MALAYSIA RENEWABLE ENERGY ROADMAP

PATHWAY TOWARDS LOW CARBON ENERGY SYSTEM

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4IR	Fourth Industrial Revolution
ACE	ASEAN Center of Energy
AI	Artificial intelligence
APAC	Asia Pacific
APAEC	ASEAN Plan of Action for Energy Cooperation
ASEAN	Association of Southeast Asian Nations
BAU	Business as Usual
bn	Billion
Btoe	Billion metric tons oil equivalent
BNEF	Bloomberg New Energy Finance
BUR	Biennial Update Report
C&I	Commercial and industrial
CAGR	Compound annual growth rate
CAPEX	Capital expenditure
CNG	Compressed natural gas
CO_2	Carbon dioxide
COD	Commercial operational date
DFI	Development financial institution
DL	Distribution licensee
EFB	Empty fruit bunch
EMEA	Europe, Middle East and Africa
EPC	Engineering, procurement, and construction
eq	Equivalent
ESG	Environmental, social and governance
EU	European Union
FFB	Fresh fruit bunch
FiT	Feed-in Tariff
FoF	Fund-of-funds
GCF	Green Climate Fund
GDP	Gross domestic product
GHG	Greenhouse gas
GITA	Green Investment Tax Allowance
GITE	Green Income Tax Exemption
GSO	Grid System Operator
GTFS	Green Technology Financing Scheme
GW	Gigawatt
GWh	Gigawatt hour
HV	High voltage

IEA	International Energy Agency
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent power producer
IRENA	International Renewable Energy Agency
IRR	Internal rate of return
JPPPET	Jawatankuasa Perancangan dan Pelaksanaan Pembekalan Elektrik dan Tarif (Planning and Implementation Committee for Electricity Supply and Tariff)
JPSPN	Jabatan Pengurusan Sisa Pepejal Negara (National Solid Waste Management Department)
KeTSA	Kementerian Tenaga dan Sumber Asli (Ministry of Energy and Natural Resources)
KPKT	Kementerian Perumahan Dan Kerajaan Tempatan (Ministry of Housing and Local Government)
ktoe	Kilotonnes of oil equivalent
kW	Kilowatt
kWh	Kilowatt hour
kWh/m^2	Kilowatt hour per meter squared
LCOE	Levelized cost of electricity
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LSS	Large scale solar
LV	Low voltage
m/s	Meter per second
M&A	Mergers and acquisitions
MAAQ	Maximum annual allowable quantity
MEIH	Malaysia Energy Information Hub
MF	Mesocarp fiber
MGFT	Malaysian Green Financing Taskforce
MIDA	Malaysian Investment Development Authority
MNRE	Ministry of Environment and Water (formerly known as Ministry of Natural Resource and Environment)
MOE	Ministry of Education
MOF	Ministry of Finance
MOH	Ministry of Health
MPOB	Malaysian Palm Oil Board
MSW	Municipal solid waste
Mtoe	Megatonne of oil equivalent
MV	Medium voltage
MW	Megawatt
MWh	Megawatt hour
MyPower	Malaysia Programme Office for Power Electricity Reform
NAPIC	National Property Information Centre
NDC	Nationally determined contributions
NEDA	New Enhanced Dispatch Arrangement
NEM	Net Energy Metering
NGO	Non-Governmental Organisation
NREL	National Renewable Energy Laboratory

NREPAP	National Renewable Energy Policy and Action Plan
O&M	Operations and maintenance
P2P	Peer-to-peer
PDP	Power Development Plan
PEST	Political, Economic, Social, and Technological
PKS	Palm kernel shell
PM	Peninsular Malaysia
POME	Palm oil mill effluent
PPA	Power purchase agreement
QCE	Qualifying capital expenditure
RD&D	Research, Development & Demonstration
RE	Renewable energy
RECs	Renewable Energy Certificates
REN21	Renewable Energy Policy Network for the 21st Century
REPPA	RE power purchase agreement
RPVI	Registered PV investor
SARE	Supply Agreement for Renewable Energy
SB	Single Buyer
SCORE	Sarawak Corridor of Renewable Energy
SEA	Southeast Asia
SEB	Sarawak Energy Berhad
SEDA	Sustainable Energy Development Authority Malaysia
SELCO	Self-consumption
SESB	Sabah Electricity Sdn. Bhd.
SLA	Service level agreement
Solar PV	Solar photovoltaic
ST	Suruhanjaya Tenaga (Energy Commission)
T&O	Technical and operational
TNB	Tenaga Nasional Berhad
TOU	Time-of-use
TPA	Third-party access
UK	United Kingdom
UKAS	Unit Kerjasama Awam dan Swasta (Public Private Partnership Unit)
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
V2G	Vehicle-to-grid
VNM	Virtual Net Metering
VOR	Variable operating rate
VRE	Variable renewable energy
WTE	Waste-to-energy

EXECUTIVE SUMMARY

RENEWABLE ENERGY IN MALAYSIA: THE TIMELINE

Renewable Energy (RE) was first introduced as the “fifth fuel” and an alternative source for the country’s power generation in 1999. It was part of Government’s intent to diversify the energy mix in the country. Various initiatives, programmes and strategies have since been introduced and implemented to support the growth of RE technologies throughout 2001-2020.

Under the Eighth Malaysia Plan (2001-2005), the Small Renewable Energy Power (SREP) Programme was introduced, along with the Biomass Power Generation and Cogen Full Scale Model Demonstration (BIOGEN) Project, leveraging the readily available oil palm-based by-products for small-scale electricity generation. Ninth Malaysia Plan (2006-2010) recorded further progress, with the development of rooftop solar becoming prominent through the Malaysia Building Integrated Photovoltaic (MBIPV) Project. The MBIPV project focused on the policy development for grid-connected PV system, market and incentive measures and capacity building programme for rooftop solar.

The programmes and projects implemented under the 8th and 9th plan led to the subsequent development of the National RE Policy and Action Plan (NREPAP) in 2010; aiming to establish a policy guide for RE development in Malaysia.

NREPAP further paved the path for RE development in the Tenth Malaysia Plan (2011 – 2015), as one of the key new areas of growth for the energy sector. During this period, the Renewable Energy Act 2011 (Act 725) and the Sustainable Energy Development Authority Act 2011 (Act 726) were enacted, leading to the establishment of Sustainable Energy Development Authority (SEDA) Malaysia as the designated authority for RE development in Malaysia. The Feed-in-Tariff (FiT) scheme was also introduced and implemented in 2011 to catalyse the growth of grid-connected RE in Peninsular Malaysia, Sabah and Labuan.

The initiative to promote RE growth progressed further under the Eleventh Malaysia Plan (2016-2020). Solar auctioning and rooftop solar quota were released for the very first time through the Large Scale Solar (LSS), Net Energy Metering (NEM) and Self-Consumption (SELCO) Programme. By the end of the 11th Plan, the growth of RE capacity in Malaysia has been substantial, from a base of 53 MW of RE connected to the grid (without large hydro) between 2001-2009 to a total installed capacity of 1.6GW between 2011-2015. By December 2020, cumulative RE capacity had reached 2.8 GW, or 8.45 GW with the inclusion of all RE resources.

Moving forward, Malaysia aims to achieve a higher RE growth, from the existing 23% or 8.45 GW RE in its power installed capacity. Malaysia Renewable Energy Roadmap (MyRER) projected to increase the share of RE to 31% or 12.9 GW in 2025, and 40% or 18.0 GW in 2035. The RE Initiatives under this roadmap are expected to support Malaysia’s commitment to greenhouse gas (GHG) emission reduction under the Paris Agreement led by the United Nations Framework Convention on Climate Change (UNFCCC). Malaysia’s global climate commitment is to reduce its economy-wide carbon intensity (against GDP) of 45% in 2030 compared to 2005 level. Realization of the Government’s vision is crucial in supporting the nation to achieve its Nationally Determined Contributions (NDC) targets.

Image for illustration purpose only

1. Total value of the goods and services produced denominated in MYR.

THE ROLE OF ENERGY SECTOR IN POST-PANDEMIC ECONOMIC RECOVERY

The COVID-19 pandemic has impacted the growth of global economy. However, the RE sector was relatively resilient in withstanding the economic adversity of the pandemic. Countries around the world have embarked on accelerating the deployment of RE as a two-pronged strategy for post-pandemic economic recovery and sustainable energy transition.

In Malaysia, a total of 1,000 MW of large-scale solar projects, 500 MW of solar rooftop quotas and 188 MW of non-solar quotas were offered to allow investment opportunities and boost the country's post-pandemic economic growth. The pandemic situation has also brought forth greater social and economic opportunity for businesses and policymakers in Malaysia to embark on greater environmental, social and governance commitments. There are increasing interest from corporations in Malaysia to realign their strategic path towards sustainability, as there is growing awareness that it is integral to financial health.

The need for post pandemic economic recovery and the need to be aligned with current energy megatrend, warrant for the Government to review its medium and long-term targets and strategies for RE development in the country. Therefore, this Malaysia Renewable Energy Roadmap is introduced to realise the Government's future RE aspiration with an anticipated cumulative investment of MYR 53 billion and 46,336 numbers of job opportunities.

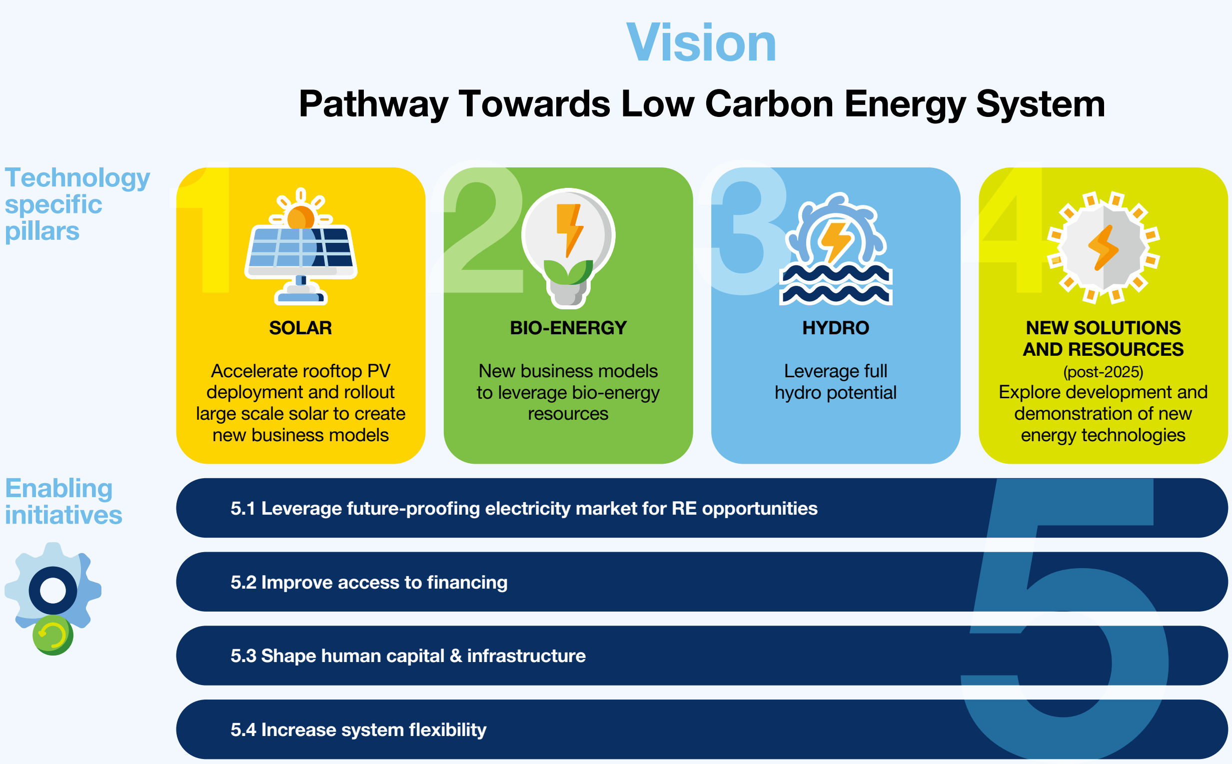
MALAYSIA RENEWABLE ENERGY ROADMAP (MyRER)

Malaysia Renewable Energy Roadmap (MyRER) is a formulation of a strategic framework (Figure 0-1) aimed at achieving 31% RE share in the national capacity mix by 2025 and attaining decarbonisation of the electricity sector by 2035.

The MyRER vision is upheld by 4 technology-specific pillars and 4 enabling initiatives. The strategic framework calls for concerted and coordinated actions from collaborations between various stakeholders in allowing Malaysia to tap into the huge potential made available through RE projects to promote improved economic, environmental and social outcomes.

Image for illustration purpose only.

Figure 0-1: MyRER strategic framework

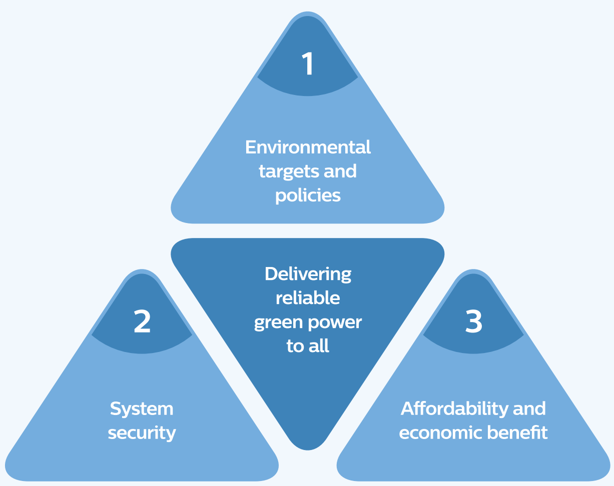


MyRER: THE MILESTONES AND ASPIRATIONS

Fossil fuel generation sources remain dominant in the national installed capacity mix. The share of RE in Malaysia remained below the global and regional average. As of the end of 2020, RE accounted for 23% of the national power installed capacity compared to the global average of 37% and the Southeast Asia regional average of 30%[2]. Hence, there is a pressing need to accelerate RE deployment in Malaysia to meet the committed RE and climate targets, by strengthening existing programmes and introducing new approaches, in parallel with the Government's practices in future-proofing existing electricity market regulations and power sector industry practices.

This Roadmap shall be the forward-looking document outlining related strategies in accelerating RE deployment in Malaysia. More importantly, the Roadmap aims to strike a balance between environmental targets, preserve affordability and economic benefits, and maintain system security by mitigating the impact of variable renewable energy (VRE) sources (see Figure 0-2), ultimately enabling the Malaysia power sector to deliver reliable and affordable green power to all.

Figure 0-2: Guiding principles for the pursuit of reliable green power



This Roadmap assessed two distinct scenarios for RE capacity evolution up to year 2035, with Scenario 1 representing "Business as Usual, BAU" and Scenario 2, "New Capacity Target, NCT".

Scenario 1

BUSINESS AS USUAL (BAU)

This scenario considers implementing existing policies and programmes without further extension and/or introduction of new programmes. The implementation of approved, committed and announced capacities under existing programmes (i.e., projects under the FiT, LSS and NEM programmes) will lead to 11.7 GW projected RE capacity in 2025. Share of renewables in the installed capacity shall reach 29% in 2025 with minimal future RE growth, resulting in 32% in 2035.

Scenario 2

NEW CAPACITY TARGET (NCT)

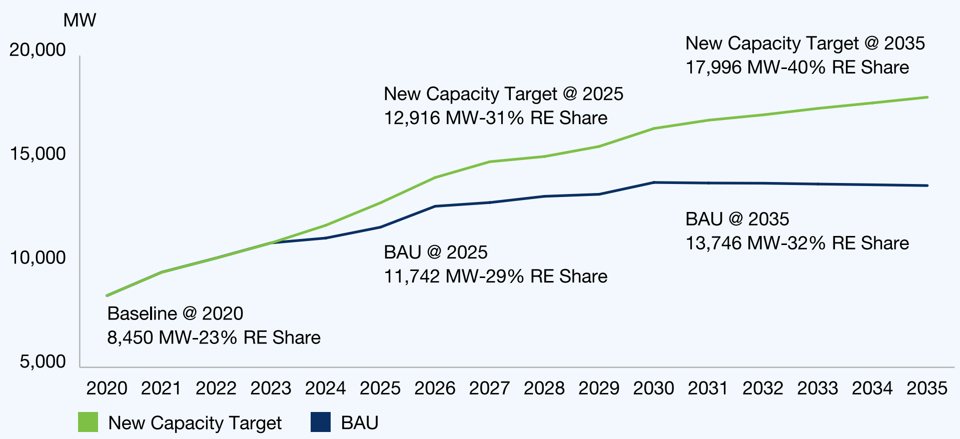
This scenario targets a higher RE capacity by 2035, with further decarbonization of the electricity sector in Malaysia. This scenario is aligned with the capacity development plan of Planning and Implementation Committee for Electricity Supply and Tariff (JPPPET 2020) for Peninsular Malaysia, JPPPET 2021 for Sabah and current outlook for Sarawak. This scenario is designed to achieve the national target of 31% RE share with 12.9 GW of RE installed capacity by 2025, while prioritizing system stability in the choice of RE technologies.

Post 2025 foresees greater RE deployment with RE target of 40% by 2035, in which penetration of solar during peak demand reaches 30%. Therefore, implementation of specific measures is required in ensuring system stability, including roll-out of energy storage technologies as well as improving system flexibility post 2025. These measures are expected to enable a shift towards flexible and dispatchable solar generation.

2. ASEAN RESSN Report

The comparison of the two scenarios is summarized in Figure 0-3 below.

Figure 0-3: Summary of RE capacity evolution and RE share in the MyRER



RE POTENTIAL: LEVERAGING INDIGENOUS RENEWABLES IN MALAYSIA

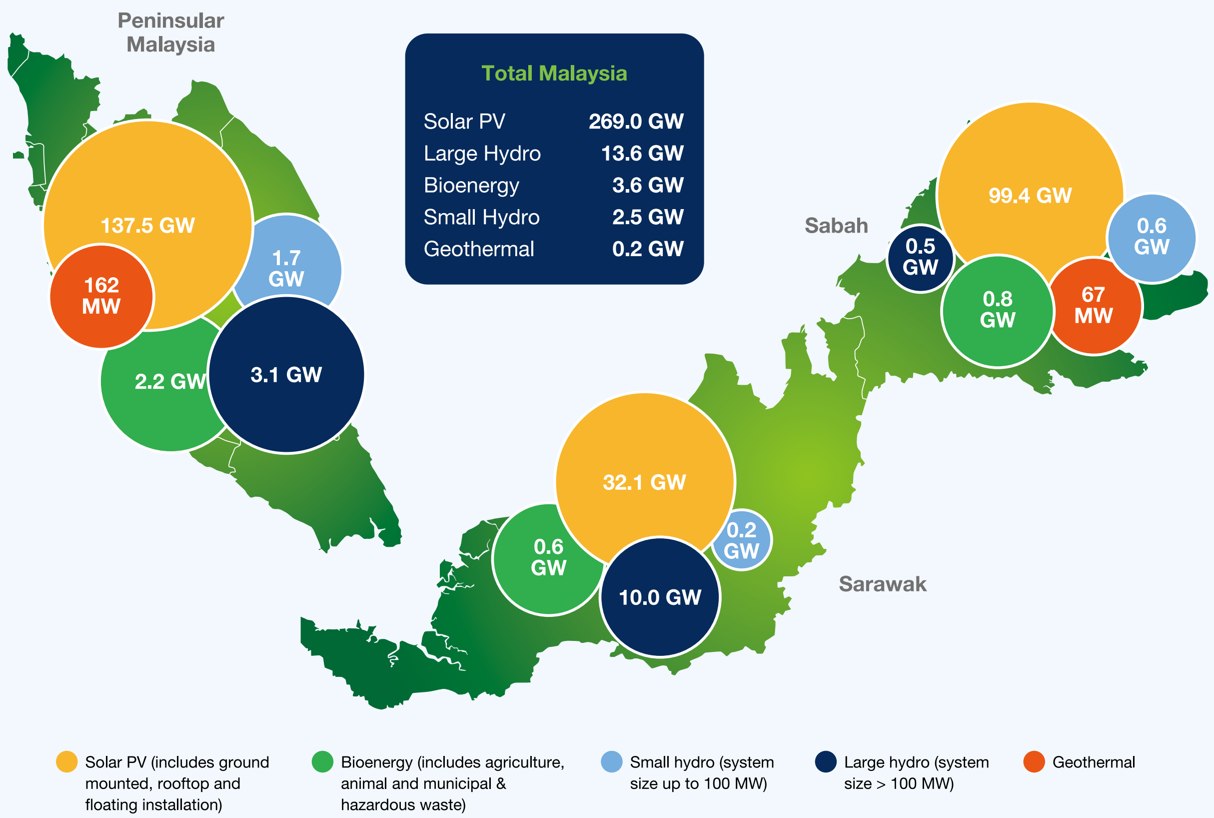
A review of Malaysian RE resource potential has been conducted, leading to the identification of the following resource potential (see Figure 0-4):

- 269 GW potential for solar PV, dominated by ground-mounted configurations (210 GW), including considerable potential from rooftop (42 GW) and floating configurations (17 GW)
- Close to 13.6 GW (13,619 MW) resource potential for large hydro (above 100MW); whereby 3.1 GW is identified in Peninsular Malaysia, 493 MW in Sabah, and 10 GW in Sarawak
- 3.6 GW resource potential for bioenergy, including biomass (2.3 GW), biogas (736 MW), municipal solid waste (516 MW)
- 2.5 GW resource potential for small hydro (up to 100 MW)
- 229 MW of geothermal resource potential

The RE technical potential assessment considered among others:

- Malaysia's advantageous geographical location offers abundance of indigenous natural resources, readily available to be utilized for RE power generation. Malaysia's proximity to the equator provides strong solar irradiance in the range of 1,575 – 1,812 kWh/m2 throughout the year, comparable to countries with more mature and developed solar PV markets;
- The potential in approximately 450 palm oil mills across Malaysia, processing an average of 95.5 million tons of fresh fruit bunch (FFB) annually, in which the waste from palm oil processing can be utilized as feedstock for bioenergy power generation, either through biomass combustion or biogas capture technologies;
- Available agricultural and husbandry residues from rice production, wood processing and animal waste which can be used for power generation;
- Growth in population and urbanization in Malaysia contributes to the increase in production of municipal solid waste, an estimated average of 9.5 million tons of solid waste were generated every year. This can potentially be used for bioenergy power generation, leveraging waste-to-energy (WTE) technologies; and
- 189 river basins which can support small hydro power generation.

Figure 0-4: Summary of RE resource potential in Malaysia



The RE resources technical potential provided the basis for the capacity projection in this Roadmap. Taking cognizant that RE integration with a balanced mix between firmed and variable renewables is important to maintain a stable and reliable electricity supply system, Figure 0-5 and 0-6 illustrate the recommended RE capacity mix based on New Capacity Target scenario, which will contribute towards ensuring long-term energy security, while decarbonizing Malaysia's power sector. The RE target is determined according to the technical potential available for each RE resource, with consideration for fair growth opportunities for each region.

Figure 0-5: RE Capacity Mix to achieve the target in 2025

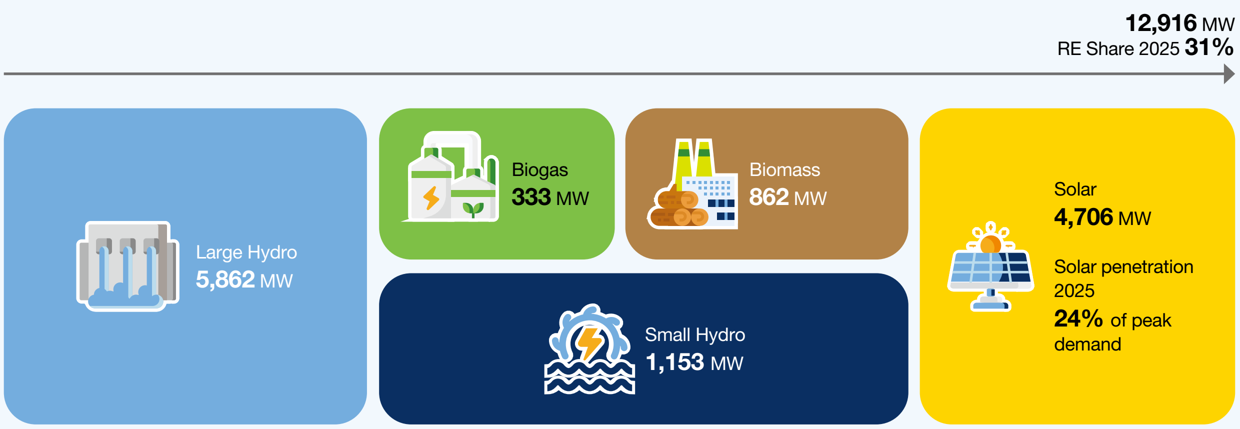
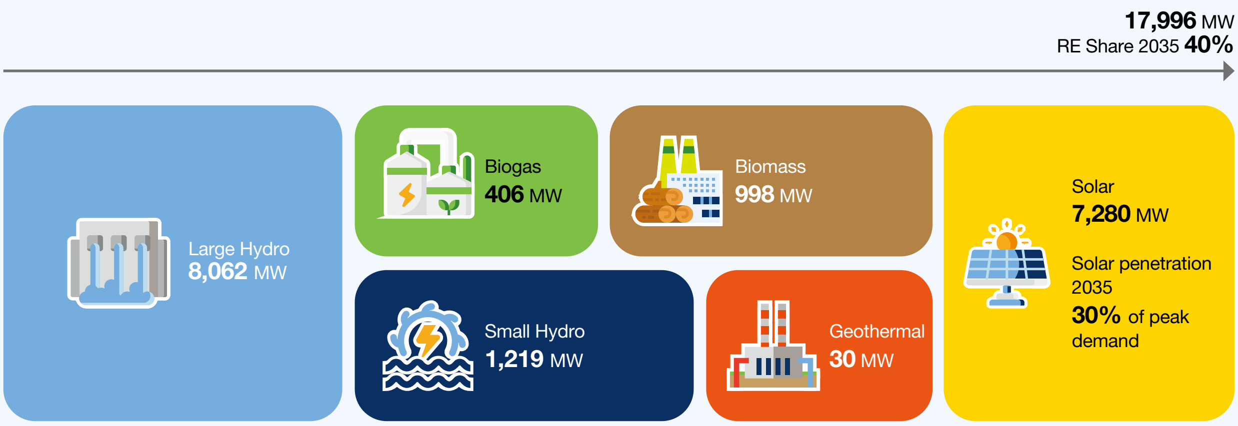


Figure 0-6: RE Capacity Mix to achieve the target in 2035



MYRER: THE STRATEGIC FRAMEWORK

The Roadmap defines a strategic framework driven by 4 technology-specific Strategic Pillars (SP) and supported by 4 cross-technology Enabling Initiatives (EI) (see Figure 0-1). The framework takes into account the outcome of the Roadmap assessment on available RE resources, existing institutional and regulatory framework, industry practices and technology adoption, as well as projected future social and economic development. Key actions are planned to realize respective milestone targets up to year 2025, and post 2025 to 2035.

ROADMAP STRATEGIC PILLARS

The Roadmap strategic pillars with milestone development target for 2025 will be achieved through enhancement of existing programmes. Meanwhile, the 2035 development milestones will be achieved with the implementation of new business models, in line with the Government's strategy in future-proofing its existing electricity market regulatory and power sector industry practices.

STRATEGIC PILLAR 1: SOLAR

The Solar energy pillar is built upon existing programmes (i.e; NEM and LSS auctions) but to be complemented with the possibility of introducing new business models.

The key actions towards 2025 for SP1 are as follows:

i. Review future NEM programmes for rooftop solar and the offtake tariffs to gradually converge with the energy costs for a more equitable socialization of grid and system operation costs. Decrease in NEM tariffs and grandfathering of contracts will be continued to create incentives for early movers; supporting the rate of uptake under NEM;
ii. Explore new business models in addition to those enabled by the NEM and LSS programmes. These include corporate PPAs, third-party access framework and providing greater avenues for distributed generations, monetization of environmental attributes through Renewable Energy Certificates (RECs); and
iii. Explore LSS auctions focusing on modern technologies with lesser land use such as floating solar. The potential implementation of existing hydroelectric basins and water bodies shall be assessed to address the large land requirements, while utilizing the existing grid connection facilities. Engagement and involvement of state Governments to identify suitable sites for solar development will be enhanced, thereby de-risking solar projects and allowing solar costs to decrease.

The key actions for post 2025 shall include the introduction of a RE programme framework as follows:

i. Improve and continue solar auctions to ensure competitive tariff. Auction format will be regularly reviewed to align with evolving technological advances and best global practices;
ii. Explore framework for deployment of solar quota based on direct corporate offtake or different forms of PPAs;
iii. Enhance existing rooftop programmes including exploring possible frameworks to allow non-utility offtakers under NEM; and
iv. Facilitate, encourage and increase participation of Government agencies in Government solar rooftop programmes.

STRATEGIC PILLAR 2: BIOENERGY

The Bioenergy pillar aims to increase bioenergy capacity by supporting the rollout of biomass, biogas and WTE capacity under the existing FiT via new business models (i.e; auctions and tendering programmes), as well as exploring potential opportunities in bio-CNG and biomass co-firing.

The key actions towards 2025 for SP2 are:

i. Explore the feasibility for clustering of bioenergy power for power generation to improve project economics;
ii. Assess auction systems beyond the FiT to support additional capacity build-up for post 2025;
iii. Conduct a feasibility study of grid extensions to allow additional development of bioenergy clusters by encouraging off-grid bioenergy power plants to re-power and upsize, as well as building new off-grid and micro-grid power plants;
iv. Explore possibility of a net metering scheme for bioenergy resources;
v. Leverage available bioenergy feedstock from municipal solid waste for the development of Waste to Energy (WTE) facilities as a two-pronged strategy in addressing the waste management issue and in supplying energy to the national grid;
vi. Conduct feasibility study of bio-CNG power generation and biomass co-firing in coal-fired power plants; and
vii. Encourage studies and assessments on the improvement in bioenergy power generation technology to be conducted.

The key actions for post 2025 shall build upon the strategies implemented by 2025 to support further capacity build-up as follows:

i. Recommend a new auction mechanism (beyond FiT) to support additional capacity build-up with improved by-products management towards circular economy;
ii. Undertake syndication of bioenergy potential with possible grid extensions to identify additional development of bioenergy clusters;
iii. Improve and review energy purchase framework for WTE projects to ensure equitable socialization cost;
iv. Explore the implementation of equitable and feasible support mechanisms for bio-CNG and biomass co-firing; and
v. Support improvement in bioenergy power generation technology.

STRATEGIC PILLAR 3: HYDRO

The Hydro pillar supports accelerated deployment and operation of hydro generation capacity.

The key actions towards 2025 for SP3 are as follows:

i. Continue to optimize small hydro FiT through auctioning while considering differences in development costs for low-head and high-head system;
ii. Encourage hydro-geological study for identification and characterization of new high potential sites for small hydro development. The study shall lead to development of open access geo-referenced database that will be utilized by developers;
iii. Explore lifetime extension of existing, peaking large hydro plants to support greater VRE penetration;
iv. Coordinate with state authorities to expedite approvals and facilitate implementation and operation regulations for hydro plants development; and
v. Devise and improve existing tendering process format for small hydro development.

The key actions for post 2025 shall support the development of remaining potential resource to meet prevailing energy demand as follows:

i. Continue to encourage identification and characterization of new sites for small hydro through hydrogeological study;
ii. Enhance project development coordination and facilitation with state authorities to expedite approvals including facilitation on hydro plants related development and operation regulations; and
Iii Assess deployment of large hydro, as part of the national power development plan through collaboration between regulators, state authorities and utilities.

STRATEGIC PILLAR 4: NEW TECHNOLOGY AND SOLUTIONS

The new technology and solutions pillar supports roll-out of new RE resources post 2025 and explores solutions to maintain system stability under high VRE penetration.

The key actions towards 2025 for SP4 under new technology and solutions pillar are as follows:

i. Explore new RE technologies, resources and solutions for efficient and cost-effective RE deployment; and
ii. Assess required energy storage roll-out to maintain system stability.

The key actions for post 2025 under new technology and solutions pillar are:

i. Conduct feasibility study and economics assessment on implementation of new RE sources including geothermal, onshore and offshore wind; and
ii. Prioritize and roll out cost-effective energy storage solutions (i.e. battery storage and hydrogen solution).

ENABLING INITIATIVES

There are four Enabling Initiatives (EI) supporting the implementation of the action plans for each strategic pillar. The initiatives are as follows:

i. Future proofing existing electricity regulatory and market practices to enhance private sector participation and to provide greater customer choice in choosing RE-powered electricity, including exploring the prospect for corporate PPA and Third-Party Access (TPA) framework. The existing green tariffs and REC mechanism will also be improved to enable direct procurement of REC from utilities or mandated party in meeting both public and private sectors demand;

ii. Improve access to green financing to increase financial flows vis-à-vis the Government's intent to accelerate RE deployment in energy transition. This initiative includes enhancing existing fiscal and non-fiscal incentives, exploring new incentives for RE financing, and continuous engagement and facilitation with financial institutions;

iii. Increase system flexibility by exploring feasible framework for demand-side management, smart grids including battery energy storage system integration to improve grid management (through solar forecasting, dispatching, grid and distribution codes) (See Chapter 6.5.2.4). This shall also include creating an organized markets for grid balancing services, allowing third parties to provide innovative grid management solutions that will also be explored to create new economic activities; and

iv. Develop awareness and future readiness to promote RE-centric society. This initiative includes human capital development, supporting future power sector transition as well as efforts to strengthen technology innovation in RE. In line with 4IR initiative, technology innovation comprises of digitalization of the power sector through the implementation of distributed energy systems, advanced metering infrastructure, automated distribution, virtual energy trading and smart grids.

IMPACT ON JOBS AND INVESTMENTS IN THE RE SECTOR

The New Capacity Target scenario shall offer vast job and investment opportunities in the RE sector for the period of 2021-2025, with MYR 19.93 bn cumulative investment from 2021 to 2025 and 28,416 jobs by 2025, not accounting jobs related to manufacturing of RE equipment.

Post 2025, sustained RE deployment shall ensure continued socio-economic impact during the period of 2026-2035, with estimated MYR 33.07 bn in cumulated investment and 46,636 jobs in the RE sector. The illustration of the impact on jobs and investments in the RE sector is as presented in Figure 0-7.

Figure 0-7: Summary of impact on jobs and investments in the MyRER

	Scenario **BAU**		Scenario **New Capacity Target**	
Cumulative Investment (MYR bn)	2021-2025 **16.12**	2026-2035 **19.51**	2021-2025 **19.93**	2026-2035 **33.07**
Employment Impact (# of Jobs)	2025 **20,385**	2035 **27,786**	2025 **28,416**	2035 **46,636**

IMPACT ON CARBON EMISSIONS

In the New Capacity Target scenario, the increase in share of renewables will gradually displace gas generation. By 2035, the reduction of carbon emission for NCT is projected to be -11% against BAU.

For Peninsular Malaysia, under the New Capacity Target scenario will achieve a CO_2 emission intensity reduction of 45%, reaching 0.053 kgCO_2/GDP in 2030 and a further reduction to 0.039 in 2035. The corresponding target for GHG emissions intensity of the power sector for Peninsular Malaysia is 0.053 kgCO_2/GDP in 2030 (45% decline from 0.096 kgCO_2/GDP in 2005). For Sabah, the initiative under the Roadmap is expected to achieve a 41% reduction, reaching 0.003 kgCO_2/GDP in 2030 (from 0.052 kgCO_2/GDP in 2005). For Sarawak significant carbon intensity reduction has been realized with the commissioning of Bakun and Murum HEP since 2011, reaching 0.062 kgCO_2/GDP in 2025 and further reduction of 0.028 kg CO_2/GDP are anticipated as the renewable portfolio increases from current capacity mix to year 2030. The illustration of the impact of the Roadmap on carbon emissions is as shown in Figure 0-8.

Figure 0-8: Summary of impact on carbon emissions in the MyRER

	Scenario **BAU** 2025	Scenario **BAU** 2035	Scenario **New Capacity Target** 2025	Scenario **New Capacity Target** 2030	Scenario **New Capacity Target** 2035
Impact of carbon emissions in P. Malaysia					
CO_2 emission (millions tonnes)	**94.67**	**88.23**	**94.20**		**78.35**
CO_2 intensity (tonnes/MWh)	**0.71**	**0.56**	**0.70**		**0.50**
CO_2 intensity (kgCO_2/GDP)			**0.071**	**0.053**	**0.039**
Impact of carbon emissions in Sabah					
CO_2 emission (millions tonnes)	**3.51**	**3.56**	**3.53**		**3.10**
CO_2 intensity (tonnes/MWh)	**0.43**	**0.36**	**0.43**		**0.31**
CO_2 intensity (kgCO_2/GDP)			**0.040**	**0.031**	**0.028**
Impact of carbon emissions in Sarawak					
CO_2 emission (millions tonnes)	**11.38**	**7.76**	**11.38**		**7.76**
CO_2 intensity (tonnes/MWh)	**0.32**	**0.19**	**0.32**		**0.19**
CO_2 intensity (kgCO_2/GDP)			**0.062**	**0.028**	**0.028**

WAY FORWARD

The MyRER formulates strategies to achieve the Government's committed target of 31% RE share in the national installed capacity mix and to further decarbonize the power generation sector until 2035 by maintaining affordability and system stability. To achieve the stipulated RE targets and aspirations, commitments by policy makers, industry players and strategic partners including financial institutions shall be the determinant in ensuring the successful implementation of this Roadmap. This Roadmap will optimize the socio-economic benefits from the development of RE in Malaysia, whilst positively contributing towards the global climate-change agenda in decarbonizing the power sector for a better future.

Image for illustration purpose only.

MyRER

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chapter one

INTRODUCTION

INTRODUCTION

SUMMARY

In 2020, the Ministry of Energy and Natural Resources of Malaysia (KeTSA) set a target to reach 31% of RE share in the national installed capacity mix by 2025. This target supports Malaysia's commitment under the 2015 Paris Agreement led by the United Nations Framework Convention on Climate Change (UNFCCC) to reduce GHG emission intensity by 45% from the 2005 level by 2030. Under this roadmap, the corresponding GHG emissions intensity target for the power sector in Peninsular Malaysia is 0.053 kgCO2/GDP[3] in 2030 (45% decline from 0.096 kgCO_2/GDP[2] in 2005).

The Malaysia Renewable Energy Roadmap (MyRER) is commissioned to develop a national strategic plan to guide the Malaysia's renewable energy policy development towards the RE share target of 31% in the national capacity mix in 2025 and support further decarbonization of the electricity sector in Malaysia through the 2035 milestone. This is expected to drive a reduction in GHG emission in the power sector to support Malaysia in meeting its NDC[4] 2030 target of 45%[5] reduction in its economy-wide carbon intensity (against GDP) in 2030 compared to 2005 level.

The scope of MyRER includes three workstreams; assessing the baseline installed capacity and RE resources potential, developing technology-specific RE targets and scenarios, and developing a strategic roadmap.

The guiding principles for MyRER follow the energy trilemma: sustainability, reaching RE share targets and CO2 reduction, ensuring affordability and economic benefits by minimizing the impact of increased RE on the cost of power generation, and preserving system stability by mitigating the impact of VRE on the power supply.

The MyRER considers two distinct scenarios for RE development in the nation towards the 2025 Government committed RE target and through to the 2035 milestone:

1. **Business as Usual (BAU)** scenario considers the implementation of existing policies and programmes without further extension and/or introduction of new programmes; and
2. **New Capacity Target** scenario aims for higher RE capacity target to align with further decarbonization of electricity sector in Malaysia toward 2035 milestone. This scenario is aligned with the capacity development plan of Planning and Implementation Committee for Electricity Supply and Tariff (JPPPET 2020) for Peninsular Malaysia, JPPPET 2021 inputs for Sabah and current outlook for Sarawak.

3. Total value of the goods and services produced denominated in MYR
4. KASA (2021); Malaysia's Update of Its First Nationally Determined Contribution to the UNFCCC
5. The 45% of carbon intensity reduction is unconditional

1.1 CONTEXT

Renewable Energy (RE) was first introduced as the "fifth fuel" and an alternative source for the country's power generation in 1999. It was part of Government's intent to diversify the energy mix in the country. Various initiatives, programmes and strategies have since been introduced and implemented to support the growth of RE technologies throughout 2001-2020.

Under the Eighth Malaysia Plan (2001-2005), the Small Renewable Energy Power (SREP) Programme was introduced, along with the Biomass Power Generation and Cogen Full Scale Model Demonstration (BIOGEN) Project, leveraging the readily available oil palm-based by-products for small-scale electricity generation. Ninth Malaysia Plan (2006-2010) recorded further progress, with the development of rooftop solar becoming prominent through the Malaysia Building Integrated Photovoltaic (MBIPV) Project. The MBIPV project focused on the policy development for grid-connected PV system, market and incentive measures and capacity building programme for rooftop solar.

The programmes and projects implemented under the 8th and 9th plan led to the subsequent development of the National RE Policy and Action Plan (NREPAP) in 2010; aiming to establish a policy guide for RE development in Malaysia.

NREPAP further paved the path for RE development in the Tenth Malaysia Plan (2011 – 2015), as one of the key new areas of growth for the energy sector. During this period, the Renewable Energy Act 2011 (Act 725) and the Sustainable Energy Development Authority Act 2011 (Act 726) were enacted, leading to the establishment of Sustainable Energy Development Authority (SEDA) Malaysia as the designated authority for RE development in Malaysia. The Feed-in-Tariff (FiT) scheme was also introduced and implemented in 2011 to catalyse the growth of grid-connected RE in Peninsular Malaysia, Sabah and Labuan.

The initiative to promote RE growth progressed further under the Eleventh Malaysia Plan (2016-2020). Solar auctioning and rooftop solar quota were released for the very first time through the Large Scale Solar (LSS), Net Energy Metering (NEM) and Self-Consumption (SELCO) Programme. By the end of the 11th Plan, the growth of RE capacity in Malaysia has been substantial, from a base of 53 MW of RE connected to the grid (without large hydro) between 2001-2009 to a total installed capacity of 1.6 GW between 2011-2015. By December 2020, cumulative RE capacity had reached 2.8 GW, or 8.45 GW with the inclusion of all RE resources.

Moving forward, Malaysia aims to achieve a higher RE growth, from the existing 23% or 8.5 GW RE in its power installed capacity, the Roadmap projected to increase the share of RE to 31% or 12.9 GW in 2025, and 40% or 18.0 GW in 2035. The RE initiatives under this Roadmap are expected to contribute towards Malaysia's global climate commitment with set under Peninsular Malaysia power sector in achieving a reduction of 45% GHG emission per GDP intensity in the power sector in 2030 compared to the 2005 baseline, and a further 60% in 2035.

1.2 THE ROLE OF ENERGY SECTOR IN POST-PANDEMIC ECONOMIC RECOVERY

The COVID-19 pandemic has impacted the growth of global economy. However, the RE sector was relatively resilient in withstanding the economic adversity of the pandemic. Countries around the world have embarked on accelerating the deployment of RE as a two-pronged strategy for post-pandemic economic recovery and sustainable energy transition.

In Malaysia, a total of 1,000 MW of large-scale solar projects, 500 MW of solar rooftop quotas and 180 MW of non-solar quotas were offered in 2021 to allow investment opportunities and boost the country's post-pandemic economic growth. The pandemic situation has also brought forth greater social and economic opportunity for businesses and policymakers in Malaysia to embark on greater environmental, social and governance commitments. There are increasing interest from corporations in Malaysia to realign their strategic path towards sustainability, as there is a growing awareness that it is integral to financial health.

The need for post-pandemic economic recovery and the need to be aligned with current energy megatrend warrant the Government to review its medium, long-term targets and strategies for RE development in the country. Therefore, this Malaysia Renewable Energy Roadmap is introduced to realise the Government's future RE aspiration with an anticipated cumulative investment of RM43 billion and 46,636 job opportunities.

As of end of 2020, the installed capacity of renewables stands at 8.45 GW or 23% of national installed capacity. In Malaysia's case, share of renewable sources lags the global average and also the average RE share in ASEAN countries (see Chapter 2.4). Globally, RE account for 37%[6] of the total installed capacity

Against this backdrop, there is an urgent need for Malaysia to accelerate the growth of power generation from RE sources. Consequently, the Government has mandated the formulation of the MyRER to provide the plan towards achieving its vision.

Due to its geographical location, climate and rich agricultural activity, Malaysia is blessed with abundant renewable energy resources, for example:

- Located near the equator, Malaysia enjoys high year-round solar irradiation for solar PV generation;
- Malaysia's agricultural sector has large potential to provide biomass waste to be utilized in power generation, e.g. palm oil waste, animal waste, etc.; and
- Malaysia has numerous river basins with excellent hydrogeological conditions for hydropower generation both at large and small scale.

6. IRENA, Renewable Capacity Statistics 2021 & Renewable Energy Statistics 2020

1.3 DEFINITION OF RENEWABLE ENERGY FOR MyRER

MyRER covers RE power generation sources in Malaysia, including grid-connected and off-grid generation.

RE resources considered in the MyRER include the following:

- Bioenergy:
  - Agricultural waste: Palm oil waste and Palm Oil Mill Effluent (POME), wood residues, and other agricultural waste (e.g. rice husk and straw, animal waste);
  - Municipal solid waste (MSW) and landfill gas;
- Hydropower of all capacities. Small hydro of up to 100 MW are assessed separately;
- Solar photovoltaics (PV) assessment based on ground-mounted, rooftop and floating applications; and
- Other technologies, such as geothermal power generation and wind energy.

1.4 OBJECTIVES AND SCOPE

The objectives of MyRER are:

- To determine the renewable energy targets in the electricity mix up to 2035; and
- To establish strategies required to achieve renewable energy targets.

MyRER covers the assessment of baseline and resource potential[7], formulation of RE targets and scenarios, and a strategic roadmap (Figure 1-1).

Figure 1-1: Scope covered in MyRER

1. BASELINE & RESOURCE POTENTIAL

Data Collection and synthesis

- Synthesis of historical and current data on Malaysia electricity sector to build **baseline of RE**
- Review of **resource availability** for renewables

2. RE TARGET & SCENARIOS

Capacity Planning

- Setting of **RE capacity targets for 2025** in line with Government aspirations
- Development of **RE scenarios for 2025**

3. RE STRATEGIC ROADMAP

Development of power plants

Generation & sales of electricity

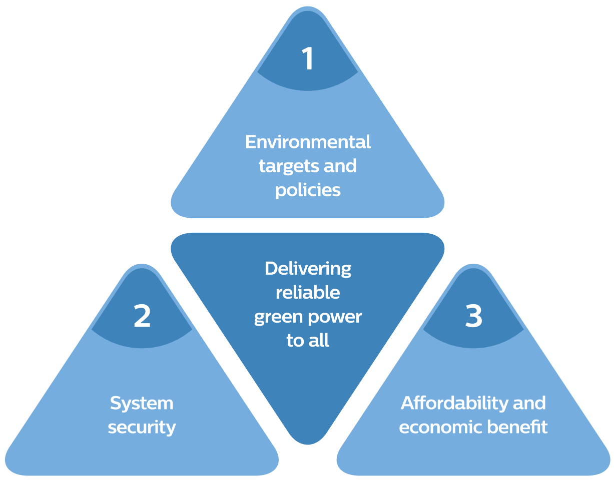
- Setting of **yearly plant-up roadmap** to achieve 2025 RE capacity targets and 2035 scenarios
- Setting of **strategies and key actions** to achieve RE capacity target and scenarios
- Assessment of impact of RE capacity targets on **socio-economic indicators**

7. From existing data available

1.5 GUIDING PRINCIPLES

Three guiding principles were established to ensure that MyRER strikes a balance between environmental targets, economic benefits, and system security (the "Energy Trilemma") as shown in Figure 1-2.

Figure 1-2: Guidelines principles for the pursuit of reliable green power



- MyRER is aligned with and supports key environmental targets and policies in Malaysia, i.e.:
  - Increase in RE capacity to achieve 31% share in the national installed capacity mix by 2025;
  - Reduction of GHG supporting the achievement of NDC and climate pledge for power sector;
- MyRER defines pathways to achieve the transition toward RE by generating socio-economic benefits:
  - Impact on capital investment and jobs in the RE sector are forecasted as the key socio-economic metrics in MyRER; and
- In order to preserve system stability, MyRER develops mitigation strategies for potential impact of VRE sources in alignment with Single Buyer and the Grid System Operator (GSO).

1.6 NATIONALLY DETERMINED CONTRIBUTION

MyRER supports Malaysia's commitment to reduce GHG emission under the Paris Agreement led by United Nations Framework Convention on Climate Change (UNFCCC) in response to climate change threat. Under the NDC set in the Paris Agreement in August 2021, Malaysia has revised its commitment to reduce unconditional carbon intensity (against GDP) of 45% in 2030 compared to 2005 level.

The NDC target is developed on a country-wide basis, and it includes all sectors, e.g., public electricity, manufacturing, transport, industrial processes and agriculture. As of 2015, public electricity contributed approximately 30%[8] of total greenhouse gas emission in Malaysia. Thus, reduction in greenhouse gas emission in the electricity sector will greatly impact Malaysia's progress to achieve the NDC targets. Post 2030, electricity sector aspires to pursue decarbonizing of the sector with targeted reduction of GHG emission per GDP by 60% from the 2005 level by 2035.

1.7 SCENARIOS FOR RE CAPACITY EVOLUTION TO 2035

MyRER considers two distinct scenarios for RE development in the nation toward the 2025 Government target and through to 2035:

1. **Business as Usual (BAU) scenario** considers the implementation of existing policies and programmes without further extension and/or introduction of new programmes; and

2. **New Capacity Target (NCT) scenario** aims for much higher RE capacity target to align with further decarbonization of electricity sector in Malaysia toward 2035 milestone. This scenario is aligned with the capacity development plan of Planning and Implementation Committee for Electricity Supply and Tariff (JPPPET 2020) for Peninsular Malaysia, JPPPET 2021 for Sabah and current outlook for Sarawak. It represents the official commitment by the Government in achieving the 31% and 40% RE target by 2025 and 2035 respectively.

Image for illustration purpose only.

8. BUR to the UNFCC, MNRE 2015

MyRER

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chapter two

THE CONTEXT OF GLOBAL AND REGIONAL ENERGY TRENDS

THE CONTEXT OF GLOBAL AND REGIONAL ENERGY TRENDS

SUMMARY

GLOBAL ENERGY TRENDS TO 2040

Global primary energy demand growth is expected to slow down from ~2% CAGR (2000-2018) to ~1% CAGR (2018-2040) as a result of four key drivers: (1) slowing population growth or negative growth in the US, Europe, Japan and parts of Asia, (2) slow economic growth in Europe, (3) decrease in energy intensity due to structural shift from a manufacturing-based economy to a service-based economy in Asia and (4) decrease in energy intensity due to systemic efficiency improvements.

Renewables and natural gas are expected to have an increasing role in primary energy supply. Renewables are emerging as an affordable solution to meet global decarbonization targets. Natural gas is increasingly regarded as a bridging fuel within the energy transition as alternative to coal and oil.

In the final energy consumption, electricity is expected to display the fastest growth, at 2.1% CAGR due to electrification of industry and transportation, increase in household appliances, and rural electrification.

RENEWABLE ENERGY TRENDS – GLOBAL

Globally, RE is increasingly becoming a key source in the power generation mix. In 2020, RE share in generation capacity reached 36.6%. Since 2012, renewables have overtaken conventional generation fuels in terms of new installed capacity additions, and in 2020, renewables contributed to as much as 82% of capacity additions worldwide.

This transition can be attributed to Political, Economic, Social and Technology (PEST) drivers: (1) support policies driven by GHG reduction goals, (2) increasing availability of debt and equity financing, and emergence of new configurations and business models, (3) mounting public opposition to coal and nuclear power generations; and (4) rapid decline in cost of RE technologies such as solar and wind.

Germany was among the pioneer countries to introduce renewables through a very attractive Feed-in Tariff (FiT) system. As a result, it achieved very high wind and solar PV penetration (54% of total installed capacity).

In India, government-driven initiatives such as de-risking of site development and sharing of infrastructure costs, coupled with the introduction of competitive auction systems were successful in delivering large renewable capacities at very competitive off-take prices.

RENEWABLE ENERGY TRENDS – SOUTHEAST ASIA (SEA)

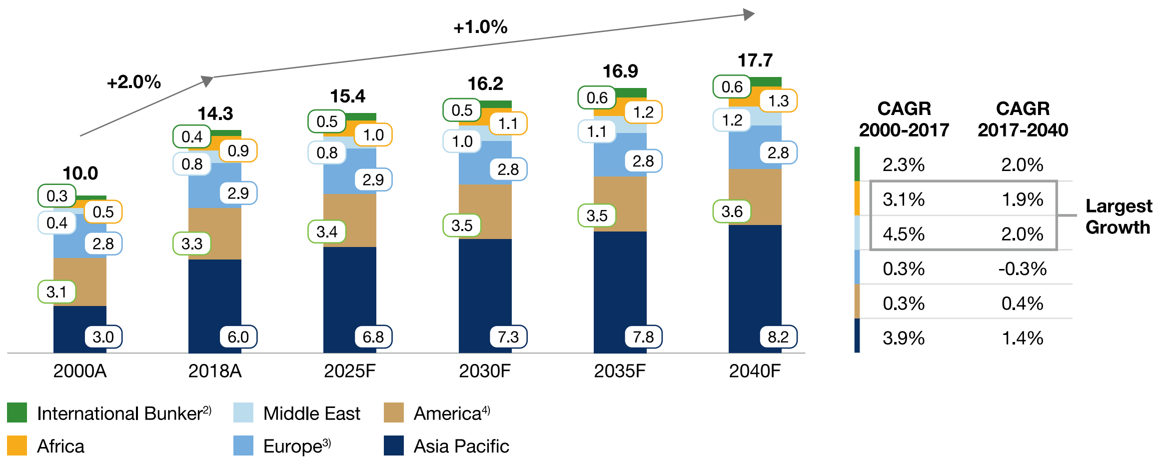
In SEA, RE installed power capacity reached 26% in 2020. Hydropower contributes 56% of total RE installed capacity in the region. VRE such as solar PV and wind remain marginal, at 29%, despite the region's rich availability of these resources. Policies and incentives to promote variable RE were implemented in SEA much later than in other geographies with higher income levels, as variable RE were still expensive at the time.

