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A Lesson of Solar Energy Development in Malaysia and Indonesia

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ABSTRACT

To address environmental issues, Indonesia aims to achieve a 23% renewable energy share by 2025 and 31% by 2050. According to National Energy Plan (RUEN), the target for solar energy installed capacity is 6.5 GW by 2025 and 45 GW by 2050. Looking at one of Indonesia neighboring country, Malaysia, have a significant growth on solar energy as a result from their policy framework, role of national electricity company, and the PV industry condition. Therefore, this paper will be projecting Indonesia's progress on solar energy target in RUEN using Malaysia's approach and Tenaga Nasional Berhad (TNB) initiatives and using Business as Usual (BAU) scheme, in which the result shows that achievement on RUEN target still below 22% for both schemes.

Keywords: Solar Energy, National Energy Plan (RUEN), Policy Framework, National Electricity Company, PV Industry
JEL Classifications: Q01, Q20, Q48

1. INTRODUCTION

Transitioning from fossil fuel to much cleaner energy (renewable energy) in the energy mix is a route that every nation must take in order to eliminate environmental issue, and Indonesia is no exception. One of the goals of RUEN is achieving optimal primary energy mix, and Indonesia has set a target on the National Energy Policy (KEN) that renewable energy will be 23% of the primary energy mix by the year of 2025. Thus, comparing Indonesia development on solar energy with another country in ASEAN will be conducted. Notably, as of 2020, Indonesia's total installed solar energy capacity (185.33 MW) lags Malaysia's capacity in 2014 (205 MW), indicating a 6-year lag in Indonesia's solar energy development.

This paper will be projecting Indonesia`s achievement of their RUEN target on installed solar energy capacity by 2025 and 2050. The projection is divided using on-going approach or Business as Usual (BAU) scenario that is implemented in Indonesia and using on-going Malaysia and TNB approach on solar energy development by 2025. By examining the projection, this paper aims to provide valuable insights for future decision-making on the policy framework for solar energy deployment in Indonesia based on the comparison and evaluation. And for the PLN, the TNB approach on solar energy development in Malaysia could be set as a benchmark on PLN future initiative to help Indonesia on achieving their solar energy target.

2. POLICY FRAMEWORK

2.1. Feed-in Tariff (FiT)

FiT policy was implemented in Malaysia from 2011-2016. During the active period of FiT policy, solar energy capacity installed in

Malaysia rose from 1 MW in 2011 to 344 MW in 2016 (IRENA, 2022). In Malaysia, tax money is not used to pay for the FiT. Instead, the expense of the FiT is passed through to larger end users in the form of a RE fund. Large power consumers (those who use more than 200 kWh per month) must pay an additional 1.6% of the total electricity bill. The digression rate for solar PV technology represents the technology's maturity and capacity for cost reduction (Almaktar et al., 2013). The FiT rate of solar PV (individual) in Malaysia for the capacity up to and including 4 kW on 2012 is 1.23 RM/kWh and on 2016 is digressing to 0.8429 RM/kWh, this data can be seen on SEDA portal.

With the introduction of the FiT policy under MEMR Regulation No. 17/2013, Indonesia also launched a push for the deployment of solar power. In contrast to Malaysia, Indonesia's expansion of solar PV capacity during the FiT period made modest progress for a few reasons. A local content criterion included in the solar FIT created by Regulation 17/2013 was under review by the Supreme Court and was not resolved until 2016 (Guild, 2019). The comparison of FiT implementation in Indonesia and Malaysia can be seen in Table 1.

Biaya Pokok Penyediaan (BPP), a new FiT framework, was unveiled by Indonesia in 2017. According to the BPP plan, the tariff is set based on the national and regional average cost of power generation (no more than 85% of regional BPP). It implies that areas (like West Java) where cheap coal dominates the electrification are inaccessible to solar PV installations (Sreenath et al., 2022).

2.2. Net Metering (NEM)

Following the completion of the FiT quota under the supervision of the Sustainable Energy Development Authority Malaysia (SEDA Malaysia), the Net Metering (NEM) system was implemented in Malaysia in 2016 (Shafiruddin and Zainudin, 2021). The government allocated a 500 MW quota for NEM scheme with 100 MW each year capacity limit. The initial phase (NEM 1.0) was not commercially appealing due to its poor financial return.

The Malaysian government adopted NEM 2.0 in 2019 with the true net metering concept, allowing users to export excess energy on a one-to-one basis with a 500 MW allotment. This implies that every 1 kWh of power used by PV installers can be offset by 1 kWh of grid electricity on their subsequent electricity bill.

It is described by Ilham et al., (2022) that after the allocated quota for NEM 2.0 was fulfilled in 2020, NEM 3.0 scheme is implemented and will be effective from 2021 to 2023 with another 500 MW quota allocation. Through this program, three (3) initiatives have been established and have its targeted participant: NEM Rakyat for domestic solar PV consumers, NEM GoMEn for government entities, and NOVA for commercial and industrial energy users.

In 2018, the Indonesian government published Regulation No. 49, which creates a net metering program for PLN customers who own solar rooftop systems and have extra electricity that may be sent back into the grid. These customers can be residential, commercial, or industrial. With this legislation, the MEMR chose to value exported power credits at 65% of the PLN pricing rather than at 100% (IEEFA Report, 2019).

The conclusion established in the 2017 audit of PLN by the State Audit Board (BPK) that power generating expenditures comprised 62% of PLN's overall operating costs served as the apparent justification for the decision. Transmission and distribution expenses as well as line losses are responsible for the remaining 38% (Devine et al., 2018). MEMR is aiming to enforce the concept that a credit of 65% should be sufficient to attract individuals to install solar rooftop units by using the operating model of PLN as a point of reference.

