

A review of renewable energy development and its policy under nationally determined contributions in ASEAN

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Abstract

ASEAN's energy demand is projected to expand 2.4 times by 2040 according to the 5th ASEAN Energy Outlook. In 2040, ASEAN's GDP is projected to have a threefold increase from only USD 2.56 trillion in 2015 and the region's total population grows to over 760 million with 0.7% per year on average comparing to 630 million in 2015. Rising energy demand will influence the security of ASEAN energy supply and the ability to generate economic value while these lead ASEAN transforming to be a more energy-intensive economy in the region.

Limited energy resources plus swift economic and socio development upswing prompts ASEAN to develop more renewable energy sources as one of the most crucial solutions for future energy challenge within the region. Under regional blueprint of energy named as ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025, ASEAN seeks an opportunity to ensure the sustainable energy supplies by committing on 23% renewable energy contributions in its total primary energy supply (TPES) by 2025. With this regard, the pathways for energy interconnection and nationally determined contributions (NDCs) in ASEAN has been introduced with the purpose to enhance further their regional collaboration to charter the way forward and seize the potential opportunities and benefits for the entire region. This paper intends to highlight some effective energy policy frameworks in deploying renewable energy potentials to support the NDCs of each ASEAN Member States (AMS) and to suggest several recommendations to unlock such potentials towards a united, inclusive, sustainable and resilient community.

Keywords: Renewable energy, nationally determined contributions, ASEAN

1. Introduction

It is a fact that many natural disasters are prevailing worldwide including the recent natural disasters such as flood and typhoon in western areas of Japan destroying infrastructure and leaving many people death [1]. Moreover, the Mangkhut storm does affect Philippines and Hong Kong causing severe damages with winds of up to 269 kilometers an hour, leaving at least eight dead and sending about 206,000 people to shelters [2]. Apart from natural disasters, it's globally acknowledged that climate change is increasing the number of extreme weather events and affects sea levels. Paris Agreement on climate change has been ratified by all 10 ASEAN Member States [3] with the commitment to cut down the emissions of greenhouse gas (GHG) since some significant challenges have been confronted by the emerging countries in ASEAN. Particularly in responding to the growing urbanization which in one part results in negative effect to energy security, air pollution, people livelihood and in long run impacting globally such as the rising of earth temperature and climate change. Surely enough, there are a number of existing policies in place; however, an energy trend is moving toward unpredictable future which are incompatible with the development goals focusing on sustainability, affordability and accessibility of energy for all, especially long-term target of climate change [4]. In response to all these problems, 161 intended nationally determined contributions (INDCs) were submitted to United Nations Framework Convention on Climate Change (UNFCCC) in 2015 [5] including Brunei Darussalam [6], Cambodia [7], Indonesia [8], Lao PDR

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[9], Malaysia [10], Myanmar [11], Philippines [12], Singapore [13], Thailand [14] and Vietnam [15].

As one of the most dynamic and fastest growing economic in the region, ASEAN has attracted global attention, especially on its future development with the growth is expected to keep its pace and projected to increase by 5-7% per year. The global transition is happening now together with population growth in ASEAN which is expected to increase to over 760 million with 0.7% per year on average comparing to 630 million in 2015 according to the 5th ASEAN Energy Outlook (AE05) [16], and investment in the renewable energy technology is one of the most promising options, which will lead to achieve a cleaner energy to fulfill the electricity demand in the near future. This will contribute to the policy under Nationally Determined Contributions (NDC) in ASEAN with the principle and objective to bring down to some extent worldwide average temperature to 1.5 °C by the middle of the century according IPCC Special Report on Global Warming. This target; nonetheless, still remain to be seen [17]. With this regard, the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 has been directed, amongst others, to promote the Nationally Determined Contributions (NDCs) in the light of global environmental concerns and to drive cleaner energy and renewable energy initiative for ASEAN towards enhancing regional energy security [18].

This paper is divided into six (6) sections. Section 1: Introduction; Section 2: Renewable Energy Policy Review in ASEAN; Section 3: Nationally Determined Contributions (NDCs) Targets and its Challenges; Section 4: Methodology in Policy Analysis; Section 5: Findings and Recommendations; Section 6: Conclusions. This paper will bring a new perspective for ASEAN policy makers as a tangible effort to meet the rising demand of energy with the core foundation in foreseeable future of green, affordable and cleaner energy technologies.

