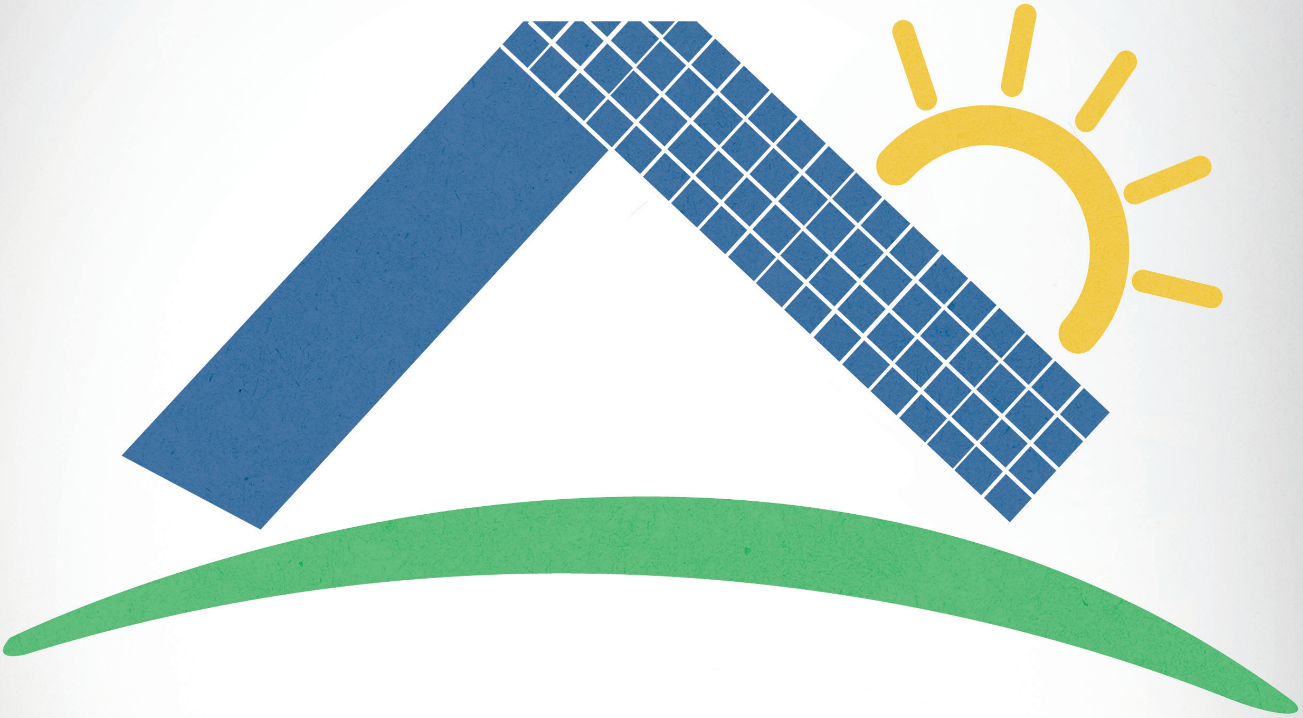
Centre for Science and Environment

INTERNATIONAL SOLAR ALLIANCE



A Case for Solar Rooftop in Indonesia

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THE POWER SCENARIO IN INDONESIA

Ninety-five per cent of the primary energy requirement in Indonesia is met through fossil fuels — oil, gas and coal. However, because of the country's limited reserves of these fuels as well as its commitment to the international community to reduce greenhouse gas emissions by 29 per cent by 2030, it must work towards reducing this dependence. The National Energy Policy (NEP) of 2014 aims to do just that — it will cut this dependence down from 95 to 72 per cent by 2025.[1]

But Indonesia faces many challenges in achieving this target. Approximately 41 million Indonesians (16 per cent of the total population) live without electricity,[2] and around 12,000 villages are without power in the country. In addition to meeting the growing demands of the nation and adding new capacity, maintaining reliable and affordable electricity supply across 900 islands poses a major challenge for the state electricity provider, Perusahaan Listrik Negara (PLN). To address growth needs, the NEP plans to add 35 GW of new generation over the next five years (2014-2019), with 25 per cent of it coming from new and renewable energy sources.

Demand and supply

The overall electricity demand in Indonesia has grown at an average rate of 7.1 per cent per annum, with the total demand rising from 134.6 TWh (terrawatt hour) in 2009 to 202.8 TWh in 2015.[3] At the end of 2015, Indonesia's total electricity generation capacity was around 55.5 gigawatt (GW), generating around 202.8 TWh. The islands of Java and Bali account for about three quarters of Indonesia's power consumption. With demand slated to increase by 2.5 times in the next 10 years, and mainly in these two provinces, Indonesia would need new generation capacity at a faster pace, as well as specific strategies for demand-side management.

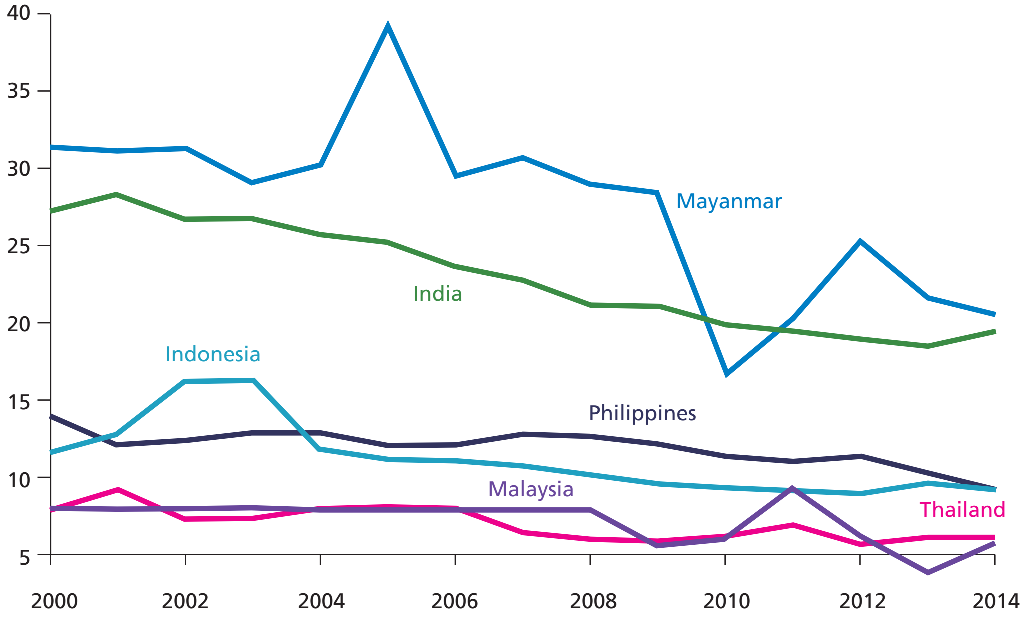
According to a study by Indonesia Investments (a privately held investment company based in Delft, the Netherlands), the existing electricity reserve margins in Java are about 27 per cent.[4] However, both Java and Bali can potentially be hit by a power crisis in coming years as the margins are projected to decline to 16 per cent due to growing demand (far below the 30 per cent level which is considered safe).

Transmission and distribution

The main barrier to improving electrification rates in Indonesia is finance for its transmission and distribution (T&D) infrastructure. In 2014, the PLN operated about 925,300 circuit-km of distribution lines and 46,800 MVA (megavolt amperes) of transformer capacity.[5] The network has deteriorated due to lack of upkeep, and it is reported that several areas — particularly those with high load densities such as Jakarta, Bandung and Surabaya — are overloaded and unreliable.

