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THE ROLE OF RENEWABLE ENERGY IN RESOLVING ENERGY INSECURITY IN ASIA

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Abstract

Energy security implies the availability, affordability, applicability, plausibility and acceptability of countries' energy supply. Implying the sustainability of countries' energy supplies, energy insecurity is widespread across Asia. Southeast Asia (SEA) serves as an example for Asia's energy insecurity. Notwithstanding efforts to expand its share of renewable energy (renewables), fossil energy dominates the regional energy mix. Various factors have created obstacles for the expansion of renewables in SEA, prolonging this environmentally unsustainable situation. Their addressing demands a comprehensive approach to ensure the energy requirements of the regional countries and also their social and economic development in determining their choice of energy. Singapore and the Philippines serve as good examples of energy insecurity in SEA, having fossil energy-dominated energy mixes. Expanding the share of renewables in their energy mixes demands different plans linked to their sustainable development, which is true for the rest of SEA. However, achieving this objective demands different routes, given their differences in terms of the availability, affordability, applicability, plausibility and acceptability of energy, particularly those of environmentally clean renewables. It necessitates sustainable energy to make such renewables a necessity whose local production could serve as an engine for economic development while simultaneously ending their energy insecurity.

Keywords: renewable energy, energy security, climate change, sustainable development, sustainable energy

JEL Classification: Q42

Contents

1. INTRODUCTION

Energy security, as an inter-disciplinary field, focuses on various factors (e.g., energy, natural resources, environmental, economic, social, political/geopolitical, military/ security and technological) and issues (e.g., economic, energy and foreign policies, crises and conflicts, climate change and sustainable development/energy) affecting countries' efforts to firmly secure their energy requirements in an environmentally and economically sustainable manner while being socially acceptable. It also focuses on how these efforts influence the aforementioned factors and issues, in turn. In other words, it involves the availability, affordability, applicability, plausibility and acceptability of energy for countries.

Implying the sustainability of countries' energy supply, energy insecurity is widespread in Asia. Within this context, Southeast Asia (SEA) serves as an example of Asia's energy insecurity. Despite the regional countries' efforts to expand their share of renewable energy (hereafter renewables), fossil energy (oil, gas and coal) still dominates the regional energy mix. Various factors have created obstacles to the expansion of renewables in SEA, thus prolonging this environmentally unsustainable situation. Addressing these factors demands a comprehensive approach to ensure the energy requirements of the regional countries as well as their social and economic development, all of which determine their choice of energy.

Having fossil energy-dominated energy mixes, Singapore and the Philippines serve as good examples of energy insecurity in SEA. Expanding the share of renewables in their energy mixes demands different plans linked to their sustainable development, which is true for the rest of SEA. Yet, achieving this objective requires different methods, given their differences in terms of the availability, affordability, applicability, plausibility and acceptability of energy supplies, particularly those of environmentally clean renewables (e.g., hydro, wind, solar and geothermal). The latter requires sustainable energy to make such renewables a necessity, the local production of which could serve as an engine for economic development while ending their energy insecurity.

To shed light on this paper's main argument, section 2 discusses the context of energy security in SEA while elaborating on different definitions of energy security and their respective implications. Serving as a background to the main argument, section 3 studies energy insecurity in SEA and the obstacles to renewables in this region; it concentrates on Singapore and the Philippines as case studies. Specific reasons for the domination of fossil energy in Singapore and the Philippines are the focus of section 4, which is followed by section 5, which discusses the relationship between sustainable development and sustainable energy in SEA and how renewables could benefit the region's sustainable development. Finally, section 6 serves as the conclusion and provides certain policy recommendations for SEA on how to deal with regional countries' energy insecurity by removing the obstacles to the expansion of renewables in the regional countries.

2. CONTEXT OF ENERGY SECURITY

Energy security implies the availability, affordability, accessibility, plausibility and acceptability of energy for countries.[1] Apart from the so-called traditional definition of energy security focusing on the availability and affordability of energy supplies as defined, for instance, by the International Energy Agency (IEA), i.e., "the uninterrupted availability of energy sources at an affordable price" (IEA 2019), other definitions have also been suggested such as the following broader perspective by Taghizadeh-Hesary et al. (2019a):

The multi-faceted characteristics of energy security range from the inherent economic aspect of energy security to the strategic and geopolitical nature of energy security. This in turn presents four broadly defined dimensions on which energy security could be defined—economic, political, geopolitical, and institutional, legal, and regulatory context. The first dimension is the economics of energy security, which mainly covers the consequences of import dependence and instability of energy markets. The second dimension is the political economy of energy security, which specifically examines inter-relations between crude power and oil-importing and oil-exporting countries. The third dimension is the geopolitics of international relations, which explores how the geopolitics influences and shapes coalition, cooperation, or unilateral action for energy security. The fourth dimension is the aspect of energy security in terms of institutional, legal, and regulatory frameworks in the local, regional, and international contexts.

Sopitsuda Tongsopit et al. (2016) offers another definition focusing on four elements, namely the availability, acceptability, affordability and applicability of energy supplies for countries.

This paper uses one of its author's definitions (Peimani 2011) as it is comprehensive and thus involves not only the economic elements (availability and affordability), but also political/security (accessibility), environmental and developmental (plausibility) and social (acceptability) ones in assessing countries' energy security.