2. Renewable Energy Policy Review in ASEAN

Recognizing the important role of practical-based actions with an attempt to climate change response and growing energy demand in the region, the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 has been introduced with the target of 23% share of renewable energy in energy mix by 2025 [19]. As illustrated in the 5th ASEAN Energy Outlook, renewable energy is projected to be the main energy contributions in ASEAN Targeted Scenario (ATS), especially in power generation, resulting in more adapted frameworks for energy policy analysis in the intended nationally determined contributions. The APAEC 2016-2025 Phase I comprises of seven (7) programme areas such as: 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. These programmes have been implemented in ASEAN and has become the prominent strategies to achieve energy target [20]. To highlight some of the programme areas, the ASEAN Power Grid (APG) aims to interconnect the 10 AMS through cross-border bilateral connectivity and gradually expand to multilateral schemes leading to a total integrated APG grid system while the regional energy policy and planning (REPP) programme aims to achieve ASEAN's energy cooperation goals and targets and strengthen collaboration with dialogue partners, international organizations and industry stakeholders, in order to better ASEAN's profile in energy sector internationally. With this regard, the ASEAN's aspirational target in the medium-term is to reduce energy intensity (EI) by 20% in 2020 based on 2005 level through energy efficiency and conservation as well as renewable energy development. Fig. 1 indicates that renewable energy presents a huge potential in the region with 3.6 to 5.3 kWh/m²/day of solar irradiation and 1.2 m/s to 6.5 m/s of wind speed while there is around 30 GW of geothermal energy. If geothermal is taken into consideration, the potential capacity of 28.9 GW, 1.2 GW and 0.34 GW are in Indonesia, the Philippines and Vietnam, respectively which has the largest share among the 10 countries. For hydropower, the top on the list are Indonesia with approximately 75 GW and Myanmar 40.4 GW. In addition, Indonesia and Thailand consist of 32.6 GW and 2.5 GW of biomass, respectively. Ocean energy is not quite potential in this region as shown there is no ocean energy in Lao PDR, Myanmar, Cambodia and Thailand. The detail energy potential is illustrated in Fig. 1.

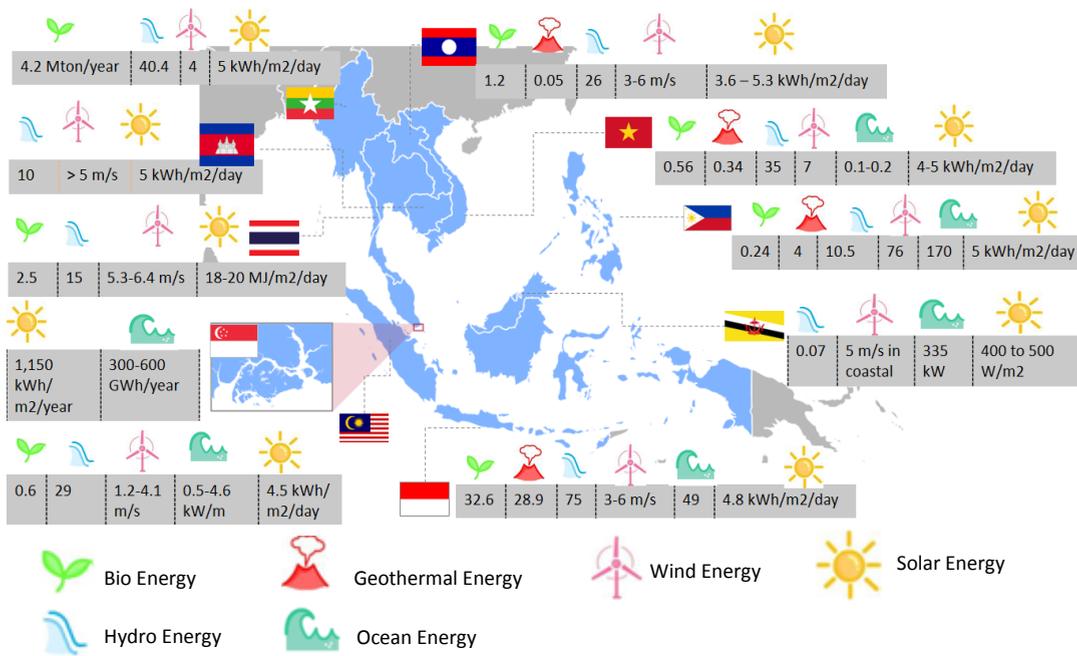


Fig. 1. The potential of renewable energy in ASEAN (in GW, else stated) Source: ASEAN Centre for Energy (ACE), 2016

ASEAN has come a long way and has achieved so many accomplishments in energy sector both in their national target and regional target. In 1990, ASEAN total primary energy supply (TPES) was only 238 million tonnes of oil equivalent (Mtoe) while there was a sharp increase to 627 Mtoe in 2015 [20]. Since 2000, coal has the largest share in power generation mix with a lot of coal utilization projects and coal-fired power plants being operated regionally. There is a remarkable increasing share of renewables which is quite an important step in realizing the minimum use of fossil fuels. Those renewable energy; namely, solar PV, hydropower, wind energy, geothermal, biomass and others while in residential sector equally sees the drop down of bioenergy share [21].

