IRENA
International Renewable Energy Agency

REmap
A Renewable Energy Roadmap

EXECUTIVE SUMMARY





RENEWABLE ENERGY PROSPECTS:

INDONESIA

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

The full country report for Indonesia is available at **www.irena.org/remap**

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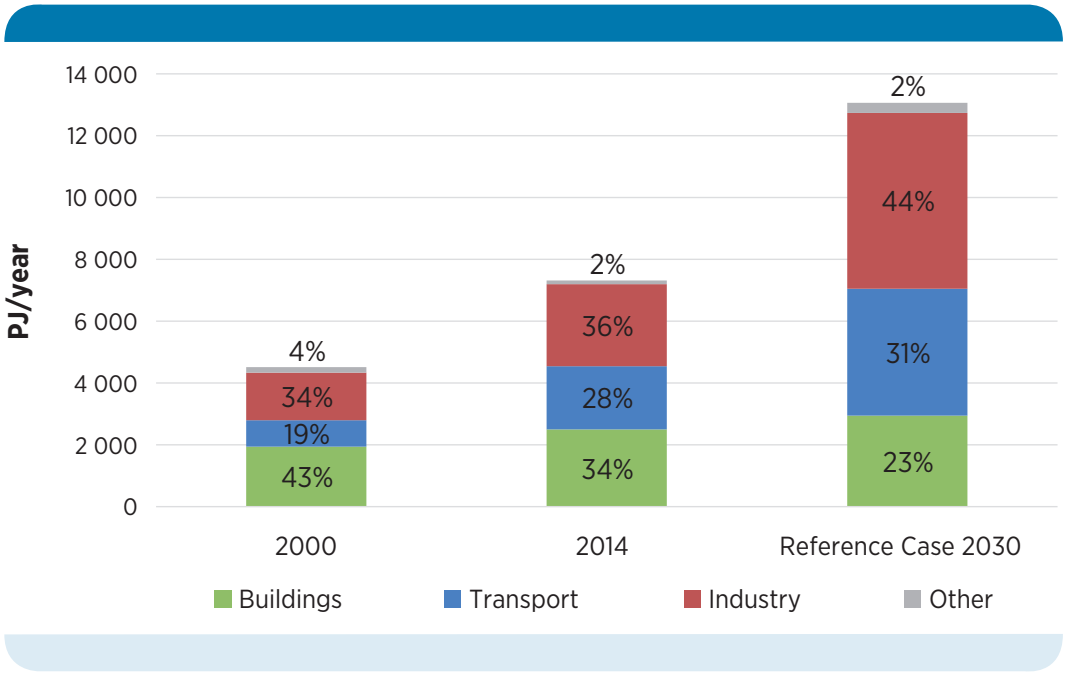
Rapid growth in energy consumption

Indonesia is among the world's fastest growing countries in terms of energy consumption. This is fuelled by robust economic development, increasing urbanisation and steady population growth. The country is the largest energy user in the Association of Southeast Asian Nations (ASEAN), accounting for nearly 40% of total energy use among ASEAN members. Between 2000 and 2014, energy consumption in Indonesia increased by nearly 65%. In a business-as-usual outlook (the "Reference Case" in this study), it is set to grow another 80% by 2030. Indonesia is therefore crucial to a renewable energy transition for the region as a whole.

Indonesia's electricity consumption will more than triple by 2030. Economic growth means rising use of electricity for cookers, fans, air conditioning and other appliances. At the same time, Indonesia is expanding electricity access in remote areas and islands. More than 10% of the country's population still lacks access to electricity, but the government is aiming for near-100% electrification by 2026.

Transport and industry show the fastest expected growth in energy use. For both sectors, energy consumption is expected to more than double between today and 2030. About 1 million motor vehicles and 7.5 million motorcycles and scooters are added to Indonesia's roads every year, further exacerbating the already severe air pollution in urban centres. Industrial energy use is expanding in line with economic growth, with large industries such as cement, aluminium, paper and ceramics accounting for a majority of the increase.

