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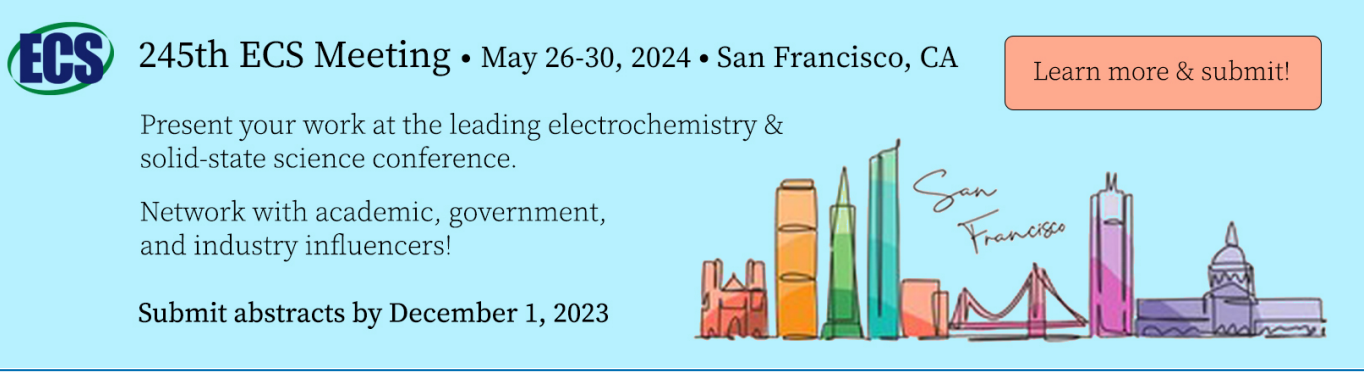

Integration of Variable Renewable Energy, Electric Vehicle, and Smart Microgrid in ASEAN: A Focus Group Discussion Approach

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Abstract. Southeast Asia is expecting rapid growth in energy and vehicle demand. Variable renewable energy such as solar and wind have high potential in the region. ASEAN aims to increase the renewable energy share in power capacity to 35% 2025. The increase in renewable energy share can drive a shift in the current energy management system. The adoption of electric vehicles can bridge the link between the energy and vehicle sectors towards a green transformation. Electric vehicles that are powered by electricity from renewable sources creates demand by consuming energy from the grid, but it can also serve as battery storage that can discharge energy back to the grid if needed. It is known that the intermittent nature and high penetration of variable renewable energy can lead to power instability. However, microgrids can be designed and incorporated with electric vehicles and variable renewable energy deployments to enhance the reliability and stability of the power system. The engagement with key stakeholders related to the deployment of the platform for the use of these three technologies is crucial to gain better insight on the market status, including the current and future price and penetration trends, and deployment opportunities and barriers. A focus group discussion involving related stakeholders on the aspects of policies and targets, technology readiness, and implementation strategies, was thus conducted. The results showed that there have been concrete policies on the renewable energy installation targets among the countries. Electric vehicles penetration is also an existing priority with different countries having varying targets for the electric vehicle fleets and charging stations. However, for microgrids, it was found that there is less information on their deployment and application. As such, more detailed technical and economic assessment following its potential connection to current grid with other features including variable renewable energy and electric vehicles, as well as the available smart features in optimising power scheduling, should be carried out.

1. Introduction

The Association of Southeast Asian Nations (ASEAN) consists of 10 member states in Southeast Asia which promote the intergovernmental cooperation between the member states and other countries. The region has one of the fastest growths in electricity demand, with major consumers being Indonesia

(26%), Vietnam (22%), Thailand (19%), and Malaysia (15%) [1]. To achieve a greener region, ASEAN has worked on to increase its renewable energy generation and improve energy efficiency [2]. ASEAN aims to achieve 23% renewable energy (RE) target in its energy mix and 35% in its installed capacity by 2025 [3]. Traffic congestion and its associated environmental impacts, such as air pollution and greenhouse gas (GHG) emission, have long been an issue to be tackled. Channelling RE sources to fuel the transport system can significantly contribute to the green transformation of the region. A study showed that the adaption to renewable sources is evident in the transport sector with the expected increase in RE share from the current 1% to about 50% by 2050, contributed by the use of biofuels, electric vehicles, renewable energy, and energy efficiency [4].