ASEAN is a regional community which in the last two decades has been ignored by the world; but now has united herself to be a place with abundant opportunities. Total ASEAN trade is 2.3 trillion in USD. Total ASEAN trade grew by 700 million USD between 2007 and 2015 despite the moderation in global trade growth. ASEAN's total trade by partner in 2015 accounted for 24%, being the biggest share of ASEAN's total trade in intra-ASEAN. As far as ASEAN economy is concerned, ASEAN economy in 2015 ranked the 6th largest globally and in Asia, it is the 3rd largest economy. Also, ASEAN population was the third largest in the world in 2015. More than half of the population were below 30 years of age and 47.7 % lived in urban areas. Therefore, ASEAN turns herself into an investment hub in the century to come.

This trend represents the surging share of energy scenario in this diversity region. On top of that, renewable energy in power generation is given a priority, particularly power grid and cross-border interconnection. The countries in ASEAN have injected more renewable energy into the grid by replacing the plan for coal-fired power plant. Power grid is having the importance role in the energy and expected to remain the same for next decade. ASEAN Member States (AMS) have to upscale their targets on renewable energy (RE) power sector, biofuels for transport and modern biomass for industry to reach the 23% RE in 2025 as shown in Fig. 2.

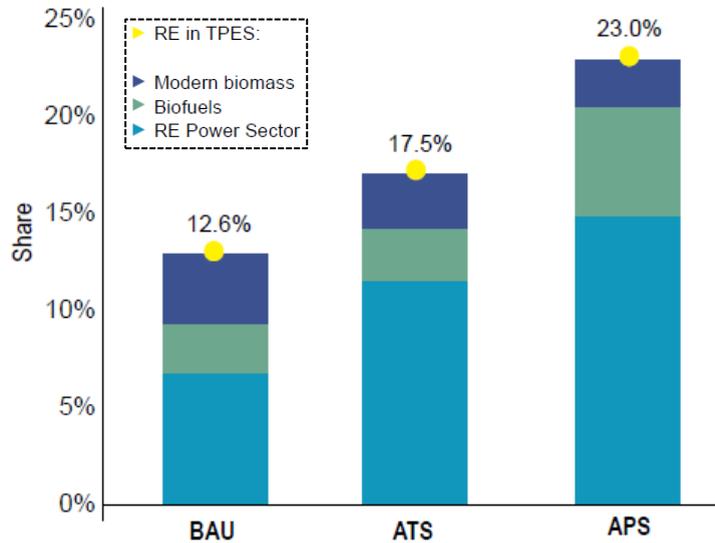


Fig. 2. Distribution of renewable energy share in 2025 Source: ACE, 2016

RE Power Sector is the most contributing sector as ASEAN will need to have 42% power generation coming from renewables. In Business as Usual Scenario (BAU) 2025 [16], the 12.6% RE share is composed of 6.6% from RE generation in the power sector, 2.5% by biofuels and 3.5% by other RE in Total Primary Energy Consumption (TFEC) (comprising modern biomass, and biogas). Of note, modern biomass refers to biomass used in TFEC sectors other than traditional biomass which refers to all types of energy used in residential sectors. Biomass-fueled power plants are however considered in the power sector.

In AMS Target Scenario (ATS) it reaches a share of 17.5% in 2025 (with 2.5% for biofuels and 3.2% for modern biomass) but while biofuels and modern biomass contribute similarly to BAU, RE electricity in the power sector represents a share of 11.7% of TPES. It should be noted that ATS is when the national target of each AMS is achieved. ASEAN Progressive Scenario (APS) shows, in the conception of the scenario, a share of 23% of RE in TPES in 2025. The power sector contributes the most, with 15%, if it is translated into power generation (or installed capacity) is about 42%, followed by biofuels with 5.5% and modern biomass with 2.5%. In other word, APS scenario is when the regional target is achieved.

TPES will considerably increase during the projection period. Substantial savings can be achieved in ATS and APS. In 2040 in all scenarios, oil is still the largest fuel in the primary energy mix followed by coal in BAU and ATS. In APS, RE is the second largest fuel, a result of more ambitious initiatives for RE. A number of populations in rural and remote areas are still relying on traditional biomass, but it loses its relevance in the ASEAN energy mix by decreasing its share from 10.6% in 2015 to only 5.8% in 2040 under ATS [16]. Renewable Energy across ASEAN Member States (AMS) had a circulated installed capacity of around 23,650 MW in 2006. It continuously expands to reach 51,700 MW by 2014. Best practices throughout the region have been highlighted to promote further successful development in the ASEAN region [22].

For installed capacity projections in ASEAN Member States Target Scenario (ATS) as illustrated in Fig. 3, ASEAN Centre for Energy has identified that coal will be the fastest growing fuel until 2040 in power generation. ASEAN has the Coal Fired Power Plant (CFPP) capacity of 63 GW in 2015 and projected to be 95 GW in 2025 and 196 GW in 2040, becoming the largest % in the electricity generation mix by 2025.

