

Policy Brief

Balancing Promise and Reality: Bioenergy's Role in ASEAN's Energy Security and Decarbonisation

Key Messages:

- Bioenergy is ASEAN's most plentiful renewable resource and can enhance energy security through domestically and sustainably sourced fuels.
- Agricultural and forestry residues remain significantly underutilised, while open burning continues to cause air pollution (PM2.5), haze, and greenhouse gas emissions.
- Sustainability risks – land use competition, biodiversity loss, and water stress – must be managed through clear and harmonised standards.
- High logistics and transport costs constrain competitiveness; investment in rural collection and processing hubs is essential.
- Bioenergy complements, rather than competes with, other renewables due to its dispatchability—the ability to generate power on demand.
- Regional cooperation under ASEAN mechanisms, the Asia Zero Emission Community (AZEC), the ASEAN Centre for Energy (ACE), and ERIA can accelerate technology transfer, harmonise sustainability frameworks, and facilitate intra-regional trade.

ASEAN is entering a decisive phase in its energy transition. Regional energy demand is projected to rise substantially in the coming decades, while continued reliance on imported fossil fuels exposes economies to price volatility and supply disruptions. At the same time, climate risks are intensifying, underscoring the urgent need to accelerate decarbonisation without compromising economic growth. Bioenergy – derived from agricultural and forestry residues, organic waste, and energy crops – sits uniquely at the intersection of these dual imperatives.

As the region's most abundant renewable energy resource, bioenergy can support energy security, create rural livelihoods, enhance residue management, and deliver substantial emissions reductions when sustainably developed. Yet expectations must be balanced with realistic assessments of land and water availability, logistics, technology readiness, and sustainability governance. Overestimating the resource base or underestimating supply chain constraints risks undermining credibility, investment, and long-term policy goals.

To ensure bioenergy contributes meaningfully to ASEAN's energy transition, policymakers should prioritise waste and residue feedstocks, strengthen sustainability certification, invest in logistics infrastructure, foster technological innovation, advance regional cooperation, and intraregional trade. Bioenergy will not replace fossil fuels outright, but as part of a diversified energy mix, it can help reduce reliance on fossil fuels, curtail waste burning, and support a just and inclusive transition – if governed with discipline and pragmatism.

Bioenergy in ASEAN's Energy Transition Landscape

ASEAN's energy demand is projected to rise sharply over the next decades due to economic growth, urbanisation, industrialisation, and the rapid expansion of data centres. At the same time, fossil fuels still account for more than 80% of the region's primary energy supply, leaving countries vulnerable to market fluctuations and external shocks. Recent supply disruptions and spikes in global LNG and coal prices have reinforced this vulnerability.

Bioenergy presents a strategic opportunity. Unlike solar and wind, biomass-based energy can provide firm and dispatchable power – highly valuable for ensuring grid stability in a rapidly electrifying region. Biomass resources are distributed across both mainland and archipelagic Southeast Asia, making bioenergy particularly relevant for remote communities, agricultural regions, and island grids that face high diesel generation costs.

Crucially, bioenergy is not a new concept for the region. Indonesia, Malaysia, Thailand, and the Philippines have implemented biofuels mandates for more than a decade. These programmes show that bioenergy can support domestic industries, reduce waste, and strengthen local value chains. The challenge today is to align bioenergy development with sustainability principles and modern energy system needs.

The Development Promise: Energy Security, Rural Livelihoods, and Decarbonisation

Strengthening Energy Security

Bioenergy's most immediate value lies in enabling countries to reduce their reliance on imported fuels. Because biomass can be sourced locally, bioenergy enhances energy sovereignty and reduces exposure to volatile oil and gas markets.

ASEAN countries with abundant agricultural production – such as Indonesia, Thailand, Viet Nam, and the Philippines – possess substantial biomass resources in the form of rice straw, rice husk, sugarcane bagasse, palm residues, maize stover, cassava residues, coconut residues, and livestock waste. Indonesia alone generates approximately 146 million tonnes of biomass residues annually (ERIA and ACE, 2025), while Thailand produces more than 135 million tonnes of agricultural residues from sugarcane, cassava, and rice combined (Gonocruz, Kudoh, and Anbumozhi, 2025). Thailand’s total biomass potential is estimated at 296 million tonnes per year, with an energy equivalent of nearly 70 million tonnes of oil equivalent (Ninomiya et al., 2025). ERIA’s regional assessments consistently identify these feedstocks as amongst the most scalable renewable energy resources in the region.

