in the power generation and transport sectors. Interestingly, countries like Australia, Brunei Darussalam, Indonesia, Malaysia, and New Zealand are identified as well-positioned for extensive hydrogen adoption due to their advantageous combination of low supply costs and high-income levels.

The research identifies liquid hydrogen as the preferred form for long-distance transport and large volumes and emphasises the importance of establishing regional and global hydrogen supply chains for the evolution of future energy markets. Global hydrogen trading is anticipated to commence between 2020 and 2030, with projections of a global hydrogen energy network by 2040–2050, signalling a significant shift in international energy dynamics.

The research outlines a phased approach to hydrogen development in the ASEAN region. From 2026 to 2030, ASEAN could transition to blue hydrogen energy exports, leveraging CCUS technologies. Beyond 2030, as renewable energy costs continue to decline, green hydrogen energy is expected to take centre stage, dominating both domestic applications and export markets.

While the research presents an optimistic outlook for hydrogen's future in ASEAN, it acknowledges challenges; nevertheless, the potential benefits are significant. Research to date suggests a gradual but steady transition from fossil fuel-based to green hydrogen production, driven by technological advancements, declining renewable energy costs, and increasing climate ambitions.

Related Publications

- Hydrogen Sourced from Renewables and Clean Energy: A Feasibility Study of Achieving Large-scale Demonstration (ERIA Research Project Report 2021, No.19)
- Demand and Supply Potential of Hydrogen Energy in East Asia - Phase 3 (ERIA Research Project Report 2022, No.04)
- Hydrogen Demand and Supply in ASEAN's Industry Sector: Current Situation and the Potential of a Greener Future (2024)

Biofuel and Biomass Energy

Research conducted by ERIA has provided comprehensive insights into the biofuel and biomass energy sector in Asia. This research was motivated by the potential of biofuels as an alternative energy source to mitigate CO₂ emissions, particularly in the transport sector, while also pursuing the broader goals of supporting farmers, GHG reduction, and increased energy independence in Asian countries.

ERIA's studies reveal that while the share of biofuels in Asia's transport fuel demand remains minimal at about 3%, demand is growing significantly. The research reports an increase of 8,700 million litres year-on-year in ASEAN+6 countries. This growth is expected to continue, driven by supportive government policies and higher blending requirements in countries like India and Indonesia.

From an environmental perspective, the studies highlight the potential of biofuels to reduce CO₂ emissions in the transport sector. However, they also emphasise the need to promote non-food feedstocks and crops with lower environmental burdens to minimise trade-offs with food production and water consumption. This finding underlines the importance of sustainable biofuel production practices.

The research notes the evolution of biofuel production technologies, from first-generation (1G) to fourth generation (4G), with each generation offering improved efficiency and sustainability. Algal biomass (3G) and genetically engineered feedstocks (4G) showed particular promise for high-yield, sustainable biofuel production, pointing to future directions for technological development in the sector.

In terms of market dynamics, studies found that biofuel prices are closely linked to feedstock prices, crude oil prices, distribution costs, and biofuel policies. Interestingly, domestic biofuel prices often diverge from international prices due to local policies and feedstock availability, highlighting the complex interplay between global and local factors in biofuel markets.

Based on these findings, the research provided several policy recommendations. These include promoting non-food feedstocks, encouraging production of low water-consuming crops, establishing efficient supply chains, implementing certification systems for GHG savings, promoting flex fuel vehicles, and providing financial incentives for higher ethanol blends. These recommendations aim to address the challenges and leverage the opportunities identified in the biofuel sector.

Overall, the research reveals a complex interplay of technological advancements, policy interventions, and market forces shaping the biofuel landscape in Asia. While biofuels show significant potential for enhancing energy security and environmental sustainability, realising these benefits requires careful policy design and technological innovation. The research emphasises the need for a holistic approach that considers not only environmental benefits but

also the economic and social impacts of biofuel production and use. It underscores the importance of continued investment in advanced biofuel technologies and supportive policy frameworks.

Related Publications

Evaluation of CO₂ Emissions Reduction by Mobility Electrification and Alternative Biofuel Introduction in East Asia Summit Countries (ERIA Research Project Report 2020, No.15)
 Analysis of Future Mobility Fuel Scenarios Considering the Sustainable Use of Biofuels-Phase-2 (ERIA Research Project Report 2022, No.16)

Natural Gas as a Transitional Fuel

Research conducted by ERIA has shed light on the complex role of natural gas as a transitional fuel in Southeast Asia. This comprehensive study was motivated by the dramatic increase in liquefied natural gas (LNG) imports in ASEAN countries, rising from almost zero in 2010 to 12 million tonnes per annum by 2020.

