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STUDY ON THE SUCCESS AND LIMITATIONS OF FEED IN TARIFF (FIT) MECHANISM IN MALAYSIA

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Abstract

Malaysia have set an ambitious target for the national Renewable Energy (RE) installed capacity mix at 31% and 40% by 2025 and 2035 respectively. Based on the current RE growth rate, it will be a hustle for the government to meet the target. The growth of each RE sources also differs significantly even though similar FiT design mechanism applies for all RE sources available in Malaysia. Therefore, in this research project, the RE installed capacity mix is forecasted for Business as Usual (BAU) and alternative new RE projects scenario. The analysis of success and limitations of each RE sources under Feed in Tariff (FiT) mechanism is also done through a questionnaire survey to the energy sector personnel in Malaysia. The response were then analyzed using Oneway Analysis in JMP15 software.

Keywords: FiT, RE Installed Capacity Mix, Success Factors, Limitation Factors

Highlights:

- Under BAU scenario, the RE Installed Capacity Mix target could not be achieved.
- Under alternative new RE project scenario, the RE Installed Capacity Mix target could be achieved.
- Each of RE sources under FiT have their individual factors that influence its development.

1. INTRODUCTION

Malaysia have been continuously working towards the development of RE since 2000s through five fuel policy. However, the implementation of Small Renewable Energy Power Programme from 2001 to 2008 have a very limited achievement. Therefore, in 2010, National RE Policy and Action Plan (NREPAP) was introduced to enhance the utilization of RE resources in order to contribute to the national electricity supply, security and sustainable social-economic development. The primary thrusts is the establishment of an appropriate regulatory framework which is RE Act 2011, that leads to the formation and execution of FIT mechanism to enhance the development of RE and achieve the objectives of NREPAP. Under FiT mechanism, Distribution Licensees (DLs) are obliged to buy electricity supplied to the grid from indigenous RE sources by Feed in Approval Holder (FIAH) at a predetermined premium rate for a certain duration. DLs refers to the companies holding the license to distribute electricity in Malaysia such as TNB and SESB whereas FiAH refers to the individual or company who holds a feed-in approval certificate issued by SEDA Malaysia. The holder is eligible to sell electricity from RE sources at the specified FiT rate. The RE sources under FiT are biomass, biogas, solar PV. and small hydro while FiT duration for all RE sources are 21 years. The FiT mechanism is applicable in all states in Malaysia except Sarawak as it has its own legislation and regulations for electricity sector. Apart from FiT scheme, NREPAP also underpins the establishment of SEDA Malaysia. SEDA is a statutory body formed under the SEDA Act 2011 (Act 726) and was established in 2011 for administering and managing the implementation of FiT mechanism. SEDA is also responsible for advising ministers and government entities on matters concerning sustainable energy and implementing the FiT scheme (SEDA Annual Report, 2011). The FiT rate offered by SEDA is dependent on the type of RE sources, RE installed capacity, bonus FiT Criteria and FiT Commencement. The FiT mechanism was funded by the RE fund which is created under Section 23 of RE Act 2011. Primarily, the government had given RM 300 million to RE fund to accelerate FiT enactment. The fund was then contributed through a surcharge of 1% of the total electricity bill per month of consumers of DLs such as TNB, or commonly known as AoT. The surcharge was then increased to 1.6% in 2014. The surcharge is not applied to domestic customers with less than 300kWh per month of electricity consumption.

2. NET ENERGY METERING (NEM)

The increasing demand for solar PV under FiT mechanism have reduced the cost of solar PV system by 23% from 2011 to 2016, which is from RM 9000 per kW to RM 6900 per kW (Oh et al., 2018). This leads to the development of more solar farms in Malaysia as shown in Table 1.

Table 1: Solar Farm in Malaysia under FiT (Oh et al., 2018).

Investors	Location	Capacity (MW)
Amcorp Properties	Negeri Sembilan	10.25
Cypark Resources	Negeri Sembilan	8
Sunedison's	Sepang	5
KLIA	Kuala Lumpur	4
KLIA2	Kuala Lumpur	10
Gading Kencana's	Melaka	8
Kumpulan Melaka's	Melaka	5

Each farm signed a 21-year power purchase agreement with TNB under the FiT scheme at a rate of between 80 and 90 sen per kWh on average. The overwhelming response for solar PV individual category under FiT was observed when the first batch of 500 kW quota of the predetermined 1500 kW were fully subscribed within an hour and the scheduled release of the second batch was deferred due to unexpected heavy incoming traffic to SEDA's portal. The NEM scheme were implemented in November 2016, specifically for solar PV resources due to its significant development under the FiT mechanism with the government's intention to replace the FiT mechanism by 2018. Upon the introduction of NEM, all solar PV quota under FiT mechanism were shifted to NEM scheme. Therefore, the resource available under FiT mechanism after NEM are small hydro, biomass and biogas. NEM 1.0 were introduced in November 2016. A total of 500MW were provided with 100MW capacity allocated each year from 2016 to 2020. NEM 1.0 had a slow uptake rate as out of 200MW only 5.24MW have been taken up by the end of 2017. Therefore NEM 2.0 were implement effective January 2019, where the excess energy is exported to the grid based on one-to-one basis rather than Displaced Cost previously. Under NEM 2.0, the electricity generated will be first consumed by the consumers and the excess energy will be transferred to the grid, where 1kWh of electricity exported will be offset against the 1kWh consumed from the grid. Therefore, the consumers can lessen their monthly electricity bill from the grid. As a result, the capacity approved NEM applications increase significantly from 27.80MW in 2018 to 103.22MW in 2019 and 295.85MW as of September 2020 (SEDA Annual Report, 2018). Effective 2021, NEM 3.0 were introduced to encourage more consumers to installed solar PV in the rooftop, with a sum of quota allocation is up to 500 MW from 2021 to 2023, where it is divided into three new schemes which are 100MW for Program NEM Rakyat, 100 MW Program NEM GoMEn and 300 MW for Program NOVA (SEDA Portal, 2021).

Since FiT implementation in 2011, the cumulative installed capacity of RE power plant varies based on the total number of applications received, approved and revoked each year.

