RESEARCH REPORT

Clean, Green, Renewable Energy and the Standards Landscape across the ASEAN-Australia-New Zealand Free Trade Area (AANZFTA)

January 2026

About Standards Australia

Standards Australia is Australia's peak independent, non-government, not-for-profit standards organisation. We work with national, regional and international partners across various industry, government, academia, and consumer groups, to help address the challenges and opportunities that are common to all. Our vision is to ensure that communities have safe and reliable access to quality goods and services to support growth, resilience and development.

Standards Australia represents Australia at the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) and specialises in the development and adoption of internationally aligned standards. We endeavour for regional and international standards harmonisation to share the benefits with our regional neighbours and international community.

Standards Australia has more than hundred years of experience in developing, adopting and implementing standards. As a national standards body, we are keenly aware of the benefits and challenges in the standards world. It is within our vision to be a trusted partner in the ASEAN-Australia-New Zealand Free Trade Area (AANZFTA) to provide trusted solutions that improve lives in the present and for the years to come. This vision has taken on renewed importance as we grapple with the challenges and risks in the clean, green, renewable energy-based transition, including risks of energy security and climate resilience, and the need for sustainable development. We work with a diverse group of stakeholders nationally and internationally to respond to challenges and to optimise opportunities to promote a shared future in our region.

***Disclaimer**: This document contains general information and is not formal advice. While every effort is made to ensure the accuracy of the information contained herein, Standards Australia Limited does not endorse or warrant the accuracy, reliability, or fitness for any purpose of any information provided or any opinions expressed by the authors. You should seek independent advice on any matter related to the use of the information. In no event will Standards Australia be liable for any loss or damage whatsoever arising from the use of the information and Standards Australia, accepts no liability for any errors, omissions or opinions expressed, and no responsibility is accepted with respect to the standing of any firms, companies or individuals mentioned.*

Contents

Abbreviations and Acronyms

AANZFTA	ASEAN-Australia-New Zealand Free Trade Area (Agreement)
ACCSQ	ASEAN Consultative Committee for Standards and Quality
ASEAN	Association of Southeast Asian Nations
BESS	Battery Energy Storage Systems
CO_2	Carbon dioxide
EU	The European Union
Gt	Gigatonnes
GW	Gigawatt
HS Codes	Harmonized System Codes
IEA	The International Energy Agency
IEC	International Electrotechnical Commission
IECRE	IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications
ISO	International Organization for Standardization
kWh	Kilowatt-hour
LCOE	Levelised Cost of Energy
MRA	Mutual Recognition Arrangement
m/s	Meters per second
Mtoe	Million Tonnes of Oil Equivalent
MW	Megawatt
MWh	Megawatt-hour
MWp	Megawatt-peak
PV	Photovoltaic
SC	Subcommittee
Solar PV	Solar Photovoltaic
TBT	Technical Barriers to Trade
TC	Technical Committee
UN	United Nations
US	United States
USD	United States Dollar
WTO	World Trade Organisation
µm	Micrometre

Executive Summary

This report, prepared by Standards Australia, provides a comprehensive analysis of the clean, green, renewable energy landscape across the ASEAN-Australia-New Zealand Free Trade Area (AANZFTA). It aims to support deeper regional cooperation and dialogue to accelerate the region's energy transition by providing analysis of national priorities, trade volumes, regional policies, multilateral networks, the significance of standards and the region's degree of standardisation.

The AANZFTA Parties face rising energy demands, infrastructure challenges, and climate risks. Clean, green, renewable energy – spanning battery energy storage systems (BESS), geothermal, hydropower, solar, and wind – is critical to addressing these challenges and achieving energy security, economic resilience, climate goals and sustainable development. In response to these shared challenges, the report identifies several key findings across trade volumes, regional policies, national priorities and standards.

Key Findings

- **Trade landscape**: In 2024, the AANZFTA Parties collectively imported approximately USD 27.9 billion and exported USD 33.5 billion in clean, green, renewable energy-related products, totalling over USD 61.4 billion in trade with a trade surplus of USD 5.6 billion. BESS and solar technologies led both import and export volumes.
- **Policy landscape**: Five regional or multilateral policies were identified, four of which are currently in force. These policies – such as the *ASEAN Plan of Action for Energy Cooperation* and the *ASEAN Strategy for Carbon Neutrality* – highlight growing regional alignment on clean, green, renewable energy, with varying levels of engagement from Australia and New Zealand.
- **National priorities**: Across AANZFTA Parties, BESS, solar, and wind are consistently prioritised, while geothermal and hydropower receive more varied attention depending on national contexts.
- **Standards landscape**: The report mapped 16 relevant international committees across the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC). While overall participation from the AANZFTA Parties remains low, there is relatively strong engagement in BESS and wind sectors – highlighting significant opportunities to deepen regional involvement in international standardisation.
- **Role of standards**: Standards in general play a vital role in improving product quality, safety, reliability, while enabling efficiency and interoperability across processes and systems. International standards harmonisation can support policy coherence, regulatory alignment, risk mitigation and investor confidence – ultimately facilitating trade and investment in clean, green, renewable energy. Case studies included in this report demonstrate these benefits – such as the United States' adoption of IEC wind energy standards – demonstrating how the adoption of international standards helped reduce financial risk, attract capital, enable innovation, and drive market growth.

This work aligns with the World Trade Organisation's (WTO) Agreement on Technical Barriers to Trade (TBT), which encourages the use of international standards to reduce unnecessary obstacles to trade.[1] It also supports the objectives of AANZFTA Agreement Chapter 6 – *Standards, technical regulations and conformity assessment procedures*, which promotes regulatory coherence, mutual recognition, and cooperation in standards and conformity assessment procedures among Parties.[2]

Building on these findings, the report identifies several strategic considerations to guide future regional cooperation.

Strategic Considerations

- **Standards harmonisation potential**: Greater alignment with international standards can reduce technical barriers to trade, streamline conformity assessment, and enable mutual recognition across AANZFTA.
- **Capacity building**: Increasing participation in international standards development – especially in underrepresented sectors like geothermal – can ensure regional needs are reflected in global frameworks, improve awareness of international best practices and drive greater international standards adoption.
- **Regional Collaboration**: Strengthening multilateral networks, and policy and regulatory coordination can accelerate clean, green, renewable energy deployment, enhance supply chain resilience, and attract investment.

As the region navigates the complexities of the energy transition, this report provides a foundation for informed dialogue and collective action. Harmonised standards, shared priorities, and deeper regional engagement will be essential to unlocking the full potential of clean, green, renewable energy and securing a sustainable, inclusive energy future.

This report was developed as part of the *AANZFTA Implementation Support Programme*, contributing to ongoing efforts to strengthen regional cooperation in international standards and facilitate trade in clean, green, renewable energy.[3]

Introduction

The clean, green, renewable energy-based transition is critical to securing affordable, reliable, and sustainable power systems, reducing global emissions, and strengthening long-term economic and climate resilience across the AANZFTA. Energy demand across ASEAN, Australia, and New Zealand is increasing – with ASEAN's energy demand forecasted to grow by 73 per cent from 2023 levels to 746.2 Mtoe by 2050, while New Zealand's electricity demand could grow by 82 per cent by 2050.[i,4] Yet, ASEAN's high dependence on imported energy, limited diversification of energy resources, and Australia's ageing energy generation infrastructure and limited progress in clean, green, renewable energy uptake, collectively poses growing challenges to the region's energy security and economic stability.[5] With rising global temperatures and escalating global emissions – CO2 emissions reaching a record high of 37.8 Gt in 2024 – the region's climate resilience and its shared path towards sustainable growth is increasingly at stake.[6]

Accelerating the deployment of clean, green, renewable energy technologies is essential to the region's energy transition. Yet, fragmented technical standards and regulatory requirements can hinder trade and the efficient uptake of relevant technologies.

In line with AANZFTA Agreement Chapter 6 – *Standards, Technical Regulations and Conformity Assessment Procedures*, this report seeks to support deeper cooperation and collaboration among the AANZFTA Parties, harmonising regional frameworks, standards and technical requirements to increase trade, investment and accelerate the deployment of clean, green, renewable energy technologies and services. This report draws on comprehensive desktop research to analyse the landscape of clean, green, renewable energy across the AANZFTA, with a focus on battery energy storage systems (BESS), geothermal, hydropower, solar and wind. It examines trade volumes, priority sectors, regional policies, and multilateral networks related to clean, green, renewable energy, while also assessing the standards landscape – including the role of standards and the region's participation in key, relevant international standards committees of the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC).

The report is structured in three main parts: the first provides an overview of clean, green, renewable energy; the second explores the trade and policy landscape, including priority sectors and relevant multilateral networks; and the third explores the role of standards in the region's energy transition, including an overview of the relevant international standards committees and the region's participation in these committees.

i Forecasted energy demand has been measured in Million Tonnes of Oil Equivalent (Mtoe) from the original source.

1. Overview of Clean, Green, Renewable Energy

The United Nations (UN) has defined renewable energy as the energy "derived from natural sources that are replenished at a higher rate than they are consumed."[7] While the terms 'renewable' and 'clean' energy are often used interchangeably, they are not strictly synonymous.

'Clean energy' can be conceptualised as "energy sources that do not emit greenhouse gases or other pollutants during their production."[8] As such, not all clean energies are 'renewables' nor are all renewables 'clean energy'. For example, bioenergy is considered a form of renewable energy yet cannot be guaranteed as a 'clean energy' source as it may release pollutants depending on its processes.[9] On the other hand, nuclear energy is considered as a form of 'clean energy,' yet it is a non-renewable energy since it depends on uranium, a finite resource.[10]

Lastly, green energy can be conceptualised as energy that is derived from completely natural sources, while having minimal to no ongoing environmental impact.[11] These definitions have been simplified in Table 1 below.

Table 1 – Definitions of clean energy, green energy and renewable energy

Energy classification	Definition
Clean Energy	"Energy sources that do not emit greenhouse gases or other pollutants during their production."[12]
Green Energy	Energy that is derived from a completely natural source while having minimal to no ongoing environmental impact.[13]
Renewable Energy	"Derived from natural sources that are replenished at a higher rate than they are consumed."[14]

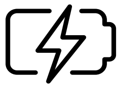
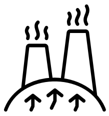
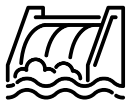
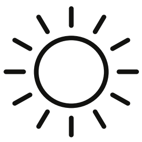
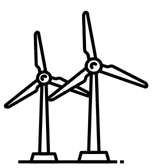
This research focuses on five broad sectors across the clean, green and renewable energy space, as follows:

1. Battery energy storage systems (BESS)
2. Geothermal energy
3. Hydropower (hydroelectric energy)
4. Solar energy
5. Wind energy.[ii]

A summary on each of these sectors are presented in Table 2 below.

ii It is acknowledged that there are other relevant sectors across the clean, green and renewable energy space such as nuclear energy, bioenergy and carbon capture, utilisation and storage (CCUS) among others – which may be considered for future initiatives.

Table 2 – Summary of the five clean, green, renewable energy sectors in scope

Sectors	Summary
BESS 	Battery energy storage systems rely on rechargeable battery technology, which uses chemicals to absorb and release energy on demand.[15] There are various types of battery chemistries in existence such as lithium-ion, lead-acid, sodium-sulphur, and flow batteries among others.[16]
Geothermal energy 	Geothermal energy is the heat derived from the Earth's crust, carried by liquid and/or steam to the earth's surface.[17] Geothermal energy can be broadly segmented to two applications: 1. Electricity generation – Geothermal power plants draw steam or hot liquid from beneath the earth's surface to power turbines, which in turn drive generators to produce electricity. There are three major types of geothermal power plants – dry steam; flash steam; and binary-cycle.[18] 2. Heating and cooling – Geothermal heat pump systems take advantage of the constant ground temperature below the Earth's surface to provide heating during colder periods and cooling during warmer periods.[19]
Hydropower 	Hydropower utilises turbines and generators to convert the kinetic energy of flowing water into electricity.[20] There are three main types of hydropower plant configurations: 1. Dams with reservoirs – usually a large hydropower system that uses a dam to store water in a reservoir. Releasing the water from the reservoir, it flows, spins a turbine and activates a generator to produce electricity.[21] 2. Run-of-the-river plants (with no reservoirs) – utilises the natural downward flow of rivers to generate electricity, while not involving any substantial storage.[22] 3. Pumped Storage plants – consist of two or more natural or artificial reservoirs at different elevations. When electricity production exceeds energy demand, water is pumped from the lower to the higher reservoir to store energy. During times of peak energy demand, water flows back from the higher to the lower reservoir, flowing through the turbine to generate electricity and meet energy demand.[23]
Solar energy 	Solar energy can be segmented into two sub-categories: 1. Solar photovoltaic energy: A solar photovoltaic energy system relies on a semiconductor cell, also known as a solar photovoltaic (PV) cell, to convert sunlight (photon energy) into electricity.[24] A solar PV cell is encased in glass, and/or plastic, and an aluminium frame for protection.[25] Solar PV cells are connected together in chains to form a solar panel or modules. Several of these can be connected to form solar arrays.[26] 2. Solar thermal energy: A solar thermal energy system converts sunlight into heat (or thermal energy) which can then be converted into electricity via a steam turbine, or for the purposes of solar heating, to heat space or water.[27]
Wind energy 	A wind turbine harnesses the kinetic energy of air flow to spin an electric generator to produce electricity. There are three major elements that cause variances in wind energy systems, which are: 1. Turbine type (vertical/horizontal axis); 2. Installation characteristic (onshore/offshore); and 3. Grid connectivity (connected/stand-alone).[28]

1.1 The Role of Clean, Green, Renewable Energy in the Energy Transition

Energy is central to the functioning of economies, infrastructure, technologies and households. Clean, green, renewable energy is well-positioned to deliver secure, economical and sustainable energy – playing a vital role across policy, economic, environmental and social dimensions. In particular, it contributes to energy security, potentially improving energy availability, affordability, reliability, and sustainability – factors essential for economic growth and stability, social well-being, and national security.[29]

Clean, green, renewable energy is significant in mitigating climate change, offering a potential solution to the root cause of greenhouse gas emissions, with the energy sector being the largest source of global emissions, and fossil fuels contributing to greater than 75 per cent of the total global emissions.[30] Energy sources such as geothermal, hydropower, solar and wind, along with the aid of BESS for energy storage, offer pathways for sustainable energy transition, helping to cut emissions by reducing dependence on highly pollutive energy sources such as coal, gas and oil.[31]

Since 2019, clean, green, renewable energy, along with electric vehicles, is estimated to have prevented 2.6 billion tonnes of CO2 annually, equivalent to approximately 7 per cent of the global emissions in 2024.[32] Despite a global 4.3 per cent increase of electricity demand and 2.9 per cent GDP growth in 2024, global emissions growth slowed to 0.8 per cent. Clean, green, renewable energy accounted for 80 per cent of the growth in global electricity generation, contributing to 40 per cent of the total generation for the first time.[33]

Clean, green, renewable energy is forecasted to potentially provide cheap electricity to approximately 65 per cent of the world's total electricity supply by 2030, with a further potential to decarbonise 90 per cent of the power sector by 2050 – a crucial opportunity to significantly reduce greenhouse gas emissions and help mitigate climate change globally.[34]

Section 1 – Case Study 1: The Philippines' "ACCESS" Solar Project [35]

The *Accelerating Community Electricity Services using Solar* (ACCESS) project, was implemented by the Philippines' Department of Energy (DOE) and funded by the World Bank-Global Environment Facility (WB-GEF), running from 2006 to 2011. This project aimed to improve the quality of life of communities living in un-electrified off-grid *barangays* and households by providing electricity using solar PV systems.[36,iii]

This project was developed in response to the Philippines' infrastructure and electricity accessibility challenges, which constrains sustainable development, especially in poor remote areas such as those of *barangays*. People residing in these areas have relied on kerosene as the "primary lighting fuel, followed by dry-cell batteries and small diesel-powered generators," while fuelwood was depended on for cooking and heating. These communities are located in remote locations where extending the grid would be unviable, or "prohibitively expensive" due to high transmission losses and operating costs. To address these challenges, the ACCESS project adopted solar energy systems. In total, the project led to the installation of 765 communal solar PV facilities, providing electricity to 6,513 households and to 283 remote off-grid *barangays*, transitioning away from fossil fuels (kerosene) and avoiding an estimate of 1,830 tonnes of CO_2 emissions annually.

This solution improves energy accessibility and affordability, enhances quality of life, fosters social equity, and supports socio-economic growth, while ensuring commercial viability and environmental sustainability.

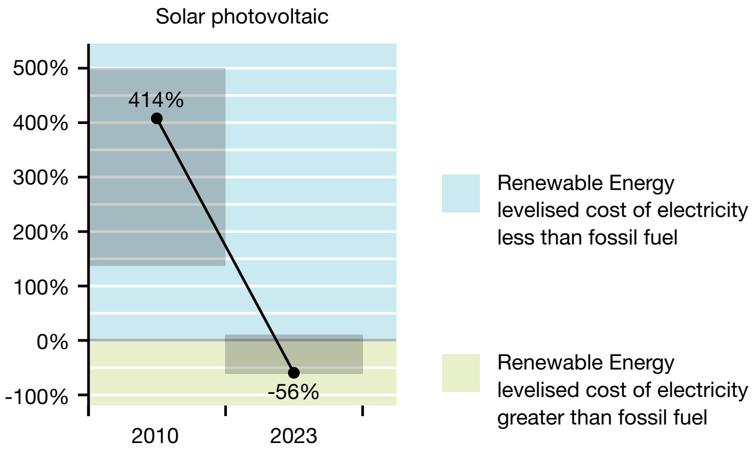
iii According to Merriam-Webster, *barangay* is a "unit of administration in Philippine society consisting from 50 to 100 families under a headman."