Figure 1: Breakdown of total final energy consumption in Indonesia, 2000, 2014 and in the Reference Case for 2030

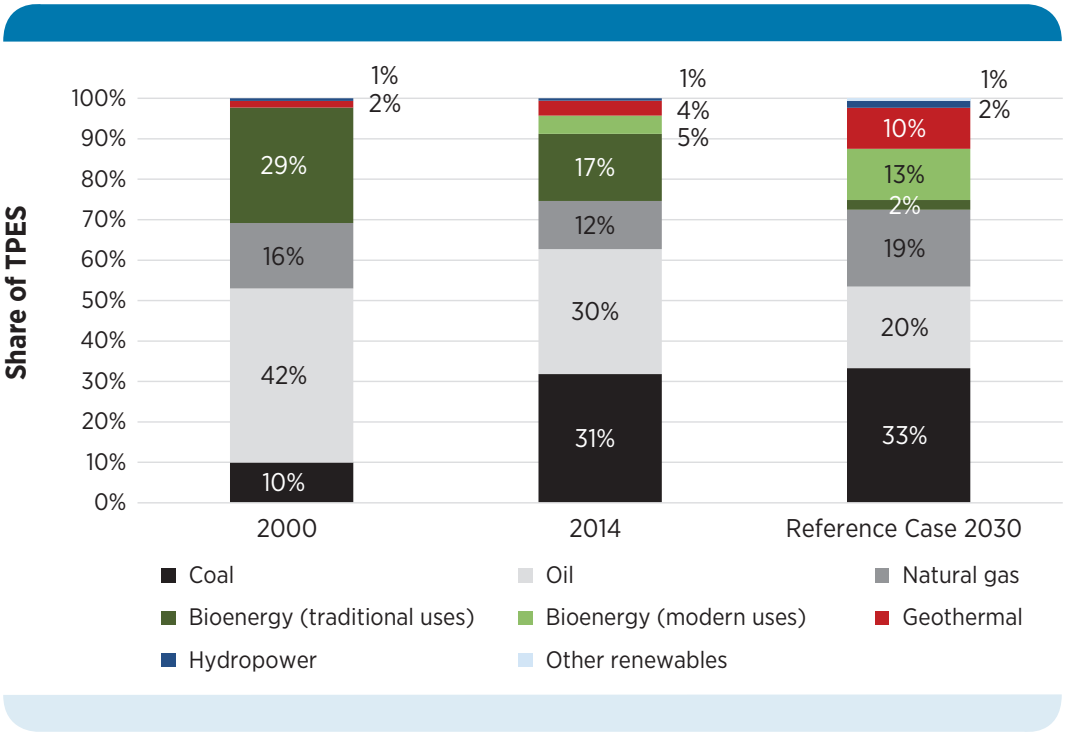


Sustainability concerns amid a changing energy supply mix

The use of coal is rising to meet domestic growth in energy demand. At the turn of this century, only about 10% of Indonesia's energy needs were met by coal. Currently, coal accounts for almost one-third of the energy supply. This rapid expansion is an outcome of government policy aimed at meeting high growth in energy demand while reducing imports of petroleum products. Indonesia is the fourth largest producer of coal worldwide and was the largest exporter in 2014. Coal increasingly is consumed domestically amid stagnant domestic production of natural gas and oil. Based on the Reference Case, the use of coal would more than double by 2030 from today's levels. This not only would mean additional greenhouse gas emissions from coal combustion, but it also would exacerbate air pollution and issues related to water contamination and scarcity.

Traditional uses of bioenergy dominate renewable energy use in Indonesia. A majority of renewable energy use in Indonesia is represented by traditional uses of bioenergy (mainly for cooking) in the country's rural areas and remote islands. Although the share of traditional bioenergy uses in the energy supply mix has declined, an estimated 24.5 million households (40% of all households) still rely primarily on fuelwood for cooking. This practice results in indoor air pollution which is associated with 165 000 premature deaths in Indonesia per year. In the Reference Case, mainly through the uptake of

Figure 2: Fuel mix in primary energy supply, 2000, 2014 and in the Reference Case for 2030



electricity and liquefied petroleum gas (LPG) for cooking, the number of houses relying on fuelwood would drop to about 8 million by 2030.