Variable renewable energy (vRE) such as solar and wind have high potential in tropical regions such as ASEAN. In the 6th ASEAN Energy Outlook (AEO6), the potential of additional solar and wind power was estimated to be 66 GW and 8 GW, based on 40 solar cities and 20 wind cities [2]. These cities were selected based on their locations with high grid connectivity potential. One challenge with vRE is its intermittent properties and unstable supply. Electric vehicle (EV) that is driven by electricity releases no tailpipe emission. However, this environmental benefit can only be credited if the electricity is derived from RE sources. Microgrid (MG) can be considered as a smaller version of centralised electricity system which regulates and distribute electricity to consumer locally [5]. There have been many works addressing the optimisation and scheduling of MG with RE sources. For example, Luo et al. [6] presented a modified bat algorithm to address the high degree of uncertainties for grid-connected MG with solar PV. Wei et al. [7] proposed the use of robust optimisation method to express the uncertainty of interconnected MG, considering the uncertainty of wind power, under a peer-to-peer trading framework. A smart MG with intelligent operations and smart metering systems are important for its optimal operation [8].

The integration of vRE-EV-MG is therefore promising to support the wider deployment of vRE and EV. However, as vRE such as wind and solar are intermittent in nature and commonly come as nondispatchable energy, the forecasting of the generation input and controllable loads are important for the integration into MG for EV charging [9]. The high penetration of the fluctuating vRE in the MG could burden the system operation and the battery storage of the vehicles [10]. The penetration of EVs in the transport fleet can also introduce random new loads to the grid. Therefore, further assessment on the coordination among EV, vRE, and MG components requires further assessments in terms of the fluctuation of vRE sources, the market price, and consumer load demand and charging schemes at different penetration levels [11]. Significant system power fluctuations might be occurring if the charging of EV is not coordinated, especially at large-scale adoption [12]. Thus, there is a need to study the modelling of their integration in a system considering different scenarios. Furthermore, a deeper insight into the current and future trends of the mentioned technologies in the ASEAN member states (AMS) is deemed necessary. That said, the main objective of this work is to engage with the key stakeholders related to the deployment of the three technologies' platforms in order to gain insights on the current and future adoption trend of the region which can be utilised for further modelling of its optimal deployment.

2. Materials and Methods

Focus group discussion (FGD) through the involvement of stakeholders from various AMS was designed and conducted to gain a better insight into the current and future of the vRE-EV-MG integration market. In collaboration with the ASEAN Centre for Energy (ACE), an online FGD was conducted on 25th August 2021. The FGD has around 80 participants coming from Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, and Singapore. The participants were from energyrelated ministries and agencies, industry experts, and researchers. The participants were divided into three modules, namely on policy (module 1), technology (module 2), and implementation (module 3). The FGD framework is shown in Figure 1.

