EXECUTIVE SUMMARY

RENEWABLE ENERGY OUTLOOK FOR ASEAN

TOWARDS A REGIONAL ENERGY TRANSITION

2ND EDITION

The key findings and executive summary are taken from: IRENA & ACE (2022), *Renewable energy outlook for ASEAN: Towards a regional energy transition* (2nd ed.), International Renewable, Energy Agency, Abu Dhabi; and ASEAN Centre for Energy, Jakarta.

ISBN: 978-92-9260-467-7

Report available for download: www.irena.org/publications.
For further information or to provide feedback: publications@irena.org

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. **www.irena.org**

About ACE

Established on 1 January 1999, the ASEAN Centre for Energy (ACE) is an intergovernmental organisation within the ASEAN structure representing the 10 ASEAN Member States (AMS) interests in the energy sector. It is guided by a Governing Council composed of Senior Officials on Energy from each AMS and a representative from the ASEAN Secretariat as an ex-officio member. Hosted by the Ministry of Energy and Mineral Resources of Indonesia, the office is located in Jakarta. For more information, visit **www.aseanenergy.org**

Acknowledgements

This report was prepared by IRENA in close collaboration with the ASEAN Centre for Energy (ACE), with the support of the ASEAN Secretariat and engagement from ASEAN Member States, including: Ministry of Energy Brunei Darussalam, Ministry of Mines and Energy Cambodia, Ministry of Energy and Mineral Resources Indonesia, Ministry of Energy and Mines Lao PDR, Ministry of Energy and Natural Resources Malaysia, Ministry of Electricity and Energy Myanmar, Department of Energy Philippines, Energy Market Authority Singapore, Department of Alternative Energy Development and Efficiency Thailand, and the Ministry of Industry and Trade Viet Nam.

Brunei Darussalam: Abdul Matiin Bin Hj Md Kasim, Hadinah Yahaya, Shaikh Mohamad Faiz Bin Shaikh Hj Fadilah. **Cambodia**: Chiphong Sarasy. **Indonesia:** Andriah Feby Misna, Tony Susandy, Elis Heviati, Senda Kanam, Suharyati, Jamaludin Lastiko, Edwin Nugraha Putra, Herian Atma. **Lao PDR:** Boualom Saysanavong, Phouttavanh Phommachan. **Malaysia:** Esther Lew. **Myanmar**: Win Myint. **Philippines:** Mylene C. Capongcol, Marissa P. Cerezo, Michael O. Sinocruz. **Thailand:** Lumyai Mungpangklang, Narapandra Yamalee, Prasert Sinsukprasert, Siriyapohn Petchamli, Sutthasini Glawgitigul, Watcharin Boonyarit, Yaowateera Achawangkul. **Singapore:** Latha Ganesh, Agnes Koh, Brian Tham, Lucius Tan, Lee Seng Wai, Kim Jin, Haolin Jia, Lindy Tan, Yingxian Huang, Sophie Gan, Lionel Choo, Jia Yong Leong, Wai Ying Ho, Guang Yong Ong, Christopher Gan, Wenkang Wong, Yvonne See, Zahin Amrad. **Viet Nam:** Nguyen Ninh Hai, Nguyen Hoang Linh. **ASEAN Centre for Energy:** Septia Buntara Supendi, Monika Merdekawati, Zulfikar Yurnaidi. **ASEAN Secretariat:** Marie Gail de Sagon, Muhammad Indra Wahyudin.

The report was authored by Adam Adiwinata, Zainab Omolade Ajibade, Seán Collins, Maisarah Abdul Kadir, Raul Miranda, Walter Sanchez and Nicholas Wagner under the guidance of Dolf Gielen (Director, IRENA Innovation and Technology Centre), Ricardo Gorini (Senior Programme Officer, Renewable Energy Roadmaps), and Emanuele Taibi (ex-IRENA).

Additional valuable comments and suggestions were provided by IRENA colleagues Ahmed Badr, Badariah Yosiyana, Bishal Parajuli, Diala Hawila, Elizabeth Press, Emanuele Bianco, Francis Field, Gurbuz Gonul, Gondia Sokhna Seck, Herib Blanco, Ines Jacob, Michael Renner, Michael Taylor, Nazik Elhassan, Paul Komor, Paula Nardone, Rabia Ferroukhi, Simon Benmarraze, Stephanie Clarke, Ute Collier and Xavier Casals. The following colleagues also provided methodological and analytical support for the report: Maria Vicente Garcia, Krisly Guerra, Gayathri Prakash and Rodrigo Leme. The editor of this report was Stefanie Durbin.

IRENA would like to thank the Government of Denmark for supporting IRENA with the work that formed the basis of this report. Specifics thanks go to Dorthea Damkjær, Laura Skøt, Niels Bisgaard Pedersen, Simon Fløe Nielsen, Anders Kruse, Nadeem Niwaz, Stefan Petrović, Aisma Vitina, Thomas Capral, Loui Algren.

