



The ASEAN climate and energy paradox

Indra Overland^{a,*}, Haakon Fossum Sagbakken^a, Hoy-Yen Chan^b, Monika Merdekawati^b, Beni Suryadi^b, Nuki Agya Utama^b, Roman Vakulchuk^a

^a Norwegian Institute of International Affairs (NUPI), NUPI, C.J Hambros Plass, 0139, Oslo, Norway

^b ASEAN Centre for Energy (ACE), Soemantri Brodjonegoro II Building, 6th fl., Directorate General of Electricity, Jl. HR. Rasuna Said Blok X-2, Kav. 07-08, Jakarta 12950, Indonesia

ABSTRACT

This article carries out a multisectoral qualitative analysis (MSQA) and policy integration analysis of six sectors important for climate mitigation in Southeast Asia in order to assess the status of the climate-energy nexus in the region. It concludes that Southeast Asia will be heavily affected by climate change but the mitigation efforts of the member states of the Association of Southeast Asian Nations (ASEAN) are incommensurate with the threat they face. Their nationally determined contributions under the Paris Agreement are modest, they have a low proportion of renewable energy in their energy mixes, a modest target for raising the share of renewable energy and they are not likely to reach this target. The ASEAN countries have also been slow to adopt electric vehicles and to accede to the International Renewable Energy Agency (IRENA), while continuing to burn their forests, channel subsidies to fossil fuels and invest in new coal power plants. If ASEAN accelerated decarbonization, it could seize business opportunities, secure its standing in the international political system and climate justice discussions, and increase its chances of reaching the United Nations Sustainable Development Goals (SDGs).

1. Introduction

This paper builds on the concept of a paradox in ASEAN's energy policies and climate ambitions introduced by Shi (2016) [1]. It starts with a preliminary discussion of climate vulnerability and the nationally determined contributions (NDCs) of the ASEAN member states under the Paris Agreement. The paradox is further explored through a systematic review of six key sectors where the contradiction between ASEAN climate vulnerability and decarbonization efforts are notable: (1) the development of renewable energy; (2) handling of emissions in the transportation sector; (3) coal power developments; (4) fossil fuel subsidies; (5) forest management; (6) the role of the ASEAN countries in global clean energy cooperation.

The analytical framework for this paper draws on two separate strands of literature: multisectoral qualitative analysis (MSQA) and policy integration analysis. The purpose of MSQA is to compare strengths and weaknesses across multiple sectors [2–4]. The purpose of policy integration analysis is to assess whether policies in different sectors are commensurate with each other [5–7]. Policy integration analysis is often carried out when there is a need to overcome policy incoherence, sometimes referred to as “silos”, for example between climate and energy policies [8–10].

This framework was chosen to make it possible to bring together in one discussion the disparate climate and energy issues in the ASEAN member states and to be able to draw overarching, policy-relevant conclusions. These methodological choices also make it possible to produce something different from and complementary to the many high quality,

highly technical and often narrow studies of energy issues in Southeast Asia [11–14]. While such studies produce rigorous insights into specific issues [15–20], there is a gap in the literature in terms of laying the basis for overarching policy recommendations for the ASEAN member states.

1.1. Southeast Asia is vulnerable to climate change

Climate change is projected to have an outsized impact on the ASEAN member states, threatening their prosperity and welfare. The region is one of the most vulnerable to climate change globally. Myanmar, the Philippines, Thailand, and Vietnam are already among the 10 states in the world that have suffered the most in human and material terms from climate-related weather events over the past 20 years [21]. According to the 2020 issue of the Global Climate Risk Index (GCRI), the Philippines was the 2nd most affected country from such events in 2018 [22], suffering damages of USD 4.5 billion that year alone. In 2015, the Asian Development Bank predicted that climate change has the potential to cut the region's GDP by 11% by the end of the 21st century [23] (see Table 1 for a summary of the risks). Looking ahead, the Southeast Asian countries face the prospect of increasingly severe flooding, more extreme weather events [24], and large-scale loss of fertile coastal land. This will in turn impact their water supply [25] and agriculture [26].

Southeast Asia's vulnerability to climate change is rooted in the region's unique geography [27]. Most of the region's mainland population lives in low-lying plains or coastal river deltas. The major island states, Indonesia and the Philippines, have over 54,000 and 36,000 km of coastline respectively, and most of their inhabitants live in coastal areas. Sea level rise may therefore have major consequences for ASEAN: if all the

* Corresponding author.

E-mail address: io@nupi.no (I. Overland).

Table 1
Climate-related risks in Southeast Asia.

Climate and geography	Socioeconomic
<ul style="list-style-type: none"> • Rising sea level • Frequent and more severe flooding • Increased extremity of weather events • Loss of fertile coastal land • Negative impact on irrigation systems 	<ul style="list-style-type: none"> • Large general economic losses (11% of GDP by 2100) • Severe impact on agriculture and fisheries • Rising unemployment • Higher domestic, intra-regional and inter-regional migration • Negative impact on urban centers • Rising food insecurity and hunger • Rising poverty • Severe health risks • Spread of diseases

ice on Greenland melts, global sea levels will rise by 7 m. In the most extreme scenario, if Antarctica's ice melts, sea levels will rise by 65 m [28]. Rising sea levels will intensify domestic, intra-regional and inter-regional migration, exacerbating social, economic and political risks to member states.

