Solar

RE is still in its early stage in Malaysia, significant attempts have been made to improve and foster the use of RE resources through government policies and programs such as the Feed-in-Tariff mechanism, Net Energy Metering, Large Scale Solar and Self Consumption Programs. The main objective of the implementation of such policies is to encourage communities and individuals to consider RE as an alternate energy source.

Solar is one of the key renewable energy sources focused on by the Malaysian Government to support the country in attaining the renewable energy (RE) installed capacity of 31% in 2025 and 40% in 2035. The RE capacity is targeted at 70% by 2050. The Government has introduced various cost-reducing programs to promote and spearhead the use of solar such as Feed-in-Tariff, Large Scale Solar Photovoltaic (LLS), Net Energy Metering (NEM), Supply Agreement for renewable energy (SARE) and Peer-to-Peer Solar Energy Trading (P2P). In addition, Malaysia also provides financial incentives such as Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE) to attract potential investors and industry players to invest in solar energy and grow the renewable energy market.

The FiT mechanism administered by the Sustainable Energy Development Authority (SEDA) was designed to correspond to the National Renewable Energy and Action Plan (2010), that suggested the requirement of legislative solutions to increase the renewable energy share in Malaysia's energy mix. The types of resources included in the FiT mechanism are biogas, biomass, hydropower and solar photovoltaic power.

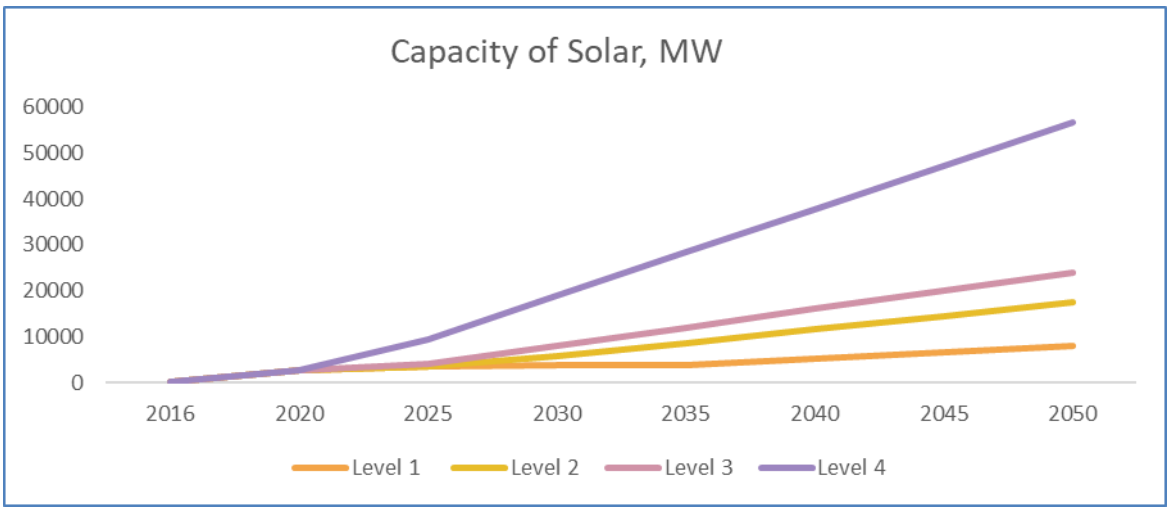
In the base year 2016, the share of solar was only 0.9% in the generation mix, which has an installed capacity of 290MW.

Level 1
By 2050 it is assumed that the share of solar increased to 11.16% or 7.96GW based on government announcement in 2018 on 31% RE in capacity mix by 2025.

Level 2
Planning and Implementation Committee for Electricity and Supply Tariff of Malaysia (JPPPET) had conducted analysis on demand and supply for 5 to 20 years of generation development. Based on this planning, it is assumed that by 2050, the share of solar will increase to 21.37% or 17.5 GW .

Level 3
It is assumed that by 2050, the installed capacity for solar is 24 GW which is 21.67% in capacity mix . It was assumed the demand for solar will decrease by penetration of new RE sources in Malaysia such as wind, wave, OTEC and hydrogen.