However, major ASEAN countries have developed aggressive RE share targets. In the long term, most ASEAN countries aim to increase RE share in their installed capacity or generation mix to 30-40% between horizon years of 2030-2050.

2.1 GLOBAL ENERGY TRENDS TO 2040

GROWTH OF PRIMARY ENERGY DEMAND IS EXPECTED TO DECLINE

Figure 2-1: Global primary energy demand by region (IEA New Policies Scenario), 2000 – 2040F



Note: Based on IEA New Policies Scenario. International bunkers are defined by the IEA as the energy consumption of ships and aircrafts. Europe includes Eurasia. Americas include North, Central and South America

Source: IEA (2018)

Although population increase and economic expansion are continuing on a global scale, primary energy demand growth is expected to slow down. Between 2000 and 2018, primary energy demand grew by more than 40% from 10 billion tonnes (btoe) of oil, equivalent to 14.3 btoe, corresponding to a Compound Annual Growth Rate (CAGR) of approximately 2%. According to the International Energy Agency (IEA)[9], primary energy demand growth between 2018 and 2040 is expected to slow down to a CAGR of about 1% (Figure 2-1). This trend is attributed to the following reasons:

- Slowing population growth or negative growth in the US, Europe, Japan and parts of Asia;
- Slow economic growth in Europe;
- Decrease in energy intensity due to structural shift from an energy intensive manufacturing-based economy to a service-based economy in Asia; and
- Decrease in energy intensity due to systemic efficiency improvements.

Primary energy demand growth is expected to exceed 2% growth only in Africa, where population and economic growth are still ongoing at a fast pace and in the Middle East, where energy intensity is expected to remain high.

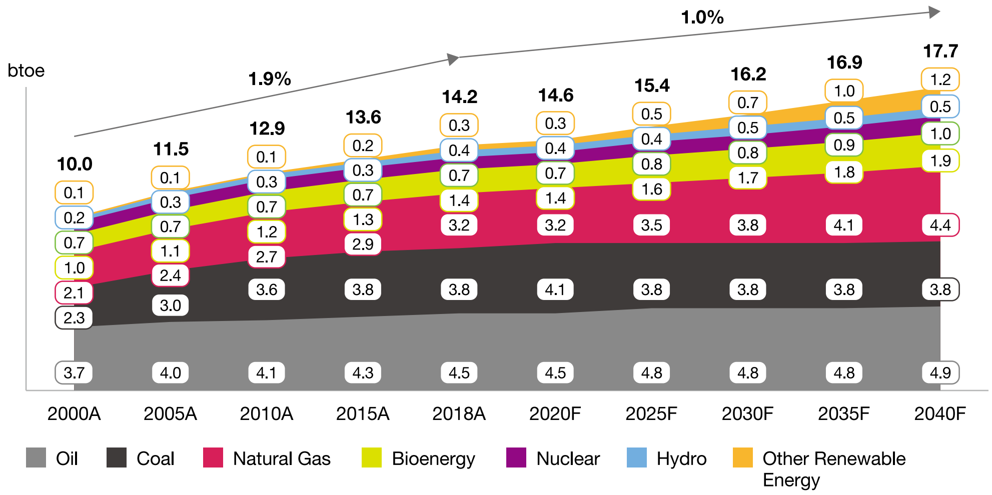
In ASEAN, overall energy demand is expected to grow by almost 50%[10] between 2018 and 2030.

Image for illustration purpose only.

9. International Energy Agency, World Energy Outlook, New Policies Scenario, 2018.
10. IRENA, Renewable Energy Outlook for ASEAN, 2016

INCREASING ROLE OF RENEWABLE SOURCES AND NATURAL GAS AS PRIMARY ENERGY SOURCES

Figure 2-2: Global primary energy demand by fuel based on IEA New Policies Scenario, 2000 – 2040F



CAGR 2000-2018	CAGR 2018-2040
8.8%	7.0%
2.7%	1.8%
0.1%	1.5%
1.8%	1.3%
2.4%	1.5%
2.8%	0.0%
1.1%	0.4%

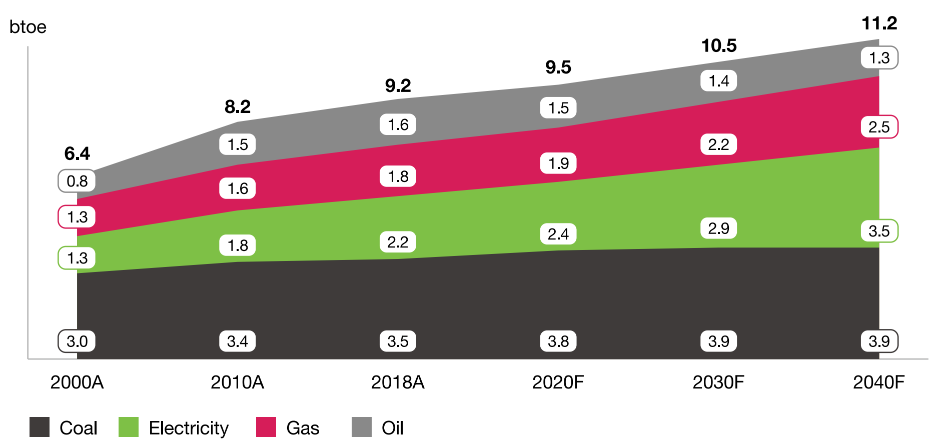
Source: IEA (2018)

IEA[7] also expects demand growth to vary considerably depending on the type of energy source, or fuel. Strong growth in demand for renewable sources (2018-2040 CAGR at 7%) and sustained growth in natural gas demand (2018-2040 CAGR at 1.5%) are forecasted, while demand for coal and oil is expected to remain stagnant.

These diverging trends are supported by the following considerations:

- Renewable energy sources are increasingly affordable in reaching global decarbonization targets; rapid cost reductions in solar PV and wind energy are driving large scale deployment of these sources (see Figure 2-11)[11];
- Increasing availability and affordability of natural gas as a low-carbon alternative to coal and oil: emergence of shale gas technologies in the US and advances in liquified natural gas (LNG) transportation are driving cost reduction and increasing availability of natural gas for power generation, substituting coal, and in industrial processes, substituting oil and coal; and
- Expected shift to electric vehicles and alternative transportation fuels (bio-fuels, hydrogen) is further impacting oil demand negatively.

Figure 2-2: Global primary energy demand by fuel based on IEA New Policies Scenario, 2000 – 2040F



CAGR 2000-2018	CAGR 2018-2040
3.7%	-1.1%
1.7%	1.6%
3.0%	2.1%
1.0%	0.4%

Source: BP Energy Outlook 2019

11. IRENA (2020) RE Power Generation Cost 2019

Electricity is expected to play an increasingly important role in final energy consumption (Figure 2-3); in their 2019 Energy Outlook[12], BP forecasted electricity consumption to grow at a CAGR of 2.1% between 2018 to 2040. As a result, the share of electricity in final energy consumption is expected to grow by 7 percentage points from 24% in 2018 to 31% in 2040. Key trends supporting this growth are as follows:

- Electrification of industrial processes. For example, manufacturing industries are increasing the use of electrically-powered machines to automate industrial processes;
- Expected increase in usage of cooling in commercial and residential properties, as a result of improved standard of living;
- Growth of household electrical appliances as a result of improved standards of living, as well as gradual switch from fuel oil to electricity in heating and from liquified petroleum gas (LPG) to electricity for cooking;
- Increasing penetration of electric vehicles; and
- Electrification of rural areas in developing countries (e.g. Africa, India and specific countries in Southeast Asia such as Myanmar and Cambodia).

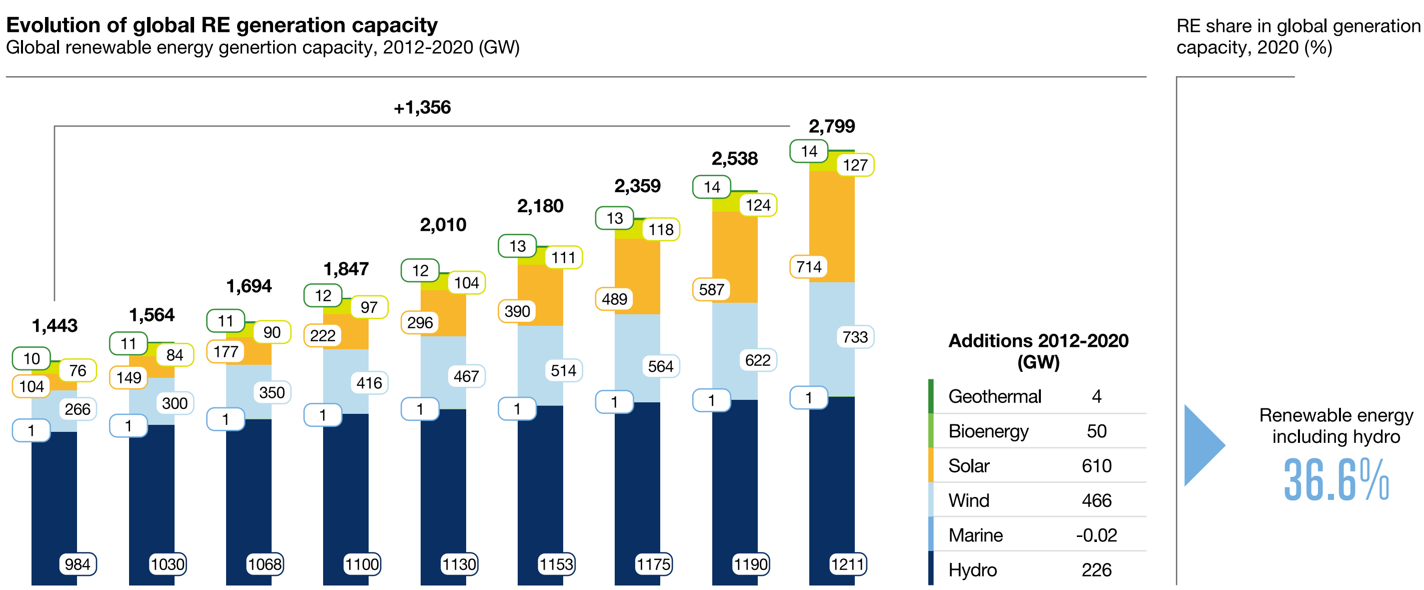
2.2 RENEWABLE ENERGY TRENDS – GLOBAL

RENEWABLE SOURCES ARE BECOMING A CRUCIAL COMPONENT OF THE POWER GENERATION MIX

The deployment of renewable energy sources in power sector has accelerated considerably in the past few years. According to the International Renewable Energy Agency (IRENA), between 2012-2020, 1,356 GW of new renewable capacity has been installed globally[13]. Solar PV and wind have become the main contributor to the RE capacity additions with 610 GW and 466 GW respectively (Figure 2-4). Solar PV installed capacity increased by almost six-fold between 2012 to 2020, and wind generation installed capacity increased by more than double during the same period.

As a result of these large capacity additions, as of 2020, renewable sources account for 36.6% of total installed capacity.

Figure 2-4: Global renewable energy installed capacity, 2012-2020

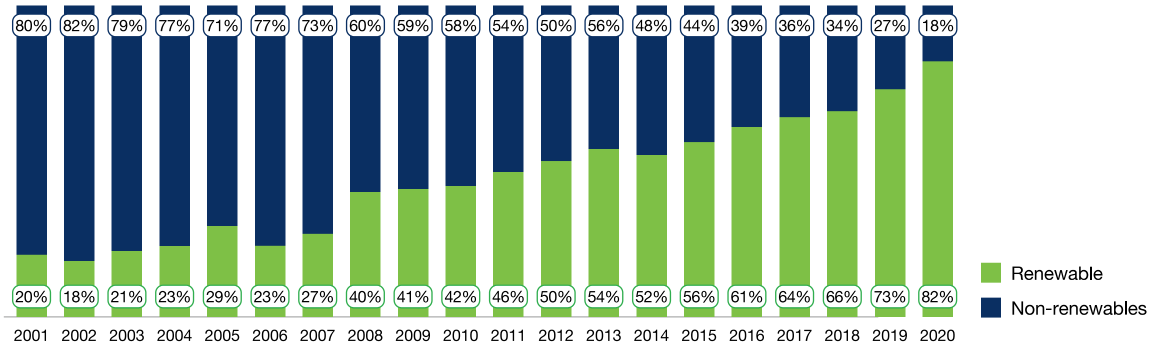


Source: IRENA-Renewable Capacity Statistics 2021; & Renewable Energy Statistics 2020

12. BP, Energy Outlook, 2019
13. IRENA-Renewable Capacity Statistics 2021; & Renewable Energy Statistics 2020

Most remarkably, since 2012 renewables have overtaken conventional generation fuels in terms of new installed capacity additions, and in 2020, renewables contributed to as much as 82% of capacity additions worldwide (Figure 2-5).

Figure 2-5: Global power capacity additions by energy type, 2001-2020

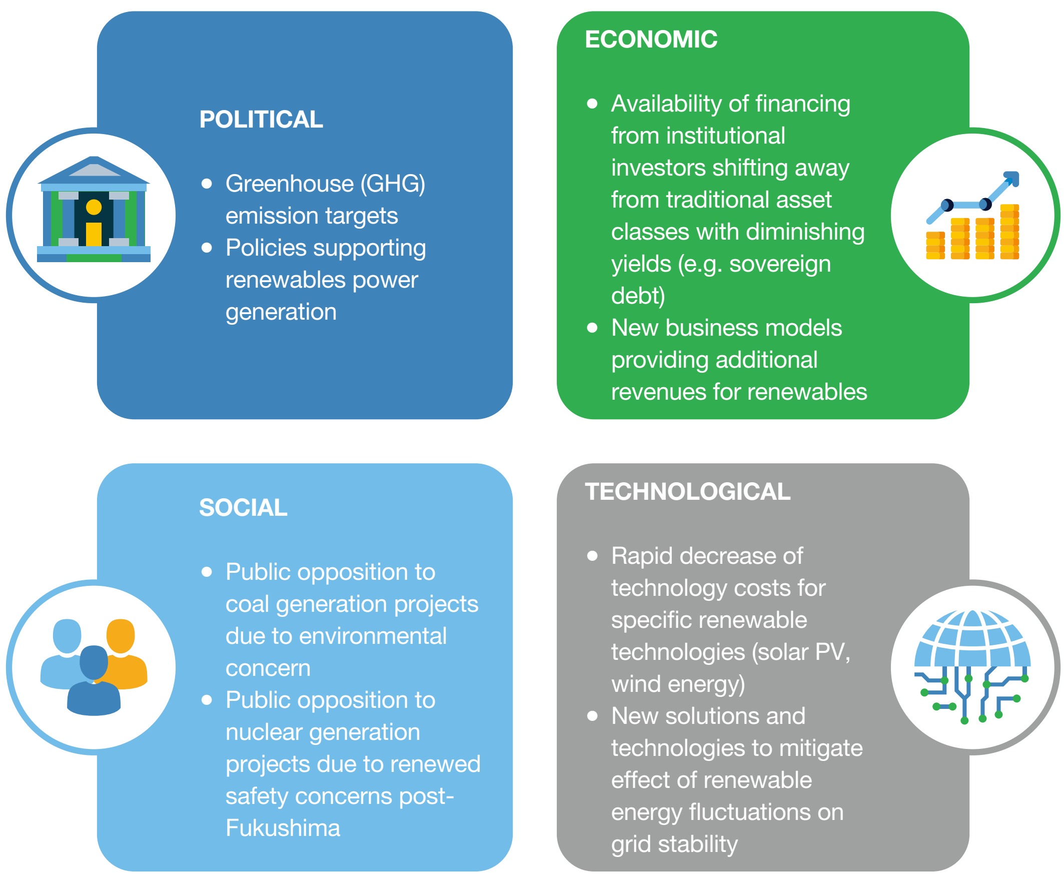


Source: IEA; IRENA; REN21 (2020)

KEY POLITICAL, ECONOMIC, SOCIAL AND TECHNOLOGICAL DRIVERS ARE SUPPORTING THE SHIFT FROM CONVENTIONAL TO RENEWABLES POWER GENERATION

The ongoing global transition to renewables can be attributed to multiple drivers along key Political, Economic, Social and Technology dimensions (PEST) as illustrated in Figure 2-6.

Figure 2-6: PEST analysis of key drivers of renewable power generation



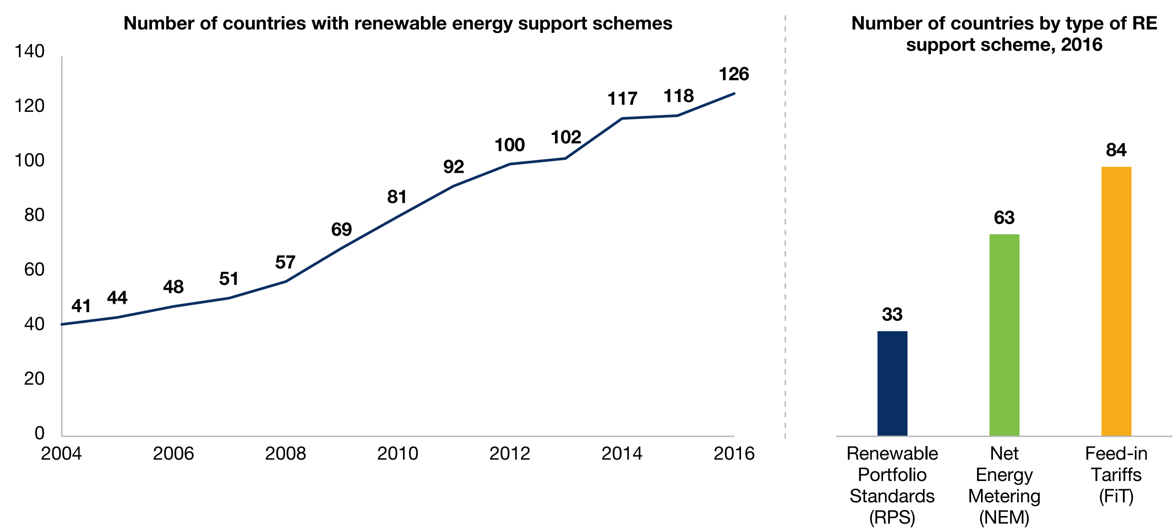
2.2.1 RE DRIVERS: POLITICAL

SUPPORT POLICIES DRIVEN BY GHG REDUCTION GOALS

Since 2004, the number of countries promoting renewables through specific support schemes has more than tripled (Figure 2-7). One of the largest factors accelerating the uptake of renewables support schemes is the desire to mitigate GHG emissions. Globally, the power generation sector is typically a large contributor to GHG emissions. In Malaysia, power generation accounts for approximately 30% of total GHG emissions, hence most decarbonization strategies undertaken by countries have focused on increasing renewable sources for power generation, as well as improving energy efficiency. In particular, solar PV and wind power capacity can be quickly scaled up, thus providing an effective way of mitigating carbon emissions from power generation.

Decreasing energy use through systemic efficiency[15] can also drive down carbon emissions. Retrofitting existing buildings and implementing low carbon heating and cooling technologies and solutions for new building, promoting distributed generation and circular economy initiatives to reduce energy consumption in industries are some strategies implemented globally.

Figure 2-7: RE support schemes by number of countries, 2004-2016



Source: REN21; IRENA

There are five common types of renewable energy support mechanisms that have been implemented globally (Figure 2-8):

1. Pricing policies introduce regulations on prices for off-take of renewable energy power from generators. Generators may be granted a regulated off-take price for a fixed number of years. The price can be fixed (Feed-in Tariff) or can be calculated based on a premium over variable market prices (Feed-in Premium). Price setting mechanisms have evolved, shifting from administratively set rates to competitive prices set through auctions. In addition, in certain jurisdictions, end customers (e.g. residential, commercial and industrial customers) installing renewable generation sources on their premises are allowed to offset their energy usage by using part of the power generated on site (Net Energy Metering – NEM).

2. Grid access and dispatch priority policies ensure that renewable generators are granted access to the electricity grid to sell renewable power and that renewable sources are prioritized over other generation sources when dispatching power plants. This ensures that most of the power generated through renewables can be sold, thus decreasing revenue risks for generators.

3. Obligatory quotas are generally used as an alternative to pricing support policies. They introduce obligations for utilities and/or large power consumers to meet a minimum quota of renewable generation in their power procurement volumes. This supports demand of renewable power.

4. Even in the presence of pricing policies and obligatory quotas, RE developers still face a certain level of risk in accessing and developing land for renewable projects. In certain jurisdictions, most notably in India (see also Chapter 2.4), Government avails pre-developed sites and interconnection points to RE developers, thus de-risking the development phase.

14. BUR to the UNFCCC, MNRE, 2015
15. World Economic Forum, Systemic Efficiency, accessed at: https://www.weforum.org/projects/systemic-efficiency

5. In addition to the measures above, financing support has also been utilized to promote RE. As technology costs for solar PV and wind generation have decreased substantially, in recent years, financing support focuses less on grants and tax exemptions, and more on improving access to finance, and capital market through e.g., Green Bonds programmes.

Figure 2-8: Government support mechanisms or policies for renewable energy

Type of support	Type of initiative	Description
Pricing policies	• Feed-in Tariff (FiT) / Feed-in Premium (FiP), Contract-for-Difference • Auctions • Net energy metering (NEM)	• **FiT / FiP:** Guarantees RE producers off-take to the grid and fixed tariffs over a fixed period; tariff competitiveness varies **by procurement mechanism** • **Auctions:** Award RE projects based on lowest bid price, allowing **market to determine RE prices** and increase competitiveness • **NEM:** Allow **self-consumption of RE and to export excess electricity** back to the grid at fixed prices
Grid access and priorities	• Guaranteed grid access • Preferential RE dispatch	• **Guaranteed grid access**: Secure connection of RE generation units to grid • **Preferential RE dispatch**: Grid operators are obliged to dispatch renewable energy first before conventional energy
Obligatory quotas	• Renewable Portfolio Standard • Renewable Energy Certificate	• **Renewable Portfolio Standard (RPS)**: **Set RE generation mandate**, with framework for **monitoring and enforcement** • **Renewable Energy Certificate (REC)**: Tradable certificate to **offset generation portfolio**
Project development de-risking	• Government participation in the value chain	• Government involvement in **project development value chain to reduce investor risk**
Financing support	• Tax incentive & exemptions, grants, green bond, etc.	• Financing support to **address high upfront cost of renewable generation**

Source: REN21; IRENA

2.2.2 RE DRIVERS: ECONOMICS

INCREASING AVAILABILITY OF EQUITY AND DEBT FINANCING FOR RE

Renewable projects require high upfront capital investment; thus the availability of financing is a crucial factor in enabling the shift to renewable generation. Financing is obtained through equity participation in projects or through debt, e.g. loans from banks or bonds.

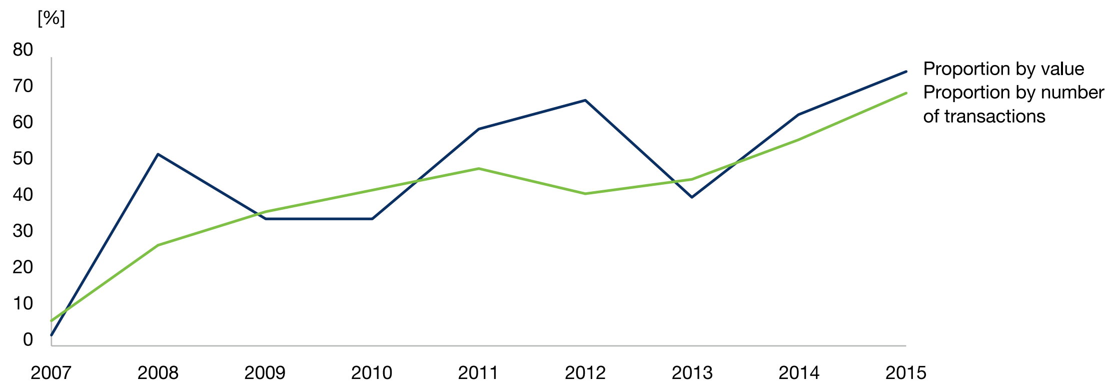
One of the key drivers of RE development in Europe has been the availability of equity financing from financial investors and debt financing from banks.

By 2015, financial investors such as pension funds, sovereign wealth funds, dedicated green investment funds and private equity funds accounted for more than 70% of value invested into renewable assets in Europe[16] (Figure 2-9). Favourable regulatory environment ensuring low risks for renewable power generation, coupled with decreasing yields in more traditional asset classes such as sovereign bonds, prompted financial investors to explore renewables as a new asset class with attractive risk/reward profile.

In addition to equity financing, increasing understanding by lenders of the risk profile of renewable generation and the emergence of green financing options such as green bonds and green sukuk (in Malaysia, the Middle East, and Indonesia), has increased the availability of debt financing at lower costs. This also allowed renewable energy projects to raise increasing amount of debt, thereby increasing the financial leverage and the internal rate of returns (IRR) of renewable projects[17].

16. MergerMarkets-mergers & acquisition (M&A) transactions database; includes secondary market transactions such as acquisition of existing assets and assets under construction
17. For Solar PV and wind, debt:equity ratio is typically 80:20

Figure 2-9: Proportion of M&A transaction on renewable asset (including secondary transactions) done by financial investors in Europe



Source: SEDA; MergerMarkets

NEW CONFIGURATIONS AND BUSINESS MODELS

The RE energy transition has also been supported by emerging configurations and business models in the energy sector, as summarized in Figure 2-10 below.

Figure 2-10: New configurations and business models

New configurations and business models	
1. Corporate sourcing	• Corporate sourcing emerges as a sizeable market for solar PV development due to introduction of green procurement policies by large corporations • Options for corporate sourcing, corporate PPAs, utility green procurement, renewable energy certificates, etc.; Corporate PPA arrangement provide solar PV developers subsidy-free revenue certainty
2. Power decentralization – distributed energy system	• Distributed energy resources are disrupting the traditional power generation markets and distribution model by enabling two-way flow of electricity • Rise of prosumers with preferences to select their own power sources • Solar leasing models to facilitate financing and uptake of decentralized RE in industrial and commercial sectors
3. Emerging configurations	• Expanding beyond ground-mounted solar configurations: – Floating solar PV – Rooftop solar PV including off-site solar PV systems supporting Virtual Net Metering (VNM)
4. Rural and off-grid electrification	• Globally, achieving 100% electrification remains a challenge, especially in rural areas which is hindered by challenging geography and low population densities • Off / mini-grid solutions could serve as a comparatively economical alternative to achieve reliable universal electrification; in remote locations, indigenous renewable resources without subsidies could potentially be competitive with imported fossil fuels (diesel generators)
5. Ancillary services to the grid – energy storage	• Higher shares of VRE, as well as distributed generation applications require energy storage solutions to store and release energy when needed • Energy storage technologies can cover multiple applications from balancing demand variation to stabilization of intermittent supply
6. Digitalization of electricity system	• Digitalized energy systems can enable peer-to-peer energy trading between prosumers and consumers • Grid digitalization provides actionable data to monitor and optimize operations

2.2.3 RE DRIVERS: SOCIAL

MOUNTING PUBLIC OPPOSITION TO COAL AND NUCLEAR GENERATION

In the past few years, public opposition to coal generation and nuclear power has mounted.

In the United Kingdom (UK), public opposition and activism by environmental groups is a key factor behind the demise of coal as a key source of power generation. As of 2018, coal accounts for only 5% of UK's power generation, down from 80% in the early 1990's and about 35% in the early 2000's. Coal generation capacity in the UK has been replaced by renewables and gas-fired power plants[18].

Public opposition to fossil generation is by no means limited to developed economies such as the UK, as shown by demonstrations held in Thailand against a proposed coal power plant in Krabi[19].

Additionally, financing and insurance for new coal-fired power plants are getting challenges to secure as financial institutions either impose higher premiums or will not finance due to their commitment to ESG policies.

18. Financial Times, How Britain ended its coal addiction, https://www.ft.com/content/a05d1dd4-dddd-11e9-9743-db5a370481bc, 2019, accessed on 5 November 2019
19. The Nation Thailand, Opponents to boycott new Krabi power plant hearing, https://www.nationthailand.com/national/30337304, 2018, accessed on 5 November 2019

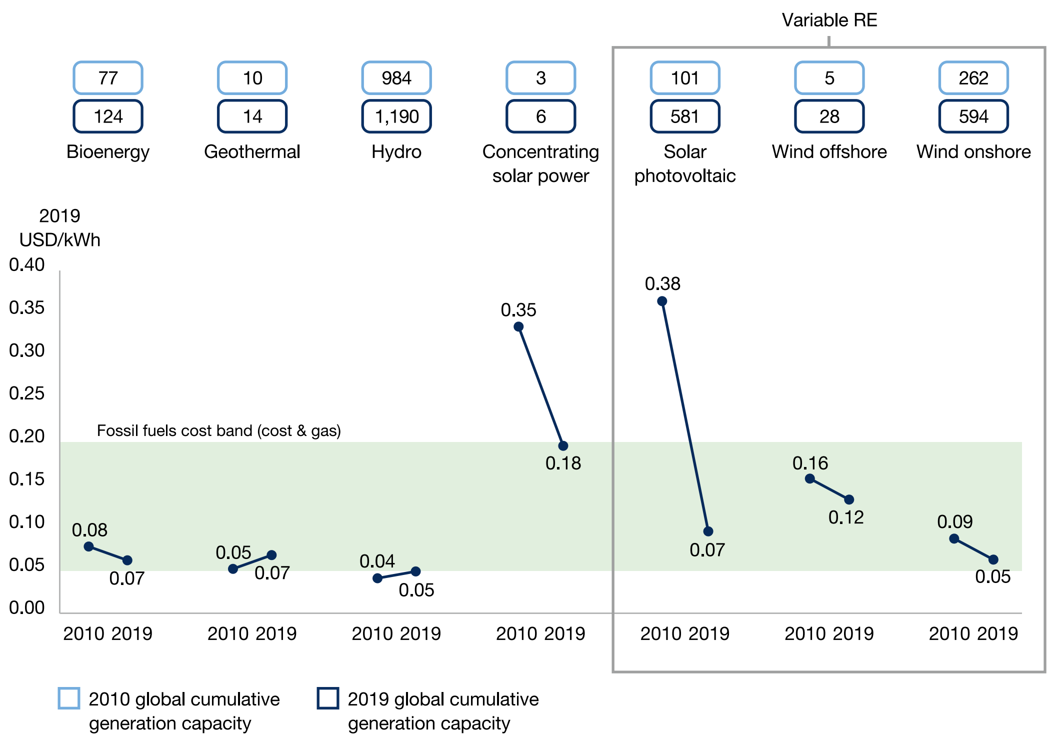
Perhaps a greater concern on the future of coal fired power plants is a possibility of countries with high environmental commitment imposing cross-border carbon tax adjustment, so goods produced cheaply from countries with high carbon footprint will not pass their carbon liability to countries observing high environmental compliances.

Opposition to nuclear power was accelerated in the aftermath of the Fukushima Daiichi Nuclear accident in March 2011. Major countries such as Germany and Italy have opted for complete phase-out of nuclear power. Growth in renewable capacity was crucial in providing a substitute for nuclear shutdowns[20].

2.2.4 RE DRIVERS: TECHNOLOGY

RAPID DECLINE IN EQUIPMENT AND CONSTRUCTION COSTS

Figure 2-11: Average levelized cost of electricity (LCOE) for utility scale renewable technologies



Source: IRENA (2020) RE Power Generation Cost 2019

Since 2010, the average LCOE of solar PV and wind power has significantly decreased and by 2019, is comparable to the average LCOE[21] of conventional coal and gas generation. Solar PV costs have dropped by approximately 82%. LCOE of offshore and onshore wind has also declined by approximately 30%-38% (Figure 2-11).

The decrease in RE cost for solar PV and wind generation can be attributed to the following reasons:

- Competitive procurement of renewable power through auctions and quota system to promote competition among project developers;
- Economies of scale and technology innovation due to:
  - Increased scale in manufacturing of key components such as solar PV modules, inverters and wind turbines;
  - Reduction in manufacturing cost of all components as manufacturing shifted to low-cost countries;
  - Increased efficiency of generation due to technology advances. This is particularly true for wind power, as average installed turbine size has increased from 1.8 MW in 2010 to 2.7 MW in 2017[22]. The most recent turbine models from leading manufacturers can be as large as 6 to 10 MW. As larger turbines have higher capacity factors, this has resulted in overall decrease in LCOE;

20. Deutsche Welle, How far along is Germany's nuclear phase-out?, 2015, https://www.dw.com/en/how-far-along-is-germanys-nuclear-phase-out/a-18547065, accessed on 5 November 2019
21. IRENA (2020) RE Power Generatoin Cost 2019
22. Power Technology, Wind turbines continue to grow in size, https://www.power-technology.com/comment/wind-turbines-continue-grow-size/, 2018, accessed on 5 November 2019

- Maturing learning curve for construction as engineering, procurement and construction (EPC) providers become increasingly efficient and expand to new markets, bringing best practices in project engineering and construction; and
- Improvement in economics of combined energy storage-wind and/or storage-solar generation system as a result of declining energy storage system prices[23].

Typically, renewable resources that do not rely on commercial feedstock are said to have zero marginal cost. In this regard, resources such as hydro, solar and wind can achieve a low LCOE.

In contrast to these forms of power generation, other renewable technologies such as biomass and geothermal have witnessed flat or slowly increasing costs. For these mature technologies, the increase in scale of manufacturing and technology innovation have not been sufficient to mitigate material and labour cost escalation. Although maturity of these technologies is the main factor driving this trend, there are other issues as well such as limitation in feedstock due to competing uses for biomass, and high exploratory cost and site-specific requirements for geothermal.

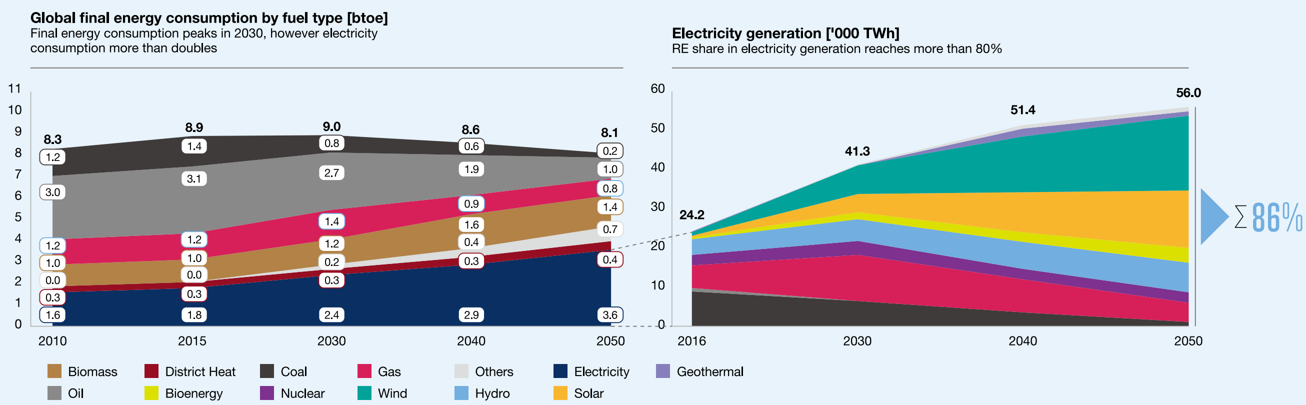
Case study
IRENA REmap 2050

REmap 2050 is a scenario for the evolution of renewable energy at global level published by IRENA. The scenario highlights immediately deployable, cost-effective options for countries to fulfil climate commitments and limit the rise of global temperatures.

In the latest scenario published in April 2019, a two-pronged transformation of the energy system combining (1) increased use of electricity in final energy consumption and (2) increased use of renewables in electricity generation, coupled with improving energy efficiency is envisaged to accelerate the deployment of renewables in the overall energy mix[24].

According to IRENA, ramping up electricity to half of the global energy mix (up from one-fifth in 2018), in combination with increased renewables share to more than 80% of the power generation mix would be effective in reducing use of the fossil fuels responsible for most GHG emissions. Coupled with energy efficiency, improved energy intensity can deliver higher reduction in GHG emissions.

Furthermore, IRENA's results show that energy-related CO2 emission reductions would have to decline 70% by 2050, compared to current levels, to meet climate goals. A large-scale shift to electricity generated using renewables could deliver 60% of those reductions; 75%, if renewables for heating and transport are factored in, and 90% with ramped-up energy efficiency.

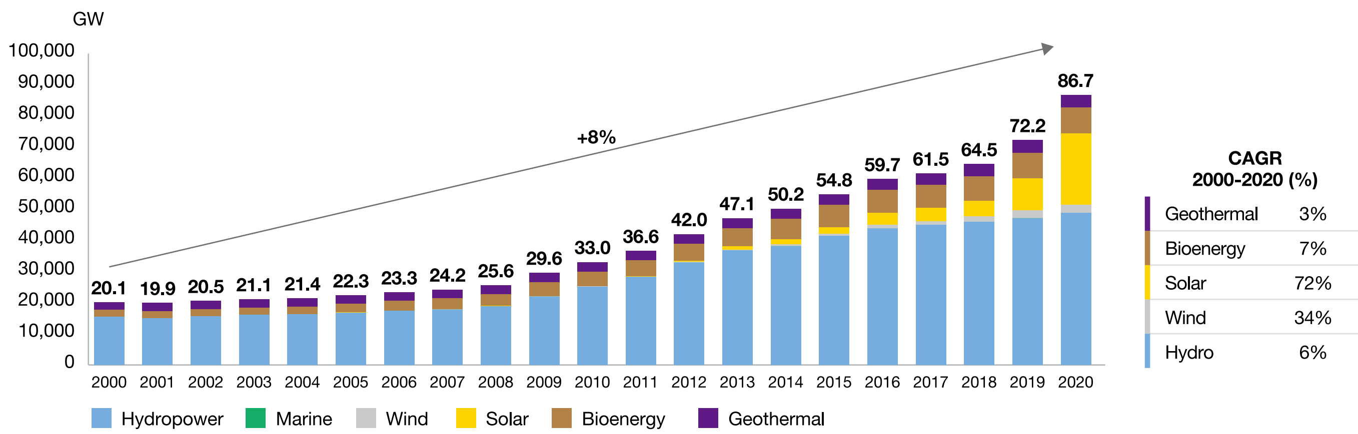


23. In some jurisdictions, like India, subsidies are provided to encourage the creation of local manufacturing base energy storage system in states where there is large demand for solar PV system
24. IRENA, Global energy transformation: A roadmap to 2050, 2019

2.3 RENEWABLE ENERGY TRENDS – SOUTHEAST ASIA

DESPITE SUSTAINED GROWTH, THE DEVELOPMENT OF RENEWABLE ENERGY IN SOUTHEAST ASIA – PARTICULARLY SOLAR PV AND WIND – LAGS BEHIND GLOBAL AVERAGE

Figure 2-12: Evolution of RE capacity by source in Southeast Asia



Source: IRENA – Renewable Capacity Statistics 2021; & Renewable Energy Statistics 2020

In Southeast Asia (SEA), renewable installed capacity has more than tripled since 2000, growing from 20 GW in 2000 to 87 GW in 2020 with an average CAGR of 8%[25] (Figure 2-12).

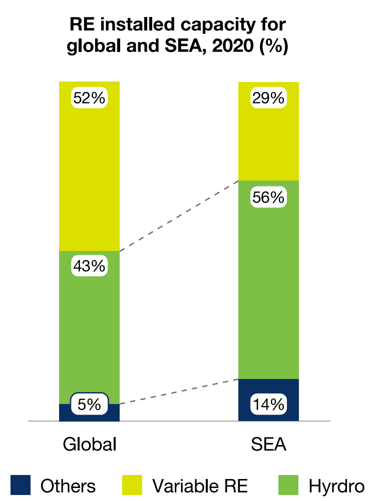
While the level of RE share in the installed capacity mix in SEA is relatively on par with global average, the mix of RE generation technologies deployed in SEA differs substantially from global average.

Figure 2-13 shows that globally, the renewable installed capacity mix is relatively balanced between hydro (49% share) and other RE (50% share, including non-VRE such as solar PV, wind, bioenergy, and others.). Similarly in Southeast Asia, hydropower accounted for 56% of RE capacity, and the VRE capacity only gradually increased starting 2010. (Figure 2-12)

These gaps with global average are a result of the lag in development for VRE sources such as solar PV and wind. Policies and incentives to promote VRE started off in the SEA much later than in other geographies with higher income levels as VRE were still expensive at that time. For example, the Renewable Energy Act was only implemented in Malaysia in 2011, approximately ten years later than countries in Europe (Germany in 2000).

Policy directions in SEA are changing in favour of an increasing role of variable renewable sources in the region's energy mix. National targets have been set in some countries (see Chapter 2.4) and inter-regional initiatives, such as the ASEAN Plan of Action for Energy Cooperation (APAEC 2016-2025) include aspirational target for RE share.

Figure 2-13: Comparison of installed capacity by type of RE between global and Southeast Asia, 2020



Note: Variable RE includes solar PV, onshore wind and offshore wind; Others include bioenergy, geothermal and marine
Source: IRENA — Renewable Capacity Statistics 2021; & Renewable Energy Statistics 2020

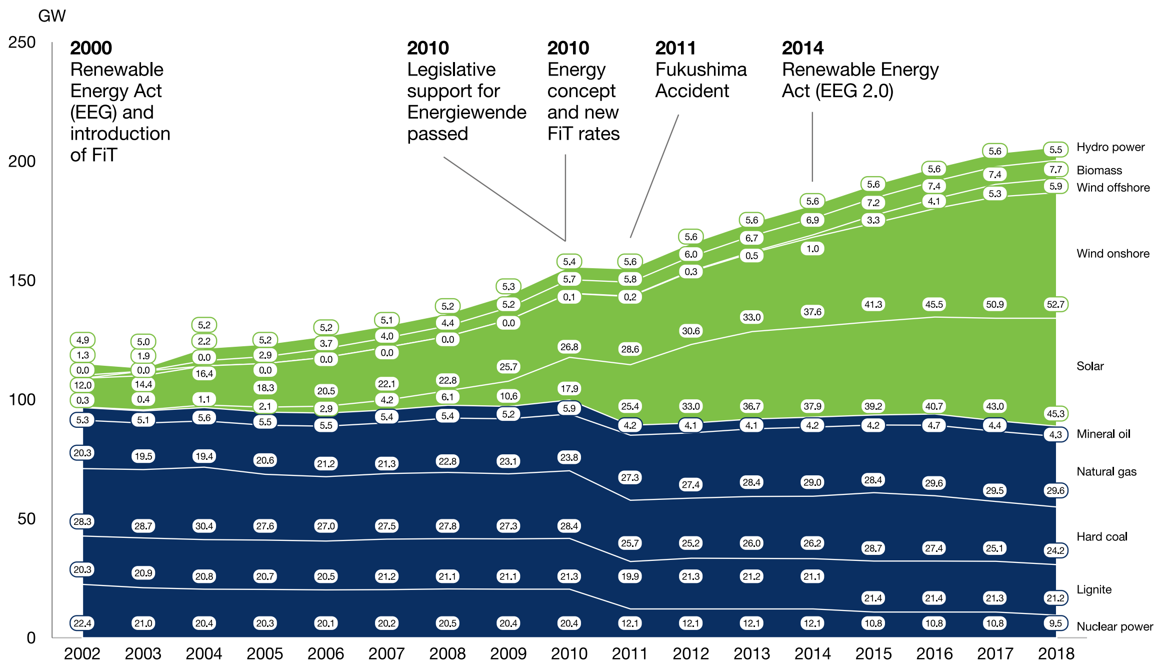
25. IRENA, Renewable Electricity Capacity and Generation Statistics, 2019

2.4 SELECTED INTERNATIONAL BENCHMARKS

GERMANY: THE PROTOTYPE OF ALL ENERGY TRANSITIONS

Germany is often credited as the first country that successfully embarked on a transition of the energy system ("Energiewende"), based on increased penetration of VRE sources (wind power and solar PV) (Figure 2-14).

Figure 2-14: Evolution of installed capacity by fuel in Germany, 2002-2018



Energiewende targets in 2050

Metrics	Targets
GHG emissions reduction	80 to 95%
RE share in gross final energy consumption	60%
RE Share in gross power consumption	80%
Primary energy consumption	-50%
Gross electricity consumption	-25%

Note: Energiewende targets for 2050: Baseline for GHG emissions reduction, final energy consumption and gross power consumption is 1990, and baseline for primary energy consumption and gross electricity consumption is 2008
Source: Fraunhofer ISE

As of 2018, the share of renewable sources including hydro in the installed capacity mix stands at 57%; wind and solar PV capacity accounts for 50% of total installed capacity.

In the early 2000's, at the beginning of the Energiewende, Germany had a relatively modern portfolio of conventional plants including natural gas, coal and nuclear assets that had significant remaining lifetime. In addition, electricity demand growth was stagnant due to slow population and economic growth.

As a result, introduction of renewable capacity could not be achieved by substituting or retiring conventional plants, nor did it align with developing demand-supply gaps driven by increasing consumption.

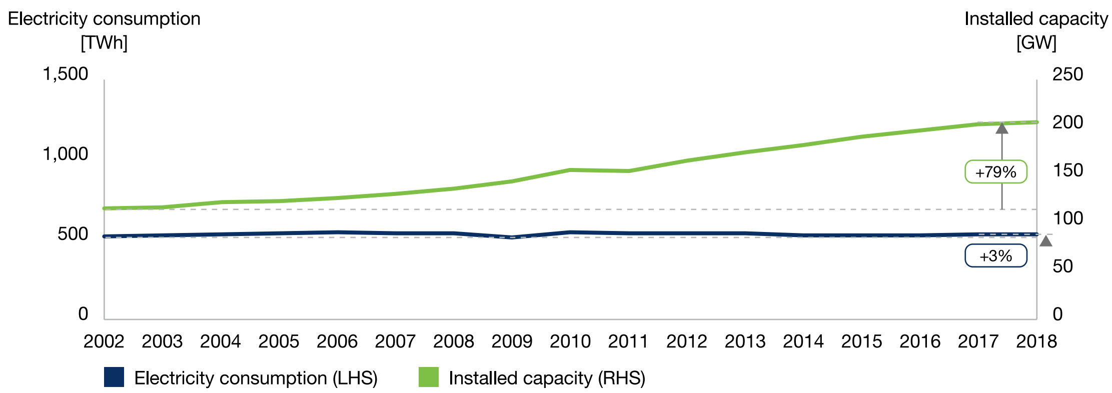
Instead, new renewable capacity was added on top of existing conventional capacity by promoting investment into renewables through a generous Feed-in Tariff system. Only after the nuclear phase-out started in 2012, renewables played a role substituting decreasing nuclear capacity. As a result, between 2002 and 2018, while electricity consumption only increased by 3%, total installed capacity increased by 79% (Figure 2-15) and this is in part due to lower capacity factors of RE[26].

As renewables have dispatch priority, the result of this build-up of installed capacity has been a decrease in the utilization of conventional plants, particularly gas-fired power plants. Lower capacity factors for conventional assets have made them increasingly unviable, diverting investment from conventional assets to renewables.

On the other hand, the attractiveness of the Feed-in Tariff (FiT) has resulted in increased installations of distributed renewables with declining cost as RE market scales up. The success of the FiT has spawned organic progression to other RE schemes which require less subsidies such as the regulated tendering and net energy metering.

26. Bundesverband der Energie-und Wasserwirtschaft (BDEW), 2018

Figure 2-15: Electricity consumption and installed capacity in Germany, 2002-2018

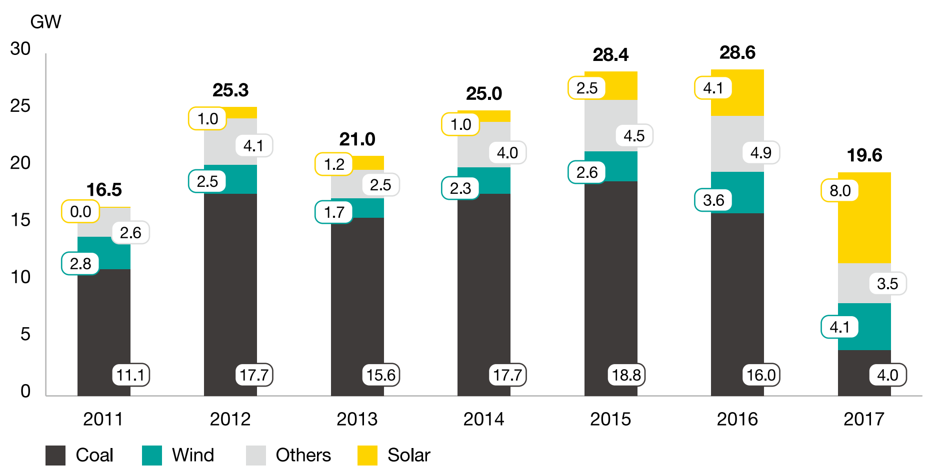


Source: Bundesverband der Energie-und Wasserwirtschaft (BDEW)

INDIA: THE REMARKABLE SHIFT FROM COAL TO RENEWABLES OF A DEVELOPING COUNTRY

India had relied on coal power generation to power its expansion and ambitions to become a leading global economy. Between 2011 and 2016, India saw 11-19 GW of net coal capacity additions annually. In 2017, for the first time, renewables became the largest contributor to net capacity additions, surpassing coal – India saw twice as much as solar PV additions (8 GW) than coal capacity additions (4 GW)[27] (Figure 2-16).

Figure 2-16: Net generation capacity additions by fuel in India, 2011-2017



Source: BNEF (2018)

The shift away from coal was motivated by four reasons:

- Increasing difficulty in sourcing high-quality coal domestically as most Indian coal has low calorific value and high ash content. This increased the required investment and costs to source coal locally;
- Increased dependency on higher-quality coal imports from Indonesia, Australia and South Africa and corresponding adverse economic impact: imported coal penetration in total coal consumption increased from 3% in the 1990's to 14%, impacting adversely India's trade balance[28];
- Strong recovery in power demand driven by healthy growth in production levels from electro-intensive sectors such as cement, aluminum and steel; and
- Environmental concerns related to both coal mining and coal power generation.

27. Bloomberg New Energy Finance (BNEF), 2018
28. India Ministry of New & Renewable Energy

In order to substitute part of new coal additions, India identified solar PV and wind as the most competitive sources; in particular, due to high insolation and vast landmass, even taking into account only ground-mounted configurations, India has a solar resource potential equivalent to 1,143 GW[29].

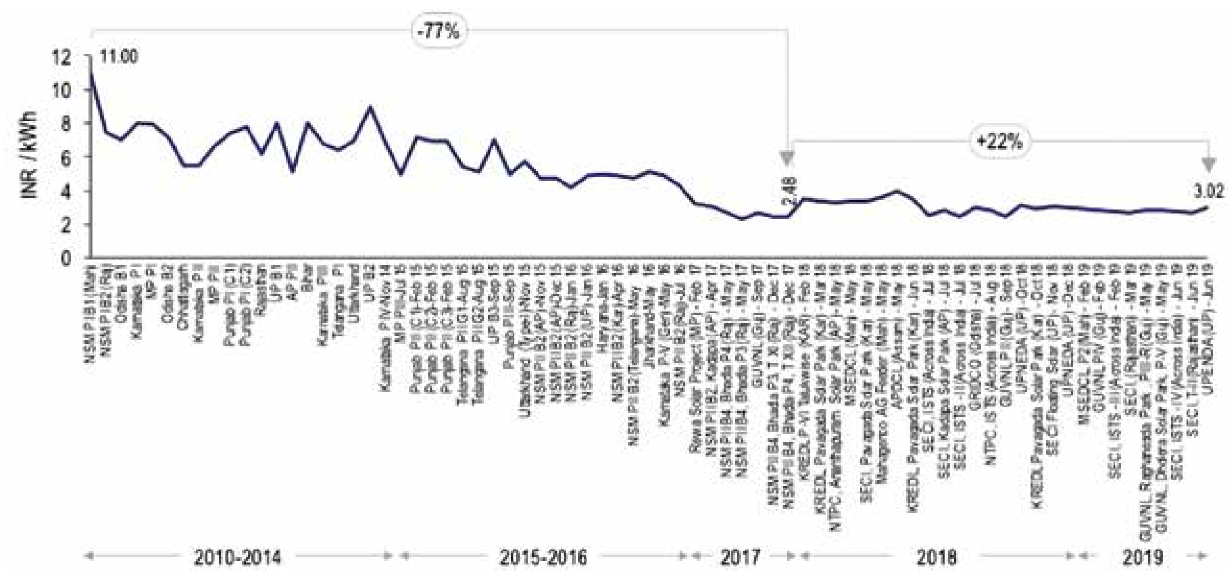
In order to minimize the cost of solar PV additions, India adopted a coherent strategy, hinging on three key levers:

- Leverage competition between developers; FiT levels were not administratively set, but were determined through an auction process where the lowest bidder is awarded the FiT rights;
- Minimize development risks; the Government set up a solar park scheme whereby it would provide pre-developed land and interconnection points to the developers; and
- Leverage scale; individual project sizes are very large ranging from a few hundred MW to GW-scale projects. This not only creates economies of scale, but also entices large international investors to compete at auctions, bringing down the FiT levels even further.