Fig.1 shows the cumulative installed capacity that have achieved commercial operation under FiT for small hydro, biomass and biogas sources under FiT mechanism. As of July 2021, the total installed capacity of non – solar resources under FiT mechanism in 263.35 MW in which biogas from landfill and agricultural waste constitute of 39.7%, small hydro constitutes of 26.7%, and biomass at 22.88%. Fig.2 shows the cumulative installed capacity of solar PV for FiT and NEM schemes respectively. During NEM 1.0 from 2017 to 2018, the uptake rate were slow where the installed capacity increased from 375 MW to 536 MW. The implementation of NEM 2.0 in January 2019 have boost the solar PV installed capacity from 536 MW in 2018 to 882 MW in 2019. In 2015, 21st session of the Conference of Parties (COP21) of the United Nations Framework Convention of Climate Change (UNFCCC) was held in Paris which leads to the endorsement of Nationally Determined Contribution (NDC) and adaptation of Paris Agreement by 195 participating countries including Malaysia that aims to reduce GHG emissions and limit the global average temperature rise. In accordance with the agreement, Malaysia had pledged to reduce its carbon emission intensity per GDP by 35% in 2030 relative to the 2005 level, or 45% with support from developed countries. In 2021, Malaysia had further strengthened its COP21 commitment by revising the national RE capacity mix target from 20% to 31% by 2025 and 40% by 2035. The Government has also included large hydro resources as part of RE definition for Malaysia, consistent with practices adopted by other countries internationally. The RE installed capacity mix, including large hydro is 21.6% at the end of 2019 and it is expected to increase by 10% in the next 5 years. (Energy Commission, 2021). Fig.3 shows the RE installed capacity mix from 2009 to 2019, including large hydro in Malaysia.

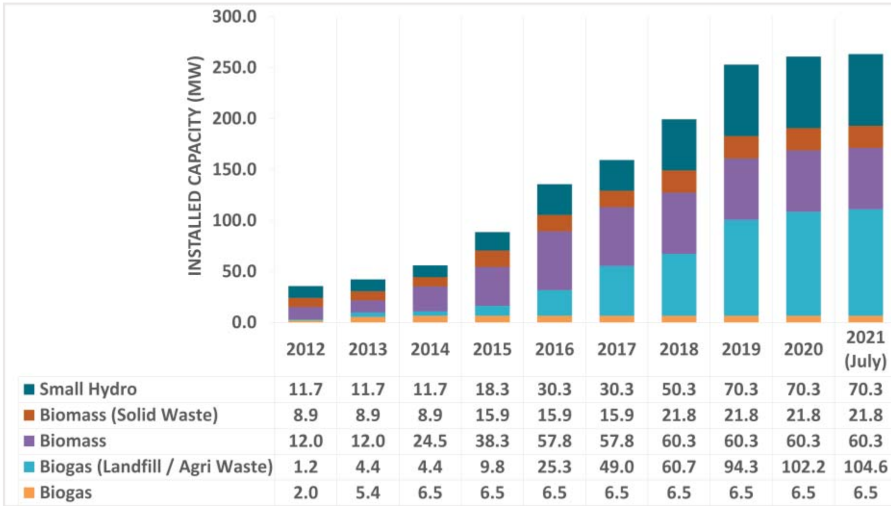

Fig.1: Cumulative Installed Capacity of Non-Solar Resources under FiT from 2012 to July 2021 (SEDA Portal, 2021).

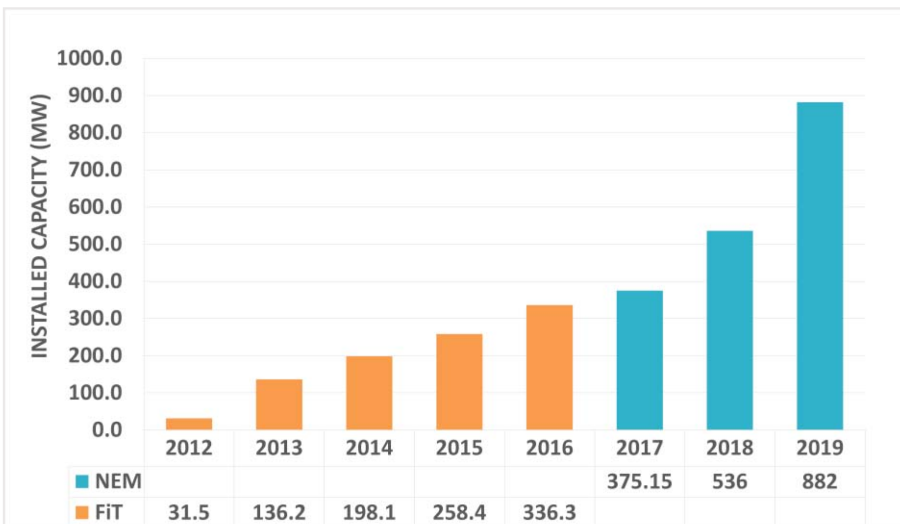

Fig.2: Cumulative Installed Capacity of Solar PV under FiT from 2012 to July 2019 (SEDA Portal, 2021, Husain et al., 2021).

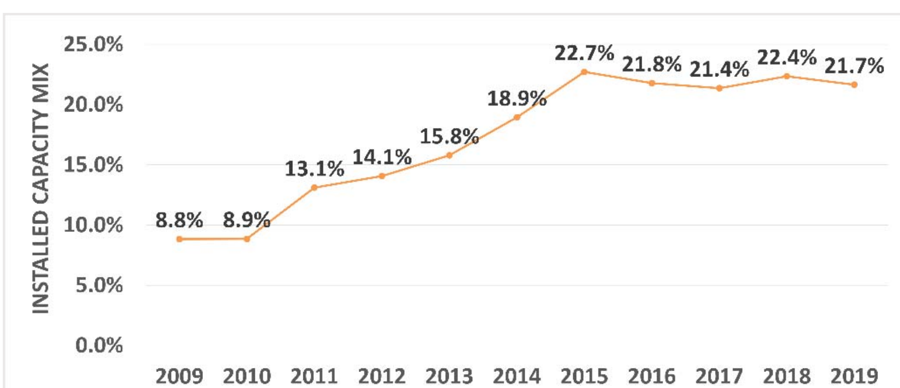

Fig.3: RE Installed Capacity Mix Percent in Malaysia from 2009 to 2019 (Energy Commission, 2009 -2019).