Disclaimer

EXECUTIVE SUMMARY

RENEWABLE ENERGY OUTLOOK FOR ASEAN

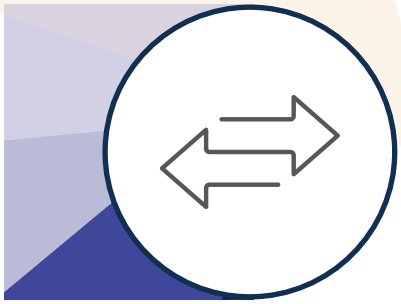
TOWARDS A REGIONAL ENERGY TRANSITION

2ND EDITION

KEY FINDINGS

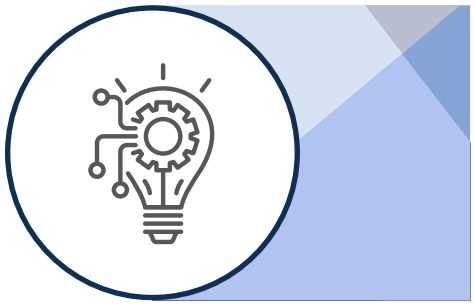
The Association of Southeast Asian Nations (ASEAN) is at a pivotal point in its collective energy future. This report outlines energy transition pathways that focus on renewables, end-use electrification, energy efficiency and emerging technologies, such as hydrogen. The main focus of this report is the 1.5°C Scenario (1.5-S), an energy pathway for ASEAN that is aligned with IRENA's global 1.5-degree pathway from the *World Energy Transitions Outlook*.

This report shows how the region can transition from just 19% **renewable energy share** in final energy in 2018 to 65% by 2050, and in the process reduce energy-related carbon dioxide (CO_2) emissions by 75% compared to current policies.



In the near-term to 2030, emphasis should focus on key transition technologies such as increasing solar PV to over 240 gigawatts (GW) of installed capacity, putting over 13 million battery-electric vehicles on the road with 3.7 million charging stations, and widescale efforts focusing on improving energy efficiency, materials efficiency and circular economy, and scaling up sustainable bioenergy, hydropower and geothermal energy sources.

In the longer-term, regional **power system integration** should be fostered and improved to further utilise a total renewable energy power expansion reaching around 2 770 GW to 3 400 GW by 2050 in the 1.5-S. Coal power plant phaseout should be expedited in the near-term, and expansion of fossil fuel dependent infrastructure avoided wherever possible to avoid stranded assets.



Transmission and distribution grids will need expansion and reinforcement to meet growing electricity consumption and enable more efficient and reliable system operation. This sees an international expansion of lines nearing a total 200 GW by 2050 in the 1.5-S, deepening power system integration across ASEAN.

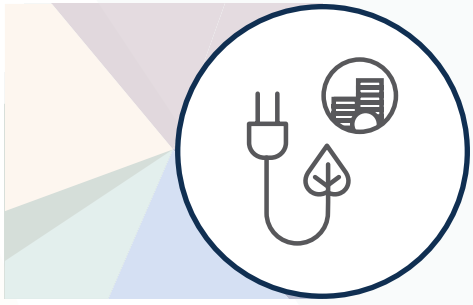
Renewable power capacity, power grids and infrastructure, and enabling technologies (*e.g.* storage), will need to see over USD 5 trillion (United States dollars) in **investment** over the period to 2050, making up two-thirds of total energy investment.

Energy efficiency measures and technology standards should be considered a first principle, with corresponding cumulative investments of USD 1616 billion until 2050, which in turn will bring energy intensity down 45% by 2050, compared to 2018 levels.

In transport, **EVs will need to grow** to more than 100 million battery-EV cars, and almost 300 million electric two- and three-wheelers by 2050.

Bioenergy is also important in all end-use sectors, particularly for modes such as aviation and for some industrial sectors. Domestic bioenergy use will need to more than double to 7.6 exajoules (EJ) by 2050.

Clean hydrogen and its derivatives provide an alternative solution for decarbonising shipping and are important for some heavy manufacturing industrial processes. Hydrogen demand for domestic uses will exceed 11 million tonnes (Mt), while additional fuel will be needed for international bunkering.



The 1.5-S can **reduce total costs related** to energy supply by as much as USD 160 billion cumulatively to 2050. Additionally, avoided externalities resulting from 1.5-S range from USD 508 to USD 1580 billion cumulatively to 2050. All in all, the transition can be achieved at a lower cost than the Planned Energy Scenario, this report's reference case.

EXECUTIVE SUMMARY

The Southeast Asia region is expected to see rapid economic growth over the next few decades. Driven by this, as well as population growth, energy demand in the region will grow rapidly too. Today's energy supply, meanwhile, is dominated by fossil fuels, which make up over 85% of primary energy.

Southeast Asia therefore stands at a crossroads. It can go down a path of continued reliance on fossil fuels – more of which are coming from non-indigenous sources (ACE, 2020a) – and thereby increase its exposure to volatile, and increasingly expensive, global commodity markets. Or, alternatively, the region can choose to use its ample, affordable and indigenous local renewable energy resources.

By the end of 2018, the total installed electricity generation capacity of all ten ASEAN member states was 252 GW, with 28% of that capacity coming from renewable sources, mostly hydropower. In 2020, that share had increased to 33.5% (ACE, 2022a), due in part to the rapid expansion of solar photovoltaics (PVs). The power sector is one of the major sectors contributing to ASEAN's energy-related CO_2 emissions as a result of it being heavy reliant on fossil fuels.

Coal retirement, coupled with the continued expansion of renewables, is one important step in aligning with net-zero targets. Half of ASEAN member states are signatories to the international effort to end coal utilisation in the power sector. Brunei Darussalam, Indonesia, the Philippines, Singapore and Viet Nam signed on to the Global Coal to Clean Power Transition statement during the 26th United Nations Climate Change Conference (COP26) (ACE, 2022a). These commitments cover three-quarters of ASEAN's coal emissions. Many are also participating in an early coal retirement initiative under the leadership of the Asian Development Bank, which has signed up around 25 GW for early retirement.