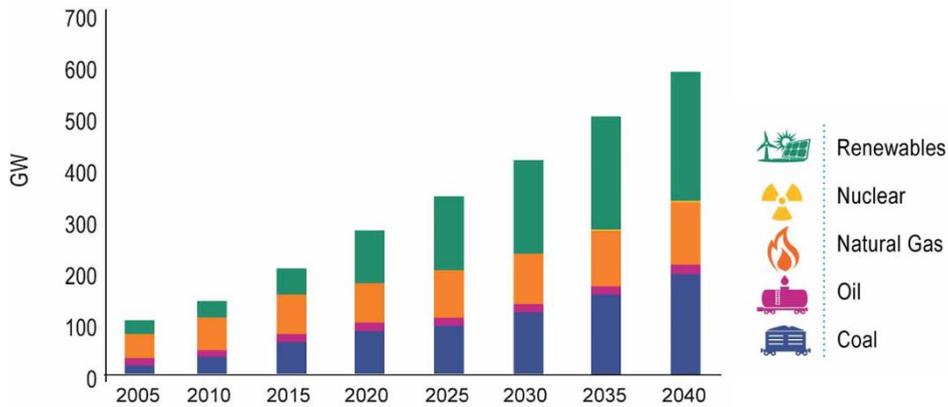


Fig. 3. Installed capacity projections in ATS by technology source: ACE, 2016

The 10 ASEAN Member States have total RE Installed Power Capacity in 2006 and 2014 accounting for 541,993.70 GWh and 856,279.53 GWh, respectively. It is also presented total installed capacity of 918,228.87 GWh in 2015 based on the ASEAN Centre for Energy (ACE). With the precise projection of this global trend, ASEAN countries could take these opportunities to tap those potential benefits which will serve as a national interest and finally as the interest of entire region. By 2025, the blueprint has drawn its direction toward the technologies to support the development of renewable energy, generating the power for electricity supply that it is believed to be cheaper than those produced from various sources of non-renewable energy or fossil fuels [23]. Additionally, regional cooperation for RE can be understood as the purposeful collaboration of AMS on issues related to the deployment of RE; it may encompass both the cooperation between two or more AMS and the cooperation among all AMS [24]. It should equally be noted that through concerted efforts to reach RE targets regionally supportive policy frameworks have been introduced, paving the way for private sector and other relevant stakeholders to make investment on energy [25].

3. Nationally Determined Contributions (NDCs) Targets and Its Challenges

Country emission profile and alignment of NDCs [5] and the National Green House Gases Emission (including energy; industrial processes; agriculture; waste; land-use change and forestry; bunker fuels) for ASEAN will be presented in Table 1.

Table 1. GHG Emission in 2012-2014 (MTCO₂ eq)

Country	2012	2013	2014
Brunei Darussalam	19.80	19.92	20.21
Cambodia	50.87	51.88	52.85
Indonesia	2159.46	2164.07	2474.88
Lao PDR	29.28	29.36	29.62
Malaysia	150.86	171.55	196.12
Myanmar	198.52	201.84	212.63
Philippines	105.09	115.09	124.74
Singapore	205.80	207.32	206.07
Thailand	384.89	395.44	389.31
Vietnam	230.02	241.58	254.71

Source: World Resource Institute (2018)

Rising use of fossil fuel prompts the immediate action to be taken by the countries involved because when it keeps its pace, the impact can be tremendous, especially to the environment, human health, climate and overall atmosphere as a result of GHG emission. As demonstrated in the table 1, there is a sign of surge in emission which should be taken into consideration if the region wishes to develop sustainably with healthy economy. Alternative financing on clean energy and renewable energy could be a sound decision to cope with unpredictable hazards and the price that have to pay in the future. Another outstanding discussion in this 10 ASEAN Member States nowadays also focus on the energy efficiency, smart and green city, as well as green building.

Table 2. Intended nationally determined contributions in 10 ASEAN Member States (AMS)