2. Clean, Green, Renewable Energy Landscape in the AANZFTA

Clean, green, renewable energy trade is vital for effective and sustainable energy transition across the AANZFTA. Trade enables market scale and economic opportunity, increases deployment and reduces costs. Trade can also diversify and secure supply chains and facilitate socio-economic development with increased energy accessibility.[37]

The International Energy Agency (IEA) predicts the global market for clean technologies to triple to more than USD 2 trillion by 2035.[38,iv] Demand and market growth encourages manufacturing at scale, expanding and diversifying both supply and value chains. This process creates jobs, attracts investment, and stimulates innovation and cross-border competition, resulting in cost reductions and encouraging greater deployment. For example, utility-scale solar PVs have experienced one of the most rapid cost reductions recently, with the global weighted average in levelised cost of electricity (LCOE) declining by 90 per cent between 2010 and 2023, from USD 0.460/kWh to USD 0.044/kWh, 56 per cent lower than the average fossil fuel cost in 2023 (as seen in Figure 1 below).[39] This decline can be accredited to market growth and diversification, increased economies of scale, manufacturing optimisation, reductions in materials intensity, and technical innovations such as module efficiency improvements among others.[40]

Figure 1 – Change in global weighted average of levelised cost of electricity (LCOE) for solar photovoltaic (PV), 2010-2023 [41]



Clean, green, renewable energy trade offers economies a chance to diversify supply chains and strengthen energy security. Reliance on imported fossil fuels exposes countries to geopolitical risks and price volatility, threatening energy stability and economic performance.[42] On the other hand, enhancing AANZFTA regional trade can help diversify supply chains for raw materials and manufactured goods essential for the deployment of clean, green, renewable energy systems. This reduces reliance on concentrated markets and leverages the region's logistical proximity and resources. Diversification enhances regional value chains, accelerates deployment, improves accessibility, and facilitates supply continuity and stability. In this context, regional trade in clean, green, renewable energy is significant for energy security, infrastructure performance and socio-economic resilience across the AANZFTA, underscoring the importance of analysing import and export volumes across the region.

iv 'Triple' from the market value of USD 700 billion in 2023, that includes other clean, green, renewable energy sectors outside of the scope of this research, such as electric vehicles and electrolysers among others.

2.1 Clean, Green, Renewable Energy Trade Volume

For the purpose of this report, trade data – import and export data – has been collected and analysed from the International Trade Centre (ITC) database based on Harmonised System (HS) product codes of core, relevant products, such as *Photovoltaic AC generators* (HS Code: 8501.80). Note that HS product codes covering a diverse range of applications, beyond clean, green, renewable energy applications, such as HS 848610 – *Machines and apparatus for the manufacture of boules or wafers*, possibly relevant to solar PV wafers – have been excluded for the purpose of narrowing trade data specifically to clean, green, renewable energy applications. Please refer to Appendix A for a list of the HS product codes of core relevancy across the clean, green, renewable energy sectors within the scope of this research. 'Import' and 'export' data presented in this report are a collation of the relevant HS codes for a specific sector and therefore are indicators rather than absolute values.

2.1.1 Clean, Green, Renewable Energy Import Volume

In 2024, the AANZFTA imported approximately USD 27.9 billion worth of clean, green, renewable energy products – around 8 per cent of the world's USD 336.9 billion worth of imports for 2024 (as seen in Figure 2 below).[43,v] The region has seen a 17 per cent increase in import volumes of clean, green, renewable energy products from USD 23.9 billion in 2022 and a 13 per cent increase from USD 24.7 billion in 2023 (as seen in Figure 3 below).[44]

Figure 2 – AANZFTA's share (%) of global import value for clean, green, renewable energy products (2024)

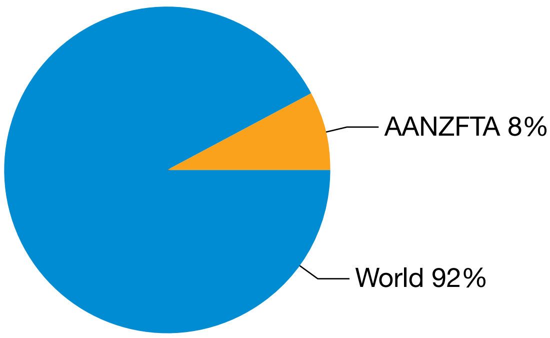
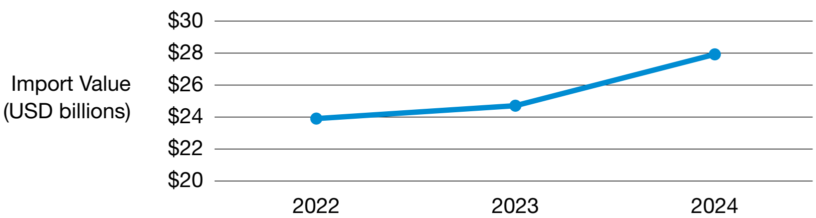


Figure 3 – Import volumes of clean, green, renewable energy products in the AANZFTA, 2022-2024 (in USD billions)



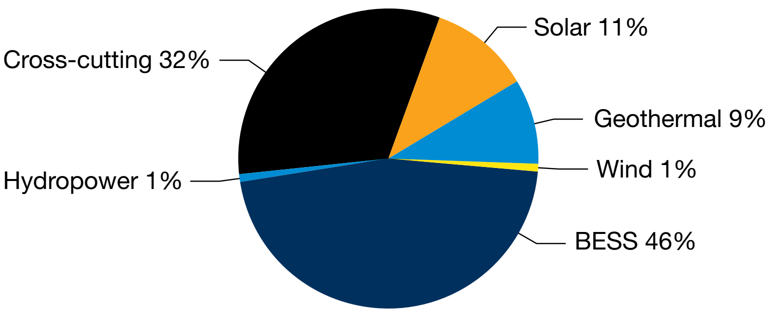
v This value is only representative of core products and does not include other sub-components of a clean, green, renewable energy system, such as steel pipes and cables etc.

Across the clean, green, renewable energy sectors, battery energy storage systems (BESS) related products appear to have the highest import value in 2024 across the region at an approximate value of USD 12.9 billion, followed by 'cross-cutting' products (USD 9 billion), solar (USD 2.9 billion), geothermal (USD 2.6 billion), wind (USD 181.2 million), and hydropower (USD 178.6 million).[45,vi] Table 3 below sets out a tabulated format of this data. Please refer to Figure 4 below for a percentage breakdown of these sectors from the region's total 2024 import volume of clean, green, renewable energy products.

Table 3 – 2024 Import values in the AANZFTA by clean, green, renewable energy sectors (in USD thousands)[46]

Sectors	2024 Import values (in USD thousand)
BESS	$12,910,447
Cross-cutting	$9,041,860
Solar	$2,980,706
Geothermal	$2,692,835
Wind	$181,176
Hydropower	$178,609
Total	**$27,985,633**

Figure 4 – Percentage share of 2024 imports in the AANZFTA region by clean, green, renewable energy sectors (%)



AANZFTA country-specific import values of clean, green, renewable energy products across these sectors are presented in a table format in Appendix B.

2.1.2 Clean, Green, Renewable Energy Export Volume

In 2024, the AANZFTA region exported approximately USD 33.5 billion worth of clean, green, renewable energy products – accounting for around 10 per cent of the world's USD 332.5 billion exports for 2024 (as seen in Figure 5 below).[47] The region has seen almost a 16 per cent increase in export volumes from USD 28.9 billion in 2022.[48] Despite previous growth, exports fell by nearly 8 per cent from 2023 to 2024, dropping from USD 36.3 billion to USD 33.5 billion, possibly highlighting emerging challenges in the trade landscape.[49] Figure 6 below displays these export trends from the AANZFTA.

vi The term 'cross-cutting' is to signify products that are relevant to one or more sectors, specifically *Static converters*, such as inverters, resistors and converters, and *Generating sets* for electricity generation.

Figure 5 – AANZFTA's share (%) of global export value for clean, green, renewable energy products (2024)

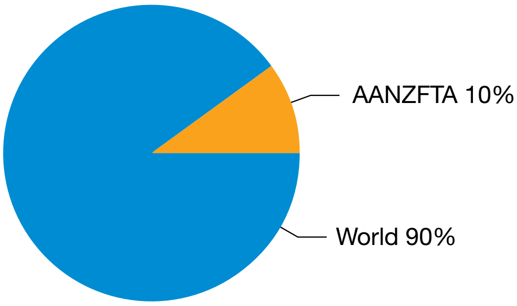
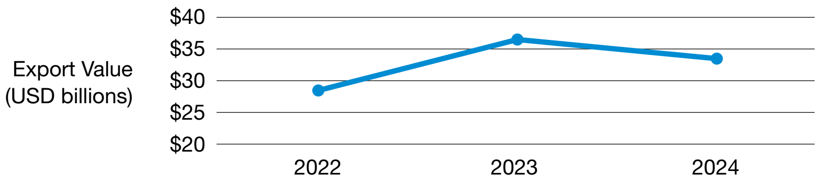


Figure 6 – Export volumes of clean, green, renewable energy products from the AANZFTA, 2022-2024 (in USD billions)



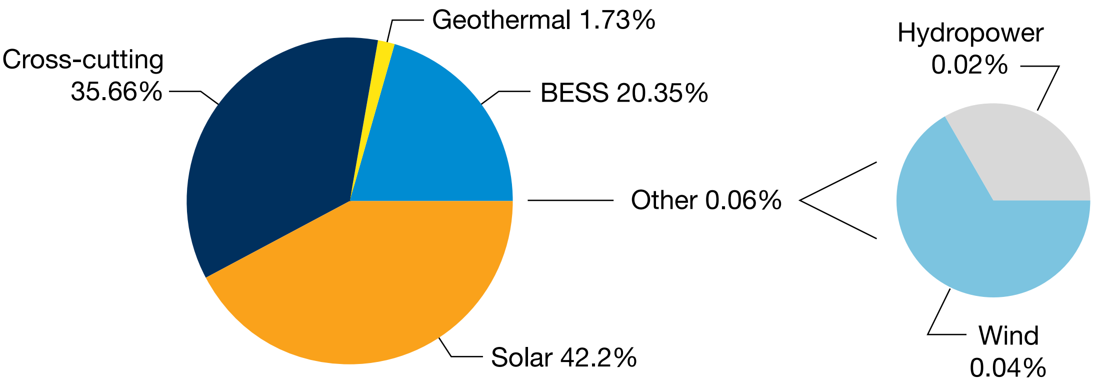
Across the clean, green, renewable energy sectors of the AANZFTA, solar products appear to have the highest export value in 2024, at approximately USD 14.1 billion, followed by 'cross-cutting' products (USD 11.9 billion), BESS (USD 6.8 billion), geothermal (USD 580.1 million), wind (13.6 million) and hydropower (USD 7.6 million).[50,vii] Table 4 below sets out a tabulated format of this data. Please refer to Figure 7 below for a percentage breakdown of these sectors from the region's total 2024 export volume of clean, green, renewable energy products.

Table 4 – 2024 Export values from the AANZFTA by clean, green, renewable energy sectors (in USD thousands)[51]

Sectors	2024 Export values (in USD thousand)
Solar	$14,133,259
Cross-cutting	$11,942,195
BESS	$6,814,288
Geothermal	$580,111
Wind	$13,594
Hydropower	$7,583
Total	**$33,491,030**

vii The term 'cross-cutting' is to signify products that are relevant to one or more sectors, specifically *Static converters*, such as inverters, resistors and converters, and *Generating sets* for electricity generation.

Figure 7 – Percentage share of 2024 imports in the AANZFTA by clean, green, renewable energy sectors (%)



AANZFTA country-specific export values of clean, green, renewable energy products across these sectors are presented in a table format in Appendix C.

Based on the AANZFTA trade volume of clean, green, renewable energy products, in 2024 the region experienced a trade surplus of approximately USD 5.6 billion. This highlights the region's growing role in global clean, green, renewable energy trade, despite a modest global share and a recent dip in export volumes.

2.2 Clean, Green, Renewable Energy Policy Landscape

Regional and multilateral policies are instrumental in advancing clean, green, renewable energy trade by establishing common frameworks, fostering shared understanding, and facilitating cross-border cooperation. They help reduce policy fragmentation, enhance predictability for investors, and enable the scale-up of technologies like solar PVs and battery storage through shared infrastructure and knowledge transfer. By setting strategic direction, policies promote stakeholder dialogue and engagement, guide resource allocation and catalyse new initiatives and programmes that contribute towards the AANZFTA's energy transition.

This research has identified **five regional or multilateral policies** relating to the clean, green, renewable energy sectors. Of these, four are in force at the time of this report and one is under development. All five policies are targeted towards the ASEAN region or ASEAN Member States, with four of these involving engagement with Australia and two of these with New Zealand.

2.2.1. ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 Phase II: 2021-2025

Abstract: This policy aims to accelerate the region's energy transition and resilience by identifying "strategies for balancing the energy trilemma of energy security, energy equity and environmental sustainability."[52] It also endeavours to serve as a platform to deepen connections within ASEAN, as well as with international organisations and dialogue partners, including Australia and New Zealand. Seven key programmes areas have been established under this policy framework, including: 'ASEAN Power Grid,' 'Trans-ASEAN Gas Pipeline,' 'Coal and Clean Coal Technology,' 'Energy Efficiency and Conservation,' 'Renewable Energy,' 'Regional Energy Policy and Planning,' and 'Civilian Nuclear Energy.'[53]

Countries in focus: This policy mainly targets ASEAN Member States but has received support from both Australia and New Zealand for initiatives such as the 'ASEAN Power Grid.'[54]

Relevant sectors: BESS, hydropower, geothermal, solar and wind.

2.2.2. ASEAN Renewable Energy (RE) Long-term Roadmap (under development)

Abstract: This roadmap aims to chart the pathways for a future economy with new and emerging sustainable systems, transforming the way renewable energy is produced, delivered, and used, in a rapidly changing environment.[55] ASEAN's Renewable Energy Sub-Sector Network (RE-SSN) and the ASEAN Centre for Energy (ACE) are developing this roadmap at the time of this report, and have involved ASEAN Member States, dialogue partners, and international organisations to establish cohesive renewable energy strategies for the ASEAN region.[56] It is hoped that the roadmap will provide guidance to more ambitious renewable energy targets, and "to boost regional investment appeals and financing opportunities."[57]

Countries in focus: ASEAN Member States are in focus, however, dialogue partners such as Australia and New Zealand, have been engaged in the process.

Relevant sectors: Broadly targeting the renewable energy sector which may cover BESS, hydropower, geothermal, solar and wind.

2.2.3. ASEAN Strategy for Carbon Neutrality (2023 – present)

Abstract: This strategy aims to address the 2.6 gigatonne CO2 emissions gap in the ASEAN region by accelerating "an inclusive transition towards a green economy, fostering sustainable growth and complementing" ASEAN Member States' national policies in achieving their respective Nationally Determined Contribution (NDC) targets.[58] By leveraging from the ASEAN region's diverse economies and resources, this strategy has set out to achieve four key outcomes, which are to "develop green industries, enhance ASEAN interoperability, embed globally credible standards and unlock green capabilities."[59]

Countries in focus: This strategy mainly targets ASEAN Member States, but has received support from Australia via the *Australia for ASEAN Futures (AUS4ASEAN)* initiative.

Relevant sectors: Broadly targeting the clean, green, renewable energy sectors which may cover BESS, hydropower, geothermal, solar and wind.

2.2.4. ASEAN Blue Economy Framework (2023 – present)

Abstract: This framework aims to guide ASEAN blue economy initiatives, encourage regional integration and cooperation, and strengthen ASEAN Members States' "capacity to maximise the sustainable use of aquatic spaces."[60] This framework identifies blue renewable energy as an important sector, highlighting the need to maximise the economic potential of ASEAN's ocean and inland water resources for energy security, including offshore wind turbines and floating solar energy systems among others.[61] It also stresses the need for skills enhancement, training and capacity building to support innovation, efficiency and productivity across ASEAN's blue renewable energy sector.[62] Under this framework, Australia is also supporting ASEAN in the Development of the ASEAN Blue Economy Implementation Plan (2026-2030).[63]

Countries in focus: This strategy mainly targets ASEAN Member States, but has received support from Australia via the Australia for ASEAN Futures (AUS4ASEAN) initiative.

Relevant sectors: Solar and Wind and potentially BESS and hydropower.

2.2.5. ASEAN Renewable Energy (RE) – Gender Roadmap (2022 – present)

Abstract: This roadmap aims to address the existing gaps in gender analysis across the ASEAN region's renewable energy policy landscape by charting a pathway that weaves women's potential contributions into ASEAN's emerging renewables market. This includes increasing the participation of women in energy projects, programmes and initiatives, leveraging from their unique experience, perspective and skills needed for effective energy transition.[64] By enhancing women's participation and visibility, this roadmap seeks to generate a positive snowball effect that advances gender equity, accelerates climate mitigation efforts, and bolsters renewable energy investments.[65]

Countries in focus: This roadmap mainly targets ASEAN Member States but has received support from various international and regional institutions, as well as from national bodies outside the AANZFTA, including Germany's *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* and the *Swedish International Development Cooperation Agency (Sida)*.

Relevant sectors: Broadly relevant across all the clean, green, renewable energy sectors which may cover BESS, hydropower, geothermal, solar and wind.

2.3 Key Priority Sectors in Clean, Green, Renewable Energy across the AANZFTA Parties

Clean, green, renewable energy priorities vary across AANZFTA Parties. Priorities are shaped by each member economies' unique context in resource availability, feasibility, and investments, as well as energy, economic and climate policies. For example, Malaysia has relatively low prioritisation of wind energy systems as the country generally has low on average wind speeds of less than 5 m/s, resulting in low wind generation capacities and unfavourable economics.[66] On the other hand, some member economies place low priority on specific sectors that have already matured. For example, New Zealand's hydropower sector, supplied 60.5 per cent of the country's electricity in 2023.[67]

Analysis of national energy policies, government platforms, and articles, reveals broad trends across the AANZFTA, where BESS, solar and wind sectors are strongly prioritised, along with moderate prioritisation of hydropower, and relatively low or no prioritisation of geothermal (as seen in Table 5 below).