The expansion of solar energy has also been constrained by a PLN restriction that began in March 2022 and lowers the maximum rooftop solar capacity installation to only 10-15% of the customer's installed power connection due to worries about overcapacity conditions, particularly in the Java-Madura-Bali (Jamali) system, and potential revenue loss (Almaktar et al., 2013; Mrad et al., 2023).

2.3. Large-Scale Solar (LSS) and Auction

From 2016, Malaysia has been establishing Large-Scale Solar (LSS) schemes under the direction of the Energy Commission (EC) through a competitive bidding procedure. The competitive bidding procedure has four cycles in place as of 2021. 138 bidders have expressed interest in LSS4, one of the latest LSS initiatives in Malaysia.

In Indonesia, under the MEMR Regulation No 17/2013, Indonesia had its first 140 MW ground-mounted solar auction mechanism, however the program was discontinued as a result of concerns expressed by the Supreme Court on foreign-partnered projects (Burke et al., 2019). Despite the court's setback, the MEMR repositioned auction program again in 2016 for solar IPPs that would have led to a greater uptake of the technology. However, the auction program in Indonesia faces issues and problems along its way.

2.4. Self-consumption (SELCO)

As an alternative for the NEM plan, Husain et al., (2021) and Sreenath et al., (2022) informed that the Malaysian government unveiled the self-consumption (SELCO) scheme in 2017. Customers that install PV systems and utilize the generated power for their own needs are covered by this. Although SELCO allows for the export of surplus power into the grid, no export charge is considered (Muda et al., 2021). However, the property will continue to be connected into the grid and be able to use grid power as required. With contribution by SELCO, the annual decentralized PV capacity installed in 2018 was 69.27 MW (Chen and Han, 2019) and in 2019 it was 66 MW (Velautham et al., 2020)

In Indonesia there is no self-consumption or other similar scheme that was introduced for consumer to take part of.

2.5. Fiscal Incentives

To boost Malaysia's green and clean economy, Malaysian government introduced Green Technology Tax Incentives in 2014. The government of Malaysia already implemented Green

Investment Tax Allowance (GITA), and Green Income Tax Exemption (GITE) to as an effort to support its renewable energy companies and it is managed by Malaysian Green Technology and Climate Change Corporation. Hui and Kock (2017) implied that the solar PV industry is one of the growth sectors in Malaysia where its growth was encouraged by the award of pioneer status, favorable investment tax allowance, and the Green Technology Financing Scheme.

Per 2019, MEMR have stated that there are no fiscal incentives that specifically regulate on renewable energy matter in Indonesia (MEMR, 2019).

3. NATION'S ELECTRICITY COMPANY PRESENCE IN SOLAR ENERGY DEVELOPMENT

3.1. TNB Presence in Malaysia Solar Energy Development

TNB and its subsidiary company had conducted initiative as an effort to support solar energy development in Malaysia that will be briefly described below:

- TNB
  Starting in 2000, the first grid-connected PV system was launched by TNB (Lau et al., 2022). Since 2016, TNB has been actively embarking on smart grid which its aim is maximum efficiency and reliability of the grid, accelerate integration of energy transition, and embedding innovations into the grid.

- TNEC
  Over the past 5 years, TNB Engineering Cooperation (TNEC) has successfully completed 3 Large Scale Solar plants with a total capacity of 109 MWac (Large Scale Solar - TNB Engineering Corporation Sdn Bhd, 2023).

- TNBX
  TNBX offers Supply Agreement - Renewable Energy (SARE) which is a tripartite arrangement between the consumer, TNBX, and a third-party Investor/Owner. Throughout the SARE contract duration, the investor/asset owner will produce solar energy and sell it to prosumers at an agreed-upon solar rate per kWh produced. For a charge, TNBX manages contracts, meters, invoicing, collections, disconnections, and customers on behalf of asset owners and investors. As March 2023, they have assisted 808 solar PV project totaling on 335 MW solar PV system (SARE | TNBX, 2023).

- GSPARX
  GSPARX is established preferred choice for one-stop rooftop solar solutions in Malaysia that committed in generating new revenue stream to the group. They offer PV installation and residential solar PV insurance. Additionally, GSPARX has been chosen by Perak Transit Bhd as a key partner to provide clean solar energy for three gas stations and a public transportation hub in Perak for the next 20 years (GSPARX, 2023). As 2022, GSPARX has secured 241 MW solar energy capacity and targeted 319 MW by 2025.

- TNBR
  Since 1993, Tenaga Nasional Berhad (TNB) has relied on TNB Research Sdn. Bhd (TNBR) as its internal solution provider. They offer a consolidated, one-stop site for technological solutions and innovation as a Research & Development (R&D) Center. Offered solution by TNBR (Research | TNB Research Sdn. Bhd. | Kajang, 2023):

1. Solar PV recycling system
2. Solar resource assessment
3. PV performance and reliability
4. Grid integration of renewable energy resources
5. Floating solar energy system

3.2. PLN Presence in Indonesia Solar Energy Development

According to Bayu and Windarta (2021), provision of electricity from upstream to downstream in Indonesia is the responsibility of PLN which included on the development of power plants from renewable energy sources. Due to Indonesia's substantial indigenous coal deposits, coal has undisputed supremacy for PLN as the baseload fuel of choice. As a result, PLN maintains a single-minded focus on major baseload supply fixes and mostly ignores advanced demand-side solutions (IEEFA Report, 2019). PLN additionally neglected to consider the possible effects of more reasonably priced battery storage, even though new storage alternatives would provide flexibility options that would improve grid stability and dependability. (World Energy Outlook, 2018). This resistance to newer grid management strategies is often deployed as a barrier to solar energy projects.

Nevertheless, PLN has done initiatives to support solar energy development in Indonesia by took part in solar projects in which will be briefly described below:

- PLN
  The realization of PLN PV rooftop customers until the fourth quarter of 2021 was 4,794 customers with a registered rooftop PLTS capacity of 48 MWp. PLN has added around 18 MW of solar power plants in 2021 spread throughout Indonesia (PT. PLN 2021 Sustainability Report, 2022).