However, for the ASEAN economies, even a minor sea level rise is a threat. While Singapore has so far successfully adapted by reclaiming land and enhancing coastal barriers, the larger ASEAN states face immediate challenges which may be more difficult to solve. For instance, the Mekong Delta currently meets over 50% of Vietnamese rice demand, yet this rice basket has recently been found to have only a mean elevation above sea-level of only 0.8 m, contrary to the existing official estimate of 2.6 m [29]. This underlines the precarity of relying on adaptation strategies such as dikes and barriers, as has hitherto been the strategy for preventing the salinization of the delta [30]. With a mean elevation of 3 m, parts of Myanmar's Irrawaddy Delta face similar challenges [31]. Thailand too, as a major global rice exporter, is vulnerable [32]. The agriculturally productive and densely populated Chao Phraya Delta is threatened by salinization [33]. Also Cambodia's low mean elevation leaves it vulnerable to flooding from the projected sea-level rise.

Most of Southeast Asia's fertile land is located in coastal areas [34]. Without major technological improvements to reduce climate vulnerability, the 2100 rice yields of Indonesia, the Philippines, Thailand, and Vietnam could drop by 50% from 1990-levels [35]. Despite an emerging trend of regional technical cooperation to enhance the climate resilience of ASEAN agriculture [36], the loss of key low-lying agricultural areas in densely populated and partly mountainous countries would have a serious impact on food production. Similarly, the fisheries are likely to undergo serious negative changes involving risks for food security in the region [37,38]. Along with hotter dry seasons in inland areas of states like Cambodia [39,40] and Myanmar [41], where over 60 million inhabitants still face food insecurity [42], this could threaten regional progress towards Sustainable Development Goal (SDG) 2, which concerns hunger. It may also make it more difficult to reduce unemployment (SDG 8), as a large share of ASEAN's population is employed in agriculture, forestry, and the fisheries, all of which are vulnerable to climate change [27].

The rapid urbanization [43] in the ASEAN member states magnifies the impact of climate-induced environmental hazards on major population centers. Major cities like Bangkok, Ho Chi Minh City, Manila, and Yangon are highly vulnerable to even moderate sea-level rise [44]. Indonesia is already grappling with this; the government decided in 2019 to relocate the city from the island of Java to East Kalimantan, partly because north Jakarta is sinking due to the combination of land subsidence and sea level rise [45]. The new capital's price tag is at least USD 33 billion [45]. Even the Prime Minister of Singapore, which is relatively well-equipped to adapt to climate risks in terms of wealth and governance [21], warned that "for us, climate change is existential" in his 2019 National Day Rally speech [46]. Apart from the rising sea level

posing a threat to the island state's small and densely populated territory, temperatures are rising twice as fast in Singapore as in the rest of the world, creating health risks in the humid tropical environment [47].

2. Southeast Asian efforts to mitigate climate change

If large-scale negative impacts of climate change are to be avoided, the global temperature rise must be limited to 1.5 °C. In order to reach this goal, non-fossil energy sources must meet 80% of global primary energy demand already by 2030, and 100% by 2050 [48]. This can only be achieved if all countries make a significant contribution. That gives rise to the question that drives the remainder of this article: is the contribution of the ASEAN member states to the mitigation of climate change commensurate with the threat that climate change poses to them as laid out in the first part of the article?

2.1. Nationally determined contributions (NDCs)

The NDCs of the ASEAN members states under the Paris Agreement do not stand out as particularly ambitious (see Table 2). Targets are characterized by an emphasis on continuing emissions growth for the foreseeable future. Only Singapore has set a goal of emissions peaking at a specific point in time, and that is not before 2030 [49]. However, even in Singapore's case this is hedged with the modifier "around" and it is not clear how many years of divergence that allows. China also aims to peak its emissions that same year [50]. However, China is one of the world's fastest growing developing economies with a much lower GDP per capita than Singapore, possessing large domestic fossil fuel reserves and more complex industry and infrastructure.

Moreover, the ASEAN NDCs are unlikely to be achieved with current policies. In its business as usual (BAU) scenario produced in 2017, the ASEAN Center for Energy (ACE) predicted that the region's CO₂ emissions per capita would increase 140% between 2015 and 2040 [51]. This would derail both regional and global climate efforts. Researchers at the Massachusetts Institute of Technology (MIT) estimated that the region must lower its emissions by 11% relative to the current trajectory just to meet the goals of its moderate NDCs [52]. However, as ACE forecasts, even if the national renewable energy and energy efficiency targets set in 2015 were achieved, ASEAN's emissions per capita would rise by 50% by 2040 [51]. By contrast, India, a poorer country than most ASEAN states, has recently revised its NDC power generation target after making rapid progress on the deployment of renewables in the past years. India is on track to meet its (also modest [53]) NDC, which is deemed in line with limiting warming to 2 °C, and the Indian government has stated that it will consider making the targets more ambitious [54]. Also Pakistan has recently raised its ambitions, aiming for solar and wind power combined to produce 20% of electricity by 2025 [55]. By contrast, none of the larger ASEAN states are likely to meet their NDCs if the current energy plans are implemented [56] and the IEA estimated that current policies would lead to the region's CO₂ emissions increasing seven times as fast as the global average during the period 2018–2040 [56].

2.2. Renewable energy

Despite positive public statements at both national and multinational levels, ASEAN's progress on adopting renewable energy has been outpaced by the region's rapacious energy demand. During the period 2000–2018, fossil fuels accounted for 85% of the growth in primary energy demand and the share of renewables in the primary energy mix stagnated [56,57].