Taking these efforts to achieve these commitments into account, renewable energy has never been so important, and the region has seen a growing deployment of renewable energy. Between 2015 and 2021, the total installed capacity from renewables jumped from 55 GW to 97 GW (IRENA, 2022a). By the end of 2021, Viet Nam, Thailand and Indonesia were leading the regional race with a total of 43 GW, 12 GW and 11 GW of installed renewable energy capacity, respectively.

ASEAN has ambitious renewables goals in the near term which, when leveraged with its huge untapped potential renewable sources, can provide local and affordable alternatives to fossil fuels. The region has aspirational targets aiming to have 23% of primary energy accounted for by renewable energy by 2025, along with a 35% share of renewable energy in installed capacity. However, investments in recent years show mixed progress on the 2025 objectives. ASEAN only had a 14.3% share of renewable energy in primary energy in 2021 (ACE, 2022a), a share that has remained more or less constant for half a decade. Yet the region also had a 33.5% share of installed renewable power capacity in 2020 (ACE, 2022a), a substantial increase just over the last couple of years. Therefore, while the installed capacity share looks within reach, the primary energy target will be a challenge.

Over the longer term, ASEAN Member States (AMS) have a wide range of both conditional and unconditional climate targets that set out levels of emission reductions. Also in the last year, many have indicated a desire to achieve net-zero emissions around mid-century. These long-term commitments require concerted and accelerated action that must begin now.

AN ENERGY TRANSITION ROADMAP FOR THE REGION'S SUSTAINABLE FUTURE

IRENA's roadmaps consider multiple possible future energy pathways. The two main scenarios are the Planned Energy Scenario (PES), which considers current and planned policies, and the 1.5°C Scenario (1.5-S), which follows IRENA's *World Energy Transition Outlook* (WETO) 1.5-S scenario aiming to reach net-zero emissions globally by 2050. For the 1.5-S, multiple power sector supply scenarios are considered for ASEAN, one with 90% renewable power generation (1.5-S RE90) and one with 100% renewable power generation (1.5-S RE100).

The ASEAN region will be a key driver of global energy-demand growth over the next three decades. Projections under the PES show that total final consumption (TFC) will increase more than 2.5-fold by 2050. The region's demand will grow about 3% annually, driven by population and economic growth, reaching over 50 exajoules (EJ) by 2050, while an energy transition effort detailed by the 1.5-S will drive a slower demand growth of 2.4% annually and save 19% of total consumption compared to the PES in the same year.

To realise the 1.5-S outlined in this report, efforts are needed across the entire energy system of ASEAN. The following table outlines some of the key indicators needed to achieve the 1.5-S. While these are not exhaustive, they outline how much of the transition is based on renewable energy use and electrification.

A wide range of measures are needed, but renewable energy will be the crucial driver in ASEAN to meet the 1.5-S.

Table 1 Select key actions for achieving the 1.5-S by 2050

				REFERENCE TIMEFRAME OR YEAR	BASE VALUE	WHERE WE NEED TO BE IN 1.5-S IN 2050
KEY ACTIONS	1	**Clean Electricity**	With electricity generation growing up to five-fold by 2050 in the 1.5-S, renewables must provide between 90-100% of the total electricity supply by 2050, up from 26% in 2019.	2019	26% 	90-100% 
	2	**Maximise indigenous use of renewables**	The share of renewables in TFEC will need to increase from 19% in 2018 to 65% by 2050. Direct electrification with renewables is the largest contributor, followed by bioenergy, but geothermal, green hydrogen and solar play important roles.	2018	19% 	65% 
	3	**Scale investment sustainably**	Average annual investment in renewable power capacity should scale five times from now until 2050 compared to the 2019-2021 annual average.	2019-2021 average	USD 15 billion/year[1] 	USD 73 billion/year 
	4	**Electrify end-uses**	The share of electricity in TFEC should increase from 22% in 2018 to 52% by 2050.	2018	22% 	52% 
	5	**Energy efficiency**	Energy efficiency measures and efficient technology are crucial. The energy intensity improvement rate will need to almost double compared to the 1.1%/year expected in the PES to 2050, to 1.9%/year in 1.5-S.	PES to 2050	1.1%/year 	1.9%/yr 
	6	**Invest in disruptive technologies**	The production of clean hydrogen and its derivative fuels must ramp up from negligible levels in 2020 to at least 11 Mt by 2050.	2020	< 0.1 Mt 	11 Mt 
	7	**Carbon management solutions**	While the measures outlined in this report reduced emissions by 75% compared to the PES, to reach net-zero emissions, CO_2 capture will be required via carbon capture and storage (CCS), bioenergy with carbon capture and storage (BECCS), or other carbon removal and storage measures.	PES	- 	-700 million tonnes of carbon dioxide in 2050 ($MtCO_2$) 