The research reveals that the surge in LNG imports reflects the region's growing need to diversify its energy sources for power generation, with natural gas emerging as a relatively clean alternative to coal. However, price volatility in LNG markets has raised concerns about the reliability and affordability of natural gas as a transitional fuel.

Despite these challenges, the studies indicate that natural gas is expected to play a crucial role in the clean energy transition, both in the short-term (2020–2030) and the long-term (2030–2050). This expectation is set against the backdrop of depleting domestic natural gas resources in the region, further accentuating the importance of this transition.

The research identifies several key strategies for ASEAN countries to navigate the challenges of using natural gas as a transitional fuel. A primary focus is on securing long-term LNG supply sources. This involves not only increasing supply from existing projects and prolonging their life expectancy, but also expanding new supply sources in regions such as North America, Australia, and East Africa.

Enhancing the region's purchasing power emerges as another crucial strategy. The research proposes that demand should be aggregated within the region to optimise cargo flow and partnerships with buyers in different regions should be considered, to take advantage of seasonal demand variations. The findings also emphasise the importance of altering LNG contract terms and conditions in global trading.

Adapting climate goals in the context of natural gas use is another key recommendation highlighted in the literature. The studies suggest a more flexible application of climate mitigation measures, including clarifying international standards for CCS, reducing flaring, and implementing other decarbonisation measures along the value chain.

Finally, ERIA's research into natural gas highlights the critical role of regional cooperation in addressing the challenges of natural gas as a transitional fuel. It advocates for a multifaceted approach that encompasses long-term planning, contract flexibility, and adaptive climate policies to maximise natural gas's potential while minimising the risks. The literature emphasises the pivotal role of governments in providing guidance and support, including equitably evaluating coal-to-gas conversion impacts and implementing balanced policies that address economic growth, energy security, and sustainability objectives. This comprehensive strategy aims to navigate the complex transition towards cleaner energy sources in the region.

Related Publications

A Flexible LNG Market and Promotion of Investment (ERIA Research Project Report 2021, No.15)
Exploring Short-term Solutions to the Global Gas Crisis (ERIA Policy Brief No.2022-04)
Effective Management of Methane Emissions in ASEAN (ERIA Research Project Report 2023, No.28)

CCUS Potential in ASEAN

Recent research conducted through the Asia CCUS Network (ACN) has provided comprehensive insights into the potential and challenges of CCUS technologies in the ASEAN and East Asian region. This research is particularly significant given the region's heavy reliance on fossil fuels and the challenge of transitioning to net-zero emissions while maintaining energy security and economic growth.

Research conducted through ACN reveals substantial potential for CCUS in Southeast Asia, with resources for an estimated 200 gigatonnes of CO₂ storage available across six countries. Indonesia, Malaysia, and Thailand lead in terms of suitable storage basins and resources. The studies highlight CCUS hubs and clusters as a promising strategy, connecting multiple CO₂ emission sources and storage sites. These hubs offer significant advantages, including reduced costs and risks, cost-effective transport and storage from small volume sources, and preservation of investments and jobs in high-emitting industrial regions.

The research identifies legal and regulatory frameworks as a critical area requiring attention. There is a need for comprehensive frameworks to govern CCUS activities, especially for transboundary projects. The studies point to Indonesia and Thailand as examples of collaborative processes in developing such frameworks, providing valuable insights for other countries in the region.

Financial analysis in the research indicates substantial investment to support net-zero commitments. ACN's research estimates that an \$880 billion investment in CCUS is needed across Southeast Asia between now and 2065. This investment could reduce the overall cost of meeting net-zero commitments by more than \$20 trillion over the same period, highlighting the long-term economic benefits of CCUS deployment.

The literature underscores the critical role of policy support in successfully implementing CCUS, emphasising the need for policies that align private investment incentives with public good. These include carbon pricing mechanisms, regulatory mandates, financial incentives, and revenue support for CCUS projects. Additionally, the research highlights significant opportunities within the regional oil and gas industry for low-cost emissions reductions and potential anchor projects for ACN. This industry involvement is identified as a key factor in accelerating CCUS deployment, suggesting that a combination of supportive policies and strategic industry partnerships could drive the advancement of CCUS technologies in the region.