Table 5 – Degree of prioritisation across battery energy storage systems (BESS), geothermal, hydropower, solar and wind sectors by AANZFTA Parties

	BESS	Geothermal	Hydropower	Solar	Wind
Australia	High	Medium	Low	High	High
Brunei	Medium	Medium	Medium	High	Medium
Cambodia	High	Medium	Low	High	High
Indonesia	High	Low	Low	High	High
Lao PDR	High	Medium	High	Low	Low
Malaysia	High	Medium	Low	High	Medium
Myanmar	Medium	Medium	High	High	High
New Zealand	High	Medium	Medium	Low	Medium
Philippines	High	Medium	Medium	High	High
Singapore	High	Medium	Medium	High	High
Thailand	High	Medium	Medium	High	Low
Viet Nam	High	Medium	Low	High	High

High Relatively high priority.
Medium Relatively moderate priority (in comparison to other priorities)
Low Relatively low to no priority (or a lack of data)

Note: Please be advised these are only indicative and priorities are subject to change based on policy and economic factors.

Below is a high-level overview of each AANZFTA Parties prioritisation. While reliable data on BESS installed capacity is currently unavailable, there is relatively strong prioritisation of this sector based on qualitative insights and projected trends. Please note that from here on, the term 'capacity targets' refer to the government policy goals for the total installed generation capacity that the country aims to achieve by a specified year.

Australia

Australia has not set nor forecasted capacity targets for specific sectors. However, the *National Renewable Energy Priority List* highlights proposed and approved generation and storage projects. As of March 2025, there is relatively strong prioritisation of wind, BESS and solar with 21 of these projects relating to wind, 12 to BESS and 7 to solar, from a total of 32 generation and storage projects.[viii] There is relatively low prioritisation towards hydropower, with only two proposed projects, while there are no projects for geothermal.[68] As of 2024, renewable energy has a 10.2 per cent share in Australia's total energy supply mix.[69]

Brunei Darussalam

Brunei Darussalam has no set or forecasted capacity targets for specific sectors. Across its policies, there is no strong emphasis on BESS, geothermal, hydropower or wind. Based on Brunei Darussalam's *National Climate Change Policy* (2020), solar is a relatively high priority, with a goal of "increasing total share of renewable energy to at least 30% of the total capacity in the power generation mix using mainly solar photovoltaic (PV) by 2035."[70] This is a significant increase from Brunei Darussalam's renewable energy share of less than one per cent from its 2023 total energy supply mix.[71]

viii Some of these projects involve one or more sectors, such as the Australian Renewable Energy Hub (AREH) project focusing on both solar and wind sectors, while the Belly Bay Wind project focusing on wind and battery sectors, among others.

Cambodia

Cambodia has relatively strong prioritisation of BESS, solar and wind, moderate prioritisation of hydropower, and no prioritisation of geothermal. By 2030, the Cambodian government plans to increase the combined generation capacity of solar and wind to 38 per cent in Cambodia's total energy supply mix – a drastic increase from the combined share of 0.8 per cent of solar and wind in Cambodia's 2023 total energy supply mix.[72] Whereas for BESS, Cambodia's *Power Development Master Plan 2022-2040*, initially set a BESS capacity target of 200 MW by 2030, however, the Cambodian government updated this target to 3,000 MW by 2030 – a 1,400 per cent increase from the initial target.[73] Hydropower faces a more moderate consideration, with a capacity target of 1,558 MW by 2030, a slight increase of 16.5 per cent from Cambodia's 2024 installed hydropower capacity of 1,337 MW.[74] In contrast, there are no capacity targets for geothermal nor are there any policy references to the sector.

Indonesia

Based on Indonesia's Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) 2025 – 2034, priority levels for each sector varies, with stronger emphasis towards BESS, solar and wind, over hydropower and geothermal.[75,ix] To outline these priorities, Table 6 below presents Indonesia's 2034 capacity targets as set in its RUPTL policy, along with Indonesia's 2024 installed capacity for each sector for comparative purposes.

Table 6 – Indonesia's 2024 installed capacity and 2034 installed capacity targets for battery energy storage systems (BESS), geothermal, hydropower, solar and wind by 2034 (MW)[76]

Sectors	2024 (MW)	2034 (MW)	Capacity increase from 2024 to 2034 (%)
BESS[77,x]	8.75-35	6,000	17,043%–68,471%
Geothermal	2,688	5,200	94%
Hydropower (incl. pumped storage)	7,225	16,000	122%
Solar	815	17,100	1,998%
Wind	152	7,200	4,637%

Lao PDR

Based on *An Energy Sector Roadmap to Net Zero Emissions for Lao PDR* (2025), there is strong prioritisation for hydropower with a capacity target of 20,000 MW by 2030 – a 96.3 per cent increase from Lao PDR's 2024 hydropower capacity of 10,189 MW.[78] Despite the absence of installed capacity values and targets for BESS, Lao PDR has recognised BESS as critically important for maintaining energy security and reliability in its roadmap.[79] For both solar and wind, there is comparatively moderate considerations with a combined capacity target of 1,000 MW by 2030 – almost a 52 per cent increase from Lao PDR's 2024/2025 combined installed capacity for solar and wind at 658 MW.[80] While geothermal appears to be a relatively lower priority against the other four sectors, the country has set a long-term capacity target of 59 MW by 2050.[81]

ix *Rencana Usaha Penyediaan Tenaga Listrik (RUPTL)* may also be understood as Indonesia's National Electricity Supply Business Plan.

x Publicly available data indicates that Indonesia's installed BESS capacity for mid-2024 was approximately 35 MWh. Based on the assumption that Lithium-ion BESS have a typical duration of 1-4 hours, it is possible to convert 35 MWh by the battery discharge duration (in hours). Therefore, if Energy (MWh) = Power (MW) x Time (hours); Energy (MWh)/Time (hours) = Power (MW); 35 MWh/(1 or 4 hours) = 8.75-35 MW.

There is no data available on Lao PDR's existing geothermal capacity, possibly indicating that the country's geothermal sector has not been developed.

Malaysia

Recognised to be vital for its energy stability, Malaysia has given BESS a relatively high priority, with its Energy Commission requesting quotation for potential BESS projects to further add 400 MW to its 60 MW BESS capacity (2024) – a potential increase by 566.7 per cent.[82] According to Malaysia's *Renewable Energy Roadmap* (2021), there is also high level of prioritisation for solar, with an installed capacity target of 7,280 MW by 2035 – a 215.7 per cent increase from Malaysia's 2024 solar capacity of 2,306 MW.[83] There is also a relatively moderate level of prioritisation for hydropower with a capacity target of 9,281 MW by 2035 – an increase by 49 per cent from 6,227 MW (2024).[84] Malaysia's National Energy Transition Roadmap (2023) have set a capacity target of 30 MW for geothermal by 2035, however there is little emphasis on geothermal and it is only considered for feasibility assessment.[85,xi] Like geothermal, wind has also been given a relatively low priority and is only considered for feasibility assessment due to the country's generally low wind speeds.[86] Both geothermal and wind sectors are yet to be developed in Malaysia.[87]

Myanmar

In 2023, Myanmar's Environmental Conservation Department revealed strong prioritisation for hydropower, solar and wind.[88] It is reported that hydropower has the highest number of planned projects of up to 33 projects, potentially adding 18,587.6 MW to its 2024 hydropower capacity of 3,269 MW, a potential increase by 468.6 per cent.[89] Myanmar's government also aims to increase a combined generation for solar and wind of up to 1268.25 MW by 2030 – a combined increase by 487.2 per cent from Myanmar's combined 2024 solar and wind capacity of 216 MW.[90] In contrast, geothermal is perceived to be a relatively low to no priority with minimal emphasis on planned capacities and development.[91] There is also limited focus on BESS across government documents and platforms. Despite this, it is worth noting that Myanmar has installed 668 kWh of BESS in 2025, indicating growing interests in the BESS sector.

New Zealand

According to New Zealand's Te Tari Tiaki Pūngao (or the Energy Efficiency and Conservation Authority), there is relatively strong prioritisation on wind, with the aim of increasing its share of electricity supply from approximately 9.1 per cent in 2024/2025 to as much as 34 per cent by 2035.[92] There is also strong considerations for BESS, with New Zealand's Te Mana Hiko (or Electricity Authority), releasing a draft *Regulatory Roadmap for Battery Energy Storage Systems* (2025) to ensure seamless BESS integration, increased investment and maximised consumer benefits.[93]

There are also moderate considerations for solar, with the aim of increasing the electricity supply share from approximately 1 per cent (2024/2025) to potentially 6 per cent by 2035.[94] In contrast, there is relatively lower prioritisation for further development of geothermal and hydropower systems as these are mature in the country and already contribute to a substantial share of the energy supply – respectively supplying 18 per cent (2021) and 57 per cent (2021) to New Zealand's total electricity supply mix.[95]

---

xi SEDA Malaysia, *Malaysia Renewable Energy Roadmap*; A feasibility assessment can be understood as a study that evaluates whether a proposed clean, green, renewable energy project is technically, economically, and/or environmentally viable to build and operate successfully.

Philippines

The Philippines has a strong prioritisation of BESS, solar and wind. As of 2024, the Philippines had an installed BESS capacity of 634 MW but plans to increase this capacity to 3,800 MW by 2033 – a potential increase by 499.4 per cent.[96] For solar, the government has set a target of adding 27,162 MW of new capacity by 2040, signalling a major scale-up from the Philippines' 2024 installed capacity of 2,971 MW.[97] Likewise, the government has also set a relatively high priority for the wind sector, with a target to add 16,650 MW of new wind capacity by 2040, indicating significant additions to the country's total 2024 installed wind capacity of 443 MW.[98] In contrast, geothermal and hydropower have received lower prioritisation, with plans to add 2,500 MW of new geothermal capacity and 6,150 MW of new hydropower capacity by 2040.[99] As of 2024, the Philippines had an installed geothermal capacity of 1,952 MW and 3,869 MW for hydropower.[100]

Singapore

As Singapore faces land and resource constraints, solar, BESS and wind are the three sectors that are prioritised out of the five sectors. Singapore's *Green Plan* targets a solar energy deployment of at least 2,000 megawatt-peak (MWp) by 2030 – a 48.4 per cent increase from Singapore's 2024 solar capacities of 1,348 MWp.[101] In relation to BESS, Singapore achieved its 2025 target of deploying 200 megawatt-hour (MWh) of energy storage in 2022.[102] In 2024, Singapore worked to expand existing BESS which included the piloting of a "battery stacking" solution.[103] Lastly, wind is also considered a high priority sector with government efforts to expand Singapore's offshore wind capacity with an "ambition to become the leading offshore wind hub" in the Asia-Pacific region.[104]

Thailand

Based on Thailand's draft *Alternative Energy Deployment Plan 2024-2037* (2025), solar is strongly prioritised with an installed capacity target of 41,582 MW by 2037 – a 1,128.8 per cent increase from Thailand's 2024 solar capacity of 3,384 MW.[105,xii] There is also strong prioritisation for BESS, with Thailand's *Power Development Plan 2024-2037 (DRAFT)*, setting a BESS capacity target of achieving 10,485 MW by 2037.[106] Notably, this follows earlier government action – such as the approval of 24 BESS projects in 2022 – which already added approximately 994 MW of BESS capacity, underscoring sustained policy support for BESS deployment.[107]

In comparison to BESS and solar, prioritisation for wind is relatively moderate, with a capacity target of 9,379 MW – an increase by 507.4 per cent from the country's 2024 wind capacity of 1,544 MW.[108] Additionally, there is relatively low prioritisation for geothermal with a capacity target of 21 MW, however this is in the context that Thailand has no geothermal capacity at the time of this report.[109]

Whilst hydropower has a relatively moderate capacity target of 3,265 MW by 2037, Thailand's 2024 hydropower installed capacity was recorded to be 3,693 MW – exceeding its 2037 target.[110] For the purpose of this report, hydropower would be considered as a lower priority, especially in consideration of solar and wind.

Viet Nam

Based on Viet Nam's revised *Power Plan VIII (Decision No. 768/QD-TTg)* (2025), there is a relatively strong prioritisation for BESS, solar and wind.[111] Information on Viet Nam's existing

---

xii Please consider the capacity targets listed in Thailand's (Draft) Alternative Energy Deployment Plan 2024-2037 (2025), as only indicative.

installed BESS capacity remains limited. However, the earlier edition of the *Power Plan VIII* (2023) set a modest capacity target for BESS at 300 MW by 2030, while the revised *Power Plan VIII* (2025) has since raised this target to 16,300 MW – a 5,333.3 per cent increase – underscoring Viet Nam's strong prioritisation of BESS.[112] For solar, the revised *Power Plan VIII* (2025) has set an installed capacity target of 73,416 MW by 2030 – a 293.3 per cent increase from Viet Nam's 2024 installed solar capacity of 18,667 MW.[113] Viet Nam has also strongly prioritised the wind sector, setting a wind capacity target of 55,061 MW by 2030 – a 790.2 per cent increase from the country's 2024 wind capacity of 6,185 MW.[114]

In contrast, Viet Nam has relatively moderate consideration for hydropower with a capacity target of 40,667 MW by 2030 – an increase of 71.55 per cent from Viet Nam's 2024 hydropower capacity of 23,707 MW.[115] Lastly, there is lower prioritisation for geothermal, with a capacity target of 45 MW by 2030, in the context that Viet Nam has no installed geothermal capacity at the time of this report.[116]

Please refer to Table 5 above that summarises the AANZFTA Parties' prioritisation across the clean, green, renewable energy sectors of BESS, geothermal, hydropower, solar and wind.

2.4 Relevant Networks of Clean, Green, Renewable Energy Sectors

This research has identified 11 regional and international institutions, organisations and forums (or referred to as 'entities' from here on) that facilitate and promote clean, green, renewable energy dialogue and collaboration.[xiii] From this 11, one of these – the ASEAN Centre for Energy (ACE) – somewhat involves all the AANZFTA Parties, serving as a platform for collaboration, cooperation, dialogue and as a knowledge hub to support policies, initiatives and stakeholder interests. Similarly, the ASEAN Ministers on Energy Meeting (ANEM) – involves only the ASEAN Member States among the AANZFTA Parties, facilitating dialogue for regional energy policy and planning on critical themes, including energy security and renewable energy among others. Across the other nine entities identified, involvement from each of the AANZFTA Party varies. Please refer to Appendix D for the full list and description of all 11 entities.

At a broader level, these entities foster greater cooperation, networking, advocacy, sharing of best practices, knowledge exchange, research and innovation, and policy and strategic alignment. Involvement in these entities also provides opportunities for the AANZFTA Parties to voice the unique challenges faced nationally and regionally, establishing dialogue and furthering opportunities to address the challenges.

By connecting various governments, industry and civil society, these organisations can potentially play a pivotal role in accelerating the region's clean, green, renewable energy-based transition.

xiii Please bear in mind that only entities that comprise of membership from 3 or more AANZFTA countries were included.

3. Role of Standards in Clean, Green, Renewable Energy

3.1 What are standards?

Standards Australia defines standards as:

> *"Voluntary documents that set out specifications, procedures and guidelines that aim to ensure products, services and systems are safe, consistent, and reliable."*[117]

Standards can be broadly categorised into three levels:

1. **International standards**: Standards developed by international standards organisations, such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).
2. **Regional standards**: Standards developed by a specific region, such as the European Union's EN standards.
3. **National standards**: Standards developed by a national standards body like Standards Australia or by other accredited bodies.

International standards such as those of ISO and IEC, as well as those developed by similar standards development organisations, are the result of a collective effort built on consensus among a diverse range of subject-matter experts. Consensus is essential for ensuring that international best practices are relevant to a broad range of stakeholder groups and is considerate of diverse socio-economic contexts. It helps promote non-discriminatory standards and supports far-reaching benefits for economies, societies and the environment.

3.2 Role of Standards in Clean, Green, Renewable Energy

Standards play a significant role in the AANZFTA's energy transition, offering various benefits to the clean, green, renewable energy sectors, including:

- **Improving the quality, reliability and safety of products, services and systems, providing socio-economic benefits.**

  Example: The IEC standard, IEC 62619: 2022, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries*, specifies requirements for safe operation of secondary lithium cells used in battery energy storage systems (BESS).[118]

- **Reducing costs through simplified contractual agreements and use of standardised components.**

  Example: The IEC standard, IEC 62446-1: 2016, *Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance*, defines the information and documentation required for the installation of a grid connected PV system. It enables project owners and contractors to reference a single, universally accepted framework in their contracts, ensuring consistency and eliminating the need for bespoke test criteria.[119]

- **Driving efficiency and cost reduction by streamlining processes and enabling interoperability across data, technologies, and systems for a seamless and integrated operating environment.**

  Example: The IEC standards series, IEC 61400-25, *Wind turbines: Communications for monitoring and control of wind power plants*, helps enable interoperability across the various wind power plant components, as well as across technologies from different vendors – facilitating communication via information exchange. This ensures the seamless operation of wind power plants with the ability to monitor and control various wind energy assets.[120]

- **Facilitating growth in knowledge and skills, supporting innovation through research and development, and equipping individuals or enterprises with the capabilities to generate more economic value.**

  Example: The IEC standard, IEC 60193:2019, *Hydraulic turbines, storage pumps and pump-turbines - Model acceptance tests*, covers the arrangements for model acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines, enabling engineers to design and validate turbines with precision.[121]

- **Establishing common language and understanding of what constitutes a product or service and what is excluded.**

  Example: The ISO standard, ISO 9488:2022, *Solar energy — Vocabulary*, defines basic terms relating to solar energy, including the field of measurement of solar radiation and solar energy utilisation in space and water heating, cooling, industrial process heating and air conditioning. By establishing a set of common language, ISO 9488 potentially simplifies trade, reduces legal risks and improves accurate knowledge transfers.[122]

Adoption of international standards enables opportunities for standards harmonisation, in which alignment can facilitate smoother international trade, enhance market access, increase efficiency in business transactions, reduce duplications in testing and verifications, and reduce unnecessary transaction costs and time.[123]

Collectively, these benefits support industry growth and innovation, positively contributing to economic development and to the energy transition. For consumers, confidence and safety are enhanced, providing a net benefit to society. Standards can also help attract investments by potentially reducing perceived risks and liability for investors, project developers, manufacturers and service providers.[124]

Section 3 – Case Study 1: Tanzania's adoption of IEC standards to enhance solar energy supply

Tanzania has faced challenges with the importation of substandard solar products that negatively impacted human health, the economy and the environment. These solar products performed poorly and had a very short product life as they were not compliant with best practices, resulting in economic losses. To address this challenge, the Tanzania Renewable Energy Association (TAREA) adopted and implemented several IEC standards, including:

- IEC 60623:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Vented nickel-cadmium prismatic rechargeable single cells*; and
- IEC 62259:2003, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Nickel-cadmium prismatic secondary single cells with partial gas recombination*.[xiv]

As a result, the inflow of non-compliant solar PV products into the Tanzanian market was reduced, improving the quality and efficiency of solar systems available. Furthermore, the adoption of IEC standards helped scale up Tanzania's access to modern energy sustainably, increasing energy accessibility – especially in remote, off-grid areas – as well as reducing emissions.[125]

xiv Both of these IEC standards were developed by IEC TC 21/SC 21 A, Secondary cells and batteries containing alkaline or other non-acid electrolytes.