Level 4
By 2050, it is assumed that the share of solar will be 33.33% or 56.62GW. With the cutting edge R&D and green technology commercialisation, more new RE resources will be introduced in generation mix of Malaysia.



Wave / Tidal / OTEC / Geothermal / Hydro

Malaysia has a long coastline with great potential to harness waves and tidal current energy from the ocean for electricity generation. Ocean energy can be categorised as tidal barrage, tidal current energy, wave energy, ocean thermal energy conversion (OTEC) power, and salinity gradient power.

Using waves or tidal as a source of renewable energy offers significant advantages. Sea waves offer the highest energy density among renewable energy sources. Electricity can be derived by harnessing the kinetic energy in the tidal stream current, namely tidal current energy.

The potential energy associated with tides can be harnessed by building barrage or other forms of turbine-equipped construction across an estuary. While the potential energy associated with ocean waves, primarily in the Straits of Malacca and the South China Sea possibly be harnessed using modular technologies such as Oscillating Water Column (OWC) devices. Ocean thermal energy conversion (OTEC) uses the temperature difference between the warm surface of the ocean and the colder layers underneath. Solar heating in the temperature gradient between the hot and cold seawater can harness significantenergy potential.

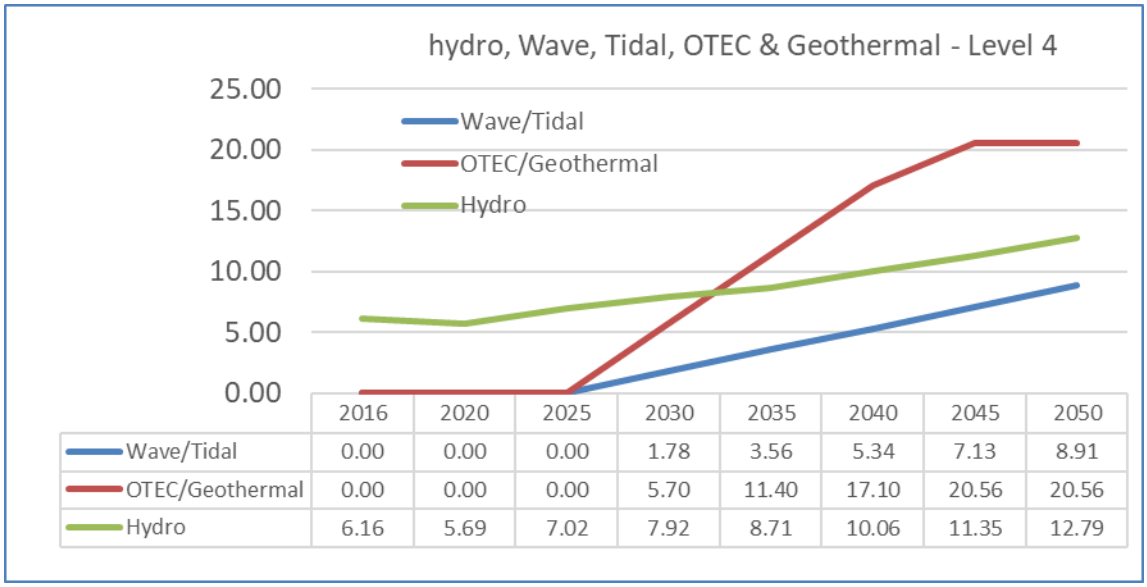
Some studies shows Malaysia has potential in wave and tidal and research activates are undergoing. In 2016,
there were no energy generated from wave or tidal in Malaysia.

Level 1
By 2050, it is assumed, hydropower capacity i s 12.79 GW and Wave, tidal current , Geothermal and OTEC technologies are yet to be commercialised in Malaysia.

Level 2
By 2050, hydropower capacity remain as 12.79GW and wave energy and tidal current technology in Malaysia have yet to be commercialized, research activities are undergoing at local universities. Hence, in 2050, there is no energy produced from wave, tidal, geothermal or OTEC.

Level 3
By 2050, wave/tidal and geothermal/OTEC technology are introduced in Malaysia with total installed capacity about 4.33GW, and 15.6GW respectively.