Given this definition, which implies the sustainability of energy for countries, energy insecurity is widespread in Asia, although there are many differences between and among the Asian countries in terms of the contributing factors. SEA serves as an example for energy insecurity on this continent in spite of the differences in the scale and scope of this phenomenon between the regional countries.

The six largest SEA countries in terms of land, population and/or GDP (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam) consumed 609.6 million tons of oil equivalent (mtoe) of energy in 2017 (Table 1), accounting for the bulk of their region's consumption,[2] registering an increase of 9.9 mtoe over their 2016 consumption of 589.7 (BP 2018).[3] Their energy consumption is increasing significantly because of their expanding economies and growing populations. SEA's annual energy growth rate in the period ending 2025 is estimated at 4%, "amounting to a rise of 50% over 2014 levels" (IRENA 2016).

[1] For a detailed discussion of this definition, see Peimani (2011).

[2] Comparable data on the smaller regional countries (Brunei Darussalam, Cambodia, the Lao PDR, Myanmar, and Timor-Leste) are unavailable.

[3] Total consumption, increased consumption and the percentage of growth were calculated by the author.

Table 1: Energy Mix of SEA 2017 (MTOE)

Country	Oil	Gas	Coal	Nuclear Energy+	Hydro-electricity	Renewables	Total
Brunei Darussalam*	–	–	–	–	–	–	–
Cambodia*	–	–	–	–	–	–	–
Timor-Leste*	–	–	–	–	–	–	–
Indonesia	77.3	33.7	57.2	–	4.2	2.9	175.2
Lao People's Democratic Republic*	–	–	–	–	–	–	–
Malaysia	36.9	36.8	20.0	–	5.6	0.4	99.6
Myanmar	–	–	–	–	–	–	–
Philippines	21.7	3.2	13.1	–	2.2	3.1	43.3
Singapore	75.3	10.6	0.4	–	–	0.3	86.5
Thailand	63.9	43.1	18.3	–	1.1	3.4	129.7
Viet Nam	23.0	8.1	28.2	–	15.9	0.1	75.3

*Comparative data are unavailable.

+SEA's energy mix lacks nuclear energy.

Source: Author's creation based on data provided in BP (2018).

This significant estimated increase makes addressing the region's energy security a priority for at least two major reasons. On the one hand, SEA's own fossil energy resources are unevenly distributed among the regional countries, leaving Singapore with no reserves and small or insignificant reserves for others (Cambodia, the Lao People's Democratic Republic, and the Philippines), as reflected in Table 2.

Table 2: Proven Reserves of Fossil Energy in SEA 2017

	Oil billion barrels	**Gas** trillion cubic meters	**Coal** million tons
Brunei Darussalam	1.1	0.3	_*
Indonesia	3.2	2.9	22,598
Malaysia	3.6	2.7	_*
Myanmar	_*	1.2	_*
Thailand	0.3	0.2	1,063
Viet Nam	4.4	0.6	3,360

*****Insignificant or no reserves at all.

Source: Author's creation based on data provided in BP (2018).

The proven regional fossil energy reserves are not enough to fully satisfy even their current energy requirements, making the region dependent on energy imports (Table 3) with its associated financial burdens and risks. Thanks to SEA's growing economies and populations, alongside improving living standards, the growing increase in energy demand will expand their dependency on energy imports.

Table 3: Energy Imports of SEA 2017

	Oil		
Country	**Production MT***	**Consumption MT**	**Imports+ mtoe**
Brunei Darussalam	5.5	_**	00.0
Indonesia	46.4	77.3	30.0
Malaysia	32.2	36.9	4.7
Myanmar	_**	_**	_**
Philippines	_**	21.7	_**
Singapore	00.0	75.3	75.3
Thailand	16.8	63.9	47.1
Viet Nam	16.1	23	6.9
	Gas		
Country	**Production BCM++**	**Consumption BCM**	**Imports BCM**
Brunei Darussalam	12	_**	0.0
Indonesia	68	39.2	0.0
Malaysia	78.4	42.8	0.0
Myanmar	18	_**	_**
Philippines	_**	3.8	_**
Singapore	00.0	12.3	12.3
Thailand	38.7	50.1	8.2
Viet Nam	9.5	9.5	0.0
	Coal		
Country	**Production MTOE**	**Consumption MTOE**	**Imports MTOE**
Brunei Darussalam	0.0	0.0	0.0
Indonesia	271.6	57.2	214.4
Malaysia	_**	20	_**
Myanmar	_**	_**	_**
Philippines	_**	13.1	_**
Singapore	0	0.4	0.4
Thailand	4.1	18.3	14.2
Viet Nam	21.3	28.2	6.9

*MT: Million tons.

**Data unavailable.

+Calculated by the author.

++BCM: Billion Cubic Meters.

Source: Author's creation based on data provided in BP (2018).

On the other hand, the current heavy consumption of oil, gas and coal by SEA countries is unsustainable and worsening climate change, with its devastating environmental, health and economic/financial consequences of delaying, damaging and, quite possibly, preventing the sustainable development of these countries should the current trend continue. Meeting their increasing energy demand with mainly oil, gas and coal will certainly have catastrophic consequences for the regional countries, as is the case in all

other regions, and worsen the expanding climate change caused by the phenomenal consumption of these pollutive fuels over the last two centuries.