ASEAN aims for renewable sources to account for 23% of the region's total primary energy supply (TPES) by 2025. However, ASEAN has weakened this target by putting the qualifier "aspirational" in front of it and the IEA and other observers predict that it will not be reached [58], as the current national energy policy frameworks are still centered on fossil fuels [56]. Renewables covered 15% of regional energy demand

Table 2
ASEAN NDCs under the Paris agreement.

	Conditional emissions reduction targets	Unconditional emissions reduction targets	Ref. point	Target year
Indonesia	41%	29%	BAU	2030
Myanmar	—	20% electricity saving, 30% RE in rural electrification, 9.4 GW hydroelectric, 260,000 units of energy efficient cookstoves, 30% reserved and protected forest	BAU	2030
Thailand	25%	20%	BAU	2030
Malaysia	45% (per unit of GDP)	35% (per unit of GDP)	2005	2030
Singapore	—	36% (per unit of GDP)	2005	2030
Brunei	—	63% energy consumption reduction, 10% renewables in primary energy mix		2035
Philippines	70%	—	BAU	2030
Vietnam	25%	8%	BAU	2030
Laos	—	30% RE in energy consumption, 191 ktCO ₂ e/year from transportation, 16,284 ktCO ₂ avoidance from hydroelectricity, 70% forest cover	2000–2015	2015–2030
Cambodia	—	27%	BAU	2030

Data source: UNFCCC 2020 [1].

in 2019, so 23% by 2025 is not an unreasonable target, also considering that the EU had a ratio of 16.7% [59] in 2015 and aims for 32% by 2030. The EU target is binding for member states, and even some of the EU's poorest members—including Bulgaria, Greece, and Lithuania—are already overperforming [60]. ACE predicted in 2017 that without changes in current policies, renewables would constitute only 13% of TPES by 2040 [51]. The International Renewable Energy Agency (IRENA) similarly predicts a shortfall in renewable energy deployment in ASEAN, rising to only 17% of TPES by 2025 [61]. The same organization estimated in 2018 that renewables look likely to meet only 21% of ASEAN energy demand by 2040, with power generation accounting for the bulk of GHG-emissions as growing electricity demand will be met by coal [56].

If it seems unfair to compare ASEAN to the EU, one can instead compare it to emerging economies in other parts of the world. Nicaragua stands out for aiming to make a leap from a 50% share of renewables in the power mix in 2013 to 90% in 2020 [62]. Even more impressively, the Guatemalans aim for an 80% share of renewables, in a country where fossil fuels made up 85% of electricity generation capacity less than a decade ago [63].

The installed capacity of non-hydropower renewables for electricity production in ASEAN grew from 6 to 15 GW between 2000 and 2016 but made significantly less progress than most other regions and countries in Asia [64]. For example, Pakistan increased its installed solar power capacity from 4 to 1568 MW between 2009 and 2018 [64]. By comparison, Indonesia's solar power capacity rose from 13 to 60 MW during the same period [64], despite policies that aimed higher [65]. Solar power still represents a negligible share of electricity production in 2020. The relative share of renewables in the primary energy mix is projected to remain low with current policy-frameworks due to the rapid growth of aggregate demand [51]. This is despite the fact that the levelized cost of electricity (LCOE) of solar PV in ASEAN fell by 65% between 2013 and 2018 [56]. However, the LCOE of solar power remained 90% higher in ASEAN than China or India [61], indicating that policy implementation and cost reduction efforts will be needed to accelerate ASEAN's energy transition [63]. Some ASEAN states are making progress in deploying renewables [63,64,67], but their growth will need to accelerate and diversify significantly if the region is to meet its climate commitments [68–74]. Vietnam has substantially expanded its use of hydropower in recent years, meeting up to 37% of its electricity demand in 2017 [57]. Similarly, Laos has expanded its hydropower capacity, mainly for export purposes. For states with smaller hydropower resources, fossil fuel sources continue to dominate: renewable energy accounted for approximately 5% of installed electricity generation capacity in Malaysia in 2017 [75]. Already in 2018, the Indonesian Minister for Energy and Mineral Resources publicly admitted that Indonesia was unlikely to meet the target of 23% renewables by 2025 [61]. Renewables accounted for 23% of Philippine electricity production in 2018 [76], but generation from

coal has doubled since 2011, and in 2018 accounted for 53% [76]. Solar power represented only 1.35% of electricity production in the country in 2018 [76], which is surprising considering that fossil fuel import dependency contributes to making the national electricity rate Asia's highest [77].

Some believe that solar power in ASEAN will always be prohibitively expensive because the ASEAN countries have less perfect conditions than the Middle Eastern countries that have achieved the lowest prices so far. It is true that the conditions in tropical, low cloud-cover, densely populated ASEAN are a significant disadvantage compared to the extremely favorable conditions in the sparsely populated desert countries of the Middle East. However, if Germany could undergo a solar revolution with its high population density and North European climate with an average of 1000 kWh/m² of solar radiation [78], then so can equatorial ASEAN with insolation levels between 1460 and 1892 kWh/m². The real achievable cost for solar power in ASEAN cannot be known until the ASEAN countries establish an attractive business climate for renewable energy investment and try out the large-scale, long-term auctions that have brought dramatic price reductions in other parts of the world.