Level 4
Government policies on emission free electricity generation accelerate the uptake of wave and tidal energy. It is assumed the installed capacity will be 12.79 GW for hydro, 8.91 GW for wave & tidal, 20.56 GW for OTEC / geothermal by deploying global technologies in Malaysia.



	2016	2020	2025	2030	2035	2040	2045	2050
Wave/Tidal	0.00	0.00	0.00	1.78	3.56	5.34	7.13	8.91
OTEC/Geothermal	0.00	0.00	0.00	5.70	11.40	17.10	20.56	20.56
Hydro	6.16	5.69	7.02	7.92	8.71	10.06	11.35	12.79

Offshore & Onshore Wind

Wind energy can be one of the significant resources to complement solar power for the electricity supply in Malaysia. The potential wind energy can be generated from onshore and offshore facilities and incorporated into solar standalone PV systems. Several pilot projects of wind power plants have been constructed in Malaysia in Pulau Layang- Layang and Kudat (Sabah), Pulau Perhentian and Setiu (Terengganu), and Kuching (Sarawak) to supply the electricity in remote areas.

However, Malaysia is situated in a low wind speed region and faces more significant challenges in developing wind energy.

The availability of wind energy in Malaysia has allowed the application of wind energy in Malaysia feasible. In Malaysia, most of the areas in the mainland experience low wind speed. Research are undergoing is islands of Malaysia

Research on wind mapping is currently undergoing to measure the mesoscale wind using more advanced and higher wind mast. The wind speed has an average value of 2 - 8 m/s and can vary according to the monsoon conditions and sites for measurement. In peninsular Malaysia, Mersing, Johor and Kuala Terengganu have been identified as high wind areas, whilein East Malaysia, Kudat and Sabah arethe highest wind potential areas.

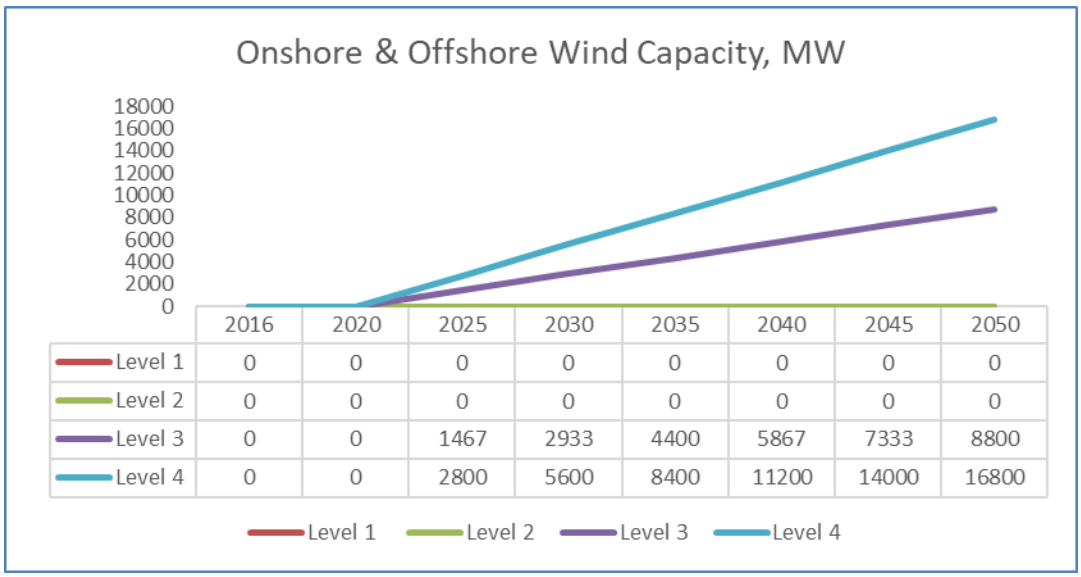
In 2016, there is no electricity produced from wind.

Level 1
Strong winds in the east coast of Peninsular Malaysia and some parts of Sabah and Sarawak indicate some feasibility but thereis no energy generated from wind.

Level 2
In Malaysia, wind turbines that are built and integrated on high-rise buildings as hybrid systems have good potential. The research institution of higher learning are conducting research on the potential of wind energy in Malaysia. There is still no wind energy in generation mix of Malaysia by 2050.