Apart from the obvious environmental unsustainability of any increase in fossil energy consumption and its negative impact on the regional populations' health, the resulting air pollution will damage the regional economies extensively. As estimated by the International Renewable Energy Agency (IRENA), SEA's "external costs caused by air pollution from fossil fuel combustion will increase by 35%, jumping from $167 billion in 2014 to $225 billion in 2025" (IRENA 2016). Hence, reducing the regional countries' dependency on fossil energy for the bulk of their energy demand and aiming at low-carbon and eventually zero-carbon economies is as much an economic necessity as an environmental one.

3. ENERGY INSECURITY IN SEA

This region has a large and growing population and expanding economies with increasing energy consumption. Appreciating the unsustainable nature of the growing consumption of fossil energy, the regional countries have sought to decrease their dependency on such energy by increasing their share of renewables in their energy mix. In particular, the Association of Southeast Asian Nations (ASEAN), of which all the regional countries except Timor-Leste are members, has tried to support and quicken the achievement of this objective as a necessity for their sustainable, secure and prosperous future. Thus, it has set a target share of 23% for renewables of the region's primary energy consumption by 2025, a major increase of its share of 9.4% in 2014. However, according to IRENA, the "current policies – including those still under consideration – only suffice to reach just under 17% renewables. This leaves a crucial six-percentage-point gap" (IRENA 2016).

As it stands today (January 2019), other regional initiatives will not help to fill this gap as they do not require any additional increase in SEA's renewable consumption than that of ASEAN. Chief among them is the initiative of APEC (Asia-Pacific Economic Cooperation), as presented in the 2014 APEC Economic Leaders Declaration. Accordingly, APEC declared its 2030 objective of doubling the share of renewables in the APEC energy mix, including in power generation, through the efforts of its 21 member countries, of which seven (Brunei Darussalam, Indonesia, Malaysia, Thailand, the Philippines, Singapore, and Viet Nam) are SEA countries (APEC 2017). Additionally, the APEC target is for the entire APEC region, which includes 14 non-SEA economies (the People's Republic of China [PRC]; Hong Kong, China; Taipei,China; Japan; the Republic of Korea; Papua New Guinea; Australia; New Zealand; Canada; the United States (US); Mexico; Chile; Peru; and the Russian Federation). Given that they account for the bulk of the APEC region's energy consumption and include four of the world's five largest energy users (the PRC, the US, the Russian Federation, and Japan), its target, which does not require the doubling of this share in every APEC member economy, can be achieved by the uneven efforts of only some of its members, while others lag behind.

In short, SEA's current energy insecurity can and should be addressed to ensure regional sustainable growth. Yet, as it stands today, the pace of events will not address this challenge in the foreseeable future. Hence, addressing it requires the identification and removal of the obstacles to the expansion of renewables in SEA.

4. OBSTACLES TO RENEWABLES AND CASE STUDIES

4.1 Obstacles to Renewables

Various factors have created obstacles to the expansion of renewables in SEA, thus prolonging this environmentally unsustainable situation characterized by a pattern of preference for fossil energy. The availability of fossil energy is a major factor. The regional countries, excluding Singapore, all have a degree of oil, gas and/or coal reserves, although none is fully self-sufficient in all these fuels and, in cases, such reserves are insignificant or small (e.g., Cambodia and the Lao People's Democratic Republic [Lao PDR]). Consequently, the majority of them have to rely on large imports of some or all of these fuel requirements to a varying extent, as evident in Table 3. Despite this, oil, gas and coal are abundant globally and in the Asia and Pacific region (e.g., Australia and the Russian Federation) of which SEA is a part. The world's single largest oil and gas-exporting region, the Persian Gulf, is not too far from SEA to which it has been a major supplier, added to North, East and West African suppliers.

Hence, the ease of accessing supplies (accessibility) is another major factor. Such supplies are, by and large, affordable despite the periods of price hikes, which mainly affect oil, while gas and coal are significantly cheaper, the main reason for the large share of coal of the region's largest energy consumer as evident in Table 4. Thus, the affordability of fossil energy is yet another reason.

Table 4: Share of Coal in SEA's Energy Mix 2017

Country	Total Coal Consumption MTOE	Total Energy Consumption MTOE	Share of Coal of Total Energy Consumption %*
Indonesia	57.2	175.2	32.64
Malaysia	20.0	99.6	20.08
Philippines	13.1	43.3	30.25
Singapore	0.4	86.5	0.46
Thailand	18.3	129.7	14.10
Viet Nam	28.2	75.3	37.45

Source: Author's creation based on data provided in BP (2018).

*Author's calculations.

Cost considerations as a component of affordability account for another major factor. Apart from the traditional renewables, which are widely available and inexpensive (e.g., wood, charcoal and animal waste), other major renewables (solar and wind) require the importation of the foreign-developed technologies, making them costly and thus not preferable. Of course, their prices have been falling for various reasons (technological advancements, large-scale production, etc.), as discussed in detail by scholars such as Farhad Taghizadeh-Hesary et al. (2019b) in their elaboration on the role of the contributing economic and monetary factors in lowering the prices of solar panels. Nevertheless, such technologies remain expensive and are not affordable for many SEA countries.

The exception is hydro-electricity, which accounts for a significant share of Viet Nam's energy mix (21.11% in 2017); other regional countries with a suitable natural environment have much smaller shares, as demonstrated in Table 5. Apart from

hydro-electricity, another exception is geothermal energy in the case of the Philippines, accounting for a significant portion of their renewables. For example, geothermal energy accounted for 14% of the Philippines's energy mix for electricity generation in 2015 (IRENA 2017b).