Liquid biofuel blending mandates – while advancing the transition to renewable energy sources – come with supply side challenges. Especially for transport, there is a strong projected increase in the use of liquid biofuels as a result of mandated biodiesel (B30) and ethanol (E20) blending from 2025 onwards. Total liquid biofuel use per year is projected to increase to 25 billion litres by 2030, compared to 1.35 billion litres of biodiesel that was blended in the first half of 2016. Today, biodiesel in Indonesia is produced from palm oil, a crop for which the government recently renewed a moratorium to prevent additional plantations.

Aiming for an affordable, secure and sustainable energy system

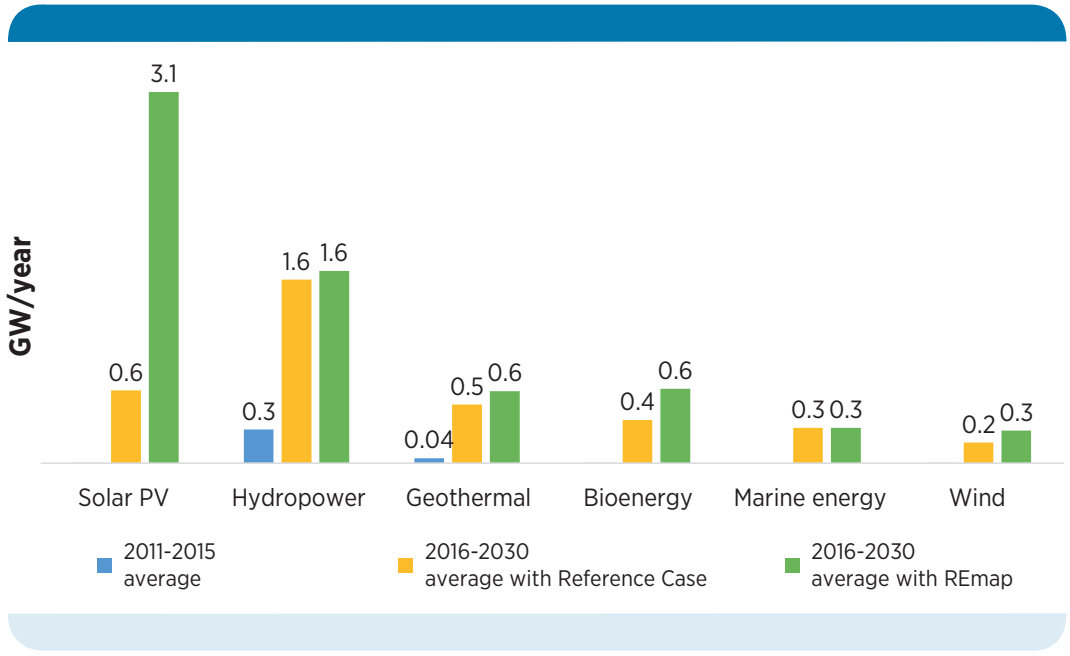
Indonesia already has ambitious targets to increase its use of renewable energy. The country has set an overall target to have modern renewables (excluding traditional uses of bioenergy) provide 23% of total primary energy supply (TPES) by 2025, and 31% by 2050. The Reference Case, which assumes that these targets are met, implies a share for renewable energy of 17% in total final energy consumption (TFEC) by 2030, up from about 6% today.

Indonesia could achieve its 2050 renewable energy targets two decades sooner. The International Renewable Energy Agency (IRENA) has worked with Indonesia's Ministry of Energy and Mineral Resources (MEMR) to develop a roadmap to 2030, highlighting ways to increase the uptake of renewable energy beyond the country's present policies and plans. Across sectors and technologies, the additional potentials ("REmap Options" in this study) increase the share of renewable energy to 23% of TFEC – or 31% of TPES – by 2030.