Following on from these realised benefits, in 2023, the Tanzania Bureau of Standards (TBS) adopted IEC 61215 series, *Terrestrial photovoltaic (PV) modules - Design qualification and type approval*, to ensure that Tanzania's solar PV systems are "designed and installed to a high standard of quality safety," while also being adopted by regulators as a basis for legal requirements.[126,xv]

Section 3 – Case Study 2: The United States (US) adoption of IEC standards from IEC TC 88, Wind energy generation systems[127]

In the mid-1990s, the US had not adopted IEC standards from IEC TC 88, Wind energy generation systems, but the IEC standards were already being used by financing agencies for "their due diligence review process for projects to meet certification requirements for loans and funding." As such, US financial institutions were "forced to conduct their own review process on domestic projects," which limited wind turbine design and innovation. However, in the late 1990s, the US adopted IEC standards from IEC TC 88, Wind energy generation systems, with compliance to these IEC standards becoming a requirement in the country.

As a result, the adoption of these standards significantly advanced the US' wind energy industry, improving product reliability and efficiency, while reducing financial risks. It has also significantly contributed to industry growth of wind energy generation systems, with the US experiencing almost 1,615 per cent growth over the span of 10 years, with the country's installed wind generation capacity jumping from around 2,000 MW in 1999 to 34,296 MW in 2009.[128]

International standards adoption also became a "key contributor in making wind power an economically viable source of electricity," while enabling mass production and effectively reducing costs across the US. The cost of electricity from wind generation prior to the US' adoption of international standards were relatively more expensive at 40 cents per kilowatt-hour (kWh) in 1979, declining by almost 92 per cent up to 3 cents per kWh in 2004 – after the US adopted IEC standards.[129] The US Department of Energy have shared how international standards compliance contributed to these financial benefits and ultimately led to industry growth, as follows:

> *"Compliance with rigorous, accepted standards assured consumers that products were reliable, which was essential for manufacturers to gain investor confidence in wind power with acceptable financial risks. Commercial viability and product reliability were integral in attracting capital and encouraging the government to provide incentives that catalyzed rapid market growth."*

As of 2024, the US is a participating member of IEC TC 88, Wind energy generation systems, sponsoring subject-matter experts from a range of interest groups including equipment manufacturers, testing laboratories and regulatory authorities among others. With a highly developed wind energy sector, the US had an installed wind generation capacity of 153,152 MW in 2024 – the second highest installed wind capacity in the world – while experiencing almost USD 330 billion of investments into its renewable wind energy sector over the last 20 years.[130]

3.3 Role of Standards in Regional Policies

Standards can help policymakers set benchmarks and expectations on how clean, green, renewable energy technologies and systems are to be deployed, setting a strategic direction for various initiatives, programmes and pilots. It can also guide policies as a foundation, laying the strategic groundwork for best practices.

---

xv The IEC 61215 series, *Terrestrial photovoltaic (PV) modules - Design qualification and type approval*, was developed by IEC TC 82, Solar photovoltaic energy systems.

Section 3 – Case Study 3: Samoa Water Authority's (SWA) development of an asset management policy based on ISO 55001, *Asset Management Systems*[131]

In 2023, the Samoa Water Authority (SWA) identified a need to update their asset management policy, which was underused and was not relevant to current practices. To ensure best practices and relevancy, the SWA asset management engineer led the development of this new policy, using a draft structure provided by the Asian Development Bank (ADB) and adapting it to fit SWA's context. The process involved researching other organisations' policies, including Australian water utilities, and incorporating recommendations from ISO 55001, *Asset Management Systems*. The entire process took less than two months and resulted in a clear, concise policy that was endorsed by SWA's management and Board. Key success factors included high-level support from the CEO, dedicated efforts from the asset management engineer, and external technical assistance. The new policy now serves as the foundation for SWA's asset management practices, delineating responsibilities and emphasising the importance of the asset management unit.

In addition to policies serving as strategic documents, they also serve as key communication mechanisms to other government departments, regulators, markets, investors, suppliers, service providers, auditors and most importantly to end users. References to standards in policies can help set expectations and ensure confidence across an array of stakeholders, further encouraging investors, suppliers and bidders. Including standards in policies can also help surface opportunities for public-private collaborations, harmonise national policy frameworks, support regulatory compliance, and assist auditors to harmonise approaches and enhance clarity on processes, procedures and specifications to audit against.[132]

Opportunity exists for regional policies to facilitate and endorse standards harmonisation, offering uniformed guidance on standards compliance throughout a given region. Such guidance can be designed as a directory of relevant international standards, international standards committees and encouragement for standards compliance by emphasising the net benefits and use-cases of international standards. Effectively, a regional policy can facilitate engagement and networking of regional stakeholders, which can help strengthen a regional supply chain and a regional market, and accelerate the deployment of clean, green, renewable energy across the AANZFTA.

3.4 Role of Standards in Legal Frameworks

Policymakers and regulators have a significant opportunity to utilise international standards as tools to shape technical basis for laws and regulations relating to clean, green, renewable energy sectors, supporting tendering processes and reducing technical barriers to trade.[133] As such, international standards can potentially contribute to regulatory harmonisation, setting common terminology, requirements and specifications to smooth the flow of trade, while reducing complications and costs from additional testing or other duplicative procedures that can occur when different regulators develop conflicting solutions.[134] For example, the European Union's (EU) Regulation 2023/1542 on batteries and waste batteries requires compliance with several ISO/IEC standards relating for QR codes and unique identifiers, and recommends considering existing international standards, particularly IEC and ISO, to complement the implementation of this regulation.[135] While not mandatory, Annex V *Safety Parameters* in Regulation (EU) 2023/1542, cites IEC 62619, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications,* as a benchmark for thermal abuse testing of lithium batteries.[136] In this context, aligning with IEC 62169 can help streamline battery exports to the EU market by reducing trade complexities, duplicative testing and unnecessary costs.

Harmonised international standards can effectively help establish regional clean, green, renewable energy certification schemes, or help government and industry engage with existing certification schemes, supporting legal recognition and compliance across jurisdictions.[137] In both Australia and New Zealand, electrical safety laws require adherence to AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*.[138] In turn, AS/NZS 3000 specifies adherence to AS/NZS 5033, *Installation and safety requirements for photovoltaic (PV) arrays*, in which AS/NZS 5033 then requires the adherence to IEC 61215 series, *Terrestrial photovoltaic (PV) modules - Design qualification and type approval*, for the installation of solar PV modules.[139] Effectively, regulators can prohibit the installation of non-compliant solar PV modules in their jurisdictions.[140] From 2025, Australia's Clean Energy Council – the peak Australian body for the clean energy industry – will require all solar PV modules in new solar installations to be compliant with the IEC 61215 series to qualify for small-scale technology certificates (STCs), some Australian state programs, as well as to meet some Distributed Network Service Providers' (DNSPs) requirements.[141] In this particular case, harmonisation around IEC 61215 series can help reduce technical barriers to trade around solar PV modules, accelerate the uptake of solar PVs and ensure regulatory alignment.

At an international level, the IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications (IECRE) provides a global certification system based on IEC international standards. This system can help facilitate global trade in clean, green, renewable energy technologies, and enable easier and faster market access, while demonstrating compliance with international best practices and assist with regulatory alignment across jurisdictions.[142] For more information on IECRE, please visit their webpage here: https://www.iecre.org/home.

It is also worth noting that the World Trade Organisation's (WTO) Technical Barriers to Trade (TBT) Agreement strongly endorses countries to base non-tariff measures on international standards as a means to facilitate trade and reduce unnecessary obstacles to trade, such as conflicting product specifications.[143] Both international standards development organisations, ISO and IEC, are consistent with the WTO's TBT committee's principles for the development of international standards – providing an opportunity for AANZFTA Parties to increase international standards adoption and harmonise across compliance requirements.

3.5 Relevant ISO & IEC Committees across Clean, Green, Renewable Energy Sectors

The research has found 16 international standards committees relevant to the five energy sectors – three for BESS, one for geothermal, two hydropower, five solar and one wind committee, as well as four committees that overlaps across multiple sectors (labelled as 'cross-cutting').[xvi] Please see Table 7 below for a list of these committees. For further details on the scope of these committees, please see Appendix E.

xvi Please note this is a narrowed scope. Therefore, it is recommended to further explore ISO and IEC platform for other relevant committees beyond the scope of this research.

Table 7 – Relevant ISO & IEC Committees for battery energy storage systems (BESS), geothermal, hydropower, solar and wind systems

Energy Sector	International Standards Committee
BESS	IEC TC 21, Secondary cells and batteries
	IEC TC 21/SC 21A, Secondary cells and batteries containing alkaline or other non-acid electrolytes
	IEC TC 120, Electrical Energy Storage (EES) systems
Geothermal	IEC TC 5, Steam turbines
Hydro	IEC TC 4, Hydraulic turbines
	ISO/TC 339, Small hydropower plants (SHP plants)
Solar	IEC TC 82, Solar photovoltaic energy systems
	IEC TC 117, Solar thermal electric plants
	ISO/TC 180, Solar energy
	ISO/TC 180/SC 1, Climate - Measurement and data
	ISO/TC 180/SC 4, Systems - Thermal performance, reliability and durability
Wind	IEC TC 88, Wind energy generation systems
Cross-cutting	IEC TC 8, System aspects of electrical energy supply
	IEC TC 8/SC 8A, Grid Integration of Renewable Energy Generation
	IEC TC 8/SC 8B, Decentralized electrical energy systems
	IEC TC 8/SC 8C, Network Management in Interconnected Electric Power Systems

BESS

There are three committees relevant to BESS as seen in Table 7 above, with two committees specifically scoped towards secondary (i.e. rechargeable) batteries and the other being more broadly scoped to energy storage systems. IEC TC 21, Secondary cells and batteries, develop standards relating to product dimensions, performance, design, safety and testing among others, for all types of secondary batteries such as lithium-ion and flow-batteries among others. At the time of this report, this committee has published 44 standards.[144]

Also relevant to secondary batteries, IEC TC 21/SC 21A, Secondary cells and batteries containing alkaline or other non-acid electrolytes, is a subcommittee under IEC TC 21. However, its scope mainly differs on battery chemistry, with IEC TC 21/SC 21 A, focusing on alkaline or other non-acid secondary batteries such as vented nickel-cadmium and sodium-based batteries among others. At the time of this report, this committee has published 33 standards.[145]

The third relevant committee, IEC TC 120, Electrical Energy Storage (EES) systems, is relatively more system oriented, with standardisation activities centred around the grid integration of energy storage systems to support grid requirements. Across the 17 standards published so far, this committee has covered aspects such as vocabulary, testing specifications, performance assessments, environmental requirements for reused batteries, and system safety among others.[146] An example standard from each of the three committees have been listed in Table 8 below for reference.

Table 8 – Example standards from three relevant international battery energy storage systems (BESS) committees

International Standards Committee	Standard Code & Title	Abstract
IEC TC 21, Secondary cells and batteries	IEC 62485-5:2020, *Safety requirements for secondary batteries and battery installations - Part 5: Safe operation of stationary lithium-ion batteries*	"Applies to the installation of one or more stationary secondary batteries having a maximum aggregate DC voltage of 1 500 V to any DC part of the power network, and describes the principal measures for protections during normal operation or under expected fault conditions against hazards generated from: electricity, short-circuits, electrolyte, gas emission, fire, explosion."[147]
IEC TC 21/SC 21A, Secondary cells and batteries containing alkaline or other non-acid electrolytes	IEC 60623:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Vented nickel-cadmium prismatic rechargeable single cells*	"Specifies marking, designation, dimensions, tests and requirements for vented nickel-cadmium prismatic secondary single cells."[148]
IEC TC 120, Electrical Energy Storage (EES) systems	IEC TS 62933-2-2:2022, *Electrical energy storage (EES) systems - Part 2-2: Unit parameters and testing methods - Application and performance testing*	"Defines testing methods and duty cycles to validate the EES system's technical specification for the manufacturers, designers, operators, utilities and owners of the EES systems which evaluate the performance of the EES systems for various applications."[149]

Geothermal

In contrast to the other four sectors, there appears to be no international standards committee dedicated to geothermal energy and/or geothermal power plants systems. One committee that may be relevant is IEC TC 5, Steam turbines, which is scoped to undertake international standardisation "in the field of steam turbines, including their design, application, installation, operation, and testing."[150] Steam turbines are essential for converting thermal energy into mechanical energy and ultimately into electricity within a geothermal energy system.[151] One example of a standard from this committee is listed below in Table 9.

Table 9 – Example standards from IEC TC 5, Steam turbines

Standard	Abstract
IEC 60045-1:2020, *Steam turbines - Part 1: Specifications*	This document "is applicable primarily to land-based horizontal steam turbines driving generators for electrical power services."[152]

Hydropower

There are two committees relevant to hydropower as set out in Table 7 – *Relevant ISO & IEC Committees for BESS, geothermal, hydropower, solar and wind systems* – with each committee undertaking standardisation activities in different areas. IEC TC 4, Hydraulic turbines, is responsible for the international standardisation of "hydraulic rotating machinery and associated equipment allied with hydro-power development."[153] Across the 32 published standards, this committee covers areas such as installation procedures of hydroelectric machines, guidelines for tendering documents, as well as hydraulic performance tests for hydraulic turbines, pump-turbines and storage pumps.[154]

ISO/TC 339, Small hydropower plants (SHP plants), is the other relevant committee within the hydropower sector. The scope of this committee however, diverges from the more technological focus of IEC TC 4, Hydraulic turbines, with the aim to standardise "in the field of site selection planning, design, construction and management" for small hydropower plants with a maximum installed capacity of 30 MW.[155] This committee has only developed three standards so far, which are all technical guidelines for the development of small hydropower plants, focussing on vocabulary, site selection planning, and design principles and requirements.[156] An example standard from each committee has been listed below in Table 10.

Table 10 – Example standards from two relevant international hydropower committees

International Standards Committee	Standard Code & Title	Abstract
IEC TC 4, Hydraulic turbines	IEC 60193:2019, *Hydraulic turbines, storage pumps and pump-turbines - Model acceptance tests*	"This document covers the arrangements for model acceptance tests to be performed on hydraulic turbines, storage pumps and pump-turbines to determine if the main hydraulic performance contract guarantees have been satisfied."[157]
ISO/TC 339, Small hydropower plants (SHP plants)	IWA 33-2:2019, *Technical guidelines for the development of small hydropower plants – Part 2: Site selection planning*	"This document specifies the general principles of site selection planning for small hydropower (SHP) projects, and the methodologies, procedures and outcome requirements of SHP plant site selection."[158]

Solar

The five committees relevant to solar energy demonstrate distinct focus areas with some minor overlaps. IEC TC 82, Solar photovoltaic energy systems, has a strong standardisation focus on photovoltaic energy systems.[159] With 147 standards published, this committee has standardised in areas such as photovoltaic device requirements and measurements, terrestrial photovoltaic module designs, testing, performance evaluation, safety requirements and building applications among others.[160]

IEC TC 117, Solar thermal electric plants, deviates from photovoltaic conversion systems and focuses standardisation on solar thermal energy conversion systems, specifically on Solar Thermal Electric (STE) plants. The 11 standards published from this committee delve into terminology, data sets, performance tests, design requirements and general requirements for systems and components of STE plants.[161]

While the two IEC committees' standardisation efforts focus on the conversion of solar energy into electrical energy, ISO committees ISO/TC 180, Solar energy, and ISO/TC 180/SC 4, Systems - Thermal performance, reliability and durability, focus on the conversion of solar energy for "space and water heating, cooling, industrial process heating and air conditioning."[162] ISO/TC 180, Solar energy has published 10 standards covering a range of aspects including solar energy vocabulary, testing of solar thermal collectors, material durability and performance specifications among others.[163] While ISO/TC 180/SC 4, Systems – Thermal performance, reliability and durability, has directly published six standards which focus on performance characterisation and testing for domestic water heating systems, as well as one for solar thermal collector fields.[164]

With 6 published standards, ISO/TC 180/SC 1, Climate – Measurement and data, undertakes international standardisation of "radiometric instrumentation, procedures for calibration, measurement and modelling practices of solar radiation for various applications."[165] An example of a standard from each of the five committees is listed in Table 11 below.