As a related component of cost considerations, financing renewable projects is a major obstacle for low-income South Asian countries. In this regard, the major challenge for filling the financing gaps of green energy is the lower rate of return and higher risk of green projects compared to fossil fuels. Yoshino, Taghizadeh-Hesary, and Nakahigashi (2019) and Taghizadeh-Hesary and Yoshino (2019c) proposed two types of innovative financing solutions to increase the rate of return and reduce the risk of investment in renewables projects. The first one is utilizing spillover tax revenue originally generated by green energy supply and returning it to green energy projects in order to increase their rate of return, making them more interesting for private investors. The second solution is the establishment of a green credit guarantee scheme in order to reduce and manage the risk of investment in renewables projects.

Table 5: Share of Renewables of SEA's Energy Mix 2017 (MTOE)

	Hydro-electricity	Other Renewables	Total Renewables**	Total Energy Consumption**	Share of Hydro-electricity of Total Consumption %**	Share of Total Renewables Of Total Consumption %**
Brunei Darussalam*	–	–	–	–	–	–
Cambodia*	1.1	0.0	1.1	–	–	–
Timor-Leste*	–	–	–	–	–	–
Indonesia	4.2	2.9	7.1	175.2	2.39	4.05
Lao People's Democratic Republic*	–	–	–	–	–	–
Malaysia	5.6	0.4	6.0	99.6	5.62	6.02
Myanmar*	–	–	–	–	–	–
Philippines	2.2	3.1	5.3	43.3	5.08	12.24
Singapore	0	0.3	0.3	86.5	0	0.34
Thailand	1.1	3.4	4.5	129.7	0.8	3.46
Viet Nam	15.9	0.1	16.0	75.3	21.11	21.24

*Comparative data is unavailable. IRENA's 2014 data is used.

**Calculated by the author.

Source: Author's creation based on data provided in BP (2018).

It should be stressed that hydro-electricity and geothermal aside, the bulk of the renewables used in SEA is biomass, also known as bioenergy, which is not environmentally clean as it emits greenhouse gases (GHG) when consumed and/or their process of production is pollutive (in the case of biofuels). For example, Indonesia has massively destroyed its forests to clear land for palm tree cultivation to produce palm oil used in many industries (e.g., food and hygiene) globally. A growing part of such oil is its use as a raw material for producing biofuel partly in Indonesia, but mainly in economically-advanced countries such as those in Europe. Indonesia produced 2,326,000 tons of oil equivalent of biofuel in 2017, registering an 11-fold increase in its production compared to 2007 when it produced 217,000 tons of oil equivalent (BP 2018).

The release of the stored CO_2 in the trees cut for land clearing added to that emitted during the intentional burning of trees, which is the fastest and cheapest method for clearing land for planting palm trees. Similarly, the massive destruction of Indonesia's forests has contributed significantly to turning it into the world's 11th largest GHG emitter, with 515 million tons of carbon dioxide emissions in 2017 (BP 2018); an unenviable rank inconsistent with its GDP of $1,015,539,000, granting it the rank of the 16th largest economy (World Bank 2018).

A major part of biomass consumed in SEA is traditional bioenergy (e.g., wood, charcoal and animal waste), used especially in rural areas, primarily for cooking as the readily available inexpensive fuel, which is the case in many other developing countries.

As a matter of fact, the major global growth of renewables, including in Asia and its sub-regions such as SEA, has been in pollutive and thus non-green bioenergy, as reported by IRENA. This type of renewables is presented as a less pollutive and more sustainable alternative to oil, gas and coal for a range of applications, including transportation (bioethanol and biodiesel) and household needs (e.g., biogas). The technological ease and low cost of their production have made them the preferable type of renewable. These two factors are especially true when the production of bioenergy is done without regard for environmental considerations, which is true in the majority of cases as reflected in the clear-cutting of forests for burning wood and charcoal production, as well as palm oil production for producing biofuels and exhausting fresh water resources for biofuel production. Consequently, as IRENA reported:

About three-quarters of the world's renewable energy use involves bioenergy, with more than half of that consisting of traditional biomass use. Bioenergy accounted for about 10% of total final energy consumption and 1.4% of global power generation in 2015 (IRENA 2017a).

The 10 forming countries of the ASEAN region consumed 49.25 mtoe of traditional bioenergy in 2015, the most recent year for which such data exist (ACE 2017). This consumption accounted for 7.83% of their total primary energy supply of 628.45 mtoe (ACE 2017).

Other factors creating obstacles to the expansion of renewables in SEA include the ease of use of fossil energy given the regional countries' decades of using oil, gas and coal, which has shaped their economies and the daily life of their populations. Finally, the lack or limited availability of indigenous renewable technology is another obstacle.

Addressing these factors and thus removing the obstacles to the expansion of renewables demands a comprehensive approach not only to ensure the energy requirements of the regional countries, but also their overall situation. The latter includes, particularly, the social and economic realms, given their significance in terms of determining the individual countries' choice of supplies for their energy needs.