3. RE INCENTIVES RECOMMENDATIONS

Few incentives can also be adapted from developed countries to improve the current FiT mechanism in Malaysia to achieve the target. Following are the success factors of each country that have been reviewed.

1.1. Germany

Germany have proved as one of the most successful countries for RE development through FiT mechanism when the installed capacity rose from 4.7GW in 1990 to 93GW in 2014 where 88% of RE power generation in 2011 were from Renewable Energy Sources Act that regulates FiT mechanism (Rahman et al., 2016). There are few features of the mechanism that results in the successful implementation. Firstly, is the dynamic model. The FiT mechanism undergoes continuous changes based on the ever-changing needs and evolving challenges such as phase I (2000 – 2009), phase II (2009 – 2011), phase III, (2012 – 2014) and employing market premium, Cap option, and 52GW PV capacity threshold. In Malaysia, apart from FiT, additional RE incentives were only introduced for solar PV system such as LSS, NEM and Self Consumption. This results in significantly higher uptake rate of solar PV than biomass, biogas and small hydro. With the low uptake rate of non-solar resources in Malaysia, the market premium and flexibility premium can be adopted as implemented in Germany where the RE power plant operators can sell their electricity generated directly into the market. Thus, in addition to the revenue obtained though fixed FiT rate, the operators will be entitled to also receive market premium (Rahman et al., 2016).

Secondly, Germany have also improvised the transmission and distribution system by ensuring a generic grid access without delay and bureaucratic hassles in order to reduce the transaction cost and also to attract more small investors in invest in RE sectors. The introduction of Technical Supports Policy have also obliged the distribution system operators to optimize, reinforce and expand the networks in order to accommodate the electricity from RE sources without delay. In Malaysia, the oil palm plantation that produces feedstocks for biomass and biogas as well as run off rivers that source the SHP power plants are located at remote locations. Installation of RE power plant in the remote location requires proper transmission to the national grid to be qualified under the FiT mechanism. Due to the additional cost required for the long transmission lines, the oil palm millers and SHP investors are reluctant to invest in these sectors. Therefore, the government of Malaysia could adopt the Technical Supports Policy by Germany to improvise the transmission and distribution system. With proper accessibility to the national grid, the vast availability of feedstocks for biomass and biogas and long runoff rives for SHP plants at the remote locations can be utilized at a maximum level.

Thirdly, in Germany, the FiT rate can also be negotiated based on the current investment cost so that the marginal profit could be maintained, where it was the key feature for the successful implementation of FiT. In Malaysia, the most crucial limitations of RE power development is the high installation and maintenance cost that cause the long payback period under FiT mechanism. In addition, the FiT rate in Malaysia also have degression rates where, the rate reduces annually. The power plants that commenced in later years will be paid with lower FiT rates due to reduction in the installation cost of RE sources. The installation cost is still high for the consumer and small investors, who intends to invest in the RE sectors. Therefore, a negotiable FiT rate based on the current investment cost in order to maintain the marginal profit can be adopted as in Germany. This initiative will significantly reduce the cost burdens on the consumers and attract more investors in the RE development.

Finally, Germany has amended the German Renewable Energy Act 2017 based on the current trend in the Europe country, in order to provide more room to implement auctions for RE projects. Under the new law, the cost of RE generation can be reduced and also accelerate the development of offshore wind farms (Rahman et al., 2016). Therefore, apart from FiT and LSS, it is recommended for Malaysia to amend RE Act 2011 auctions to incorporate reputation and technological conditions, production site selection and documentation, initiatives to promote socio-economic development, and grid access security for RE power generation (Ghazali et al, 2020). This leads to the efficient utilization of all the RE sources available in Malaysia, instead of only focusing on solar PV development

3.2 India

The RE development in India surpass Malaysia when it was ranked 4th in the world for the most attractive RE market. In 2019, India was ranked 5th in wind and solar power and 4th in renewable power installed capacity. One of the key features for the achievement is the government commitment for RE development as policies and incentives exists both in central and state level. Several states in India such as Gujarat Tender, Tamil Nadu, Karnataka and Andra Pradesh have provided auctions for the solar energy development in their states. The Uttar

Pradesh renewable energy Feed-in Tariff 2014–2019 and Jawaharlal Nehru National Solar Mission (Phases I, II and III) have been introduced by the respective states as part for the FiT mechanism for solar energy. Apart from solar, biomass and biogas projects have been developed through state level policies such as Rajasthan Generic Tariff for Biomass and Biogas Plants 2014-15, The Uttar Pradesh Captive and Renewable Energy Tariff Regulations 2014-15 and The Gujarat Biomass Feed-in Tariff Regulations 2013-2016 (Ghazali et al., 2021). As Malaysia is one of the largest producer and exporter oil palm, there are vast oil palm plantation in the country. However, certain states have a significantly higher number of oil palm mills and plantation compared to other states. Table 3 shows the number of palm oil mills by states in Malaysia. Sabah have the highest number of mills at 131, followed by Sarawak at 83 mills. The distribution of the palm oil mills is uneven in all states in Malaysia. Therefore, in order to utilize the resources more efficiently, a state level RE incentives could be implemented mainly in Sabah and Sarawak. This aids for a more transparent and detailed policy for the millers in the state particularly for bioenergy production. The millers will also be more aware of the incentives available, the government could provide proper action plan for the challenges faced while strengthening the government commitment towards the RE development and lead to an efficient utilization of the vast biomass and biogas feedstocks available.

Table 3: Number of palm oil mills by state in Malaysia. (Salleh et al., 2020).