Table 11 – Example standards from five relevant international solar committees

International Standards Committee	Standard	Abstract
IEC TC 82, Solar photovoltaic energy systems	IEC TS 61724-3:2016, *Photovoltaic system performance - Part 3: Energy evaluation method*	"Defines a procedure for measuring and analyzing the energy production of a specific photovoltaic system relative to expected electrical energy production for the same system from actual weather conditions as defined by the stakeholders of the test."[166]
IEC TC 117, Solar thermal electric plants	IEC TS 62862-3-3:2020, *Solar thermal electric plants - Part 3-3: Systems and components - General requirements and test methods for solar receivers*	"Specifies the technical requirements, tests, durability and technical performance parameters of solar thermal receivers for absorbing concentrated solar radiation and transferring the heat to a fluid used in concentrated solar thermal power plants with linear-focus solar collectors."[167]
ISO/TC 180, Solar energy	ISO 9806:2025, *Solar energy — Solar thermal collectors — Test methods*	"Specifies test methods for assessing the durability, reliability, safety and thermal performance of fluid heating solar collectors."[168]
ISO/TC 180/SC 1, Climate - Measurement and data	ISO 9060:2018, *Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation*	"Establishes a classification and specification of instruments for the measurement of hemispherical solar and direct solar radiation integrated over the spectral range from approximately 0,3 μm to about 3 μm to 4 μm."[169]
ISO/TC 180/SC 4, Systems - Thermal performance, reliability and durability	ISO 24194:2022, *Solar energy — Collector fields — Check of performance*	"Specifies two procedures to check the performance of solar thermal collector fields." [170]

Wind

The International Electrotechnical Commission's Technical Committee TC 88, Wind energy generation systems, is dedicated to the development and maintenance of international standards for wind renewable energy systems.[171] At the time of this report, this committee has published 47 standards, covering a range of aspects including design requirements, measurement techniques, performance assessments, site suitability, lightning protection, communications for monitoring and control among others.[172] Standardisation in these areas support safety, reliability, performance, interoperability and efficiency of renewable wind energy systems. One example of a standard from this committee has been listed below in Table 12.

Table 12 – Example standards from IEC TC 88, Wind energy generation systems

Standard	Abstract
IEC 61400-15-1:2025, *Wind energy generation systems - Part 15-1: Site suitability input conditions for wind power plants*	"Defines a framework for assessment and reporting of the wind turbine suitability conditions for both onshore and offshore wind power plants. This includes: a) definition, measurement, and prediction of the long-term meteorological and wind flow characteristics at the site; b) integration of the long-term meteorological and wind flow characteristics with wind turbine and balance-of-plant characteristics; c) characterizing environmental extremes and other relevant plant design drivers; d) addressing documentation and reporting requirements to help ensure the traceability of the assessment processes."[173]

For more relevant standards across these five sectors, please visit the IEC's Technical committees and subcommittees webpage here: https://iec.ch/technical-committees-and-subcommittees; as well as ISO's Technical committees webpage here: https://www.iso.org/technical-committees.html.

3.6 AANZFTA Parties Engagement in International Clean, Green, Renewable Energy Standardisation

As an indicator for the region's degree of international standards participation across the clean, green, renewable energy sectors this research assessed AANZFTA countries' engagement in relevant standards committees, as listed in Table 9 – *Relevant ISO & IEC Committees for BESS, geothermal, hydropower, solar and wind systems* (in section 3.5 of this report). At a more detailed level, there are three official statuses for standards committee engagement, which are: 'participating' member, 'observing' member, and 'non-member.'

Among the 12 AANZFTA Parties and across the 16 identified committees, there are 29 'participating' memberships (15.1 per cent), 24 'observing' memberships (12.5 per cent), and 139 'non-members' (72.4 per cent). By considering both 'participating' and 'observing' membership as 'active engagement,' the active engagement rate of AANZFTA Parties in relevant international standards committees comes to around 27.6 per cent. These figures are presented in Table 13 below. Please see Appendix F for the full mapping of AANZFA Parties' participation across the 16 committees identified.

Table 13 – AANZFTA Parties engagement in relevant international committees [xvii]

Type of Engagement	No. of Engaged Parties	Engagement rate (%)
Participating	29	15.1%
Observing	24	12.5%
'Active engagement'	53	27.6%
Non-member	139	72.4%

Table 14 below provides a more specific depiction of international standards engagement in the region by AANZFTA Parties.

Table 14 – Engagement in relevant international committees, by AANZFTA Parties [xviii]

Country	No. of committees, Participating	No. of committees, Observing	Engagement rate (%)
Australia	12	1	81.3%
Brunei Darussalam	0	0	0%
Cambodia	0	0	0%
Indonesia	2	6	50%
Lao PDR	0	0	0%
Malaysia	4	2	37.5%
Myanmar	0	0	0%
New Zealand	1	11	75%
The Philippines	2	2	25%
Singapore	5	0	31.25%
Thailand	3	2	31.25%
Viet Nam	0	0	0%
AANZFTA	**29**	**24**	**27.6%**

The figures in both Table 13 and Table 14 above reveal a significant opportunity for the AANZFTA to increase engagement with relevant international standards committees. By participating in ISO or IEC technical committees and subcommittees, countries can become actively involved in the international standardisation process, with the ability to discuss, contest and contribute to international standards development. Participation also provides the opportunity for each country to represent their interests and national requirements at a global level, ensuring that internationally developed standards are relevant and beneficial to each AANZFTA Party.

The AANZFTA Parties engagement in international standardisation can also be viewed from a sectoral perspective (as seen in Table 15 below). Evidently, the region has the highest sectoral engagement rate in BESS at 38.9 per cent, closely followed by wind (33.3 per cent), hydropower (29.2 per cent), solar (28.3 per cent) and 'cross-cutting' (22.9 per cent). The research has found no engagement in the one standards committee identified for geothermal.

It is also important to note that solar had the highest number of active engagement from the AANZFTA Parties totalling at 17, followed by BESS (14), 'cross-cutting' (11), hydropower (7) and

xvii The total possible number of engagements from the AANZFTA is 192; 12 AANZFTA Parties multiplied by the 16 international standards committees identified in this report.

xviii Engagement rate is a percentage taken from the sum of 'participating' and 'observing' membership against the 16 international standards committees identified in this report.

wind (4) (as seen in Table 15 below).[xix] These figures may indicate that there are relatively strong interests towards BESS, solar, hydropower and wind, in contrast to geothermal. This pattern also aligns with Table 5 – *Degree of prioritisation across BESS, geothermal, hydropower, solar and wind sectors by AANZFTA countries* (in section 2.3 of this report) – where the degree in international standards engagement somewhat aligns with the national priorities identified across government policies, platforms and articles.

Table 15 – AANZFTA Parties engagement in relevant international committees, by clean, green, renewable energy sectors

Domains	No. of committees, by sector	No. of Participating membership	No. of Observing membership	No. of Active Engagement	Engagement rate (%)
BESS	3	8	6	14	38.9%
Geothermal	1	0	0	0	0%
Hydropower	2	1	6	7	29.2%
Solar	5	10	7	17	28.3%
Wind	1	2	2	4	33.3%
Cross-cutting	4	8	3	11	22.9%
Total	**16**	**29**	**24**	**53**	**27.6%**

3.7 AANZFTA Conformity Assessment Landscape for Clean, Green, Renewable Energy Sectors

Conformity assessment across the AANZFTA is primarily managed through national accreditation and regulatory systems, supported by regional mechanisms that promote mutual recognition and trade facilitation. Each country maintains its own infrastructure of standards bodies, accreditation agencies, and conformity assessment organisations that test, inspect, and certify products for safety, performance, and quality – including for solar modules, inverters, and battery energy storage systems (BESS). These national systems operate within the framework of AANZFTA Agreement Chapter 6 – *Standards, technical regulations and conformity assessment procedures*, which encourages Parties to recognise equivalent assessment results from other members and to participate in cooperative arrangements or mutual recognition arrangements (MRA).[174] As such, the importance of international standards adoption and standards harmonisation is reiterated here under AANZFTA Agreement Chapter 6, where Parties are to:

> *"Give positive consideration to accepting the results of conformity assessment procedures of other Parties, even when those procedures differ from its own, provided it is satisfied that those procedures offer an assurance of… standards equivalent to its own procedures... with a view to increasing efficiency, avoiding duplication and ensuring cost effectiveness."*[175]
> – AANZFTA Agreement Chapter 6 Standards, Technical Regulations and Conformity Assessment Procedures, Article 7, Conformity Assessment Procedures

At the regional level and among ASEAN Member States, the ASEAN Consultative Committee for Standards and Quality (ACCSQ) coordinates harmonisation efforts of standards, technical regulations and conformity assessment procedures, as mandated under the *ASEAN Standards and Conformance Strategic Plan 2016–2025*.[176] This includes ACCSQ adoption of a Mutual

xix Please note that the number of 'active engagement' is the combined total of 'participating' and 'observing' membership, i.e. Across the 3 BESS committees identified, 8 AANZFTA Parties have 'participating' membership while 6 AANZFTA Parties have 'observing' membership, bringing the active engagement number to 14.

Recognition Arrangement (MRA) on conformity assessment results – such as the ASEAN Sectoral MRA for Electrical and Electronic Equipment – which enables the acceptance of testing, inspection and certifications across participating Parties, removing duplicative conformity assessments and expediating approvals, while safeguarding quality and safety for consumers.[177] However, participation in ASEAN sectoral MRAs is exclusive to only ASEAN Member States, and is not available for Australia and New Zealand.[178] At the time of this report, the ASEAN Sectoral MRAs in place are as follows:

1. ASEAN Sectoral MRA for Electrical and Electronic Equipment.
2. ASEAN Sectoral MRA for Good Manufacturing Practice (GMP) Inspection of Manufacturers of Medicinal Products.
3. ASEAN MRA on Bio-Equivalence Study Report of Generic Medicinal Products.
4. ASEAN Sectoral MRA for Inspection and Certification System on Food Hygiene for Prepared Foodstuff Product.[179]

There is further opportunity to expand ASEAN MRAs into clean, green, renewable energy sectors to facilitate smoother trade of clean, green, renewable energy technologies, supporting the region's energy security and energy transition.

Together, this multi-layered system helps enable products to freely move cross borders while assuring safety and performance. There is still opportunity to increase technical alignment in the AANZFTA, as differing national regulations and limited sector-specific MRAs continue to constrain seamless trade in clean, green, renewable energy technologies, including fragmented safety standards for BESS and solar PV, stressing the need for standards harmonisation through international standards adoption.[180]

Conclusion

This report set out to support deeper cooperation and collaboration among AANZFTA Parties by examining the clean, green, renewable energy trade, policy and standards landscape to help accelerate the region's energy transition.

Through comprehensive desktop-analysis, the report has highlighted the growing importance of clean, green, renewable energy in addressing energy security, economic resilience, and climate imperatives across the AANZFTA. It has clarified the distinctions and overlaps between clean, green, and renewable energy, and profiled five core sectors—battery energy storage systems (BESS), geothermal, hydropower, solar, and wind. Trade data reveals a growing regional market, with AANZFTA Parties collectively importing and exporting at least USD 61.4 billion in clean, green, renewable energy related products in 2024, led by BESS and solar technologies. Policy analysis uncovered five key regional policies oriented towards ASEAN, with varying levels of engagement from Australia and New Zealand, while national priorities showed strong alignment around BESS, solar, and wind. The report mapped 16 relevant ISO and IEC technical committees, revealing low overall participation from the AANZFTA – but with relatively strong engagement in BESS and wind sectors – highlighting significant opportunities to deepen regional involvement in international standardisation. Finally, it underscored the role of standards in enabling trade, guiding policy, and supporting legal frameworks, while identifying opportunities to expand mutual recognition agreements and harmonisation across the region.

Looking ahead, the AANZFTA Parties are well-positioned to lead in clean, green, renewable energy deployment by strengthening regional collaboration, increasing participation in international standardisation, and aligning policy and regulatory frameworks. Doing so will not only unlock trade and investment but also accelerate the region's path towards a secure, sustainable, and inclusive energy future.

As the region navigates the complexities of the energy transition, this report offers a foundation for informed dialogue, strategic alignment, and collective action – recognising that harmonised standards and shared priorities are key to realising the full potential of clean, green, renewable energy across the AANZFTA.

Appendices

Appendix A – Relevant HS product codes to battery energy storage systems (BESS), Geothermal, Hydropower, Solar and Wind Core Technologies

Domains	HS Product Code (4-6 digit)	HS Product Code Title	Relevancy
BESS	8507	Electric accumulators, incl. separators therefor, whether or not square or rectangular; parts thereof (excl. spent and those of unhardened rubber or textiles)	Accumulators (also known as secondary/ rechargeable batteries). Includes chemistries of Lead-acid, Nickel-based and Lithium-ion among others.
Geothermal	8406.81	Steam and other vapour turbines, of an output > 40 MW	Steam turbines
	8406.82	Steam and other vapour turbines, of an output <= 40 MW	Steam turbines
	8406.90	Parts of steam and other vapour turbines, n.e.s.	Steam turbines parts
	8418.61	Heat pumps (excl. air conditioning machines of heading 8415)	Heat pumps
	8419.50	Heat-exchange units (excl. those used with boilers)	Heat exchangers
Hydropower	8410.11	Hydraulic turbines and water wheels, of a power <= 1.000 kW (excl. hydraulic power engines and motors of heading 8412)	Hydraulic turbines
	8410.12	Hydraulic turbines and water wheels, of a power > 1.000 kW but <= 10.000 kW (excl. hydraulic power engines and motors of heading 8412)	Hydraulic turbines
	8410.13	Hydraulic turbines and water wheels, of a power > 10.000 kW (excl. hydraulic power engines and motors of heading 8412)	Hydraulic turbines
	8410.90	Parts of hydraulic turbines and water wheels incl. regulators	Hydraulic turbine parts
Solar	8541.42	Photovoltaic cells not assembled in modules or made up into panels	PV cells
	8541.43	Photovoltaic cells assembled in modules or made up into panels	PV modules & panels

Domains	HS Product Code (4-6 digit)	HS Product Code Title	Relevancy
Solar	8501.71	Photovoltaic DC generators, of an output <= 50 W	PV generators
	8501.72	Photovoltaic DC generators, of an output > 50 W	PV generators
	8501.80	Photovoltaic AC generators	PV generators
	8419.12	Solar water heaters	Solar water heaters
Wind	8502.31	Generating sets, wind-powered	Wind turbines
Cross-cutting	8504.40	Static converters	Inverters, rectifiers & converters
	8502.39	Generating sets (excl. wind-powered and powered by spark-ignition internal combustion piston engine)	Electric generating sets (solar, hydropower, geothermal)

Appendix B – Clean, Green, Renewable Energy 2024 Import Volumes across the AANZFTA, in USD Thousand [181]

	BESS	Geothermal	Hydro power	Solar	Wind	Cross-cutting	Total Import Volume
Australia	3,862,075	677,330	19,890	799,223	104,938	1,613,075	7,076,531
Brunei Darussalam	7,510	9,515	3	3,155	-	6,863	27,046
Cambodia	50,682	12,036	353	116,769	-	27,682	207,522
Indonesia	796,573	765,199	46,220	150,763	103	905,602	2,664,460
Lao PDR	17,336	6,206	16,951	30,427	48,029	11,196	130,145
Malaysia	947,161	369,615	22,561	226,972	414	1,365,732	2,932,455
Myanmar	41,438	3,372	2,195	56,489	1,300	39,701	144,495
New Zealand	189,773	66,858	7,247	72,010	325	169,428	505,641
Philippines	349,594	67,910	5,889	470,706	6,241	399,653	1,299,993
Singapore	748,761	352,970	16,258	227,433	77	1,513,305	2,858,804
Thailand	951,155	167,868	477	504,207	2,310	1,217,305	2,843,322
Viet Nam	4,948,389	193,956	40,565	322,552	17,439	1,772,318	7,295,219
AANZFTA	**12,910,447**	**2,692,835**	**178,609**	**2,980,706**	**181,176**	**9,041,860**	**27,985,633**
World	**150,810,019**	**23,247,537**	**997,855**	**55,591,021**	**6,115,906**	**100,130,991**	**336,893,329**

Appendix C – Clean, Green, Renewable Energy 2024 Export Volumes in the AANZFTA, in USD Thousand [182]

	BESS	Geothermal	Hydro power	Solar	Wind	Cross-cutting	Total Export Volume
Australia	75,157	50,849	3,176	9,623	147	126,817	265,769
NZ	8,024	3,548	458	572	-	98,264	110,866
Brunei	241	58	4	1	-	1,013	1,317
Cambodia	479	9,617	-	830,564	-	52,929	893,589
Indonesia	780,397	3,610	257	644,507	-	279,204	1,707,975
Lao PDR	2,136	65	39	402,204	-	1,974	406,418
Malaysia	1,499,494	131,785	219	2,452,195	66	1,190,370	5,274,129
Myanmar	105	-	-	-	-	51	156
Philippines	219,382	16,307	13	96,144	-	1,193,483	1,525,329
Singapore	860,085	236,257	2,619	342,714	862	1,388,895	2,831,432
Thailand	314,448	93,928	231	2,697,770	2,565	4,443,908	7,552,850
Viet Nam	3,054,340	34,087	567	6,656,965	9,954	3,165,287	12,921,200
AANZFTA	**6,814,288**	**580,111**	**7,583**	**14,133,259**	**13,594**	**11,942,195**	**33,491,030**
World	**147,124,233**	**22,735,983**	**1,042,956**	**52,719,428**	**6,410,829**	**102,477,840**	**332,511,269**

Appendix D – 11 entities promoting clean, green, renewable energy collaboration and dialogue involving AANZFTA Parties