Renewable energy use will continue to be highest in power generation. In the Reference Case, the share of renewable energy in power generation would increase to 29% by 2030. To assess the potential for additional renewable power in Indonesia, five regions (Java-Bali, Kalimantan, Maluku & Papua, Sulawesi & Nusa Tenggara and Sumatra) were distinguished, and for each, the renewable resource potential and projected power demand in 2030 was analysed. Based on this assessment, the share of renewable energy in power generation increases to 38% by 2030 with the REmap Options.

Solar photovoltaics (PV) offers much greater potential than current plans for the power sector reflect. The REmap Options for hydropower, geothermal, bioenergy and wind power are modest, given their ambitious increase in the Reference Case and the geographical mismatch in resource potential and power demand. For solar PV, however, REmap identifies potential for 47 gigawatts (GW) of installed capacity by 2030, compared to just over 9 GW in the Reference Case. This includes plans to use solar PV to provide electricity to nearly 1.1 million households in remote areas that currently lack adequate access to electricity. Especially in Java-Bali (which accounts for 70% of power demand in Indonesia) there is enough available space, good infrastructure and additional need for power to greatly

Figure 3: Annual installations of renewable power in 2011-2015, in the Reference Case for 2030 and with REmap



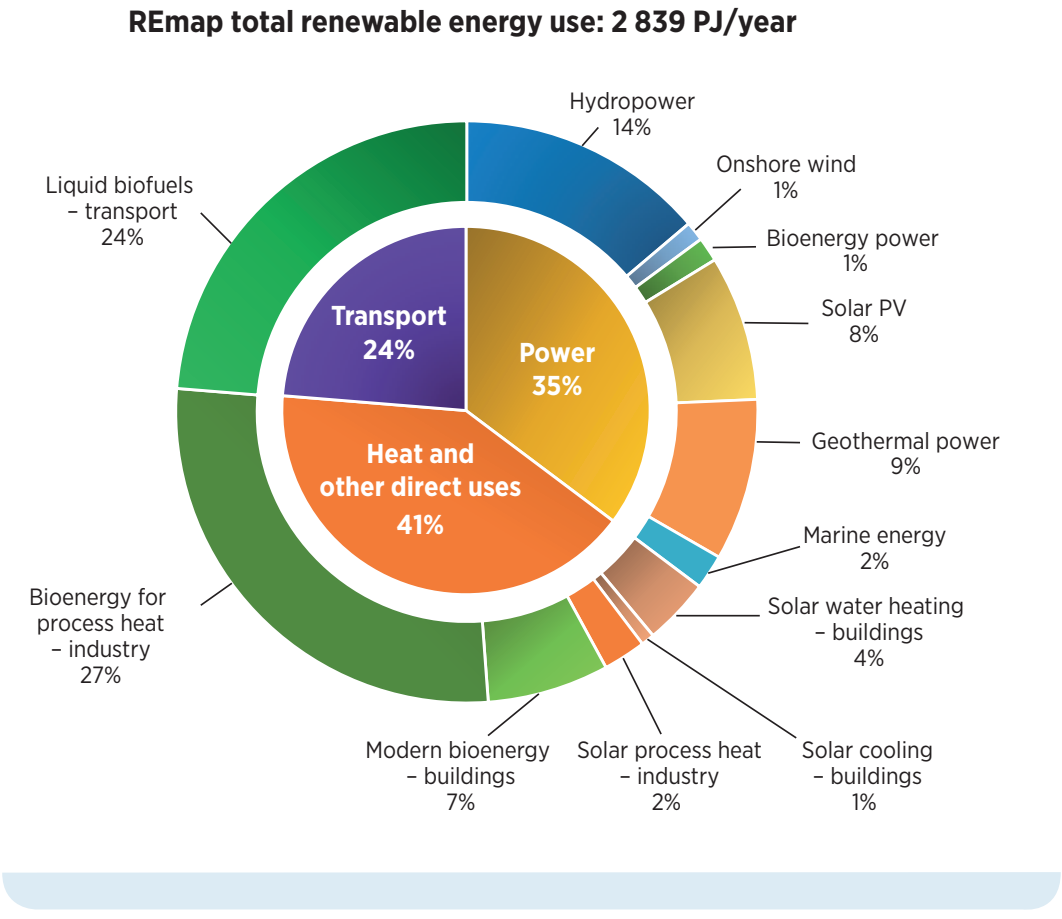
increase both rooftop and utility-scale solar PV installations.