Looking to the future, the research suggests that the strategy for implementing CCUS in ASEAN and East Asia is expected to evolve. Beyond 2040, there is an anticipated shift towards carbon recycling technologies, potentially transforming CO₂ from an emission to a valuable commodity. This shift could open new economic opportunities while contributing to emissions reduction goals.

Related Publications

- Study on the Potential for Promoting Carbon Dioxide Capture, Utilisation, and Storage (CCUS) in ASEAN Countries: Current Situation and Future Perspectives (ERIA Research Project Report 2021, No.21)
- Study on the Potential for Promoting Carbon Dioxide Capture, Utilisation, and Storage (CCUS) in ASEAN Countries Vol. II (ERIA Research Project Report 2021, No.25)
- Geological Storage Potential of CO₂ in Southeast Asia (under publication process)
- Legal and Policy Framework for Deployment of CCUS in Asia Region, focused on ASEAN (under publication process)
- Study on Financial Framework for Deployment of CCUS in the Asian Region, including ASEAN (under publication process)

2.6 Transition Finance in Asia

Transition finance has emerged as a crucial tool in the global fight against climate change in recent years, especially in rapidly growing economies. The Paris Agreement has set the stage for countries worldwide to pursue decarbonisation targets, but the pathways to achieve these goals vary significantly across regions due to differences in energy infrastructure, economic development, and financial resources.

Asia presents a unique case for transition finance due to its diverse economic landscape and varying degrees of reliance on fossil fuels. Countries such as China, India, Indonesia, Malaysia, and Singapore are at different stages of developing and implementing taxonomies and decarbonisation strategies. These frameworks aim to attract investments into both green and transition activities, recognising the necessity of a gradual transition from high-carbon to low-carbon energy sources.

In this context, ERIA has been supporting the development of transition finance in the region by facilitating multi-stakeholder dialogues and providing reference points for financial institutions and policy makers. The activities highlight the complexity of this transition in Asia, emphasising the need for region-specific guidelines and frameworks. Recognition of the gap led to the formation of the Asia Transition Finance Study Group (ATF SG), comprising major Asian and global banks, development banks, export credit agencies, financial and energy authorities, and financial associations. The group's formation underscores the recognition of Asia's unique challenges in implementing transition finance.

ATF SG's approach includes learning sessions, study group discussions, and extensive stakeholder consultations through online surveys and interviews. This collaborative approach ensures that the developed frameworks and guidelines are practical, comprehensive, and aligned with the needs of various stakeholders in the region.

ATF SG have identified several key challenges in implementing transition finance in Asia. Financial institutions face difficulties in evaluating transition technologies due to the lack of universally accepted pathways and references. This challenge is compounded by the need for localised references that consider regional specifics. Furthermore, the existence of multiple standards and taxonomies has created confusion and interoperability issues for financial institutions attempting to assess transition finance projects.

ATF SG's activity also reveals a substantial demand for transition finance across several key sectors in Asia, including energy, transport, and manufacturing. This demand is driven by national commitments to decarbonisation and the broader goals of the Paris Agreement. However, meeting this demand requires coordinated support from governments, international organisations, and the

private sector to develop supportive policies, financial incentives, and cross-border collaboration.

To address these challenges, recent initiatives have focused on developing robust, region-specific frameworks and tools. The ATF SG has been at the forefront of these efforts, creating detailed, science-based pathways and roadmaps for decarbonisation that align with the Paris Agreement. The group has also formulated comprehensive guidelines for financial institutions to assess the viability and credibility of transition finance projects.

A significant contribution to the field is the development of the Technology List and Perspectives for Transition Finance in Asia (TLP). This tool serves as a reference for suitable transition technologies in various sectors, addressing the need for region-specific guidance. The TLP and the ATF Guidelines aim to bridge the gap between global decarbonisation goals and the practical realities of implementing transition finance in Asia.

The current activities on transition finance in Asia highlight its critical role in facilitating the region's shift towards a sustainable, low-carbon future while maintaining economic stability and growth. The complex nature of this transition, coupled with the diverse economic and energy profiles of Asian countries, necessitates tailored, region-specific approaches. Ongoing research and initiatives, such as those led by the ATF SG, are crucial to develop the frameworks and tools needed to overcome the challenges and capitalise on the opportunities presented by transition finance in Asia.