As a result of these measures, the lowest FiT bids at auctions decreased from 11 INR / kWh in 2011 to 2.5 INR / kWh at the end of 2017[30]. Since then, FiT levels have increased due to new import duties on solar modules but remain very low at around 3 INR / kWh (Figure 2-17).

Image for illustration purpose only.

Figure 2-17: Lowest bid at reverse solar auctions in India, 2010-2019



Source: Mercom

29. Ecofys, The potential of solar electricity to reduce CO2 emissions
30. Mercom India Research, Solar bids in reverse auction in India, 2019

ASEAN: INCREASINGLY AGGRESSIVE RE TARGETS

Figure 2-18: Overview of renewable share targets in major ASEAN countries[31]

	Malaysia	Indonesia	Philippines	Thailand	Vietnam	Singapore
Latest RE policy	MyRER 2035	National Energy Roadmap	Sectoral Energy Plan & Roadmap	Power Development Plan	Power Development Plan	Singapore's Energy Story
Year of latest RE policy	2020	2017	2017	2019	2019	2019
Overall RE targets	31% RE installed capacity by 2025, 40% by 2035	RE installed capacity by 45 GW by 2025, 168 GW by 2050, 31% of national primary energy supply in 2050	RE installed capacity of 20 GW by 2040	33% RE installed capacity by 2037 with RE mix as following • Solar 6 GW • Biomass 5.57 GW • Wind 3 GW • Hydropower 3.3 GW • Biogas 0.6 GW • MSW 0.5 GW	32% RE installed capacity by 2030, 45% by 2050	At least 2 GW of solar by 2030, and energy storage deployment target of 200 MW post 2025

Source: UN's Regional Energy Trends report

As renewable generation costs have decreased in recent years, ASEAN countries have also revised their targets for renewable generation deployment (Figure 2-18).

Long-term RE targets in large countries in the region aim to achieve a RE share between 30-40%:

- Indonesia targets 31% by 2050 in terms of primary energy supply;
- Philippines targets 20 GW by 2040, translating into 32% installed capacity;
- Thailand targets 33% of RE installed capacity by 2037; and
- Vietnam target 32% installed capacity by 2030 and 45% by 2050.

Availability of resources also impacts RE targets. Solar PV is the preferred technology by most of the ASEAN countries due to high annual solar irradiation in the region. Most ASEAN countries are also rich in hydro resources. Due to agricultural activities in most ASEAN countries, bioenergy can be supported by availability of feedstock. Vietnam and partly Thailand have relatively ambitious targets for wind energy, owing to attractive wind conditions.

In line with regional peers, Malaysia's energy policies are also increasingly focusing on exploiting indigenous RE resources and declining technology cost to reduce reliance on fossil fuel and transition towards a greener power sector.

Image for illustration purpose only.

Case study
ASEAN Plan of Action for Energy Cooperation (APAEC 2016-2025)

The ASEAN Plan of Action for Energy Cooperation is a series of guiding policy documents to support the implementation of multilateral energy cooperation to advance regional integration and connectivity goals in ASEAN. It serves as a blueprint for better cooperation towards enhancing energy security, accessibility, affordability and sustainability under the framework of the ASEAN Economic Community or AEC for the designated period.

The APAEC 2016-2025, with the theme, “Enhancing Energy Connectivity and Market Integration in ASEAN to Achieve Energy Security, Accessibility, Affordability and Sustainability for All”, implements outcome-based strategies and action plans through seven Programme Areas. The key strategies of the seven Programme Areas of the APAEC Phase II: 2021 – 2025 are as outlined below.

The APAEC (2016-2025) has set the RE share target of 35% of Total Installed Power Capacity by 2025, which will contribute to achieving the aspirational RE share target of 23% in the ASEAN Total Primary Energy Supply and 35% in total power installed capacity.

1	ASEAN Power Grid	To expand regional multilateral electricity trading, strengthen grid resilience and modernization and promote clean and renewable energy integration
2	Trans ASEAN Gas Pipeline	To pursue the development of common gas market for ASEAN by enhancing gas and LNG connectivity and accessibility
3	Coal and Clean Coal Technology	To optimize the role of clean coal technology in facilitating the transition towards sustainable and lower emission development
4	Energy Efficiency and Conversation	To reduce energy intensity by 32% in 2025 based on 2005 levels and encourage further energy efficiency and conservation efforts
5	Renewable Energy	To achieve aspirational target for increasing the component of renewable energy to 23% by 2025 in the ASEAN energy mix, increase RE in installed power capacity to 35% by 2025
6	Regional Energy Policy and Planning	To advance energy policy and planning to accelerate the regions’s energy transition and resilience
7	Civilian Nuclear Energy	To build resource capabilities on nuclear science and technology for power generation

Source: ASEAN Centre for Energy

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MyRER

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chapter three

MALAYSIA'S ENERGY AND POWER LANDSCAPE

MALAYSIA'S ENERGY AND POWER LANDSCAPE

SUMMARY

MALAYSIA'S ENERGY LANDSCAPE

Energy policies in Malaysia have revolved around energy security through gradual fuel diversification and promotion of renewables in the Fifth-Fuel Policy.

However, hydrocarbons still contribute to most primary energy supply in Malaysia. In 2018, primary energy supply amounted to 100 Mtoe, dominated by natural gas (41%), crude oil (26%), coal and coke (22%), and petroleum product (4%). Renewables contributed approximately at 7% of primary energy supply in 2018

In Malaysia, a higher proportion of energy consumption is met through petroleum products (48%), as compared to global average (40%), driven by transportation and industry sector demand. On the contrary, Malaysia consumes a lower proportion of electricity (20%) as compared to global average (24%), reflecting relatively low residential and commercial consumption.

MALAYSIA'S POWER LANDSCAPE

Electricity consumption in Malaysia has been growing at a slightly slower rate (CAGR of 5.5% between 2010 and 2018) compared to the annual GDP growth (5.2% CAGR in the same period). While Sarawak's SCORE has attracted energy intensive industries using electricity over the past ten (10) years, industrial electricity demand in other regions (Peninsular Malaysia and Sabah) is plateauing.

Gas remains the main fuel for power generation but has been gradually displaced by coal in Peninsular Malaysia in year 2010. In Sarawak, large hydro was planted up to meet additional demand. In 2020, gas represents ~39% of total installed capacity, while coal makes up ~34% of total installed capacity. Renewables makes up for 23% in the national installed capacity mix.

Increasing reliance on imported coal, depletion of local gas reserves and slow traction in leveraging renewable resources are slowly pushing Malaysia toward becoming a net importer of power generation fuels.

In the future, when electricity market restructuring initiative is introduced, there will be greater competitive pricing, customer choice and spur economic activity in the sector. The reforms in this roadmap refer to residential customers contestability and third-party access framework to electricity grid.

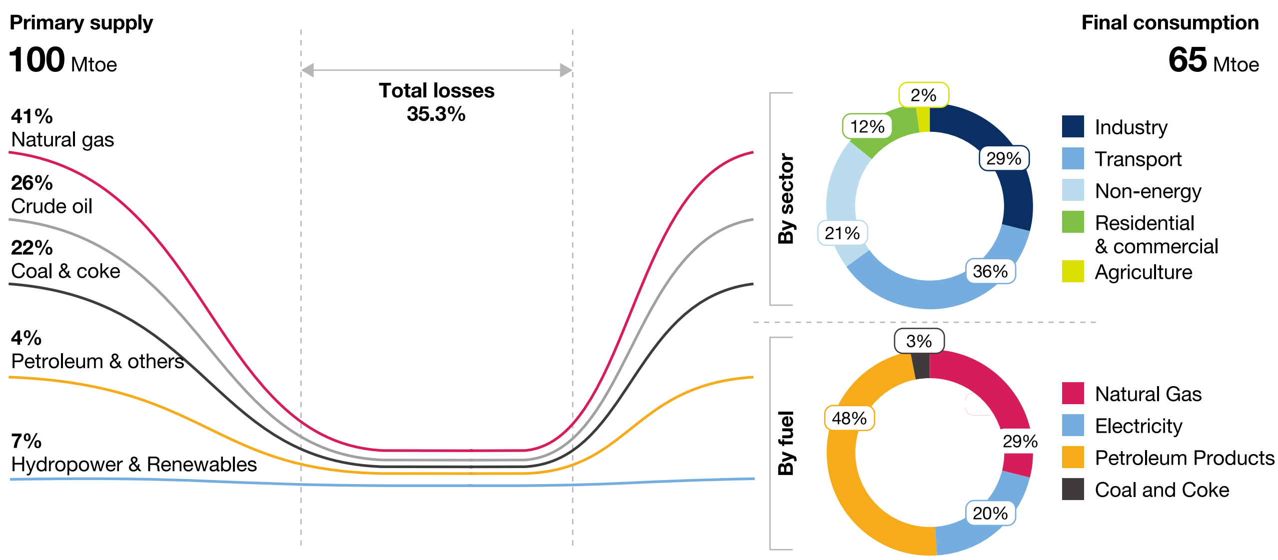
3.1 MALAYSIA'S ENERGY LANDSCAPE

MALAYSIA USES PROPORTIONATELY MORE PETROLEUM PRODUCTS AND LESS ELECTRICITY THAN THE GLOBAL AVERAGE TO MEET ITS ENERGY CONSUMPTION

Primary energy supply in 2018 amounted to approximately 100 Mtoe; after transformation and losses, approximately 65 Mtoe were used to meet final demand[32].

As of 2018, the three largest primary energy sources in Malaysia were natural gas (41%), crude oil (30%), and coal and coke (22%). On the other hand, hydropower and renewables contributed 7% of primary energy supply in 2018 (Figure 3-1).

Figure 3-1: Primary energy supply and final energy consumption, 2018



Note: Primary energy supply has netted of imports and exports; Non-energy use refers to use of products resulting from transformation process for non-energy purposes (e.g. asphalt/greases) or use of energy products (such as natural gas) as industrial feedstocks
Source: National Energy Balance 2018 (2020)

Final energy consumption is driven primarily by transport (36% of consumption) and industry (29% of consumption but increasing to 50% when including both energy and non-energy uses such as manufacturing of petrochemicals, lubricants, and others), while the residential and commercial sectors only account for 12% of energy consumption.

Reflecting high consumption from transportation and industry, a very high proportion of Malaysia's energy consumption (48%) is met by petroleum products; this is much higher than the global average which stands at 40%[33].

Reflecting relatively low residential and commercial consumption, electricity accounts for only 20% of final energy consumption in Malaysia (Figure 3-1); this is lower than the global average, where electricity accounts for 24% of final energy consumption.

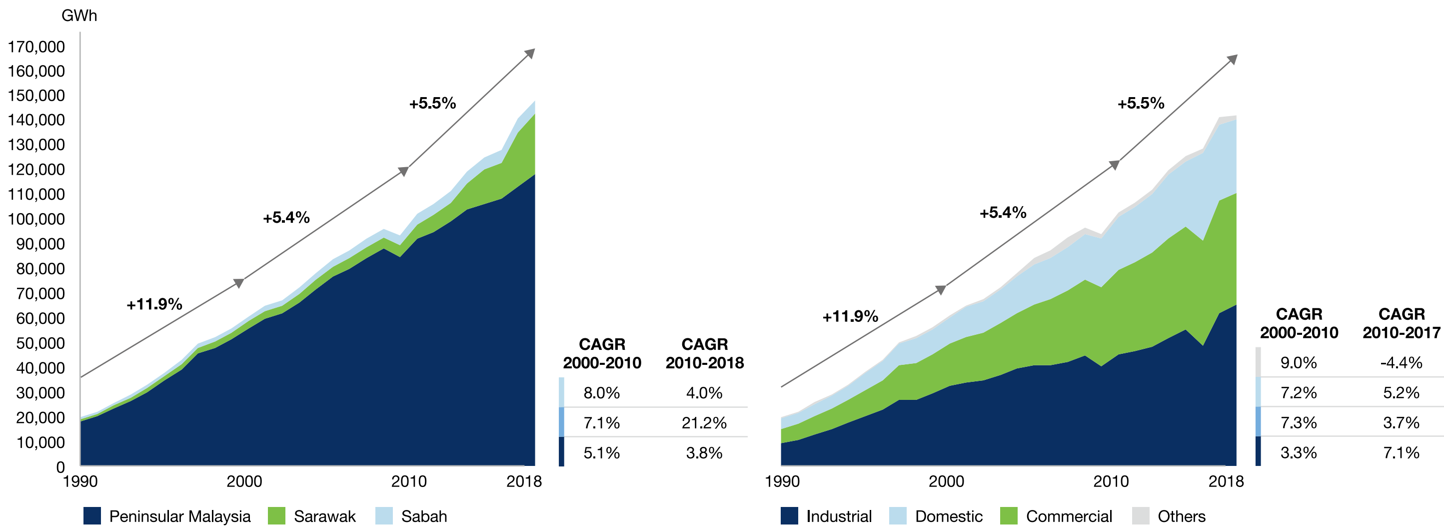
As pointed out in Chapter 2.2.4 (Case Study on IRENA REmap 2050), a key long-term strategy to increase use of renewable sources is to combine higher share of RE in electricity generation with increased share of electricity in final energy consumption. While the MyRER focuses on the first point – promoting utilization of RE in electricity generation – a shift in final energy consumption towards electrification can be advocated in order to decarbonize the broader energy sector.

32. ST, National Energy Balance 2018
33. BP, Energy Outlook, 2019

3.2 MALAYSIA'S POWER LANDSCAPE

SLOWING GROWTH OF ELECTRICITY CONSUMPTION AND CONTINUED RELIANCE ON FOSSIL FUELS FOR POWER GENERATION – WITH THE EXCEPTION OF SARAWAK

Figure 3-2: Historical electricity consumption by sector and region



Note: Electricity consumption as per TNB, SESB and SEB electricity sales; "Others" includes public lighting, mining, export and others; "Industrial" includes agriculture and industry
Source: ST; MEIH; National Energy Balance 2018

Electricity consumption growth rates in Malaysia have been slowing down due to slowing demand in the residential, commercial, and industrial sectors in Peninsular Malaysia and in Sabah (Figure 3-2). The overall increase in growth rate in the industrial sector is largely due to the launch of the Sarawak Corridor of Renewable Energy (SCORE), which has attracted energy-intensive heavy industries to the state, relying on cheap power from abundant hydroelectric resources.

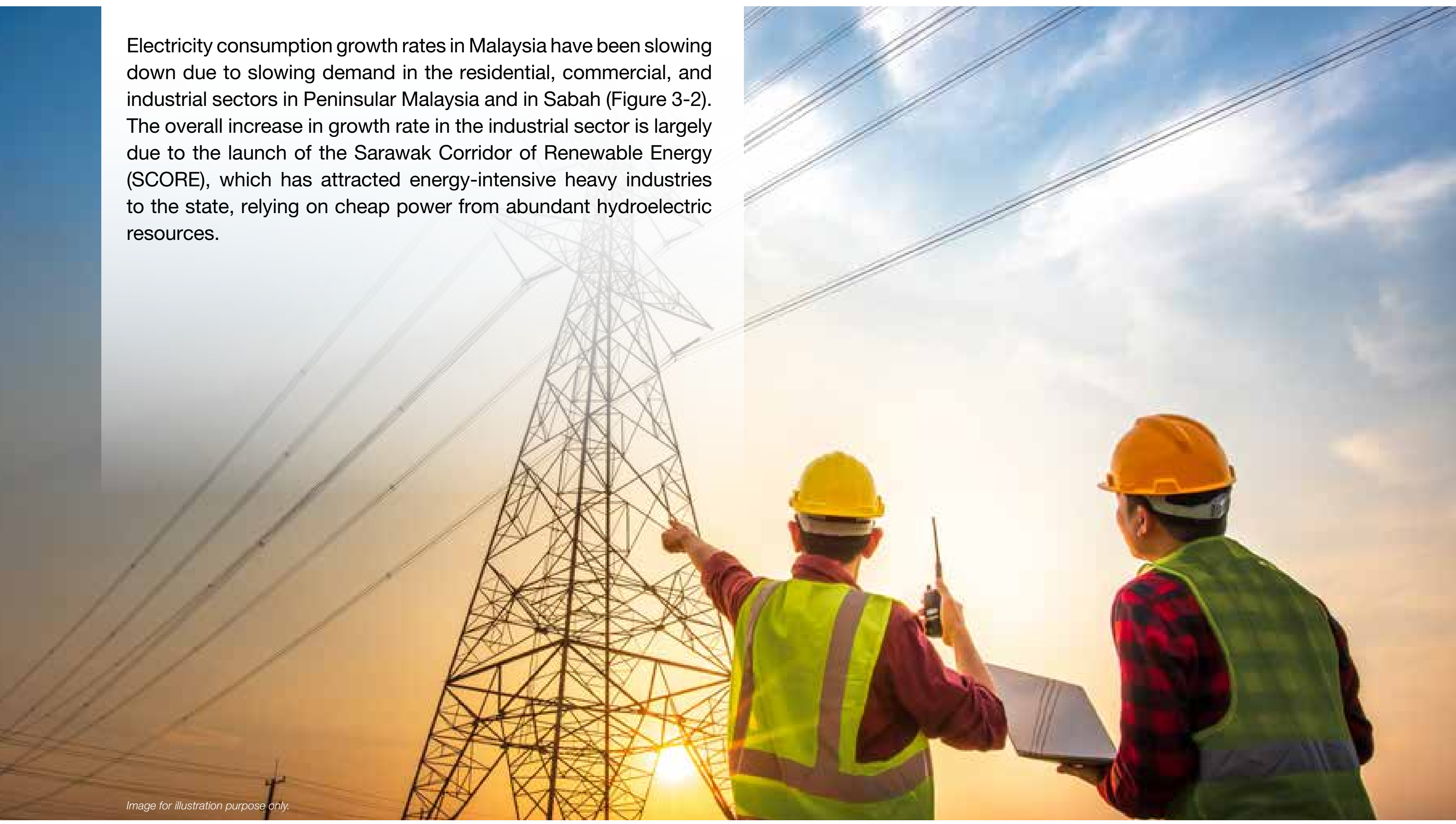


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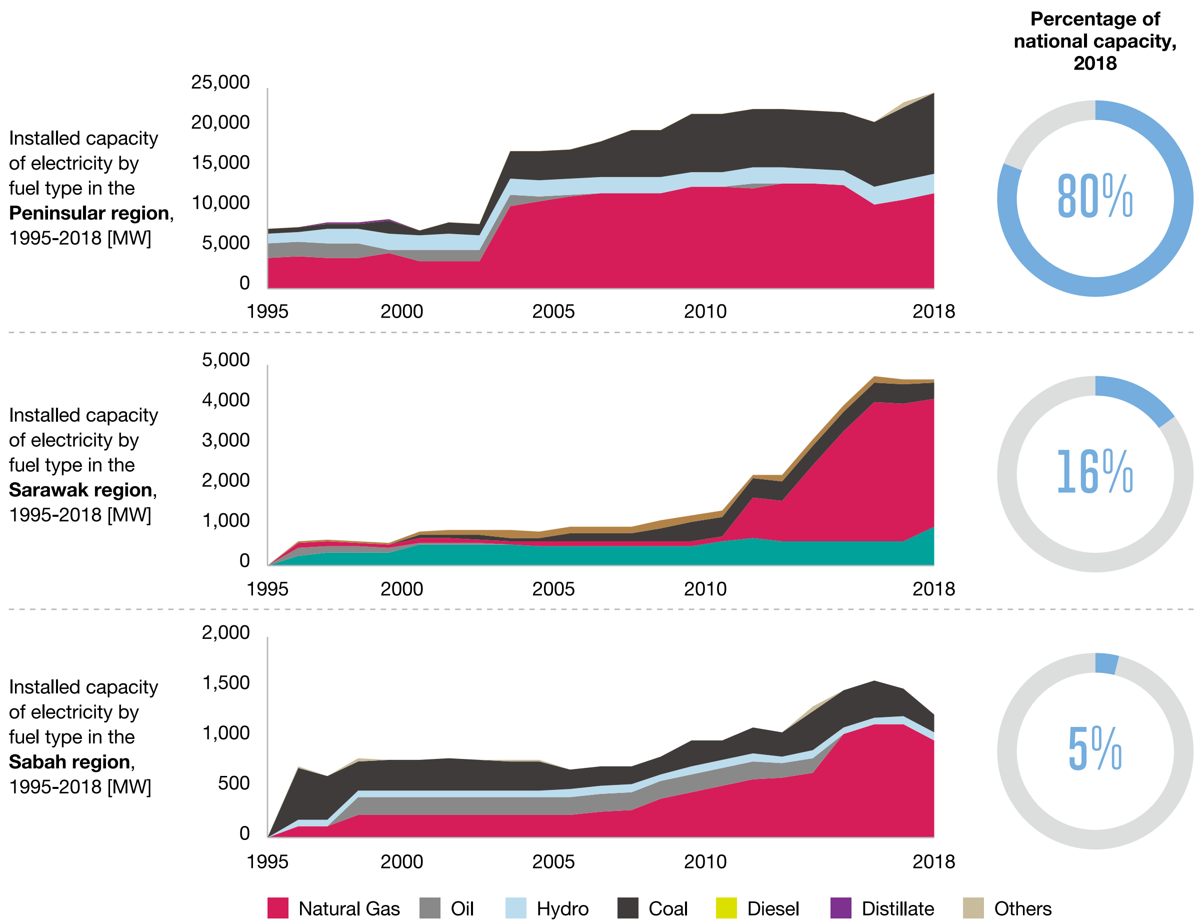
Figure 3-3: On-grid installed capacity by region, 1995-2018



Note: Figures correspond to on-grid installed capacities only; and dependable capacity for Sabah
Source: ST, MEIH, National Energy Balance 2018

Malaysia has three largely independent electricity markets corresponding to each region – Peninsular Malaysia, Sabah, and Sarawak. As of 2020, there is no interconnection between the three regions, hence the three markets are independent (Figure 3 3).

Peninsular Malaysia is by far the biggest electricity market in Malaysia, with approximately 25.8 GW of installed on-grid capacity in 2018, largely made up of coal and gas power plants.

Sarawak has approximately 5.1 GW of installed capacity, with large hydro as the main source of power generation. In 2008, Sarawak implemented SCORE, powered by its large hydro resource, which has attracted energy-intensive heavy industries to the State.

As of 2018, Sabah has approximately 1.6 GW of total installed capacity with natural gas remaining the main fuel for regional power generation.

POWER GENERATION MIX POLICIES HAVE SHIFTED MULTIPLE TIMES – DESPITE THE EFFORTS TO PROMOTE RENEWABLES IN THE PAST, MALAYSIA REMAINS RELIANT ON FOSSIL FUELS AND THE NATION COULD SOON BECOME A NET IMPORTER OF POWER GENERATION FUELS

Energy policies in Malaysia have shifted multiple times in the past four decades in response to changes in global market conditions.

In the 1970s, Malaysia's power generation mix mainly consisted of petroleum products. However, after the two oil crises in 1973 and 1979, Malaysia has taken steps to decrease its reliance on oil and rebalance the power generation mix towards gas, supported by local availability. Natural gas has since been a key fuel in power sector, and in order to meet growing energy and power demand, Malaysia started importing natural gas in 2003.

Recognizing potential shortfalls in natural gas supply, the Government opted to shift to coal as the main fuel for electricity generation due to readily available supplies worldwide and relatively low prices.

The Fifth-Fuel Diversification Policy was introduced in 2001, where renewable energy was added as the fifth main fuel in Malaysia's generation mix, joining coal, gas, hydro, and petroleum products. However, RE uptake remained slow, while coal became the primary fuel used due to its cheap import prices and global availability.

Despite being introduced into the national policy in 2001, the RE generation sector remained dormant[34], up until the Government launched the NREPAP to support the utilization of indigenous renewable resources, contributing to electricity supply and fuel supply independence. The later policy laid the foundation for the Renewable Energy Act (RE Act) and the Sustainable Energy Development Authority Act (SEDA Act), both of which were introduced in 2011.

Under the RE Act, the Feed-in Tariff (FiT) scheme was established to incentivize the development of RE power generation projects with installed capacities of up to 30 MW. To operationalize and implement the FiT mechanism, a statutory body named Sustainable Energy Development Authority (SEDA) Malaysia was formed under the SEDA Act 2011.

However, as of 2020, share of renewables in Malaysia's power sector remains modest. The installed capacity of renewables stands at 8.45 GW or 23.5% of national installed capacity. The energy input into Malaysia power stations is shown in Figure 3-4 below.

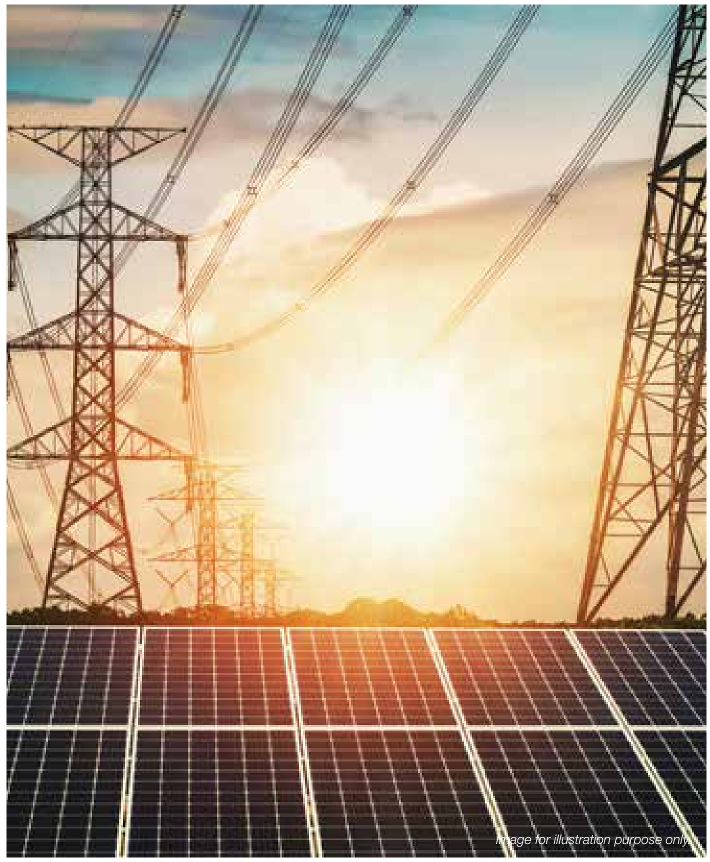
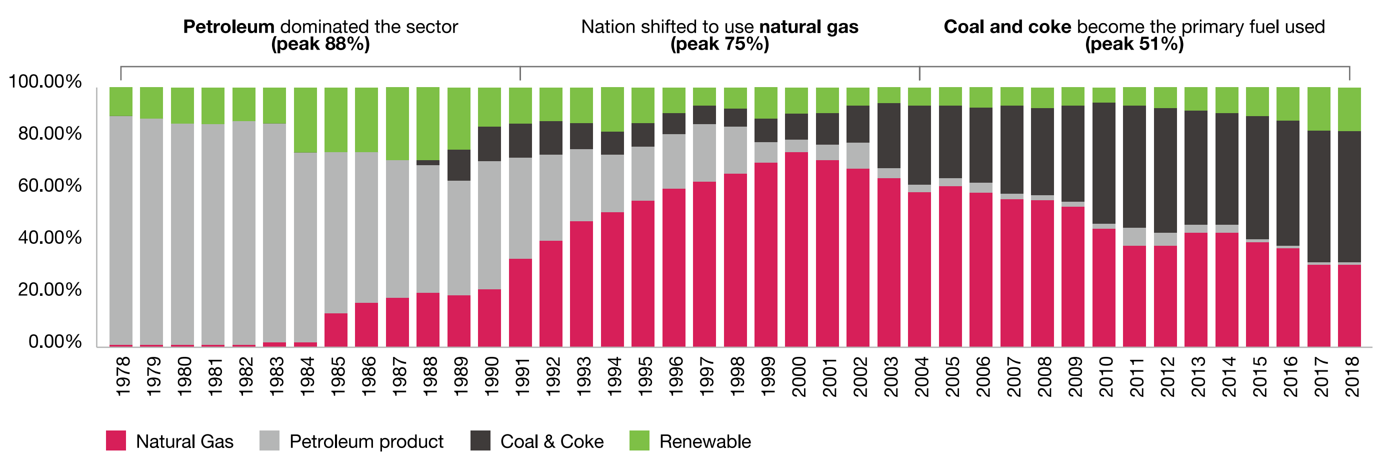


Figure 3-4: Energy input in Malaysian power stations, 1978 – 2018



Note: Renewables includes hydropower, solar, biomass, and biogas; Petroleum products includes fuel oil and diesel
Source: ST; MEIH; National Energy Balance 2018 (2020)

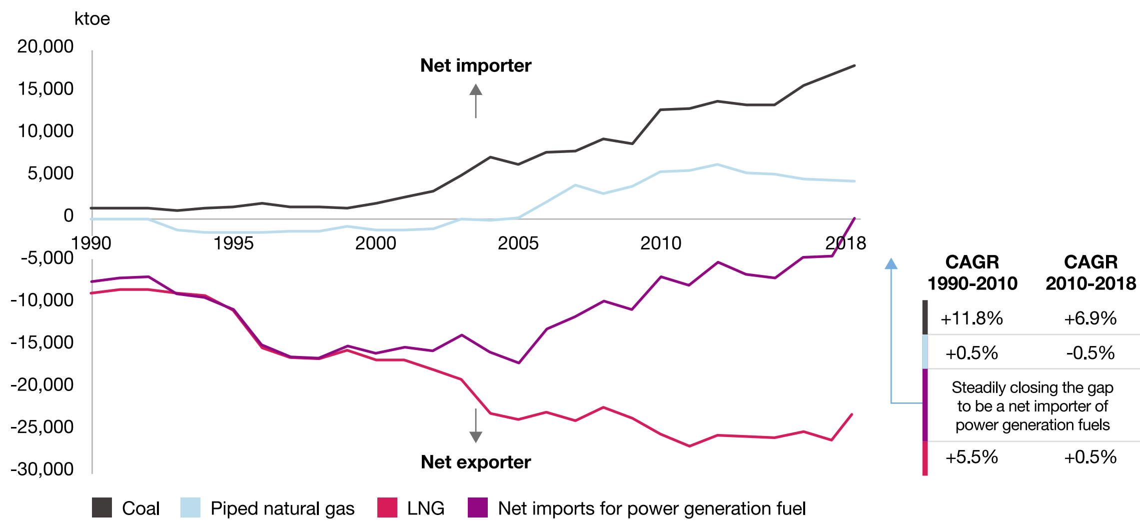
With this continued reliance on fossil fuel in the generation mix, Malaysia could soon become a net importer of power generation fuels. Malaysia is already a net importer of several key fuels: coal and piped natural gas (Figure 3-5).

The shift of power generation fuel to coal, which is wholly imported, as well as the declining local gas production put Malaysia's energy security at risk. As of 2018, Malaysia is one of the largest coal importers in the world[35].

As seen in 2018, the increase in coal prices resulted in higher electricity cost, impacting electricity tariffs (+1.35 MYR sen/kWh was imposed on non-residential consumers)[36].

34. The Small Renewable Energy Power that preceded the FiT (mandated by the RE Act 2011) was ineffective to drive the RE market due to low tariff offered to RE projects
35. Asia Pacific Energy Research Centre, Coal Report 2018, https://aperc.ieej.or.jp/file/2019/6/6/20190606_Coal_Report.pdf
36. TNB, Others Imbalance Cost Pass-Through or July-December 2018, https://www.tnb.com.my/assets/press_releases/Reference_No._GA1-29062018-00001.pdf

Figure 3-5: Import and export balance for power generation fuels



Source: SEDA; ST

FUTURE ELECTRICITY MARKET RESTRUCTURING TO INTRODUCE COMPETITIVE PRICING AND CUSTOMER CHOICE AS WELL AS THIRD-PARTY ACCESS TO THE GRID IN THE NEXT 10 YEARS

The discussion on electricity market reform has been an ongoing exercise within the Ministry and related energy agencies. Specifically, the future electricity market reform can introduce competitive pricing, increase customer choice and satisfaction, and spur further economic activity in the sector.

Although detailed policies and timeline for the electricity market reform are still under discussion, the package of measures advocated by the MyRER includes:

- Introduction of green electricity tariffs to support RE development through enhanced customer choice;
- Enhanced virtual energy trading between prosumers and electricity consumers;
- Utilization of demand side management to enhance system flexibility; in particular Time of Use (ToU) tariffs design may address "duck curve" issues that may arise as solar PV penetration increases; and
- Introduction of market mechanisms for the provision of capacity and ancillary services.

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MyRER

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chapter four

RENEWABLES IN MALAYSIA

RENEWABLES IN MALAYSIA

SUMMARY

RENEWABLE ENERGY RESOURCE AVAILABILITY

Malaysia is blessed with abundant RE resources readily exploitable for power generation; (1) year-round solar irradiation, (2) agriculture, domestic and industrial waste for bioenergy combustion or gasification and (3) river basins for small hydroelectric power. The following RE resource potential has been identified in Malaysia:

- 269 GW potential for solar PV, dominated by ground-mounted configurations (210 GW), rooftop PV system (42 GW) and floating configurations (17 GW);
- 13.6 GW (13,619 MW) resource potential for large hydro; 3.1 GW is identified in Peninsular Malaysia, 493 MW in Sabah, and 10 GW in Sarawak;
- 3.6 GW resource potential for bioenergy, including biomass (2.3 GW), biogas (736 MW), municipal solid waste (516 MW);
- 2.5 GW resource potential for small hydro (up to 100 MW); and
- 229 MW of geothermal resource potential.

CURRENT RENEWABLE ENERGY DEVELOPMENT STATUS IN MALAYSIA AND ITS CHALLENGES

As of 2020, RE installed capacity in Malaysia amounted to 8,450 MW. Large hydro is the largest contributor to RE capacity with 5,692 MW, followed by solar PV and biomass with 1,534 MW and 594 MW respectively. Small hydro capacity amounts to 507 MW and biogas to 123 MW.

On-grid RE development has been supported by four programmes; Feed-in Tariff scheme (FiT), Large Scale Solar auction (LSS), Net Energy Metering (NEM) and Self-Consumption (SELCO). FiT was the first program to be introduced in 2011, and later in 2016 NEM and SELCO, targeting rooftop solar. LSS was also introduced in 2016 which has grown as solar utility scale.

In parallel with the RE programmes mentioned above, the Malaysian government has introduced a few incentive schemes: Green Technology Financing Scheme (GTFS), Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE).

Key challenges in RE development have also been identified to formulate key actions in MyRER.

For solar PV, among the key challenges: (1) securing land for LSS; (2) securing affordable debt financing for solar PV rooftop systems; (3) capacity limits; (4) limitation of NEM scheme to assets on customers' own premises; and (5) lack of regulatory framework supporting customer choice.

Key challenges faced by bioenergy developers include: (1) suboptimal plant size and capacity factors due to feedstock procurement challenges; (2) inconsistent feedstock price and quality; (3) accessing grid connections; and (4) utilization of less efficient technologies for power generation. In addition, WTE players face specific issues like: (1) varied tipping fees across Malaysia, complicating decision-making for WTE investment; and (2) logistics of waste feedstocks as landfill sites are scattered across Malaysia.

For small hydro, among the key challenges faced by developers are: (1) long gestation period due to extensive approval process; (2) lack of regulation on upstream development; and (3) lack of data on high potential sites for hydro development.

Challenges faced by the utilities when developing large hydro projects are: (1) longer gestation period due to numerous permits required; (2) high development costs; (3) public acceptance; (4) government and policy support; and (5) lack of regulation on upstream development. In addition, other common challenges across all technologies are: (1) human capital development and (2) lack of public awareness on the importance of energy transition and Government efforts.

4.1 RENEWABLE ENERGY RESOURCE AVAILABILITY

MALAYSIA HAS ABUNDANT RENEWABLE RESOURCES READILY EXPLOITABLE FOR POWER GENERATION – SOLAR, BIOMASS AND SMALL HYDRO, WITH MORE THAN 275 GW OF POTENTIAL – BUT ALSO RESOURCES THAT MAY BE UTILIZED IN THE LONGER TERM

Malaysia has abundance of resources readily exploitable for renewable energy generation;

- solar irradiation for solar generation,
- agricultural, domestic and industrial waste for bioenergy combustion or gasification and
- rivers for small hydroelectric power.

Located near the equator, Malaysia has a substantial amount of solar resources. A study published by SEDA in 2016 reported solar irradiation of 1,575 – 1,812 kWh/m2, higher than in some of the temperate regions where solar market is already well developed (e.g. Germany has average solar irradiance of 1,088 kWh/m2)[37].

The palm oil industry is a major sector in Malaysia's economy, contributing between 5% and 7% of GDP from 2012 to 2017[38]. There are approximately 450 palm oil mills across Malaysia, processing an average of 95.5 million tons of fresh fruit bunch (FFB) annually[39], generating vast amount of waste such as empty fruit bunch (EFB), palm kernel shell (PKS) and mesocarp fiber (MF). The abundance of palm oil waste and its calorific value makes it a suitable feedstock for combustion and energy generation. In addition to palm oil waste, there has been growing interest in the industry to utilize other agricultural residues such as rice husk and straw, and also wood residue from sawmills for energy generation.

Continued growth of Malaysia's population, quality of life and urbanization have contributed to the increase in sanitary and non-sanitary solid waste[40]. It is estimated that an average of 9.5 million tons of solid waste is generated every year[41].

In 2018, the Malaysian government announced its intention to build one WTE plant in each state in order to shift toward a cleaner process of solid waste disposal. At the point of publication of this roadmap, 2 tender exercises have already been conducted by KPKT on WTE initiative in Johor and Melaka state respectively.

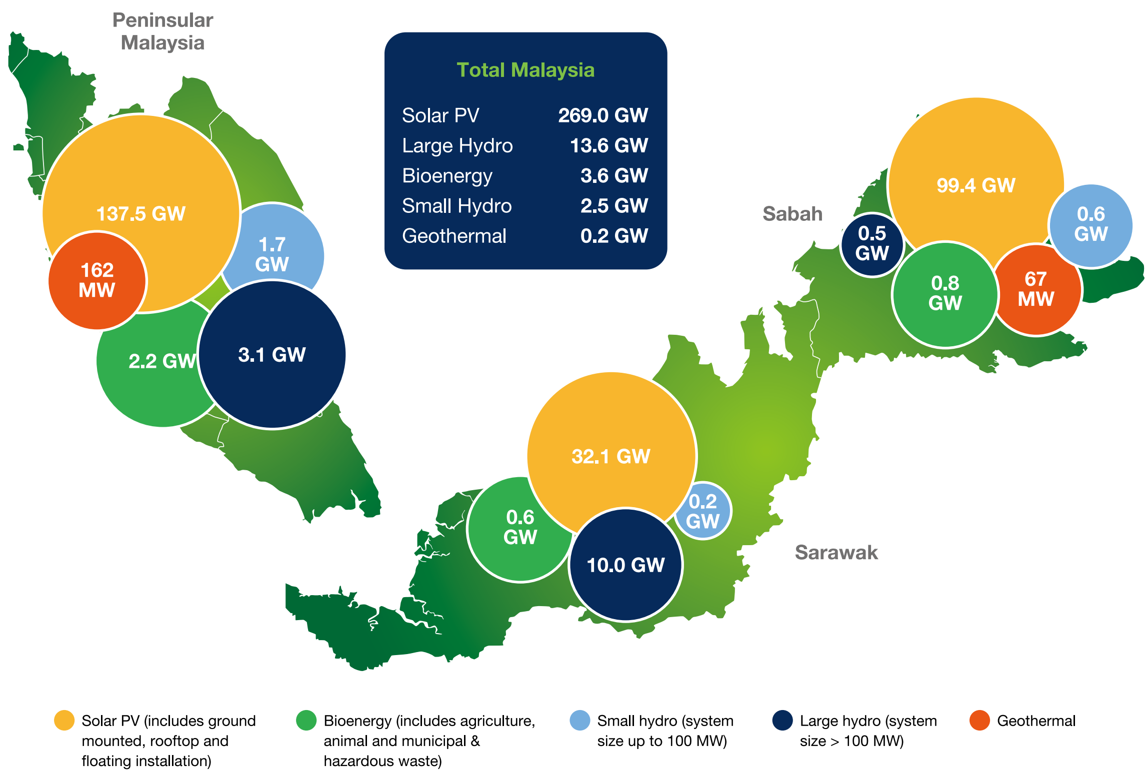
Finally, Malaysia is rich in hydroelectric power resources with a total of 189 river basins in Malaysia[42]. Although the rainfall regime is subject to seasonality, Malaysia does not experience recurring drought periods that impact significantly dispatchability of hydropower[43].

The availability of these renewable energy resources in Malaysia has been quantified as part of the MyRER. The total RE resource availability, quantified in equivalent power generation capacity (GW) in Malaysia is summarized in Figure 4-1. Solar PV has by far, the largest resource availability at 269 GW. Large hydro comes in second at 13.6 GW (13,619 MW), followed by bioenergy (biomass from agriculture waste, biogas and solid waste) at 3.6 GW, small hydro (up to 100 MW) close to 2.5 GW, and lastly geothermal resource availability has been estimated at 0.23GW. The subsequent subchapters in this report will discuss each resource potential in detail. It should be noted here that the assessment of resource availability does not consider economic feasibility and adoption barriers, such as grid connectivity.


Image for illustration purpose only.

37. Fraunhofer, Recent Facts about Photovoltaics in Germany, 2020
38. Malaysian Palm Oil Board, Malaysia: 100 years of resilient palm oil economic performance, 2018
39. SEDA analysis based on average fresh fruit bunches produced between 2014-2018. Data taken from Malaysian Palm Oil Board website http://bepi.mpob.gov.my/index.php/en/, accessed on 1 March 2019.
40. Sanitary solid waste is waste that is not hazardous or radioactive
41. Jabatan Pengurusan Sisa Pepejal Negara (JPSPN), Municipal waste disposal and treatment statistic, 2018
42. Department of Irrigation and Drainage
43. Expert interview and SEDA

Figure 4-1: Summary of RE resource potential



Aside from solar PV, bioenergy and small hydro, Malaysia also has two additional potential RE resources that could be tapped in the longer term: geothermal and wind energy.

Wind speed in Malaysia is generally low on average, less than 5 m/s. However, although accessibility issue may prevent development, a few locations in Peninsular Malaysia and North Sabah were found to have sufficient strong wind conditions that may be suitable for wind turbine installation, while other locations are depending on technology advances in low speed turbine[44].

Two studies by the Minerals and Geoscience Department of Malaysia also indicated 67 MW geothermal resources in Tawau, Sabah[45], as well as 162 MW in Ulu Slim, Perak[46].

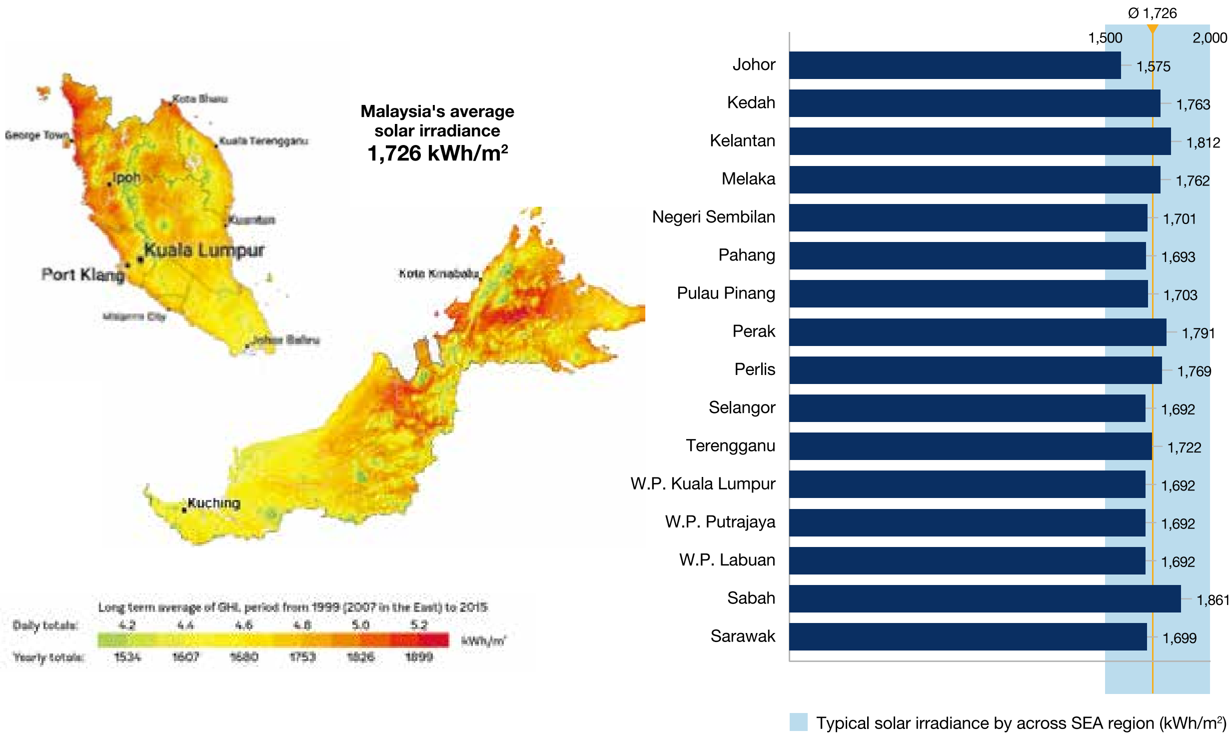
4.1.1 SOLAR PV

MALAYSIA IS RICH IN SOLAR RESOURCES (IRRADIANCE)

Due to its location around the equator, Malaysia receives approximately 1,575 – 1,812 kWh/m^2 of solar irradiance, which is close to the average solar irradiance for Southeast Asia (1,500 to 2,000 kWh/m^2)[47]. For comparison, India, with a large solar installed capacity of approximately 30 GW[48], has solar irradiance range between 1,200 to 2,200[49] kWh/m^2, while Germany has an average solar irradiance of 1,088 kWh/m^2. As solar irradiance is relatively high, solar PV is considered a viable RE option for Malaysia. Based on a study by SEDA, the north-western part of Peninsular Malaysia receives the highest solar irradiation. However other regions in Malaysia such as Sabah also have good conditions for solar PV power generation (Figure 4-2).

44. SEDA and WinDForce Management Services Pvt Ltd & Emergent Ventures (M) Sdn Bhd, Meso Scale Mapping Report, 2017
45. Ministry of Natural Resources and Environment, The Geothermal Investigation Project Sabah: Magnetotelluric (MT) Survey in Apas Kiri Geothermal Prospect, Tawau, Sabah, 2009
46. SEDA and Ministry of Natural Resources and Environment, Laporan Penilaian Sumber Geoterma Bagi Potensi Penjanaan Tenaga Boleh Baharu di Kawasan Ulu Slim, Perak, 2016
47. Meteonorm
48. The Economic Times, "How India in a short period of time has become the cheapest producer of solar power", 2019
49. National Renewable Energy Laboratory, India Solar Resource (map), 2016

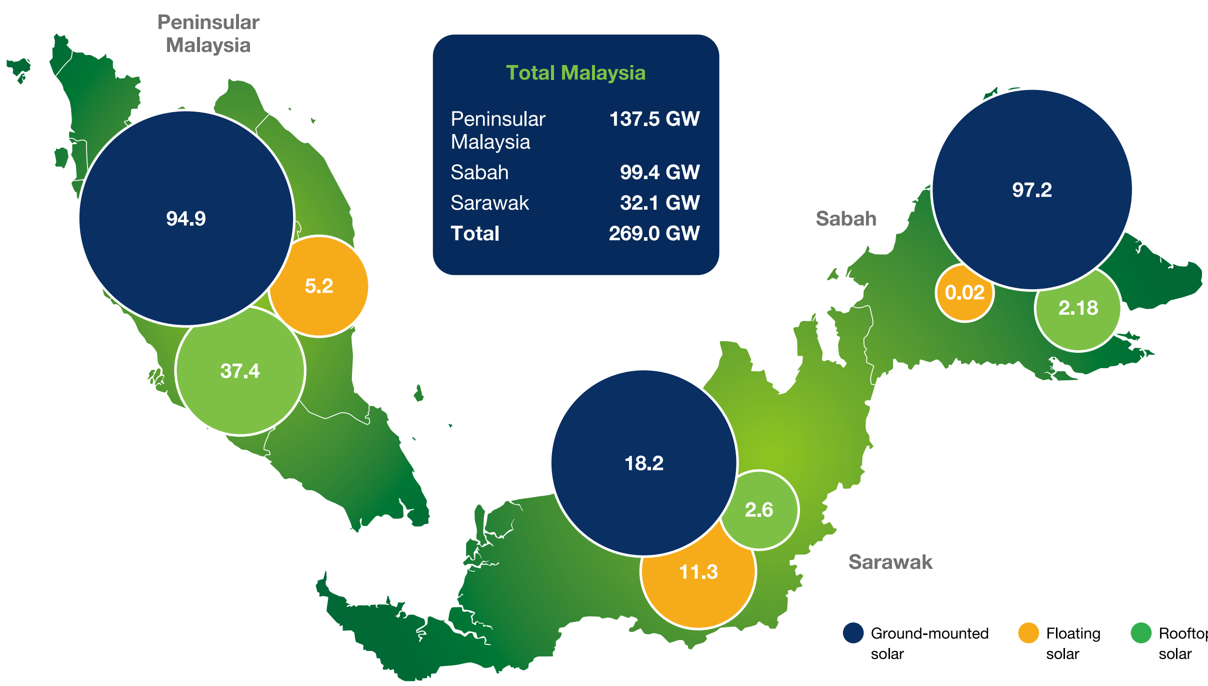
Figure 4-2: Solar irradiance in Malaysia



THREE TYPES OF SOLAR PV INSTALLATION CONSIDERED – GROUND-MOUNTED, FLOATING AND ROOFTOP

In addition to favourable irradiation, solar resource is driven by availability of areas for installation of solar PV systems. Three types of installation configurations are considered: ground-mounted solar installations on unused land, floating installations on water bodies and installations on residential, commercial, industrial and public buildings rooftops (Figure 4-3).

Figure 4-3: Solar PV resource availability by installation and by region



Ground-mounted solar PV

Ground-mounted solar PV involves installing solar PV systems on flat land. This configuration has the highest solar potential in Malaysia at 210 GW, driven by the availability of unused suitable land[50]. It is estimated from land utilization data that 4,085 km2 of unused suitable land, or 1.2% of total land area, are available in Malaysia[51]. To understand the scale of this resource, it is worth considering that even utilizing only 1% of available unused suitable land would yield 2.1 GW of ground-mounted solar PV generation capacity – almost three times the installed capacity of solar PV in Malaysia in 2018 (736 MW).

Comparing resource potential regionally, Sabah ranked the highest in ground-mounted solar PV resource at 97.2 GW, followed by Peninsular Malaysia with 94.9 GW and Sarawak at 18.2 GW. Sabah has a higher ratio of unused suitable land, corresponding to 2.6% of Sabah's total land or 1,887 km2. Peninsular Malaysia has 1,843 km2 of unused suitable land corresponding to 1.4% of total land. Sarawak has the lowest ratio of unused suitable land area (0.3%), as most of the State is covered by mountainous areas and undulating land, which is not suitable for ground-mounted solar PV installations.

Given the large resource availability, policies and strategies that are designed to realize ground-mounted solar PV potential are crucial in meeting Malaysia's RE targets.

Floating solar PV

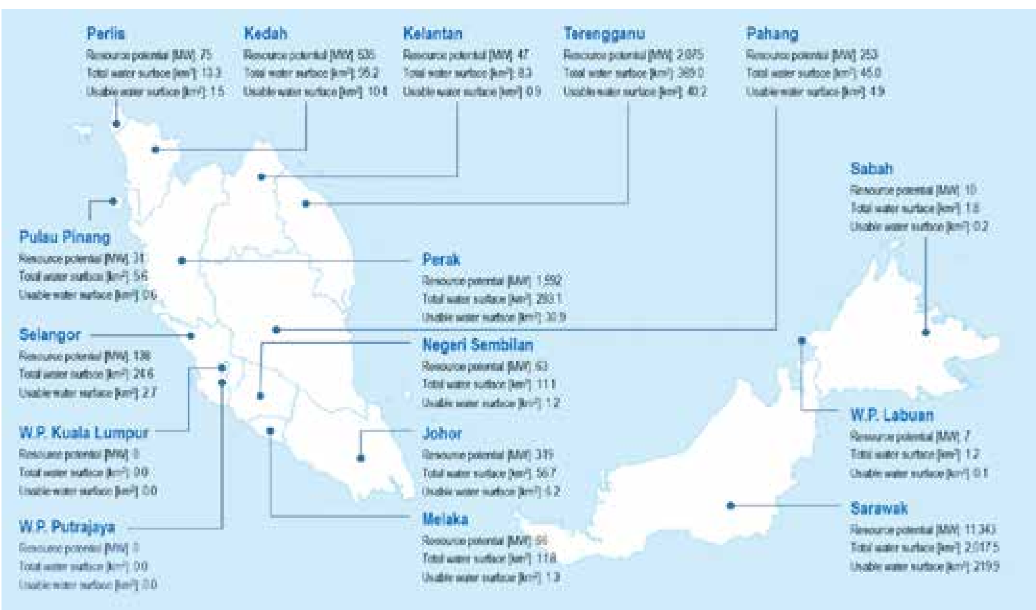
Floating solar PV involves installing PV modules on floating platforms placed on water body surfaces. The key driver for floating solar PV resource is the availability of water bodies. For the purpose of this study, only hydroelectric plant and reservoir dams were considered as these water bodies have the highest potential for connecting a floating solar PV system to a substation.