There are also the issues of voltage and grid instability which often challenge the PLN's efforts to maintain peak power. According to a 2016 report by Pricewaterhouse Coopers (PwC), regulatory uncertainty is a major barrier to investing in the power sector.[6]

GRAPH 1: TRANSMISSION AND DISTRIBUTION LOSSES IN INDONESIA AND OTHER COUNTRIES IN SOUTH AND SOUTH-EAST ASIA (2000-2014)



Source: World Bank, 2017

Despite this, Indonesia's T&D losses are currently at a moderate level of 9.5 per cent, and a five-year average of around 12 per cent. While Thailand and Malaysia have losses lower than 10 per cent, Indonesia T&D networks perfomed better than that of countries such as Mynamar and India which face losses pegged at levels higher than 20 per cent. It is worth noting that during the last decade and a half, almost all the countries have decreased their T&D losses by investing in infrastructure (*see Graph 1*).

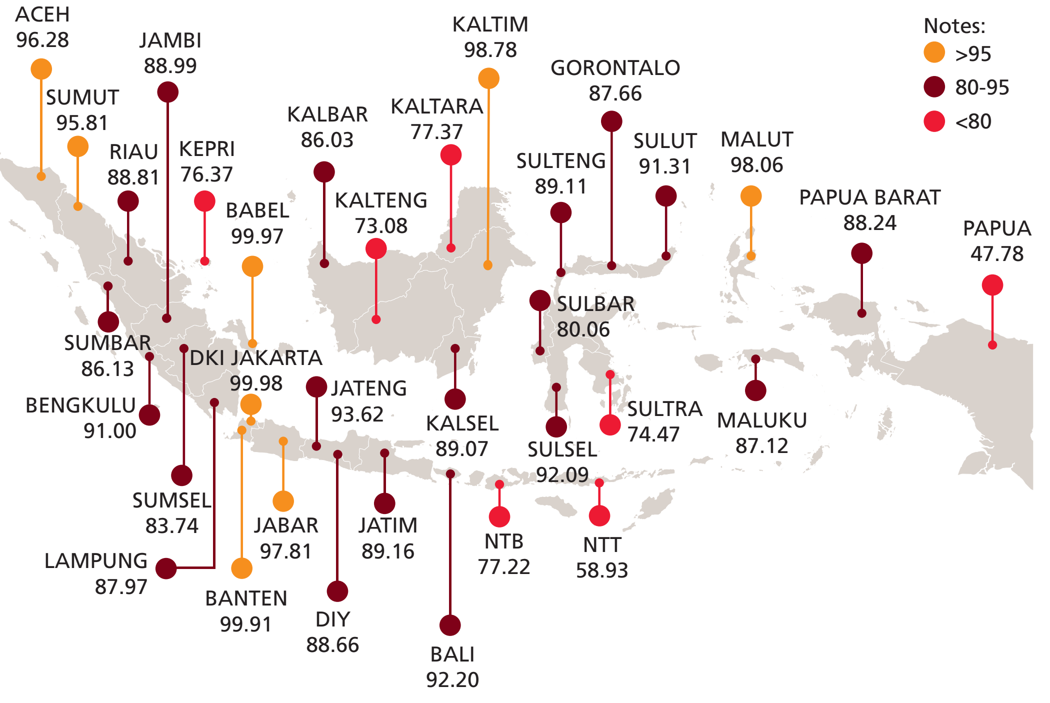
Quality of supply

Voltage can be unstable in Indonesia, resulting in brown-outs with frequent plunges to low voltage. In some areas in Bali, during peak hours from 18.00 to 22.30, the voltage can reduce to below 140 volts (acceptable voltage is 220 volts). The low voltage puts pressure on the grid, which leads to unreliable supply and high losses. This forces customers to install costly power control devices like voltage stabilisers. Multiple power control devices create a ripple effect by drawing active or reactive power from the system, deteriorating the supply as a result and increasing operational costs for PLN. The usual end result of this vicious cycle is blackouts or a system operating on rolling loads.

Rate of electrification

Based on 2016 consumption levels of 960 kWh (kilowatt hour) per capita, Indonesia is still well behind its neighboring economies. With respect to access to the grid, the picture is mixed, with electrification in the western part of the country being as high as 99.98 per cent (DKI

FIGURE 1: ELECTRIFICATION RATES IN INDONESIAN PROVINCES (2016)



Source: LAKIN DJK, 2016

Jakarta) and in the eastern part of the country as low as 47.8 per cent (Papua) (*see Figure 1*). The national average in 2016 was 91.2 per cent based on the RUPTL (Rencana Usaha Penyediaan Tenaga Listrik) 2016-2025, the government's power supply business plan; the electrification ratio has been planned to increase to 97.4 per cent by 2019 and to 99.7 per cent by 2025.

RENEWABLE ENERGY IN INDONESIA

Renewable energy investment in developed countries, as a group, fell 14 per cent in 2016, to US $125 billion.[7] The trend was reflected among emerging economies, which saw a decline in new investments by 30 per cent (US $116.6 billion). However, Indonesia saw a rise in investments in this sector amounting to US $1.36 billion in 2016 alone, compared to a total of US $4.45 billion in the previous five years (2011-2015).[8] Geothermal energy technology received the highest investment, around 80 per cent of the total (*see Table 1*).

Globally, in 2016, Indonesia had ranked first in capacity addition in geothermal installations and fifth in biodiesel production.[9] It is worthwhile to note here that while renewable energy potential in the country stands at 717 GW, the harnessed renewable energy amounts to only 8.2 GW (less than 2 per cent of the total potential).

The status of solar

The Indonesian solar PV sector has a significant potential of almost 530 GW (*see Graph 2*), though it remains relatively undeveloped. Since 1997, the output from the solar PV sector has been almost exclusively set aside for decentralised rural electrification. Table 2 shows PLN's installed solar power capacity and generation.

Programmes for PV deployment

Over the years, the government has launched various programmes and projects for solar PV deployment with the objective of supplying electricity to un-electrified villages or to replace diesel-based generation in remote regions. These projects, either funded through state budgets or by multi-lateral and bilateral assistance, have had limited success. Deployment targets under these projects have often been missed due to funding and technical constraints, while there have been reports of equipment having underperformed and / or malfunctioned due to poor quality.

Some of the major projects undertaken over the years include the following:

The Solar Home System Project

This is one of the earliest projects, launched in 1997 by the World Bank and Global Environment Facility (GEF) to electrify un-electrified villages through private sector participation. Against a targeted installation of 200,000 units of solar home systems, actual deployment was only

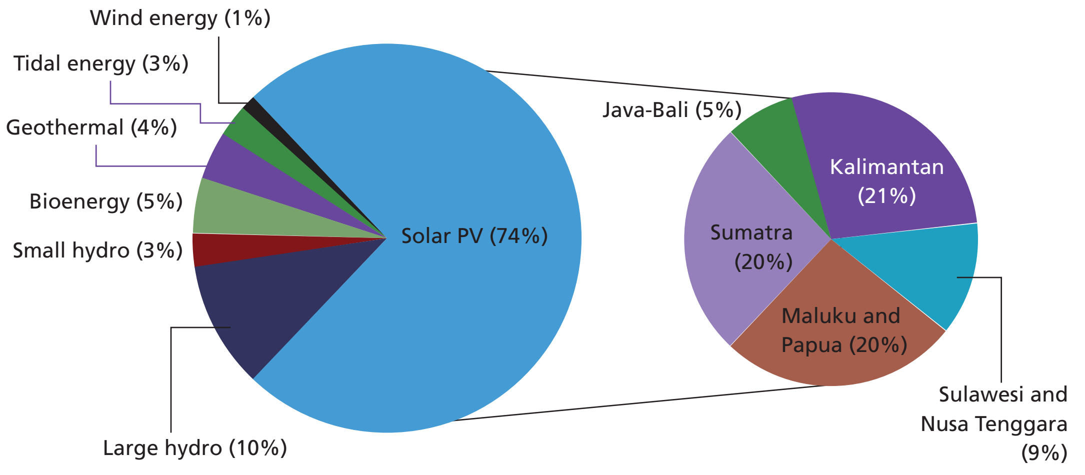
TABLE 1: RENEWABLE ENERGY SCENARIO IN INDONESIA (2015)