Related Publications

Technology List and Perspectives for Transition Finance in Asia (2022)
Asia Transition Finance Study Group (ATF SG) Annual Report (2023)



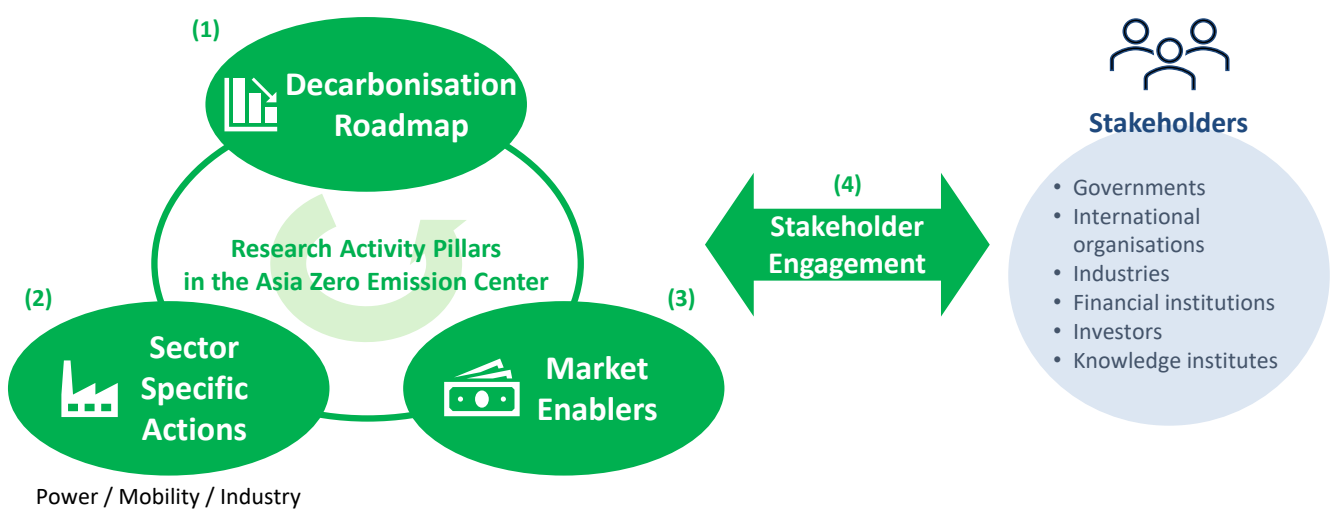
3

The Asia Zero Emission Center and the Prospective Research Programmes

The Asia Zero Emission Center (the Center) builds upon ERIA's extensive research portfolio that encompasses decarbonisation outlooks, sector-specific and cross-sectoral technology assessments for energy transition, and studies on financial mechanisms for supporting actual implementation of the technology, as described in the previous chapter. Moving forward, the Center aims to extend and deepen this comprehensive body of work while addressing additional key issues crucial for decarbonisation in Asia, closely aligning with the aspirations of AZEC including AZEC Sectoral Initiatives proposed at the second AZEC Ministerial Meeting.

From this perspective, the Center has organised 'activity pillars' as a basic concept of its activities in Figure 3.

Figure 3. Activity Pillars in the Asia Zero Emission Center



Source: Asia Zero Emission Center, 2024.




The first pillar, the Decarbonisation Roadmap, serves as a reference point for guiding plans, setting targets and timelines, and identifying key drivers to achieve carbon neutrality in each partner country. This pillar outlines optimal and practical decarbonisation pathways tailored to the circumstances of each country, as well as identifying the key sectors and technologies to be aligned with the pathways. The second pillar, Sector Specific Actions, provides more in-depth insights on those key sectors and technologies and is particularly centred in the power, mobility, and industry sectors. These focal sectors are embedded into the composition of AZEC Sectoral Initiatives.

However, moving energy transition forward in Asia requires huge and long-lasting investments due to the current immaturity and relatively high costs of green and transition technology. To drive deployment of decarbonisation technologies while securing sustained economic growth, it is crucial to coordinate the structure of the market so that necessary technologies can be evaluated properly and attract enough investments in a sustainable way. In this regard, the third pillar, Market Enablers, facilitates the adoption of decarbonisation practices in each partner country. The actual implementation and deployment of decarbonisation technologies will be an effective input to develop a more elaborate and useable Decarbonisation Roadmap, creating a positive feedback loop within the tripartite research activity pillars in the Center.