An estimated 16.6 GW of floating solar PV resource potential is available in Malaysia, covering 17 hydroelectric plants and 62 reservoir dams that made up 2,944 km2 of total water surface area.

Sarawak has the highest floating solar PV resource at 11.3 GW due to the high number and large individual size of dams, amounting to approximately 220 km2 of usable water surface (11% of total water surface in Sarawak). For example, Bakun Dam in Sarawak has a total water surface area of 695 km2, close to the size of Singapore. Its usable water surface area amounts to 69.5 km2, which could generate approximately 3.9 GW of floating solar capacity. Peninsular Malaysia has the second highest floating solar PV resource of 5.2 GW as it has multiple reservoir dams corresponding to 101 km2 of useable water surface. Sabah has the lowest floating solar PV resource of 0.01 GW, due to the limited reservoirs and hydroelectric plants in the state.

Although much smaller than ground-mounted solar PV resource, floating solar PV resource is still substantial at 16.6 GW (Figure 4-4) and is able to address the concerns on extension land uses requirement for ground-mounted potentials.

Figure 4-4: Floating solar PV resource potential and water bodies



Source: SEDA; Department of Irrigation and Drainage; Ciel-et-terre; Industry inputs

50. Unused suitable land is defined as flat land that is not classified for any specific use. Categories of land or areas excluded from consideration are water bodies, forests, agricultural land, mountainous areas, existing urban and industrial areas. The categories are defined as per PLAN Malaysia, Sarawak Land and Survey Department and Sabah Structure Plan 2033
51. Estimates based on published data from PLAN Malaysia, Sabah Structure Plan 2033 and Sarawak Land and Survey Department

Rooftop solar PV

Rooftop solar PV involves installing solar PV systems on buildings' roofs.

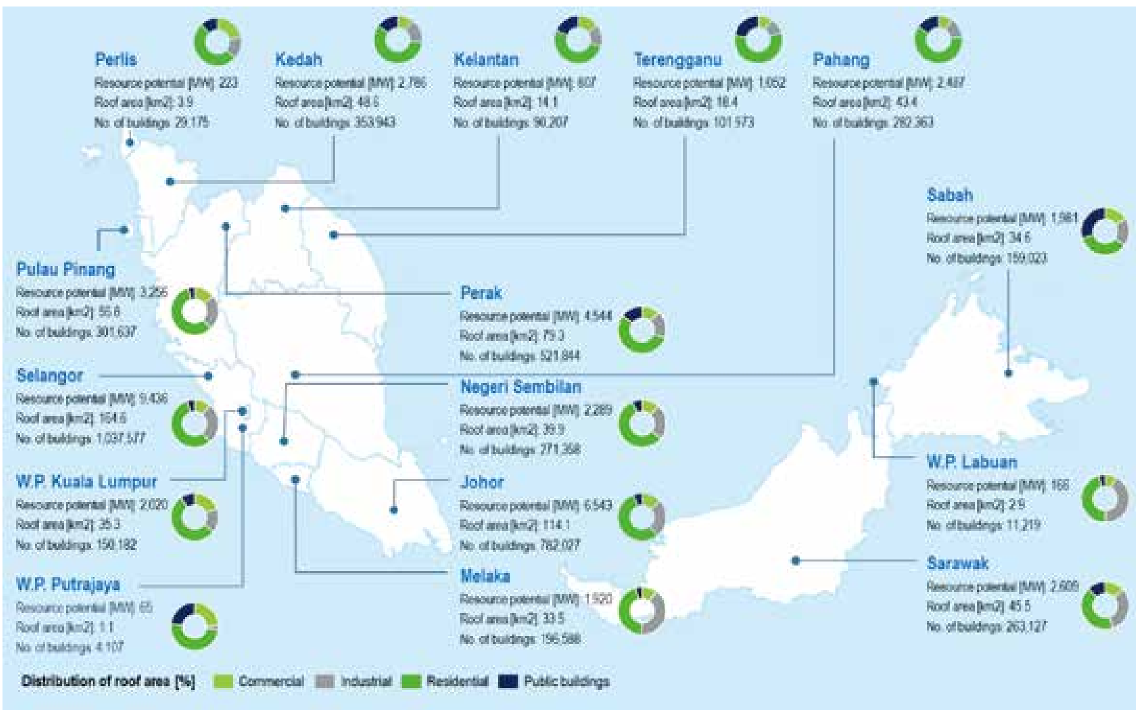
This study has found approximately 42 GW of rooftop solar PV resource availability from 4.6 million buildings[52] and 43 university campuses[50] in Malaysia. This includes residential buildings (landed and high-rise) buildings, commercial buildings (hotels, shopping malls, offices, shophouses), industrial buildings (industrial offices, factories) and buildings hosting public institutions (primary and secondary schools, universities and hospitals).

Peninsular Malaysia has by far the highest rooftop solar PV resource at 37.4 GW as it is highly urbanized. Sarawak and Sabah possess 2.6 GW and 2.2 GW of rooftop solar PV resource respectively (Figure 4-5).

Residential buildings support most of the resource potential at 22.7 GW. This comes from approximately 3.9 million residential buildings. 115,000 industrial buildings contribute to 9.9 GW of resource potential and 520,000 commercial buildings offer 5.2 GW rooftop solar PV potential. Finally, approximately 10,500 public buildings support 4.4 GW potential[53].

Rooftop solar PV has been one of the driving forces for solar PV growth globally. Countries such as Japan, India and China have adopted national rooftop PV programmes to support rooftop PV growth[54]. With the right strategy, Malaysia can unlock a portion of the estimated 42 GW of rooftop solar PV resource. Existing programmes like NEM and SELCO, which are discussed in Chapter 4.3 have been implemented and are picking up since the policy improvement was made. Strategies to promote new business models and revenue streams like P2P energy trading and corporate PPA programmes have been proposed to encourage more rooftops applications as explained in Chapter 6.1.

Figure 4-5: Summary of buildings assessed for rooftop solar PV



Source: SEDA; National Property Information Centre; Ministry of Health Malaysia; Ministry of Education Malaysia; Property and university's website

52. SEDA analysis based on published data
53. Does not include government flats and government office, both of which are accounted for already in residential homes and commercial buildings respectively
54. IEA, Market deployment strategies for PV systems in the built environment – An evaluation of Incentives, Support Programmes and Marketing Activities, 2002

4.1.2 BIOENERGY

Agricultural activities, population growth and increase in living standards have resulted in abundance of waste by-products that are either incinerated or disposed in landfill sites though could be used for power generation.

ABUNDANCE OF PALM OIL WASTE THAT CAN BE USED FOR POWER GENERATION THROUGH DIRECT COMBUSTION OR GASIFICATION (BIOGAS)

On average, 95.5 million tons of FFB are processed by approximately 450 palm oil mills each year in Malaysia[55]. The resulting residue of FFB are EFB, MF and PKS that are usually sent for mulching, or disposed, incinerated and in some cases exported overseas.

Interviews with industry experts conducted in this study found that millers typically send half of EFB produced for mulching, and they dispose or incinerate the other half[56]. On the contrary, all MF residues are disposed, incinerated or used for electricity self-consumption, and majority of PKS residue is exported overseas, mainly to Japan and South Korea, where it is used for biomass power generation under subsidized schemes.

The fraction of waste that is disposed or incinerated could be reused for power generation, thereby contributing as a bioenergy resource. Of the 19.6 million tons (dry weight) of EFB, MF and PKS that are produced each year, 12.3 million tons could be available for biomass combustion, which is equivalent to 2.3 GW of biomass resource[57].

In addition to EFB, MF and PKS, palm oil processing produces palm oil mill effluent (POME) which is often collected in disposal ponds.

POME is suitable for biogas production (gasification), which can be used a fuel for power generation through gas engines. An average of 64 million m^3 of POME is generated each year, translating to approximately 550 MW of biogas power generation resource in Malaysia

GROWING INTEREST FOR RICE HUSK AND STRAW AND WOOD RESIDUE

In addition to palm oil waste, there has been growing interest in utilizing by-products of rice production such as rice husk and straw as well as wood residue from sawmills for biomass power generation.

Malaysia has approximately 689,000 ha of paddy fields producing 2.7 million tons of rice[58], generating approximately 770,000 tons of rice husk[59] and 2.1 million tons of rice straw each year[60]. It is estimated that 50% or 1.4 million tons of rice husk and straw in Malaysia could be used for biomass combustion, while the rest is used as cattle feed[61]. This translates to 183 MW of biomass resource.

Industry data show that 1.6 million tons of wood residues are generated every year in Malaysia[62]. Approximately half of the wood residue generated is recycled as bedding material, landscape mulching and fiber for composite board products[59]. The remaining half could be used for biomass power generation. This corresponds to 815,000 tons of wood residue, translating to approximately 120 MW of bioenergy resource.

EXPLOITING SOLID WASTE LANDFILLS

On average, 9.5 million tons of solid waste are disposed in 146 landfills every year[63]. Waste management has become a growing concern in Malaysia as landfill sites are reaching full capacity. Therefore, effort is undertaken to develop WTE facilities to tackle waste management issues. Assuming all 9.5 million tons of waste is used directly for power generation through combustion, this would correspond to approximately 516 MW of biomass WTE resource. Alternatively, if the same amount of waste is converted through landfill gas, this would result in 175 MW of biogas resource.

BIOENERGY RESOURCE AVAILABILITY BY RESOURCE AND REGION

Following the estimates outlined above, the total bioenergy resource potential in Malaysia, including biomass, biogas and WTE is calculated at 3.6 GW.

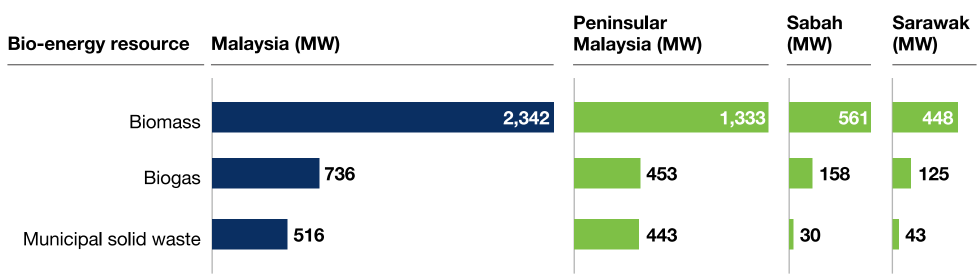
55. SEDA analysis based on average fresh fruit bunches produced between 2014-2018. Data taken from Malaysian Palm Oil Board website, http://bepi.mpob.gov.my/index.php/en/, accessed in March 2019
56. Expert interview
57. SEDA analysis based on fresh fruit bunch waste produced per fresh fruit bunch processed. Assumption taken from published study; Malaysian Palm Oil Board, Energy Conversion and Management, 2018
58. Ministry of Agriculture and Agro-based Industry Malaysia, agriculture statistics, 2016
59. Rice husk yield is 28% of each ton rice paddy produced; International Rice Research Institute, http://www.knowledgebank.irri.org/step-by-step-production/postharvest/rice-by-products/rice-husk, assessed in March 2019
60. Rice straw yield is 75% of each ton of rice paddy produced. Rice paddy and rice straw are separate components in a rice plant, hence 2.74 million tons of paddy rice includes rice and rice husk but does not include rice straw. Therefore, the sum of the total volume of rice husk and straw exceeds the total volume of paddy rice
61. Expert interview
62. Malaysia Biomass Industries Confederation, Towards Environmental & Economic Sustainability in Malaysia via Biomass Industry, 2014
63. Jabatan Pengurusan Sisa Pepejal Negara (JPSPN), Municipal waste disposal and treatment statistic, 2018

Biomass constitutes the largest resource with approximately 2.3 GW of potential in Malaysia. Peninsular Malaysia accounts for 1.3 GW, followed by Sabah and Sarawak with 561 MW and 448 MW respectively.

The total biogas resource including landfill gasification is 736 MW. Peninsular Malaysia accounts for 453 MW of resource, followed by Sabah and Sarawak with 158 MW and 125 MW of biogas resource respectively.

Solid waste for WTE combustion contributes 516 MW of bioenergy resource with Peninsular Malaysia accounting for 443 MW, followed by Sarawak and Sabah with 43 MW and 30 MW respectively (Figure 4-6).

Figure 4-6: Overview of bioenergy resource availability in Malaysia



Source: SEDA; MPOB; MBIC; JPSPN; IPCC; Department of Veterinary Services Malaysia; Biomass Energy Resource Center; Ministry of Agriculture and Agro-based Industry Malaysia; International Rice Research Institute

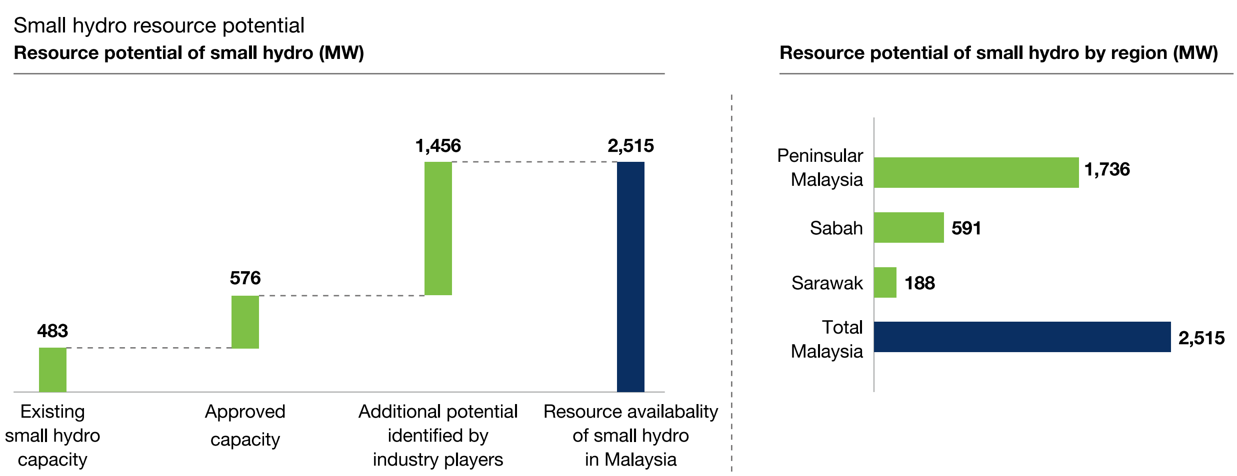
4.1.3 SMALL HYDRO

Approximately 2.5 GW of small hydro resource potential has been identified in Malaysia[64]. For the purpose of this study, small hydro resource is estimated using existing installed projects, planned projects and sites that have already been identified by industry players. The data have been collected via focus group discussions and interviews with industry players and associations.

Peninsular Malaysia has the highest resource potential at 1,736 MW, followed by Sabah with 591 MW, and Sarawak with 188 MW (Figure 4-7).

However, given the abundance of river basins in Malaysia (189 basins), potential sites that can be exploited for small hydro development may exceed the existing resource potential identified (2.5 GW), thus contributing to an even larger resource potential. To further exploit this potential, a bottom-up hydro-geological assessment of the river basins needs to be conducted. Chapter 6.3 discusses the initiative to implement such a study to identify and further develop small hydro power generation.

Figure 4-7: Small hydro resource potential



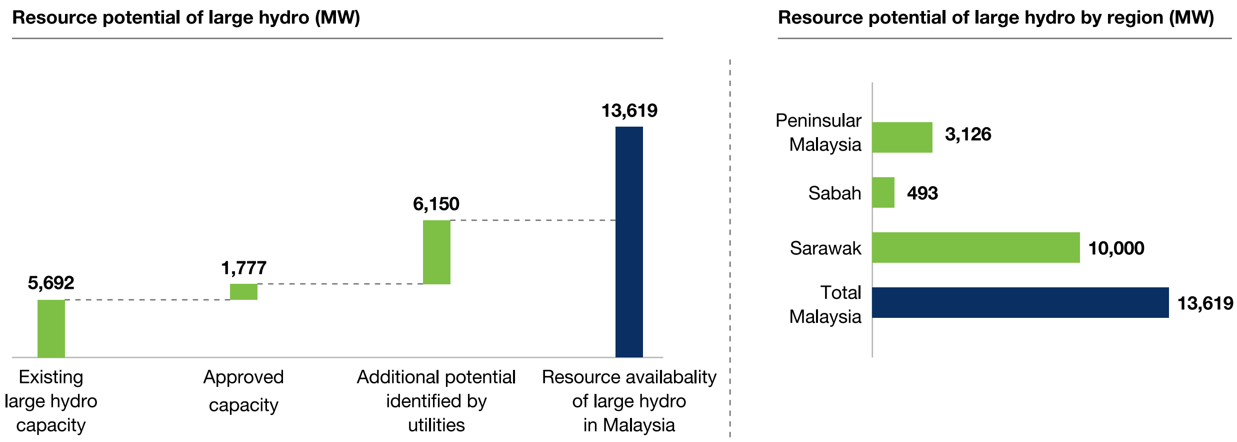
Source: SEDA; TNB; SESB; SEB; Industry players

64. Hydropower plant with system size of up to 100 MW

4.1.4 LARGE HYDRO

In Malaysia, the total large hydro resource potential that could be utilized is significant, with an estimated resource potential of 13.6 GW over the three regions in Malaysia. Around 73% of the identified resource potential (10 GW) comes from central and northern Sarawak, followed by 23% potential of 3.1 GW in Peninsular Malaysia, and the last 4% (493 MW) is identified in Sabah. Given its large potential in Malaysia, developing plans are already in place for more than half of the estimated resource potential. The large hydro capacity in Malaysia is estimated to reach 5.9 GW in 2025, with an addition of 189 MW to its existing capacity of 5.7 GW.

Figure 4-8: Large hydro resource potential



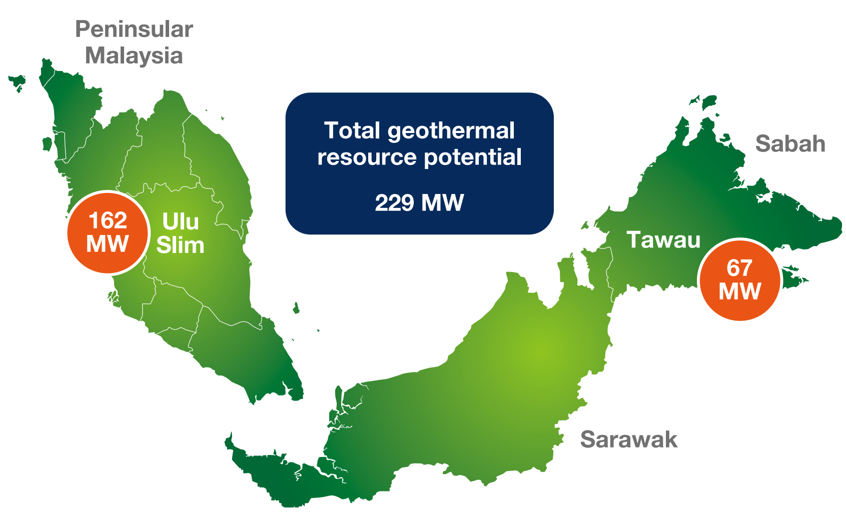
Source: SEDA; TNB; SESB; SEB

4.1.5 GEOTHERMAL

In 2009, a study commissioned by the Minerals and Geoscience Department of Malaysia, identified 67 MW of geothermal resource potential in Tawau, Sabah. The reservoir identified covers 12 km^2 with temperature ranging from 190°C to 236°C. A separate study in 2016 by the Minerals and Geoscience Department of Malaysia, found an additional 162 MW of geothermal resource in Ulu Slim, Perak (Figure 4-9).

Given the abundance of alternative RE resources (solar, bioenergy, small hydro) with fewer technical complexity[65] and lower costs[66], geothermal generation is only considered in the MyRER as an option in the long term, contributing to installed capacity by 2035.

Figure 4-9: Geothermal resource – Ulu Slim and Tawau resource potential



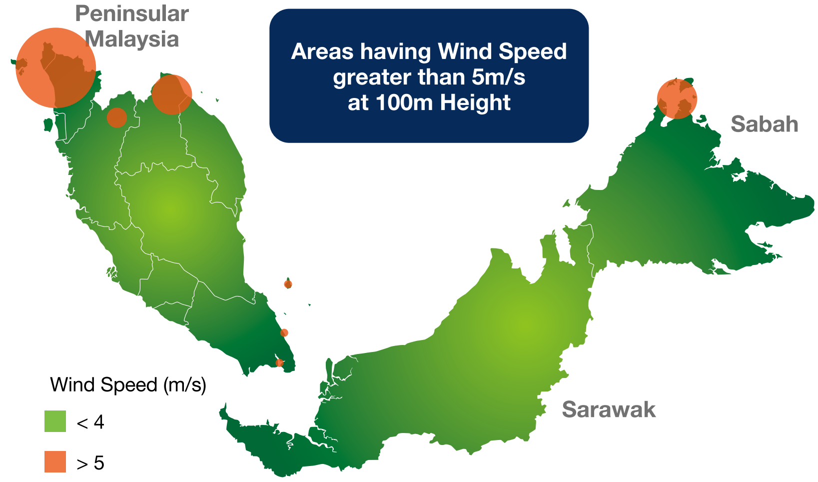
65. Expert interview
66. IRENA (2020) RE Power Generation Cost 2019

4.1.6 WIND

An onshore wind mapping study commissioned by SEDA identified suitable wind conditions for power generation in the northern part of Peninsular Malaysia and Sabah (as illustrated in Figure 4-10)[67]. Feasibility of wind generation is dependent on wind speed and cut-in speed of wind turbine. In the study, only areas with wind speed of 5 m/s or more were included in the assessment. It should be noted that at 5 m/s, the capacity factor of wind turbines would be low, resulting in unfavourable wind generation economics. Global case studies show that minimum wind speed required for profitable wind energy generation is 7-8 m/s.

In addition to low electricity yield based on current wind turbine technology for wind speed around 5 m/s, scarce site accessibility and high installation cost make wind power generation in Malaysia uneconomical. Continued development in low wind speed technology and government support may improve the economics for wind installation in the future.

Figure 4-10: Wind map study of Malaysia



Area with wind speed >5 m/s	Peninsular Malaysia	East Malaysia
	1,318 km²	**250 km²**

Note: Wind map study done at 100m height; 5 m/s – minimum wind speed required to start generating electricity
Source: SEDA; Emergent Ventures; WinDForce Management Service

4.2 EXISTING INSTALLED CAPACITY AS OF 2020

AS OF 2020, NATIONAL RE SHARE IS 23%

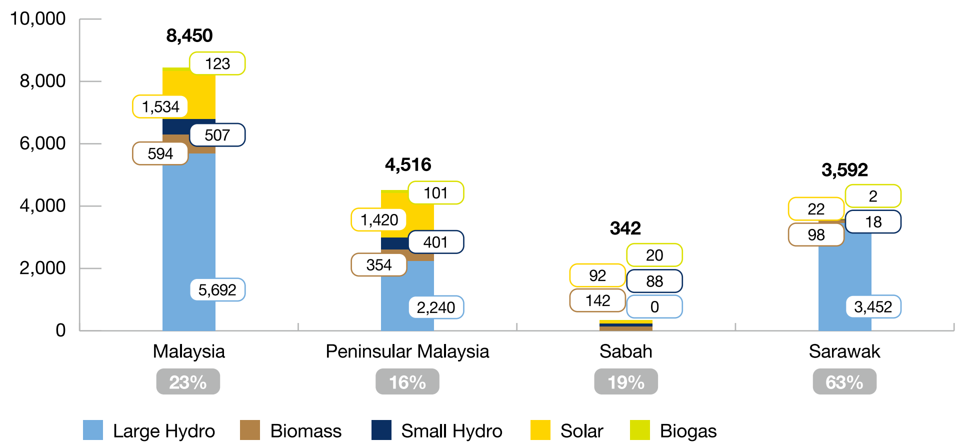
Total RE installed capacity in Malaysia as of December 2020 was 8,450 MW, corresponding to a share of RE in total installed capacity mix of 23%. Large hydro accounts for most of the installed of the capacity with 5,692 MW; 2,240 MW of large hydro is installed in Peninsular Malaysia and 3,452 MW in Sarawak. This is due to Sarawak's continuous effort to leverage the abundance of large river basins as a source of clean power generation (Figure 4-12).

This is followed by solar PV and biomass (palm oil waste), with 18% and 7% respectively. This has largely been driven by government programmes such as the FiT and LSS auction for solar and off-grid generation for biomass in Peninsular Malaysia and Sabah.

Peninsular Malaysia has the highest RE installed capacity at 4,516 MW, while Sabah and Sarawak's installed capacity stands at 342 MW and 3,592 MW respectively (Figure 4-12).

67. SEDA and WinDForce Management Services Pvt Ltd & Emergent Ventures (M) Sdn Bhd, Meso Scale Mapping Report, 2017

Figure 4-11: Renewable energy installed capacity



Source: SEDA: ST; SESB; SEB

BETWEEN 2012 AND 2020, RE INSTALLED CAPACITY GREW BY 12.1% ANNUALLY

Between 2012 and 2020, RE installed capacity grew from 3.7 GW to 8.5 GW, corresponding to an annual growth rate of 10.9%.

In 2012, the RE mix largely consisted of two third of large hydro. Post 2011, the introduction of the FiT scheme has brought strong growth in solar PV and biogas. Since 2018, growth in solar PV has benefited from LSS auctions.

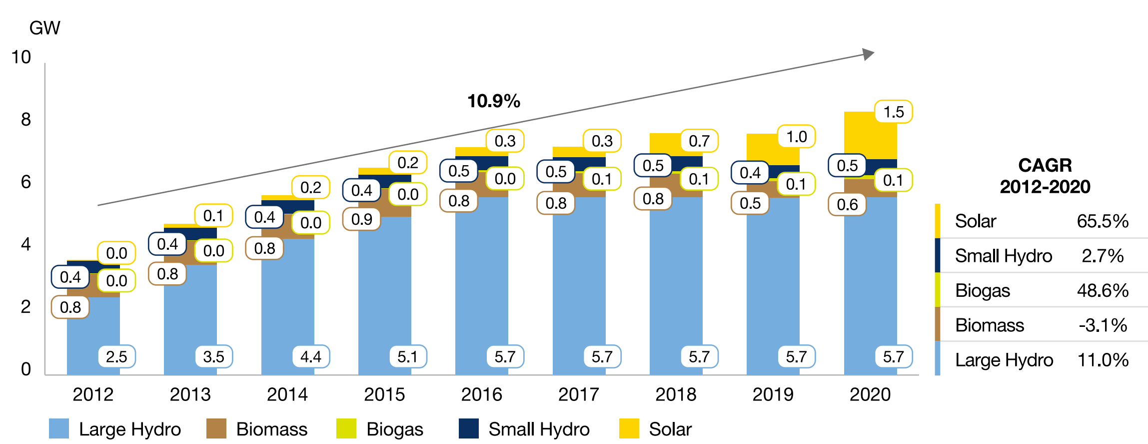
In 2014, a mandate by Malaysia Palm Oil Board (MPOB) required all expanding palm oil mills and new palm oil mills to install biogas capture equipment, thereby supporting the growth of biogas generation.

For hydro, the long gestation periods has hampered the growth of installed capacity. Small hydro projects typically take up to five years to achieve commercial operation after obtaining approval for a FiT quota. (see Chapter 4.4 for challenges).

On the other hand, growth in biomass installed capacity has remained relatively flat due to implementation challenges such as the ability to secure a stable supply of feedstock and high connection costs.

Large hydro RE capacity increased by 12.6% on a year-on-year basis from 2012 to 2020, plateauing in 2016 at 5.7 GW).

Figure 4-12: Cumulative RE capacity for Malaysia, 2012-2020



Source: SEDA: ST; SESB; SEB

4.3 EXISTING RE PROGRAMMES

4.3.1 KEY RE PROGRAMMES

Since 2012, RE development in Peninsular Malaysia and Sabah has been supported through four main programmes; Feed-in Tariff scheme (FiT), Large Scale Solar auction (LSS), Net Energy Metering (NEM) and Self-consumption (SELCO). The key RE programmes are summarized in Figure 4 14.

Feed-in Tariff scheme (FiT)

The FiT scheme was introduced on 1st December 2011 to boost RE uptake by ensuring that Distribution Licensees (DLs), such as TNB, purchase electricity produced from renewable resources at a premium rate for a fixed period.

The FiT mechanism was originally available for all the main RE resources (biomass, biogas, small hydro and solar PV). Due to the rapid decreasing costs, new mechanisms, such as LSS auctions, NEM and SELCO, have been introduced, replacing the FiT mechanism for solar PV[68].

As of the end of 2020, 574 MW of RE capacity have been installed under the FiT programme, majority of which has been taken up by solar PV (323 MW), while biomass, biogas, and small hydro have a combined cumulative installed capacity of 252 MW.

Large scale solar auction (LSS)

The introduction of LSS auction in 2016 has resulted in addition of 857 MW or 56% to the total solar PV installed capacity as of the end of 2020.

LSS is designed to support the uptake of utility-scale solar PV systems with capacities of 1-100 MW in Malaysia. The scheme uses a reverse auction system to award LSS rights based on the lowest bid for off-take prices. The minimum system capacity of LSS plants is 1 MW, while the maximum system capacity has varied depending on the auction tranche, ranging from 30 MW to 100 MW. As a result of the reverse auction system, competition between developers has pushed off-take solar prices down by 13% between 2016 to 2017. If this trend continues, solar prices may soon reach grid parity or even lower levels.

Prior to LSS auctions, 250 MW of LSS projects were awarded through a fast-track mechanism. Since 2016, Malaysia has conducted four LSS auctions:

- LSS 1 was held in 2016 for 371 MW with the lowest bid submitted at MYR 0.39 / kWh[69];
- LSS 2 was held in 2017 for 526 MW with the lowest bid submitted at MYR 0.34 / kWh, a 13% reduction from LSS 1;
- LSS 3 was held in 2019 for 490.88 MW with the lowest bid submitted at MYR 0.17 / kWh, a 50% reduction from LSS 2[70]; and
- LSS 4 was held in 2020 for about 1,000MW with the lowest bid at MYR 0.1399 / kWh, a 18% reduction from LSS 3.

Net Energy Metering (NEM)

Malaysia introduced the NEM scheme in November 2016, with a 500 MW quota. Through NEM, RE owners are allowed to sell excess electricity generated from RE to DLs.

Up to the end of 2018, excess energy generated was sold at displaced cost[71], which is lower than the average retail tariff. This has resulted in low uptake of NEM. As of end-2018, 10 MW of capacity has been installed under NEM. In January 2019, the compensation rate for excess energy for new NEM applications was increased to match the retail tariff (‘one-to-one’ offset).

Besides outright purchase of solar PV systems, NEM participants can install solar PV systems through power purchase agreements (PPA) or leasing with a Registered Solar PV Investor (RPVI). Under the leasing/PPA mode of purchase, little to no upfront investment is required, which is expected to boost NEM uptake. Additionally, TNB introduced the Supply Agreement for Renewable Energy (SARE) which integrates leasing payments with TNB’s electricity bills, offering one-stop billing process for consumers thereby reducing counter party risk for the RPVIs. RPVIs are registered and administered by SEDA.

It should also be noted that the NEM scheme is not limited to rooftop solar PV but is also open to ground- mounted solar within its own premise and the approval is on a case-by-case basis.

Self-Consumption (SELCO)

The SELCO scheme introduced in 2017 is available for solar PV system owners who intend to use the electricity generated for self-consumption purposes. Electricity generated from SELCO cannot be exported to the grid, limiting owners from securing compensation of excess energy generated. However, SELCO users benefit from the shortened installation process as the power system study is not required for system sizes up to 425 kWac. As of December 2020, 93 MW capacity has been installed under the SELCO scheme.

68. Last quota for solar FiT projects were given in 2017
69. Ongoing projects only, based on data from ST; Some projects may have been revoked post award
70. Source: www.st.gov.my
71. Displaced cost – average cost of generating and supplying 1 kWh of electricity from resources other than renewable resources through supply line up to the point of interconnection with RE installation

Large Hydro

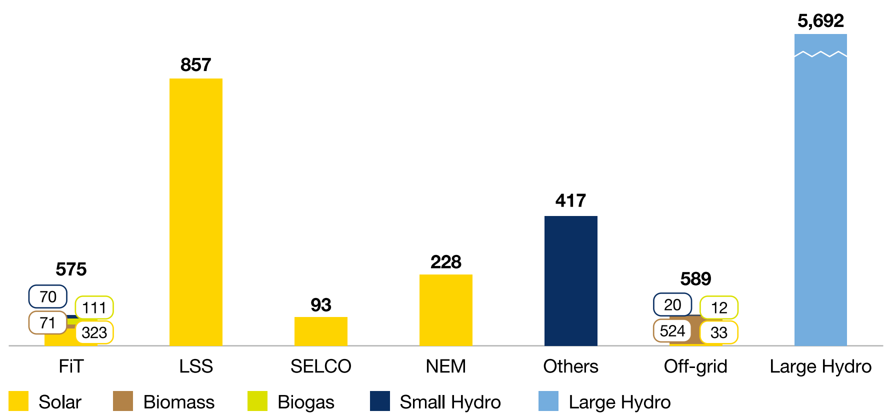
Unlike other RE schemes, the large hydro scheme is not available for application by the public or private developers. Due to its high development costs and technical requirements, all large hydro power plants in Malaysia are developed by regional utilities and the development plans, as endorsed by JPPPET. The existing large hydro installed capacity in Malaysia is 5,692 MW. The JPPPET has approved an additional 1,777 MW of large hydro power plants which are expected to operate commercially from 2026 up to 2035.

Other off-grid self-consumption

Some RE plants operate off-grid and do not receive any financial support. These plants are either used for rural electrification purposes and/or for self-consumption.

As of the end of 2020, 589 MW of capacity has been classified under this category. Biomass projects contribute mostly to this, with an installed capacity of 524 MW.

Figure 4-13: Existing installed capacities by RE support mechanisms in Malaysia



Note: "Others" include small hydro capacities owned by TNB, SESB, and SEB
Source: SEDA; ST; SESB; SEB

Image for illustration purpose only.

Figure 4-14: Key RE programmes in Malaysia, by technology

Mechanism	Year Started	Lead Organization	Program Specification	Key Insights
Feed-in Tariff (FiT) - Solar	2011	SEDA	• MYR 0.50 - 1.77/kWh • 4 kW - 30 MW • 21 years	• Discontinued in 2017 and replaced by both LSS, SELCO and NEM • Only P. Malaysia and Sabah
Large-scale Solar (LSS)	2016	Suruhanjaya Tenaga Energy Commission	• MYR 0.17 - 0.45/kWh • 1 - 100 MW • 21 years	• 3 auctions completed • 4th LSS released in 2020 with system size capped at 50 MW • Only P. Malaysia and Sabah
Solar Net Energy Metering (NEM)	2016	SEDA; Suruhanjaya Tenaga Energy Commission	• Based on consumers retail tariff • Up to 5 MW per applicant subjected to respective sectors • 10 years (one to one offset)	• Cumulative of 1 GW capacity to promote rooftop solar market • Revision of compensation rate to 'one-on-one offset' for 10 years in 2020 to induce uptake • Implementation of VNM allowing excess energy to be exported to designated premises under wholly owned subsidiary company • Only P. Malaysia
Solar Self-consumption (SELCO)	2017	Suruhanjaya Tenaga Energy Commission	• Tariff not applicable for SELCO • 75% of max demand / 60% of fuse rating • No tenure period	• Regulation began in 2017 but activity started before 2017 • SELCO replaced NEM in Sabah starting 2019
Feed-in Tariff (FiT) - Biomass	2011	SEDA	• MYR 0.27 - 0.31/kWh • Up to 30 MW • 21 years	• Includes agriculture residues: palm oil and rice husk and straw • PPA revised to 21 years from 16 years in December 2019
Feed-in Tariff (FiT) - Biogas	2011	SEDA	• MYR 0.27 - 0.32/kWh • Up to 30 MW • 21 years	• In 2019, PPA tenure period extended from 16 years to 21 years • FiT rate offered for agriculture waste and landfill waste
Feed-in Tariff (FiT) - Waste To-Energy (WTE)	2011	SEDA	• MYR 0.27 - 0.31/kWh • Up to 30 MW • 21 years	• Effective 2019 new WTE projects who wishes to apply for FiT can apply under Biomass FiT (w/o use of solid waste as fuel source bonuses) • Government to implement auction/bidding system for WTE projects started in 2020 by KPKT
Feed-in Tariff (FiT) - Small Hydro	2011	SEDA	• MYR 0.23 - 0.29/kWh • Up to 30 MW • 21 years	• No degression rates due to long gestation period • FiT rate for low head and high head introduced in 2019

• FiT rate / ave. winning bid / tariff rate • System size • Tenure / period

Note: Note: FiT rates include basic and relevant bonuses
Source: SEDA; ST

4.3.2 OTHER SUPPORTING RE PROGRAMMES

Voluntary Renewable Energy Certificates (RECs)

Renewable Energy Certificates (RECs) is a market-based instrument that certifies bearers who own one megawatt-hour (MWh) of electricity generated from a renewables resource. RECs have a clear value proposition for both bearer of the RECs and private sectors in aligning to sustainability. In national context, enabling a more vibrant and liquid RECs market (as outlined in Chapter 6.5.2.1) can accelerate transition towards low-carbon nation. In Malaysia, RECs is based on voluntary basis, and subjected to the attributes from respective RE programmes.

Currently, Malaysia is adopting several RECs trading platforms such as Malaysia Green Attribute Tracking System (mGATS), I-REC and TiGRs. mGATS is a national marketplace for RECs operated by TNBX Sdn. Bhd, a wholly-subsidiary of TNB. RECs transactions through this platform ensure a full compliance to international standards and campaigns, such as CDP, GHG Protocol and RE100.

SEDA training programmes

Since 2012, SEDA has been offering training courses to support human capital development in the RE sector. Training courses cover topics ranging from grid-connected PV system design to PV installation and maintenance, as well as from biogas operation and maintenance training to energy efficiency and management training programmes. SEDA collaborates with local training institutions and universities as its training providers. Some of the RE trainings are recognized by the National Occupational Skills Standard by the Dept. of Skills Development.

Green Technology Financing Scheme (GTFS)

Under the GTFS[72], the Government provides a rebate of 2% per annum on the interest fees charged for loans by financial institutions for the first seven years of the loan and guarantees 60% of the green components cost. This is applicable for producers of green technology (RE generators), green technology users, and energy efficiency-related projects. Uptake of the GTFS scheme has been positive, resulting in the extension of MYR 2 bn of funds during Budget 2019. Following on the positive uptake of GTFS scheme, Ministry of Finance has launched GTFS 3.0 in 2021 to further support the RE projects.

Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE)

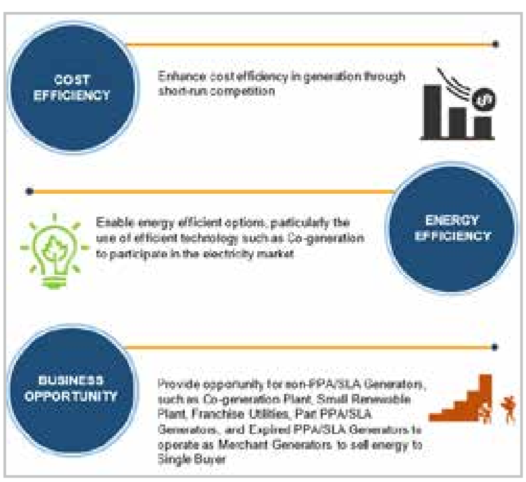
The Green Investment Tax Allowance (GITA) allows 70% of Qualifying Capital Expenditure (QCE) incurred to be offset against 70% of statutory income to reduce tax liability.

The Green Income Tax Exemption (GITE) allows green service providers to exempt 70% of their statutory income.

In October 2019, Budget 2020 announced the extension of GITA and GITE to 2023 and introduced new GITE for solar leasing companies such that 70% of statutory income for leasing companies can be offset for up to 10 years of assessment.

New Enhanced Dispatch Arrangement (NEDA)

The New Enhanced Dispatch Arrangement (NEDA) is designed to enhance short run competition and cost efficiency of the Malaysian electricity supply industry and was launched in June 2017. NEDA allows IPPs that do not have a PPA to supply power to the grid. The NEDA scheme also allows RE generators (with export capacity from 100 kW to 29.9 MW without PPA/Service Level Agreement (SLA)) to participate as price takers, i.e. the off-take price for RE generation is equal to the actual system marginal price. In December 2019, the NEDA scheme was revised to allow solar farms awarded under LSS' 3rd Auction Exercise to participate in the scheme by selling generated power in excess of the Maximum Annual Allowable Quantity (MAAQ).



4.4 KEY CHALLENGES FACED BY THE RE INDUSTRY

Uptake of RE for power generation for certain technologies has been slow in Malaysia so far. The root causes have been analyzed along the key dimensions relevant to RE project development lifecycle: (1) approval processes and land access, (2) financing, and (3) availability of feedstock for power generation (specifically for biomass projects).

4.4.1 SOLAR PV CHALLENGES

CHALLENGES IN SECURING LAND FOR LSS

With the growing interest in large-scale solar projects, demand for plots of land suitable for solar development (i.e. with flat topography, favourable irradiance and proximity to grid substations) is increasing.

Identifying potential land, validating the actual feasibility of solar development, its costs and the generation yield, obtaining the required permits, and then securing the land for development have been a recurring challenge for solar developers. The costs and uncertainties involved in this pre-development process drive the cost of solar PV projects upwards.

Globally, measures have been taken to mitigate these challenges, both in the large-scale solar PV and wind sectors. In India, State governments and local utilities pre-develop land and necessary infrastructure, e.g. interconnections, and provide it to solar developers (Solar Parks scheme). In the Netherlands, a similar scheme was adopted to auction offshore areas for wind development. The solar park scheme in India has been one of the driving forces behind the remarkable fall in strike prices in solar PV auctions (see Figure 2-17). Similar positive impact has been achieved in the Netherlands with strike prices at offshore wind auctions falling steeply.

In Chapter 6.1.2.3, it is recommended that State authorities in Malaysia play a role in providing viable land for solar development.

DIFFICULTY IN SECURING AFFORDABLE DEBT FINANCING FOR SOLAR PV ROOFTOP SYSTEMS

The cost of financing for individual solar PV system, coupled with the lack of affordable debt financing and public awareness have hampered the uptake of rooftop PV among domestic consumers. There are no RE-specific loan programmes and property owners are limited to traditional lending products, such as personal loans, credit card or mortgage extension, which typically have comparatively high interest rates.

72. Green Technology Financing Scheme, Frequently Asked Questions, https://www.gtfs.my/FAQ, accessed on 15 September 2019

In the USA, solar energy was made more affordable for all, including individual homeowners, through the federal solar tax credit (Investment Tax Credit). This allowed new residential and commercial solar system owners to deduct a portion of the cost of the system from their taxes. Since the implementation of the federal policy mechanism in 2016, the solar industry has grown by 52% per annum[73].

Financial institutions have also introduced a preferential interest loan programme for homeowners to set up individual rooftop solar system as part of their overall commitment to sustainable financing.

Aggregation of solar rooftop projects to form larger portfolios and PPAs with credit-worthy off-takers can also allow finance for solar rooftop projects using similar conditions as large scale solar projects. For example, in Singapore, multi-MW project portfolios backed by Government PPAs under the Solar Nova tendering programme were financed using non-recourse loans and high level of leverage[74]. A similar tendering scheme for Government rooftops is also recommended by the MyRER in Malaysia (see Chapter 6.1.2.1)

CAPACITY LIMITS HINDER FULL UTILIZATION OF RESOURCE POTENTIAL FOR ROOFTOP SOLAR

Under the NEM scheme, a limit on solar PV capacity corresponding to 75% of maximum demand for MV customers or 60% of fuse ratings for LV customers is imposed.

Export limits are typically imposed because electricity grids are designed to work unidirectionally. Distributed RE can give rise to two-way power flows that may result in voltage fluctuations. Solutions to address this issue include installing sensors, preventing excessive power exports, and adopting smart technologies and / or integrating battery system. For example, in Hawaii, Sunrun offers virtual power plant services through its network of distributed home solar and battery system to support the solar saturated grid in Hawaii[75].

As argued in Chapter 6.1.2.1, future NEM programmes in Malaysia (beyond NEM3.0) will should continue to review the opportunity to lift capacity limits so as to encourage scale-up of rooftop solar PV installed capacity.

LIMITATION OF NEM TO ASSETS ON CUSTOMERS' OWN PREMISES

Under the existing programme, NEM is only available for generated power using assets on the customers own premises. Renewable assets built on third parties' premises, e.g. through leasing land or rooftops, do not qualify for the NEM. This limits the ability to leverage the full potential of the NEM programme: for example, customer living in multi-storey residential buildings that do not have sufficient space to install on-site generation equipment on their own premises cannot benefit from NEM. Currently, virtual aggregation model has been introduced for commercial and industrial sector under NEM 3.0 programmes. Data gathering from this initiative enables the model to be extended to residential sector as well as to facilitate the limitation mentioned.

LACK OF REGULATORY FRAMEWORKS SUPPORTING CUSTOMER CHOICE

Customer choice, be it through direct procurement of RE via corporate PPAs or through green tariffs offered by retailers, is emerging globally as a key driver of RE uptake, complementing traditional FiT programmes (see for example discussion in Chapter 2.2.2).

The existing regulatory framework in Malaysia has yet to introduce a third-party access framework for the implementation of corporate PPAs on a large scale. In addition, green tariffs which were introduced in 2019 are still at infancy stage and are yet to achieve widespread subscription.

In Chapter 6.1.2.2, initiatives under future electricity market restructuring drives greater customer choice are discussed as key drivers of future solar capacities in Malaysia, in addition to existing NEM and LSS programmes.

4.4.2 BIOMASS AND BIOGAS CHALLENGES

Bioenergy projects, particularly biomass, have a history of unfavourable project economics and poor operational and reliability track record in Malaysia. Consequently, key stakeholders, such as financial institutions, consider these projects risky[76]. In order to regain the confidence of the financial community, a number of key challenges and issues need to be addressed, as outlined below:

SUBOPTIMAL PLANT SIZE AND CAPACITY FACTORS DUE TO FEEDSTOCK PROCUREMENT CHALLENGES

Average biomass plant size in Malaysia is 11 MW[77], which is lower than global benchmarks (e.g., in the USA, average biomass plant size is 20 MW[78]). In addition, the average capacity factor for existing plants in Malaysia is only 48%. This impacts biomass project economics through two mechanisms:

- Smaller plants have higher CAPEX per MW; and
- Low-capacity factors impact revenues negatively.

73. Solar Energy Industries Association, https://www.seia.org/research-resources/solar-itc-101
74. Singapore Housing and Development Board; expert interviews
75. Sunrun website, https://www.sunrun.com/solar-battery-storage/hi/brightbox
76. Expert interviews
77. SEDA
78. University of California Berkeley and National Renewable Energy Laboratory

Inability to secure sufficient flow of feedstock to support larger plants is the key root cause of suboptimal plant size and capacity factors. A key strategy under MyRER is clustering, i.e. the creation of centralized biomass plants using aggregated feedstock from multiple neighbouring mills (see Chapter 6.2.2.2), thereby securing larger and more reliable feedstock procurement. Target size for plants in biomass clusters is 20-30 MW with 70% capacity factors.

In order to further increase feedstock availability, challenges related to competing uses of palm oil waste also need to be addressed. In particular, EFB is also used for mulching and currently, there is no policy to support the use of EFB for biomass power generation. In Chapter 6.2.2.2, the need of cross-ministerial coordination to mandate a minimum proportion of EFB for use in power generation is discussed should the government decide to push RE from biomass EFB.

INCONSISTENT FEEDSTOCK PRICE AND QUALITY

The lack of consistency in the price and quality of feedstock (e.g. water content) are also impacting the performances of biomass power plants in Malaysia.

In most cases, palm oil millers have no stakes in biomass power plants. Hence, there is little incentive for them to stabilize feedstock prices and provide high quality feedstock.

A key strategy under MyRER, alongside clustering, is to encourage palm oil millers to take equity stakes in biomass power generation projects. This would realign the incentives towards consistent feedstock pricing and to ensure provision of high-quality feedstock (see Chapter 6.2.2.2).

LOCATION OF SOME PALM OIL MILLS IN AREAS FAR FROM GRID CONNECTIONS

As palm oil mills tend to be located in areas with low population density, they are sometimes distant from existing substations. This results in high grid connection costs, relative to biomass plant size which limits the viability of biomass projects.

As outlined in Chapter 6.2.2.2:, three measures with focus towards mitigating the challenges are as follows (1) a study to be conducted to establish feasibility of grid extensions to allow connection of additional mills; (2) support measures to be assessed in promoting off-grid power generation; and (3) assess feasibility of leveraging biomass potential which is available far from grid substations to be connected, to unlock potential in bio-CNG and co-firing in coal plants, subject to assessment of feasibility.

UTILIZATION OF LESS EFFICIENT TECHNOLOGIES FOR POWER GENERATION

Some existing biomass plants in Malaysia utilize less efficient technologies for power generation, e.g. low- efficiency boilers. MyRER advocates for a study to be conducted to establish: (1) Technologies currently deployed in Malaysia; (2) Best-practice technologies; and (3) Resulting gaps and recommended technologies to be rolled out. As outlined in Chapter 6.5.2.3, some of the key areas of technology development in bioenergy are as follows:

- technologies for treatment and upgrading of bioenergy feedstock for power generation, such as drying, pelletizing, torrefaction of biomass and production of syngas through gasification of biomass; and
- high efficiency biomass boilers and generation technologies.

4.4.3 WASTE-TO-ENERGY CHALLENGES

INCONSISTENCY IN TIPPING FEES

WTE projects generate revenue through two income streams: (1) electricity tariff from off-take of power; and (2) tipping fees that are paid to WTE projects depending on the quantity of waste received by the facility.

Tipping fees are a key contributor to the overall economics of WTE plants. Depending on the level of tipping fees, offtake electricity tariffs can be optimized. For example, if tipping fees are high, developers can bid lower offtake electricity tariffs at the auctions.

Based on current practice in Malaysia, tipping fees vary considerably depending on the region or state[79]. As a result, developers face difficulty in achieving the right economic balance between tipping fees and maintaining competitive tariff rates. At the point of publication of this document, KPKT has already established a WTE tendering framework and carried out tendering exercise for WTE.

LOGISTICS

Supply of waste feedstock is a key factor affecting the economics of WTE plants. Even though solid waste is abundant (9.5 million tons generated a year) in Malaysia, landfill sites are widely scattered across the country. This results in logistical issues as high transportation cost is required (due to proximity) when aggregating waste feedstock for WTE generation.

To address this, WTE development is targeted at landfill site with waste volume of at least 500 tons per day. This corresponds to the minimum required waste volume to achieve commercial sustainability (see Chapter 6.2.3.2).

79. Expert interviews
80. Expert interviews

4.4.4 SMALL HYDRO CHALLENGES

LONG GESTATION PERIOD DUE TO EXTENSIVE APPROVAL TIME

Securing authority's approval for the development of small hydro projects in Malaysia is a long and difficult process. Developers are required to secure 19 different permits from both state and federal authorities before construction of projects can begin, which is a process that can take up to two years[80].

When including development and construction, the gestation period for small hydro projects can be as long as five years, significantly more than other RE technologies.

As outlined in Chapter 6.3.2.1, facilitation and coordination with State authorities is required to help small hydro developers navigate the approval process and is expected to result in shortened gestation periods for small hydro projects.

LACK OF REGULATION ON UPSTREAM DEVELOPMENT

Activities carried out upstream of small hydro projects, such as logging and water flow diversions or pumping for irrigation can produce residues in the water and disrupt natural river flows. This can adversely affect the performance of small hydro plants located downstream.

There are currently no regulations in place to create buffer zones in water catchment areas to manage the development of activities upstream of small hydro plants. Coordinated effort between the authorities and small hydro developers is needed to effectively design and implement a framework regulating upstream activities (see Chapter 6.3.2.1).

LACK OF DATA ON HIGH POTENTIAL SITES FOR HYDRO DEVELOPMENT

Even though Malaysia has 189 river basins, there is a lack of centralised data to identify small hydro sites with high potential for development. This is among the detrimental factor which prevented developers from investing more aggressively in small hydro projects.

Furthermore, the collection of data on potential sites and validating actual potential on the ground take time and require funding and specialized resources. Small hydro developers do not have the financial resources and expertise to carry out such pre-development activity.

Thus, the possibility of developing an opened-source and open-access database can be explored for small hydro developers as well as to aggregate information on high-potential, available small hydro sites in Malaysia (see Chapter 6.3.2.2).

4.4.5 LARGE HYDRO CHALLENGES

LONGER GESTATION PERIOD DUE TO NUMEROUS PERMITS REQUIRED

The gestation period of a large hydro power plant takes significantly longer time to complete when compared to small hydro projects, depending on the complexity of each site of the project. Generally, it may take two to three years to get the needed approvals, then another five to seven years to construct the plant. This includes additional negotiation and compensation costs for relocations and resettlements of the local people due to its large scale of development.

The utilities will need to provide detailed, vital documentations such as: Environmental Impact Assessment (EIA), Social Impact Assessment (SIA), Development Order (DO), Heritage Impact Assessment (HIA), Environmental Management Plan (EMP), Wildlife Management Plan (WMP) and any other needed approvals by the state government.