State	Palm oil mills	State	Palm oil mills
Sabah	131	N. Sembilan	16
Sarawak	83	Terengganu	13
Pahang	71	Kelantan	11
Johor	64	Kedah	6
Perak	47	Melaka, Perlis, P. Pinang	5
Selangor	18		

Moreover, the introduction of technology – specific auctions in India such as the Five-Year Plan for National Wind Energy and National Solar Energy have aided in the parallel development of RE sources. Even though India have engaged on solar energy development, it does not halt wind and other resources as part of its carbon free initiatives (Ghazali et al., 2021; Ghazali et al., 2020). Malaysia is rich with different types of RE resources such as adequate solar irradiance, vast palm oil feedstocks and hydro potential. However, the RE incentives introduced based on technology – specific auction is only for solar PV such as LSS. This leads to the significantly higher solar PV installed capacity mix under the FiT schemes which is later shifted to NEM. In order to properly utilize all the resources available, technology specific auction could be implemented as in India, which aids in a parallel utilization of all the resources available. Similar to the state level policy, the technology specific auctions could provide investors to a detailed regulations, financial aids and opportunities to invest in the non – solar resources as well, and thus boost the government's effort to meet the target RE installed capacity mix target.

India have also established a non – banking FI called IREDA under the control of its Ministry to provide long term loans for RE and EE projects. IREDA responsibility includes promoting, developing and extending financial assistance for setting up new RE projects that includes hydro, wind, solar and bioenergy and also EE and conservation (Ghazali et al., 2021).

4. ANALYSIS OF SUCCESS AND LIMITATION FACTORS OF FIT MECHANISM

A total of 41 personnel were approached for the survey, and 13 respondents were obtained. Out of the 13 respondents obtained, 6 respondents are from SEDA Malaysia, 3 respondents from TNB Energy Services, 1 respondent each from BAC Renewable Energy and Worldwide Holdings Berhad and 2 respondents from UMPEDAC.

4.1 Solar PV

Table 4 shows the mean, standard deviation and median results based on the rank provisioned by respondents for success and limitation factors for solar PV respectively. The factor that mainly contributes to the success of solar PV is the higher FiT rate than other RE sources when solar PV were still available under FiT mechanism. 50% and more participants have strongly agreed that the higher FiT rate contributes the most. The FiT rate provided for 1MW solar PV system is RM 0.3096/kWh whereas for biogas plant above 10MW – 30MW were only RM 0.2786/kWh. This have encouraged more consumers to invest in solar PV than other RE sources under FiT mechanism. The second success factor of solar PV development is the cost reduction of solar panels in Malaysia. As one of the largest solar panel manufacturers, Malaysia have been committed to reduce the price of solar based electricity generation which results in the significant growth of solar PV in the nation. Based on the limitation factors, the factor with the largest mean value is the availability of cheaper electricity generation alternative such as fossil fuels. Even though, the price of solar PV system reduces, the installation and maintenance cost is still higher than fossil fuel sources such as coal and natural gas for electricity generation. Therefore, consumers tend to remain in the low-cost alternative than investing in solar PV power generation. The second limitation factor is the dependency on weather conditions. Since solar PV based power generation depends on the availability of adequate solar irradiance and temperature, excess power generated during the day have to be stored in energy storage system in order to be used during night and when there is not enough irradiance for power generation. Thus, a full dependency on solar PV power system by the consumers is limited by weather conditions.

Table 4: Success and Limitation Factors of Solar PV under FiT.

Success Factors	Mean	Std Dev	Median
Higher FiT rate than other RE sources	4.455	0.820	5
Reduction in the cost of solar panels.	4.364	0.924	5
Lower environmental impact	4.273	0.467	4
Trainings provided by SEDA	4.273	0.467	4
Higher employment opportunities	4.182	0.405	4
Rapid technological advancement	4.182	0.405	4
Adequate solar irradiance in Malaysia	4.091	0.701	4
Introduction of LSS	3.455	0.688	3
Limitation Factors	**Mean**	**Std Dev**	**Median**
Availability of cheaper alternatives	4.000	0.775	4
Dependent on weather conditions	3.818	0.603	4
High installation and maintenance cost	3.636	0.505	4
Complicated application process	3.455	0.688	4
Lack of knowledge and awareness	3.273	1.009	4
Lack of financial aid	3.182	0.874	3

4.2 Small Hydro

Table 5 shows the mean, standard deviation and median results based on the rank provisioned by respondents for success and limitation factors for small hydro respectively. The largest mean value for success factors is lower environmental impact than large hydro. This is mainly attributed by the impact of large hydro power plants that cause deforestation and flood levels that damage the agricultural plants. Therefore, small hydro is preferable for the usage of rural electrification with low environmental impacts. The success factors is followed by longer lifespan of small hydro power plant and opportunity for rural electrification. The respondents agree that both these factors have equal impacts on the success of small hydro in Malaysia. Small hydro power plant have a lifespan of more than 50 years which makes it preferable for the long-term dependency for electricity generation. Moreover, since most river source are located at remote locations, it makes it suitable for the rural communities to generate their own renewable based electricity in their area. The most significant limitation factor for the development of small hydro under FiT mechanism is the high capital cost of the installation of small hydro plant in which more than 50% of the respondents strongly agree to this factor. The capital cost of for SHP requires high cost of installations works, operational and management, in which there is insufficient financial aids from the FI which leads to the investors to not invest in the small hydro sectors. The second factor that is the sedimentation issues that reduces the efficiency of hydro turbine blades for power generation.

4.3 Biomass

Table 6 shows the mean, standard deviation and median results based on the rank provisioned by respondents for success and limitation factors for biomass sources respectively. Two factors were analyzed for the success factors of biomass-based power plants under FiT mechanism, which are high conversion efficiency and vast availability of biomass feedstocks. As one of the largest producers and exporter of palm oil, Malaysia is rich with oil palm plantation which provides the vast availability of biomass sources that leads to the growth of biomass based for power generation in the nation. The main limitation factors for the development of biomass sources is the requirement of pretreatment process. Pretreatment of biomass is required to remove unwanted particles and low-quality biomass before proceeding to the boiler for power generation. Therefore, additional labor cost, equipment, storage conditions and monitoring are required during the pretreatment of the EFB which causes the millers to not prefer the power generation alternative.

Table 5: Success and Limitation Factors of Small Hydro under FiT.