Dispatchable biomass power can also provide reliability where grid expansion is technically challenging or economically costly. This is particularly relevant for archipelagic nations such as Indonesia and the Philippines, where tens of millions still rely on small, isolated grids.

Advancing Rural Development

Bioenergy offers significant socioeconomic benefits for rural communities. Residues that are currently burned or left to decay can be converted into income streams for farmers. Local biomass supply chains also create jobs in collection, transport, storage, and processing.

Open burning remains a major environmental and public health challenge across Southeast Asia. Each year, millions of tonnes of rice straw, sugarcane trash, palm residues, and other biomass are burned in the open, contributing to fine particulate air pollution (PM2.5), transboundary haze, greenhouse gas emissions, and soil degradation. In Viet Nam, for example, a significant share of rice straw continues to be disposed of through open burning, although collection rates have improved in recent years with the introduction of straw balers (Gonocruz, Kudoh, and Anbumozhi, 2025). Bioenergy development – when complemented by organised residue collection systems, including appropriate mechanisation – can help reduce these practices while promoting more circular rural economies.

Supporting Decarbonisation

Bioenergy can provide substantial emissions reductions when feedstocks are sustainably sourced and supply chains are efficiently managed. ERIA’s AZEC partner country assessments find particularly strong mitigation potential in:

- biomass co-firing in existing coal plants
- upgraded biogas from livestock and organic waste
- biochar for soil enhancement and carbon sequestration

Lifecycle emissions from sustainably produced bioenergy are significantly lower than those of fossil fuels, particularly when feedstocks are derived from agricultural residues rather than dedicated energy crops.

However, realising this potential requires addressing several significant constraints.

The Limits of Bioenergy Development

Land Use and Water Stress

Large-scale cultivation of energy crops – such as sugarcane, oil palm, or fast-growing grasses – can place pressure on forests, food production, and water resources, potentially affecting food security and local food prices. ERIA’s Water–Energy–Food Nexus studies highlight that many ASEAN countries face tightening land availability and growing water stress, constraining opportunities for expansion.

Residues and wastes offer a more sustainable alternative, yet the volumes available depend on crop yields, harvest cycles, and competing uses such as soil amendment or livestock feed.

High Feedstock and Logistics Costs

Biomass is bulky, seasonally available, and geographically dispersed. Feedstock costs often represent the single largest cost component in bioenergy supply chains. In some cases, they account for more than 60% of total biomass procurement costs, while collection and transport add considerably to overall costs (Ninomiya et al., 2025).

These constraints mean that without efficient local collection systems and nearby processing facilities, many theoretically available biomass resources are economically unviable.

Technology Gaps

Bioenergy technologies range from well-established biodiesel plants to early-stage advanced biofuel facilities. Indonesia’s B40 (40% biodiesel blend) mandate and Thailand’s well-developed ethanol sector illustrate the differing levels of commercial maturity of first-generation biofuels (produced from food crops such as sugarcane, palm oil, and coconut oil) amongst ASEAN Member States (AMS). By contrast, advanced technologies – such as cellulosic ethanol, sustainable aviation fuel (SAF), and integrated biorefineries – remain largely at the pilot or pre-commercial stage and require further investment and policy support. Both Indonesia and Thailand have established roadmaps for SAF development. Indonesia targets a 1% blend by 2027, increasing to 2.5% by 2030 and 30% by 2050, while Thailand’s Alternative Energy Development Plan (AEDP) 2024 mandates a 1% SAF by 2026, rising progressively to 8% by 2036 (ERIA and ACE, 2025).

Market Competitiveness

Bioenergy competitiveness is strongly influenced by global oil prices. When crude oil prices decline, biodiesel and ethanol become less economically attractive without subsidies or fiscal incentives. Policy instability – such as frequent adjustments to blending mandates, price support mechanisms, and feedstock allocation rules – can further discourage long-term investment.

From a regional perspective, ASEAN is projected to maintain a biodiesel production surplus through 2030, driven primarily by Indonesia and Malaysia. By contrast, the region faces a persistent and potentially widening bioethanol deficit, presenting opportunities for greater intra-regional trade and cooperation (ERIA and ACE, 2025).