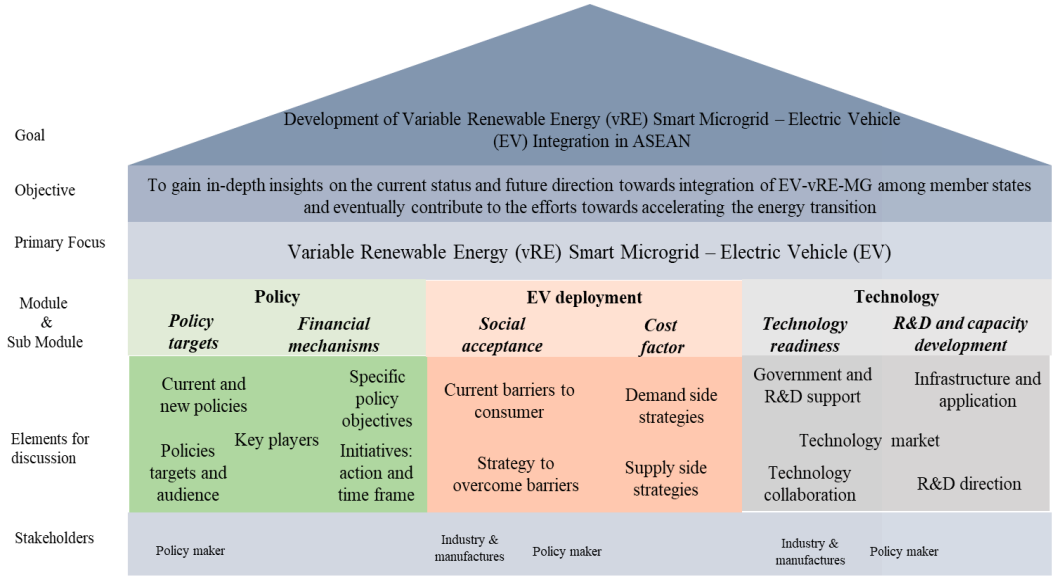

Figure 1. The overall framework for the FGD on the integration of vRE-EV-MG in ASEAN

3. Results and Discussions

3.1. Policies and Economic Instruments

The policies set by the governments shape the direction and markets of the respective technologies, as shown in Table 1. Most ASEAN countries have concrete policies and targets for vRE as a part of their existing RE implementation frameworks. For Philippines, the country has set a RE target tripled of its 2010 installed capacity, which is achieving 15.3 GW by 2030 and 20 GW by 2040 under their National Renewable Energy Programme (NREP). Malaysia also targets a 40% RE share in its power capacity mix by 2035 under its National Renewable Energy Policy (NEP). Under the Alternative Energy Development Plan (AEDP) (2015-2036), Thailand has a target of 30% RE in total final energy consumption by 2036. By 2030, Singapore will reach a solar target of at least 2 GWp by 2030 and an energy storage deployment target of 200 MW beyond 2025 [13]. Myanmar's target is at a 12% RE mix under Myanmar Energy Master Plan (MEMP) 2015. For EV, the targets are embedded in national policies related to national climate policy and national transportation. The year 2030 is an important time mark for most of the AMS. Indonesia targets to deploy 2 million four-wheelers and 13 million twowheelers EVs, Lao PDR aims to have 30% EV penetration in transport fleet and 500 EV charging stations, and Malaysia aims to have 100,000 EV cars and motorcycles, 2,000 EV buses, and 125,000 charging stations by the year 2030. As for MG, most ASEAN countries do not have clear regulations or targets on its implementation.

Table 1. Summary on policy, target, and economic instruments in several ASEAN countries (FGD Module 1)

