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POLICY BRIEF

THE IMPACT OF DISRUPTIVE TECHNOLOGIES ON THE ENERGY SECTOR

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Abstract. *Disruptive technologies such as electric vehicles, communication technologies, and robotics offer potential opportunities to develop new businesses, but almost all result in increased electricity demand. In Indonesia, growth in electricity demand has not been matched by the development of power generation capacity, which may hinder the deployment of disruptive technologies. Priority focus should be given to the development of the power sector in Indonesia, since only a reliable electricity grid would enable the deployment of new technologies capable of promoting both economic activity and environmental benefits. Indonesia is particularly well placed to deploy electric motorcycles as a disruptive technology, which could assist the transition to an electricity grid with a higher share of renewables. Following the examples of China and India would facilitate the deployment of electric motorcycles as a replacement for existing conventional two-wheelers and cars, enabling regional leadership in electric motorcycle manufacturing without placing a large burden on the electricity grid.*

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KEY POINTS

- The adoption of electric drivetrains is likely to have a profound impact on the energy sector. The deployment of disruptive technologies depends on reliable access to electricity and most technologies would lead to an increase in electricity demand.
- Indonesia is self-sufficient in coal and natural gas, but dependent on imported oil. Electrification is still among the lowest in Asia, with an annual consumption of only 814 kWh per capita; electricity generation doubled over the last decade, but generation growth has been slower than electricity demand.
- Currently, two-wheelers account for almost 90% of the fleet of light-duty passenger vehicles in Indonesia; fostering the ownership of electric cars may lead to an additional 40% demand for electricity by 2030. Electric two-wheelers could contribute to a lower dependency on oil, a reduction in emissions and noise, and an improvement in the air quality in big cities, without being a substantial burden to the electricity grid.
- Indonesia has access to an undeveloped potential of geothermal energy and natural gas. Electric motorcycles could help the transition to an electricity grid with a higher share of renewables. The deployment of new technologies could only be enabled with a reliable electricity grid and power sector.

THE IMPACT OF DISRUPTIVE TECHNOLOGIES ON THE ENERGY SECTOR

Disruptive technologies are innovations capable of creating processes and markets that disrupt existing practices and supply systems. These technologies may lead to gains in productivity and efficiency, which may offer new business opportunities, mitigation of environmental impacts, and social well-being. Yet the deployment of disruptive technologies redefines practices and equipment, requiring changes in infrastructure and energy use. This has a systemic impact on the energy sector, which in some cases may compromise the overall benefits of new technologies.

Digitalization and electrification are the core disruptive transformations influencing the energy sector. The rise of renewable power, battery storage, and electric vehicles is based on the redefinition of interactions offered by digitalization, and all of them depend on the reliability of the infrastructure for electricity generation and distribution. Redefined and facilitated interactions, and more efficient and cleaner energy services, may result from the deployment of disruptive technologies, but almost all result in increased demand for electricity. Table 4 lists the new technologies that are likely to be most disruptive to the energy sector.

Electric vehicles and autonomous cars may redefine the road transport sector. The adoption of electric drivetrains is likely to have a profound impact on the energy sector. In most countries, road transport accounts for one-fourth to one-third of total energy demand in the form of oil products (diesel and petrol); and 30% of this energy demand would have to be supplied with electricity, if internal combustion engines were to be replaced with electric drivetrains. In most countries this process would result in a substantial increase in electricity demand over a decade, which would most likely require a reconfiguration of the power sector. The adoption of autonomous vehicles may also disrupt the energy sector, but their impact is mostly dependent on the weight and number of autonomous cars. A substantial reduction in the average weight of cars may be achieved by the adoption of autonomous collision control systems, which may result in substantial energy demand reductions. For example, a 50% reduction in the average weight of passenger cars is estimated to deliver a 30% reduction in the total energy demand of the car fleet.[118] Conversely, an increase in vehicle weight, the number of cars on the roads, or the demand for transportation service would result in increased energy demand.

Batteries have been constrained by storage capacity and costs but recent developments in battery technology may enable more reliable applications. Enhanced batteries are able to increase the autonomy of electric devices and could even be used to assist microgeneration from intermittent renewable energy sources. Depending on the scale of implementation, this could facilitate the deployment of renewable electricity generation, but enhanced autonomy of electric devices may lead to an increase in overall electricity demand.

An expansion in the use of digital technologies, electronics, building automation, and robotics is taking place at a fast rate, producing new opportunities in the short run, but they are likely to have minimal effects in the energy sector. These technologies may lead to changes in the demand for electricity, but these are small energy users and thus any impacts in electricity demand are likely to be small.

Table 4. List of Disruptive Technologies and Their Impact on the Energy Sector

Technology	Description	Potential Opportunities	Impact on the Energy Sector	Magnitude of the Impact on the Energy Sector
Electric vehicles	Vehicles with battery, electric, or hybrid drivetrains	• Reduction of air pollutants • Reduction in oil dependency • Cost benefits (in some cases)	• Increased electricity demand • Consumption at times when intermittent renewable energy sources are available	Very high

[118] A. C. Serrenho et al. 2017. *Philosophical Transactions of the Royal Society A*, 375 (2095).