Intended Nationally Determined Contributions in 10 ASEAN Member States (AMS)	
Brunei Darussalam	“is committed to implement its mitigation contributions identified in its INDC through domestic efforts including implementing energy related measures; development and implementation of EEC legislative measures; power efficiency improvement; deployment of renewable energy; implementing transport related measures [6].”
Cambodia	“is committed to undertake green, low-carbon, climate-resilient, equitable, sustainable and knowledge-based society actions for adaptation and mitigation in any sectors including agriculture, energy, transportation, industrial, land-use and forest management and waste management [7].”
Indonesia	“is committed to support empowerment and capacity building, improved provision of basic services in health and education, technological innovation, and sustainable natural resource management, in compliance with principles of good governance and broader constituency strengthening [8].”
Lao PDR	“is committed to undertake mitigation and adaptation as their climate change actions in the sectors of agriculture, forestry, land use change, water resources, energy, transportation, industry and public health [9].”
Malaysia	“is committed to reduce its greenhouse gas (GHG) emissions intensity of GDP by 45% by 2030 relative to the emissions intensity of GDP in 2005. This consist of 35% on an unconditional basis and a further 10% is condition upon receipt of climate finance, technology transfer and capacity building from developed countries [10].”
Myanmar	“is committed to achieve climate resilient, low-carbon, resource efficient and inclusive development as a contribution to sustainable development with the strategic objectives of: building climate resilience of vulnerable communities; enhancing low-carbon, resource-efficient and inclusive development; enhancing sectoral capacities; and building multi-stakeholder partnerships [11].”
Philippines	“is committed to undertake emissions reduction of about 70% by 2030. The mitigation contribution is conditioned on the extent of financial resources, including technology development & transfer, and capacity building, that will be made available to the Philippines [12].”
Singapore	“is committed to reduce its emissions intensity by 36% from 2005 levels by 2030, and stabilise its emissions with the aim of peaking around 2030 [13].”
Thailand	“is committed to reduce its greenhouse gas emissions by 20 percent from the projected business-as-usual (BAU) level by 2030. The level of contribution could increase up to 25 percent, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support through a balanced and ambitious global agreement under the United Nations Framework Convention on Climate Change (UNFCCC) [14].”
Vietnam	“is committed to reduce emissions from deforestation and forest degradation, sustainable management of forests, conservation of forest carbon stocks and enhancement of forest carbon stocks and enhancement of forest carbon stocks (REDD+). The Government has issued many policies on energy saving and efficiency; renewable energy development, consistent with Vietnam’s mitigation potential and conditions, in order to contribute to energy security and environmental protection [15].”

In order to present the commitment of each countries on NDCs, this table can give a better understanding and comparison between particular statement. Reginal target still has a lot more to be discussed and implemented which serves as a good example for the regional cooperation not only for people living in ASEAN but also for the future of the generation to come.

Nationally Determined Contributions and its implication is identified not only in the energy sector, but also other industries such as transportation, energy financing, urban planning and development etc. Implementation of the NDCs will drive up the share of renewables and reduce the share of fossil fuels in general. An overall trend is to significantly reduce dependence on coal in the power mix by replacing it with renewables, nuclear, and gas [26].

Table 3. The impact of nationally determined contributions on the energy sector in ASEAN

Country	Target Type	Base Year	Target Year	Unconditional Target	Conditional Target (%)
Southeast Asia					
Brunei Darussalam	No emissions reduction target				
Cambodia	% of BAU		2030		26.7 % in energy and industries
Indonesia	% of BAU	2005	2030	29%	41
Lao PDR	No emissions reduction target				
Malaysia	% relative to GDP	2005	2030	35%	45
Myanmar	No emissions reduction target				
Philippines	% of BAU	2000	2030		70
Singapore	% relative to GDP	2005	2030	36%	40
Thailand	% of BAU	2005	2030	20%	25
Vietnam	% of BAU	2010	2030	8%	25
	% relative to GDP	2010	2030	20%	30

Source: UNFCCC, 2016

To reach INDC Targets in ASEAN, it comes with its challenges and opportunities; for example, Indonesia has introduced decentralisation and implemented nationwide; consequently, the country witnesses a big challenge to execute the particular mitigation action, comprising of promoting renewable energy and minimizing deforestation [27]. One example of renewable energy development and improving access to electricity in Indonesia is that the government has successfully increase the electrification ratio from 88.3 percent (2015) to 95.35 percent (2017), exceeding the initial target of 92.75 percent by 2017. In Vietnam, in order to realize the Intended Nationally Determined Contribution: renewable energy has very crucial role to play in meeting rising energy demand in the country. The result shows that energy demand could be reduced through high renewable energy in the mitigation efforts [28]. Geographically, some countries in ASEAN such as the Philippines, Indonesia and Vietnam are located in coastline areas. This nature gives rise to both opportunities and challenges, given the extended coastlines in the region, ASEAN is partly exposed to climate change consequences. Therefore, proactive measures cannot be taken for granted; most importantly, when it comes to global warming, climate change, and other effects from carbon emission. Heavily relying on coal is not a promising option although coal resources are still abundant in the region; namely, Indonesia, Philippines and Vietnam. More research and development could equally be done on how best emission intensity could be captured and minimized at its lowest extent. Fig. 4 shows that each country have different national emission intensity targets. Indonesia committed to promote clean and renewable energy as well as energy conservation with an aim to reduce emission intensity from 29% to 41% by 2030 while the Philippines targeted to reduce 70% of CO₂ emission by 2030. Malaysia also has an objective to cut down 35%-45% of emission intensity by 2030, followed by specific reduction targets of other countries in ASEAN. Take Cambodia as another example, there is a target for 27% emission reduction by 2030 relative to business as usual scenario (BAU) in energy industry, other industries and energy conversation.