Country	Aspect	Policy	Target	Economic instruments
Brunei	vRE	Brunei Vision 2035.	10 % of RE mix shares by 2035.	
	EV	Brunei Darussalam National Climate Change Policy (BNCCP); Land Transport Master Plan (LTMP) (2014).	60% share of vehicle sales by EV by 2035; 10% electrification of the vehicle fleet by 2035.	-
Cambodia	vRE	Power Development Plan, Cambodia Basic Energy Plan.	1.8 GW of solar capacity by 2030 (under review), 430 MW of solar by 2022.	Public-private partnership (PPP); 3.87 cent/ kWh tariff; Funding from ADB.
	EV	Ministry of Public Transportation- Vehicle registration. Ministry of Mine and Energy – EE Department	National Energy Efficiency Policy; No policy and target for EVs (but under planning).	
	MG	Rural electrification for microgrid; DC and AC mini-grids (solar and battery).		
Indonesia	vRE	Long-Term National Development Plan (RPJPN) 2005-2025;	100 MW of wind power capacity by 2025.	No incentive for electricity generated from RE. Tax allowance and tax holiday incentives are available but for a certain capacity.
		Power Development Plan 2021-2030.	51% of new installed capacity;	
	EV	Roadmap on Low Carbon Emission Vehicle.	2 million four-wheelers and 13 million two-wheelers of EV by 2030.	Tax incentive for companies that produce EV locally but regulation at the commercial level is not yet available; For locally-produced, battery-powered EV has 0 % luxury tax rate; Incentive for developing charging stations is available.
	MG	No regulation for a microgrid; No microgrid implementation in EV.		
Lao PDR	vRE	Vision 2020; Strategic Plan 2025; 5-year Power Development Plan (2016-2020).	30% renewable energy shares in total energy consumption by 2025; 20% renewable electricity mix shares by 2025.	-
	EV	National Environment Strategy and Action Plan 2016-2023; National Designated Authorities (NDAs).	30% share of the vehicle fleet by EV by 2030; 500 EV charging stations by 2030.	
Malaysia	vRE	National Renewable Energy Policy (NEP) soon to be announced in 2H 2021.	31% and 40% renewable share in the electricity mix by 2025 and 2035 (including hydropower).	Large scale solar (LSS), Net Energy Metering (NEM), Feed-in-Tariff (FiT).
	EV	National Automotive Policy (NAP); National Green Technology Master Plan 2017-2030; NKEA Electrical and Electronics (EPP 18).	To become a marketing hub for EVs by 2030; 100,000 EV-cars by 2030; 100,000 EV-motorcycles by 2030; 2,000 EV-buses by 2030; 125,000 charging stations by 2030.	

When it comes to economic instruments, the most common initiative is through tax exemption or incentives. The role of partnerships between government agencies was also highly discussed. In Cambodia, there is a tax exemption for solar projects. Although, participants cited the possibility of grid extension being a cheaper option in the country than deploying solar technology. In Indonesia, incentives have driven government-owned companies and private sectors to enter the RE market. States will also buy RE even at a higher price, as compared to conventional energy. The Indonesia's government would fund the gap between the pricing and basic cost of electricity supply by the State Electricity Company (PLN) through three mechanisms, including feed-in-tariff, ceiling price and negotiated price [14]. Malaysia is adopting several schemes, such as the Green Investment Tax Allowance and Green Income Tax Exemption to promote its RE adoption. The country has also implemented Renewable Energy Certification (RECs) programmes, although there is no trading platform available yet. Another approach for increasing vRE installation is by having large-scale battery storage, e.g. 500 MW by 2035.

Whereas to further promote EV technology, the Cambodian government has offered a 10% tax exemption on import tax for every EV car purchased. Moreover, Indonesia is considering the local production of EV components and batteries under the collaborations among government-owned companies, energy sectors, and mining sectors. Malaysia, on the other hand, is also aiming to become an EV market hub in the region with its plan to deploy a significant number of EV units within the next decade.

3.2. Current and Future Technology Direction

This section consolidated the information provided by the participants about the current market, and the existing and future technology transfer/opportunities of vRE, EV, MG in the region, as shown in Table 2.

Table 2. Current and future technological trends on several ASEAN countries (FGD module 2)