Level 3
By 2050, offshore wind energy will be built as part of the RE capacity mixed. It is assumed that the installed capacity for wind energy will be 8.8 GW.

Level 4
Level 4 assumes that by 2050 , onshore and offshore wind energy will be built with a total of 16.8 GW.



	2016	2020	2025	2030	2035	2040	2045	2050
Level 1	0	0	0	0	0	0	0	0
Level 2	0	0	0	0	0	0	0	0
Level 3	0	0	1467	2933	4400	5867	7333	8800
Level 4	0	0	2800	5600	8400	11200	14000	16800

Nuclear

Nuclear power is a mature technology. Nuclear energy resource can help in supplying non-carbon electricity for the medium-term action plan since other alternative resources might take a longer time to be developed. Hence, nuclear energy can ease the reduction of fossil fuel consumption.

Malaysia has never had a nuclear power plant (NPP). Malaysia's experience with nuclear energy is primarily with a small Triga Mark-II 1.0 MWt research reactor commissioned in 1982. It is noted that there are major challenges in the development of nuclear power in Malaysia.

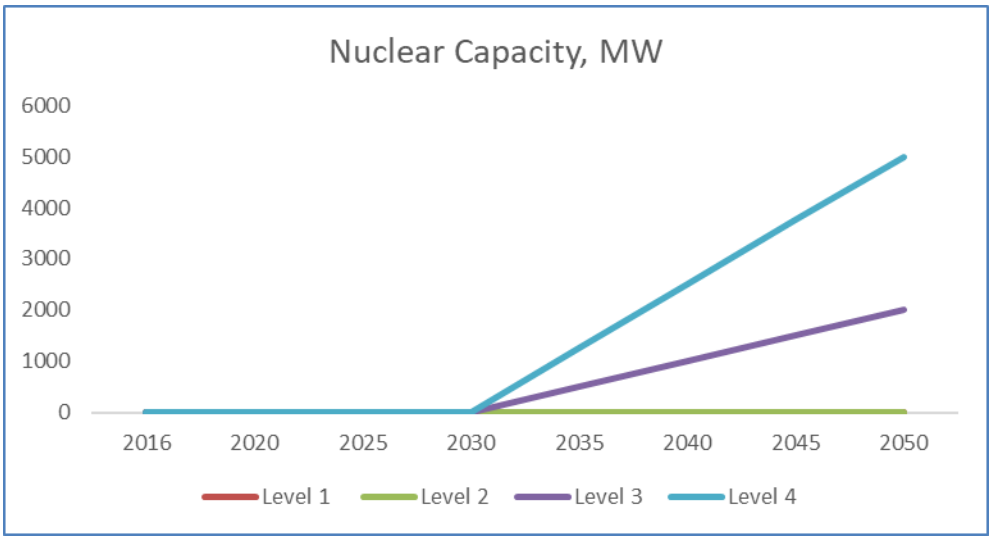
In year 2016, the public is still not accepting nuclear power due to safety issues coupled with Fukushima incident.

Level 1
Government is not favourable in developing nuclear power. By 2050, there is no electricity generated from nuclear power.

Level 2
By 2050, is it assumed there is no nuclear power due to public concern.

Level 3
The first nuclear power reactor with a total capacity of 2.0 GW will be constructed by 2050.

Level 4
With Government concern and national public opinion, nuclear power reactor with a capacity of 5.0 GW will be constructed by 2050.



Biomass & Biogas

Biomass is defined as non-fossilised and originating from indigenous plants animals and micro-organisms including but not limited to products biodegradable organic material by-products residues and waste from agriculture industrial and municipal wastes originating from Malaysia. Sources of biomass are wood and waste wood, leaves and plants, agriculture waste and municipal solid waste.

Biogas technology refers to systems that are designed to turn organic waste products into usable energy. Biogas typically consists mainly of methane, with a significant proportion of carbon dioxide, and smaller quantities of other gases such as nitrogen and hydrogen. Biogas can be produced utilizing anaerobic digesters. A biogas plant can be fed with energy crops such as sludge municipal solid waste and biodegradable wastes. Landfill gas is produced by wet organic waste decomposing under anaerobic conditions in a landfill.