Hydropower expansion was a natural choice for several ASEAN countries between 2010 and 2020: it is less dependent on novel technology, special incentives for foreign investment, or policy adaptation. The dominance of cheap hydropower in Laos, Myanmar, and Vietnam, coupled with insufficient government financial capabilities to support the introduction of other renewable energy sources until they reach a critical mass to become financially self-sustaining has made non-hydropower renewable energy unattractive for investors [79,80]. Vietnam's hydropower potential is now almost exhausted [79], and to avoid import dependence, the country is expanding its use of domestic coal reserves [81]. However, unlike Indonesia, Vietnamese reserves are insufficient to prevent it becoming a large net importer over the coming decades [82]. Thus, the limited investment in wind and solar power, even considering the growth observed in 2019 [83], over time could hurt Vietnam's energy security as well as its trade balance.

Fig. 1 highlights ASEAN's sluggish progress on diversifying its renewable energy resources beyond hydropower. Neglect of long-term, robust investment schemes across ASEAN has limited wind and solar to minor roles, and geothermal sources are only available in a few states. Therefore, unlike hydropower, their potential remains largely untapped across ASEAN [84]. Cambodia and Myanmar are still planning to launch renewable energy strategies to enhance rural electrification, although lack of financing and technical competence remain obstacles [56,69,72]. Sophisticated policy instruments in Malaysia [85,86] did boost solar power investment in the early 2010s [61,87], but risk perceptions among investors and lingering fossil fuel subsidies [85] have hampered sustained growth in recent years. Malaysia a longtime energy exporter, now faces the prospect of becoming a net energy importer unless it massively expands renewables, which will require rigorous policy implementation

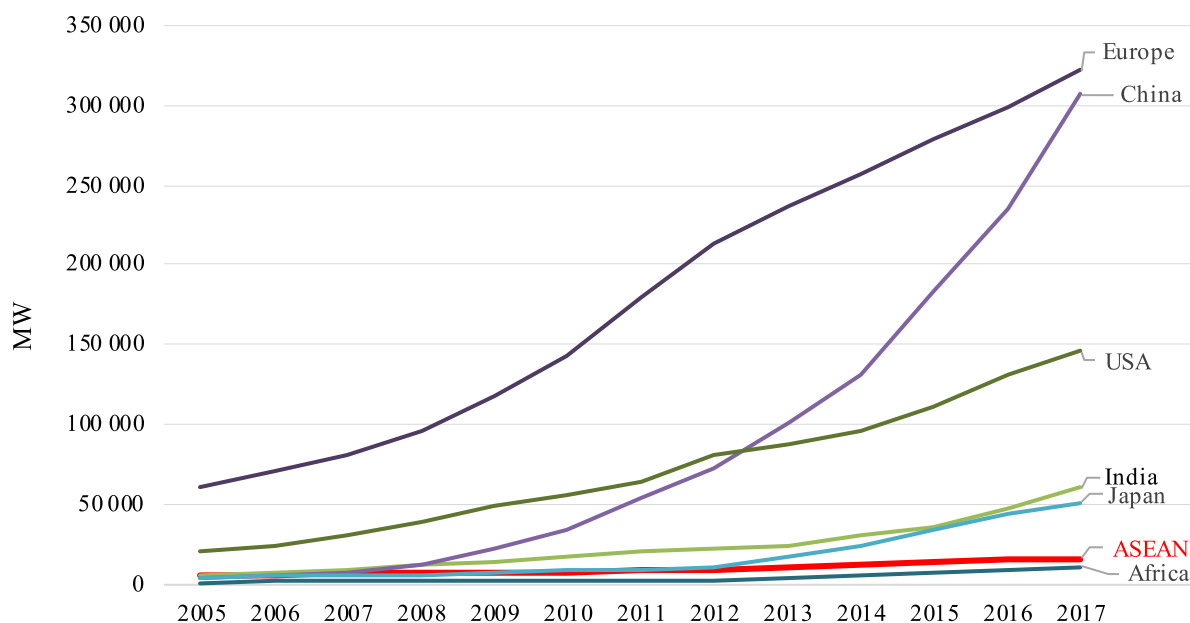


Fig. 1. Aggregate installed capacity of renewable energy sources in ASEAN, excluding hydropower (data source: IRENA 2019).

and reassurances for investors. Thailand is the exception to the rule, having seen stronger and more consistent growth in solar power than its neighbors [66,88].

2.3. Electrification of transportation

A lack of proactive policymaking has also played a part in preventing the ASEAN member states from making progress on limiting emissions from their rapidly growing transportation sectors. Transportation has the lowest penetration of renewables in any energy sub-sector in ASEAN [51,89], and accounted for 27% of the region's CO₂-emissions in 2018 [57]. Emissions of nitrogen oxides (NO_x), chiefly originating from oil use in transportation, were in 2019 projected to grow by 40% by 2040 [57].

Widespread adoption of electric vehicles (EVs) would reduce micro-level pollution in Southeast Asian cities. However, as coal is the marginal fuel for electricity generation in most ASEAN member states—that is to say, the first source that is reduced or increased when electricity consumption changes—electrification of transportation in ASEAN might in fact lead to *greater* overall air pollution and greenhouse emissions in the ASEAN countries [90].

An alternative to electrification of the transportation sector is increased use of biofuels. However, this could lead to the decimation of rainforests and wildlife in Southeast Asia. As rainforests are important carbon sinks, it would again mean that ASEAN would underperform in terms of climate mitigation under the Paris Agreement. As rainforests are also crucial for global biodiversity, symbolically important in global affairs, and resistance to palm oil is rising around the world, the reputational costs for the ASEAN member states could also be considerable. Furthermore, biofuels would not help reduce the local air pollution and traffic congestion challenges.