Source	Installed capacity (MW)
Hydro	4,826.7
Bio-energy	1,671.0
Geothermal	1,438.5
Mini and micro hydro	197.4
Solar	78.5
Wind	3.1
Tidal	0.3
Total	8,215.5

Source: General Plan of National Energy, 2017 or RUEN

GRAPH 2: SOLAR POWER GENERATION POTENTIAL IN INDONESIA

Solar PV accounts for more than two-third of the 717 GW of renewable energy potential in Indonesia



Source: International Renewable Energy Agency, 2017

TABLE 2: PLN'S INSTALLED SOLAR POWER CAPACITY AND GENERATION

Year	Installed capacity (MW)	Generation (GWh)
2011	1.23	0.72
2012	6.20	2.85
2013	7.94	5.48
2014	8.73	6.81
2015	8.86	5.28
2016	12.94	5.85

Source: PLN Statistics 2016

close to 8,000. The project had to be abandoned due to Indonesia's macro-economic crisis in the late '90s.

PLN's Hundred and Thousand Islands Projects

The PLN had initially launched a pilot project in six islands (Bunaken, Derawan, Trawangan, Banda Naira, Raja Ampat and Tomia) in 2010-11 to reduce diesel dependence in remote regions through hybrid solar power installations. It later increased the scale of interventions under the Hundred Islands Project launched in 2011-12 and the Thousand Islands Project launched in 2013-14. The two projects have a combined target of 634 MWp (megawatt peak) by 2020. Implementation has suffered due to financing and technical difficulties. After the World Bank withdrew its funding, the projects are now being deployed with support from the German Development Corporation (kfW) and the Chinese government.

Rencana Umum Energi Nasional (RUEN) solar strategies

Besides setting targets for electricity sector development, RUEN — Indonesia's national energy plan — identifies short- and medium-term strategies and action plans for achieving the identified goals. These strategies call for improving the quality of solar potential data, greater utilisation of solar power both at utility scale and at the rooftop level, and promotion of domestic upstream and downstream industries (*see Table: Strategies for solar power development identified under RUEN*). However, the timeframe identified for undertaking activities under these strategies are not aggressive enough to support Indonesia's target of increasing solar capacity to 45 GW by 2025. For instance, the government needs to refine pricing and purchasing policies for solar power on a priority basis, instead of during the indicated — and too long — timeframe of 2016-19.

TABLE: STRATEGIES FOR SOLAR POWER DEVELOPMENT IDENTIFIED UNDER RUEN

Strategy	Activities	Timeframe
Improve the quality of solar potential data	Detailed surveys by MEMR/local governments	2016-50
Increase utilisation of solar energy for electricity and for non-electrical purposes (such as heating/cooling)	Develop a solar utilisation roadmap	2016-19
	Refining pricing and purchasing policies for solar power	2016-19
	Facilitate establishment of upstream and downstream solar industry	2019-25
	Increase utilisation of solar thermal technology	2016-50
	Install solar panels at transportation facilities	2016-50
	Implement policy of using solar energy for modes of transportation	2025-50
	Facilitate transfer of solar cell technology through purchase of licenses and/or accessions	2016-19
	Facilitate R&D of solar cell technology	2016-50
	Apply the results of R&D on solar cells into industrial products	2016-50
Increase utilisation of solar rooftop potential	Facilitate greater use of solar PV panels in industrial sectors	2019-25
	Amend Building Permit Rules to implement minimum solar cell utilisation obligation of 25 per cent of rooftop area of industrial and commercial buildings, for lighting public roads and for other public facilities and buildings	2019-50
	Amend Building Permit Rules to implement minimum solar cell utilisation obligation of 25 per cent of rooftop area of luxury housing, housing complexes, and apartments	2019-50
Promote domestic solar upstream to downstream industry	Compile a list of TKDN (Domestic Component Level) industrial products and components of solar cells	2016-19
	Compile and apply SN systems, technologies and solar cell products	2016-50

Source: REUN, 2017

Photovoltaic Village Power

The programme was launched in 2012-13, funded by the Directorate General of New Renewable Energy and Energy Conservation (EBTKE) for rural electrification in off-grid communities. It targeted installation of 112 small stand-alone PV/battery systems of 15 kW each.

Energy Saving Solar Lamp (LTSHE)

The LTSHE programme targets electrification of un-electrified villages located away from PLN's grid. It is a follow-up programme of Super Ekstra Hemat Energy (SEHEN) which was initiated in 2012. The programme package includes solar panel capacity of 20 Wp, four LED lights, batteries, installation costs, and after-sales service for three years. The government has allocated a state budget of IDR 332 billion for the LTSHE programme and targets distribution of 95,729 LTSHE packages across six provinces — West Nusa Tenggara, East Nusa Tenggara, Maluku, North Maluku, Papua and West Papua. In 2018, the budget is likely to be increased to IDR 1 trillion with a target of covering 255,250 households in 15 provinces.

Program Indonesia Terang (Bright Indonesia)

The government has recently announced this national electrification initiative with the objective of electrifying six eastern provinces, with a strong focus on solar PV deployment.

Constraints for solar rooftop

Due to a number of factors, the cost of solar power in Indonesia has traditionally been on the higher side relative to global averages. The country has so far been unable to utilise the cost benefits of scale as the average size of equipment orders have remained small: annual solar capacity additions have generally ranged from 10 to 20 MW, and the largest operational project size is only 5 MW. Further, since solar project development has so far been concentrated mostly in remote areas, the cost of grid connection and equipment transportation tends to remain high, collectively accounting for 15 to 20 per cent of the project cost in certain cases.

The cost of PV installations in Indonesia is largely dependent on the international market, as these comprise either fully imported or locally assembled PV modules. The country's domestic solar power industry consists of only a limited number of small local companies engaged in assembling components imported primarily from China and Taiwan. While module import is not being taxed, some of the major auxiliary equipment (aluminum frame, ethylene vinyl acetate film, back sheet, junction box, silver solder ribbon and sealant etc) are taxed in range of 13 to 20 per cent. Also, the mandatory provision of high domestic content requirement (25.63 per cent on goods sourced, 100 per cent on services and 43.85 per cent on both combined) adds to the costs of solar power generation.

THE CASE FOR SOLAR ROOFTOP

A cost-competitive option

The solar sector has seen remarkable growth across the world, particularly due to declining module and cell prices. The global average cost of utility-scale solar PV projects declined almost 56 per cent during 2010-16 (*see Graph 3*).