Next to power generation, Indonesia's greatest renewable energy use will be in buildings. Including the contribution of renewable electricity, the share of renewable energy in TFEC in buildings increases to 37% in 2030, compared to 18% in the Reference Case. With REmap, households that would rely on traditional uses of bioenergy for cooking in the Reference Case switch to modern cook stoves that use mostly solid biomass, and to some extent ethanol. Based on an assessment of available rooftop space and realistic deployment potential, solar thermal collectors supply 30% of energy used for water heating, while solar (thermal) cooling meets 5% of energy demand for cooling in buildings.

Industry will make much greater use of bioenergy and also could scale up solar thermal systems to supply process heat. Through the assessment of the projected energy use in key industry sectors and the supply potential of different types of feedstock, the REmap Options identify potential for an additional 216 petajoules (PJ) per year of bioenergy use in industry beyond the Reference Case. This consists of more use of biogas (from food waste and palm oil mill effluent), wood residues and waste. Combined with the identified potential of 70 PJ per year for solar thermal collectors to supply process heat (in the rubber, food and textile industries), the share of renewable energy in industry TFEC increases to 21% by 2030, compared to 15% by 2030 in the Reference Case and 12% in 2014.

Bioenergy will continue to play an important role in the use of renewables in Indonesia. With REmap, more than half of all renewable

Figure 4: Breakdown of renewable energy in total final energy consumption in 2030 with REmap



energy use in Indonesia in 2030 would be in the form of bioenergy used for process heat in industry or as liquid biofuels in transport. Solar applications (including PV and thermal) account for 15% of renewable energy use in all sectors in Indonesia as envisaged by REmap, followed by hydropower (14%) and geothermal power (9%).

Indonesia could have 3 million electric four-wheeled vehicles and 42.5 million electric two- and three-wheelers on the road by 2030. Given the high increase in the use of liquid biofuel in transport in the Reference Case and the associated supply-side constraints, the REmap Options in transport focus on electric mobility. With the continued increase in vehicle ownership, nearly 6% of all four-wheeled vehicles (consisting mainly of electric cars) and 20% of two- and three-wheelers would be electric by 2030. Combined, they increase the share of renewable energy in transport TFEC to 18%, from about 3% today.

Benefits of renewable energy greatly outweigh costs

Higher renewable energy uptake would reduce the total costs of the energy system. Based on a comparison of the cost of the REmap Options and the conventional fuels which they replace, the savings to the energy system in 2030 is estimated at USD 1.7 billion per year. This is from a government perspective, which excludes subsidies on energy prices and applies a discount rate of 10%. With a market discount rate of 12% and including energy subsidies, the additional costs to the energy system are USD 1.1 billion per year. This shows the importance of further removing energy subsidies, such as on prices for electricity and selected petroleum products, as well as of lowering the cost of capital for renewable energy projects.

Renewable energy can strengthen Indonesia's energy security while greatly reducing emissions. The REmap Options reduce demand for fossil fuels by 10% relative to the Reference Case. The impact is the largest for coal (-17%) and oil (-9%) and thus would contribute to reducing imports of petroleum products, which have increased in recent years. The reduction in the use of coal, which is projected to increase in most ASEAN countries, contributes strongly to avoided carbon dioxide (CO_2) emissions with REmap, which are 150 million tonnes (Mt) per year lower than with the Reference Case.

Indonesia needs to focus more on energy efficiency and on non-energy emissions in order to achieve its Nationally Determined Contribution (NDC) in the global effort to address climate change. Indonesia's NDC aims for a 29% (unconditional) reduction in greenhouse gas emissions by 2030 compared to a business-as-usual scenario. The REmap Options would account for about half of the targeted energy-related reductions. However, the business-as-usual scenario used to determine the NDC can be considered conservative, as it does not include any renewable energy deployment or energy efficiency improvements. Furthermore, forestry accounts for more than half of Indonesia's overall targeted unconditional reductions. Therefore, reducing emissions through further energy efficiency improvements and in other sectors – particularly from land use, land-use change and forestry (LULUCF) – will be crucial as well.