Looking ahead, ERIA and ACE projections indicate that regional biofuel demand could reach substantial volumes by mid-century – potentially 20–22 billion litres of bioethanol, nearly 40 billion litres of biodiesel, and 12–13 billion litres of SAF annually. Meeting demand at this scale will require not only national effort but also coordinated regional approaches to feedstock

development, infrastructure investment, and cross-border trade (ERIA and ACE, 2025).

Sustainability Governance and Standards

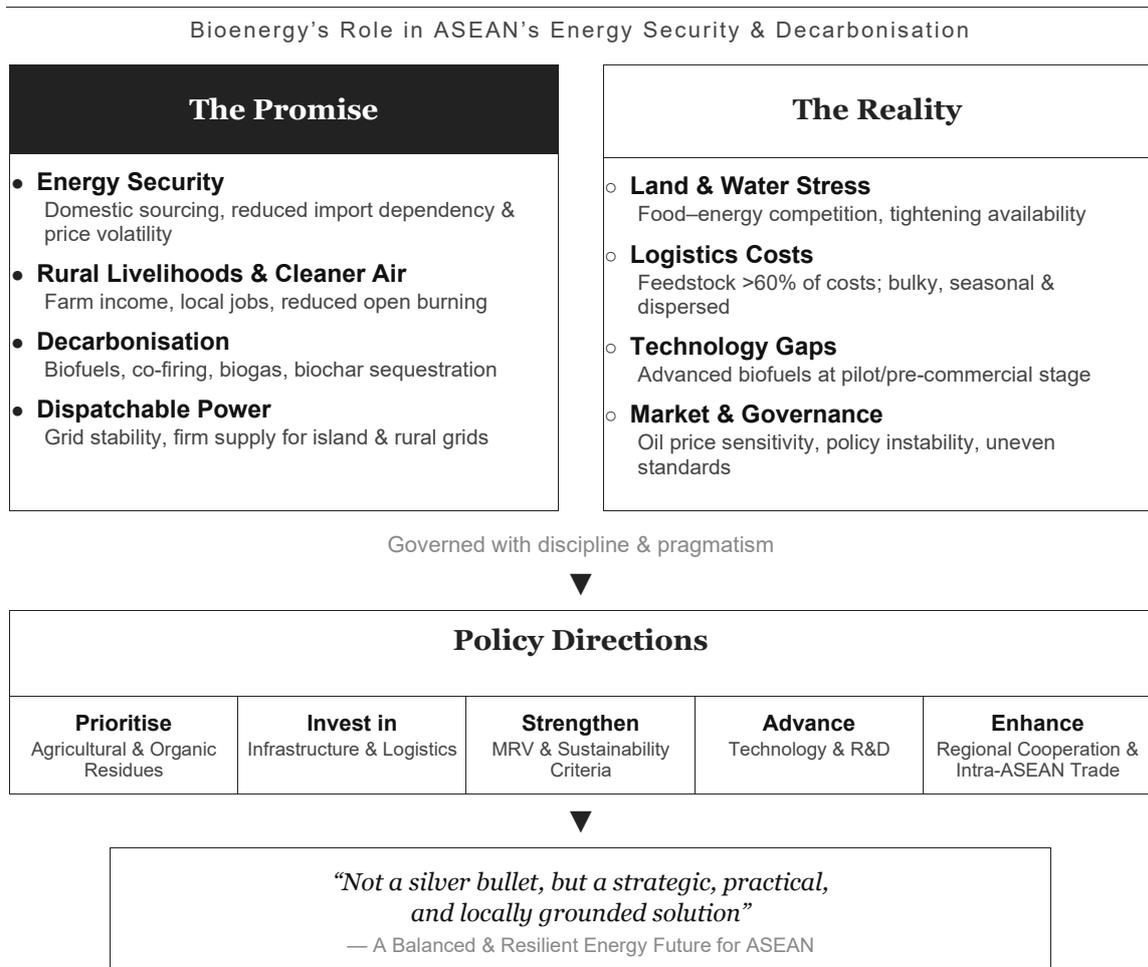
A persistent challenge across ASEAN is the uneven development of sustainability certification systems. Some countries have advanced schemes – such as Indonesia’s Indonesian Sustainable Palm Oil (ISPO) certification or Thailand’s national ethanol standards – while others rely on fragmented or voluntary frameworks.

A harmonised ASEAN-wide sustainability framework could:

- improve transparency
- reduce the risk of unsustainable practices
- facilitate cross-border trade
- enhance investor confidence
- ensure that bioenergy contributes meaningfully to climate and development goals

This alignment would also enable ASEAN to better engage in emerging global markets for low-carbon fuels, including SAF and green shipping fuels.