As the Center pursues these research activity pillars, its research will strengthen and develop consistency and comprehensive insights across the pillars. The fourth pillar, Stakeholder Engagement, fosters discussion and regional cooperation amongst AZEC partner countries. This will facilitate the dissemination of Center’s research and insights to all stakeholders. It will also feed into future AZEC activities and promote collaboration with similar international institutions and organisations.

Through these activity pillars, the Center aims to serve a platform for policy dialogue to help AZEC partner countries develop vision, roadmaps, or policies towards decarbonisation. The following subsection will delve into the Center’s current and prospective research programmes set out in Figure 4 along with the research activity pillars.

Figure 4. Prospective Research Programmes in the Asia Zero Emission Center

 Decarbonisation Roadmap		<ul style="list-style-type: none"> Decarbonisation Roadmap Development 	
 Sector Specific Actions	Power	<ul style="list-style-type: none"> Power Grid 	<ul style="list-style-type: none"> Hydrogen and Ammonia Biofuel / Biomass Natural Gas as a Transitional Fuel CCUS / Carbon Recycling Critical Minerals
	Mobility	<ul style="list-style-type: none"> Future Mobility 	
	Industry	<ul style="list-style-type: none"> Energy Efficient Equipment 	
 Market Enablers		<ul style="list-style-type: none"> Green / Transition Finance Carbon Market 	

Source: Asia Zero Emission Center, 2024.

3.1 Decarbonisation Roadmap

The Decarbonisation Roadmap will enable the Center to continue to update the quantitative analysis model for the entire energy system covering the whole ASEAN region. It will streamline the data flow and the calculation logic of the model, reflecting the latest trends and policies in each country, and will incorporate available insights collected from other programmes.

In addition, the Center will promote stakeholder consultations based on the outcomes of the analysis. It will disseminate its findings to a range of stakeholders by utilising the existing platforms in ERIA and other communication tools with particular reference to the promotion of

transition finance. By incorporating collected feedback into the analysis model, the Center will strengthen the credibility and transparency of its roadmap, aiming to create a comprehensive and practical decarbonisation roadmap that accurately reflects each country's unique circumstances in Asia.

While deepening country-specific insights and identifying key elements to be aligned with the pathway toward carbon neutrality, the Center will also consider more granular analysis such as sectoral- and industrial-level roadmaps and pathways based on the results from high-level analysis.

3.2 Sector Specific Actions

Power Grid

The Center focuses on several key initiatives to enhance the APG and promote sustainable energy transition. The first is to establish multilateral power trade institutions. The Center aims to develop an intergovernmental agreement to create institutions with APG Generation and Transmission Planning and Transmission System Operation functions.

The second initiative is to integrate new technologies for a smarter, flexible, and resilient low-carbon energy transition. This involves identifying and implementing new grid technologies, estimating their benefits, developing deployment roadmaps, and identifying priority pilot projects.

The third initiative is to enhance cybersecurity for distributed energy systems. The Center focuses on the Energy Resource Aggregation Business framework. In this framework, various systems are operated by interconnection with each other via the Internet and other networks. There are concerns that any weak cybersecurity measures may affect the use of electricity by consumers. Therefore, the project will research institutional developments in distributed energy resource use and cybersecurity in ASEAN countries. The goal is to develop guidelines and a roadmap for cybersecurity in ASEAN–Japan cooperation.

Future Mobility

Decarbonisation of the mobility sector is crucial but requires a shift to more efficient propulsion technologies, which may initially increase costs. The Center's project aims to assess the mid-century scenario without decarbonisation measures and formulate optimal strategies to achieve net-zero emissions.

The project focuses on two main shifts from the current internal combustion engine technologies to low-carbon next generation vehicle technologies, and from the current domination of an individual, human operated, private, and fossil fuel-based mobility and transport system to one that is more connected, autonomous, shared, and electric-based.

A key initiative is the development of the Masterplan for the ASEAN–Japan Next Generation Vehicle Industry Strategy. This plan will address technological shifts in road transport modes, with a focus on the powered four-wheelers, considering industry strategies, supply chains, and end-of-life vehicle management. The main objective of the study is to provide a guide for policy makers, industry players, and other stakeholders to strengthen the competitiveness of ASEAN's automotive industry while decarbonising.