By the first half of 2017, the cost of utility-scale PV systems had dropped lower than US $1 per Wp in several countries. Costs dipped in India and China to US $0.65 per Wp and US $0.80 per Wp respectively, primarily due to high competition and low labour costs. Japan remained the highest-priced market with utility systems costing US $2.07 per Wp due to higher engineering and scrutiny costs.[10]

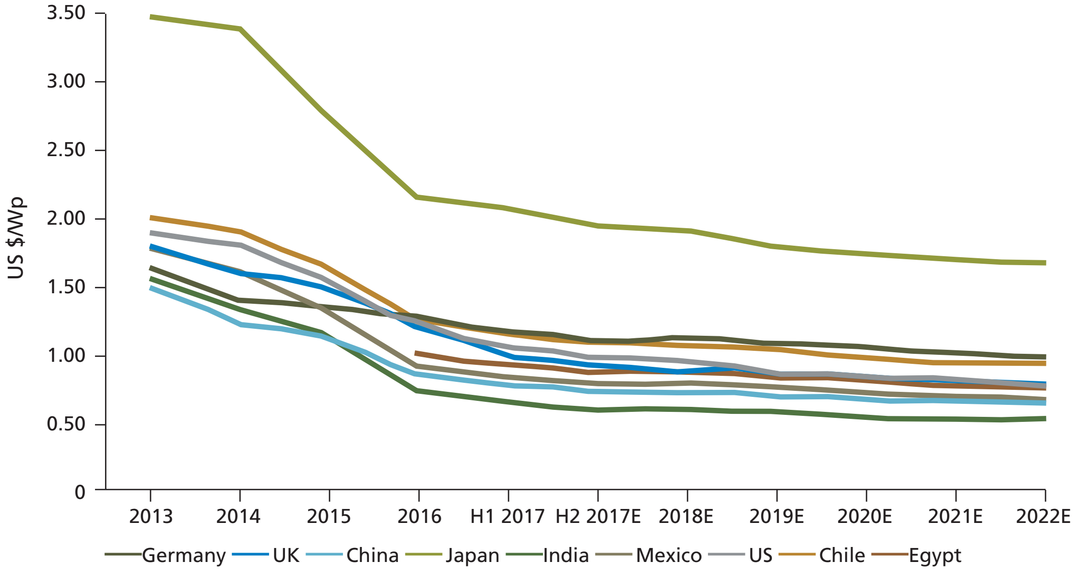
The global average cost of generation has seen a steep decline over the last five-six years (*see Graph 4*). According to the *REN21 Global Status* report, between 2010 and 2016, the levelised cost of electricity for solar PV (greater than 1 MW installed capacity) fell by 67 per cent. The solar rooftop segment in Indonesia is following the same trajectory.

The declining cost of solar rooftop

The International Energy Agency (IEA) conducted a study in 2014 to establish a *Technology Road Map of Solar PV Energy in Indonesia*.[11] The study projected that costs of PV rooftop systems will continue to decrease (*see Graph 5*). It showed that the cost of solar installation would be around US $1,800-4,800 per KWp, with an average of US $2,100 per KWp in 2015; the average was expected to drop to US $1,500 per KWp by 2020. However, in the past two-three years the module prices have crashed dramatically, and even faster than these estimates.

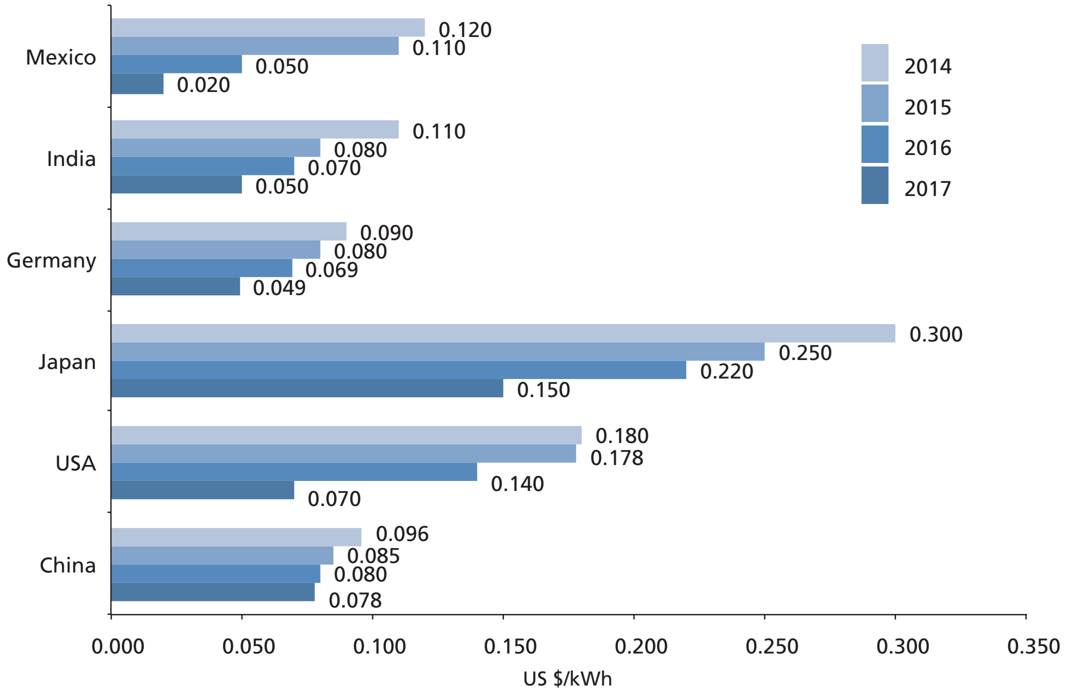
According to a 2017 analysis done by the UK-based consultancy Mott MacDonald,[12] capital costs of solar rooftop in Indonesia range from US $1,100-1,700 per KWp. This is comparable

GRAPH 3: UTILITY-SCALE SOLAR PV PRICING



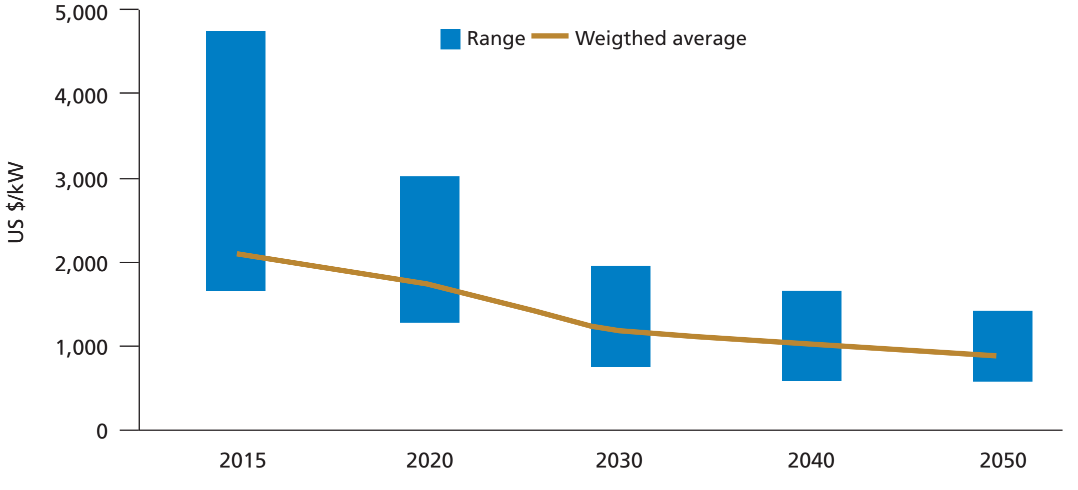
Source: GTM Research, 2017

GRAPH 4: DECLINE OF LEVELISED COSTS OF ELECTRICITY FROM SOLAR PV PROJECTS ACROSS COUNTRIES (US $ PER KWH)



Source: Compiled from various sources

GRAPH 5: COSTS OF SOLAR PV ROOFTOP SYSTEMS IN INDONESIA



Source: IEA, 2014

to costs in most South and South-east Asian nations (*see Table 3*). However, more recent information from India suggests that capital costs have dipped to around US $820 per KWp compared to the US $950-1,400 per KWp mentioned in the analysis.