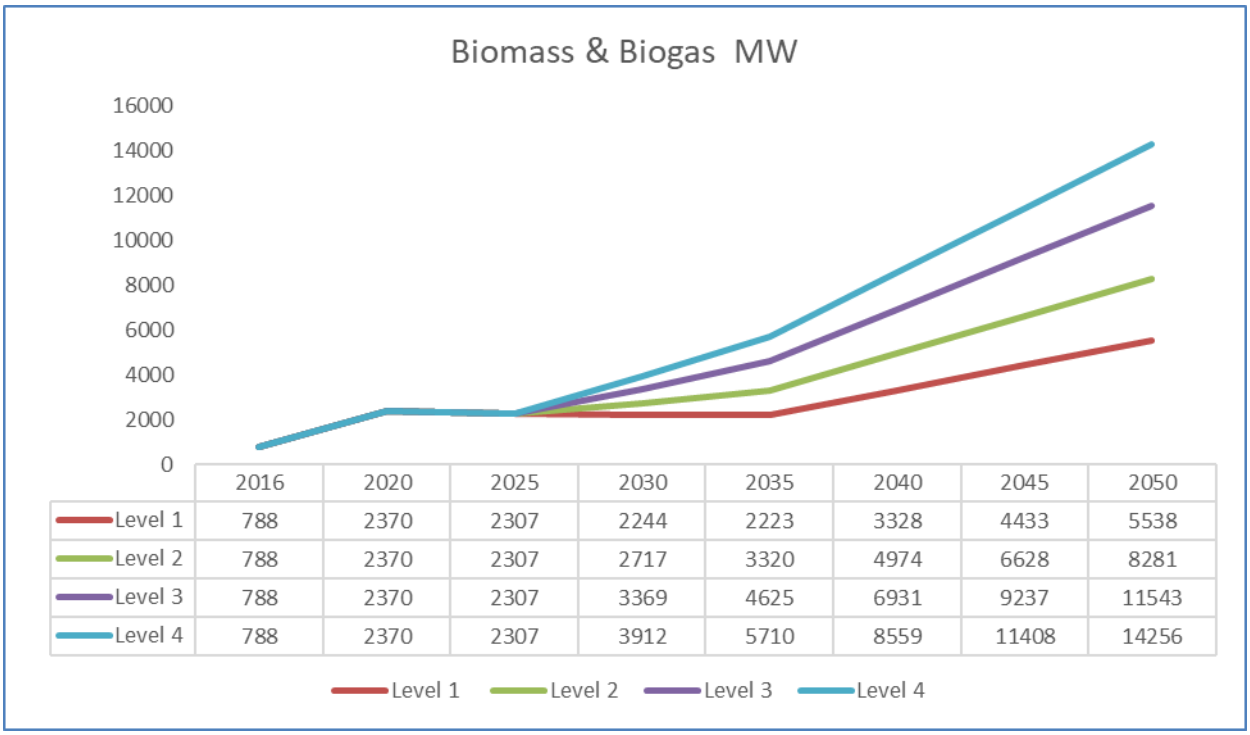
In Malaysia, bioenergy has a direct impact on the demand for biomass & biogas. In 2016, nearly 0.84 GW electricity i s generated by biomass & biogas sources. in general, palm oil waste accounts for 94% of biomass feedstock while the remaining contributors are agricultural and forestry by-products, such as wood residues (4%), rice (1%), and sugarcane industry wastes (1%).

Level 1
Currently, concerted efforts and various biomass energy programs are supporting by the government for development, demonstration and commercialization such as Feed-in-tariff (FiT) mechanism. By 2050, i t i s assumed that a total of 5.54GW biomass & biogas installed capacity will be installed.

Level 2
Based on the sustainable development framework for bioenergy in Malaysia, it is assumed by 2050, Malaysia will installed a total of 8.28GW biomass and biogas plants.