The obvious solution then would appear to be greater emphasis on public transportation infrastructure. This would serve to limit further traffic congestion: as four-wheel vehicle ownership rises in the region, traffic congestion is likely to worsen unless convenient alternative forms of urban personal transportation are made available. Some Southeast Asian countries are showing promise in this regard, despite severe delays [91], and the ASEAN governments might benefit from observing and learning from each other. For example, the highly developed public

transit systems in Bangkok and Singapore could be emulated by other cities in the region.

2.4. Subsidies for fossil fuels

Fossil fuel subsidies amounted to USD 35 billion in ASEAN in 2018 [56]. This contrasts with ASEAN's investment in renewable energy that year of slightly more than USD 7 billion [151]. Despite improving renewable energy incentives, fossil fuel subsidies in several ASEAN states have undermined the competitiveness of renewable energy in electricity generation [1].

While officially intended to support low-income citizens, fossil fuel subsidies tend to strongly benefit higher-income households (which have higher energy consumption) and industrial consumers while draining fiscal resources [92]. For example, in Indonesia, fossil fuel subsidies were equal to 11% of GDP in 2015 [93]. The government decided to remove gasoline subsidies in 2016, saving the Indonesian state budget USD 8 billion [93]. These savings were spent on infrastructure development and social programs across the country. However, when oil prices started growing again and straining consumers in 2017, the Indonesian government caved in and adopted new fuel subsidies [93]. By 2018, Indonesia was again the fifth largest fossil fuel subsidizer in the world [94]. Fig. 2 highlights Indonesia's role as ASEAN's main fuel subsidizer and also shows that cumulative regional subsidies between 2010 and 2018 amounted to over USD 322 billion.

2.5. Rapid expansion of coal power

Southeast Asia was one of very few regions in the world in which coal's share in electricity production grew in 2018 [56]. Even the United States, which had one of the world's most climate-skeptic governments and had declared that it would exit the Paris Agreement, was pivoting away from coal [95]. By contrast, between 2010 and 2015, ASEAN added 25 GW of coal capacity, accounting for 42% of total added electricity generation capacity during this period [96] (see Fig. 3).

While global demand for coal will remain flat, it is expected to grow 3% per year in ASEAN up to 2040 [56]. Coal is projected to account for over 50% of electricity production in Vietnam by 2030 [96]. It already accounts for more than 50% of electricity production in the Philippines [76] and in late 2017 the country had over 10 GW of new coal power in the pipeline [97]. Even Laos, which has historically been almost wholly

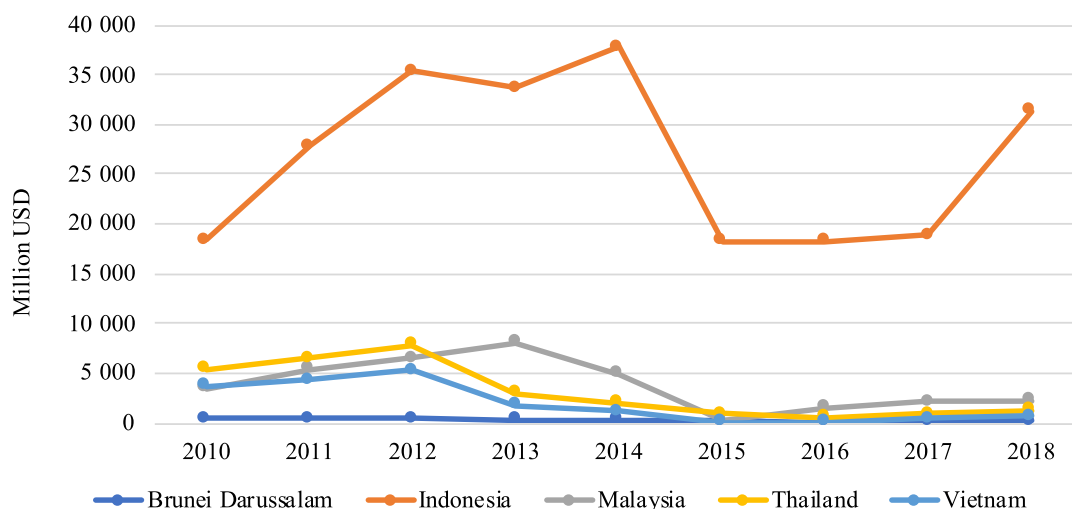


Fig. 2. Fossil fuel consumption subsidies in ASEAN states, 2010–2018 (source of data: IEA, 2018).