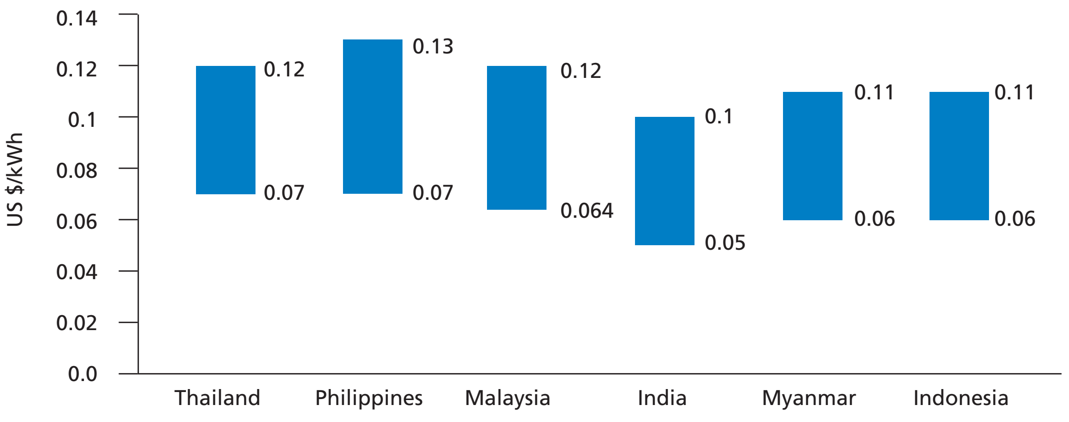
In terms of cost of generation, Indonesia seems to follow the developments across the globe. The Mott MacDonald study quotes the levelised cost of generation (LCOE) at around US $0.06-0.11 per unit of electricity (kWh) in Indonesia. In comparison, a grid-connected solar rooftop system would cost around US $0.08 per kWh in India (*see Graph 6*).

TABLE 3: CAPEX COSTS FOR DIFFERENT NATIONS IN SOUTH AND SE-ASIA

	Indonesia	Thailand	Philippines	Malaysia	Myanmar	India
CAPEX (in US $ per kW)	1100-1700	1100-1700	1200-1800	1100-1700	1000-1600	950-1400

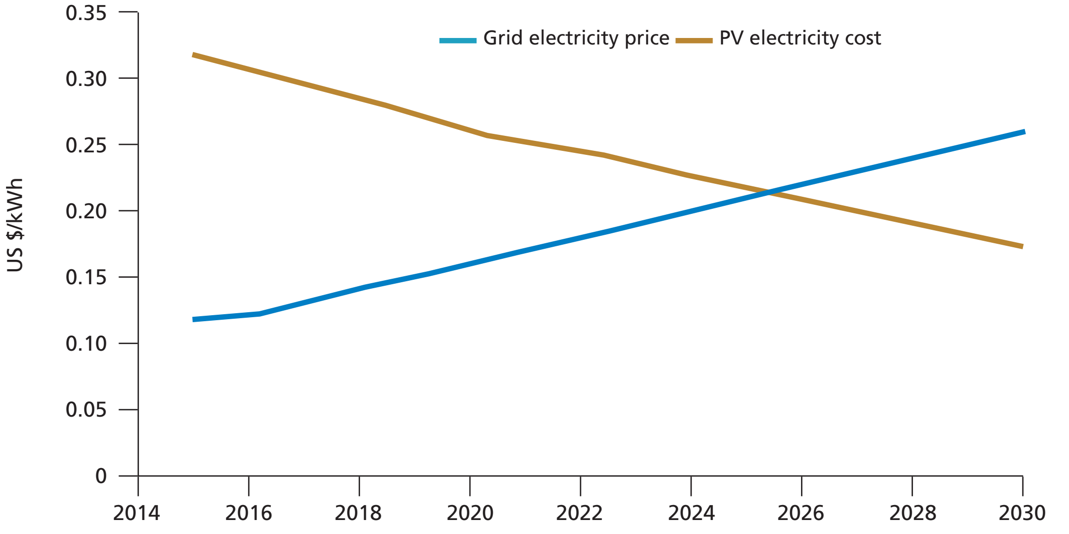
Source: Mott MacDonald, 2017

GRAPH 6: SOLAR PV ROOFTOP LCOE FOR MAJOR SOUTH-EAST ASIAN NATIONS



Source: Mott MacDonald, 2017

GRAPH 7: TRENDS IN PLN GRID ELECTRICITY PRICES VS PV ELECTRICITY COST



Source: PLN, 2016

Increasing electricity tariffs

The PLN expects the electricity tariffs, which range between US $0.03 to 0.10 per unit (*see Annexure on electricity tariff structures and slabs*), would rise to around US $0.15 per unit by 2020. Rooftop solar power prices, in comparison, were projected to fall from around US $0.30 per unit to little more than US $0.15 per unit. But this PLN analysis of solar rooftop LCOE needs updation — the current estimates are around US $0.06 to 0.11 per unit.[13]

However, given that PV solar costs, based on actual bids by companies all over the world, have reached below US 5 cents/unit, grid parity will be achieved much earlier — maybe within two-three years, even in Indonesia. Indeed, the cost of solar PV electricity would already be lower than that supplied by the grid in Indonesia for a number of customer types.

The average tariff rates for residential and social sector consumers with fairly small connected load of 1.3 KW are higher than the solar rooftop cost of generation at US $0.06 per kWh. Similarly, tariff rates for industrial, commercial, government and street lighting segments are higher at US $0.08 per kWh to US $0.10 per kWh. The average tariff rates are also on the higher side in cities like Tarakan, Batam, Jakarta, Yogyakarta and Banten. It makes economic sense for consumers with tariffs higher than US $0.06 per unit to install solar rooftop and partially or completely supplement their electricity supply. With the gradual increase in retail tariffs and the projected decline in solar PV costs, the competitiveness of rooftop installations is expected to improve for even larger sets of customers in the coming years.

Indonesia has witnessed its electricity tariffs go up because of withdrawal of subsidies by the government. In order to gain international investment for its power plants, President Joko Widodo's government has been phasing out electricity subsidies since 2014. Another reason behind this move was to reduce the budget expenses for the country.[14]

In 2014, the government announced that it would cut down its IDR 280 trillion (US $24 billion) subsidy bill by increasing tariffs for its biggest electricity consumers.[15] This came on the back of the fact that because of the reducing value of the Indonesian Rupiah, the government ended up increasing budget estimates by 15 per cent. This led to a 10-11 per cent hike for all consumers except government and households with connections less than 5.5 kVA, which received a tariff hike of around 5.5 per cent. This hike came into effect in November 2014.

Then again, in 2016, PLN announced that the subsidy for 900-VA customers would be gradually revoked starting from January to May 2017. About 4.3 million 900-VA and 450-VA customers who are qualified to receive government subsidies, were made eligible for cheap electricity. PLN estimated that the 18.7 million consumers who had a 900-VA connection can afford to pay for their electricity without subsidies. In the latter half of the decade, the subsidy for electricity fell from IDR 103.33 trillion in 2012 to only IDR 59.23 trillion in 2016.[16]

Offsetting the use of diesel gensets

Indonesia has at least 11 cities of over a million residents (medium-sized cities) each; Jakarta is considered a megacity. Major cities such as Bandung, Surabaya, Medan, Semarang etc are facing problems with both the quality of power and outages.[17] This disturbs daily household needs as well as business operations. There have been many reports in the media about business and industrial entities raising these issues.

A 2015 Asian Development Bank (ADB) report titled *Improving the Investment Climate in Indonesia* says power outages are one of the most important factors in hindering business operations.[18] According to it, power outages result in production losses amounting to around 4 per cent of total sales in the (surveyed) firms. Starting a business in Indonesia is also constrained by delays in acquiring electricity connections. Power interruptions have prompted firms to rely on private generators, which now supply more than one third of the energy requirements in some regions.