Entities	Relevant Sectors	AANZFTA Countries Involved	Overview
ASEAN Centre for Energy (ACE)	All	All	The key intergovernmental organisation that manages dialogues and interests across the energy sector. It serves as a platform for collaboration and catalysing cooperation, while also serving as a knowledge hub and think tank, providing research and data solutions.[183] Some significant examples of collaboration under ACE are the ASEAN International Conference on Energy and Environment (AICEE) and the ASEAN Energy Business Forum.[184]
ASEAN Ministers on Energy Meeting (AMEM)	All	ASEAN	Involves dialogue between key energy policymakers of ASEAN Member States, discussing on areas such as renewable energy, regional energy policy and planning, and energy security among others.[185]
Asia Pacific Urban Energy Association (APUEA)	Unspecified	Members from: Malaysia, Singapore, Thailand.	Aims to promote "public and private sector collaboration to develop sustainable urban energy systems that support liveable cities across the Asia Pacific region."[186]
Asia-Pacific Economic Cooperation's (APEC) Energy Working Group (EWG)	All	Australia, Brunei Darussalam, Indonesia, Malaysia, New Zealand, the Philippines, Singapore, Thailand, Viet Nam	Aims to maximise the economic and social benefits from the energy sector, while mitigating the environmental effects of energy supply and use in the APEC region. This regional platform facilitates collaboration and dialogues, as well as workshops and peer-reviews for low-carbon energy policies.[187]
International Renewable Energy Agency (IRENA)	All	Australia, Brunei Darussalam, Cambodia, Indonesia, Malaysia, New Zealand, the Philippines, Singapore, Thailand, Viet Nam	A global intergovernmental agency for energy transformation, serving as a platform for international cooperation, and providing data and analysis to support strategic direction for renewables-based energy transitions[188]
International Energy Agency (IEA)	All	Australia, New Zealand, Indonesia, Singapore, Thailand	An intergovernmental organisation, facilitating global dialogue and providing data and analysis, along with policy recommendations to ensure a global uptake of reliable, affordable and clean energy.[189]
World Energy Council	All	Australia, Indonesia, New Zealand, Singapore, Thailand	A non-governmental, non-commercial and an UN-accredited organisation that promotes the sustainable supply and use of energy for the benefit of all people.[190] It facilitates dialogue and global networking across government, private and state corporations, academia and civil society, while providing insights, activities and tools to support clean, affordable and reliable energy.[191]

Entities	Relevant Sectors	AANZFTA Countries Involved	Overview
International Geothermal Association (IGA)	Geothermal	Affiliated organisations from: Australia, Indonesia, New Zealand, the Philippines.	Aims to "encourage, facilitate and promote the development of geothermal resources, as well as innovative research in geothermal technologies."[192] It also supports capacity building, funding mechanisms, standards and facilitate dialogue across stakeholders.
International Hydropower Association (IHA)	Hydropower	Members from: Australia, Malaysia. *Note: There are also various corporate members deeply engaged in the AANZFTA.	A non-profit membership organisation, with members operating in more than 120 countries. IHA serves as a platform for advocacy, research, policy initiatives and value alignment, all to promote sustainable development and operation of hydropower.[193]
Global Solar Council	BESS, Solar	Members from: Australia, Malaysia, New Zealand.	Serves as a platform for knowledge exchange, network building, collaboration and capacity building.[194] It also advocates for effective policies, representing the solar industry at key international forums such as the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC).[195]
Global Wind Energy Council (GWEC)	Wind	Members from: Australia, Malaysia, New Zealand, the Philippines, Singapore, Thailand, Viet Nam.	An international trade association, representing the wind power sector globally. This association represents over 1,500 companies, organisation and institutions in more than 80 countries.[196] GWEC facilitates strategic dialogue with governments and key stakeholders to raise awareness and foster collaboration to strengthen wind capacities across countries. It also serves as an advocacy and research body for the wind sector, helping to shape government policy decisions.[197]

Appendix E – List of Relevant International Standards Committees to Clean, Green, Renewable Energy Sectors

Relevant Sector	Standards Committee	Standards Committee Scope
BESS	IEC TC 21, Secondary cells and batteries	“To provide standards for all types of secondary i.e. rechargeable cells and batteries as related to their chemistry, product dimensions, marking and performances, the intrinsic safety of the design, the qualification tests for selected applications and the safety rules for installation, operation, maintenance and disposal.”[198]
	IEC TC 21/ SC 21A, Secondary cells and batteries containing alkaline or other non-acid electrolytes	“To prepare standards regarding product and test specifications for all secondary cells and batteries of sealed and vented designs containing alkaline or other non-acid electrolytes. To support other technical committees standardizing application oriented systems using secondary cells and batteries.”[199]
	IEC TC 120, Electrical Energy Storage (EES) systems	Standardization in the field of grid integrated EES systems in order to support grid requirements, with focuses on system aspects on EES systems rather than energy storage devices; investigates system aspects and the need for new standards for EES systems; and focuses on the interaction between EES systems and Electric Power Systems (EPS).[200]
Geothermal	IEC TC 5, Steam turbines	“Standardizations in the field of steam turbines, including their design, application, installation, operation, and testing. Note: In support the advancement of renewable energy power generation, TC5 also focus to include various application scenarios for steam turbines for example: biomass thermal power turbine, geothermal power generation turbines, air turbine expander, etc.”[201]
Hydropower	IEC TC 4, Hydraulic turbines	“To prepare international standards and reports for hydraulic rotating machinery and associated equipment allied with hydro-power development.”[202]
	ISO/TC 339, Small hydropower plants (SHP plants)	“Standardization in the field of site selection planning, design, construction and management for SHP plants development up to 30 MW.” [203]
Solar	IEC TC 82, Solar photovoltaic energy systems	“To prepare international standards for systems of photovoltaic conversion of solar energy into electrical energy and for all the elements in the entire photovoltaic energy system. In this context, the concept "photovoltaic energy system" includes the entire field from light input to a photovoltaic cell to and including the interface with the electrical system(s) to which energy is supplied.” [204]
	IEC TC 117, Solar thermal electric plants	“To prepare international standards for systems of Solar Thermal Electric (STE) plants for the conversion of solar thermal energy into electrical energy and for all the elements (including all sub-systems and components) in the entire STE energy system. The standards would cover all of the current different types of systems in the STE field, as follows: Parabolic trough; Solar tower; Linear Fresnel; Dish; Thermal storage.” [205]
	ISO/TC 180, Solar energy	“Standardization in the field of solar energy utilization in space and water heating, cooling, industrial process heating and air conditioning.” [206]

Relevant Sector	Standards Committee	Standards Committee Scope
Solar	ISO/TC 180/ SC 1, Climate - Measurement and data	“Standardization of radiometric instrumentation, procedures for calibration, measurement and modelling practices of solar radiation for various applications such as weather, climate, solar energy, space and water heating, cooling, industrial process heating and air conditioning.” [207]
	ISO/TC 180/ SC 4, Systems - Thermal performance, reliability and durability	Scope not publicly available. It is a subcommittee under the ISO Technical Committee ISO/TC 180, Solar Energy, with international standardisation relating to solar energy.[208]
Wind	IEC TC 88, Wind energy generation systems	“To develop and maintain standards in the field of generation of electrical energy from wind power plants onshore and offshore, and their integration in, and interaction with, systems with which energy is exchanged inside the power plant.”[209]
Cross-cutting	IEC TC 8, System aspects of electrical energy supply	International standardisation in relation, but not limited to: Terminology for the electricity supply sector; Characteristics of electricity supplied by public networks; Network management from a system perspective; Connection of network users (generators and loads) and grid integration; Design and management of de-centralized electricity supply systems (e.g. microgrids, systems for rural electrification).[210]
	IEC TC 8/ SC 8A, Grid Integration of Renewable Energy Generation	“To prepare and coordinate, in co-operation with other TC/SCs, the development of international standards and other deliverables for grid integration of variable power generation from renewables such as PV, wind energy with emphasis on overall system aspects of electricity supply systems (grids) as defined in [IEC TC 8] scope.” [211]
	IEC TC 8/ SC 8B, Decentralized electrical energy systems	“To develop IEC publications enabling the development of secure, reliable and cost-effective systems with decentralized management for electrical energy supply, which are alternative, complement or precursor to traditional large interconnected and highly centralized systems. This includes but is not limited to AC, DC, AC/DC hybrid decentralized electrical energy system, such as distributed generation, distributed energy storage, virtual power plants and electrical energy systems having interaction with multiple types of distributed energy resources.” [212]
	IEC TC 8/SC 8C, Network Management in Interconnected Electric Power Systems	“Standardization in the field of network management in interconnected electric power systems, including design, planning, operation, control and market integration,” as well as covering “issues contributing to the resilience, reliability, security, stability of the interconnected electric power systems.” [213]

Appendix F – Mapping of AANZFTA Parties' Engagement across relevant International Standards Committees

Relevant Sector	Standards Committee	Australia	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	New Zealand	The Philippines	Singapore	Thailand	Viet Nam
BESS	IEC TC 21, Secondary cells and batteries	P	N	N	O	N	O	N	O	N	P	N	N
BESS	IEC TC 21/SC 21A, Secondary cells and batteries containing alkaline or other non-acid electrolytes	P	N	N	O	N	P	N	O	N	P	N	N
BESS	IEC TC 120, Electrical Energy Storage (EES) systems	P	N	N	N	N	N	N	O	P	P	N	N
Geothermal	IEC TC 5, Steam turbines	N	N	N	N	N	N	N	N	N	N	N	N
Hydropower	IEC TC 4, Hydraulic turbines	N	N	N	O	N	O	N	O	N	N	N	N
Hydropower	ISO/TC 339, Small hydropower plants (SHP plants)	O	N	N	P	N	N	N	O	N	N	O	N
Solar	IEC TC 82, Solar photovoltaic energy systems	P	N	N	P	N	P	N	P	P	P	P	N
Solar	IEC TC 117, Solar thermal electric plants	N	N	N	N	N	N	N	N	N	N	N	N
Solar	ISO/TC 180, Solar energy	P	N	N	O	N	N	N	O	O	N	O	N
Solar	ISO/TC 180/SC 1, Climate - Measurement and data	P	N	N	N	N	N	N	O	O	N	N	N
Solar	ISO/TC 180/SC 4, Systems - Thermal performance, reliability and durability	P	N	N	N	N	N	N	O	N	N	N	N
Wind	IEC TC 88, Wind energy generation systems	P	N	N	O	N	N	N	O	N	P	N	N
Cross-cutting	IEC TC 8, System aspects of electrical energy supply	P	N	N	O	N	P	N	O	N	N	N	N
Cross-cutting	IEC TC 8/SC 8A, Grid Integration of Renewable Energy Generation	P	N	N	N	N	P	N	O	N	N	P	N
Cross-cutting	IEC TC 8/SC 8B, Decentralized electrical energy systems	P	N	N	N	N	N	N	N	N	N	P	N
Cross-cutting	IEC TC 8/SC 8C, Network Management in Interconnected Electric Power Systems	P	N	N	N	N	N	N	N	N	N	N	N

P = Participating membership of ISO or IEC international standards committee
O = Observing membership of ISO or IEC international standards committee
N = Non-member of ISO or IEC international standards committee

Endnotes

1 "Technical barriers to trade," World Trade Organization, accessed October 30, 2025, https://www.wto.org/english/tratop_e/tbt_e/tbt_e.htm.

2 "Chapter 6: STANDARDS, TECHNICAL REGULATIONS AND CONFORMITY ASSESSMENT PROCEDURES," Australian Government Department of Foreign Affairs and Trade (DFAT), accessed October 30, 2025, https://www.dfat.gov.au/sites/default/files/aanzfta_chapter06.PDF.

3 ASEAN, Australian Aid, and New Zealand Foreign Affairs & Trade, *The AANZFTA Implementation Support Programme: An Overview* (ASEAN, 2023), https://aanzfta.asean.org/uploads/2023/08/AEM-CER%20Communication%20Package%20-%20AISP%20Overview%20-%20RT4D.pdf.

4 ASEAN Centre for Energy, *ASEAN Energy Investment 2024* (ASEAN Centre for Energy, 2024), https://aseanenergy.org/wp-content/uploads/2024/09/ASEAN-Energy-Investment-2024.pdf; New Zealand Government: Ministry of Business, Innovation & Employment, *Electricity Demand and Generation Scenarios: Results summary* (New Zealand Government, 2024), https://www.mbie.govt.nz/assets/electricity-demand-and-generation-scenarios-report-2024.pdf.

5 ERIA Study team, "Rising Oil Import Dependency and Oil Stockpiling in ASEAN," in *The Strategic and Economic Value of Joint Oil Stockpiling Arrangements for Middle East Exporters and ASEAN Importers*, ed. ERIA (ERIA, 2022), https://www.eria.org/uploads/media/Research-Project-Report/RPR-2022-09/08_Chapter-1-Rising-Oil-Import-Dependency-and-Oil-Stockpiling-in-ASEAN.pdf; Beni Suryadi, "ASEAN Energy Sector Challenges and Prospects," ASEAN Centre for Energy, accessed October 30, 2025, https://aseanenergy.org/asean-energy-sector-challenges-and-prospects/; "Key Energy issues," The Climate Council, accessed October 30, 2025, https://www.energyfactsaustralia.org.au/key-issues/key-energy-issues/; IEA, Energy Security in ASEAN +6 (IEA, 2019), https://iea.blob.core.windows.net/assets/e1eb71ef-da15-43d9-a01e-d0ec8f0296e2/Energy_Security_in_ASEAN6.pdf.

6 "Current GHG Levels," NOAA, accessed October 30, 2025, https://www.climate.gov/ghg/current-levels; "Global Energy Review 2025: CO2 Emissions," IEA, accessed October 30, 2025, https://www.iea.org/reports/global-energy-review-2025/co2-emissions; Steven Bernard, "Rising trend for warmer temperatures shows in latest monthly climate data," *The Financial Times*, October 9, 2025, https://www.ft.com/content/5e0ffa31-7d16-48a5-9264-13c2de32fdd2.

7 "What is renewable energy?" United Nations, accessed October 30, 2025, https://www.un.org/en/climatechange/what-is-renewable-energy.

8 "What is clean energy, and is it the same as green energy and renewables?" Iberdrola, accessed October 30, 2025, https://www.iberdrola.com/sustainability/clean-energy.

9 "Bioenergy/Energy from waste," Australian Government: Australian Renewable Energy Agency (ARENA), accessed October 30, 2025, https://arena.gov.au/renewable-energy/bioenergy/; Jacob Marsh, "Biomass energy: Advantages and disadvantages," EnergySage, last modified March 9, 2022, https://www.energysage.com/about-clean-energy/biomass/pros-and-cons-biomass/.

10 Iberdrola, "What is clean energy."

11 Iberdrola, "What is clean energy."

12 Iberdrola, "What is clean energy."

13 Iberdrola, "What is clean energy."

14 United Nations, "What is renewable energy?"

15 "Battery Storage," Australian Government: Australian Renewable Energy Agency (ARENA), accessed October 30, 2025, https://arena.gov.au/renewable-energy/battery-storage/.

16 "Battery Energy Storage System (BESS)," Edina, accessed October 30, 2025, https://www.edina.eu/power/battery-energy-storage-system-bess.

17 IRENA, *Geothermal Power Technology Brief* (IRENA, 2017), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Aug/IRENA_Geothermal_Power_2017.pdf.

18 "Electricity Generation," U.S. Department of Energy, accessed October 30, 2025, https://www.energy.gov/eere/geothermal/electricity-generation.

19 "Geothermal Heat Pumps," U.S. Department of Energy, accessed October 30, 2025, https://www.energy.gov/energysaver/geothermal-heat-pumps.

20 "How Hydropower Works," U.S. Department of Energy, accessed October 30, 2025, https://www.energy.gov/eere/water/how-hydropower-works.

21 "Types of Hydropower Plants," U.S. Department of Energy, accessed October 30, 2025, https://www.energy.gov/eere/water/types-hydropower-plants; Paul Lako and Masaomi Koyama, *Hydropower Technology Brief* (IEA-ETSAP and IRENA, 2015), https://www.ourenergypolicy.org/wp-content/uploads/2015/06/IRENA-ETSAP_Tech_Brief_E06_Hydropower.pdf.

22 Lako and Koyama, *Hydropower Technology Brief*.

23 Lako and Koyama, *Hydropower Technology Brief*.

24 "Solar Energy," Australian Government: Australian Renewable Energy Agency (ARENA), accessed October 30, 2025, https://arena.gov.au/renewable-energy/solar/.

25 "Solar Photovoltaic Technology Basics," U.S. Department of Energy, accessed October 30, 2025, https://www.energy.gov/eere/solar/solar-photovoltaic-technology-basics.

26 ARENA, "Solar Energy"; U.S. Department of Energy, "Solar Photovoltaic Technology Basics."

27 "Concentrated solar thermal," Australian Government: Australian Renewable Energy Agency (ARENA), accessed October 30, 2025, https://arena.gov.au/renewable-energy/concentrated-solar-thermal/.

28 "Wind energy," Australian Government: Australian Renewable Energy Agency (ARENA), accessed October 30, 2025, https://arena.gov.au/renewable-energy/wind/; Paul Lako and Masaomi Koyama, *Wind Power Technology Brief* (IEA-ETSAP and IRENA, 2016),https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA-ETSAP_Tech_Brief_Wind_Power_E07.pdf.