Scaling up renewables can save Indonesia between USD 15.6 billion and USD 51.7 billion per year when the impacts on air pollution and climate change are included. With REmap, the avoidance of premature deaths and the savings that come with reduced health costs from reductions in outdoor air pollution are valued at USD 3.0 billion to USD 9.7 billion per year. Reduced externalities from indoor air pollution account for another USD 10.4 billion to USD 31.3 billion per year, due to the substitution of traditional uses of bioenergy for cooking. As said, the REmap Options also would lead to a reduction of 150 Mt of CO_2 emissions per year which, with a carbon price of USD 17 to USD 80 per tonne equates to savings of USD 2.2 billion to USD 10.7 billion per year in 2030. The reduced system costs and externality savings equal 0.5% to 1.7% of Indonesia's forecasted gross domestic product in 2030.

Greater renewable energy deployment will create more jobs and stimulate technology transfer. Earlier IRENA work has indicated the potential for 1.3 million jobs in the renewable energy sector in Indonesia by 2030, up from just over 100 000 today. Scaling up the market for renewable energy technologies provides significant opportunities for localising parts of the value chain, such as through local manufacture of solar panels and electric vehicles, with the associated technology transfer having the potential to come with additional positive effects to the economy.

Investments in renewable energy need to accelerate rapidly in Indonesia. Annual investment in renewable energy capacity in the Reference Case is estimated at, on average, USD 9.4 billion in 2015-2030. With the REmap Options this would increase to USD 16.2 billion. The power sector accounts for USD 13.2 billion, nearly half of which is for solar PV. Given the modest level of investments today, a rapid acceleration is required for Indonesia to capture its renewable energy potential.

Challenges in accelerating renewable energy deployment

For Indonesia to accelerate its uptake of renewable energy, several challenges have to be addressed. These challenges are different for the power sector and for the energy end-use sectors of transport, buildings and industry. Bioenergy, given its cross-cutting application across sectors and technologies, warrants its own assessment.

In the power sector, several broad barriers are evident, along with technology-specific challenges:

- Grid integration of variable renewable energy (VRE) might come with challenges given the highly fragmented nature of Indonesia's grid, with many small grids in remote locations;
- For off-grid areas there is a lack of bankable off-takers, the risk of inadequate system design, and operational issues due to the insufficient operation and maintenance (O&M) of systems;
- Cost recovery for PLN (the national utility) remains an issue as feed-in tariffs for renewable energy generally exceed the price that PLN charges to consumers of electricity; however, a recent Ministerial Degree will affect feed-in tariff pricing and limit renewable energy tariffs to between 85% and 100% of PLN's regional production price;
- Project finance opportunities for renewable energy projects in Indonesia are limited at present, as local banks do not allocate sufficient resources to this segment;
- Land acquisition issues are common due to a lack of clarity regarding land ownership in many locations, while the process for acquiring land is often costly and time consuming;
- Technology-specific challenges (*e.g.*, for solar PV, wind, etc.) include a lack of awareness of solutions, the need to build local capacity, a lack of streamlined permitting and regulatory frameworks, and the absence of detailed resource assessments.

In the end-use sectors, Indonesia needs to address key challenges as well:

- Solar thermal for water heating and cooling in buildings has great potential;

however, limited awareness of solutions and a lack of design standards are holding back the market;

- Limited awareness in industry of the potential for solar collectors to supply process heat and their intermittent supply of energy pose barriers, as well as space limitations which might be an issue for existing plants;
- The focus for renewable energy in transport is on liquid biofuels, whereas electric mobility remains largely unaddressed. A lack of infrastructure and regulatory frameworks is holding back the identified potential for electric four-wheeled vehicles and two-and-three wheelers.