Country	Aspect	Current Market	Existing technology transfer/ opportunities	Future technology transfer/ opportunities
Indonesia	vRE	Includes solar rooftop geothermal, some wind energy	Locally built vRE plants; Developing a floating solar PV by the year 2022.	Some universities are researching on designing and manufacturing their EV model.
	EV	Includes electric bicycle, electric taxi, public transportation, hybrid car, electric car	Local battery manufacturing and charging station.	Government-built large industrial complex for Ni-battery industry and charging stations.
	MG	Pilot project on smart MG in Thousand Island	The Association of Smart Microgrid in Indonesia.	The smart MG is possible in populated areas, e.g. Jakarta.
Malaysia	vRE	Mostly solar and hydro, Not much on wind energy due to location and wind speed RE target 40 % by 2035	Various supportive mechanisms from the government; The potential of wind energy is limited.	Floating solar implementation; Grid upgrading; Energy storage technology; Geothermal energy; Net metering (NEM).
	EV	Includes electric cars, hybrid cars, and electric buses (Kuala Lumpur and Sarawak)	Mobile app showing the location of the EV charging stations; Limited charging units; Most technologies are imported; Partial EVs are locally manufactured.	Electric bus for public transportation; Fast charging technologies; Increase availability of charging stations, e.g. shopping malls and selected buildings in city centres.
	MG	Existing small renewable energy program	30 MW of battery for MG by 2030.	-

Table 2. Current and future technological trends on several ASEAN countries (FGD module 2) (cont.)

Country	Aspect	Current Market	Existing technology transfer/ opportunities	Future technology transfer/ opportunities
Singapore	vRE	Includes floating solar farm and solar PV.	-	-
	EV	Electric cars; Phase-out ICE vehicles by 2040.	-	Promoting vehicle-to-grid (V2G).
	MG	Projects are still in progress; Most islanded connection.	-	-

For Indonesia, solar energy remains to be one of the major vRE resource that spread across the country. The introduction of an export-import mechanism for solar rooftop is considered as one of its accelerating mechanisms. The price of EVs is still relatively higher than conventional cars, therefore the country considering local manufacturing of battery and EV models which can help to bring down the price of EVs and make EVs more affordable to the public. To promote EVs, Indonesia government also offered 0% luxury tax rate for battery-powered EV, whereas plug-in hybrid will be taxed at 5% [15]. For Malaysia, solar energy is also the main vRE resource. Although the Malaysian government has many supporting mechanisms such as Fit-in-Tariff (FiT), Net Metering Measurement (NEM), LargeScale Solae (LSS), and New Enhanced Dispatch Arrangement (NEDA), the cost of solar technologies are still high. Energy storage technology, such as battery energy storage systems (BESS) is also needed to alleviate the intermittent nature of solar energy and its storage capacity. Thus, strategies in reducing cost for solar technologies and associated BESS is considered the main accelerating factors in the region. The EV price in Malaysia, similar among other AMS, is still relatively higher compared to the cost in other regions of the world. Representatives from Malaysia have pointed the need for strong government policy and incentive mechanisms to drive EV adoption and the EV industry value chain. Representatives from Singapore also shared policies in phasing out internal combustion engine (ICE) vehicles are one of the main drivers to promote EV adoption. Singapore has the target to phase out its ICE vehicles by 2040. Meanwhile, representatives from Thailand shared that the RE price in their country is not competitively attractive and requires additional costs on the backup power.

3.3. Challenges and Strategies Implementation

In terms of implementation, participants were asked to discuss the main challenges or barriers in vRE, EV, and MG deployment, as shown in Table 3. It was cited that the main challenges are related to three main aspects: costing, technology maturity, and infrastructure availability. The high cost of vRE installation and EV ownership, coupled with competitive grid price and lack of green investment contributes to the main financial barriers. For technology maturity, the intermittent nature of the vRE leading to power fluctuation and grid flexibility remains a major concern. The maintenance and longevity of the battery were cited for EVs. Meanwhile, for MG, it was pointed out that its potential has not been fully realised and the lack of charging stations or areas was cited for infrastructure.