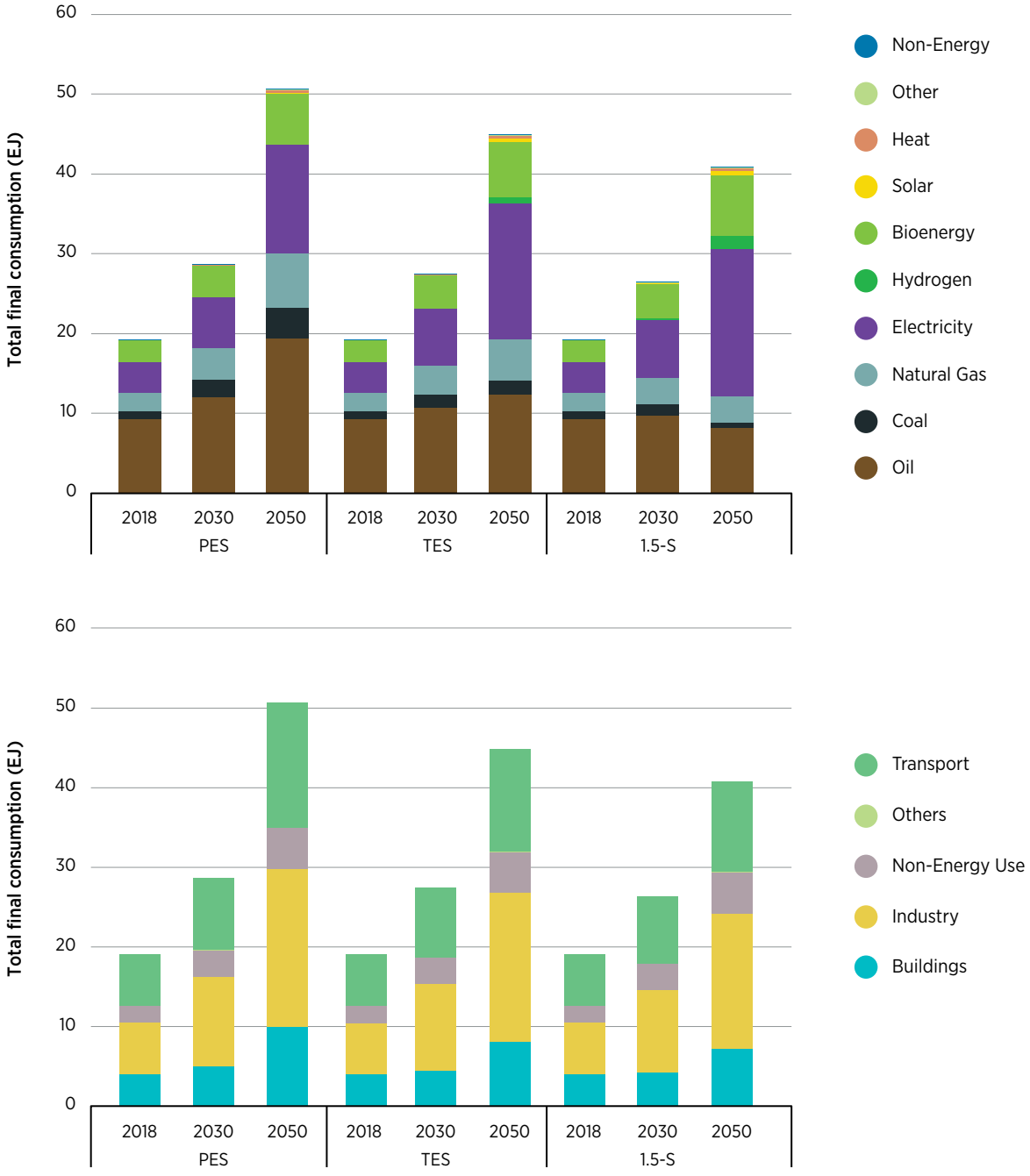
[1] *Source:* (BloombergNEF, 2022) (ASEAN & UNCTAD, 2021).

The energy mix in ASEAN will transform significantly in the 1.5-S. Renewables, both direct-use and from renewable-based electrification, will make up two-thirds of energy demand. Electricity, which is largely renewable based in the 1.5-S by 2050, makes up 52% of final energy demand. Meanwhile, overall bioenergy use will need to more than double and will be crucial in some end-use sectors, such as industry.

This report also assesses a scenario called the Transforming Energy Scenario (TES), which is less ambitious than 1.5-S and considers the readily available, and affordable, technologies at the expense of slightly higher emissions (around 1 gigatonne [Gt] vs 0.7 Gt for 1.5-S). While both the PES and TES require removal of CO_2 emissions through carbon management solutions, TES would require about 50% more removals to enable net-zero emissions.

The energy mix in ASEAN will grow but will also need to be substantially transformed by 2050.

Figure 1 Southeast Asia's total final consumption, by scenario, 2018, 2030, 2050



Industry energy demand will increase 3.6% per year. In the 1.5-S, the sector will become considerably less reliant on fossil fuels, which currently dominate the sector's energy supply. Instead, industrial process heat will transition towards the use of electricity, biomass and green hydrogen. A wide mix of technologies are necessary for industry, which includes hard-to-electrify industrial processes and feedstock requirements. ASEAN industry can also benefit from the technologies found in the 1.5-S. With a significant supply of critical materials needed for many energy transition technologies, the region could become a powerhouse of manufacturing.

The transport sector will see two parallel paths, one focused on electrifying modes such as passenger road vehicles, and another that will require cleaner fuels. The car fleet will need to grow to more than 100 million battery EV cars and almost 300 million electric two- and three-wheelers. Biofuels are also important for some modes, such as freight, aviation and inland shipping. Meanwhile, hydrogen and its derivatives are important for international shipping.