Success Factors	Mean	Std Dev	Median
Lower environmental impact	4.091	0.539	4
High rainfall volume and hydro potential	4.000	0.632	4
Longer lifespan	4.000	0.447	4
Rural electrification	4.000	0.447	4
Employment opportunities	3.636	0.505	4
Limitation Factors	**Mean**	**Std Dev**	**Median**
High capital cost	4.727	0.467	5
Sedimentation issues	4.273	0.786	4
Lack of awareness	3.818	1.079	4
Long gestation period	3.818	0.405	4
Poor access to grid	3.727	0.786	4
Dependent on weather conditions	3.636	0.674	4
Lack of skilled personnel	3.364	1.120	3
Lack of technical facilities	3.364	0.924	3
Lack of technology development	2.636	1.120	3
Lack of private sector participation	2.455	1.753	2

Secondly, the uncertainty of the feedstock supply also hinders the development of biomass power generation. This is largely due to the various ownership and the remote locations of the oil palm plantations in Malaysia that impacts the supply security for the investors to develop biomass power plant.

4.4 Biogas

Table 7 shows the mean, standard deviation and median results based on the rank provisioned by respondents for success and limitation factors for biogas respectively. The largest mean value for success factors of biogas sources is its vast availability of POME feedstocks in Malaysia. Similar to biomass, development of biogas power plant is also attributed by the large oil palm plantation in Malaysia which provides POME as a feedstock for biogas generation. The second success factor of biogas is the revenue increment. This is due to the long production hours of biogas and selling the power generated under FiT mechanism results in higher revenue for the investors. The limitation factor with the largest mean value is the lack of FiT regulations for biogas. This is attributed by the inadequate regulations for the pretreatment of POME feedstock for biogas generation that leads the millers to not invest in the biogas sector.

Table 6: Success and Limitation Factors of Biomass under FiT.

Success Factors	Mean	Std Dev	Median
Availability of feedstock	4.231	0.832	4
High conversion efficiency	3.154	0.899	3
Limitation Factors	**Mean**	**Std Dev**	**Median**
Requirement of pretreatment process	4.077	0.760	4
Uncertainty of feedstocks supply	4.000	0.707	4
Poor access to grid	3.615	0.506	4
Lack of awareness	3.538	0.967	4
High opportunity cost	3.385	0.870	4
High transportation cost	3.308	0.855	4
Lack of skilled personnel	3.308	0.751	3
Insufficient FiT quota	3.231	1.092	3
Insufficient rate of return.	3.154	0.899	3
Feedstock issues	3.077	0.862	3
Insufficient financial	3.000	0.913	3

The second factor is shift to bio – CNG. The shift from biogas to bio – CNG happened mainly due to the poor access to the national grid from the biogas power plant to sell excess electricity under FiT mechanism and the competitive price of bio – CNG than fossil fuels. Therefore, miller prefers the bio – CNG sector than biogas.

5. METHODOLOGY

5.1 BAU Scenario

Under the BAU scenario, a timeseries model which is the RE installed capacity mix of each RE resources in Malaysia is used to analyze, describe and explain the timeseries dataset and to predict the future values of the series based on the historical datasets. Fig.4 shows the Non-Linear Autoregressive (NAR) neural network design that can train the historical timeseries from that series of past values Y (t – 1), Y (t – 2),….Y (t – d), called feedback delays, with d is the time delay parameter.

Table 7: Success and Limitation Factors of Biogas under FiT.

Success Factors	Mean	Std Dev	Median
Vast availability of POME feedstock	4.250	0.452	4
Revenue increment	4.167	0.577	4
Directive by MPOB	4.000	1.279	4.5
Implementation of e-bidding system	3.833	1.030	4
Limitation Factors	**Mean**	**Std Dev**	**Median**
Lack of FiT regulations	3.750	0.622	4
Shift into bio-CNG	3.583	0.515	4
Poor access to the grid connection	3.417	0.900	3.5
Insufficient FiT rate	3.250	1.138	4
High Capital Cost	3.167	0.835	3
Lack of awareness	3.000	0.953	3
Lack of technological maturity	2.917	1.084	3
Requirement of pretreatment process	2.917	1.443	4
Lack of skilled personnel	2.833	0.937	2.5

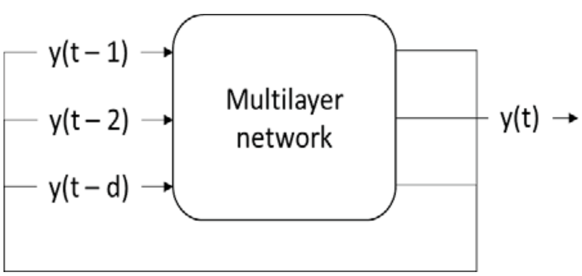

Fig.4: NAR Neural Network Design Mechanism

The methodological flow of NAR – Neural Network Time Series (NNTS) and the specific MATLAB R2021a coding done to simulate the training model and to forecast the values for the next timesteps are as follows:

Collection of Data

RE Installed Capacity mix data, including large hydro from 2009 to 2019 is chosen in order to forecast the results for 2020 to 2035. The installed capacity mix of solar PV, hydropower, biomass and biogas is obtained from National Energy Balance Report by Energy Commission Malaysia as shown in Table 8.

Table 8: Installed Capacity Mix by RE sources from 2009 to 2019 (Energy Commission, 2009-2019).