- PLN Indonesia Power (PLN IP)
  With a maximum capacity of 561 kWp, PLN IP has successfully run the largest floating solar power plant in Indonesia in the Tambak Lorok area, Semarang (Chandak, 2023). Besides that, PLN IP also provides engineering consultation services, procurement, solar power plant construction, operation, and maintenance services as well as project investors.

- PT. Indo Tenaga Hijau
  Through this subsidiary company, they have completed more than 20 projects with the total capacity installed over 1120.5 kilowatts (kWp) (PT Indo Tenaga Hijau, 2023).

- PLN Nusantara Power
  Based on the portfolio, PLN Nusantara Power involved in three solar projects: Cirata floating solar PV, Cirata solar PV, and Public Electric Vehicle Charging Stations (SPKLU) PV project in Bali. The total solar capacity secured from the projects is around 146 MW (Solar PV Archives, 2023).

There are two main points that PLN has done: PV rooftop and solar projects. The number of solar installed capacity that initiated by PLN is still far below when compared to the number of TNB's initiatives in Malaysia and can be observed in Figure 1. The diversity of the solar energy initiative also become a matter that PLN should consider.

4. PV SYSTEM INDUSTRY CHAIN

4.1. PV System Industry Chain Condition in Malaysia

The first stage in PV system industry chain is research & development (R&D). The R&D activities and the enhancement of PV technology in Malaysia are largely under the purview of MOSTI. Per 2019, R&D jobs related to solar PV in Malaysia (besides R&D companies) totaling 50 jobs (Velautham et al., 2020).

The next stage is raw material and wafer processing. Malaysia already has company that produce raw material, such as silicon feedstock, and company that fabricate ingot and wafer. After raw material and wafer processing, component integration is the next stage. The capacity to produce solar PV modules and solar cells combined in Malaysia is expected to be 8898.2 MW and 8582.5 MW, respectively.

The cost of PV systems keeps falling due to rising PV deployment, supportive governmental regulations, and intensive R&D, enabling PV systems attractive and cost-efficient (IESR 2022). Based on IEA national survey report, the typical module prices in Malaysia is declining where its 5.8 RM/Wp in 2011 and become 1.06 RM/Wp in 2019. The declining trend is also occurred in building applied PV system prices installation, in 2011 the price is 11 RM/Wp whereas in 2019 the price is 5.58 RM/Wp (Velautham et al., 2020).

4.2. PV System Industry Chain Condition in Indonesia

Solar panel manufacturers in Indonesia are incorporated in an association, namely the Asosiasi Pabrikan Panel Surya Indonesia (APAMSI). The percentage of panels from within the country is 92.5%, the percentage of imported panels is 7.1% and the panel group without an identity of origin is 0.4%. To fulfill the government's plans listed in RUEN regarding the development of 6.5 GW solar energy in 2025, the capacity that must be achieved annually is 1300 MW, but currently by looking at Ni et al., (2021), the total production capacity of APAMSI members is only 700 MWp/year which shows the production capacity of APAMSI members has not been able to meet the national target of PLTS in 2025.

Currently, only module assembly is done in Indonesia for PV production. This indicates that Indonesia is still unable to carry out local component manufacture and R&D for the PV industrial chain. From the APAMSI online data that was released in 2020 that was mentioned by Ni et al., (2021) and from IEA report that was also published on 2020 (Velautham et al., 2020), Indonesia and Malaysia PV module production capacity in 2019 can be compared on the Figure 2.

5. PROJECTION OF INDONESIA ACHIEVEMENT ON RUEN SOLAR ENERGY TARGET IN 2025

The projection will be using a quantitative forecasting method, a scenario analysis, to be able to determine each of the approaches' achievement by 2025. The time period of the projection is from 2022—2025, spanning 4 years, and further in this paper this timespan called a cycle. The consideration to start in 2022 is because the starting point of this projection is using IRENA report of 2021. The projection makes several assumptions. First, Indonesia and PLN are assumed able to implement all the approach despite any real-world constraint. Second, the addition of each approach is an assumption based on the reflection of the accomplishment of the approach in Malaysia. Third, Indonesia is assumed capable to fund all the approach expense and fulfill the criteria on the financial system. Besides assumptions, a limitation of the projection determined: it does not consider any political condition that could affect to the solar energy development, does not considering future policy or program that still on the pilot phase, and the data will be limited to only from gathered references from paper, journal, official report, and official website. The flowchart mechanism on the projection can be seen in Figure 3.

5.1. Using Malaysia and TNB Approach

Malaysia and TNB approach are one of the strategies that will be benchmarked on projecting Indonesia solar energy development because of their accomplishment. The approach can be grouped into several groups:

- Based on the newest NEM schemes in Malaysia (NEM 3.0), Indonesia could offer quota with the amount of 100 MW on government building (benchmarking NEM GoMen) and 300 MW on commercial & industry (benchmarking NOVA). If the quota is fully allocated, then there will be addition of 400 MW to the installed capacity. NEM rakyat will be not considered because it could cause over-lapping with rooftop PV installation.
- For SELCO scheme, Malaysia has secured 135.27 MW of solar energy capacity in 2 years (Chen and Han, 2019; Velautham et al., 2020). By following this scheme, Indonesia could add 270.54 MW in 4 years to their decentralized PV system.
- In terms of installing rooftop PV, through GSPARX, TNB has installed 25 MWp in 2019 and 125 MWp in 2022, increasing 400%. PLN has only added 18 MWp in 2021 to the total of 48 MWp. Using the growth of rooftop installation in 4 years by TNB, PLN could add up to 90 MW by 2025.
- From the solar project, TNB has completed 3 LSS with a total capacity of 109 MW. Considering PLN follow this initiative, with this number PLN could add 109 MW capacity to their existing portfolio.
- A creative initiative has been conducted by TNB through TNBX that established SARE agreement. Through this initiative, TNBX have assisted 808 solar PV project totaling on 335 MW solar PV system. Assuming PLN adopt this initiative,

using TNB number PLN could also secured 335 MW.