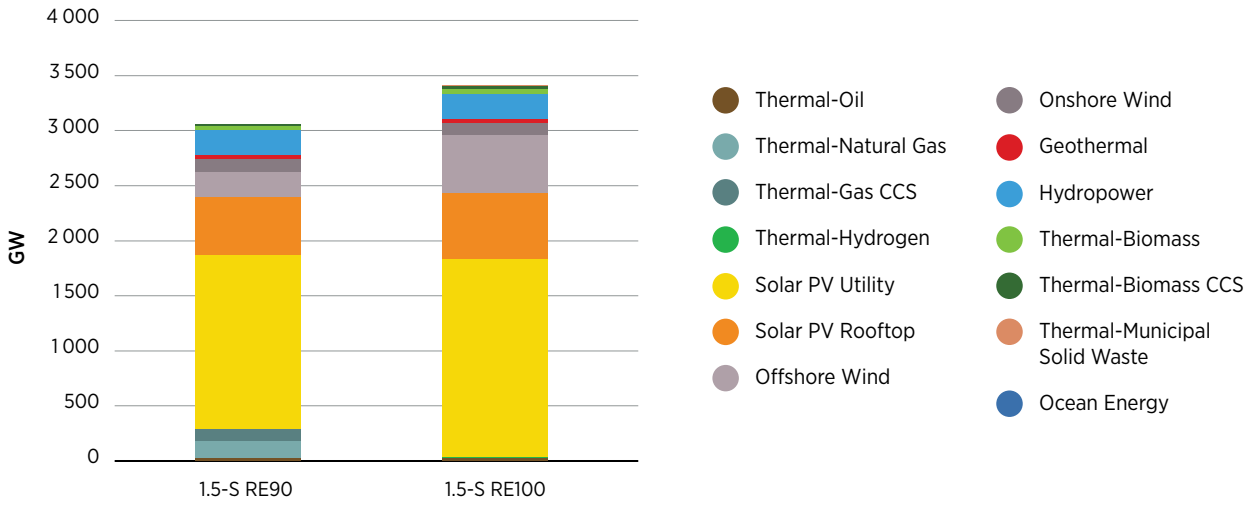
The building sector's energy demand will grow nearly 3% annually, reaching 10 EJ by 2050 in the PES. Space cooling will dominate energy demand in buildings, growing from 17% share in 2018 to almost half in 2050. The share of cooking energy demand will fall below 20% mainly due to the phaseout of traditional biomass and the transition towards clean cooking technologies, mainly liquefied petroleum gas (LPG) in the PES and electrification in the 1.5-S. Overall electrification, and more stringent energy efficiency standards and technology, will reduce the building sector's energy consumption by 27% in the 1.5-S compared to the PES, with electricity becoming the dominant fuel consumed in the sector.

Electricity consumption in ASEAN today is around 1 100 terawatt hours (TWh)/year. Electricity will become the dominant energy carrier in 1.5-S, increasing fivefold compared to today. Even in the PES it will still rise considerably to become the second-largest carrier, growing nearly fourfold under the current policy trajectory. How power generation capacity is expanded to meet this will be instrumental with regard to CO_2 emissions.

To chart possible alternatives to a reliance on fossil fuels in power generation, this report presents two routes forward for the region's power system: a 100% renewables system, and one that reaches 90% renewables and allows some remaining fossil fuel generators (mostly natural gas). The differentiation may not seem large, but in practice closing the remaining 10% gap requires significant additional storage and transmission expansion. Solar PV is key across all scenarios due to its abundant resources across the region. However, the 100% renewable energy scenario will need a very significant expansion of solar, up to 2 400 GW, and a similarly large expansion of battery storage.

The power sector will see demand increase fivefold; in the 1.5-S, solar PV will be the crucial technology.

Figure 2 Southeast Asia's power capacity alternatives for 1.5-S, in 2050



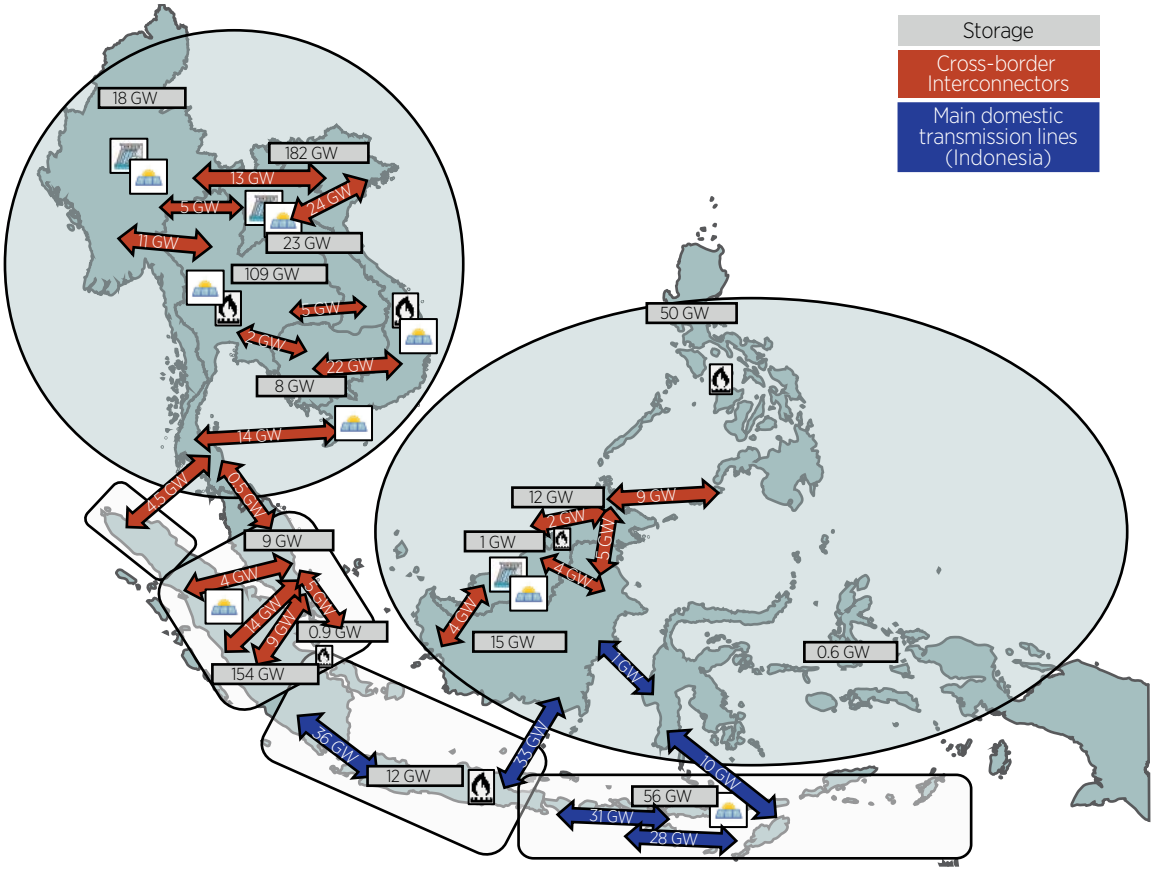
The significant level of growth in renewable electricity in the 1.5-S requires flexibility of the power system, particularly in transmission and storage assets. Tailoring consumption to when the sun is shining with smart charging of EVs and power-to-X helps harness the most solar resources while alleviating the need for additional storage. Hydropower and bioenergy help to balance supply and demand. Batteries will have a key role to play starting in the 2030s and beyond but will be deployed this decade in some applications.