Year	Installed Capacity Mix			
	Solar PV	Hydropower	Biomass	Biogas
2009	0.00%	8.67%	0.17%	0.00%
2010	0.00%	8.65%	0.21%	0.00%
2011	0.00%	10.49%	2.62%	0.00%
2012	0.00%	11.38%	2.69%	0.00%
2013	0.00%	13.22%	2.58%	0.00%
2014	0.54%	15.93%	2.43%	0.05%
2015	0.74%	18.78%	2.83%	0.37%
2016	0.88%	18.56%	2.25%	0.10%
2017	1.05%	17.93%	2.19%	0.20%
2018	2.35%	18.15%	1.63%	0.24%
2019	2.92%	17.11%	1.22%	0.41%

Data Import

The historical data from Microsoft Excel 365 is imported to MATLAB 2021a. The parameters are specified as X which represents 'Year' and Y represents 'Solar PV Installed Capacity Mix'. The MATLAB code is as shown below:

```
RE = xlsread('REINSTALLEDMATLAB.xlsx','Sheet1','A3:B14');
X=RE(:,1);
Y=RE(:,2);
```

Development of NAR – NNTS

NAR problem is selected in NNTS model and Y is specified as the prediction target.

```
T = tonndata(Y,false,false);
```

Choosing Training Function

In this research, training is initially done using Levenberg–Marquardt, Bayesian Regularization and Scale Conjugate Gradient to identify the most suitable algorithm for the historical datasets based on Mean Squared Error and R value. The coding for each training algorithm is shown below:

```
trainFcn='trainlm';
trainFcn='trainscg';
trainFcn='trainbr';
```

Development of NAR Network

The open loop network is created using 2 feedback delays and 10 hidden layers as below:

```
feedbackDelays = 1:2;
hiddenLayerSize = 10;
net = narnet(feedbackDelays,hiddenLayerSize,'open',trainFcn);
```

Function Processing and Data Preparation for Training and Simulation

Processing settings for feedback input in NAR are automatically applied to feedback output. Next, the function PREPARETS is used to prepare timeseries data for a particular network, shifting time by the minimum amount to fill input states and layer states. The function keeps the original time series data unchanged and customize it for networks with differing numbers of delays, with open loop or closed loop feedback modes.

```
net.input.processFcns = {'removeconstantrows','mapminmax'};
[x,xi,ai,t] = preparets(net,{},{},T);
```

Splitting of Dataset

```
[x1,xio,aio,t] = preparets(net,{},{},T);
[y1,xfo,afo] = net(x1,xio,aio);
[netc,xic,aic] = closeloop(net,xfo,afo);
[y2,xfc,afc] = netc(cell(0,16),xic,aic);
```

The dataset is divided into 70:15:15 percent ratio into training set, validation set and testing set, respectively as shown:

```
net.divideFcn = 'dividerand';  % Divide data randomly
net.divideMode = 'time';  % Divide up every sample
net.divideParam.trainRatio = 70/100;
net.divideParam.valRatio = 15/100;
net.divideParam.testRatio = 15/100;
```

Performance Function

Mean Squared Error is chosen as the performance function.

```
net.performFcn = 'mse';  % Mean Squared Error
```

Training, Testing and Recalculation of Training, Validation and Test Performance

The dataset is trained in the network to obtain the output and performance is recalculated as shown:

```
% Train the Network
[net,tr] = train(net,x,t,xi,ai);

% Test the Network
y = net(x,xi,ai);
e = gsubtract(t,y);
performance = perform(net,t,y);

% Recalculate Training, Validation and Test Performance
trainTargets = gmultiply(t,tr.trainMask);
valTargets = gmultiply(t,tr.valMask);
testTargets = gmultiply(t,tr.testMask);
trainPerformance = perform(net,trainTargets,y);
valPerformance = perform(net,valTargets,y);
testPerformance = perform(net,testTargets,y);
```

Closed loop network

The open loop network is converted to closed loop network to perform multi – step prediction. The function CLOSELOOP replaces the feedback input with a direct connection from the output layer.

```
netc = closeloop(net);
netc.name = [net.name ' - Closed Loop'];
view(netc)
[xc,xic,aic,tc] = preparets(netc,{},{},T);
yc = netc(xc,xic,aic);
closedLoopPerformance = perform(net,tc,yc);
```

Multi – Step Prediction

It is useful to simulate a network in open-loop form for as long as there is known data T, and then switch to closed-loop to perform multistep prediction. The open-loop network is simulated on the known output series, then the network and its final delay states are converted to closed-loop form to produce predictions for 16 more timesteps from 2020 to 2035.

5.2 Alternative New RE Project Scenario

The new RE projects planned under the Generation Development Plan by Energy Commission from the year 2021 onwards, to achieve the national RE installed capacity mix target by 2025 and 2035 were reviewed. The review includes projection of RE generation capacity, progress of the implementation of transmission projects and retiring plants. The Generation Development Plan consists of new RE projects, Combined Cycle Gas Turbine (CCGT) and Battery Energy Storage System (BESS) plants. (Energy Commission, 2021). The Renewable Capacity Statistics 2021 Report from IRENA were also reviewed for the RE installed capacity mix in the year 2020. As a result of the review, the RE installed capacity mix have been re forecasted from 2020 to 2035. Further recommendations were proposed to enhance the RE incentives in Malaysia based incentives implemented by countries with successful RE sectors which are German and India.

5.3 Analysis of Success and Limitation Factors of FiT mechanism

A questionnaire survey through Google Forms is conducted to determine the success and limitation factors for solar PV, small hydro, biomass and biogas sources. The questionnaire survey form can be divided into four RE sources which are solar PV, small hydro, biogas and biomass sources. Each of the RE sources is categorize into two parts for the success and limitations factors. The factors are listed, and the participants are required to rank the factor using five – point Likert scale in which 1 represent "strongly disagree" and 5 represent "strongly agree" as shown in Fig.5.

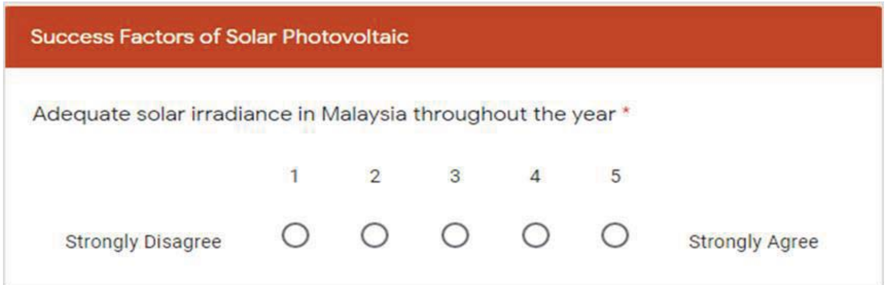

Fig.5: Five-point Likert Scale

For a more reliable data on each RE sources, only participants who worked regularly and have knowledge in the specific RE sector will be permitted to respond for the listed factors in the survey. The criteria for the participants in the survey are as listed below:

i. Currently working in the department RE in a company in Malaysia.
ii. Have knowledge and experience working in the development of the RE sources.
iii. Possess as least a year of working experience in the implementation of FiT mechanism in Malaysia.