Energy Efficient Equipment

The Center aims to promote carbon neutrality in Asia by encouraging the adoption of energy-efficient equipment, specifically heat pumps and small, once-through boilers. However, inadequate standards and regulations for these technologies present barriers to their widespread implementation.

To address this issue, the Center is conducting surveys in India, Thailand, and Viet Nam – countries with high potential for economic growth and significant food industry needs. These surveys will assess the current state of commerce to form de facto values and gather information necessary for governments and standardisation organisations to establish formal standards.

The short-term work plan includes research on equipment needs, on means of building capacity for equipment use and management, and on ways of harmonising manufacturing and safety standards and regulations. This comprehensive research aims to lay the groundwork for effective implementation of these energy-efficient technologies.

The results of the research are expected to lead to the implementation of on-site demonstrations to increase adoption rates and to increase capacity building. This will be done by, for example, familiarising local students and other users with standards and regulations to enable them to manufacture safely and in an energy-efficient way. It will include other activities to disseminate standards and regulations that reflect the energy efficiency common to the rest of Asia.

Cross-sectoral: Hydrogen and Ammonia

Achieving carbon neutrality in ASEAN requires diverse pathways, including the integration of hydrogen and ammonia into the energy mix. The region's vast, untapped renewable energy potential presents significant opportunities for producing low-carbon hydrogen and ammonia. However, these low-carbon alternatives currently face cost challenges compared to their fossil fuel-derived counterparts.

The Center is addressing these challenges through ongoing projects that analyse regional supply and demand potentials for hydrogen and ammonia. Short-term goals include mapping current findings, identifying research gaps, and developing country-specific hydrogen roadmaps and a regional hydrogen masterplan. These plans will encompass value chain technologies, supply costs, regulatory frameworks, and carbon intensity accounting for hydrogen production.

Future research will expand into several key areas. The Center will investigate the cost feasibility and market potential of low-carbon hydrogen and ammonia in the transport sector, exploring how these alternative fuels can be integrated into various modes of transportation. A similar analysis will be conducted for industry sectors, examining the potential applications and economic viability of hydrogen and ammonia in different industrial processes. Additionally, the research will assess the carbon emission reduction potential of hydrogen and ammonia use in industrial applications, quantifying the environmental benefits of transitioning to these cleaner energy sources.

Cross-sectoral: Biofuel / Biomass

The biomass industry has the potential to create new markets and jobs, boosting both income and environmental goals. Thus, the Center will study the sustainable biomass utilisation integrated approach. This study aims to analyse the current position of biomass utilisation across all sectors of the East Asia Summit region, particularly land usage for food and water resources. It will also guide East Asia Summit countries to achieve biomass production for bioenergy without compromising food and water security, land availability, or its impact on climate change.

The study will involve a literature review of biomass utilisation related to the water-energy-food nexus in East Asia Summit countries. It will highlight the availability of feedstocks in each country alongside relevant data indicators, including those relating to water, energy, food, land and climate. This comprehensive approach will ensure a holistic understanding of the biomass industry's potential and its implications for sustainable development in the region.

Cross-sectoral: Natural Gas as a Transitional Fuel

ERIA has been involved in the Gas Policy Development Project Phase 3 which aims to assist the Department of Energy of the Government of the Philippines to implement the Philippine Downstream Natural Gas Regulation and to promote LNG market development through regulation creation, research, capacity building, and a policy advisory. This includes developing the Philippine National Standards for natural gas products and facilities, drafting regulations for critical agencies and local governments, and creating an inspection manual for midstream and downstream projects.

Research efforts will focus on the economic feasibility of small-scale LNG supply for specific regions, identifying anchor markets for gas-to-power projects, and assessing the viability of LNG in economic zones. Additionally, a life cycle assessment of local natural gas applications will be conducted to evaluate environmental impacts and carbon reduction benefits.

Capacity-building activities will include short-term training and policy exchange for government energy practitioners, as well as long-term research grants and lectures for academia and the public. The project will also provide policy advisory services, particularly on fostering a vibrant LNG industry through relevant bills, policies, and standards.

Cross-sectoral: CCUS/Carbon Recycling

As noted, the ACN provides a platform for policymakers, financial institutions, industry players, and academia to collaborate to ensure the successful development and deployment of CCUS in Asia. Current and short-term ACN activities include forums, workshops, and feasibility studies on CCUS pilot projects.