- According to the IEA National Survey Report of Malaysia, the module production capacity increasing between 2018 and 2019 from 5427 MW in 2018 into 8898.2 MW in 2019 (Chen and Han, 2019; Velautham et al., 2020). Malaysia has increased their PV module production for 3471.2 MW or adding it about 63.96%. Currently, from Daftar Anggota – APAMSI (2023), the total PV module capacity is 700 MW/year (APAMSI, 2023). If Indonesia capable to follow the development growth of PV industry in Malaysia, in 2025 or in 2 years span, Indonesia will increase their PV module production capacity into around 1881.8 MW/year by 2025.

The result of projected solar energy capacity addition in Indonesia by 2025 using Malaysian government and TNB approach can be seen in Table 2.

There are several data and findings that can be used for further analysis:

1. Total capacity installed in Indonesia on 2021 (IRENA, 2022): 211 MW
2. Solar energy capacity addition target from 2022—2025: 4900 MW
3. Total projection of Indonesia's solar energy capacity addition: 1204.54 MW
4. Installed solar energy capacity target on RUEN for 2025: 6500 MW
5. Projection of Indonesia's installed solar energy capacity by 2025: 1415.54 MW
6. Projected Indonesia achievement on RUEN target by 2025: 21.77%
7. Projected PV module production capacity by 2025: 1881.8 MW/year

Looking ahead, Indonesia has set ambitious targets for solar energy capacity addition based on RUEN from 2022 to 2025, with a total goal of 4900 MW capacity installed. This includes specific yearly targets of 900 MW in 2022, 1200 MW in 2023, 1300 MW in 2024, and 1500 MW in 2025 (Presidential Regulation No. 22 of 2017 on National Energy General Plan, 2017).

5.2. Using Indonesia Business as Usual (BAU) Scheme

This projection on Indonesia achievement on the RUEN target by 2025 will use Indonesia on-going approach on solar energy development in Indonesia and without any addition of approach. From the gathered information, there are approaches that will be considered in this projection, such as:

- From 2018-2021 (4 years), Indonesia have implemented new FiT framework and NEM scheme for solar rooftop. On the time span of 4 years, Indonesia have only installed 113 MW according to IRENA. This number will be use as the benchmark for the 2022-2025 projection.
- Based on their initiatives, PLN has already secured 147.68 MW from their solar projects. Assuming PLN could achieve this number in 4 years, an addition of 147.68 MW can be added into the projection.
- The growth of local PV module production in Indonesia can be determined by using data from APAMSI. From 2020 to mid-2023 it increases from 470 MW/year into 700 MW/year, or it can be said it grow for about 92 MW/year. Assuming the growth rate is constant until 2025, the production capacity could reach 930 MW/year by 2025.

The result of projected solar energy capacity addition in Indonesia by 2025 using BAU scheme can be seen in Table 3.

There are several data and findings that can be used for further analysis:

1. Total capacity installed in Indonesia on 2021 (IRENA, 2022): 211 MW
2. Solar energy capacity addition target from 2022—2025: 4900 MW
3. Total projection of Indonesia's solar energy capacity addition: 260.68 MW
4. Installed solar energy capacity target on RUEN for 2025: 6500 MW
5. Projection of Indonesia's installed solar energy capacity by 2025: 471.68 MW
6. Projected Indonesia achievement on RUEN target by 2025: 7.26%
7. Projected PV module production capacity by 2025: 930 MW/year

The comparison between the two projections of Indonesia achievement on RUEN target in solar energy by 2025—using Malaysia & TNB approach and BAU scheme—can be summarized and can be seen in Table 4.

6. FORECASTING AND ANALYZING INDONESIA'S ACHIEVEMENT ON SOLAR ENERGY CAPACITY BY 2050

The forecasting method that will use is regression linear which presupposes that the previous relationship will be maintained in the future. The growth is assumed to be constant from the 2022—2025 projection on the previous chapter. The general form of a simple linear regression equation can be seen below:

$$y = mx + b$$

Where in this equation,
y = dependent variable which will be forecasted
m = slope of the regression line
x = independent variable which will be used to make the prediction
b = y-intercept of the regression line

6.1. Forecasting Calculation and Result by 2050

There are three subject that will be forecasted: Indonesia using BAU scheme, Indonesia using Malaysia & TNB approach, and Malaysia using their BAU scheme. The range of the forecasting will be start at the determined 2025 projection until 2050 with the interval of 5 years.

- Indonesia using Business as Usual (BAU) Scheme

A linear regression forecasting method will be used to determine the projection of Indonesia's installed solar energy capacity from 2021—2050 using BAU scme. First, the slope (m) can be determined using data from 2021 and the projected result of 2025 as a point (2021, 211 MW) and (2025, 471.68):

$$m = \frac{471.68 - 211}{2025 - 2021} = 65.17\,MW\ /\ year$$

Next, calculating the y-intercept (b) using the formula:

$$b = y - mx = 211 - 65.17(2021) = -131497.57\,MW$$

Then, with the slope and the y-intercept is determined, a linear equation is could be determined:

$$y = mx + b = 65.17x - 131497.57$$

Using the linear equation, this method could display a forecasting of installed solar energy capacity until 2050. The result can be seen below:

- 2030: y = 65.17(2030) – 131497.57 = 797.53 MW
- 2035: y = 65.17(2035) – 131497.57 = 1123.38 MW
- 2040: y = 65.17(2040) – 131497.57= 1449.23 MW
- 2045: y = 65.17(2045) – 131497.57 = 1775.08 MW
- 2050: y = 65.17(2050) – 131497.57 = 2100.93 MW

Using the determined function for this scheme, a required time for this scheme to surpass the 2025 & 2050 RUEN target can be forecasted.