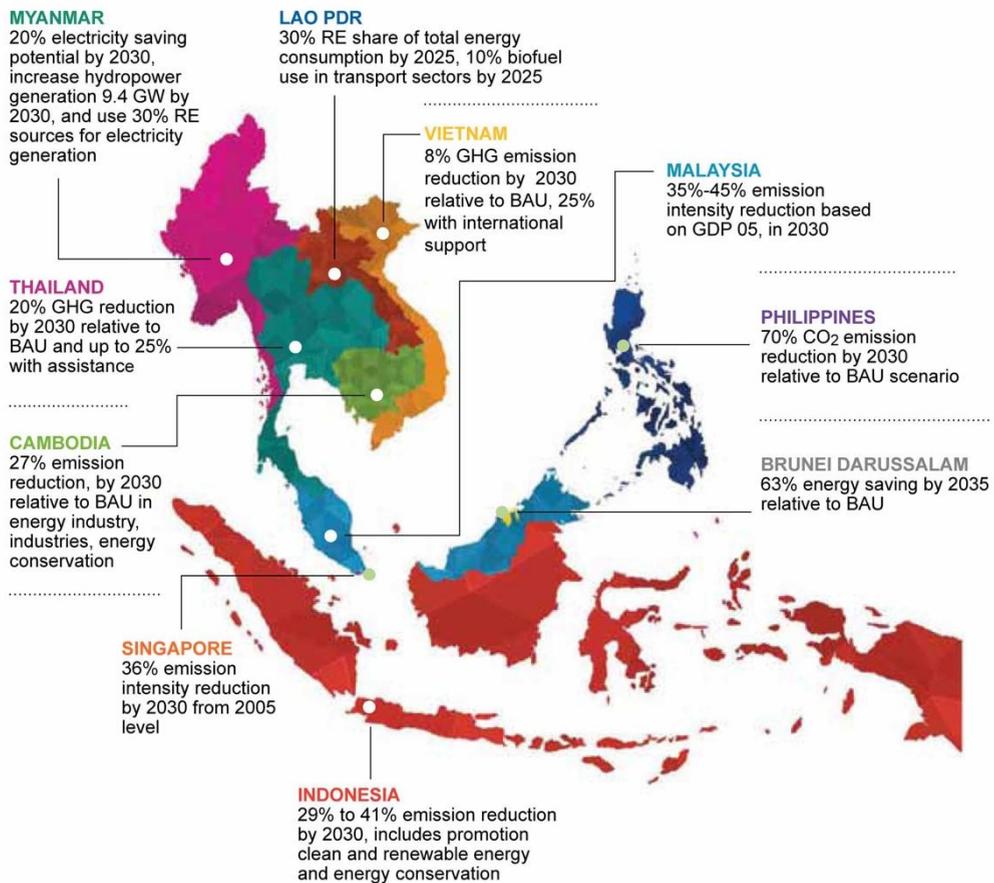


Fig. 4. Nationally Determined Contributions (NDCs) by ASEAN Source: ACE, 2018

In comparison to global level, in order to reach the goal of its pathway whereby 1.5 °C emission consistently based on IPCC report, there must be a price to pay in comparison to the cost in implementing their own NDCs as high as three times [29]. Apart from renewable energy development, the association could at the same time focus on multilateral trading and energy interconnection between the countries. This scenario at one hand strengthens the mutual understanding and cooperation; on the other hand, helps to transfer the energy surplus in one nation to another nation that is in the shortage of energy. In power generation, it will help to reduce energy poverty, resulting in more people having access to electricity. The bottom line is economic development in ASEAN which is the ultimate goal of ASEAN Economic Community (AEC); some important strategies for countries in ASEAN could be the technology transfer; the priority of energy policy; GHG inventory improvement; the planning of mitigation targets as well as disaster risk management.

4. Methodology in Policy Analysis

To capture benefits from the renewable energy development, an integrated RE policy approach and long-term planning based on systematic learning and experimentation is needed. Integrating the policy process across sectors is necessary to foster synergies and to potentially expand the market for clean energy technologies beyond electricity generation. Specifically, linking energy policy aimed at diversifying the energy mix and improving energy security with industrial policy seeking to achieve economic transition (structural transformation) can contribute to achieving higher levels of

decarbonization. Promoting large-scale deployment of renewables and linking these technologies to applications in various sectors, such as housing, agriculture, and transportation, can open up the range of applications and thus enlarge the market [30]. Prior to the result, RE energy policy analysis under NDCs in each AMS and practice-based action on renewable energy development is carried out to test and validate its feasibility and practicality of the analysis. Some methodology using “what-if” scenario to analysis energy policy confess that the result is quite uncertain and out of cope for scientific tool. Therefore, “what-if” scenario will not be used in this paper. Fig. 5 suggests that this review paper is designed with various sources of related documents and policies. There are three simple steps in this process. Firstly, related literature review and policies is conducted mostly based on the data and statistics available at ASEAN Centre for Energy and its database with the consultation with relevant stakeholders and agencies with a purpose to fine tune the presented topic. Secondly, policy analysis is carried out with concrete foundation of outcome-based strategies which are implemented in the ASEAN Member States (AMS), particularly on the successful policies in enhancing the renewable energy development and accelerating ASEAN energy transition. Thirdly, policy recommendations are highlighted to suggest some practical solutions and frameworks for policy makers, researchers, investors and associated key stakeholders to consider the current status of renewable energy development in abreast with nationally determined contributions.