The questionnaire were shared to respective personnel at SEDA, Energy Commission Malaysia, TNB Energy Services, private RE companies and expertise in RE sector in Malaysia. A total of 41 personnel were approached to conduct the survey. The response on the Five – point Likert scale of each factor is exported to JMP15 software. The data is analyzed using 'Fit Y by X' function using 'Oneway Analysis'. 'Rank' is selected as the Y function and 'Factors' is selected as the X function. 'Means and Std Deviation' of the data is the generated. The factor with the highest mean value is chosen as the most influential factor. When two factors have equal mean value, the factor with a lower standard deviation value is selected (Namasudra et al., 2021).

6. RESULTS AND DISCUSSION

6.1 BAU Scenario

Fig.6 shows the forecasted results for the installed capacity mix of each RE sources for 2020 to 2035 based on the historical installed capacity mix time series datasets from 2009 to 2019 under the BAU scenario. The forecasted values are only based on the historical uptake rate of each RE sources from 2009 to 2019, in assumption that the historical RE incentives applies for the future with no additional RE projects and significant changes in incentives are made. Based on the BAU scenario forecasted results, hydropower remained as the largest contributor of RE installed capacity mix as large hydropower have been included under RE definition in Malaysia since 2020. This is followed by solar PV where the uptake rate is forecasted to increase, mainly due to the implementation of Large-Scale Solar (LSS) and NEM schemes. The remaining RE sources which are biomass and biogas are also forecasted to improve until 2035. Fig.7 shows the overall forecasted national RE installed capacity mix that is obtained through the summation of each installed capacity mix of the RE resources. The capacity mix shows an increment but does not meet the target. The capacity mix forecasted in 2025 is 25.52% versus the target of 31% whereas in 2035 is 39.20% versus the target at 40%. (Energy Commission, 2021). Therefore, with BAU scenario that consists of the historical RE incentives, RE uptake rate and project progress rate, Malaysia may not achieve the RE installed capacity target set. Additional incentives and RE projects are required to be implemented to meet the target.

6.2 Alternative New RE Projects Scenario

Fig.8 shows the forecasted RE installed capacity mix from 2020 to 2035 for alternative new RE projects scenario. Under the scenario, the forecasted values are not based on the historical RE installed capacity mix but based on the Generation Development Plan of RE projects by Energy Commission Malaysia for 2021 onwards and IRENA for the year 2020. (IRENA, 2021). In this scenario, the historical RE growth rate is not taken into consideration. Under the alternative new RE projects scenario, the predicted values can achieve the RE installed capacity mix target exactly at 31% and 40% in 2025 and 2035 respectively.

To achieve the target, approximately 8531MW of RE installed capacity are required. Currently, the total RE installed capacity is approximately 7353 MW, therefore additional of 1178 MW of new RE capacities are planned to be developed in Peninsular Malaysia from 2021, where 1098 MW will be from solar and 80MW from non-solar resources. In the additional RE capacities, 619 MW and 559 MW is projected to be commissioned in 2024 and 2025 respectively. An additional 2,414 MW of RE capacity would be developed in Peninsular Malaysia from 2026 to 2035. Malaysia have also planned to develop CCGT from 2029 due to substantial capacity retirement and higher electricity demand. BESS with a capacity of 100 MW had also been planned for installation annually into the system from 2030 – 2034 due to the increment of RE projects. As a result of the Generation Development Plan for 2021 onwards and statistics from IRENA for 2020, the RE installed capacity is projected to increase from 17% in 2021 to 32% in 2035. In this research project, it is assumed that the RE installed capacity in Sabah and Sarawak is 5% from 2021 to 2025 and 8% from 2026 to 2035. Increment of the RE share is in line with the projected reduction of the share of coal from 37% in 2021 to 21% in 2035.

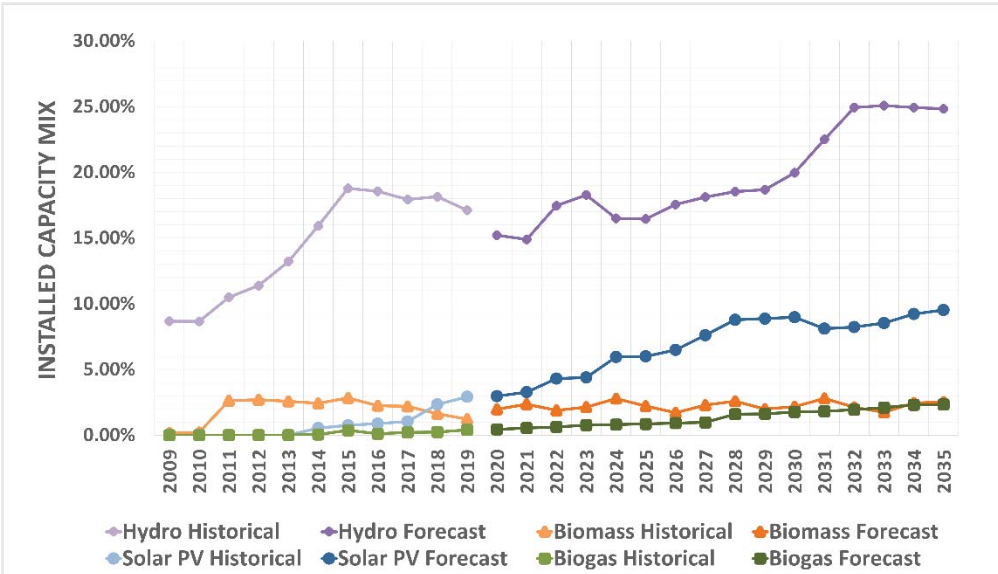

Fig.6: Historical and Forecasted Installed Capacity Mix by each RE sources.