For the 2025 RUEN target:

6500 = 65.17x – 131497.57

$$x \approx 2118.$$

For the 2050 RUEN target:

$$x \approx 2709$$

So, using BAU scheme the 2025 RUEN target will be surpassed on the year of 2118 and for the 2050 RUEN target it will be surpassed on the year of 2709.

- Indonesia using Malaysia & TNB Approach

This linear regression forecasting considering the growth of PV installation by PLN is constant from the 2025 projection. First, the slope (m) can be determined using data from 2021 and the projected result of 2025 as a point (2021, 211 MW) and (2025, 1415.54 MW):

$$m = \frac{1415.54 - 211}{2025 - 2021} = 301.135\,MW\ /\ year$$

Next, calculating the y-intercept (b) using the formula:

$$b = y - mx = 211 - 301.135(2021) = -608382.835\,MW$$

Then, with the slope and the y-intercept is determined, a linear equation is could be determined:

$$y = mx + b = 301.135x - 608382.835$$

Using the linear equation, this method could display a forecasting of installed solar energy capacity until 2050. The result can be seen below:

- 2030: y = 301.135(2030) - 608382.835 = 2921.215 MW
- 2035: y = 301.135(2035) - 608382.835 = 4426.89 MW
- 2040: y = 301.135(2040) - 608382.835 = 5932.565 MW
- 2045: y = 301.135(2045) - 608382.835 = 7438.24 MW
- 2050: y = 301.135(2050) - 608382.835 = 8943.915 MW

Using the determined function for this scheme, a required time for this scheme to surpass the 2025 & 2050 RUEN target can be forecasted.

For the 2025 RUEN target:

$$6500 = 301.135x - 608382.835$$

$$x \approx 2042$$

For the 2050 RUEN target:

$$45000 = 301.135x - 608382.835$$

$$x \approx 2170$$

Figure 1: Installed Solar Capacity from TNB & PLN Initiatives

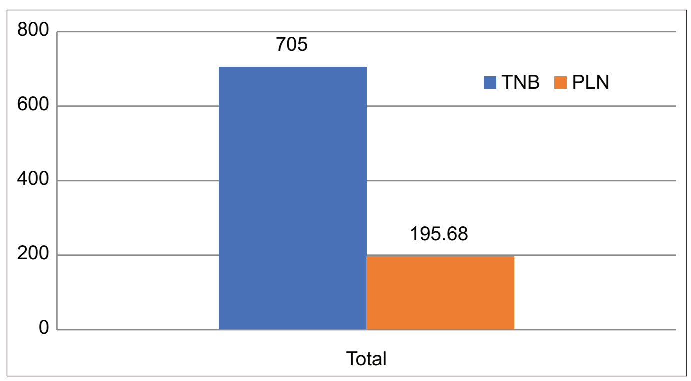
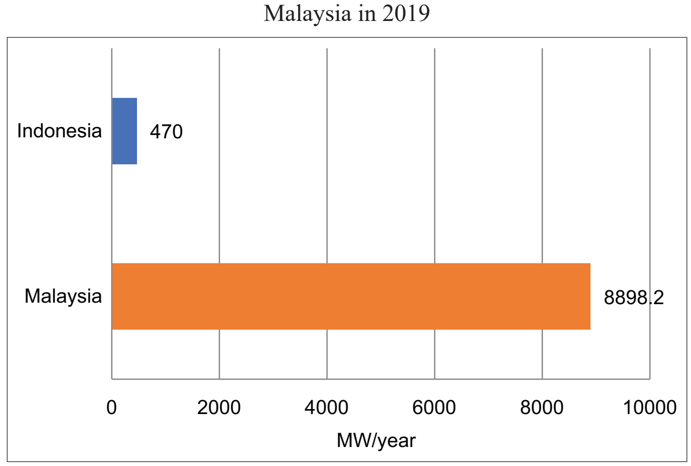


Figure 2: Comparison of PV Module Production of Indonesia and Malaysia in 2019



So, using Malaysia and TNB approach, the 2025 RUEN target will be surpassed on the year of 2042 and for the 2050 RUEN target it will be surpassed on the year of 2170.