Level 3
It is assumed by 2050 the bio-energy installed capacity will reach 11.54GW as planned in the policy suggestions on the sustainable development framework

Level 4
By 2050, a more ambitious target with bioenergy installed capacity of 14.26 GW will increase the percentage of RE penetration to 76.49%



	2016	2020	2025	2030	2035	2040	2045	2050
Level 1	788	2370	2307	2244	2223	3328	4433	5538
Level 2	788	2370	2307	2717	3320	4974	6628	8281
Level 3	788	2370	2307	3369	4625	6931	9237	11543
Level 4	788	2370	2307	3912	5710	8559	11408	14256

Gas with CCS

Energy security has always been an important issue highlighted by various agencies in supporting Malaysia's socio-economic growth trajectory towards becoming a high-income nation. However, the underlying concerns in Malaysia with respect to its National energy security Is on how to ensure a continuous supply of the energy at affordable prices as a result of depleting Indigenous oil and gas resources in the country.

In order to build a sustainable, greener environment in energy platforms for growth, it is important to manage Malaysia's high dependence on fossil fuels. Therefore, moving towards cleaner power generation such as advanced efficient coal and gas power plant (i.e., Ultra Supercritical boiler for coal power plant and H-Frame turbine for gas power plant technologies) with carbon capture and storage technology and, simultaneously intensifying the electricity generation development of 20-30% of Renewable Energy.

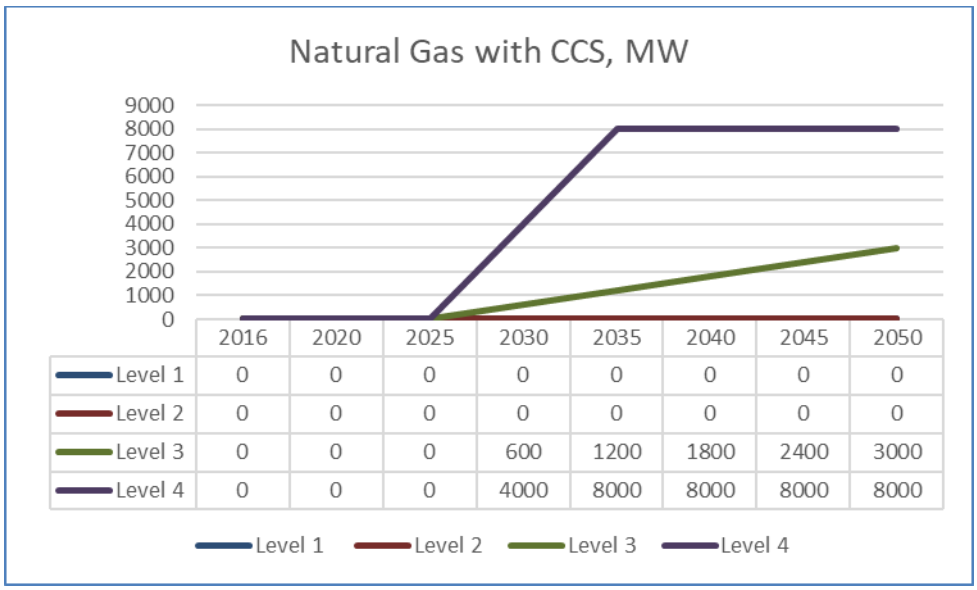
In Malaysia, Natural Gas is widely used energy industries and for industrial activities such as the production of steel, glass and ceramics. In 2016, Malaysia depending on fossil fuel to generate electricity. There are 14.2 GW of CCGT and OCGT power plants installed without CCS technology

Level 1
By 2050, there is no gas plant with CCS technology

Level 2
With the government 30% RE shares in generation mix, there will no natural gas power plant installed with CCS technology

Level 3
It is assumed more RE technologies will be deployed. Hence, it is expected 3.0 GW natural gas plants will installed with CCS technology by 2050

Level 4
New RE sources such as wind, wave and tidal current, OTEC, hydrogen and nuclear will replace natural gas and coal. Malaysia will generate carbon-free electricity by 2050 with installing of 8GW natural gas plants with CCS technology.



	2016	2020	2025	2030	2035	2040	2045	2050
Level 1	0	0	0	0	0	0	0	0
Level 2	0	0	0	0	0	0	0	0
Level 3	0	0	0	600	1200	1800	2400	3000
Level 4	0	0	0	4000	8000	8000	8000	8000

Storage System technologies

The storage system of electricity allows an oversupply of electricity generated in the daytime to be stored and used in the nights when demand is highest. An over-supply in the summer could be due to the generation of electricity from solar panels (or other renewables) exceeding the demand. During the wet season, the lower radiation that supply from solar panels is lower at the same time as demand for electricity for li ghting and cooling is higher. Battery storage allows electricity demands to be met that would otherwise be wasted.