TABLE 4: PLN'S AVERAGE SALE PRICE ACROSS CUSTOMER CATEGORIES (IDR PER KWH)

Year	Household	Industry	Commercial	Social	Government Buildings	Street Lighting	Average
2008	588	622	851	581	847	665	653
2009	589	644	891	578	870	663	670
2010	616	661	934	624	953	746	699
2011	618	695	951	646	940	792	714
2012	632	710	965	678	969	803	728
2013	692	796	1,117	757	1,092	911	818
2014	758	978	1,266	810	1,256	1,097	940
2015	837	1,143	1,284	812	1,325	1,459	1,035
2016	844	1,052	1,201	816	1,235	1,415	991
Growth	5.29%	7.79%	5.05%	4.97%	5.53%	11.39%	6.15%

Note: IDR 1= US $ 0.00007
Source: PLN, 2016

Jakarta experiences one of the highest number of days of power outages among all cities. According to a Reuters report, from big multinational manufacturers to small neighborhood restaurants, businesses in Indonesia are investing in diesel gensets because of the blackouts, thus paying a higher price for the power they use.[19] Among foreign investors, the Japanese have been the most vocal with complaints about power shortages.

The question of access in the islands

Apart from Jakarta, many other regions are prone to power cuts and dips in frequency. The non-availability of quality power can have severe spillover effects. For instance, despite being blessed with abundant natural resources and large markets, North Sumatra and Aceh have struggled to attract foreign investors, mainly because of infrastructure problems, including those related to erratic electricity supply.

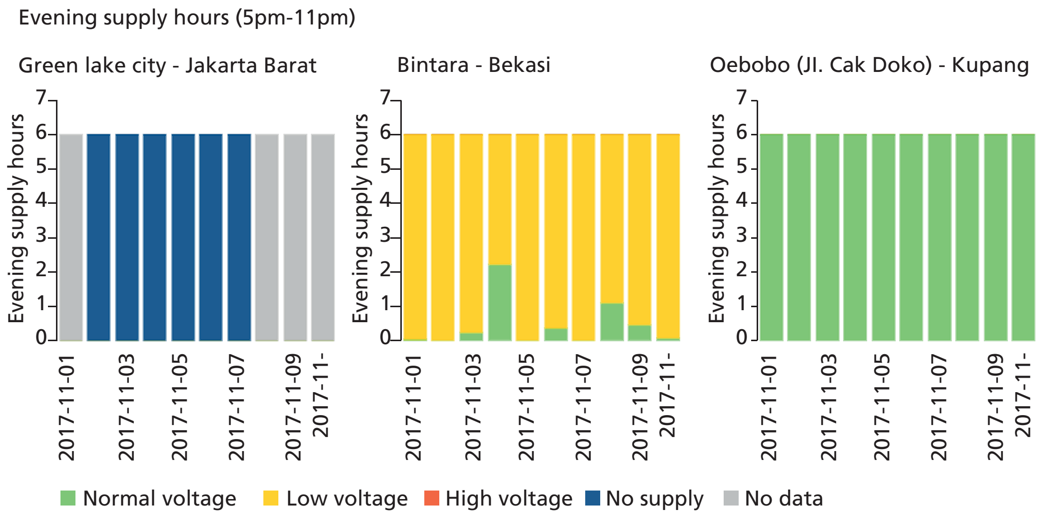
Although a large section of Indonesia's 250 million people is concentrated on the two main islands of Java and Sumatra, there are more than 900 permanently inhabited islands. This throws a logistical challenge for maintaining a reliable electricity grid supply, particularly in Eastern Indonesia where it will be expensive to extend the T&D network.

Power cuts

A WRI-Prayas initiative has studied power cuts at 25 different sampling points across cities in Indonesia. The Graph 8 presents the comparison for three different cities — Jakarta, Bekasi and Kupang — for around 10 days of electricity patterns (November 1-11, 2017) for the evening peak hours (17.00-23.00). In the Green Lake City area of Jakarta, power cuts happened for six hours during the evening peak time. In Bekasi, power remained, but there were voltage dips. Interestingly, the Oebobo area in Kupang city had power with normal voltage.

The data reveals that despite being connected to the grid, power voltage levels were fairly low throughout the 25 locations monitored (210 volts being low, 220 volts being normal and 250 volts being high). Low power voltage levels affect appliance performance or the ability to charge electronics such as mobile phones. It was also observed that in most locations, installed electricity capacity exceeded consumption, meaning that buildings are consuming much less

GRAPH 8: POWER QUALITY OF CERTAIN AREAS IN SELECT CITIES



Source: WRI-Prayas, 2017

electricity than they have access to, and therefore should not be experiencing problems with their quality or their supply. Yet many buildings continue to experience these problems.

All monitored locations experienced some degree of electricity interruptions, lasting from less than 15 minutes to several hours, pointing to the fact that being connected does not mean having a continuous supply of electricity.

Short term solutions

In 2015, the PLN sought the services of a 'floating power plant' (running on diesel) from Turkey.[20] This marine vessel power plant (MVPP) was supposed to bridge the power deficit of around 125 MW. PLN says that supplying reliable and uninterrupted power to more than 9,000 islands throws extreme logistical and technical challenges. Plants like this are used to offset sudden breakdowns on islands, and their mobility helps in maintaining the grid balance. However, operating the floating plant will require transportation of fuel and maintenance logistics, which is clearly a costly and temporary solution for a long-standing problem.

As per a CSE analysis, based on the prices of November 2017, a diesel gen-set with efficiency in the range of 0.3-0.6 liter/kWh and with average diesel price of US \$0.68 per litre (current price in Indonesia), would generate electricity at a cost of US \$0.2-0.4 per kWh. Diesel prices in Indonesia are dependent on global petroleum prices: the cost of generation has thus witnessed wide fluctuations, including a high of US \$0.59 per kWh in 2015. Even the cost of PLN's gas-based power generation has been increasing for the past five years to reach US \$0.23 per kWh in 2016.

With prices of solar rooftop under US \$0.06-0.11 per kWh and with battery prices hovering around US \$0.15 per unit, solar becomes a good option as it can complement the grid supply and also reduce the use of diesel generators. It can be an environment-friendly source of reliable and cheaper off-grid power in cities as well as in remote islands.

Immense potential

There are no comprehensive studies to assess the potential of solar PV rooftop systems in Indonesia. Scientific estimation of a region's rooftop potential will require detailed modeling and assessment of solar radiation, rooftop area, shade analysis, load profiles etc which is beyond the scope of this paper. For the purpose of gauging Indonesia's solar rooftop potential, various indicators — urban area, solar insolation, land use pattern etc — can be explored to arrive at broad estimates.

Indonesia is urbanising at a rapid pace with cities and towns growing at an average rate of 4.1 per cent per year, as per World Bank estimates.[21] The total urban land area in the country, estimated to be 42,077 sq km, is the highest in South-east Asia. Fortunately Indonesia's urban areas experience high solar insolation required for solar power generation. For instance, in Jakarta, the solar irradiance level is estimated to vary from 4.2 to 5.7 kWh per sq metre per day during the year. The variability of the PV system output is also estimated to be low — pointing to a high rooftop development potential.

Data on land use pattern for the country's urban area is not available, but assumptions can be established based on Jakarta to estimate the total eligible rooftop area in residential, commercial, institutional and industrial buildings. As per available information, 45 per cent of Jakarta's 740 sq km of total land area includes residential, commercial, industrial, institutional and government buildings (*see Table 5*). It can be assumed that a majority of the potential industrial, commercial, institutional and government consumers will be able to afford the high up-front cost of rooftop installations. This, however, may not be true for all residential consumers.