29 "What Is Energy Security and Why Is It Important?" Sustainability Directory, last modified December 4, 2025, https://energy.sustainability-directory.com/question/what-is-energy-security-and-why-is-it-important/.
30 "Causes and Effects of Climate Change," United Nations, accessed October 30, 2025, https://www.un.org/en/climatechange/science/causes-effects-climate-change.
31 "Net Zero Coalition," United Nations, accessed October 30, 2025, https://www.un.org/en/climatechange/net-zero-coalition.
32 "Global Energy Review 2025: Key findings," IEA, accessed October 30, 2025, https://www.iea.org/reports/global-energy-review-2025/key-findings; "Annual carbon dioxide (CO_2) emissions worldwide from 1940 to 2025," Statista, accessed October 30, 2025, https://www.statista.com/statistics/276629/global-co2-emissions/.
33 IEA, "Global Energy Review 2025: Key findings"; IEA, "Growth in global energy demand surged in 2024 to almost twice its recent average," IEA, March 24, 2025, https://www.iea.org/news/growth-in-global-energy-demand-surged-in-2024-to-almost-twice-its-recent-average; "GDP growth (annual %)," The World Bank Group, accessed October 30, 2025, https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG.
34 "Renewable energy – powering a safer and prosperous future," United Nations, accessed October 30, 2025, https://www.un.org/en/climatechange/raising-ambition/renewable-energy.
35 United Nations Development Programme (UNDP), *Power to the people: Solar energy for a better quality of life, social equity and socio-economic growth in the Philippines* (United Nations Development Programme (UNDP), 2011), https://files.acquia.undp.org/public/migration/asia_pacific_rbap/EE-2012-Case1-ACCESS.pdf.
36 "barangay," Merriam-Webster, accessed October 30, 2025, https://www.merriam-webster.com/dictionary/barangay.
37 IEA, Energy Technology Perspectives 2024 (IEA, 2025), https://iea.blob.core.windows.net/assets/25e2dab4-fe00-4e97-81e8-8f900ad5a0b6/EnergyTechnologyPerspectives2024.pdf.
38 IEA, *Energy Technology Perspectives 2024*.
39 IRENA, *Renewable power generation costs in 2023* (IRENA, 2024), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Sep/IRENA_Renewable_power_generation_costs_in_2023.pdf.
40 IRENA, *Renewable power generation costs in 2023*.
41 IRENA, *Renewable power generation costs in 2023*.
42 Khalid Khan et al., "Does renewable energy development enhance energy security?" Utilities Policy 87, no. 101725 (2024): 1-10, https://doi.org/10.1016/j.jup.2024.101725.
43 "Trade Map," International Trade Centre (ITC), accessed October 30, 2025, https://www.trademap.org/Index.aspx.
44 ITC, "Trade Map."
45 ITC, "Trade Map."
46 ITC, "Trade Map."
47 ITC, "Trade Map."
48 ITC, "Trade Map."
49 ITC, "Trade Map."
50 ITC, "Trade Map."
51 ITC, "Trade Map."
52 ASEAN Centre for Energy (ACE) et al., *ASEAN PLAN OF ACTION FOR ENERGY COOPERATION (APAEC) 2016-2025 PHASE II: 2021-2025* (ASEAN Centre for Energy (ACE), 2023), https://asean.org/wp-content/uploads/2023/04/ASEAN-Plan-of-Action-for-Energy-Cooperation-APAEC-2016-2025-Phase-II-2021-2025.pdf.
53 ASEAN Centre for Energy (ACE) et al., *ASEAN PLAN OF ACTION FOR ENERGY COOPERATION (APAEC) 2016-2025 PHASE II*.
54 ASiANPOWER staff reporter, "ACE secures $120,000 to fuel ASEAN energy cooperation," *ASiANPOWER*, August 2025, https://asian-power.com/news/ace-secures-120000-fuel-asean-energy-cooperation; "Australia-ASEAN Centre for Energy Cooperation Arrangement Signed," Australian Embassy Indonesia, published December 12, 2024, https://indonesia.embassy.gov.au/jakt/MR24_115.html.
55 ASEAN Centre for Energy (ACE) et al., *ASEAN PLAN OF ACTION FOR ENERGY COOPERATION (APAEC) 2016-2025 PHASE II*.
56 ASEAN Centre for Energy (ACE) et al., *ASEAN PLAN OF ACTION FOR ENERGY COOPERATION (APAEC) 2016-2025 PHASE II*; ASEAN Centre for Energy (ACE), "Enhancing ASEAN's Renewable Energy Sector: Aligning the APAEC Post 2025 Framework with the ASEAN RE Long-term Roadmap Decarbonisation Pathways," ASEAN Centre for Energy (ACE), July 7, 2025, https://aseanenergy.org/post/enhancing-aseans-renewable-energy-sector-aligning-the-apaec-post-2025-framework-with-the-asean-re-long-term-roadmap-decarbonisation-pathways/.
57 ASEAN Centre for Energy (ACE), "Enhancing ASEAN's Renewable Energy Sector."
58 ASEAN, *ASEAN STRATEGY FOR CARBON NEUTRALITY* (ASEAN, 2023), https://asean.org/wp-content/uploads/2023/08/Brochure-ASEAN-Strategy-for-Carbon-Neutrality-Public-Summary-1.pdf; ASEAN, ASEAN for Business Bulletin: ASEAN Sets Course for a Carbon Neutral Future (ASEAN, 2024), https://asean.org/wp-content/uploads/2024/01/ASEAN-for-Business-Bulletin-January-2024.pdf; ASEAN Secretariat, "ASEAN charts course for a sustainable future with ambitious ASEAN Strategy for Carbon Neutrality," *ASEAN Secretariat*, August 19, 2023, https://asean.org/asean-charts-course-for-a-sustainable-future-with-ambitious-asean-strategy-for-carbon-neutrality/.
59 ASEAN Secretariat, "ASEAN charts course for a sustainable future"; ASEAN, *ASEAN STRATEGY FOR CARBON NEUTRALITY*.
60 ASEAN and ERIA, *ASEAN BLUE ECONOMY FRAMEWORK* (ASEAN, 2023), https://asean.org/wp-content/uploads/2023/09/ASEAN-Blue-Economy-Framework.pdf.
61 ASEAN and ERIA, *ASEAN BLUE ECONOMY FRAMEWORK*.
62 ASEAN and ERIA, *ASEAN BLUE ECONOMY FRAMEWORK*.
63 ASEAN, *Terms of Reference: Development of the ASEAN Blue Economy Implementation Plan (2026–2030)* (ASEAN, 2025), https://asean.org/wp-content/uploads/2025/04/250430_Tender-TOR_ASEAN-Blue-Economy.pdf.

64 ASEAN Centre for Energy (ACE), *ASEAN RE-Gender Roadmap: Roadmap on Accelerating ASEAN's Renewable Energy Deployment through Gender-Responsive Energy Policy* (ASEAN Centre for Energy (ACE), 2022), https://asiapacific.unwomen.org/sites/default/files/2023-06/asean-re-gender-roadmape6b5.pdf.
65 ACE, *ASEAN RE-Gender Roadmap*.
66 Sustainable Energy Development Authority (SEDA) Malaysia, *Malaysia Renewable Energy Roadmap* (Sustainable Energy Development Authority (SEDA) Malaysia, 2021), https://www.seda.gov.my/reportal/wp-content/uploads/2021/12/MyRER_webVer-1.pdf.
67 New Zealand Government: Ministry of Business, Innovation & Employment. *Energy in New Zealand 2024* (New Zealand Government: Ministry of Business, Innovation & Employment, 2024), https://www.mbie.govt.nz/assets/energy-in-nz-2024.pdf.
68 "National Renewable Energy Priority List," Australian Government: Department of Climate Change, Energy, the Environment and Water (DCCEEW), last modified March 17, 2025, https://www.dcceew.gov.au/energy/renewable/priority-list#toc_2.
69 "Australia: Energy mix," IEA, accessed October 30, 2025, https://www.iea.org/countries/australia/energy-mix.
70 Brunei Climate Change Secretariat (BCCS), *Brunei Darussalam National Climate Change Policy* (Brunei Climate Change Secretariat (BCCS), 2020), http://www.mod.gov.bn/Shared%20Documents/BCCS/Brunei%20National%20Climate%20Change%20Policy.pdf.
71 "Brunei Darussalam: Energy mix," IEA, accessed October 30, 2025, https://www.iea.org/countries/brunei-darussalam/energy-mix.
72 "Cambodia: Energy mix," IEA, accessed October 30, 2025, https://www.iea.org/countries/cambodia/energy-mix; "Cambodia : Utility-Scale Battery Energy Storage Project," Asian Development Bank, accessed October 30, 2025, https://www.adb.org/projects/59110-001/main.
73 Asian Development Bank, "Cambodia : Utility-Scale Battery Energy Storage Project."
74 Julian Prime et al., *Renewable Capacity Statistics 2025* (IRENA, 2025), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2025/Mar/IRENA_DAT_RE_Capacity_Statistics_2025.pdf; Royal Government of Cambodia: Ministry of Mines and Energy (MNE), *Cambodia Power Development Master Plan 2022-2040* (Royal Government of Cambodia: Ministry of Mines and Energy (MNE), 2022), https://vdb-loi.com/wp-content/uploads/2023/06/Final-PDP-Cambodia-English-version.pdf.
75 Republic of Indonesia: Ministry of Energy and Mineral Resources, *RUPTL PT PLN (Persero) TAHUN 2025-2034* (Republic of Indonesia: Ministry of Energy and Mineral Resources, 2025), https://gatrik.esdm.go.id/assets/uploads/download_index/files/4ec39-materi-paparan-ruptl-2025-2034.pdf; Republic of Indonesia: Ministry of Energy and Mineral Resources, RENCANA USAHA PENYEDIAAN TENAGA LISTRIK (RUPTL) (Republic of Indonesia: Ministry of Energy and Mineral Resources, 2025), https://gatrik.esdm.go.id/assets/uploads/download_index/files/b967d-ruptl-pln-2025-2034-pub-.pdf.
76 Republic of Indonesia: Ministry of Energy and Mineral Resources, *RUPTL PT PLN (Persero) TAHUN 2025-2034*; Republic of Indonesia: Ministry of Energy and Mineral Resources, *RENCANA USAHA PENYEDIAAN TENAGA LISTRIK (RUPTL)*; Prime et al., *Renewable Capacity Statistics 2025*.
77 Fabby Tumiwa, *Maximizing Renewables Utilization to Enhance Domestic Energy Security : The Case of a 100% Renewable Energy Island* (Clean, Affordable and Secure Energy (CASE) for Southeast Asia, 2025), https://caseforsea.org/wp-content/uploads/2025/07/Session-2A_100-Renewable-Energy-Island-Indonesia_IESR.pptx.pdf; Ashok Willis, "Understanding Energy Storage Duration," *Gridcog*, December 12, 2024, https://www.gridcog.com/blog/understanding-energy-storage-duration; "MW to MWh Calculator," HBOWA New Energy, published December 11, 2024, https://www.pretapower.com/the-difference-between-mw-and-mwh-why-it-matters/#To_convert_MWh_to_MW.
78 ASEAN Centre for Energy (ACE), *An Energy Sector Roadmap to Net Zero Emissions for Lao PDR* (ASEAN Centre for Energy (ACE), 2025), https://aseanenergy.org/wp-content/uploads/2025/05/An-Energy-Sector-Roadmap-to-Net-Zero-Emissions-for-Lao-PDR.pdf; Prime et al., *Renewable Capacity Statistics 2025*.
79 ASEAN Centre for Energy (ACE), *An Energy Sector Roadmap to Net Zero Emissions for Lao PDR*.
80 ASEAN Centre for Energy (ACE), *An Energy Sector Roadmap to Net Zero Emissions for Lao PDR*; Prime et al., *Renewable Capacity Statistics 2025*; "600 MW Monsoon Wind achieves commercial operation, delivering clean energy across borders," ACEN, published August 28, 2025, https://www.acenrenewables.com/2025/08/600-mw-monsoon-wind-achieves-commercial-operation-delivering-clean-energy-across-borders/.
81 ASEAN Centre for Energy (ACE), *An Energy Sector Roadmap to Net Zero Emissions for Lao PDR*.
82 "Battery Energy Storage System (BESS): A Lucrative Investment Opportunity in Malaysia for Businesses in the Green Energy Sector," Malaysian Investment Development Authority (MIDA), accessed October 30, 2025, https://www.mida.gov.my/battery-energy-storage-system-bess-a-lucrative-investment-opportunity-in-malaysia-for-businesses-in-the-green-energy-sector/; David Thoo and Patrick Tan, "Malaysia's 400 MW/1,600 MWh BESS Auction (MyBeST): A Strategic Primer for RFP Bidders," Aurora Energy Research, June 30, 2025, https://auroraer.com/resources/aurora-insights/articles/malaysias-400-mw-1600-mwh-bess-auction-mybest-a-strategic-primer-for-rfp-bidders; Blathnaid O'Dea, "Malaysia commissions its first big BESS at coal-fired power plant site," *PV Magazine*, February 25, 2025, https://www.ess-news.com/2025/02/25/malaysia-bess-battery-energy-storage-utility-scale-sarawak-energy/.
83 SEDA Malaysia, *Malaysia Renewable Energy Roadmap*; Prime et al., *Renewable Capacity Statistics 2025*.
84 SEDA Malaysia, *Malaysia Renewable Energy Roadmap*; Prime et al., *Renewable Capacity Statistics 2025*.
85 Government of Malaysia: Ministry of Economy, *National Energy Transition Roadmap* (Government of Malaysia: Ministry of Economy, 2023), https://ekonomi.gov.my/sites/default/files/2023-08/National%20Energy%20Transition%20Roadmap.pdf.
86 SEDA Malaysia, *Malaysia Renewable Energy Roadmap*.
87 "Malaysia: Overview," IEA, accessed October 30, 2025, https://www.iea.org/countries/malaysia.

88 THI THI SOE MIN, *RENEWABLE ENERGY SITUATION IN MYANMAR* (The Republic of the Union of Myanmar: Environmental Conservation Department, 2023), https://www.nstda-tiis.or.th/wp-content/uploads/2023/10/06_Renewable-energy-situation-in-Myanmar_TTSM.pdf.
89 THI THI SOE MIN, *RENEWABLE ENERGY SITUATION IN MYANMAR*; Prime et al., *Renewable Capacity Statistics 2025*.
90 THI THI SOE MIN, *RENEWABLE ENERGY SITUATION IN MYANMAR*; Prime et al., *Renewable Capacity Statistics 2025*.
91 THI THI SOE MIN, *RENEWABLE ENERGY SITUATION IN MYANMAR*; The Republic of the Union of Myanmar: National Energy Management Committee, *National Energy Policy* (The Republic of the Union of Myanmar: National Energy Management Committee, 2014), https://policy.asiapacificenergy.org/sites/default/files/Myanmar_National_Energy_Policy_English_Dec_2014.pdf; The Government of the Republic of the Union of Myanmar National Energy Management Committee, *Myanmar Energy Master Plan* (The Government of the Republic of the Union of Myanmar National Energy Management Committee, 2015), https://policy.asiapacificenergy.org/sites/default/files/1_2015-12-Myanmar_Energy_Master_Plan_red-2.pdf.
92 "Wind energy in New Zealand," New Zealand Government: Energy Efficiency & Conservation Authority (EECA), accessed October 30, 2025, https://www.eeca.govt.nz/insights/energy-in-new-zealand/renewable-energy/wind/; "Electricity in New Zealand in 2024/2025," LowCarbonPower, accessed October 30, 2025, https://lowcarbonpower.org/region/New_Zealand.
93 New Zealand Government: Electricity Authority, *A regulatory roadmap for battery energy storage systems* (New Zealand Government: Electricity Authority, 2025), https://www.ea.govt.nz/documents/7557/A_regulatory_roadmap_for_battery_energy_storage_systems_paper.pdf.
94 LowCarbonPower, "Electricity in New Zealand in 2024/2025"; "Solar energy in New Zealand," New Zealand Government: Energy Efficiency & Conservation Authority (EECA), accessed October 30, 2025, https://www.eeca.govt.nz/insights/energy-in-new-zealand/renewable-energy/solar/.
95 "Geothermal energy in New Zealand," New Zealand Government: Energy Efficiency & Conservation Authority (EECA), accessed October 30, 2025, https://www.eeca.govt.nz/insights/energy-in-new-zealand/renewable-energy/geothermal/; "Hydroelectricity in New Zealand," New Zealand Government: Energy Efficiency & Conservation Authority (EECA), accessed October 30, 2025, https://www.eeca.govt.nz/insights/energy-in-new-zealand/renewable-energy/hydroelectricity/.
96 Alena Mae S. Flores, "Gov't bets on battery energy storage to power the nation," *Philippine Manila Standard Publishing*, February 10, 2025, https://manilastandard.net/spotlight/314555853/govt-bets-on-battery-energy-storage-to-power-the-nation.html; https://legacy.doe.gov.ph/sites/default/files/pdf/energy_statistics/03_Installed%20and%20Dependable%20Capacity.pdf.
97 "2024 POWER STATISTICS," Department of Energy Philippines, accessed October 30, 2025, https://legacy.doe.gov.ph/sites/default/files/pdf/energy_statistics/03_Installed%20and%20Dependable%20Capacity.pdf; Prime et al., *Renewable Capacity Statistics 2025*.
98 Department of Energy Philippines and National Renewable Energy Board, *National Renewable Energy Program 2020-2040* (Department of Energy Philippines and National Renewable Energy Board, n.d.), https://legacy.doe.gov.ph/sites/default/files/pdf/renewable_energy/nrep_2020-2040_0.pdf; Prime et al., *Renewable Capacity Statistics 2025*.
99 Department of Energy Philippines and National Renewable Energy Board, *National Renewable Energy Program 2020-2040*.
100 Prime et al., *Renewable Capacity Statistics 2025*.
101 "Singapore Green Plan 2030: Our Targets," Government of Singapore, accessed October 30, 2025, https://www.greenplan.gov.sg/targets/; "Singapore Energy Statistics 2025: Chapter 6: Solar," Government of Singapore: Energy Market Authority of Singapore, accessed October 30, 2025, https://www.ema.gov.sg/resources/singapore-energy-statistics/chapter6.
102 Government of Singapore, "Singapore Green Plan 2030: Our Targets."
103 Marija Maisch, "Sembcorp to expand Southeast Asia's biggest battery storage site," *PV Magazine*, October 24, 2024, https://www.ess-news.com/2024/10/24/sembcorp-to-expand-southeast-asias-biggest-battery-storage-site/.
104 "WindEnergy Conference and Exhibition launched in Singapore to accelerate growth of renewables in Asia-Pacific," Wind Energy Hamburg, published November 27, 2025, https://www.windenergyhamburg.com/news-details/article/windenergy-hamburg-expandiert-nach-asien-konferenz-und-ausstellung-in-singapur-geplant.
105 Yaowateera Achawangkul, *New and Renewable Energy Development in Thailand* (Royal Thai Government: Department of Alternative Energy Development and Efficiency, 2025), https://www.egnret.ewg.apec.org/Upload/202503101437722759351.pdf.
106 Royal Thai Government: Ministry of Energy – Energy Policy and Planning Office, *Thailand's Power Development Plan 2024-2037 Draft (PDP 2024) and Natural Gas Management Plan 2024-2037 Draft (Gas Plan 2024)* (Royal Thai Government: Ministry of Energy – Energy Policy and Planning Office, 2025), https://www.oap.go.th/wp-content/uploads/2025/02/%E0%B8%A3%E0%B9%88%E0%B8%B2%E0%B8%87-%E0%B9%81%E0%B8%9C%E0%B8%99%E0%B8%9E%E0%B8%B1%E0%B8%92%E0%B8%99%E0%B8%B2%E0%B8%81%E0%B8%B3%E0%B8%A5%E0%B8%B1%E0%B8%87%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%9C%E0%B8%A5%E0%B8%B4%E0%B8%95%E0%B9%84%E0%B8%9F%E0%B8%9F%E0%B9%89%E0%B8%B2-Power-Development-Plan-PDP.pdf.
107 "Thailand Requires More Battery Energy Storage Systems to Meet Clean Energy Targets," Asian insiders Korea, accessed October 30, 2025, https://asianinsiders.com/2024/07/16/thailand-battery-energy-storage-systems-future/.
108 Achawangkul, *New and Renewable Energy Development in Thailand*.
109 Achawangkul, *New and Renewable Energy Development in Thailand*.