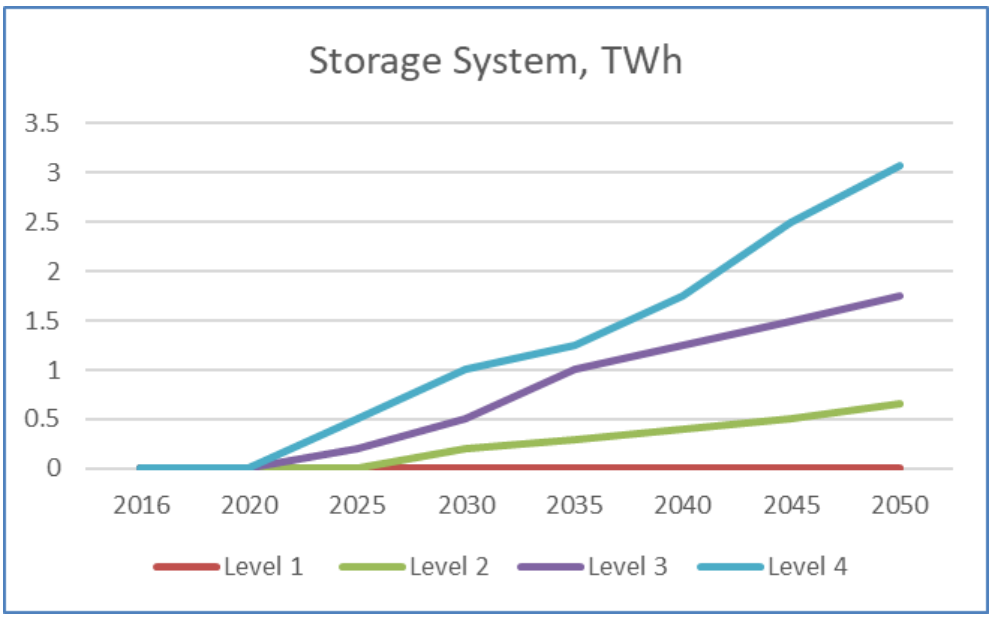
In the calculator, it is expected that the facilities to support the renewable energy and hydrogen economy will be completed by pha ses in 2050.

Level 1
There is no conversion and storage of excess electricity.

Level 2
By 2050, it is expected 0.876 TWh of energy storage facilities will be developed.

Level 3
It is assumed more than 20% RE will be compromised for production of hydrogen. By 2050, 1.752 TWh energy will be stored.

Level 4
By 2050, with more advanced battery technology, 3.066 TWh battery storage will be added into generation mixed in Malaysia.



Short Term Balancing

ASEAN Member States will intensify collaboration with its partners to achieve greater energy security and enhance ASEAN connectivity. It called for greater support and cooperation from Governments, industries, companies and individuals in order to achieve a sustained and cost-efficient energy supply without depriving future generations.

Interconnection Projects of ASEAN Power Grid (HAPUA, 2015) has also identified three (3) APG Priority Projects for completion and three (3) additional APG projects that will commence construction out of the sixteen (16) APG planned and committed projects for commencement.

Malaysia also aspires to be interconnected to Indonesia via West Kalimantan via Sarawak, Sumatra through Malacca-Pekan Baru, East Kalimantan via Sabah and e Sarawak-Brunei-Sabah.

In the base year 2016 in MCAS, Short-term demand shifting potential through interconnection.

Level 1
Level 1 assumes that by 2050 , Short term demand shifting potential through interconnection remained 0.25 GW

Level 2
Level 2 assumes that by 2050 , Short term demand shifting potential through interconnection amounts to 0.58 GW of interconnectors capacity.

Level 3
Level 3 assumes that by 2050 , Short term demand shifting potential through interconnection amounts to 0.70 GW of interconnectors capacity.

Level 4
Level 4 assumes that by 2050 , Short term demand shifting potential through interconnection amounts to 1.0 GW of interconnectors capacity.