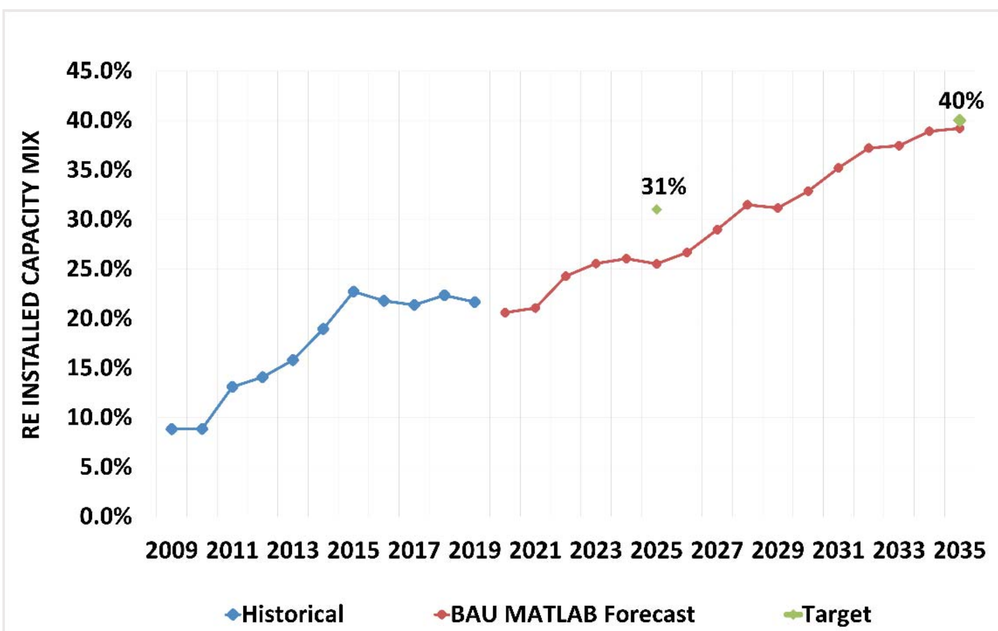

Fig.7: Historical and BAU Forecasted Overall RE Installed Capacity Mix.

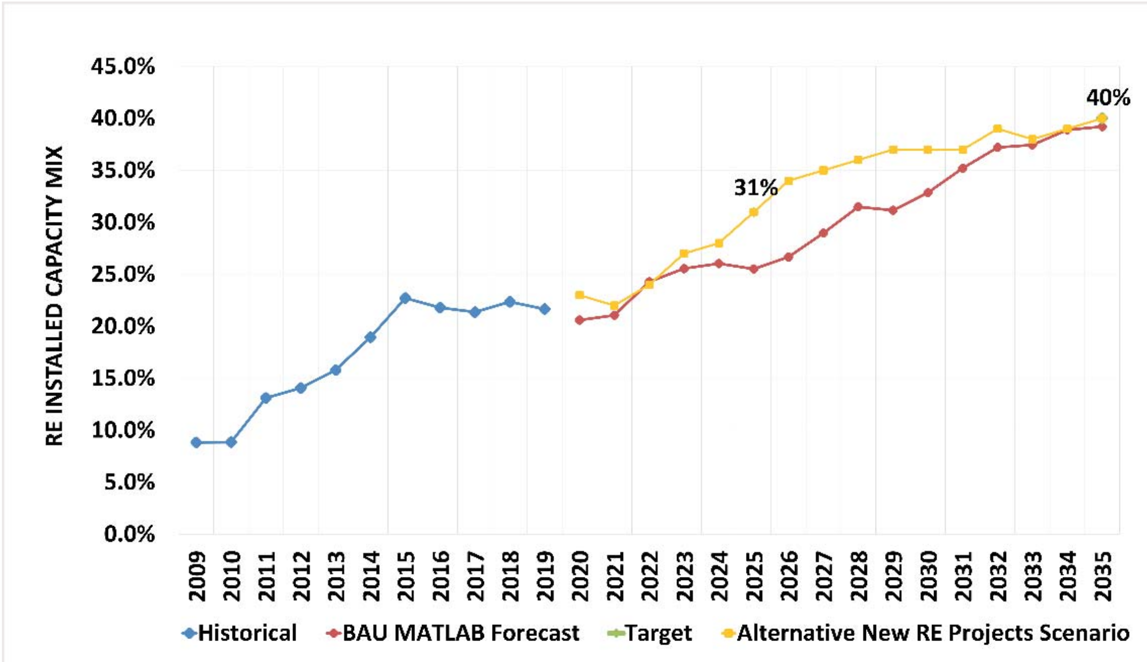

Fig.8: Historical, BAU and Alternative RE Projects Scenarios Forecasted of RE Installed Capacity Mix.

Table 8: Summary of Success and Limitation Factors from survey respondents.

RE Sources	Success Factors	Limitation factors
Solar PV	• Higher FiT rate • Cost reduction of solar panels	• Availability of cheaper alternatives • Dependent of weather conditions
Small Hydro	• Lower environmental impact • Longer lifespan • Rural electrification	• High capital cost • Sedimentation issues
Biomass	• Vast availability of feedstocks	• Requirement of pretreatment process. • Uncertainty of the feedstock.
Biogas	• Vast availability of POME feedstocks. • Revenue increment	• Lack of FiT regulations • Shift from biogas to bio – CNG

7. CONCLUSION

As a conclusion, the forecasted results of RE installed capacity mix under BAU scenario does not meet the target set by the government. The forecasted value for 2025 is 25.52% versus the target of 31% and for 2035, the forecasted value is 39.20% versus target of 40%. Therefore, based on the growth rate of historical RE installed capacity mix and the current RE incentives provided, the target could not be achieved. However, for the alternative new RE projects scenario which is based on the Generation Development Plan by Energy Commission for 2021 onwards, the predicted results shows that the target is achievable exactly at 31% and 40% for 2025 and 2035 respectively. To further increase the RE installed capacity mix, RE incentive recommendations from Germany and India could also be adapted. The analysis of success and limitation factors of FiT mechanism shows an insight from the perspective of the energy authorities and RE sector expertise in Malaysia. Based on the response, the RE sources have its individual influencing factors that results in the difference in their growth rate. A summary of the significant success and limitation factors by RE sources is shown in Table 8.

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