HIGH DEVELOPMENT COSTS

The large hydro projects in Malaysia are all developed by regional utilities (namely TNB, SESB, and SEB) due to high commitment for each project especially in terms of costs, and all the costs have to be borne by the utilities upfront. The common development costs are inclusive of the: preliminary project feasibility study, local community relocation and resettlement compensation, and water rights royalty. Depending on the total project costs, this will affect the project viability (how much resource potential could be utilised by the large hydro power plant) and tariff passthrough to the consumers in the end.

PUBLIC ACCEPTANCE

While preparing the needed vital documents listed above, the utilities are required by the state government to engage with the local NGOs and communities to understand their needs and to ensure their livelihoods will not be affected. The NGOs' concerns are mainly on the environmental aspect while local communities are concerned about native customary rights, ancestral lands and livelihoods. The consensus is usually achieved by a mutual two-way communication to reduce the common misunderstanding and to improve the public acceptance towards large hydro projects.

GOVERNMENT AND POLICY SUPPORT

A concise and coherent government and policy support is pivotal to the development of large hydro projects. For example, the federal and state government shall align their support for large hydro projects and this includes tax incentive (such as pioneer status or import duty reduction). This alignment provides same level of support for all forms of renewables and can help to lower the cost of borrowings. Like all renewable projects, there is no income during the gestation period until the project is commissioned and in the case of large hydro, the gestation period is significantly longer than other renewable technologies.

LACK OF REGULATION ON UPSTREAM DEVELOPMENT

Similar to the challenges faced by small hydro RE projects, there are currently no regulations in place on upstream development. The exception to this is the Sarawak state, in which the upstream development will be regulated by the newly proposed Lake Development Authority. Relevant regulators shall act together in order to preserve the water quality downstream and maintain the plant performance. As per current practice, the development of large hydro is to adhere to sustainability standards and is to address mitigation plan in line with the Environmental Impact Assessment's outcomes.

4.4.6 CROSS-TECHNOLOGY CHALLENGES

Interview with key stakeholders revealed that additional challenges exist across different technologies as discussed below:

HUMAN CAPITAL DEVELOPMENT

Malaysia lacks a pool of skilled and semi-skilled human resources with specific knowledge in RE. Efforts have been put in by government agencies in producing local talent pools since 2012, though it was not sufficient as specific areas for large scale RE projects require years of experience. The specific areas with large gaps in human resource availability are EPC, and Operation and Maintenance of RE plants. In addition, understanding of issues and risk/reward profile of RE projects is generally lacking in financial institutions in Malaysia.

In Chapter 6.5.2.3, a set of initiatives is described to develop a pool of human resources including in the financial sector.

LACK OF PUBLIC AWARENESS ON THE IMPORTANCE OF ENERGY TRANSITION AND GOVERNMENT EFFORTS

Malaysia's current transition towards a developed nation status comes in parallel with its ambitions towards global climate sustainability.

In the past decade, policy direction has shifted in favour of RE to increase its share in the nation's energy mix. However, public understanding on the urgency of energy transition and the opportunities available to participate in this emerging RE sector is still low.

Public awareness on RE benefits is still lacking, in key areas e.g.: (1) Importance of RE in mitigating impacts of climate change and contributing to environmental sustainability; (2) Role of RE in improving energy security by reducing reliance on imported fuel; and (3) Increasing affordability and socio-economic benefits of RE. In addition, there is also low awareness of Government policies in spurring the RE power generation sector.

The MyRER includes initiatives to drive the development of a RE-centric society as described in Chapter 6.5.2.3.

Image for illustration purpose only.

chapter five

RENEWABLE ENERGY CAPACITY MIX TO 2035

RENEWABLE ENERGY CAPACITY MIX TO 2035

SUMMARY

Based on the expected evolution of installed capacity, in order to reach the Government target of 31% RE share in the national installed capacity mix, a total of 12,916 MW of RE capacity is required by 2025. This corresponds to 4,466 MW of renewable capacity additions from 2021 to 2025.

The MyRER considers two distinct scenarios: (1) a Business as Usual (BAU) scenario; and (2) a New Capacity Target (NCT) scenario, representing the Malaysian Government's official and committed pathway to reach the 31% RE target by 2025 and 40% by 2035 for further decarbonization of the power sector.

In the **BAU** scenario, considering only implementation of existing policies and committed programmes, the projected share of renewables in the installed capacity only reaches 29% in 2025, falling short of the 31% Government national RE target by 1,174 MW. Minimal future RE growth occurs post 2025, resulting in 32% in 2035. This target is falling short of the 40% national RE target by 4,250MW.

The **NCT** scenario is designed to achieve the target of 31% RE share by 2025 while ensuring that penetration of variable renewable energy (VRE, in this case solar PV) does not exceed 24% of peak demand in Peninsular Malaysia and 20% in Sabah. The thresholds were established by the Grid System Operator (GSO) in Peninsular Malaysia and SESB in Sabah due to concerns that the system may become unstable in case solar generation reaches maximum levels in very low demand days. In order to reach the Government RE target, the New Capacity Target scenario contemplates additional new capacity of 4,466 MW in Malaysia by 2025 while additional 5,080 MW is needed from 2025 to arrive at 40% RE in 2035. In case post-2025 solar PV penetration exceeds 30% of peak demand in Peninsular Malaysia, specific measures to ensure system stability must be embedded, including roll-out of energy storage solutions, as well as improving system flexibility. These measures are expected to enable a shift towards flexible and dispatchable solar generation. In this regard, the concern for the tolerance of solar penetration's peak demand will be less relevant when solar reaches the state of being dispatchable.

5.1 RETAINED SCENARIOS FOR RENEWABLE CAPACITY EVOLUTION

Two scenarios for renewable capacity evolution were developed as part of the MyRER: (1) a Business-as-Usual (**BAU**) scenario; and (2) a New Capacity Target (**NCT**) scenario, representing the Malaysian Government's official and committed pathway to reach the 31% RE target by 2025 and 40% by 2035; for further decarbonization of the power sector in the 2035-time horizon.

Business-as-usual (BAU) scenario

The BAU scenario represents the baseline evolution of RE capacity in case no additional action is taken to further drive the RE agenda. Up to 2035, the BAU scenario takes into account only the implementation of already-approved and committed / announced capacities under existing programmes, i.e. new capacities under the FiT programme as well as announced and awarded capacities under non-FiT programmes (LSS, NEM).

Based on SEDA's estimates, the BAU scenario would fully allocate the RE fund by 2025[81] – no further new FiT quota will be given out post 2025.

Solar PV is supported by LSS auctions, the NEM scheme and SELCO scheme. As part of the BAU, the remaining committed and announced capacity for LSS auction (LSS 4), as well as the remaining quota available for the NEM scheme are forecasted to come online by 2025.

Fossil fuel and large hydro capacities in the BAU scenario follow the announced schedule of plant up and retirements up to 2035, in line with the latest capacity development plan (2020) by Energy Commission.

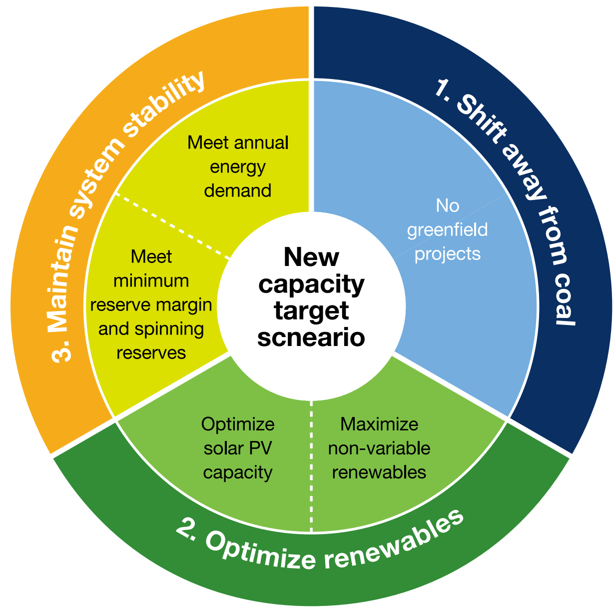
As shown in Chapter 5.2.1, under the BAU scenario, the projected share of renewables in the national installed capacity only reaches 29% in 2025, falling short of the 31% Government target. The corresponding shortfall to the Government target amounts to 1,174 MW.

New Capacity Target (NCT) scenario

The NCT scenario aims for higher RE capacity target to align with further decarbonization of electricity sector in Malaysia toward 2035 milestone. This scenario is aligned with the capacity development plan of Planning and Implementation Committee for Electricity Supply and Tariff (JPPPET 2020) for Peninsular Malaysia, JPPPET 2021 for Sabah and current outlook for Sarawak. In realizing more RE potentials in Sabah, additional inputs are gathered based on agreement with Sabah Electricity Sdn. Bhd. (SESB) and will be the basis in formulating JPPPET 2022 for Sabah.

In the NCT scenario, solar PV penetration is capped at 24% of peak demand in Peninsular Malaysia and 20% in Sabah in order to ensure system stability with minimal measures. It assumes additional RE capacity of 4,466 MW in Malaysia by 2025. While post-2025, additional 5,080 MW is required with target reaching of 40% RE by 2035.

Solar penetration increases from 24% of peak demand in Peninsular Malaysia in 2025 to reach 30% of peak demand by 2035, requiring measures to ensure system stability (see Chapter 6.4.3.3).



The NCT scenario is optimized following three key principles

1. **Reducing coal-fired power generation**; this is achieved by avoiding new greenfield coal plant up post 2025 whilst reducing reliance on coal in the capacity mix;
2. **Optimize renewables**; utilization of remaining non-variable resource potential and solar PV capacity is added as the main contributor to meeting annual energy demand; and
3. **Maintain system stability**; additional gas-fired capacity is optimized to fill any annual energy demand gaps and meet key system stability criteria, such as (1) maintain minimum reserve margin as determined by SB/GSO to comply with LOLH – Loss-of-Load Hours criteria. It should be highlighted that the simulation of peak demand evolution up to 2035 used in the reserve margin calculation is based on the same load profile assumptions as in the forecast up to 2025; actual evolution of peak demand to 2035 may be affected by shift of peak towards evening hours, thus impacting reserve margin projections; (2) maintain minimum spinning reserves (on top of operating reserves) determined as 11% of installed VRE capacity as per SB/GSO guidelines; and (3) ensure adequate level of power system inertia, in case of high solar PV penetration and low demand. As a result of high VRE penetration, appropriate energy storage capacity is deployed to maintain grid stability.

81. SEDA's forecasted RE fund is estimated based on JPPPET (2019) sales forecast and existing displaced cost

5.2 SCENARIOS TO 2025

5.2.1 BAU SCENARIO TO 2025

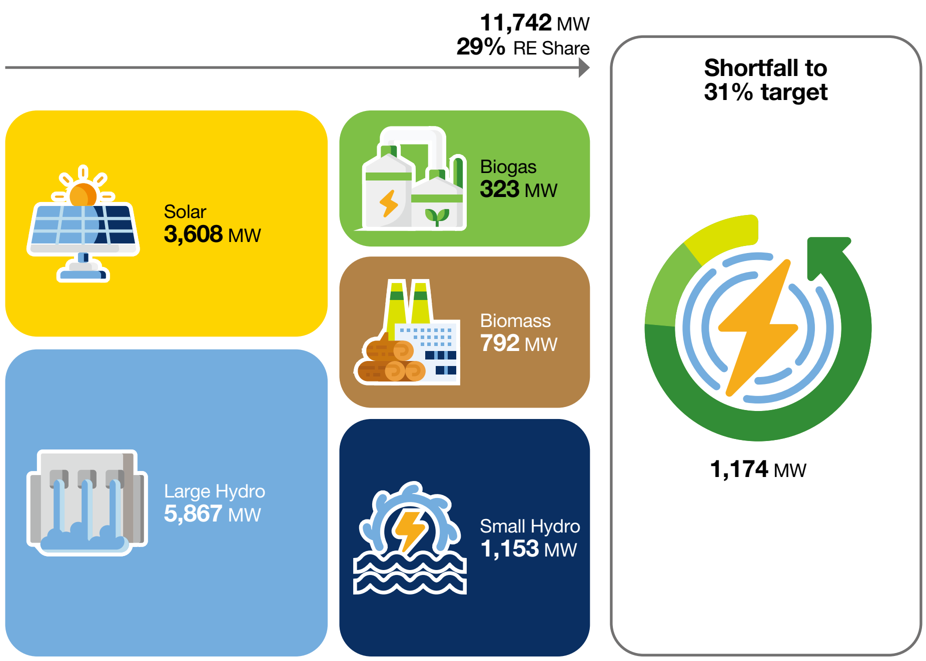
5.2.1.1 2025 RE CAPACITY BY TECHNOLOGY

The BAU scenario considers continued administration of the FiT programme and plant up of committed and announced non-FiT solar capacities. Under these assumptions, 11,742 MW of renewables are expected to be installed by 2025, through the following mechanisms:

- Continued administration of the FiT using available resources in the RE fund for biomass, biogas and small hydro; and
- Remaining plant up of awarded solar PV capacities under LSS 1 to LSS 4 and remaining capacity under NEM 3.0, as well as off-grid capacity for rural electrification in Sarawak.

In the BAU scenario, the projected share of renewables in the national installed capacity only reaches 29% in 2025, falling short of the 31% Government target. The corresponding shortfall to the Government target is as shown in Figure 5-1.

Figure 5-1: Planned 2025 capacity – BAU scenario



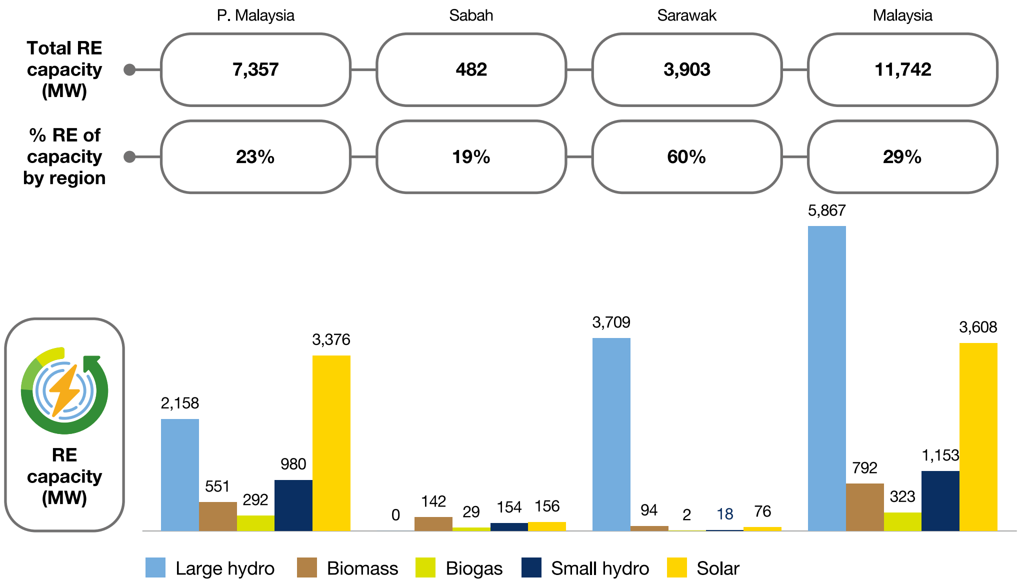
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

5.2.1.2 2025 RE CAPACITY BY REGION

The breakdown of RE capacity by region in 2025 under the BAU scenario is illustrated in Figure 5 2. Peninsular Malaysia contributes approximately 7.4 GW of RE capacity or 23% RE share. Sabah represents a 19% RE share at 482 MW in the planned national RE capacity in 2025, despite being the only region with no large hydro.

On the other hand, Sarawak has the highest RE share at 60% with capacity contribution of 3,903 MW, mainly from large hydro. This reflects a 33% share from total installed RE capacity in the country.

Figure 5-2: Planned 2025 capacity by region – BAU scenario



Note: Evolution of RE capacity in Sabah is subject to handing over of SESB to the State
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

5.2.2 NEW CAPACITY TARGET SCENARIO TO 2025

5.2.2.1 2025 RE CAPACITY BY TECHNOLOGY

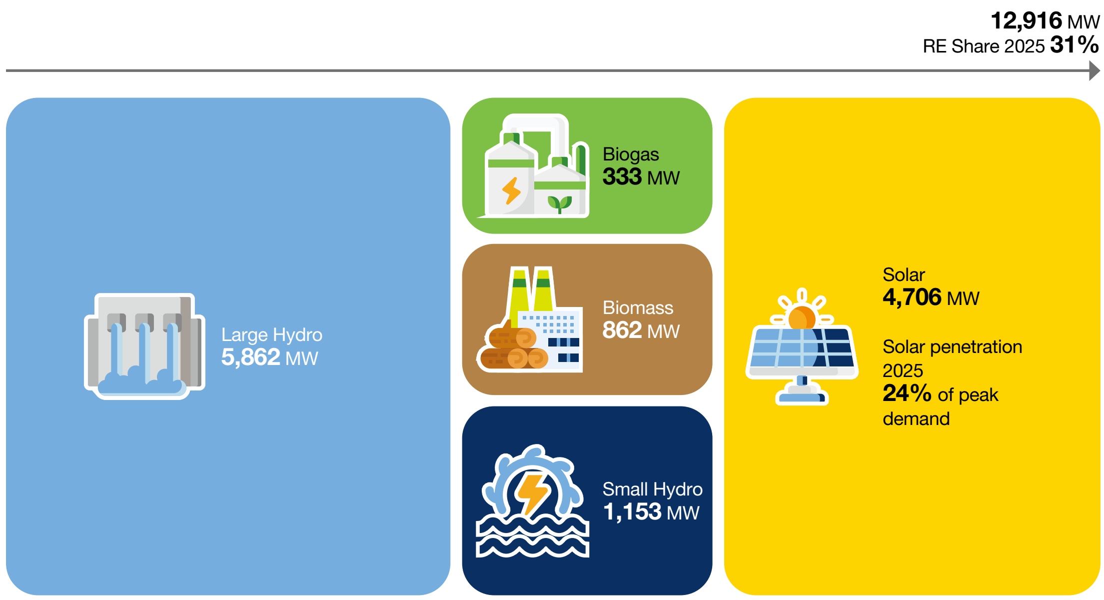
The NCT scenario for 2025 achieves the Government's national target of 31% RE share. This corresponds to 12,916 MW of RE installed capacity by 2025, and a total 4,466 MW of renewable capacity additions from 2021 to 2025.

Compared to the BAU scenario, the New Capacity Target scenario contemplates an additional 1,174 MW of RE capacity. The additional growth in the New Capacity Target scenario from the BAU scenario is driven by solar and bioenergy as in Figure 5-5.

In the NCT scenario, a threshold for system stability was set by limiting solar penetration at 24% of peak demand in Peninsular Malaysia and 20% in Sabah. This was due to concerns among system operators that on low-demand days (e.g. major public holidays), high levels of solar penetration may cause stability issues[82]. Solar penetration limit assessment for Peninsular Malaysia from the DNV-GL study can be seen in Figure 5-4. Periodic assessment to review the penetration limit to stay in line with the latest developments with respect to grid readiness and technologies breakthroughs is crucial to ensure fair opportunities for cross-sectors to benefit from the values propositions via PV technologies.

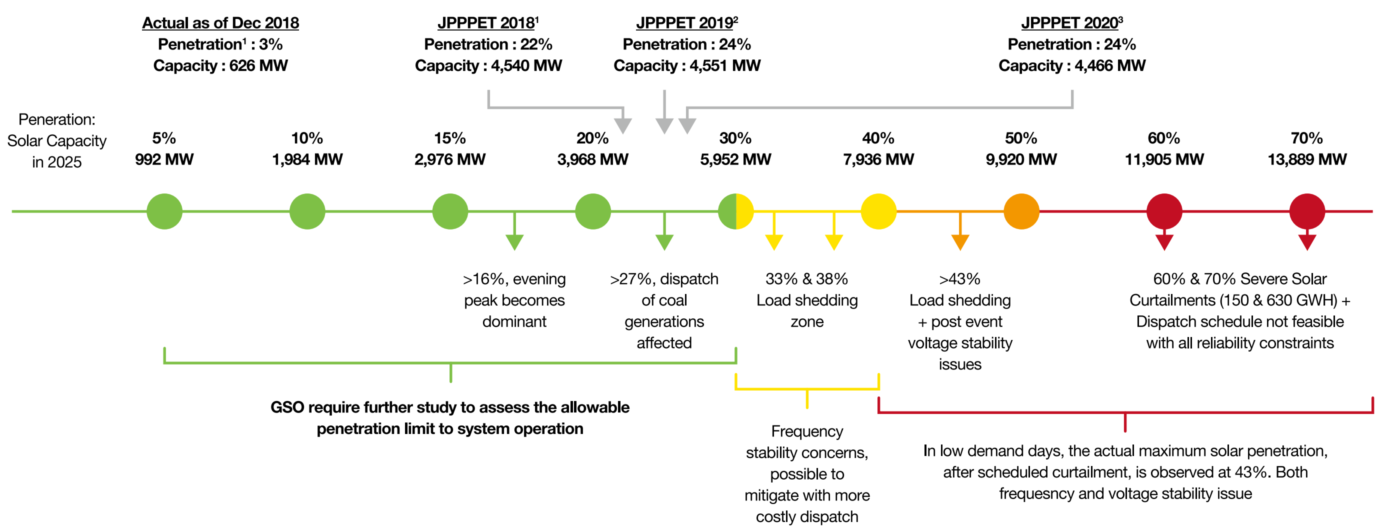
82. Analysis conducted by the Grid System Operator (GSO) and ST

Figure 5-3: Planned 2025 capacity – New Capacity Target scenario



Note: Solar penetration of 24% of peak demand is applicable only for Peninsular Malaysia and 20% in Sabah
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

Figure 5-4: Solar penetration limit assessment for Peninsular Malaysia from the DNV-GL study

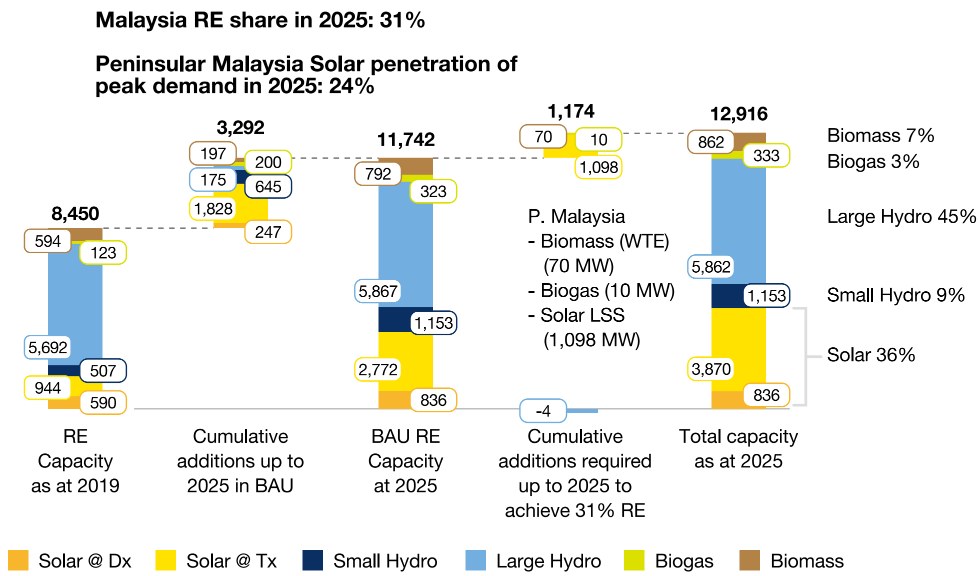


Notes:
1. JPPPET 2018 solar penetration based on peak demand (without solar) of 20,775 MW in 2025
2. JPPPET 2019 solar penetration based on peak demand (without solar) of 18,958 MW in 2025
3. JPPPET 2020 solar penetration based on peak demand (without solar) of 18,608 MW in 2025

- Solar PV Penetration levels does not include 8 MW Off-Grid Solar
- Requires additional spinning reserve of 11% Solar PV capacity, based on 1/2 hour dispatch interval
- GSO to evaluate additional regulation requirement based on actual real time variability of RE (i.e. system resilience and inertia response with increasing RE)

Source: DNV-GL (2018); SB Peninsular Malaysia

Figure 5-5: Breakdown of additions for RE capacity for Malaysia up to 2025 – New Capacity Target scenario



Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah, SESB; SEB

5.2.2.2 2025 RE CAPACITY BY REGION

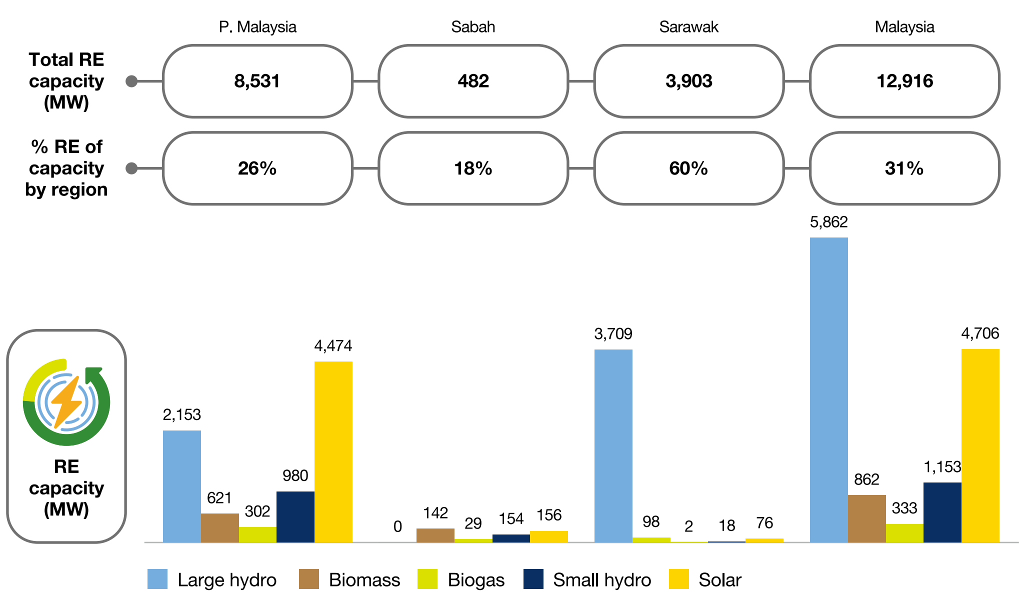
The breakdown of RE capacity in 2025 by region is illustrated in Figure 5-6.

Peninsular Malaysia achieves 8,531 MW of RE capacity with RE share in installed capacity reaches 26%. Solar penetration in Peninsular Malaysia reaches 24% of peak demand.

Sabah reaches 482 MW of RE capacity by 2025, corresponding to 18% RE share in installed capacity.

In Sarawak, RE capacity contribution is 3,903 MW, corresponding to 60% RE share.

Figure 5-6: 2025 capacity by region – New Capacity Target scenario



Note: Evolution of RE capacity in Sabah is subject to handing over of SESB to the State
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

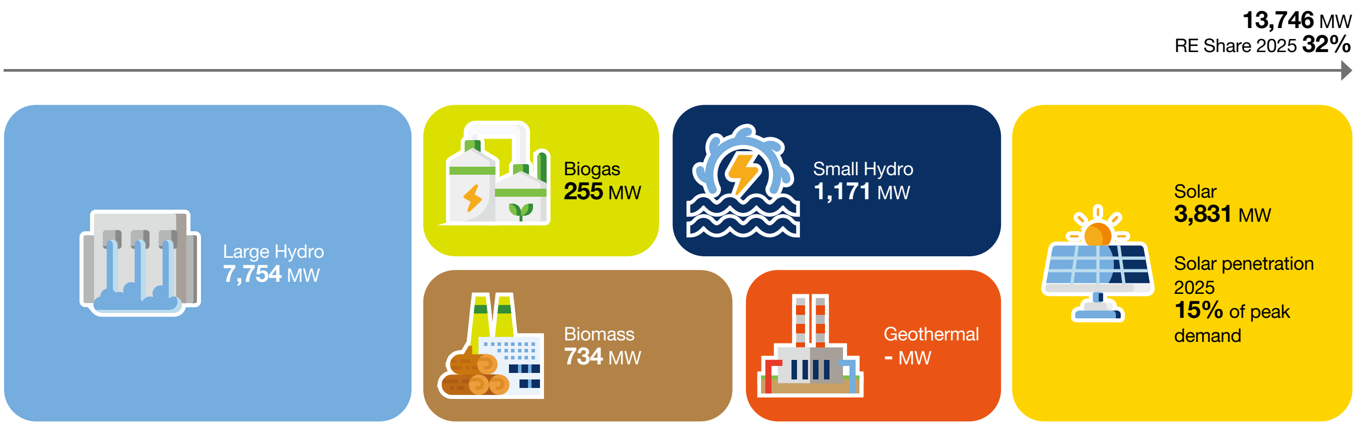
5.3 SCENARIOS TO 2035

5.3.1 BAU SCENARIO TO 2035

In the BAU scenario to 2035, RE share at national level remains nearly flat at 29% in 2025 to 32% in 2035. From a RE capacity of 11,742 MW in 2025, only additional 2,004 MW are planned between 2026 - 2035, leading to a total RE capacity of 13,746 MW in 2035 (Figure 5-7).

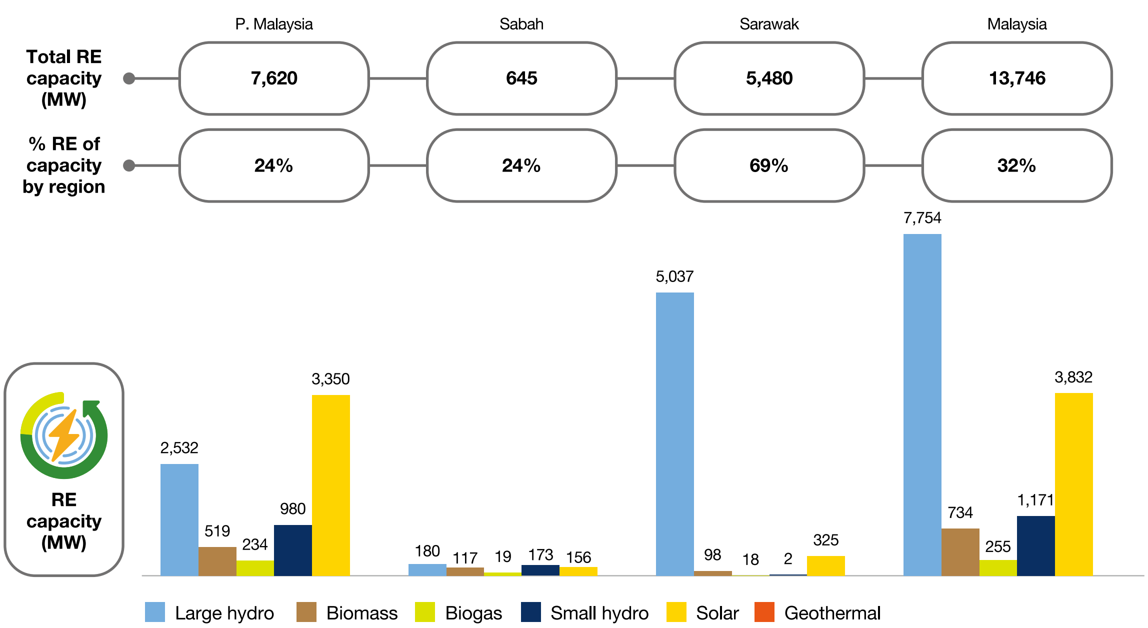
By region, Sarawak has the highest RE share in the country at 69% with 5,480 MW installed capacity, in which 5,037 MW is generated from large hydro, followed by Sabah with 645 MW or 24% RE share, while Peninsular Malaysia is at 7,620 MW reflecting a 24% RE share (Figure 5-8).

Figure 5-7: 2035 capacity – BAU scenario



Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

Figure 5-8: 2035 capacity by region - BAU scenario



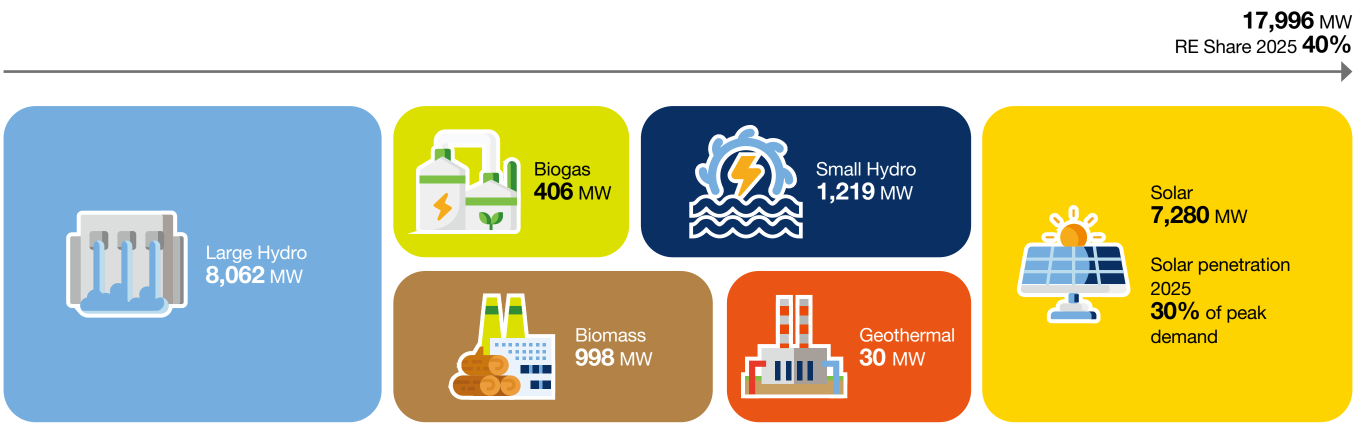
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

5.3.2 NEW CAPACITY TARGET SCENARIO TO 2035

5.3.2.1 2035 RE CAPACITY BY TECHNOLOGY

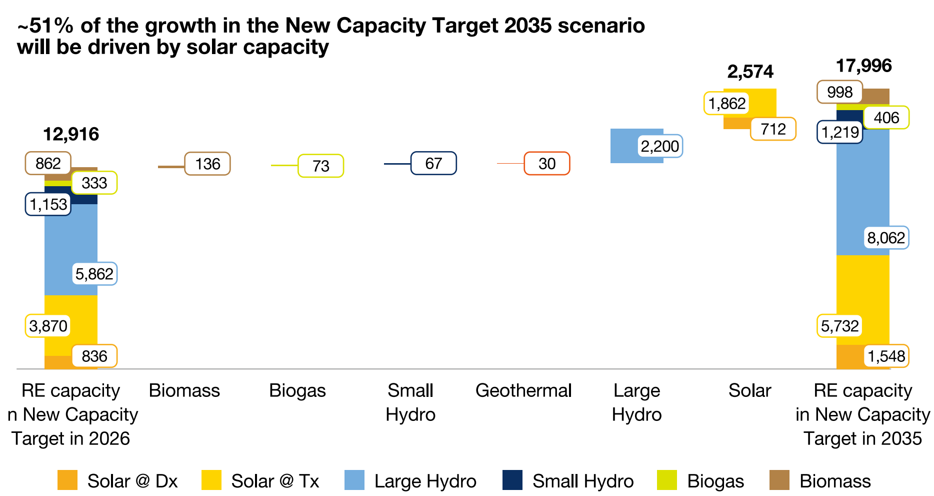
As discussed in Chapter 5.1, the NCT scenario represents the Malaysian Government's official and committed pathway to reach the 31% RE target by 2025 and additional capacity evolution is provided post 2025, reaching 17,996 MW or 40% of RE in the national installed capacity mix by 2035 (see Figure 5 -). The RE technology capacity is shown in Figure 5-10 in which 51% of the growth will be driven by solar capacity. However, solar PV penetration in Peninsular Malaysia will reach 30%, breaching the 24% limit set by GSO (see Figure 5-10). In this regard, flexibility measures will have to be deployed including energy storage and other measures to ensure grid stability).

Figure 5-9: 2035 capacity – New Capacity Target scenario



Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

Figure 5-10: Breakdown of additions for RE capacity for Malaysia post 2025 – New Capacity Target scenario



Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

5.3.2.2 2035 RE CAPACITY BY REGION

The breakdown of RE capacity by region in 2035 under the New Capacity Target scenario is illustrated in Figure 5-11.

In the 2035 New Capacity Target scenario, RE share is expected to increase from 31% in 2025 to 40% by 2035 (Figure 5-12).

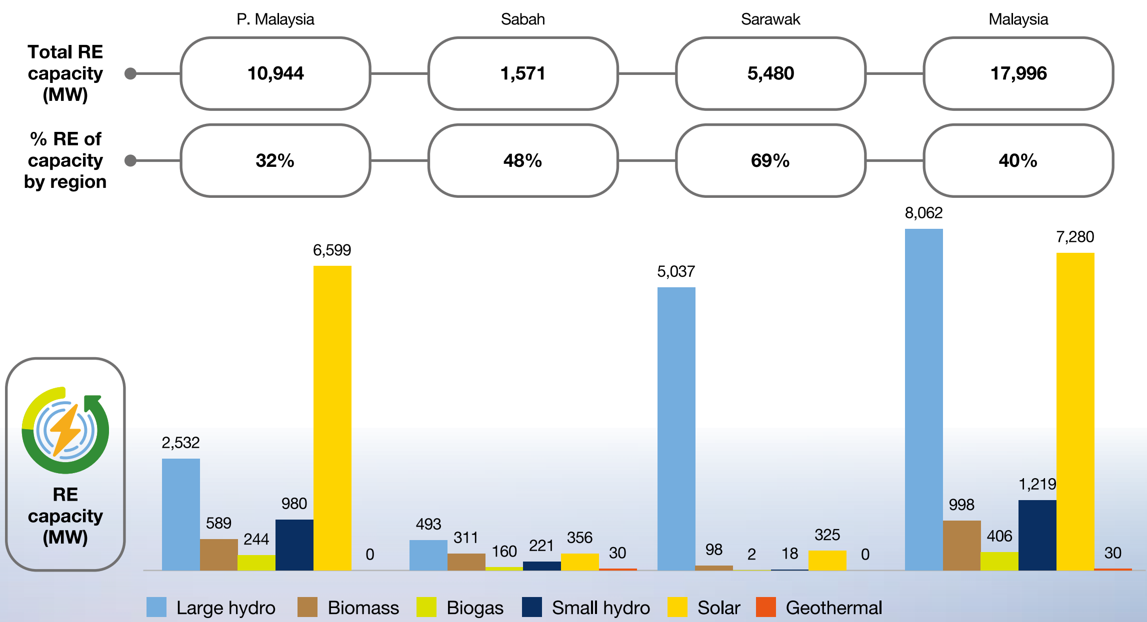
Peninsular Malaysia achieves 10,944 MW of RE capacity corresponding to 32% RE share in installed capacity. Sabah reaches 1,571 MW of RE capacity corresponding to 48% RE share in installed capacity.

In Sarawak, RE capacity reaches 5,480 MW corresponding to 69% RE share in installed capacity, the biggest in the country. This is reflected from the vast capacity of large hydo installed in the region at 5,037 MW.

The 2035 New Capacity Target scenario involves no greenfield coal plant up post 2025. The resulting decrease in coal-fired generation due to the gradual retirement of existing coal plants is compensated mainly by introducing new RE capacity. Reduced reliance on coal resources in the capacity mix will contribute further to the carbon intensity reduction.

In Peninsular Malaysia, solar penetration in peak demand grows to 30% by 2035, well beyond the 24% threshold for system stability (Figure 5-11). Consequently, under the 2035 New Capacity Target scenario, MyRER advocates for a gradual roll-out of energy storage systems (See Chapter 6.4.3.3), in combination with other measures to enhance system flexibility (see Chapter 6.5.2.4).

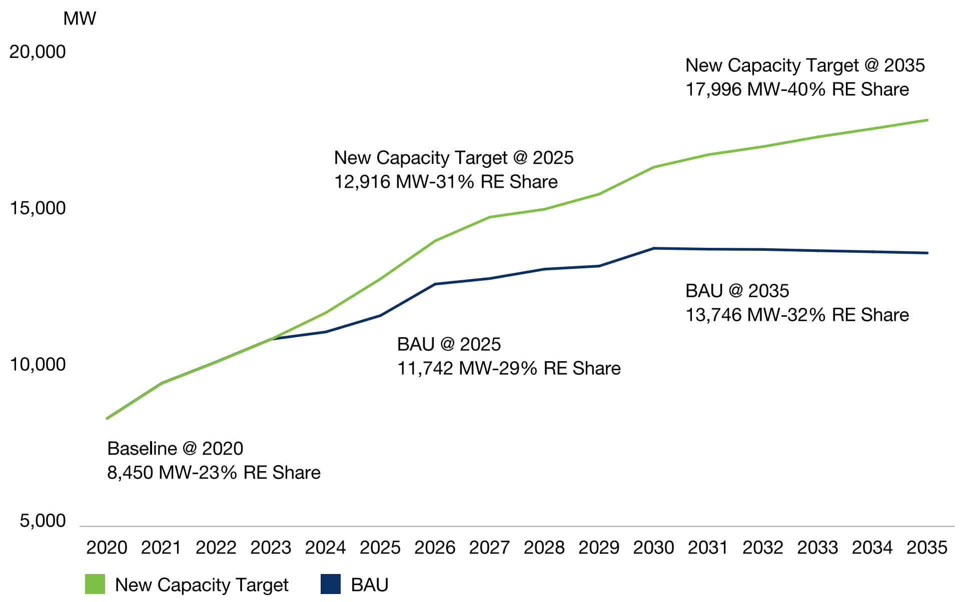
Figure 5-11: 2035 RE capacity by region – New Capacity Target scenario



Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

Image for illustration purpose only.

Figure 5-12: Summary of RE capacity – BAU vs New Capacity Target



Source: Summary of RE capacity and generation– BAU vs New Capacity Target

Figure 5-13: Summary of RE capacity and generation– BAU vs New Capacity Target

Scenario **BAU**	**2025**		**2035**
11,742 Total RE capacity (MW)	**39,366** Total RE generation (GWh)	**13,746** Total RE capacity (MW)	**50,618** Total RE generation (GWh)
Scenario **New Capacity Target**	**2025**		**2035**
12,916 Total RE capacity (MW)	**41,640** Total RE generation (GWh)	**17,996** Total RE capacity (MW)	**57,233** Total RE generation (GWh)

Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; SEB

MyRER

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chapter six

STRATEGIC FRAMEWORK AND INITIATIVES FOR 2025 AND 2035

STRATEGIC FRAMEWORK AND INITIATIVES FOR 2025 AND 2035

SUMMARY

STRATEGIC FRAMEWORK

MyRER has been formulated to support Malaysia's vision to achieve 31% RE share in the national installed capacity mix by 2025. Furthermore, the MyRER designs a pathway to enhance decarbonization of the electricity sector through 2035. The MyRER strategic framework builds upon four technology-specific pillars:

- Solar pillar;
- Bioenergy pillar;
- Hydro pillar; and
- New solutions and resources pillar, including geothermal, wind and energy storage technologies.

These four pillars are supported by cross-technology enabling initiatives, along four areas: (1) future-proofing existing electricity regulatory and market practices; (2) access to financing; (3) future readiness; and (4) increased system flexibility.

The framework takes into account the outcome of MyRER's assessment on available RE resources, existing institutional and regulatory framework, industry practices and technology adoption as well as projected future social and economic development. Key actions are planned to realize respective milestone targets up to year 2025, and post 2025 to 2035 horizon.

ROADMAP STRATEGIC PILLARS

The Roadmap strategic pillars with milestone development target for 2025 will be achieved through enhancement of existing programmes. Meanwhile, the 2035 development milestones will be achieved with the implementation of new business models in line with the Government's strategy in future-proofing its existing electricity market regulatory and power sector industry practices.

STRATEGIC PILLAR 1: SOLAR

The Solar energy pillar is built upon existing programmes (i.e; NEM and LSS auctions) but to be complemented with the possibility of introducing new business models.

The key actions towards 2025 for SP1 are as follows:

i. Review future NEM programmes for rooftop solar and the offtake tariffs to gradually converge with the energy costs for a more equitable socialization of grid and system operation costs. Decrease in NEM tariffs and grandfathering of contracts will be continued to create incentives for early movers; supporting the rate of uptake under NEM;
ii. Explore new business models in addition to those enabled by the NEM and LSS programmes. These include corporate PPAs, third-party access framework and providing greater avenues for distributed generations, monetization of environmental attributes through Renewable Energy Certificates (RECs); and
iii. Explore LSS auctions focusing on modern technologies with lesser land used such as floating solar. The potential implementation of existing hydroelectric basins and water bodies shall be assessed to address the large land requirements while utilizing the existing grid connection facilities. Engagement and involvement of state Governments to identify suitable sites for solar development will be enhanced, thereby de-risking solar projects and allowing solar costs to decrease.

The key actions for post 2025 shall include the introduction of a RE programme framework as follows:

i. Improve and continue solar auctions to ensure competitive tariff. Auction format will be regularly reviewed to align with evolving technological advances and best global practices;
ii. Explore framework for deployment of solar quota based on direct corporate offtake or different forms of PPAs;
iii. Enhance existing rooftop programmes including exploring possible frameworks to allow non-utility offtakers under NEM; and
iv. Facilitate, encourage and increase participation of Government agencies in Government solar rooftop programmes.

STRATEGIC PILLAR 2: BIOENERGY

The Bioenergy pillar aims to increase bioenergy capacity by supporting the roll-out of biomass, biogas and WTE capacity under the existing FiT via new business models (i.e; auctions and tendering programmes), as well as exploring potential opportunities in bio-CNG and biomass co-firing.

The key actions towards 2025 for SP2 are:

i. Explore the feasibility for the clustering of bioenergy power for power generation to improve project economics;
ii. Assess auction systems beyond the FiT to support additional capacity build-up for post 2025;
iii. Conduct a feasibility study of grid extensions to allow additional development of bioenergy clusters by encouraging off-grid bioenergy power plants to re-power and upsize, and building new off-grid and micro-grid power plants;
iv. Explore possibility of a net metering scheme for bioenergy resources;
v. Leverage available bioenergy feedstock from municipal solid waste for the development of Waste to Energy (WTE) facilities as a two-pronged strategy in addressing the waste management issue and in supplying energy to the national grid;
vi. Conduct feasibility study of bio-CNG power generation and biomass co-firing in coal-fired power plants; and
vii. Encourage studies and assessments to be conducted on improvement in bioenergy power generation technology.

The key actions for post 2025 shall build upon the strategies implemented by 2025 to support further capacity build-up as follows:

i. Recommend a new auction mechanism (beyond FiT) to support additional capacity build-up with improved by-products management towards circular economy;
ii. Undertake syndication of bioenergy potential with possible grid extensions to identify additional development of bioenergy clusters;
iii. Improve and review energy purchase framework for WTE projects to ensure equitable socialization cost;
iv. Explore the implementation of equitable and feasible support mechanisms for bio-CNG and biomass co-firing; and
v. Support improvement in bioenergy power generation technology.

STRATEGIC PILLAR 3: HYDRO

The Hydro pillar supports accelerated deployment and operation of hydro generation capacity.

The key actions towards 2025 for SP3 are as follows:

i. Continue to optimize small hydro FiT through auctioning while considering differences in development costs for low-head and high-head system;
ii. Encourage hydro-geological study for identification and characterization of new high potential sites for small hydro development. The study shall lead to development of open access geo-referenced database that will be utilized by developers;
iii. Explore lifetime extension of existing large hydro peaking plants to support greater VRE penetration;
iv. Coordinate with state authorities to expedite approvals and facilitate implementation and operation regulations for hydro plants development; and
v. Devise and improve existing tendering process format for small hydro development.

The key actions for post 2025 shall supports development of remaining potential resource to meet prevailing energy demand as follows:

i. Continue to encourage identification and characterization of new sites for small hydro through hydrogeological study;
ii. Enhance project development coordination and facilitation with state authorities to expedite approvals including facilitation on hydro plants related development and operation regulations; and
Iii Assess deployment of large hydro, as part of the national power development plan through collaboration between regulators, state authorities and utilities.

STRATEGIC PILLAR 4: NEW TECHNOLOGY AND SOLUTIONS

The new technology and solutions pillar support roll-out of new RE resources post 2025, as well as exploring solutions to maintain system stability under high VRE penetration.

The key actions towards 2025 for SP4 under new technology and solutions pillar are as follows ;

i. Explore new RE technologies, resources and solutions for efficient and cost effective RE deployment; and
ii. Assess required energy storage roll-out to maintain system stability.

The key actions for post 2025 under new technology and solution pillar are:

i. Conduct feasibility study and economics assessment on implementation of new RE sources including geothermal, onshore and offshore wind; and
ii. Prioritize and roll-out cost-effective energy storage solutions (i.e., battery storage and hydrogen solution).

ENABLING INITIATIVES

There are four Enabling Initiatives supporting the implementation of the action plans for each strategic pillar. The initiatives are as follows:

i. Future-proofing existing electricity regulatory and market practices to enhance private sector participation and to provide greater customer choice in choosing RE powered electricity, including exploring the prospect for corporate PPA and Third-Party Access (TPA) framework. The existing green tariffs and REC mechanism will also be improved to enable direct procurement of REC from utilities or mandated party in meeting both public and private sectors demand;

ii. Improve access to green financing to increase financial flows vis-à-vis the Government's intent to accelerate RE deployment in energy transition. This initiative includes enhancing existing fiscal and non-fiscal incentives, exploring new incentives for RE financing and continuous engagement and facilitation with financial institutions;

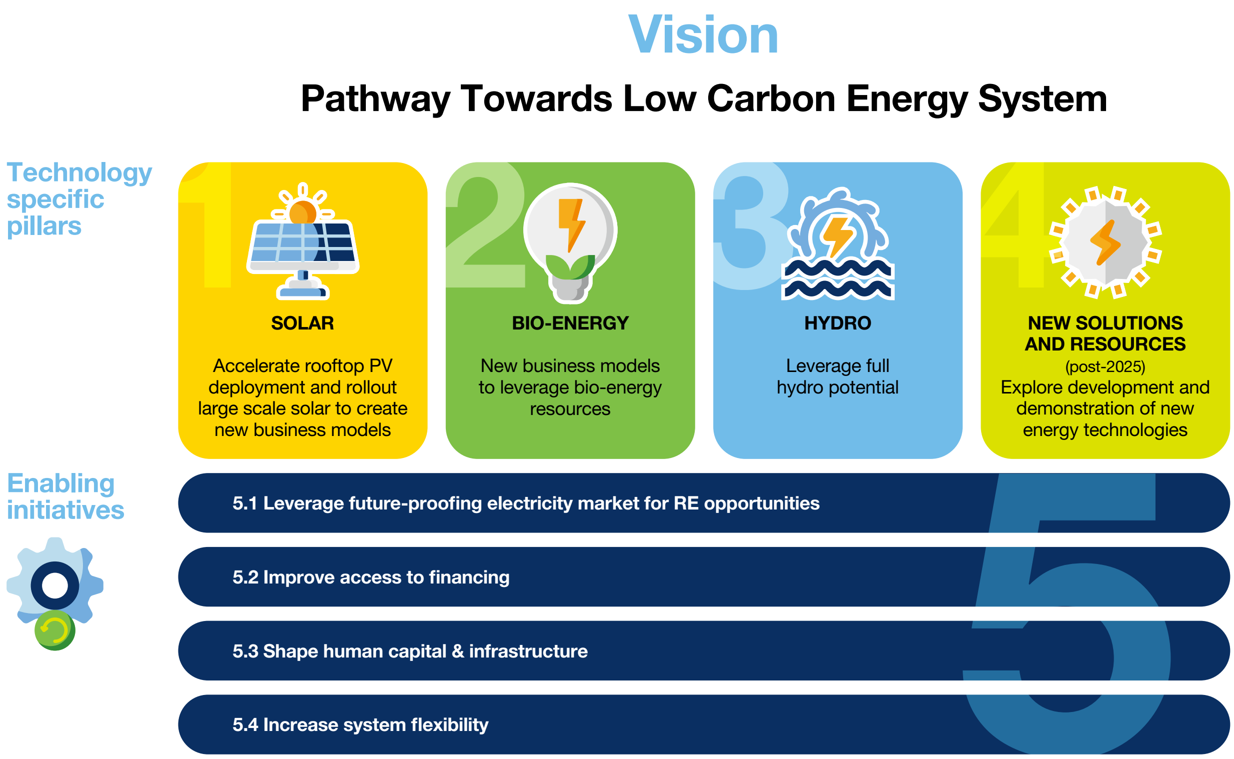
iii. Increase system flexibility by exploring feasible framework for demand-side management, smart grids including battery energy storage system integration to improve grid management (through solar forecasting, dispatching, grid and distribution codes) (See Chapter 6.5.2.4). This shall also include creating an organized markets for grid balancing services, allowing third parties to provide innovative grid management solutions that will be explored to create new economic activities; and

iv. Develop awareness and future readiness to promote RE-centric society. This initiative includes human capital development, supporting future power sector transition as well as efforts to strengthen technology innovation in RE. In line with 4IR initiative, technology innovation comprises of digitalization of the power sector through the implementation of distributed energy systems, advanced metering infrastructure, automated distribution, virtual energy trading and smart grids.