Table 3. Challenges and barriers for vRE-EV-MG on selected ASEAN countries (FGD Module 3)

Country	Aspect	Challenges
Malaysia	vRE	• Cost of the PV system and battery cost; additional cost for supporting device (such as energy storage) for solar resource; not competitive with grid price • Variability of solar energy and relatively low solar irradiance; wind energy is limited by wind speed insufficiency • Energy storage technology market has not yet matured • Solar is not dispatchable where power plants are also needed for the night • Policies with clear vRE target but not on penetration level
	EV	• Relatively higher cost of EV ownership and low aftermarket value • Lifetime and costing of EV battery affecting the depreciation value • Low number of charging stations and charging area infrastructures • Lack of marketing promotion, awareness programs, and market study • Lack of knowledge on EV maintenance, service centre, and workshop • Relatively different "refuelling" behaviour as compared to the ICE market
	MG	• Currently, the main grid supply is still sufficient, MG most likely for rural area • The potential for integrating MG with EV is not fully realised
Indonesia	vRE	• Absence of active financing and investment • Availability of technology and vRE potential is not fully realised • Doubt in grid flexibility
	EV	• High tax imposed on EV; High EV price and infrastructure cost • Other energy sources, e.g., biofuels and fossil fuel, are cheaper • Lack of infrastructure, e.g., for servicing and charging • Comparative assessment of MG and nano-grid installation cost and breakeven point
Thailand	vRE	• Insufficient incentive • Mismatch between RE supply and demand • Power fluctuation due to the intermittent nature of vRE
	EV	• High EV car price as compared to ICE city car • Lack of fast charging station
	MG	• Insight on the real travel range of EV and battery life cycle management

Several strategies were recommended to overcome such barriers during the discussion. Firstly, for vRE, Indonesia's representative pointed out the importance for officials to acknowledge the need for developing RE for the country; and for the long term, to assess the potential for manufacturing local RE generation or direct current appliances. Thailand's representatives shared that the government could invest more in floating solar projects in dams for the short term, improve demand response management system by measuring RE supply in the medium term, and integrating all vRE into virtual power plant system in the long term.

Secondly, for EV, majority of the participants acknowledged the need for tax allowance and incentives on reducing EV cost and increase charging station availability. For Malaysia, incentives such as reduction on income tax and duty tax, EV ownership cost, and technology promotional programs should be pursued in the short and medium term. Meanwhile, the long-term strategy can be built upon multiple partnerships between the government, car manufacturers, and consumers for the local EV industry value chain. For Indonesia, more charging stations, new public EV transportation, and increased awareness of EV should be pursued in the short term, and establishment of policies that would enable the shift from fossil fuel to RE for EV charging, phasing out high emission vehicles, and imposed a lower tax on EV for the medium term. Meanwhile for the long term, efforts towards setting up local EV manufacturers to offer EV at lower cost ought to be considered. For Thailand, actions to increase the availability of fast-charging stations and to increase EV subsidy are of priority. A sound battery recycles management system is also needed. For the long term, the target is to have a fast-charging station installed every 10 km. The availability of public charging stations is a key driver for a growing EV market [16]. The smart charging stations can reduce production costs for EV charging and investment cost for grid-connected storage [17].

Thirdly, on MG, different perspectives on the future strategies were raised. For Malaysia, the country is most likely to focus on the smart grid and its integration with vRE and EV penetration in the short term. For Indonesia, the short-term strategies would be to increase the integration of RE on a larger scale and to reduce electricity tariffs by controlling the peak electricity loads. The development of the rural or remote area would be the main aspect for medium-term strategy. Whereas, for the long-term, the country is looking into community energy storage. For Thailand, identification of the critical peak pricing would be the main emphasis in the medium-term to better assess the installation cost between micro-and nano-grid. The deployment of the MG can also face technical challenges such as protection schemes against fault current, modes of operation, two-way power flow, and quality of communication network [5].

3.4. Summary and Recommendations

The FGD had provided insights from multiple perspectives regarding the three technological components, i.e. vRE, EV and MG, respectively and collectively, towards the decarbonisation pathways in the ASEAN region. Promoting sustainable energy transformation, especially through vRE and EV, have been outlined in several member states. As such, Malaysia and Indonesia were selected for the following discussion on their available policies and future direction.