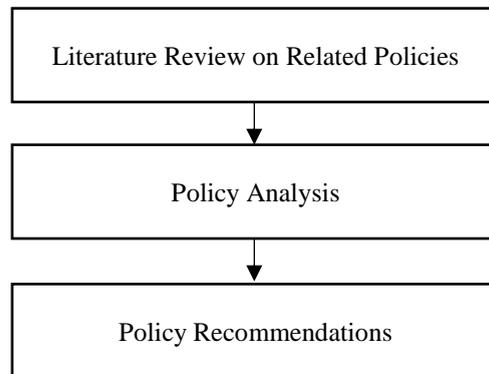


Fig. 5. Simple policy review methodology

ASEAN region is solution hub for integrating energy market and mobilizing its resources of renewable energy, giving rise to the electricity generation and eliminating energy poverty as stated by Master Plan on ASEAN Connectivity. Among others, feed-in-tariffs (FIT) in the ASEAN energy sector has been given a spotlight because it is expected to considerably help the promotion of RE. Due to its diversity in culture, region and even political system, this could potentially be the deadlock for the development plan; for instance, political concern as mentioned could slow down the process if implemented without sound management. In ASEAN Feed-in-Tariff Mechanism Report [31], feed-in-tariffs (FIT) is only developed in five (5) countries in ASEAN: Indonesia, Malaysia, Philippines, Thailand, and Vietnam. FiT is the stepping stone for ASEAN to foster renewable energy development in the region, since it has significant impact to the rise of installed capacity in ASEAN. FiT still has a significant role to play even though some countries have moved from FiT because the RE market is mature enough and ready to move for auction. If consumer behavior on technology products which affect energy sector is taken into account, related policy is one of the effective and efficient way when aiming at dealing with people behavior in household level to promote renewable energy technology because at the end of day, the development is for the benefits of the people, so technology alone is not adequate, it has to deal with how to promote and improve those technology to be well-suited for the consumer at the most comfortable level. In analysis the policies frameworks in ASEAN, feed-in-tariffs starts to be one of the promising options for the countries while some such as Lao PDR and Myanmar are reluctant to implement this kind of policy since it is

instead seen as some kind of government subsidy. In this circumstance, a joint discussion or study to identify the initiatives to implement this policy is desperately needed to provide well-rounded information intending to change the perspectives of policy makers, government and relevant energy key players.

In ASEAN Power Cooperation Report [32], ACE identifies the current status of ASEAN power market in each AMS. ACE also inform the success story of LTMS (Lao PDR, Thailand, Malaysia, Singapore) and inform the challenges and opportunities in the multilateral project. Recommendation from ACE is also provided in this report which is very useful for the further cooperation in power sector. The analysis reveals that to turn nationally determined contributions into reality, investment on renewable energy can be set as the main priority not just for investors but also for policy makers who intend to put energy-related policies in place because in the last few years, there are a number of competitive options for renewable energy development. However, it is highlighted that the slice share of renewable energy still presents in power generation mix which adequate incentive coming from RE policy can be used to enhance the energy infrastructure required in the region. Some proposed technical mechanism have been laid out to strengthen more studies on power interconnection and a large scale transmission line which could contribute the most to the region. The report also highlighted some effective and efficient power cooperation platform, particularly on technical standards between the nations. The power cooperation direction also pointed to some outstanding topics such as clean energy development, studies on high capacity units, HV and UHV DC transmission as well as system stability after AC grid interconnection. An analysis of Levelized Cost on Energy (LCOE) [33] on some technologies such as solar energy, biomass and hydropower additionally shows that “keeping the renewable energy option open” is a sound decision because there are needs for renewable energy investment in the power sector within the next decades. However, LCOE depends on country’s situation and also the technologies. LCOE for solar energy is still higher than other types of renewable energy. In particular, solar for large scale is cheaper than the small scale. The impact of some policies may have some sensitivity to LCOE, such as tax, contract period and so on.