MyRER STRATEGIC FRAMEWORK

In alignment with Government targets and key boundary conditions (the 'Energy Trilemma' as outlined in Chapter 1.4), the strategic framework of the MyRER is designed to achieve 31% share of RE in the national installed capacity mix by 2025 and, through 2035, enhancing further the decarbonization of the electricity sector, while ensuring affordability, system stability and environmental sustainability. In order to realize this vision, the MyRER strategic framework hinges on four technology-specific pillars, supported by cross-technology enabling initiatives.

Figure 6-1: Strategic framework for 2035



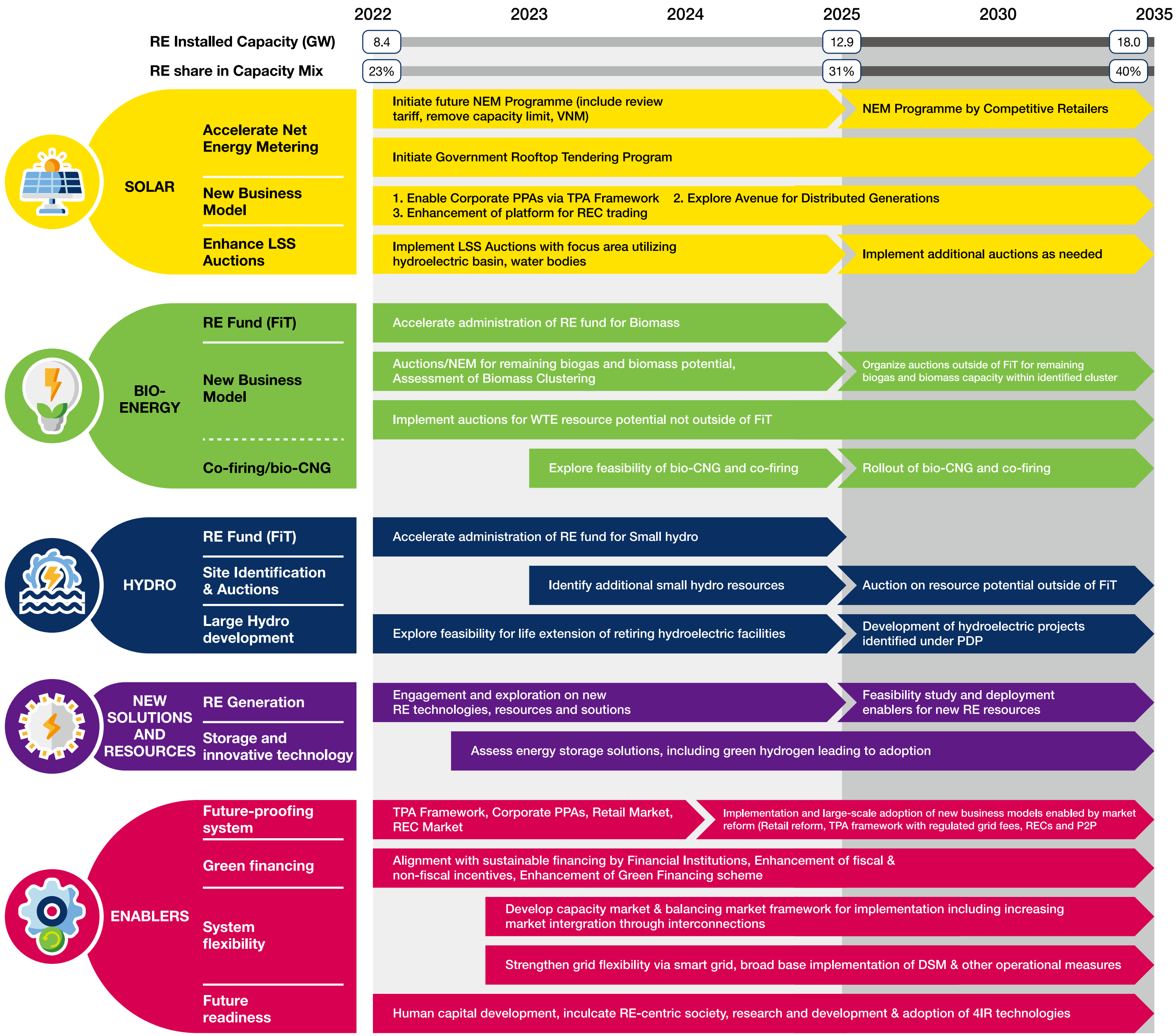
Three pillars are designed to develop readily available RE resources in Malaysia: solar PV, bioenergy, and hydro resources, forming the backbone of renewable generation growth. As of December 2019, a total of 8,170 MW of RE across the three core resources have been installed in Malaysia. MyRER aims to leverage upon the existing untapped resources (solar PV, bioenergy, hydro) potential to drive the roadmap through 2025 and 2035. Post 2025, it is expected that new technologies and resources may also support the MyRER ambitions, forming a fourth pillar.

In order to achieve the 2025 Government target for 31% RE share in Malaysia by 2025, MyRER has developed detailed strategies for each component of the strategic framework up to 2025 (Figure 6-1). MyRER has a longer-term vision to decarbonize the power generation mix beyond 2025. High-level strategies through to 2035 have been detailed as part of the MyRER. An overview of the overall MyRER roadmap is shown in Figure 6-2.

The strategies proposed in MyRER have been prioritized based on:

- Continuation and improvement of existing programmes; addressing existing challenges and implementing improvement measures for ongoing RE programmes such as the FiT, NEM, and LSS;
- Realistic commercial operational date (COD) for different technology; launch of initiatives (quota release, auctions) in a timely manner to achieve capacity target by 2025;
- System stability; ensuring balanced mix between VRE and non-VRE; and
- Alignment with existing national roadmaps and initiative; proposed key actions are aligned with adjacent roadmaps such as the Green Financing Taskforce and ongoing discussion on Malaysia's future electricity market reforms.

Figure 6-2: MyRER roadmap



6.1 SOLAR PILLAR

6.1.1 OVERALL STRATEGY TO 2035

Figure 6-3: Solar initiatives

SOLAR INITIATIVES	KEY ACTIONS UP TO 2025	KEY ACTIONS POST 2025
1.1 Accelerate Net Energy Metering (NEM)	• Enhancement of existing NEM programme - Accelerate NEM approval procedures - Promote awareness of NEM - Explore potential for government rooftop tendering program • Future NEM programmes - Review net metering tariff - Lift capacity limit restriction - Include Virtual Net Metering	• Liberalization of NEM tariff and new retailers to take role of off-takers • Continued implementation of government rooftop tendering program
1.2 Introduce new business model	• Enable corporate PPAs in line with Third Party Access framework • Pilot and implement P2P energy trading • Enhanced platform for RECs trading from rooftop and large scale solar, supporting corporate PPAs and Green tariff	• Large scale adoption of corporate PPAs in line with market reforms
1.3 Enhance large scale solar auctions	• Continue to promote floating solar PV in LSS auctions • Identify new LSS sites with state level cooperation	• Auction design to align with evolving technological advances and global best practices

6.1.2 DETAILED KEY ACTIONS UP TO 2025

6.1.2.1 INITIATIVE 1.1 – ACCELERATE NET ENERGY METERING (NEM)

The NEM scheme was first launched in 2016 ("NEM 1.0"), offering access to solar rooftop for self-consumption and ensuring that excess electricity could be sold to the grid at a fixed rate. The electricity sold is "netted off" from monthly electricity bills. In NEM 1.0, the fixed rate for excess electricity was set at the displaced cost, which is lower than the retail tariff. In November 2016, the NEM 1.0 scheme was allocated a quota of 500 MW up to 2020, with an expectation of 100 MW allocation per year.

From 2016 to 2018, only 10 MW of capacity under NEM were installed in Malaysia. The lackluster progress of NEM was due to several factors, including lengthy administrative processes, maximum capacity limits, unattractive pricing for exported electricity and low awareness of the programme.

Since January 2019, a revised NEM scheme ("NEM 2.0") offered a better compensation for excess solar electricity based on a one-to-one retail tariff offset mechanism, replacing the previous displaced cost off-set mechanism. Due to this, the take-up rate in 2019 alone is 3.68 times more than the take up of 2016-2018.

In addition, NEM 3.0 was announced in 2021 with additional 500 MW quota to be offered (2021-2023). Focus is given to commercial and industrial users through the Net Offset Virtual Aggregation (NOVA) Program to benefit from generation excess sold at market price or System Marginal Price (SMP). Virtual aggregation under this program allows generation excess to be distributed up to three different electricity bill accounts among its wholly owned subsidiaries. Measures to further improve these programmes are also outlined in this Chapter.

Image for illustration purpose only.

ENHANCEMENT OF EXISTING NEM PROGRAMMES

Accelerate NEM approval procedures

The NEM administrative process is lengthy and can take up to three months[83]. For comparison, the time taken to complete construction is estimated at two to three months[84], so administrative procedures take up more than 50% of the overall development process. Key parties, e.g. ST, SEDA, TNB and the PV industry are collaborating to facilitate approval process for NEM in an effort initiated since 2019. The administrative process has improved since then and it is estimated that through streamlining of the approval workflow, the time required for the administrative process could be reduced by approximately 30%.

Promote awareness of NEM

Low uptake of NEM 1.0 was partly due to limited awareness of the programme across customer segments. A series of awareness campaigns promoting NEM especially for rooftop application and highlighting its wide applicability across RE technologies will be accelarated with targeted sectors by collaborating with the relevant associations. In particular, during the current pandemic situation, leveraging on online platform enables wider range of reach to identify customer segments.

Explore potential for government rooftop tendering program

The Government may also take an active role in initiating the roll-out of rooftop solar PV. With an estimated 4.4 GW of rooftop potential from public buildings in Malaysia (Figure 6-4), the Government could aggregate public building rooftops and tender out space to developers or install solar PV systems leased from RPVI. Power generated from rooftops could then be purchased by Government entities through long-term PPAs with developers.

This scheme could significantly decrease the financing cost of rooftop solar PV projects and bring it in line with LSS projects. By aggregating large portfolios of rooftops and leveraging government-backed PPAs, developers would be able to finance rooftop projects using a higher proportion of debt financing, with lower cost of capital than equity financing.

In order to implement this scheme, the procurement of electricity by the Government PPA models needs to be addressed. This will enable Government to lower their expenses on electricity bills and in turn, lead the nation by example in driving the sustainable energy agenda. Under NEM 3.0 programme, a specific category with allocation of 100 MW is for facilitating this initiative and will be further reviewed accordingly.

Figure 6-4: Government rooftop tendering

Type of buildings	Rooftop availability: Potential capacity (MW_{AC}[1])		Rooftop availability: Rooftop space (km^2)	Jurisdiction: Centralized	Jurisdiction: Agencies involved
Government offices	35	PM 33 MW Sabah 1.26 MW Sarawak 0.96 MW	0.25	No	• Individual Ministries
Low cost flats	178	PM 164 MW Sabah 11 MW Sarawak 3 MW	1.24	Partial	• Ministry of Housing & Local Government • State level agencies
MOH Hospitals	179	PM 131 MW Sabah 26 MW Sarawak 22 MW	1.25	Yes	• Ministry of Health
Flats	210	PM 197 MW Sabah 10 MW Sarawak 4 MW	1.47	Partial	• Ministry of Housing & Local Government • State level agencies
Universities	591	PM 492 MW Sabah 37 MW Sarawak 61 MW	4.12	Yes	• Ministry of Education
Schools	3,229	PM 2,479 MW Sabah 524 MW Sarawak 226 MW	22.53	Yes	• Ministry of Education
Total	4,422		30.86		

Note: Availability of Government rooftops space for low cost flats and flats are subject to the types of land title.
Source: SEDA; National Property Information Center; Ministry of Health; Ministry of Education

83. For commercial / industrial and agriculture customer up to 72 kW
84. SEDA

FUTURE NEM PROGRAMMES

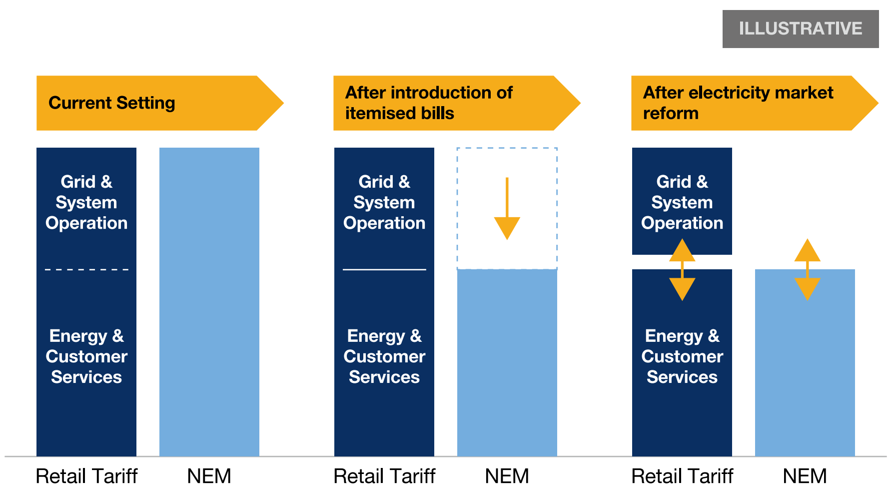
Review Net Energy Metering tariffs

As technology costs of solar PV decline and electricity market reform is implemented, opportunities to review the compensation structure for the NEM programme may emerge.

NEM 2.0 operates on a one-to-one tariff offset and continues in selective categories under the current NEM 3.0. Consequently, NEM customers are not only compensated for energy costs, but also for grid and system operation costs, despite being connected to the grid and enjoying balancing from system operation. The offtake tariffs will be reviewed upon formulation of future NEM programme, to ensure offtake tariffs will remain attractive and suit value propositions within customer segments. The offtake tariffs are expected to gradually converge with the energy costs for a more equitable socialization of grid and system operation costs.

As part of future-proofing electricity market initiatives, itemized billing is expected to be made available, and this could allow gradual review of the NEM compensation tariff to converge to the cost of energy and customer services. This transition may lead to the liberalization of NEM compensation, and allow retailers to set tariffs depending on specific marketing strategies (Figure 6-5).

Figure 6-5: Proposed transition to Future NEM



Note: Retail tariff for grid and system operation include transmission charges, distribution charges, Single Buyer operations charges, grid system operator charges

The gradual decline in the NEM compensation is also aimed to incentivize "early movers" to take up the existing NEM 3.0 programme.

Lift capacity limits restriction

In 2018, the allowed rooftop PV capacity under NEM for low voltage industrial and commercial customers is limited to 60% of fuse rating or 75% of the maximum demand, whichever the lowest. Lifting of this capacity limit will enable available rooftop space to be fully leveraged for solar PV generation. After reviewing the industry's request, the NEM guidelines were amended by end of 2019 to revert to 60% of fuse rating for low voltage industrial and commercial customers which allows for higher PV installation. Moving forward, the future NEM programme should continue to review if further capacity limit should be lifted to encourage upscaling of PV rooftop market.

Include Virtual Net Metering (VNM)

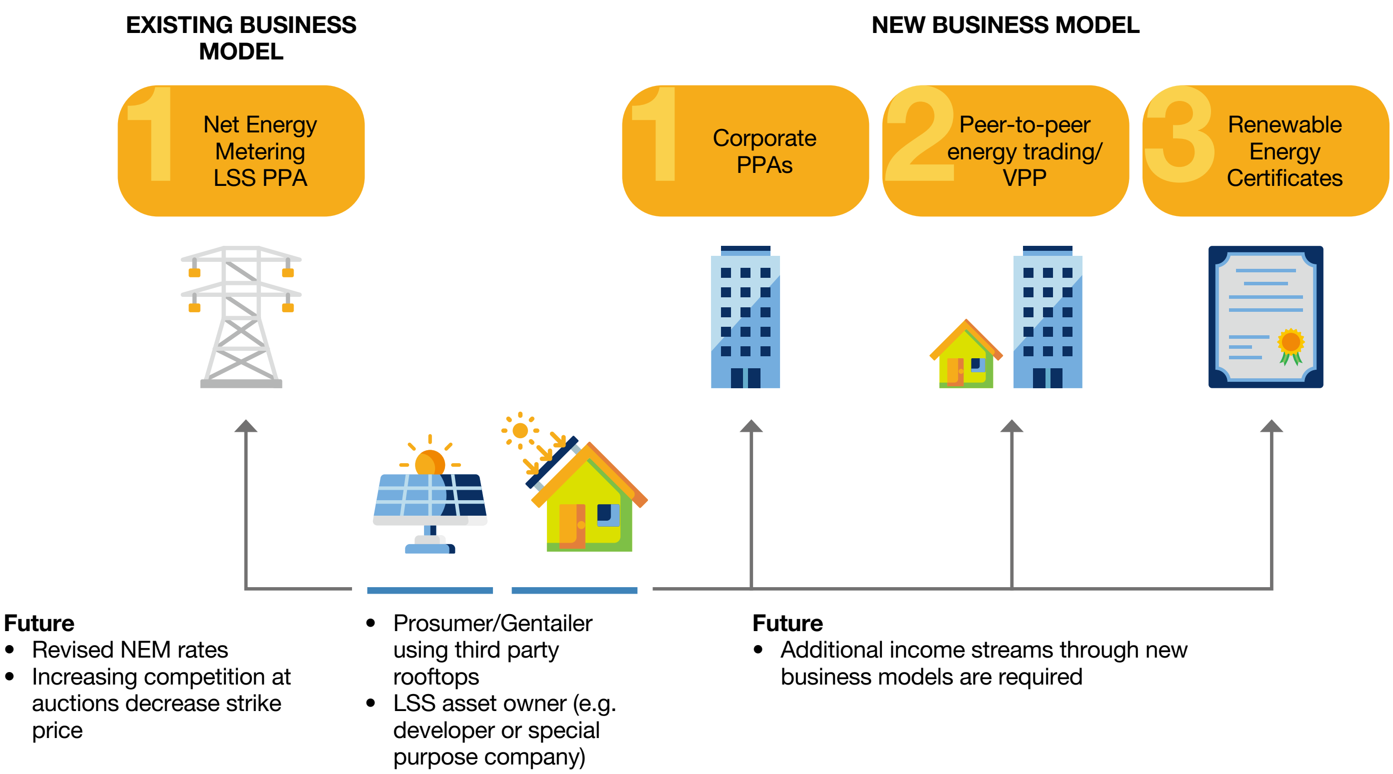
The concept of a NEM will require solar PV system to be installed within the same premise as the electricity customer. Virtual Net Metering (VNM) is a scheme allowing RE systems that are owned by a customer, but installations are located off-site. In some PV markets, this is also referred to as "Community Solar" and each customer receives credits on their electric bill, corresponding to the excess energy produced by their share of the RE installation. The key benefit of VNM is that it allows customers without sufficient space on their premises (for example government or businesses with multiple building assets) to benefit from NEM. Consideration should be given to include VNM in future NEM programmes and not limited to electricity bill accounts under the same company. Currently, virtual aggregation model has been introduced for commercial and industrial sector under NEM 3.0 programme. Data gathering from this initiative enables the model to be extended to residential sector as well as to facilitate for the limitation mentioned and moving towards the VNM scheme.

6.1.2.2 INITIATIVE 1.2 – INTRODUCE NEW BUSINESS MODELS

In addition to building on existing programmes, MyRER advocates for the implementation of new configurations and business models in parallel with regulatory restructuring under MESI 2.0.

Figure 6-6 below shows potential new business models that could create additional income streams for rooftop solar PV and LSS.

Figure 6-6: New business models for rooftop and LSS



ENABLE CORPORATE PPAs IN LINE WITH THIRD-PARTY ACCESS FRAMEWORK

In Malaysia, on-site corporate PPAs are already viable under the current regulatory structure and economics.

In on-site PPAs, a developer owns and operates a solar PV rooftop system on the customer's premises and sells the electricity generated from the solar system to the customer at a guaranteed rate. With current technology costs, developers are already able to offer rates 15 - 30% lower than regulated tariffs[85], making this scheme attractive to customers. The developer can also leverage on the NEM scheme and pay back the rooftop owner for any excess electricity sold to the grid. Because the electricity supply does not utilize the grid (it is entirely "behind the meter"), onsite PPAs do not require third-party access to the grid and are therefore, already possible without any electricity regulatory reform.

Off-site or "front-of-meter" PPAs involve a developer selling power from a RE generation plant that is located outside of the customer's premises. Because this involves utilizing the electricity grid to supply the customer, off-site PPAs require a framework for third-party access (TPA) to the grid. ST is currently developing such a framework defining third-party access rules and wheeling charges for grid use.

The importance of the TPA framework is discussed in detail in Chapter 6.5.2.1.

PILOT AND IMPLEMENT PEER-TO-PEER (P2P) ENERGY TRADING

P2P energy trading is a trading mechanism between prosumers (consumers that also produce their own electricity through, e.g., rooftop solar PV) and consumers. The concept of P2P energy trading is premised on a sharing economy and underpinned by digital systems. P2P energy trading enables a prosumer to sell its excess solar electricity to a consumer willing to purchase it from the prosumer. The potential benefits of P2P energy trading include:

- For prosumers, possible monetary benefits from sale of excess solar electricity. Benefits are realized if prosumers can sell the excess solar electricity at a rate higher than that offered through NEM;
- For consumers, potential savings by purchasing solar electricity from prosumers. Savings are possible if the rate offered by the prosumer is lower than the electricity rate offered by the retailer;
- For Government, P2P energy trading is a market-based mechanism that can support renewables without the need of subsidies or regulated tariffs; and
- For grid system operators this scheme can potentially result in avoided capital investments in grid infrastructure as P2P energy trading occurs through the distribution grid and does not rely on the transmission grid. In this regard, P2P energy trading can reduce transmission losses.

85. SEDA estimates from existing tariffs and solar LCOE
86. Respective companies websites

The P2P energy trading provides an option for consumers to purchase excess solar electricity that is generated from a solar PV system which is located off-site. The counterparty risk of this business model is lower compared to PPA for solar PV systems that are built at the customer's site as the PV system investors have full control of their assets. P2P energy trading also supports aggregation of small distributed RE generations into virtual power plants (VPPs) and fractionalizing of energy assets (such as utility scale energy storage providing "storage-as-a-service"). Globally, various P2P pilot projects have been conducted by companies such as Power Ledger, Electrify, SonnenGroup and LO3 Energy[86].

Malaysia has conducted an 8-month pilot P2P project (as shown in Figure 6-7) that allowed prosumers and consumers to leverage on arbitrage opportunities from different tariff categories (see Figure 6-8). The objectives of the P2P pilot project operating under a regulatory sandbox are to (1) assess technical implementation readiness and aggregator roles; (2) identify challenges and mitigation actions in operationalising the trading and (3) identify required regulatory enhancements (if any) to allow nationwide roll-out.

Depending on the policy direction of the Government, nationwide roll-out of P2P energy trading can be envisioned, providing an additional mechanism supporting investment in RE generation.

Figure 6-7: Concept of pilot P2P project in Malaysia

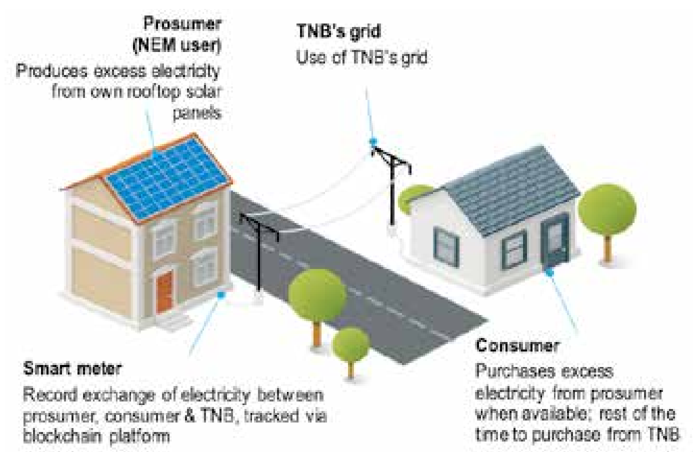
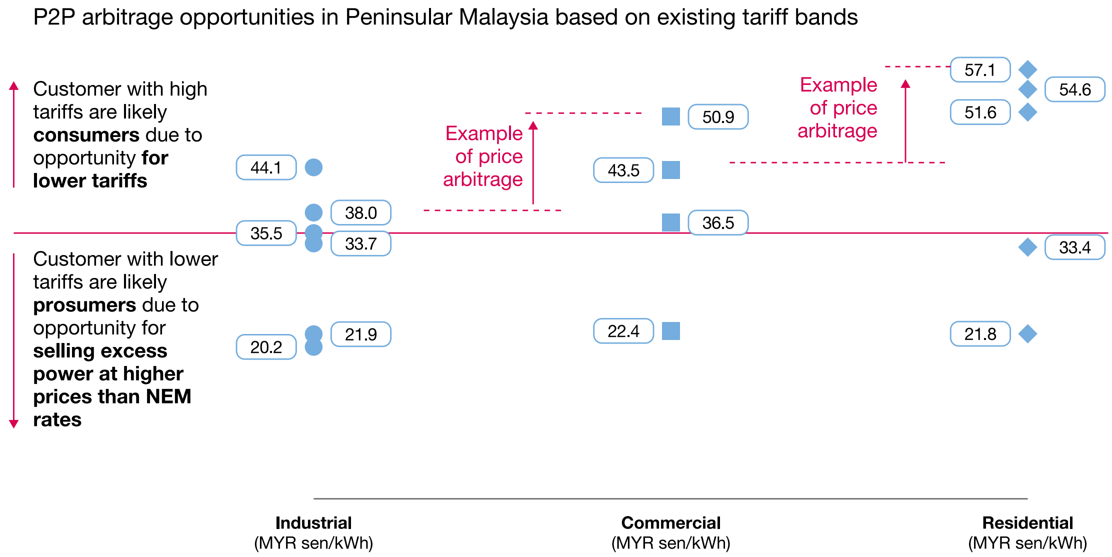


Figure 6-6: P2P energy arbitrage opportunities in Peninsular Malaysia based on existing tariff bands



Source: SEDA; TNB

ENHANCE PLATFORM FOR RECS TRADING FROM ROOFTOP AND LARGE SCALE SOLAR, SUPPORTING CORPORATE PPAs AND GREEN TARIFFS

Green attributes could be a source of additional income for RE asset owners via RECs. In Peninsular Malaysia, TNB owns the green attributes for LSS and has introduced green tariffs backed by RECs from LSS.

Moving forward, various options could be made available for different RE asset owners to monetize green attributes. These strategies are discussed in detail in Chapter 6.5.2.1.

6.1.2.3 INITIATIVE 1.3 – ENHANCE LARGE SCALE SOLAR AUCTIONS

CONTINUE PROMOTING FLOATING SOLAR PV IN LSS AUCTIONS

Although globally the total installed floating solar PV capacity is low compared to ground-mounted applications, Malaysia is among the countries that have pioneered such applications. One project under FiT and another pilot project by TNB have been commissioned to testbed floating solar system performance. Meanwhile, there are three large scale solar PV projects that have already been awarded in Peninsular Malaysia with a cumulative capacity about 70 MW (located at Tolk Uban lake in Kelantan and in Kuala Langat). In addition, Sarawak has already initiated plans to trial 30 MW of floating solar PV at the Batang Ai hydroelectric plant dam by 2022[87].

In future LSS auctions, there will be continuous support for floating solar targeting existing hydroelectric plant dams and water bodies. Floating solar PV installation on hydroelectric dams has multiple benefits:

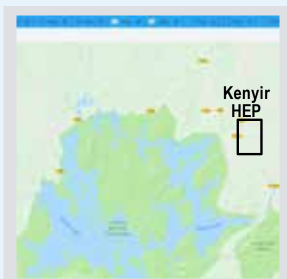
- Promotes the conservation of state land required for LSS. Large reservoir areas in both Peninsular Malaysia and Sarawak could be utilized for floating solar PV;
- Allows to leverage the existing hydroelectric plant grid connection, thus avoiding additional interconnection cost; and
- Enhances energy yield, due to the cooling effect of water on solar PV modules[88].


Image for illustration purpose only.

87. Sarawak Energy Berhad
88. SERIS, Solar Energy Research Institute Singapore, Korea Water Resources Corporation – incremental performance improvement of up to 10% on capacity factors due to cooling

Case study
Leveraging large hydroelectric plant dams for floating solar PV

Large hydroelectric power dam such as Kenyir, Temenggor and Chenderoh are built on reservoirs with large water surface areas that potentially can be used for floating solar PV installation. Even by using only part of the reservoir area, significant capacity can be built. For example, using approximately 10%[89] of the Kenyir, Temenggor and Chenderoh reservoirs can yield 2 GW, 1 GW and 115 MW capacity respectively. Because these hydroelectric power plants are owned by TNB, there is potential to leverage TNB's interconnection point for floating solar PV systems, thus reducing interconnection costs.

	Kenyir HEP Dam	Temenggor HEP Dam	Chenderoh HEP Dam
State	Terengganu	Perak	Perak
Reservoir area	369 km^2	174 km^2	20.5 km^2
Potential capacity[1)]	2,075 MW	978 MW	115 MW
Ownership	Tenaga Nasional Berhad	Tenaga Nasional Berhad	Tenaga Nasional Berhad
Map			

Source: SEDA; Department of Irrigation and Drainage

IDENTIFY NEW LSS SITES WITH STATE-LEVEL COOPERATION

Appetite for LSS investments is high, as highlighted by the outcome of the LSS 3 auction conducted in 2019 (112 bids totaling 6.73 GW of capacity were received, corresponding to 13 times the auctioned capacity of 500 MW).

However, as capacity builds up, land locations with relatively high irradiance and proximity to grid connections will become scarcer as highlighted in Chapter 4.4.1 earlier. Hence, measures to facilitate land access are needed. Global best practices (see discussion on India's solar park scheme in Chapter 2.4) suggest that Governments can play an important role in facilitating access to land. Government action can contribute to de-risking solar PV projects, thereby allowing developers to bid more aggressively at solar auctions, thus decreasing offtake prices.

6.1.3 DETAILED KEY ACTIONS POST 2025

6.1.3.1 INITIATIVE 1.1 – ACCELERATE NET ENERGY METERING (NEM)

LIBERALIZATION OF NEM TARIFFS AND NEW RETAILERS TO TAKE ROLE OF OFF-TAKERS

Post 2025, NEM offtake tariffs can be liberalized (see also Chapter 6.1.2.1 for proposed evolution of NEM tariffs along different stages of market restructuring). In addition, as new players gradually enter the retail business alongside TNB, these can take the role of off-takers of excess solar electricity under NEM.

In this scenario, retailers will be free to set NEM rates depending on their marketing strategies. Thus, multiple NEM rates may emerge, depending on the specific retailer, and each retailer may offer different NEM rates depending on specific customer segments.

In markets with well-developed retail competition and with strong push for solar generation, such as Australia, competitive retailers already offer targeted tariff packages combining retail tariffs and solar offtake tariffs[90].

89. Based on existing floating solar PV plants, average utilization of water reservoir surface for solar power generation is 10.9%
90. See for example AGL Energy: https://www.agl.com.au/get-connected/electricity-gas-plans?cidi=A10221#/

The evolution towards liberalized NEM rates is expected to increase customer choice and favour the development of NEM offerings that closely match requirements of specific customer segments, thus increasing the overall attractiveness of the NEM scheme. However, further studies including the regulatory framework to enable this need to be conducted by the electricity regulator (ST).

CONTINUED IMPLEMENTATION OF GOVERNMENT ROOFTOP TENDERING PROGRAM

As outlined in Chapter 6.1.2.1, tendering of rooftops on Government buildings will become an important driver of solar PV rooftop market. As the estimated potential from Government buildings is significant (approximately 4.4 GW), scaling up of this program may take several years and extend beyond 2025. Thus, initiation on standard government contract and tendering template for government rooftops could help to further support build-up of solar PV rooftop market besides the commercial and industrial sectors.

6.1.3.2 INITIATIVE 1.2 – INTRODUCE NEW BUSINESS MODELS

LARGE SCALE ADOPTION OF CORPORATE PPAs IN LINE WITH EMERGING MARKET REFORMS

Further implementation of electricity market restructuring can enable large scale adoption of corporate PPAs, thereby supporting investment in RE generation in the long term. The MyRER advocates for appropriate grid access tariffs to be introduced in order to make front-of-meter PPAs for RE projects to be viable for a wide range of customer segments. In addition, increasing liquidity of the wholesale market as the number of trading counterparts and trading volumes increase should enable synthetic PPAs, further facilitating corporate procurement of RE (for a more detailed discussion of PPAs, see also Chapter 6.5.2.1).

6.1.3.3 INITIATIVE 1.3 – ENHANCE LARGE SCALE SOLAR AUCTIONS

AUCTION DESIGN TO ALIGN WITH EVOLVING TECHNOLOGICAL ADVANCES AND GLOBAL BEST PRACTICES

LSS auctions are expected to be a key driver of additional solar capacity post 2025. Release of quota for future LSS auctions would need to consider evolution of installed capacity versus pre-defined targets and in particular, take into account capacity awarded through corporate PPAs, as well as the rate of adoption of solar PV rooftop applications.

Auction design will be regularly reviewed to ensure alignment with evolving technological advances and global best practices, as captured by leading international bodies (e.g. IRENA[91]).

Additionally, as solar penetration in the grid increases, LSS auctions could include revisions to allow mechanisms to mitigate variable output of solar PV generation, e.g., provisions for firm PPAs, using energy storage technologies in combination with solar.

Image for illustration purpose only.

91. IRENA, Renewable Energy Auctions, Status and Trends Beyond Price, 2020

6.2 BIOENERGY PILLAR

6.2.1 OVERALL STRATEGY TO 2035

Figure 6-9: Bioenergy initiatives

BIO-ENERGY INITIATIVES	KEY ACTIONS UP TO 2025	KEY ACTIONS POST 2025
2.1 Accelerate administration of RE fund through FiT and clustering	• Explore feasibility of biomass power plants implementation through clustering of mills, coupled with equity participation by palm oil millers	
2.2 Conduct auctions/NEM for remaining biogas and biomass potential	• Conduct feasibility study for grid extension to leverage resource potential outside of identified clusters, decision to extend will be based on result of study • Encourage capturing of identified potential from remote mills, through off-grid generation • Explore feasibility of NEM for bioenergy	• Organize auctions outside of FiT for remaining biogas and biomass capacity within identified clusters
2.3 Tender Waste-to-Energy (WTE) plants	• Set up tendering process framework and conduct auction for WTE projects	• Continue implementation of WTE plants at all viable sites
2.4 Explore other opportunities to maximize bio-energy resource	• Establish feasibility of bio-CNG utilization and co-firing of biomass • Conduct technology improvement study for bio-energy power generation	• Explore the implementation and incentive mechanism for bio-CNG co-generation and biomass co-firing, depending on outcome of feasibility studies

6.2.2 DETAILED KEY ACTIONS UP TO 2025

6.2.2.1 INITIATIVE 2.1 – ACCELERATE ADMINISTRATION OF RE FUND THROUGH FIT AND CLUSTERING

EXPLORE FEASIBILITY OF BIOMASS POWER PLANTS THROUGH CLUSTERING OF MILLS, COUPLED WITH EQUITY PARTICIPATION BY PALM OIL MILLERS

Economics of biomass projects is challenging in Malaysia as plants face several operational challenges, such as securing reliable volumes of feedstock supply, feedstock prices fluctuations, as well as issues with feedstock quality[92]. As highlighted in Chapter 4.4, these challenges have resulted in relatively low biomass plant utilization (approximately 48%) and low average system size (approximately 11 MW)[93] which increase LCOE.

Biomass clustering and equity participation of palm oil millers in biomass powerplants are recommended as solutions to these challenges, through two aspects:

1. Aggregation of feedstock from multiple neighboring feedstock sources (e.g. palm oil mills) to support larger biomass plants (at least 20-30 MW); and
2. Encourage feedstock providers (e.g. palm oil mills) to participate as co-investors in biomass power generation plant. This would incentivize millers to ensure reliable delivery of high-quality feedstock.

With larger and stable flow of feedstock, improved plant utilization and larger capacity plants can be achieved. Assuming 70% utilization, in line with global average, the levelized cost of generation is expected to decline by approximately 10% compared to current levels[94]. In addition, larger system size (30 MW) would decrease the capital expenditure per MW.

92. Expert interviews
93. Based on actual SEDA FiT projects
94. SEDA analysis based on survey results from IRENA

These strategies will also allow a better utilization of the RE fund, enabling "more MW for the same amount of money". This is because FiT rates for larger plants (>10 MW to 20 MW) are lower at MYR 34.86 sen / kWh vs MYR 36.85 sen / kWh for a smaller plant (≤10 MW)[95].

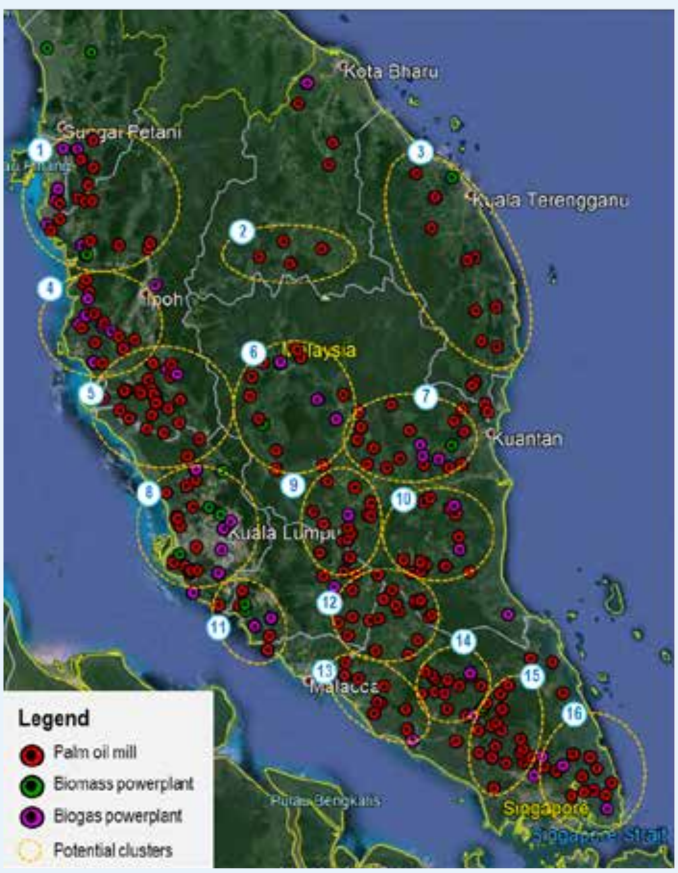
These strategies may be jointly facilitated and administered by MPOB and SEDA if the following conditions are fulfilled:

- Interest of feedstock providers within each cluster to co-own biomass power generation plants through joint ventures; and
- FiT compensation scheme that incentivizes plants / clusters that can achieve higher capacity factors in line with global best practice (approximately 70%[96]).

Case study
Improving the economics of biomass combustion projects

Global benchmarks from IRENA have shown that biomass plants economics improve with increasing plant capacity[97]. Based on data from Asia Pacific, Middle East, Africa, and South America, it is shown that with increasing system size from 10 MW to 30 MW, the levelized cost of generation decreases by 43% from 0.41 EUR / kWh to 0.23 EUR / kWh[98]. This is driven by economies of scale, favourably impacting equipment and interconnection costs per MW and by increasing plant utilization, Malaysia could create clusters of palm oil mills providing feedstock to biomass power plants. This would enable biomass power plants to aggregate feedstock and support larger biomass power plant, thus reducing the cost of generation per kWh.

Based on relative location of palm oil mills and grid substations, 16 clusters are identified with potential to support 444 MW of biomass generation capacity. This resource potential of 444 MW has been estimated based on current grid topology and coverage of geographic areas. Part of this capacity could be implemented under the FiT programme, while the remaining capacity could be supported by additional mechanisms, e.g. auctions and/or NEM.



Clustering will be key to realize biomass potential

1. Sungai Petani
2. Gua Musang
3. Kuala Berang
4. Taiping
5. Teluk Intan
6. Padang Tengku
7. Kuantan
8. Kuala Selangor
9. Kemayan
10. Bandar Tun Abdul Razak
11. Sepang
12. Bahau
13. Jasin
14. Chaah
15. Kulai
16. Kota Tinggi

95. Assuming with FiT bonuses included
96. Expert interviews
97. IRENA, Renewable Power Generation Costs in 2018, 2019
98. Generation cost estimated based on survey results from IRENA

6.2.2.2 INITIATIVE 2.2 – CONDUCT AUCTIONS / NEM FOR ADDITIONAL BIOGAS AND BIOMASS POTENTIAL

CONDUCT FEASIBILITY STUDY OF GRID EXTENSION IN ORDER TO CAPTURE RESOURCE POTENTIAL OUTSIDE OF IDENTIFIED CLUSTERS; DECISION TO EXTEND THE GRID WILL BE BASED ON RESULT OF STUDY

Part of the palm oil residue resource is "stranded" in clusters that are too far from the existing grid to be connected. If the grid is extended, part of these clusters may also be connected, adding new exploitable resource potential. It is recommended that a feasibility study be conducted to determine:

- Location of the stranded resources;
- Costs of grid extension to these stranded mills (from palm oil and other agricultural activities); and
- Extent of resource potential that can be connected to the grid cost-effectively. Depending on the results of this study, grid extension may be planned and constructed.

ENCOURAGE CAPTURING POTENTIAL IN REMOTE MILLS THROUGH OFF-GRID GENERATION

New measures could be developed to leverage remaining potential of mills (palm oil and other agricultural activities) outside of the clusters and grid coverage through off-grid generation. For example, measures could be introduced to encourage:

- Repowering and upsizing existing off-grid power plants; and
- New set up of off-grid power plants using high efficiency solutions, e.g. combined heat and power generation.

EXPLORE FEASIBILITY OF NEM FOR BIOENERGY

Although the NEM programme has been implemented via solar PV generation, the existing regulations allow other RE sources, such as biogas, to benefit from NEM model. Assessment on this potential allows bioenergy investors to gain additional avenue to utilise their available resources beyond their own consumptions and upscale the bioenergy capacity.

6.2.2.3 INITIATIVE 2.3 – TENDER WASTE-TO-ENERGY (WTE) PLANTS

SET-UP TENDERING PROCESS FRAMEWORK AND CONDUCT AUCTION FOR WTE PROJECTS

Total WTE capacity planned by 2025 is supported by the existing FiT scheme as well as auctions under a new tendering scheme that is beyond the FiT. This includes WTE projects that are adjacent to landfill sites with waste volumes exceeding 500 tons per day to ensure economies of scale are achieved and logistic challenges are mitigated.

In order to achieve successful tendering of WTE capacities, close cooperation between relevant ministries is crucial to establish an enhanced tendering and energy purchase framework.

Once the tendering framework is agreed among relevant ministries, auctions to achieve build-up RE target capacities by 2025 should be conducted timely.

6.2.2.4 INITIATIVE 2.4 – EXPLORE OTHER OPPORTUNITIES TO MAXIMIZE BIOENERGY RESOURCES

ESTABLISH FEASIBILITY FOR BIO-CNG UTILIZATION AND CO-FIRING OF BIOMASS

As mandated by MPOB in 2014, all expanding mills and new mills must install equipment to capture biogas from POME. Biogas from mills that are too far away from a connection point could be utilized as bio-CNG to be injected in existing gas pipeline for co-generation plants. Feasibility of this scheme and resulting target capacities are to be explored further.

Co-firing of biomass in coal power plants could also be explored within existing coal power plants and way forward. Policy support will be required to promote co-firing and further feasibility studies are to be conducted including possibility of reviewing existing PPAs and addressing challenges involved.

CONDUCT TECHNOLOGY IMPROVEMENT STUDY FOR BIOENERGY POWER GENERATION

As outlined in Chapter 4.4, technologies deployed in existing bioenergy plants are sometimes less efficient. A study will be conducted to establish:

- Technologies currently deployed in Malaysia;
- Best-practice technologies;
- Resulting gaps and recommended technologies to be rolled out. As explained in Chapter 6.5.2.3, some of the key areas of technology development in bioenergy are as follows: (1) technologies for treatment and upgrading of bioenergy feedstock for power generation, such as drying, pelletizing, torrefaction of biomass, and production of syngas through gasification of biomass; (2) high efficiency biomass boilers and generation technologies.

6.2.3 DETAILED KEY ACTIONS POST 2025

6.2.3.1 INITIATIVE 2.2 – CONDUCT AUCTIONS / NEM FOR ADDITIONAL BIOGAS AND BIOMASS POTENTIAL

ORGANIZE AUCTIONS OUTSIDE OF FIT FOR REMAINING BIOGAS AND BIOMASS CAPACITY WITHIN IDENTIFIED CLUSTERS

Under the New Capacity Target scenario, the biomass for agriculture waste resources potential is expected to be maximized in Peninsular Malaysia by 2035 to support the 40% RE target. After the FiT quota are fully allocated, the remaining required capacity could be tendered through new business models such as auctions. The combined capacity that is estimated to be available under identified clusters is about 444 MW.

However, in order to achieve beyond the New Capacity Target scenario target by 2035, biomass potential other than the 133 palm oil mills of the clustering coverage will need to be captured and auctioned. In order to do so, three main directions are outlined in the sections below:

- Increase resource (palm oil waste) available for power generation by mandating a minimum proportion of EFB for use in power generation and reviewing existing tariffs (for all agriculture waste);
- Extend the grid coverage to allow additional mills (palm oil and other agricultural activities) to be clustered; in order to assess the economics of this option and mill owners willingness, a feasibility study is recommended; and
- Create measures to capture potential in remote mills (palm oil and other agricultural activities), e.g. through off-grid generation.

6.2.3.2 INITIATIVE 2.3 – TENDER WASTE-TO-ENERGY (WTE) PLANTS

CONTINUE IMPLEMENTATION OF WTE PLANTS AT ALL VIABLE SITES

Remaining WTE potential can be awarded through auctions post 2025, subject to its feasibility and viability to maximise further WTE potentials. Priorities will be given to all viable landfill sites (>500 tpd). Improvement and revision of the current energy purchase framework of WTE projects will be the key towards promoting a more competitive pricing scheme that attracts participation from both private and public sectors.

6.2.3.3 INITIATIVE 2.4 – EXPLORE OTHER OPPORTUNITIES TO MAXIMIZE BIOENERGY RESOURCES

EXPLORE THE IMPLEMENTATION AND INCENTIVE MECHANISM FOR BIO-CNG CO-GENERATION AND BIOMASS CO-FIRING, DEPENDING ON OUTCOME OF FEASIBILITY STUDIES

Depending on the outcome of feasibility studies on bio-CNG and biomass co-firing in coal plants, as outlined in Chapter 6.2.2.4, implementation of incentive mechanisms can be considered post 2025.

For bio-CNG, incentives could include (1) price adder for bio-CNG as compared to standard CNG from non-renewable sources, (2) incentives on offtake price for the portion of electricity generated from bio-CNG in gas-fired power plants.

For biomass co-firing, incentives on the offtake price for the portion of electricity generated from biomass in coal-fired power plants could be introduced.


Image for illustration purpose only.

6.3 HYDRO PILLAR

6.3.1 OVERALL STRATEGY TO 2035

Figure 6-10: Hydro initiatives

HYDRO INITIATIVES	KEY ACTIONS UP TO 2025	KEY ACTIONS POST 2025
3.1 Accelerate administration of RE fund through FiT	• Optimize small hydro FiT • Facilitate and coordinate discussion with State authorities to expedite approvals • Coordinate regulatory changes on upstream activities	• No new FiT quota after RE fund fully allocated
3.2 Identify additional resource availability by site	• Conduct a hydro-geological study to identify additional sites beyond current resource potential - Create taskforce of subject matter experts - Create a long list of sites - Prioritize small-hydro sites for development - Create an open-access geo-referenced resource potential database	• Site study expected to be completed by 2025
3.3 Auctioning of future capacity	• Set up and conduct auctions for additional small hydro capacity beyond FiT	• Conduct auctions for remaining small hydro potential and sites newly identified in 3.2
3.4 Large Hydro potentials		• Deployment of large hydro will be assessed as part of the national power development plan driven by collaboration between regulators, State authorities and utilities • Explore life extension of existing large hydro peaking plants to support greater VRE penetration

6.3.2 DETAILED KEY ACTIONS UP TO 2025

6.3.2.1 INITIATIVE 3.1 – ACCELERATE ADMINISTRATION OF RE FUND THROUGH FIT

OPTIMIZE SMALL HYDRO FIT

Since 2019, an e-bidding mechanism has been introduced where small hydro developers bid for the FiT projects.

New Capacity Target prices for e-bidding are set separately for high head and low head projects (respectively 0.26 MYR/kWh and 0.29 MYR/kWh), to reflect higher costs for low head projects.

FACILITATE AND COORDINATE DISCUSSION WITH STATE AUTHORITIES TO EXPEDITE APPROVALS

The extended Federal and State-level permit application process required for small hydro developments is a major hurdle and deterrent for hydro developers.

A critical success factor to ensure that smooth implementation of small hydro projects is to secure the buy-in of state authorities to support small hydro development. Facilitating and coordinating regular engagements with state authorities could help small hydro developers to navigate and hasten the approval process.

COORDINATE REGULATORY CHANGES ON UPSTREAM ACTIVITIES

Upstream activities, such as logging, can disrupt natural river flow and produce residues affecting hydro plant performance downstream. This issue could be resolved by enforcing policies to regulate activities upstream of small hydro plants. A coordinated effort between the authorities and small hydro developers is needed to effectively implement this initiative.

6.3.2.2 INITIATIVE 3.2 – IDENTIFY ADDITIONAL RESOURCE AVAILABILITY BY SITE

CONDUCT A HYDRO-GEOLOGICAL STUDY TO IDENTIFY ADDITIONAL SITES

As discussed in Chapter 4.1.3, Malaysia is rich in hydroelectric power potential, with 189 river basins ready to be exploited. A bottom-up hydro-geological assessment of the river basins is needed to identify small hydro sites that could further support the growth of small hydro sites suitable for development. The assessment could be implemented in four steps:

1. **Create taskforce of subject matter experts**
   A countrywide hydro-geological assesment conducted by local and international experts familiar with the local geography and possesses te required technical knowledge is needed.

2. **Create a long list of sites**
   A preliminary list of all sites is first created through consolidation and aggregation of past studies and existing data sources. A database will need to be created include all available data (e.g., head, hydrology) for each site.

3. **Prioritize small-hydro sites for development**
   After the creation of the preliminary list of sites, a filtering process will be carried out to identify and rank the sites based on potential for small hydro development. The filtering process is conducted in two phases; (i) high potential site selection from available data, and (ii) on-the-ground validation.

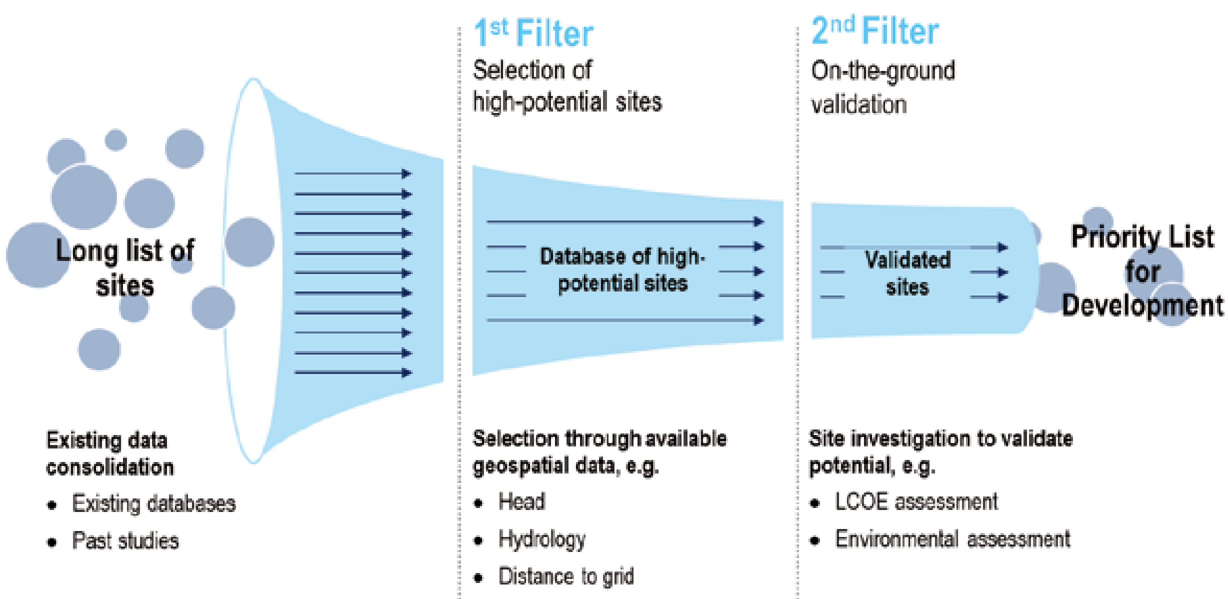
   High potential site selection is conducted through an assessment of all the sites using available geospatial data. This is to include river head, water flow velocity, seasonal hydrology changes, topography, distance of river location to nearest interconnection, and others.

   After the high potential sites are identified, an on-the-ground assessment will be done to validate the feasibility of these sites. A preliminary economic and environmental feasibility study will be performed at this stage to further narrow down the list of potential sites.

   Depending on the amount of geospatial data available and the result of site validation, further iteration is expected to refine the list.

4. **Create an open access geo-referenced resource potential database**
   An open-access database is proposed to be created in order to support small hydro developers in assessing project feasibility and the investment decision-making process, while maintaining clear potential that can be assessed by relevant parties.