TABLE 5: JAKARTA'S LAND USE DISTRIBUTION PATTERN

Category	Share in total area (%)
Slum area	27
Industry and warehouse	7
Commercial and business	10
Government facility	3
Transportation facility	13
Education and public facility	3
Residential area	22
Forestry	6
Swamp, river and pond	4
Park and cemetery	4
Agriculture and open space	1
Total	100

Source: Slums down the drain — Study done by Vrije Universiteit, Amsterdam, 2015, https://www.slideshare.net/JoachimSchellekens/slums-down-the-drain

The potential for solar rooftop can be assessed on the basis of a study done for the National Capital Territory of New Delhi in India. NCT, Delhi is estimated to have a total land area of around 1,484 sq km, with around 700 sq km of built area. Approximately, 30 per cent of the land is covered with trees and roads, and 490 sq km of developed areas is available for rooftop space. It is likely that there would be certain buildings that cannot be used for installing solar rooftop systems because they are either too old, or are monuments or religious structures. Removing another 10 per cent of such buildings, it gives us 441 sq km of buildings with suitable rooftop space. A total capacity of 3.65 GW of rooftop solar can be installed, given that 10 per cent of the available space is conducive to rooftop installation because of direction and availability of roof space.

On a similar scale, Jakarta's 333-sq km area would have a usable roof space of about 30 sq km which — in all likelihood — would be technically and economically suitable for solar rooftop development. Given that about 12 sq m area is required to install a solar PV system of 1 kWp, the estimated rooftop solar potential for Jakarta could be 2.5 GW.

Another approach for estimating potential can be through the assumption that customers who are paying around US $0.07 per unit, would be likely to move to solar rooftop since it makes sound economic sense. These would ideally be consumers under the connection slab of over 900 V-RTM (*see Annexure on electricity tariff structures and slabs*), they are the ones paying higher electricity charges and do not get the benefits of subsidised power. Besides them, consumers with higher load slabs (of above 3,500 VA) in regions which are plagued by power cuts, can take recourse to solar rooftop, thereby reducing the use of diesel gensets.

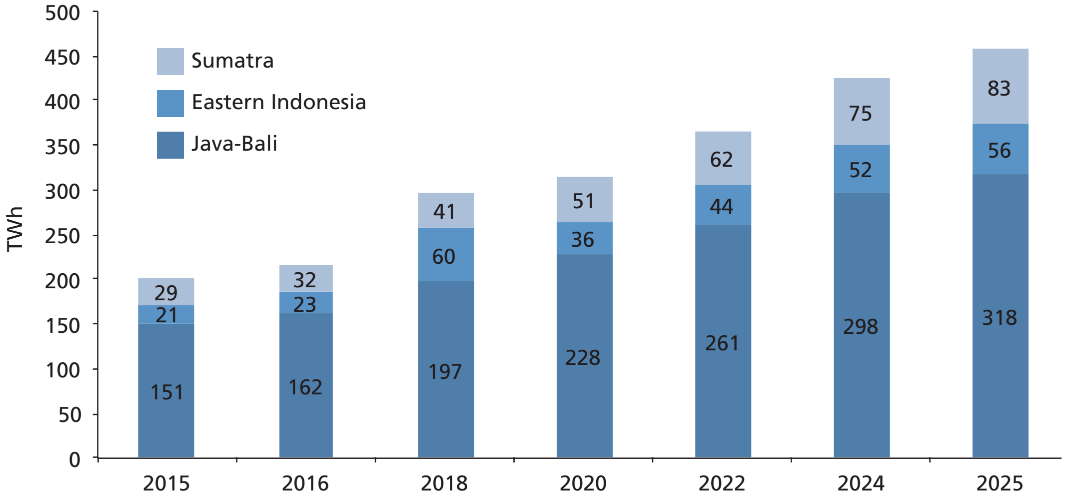
A gross estimate of Jakarta's solar rooftop potential can be made based on the assumption that if 10 per cent of consumers in the city — around 200,000 households — install just 1 KW each, Jakarta can install 200 MW of solar rooftop capacity and reduce its dependence on diesel to some extent. This can also significantly bring down the stress on the grid and provide reliable back-up power to consumers during outages. These are conservative figures as the total number of potential customers has been estimated to reach up to 1.2 million in 2020 — hence, the actual potential might be much higher.

Ensuring energy security

Electricity demand in Indonesia is projected to increase at a high compound annual growth rate of 8.6 per cent over the next decade (*see Graph 9*). To meet this demand, the government has sketched out elaborate plans to build mega power projects. However, a significant chunk of the growing demand burden can be effectively met through rooftop solar PV installations, given that large projects entail high gestation periods and billions of dollars in project and grid investments. Most large generation projects, both in the public and private sectors, have missed commissioning deadlines due to numerous development challenges. Additionally, under-investments in renovation and modernisation of older power plants also threaten the country's energy security.

There are costs associated with adding more large-scale plants into an already overburdened transmission and distribution system. Investment in grid infrastructure is an expense that most countries have not been able to determine yet. On the other hand, more and more intermittent power being fed into the grid requires grid flexibility and does have certain costs.

GRAPH 9: PROJECTED INCREASE IN ELECTRICITY REQUIREMENT IN JAVA-BALI GRID 2015-24 (TWH)



Source: PLN's RUPTL, 2016-25

The other issue is increase in operational costs of the systems, which would include costs to the existing power system — reduced utilisation, increase in reserve capacity etc.

According to IRENA's *Renewable Energy Integration in Power Grids* report[22], upgrading the grid and the costs involved would be determined by the existing features of the grid. IRENA estimates them to be around US $0.6-3.5 per MWh as grid costs and US $17-30 per MWh as system operations costs. It also estimates that for a 10 per cent increase in the share of electricity generated from renewable sources, there needs to be a 1.5-4 per cent increase in the share of variable capacity. Another estimate by German consultancy Agora Energiewende[23] puts the estimates at US $5-15 per MWh.

Again, this makes a case for rooftop solar installation because it can provide flexibility to manage demand. The advantage that decentralised generation like solar rooftop has over centralised generation is the fact that adding 10-15 per cent of capacity to the grid does not require huge investments from the distribution company. In addition, decentralised systems do not have T&D losses since the consumption occurs at the point of generation. The scope of utilising rooftop installations increases further as a majority of the demand will continue to be concentrated in the largely urban Java-Bali grid region — accounting for 70 per cent of the country's electricity demand in 2025.

Rooftop installations also represent a long-term reliable source of power. With frequent blackouts and poor quality of power supply in other smaller towns and cities, distributed generation can help ensure power supply stability in wake of such challenges. Even the Java-Bali region has experienced prolonged blackouts in the past because of fuel supplies to power stations being impacted due to natural disasters.

Feed-in-tariffs — an option miscalculated

In February 2017, the Indonesian government adopted an entirely new feed-in-tariff (FiT) mechanism for the renewable energy sector, including solar. While the FiTs were earlier fixed by the government, these are now to be determined based on negotiations between PLN and IPPs, subject to a cap determined by regional electricity supply costs. The FiT for all renewable energy projects (other than geothermal and waste-to-energy) has been capped at 85 per cent of the regional electricity generation cost, if the regional cost is above the national average. This cap is equal to the regional cost if it is lower than the national average.

The national average cost of generation in Indonesia, which is largely dependent on low cost electricity sources like coal and gas, was US $0.07 per kWh in 2016. Indexing of tariffs with such low costs implies significant reduction in solar PV tariffs compared to the previous FiT regime.

In remote provinces like East Nusa Tenggara (NTT) and Maluku, the regional cost of power generation has been high — US $0.18 per kWh — compared to the regional generation costs in the western provinces of Java-Bali (US $0.07 per kWh) (see Graph).