Briefly, ease of use, availability, accessibility and affordability of fossil energy to which the SEA are accustomed have made oil, gas and coal socially acceptable, although their expanding health, environmental and economic costs are challenging its acceptability to a varying extent depending on its significance in the regional countries. Hence, their environmental and developmental challenges and associated health hazards are increasingly causing populations to question their use of oil, gas and coal as the main source of energy for the SEA countries and thus their unsustainable nature, resulting in energy insecurity.

4.2 Case Studies

Singapore and the Philippines serve as good examples to examine the phenomenon of energy insecurity in SEA, given their respective rank as one of the region's most and least prosperous countries, respectively.[41] Despite their many differences in terms of energy requirements and the availability of means to satisfy them, their energy mixes are dominated by fossil energy, although that of the Philippines has a larger share of renewables.

Table 6: Share of Renewables and Fossil Energy of the Energy Mixes of Singapore and the Philippines (MTOE)

	Hydro-electricity (MTOE)	Other Renewables (MTOE)	Total Renewables** (MTOE)	Total Energy Consumption** (MTOE)	Share of Total Renewables of Total Energy Consumption**	Share of Total Fossil Energy of Total Consumption**
Philippines	2.2	3.1	5.3	43.3	12.25%	87.75%
Singapore	–*	0.3	0.3	86.5	0.34%	99.66%

*Singapore has no river suitable for dam building.

**Calculated by the author.

Source: Author's creation based on data provided in BP (2018).

4.2.1 Singapore

Fossil energy accounted for practically the entire energy consumption of Singapore in 2017 (99.65%) when its total energy consumption of 86.5 mtoe (Table 6) left a negligible share of 0.34% for renewables. Waste-to-energy accounted for the bulk of its renewables, except for a small amount of solar energy. The country has four waste-to-energy power generators (NEA 2019a), while the bulk of its electricity is generated by gas. In 2017, the country's energy mix for electricity generation consisted of gas (95.15%), petroleum products (0.67%) and others (4.18%) (EMA 2018a). "Others" consisted of municipal waste, biomass and solar (2.9%) and coal (1.3%).[5] Diesel and fuel oil accounted for the bulk of petroleum products (EMA 2018b). The share of solar energy of the country's electricity generation was only 0.2% (EMA 2018c).

Singapore encourages waste-to-energy for which municipal waste and biomass are used as a means to address the country's waste management and minimize the need for landfill space, a necessity because of its land scarcity, while diversifying its aforementioned energy mix using the most practical type of renewables. Singapore's National Environment Agency (NEA) describes the process as follows:

At source where the waste is generated, recyclables are sorted and retrieved for processing to conserve resources. The remaining waste is collected and sent to waste-to-energy plants for incineration.

Incineration reduces the waste by up to 90%, saving landfill space, and the heat is recovered to produce steam that propels turbine-generators to generate electricity, providing up to 3% of the island's electricity needs. The incineration ash and other non-

[4] Cambodia, the Lao PDR, and Timor-Leste are less-developed and less-prosperous than the Philippines, but comparable data on them are unavailable.

[5] Figures are rounded up by the source, i.e., Singapore's EMA.

incinerable wastes are then transported to the Tuas Marine Transfer Station (TMTS) from where they are barged to Semakau Landfill for final disposal. (NEA 2019b).

With its existing technologies, the country has a limited potential for renewables given its lack of a suitable environment for all types of renewables except a limited amount of solar, as stressed by the country's Energy Market Authority (EMA):

In Singapore, we have limited renewable energy options. There are no hydro resources, our wind speeds and mean tidal range are low, and geothermal energy is not economically viable. Solar energy remains the most viable renewable energy option for Singapore when it becomes commercially viable (EMA 2018d).

While solar is an option pursued by Singapore, the country's very small land surface (722.5 square kilometers, 2017), with a population of over 5 million (5.61 in 2017) (Singstat 2017), creates challenges to its expansion. Land scarcity leaves rooftop solar panels as the main suitable option, now accounting for almost all of the installed grid-connected solar panels.

While Grid-connected installed capacity grew sharply from 7.7 MWac in 2012 to 96.7 MWac in 2016, its growth had moderated recently and total installed capacity stood at 114.8 MWac in 1Q 2018. This growth is likely to increase. The Housing & Development Board (HDB) and the Economic Development Board (EDB) are jointly spearheading the acceleration of the deployment of solar PV [photovoltaic] systems in Singapore through the SolarNova project, which was launched in 2014. As part of this effort, three solar leasing tenders have been called to-date. Singapore is expected to reach the committed solar PV capacity of 350 MWp via this project by 2020 (EMA 2018e).

The country has sought to expand its solar power generation within its geographical limits by exploring pioneering technologies recently used in other countries (e.g., the PRC) such as floating solar panels on its water reservoirs "where sun meets water", as the technology's respective estimated global potential 400 gigawatts growth is described (World Bank 2018). Its Tengeh Reservoir has already been used for testing solar panels for such purpose on a small scale (1 MWp), with positive results to prompt Singapore's national water agency (PUB) to deploy a 50MWp floating solar panel system at the Reservoir by 2021 (Strait Times 2018a). Additionally, it is now building a large offshore floating solar panel system near Singapore's northern shores, which is, reportedly, "one of the world's largest sea-based floating photovoltaic (PV) system[s]" to generate about 6,388 MWh annually; it is scheduled to become operational in 2019 (Strait Times 2018b).