Figure 6-11: Small and mini hydro sites identification process



Source: SEDA; World Bank

6.3.2.3 INITIATIVE 3.3 – AUCTIONING OF FUTURE CAPACITY

SET UP AND CONDUCT AUCTIONS FOR ADDITIONAL SMALL HYDRO CAPACITY BEYOND FIT

Similar to biomass projects, in order to achieve the New Capacity Target scenario in 2025, new mechanism to support additional small hydro capacities beyond the FiT programme will be required, which will also include the tendering process framework.

After the FiT quota has been fully allocated, new small hydro projects can be awarded through auctions to encourage continuous competitive bidding process.

6.3.3 DETAILED KEY ACTIONS POST 2025

6.3.3.1 INITIATIVE 3.2 – IDENTIFY ADDITIONAL RESOURCE AVAILABILITY BY SITE

SITE STUDY EXPECTED TO BE COMPLETED BY 2025

As the hydro-geological site study is expected to be completed by 2025, the key actions will be dependent on the outcome of the study.

6.3.3.2 INITIATIVE 3.3 – AUCTIONING OF FUTURE CAPACITY

CONDUCT AUCTIONS FOR REMAINING SMALL HYDRO POTENTIAL AND SITES NEWLY IDENTIFIED IN INITIATIVE 3.2

New small hydro capacities identified in the site study can be awarded through auctions post 2025, subject to its feasibility and viability to maximise further hydro potentials with strong policy support where necessary to encourage continued competitive bidding process in its implementation.

6.3.3.3 INITIATIVE 3.4 LARGE HYDRO POTENTIAL

EXPLORE LIFE EXTENSION OF EXISTING LARGE HYDRO PEAKING PLANTS TO SUPPORT GREATER VRE PENETRATION

Large hydro facilities have the potential to continue operations beyond its PPA term, with the civil structures are designed to remain durable up to 100 years. The initial investment in constructing the large hydro facilities are mostly allocated for the civil structure costs. Hence, assessment on life extension programme may utilize this potential, while incorporating additional features including coupling with floating solar or pumped-storage to improve the capacity factor and to support greater VRE penetration.

DEPLOYMENT OF LARGE HYDRO WILL BE ASSESSED AS PART OF THE NATIONAL POWER DEVELOPMENT PLAN DRIVEN BY COLLABORATION BETWEEN REGULATORS, STATE AUTHORITIES AND UTILITIES

Post 2025, several sites for development of large hydro projects have been identified, and currently being assessed as part of the national power development. Close collaboration between regulators, State authorities and utilities is crucial in ensuring timely completion of the large hydro projects, and in adherence to the local and international standards including:

a) Technical compliance – International Commission on large Dams (ICOLD)
b) Social and environmental compliance – International Hydropower Association (IHA), Hydropower Sustainability Assessment Protocol (HSAP)
c) Local technical compliance – Malaysian National Committee on Large Dams (MYCOLD)

Currently, the assessment to extend life of retiring hydroelectric facilities along Sg. Perak is undertaken by TNB under the purview of ST. Aside from enabling the facilities to continue operation beyond its expiring PPA, the latest technology improvements allow higher capacity to be delivered.

Image for illustration purpose only.

6.4 NEW SOLUTIONS AND RESOURCES PILLARS

6.4.1 OVERALL STRATEGY TO 2035

Figure 6-12: New solution and resources initiatives

NEW SOLUTIONS AND RESOURCES INITIATIVES	KEY ACTIONS UP TO 2025	KEY ACTIONS POST 2025
4.1 Explore new RE resources	• Facilitate discussion to explore new RE technologies, resources and solutions for efficient and cost effective RE deployment	• Explore offshore and onshore wind potential and feasibility of wind energy integration
4.2 Roll-out of new solutions to ensure system stability	• Assess required energy storage to avoid curtailment and ensure system stability	• Adopt cost competitive storage solutions in the short term and explore initiatives to develop storage technologies, e.g. green hydrogen in the long term • Determine and implement appropriate deployment strategies for storage systems including decentralized and centralized options

6.4.2 DETAILED KEY ACTIONS UP TO 2025

6.4.2.1 INITIATIVE 4.1 – EXPLORE NEW RE RESOURCES

FACILITATE DISCUSSION TO EXPLORE NEW RE TECHNOLOGIES, RESOURCES AND SOLUTIONS FOR EFFICIENT AND COST-EFFECTIVE RE DEPLOYMENT

Current RE resources that are being utilised within the current programmes including solar, biomass, biogas, hydroelectric and geothermal. Two studies have been conducted to identify up to 229 MW of geothermal potential in Tawau, Sabah, and Ulu Slim, Perak. Given the relative complexity and high capital costs of geothermal projects, it is expected that these resources may be developed only post 2025.

In order to support development of these additional non-VRE resources, given that the RE fund will be fully deployed by 2025, it will be important to set up an auction mechanism outside of the FiT mechanism for geothermal projects. With emerging trend of new technologies, SEDA alongside with Ministry, ST and utilities will facilitate discussion in exploring beyond abovementioned RE resources. Technical and commercial consideration are two crucial areas to ensure the feasibility to embark on new RE resources either under FiT scheme or beyond, to open up new economics sector within the new technologies, and to continue innovative solutions in accelerating the clean energy transition and have better diversification of energy resources in meeting the electricity demand.

6.4.2.2 INITIATIVE 4.2 – ROLL-OUT OF NEW SOLUTIONS TO ENSURE SYSTEM STABILITY

ASSESS REQUIRED ENERGY STORAGE AND GRID FLEXIBILITY TO AVOID CURTAILMENT AND ENSURE SYSTEM STABILITY

Based on a study conducted by DNV-GL for Single Buyer[99], the grid system in Peninsular Malaysia is technically able to accommodate up to 30% solar penetration in the peak demand. The New Capacity Target scenario involves solar penetration well below the 30% limit within the 2025-time horizon.

However, concerns are mounting that some mitigation measures may be needed when solar penetration exceeds 24% of peak demand in the New Capacity Target scenario. The system may become unstable in case solar generation reaches maximum levels in very low demand days (worst case scenario of clear weather throughout Peninsular Malaysia during major national holidays), thereby requiring measures such as energy storage[100].

Up to 2025, solar penetration maintains at 24% only in the scenario. Consequently, minimum additional measures such as energy storage will be required up to 2025, leaving sufficient time for planning and selection of the best options. However, by 2035, solar penetration would have reached 30% for the New Capacity Target scenario in Peninsular Malaysia.

99. DNV-GL, Consultation Services On Renewable Energy Penetration Study For Peninsular Malaysia And Sabah Final Report for Peninsular Malaysia System For The Single Buyer, 2018 (DNV-GL study)
100. Briefing to KeTSA by Single Buyer and the Grid System Operator

In order to select appropriate options to maintain system stability, a study to be conducted to assess the following aspects:

- Feasibility and costs of mitigation through energy storage; this will include an assessment of required energy storage capacity by 2025 and up to 2035, and overall implied costs for this solution. The capacity development plan (2020) has included plans for utility-scale energy storage post 2025 in addressing the higher penetration from solar resources; and
- Additional recommended measures to improve grid flexibility (see Chapter 6.5.2.4 for a discussion of possible measures).

6.4.3 DETAILED KEY ACTIONS POST 2025

6.4.3.1 INITIATIVE 4.1 – EXPLORE NEW RE RESOURCES

Conduct assessment and deployment enablers towards harnessing the geothermal potential post 2025, auctions for identified geothermal capacities could be conducted to support maximization of non-VRE potential in Malaysia. An existing study has identified geothermal potential in Ulu Slim and Tawau. The New Capacity Target scenario expects at least 30 MW of geothermal to be commercially operational by 2035. Assessment on its feasibility and deployment enablers will be continued towards harnessing the geothermal potential.

6.4.3.2 INITIATIVE 4.2 – EXPLORE OFFSHORE AND ONSHORE WIND POTENTIAL

EXPLORE OFFSHORE AND ONSHORE WIND POTENTIAL AND FEASIBILITY OF WIND ENERGY INTEGRATION

As discussed in Chapter 4.1.6, preliminary estimates of wind potential in Malaysia have been conducted. To fully assess the realistic wind potential, further investigation will need to take into account new sites, including offshore locations, their grid connectivity and advances in wind technologies. For offshore sites, bathymetric studies will be needed to determine ocean depths of potential areas. Some of the key points to be considered are as follows:

- **Grid connectivity**; locations with higher wind speed may not be connected to the grid or may be located on islands / offshore with no connectivity to the main grid (e.g., Banggi Island in Sabah);
- **Technology advancements in onshore wind**; Focus on new technologies for low-speed wind turbines;
- **Technology advancements in offshore wind**; Focus on (1) increasing size of offshore turbines allowing greater capacity factors; and (2) new technologies potentially allowing cost-effective deployment in deep-sea areas, including new floating configurations being tested in e.g., Japan;
- **System stability issues** due to variability of wind generation, mitigation measures such as energy storage including green hydrogen could be considered; and
- **Outlook for grid strengthening measures and new interconnection**, especially in Sabah, where current grid is particularly sensitive and isolated.

6.4.3.3 INITIATIVE 4.2 – ROLL-OUT OF NEW SOLUTIONS TO ENSURE SYSTEM STABILITY

At 30% solar penetration level in relatively low demand days such as on weekends, excess solar PV generation may cause some baseload plants to shut down and result in frequency stability issues[101].

Energy storage could be used to mitigate these issues through the following mechanisms:

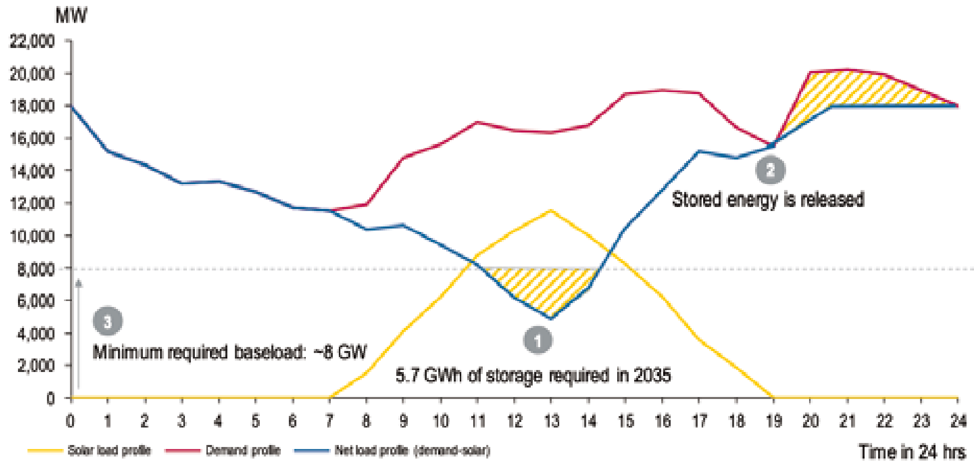
- Avoid reducing online conventional generation, thereby ensuring sufficient spinning reserves, complemented by synthetic inertia to mitigate any frequency drops. In the DNV-GL study, it is estimated that the required level of online conventional generation to maintain system stability is approximately 8 GW;
- Mitigate sharp evening ramp as energy storage will bring down evening peaks and ease the ramping requirement of conventional generation (between 19:00 and 21:00); and
- Avoid solar PV energy curtailment during days of low demand.

Figure 6-13 below has been derived as part of the DNV-GL study's projection for Peninsular Malaysia on a low demand day, illustrating the role of energy storage in modulating the net load profile to integrate high solar PV generation volumes. Based on preliminary analysis, it is estimated that 5.7 GWh of energy storage will be required in 2035 to maintain system stability.

However, it should be noted that a full study is in the pipeline to estimate the required energy storage capacity, as recommended in Chapter 6.4.2.2.

101. DNV-GL, Consultation Services On Renewable Energy Penetration Study For Peninsular Malaysia And Sabah Final Report for Peninsular Malaysia System For The Single Buyer, 2018 (DNV-GL study)

Figure 6-13: Load profiles on low-demand days and role of energy storage under solar PV capacity



Source: SEDA; DNV-GL (2018)

ADOPT COST COMPETITIVE ENERGY STORAGE SOLUTIONS IN THE SHORT TERM AND EXPLORE INITIATIVES TO DEVELOP NEW STORAGE TECHNOLOGIES, E.G., GREEN HYDROGEN IN THE LONGER TERM

As shown in Figure 6-14, battery storage, flow batteries, pumped hydro, and green hydrogen storage cover a wide variety of applications relevant to preserving grid stability in the presence of VRE.

Battery storage is more adapted to relatively smaller scale energy storage and provides quick sub-second response to enable fast ancillary services such as frequency regulation. In addition, rapid decline in battery cost is expected in the next years[102].

Green hydrogen storage is adapted to larger scale applications, such as storing large volumes of excess energy from hydro or wind energy assets for longer periods.

Given the high cost of equipment for hydrogen generation (electrolyzers)[103], economic viability for green hydrogen can only be realized by ensuring high utilization rate of the electrolyzer which requires excess energy for extended periods[104].

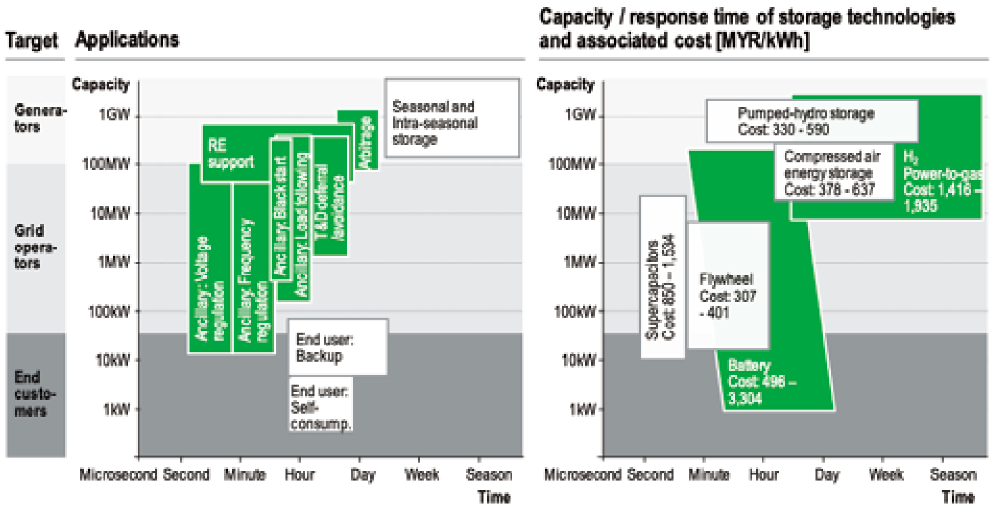
Other energy storage technologies, such as lithium-ion batteries, flow batteries and pumped hydro will be considered in the shorter term, as technology and cost maturity are greater than green hydrogen[105].

Pilot project for utility-scale energy storage have been earmarked in coming years, enabling real-time data to be used in assessing the optimal utilization of energy storage with respect to the current grid operational regimes, and provide insights in developing framework towards adoption of cost-competitive initiatives and deployment strategies for storage systems. Both decentralized and centralized options will be explored to best deploy energy storage systems that suits the grid requirements.

Image for illustration purpose only.

102. Derived from Bloomberg New Energy Finance, National Renewable Energy Laboratory
103. IEA, 2019; alkaline electrolyzer Capex is estimated in the range 500 approximately 1,400 USD/kW. Future prices (post-2030) are estimated at around 450 USD/kW
104. For example, assuming that natural gas prices in Malaysia will reach 9.31 USD/MMBtu in 2035 as per SB projections and 450 USD/kW electrolyzer costs, green hydrogen is price competitive with natural gas only beyond 2,000 hours per year utilization of the electrolyzer which require availability of excess renewable energy for at least 22% of the time in the year
105. IRENA, Electricity storage and renewables: Costs and markets to 2030, 2017

Figure 6-14: Energy storage applications and technologies



DETERMINE AND IMPLEMENT APPROPRIATE DEPLOYMENT STRATEGIES FOR ENERGY STORAGE SYSTEMS INCLUDING DECENTRALIZED AND CENTRALIZED OPTIONS

Two deployment strategies may be considered for energy storage (Figure 6-15):

- **Decentralized approach**: solar PV plants could have their own dedicated energy storage facilities. This would offer more energy storage flexibility and has lower absolute upfront investment cost. However, decentralized energy storage does not allow to leverage on economies of scale, and with multiple storage sites, this approach may increase maintenance costs; and
- **Centralized approach**: “giga-storage farms” could leverage economies of scale and optimize maintenance costs. In this form, energy storage could also be delivered through “storage-as-a-service” business models provided by independent investors / energy storage operators to either solar plant developers or to the grid system operators (See also Chapter 6.5.2.4.) Alternatively, it could also be managed by the grid operators – in this case, investments will be recovered as part of transmission and distribution costs. Another advantage of giga-storage farms is the potential to be retrofitted on retired power plant sites, e.g. coal or gas plants, allowing to leverage pre-existing grid interconnection. In addition, energy storage farms could be integrated with manufacturing and recycling facilities (see case study below).

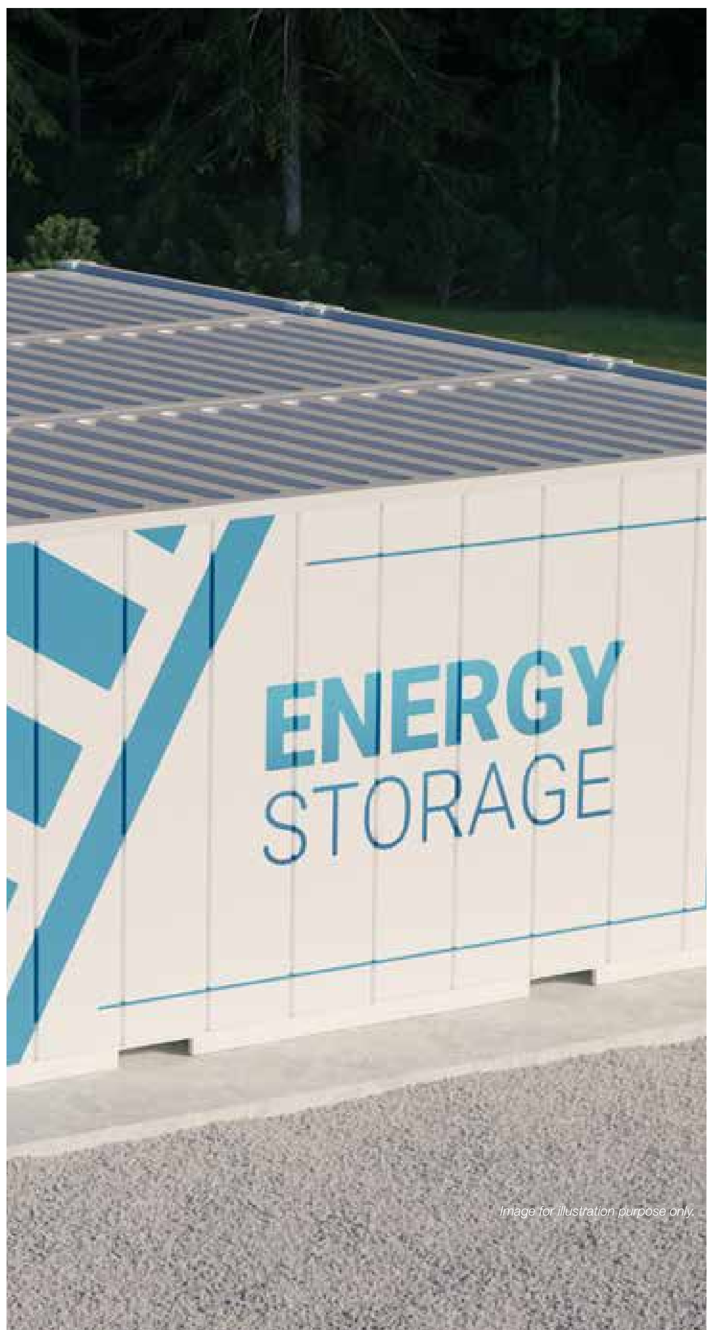


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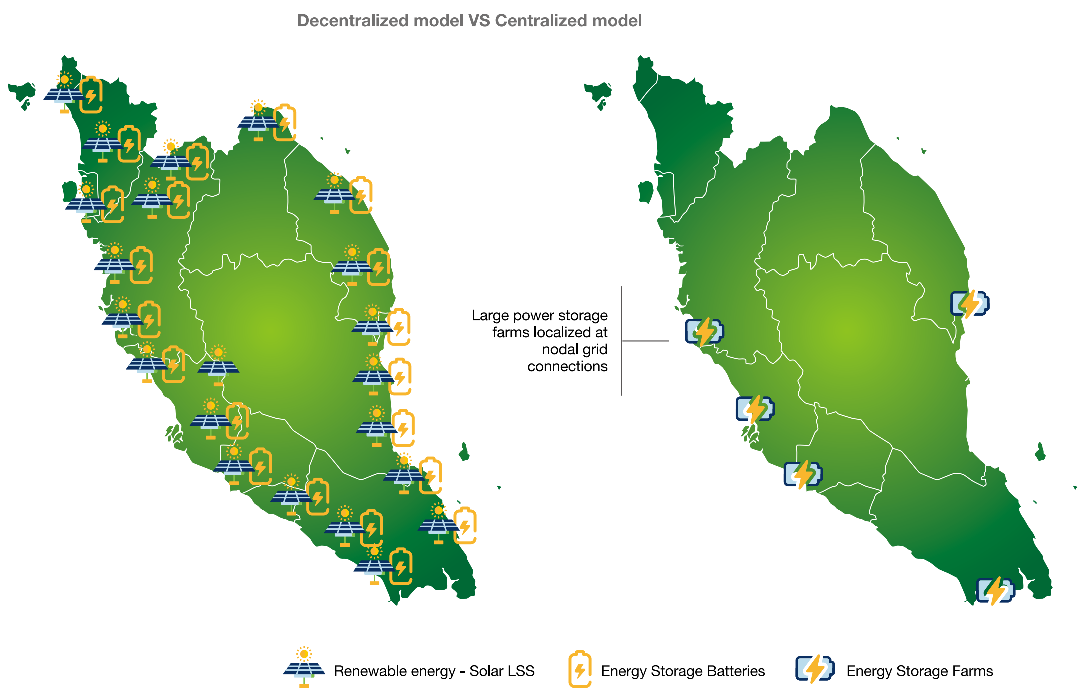
Figure 6-15: Illustrative model for the type of energy storage deployment options



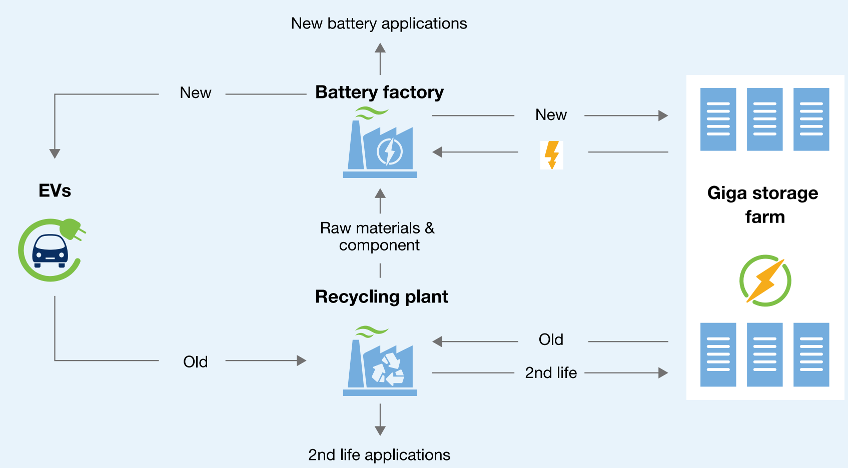
Case study
Illustrative vision for integrated giga-storage farm, battery production / recycling

An integrated giga-storage farm that also hosts a battery manufacturing and recycling site will support the concept of circular economy by integrating end-to-end component of a battery lifecycle.

Utility-scale energy storage could leverage on 2nd life batteries, e.g., EVs that no longer meet the performance standard could be repurposed for use on less demanding application such as for stationary energy storage. The end-of-life batteries from the giga-storage farm could then be recycled onsite to extract raw materials for use in new battery production.

The onsite battery manufacturing plant can leverage on on-site recycled materials in its production, ultimately supplying EVs with newly produced batteries from the integrated plant.

For example, Daimler, together with its subsidiary (Accumotive) and joint ventures (Coulomb and Remondis) designed a value chain to make full use of the battery and to achieve the recycle and reproduction at the end of lifecycle. It can enlarge the eco-friendly feature of EVs while the service life of Li-ion battery will be prolonged as the new stationary battery. In all, it will contribute to a more economical, efficient and cleaner ecosystem of EVs[106].



106. Daimler, 2nd use battery storage, https://www.daimler.com/sustainability/resources/2nd-use-battery-storage.html

6.5 ENABLING INITIATIVES

6.5.1 OVERALL STRATEGY TO 2035

Figure 6-16: Key enabling initiatives

ENABLE INITIATIVES	KEY ACTIONS UP TO 2025
5.1 Future-proofing electricity regulatory and market practices	• Implement Third Party Access (TPA) framework and other measures to facilitate direct procurement of renewable energy through corporate PPAs • Promote retail competition to support customer choice • Large scale adoption of new business models and offtake structures enabled by market reform • Create liquid and vibrant voluntary REC market, including large hydro assets
5.2 Green financing	• Implement best practices to increase level of financial flows towards accelerating RE deployment in energy transition • Enhancement of fiscal and non-fiscal incentives • Leverage on Funds-of-Funds (FoF)
5.3 Public awareness and readiness	• Inculcate RE-centric society • Human capital development: Develop pool of skill and semi-skill RE human resources including financial sector • Coordination of RD&D to strengthen technology innovation • Leverage on 4IR initiatives to digitalization of the power sector encompasses the implementation of distributed energy systems, advanced metering infrastructure, automated distribution, virtual energy trading and smart grids
5.4 System flexibility	• Broad-base deployment of demand side management • Strengthening of the grid through smart grid initiatives • Implement operational measures to manage increased penetration of VRE • Create organized markets allowing third parties to provide innovative grid management solutions • Increase market integration and multilateral power trading framework through interconnections

6.5.2 DETAILED KEY ACTIONS UP TO 2035

6.5.2.1 INITIATIVE 5.1 – FUTURE-PROOFING ELECTRICITY REGULATORY AND MARKET PRACTICES

IMPLEMENT THIRD-PARTY ACCESS (TPA) FRAMEWORK AND OTHER MEASURES TO FACILITATE DIRECT PROCUREMENT OF RENEWABLE ENERGY THROUGH CORPORATE PPAs

Globally, direct corporate sourcing of RE has been on the rise as an alternative to traditional procurement from utilities companies or building with own generation assets. Over 33 GW of PPA deals have been signed globally between 2008-2018[107]. PPAs provide corporations with clean energy while taking advantage on a range of economic, reputational and sustainability benefits, such as long-term electricity price stability.

Global corporate PPA activities are largely driven by the North American market, contributing to over 67% of the 33 GW, followed by Europe, Middle East and Africa (EMEA) at 18%. Asia Pacific (APAC) is estimated to contribute approximately 15%. Corporate PPAs in APAC has been largely driven by PPA growth in India where solar PV costs have already dropped and reliability of supply from utilities remains challenging[108]. Corporate PPAs are also becoming more relevant in SEA, driven by increasing green procurement policies of major corporates.


Image for illustration purpose only.

107. Bloomberg New Energy Finance, Corporate Energy Outlook, 2018
108. IRENA, Corporate Sourcing of Renewables: Market and Industry Trends, 2018

Case study
The rise of corporate PPAs – RE100 Alliance

An RE100 Alliance has been established to pursue corporate renewable procurement. Under the RE100, 242 global and influential companies (as of September 2020) across a wide range of sectors have made a commitment to use 100% renewable electricity. In part driven by RE100 Alliance, SEA has also witnessed a flurry of corporate PPAs.

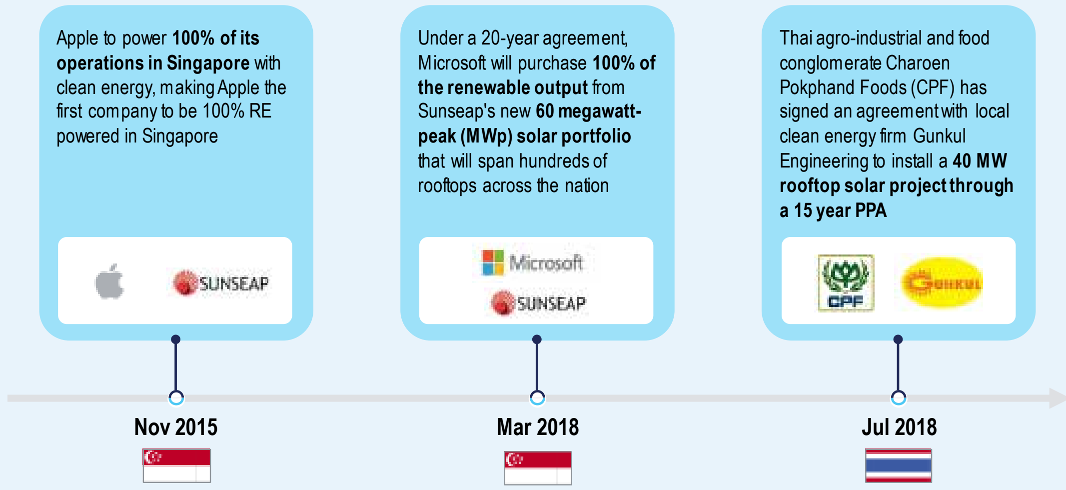
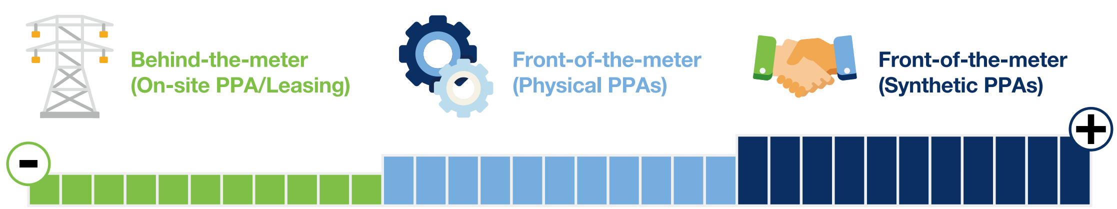


Figure 6-17: Evolution of PPAs



Depending on the level of market maturity and regulatory environment, several types of corporate PPAs are possible, with varying potential to support RE growth.

Under existing regulations in Malaysia, behind-the-meter (BTM) PPAs are already possible. In these schemes, the RE developer can sell power to the off-taker through on-site RE plants. The RE developer can also sell any excess power through NEM scheme, as existing regulations allow export of excess generation to grid.

Third-party access to the grid is required for front-of-the-meter (FTM) PPAs (physical and synthetic). In physical PPAs, the supplier sells power to two off-takers through the RE plant, or portfolio thereof. The imbalance between supplier / off-taker is settled by the utility / retailer, which acts as the balancing responsible party or seller / buyer of last resort. Physical PPAs require grid access and negotiation of balancing fees to be paid by the supplier and/or off-taker to the balancing responsible party. Physical PPAs can enable the implementation of P2P energy trading to complement NEM framework. In the longer term, as competition is introduced in the retail market, new entrants will be allowed to act as balancing responsible parties besides TNB.

In synthetic PPAs, the supplier offers hedging of electricity price to the off-taker through financial contracts. Typically, the PPA price is determined as a contract for differences between an agreed strike price and fluctuating wholesale market price. The physical delivery / off-take is settled by supplier and off-taker independently through wholesale market transaction. This type of PPA is only possible if sufficient liquidity exists in wholesale power markets.

As front-of-the-meter PPAs require utilization of the grid, the RE generator will have to shoulder the grid access tariffs to deliver power to the off-taker[109]. If grid charges are too high, the competitiveness of RE PPAs is hampered. Hence MyRER strongly advocates for moderate grid charges at least in the interim to favour growth of corporate RE procurement.

109. The reverse arrangement is also possible, whereby the off-taker pays energy costs to the RE generator and grid costs to the grid operator

In addition, grid access charges are to be set with a clear and transparent mechanism, and prospective tariffs will remain transparent and be communicated at least for the following three to five years to create certainty for investors.

LARGE SCALE ADOPTION OF NEW BUSINESS MODELS AND OFFTAKE STRUCTURES ENABLED BY MARKET REFORM

Implementation of electricity market restructuring can allow widespread implementation of new business models such as corporate PPAs and virtual energy trading. Introduction of third-party access framework and the expected increasing liquidity of wholesale markets will enable a wide variety of corporate PPA structures, including physical and synthetic contracts. These contracts can be applied across all RE technologies, not only solar PV. Thus, RE projects will be able to access additional sources of revenues.

In parallel, innovative off-take structures such as revenue proxy swaps, may be introduced by market players[110]. These new products will allow better management of uncertainties related to VREs, thereby decreasing the risk of these projects.

Thus, the combination of new income streams and new offtake structures will greatly improve bankability of RE projects, allowing RE development to become increasingly independent from regulatory incentives.

PROMOTE RETAIL COMPETITION TO SUPPORT CUSTOMER CHOICE

In liberalized markets, green tariffs have emerged as way for electricity retailers to differentiate their offerings.

Electricity suppliers purchase RECs for RE generation, bundling them with electricity supply to structure green tariffs for consumers. Hence, green tariffs can generate demand for RECs and consequently support investment in RE generation.

TNB is offering green tariffs to electricity consumers commencing January 2020[111]. The green tariff is priced at MYR 8 sen/kWh and sold in 100 kWh blocks.

Image for illustration purpose only.

110. In the US market these new products are now being developed. See for example "A Better Way For Corporations To Buy Green Power? The Proxy Revenue Swap", Forbes April 8 2019
111. TNB website, accessed at https://www.tnb.com.my/mygreenplus

Case study
Green tariffs - competitive strategies in liberalized energy markets

Green tariffs already exist in Singapore, Australia, and most EU markets, e.g., Germany and the Netherlands. Green tariffs are used by competitive retailers as part of their strategies to differentiate offering.

In 2018, Singapore launched the Open Electricity Market initiative to encourage competition and innovation in the power sector. This has introduced competition in the electricity retail segment that was previously dominated by SP Group. Since the electricity market reform launch, new entrants have utilized green tariffs to differentiate their offerings from competition, setting residential green tariffs at a lower level than regulated tariffs but at a premium compared to non-regulated tariffs.

Residential electricity tariffs offered in Singapore [SGD $ ct/kWh]
.

	Regulated	Non-regulated	Green electricity		
	Conventional	Conventional	Partial solar	100 % solar	Carbon neutral
SPgroup	24.39	N/A	N/A	N/A	N/A
SembCorp	N/A	18.65	N/A	21.40	N/A
SUNSEAP	N/A	18.45	21.61	23.01	N/A
Geneco	N/A	17.78	N/A	22.88	19.26
iswitch	N/A	N/A	N/A	N/A	17.71

In Australia, customers can voluntarily purchase green electricity by paying a premium over the conventional electricity tariff. Both the conventional tariff and the premium depend on the supplier.

Commercial electricity tariffs offered in New South Wales [Australia $ ct/kWh]

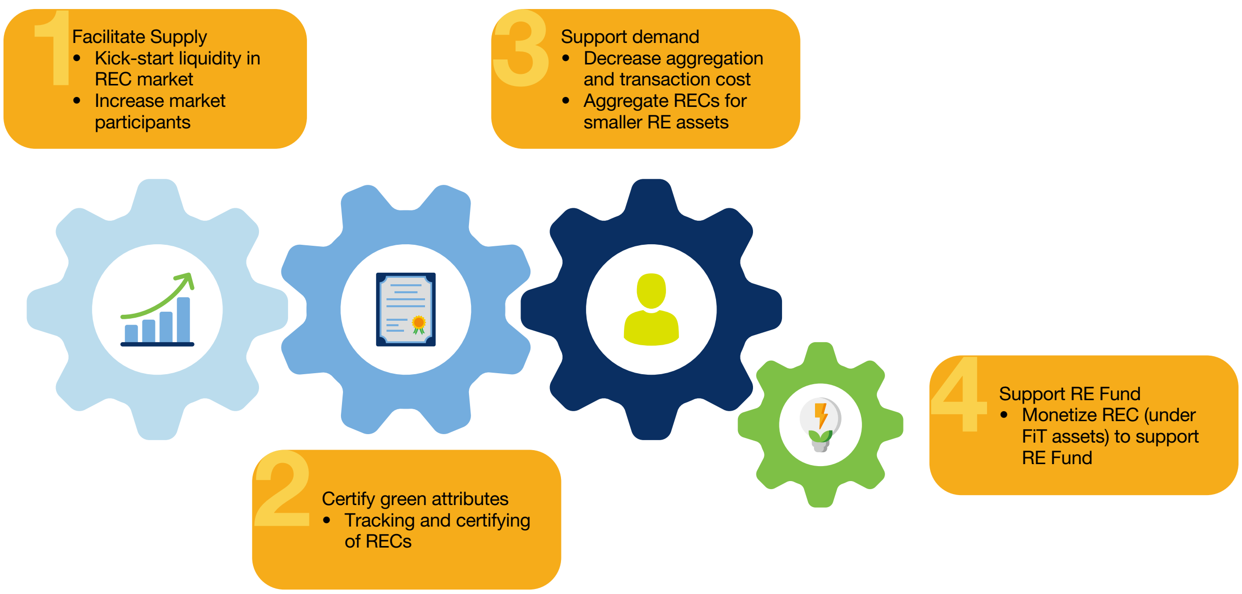
	Conventional electricity [AUD cents/ kWh]	Green electricity [AUD cents/ kWh]	% increase in tariff
EnergyAustralia	27.5	5.0	+18%
agl	27.7	5.5	+20%
red energy	28.4	5.8	+20%
POWERSHOP	30.7	8.5	+28%
Diamond Energy	32.4	5.5	+17%

CREATE A LIQUID AND VIBRANT VOLUNTARY REC MARKET, INCLUDING LARGE HYDRO ASSETS

RECs can facilitate the take-up of corporate PPAs and green tariff programmes while providing additional income streams for RE asset developers. Corporates can utilize RECs to purchase green attributes from RE developers and meet their RE procurement goals. In addition, utilities can utilize RECs to purchase green attributes from RE developers and package green tariffs.

In order to create a vibrant and liquid REC market, a strategy based on four key points is recommended (Figure 6-18). The REC market should incorporate flexible procurement from utilities or mandated party in meeting both public and private sectors demand. In line with the current transition towards sustainability from private sectors, the REC market is expected to be on high demand and will be able to create new trading models.

Figure 6-18: REC strategies



1. Facilitate supply of RECs

Malaysia potentially has huge supplies of RECs for the market. Sources of RECs include (1) hydro assets – mostly owned by SEB, and also by TNB, (2) LSS plants, whose RECs are assigned to TNB, (3) assets under FiT whose RECs are in principle owned by the Government and (4) NEM/SELCO assets whose RECs are owned by asset owners.

In order to enable liquidity of RECs supply, three measures are recommended:

- All renewable assets, including large hydro assets, to be encouraged in generating RECs to initiate market liquidity. For example, in Europe, hydroelectric assets generate about 77% of available certificates. This allowed the certificates market to become very liquid with volumes totaling approximately 500 TWh or 17% of total power consumption in EU 28 countries[112]. In Malaysia, SEB has, at the end of 2019, commenced REC trading for their Batang Ai hydro generations while TNB is monetizing LSS RECs under their green tariff offering to consumers;

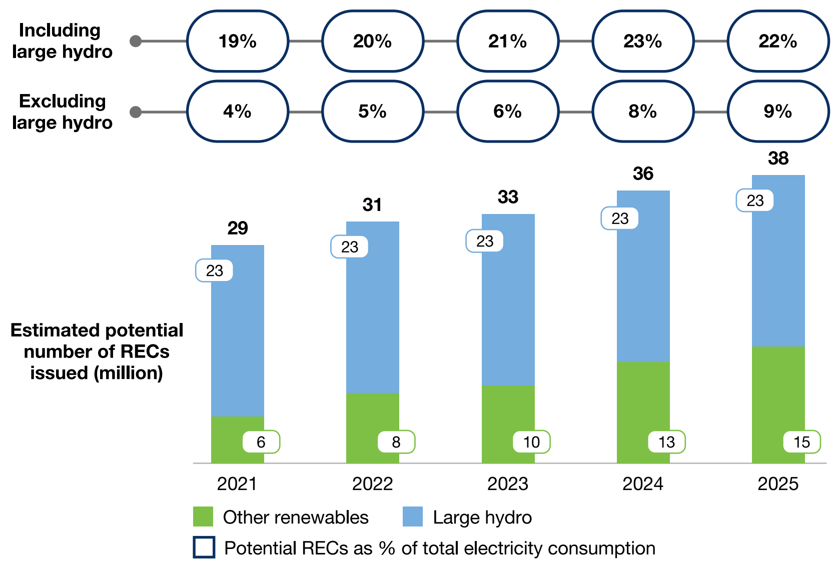
112. Data from Eurostat and ICIS

- The number of REC suppliers to be enhanced. For this, REC ownership for assets that are unsubsidized[113] (e.g. LSS), could be given to the asset owner to further reduce their bid price as the RECs can offer additional source of revenue to the LSS developers[114]; and
- Aggregation of RECs by the off-takers and available market aggregator are encouraged to allow owners of smaller RE assets to issue and monetize RECs. This would allow NEM and SELCO asset owners to issue RECs more easily through market aggregators.

If all renewable assets are leveraged to generate RECs, then the estimated number of certificates issued in one year would be approximately 29 million in 2021, corresponding to 19% of total power consumption in Malaysia, growing to 38 million by 2025 or 14% of power consumption. If large hydro assets are excluded, RECs issuance could still cover 4% of electricity consumption in 2021, growing to 9% by 2025[115].

Image for illustration purpose only.

Figure 6-19: Potential volume of REC generation in Malaysia, 2020-2025 for the New Capacity Target scenario



Note: Excluding peaking plant and off-grid capacities; Assuming 1TWh = 1 million RECs

2. Create a tracking and certification system for green attributes

In order to effectively connect the supply of RECs with demand, a tracking and certification system needs to be put in place to ensure the relevance of green attributes attached with RECs.

Large global corporate buyers often require a certification system to ensure that REC quality satisfies their global standards. Although global standards for REC exist and are promoted by corporates, the Government could play a key role in this area to promote the creation of an REC standard.

As an early mover among ASEAN countries, Malaysia can take the lead in developing an REC standard that may be adopted in the wider ASEAN region and beyond. This would also place Malaysia as prime investment destination in the region for corporates with ambitious RE procurement targets.

3. Support demand

Globally, REC demand is generated by utilities purchasing green attributes to package green tariffs, and for corporates, by purchasing green attributes to meet their corporate ESG goal.

113. For assets owners that already enjoy guaranteed premium off-take through the FiT scheme, allowing REC monetization would result in a "double support" system. Instead FiT RECs could be owned by the FiT programme implementing agency (SEDA) and revenues from sales of FiT RECs could be used to support the RE fund to finance the FiT programme (see point 4 in this Chapter)
114. As of 2018, RECs generated by LSS assets are automatically owned by TNB, not by the respective owners of LSS assets
115. These figures assume plant up of renewables as per New Capacity Target scenario

In Malaysia, TNB has introduced green tariff riders based on green attributes[116] which was announced in October 2019. Promotion of corporates to comply with their ESG goals in Malaysia supports REC demand especially in the interim when third-party access framework is not in place yet and corporate PPAs are limited to behind-the-meter contracts (see Chapter 6.5.2.1).

Prospect to create demand outside of Malaysia can be explored at the ASEAN level through the development of harmonized REC standards among countries to encourage greater RECs trading within the region. The standards should also be expanded to adopt the requirements of RECs by other APAC countries (such as Japan, South Korea, Taiwan) so that the regional market for RECs can be increased.

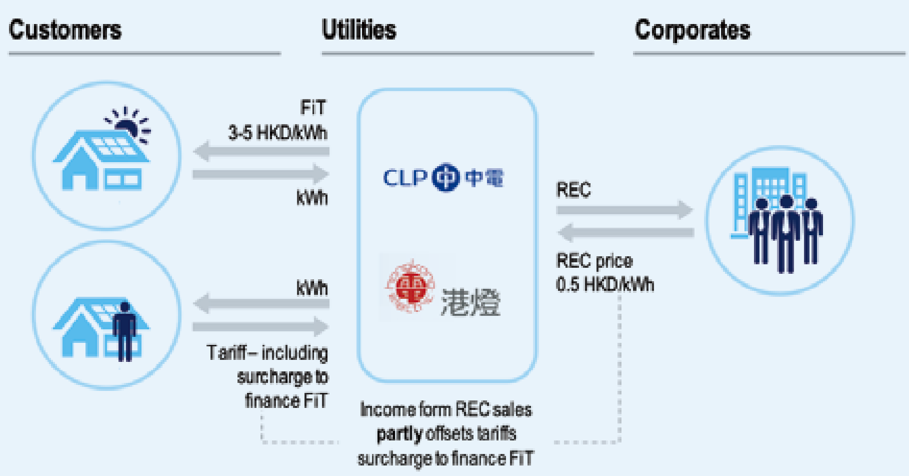
4. Monetization of RECs to support RE fund

Within the framework of a voluntary market for RECs, green attributes could become a source of additional income for the RE fund in addition to the 1.6% surcharge on electricity bills. As FiT asset owners already receive guaranteed offtake at a premium rate, the ownership of the RECs generated by FiT assets is currently being explored to be monetized by the Government and channelled back to the RE Fund for future RE development. A similar scheme was put in place in Hong Kong (see case study below).

Case study

RECs in Hong Kong partly offsets tariff surcharge to finance FiT energy markets

Hong Kong introduced FiT on rooftop solar systems and leverages RECs to partly finance FiT scheme. Customers can sell solar electricity from their own rooftop systems at the FiT rate but are not entitled to own and monetize REC. This allows the utilities, who purchase power generated from rooftop systems at FiT rate to own the RECs to be sold to corporates, which offers additional monetization option from REC sales to partly offsets tariffs surcharge to finance FiT.



6.5.2.2 INITIATIVE 5.2 – GREEN FINANCING

IMPLEMENT BEST PRACTICES TO INCREASE LEVEL OF FINANCIAL FLOWS TOWARDS ACCELERATING RE DEPLOYMENT IN ENERGY TRANSITION

Financing for some RE projects (such as solar PV and small hydro) has improved since the implementation of the FiT scheme. Nevertheless, there are additional improvement areas that have been identified by local financial institutions:

- Lack of understanding of RE project by the financial institutions;
- Existing implementation challenges resulting in track record of construction delays and project default for some RE projects; and
- Bankability of small RE projects whose sponsors are perceived to have lower creditworthiness compared to utility-scale projects.

In response, the Malaysian Green Financing Taskforce (MGFT) led by the Securities Commission of Malaysia was set up to resolve operational issues that are hindering the availability of affordable green financing and develop an ecosystem that will support the growth of a viable and sustainable green economy. In July 2019, eight recommendations from the MGFT were tabled across three core themes:

(1) Process changes, (2) Product, and (3) Education, awareness and knowledge (see case study on next page).

116. Focus Group Discussion

Case study
Summary of Malaysian Green Financing Taskforce recommendations

The MGFT has proposed the following recommendations to address financing issues faced by stakeholders in the RE sector:

- Improve efficiency and clarity of the financing application process: Provide technical specifications and summary reports to financial institutions to improve efficiency and clarity of the process;
- Enhance financial strength of project sponsors: Project sponsor to show evidence or proof of financial capacity at least 20% of the total capital cost;
- Coordinated government interface and targets: Draw up a proposal on facilitation of RE project at state level which will be presented in meeting with Chief Ministers chaired by Prime Minister;
- Streamlining of projects to be channelled to private sector: Categorize project sponsors into distinct categories e.g., by plant size and ability to finance past projects to assist the private sector in assessing the project sponsor and providing the appropriate amount of capital;
- Building supply of dedicated green products: Provide tax incentives, including to residential buildings, and grants as well as enhance current policies to drive supply;
- Financial solutions to meet current financing gaps: Collaborate with Development Financial Institutions (DFI) or financial institutions through a back-to-back funding arrangement, implement RECs, utilize fund-of-funds (FoF) to generate a pooled climate change fund, and formalize access to Green Climate Fund (GCF) to increase financing solutions;
- Enhancing awareness through branding programmes: Introduce national-level branding programmes targeted to corporations, institutional investors, retail investors, and the general public to enhance awareness about the green economy and RE; and
- Centralized Green Financing Center of Excellence: Establish a Centralized Green Financing Center of Excellence to provide education, knowledge, and a platform for collaboration and information sharing regarding the green technologies and RE.

Source: Malaysian Green Financing Taskforce 2019

From the MGFT's recommendations, two key actions are highlighted to improve access to financing for RE projects: fund-of-funds (FoF) schemes involving finance institutions, investors, commercial banks and funds to support RE projects, as well as extending existing incentives beyond 2020. Though this initiative is currently on hold, the recommendations from this task force remains relevant in improving the access to green financing.

LEVERAGE FUND-OF-FUNDS (FOF)

A FoF financing structure creates additional layers between investors and developers, achieving diversification across investors and assets. Financing cost may be reduced, and additional fund may be sourced to support RE development:

- Multiple investors (both public and private) can be pooled together to invest in a portfolio of funds, diversifying investor's risk and insulating investors from project risk;
- Injection of debt through tranches by Multilateral Development Banks (MDBs), Development Financial Institutions (DFIs), institutional investors, commercial banks and even philanthropists funds to lower expected return of total portfolio, thus reducing financing cost for RE developers; and
- Portfolio approach to invest in multiple RE assets across Malaysia and across multiple technologies, achieving diversified the risk exposure.

ENHANCEMENT OF FISCAL AND NON-FISCAL INCENTIVES

The existing GTFS, GITA and GITE programmes are due to expire by 2023. Key proposed measures include:

- Extension of GTFS beyond 2023. Recent launch of GTFS 3.0 driven by Danajamin filled the gaps in previous GTFS 2.0 to allow more attractive financing solutions for available RE resources, with increased allocation on the fiscal incentives;
- Alignment with sustainable financing framework. Engagement with Financial Institutions to address the current concerns and gaps in promoting shift from conventional financing and recognition of RE as an asset class enables better financing option to RE projects;
- GITA and GITE may also be extended to companies offering solar leasing and PPA services.

As of October 2019, Malaysian Investment Development Authority's (MIDA), GITA and GITE have been extended until 2023 under the Budget 2020 announcement.

6.5.2.3 INITIATIVE 5.3 – PUBLIC AWARENESS AND READINESS

INCULCATE RE-CENTRIC SOCIETY

This is to address a society that is currently lacking in awareness of the need to embrace a cleaner form of electricity generation for the purpose of mitigating climate change. This change in society's attitude is important as it means that policies that are politically challenging to implement will have greater acceptance when the public at large understand the rationale behind the policy decision.

HUMAN CAPITAL DEVELOPMENT: DEVELOP POOL OF SKILLED AND SEMI-SKILLED HUMAN RESOURCES INCLUDING THE FINANCIAL SECTOR

As highlighted in Chapter 4, there is a current lack of talent pool within the RE sector. In this regard, human capital development is important to support Malaysia's transition into a RE-centric economy and could be implemented along the following directions:

- **Thought leadership in green energy policies**: Strengthen local institutions, e.g. think tanks or dedicated university departments, focusing on advancing renewable energy policies in Malaysia. These institutions could support human capital development through specific training and research programmes that would allow (1) to develop local energy policy thought leaders; and (2) to attract globally-renowned energy policy thought leaders;
- **RE technology innovation**: Develop structured programmes and industry alliances to support training and research in RE technologies for universities and/or private research institutions;
- **Sustainable pool of local talent**: Develop RE-specific vocational curricula in local institutions to train skilled and semi-skilled human resources, focusing on creating a domestic pool of talent for the EPC, and Operations and Maintenance (O&M) sectors; and
- **Awareness and knowledge building in the financial sector**: In line with the recommendations by MGFT, capacity development in financial sector is needed to enhance knowledge of environmental, social and corporate governance (ESG).

COORDINATION OF RD&D TO STRENGTHEN TECHNOLOGY INNOVATION

RD&D effort in renewable energy and energy transition solutions will be crucial in ensuring future-proofing of the energy transition.

Coordination and collaboration are required between government-funded research bodies, utility companies, industry, start-ups, and venture-capital funds in creating a conducive ecosystem for technology innovation in Malaysia.

Based on the focus ares of MyRER, below is a selection of the most prominent R&D topics. Other topics with high strategic importance for decarbonization but that are not directly supporting the MyRER are not listed here but should be considered in wider R&D strategies for the energy sector (e.g. solar heat integration in industrial processes, bio-fuels for transportation). It is important to note that R&D activity on these topics can be initiated before 2025, however it may continue post 2025.

- RE power generation
  - → High-efficiency and low-emission biomass boilers
  - → WTE technology development
  - → Increasing efficiency of solar PV modules
  - → New materials and designs for floating solar configurations
  - → New materials and designs for rooftop configurations
  - → Development of high efficiency low-head hydro turbines
  - → Low speed wind technologies
  - → Geothermal technologies

- Energy Storage
  - → New battery chemistries and materials
  - → Green hydrogen production through electrolysis
  - → Fuel cells
  - → Other energy storage technologies (e.g. compressed air, heat storage)

- Digitalization
  - → Smart grid
  - → Communication networks and protocols for remote sensors
  - → Cybersecurity
  - → Software development for energy storage system control
  - → Vehicle-to-grid technology development
  - → AI-enabled forecasting

- Technologies supporting systemic efficiency
  - → High-efficiency generation technologies
  - → Low carbon cities and buildings
  - → High efficiency grids (e.g. direct current transmission and superconducting cables)

LEVERAGE ON 4IR INITIATIVES TO DIGITALIZATION OF THE POWER SECTOR ENCOMPASSES THE IMPLEMENTATION OF DISTRIBUTED ENERGY SYSTEMS, ADVANCED METERING INFRASTRUCTURE, AUTOMATED DISTRIBUTION, VIRTUAL ENERGY TRADING AND SMART GRIDS

Fourth industrial revolution (4IR) technologies are key enablers of some of the measures supporting the MyRER. For example, P2P energy trading is enabled by IoT (smart metering) and implementation of peer-to-peer trading protocols using distributed ledger technologies (DLTs) that provide greater data security, transparency and traceability. Distributed energy systems and smart grids rely heavily on IoT for sensing, communication, and control of equipment such as RE generation, energy storage, and grid assets.