Challenges can arise for bioenergy on both the supply and demand sides. Concerns about the sustainability of supply, despite the potential of yield improvements and the use of degraded lands, pose a challenge to Indonesia's targets for liquid biofuel blending. In industry, the potential of using residues and waste comes with the challenges of high transportation cost, seasonality of feedstock supply, the lack of a local grid to interconnect (power) projects, and competition for the feedstock with other uses (*e.g.*, the use of trunks and leaves to replenish soil). The accelerated use of modern cook stoves – using solid biomass and ethanol instead of traditional uses of bioenergy for cooking – is challenged by limited awareness and high required upfront investment.

Areas for action

Various solutions are available to promote higher uptake of renewable energy in Indonesia. These can be grouped into three main areas for action:

1. **Intensify efforts to meet the growing demand for electricity by capturing the full potential of Indonesia's vast renewable energy resources.**

Indonesia is endowed with phenomenal resources for renewable power generation. To capture the country's potential and address the existing challenges, Indonesia's policy makers and energy decision makers are encouraged to:

- Align the targets for renewable energy deployment among different stakeholders and incorporate the expected deployment of VRE in transmission and distribution plans. Consider using energy storage to smooth integration of VRE and introduce priority dispatch for renewable energy generation.
- Identify funds that can cover the gap between renewable energy power purchase agreements (PPAs) and the revenues that PLN receives from consumers. The process for PLN to negotiate PPAs directly with developers for projects should be more standardised and should include more detailed requirements.
- Establish larger off-grid working areas encompassing multiple villages to achieve economies of scale for off-grid solutions, and consider expanding PLN's responsibilities to build and own distribution networks in off-grid locations to further reduce the cost to off-grid solution providers. Create an entity responsible for overseeing O&M of mini-grid systems – involving local

communities – and expand the use of standardised survey methodologies to ensure that systems are scaled adequately.

- Increase awareness of opportunities among commercial banks and send clear signals that renewables will receive long-term, stable policy support. Create standard procedures and performance indicators for project development documents.
- Involve local communities early in the project development phase and consider providing additional services from projects (such as providing electricity) to communities. Large regional differences in the cost of land should be reflected more in feed-in tariffs, and the government could take a more active role in providing lands for projects.
- Address other barriers specific to each of the renewable power technologies – which consist mainly of increasing awareness and local capacity building and maximising local value; streamlining permitting and regulatory frameworks; and expanding resource assessments.

2. Increase the focus on renewable energy opportunities in industry, buildings and transport.

To fully capture the potential of renewable energy to reduce emissions and air pollution, more attention to these end-use sectors is recommended. Here, Indonesia has several options:

- Consider requirements for solar water heater installations in building codes and demonstration projects for solar cooling technologies.
- Highlight the potential for solar thermal energy to substitute for petroleum products, for example through local demonstration projects. Consider solar thermal storage capacity and/or hybrid solutions in the design and construction of new industrial plants.
- Combine infrastructure investments (such as charging infrastructure at large parking lots in cities) with support policies (*e.g.*, tax exemptions) to expand the market for electric vehicles and electric two- and three-wheelers. Electric mobility, when powered by renewable energy, could play an important role in reducing air pollution in cities and in reducing the reliance on liquid fuels in transport. Policy support for electric mobility is crucial given the immaturity of the market in Indonesia and the relatively high cost compared to conventional cars and electric two- and three-wheelers.

3. Develop an integrated and comprehensive bioenergy programme that captures Indonesia's potential and ensures its use in a sustainable manner.

Indonesia's abundant resources for bioenergy can be used in multiple applications spanning all economic sectors. The detailed recommendations provided in the report include this key suggestion:

- Develop a comprehensive bioenergy programme with the objective of maximising the sustainable use of the local resource through gradually increasing targets across sectors. Innovative approaches and technologies on both the supply side and demand side should be included,

while the sustainability of bioenergy use in Indonesia should be safeguarded. Solutions with a high impact and low cost should be prioritised. One example is increasing the use of biogas produced from palm oil mill effluent, which not only was found to be a cost-competitive option, but also avoids methane emissions that occur when the biogas is not used. The efforts of the Indonesia Clean Stove Initiative and the Indonesia Domestic Biogas Programme also should be expanded to advance the dissemination of modern cook stoves based on bioenergy.

The full REmap report for Indonesia is available at *www.irena.org/remap.*

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