- Malaysia using Business as Usual (BAU) Scheme

Figure 3: Flowchart for Projection Mechanism

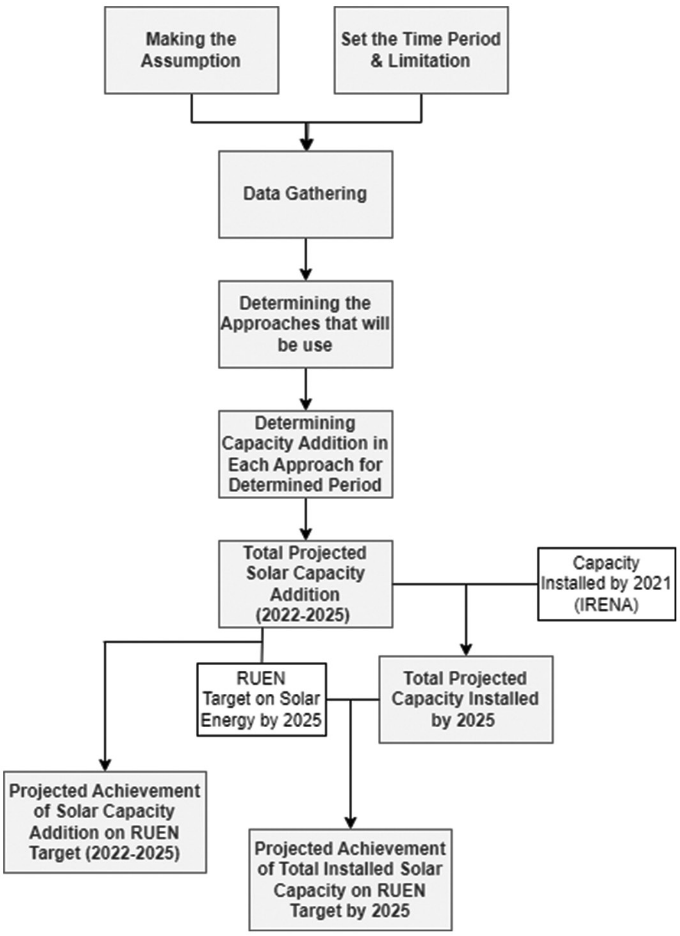


Figure 4: Projected Indonesia Achievement on 2025 RUEN Target

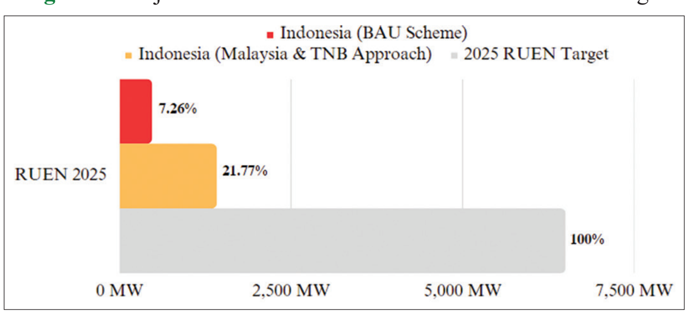
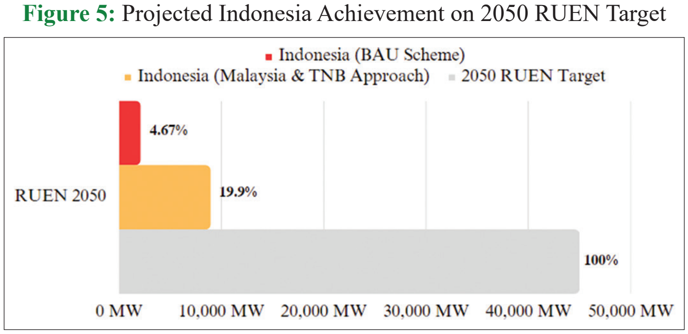


Figure 5: Projected Indonesia Achievement on 2050 RUEN Target



Because this paper does not conduct a projection for Malaysia by 2025 the two point that will used in this forecasting is

Figure 6: Progress of the Forecasting Result on the Maintained RUEN Target

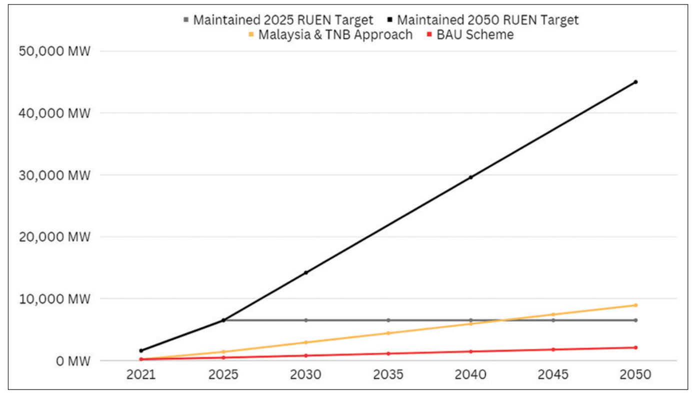


Figure 7: REmap Scenario Comparison for Indonesia and Malaysia

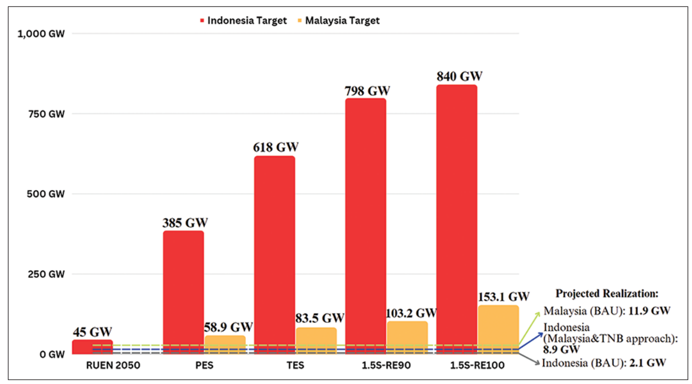


Table 1: Comparison on implemented FiT policy in Indonesia and Malaysia

Indicators	Indonesia	Malaysia
Participant	By project (auction scheme)	All (residential and commercial)
Degradation on FiT rate	No	Yes (annually)
Addition rate for using local content	Yes	Yes (only on 2013–2014)
Statutory body that responsible on administering FiT system	No	Yes (SEDA)
RE fund to covers government expense on FiT policy	No	Yes

SEDA: Sustainable Energy Development Authority Malaysia

Table 2: Projected solar energy capacity addition in Indonesia by 2025 using Malaysia and tenaga nasional berhad approach

Approach	Projected addition (MW)
Updated NEM scheme	400
Applying SELCO scheme	270.54
Rooftop PV installation	90
Solar projects	109
SARE	335
Total	1204.54

SARE: Supply agreement - renewable energy, NEM: Net metering, SELCO: Self-consumption from 2017 and 2021. The consideration is it has the same time span with the Indonesia's forecast method (4 years). First, the slope (m) can be determined using the points (2017, 394 MW) and (2021, 1787 MW):

$$m = \frac{1787 - 394}{2021 - 2017} = 348.25 MW / year$$

Next, calculating the y-intercept (b) using the formula:

$$b = y - mx = 394 - 348.25(2017) = -702026.25 MW$$

Then, with the slope and the y-intercept is determined, a linear equation is could be determined:

$$y = mx + b = 348.25x - 702026.25$$

Using the linear equation, this method could display a forecasting of installed solar energy capacity until 2050. The result can be seen below:

- 2030: y = 348.25(2030) - 702026.25 = 4921.25 MW
- 2035: y = 348.25(2035) - 702026.25 = 6662.5 MW
- 2040: y = 348.25(2040) - 702026.25 = 8403.75 MW
- 2045: y = 348.25(2045) - 702026.25 = 10145 MW
- 2050: y = 348.25(2050) - 702026.25 = 11886.25 MW

The summary of the result of the solar energy capacity forecasting for 2050 can be seen in Table 5.