In addition to these ongoing activities, ACN will conduct a cross-border CCUS project. This initiative aims to identify potential obstacles in the policy and financial framework of cross-border CCUS projects and suggest solutions based on knowledge synthesis and stakeholder dialogues, focusing on major Asia-Pacific countries.

The project will address several critical research issues in cross-border CCUS operations, including liability determination, risk allocation, and the implications of environmental regulations. The project will also cover the impact of international trade laws and tax schemes on such projects. Additionally, the research will tackle the complex challenge of pricing CO₂ leakage in cross-border contexts and develop strategies to incentivise engagement in cross-border CCUS activities. Another issue to be explored is the role of public–private partnerships in facilitating these projects.

ACN will also conduct research on the risk and liability of CCS, CCS project measurement, reporting, and verification (MRV), carbon accounting, and carbon recycling in ASEAN. This comprehensive approach aims to address the multifaceted challenges of implementing CCUS technologies across national boundaries in the Asia-Pacific region.

Cross-sectoral: Critical Minerals

Global critical mineral demand is expected to increase dramatically in the coming decades, from 7.1 million tonnes in 2020 to 42.3 million tonnes in 2050. This surge is driven by the global commitment to decarbonisation, as clean energy technologies require significant quantities of critical minerals. However, establishing downstream processing of these materials in Southeast Asia presents a significant challenge.

Secured and resilient (reliable) critical mineral supply chains are essential for energy transition, including those for nickel, tin, rare-earth elements, and bauxite. These supply chains are key to scaling up the installation of wind turbines, advanced batteries, electrolysers, and clean energy grids. Southeast Asia possesses substantial natural reserves of key critical minerals, which are not yet fully explored. To become a hub for critical mineral supply, this region will need support from experienced countries in the field, such as Japan and Australia.

Consequently, the Center will hold a series of forums at various policy levels. The intended outcome is a set of policy papers to guide the development strategy for building a secure and

resilient supply chain of critical minerals in ASEAN, East Asia, and beyond. Moreover, the Center will conduct research studies on the critical mineral value chain, hold two working group meetings, and publish books on the subject by 2025.

3.3 Market Enablers

Green/Transition Finance

Transition technologies are vital for achieving carbon neutrality under the Paris Agreement, particularly in Asia, due to the region's energy portfolio, economic conditions, and renewable energy resources. However, financial institutions face challenges when making financial decisions because of the uncertain market environment. The ATF SG was formed in 2021 to discuss these specific challenges and find potential solutions for a 'just and orderly transition,' as noted in the previous chapter.

Moving forward, ATF SG will continue dialogues amongst various stakeholders and publish its annual report for the financial year 2024, which highlights policy recommendations to unblock the bottlenecks of transition finance, and in-depth research papers on blended finance as a useful tool to make transition projects bankable.

In addition, the Center will expand the scope of TLP as a reference to assess potential transition technologies in Asia. The Phase 2 of TLP expansion (May 2024–January 2025) consists of the following components: (i) an inclusive list of technology covering both green and transition technologies for energy, power, and industry decarbonisation, (ii) technology deep-dive analysis for ~20 technology for the end-use and industry sectors, and (iii) technology deep-dive analysis for ~20 technology for energy and power sectors.

The Center will engage with financial institutions, governments, and industry players to promote the TLP. This engagement aims to encourage stakeholders to reference the TLP and incorporate its contents when creating their own decarbonisation roadmaps and strategies. By facilitating this knowledge transfer, the Center seeks to enhance the alignment of various sector strategies with current technological capabilities and future innovations in the field of decarbonisation.

The ASEAN region has great potential to find financial sources for low-carbon investment. This can be seen in the fact that, for example, it has consistently high levels of domestic savings compared to its gross domestic product. Given the amount of investment required for energy transition, it is also crucial to attract both public and private funds to fill the financial gap in the region. The Center will consider a robust financial mechanism for redirecting domestic savings in ASEAN to low-carbon investments within the region, as well as to explore an effective financial framework for driving public–private collaboration.

Green digital finance is taking centre stage to improve the financial system's effectiveness in mobilising capital towards a green and inclusive economy with a sustainable development goal. In cooperation with the National Bank of Cambodia, the Center will help build stakeholder capacity through workshops on issues related to green and digital innovation and will seek opportunities to develop environmental, social, and governance principles and green digital financing in Cambodia.