Despite these encouraging projects, a major expansion of renewables in Singapore in the foreseeable future is highly unlikely, at least with the existing technologies, which are not suitable for the country given its aforementioned geographical and geological restrictions. While the use of rooftop and floating solar panels will become more common, their contribution to the country's electricity generation will be small; waste-to-energy will therefore remain the largest and most commonly used type of renewables in Singapore.

4.2.2 The Philippines

Fossil energy dominates the Philippines' energy mix, as in Singapore (Table 6). Oil, gas and coal accounted for 87.75% of its mix of 43.3 mtoe in 2017 equal to 38 mtoe. Of course, at 12.25%, its share of renewables, including hydro-electricity, its energy mix is much larger than that of Singapore. Lacking any significant reserves of oil, gas and coal, the country's heavy dependency on their imports with its tremendous financial burden on the economy has been a major incentive for the country to increase the production and consumption of renewables. The country's geographic and geological characteristics have provided a suitable ground and potential for the expansion of renewables,

particularly in certain fields. Based on the most recent available statistics (2017), the Philippines's geothermal sector (868 MW) now ranks second globally after the United States (3591 MW) (Think Geoenergy 2019). Unlike most renewables (wind and solar), geothermal is not an intermittent source of energy and thus it is suitable for supplying baseload electricity.

Appreciating the necessity of decreasing its fossil fuel consumption for health and environmental reasons and being mindful of the heavy cost of its dependency on imported fossil energy, the Philippines' government has sought to encourage and facilitate the production of indigenous renewables by using its largely unharnessed potential.

As a recent major example, its National Renewable Energy Program (NREP) of 2011 "outlines the policy framework enshrined in Republic Act 9513" by stating:

the strategic building blocks that will help the country achieve the goals set forth in the Renewable Energy Act of 2008. The NREP signals the country's big leap from fragmented and halting RE [renewable] energy initiatives into a focused and sustained drive towards energy security and improved access to clean energy. The NREP sets out indicative interim targets for the delivery of renewable energy within the time frame of 2011 to 2030 (DOE 2019a).

The NREP seeks a three-fold increase in the Philippines' renewable-based capacity of 2010 to 15,304 MW by the year 2030 (DOE 2019b). Apart from institutionalizing "a comprehensive approach to address the challenges and gaps that prevent and/or delay wider application of RE technologies in a sustainable manner," and outlining "the action plans necessary to facilitate and encourage greater private sector investments in RE development," the NREP intends to realize the following specific objectives:

1. Increasing geothermal capacity by 75.0%;
2. Increasing hydropower capacity by 160%;
3. Delivering an additional 277 MW biomass power capacity;
4. Attain wind power grid parity with the commissioning of 2,345 MW additional capacity;
5. Mainstreaming an additional 284 MW solar power capacity and work towards achieving the ultimate target of 1,528 MW;
6. Developing the country's first ocean energy facility (DOE 2019b).

Despite governmental support, the Philippines still lags behind its extensive renewable potentials in hydro, ocean energy, geothermal, wind and solar. According to the available statistics provided by its Department of Energy (DOE), many renewable projects have been awarded in these fields, most of which have not been implemented. Of the awarded projects, only geothermal, biofuel and biomass ones have exceeded the expected potentials as apparent in Table 7, although the fact that the awarded projects are still a fraction of the country's achievable potential in renewables should be kept in mind.

Table 7: Summary of the Philippines Awarded Renewable Energy Project by End of 2017

	Awarded Projects		Potential Capacity MW*		Installed Capacity MW	
	Commercial	**Own-Use**	**Commercial**	**Own-Use**	**Commercial**	**Own-Use**
Hydro Power	444	–	13,467.53	–	974.79	–
Ocean Energy	7	–	26.00	–	–	–
Geothermal	41	–	575.00	–	1,906.19	–
Wind	65	1	2,461.50	–	426.90	0.006
Solar	216	16	6,882.92	4.286	905.18	3.218
Biomass	55	24	346.68	16.77	407.15	128.16
Sub-Total	828	41	23,759.63	21.056	4,620.21	131.38
Total	**869**		**23,780.69**		**4,751.59**	

*MW = megawatt.

Source: Author's creation based on data provided in DOE (2019c).

4.2.3 Comparative Analysis

The Philippines and Singapore have both taken measures to create and expand their renewables sectors. As is the case in all other countries, both in SEA and other regions, these measures are mainly aimed at replacing fossil energy with renewables for electricity generation, but not as an alternative to liquid fuel for transportation. As it stands, these two countries, like other ASEAN nations, will not be able to meet ASEAN's aspirational target for their renewable energy mix share (23%) by 2025 and thus must increase their efforts to cover the projected gap of 6%. The following Tables 8 and 9 reflect this situation. Using their actual achievements in 2014 as the reference date, they compare the Philippines' and Singapore's government-projected expansion of their electricity generation by renewables by the target year (Reference Case 2025) with the required increase in their electricity generation to meet the target share in renewables (REmap 2025).

Thus, in the case of the Philippines, the actual renewable electricity generation in 2014 (19.8 WWh) was 25.62% of total electricity generation, reflecting the large share of GHG-emitting fossil energy in the country's electricity generation. As it stands, the Philippines' renewable share of its electricity generation will increase to 28.47% (40.6 WWh) in 2025, while it must reach 32.56% (46.7 WWh) to meet the target share. The projected volume of generated electricity in 2025 matches the required volume only in the cases of hydropower and geothermal, but lags behind in wind, solar PV and biofuels, as reflected in Table 8.