6.2. IRENA REmap (2018—2050)

The Indonesia Energy Transition Outlook was designed and elaborated using the IRENA REmap approach, creating technical pathways with a focus on energy efficiency. PLEXOS was used to simulate the power industry, including solar energy, for capacity growth and operational flexibility, with an additional operational flexibility evaluation using IRENA's FlexTool product (IRENA, 2022; IRENA 2023).

For in this paper, the gathered data from the REmap include the population and GDP assumption, total installed solar energy capacity, and total investment requirement by each scenario.

The REmap will use three scenarios:

- Planned Energy Scenario (PES)

Reflects existing plans and further anticipated aims or policies that were settled on at the time the analysis was done.

- Transforming Energy Scenario (TES)

Energy path focused mostly on competitively priced low- and zero-carbon technologies that are presently accessible.

- 1.5˚C Scenario (1.5-S)

This presents strategies to further lower CO_2 emissions in the energy system in challenging sectors and is a more ambitious energy roadmap. A scenario with 90% renewable electricity generation (RE90) and a case with 100% renewable energy generation (RE100) were both examined for the power industry.

The REmap assumption for the population and GDP in Indonesia and Malaysia can be seen below:

The summarized of the REmap simulation result on installed solar energy capacity from each scenario in Indonesia and Malaysia can be seen in Table 7.

Comparing with the RUEN model, the simulation from REmap shows that the target on 2050 is far higher than the 2050 RUEN target, which is 45.000 MW or 45 GW of installed solar energy. The main reason is the RUEN model only targeting 31% of renewable energy share from the total primary energy mix by 2025. The other reason could because of the different focus on distributing the potential project from several other renewable sources when planning the strategy in achieving their renewable energy share target.

Table 3: Projected solar energy capacity addition in Indonesia by 2025 using business as usual scheme

Approach	Projected addition (MW)
On-going policy	113
PLN initiatives	147.68
Total	260.68

Table 4: Summarized projection result of indonesia achievement on solar energy target in rencana umum energi nasional by 2025

Scheme used	Total projection of solar capacity addition (MW)	Projected achievement of solar capacity addition (%)	Projection of installed solar capacity by 2025 (MW)	Projected achievement on RUEN target by 2025 (%)	Projected PV module production capacity by 2025 (MW/year)
BAU	260.68	5.32	471.68	7.26	930
Malaysia and TNB approach	1204.54	24.58	1415.54	21.77	1881.8

BAU: Business as usual, TNB: Tenaga nasional berhad, RUEN: Rencana umum energi nasional

Table 5: Summarized forecasting result on solar energy capacity for 2050

Scheme Used	2030	2035	2040	2045	2050
Indonesia (BAU scheme) (MW)	797.53	1123.38	1449.23	1775.08	2100.93
Indonesia (Malaysia and TNB approach) (MW)	2921.215	4426.89	5932.565	7438.24	8943.915
Malaysia (BAU scheme) (MW)	4921.25	6662.5	8403.75	10145	11,886.25

BAU: Business as usual, TNB: Tenaga nasional berhad

Table 6: Population and GDP assumption for Indonesia and Malaysia

Assumption	2018	2030	2050
Indonesia			
Population (million persons)	265	296	335
GDP (million USD)	958,671	1,486,911	3,761,325
GDP per capita (USD/capita)	3617	5016	11,228
Malaysia			
Population (million persons)	32.4	36.1	40.7
GDP (million USD)	348,948	506,138	934,665
GDP per capita (USD/capita)	10,753	14,004	22,975

6.3 Comparison and Analysis on Forecasting Result, RUEN Target, and IRENA REmap Scenarios

6.3.1. RUEN 2025 & 2050 target on installed solar energy capacity

It is worth noting that the installed solar energy capacity target outlined in RUEN, Indonesia's National Energy Plan, for the year 2025 is set at 6500 MW. The total projection of Indonesia's solar energy capacity by 2025 can be estimated by adding installed capacity in 2021 and the projected solar capacity addition by 2025, resulting 1415.54 MW with the Malaysia & TNB

Table 7: Total installed solar energy capacity model of Indonesia and Malaysia (IRENA REmap)

	IRENA REmap: Total installed solar energy capacity							
	2018	2030			2050			
		PES	TES	1.5-S	PES	TES	1.5-S RE90	1.5-S RE100
Indonesia (GW)	0	5	48	66	385	618	798	840
Malaysia (GW)	0.4	8.6	10.6	17.1	58.9	83.5	103.2	153.1