Figure 1: Conceptual Framework — Balancing Promise and Reality in ASEAN’s Bioenergy Development



Source: Compiled by the author.

Policy Directions for a Realistic and Effective Bioenergy Strategy

Prioritise Agricultural and Organic Residues

Agricultural residues should form the backbone of ASEAN’s bioenergy future. Utilising waste streams avoids land-use conflicts, reduces open burning, and delivers climate benefits at lower cost. ERIA has identified rice straw, rice husk, sugarcane bagasse, rubberwood residues, palm kernel shells, cassava residues, coconut residues, and livestock waste as amongst the region’s most scalable bioenergy feedstocks. Over the longer term, emerging second-generation biofuel technologies (which convert non-food biomass) could enable

the conversion of these agricultural and organic residues into liquid biofuels, further expanding the feedstock base beyond current first-generation pathways.

Invest in Infrastructure and Logistics

Efficient supply chains require:

- continued deployment of appropriate mechanisation
- organised collection points
- rural biomass hubs
- improved feeder roads
- compacting and pre-processing facilities

- digital tools for tracking feedstock availability

Such systems can reduce supply-chain costs while improving reliability and bankability.

Strengthen Monitoring, Reporting, and Verification (MRV)

ASEAN should move toward regionally aligned MRV requirements for emissions reduction, land-use impacts, and sustainability criteria. This is essential for integrating bioenergy into carbon markets and international fuel supply chains.

Invest in Technology and R&D to Support Diversification

Emerging and advanced biofuels – including cellulosic ethanol, green diesel, and sustainable aviation fuel – remain at early stages of development in ASEAN, constrained by high capital costs and technical barriers. Continued investment in research and development (R&D), pilot projects, and commercialisation support is therefore essential. Policy frameworks should encourage a diverse portfolio of bioenergy technologies tailored to locally available feedstocks and end-use requirements (Ninomiya et al., 2026), including:

- Pelletisation and densification to improve biomass logistics and transport efficiency
- Gasification and anaerobic digestion for decentralised power and heat generation
- Biomass co-firing as a near-term transition pathway within existing power systems
- Biogas and biomethane for cooking, transport, and industrial applications
- Biochar production to enhance soil health and deliver carbon sequestration benefits

Bioenergy development need not be confined to conventional liquid biofuels. Promising pathways also include hybrid systems that combine bioenergy with solar power, improving system flexibility and resilience.

Enhance Regional Cooperation and Intra-ASEAN Trade

ASEAN's bioenergy ecosystem remains uneven – Indonesia and Malaysia maintain biodiesel surpluses, while the region faces a persistent bioethanol deficit. Enhanced regional cooperation – through the Renewable Energy Sub-Sector Network (RE-SSN) facilitated by the ASEAN Centre for Energy (ACE), and supported by AZEC and ERIA – can help address these imbalances by harmonising standards, enabling intra-regional trade, and fostering technology transfer and knowledge sharing.

Illustrative modelling suggests that redirecting just 1 billion litres of biofuel trade within ASEAN could reduce aggregate fuel import costs by US\$100–150 million annually, while retaining US\$600–800 million in economic value within the region (ERIA

and ACE, 2025). More broadly, strengthened cooperation under the ASEAN Secretariat, AZEC, ACE, and ERIA can:

- Facilitate technology transfer and scale successful pilot projects
- Develop regional trade in biomass feedstocks and low-carbon fuels
- Harmonise sustainability standards and certification systems
- Improve data sharing and regional market transparency

Conclusion

Bioenergy is not a silver bullet for ASEAN's energy transition, but it is a strategic, practical, and locally grounded solution that can meaningfully support the shift toward cleaner and more secure energy systems. Its value lies not in replacing fossil fuels outright but in complementing solar, wind, and hydropower while strengthening rural economies and reducing waste burning.

The region's responsibility is to pursue bioenergy development with both ambition and realism. Overestimating its potential risks misallocation and policy disappointment; underestimating it could leave significant social, economic, and environmental benefits untapped.

With clear sustainability safeguards, targeted, coherent and consistent policies, their effective implementation, tangible investment, stronger regional cooperation and intra-regional trade, bioenergy can become a reliable component of ASEAN's balanced and resilient energy future – one that addresses climate risks while supporting inclusive growth and long-term energy security.

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