Given the need for sizeable power assets, strategic considerations need to be applied in carrying out capacity expansion plans to operate the system by 2050. Potential issues can be addressed by opting for more circuits of lower capacity in the case of transmission lines, rather than a few larger ones, and by adopting fast-frequency reserves for small and medium grids in the medium term and large grids in the long term. Also in the long term, the system should be planned to enable it to cope with fewer synchronous power producers, with grid forming inverters likely to play a leading role.

Importantly, the full potential of renewables requires open markets and the alignment of regulations between national transmission system operators (TSOs). The former ensures that the least-cost merit order based on short-run marginal cost is followed across the region, and eventually also is followed even for ancillary services. Common regulations secure reliability across the region by setting norms for the provision of services (energy, regulation, reserves), the amount to be procured at each time scale, and the practices followed by TSOs. The region should also significantly expand transmission capacity in the 1.5-S, including both cross-border interconnectors and domestic transmission lines.

Transmission expansion will be critical for tapping resources across ASEAN and bringing electricity to load centres.

Figure 3 Transmission lines and batteries in 2050, 1.5-S RE90



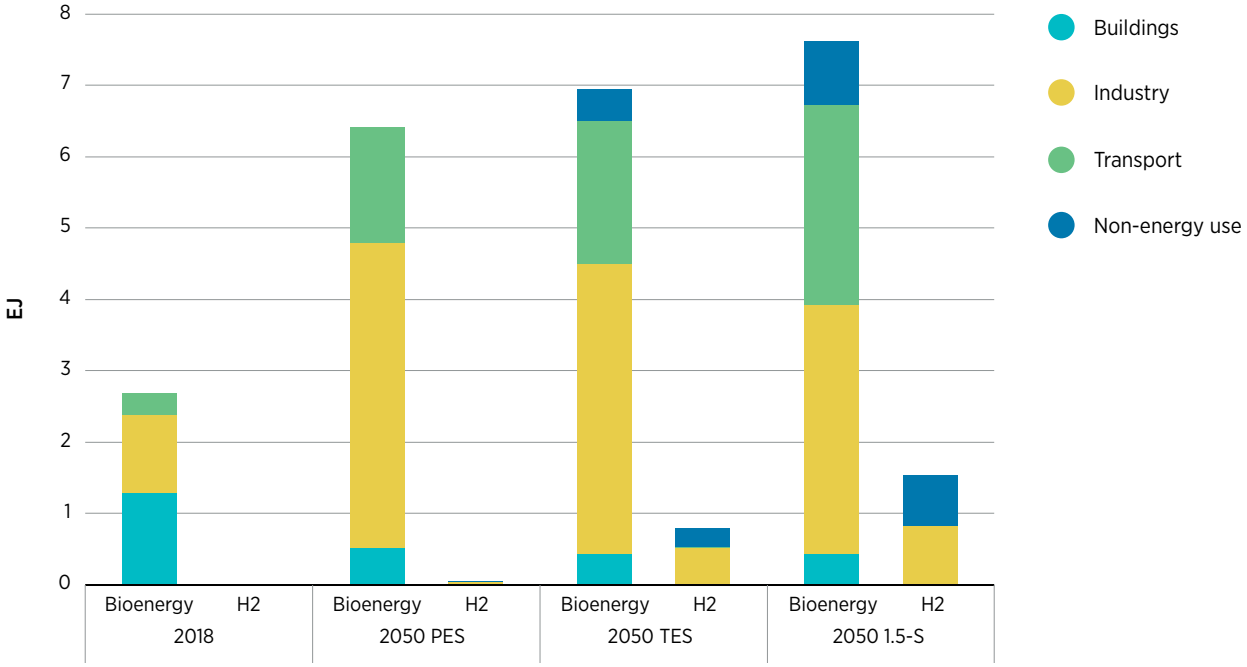
Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