PES: Planned energy scenario, TES: Transforming energy scenario

Table 8: Problem analyzation by a problem-solving method

Subject	Problem statement	Defining root cause	Proposed solution
Solar energy development in Indonesia	Declining progress on the projected RUEN target achievement (2025–2050)	The approach from both schemes does not capable to secure a large amount of solar capacity comparing to the RUEN target and not progressive enough	Indonesia needs an immediate breakthrough solution or framework to catch up with the target
FiT policy	Due to the lack of financial incentives and ongoing grid connection fees, the addition of solar capacity in Indonesia showed slow progress and was not commercially appealing	The solar tariff based on the BPP that may be fluctuate and discounted the export energy	Create a commercially attractive FiT rate that will be decrease from time to time Implement RE fund mechanism to covers the expense on FiT policy
NEM policy	PLN failed to attract consumers due to the lack of monetary benefits and monthly grid connection charges	The MEMR decided to value exported electricity at 65% of the PLN tariff Rooftop solar installation is limited by PLN to a maximum capacity of just 10%–15% of the customer's installed electricity connection	Government gives allocated quotas to the new NEM policy that accordingly to the capability of the grid capacity Implement a new NEM policy or revise the current one to permits consumers to export excess energy on a one-on-one basis Benchmark other nation on their NEM policy
Solar project/IPP	Regulation and infrastructure that drove down investor confidence to invest	The absence of spinning reserves and the problems PLN has on controlling intermittency phenomena Insufficient regulations and inadequate governance in the energy sector forced Indonesian policymakers to make frequent and unpredictable changes to their policies	PLN must upgrade and invest on the electricity grid infrastructure by applying smart grid or another method Reconsider all the on-going policy on solar energy and create a long-term policy framework Conduct transparency on the power sector Use and involve suitable public consultation
PLN initiatives	The contribution on Indonesia's solar capacity from PLN initiatives is far less than TNB on Malaysia	PLN initiatives is considered not diverse enough There is no effort to enhance R and D to boost the solar development	Create a subsidiary company to focuses on the R and D and new initiatives Create a well-planned solar energy business on a long-term plan Implement green electricity tariff
PV industry	PV module production capacity in Indonesia is far below compared to Malaysia	TKDN regulation drawbacks Only limited to module assembly process	Review the TKDN regulation by benchmarking other nation Consider more on investment requirements, electricity prices, and manufacturing costs Implement long-term fiscal incentives Create a training system to increase human resource capacity development
RUEN target	Indonesia could not achieve their target from RUEN by 2025 on solar capacity matter	Too ambitious on setting the target PLN have a discrepancy on their plan from the solar energy target on RUEN	Create 2 projection to determine target: using BAU scheme and NCT scheme Increasing coordination with PLN and all the stakeholders involved in solar energy development before setting the target Reconsider and revised the RUEN target

NCT: New capacity target, BAU: Business as usual, NEM: Net metering, BPP: Biaya Pokok Penyediaan, RUEN: Rencana umum energi nasional, TNB: Tenaga nasional berhad approach and 471.68 MW with the BAU scheme. Then, the total projection can be compared to the RUEN target to determine Indonesia's achievement on the target by 2025. The projected Indonesia achievement on RUEN target by 2025 is 21.77% with the Malaysia & TNB approach and only 7.26% with the BAU scheme and the comparison is presented in Figure 4.

The target that has been set for installed solar capacity in RUEN by 2050 is 45000 MW or 45 GW. Using the forecasting method, a projection of Indonesia achievement on achieving the RUEN target in 2050 can be determined. Using the BAU scheme, Indonesia achievement is 4.67%, dropping 2.57% compared to their projected achievement in the 2025 RUEN target. The declining trend also occurred when using the Malaysia & TNB approach, dropping 1.87%. It means to make the achievement trend increasing, it required a breakthrough solution/framework that could secured more solar capacity than both schemes, so it could boost the progress into having an increasing trend. The full comparison for 2050 projection is presented in Figure 5.

RUEN targeted 6500 MW of installed solar capacity on 2025 and 45000 MW on 2050. From the forecasting result, Indonesia could not surpass the target on time, whether it use the BAU scheme or using Malaysia & TNB approach. Indonesia will surpass the 2025 RUEN target on the year of 2118 by using BAU scheme and on the year of 2042 if using the Malaysia & TNB approach. Compared to the BAU scheme, using Malaysia & TNB approach will help Indonesia to surpass the 2025 RUEN target 76 years early. The progress of both schemes on the maintained 2025 and 2050 RUEN target can be seen in Figure 6.

6.3.2. IRENA REmap scenarios for 2050

Malaysia have lower in the total capacity projection of solar PV capacity on the REmap, lower than 15-20% from Indonesia (on every scenario). The projection of every scenario and REmap for 2050 is presented in Figure 7. However, based on the forecasting result for 2050, Malaysia in the BAU scheme, have a higher achievement than Indonesia in their BAU scheme, about 5 times higher. Thus, with lower achievement in solar energy capacity but with higher target to achieve in order to reduce the emission, Indonesia need a breakthrough innovation to boost their solar development.

6.3.3. Discussion: Analysis based problem solving method

There are factors that contributes to incapability of Indonesia on achieving their RUEN target on the number of installed solar capacity. From the several factors that has been mentioned, the problem is stated to be able to find the root cause of the problem. By defining the root cause of the problems, there are several proposed solutions to address the problems. And all the proposed solution needs a further study to be able to be implemented according to Indonesia condition in the future. The full flow of this problem-solving method can be seen on Table 8.

7. CONCLUSION

In conclusion, this paper provides a projection of Indonesia's achievement on solar energy capacity target in National Energy Plan (RUEN) using Business as Usual (BAU) Scheme and Malaysia & TNB approach. Based on the analysis, there are several key conclusions including:

1. With a policy that has more benefit to offered and clear framework, solar energy development in Malaysia is increasing significantly compared to Indonesia which has a solar energy policy that considered not commercially attractive and modified unpredictably.
2. As Malaysia's biggest electricity company, TNB has secured solar energy capacity around 705 MW, three times larger than PLN—which only secured around 195.68 MW—through their diverse initiative and programs.
3. From the PV industry chain aspect, Malaysia already conducted R&D, raw material and wafer processing, component integration, cell production, and module production which has a capacity of 8898.2 MW/year as 2019. Meanwhile Indonesia still limited to module production which has a capacity of 470 MW/year as 2019.
4. The projected Indonesia's achievement on the solar energy capacity target in RUEN by 2025 is only 7.26% using BAU scheme and 21.88% while using Malaysia & TNB approach.
5. The projection shows that using Malaysia & TNB approach, Indonesia will achieve the 2025 RUEN target 76 years early than using BAU scheme, and a solution in a form of strategic action that has been determined from the analysis-based problem-solving method in order to boost the solar energy development.

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