6.5.2.4 INITIATIVE 5.4 – SYSTEM FLEXIBILITY

Solar sources can potentially impact grid system stability, due to their fluctuating nature. VREs introduce uncertainties in supply forecasting, making it difficult to control demand-supply balance.

As shown by global examples (see case study below), specific initiatives can be implemented to increase system flexibility and facilitate integration of VREs. Initiatives applicable in Malaysia within the 2025 timeframe are outlined in this Chapter.

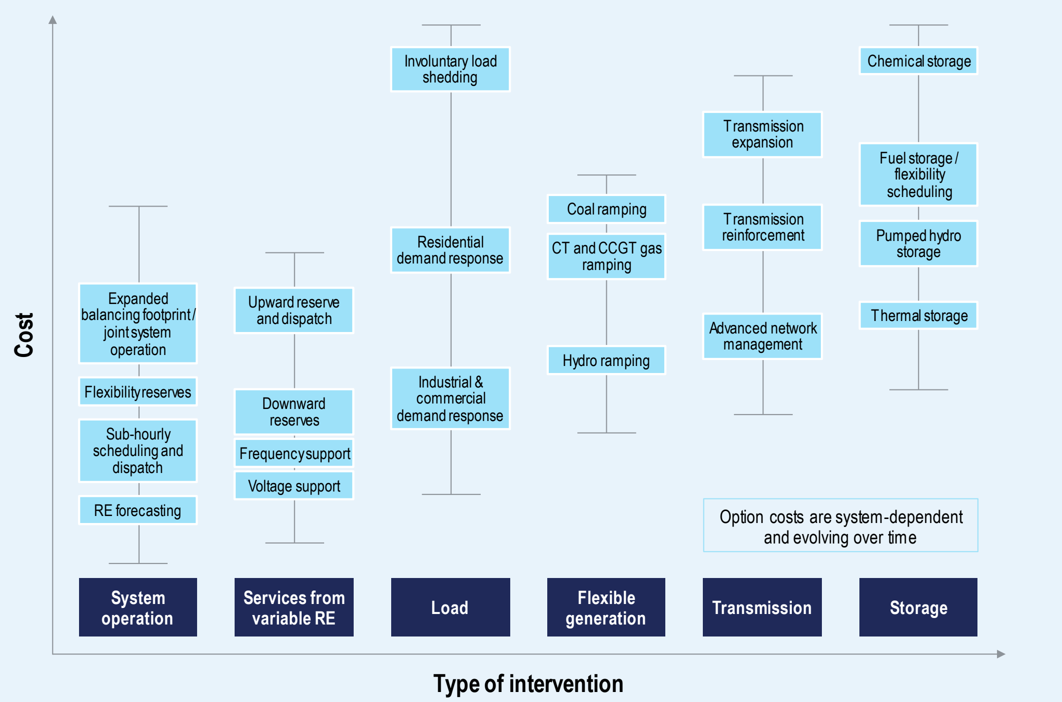
Case study
Measures to cope with high VRE penetration globally

	Germany	California	Hawaii	Spain
Variable RE installed capacity, 2016 [GW]	90.3 GW	19.3 GW	0.99 GW	30.1 GW
VRE penetration out of total installed capacity 2016 [%]	45.8%	22.9%	32.9%	28.5%
Control measures adopted	• Develop interconnection standards • Coordinate grid controls amongst grid operators • Implement VRE forecast • Improve flexibility • Implement balancing market	• Develop interconnection standards • Improve VRE forecast • Improve power system response time • Redesign balancing market mechanism • Integrate battery storage	• Implement renewable forecast program; REWatch • Active reserves allocation • Relax fixed operating schedules thermal plants • Integrate energy storage and demand response	• Develop interconnection standards • Implement VRE forecast • Build new interconnection capacity with France • Implement flexibility programs

Figures below are VRE penetration out of total installed capacity. **If calculated out of peak demand, VRE penetration will be higher**

Ø 33

Source: DNV-GL

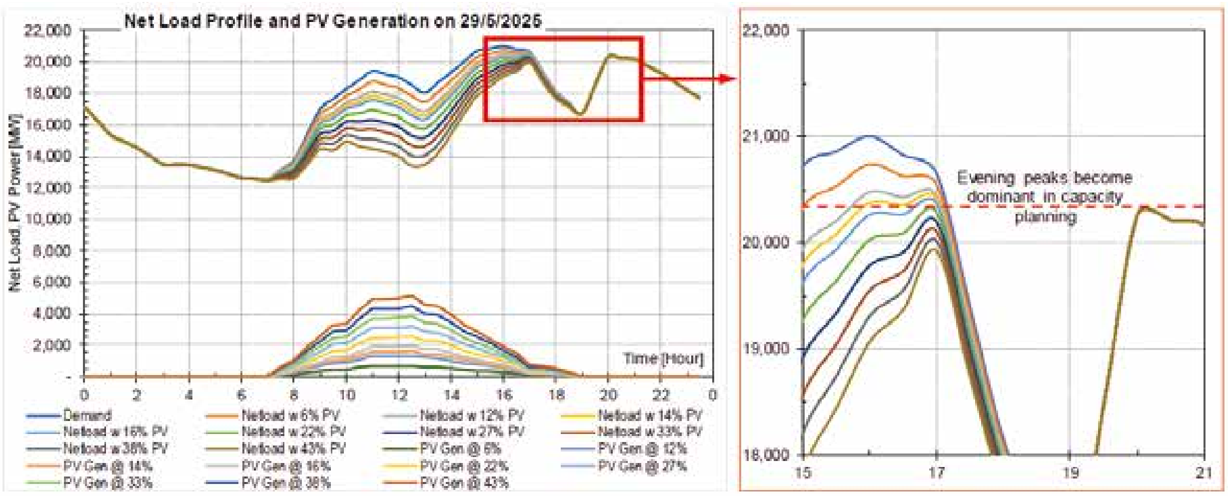


Source: NREL, USAID

BROAD-BASE DEPLOYMENT AND OPTIMIZATION OF DEMAND SIDE MANAGEMENT

In jurisdictions with high penetration of solar at distribution level, the net demand for energy declines during mid-day when solar production peaks. Above a certain level of solar penetration, the main demand peak is shifted from mid-day to evening hours (Figure 6-20). According to simulations by DNV-GL, with PV penetration beyond 22%, the evening peak may become dominant during evening hours and other energy sources will need to be quickly ramped up to meet the peak demand. This requires increased flexibility in the system that can be achieved by installing flexible generation assets (e.g. fast-response gas plants), by deploying energy storage (discussed in Chapter 6.4.3.3), or through demand response.

Figure 6-20: Peninsular Malaysia's load profile at different PV penetration



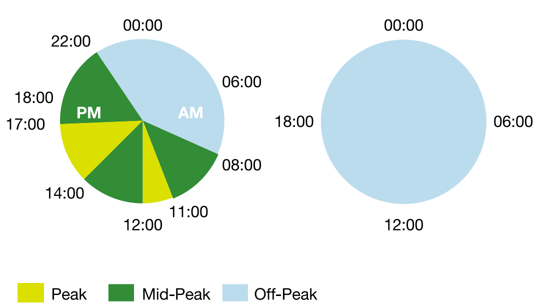
Source: DNV-GL

In terms of demand response, the time-of-use (TOU) scheme is one area of demand side management that could be optimized to shift the TOU peak pricing period to evening hours in order to minimize peak demand and minimize additional investment in peaking capacity and/or energy storage.

The current TOU is available only to C, D and E category commercial and industrial (C&I) customers. TOU could be extended to C&I customers in B tariff category and residential customers (Figure 6-21).

Figure 6-21: Enhanced TOU scheme implemented by TNB

Enhanced Time of Use periods at TNB



- Current peak pricing between 11:00-12:00 and 14:30-17:00
- **Shift TOU peak period to evening hours in line with duck curve** and introduce peak pricing during w-e

Scope of TNB Enhanced Time of Use

Tariff category	Demand charge [MYR/kW/Month]		Energy charge [sen/kWh]		
	Peak	Mid-Peak	Peak	Mid-Peak	Off Peak
Commercial C1 MV ETOU	34.00	28.80	58.40	35.70	28.10
Commercial C2 MV ETOU	48.40	42.60	63.60	33.90	22.40
Industrial D LV ETOU	42.10	37.20	48.40	32.70	24.90
Industrial E1 MV ETOU	35.50	29.60	56.60	33.30	22.50
Industrial E2 MV ETOU	40.00	36.00	59.20	33.20	21.90
Industrial E3 HV ETOU	38.30	35.00	57.60	32.70	20.20

- Scope limited to C&I customers in C Tariff Category and above
- Consider **extending to C&I customers** in B Tariff Category and **residential customers** in parallel with roll-out of advanced metering infrastructure

Source: SEDA; TNB

STRENGTHENING OF THE GRID THROUGH SMART GRID INITIATIVES

The deployment of smart grid technologies is essential for energy transition, and it is an on-going effort by TNB through their investment in the Grid of the Future[117].

These technologies allow more precise monitoring and control of the grid and distributed assets with multiple benefits, for example: (1) allow granular understanding of grid conditions at local level, thereby informing planning of grid strengthening measures and, whenever possible, of VRE deployment;

(2) allow real time monitoring of grid load conditions that can be used to trigger effective mitigation measures in case of events affecting grid stability; and (3) allow incorporation and control of demand-side resources, such as demand response, batteries and others that can be used to increase grid flexibility.

IoT enables aggregation of distributed loads into demand-response pools that can be remotely controlled, thereby creating virtual capacities that can be automatically dispatched for grid balancing or other purposes. Leading demand-response providers in Europe and the US utilize IoT to aggregate and dispatch thousands of industrial and commercial sites under management in different locations and industries, e.g. heavy industry, retail, public buildings, hotels and others. Consequently, demand-response can be scaled up and achieve GW-scale aggregated capacities. In addition, large amount of data collected from connected devices can be examined using big data analytics and from this analysis, forecasts how loads respond to demand-response dispatch signals through AI algorithms.

AI is employed to increase flexibility in demand-response, enabling to deliver "fine-detail" modulation of loads. This is achieved by enabling more accurate forecasting of how different loads respond to a demand-response dispatch signal depending on external conditions (e.g. weather, time of the day, and others). Algorithms incorporating external conditions allow to optimize dispatch schedules and create robust load shedding curves that closely fit grid balancing requirements.

IMPLEMENT OPERATIONAL MEASURES TO MANAGE INCREASED PENETRATION OF VRE

Measure pertaining to grid and generation assets operation may also be implemented to allow better management of increase VRE penetration. These include improvement in demand/supply forecasting, scheduling, and dispatching, as well as flexibility of fossil plants:

- Grid operator to include VRE forecasting and establish a renewable energy coordination and forecast center;
- Establish technical grid and distribution codes for VREs based on global best practices, third-party access framework and network connection rules;
- Improve dispatching of generation by shortening dispatch intervals, e.g. ½ hour intervals;
- Allow updates of generation schedule shortly before dispatch[118]; and
- Increase flexibility of existing fossil fuel plants and plan for the introduction of fast-response gas plants[119].

117. Energy Insider, 2019, accessed at: https://govinsider.asia/smart-gov/malaysia-tnb-fazlur-rahman-smart-grid-renewables/
118. DNV-GL, Consultation Services on Renewable Energy Penetration Study For Peninsular Malaysia And Sabah Final Report for Peninsular Malaysia System For The Single Buyer, 2018 (DNV-GL study)
119. For example, coal ramping, see also "Principles of Energy Storage" by NREL, 2019

CREATE ORGANIZED MARKETS ALLOWING THIRD PARTIES TO PROVIDE INNOVATIVE GRID MANAGEMENT SOLUTIONS

In Malaysia, investment and operation of grid balancing systems is conducted by the grid system operator.

In most deregulated markets, e.g. in Europe and the US, third parties can offer grid balancing services to system operators through dedicated organized markets[120]. Private sector participants compete to provide grid balancing services. By introducing competition, costs can be optimized, and grid operators can then focus on regulation and administration, leaving investment and management of assets for grid balancing to independent third parties.

Another advantage of opening the market for balancing services is to ensure that participants identify and invest in newer, cost-effective and creative solutions or technologies. For example, in Europe and the US, some players already offer balancing services based on energy storage technologies or aggregation of demand-response[121].

Post 2025, in addition to demand-response aggregation and stationary energy storage solutions, provision of grid balancing services through vehicle-to-grid (V2G) technologies by exploiting the increasing penetration of electric vehicles may also become possible.

Following electricity market reform in Malaysia, in the longer-term organized markets could also be set up for the procurement of grid management services fostering roll-out of innovative solutions.

INCREASE MARKET INTEGRATION THROUGH INTERCONNECTIONS

An additional mechanism to improve system flexibility is to increase market integration through interconnections: e.g., integrate Peninsular Malaysia, Sabah, and Sarawak, allowing to export excess RE generation (especially during high RE generation peak) between the regions, thus facilitating demand and supply balancing.

Integration of Malaysia's regional markets also serves to support the ASEAN power grid across the East-West corridor, fostering regional grid stability.

Within the 2025 time-horizon, progress is expected through the planned 50 MW connection between Sabah and Sarawak, which is due to be commissioned in 2022.

Post 2025, integration between regional markets in Malaysia and between Malaysia and ASEAN is one of key areas for assessment and embarkment.

As advocated by the International Energy Agency[122], strengthening of interconnectors capacity between ASEAN member states coupled with increased coordination and regulatory harmonization between regional markets is in plan, and expected to be achieved in order to establish a multilateral power trading framework in the region. Among other benefits, this will allow to integrate higher shares of variable renewable energy in the regional electricity system.


Image for illustration purpose only.

120. Expert interviews
121. For example, ENERNOC (has since been rebranded to Enel X) offers services to grid operators based on aggregation of demand-response from 8,000 Commercial and Industrial customers covering 14,000 sites with a total capacity of approximately 6 GW. See also: https://www.enelx.com/en/stories/2017/08/enernoc-global-leader-in-smart-energy-management
122. IEA, " Establishing multilateral power trade in ASEAN", September 2019

MyRER

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chapter seven

RE 2025 AND 2035 TRANSITION OUTCOMES

RE 2025 AND 2035 TRANSITION OUTCOMES

SUMMARY

This section highlights the transition impact with respect to the energy mix, carbon emissions and socio-econmics benefits. RE resources inclusive of large hydro is defined under this study. However, large hydro is reported under its own category aside from other RE resources to differentiate RE capacity that is market-driven via existing RE programmes (I.e. RE classification) and capacity that is commonly utility-driven (I.e. large hydro classification).

OUTCOMES TO 2025

Up to 2025, 1.2 GW of RE capacity additions are planned to reach the RE 31% target. Increase in RE capacity to meet the 31% target by 2025 does not displace planned non-RE capacity additions, i.e. the non-RE capacity build-up is the same as in BAU scenario.

Increased renewable generation (23% share in the generation mix in 2025, up from 20% in 2021) is expected to displace gas generation (23% share in 2025, down from 24% in 2021) while coal continues to dominate the generation mix (54% share in 2025, down from 56% in 2021).

As RE generation does not displace coal generation, impact on carbon emissions up to 2025 is limited (reduction of 0.4% in the New Capacity Target scenario compared to BAU).

The build-up of RE capacity will support over MYR 19.93 bn of cumulative investment in RE from 2021 to 2025 and result in the employment of about 28,416 jobs in 2025.

OUTCOMES POST 2025

Post 2025, 7.1 GW of coal capacity under existing PPAs is expected to be retired. The New Capacity Target scenario sets a pathway to displace some of the coal capacity with RE and natural gas. RE share in the capacity mix increases to 40% by 2035, natural gas increases to 41% share, while the share of coal drops to 18%.

As a result, RE generation share increases from 23% in 2025 to 27% in 2035, close to coal generation at 27% in 2035. Gas-fired generation increases to 45% of the mix. It is important to note that as technologies evolve enabling greater dispatchability of VRE, successive iteration of the New Capacity Target scenario can be developed, setting higher aspirational targets for RE share while limiting increase in gas-fired generation.

The New Capacity Target scenario drives significant decarbonization, achieving 11% and 13% reduction in carbon emissions versus the BAU scenario in 2035 the power sector in Peninsular Malaysia and Sabah.

Post 2025, aggressive RE deployment in the New Capacity Target scenario results in a cumulative 2026-2035 investment, amounting to nearly MYR 33.07 bn and resulting in the employment of about 46,636 jobs in 2035.

7.1 RE 2025 TRANSITION OUTCOMES

7.1.1 CAPACITY AND GENERATION MIX

CAPACITY MIX

Figure 7-1: Comparison of Malaysia capacity mix for BAU and New Capacity Target scenarios for 2020 and 2025

		Scenario **BAU**	Scenario **New Capacity Target**
Installed capacity	**2020**	**2025**	**2025**
Gas	36%	37%	36%
Coal	37%	32%	31%
Hydro	16%	14%	14%
Others	3%	3%	3%
RE	8%	14%	17%
Total capacity (MW)	**35,983**	**41,029**	**42,292**
RE Share	**2020**	**2025**	**2025**
Malaysia RE share (%)	23%	29%	31%
Peninsular Malaysia solar penetration (%)	N/A	18%	24%

Note: Peninsular Malaysia solar penetration is the ratio of PM's on-grid solar capacity over peak demand (without solar)
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

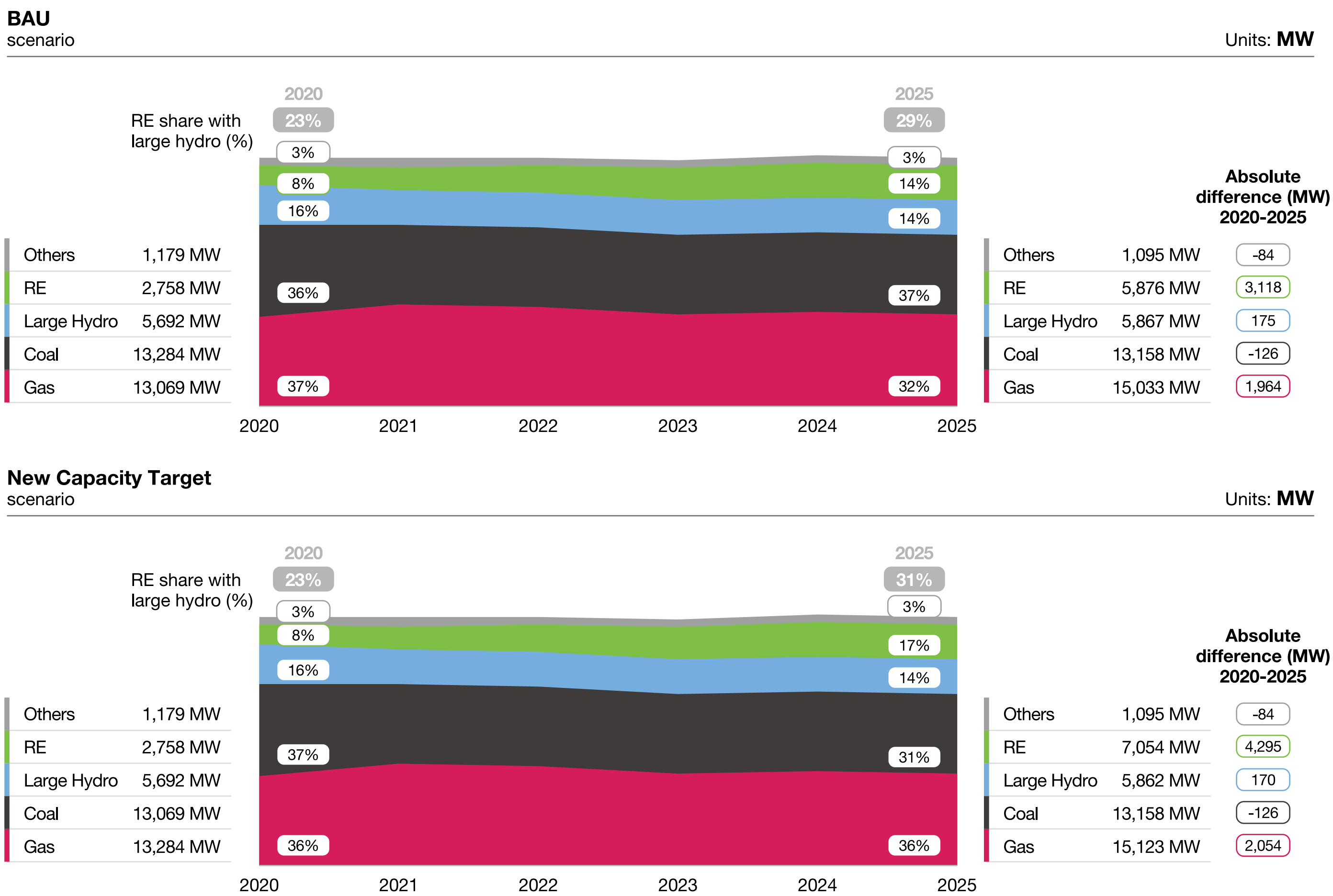
IN NEW CAPACITY TARGET SCENARIO UP TO 2025, ADDITIONAL RE DOES NOT DISPLACE FOSSIL CAPACITIES

As of December 2020, the RE share of installed capacity in Malaysia is 23%. Gas and coal dominate the capacity mix, accounting for 36% and 37% of capacity respectively.

In order to reach the 31% RE mix target in 2025, additional RE capacity build-up is planned alongside existing and committed fossil fuel plants. From 2021 to 2025, 4.5 GW of RE net capacity additions are planned under the New Capacity Target scenarios. In addition, 5.7 GW gas capacity additions are expected within the period of 2021-2025.

In New Capacity Target scenarios up to 2025, there is no displacement of fossil fuel capacities by increasing RE capacity, i.e. the build-up of non-RE capacities is the same as in the BAU scenario.

Figure 7-2: Capacity mix for Malaysia for BAU and New Capacity Target scenarios, 2020-2025



Note: Others includes interconnection, diesel and distillate and industrial heat and process
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

GENERATION MIX

Figure 7-3: Comparison of Malaysia generation mix for BAU and New Capacity Target scenarios for 2021 and 2025

		Scenario BAU	Scenario New Capacity Target
Generation Mix	**2021**	**2025**	**2025**
Gas	24%	24%	23%
Coal	56%	54%	54%
Hydro	16%	15%	15%
Others	0.1%	0.1%	0.1%
RE	4%	7%	8%
Total generation (GWh)	**165,853**	**177,380**	**177,381**

Note: Others includes interconnection, diesel and distillate and industrial heat and process; Figures may not sum to 100% due to rounding
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

IN NEW CAPACITY TARGET SCENARIO WITHIN THE 2025-TIME HORIZON, INCREASE IN RE GENERATION DISPLACES THE HIGHER MARGINAL COST GAS GENERATION, BUT NOT COAL

In 2021, coal contributes more than half (56%) of the generation mix as the key baseload generation fuel with the lowest marginal cost. Gas and RE generation account for 24% and 20% of total generation respectively.

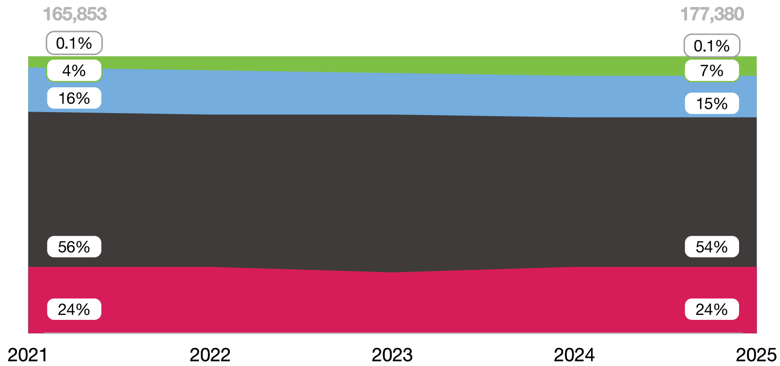
In the New Capacity Target scenario as RE generation increases, it progressively displaces gas generation. This is because gas is the fuel with the highest marginal cost. Gas contribution in the national generation mix declines from 24% in 2021 to 23% in 2025.

However, the increase in RE generation is not sufficient to have a significant impact on coal generation which still makes up more than half of the generation mix, at 54% in 2025. Upon achieving the 31% RE national target in 2025, RE contributes approximately 23% of the generation mix, up from 20% in 2021 (Figure 7-3 and Figure 7-4).

Figure 7-4: Generation mix for Malaysia for BAU and New Capacity Target scenarios, 2020-2025

BAU scenario

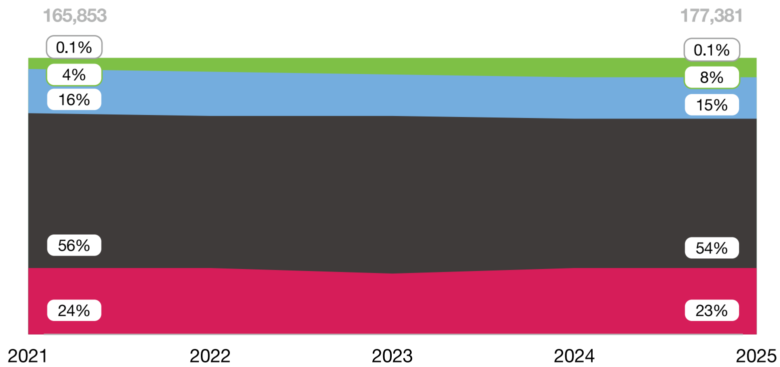
Units: **GWh**



2021	GWh	2025	GWh	GAGR 2021-2025
Others	211 GWh	Others	121 GWh	-13.0%
RE	6,085 GWh	RE	12,450 GWh	19.6%
Large Hydro	26,851 GWh	Large Hydro	29,916 GWh	0.1%
Coal	92,599 GWh	Coal	95,580 GWh	1.3%
Gas	40,106 GWh	Gas	42,313 GWh	0.8%

New Capacity Target scenario

Units: **GWh**



2021	GWh	2025	GWh	GAGR 2021-2025
Others	211 GWh	Others	122 GWh	-14.5%
RE	6,068 GWh	RE	14,724 GWh	24.8%
Large Hydro	26,852 GWh	Large Hydro	29,916 GWh	0.1%
Coal	92,603 GWh	Coal	95,488 GWh	0.02%
Gas	40,101 GWh	Gas	40,131 GWh	0.8%

Note: Others includes interconnection, diesel and distillate and industrial heat and process;
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

7.1.2 CARBON EMISSIONS

Figure 7-5: Comparison of carbon emissions impact for BAU and New Capacity Target scenarios for 2025

	Scenario **BAU** **2025**	Scenario **New Capacity Target** **2025**
Impact of carbon emissions in P. Malaysia		
CO_2 emission (millions tonnes)	**94.67**	**94.20**
CO_2 intensity (tonnes/MWh)	**0.71**	**0.70**
CO_2 intensity (kgCO_2/GDP)	-	**0.071**
Impact of carbon emissions in Sabah		
CO_2 emission (millions tonnes)	**3.51**	**3.53**
CO_2 intensity (tonnes/MWh)	**0.43**	**0.43**
CO_2 intensity (kgCO_2/GDP)	-	**0.040**
Impact of carbon emissions in Sarawak		
CO_2 emission (millions tonnes)	**11.38**	**11.38**
CO_2 intensity (tonnes/MWh)	**0.32**	**0.32**
CO_2 intensity (kgCO_2/GDP)	-	**0.062**

Source: SEDA, ST, SB Peninsular Malaysia, SB Sabah, SESB, MOU, SEB

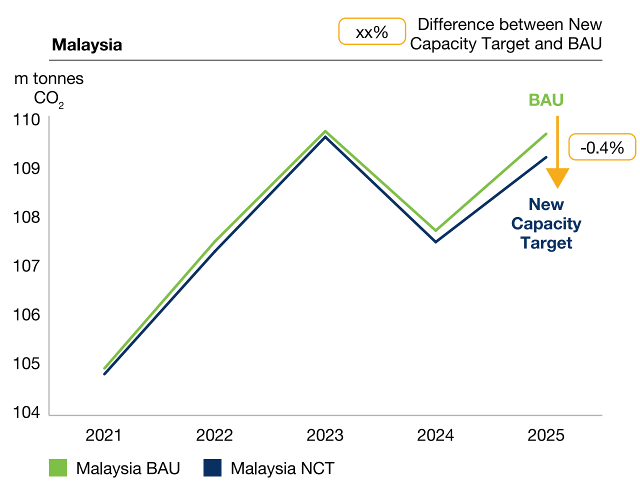
DECARBONIZATION IN NEW CAPACITY TARGET SCENARIO UP TO 2025 IS LIMITED AS RE DOES NOT DISPLACE COAL GENERATION

The New Capacity Target scenario has limited impact on carbon emissions up to 2025.

In total, the New Capacity Target scenario reduces carbon emissions by 0.4% as compared to the BAU scenario.

This is because up to 2025, RE displaces gas generation but does not displace coal generation[123].

Figure 7-6: Total GHG emission for Malaysia for BAU and New Capacity Target scenarios, 2021-2025



Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

123. Intergovernmental Panel on Climate Change, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, 2006; coal has an emissions factor of 96.1 kg CO2/GJ, over 70% more than the carbon emissions factor of natural gas, which is 56.1 kg CO2/GJ; thus, displacing coal has much greater impact than displacing natural gas

7.1.3 SOCIO-ECONOMIC OUTCOMES

THE NEW CAPACITY TARGET SCENARIO GENERATES COMPARABLE SOCIO-ECONOMIC IMPACT BY 2025, SUPPORTING OVER MYR 19.93 BN OF CUMULATIVE INVESTMENT AND 28,416 JOBS

Figure 7-7: Comparison of key socio-economic impact indicators for BAU and New Capacity Target scenarios for 2025

	Scenario **BAU**	Scenario **New Capacity Target**
Cumulative Investment (MYR bn)	2010-2025 **16.12**	2021-2025 **19.93**
Employment Impact (# of Jobs)	2025 **20,385**	2025 **28,416**

Figure 7-8: Cumulative capital investment by technology for BAU and New Capacity Target scenarios by 2025

Cumulative Investment (MYR bn)	Scenario **BAU** **2021-2025**	Scenario **New Capacity Target** **2021-2025**
Biogas	1.51	1.58
Biomass (Agriculture and WTE)	2.37	3.23
Small Hydro	6.01	6.01
Solar Rooftop	1.23	1.23
Solar LSS	5.01	7.88
Geothermal	-	-
Large Hydro	-	-
Total	**16.12**	**19.93**

The cumulative capital investment[124] expenditure in the New Capacity Target scenario from 2021 to 2025 is estimated at MYR 19.93 bn. During this period, investment in LSS assets amounts to MYR 7.88 bn, while small hydro is expected to contribute MYR 6.01 bn in investment.

Biomass, which includes biomass agriculture and WTE, is expected to contribute MYR 3.23 bn, while biogas and solar rooftop contribute MYR 1.58 bn and MYR 1.23 bn respectively.

124. Expert interviews, SEDA, Roland Berger - 1) Cost reduction of approx. 2% applied to solar equipment on a yearly basis; 2) Considers new planted up capacity only

EMPLOYMENT IN RE JOBS

Figure 7-9: Total employment by technology for BAU and New Capacity Target scenarios in 2025

Total Employment (# of jobs)	Scenario BAU	Scenario New Capacity Target
	2025	**2025**
Biogas	4,277	4,559
Biomass (Agriculture and WTE)	7,329	8,129
Small Hydro	3,858	3,858
Solar Rooftop	4,026	4,026
Solar LSS	895	7,848
Geothermal	-	-
Large Hydro	-	-
Total	**20,385**	**28,416**

Implementation of the New Capacity Target scenario is expected to support almost 28,416[125] direct and indirect jobs in the RE sector in 2025.

Direct employment includes jobs related to core activities of RE generation, such as management, corporate and administrative jobs, and jobs in RE plant operations and maintenance[126]. Indirect employment refers to jobs at service and material providers such as fuel supply[127], engineering, procurement, construction (EPC), and equipment manufacturing/preparation. Direct employment depends on cumulative installed capacity, thus tends to increase with increasing RE installed capacity. On the other hand, indirect employment depends on annual capacity additions, hence it can increase or decrease, depending on the rate of deployment of RE capacities.

In the New Capacity Target scenario, biomass power generation is expected to contribute the most to employment with 8,129 jobs in 2025. Solar LSS is expected to be the second biggest employment contributor with 7,848 jobs in 2025, followed by biogas and solar rooftop with 4,556 and 4,026 jobs respectively. Small hydro supports only 3,858 jobs in 2025 as plants require only minimum workforce for operation and maintenance due to availability of automation systems (Figure 7-9).

125. Expert interviews, SEDA, Roland Berger
126. European Union Energy Initiative, The Employment Effects of Renewable Energy Development Assistance, 2017
127. Only applicable to bioenergy

7.2 RE 2035 TRANSITION OUTCOMES

7.2.1 CAPACITY AND GENERATION MIX

CAPACITY MIX

Figure 7-10: Comparison of Malaysia capacity mix for BAU and New Capacity Target scenarios for 2020 and 2035

		Scenario **BAU**	Scenario **New Capacity Target**
Installed capacity	**2020**	**2035**	**2035**
Gas	36%	42%	41%
Coal	37%	24%	18%
Hydro	16%	18%	18%
Others	3%	3%	2%
RE	8%	14%	22%
Total capacity (MW)	**35,983**	**42,983**	**45,588**
RE Share	**2020**	**2035**	**2035**
Malaysia RE share (%)	24%	32%	40%
Peninsular Malaysia solar penetration (%)	N/A	15%	30%

Note: Peninsular Malaysia solar penetration is the ratio of PM's on-grid solar capacity over peak demand (without solar); Figures may not sum to 100% due to rounding
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

POST 2025, THE NEW CAPACITY TARGET SCENARIO SETS A HIGHER TARGET TO REDUCE DEPENDENCY ON COAL THROUGH RE AND GAS

Post 2025, 7.1 GW of coal capacity under existing PPAs is expected to be retired under New Capacity Target scenario, but additional 1.2 GW and 1.9 GW of new gas and hydro capacity are expected to meet the power demand.

The New Capacity Target scenario advocates for no new coal plant up post 2025 and sets to accelerate Malaysia's energy transition by replacing some retiring coal plants with RE and gas-fired capacities.

As a result, in 2035, RE emerges as a crucial component of the capacity mix with 40% share. Natural gas is maintained in the national capacity mix with 41% share, slightly up from 36% share in 2020, while coal contribution in the capacity mix sharply declines from 37% in 2020 to 18%% in 2035.

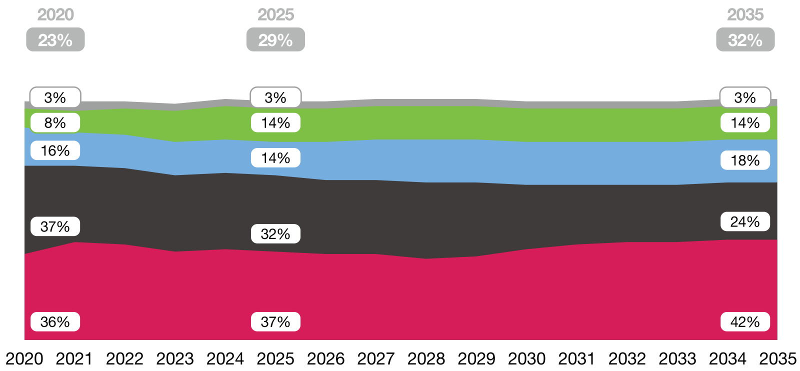
Under the New Capacity Target scenario, RE reaches 40% share in the capacity mix, supporting Malaysia's longer-term vision towards decarbonization of the power sector. Reserve margin in 2035 meets ST's target level to maintain system stability at 20%[128].

128. Assuming a solar capacity credit of 17%

Figure 7-11: Capacity mix for Malaysia for BAU and New Capcity Target scenarios, 2020-2035

BAU
scenario

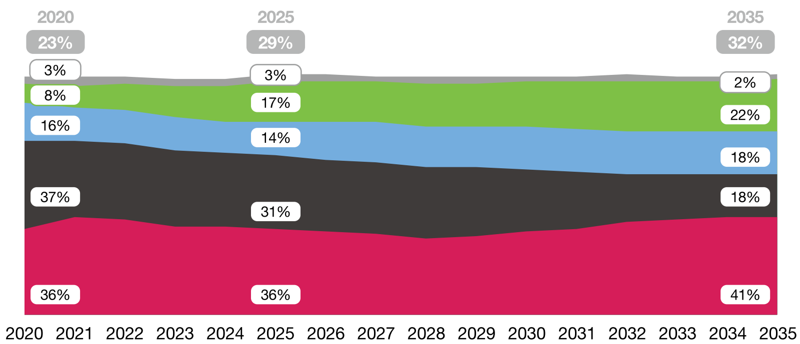
Units: **MW**



	2020	2035	Absolute difference (MW) 2020-2025	Absolute difference (MW) 2025-2035
Others	1,179 MW	1,165 MW	-84	70
RE	2,758 MW	5,991 MW	3,118	115
Large Hydro	5,692 MW	7,754 MW	175	1,888
Coal	13,284 MW	10,104 MW	-126	-3,054
Gas	13,069 MW	17,968 MW	1,964	2,935

New Capacity Target
scenario

Units: **MW**



	2020	2035	Absolute difference (MW) 2020-2025	Absolute difference (MW) 2025-2035
Others	1,179 MW	1,115 MW	-84	20
RE	2,758 MW	9,934 MW	4,295	2,880
Large Hydro	5,692 MW	8,062 MW	170	2,200
Coal	13,284 MW	8,004 MW	-126	-5,154
Gas	13,069 MW	18,473 MW	2,054	3,350

Note: No forecast for Sarawak after 2030, capacity assumed to be constant after 2030; Others includes interconnection, diesel and distillate, and industrial heat and process
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

SUCCESSIVE ITERATIONS OF NEW CAPACITY TARGET SCENARIO COULD PAVE THE WAY FOR HIGHER RE SHARE

The New Capacity Target scenario adheres to SB/GSO's minimum reserve margin requirement to comply with the Loss-of-Load Hours criteria. Due to the low capacity credit of solar, set at 17%[129], gas-fired capacity is required to ensure that the minimum level of 20% reserve margin is maintained.

Post 2025, roll-out of energy storage technologies is expected to enable greater dispatchability of VRE. Combined solar/battery plants may provide flexible and dispatchable solar generation. This would increase the effective capacity credit of combined solar/battery plants limiting the need of additional gas-fired capacity, thus enabling higher share of RE in the capacity mix.

To support this, a study will need to be carried out to determine: (1) capacity credits of combined solar/battery plants to be used in the calculation of reserve margin; and (2) relative cost of meeting minimum reserve margin with combined solar/battery plants versus gas-fired power plants.

Hence, as energy storage technologies evolve and enable greater dispatchability of VRE, successive iteration of the New Capacity Target scenario can be developed, setting even higher aspirational targets for RE share in Malaysia.

129. SB Peninsular Malaysia

Image for illustration purpose only.

GENERATION MIX

Figure 7-12: Comparison of Malaysia generation mix for BAU and New Capacity Target scenarios for 2021 and 2035

		Scenario **BAU**	Scenario **New Capacity Target**
Generation Mix	**2021**	**2035**	**2035**
Gas	24%	41%	45%
Coal	56%	34%	27%
Hydro	16%	18%	19%
Others	0.1%	0.2%	0.1%
RE	4%	6%	9%
Total generation (GWh)	**165,853**	**210,358**	**209,598**

Note: Others includes interconnection, diesel and distillate and industrial heat and process;
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

IN THE NEW CAPACITY TARGET SCENARIO, RE GENERATION ALMOST REACHES COAL GENERATION BY 2035

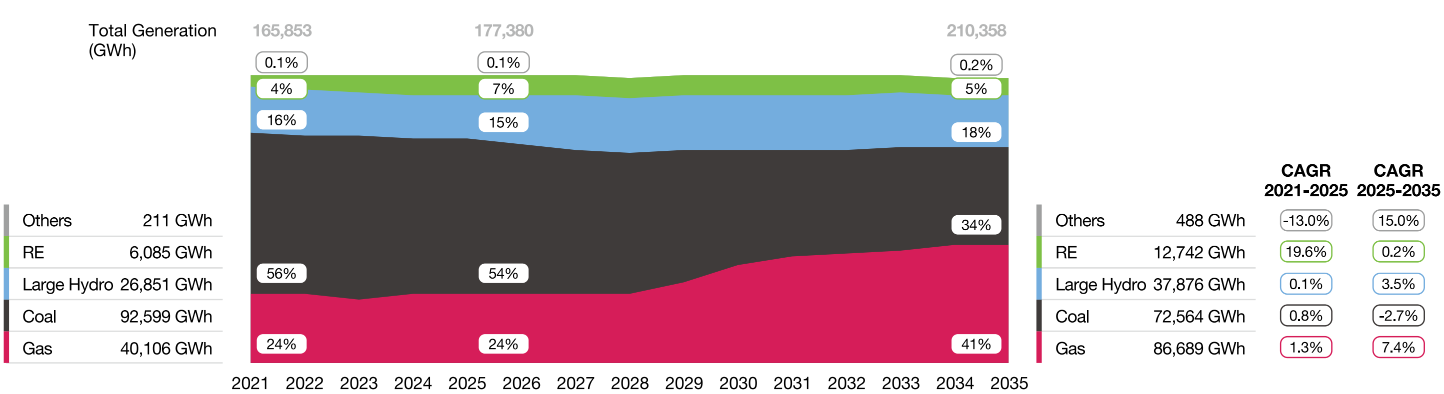
The share of coal in the generation mix drops from 54% in 2025 to 27% in 2035. The decline in coal generation scenario is met by gas and RE that contribute 45% and 27% of the generation mix respectively by 2035.

Image for illustration purpose only.

Figure 7-13: Generation mix for Malaysia for BAU and New Capacity Target scenarios, 2021-2035

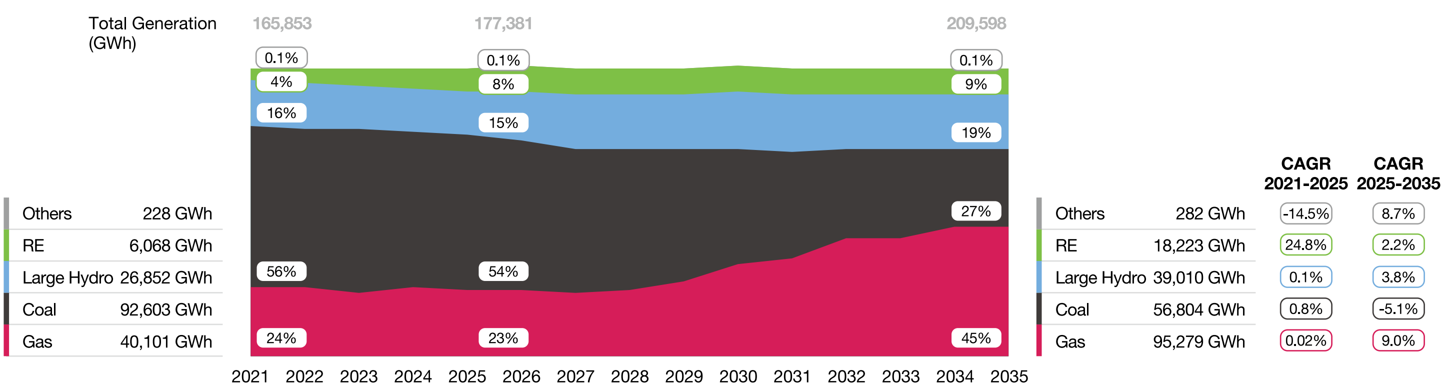
BAU
scenario

Units: **GWh**



New Capacity Target
scenario

Units: **GWh**



Note: No forecast for Sarawak after 2030, generation assumed to be constant after 2030. Others includes interconnection, diesel and distillate and industrial heat and process;

Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

CARBON EMISSIONS

Figure 7-14: Comparison of carbon emissions impact for BAU and New Capacity Target scenarios in 2035

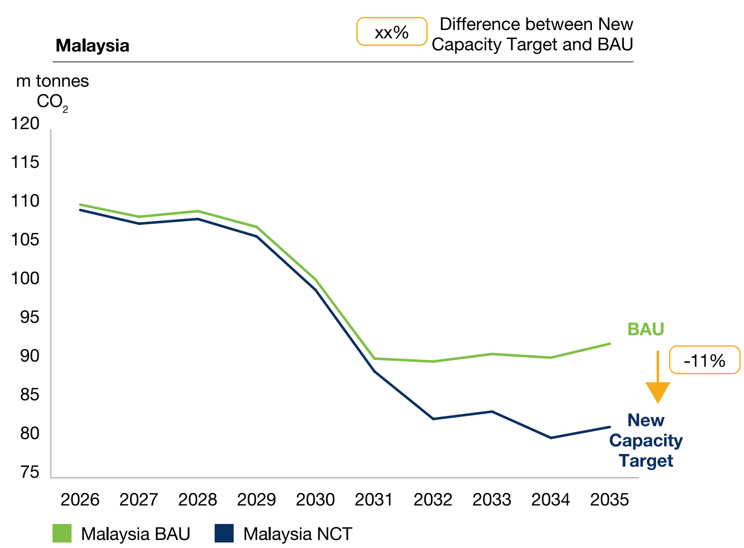
	Scenario **BAU** **2035**	Scenario **New Capacity Target** **2035**
Impact of carbon emissions in P. Malaysia		
CO_2 emission (millions tonnes)	**88.23**	**78.35**
CO_2 intensity (tonnes/MWh)	**0.56**	**0.50**
CO_2 intensity (kg/GDP)	-	**0.039**
Impact of carbon emissions in Sabah		
CO_2 emission (millions tonnes)	**3.56**	**3.10**
CO_2 intensity (tonnes/MWh)	**0.36**	**0.31**
CO_2 intensity (kg/GDP)	-	**0.028**
Impact of carbon emissions in Sarawak		
CO_2 emission (millions tonnes)	**7.76**	**7.76**
CO_2 intensity (tonnes/MWh)	**0.19**	**0.19**
CO_2 intensity (kg/GDP)	-	**0.028**

Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

THE NEW CAPACITY TARGET SCENARIO TAKES LARGE STRIDES IN DECARBONIZING THE POWER SECTOR AFTER 2025 AND SUPPORTS ACHIEVEMENT OF MALAYSIA'S NDC'S COMMITMENT

As a result of displacement of coal generation by RE and gas-fired generation, the New Capacity Target scenario results in 11% emission reduction versus BAU in 2035.

Figure 7-15: Total GHG emission in Malaysia for 2026 to 2035



Note: No forecast for Sarawak after 2030
Source: SEDA; ST; SB Peninsular Malaysia, SB Sabah; SESB; MOU, SEB

Malaysia's NDC commitments is to reduce its economy-wide carbon intensity (against GDP) of 45% in 2030 compared to 2005 level. The corresponding target for GHG emissions intensity of the power sector for Peninsular Malaysia is 0.053 kgCO_2/GDP[130] in 2030 (45% decline from 0.096 kgCO_2/GDP[131] in 2005).

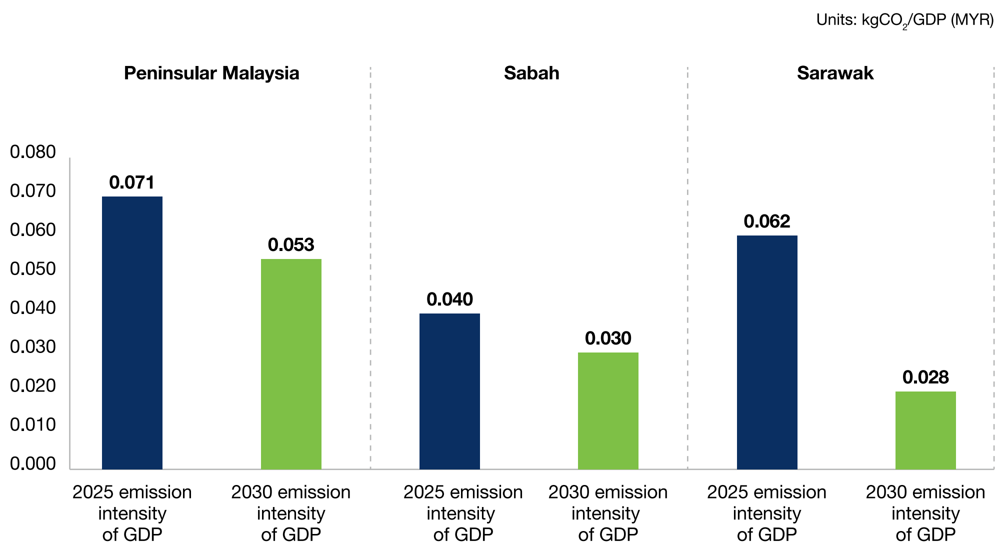
For Peninsular Malaysia, under the New Capacity Target scenario it will achieve a CO_2 emission intensity reduction of 45%, reaching 0.053 kgCO_2/GDP131 in 2030. The BAU scenario will not meet the NDC target (0.054 kgCO_2/GDP[131] emission intensity in 2030). Further decline of 60% (0.038 kgCO_2/GDP) is expected to reach by 2035 due to reduction in coal generation.

For Sabah, initiative identified under the Roadmap is expected to support GHG emission intensity reduction of 41%, reaching 0.03 kgCO_2/GDP in 2030 (from 0.052 kgCO_2/GDP in 2005), post 2025 reduction will increase to 46% as compared to 2005 level.

While for Sarawak, significant carbon intensity reduction has been realized with the commissioning of Bakun and Murum HEP since 2011, reaching 0.062 kgCo2/GDP in 2025 and further reduction of 0.028 kgCO_2/GDP are anticipated as the renewable portfolio increases from current capacity mix to year 2030.

Image for illustration purpose only.

Figure 7-16: Target emission intensity corresponding to NDC



Source: SB Peninsular Malaysia, ST, MoU & SEB

The New Capacity Target scenario supports achievements of the target reduction for the Malaysian power sector by 2030. This creates room to address any possible uncertainties in forecast, such as:

- Discrepancy between 10-year GDP projections and actual GDP evolution; and
- Lower than expected GHG emissions reduction from other sectors that would increase the burden on the power sector to reduce emissions.

130. Total value of the goods and services produced denominated in MYR

7.2.3 SOCIO-ECONOMIC OUTCOMES

THE NEW CAPACITY TARGET SCENARIO SUPPORTS ALMOST MYR 33.07 BN OF CUMULATIVE INVESTMENT IN THE 2026-2035 PERIOD AND OVER 46,636 JOBS IN 2035

Figure 7-17: Comparison of key socio-economic impact indicators for BAU and New Capacity Target scenarios 2035

	Scenario **BAU**	Scenario **New Capacity Target**
Cumulative Investment (MYR bn)	2026-2035 **19.51**	2026-2035 **33.07**
Employment Impact (# of Jobs)	2035 **27,786**	2035 **46,636**

CAPITAL INVESTMENT

Figure 7-8: Cumulative investment by technology for BAU and New Capacity Target scenarios for 2026 to 2035

Cumulative Investment (MYR bn)	Scenario **BAU** **2026-2035**	Scenario **New Capacity Target** **2026-2035**
Biogas	-	1.06
Biomass (Agriculture and WTE)	0	2.00
Small Hydro	0.23	0.66
Solar Rooftop	0.002	2.21
Solar LSS	0.52	3.73
Geothermal	-	0.44
Large Hydro	18.76	22.96
Total	**19.51**	**33.07**

The New Capacity Target scenario supports sustained capital investment[131], in the 2026 to 2035 period. Cumulative investment over this period is estimated at MYR 33.07 bn as compared to BAU scenario at RM 19.51 bn for the same period. Hydro, large scale solar and bioenergy are the largest contributors to investment.

131. Expert interviews, SEDA, Roland Berger - 1) Cost reduction of approx. 2% applied to solar equipment on a yearly basis; 2) Considers new planted up capacity only

EMPLOYMENT IN RE JOBS

Figure 7-19: Total employment by technology for BAU and New Capacity Target scenarios in 2035

Cumulative Investment (MYR bn)	Scenario BAU	Scenario New Capacity Target
	2035	2035
Biogas	3,201	5,313
Biomass (Agriculture and WTE)	6,609	9,082
Small Hydro	1,858	1,934
Solar Rooftop	3,910	9,611
Solar LSS	978	4,239
Geothermal	-	28
Large Hydro	11,230	16,430
Total	**27,786**	**46,636**

In 2035, implementation of the New Capacity Target scenario is expected to generate 46,636 direct and indirect jobs[132], as compared to BAU scenario with only 27,786 jobs.

Large hydro is expected to contribute a total of 16,430 jobs in 2035. Solar rooftop is expected to be the second biggest jobs contributor in 2035 with 9,611 jobs, followed by biomass rooftop with 9,082 jobs, biogas with 5,313 jobs and solar LSS with 4,239 jobs.

132. Expert interviews, SEDA, Roland Berger

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