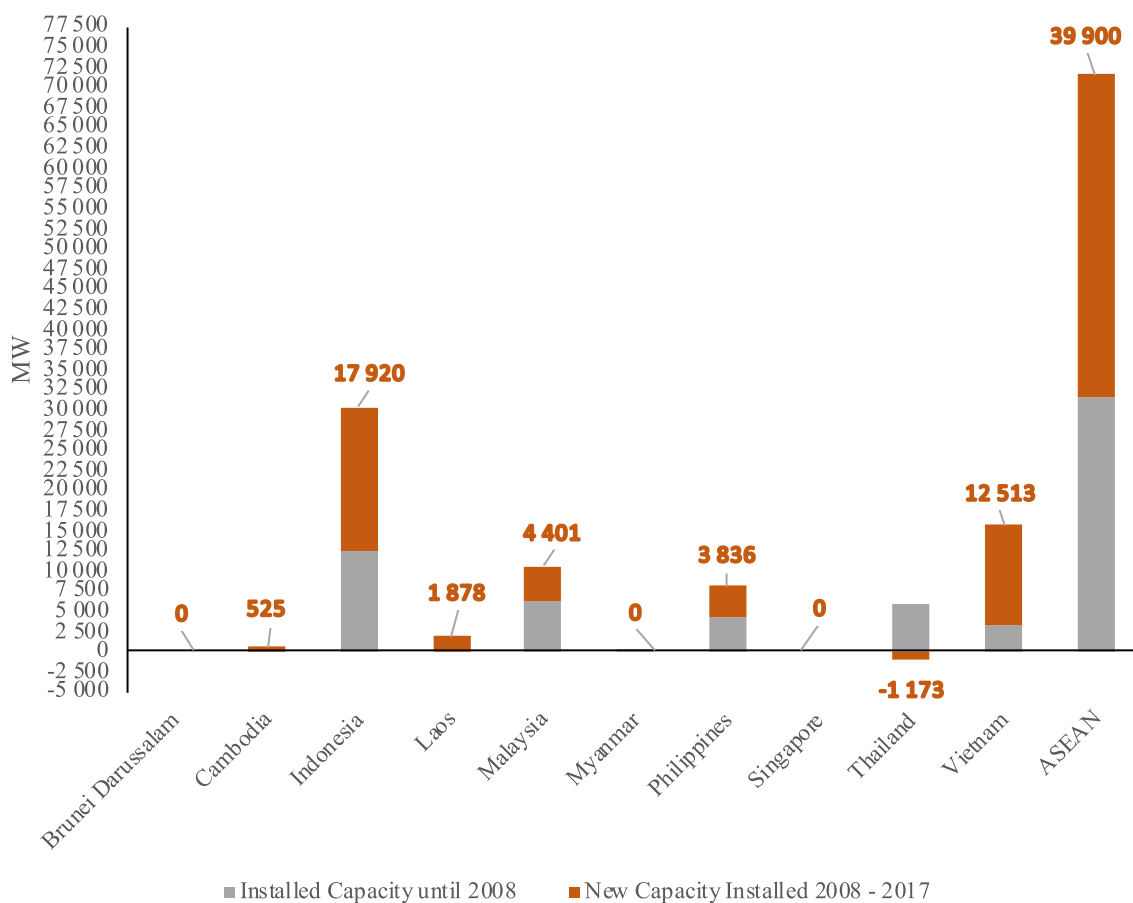


Fig. 3. Existing and added coal power capacity in ASEAN, 2008–2017 (source of data: ACE [98]).

reliant on hydropower for electricity, has seen coal-fueled electricity production rise from negligible amounts to over 10 000 GWh in 2017 [98]. By 2030, it is projected that coal will overtake natural gas, a less dirty fuel, as the main power source in ASEAN [56]. If the trend continues, coal will account for almost 50% of ASEAN’s projected 2.4 gigatons of CO2 emissions in 2040 [56].

These developments are paradoxical for several reasons. First, only Indonesia has sufficient coal reserves to avoid imports in the long-term.

In the other ASEAN countries, the rising coal consumption will increasingly also become a burden on the trade balance. Second, renewables are rapidly becoming cost-efficient worldwide and may leave coal assets stranded and investments lost. It has been estimated that in Indonesia, the Philippines, and Vietnam it will be cheaper to build new solar power than new coal plants by 2022; and by 2029 it will be cheaper to build new solar power than to use *already built* coal plants in all three countries [99–102]. Third, coal may also be detrimental for tourism, which is

one of the main sources of foreign currency earnings and employment in small- and medium-sized enterprises in Southeast Asia. Fourth, the adverse local health [103], harvest [104] and environmental effects of coal-fired powerplants are well-known, threatening to derail ASEAN's trajectory to achieve SDG 4, concerning health. One recent study put excess annual deaths resulting from coal emissions in ASEAN at around 20 000, which with current energy plans would rise to nearly 70 000 in 2030 [105]. Air pollution is the second-leading global cause of non-communicable diseases, accounting for 1.36 million deaths in Indonesia alone in 2016, equivalent to 73% of all deaths in the country [106]. Thus, the current energy trajectory might have unintended social consequences related to public health [107], which is another SDG target that ASEAN looks unlikely to achieve. Fifth, many investments in Southeast Asian coal power plants are made by Chinese firms, whose limited engagement with local communities aggravate local skepticism [108].

There is vocal local opposition to some coal power projects in Indonesia, the Philippines, and Thailand [109]. In Thailand, this has caused the authorities to reconsider the viability of coal. As coal is unpopular with parts of the population, and domestic gas reserves are dwindling, the Thai government faces a choice as to whether to import more coal and natural gas or expand the role of renewables [110]. This is a choice that most ASEAN states will face.