In the case of Singapore, the share of renewables in its electricity generation in 2014 was 1.90% (0.92 WWh) of the country's total electricity generation of 48.27 WWh, indicating the almost total domination of GHG-emitting fossil energy in the country's electricity generation energy mix. According to its government projections, the expected growth in renewables will secure a share of only 2.26% (1.47 WWh) of the country's total electricity generation in 2025. Meeting the ASEAN's aspirational goal means that Singapore must increase this share to 9.53% (6.18 WWh) of that year's total projected electricity generation of 64.81 WWh. Lacking hydropower, wind, geothermal and marine energy, the expected growth in biofuel and solar PV will not be large enough to help the country match the required growth in renewables to meet the aspirational target, which requires not only large contributions from biofuels and solar PV, but also from wind, marine and other types of renewables.

Table 8: Share of Renewables in Electricity Generation in 2014 and Projected Shares in 2025 – The Philippines

	Unit	2014	Reference Case 2025	REmap 2025
Total electricity generation	TWh check	77.3	142.6	143.4
Renewable generation	TWh	19.8 25.62% of Total	40.6 28.47% of Total	46.7 32.56% of Total
Hydropower	TWh	9.1	14.8	14.8
Wind	TWh	0.2	0.6	2.2
Biofuels (solid, liquid, gaseous)	TWh	0.2	2.5	3.8
Solar PV	TWh	0.0	2.6	5.7
Geothermal	TWh	10.3	20.1	20.1
Marine, other	TWh	0.0	0.0	0.0
Non-renewable generation	TWh	57.5	101.9	96.8

Source: Author's creation based on data provided in IRENA (2016).

Table 9: Share of Renewables in Electricity Generation in 2014 and Projected Shares in 2025 – Singapore

	Unit	2014	Reference Case 2025	REmap 2025
Total electricity generation	TWh	48.27	64.81	64.81
Renewable generation	TWh	0.92 1.90% of Total	1.47 2.26% of Total	6.18 9.53% of Total
Hydropower	TWh	0.00	0.00	0.00
Wind	TWh	0.00	0.00	0.83
Biofuels (solid, liquid, gaseous)	TWh	0.88	1.18	1.51
Solar PV	TWh	0.04	0.29	3.34
Geothermal	TWh	0.00	0.00	0.00
Marine, other	TWh	0.00	0.00	0.50
Non-renewable generation	TWh	47.35	63.34	58.63

Source: Author's creation based on data provided in IRENA (2016).

4-2-4 Specific Reasons for the Domination of Fossil Energy in Singapore and the Philippines

By and large, the above-mentioned obstacles to the expansion of renewables have served as the common reasons justifying the Philippines' and Singapore's opting for fossil energy as their main source of energy. However, the differences in their overall situations demand different solutions in order to significantly expand the renewables share of their energy mixes. The cost of switching to renewables is certainly a common reason discouraging not just for these two countries or SEA countries in general, but for just about any other country in the expansion of renewables, as discussed in detail in many scholarly works and, most recently, by J. Sachs et al. (2019) in their dealing with the importance of green financing.

However, cost is more of a reason for the Philippines as a middle-income SEA country than for Singapore, the region's wealthiest and most developed country, although it is certainly a major consideration for Singapore as well. Despite this, Singapore's lack of potential for hydro and geothermal eliminates these two renewables as options. Weak

wind speeds mean the commonly-used horizontal wind turbines are not an option for it either. Lacking gas and oil reserves, making it 100% dependent on imports, the local availability of these fuels is not the reason for the negligible share of renewables in its energy mix, although their global availability compensates for this shortcoming, while creating a very heavy financial burden on the country.

Having said that, land scarcity is the single major obstacle for the limited growth of renewables. This explains why the country, which is blessed with sunshine, has had very limited progress in solar energy, notwithstanding its aims at turning itself into a hub of research and development for solar technology and eventually a technology exporter. To this end, it established the Solar Energy Research Institute of Singapore (SERIS) in 2008 to, for example, "conduct industry-oriented R&D in solar energy technologies and their integration into power systems and buildings" (APERC 2018). Hence, removing the major obstacles to renewables' expansion in Singapore necessitates that the country addresses this issue through certain innovations to be discussed in this paper's section on policy recommendations.

In the case of the Philippines, land scarcity is not a reason for the limited progress of renewables, although such progress is much larger than that of Singapore, nor are the geological realities, as the country has unharnessed potential for geothermal, wind, solar, ocean and hydro energy. Surely, the Philippines' reserves of oil and coal in particular, while not enough to wholly meet its requirements of fossil energy, have created an incentive to use them. Nevertheless, the cost of switching to renewables, which requires imported technology, has certainly functioned as a major disincentive. This explains why locally-available renewables, i.e., traditional biomass, are widely used in SEA, including the Philippines. Addressing the cost issue is therefore the main solution in expanding the renewables energy mix share for as long as the country is dependent on foreign technology for this purpose.