One research argues that much remain to be done to achieve a greener energy mix in ASEAN. Some major efforts and initiatives have been underscored as roadmap for ASEAN including, revising the policy on fossil fuels subsidies; minimizing energy poverty through renewable energy efficiency; tapping the existing market integration through regional connectivity and globalization; as well as focusing on the national existing plans on energy. To go into those days, national government in the region is priorities because those action-based strategies inevitably needs sound management, wise leadership, political determination and well-defined policies and concrete actions for relevant stakeholders [34]. The importance of renewable energy also described as the way forward to sustainable and inclusive growth for ASEAN, especially renewable energy in the form of solar, hydropower, biomass and others [35]. As stated, the trend of renewable energy nowadays is about smart grid, energy efficiency, energy storage both for thermal and electricity. The International Energy Agency (IEA) also projects that in 2040, 37% of power generation from renewable energy worldwide will be reached if Paris Agreement is abide by the nations with accounting for only 23% in current trend today [36].

5. Findings and Recommendations

Among the ten ASEAN countries, Thailand, the Philippines, Vietnam and Myanmar are highly exposed to climate change based on the Global Climate Risk Index [37]. Consequently, this research paper “A Review of Renewable Energy Development and its Policy under Nationally Determined Contributions in ASEAN” comes up with policy recommendations as follows: Available renewable energy technologies such as solar energy, wind energy, hydropower, geothermal and biomass will have to be explored by the region with the ultimate goal to establish low emission power system. Attention and priority should be focused on technologies to tap energy sources from hydropower, geothermal and biomass because it is vastly available at the cheapest cost; at the same time, the development standard should be strictly executed to ensure long-term benefits, avoiding the technical failure. The energy cooperation, cross-border energy interconnection and multilateral trading between countries should be

maintained and encouraged as it is the crucial step to realize the regional development. The existing multilateral trading between Laos PDR, Thailand and Malaysia could be set as good example and open the ways for more cooperation in other countries. Additionally, Feed-in-Tariffs (FiT) is the stepping stone for ASEAN to foster renewable energy development in the region, since it has significant impact to the rise of installed capacity in ASEAN. The main purpose of FiT is to create RE market in the initial stage to attract the investor because it can make RE more competitive than other conventional sources. It should be also taken into consideration for the fact that FiT is great tool but need to be continuously reviewed and finally changed to auction when the market is established to further lower the cost of RE.

To realize the ambition for the sufficient energy supply to meet the constantly-growing economic community, carbon dioxide emissions reduction has to go hand-in-hand with the expansion of clean energy and modern renewables specially in its energy mix because the target is set and the agreement is made. Depending on renewable energy development which ignoring the emissions from coal and other sectors would turn into ineffective policy execution that has been introduced by the countries in ASEAN. ASEAN member states should lay out more energy policies to introduce more financial incentives for renewable energy in their own countries. At the ASEAN level, smart grid sees the growing trend whereby solar power plant could connect to the national grid owned by the government. This grid provides the meeting points between energy supply and demand. The idea of transboundary grids is being promoted in the ASEAN Power Grid. This grid is expected to make a major contribution to maximizing ASEAN's benefit in avoiding the cost of power generation. In building and construction sector, energy efficiency has monumental roles to play to assist the investor pinpoint the minimum usage of electricity and water in the building, resulting in energy saving, resource allocation and economic expansion.

The balance between supply-demand together with the readiness of the system as well as the cost efficiency should be evaluated when it comes to the development of RE power plants. Renewable Energy based on industrial development could also be one of the promising options for countries in ASEAN including small scale and large scale. Particularly solar PV, ASEAN could develop centralized solar PV to electrify isolated/remoted areas that relatively far from existing grids so that energy poverty could be reduced. Energy interconnection through solar power grid should be studied further to enable a large transmission of power from country to country, resulting in economic development and prosperous future for ASEAN nations.

6. Conclusion

In conclusion, some effective energy policy frameworks in deploying renewable energy potentials to support the NDCs of each ASEAN Member States (AMS) are recommended to achieve those targets. Renewable energy incentives and Feed-in-Tariff (FiT) are highlighted to promote higher share of RE in power generation mix. Government subsidies on renewable energy projects are encouraged, especially on solar photovoltaic (PV) while well-defined regulations should be in place. Attention and priority should be focused on technologies to tap energy sources from hydro, geothermal and biomass because it is vastly available at the cheapest cost. Energy interconnection through solar power grid should be studied further to enable a large transmission of power from country to country, resulting in economic development and prosperous future for ASEAN nations towards a united, inclusive, sustainable and resilient community. Additional investigation should be conducted on the barriers and loopholes during renewable energy policy implementation and the national directions for each country beyond 2030.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

It should be noted that Mr. Visal VENGG who is the corresponding author had written and revised the

entire paper while Ms. Nadhilah Shani had reviewed and provided additional comments. Mr. Beni Suryadi and Mr. Aloysius Damar Pranadia had also contributed to this work, particularly on technical advice as well as data verification. It is confirmed that all authors had approved the final version.

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