2.6. Forest management

While the ASEAN member states have expanded coal utilization swiftly, action to halt the deforestation has been slow, although improving recently. Laos and Vietnam have set targets for forest coverage of their territories at 70% and 45% respectively. Indonesia still has one of the highest deforestation rates in the world, even though improved law enforcement and legal protections [111] have lowered it somewhat [112] after years of inefficient policies [113–116], public discontent [117], and international pressure. Regional cooperation has inadequately focused on protecting the forests in Indonesia to prevent local smog [113,116], yet the burning of forests and draining of peatlands [118–123] also raises Indonesia's total emissions to a level that makes it the third largest GHG-emitter in the world after China and the USA [112]. Meanwhile, Myanmar's deforestation rate is one of the fastest growing in the world due to mismanagement and illegal logging [122]. According to the Burmese Forest Department, forests occupied 39 million hectares in Myanmar in 1990 but had dropped to 29 million hectares by 2015 [123].

Forests function as carbon sinks, not only counteracting GHG-emissions, but also giving states like Indonesia and Malaysia credibility and leverage in international climate negotiations. Unlike most other ASEAN member states, which have to focus on cutting emissions from power generation and transportation, Indonesia could fulfill much of its NDC simply by preventing forest fires [112]. Indonesia's ongoing partnership with the UN program Reducing Emissions from Deforestation and Forest Degradation (REDD+) [124] is one example of how the ASEAN countries can craft successful international agreements that benefit themselves, but it remains a relatively uncommon example of international climate cooperation by an ASEAN member state.

2.7. The role of ASEAN in global energy cooperation

The Southeast Asian states vary in terms of global energy cooperation, but most are keeping a low profile. Almost all the countries in the world have joined IRENA, including major hydrocarbon exporters such as Iraq, Russia, and Saudi Arabia [125]. By contrast, nearly half of the ASEAN countries still stand outside IRENA [125]. Cambodia has belatedly chosen to join and is now at the accession stage, along with a few other remaining stragglers such as Burundi, the Democratic Republic of the Congo, Libya, and Syria [125]. Laos, Myanmar, and Vietnam have yet to apply for formal membership, which could bring expertise and

resources to their energy transition. In sum, a smaller ratio of Southeast Asian states are members of IRENA than any other region in the world.

Only Cambodia is a member of the International Solar Alliance, and only Malaysia and the Philippines participate in the Friends of Fossil Fuel Subsidy Reform. No ASEAN member state participates in initiatives like the Cartagena Dialogue or the Carbon Neutrality Coalition, and only the Philippine Province of Negros Oriental is a member of the Powering Past Coal Alliance, with no ASEAN countries represented at the nation-state level [126]. Curiously, ASEAN affiliation with the inter-governmental Renewables Club has thus far been limited to the Asian Golf Industry Federation, based in Singapore.

3. Discussion: how to address the paradox?

Climate change to date is largely not the fault of ASEAN but the industrialized countries of Europe, North America, and East Asia. However, due to its geography, Southeast Asia's future prosperity and security depend on the success of climate mitigation. It is therefore paradoxical that the Southeast Asian states are not participating more proactively in the global mitigation effort. A stronger environmental stance now could also provide a better basis for demands for climate justice.

ASEAN has received less international attention than large nation-state GHG-emitters like Brazil, China, and India, but this is likely to change. ASEAN's population is already greater than that of the EU and is projected to exceed 715 million by 2030 [127]. ASEAN is also likely to become the world's fourth largest economy by 2030 [96]. Thus, its weight in global energy affairs will come into the limelight in the next decade and global scrutiny of its energy and climate policies will likely grow. Both the international standing and competitiveness of the Southeast Asian states will be affected by the policy decisions they make. In the next paragraphs, we suggest six policy measures that could help the ASEAN countries address the climate-energy paradox and achieve greater policy coherence in the medium and long run.

Avoid the short-term affordability perspective in energy policy planning. ASEAN's limited NDCs and renewable energy targets, and the considerable risk that they will not be reached, are often attributed to the need to provide affordable and secure energy [1]. However, rapidly changing global trends challenge this narrative. The cost of renewables is falling dramatically, while the ASEAN member states, apart from Indonesia, lack the domestic energy resources to continue the current reliance on fossil fuels. Emphasis on long-term contracts for renewable power producers can also drive down costs [70,81]. Thus, a focus on short-term, perceived affordability and energy security paradoxically may lead to stranded assets and threaten ASEAN energy security in the long run [128]. It also exposes the ASEAN countries to stranded asset risk in the long term as coal plants may become obsolete. In Indonesia, the Philippines, and Vietnam, energy assets worth USD 60 billion may become stranded as early as the 2020s [102].

In theory and at a purely technical level, carbon capture and storage (CCS) could be used to mitigate emissions from coal plants [129–131]. However, so far, cost-effective CCS has not been successfully developed, despite billions of dollars of investment in research and test facilities at multiple locations around the world. While CCS could potentially enable coal usage in industrial processes requiring intense heat, such as cement and metals production, its high costs are unlikely to ever become competitive in power generation, especially considering how rapidly the costs of renewable energy and energy storage are falling. Finally, the ASEAN countries are not at the forefront of CCS research. Even if CCS is successful at some point in the future, it is likely to take even longer before such technology is deployed in the ASEAN countries. Currently, most coal plants in Southeast Asia do not even use the most efficient coal combustion technologies.

Focus on leapfrogging in building renewable energy infrastructure. In areas with well-established energy infrastructure such as the EU or Japan, the energy transition requires expensive and difficult adaptation measures and the loss of substantial sunk costs. ASEAN has the chance to

avoid falling into this trap by developing power generation systems with a large share of renewable energy from the outset. Thailand's rapid progress towards its 2030 solar power installation targets signals the potential that plummeting renewable energy costs hold for the ASEAN countries [110], as does the steep rise in regional investment in solar power in 2019 [56]. Investment in renewable energy can be further ramped up by enhancing regional energy connectivity to help handle the intermittency of renewables [132]. Furthermore, solutions like Home-town Investment Trusts (HIT) [133], through which local investors fund local renewable energy projects, could be further explored by all ASEAN governments as a supplementary approach in order to accelerate off-grid renewable power development.