5. SUSTAINABLE DEVELOPMENT AND SUSTAINABLE ENERGY

In a broad sense, sustainable development is the main objective of the Philippines and Singapore and, in fact, in all the SEA countries, even though achieving this objective demands different approaches and plans. The reason lies in their differences with respect to their current level of development, on the one hand, and the availability, affordability, applicability, plausibility and acceptability of supplies of energy to fuel such development on the other. Consequently, sustainable development necessitates sustainable energy to make environmentally clean renewables (wind, solar, geothermal and run off-river hydro), but not all types of renewables (e.g., biomass and biofuel) a necessity. After all, **renew-ability does not mean energy sources are non-pollutive and thus environmentally clean.**

Added to generating clean energy for the aforementioned countries as representatives of their region and, in a broad sense, Asia, the local production of the required renewable technologies could, in itself, serve as an engine of economic development and/or its consolidation, depending on the case (i.e., the level of development of a given country and the available options for development). This is a feasible solution, of course, to a varying extent depending on the concerned countries' industrial and scientific development, among other factors.

6. CONCLUSION AND POLICY RECOMMENDATIONS

Briefly, environmentally clean renewables have an essential role in ending energy insecurity in Asia in a sustainable manner, which cannot be achieved using other types of energy. While some of these types are environmentally unsustainable (e.g., coal and thus coal-fired electricity generators), another type, which does not emit GHG (nuclear power generators), is perhaps too costly and/or unaffordable for many Asian countries, including SEA ones. As a result, renewables are the best option for the majority of the SEA countries, which are developing and low or middle-income. However, given most of the major types of renewables are intermittent sources of energy, not being available all the time (e.g., wind and sunshine), a combination of intermittent (wind, solar and ocean energy) and continuous (mainly hydro, run-off river hydro and geothermal) energy needs to be used together to ensure the availability of reliable alternative energy to oil, gas and coal for a large part of countries' energy needs for commercial, industrial, residential and agricultural activities. For the total replacement of fossil energy and permanently halting the bulk of human-made emissions and related unsustainable practices (e.g., the rapid depletion of fresh water resources), environmentally clean alternatives to fossil liquid fuels (gasoline and diesel fuel) for transportation are yet to be developed at a large scale. In spite of the common belief, the currently-available biofuels are not sustainable alternatives to such fuels. This is because of their unsustainable water and fossil energy-intensive nature at the production level and/or the damage they inflict to the environment, especially to forests, at the cultivation level due to these environments being destroyed to clear land to grow raw materials such as corn and palm trees.

The ten SEA countries are yet to harness, at least to a significant extent, let alone fully, their renewable potentials for a differing number of the above-mentioned factors. Given cost is an obstacle for all of them despite the differences among them as to its actual preventive strength (i.e., from a factor to the single most important one), addressing it is a necessity for which certain options are recommended.

Opting for less-technologically challenging renewables, which are environmentally clean unlike biomass but can easily or relatively easily be developed in all these countries, is one option. Examples include solar boilers; these use direct sunshine to boil water and thus do not require the sophisticated technology needed to turn sunbeams into electricity, which is not locally available and/or is too expensive to be affordable at a large-scale. Such boilers, which can easily be installed on the rooftops of all buildings, large and small alike, will replace a significant amount of fossil energy now used for boiling water for a range of consumers from small-scale residential to large-scale commercial/industrial ones. Advancing modern technology in the SEA countries is a fortunate by-product of developing and manufacturing water boilers for these countries.

Also known as run-off river hydro, small hydro generators constitute inexpensive and thus affordable types of renewable technologies for all the regional countries. They can easily be developed in all of them, including the Philippines, as has been the case in the low- and middle-income countries of the Asia and Pacific region such as India. There is a wide-range of run-off river hydro options, which, by and large, are not technologically complicated and can meet the small-scale electricity needs of the regional countries.

Vertical wind turbines are a serious option for all the regional countries. They require much weaker winds than those needed for the widely-used large horizontal ones and are less-expensive and much easier to locally develop, install and maintain. These are an especially sensible option for Singapore, which suffers from land scarcity, as they can be installed on rooftops. Singapore is currently using a small fraction of its rooftops to

install solar panels, now exclusively part of those of its government-built HDB (Housing Development Bureau) buildings for mainly low-income families. Therefore, the country still has hundreds of such rooftops, as well as thousands of its large high-rise ones to be used for small vertical turbines.

Singapore, which can afford to import advanced foreign technologies, can also use some of its rooftops for vertically concentrated solar, which has been developed to provide the benefits of in-use horizontal ones for large-scale solar energy generation, without taking up the space required by the latter.

Adding platforms to the sides of rooftops for solar panels, concentrated solar units, solar water boilers and vertical wind turbines can help Singapore to create space to expand its renewables generation and thereby overcome the challenge of land-scarcity to a significant extent. This is a solution for all other countries suffering from land scarcity in Asia and elsewhere.

Apart from horizontal solar technologies, these recommended measures are relatively feasible, inexpensive and easy-to use technologies that can be developed locally. Once adopted, they will help the SEA countries, low- or high-income alike, decrease their dependency on fossil energy, meet their growing electricity requirements, including those of their rural areas demanding small-scale technologies, and reduce the financial burden of their heavy imports of fossil energy, while also substantially reducing their GHG emissions.

Thanks to their expanding production and technological developments, the ongoing declining cost of renewables technologies, which are not currently produced in these countries, such as wind and solar energy, will make them more affordable to import for the regional countries, particularly the low- and medium-income ones (e.g., Cambodia, the Lao PDR, and the Philippines) in the future so long as they lack their home-grown technologies.

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