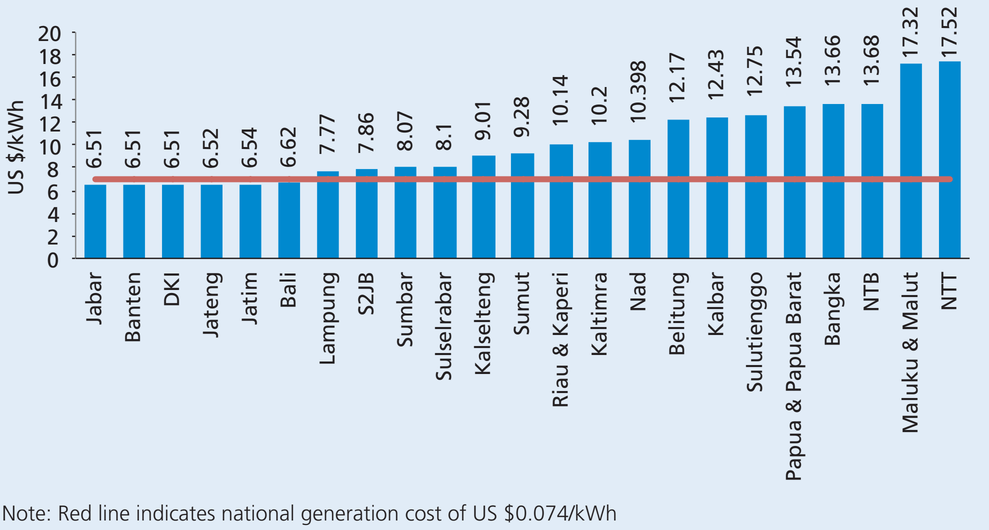
The feed-in tariff model that PLN has designed seems to be a disincentive for new developers to install solar and wind, since the cap of 85 per cent would limit the tariff that the developers would receive. Why would a developer invest in a system when power is being bought at the rate of US $0.17 from fossil fuels, but the renewable energy developer will not receive more than US $0.144? The concept of FiT is that the developer is paid an amount which is higher than the generation cost — but the PLN's model seems to reduce it to 85 per cent of the generation costs.

Net metering could be an option

Instead of basing all the development on the FiT scheme, solar rooftop can be promoted using net metering where the electricity bill of the consumer declines without the burden of procuring more power being added on to PLN. This would help manage demand and reduce dependency on the grid. It also makes sense for consumers who are paying tariffs of over US $0.07 per unit, since the cost of generating power on the rooftop using solar technology would be lower for them. The reduced cost of solar power procurement should encourage PLN to promote solar rooftop, especially in remote islands and their villages.

GRAPH: PLN'S REGIONAL POWER GENERATION COSTS IN 2016 (AVERAGE COST US $0.074/KWH)

The costs are significantly higher in the eastern provinces



Note: Red line indicates national generation cost of US $0.074/kWh
Source: MEMR, 2017

CONCLUSION

Rooftop solar should have a big and immediate role to play in the Indonesian energy sector. It must not wait till 2022 when PLN thinks grid parity would be achieved. Grid parity is already on the cusp and it is time to create support mechanism to help this sector grow.

1. The cost of solar rooftop has declined and is in the range of US $0.06-0.13 per unit, according to some studies. In many places in Indonesia, the electricity tariff is much higher than rooftop tariff, so installing these systems for personal use can yield financial benefits for the consumers, especially if net metering is introduced in the country.

2. Electricity tariffs in Indonesia have gone through various revisions and have increased every year — investing in solar rooftop systems makes sense because of this as well. Segments of population which pay around US $0.10 per unit for electricity, should move to solar rooftop to partially offset the electricity supply from the grid.

3. The supply from PLN is not reliable and differs in quality from place to place. Investing in solar rooftop, therefore, makes sense to ensure cheaper and qualitatively better supply, with reduced dependence on PLN. This can also save money for PLN, by providing it the option of doing away with expensive solutions like the floating power plant.

4. For the 900 permanently inhabited Islands, solar rooftop or a mini-grid system is a far better and cheaper option than expensive and polluting diesel power.

5. Solar rooftop can be an effective means for meeting the increasing demand for power, without wasting money on large projects with high gestation periods and grid investments. Decentralised generation can save money by reducing the T&D losses and the burden on the land.

ANNEXURE

ELECTRICITY TARIFF STRUCTURES AND SLABS IN INDONESIA

Customer type	Power limit	Tariff slab in US Cents per kWh
S-1	220 VA	US $1.10 per month
S-2	450 VA	0-30 kWh — 1 Cent
		30-60 kWh — 2 Cents
		Above 60 kWh — 3 Cents
S-2	900 VA	0-20 kWh — 1 Cent
		20-60 kWh — 2 Cents
		Above 60 kWh — 3 Cents
S-2	1300 VA	5 Cents
S-2	2200 VA	5 Cents
S-2	3500 VA below 200 kVA	7 Cents
S-3	Above 200 kVA	Above 8 Cents

Recommendation: *Although subsidised, S-2 and S-3 category consumers should opt for solar rooftop since they are paying higher tariffs than the generation cost of electricity from rooftop systems.*

Customer type	Power limit	Tariff slab in US Cents per kWh
R-1	Below 450 VA	0-30 kWh — 1 Cent
		30-60 kWh — 3 Cents
		Above 60 kWh — 4 Cents
R-1	900 VA	0-20 kWh — 2 Cents
		20-60 kWh — 3 Cents
		Above 60 kWh — 4 Cents
	900 VA-Run Time Meter	10 Cents
R-1	1300 VA	10 Cents
	2200 VA	10 Cents
R-2	3500 VA to 5500 VA	10 Cents
R-3	6600 kVA	10 Cents

Recommendation: *Some customers with a connection of more than 900 V-RTM under R-1, R-2 and R-3 categories, who have large connected loads and pay higher tariffs, are viable targets for installing solar rooftop.*

Customer type	Power limit	Tariff slab in US Cents per kWh
Business consumers		
B-1	Below 450 VA	0-30 kWh — 2 Cents
		Above 30 kWh — 3 Cents
B-1	900 VA	0-30 kWh — 2 Cents
		Above 30 kWh — 3 Cents
B-1	1300 VA	7 Cents
B-1	2200 VA to 5500 VA	8 Cents
B-2	6600 VA to 200 kVA	10 Cents
B-3	Above 200 kVA	Based on various power factors

Recommendation: *Solar rooftop is recommended for any consumer paying higher than US $0.07 per unit — these, thus, would include B-1 with a capacity of 1,300 VA and higher, and the B-2 and B-3 categories.*

Customer type	Power limit	Tariff slab in US Cents per kWh
Industrial		
I-1	Below 450 VA	0-30 kWh — 1 Cent
		Above 30 kWh — 3 Cents
I-1	900 VA	0-30 kWh — 2 Cents
		Above 30 kWh — 3 Cents
I-1	1300 VA	7 Cents
I-1	2200 VA to 5500 VA	7 Cents
I-1	3500 VA to 14 kVA	8 Cents
I-2	14 kVA to 200 kVA	Above 8 Cents
I-3	Above 200 kVA	Above 9 Cents
I-4	Upto 30,000 kVA	Above 9 Cents

Recommendation: *Recommended for categories higher than I-1 and 1,300 VA capacity, the consumer would benefit financially from solar rooftop.*

Customer type	Power limit	Tariff slab in US Cents per kWh
Government tariffs		
P-1	Below 450 VA	4 Cents
P-1	900 VA	4 Cents
P-1	1300 VA	8 Cents
P-1	2200 VA to 5500 VA	8 Cents
P-2	6600 VA to 200 kVA	Above 9 Cents
P-3	Above 200 kVA	10 Cents

Recommendation: *Ideally, to promote solar rooftop, all government buildings and consumptions should install it. It is also recommended for any consumer paying higher than US $0.07 per unit — which means P-1 with a capacity of 1,300 VA and higher, and P-2 and P-3 categories of consumers.*

#Exchange rate 1 USD = 13,552 Indonesian Rupiah (IDR), conversion rates as on December 8, 2017.
Source: PLN Tariff Order, 2017

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