According to WETO, bioenergy makes up over 50% of renewable energy use globally today. Achieving the net-zero goal will not be possible with renewable electricity and energy efficiency alone. Bioenergy will represent 25% of total primary energy supply globally by 2050 in IRENA's 1.5°C Scenario (IRENA, 2022b). In ASEAN, bioenergy plays an important role today, and that will continue. In absolute terms, the increase will be from around 2.7 EJ (primary) in 2018 to 7.6 EJ by 2050 in the 1.5-S. In 2018, around 14% of final energy came from bioenergy sources in the region, with a little under half from traditional sources of bioenergy. By 2050 in the 1.5-S, the share will increase to 19%, with all traditional uses of bioenergy replaced with modern bioenergy. Scaling up bioenergy use will therefore be crucial for the region to meet its energy and climate goals, and doing so must coincide with bioenergy use that is sustainable and affordable (IRENA, 2022c).

Clean hydrogen will provide a complementary solution in the region's ambitious climate objectives. Hydrogen is clean when its manufacture results in no CO_2 emissions. Two main routes to clean hydrogen are producing it via carbon-free electricity (green hydrogen) and producing it from fossil fuels, typically natural gas, combined with CCS (blue hydrogen). The majority of clean hydrogen produced in ASEAN in the 1.5-S is green hydrogen. Clean hydrogen will play a role in industry sectors such as iron and steel, aluminium, chemicals and international bunkering for shipping. The 1.5-S shows more than 11 Mt of demand for domestic uses alone, in addition to further demand for international bunkering fuels (namely for international shipping).

Biofuels and hydrogen have an important role to play in sectors where direct electrification is not possible.

Figure 4 Bioenergy and hydrogen use in the end-use sectors, by scenario, 2018, 2050

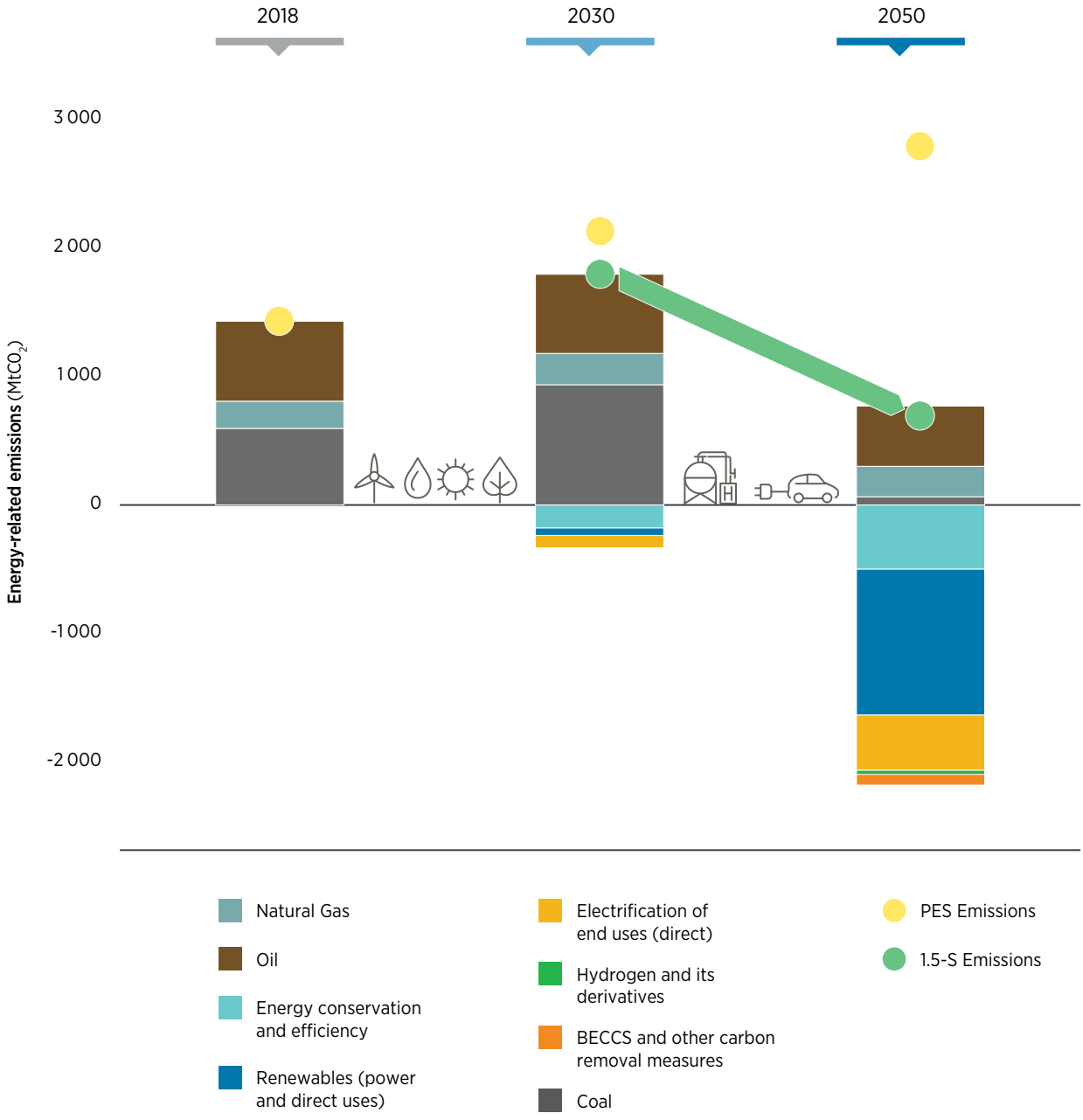


Note: International bunkering is excluded from the figure.