During the COP-26, Malaysia has revealed a more ambitious plan to reduce the country GHG emission intensity by 45% based on the Gross Domestic Product (GDP) by 2030, and to achieve carbon neutral as early as 2050. The country's Long-Term Low Emissions Development Strategy is also expected to be finalised by 2022 [18]. Malaysia will also be launching its Voluntary Carbon Market initiative for carbon credit trading [19]. In addition to these efforts, Malaysia has a 40% renewable target by 2035, and solar is identified to has the highest potential. The country plans to install battery energy storage system, up to 500 MW capacity [20]. This is expecting to offer better power energy security and stability from solar energy. Nevertheless, the solar-based vRE with lower cost and availability of solar-PV based technology such as net energy metering and large-scale solar PV are still of critical importance. The recently announced Budget 2022 has outlined initiative favourable to EV adoption and installation of EV charging facilities [21]. These initiatives include full exemption from import and excise duties and sales tax for EV industry, 100 % road tax exemption for EV vehicles and individual income tax relief [22]. Another challenge would be the quick deployment of fast-DC charging facilities. Malaysia has 500 public AC charging stations but with 9 public DC fast-charging stations [23]. A target of having1,000 DC rapid charging stations by 2025 has been set, which calls for strategic collaborations and coordination among various parties.

For Indonesia, it has a target to reduce 29% of GHG emission by 2030. In terms of renewable energy, the country plans to have 23 % RE use by 2025 and 31 % by 2050 [24]. Based on the RE roadmap, solar PV has a potential of 47 GW by 2030. However, report has shown that the average cost per megawatt of solar PV capacity is higher [25]. Tachev [25] identified that the target needs high investment and optimal allocation of these investments, where financing opportunities for new projects faces challenges like land acquisition issues and local bank policies. Fossil fuels account for nearly half of power investment [26]. Indonesia also aims to become a major EV hub through its EV roadmap. The country aims to reach an adoption of 2.1 million electric motorcycle and 400,000 electric cars. Out of these, 20 % will be locally manufactured by 2025 [27]. The state-owned electricity giant PLN has opened for both commercial and public sectors to invest in order to meet its target of installing 31,000 additional EV charging stations by the year 2030 [28]. Given the high target for electric motorcycle, the rapid deployment of charging stations to satisfy the charging demand is critical to achieve its EV market adoption. Having blessed with abundant of nickel reserves, which is an important raw material to produce EV battery, strategies to encourage and accelerate the development of local processing plant is also in need to meet the EV target [29]. As Indonesia has many islands and larger land area, grid integration of vRE could be challenging, with many small grids distributed in remote locations [26].

Both countries have embarked on their decarbonisation pathways with policies and targets for renewable energy and EV adoption. Despite these efforts, some major challenges could be the absence of policy or targets in phasing out petroleum subsides and internal combustion engine or petroleum-

based vehicles. In addition, in order to achieve the respective targets in a near future, policies enabling a favourable environment attracting private sector and international investment are likely to be the key. The higher cost of renewables and EV are also turning away potential consumers. These could be more challenging recently due to the shrink of global economic from COVID-19 impact.

4. Conclusions

The paper presented the overview of the current and future markets of vRE, EV, and MG from the perspectives of policymakers, industries, and other stakeholders from several ASEAN member countries through an FGD platform. The cost, technology maturity, and infrastructure availability remain the main barriers to the adoption of these technologies in the region. As the deployment and adoption of these technologies are currently associated with higher cost, a further study which assesses the performance of this integrated system considering the technological and socioeconomic benefits, such as environmental sustainability, energy security, grid stability, GHG reduction, etc., against the investment and operational cost, would be important in optimising its design across different time scales. In addition to initiatives such as tax exemption and feed-in-tariffs, formulation of electricity tariffs favourable for EV users and vRE consumers through MG distribution, as well as attracting private and foreign investments, could be looked into.

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