Carbon Market

Carbon pricing mechanisms, including taxes, compliance markets (cap-and-trade systems) and voluntary carbon markets are designed to change the behaviour of GHG emitters, reflecting the 'polluter pays' principle. These mechanisms aim to account for the social costs of climate change, incentivising emission reduction through innovation or carbon-offsetting investments.

Both developing and advanced Asian economies are cautiously and gradually adopting carbon mechanisms with price stability instruments – such as free allocation through floor ceilings and market stability reserves – to maintain industrial competitiveness. On the other hand, these mechanisms can create a gap between current prices and necessary prices to meet nationally determined contribution targets. To establish a fair policy, wider sectoral coverage is needed while securing appropriate compensating methods for people and labourers negatively affected by carbon pricing. A regionally recognised and transparent MRV system is also crucial for effective carbon pricing and could replace the current MRV methods used to design emission trading schemes and measure the carbon tax that vary across Asian economies and are filled with uncertainties. When developing and designing new carbon pricing approaches, national and regional frameworks should consider existing principles, and linkages across national, subnational, and international compliance mechanisms and minimise risks related to carbon leakages.

The Center aims to facilitate and expedite the implementation of the carbon market in Asia by addressing barriers and necessary conditions for a freely competitive market. As part of its future work plan, the Center will first focus on providing an overview of the current development of carbon pricing and markets in the region. Building on this foundation it will work towards enhancing policy coordination and regional cooperation. This will involve sharing best practices, facilitating cross-border trading, and benchmarking against global standards.

To ensure consistency and reliability in carbon market operations, the Center will conduct a study on a regional framework for MRV, as well as prioritise capacity building and knowledge sharing. Through a series of consultations and forums on carbon markets, the Center will support countries in their preparedness for carbon market development.



4

Concluding Notes

This paper has delineated the Asia Zero Emission Center's structure, objectives, and proposed activities, which collectively demonstrate a comprehensive strategy for addressing the complex challenges of decarbonisation in Asia.

Asia's transition to a diversified and sustainable energy system is gaining momentum, driven by national targets and supportive government policies. Fast-growing economies in the region need coherent and decisive plans for timely implementation of decarbonisation technologies and effective policies for opening markets and adopting new technologies. Innovation, robust research and development investment, and capacity building are also essential for cost-effective and seamless technology adoption. The energy transition for Asia's rapidly industrialising economies requires substantial investment, with significant initial outlays. Given the magnitude of investment required, government and concessional funding would not be sufficient. Innovative financing models, carbon markets, and pricing mechanisms need to be adopted to attract private investment into the market and bridging the funding gap.

The establishment of the Center represents an important development in the region's approach to achieving carbon neutrality. The framework of its tripartite research activity pillars, comprising the Decarbonisation Roadmap, Sector Specific Actions, and Market Enablers, embodies a sophisticated strategy for navigating the complexities of the energy transition in Asia, aligned with the principles of AZEC. The prospective research programmes outlined in this paper, spanning areas such as power grid enhancement, future mobility, energy efficiency, and alternative energy sources, illustrate the Center's commitment to addressing key technological and infrastructural challenges. Moreover, the focus on green/transition finance and carbon market development underscores the recognition of economic mechanisms as critical enablers of the low-carbon transition.

The Center's emphasis on multi-stakeholder engagement and cross-organisational collaboration is a notable strength built upon continuous dedication to ASEAN and East Asia since the establishment of ERIA. By facilitating active interaction amongst governments, international organisations, industries, financial institutions, investors, startups, and knowledge institutes, the Center will serve as a platform for policy dialogue and will be a knowledge hub for diverse stakeholders. In close liaison with ASEAN initiatives such as ASEAN Strategy for Carbon Neutrality and ASEAN Blue Economy Framework, as well as regional institutions such as the ASEAN Center for Energy and the ASEAN Center for Climate Change, the Center will contribute to simultaneously achieving decarbonisation, economic growth, and energy security, in this most dynamically evolving region of the world.

Overall, the Center represents a significant institutional innovation in Asia's climate change mitigation efforts. Its comprehensive, collaborative, and regionally tailored approach positions it as a potentially influential entity in shaping the future of energy and environmental policy across Asia. Leveraging its full capabilities, the Center will continue to advocate AZEC activities by providing critical policy insights and recommendations, including a report as articulated in the Joint Statement and its attached document at the 2nd AZEC Ministerial Meeting. The Center's ongoing development and implementation of its programmes warrant close attention from policymakers, researchers, and stakeholders involved in the region's sustainable development.

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