At first glance, nuclear power might represent an alternative emissions-free and stable energy leap-frogging target [134]. Aside from the high capital investment costs of nuclear plants, the location of several ASEAN states within the seismically unstable Circum-Pacific Ring of Fire heightens the risks for such plants in large states like Indonesia and the Philippines. In addition, most of the ASEAN member states lack both a technological and scientific advantage when it comes to nuclear energy and would be heavily dependent on foreign technologies and expertise. They also lack indigenous nuclear fuel sources. Thus, a move towards nuclear power would also be a move towards energy dependence, energy insecurity and a negative contribution to trade balances. The sum of these points is that it is unlikely that nuclear power can compete with renewables in the ASEAN countries.

Accelerate regional power interconnectivity and prepare roadmaps for facilitating future electricity trade. ASEAN has made significant progress at the sub-regional level in exploring the potential for power trade, a longstanding flagship project of the association [135]. A recent study by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) highlights a variety of strategic options available for ASEAN both as a self-contained region and as a component of broader power interconnectivity in the Asia Pacific [136,137]. The ASEAN Power Grid (APG) and power integration projects such as the Greater Mekong Region [138], which includes China, can enable significant power purchasing and potentially an integrated power trading market. This can in turn incentivize further deployment of intermittent renewable energy across ASEAN as it can help balance grids and variable production from renewable sources [139–141]. Despite high up-front capital investment costs, it would also reduce long-term electricity costs for ASEAN and constitute a significant step towards greater regional integration, an ambition in its own right for ASEAN. Regulatory alignment would be an important early step to accelerate this effort [142].

Phase out fossil fuel subsidies and promote local micro-grid and off-grid solutions. Solar power is rapidly becoming the cheapest source of electricity globally [143] and can be rolled out significantly faster than coal-powered plants, which are subsidized across ASEAN [92]. The expansion of coal and its subsidization are claimed to be needed to increase electrification rates and limit the financial burden on low-income households [1]. According to the IEA in late 2019, over 45 million ASEAN citizens lack access to electricity [56], many of them in Cambodia and Myanmar, and to a lesser extent Indonesia, Laos, and the Philippines [57] (lack to access of electricity is defined in accordance with IEA guidelines [144]). However, communities lacking electricity are concentrated in remote areas and can likely be electrified most cost-efficiently by local micro-grid and off-grid solutions rather than large-scale coal power plants [145,146]. Such communities therefore do not benefit greatly from current subsidies, which mainly benefit industrial consumers [92].

Recognize the energy transition as a business opportunity. Climate mitigation is not only a burden. As countries as different as China and Denmark have demonstrated, the energy transition represents a major opportunity for businesses, exports, and job creation. Many countries are positioning themselves aggressively to reap these opportunities. If other countries wish to have a chance in the race, they need to act swiftly. Malaysia has successfully emerged as a major producer of solar panels

for the global market [147], but paradoxically has yet to fully capitalize on this for domestic power generation. Singapore could leverage its role as a financial hub to promote clean energy investment throughout ASEAN, but has yet to maximize this potential [148]. Indeed, considering the significant financial risks associated with coal plants and the economic effects of climate change, the broader ASEAN banking sector could focus more on green finance and renewables [149].

Enhance capacity building through ASEAN, IRENA, UN ESCAP and other international organizations. The declining cost of renewable energy makes it increasingly feasible for the ASEAN member states to embrace a climate-oriented energy trajectory—if national governments seize the opportunity. While limited state finances and lack of expertise remain challenges in some cases, the capacity for coordination offered by ASEAN as a regional body could help compensate for this [150]. In order to strengthen their capacity, the ASEAN countries could also expand cooperation with UN ESCAP and join IRENA.

4. Conclusion

It is paradoxical that ASEAN's climate change mitigation efforts to date are not commensurate with the multifaceted threats that climate change poses to the region. The continued emphasis on and subsidization of fossil fuels is quadruply paradoxical because it is not only detrimental for the climate but also poses a public health hazard, is costly in the short term, and carries a longer-term stranded asset risk. ASEAN could invest more in public transportation infrastructure to limit both current and future greenhouse gas emissions, improve urban air quality as the region rapidly urbanizes, and increase the mobility of the poor. Forest management in Southeast Asia can also be improved, as can the region's engagement in international cooperation on energy issues. ASEAN's efforts to combat climate change are intimately linked to its economic prospects and ability to deliver on multiple SDGs. While the challenges are by no means insurmountable, the countries of Southeast Asia have a narrow window of opportunity to capitalize on their strengths before the economic, reputational, ecological and political consequences of climate change for the region become unmanageable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This article is a product of the ASEAN Climate and Energy Project (ACCEPT), which is supported by ASEAN and the Norwegian Ministry of Foreign Affairs and carried out jointly by the ASEAN Center for Energy and the Norwegian Institute of International Affairs. The funding sources did not play a role in determining the design or conduct of the study and its findings do not necessarily represent the views of any of the institutions involved and are the sole responsibility of the individual researchers involved.

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