ASEAN's energy-related CO_2 emissions in 2018 were just under 1.5 Gt – around 4% of global emissions. In the near term to 2030, emissions will rise to 2.1 Gt in the PES in 2030, and to 1.8 Gt in the 1.5-S. Looking out to 2050, in the PES emissions will reach almost 2.8 Gt. The power sector will be the largest emitter, followed by transport and industry. These three together make up over 90% of the region's energy-related CO_2 emissions. By mid-century, the region's emissions under the 1.5-S will be reduced by 75% compared to the PES level in 2050 and reduced to half of today's emissions. A little over half of that reduction will be the result of renewables used in both power generation and direct use, with another 20% resulting from direct electrification (powered by renewables), and around 25% coming from energy efficiency measures. To reach net zero, carbon dioxide removal will be required on the order of around 0.7 Gt in 2050, which is consistent with the pathway to net-zero emissions that is outlined globally in IRENA's WETO.

The bulk of energy-related CO_2 emissions savings will come from renewables, energy efficiency, and direct electrification.

Figure 5 Energy-related CO_2 emissions and savings, by technology type, 2018, 1.5-S in 2030 and 2050



Wide-scale investment is needed across the entire energy system in ASEAN, from supply to infrastructure to the end-use sectors. Significant investment of about USD 200 billion to USD 245 billion annually will need to be directed into renewables, energy efficiency and enabling technologies and infrastructure over the period to 2050 to achieve the 1.5-S. In cumulative terms, the 1.5-S foresees investment of about USD 6.3 trillion to USD 7.3 trillion to reach the RE90 and RE100, respectively – about 2.5 to 3 times the investment needed in the PES.

In the nearer-term to 2030, solar PV installed capacity will need to reach 240 GW across the region, requiring investment of USD 150 billion within this decade. Grid investment will require nearly USD 200 billion, including national and international transmission expansion. Significant additional investment is needed in key enabling technologies such as EVs and charging stations, biofuel supply, and energy efficiency.

Wide-scale and significant investment scale-up will be required.

Table 2 Select technology scale-up and cumulative investment needs to 2030 and 2050

				SHORT TERM TO 2030 (1.5-S)		LONG TERM TO 2050 (1.5-S RE90)		LONG TERM TO 2050 (1.5-S RE100)	
				PARAMETER	TOTAL INVESTMENT 2018-2030 (USD BILLION)	PARAMETER	TOTAL INVESTMENT 2018-2050 (USD BILLION)	PARAMETER	TOTAL INVESTMENT 2018-2050 (USD BILLION)
INVESTMENT REQUIREMENT	POWER	**Solar PV**	Total Installed capacity (GW)	241	156	2 108	1 083	2 402	1 245
		Other renewable energy (non-hydro)	Total Installed capacity (GW)	56	90	2 769	706	3 390	1 793
		Hydro	Total Installed capacity (GW)	73	56	227	368	227	368
	GRID AND FLEXIBILITY	**Transmission** (intl.)	km (thousand)	34	13	665	252	755	285
		Transmission (national)	km (thousand)	247	92	1 247	461	1 247	461
		Distribution	km (thousand)	2 739	69	13 811	346	13 811	346
		Storage	GW	15	8	666	161	1175	306
	BIOFUELS SUPPLY	**Biofuels**	million litres	57 475	66	118 133	235	118 133	235
	ELECTRIFICATION	**EV chargers**	million units	3.7	47	35	419	35	419
		EV cars	million units	13	652	109	6 390	109	6 390

Note: GWh = gigawatt hours; km = kilometre.

When considering a wider cost perspective that includes fuel costs, operation and maintenance (O&M), and financing costs, over the period to 2050 the region will spend USD 28.3 trillion on its energy system in the PES. Of the transition scenarios, TES has the lowest cost, at USD 27 trillion, but it also has the highest emissions. Of the 1.5-S cases, RE90 is the lowest cost – USD 28.1 trillion – around USD 0.16 trillion lower than the PES, and 1.5-S RE100 has the highest cost – USD 29.4 trillion – or USD 1.1 trillion higher than the PES.

The Southeast Asia region must act now to reverse its reliance on fossil fuels, more of which are coming from non-indigenous sources, thereby increasing exposure to volatile and increasingly expensive global commodity markets. The region should transition towards energy transformation pathways utilising ample, affordable and indigenous local renewable energy resources, using technologies applicable to the energy supply and end-use sectors, while respecting the context, status and characteristics of each country and the region as a whole.

With more renewable energy projects, higher ambition targets for EV implementation, and several ASEAN countries being home to the world's largest nickel and other key mineral resources, foreign investment in energy transformation will benefit the countries in developing their industrial sectors, increasing their human resources capacity and receiving technology transfer. Policies will need to support expanding local industries to take advantage of the significant value chain that will need to be created. The market needs signals that allow investments in competitive GW-scale manufacturing capacity from technologies ranging from solar PV modules to larger balance of system components, batteries and EVs.

The findings outlined in this report highlight the pivotal role that renewables will need to play in the ASEAN region. The study shows that renewable potentials are vastly underutilised and most can be expanded for less cost to end-consumers than conventional energy sources. They also present significant economic opportunity as well as opportunities to create local value chains and industries.

IRENA
International Renewable Energy Agency

www.irena.org