110 Achawangkul, *New and Renewable Energy Development in Thailand*; Prime et al., *Renewable Capacity Statistics 2025*.
111 Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making, "DECISION 768/QD-TTG: THE PRIME MINISTER APPROVES THE ADJUSTMENT OF THE VIII POWER PLANNING," *Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making*, April 21, 2025, https://xaydungchinhsach.chinhphu.vn/quyet-dinh-768-qd-ttg-thu-tuong-chinh-phu-phe-duyet-dieu-chinh-quy-hoach-dien-viii-119250417074054718.htm.
112 Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making, "DECISION 768/QD-TTG: THE PRIME MINISTER APPROVES THE ADJUSTMENT OF THE VIII POWER PLANNING"; *Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making*, "FULL TEXT: Power planning VIII," Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making, May 18, 2023, https://xaydungchinhsach.chinhphu.vn/toan-van-quy-hoach-phat-trien-dien-luc-quoc-gia-119230516163152 44.htm.
113 Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making, "DECISION 768/QD-TTG: THE PRIME MINISTER APPROVES THE ADJUSTMENT OF THE VIII POWER PLANNING"; Prime et al., *Renewable Capacity Statistics 2025*.
114 Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making, "DECISION 768/QD-TTG: THE PRIME MINISTER APPROVES THE ADJUSTMENT OF THE VIII POWER PLANNING"; Prime et al., *Renewable Capacity Statistics 2025*.
115 Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making, "DECISION 768/QD-TTG: THE PRIME MINISTER APPROVES THE ADJUSTMENT OF THE VIII POWER PLANNING"; Prime et al., *Renewable Capacity Statistics 2025*.
116 Government of Viet Nam: Government Electronic Newspaper: Policy and Law Making, "DECISION 768/QD-TTG: THE PRIME MINISTER APPROVES THE ADJUSTMENT OF THE VIII POWER PLANNING."
117 "What is a Standard?" Standards Australia, accessed October 30, 2025, https://www.standards.org.au/standards-development/what-is-standard.
118 "IEC 62619," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/64073.
119 "IEC 62446-1," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/24057.
120 Anders Johnsson and Lars Eeg Højholt, Use *of IEC 61400-25 to secure access to key O&M data* (USE61400-25 International Users Group, 2016), http://use61400-25.com/wp-content/uploads/2016/05/170_Eow2007fullpaper.pdf; "IEC 61400-25-1," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/29062.
121 "IEC 60193," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/60951.
122 "ISO 9488:2022," ISO, accessed October 30, 2025, https://www.iso.org/standard/74269.html?browse=tc.
123 Gideon Richards and Kyung-Jin Boo, *International Standardisation in the Field of Renewable Energy* (IRENA, 2013), https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/International_Standardisation_-in_the_Field_of_Renewable_Energy.pdf; ISO, *Economic benefits of standards* (ISO, 2014), https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/ebs_case_studies_factsheets.pdf; Paul Waide and Daniele Gerundino, *INTERNATIONAL STANDARDS TO DEVELOP AND PROMOTE ENERGY EFFICIENCY AND RENEWABLE ENERGY SOURCES* (OECD/IEA, 2007), https://iea.blob.core.windows.net/assets/5052065e-d3ca-4f62-862d-5e5a905154bf/Standards.pdf.
124 Richards and Boo, *International Standardisation in the Field of Renewable Energy*.
125 United Nations Economic Commission for Europe (UNECE), *Case Studies: Standards for Climate Action* (United Nations Economic Commission for Europe (UNECE), 2018), https://unece.org/fileadmin/DAM/trade/wp6/documents/2018/Standards_for_SDGs/SDG13/SDG13_case_studies.pdf.
126 IEC, *Climate action kit: Case Study – Tanzania* (IEC, 2023), https://iec.ch/system/files/2023-10/iec_2023_climate_action_kit_tanzania_0.pdf.
127 Wind Energy Technologies Office, "International Agreements on Wind Energy Standards," *U.S. Department of Energy*, April 29, 2024, https://www.energy.gov/eere/wind/articles/international-agreements-wind-energy-standards.
128 "Energy timelines: Wind," U.S. Energy Information Administration (EIA), accessed October 30, 2025, https://www.eia.gov/kids/history-of-energy/timelines/wind.php; Prime et al., *Renewable Capacity Statistics 2025*.
129 U.S. Energy Information Administration (EIA), "Energy timelines: Wind."
130 Prime et al., Renewable Capacity Statistics 2025; "Land-Based Wind Energy Technology Update," Energy Technologies Area, Berkeley Lab, accessed October 30, 2025, https://emp.lbl.gov/wind-technologies-market-report; "Wind Power Facts," American Clean Power, accessed October 30, 2025, https://cleanpower.org/facts/wind-power/.
131 Christine McCormack, *Guide to Asset Management Improving Planning for the Pacific Water Sector* (Pacific Region Infrastructure Facility (PRIF), 2024), https://www.theprif.org/sites/theprif.org/files/documents/Asset%20Management%20Guide_web%20publication_121124.pdf.
132 Richards and Boo, *International Standardisation in the Field of Renewable Energy*.
133 Richards and Boo, *International Standardisation in the Field of Renewable Energy*.
134 IEC, ISO and ITU, *World Standards Cooperation: International Standards & trade agreements* (ISO, 2018), https://www.iso.org/files/live/sites/isoorg/files/standards/benefits_of_international_standards/WSC_International_Standards_%26_trade_agreements_2018.pdf.
135 "REGULATION (EU) 2023/1542 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL – of 12 July 2023 – concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC," Publications Office of the European Union, published July 28, 2023, https://eur-lex.europa.eu/eli/reg/2023/1542/oj/eng.
136 Publications Office of the European Union, "REGULATION (EU) 2023/1542."
137 "Understanding the Importance of Renewable Energy Certification in Legal Frameworks," Lawmara Editorial Team, Lawmara, published June 24, 2024, https://lawmara.com/renewable-energy-certification/.
138 "AS/NZS 3000:2018," Standards Australia Store, Standards Australia, accessed October 30, 2025, https://store.standards.org.au/product/as-nzs-3000-2018.

139 "AS/NZS 5033:2021," Standards Australia Store, Standards Australia, accessed October 30, 2025, https://store.standards.org.au/product/as-nzs-5033-2021; "TC 82: Solar photovoltaic energy systems: Publications," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:22:717465451632948::::FSP_ORG_ID,FSP_LANG_ID:1276,25.
140 "PV modules standards change," Clean Energy Council, accessed October 30, 2025, https://cleanenergycouncil.org.au/industry-programs/products-program/modules/standards-change.
141 "PV modules standards change," Clean Energy Council, accessed October 30, 2025, https://cleanenergycouncil.org.au/industry-programs/products-program/modules/standards-change.
142 "Who benefits," IECRE, accessed October 30, 2025, https://www.iecre.org/who-benefits.
143 World Trade Organization, "Technical barriers to trade."
144 "TC 21: Secondary cells and batteries: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:607159016202784::::FSP_ORG_ID,FSP_LANG_ID:1290,25.
145 "SC 21A: Secondary cells and batteries containing alkaline or other non-acid electrolytes: Publications," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:22:621246281096912::::FSP_ORG_ID,FSP_LANG_ID:1410,25.
146 "TC 120: Electrical Energy Storage (EES) systems: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:607159016202784::::FSP_ORG_ID,FSP_LANG_ID:9463,25.
147 "IEC 62485-5," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/29086.
148 "IEC 60623," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/27755.
149 "IEC Technical Specification 62933-2-2," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/64570.
150 "TC 5: Steam turbines: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:333864105343900::::FSP_ORG_ID,FSP_LANG_ID:1226,25.
151 IEC editorial team, "New standard for geothermal steam turbines," *IEC*, July 8, 2020, https://www.iec.ch/blog/new-standard-geothermal-steam-turbines; "How Does A Steam Turbine Work?" Allied Power Group, accessed October 30, 2025, https://alliedpg.com/latest-articles/steam-turbine-work/.
152 "IEC 60045-1," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/34370.
153 "TC 4: Hydraulic turbines: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:333864105343900::::FSP_ORG_ID,FSP_LANG_ID:1228,25.
154 "TC 4: Hydraulic turbines: Publications," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:22:333864105343900::::FSP_ORG_ID,FSP_LANG_ID:1228,25.
155 "ISO/TC 339: Small hydropower plants (SHP plants)," ISO, accessed October 30, 2025, https://www.iso.org/committee/9065608.html.
156 "Standards by ISO/TC 339: Small hydropower plants (SHP plants)," ISO, accessed October 30, 2025, https://www.iso.org/committee/9065608/x/catalogue/p/1/u/0/w/0/d/0.
157 "IEC 60193," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/60951.
158 "IWA 33-2:2019," ISO, accessed October 30, 2025, https://www.iso.org/standard/79364.html?browse=tc.
159 "TC 82: Solar photovoltaic energy systems: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:200063101339374::::FSP_ORG_ID,FSP_LANG_ID:1276,25.
160 "TC 82: Solar photovoltaic energy systems: Publications," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:22:200063101339374::::FSP_ORG_ID,FSP_LANG_ID:1276,25.
161 "TC 117: Solar thermal electric plants: Publications," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:22:200063101339374::::FSP_ORG_ID,FSP_LANG_ID:7851,25.
162 "ISO/TC 180: Solar energy," ISO, accessed October 30, 2025, https://www.iso.org/committee/54018.html; "Standards by ISO/TC 180/SC 4: Systems - Thermal performance, reliability and durability," ISO, accessed October 30, 2025, https://www.iso.org/committee/54032/x/catalogue/.
163 "Standards by ISO/TC 180: Solar energy," ISO, accessed October 30, 2025, https://www.iso.org/committee/54018/x/catalogue/p/1/u/0/w/0/d/0.
164 "Standards by ISO/TC 180/SC 4: Systems - Thermal performance, reliability and durability," ISO, accessed October 30, 2025, https://www.iso.org/committee/54032/x/catalogue/p/1/u/0/w/0/d/0.
165 "ISO/TC 180/SC 1: Climate - Measurement and data," ISO, accessed October 30, 2025, https://www.iso.org/committee/54024.html.
166 "IEC Technical Specification 61724-3," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/25466.
167 "IEC Technical Specification 62862-3-3," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/28615.
168 "ISO 9806:2025," ISO, accessed December 5, 2025, https://www.iso.org/standard/78801.html.
169 "ISO 9060:2018," ISO, accessed October 30, 2025, https://www.iso.org/standard/67464.html?browse=tc.
170 "ISO 24194:2022," ISO, accessed October 30, 2025, https://www.iso.org/standard/78074.html?browse=tc.
171 "TC 88: Wind energy generation systems: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:201933084320506::::FSP_ORG_ID,FSP_LANG_ID:1282,25.
172 "TC 88: Wind energy generation systems: Publications," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:22:201933084320506::::FSP_ORG_ID,FSP_LANG_ID:1282,25.
173 "IEC 61400-15-1," IEC, accessed October 30, 2025, https://webstore.iec.ch/en/publication/29169.
174 DFAT, "Chapter 6: STANDARDS."
175 DFAT, "Chapter 6: STANDARDS."
176 ASEAN, *ASEAN STANDARDS AND CONFORMANCE STRATEGIC PLAN 2016 -2025* (ASEAN, 2021), https://asean.org/wp-content/uploads/2021/01/ASEAN-Standards-and-Conformance-Strategic-Plan-2016-2025.pdf.
177 "Standards and Conformance: Overview," ASEAN Secretariat, ASEAN, accessed October 30, 2025, https://asean.org/our-communities/economic-community/standard-and-conformance/.

178 ASEAN Consultative Committee for Standards & Quality, *GUIDELINES FOR THE DEVELOPMENT OF MUTUAL RECOGNITION ARRANGEMENTS: SECOND EDITION* (The ASEAN Secretariat, 2018), https://asean.org/wp-content/uploads/2021/10/Guidelines-for-the-Development-of-MRAs-Second-Edition-September-2018.pdf.
179 ASEAN Secretariat, "Standards and Conformance: Overview."
180 Zahrah Zafira et al., *Policy Brief No. 7: Mapping the Current State of Electrical Safety Regulations in ASEAN: Preliminary Assessment of Electrical Safety Standards and Practices for Solar Photovoltaics (PV) and Battery Energy Storage Systems (BESS)* (ASEAN Centre for Energy (ACE), 2024), https://aseanenergy.org/wp-content/uploads/2024/09/Policy-Brief_Mapping-the-Current-State-of-Electrical-Safety-Regulations-in-ASEAN-Preliminary-Assessment-of-Electrical-Safety-Standards-and-Practices-for-Solar-PV-and-Battery-Energy-Storage-Systems.pdf.
181 ITC, "Trade Map."
182 ITC, "Trade Map."
183 "About," ASEAN Centre for Energy (ACE), accessed October 30, 2025, https://aseanenergy.org/about/introduction/.
184 "5th AICEE," ASEAN Centre for Energy (ACE), accessed October 30, 2025, https://asean-aebf.com/5th-aicee/.
185 ASEAN, *JOINT MINISTERIAL STATEMENT OF THE 42nd ASEAN MINISTERS ON ENERGY MEETING (AMEM)* (ASEAN, 2025), https://asean.org/wp-content/uploads/2024/09/JMS-42nd-AMEM-Adopted.pdf.
186 "About Us," Asia Pacific Urban Energy Association (APUEA), accessed October 30, 2025, https://www.apuea.org/about-apuea.
187 "Energy," Asia-Pacific Economic Cooperation (APEC), accessed October 30, 2025, https://www.apec.org/groups/som-steering-committee-on-economic-and-technical-cooperation/working-groups/energy.
188 "About IRENA," IRENA, accessed October 30, 2025, https://www.irena.org/About.
189 "About: Mission," IEA, accessed October 30, 2025, https://www.iea.org/about/mission.
190 "About Us," World Energy Council, accessed October 30, 2025, https://www.worldenergy.org/about-us.
191 World Energy Council, "About Us."
192 "About IGA," International Geothermal Association (IGA), accessed October 30, 2025, https://worldgeothermal.org/about.
193 "About IHA," International Hydropower Association (IHA), accessed October 30, 2025, https://www.hydropower.org/who-we-are/about-iha.
194 "Our Work," Global Solar Council, accessed October 30, 2025, https://www.globalsolarcouncil.org/our-work/.
195 "About GSC," Global Solar Council, accessed October 30, 2025, https://www.globalsolarcouncil.org/about/.
196 "About Us," Global Wind Energy Council (GWEC), accessed October 30, 2025, https://www.gwec.net/about-us.
197 "Asia," Global Wind Energy Council (GWEC), accessed October 30, 2025, https://www.gwec.net/asia.
198 IEC, "TC 21: Secondary cells and batteries: Scope."
199 "SC 21A: Secondary cells and batteries containing alkaline or other non-acid electrolytes: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:621444954171529::::FSP_ORG_ID,FSP_LANG_ID:1410,25.
200 IEC, "TC 120: Electrical Energy Storage (EES) systems: Scope."
201 IEC, "TC 5: Steam turbines: Scope."
202 IEC, "TC 4: Hydraulic turbines: Scope."
203 ISO, "ISO/TC 339: Small hydropower plants (SHP plants)."
204 IEC, "TC 82: Solar photovoltaic energy systems: Scope."
205 "TC 117: Solar thermal electric plants: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:7851,25.
206 ISO, "ISO/TC 180: Solar energy."
207 ISO, "ISO/TC 180/SC 1: Climate - Measurement and data."
208 "ISO/TC 180/SC 4: Systems - Thermal performance, reliability and durability," ISO, accessed October 30, 2025, https://www.iso.org/committee/54032.html.
209 IEC, "TC 88: Wind energy generation systems: Scope."
210 "TC 8: System aspects of electrical energy supply," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:::::FSP_ORG_ID:1240.
211 "SC 8A: Grid Integration of Renewable Energy Generation: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:609779458084806::::FSP_ORG_ID,FSP_LANG_ID:10072,25.
212 "SC 8B: Decentralized electrical energy systems: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:::::FSP_ORG_ID:20639.
213 "SC 8C: Network Management in Interconnected Electric Power Systems: Scope," IEC, accessed October 30, 2025, https://www.iec.ch/dyn/www/f?p=103:7:702485600949427::::FSP_ORG_ID,FSP_LANG_ID:25987,25.

standards.org.au