Technology	Description	Potential Opportunities	Impact on the Energy Sector	Magnitude of the Impact on the Energy Sector
Autonomous vehicles	Vehicles capable of travelling without a driver	• Decrease in the risk of vehicle collisions • New business models to explore transport service instead of vehicle ownership	• Highly dependent on the weight and number of autonomous vehicles – transport energy demand may increase or decrease accordingly	Moderate
Battery storage	Capacity to store electricity from the power grid or from intermittent sources to be used later in electricity devices or to feed the power grid	• Increased autonomy of electric devices • Increased reliability on the use of intermittent renewable sources	• Increased electricity demand • Increased reliability on the use of intermittent renewable sources	Moderate
Digital communication and electronic technologies	Deployment of communication technologies and devices to process and reproduce digital information	• Enhanced communication • Enhanced process of digital information • Facilitated reproduction of digital information	• Increased electricity demand	Low
Building automation	Smart technologies to control services and energy uses in buildings	• Efficiency gains • Productivity gains • Automation	• Possible net energy savings • Additional electrical equipment and risk of rebound may limit or offset net savings	Low
Robotics	Deployment of autonomous machines to replace or support human labour	• Productivity gains • Automation	• Increased electricity demand • Additional equipment leads to increased energy demand for manufacturing	Low/ Moderate
Smart meters	Electricity meters showing instantaneous consumption	• Enhanced awareness of energy uses • Potential behaviour changes to reduce energy demand	• Potential reduction in electricity demand	Low
Smart grids	Control and conditioning of electricity production, distribution, and consumption	• Optimization of efficiency • Increased reliability and flexibility of the grid	• Enhanced potential for use of intermittent renewable energy sources • Optimized management of electricity generation	Moderate/ High

Source: Author's elaboration

Smart meters and smart grids may optimize the management of electricity generation and distribution by controlling demand and selecting optimized power generation for each time of the day. Although this may lead to a reduction in overall demand and the optimization of renewable power generation, centralized control of individual equipment limits the flexibility and freedom of electricity demand, which may hinder the level and pace of deployment of this technology. Smart meters alone are able to be deployed in the short term, informing final users of real-time energy demand and costs. Recent experiences of the deployment of smart meters for domestic users show changes in consumer behaviour shortly after the installation of smart meters. Depending on the level of access to electricity, most domestic energy demand is associated with heating or cooling and these uses mostly depend on building conditions and infrastructure. Therefore, the scale of impact of smart meters in the energy sector is likely to be limited.

The deployment of many disruptive technologies depends on reliable access to electricity, and most technologies would lead to an increase in electricity demand. The levels of access to electricity in Indonesia are still low, and configuration of the power sector is likely to continue to be transformed and to expand over the next decade. Some disruptive technologies may bring additional challenges to the process of electrification in Indonesia. A transition to electric vehicles is likely to be most disruptive to the power sector in Indonesia over the next decade. The next sections detail the current state of the energy sector and the opportunities and impacts that the adoption of electric vehicles in Indonesia would bring to the energy sector.

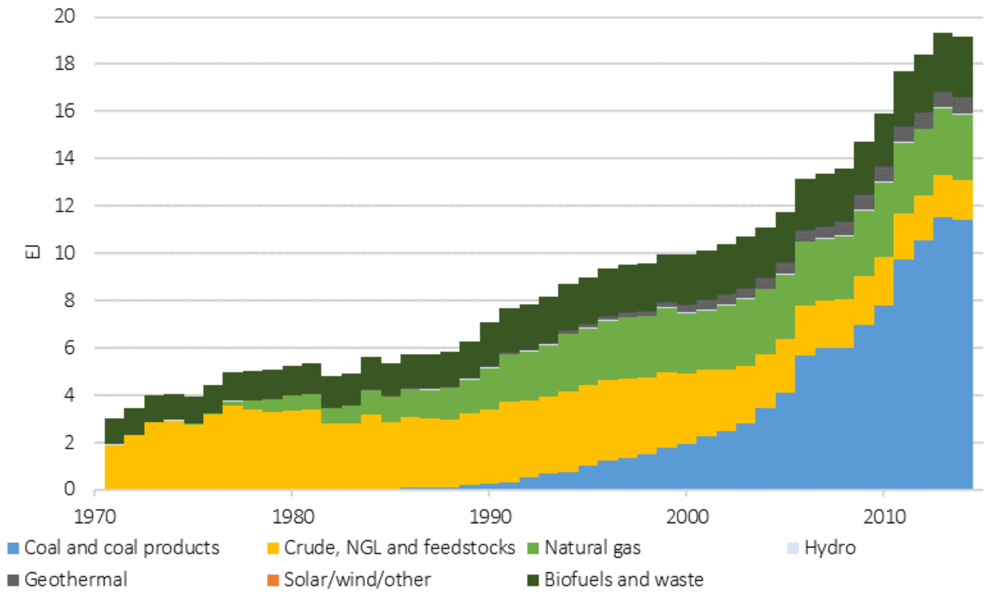
ENERGY SECTOR IN INDONESIA

The Indonesian energy sector has been under permanent transformation over recent decades – energy production increased six-fold and energy demand increased four-fold since the early 1970s. However, new disruptive technologies, climate change, and the political and economic context will require further transformations in the infrastructure of energy supply.

Energy Production

Indonesia is currently the largest global coal exporter and the 10th global producer of natural gas. Although Indonesia has long been a net energy exporter, significant transformations have occurred in the composition of energy production in recent decades (Figure 16). Until 2003, Indonesia was a net oil exporter, and oil was the main source of primary energy production. A decrease in production combined with an increase in domestic demand for oil products transformed Indonesia into a net oil importer. Since the 1980s, Indonesia has become an important global producer of natural gas, but its production has been steady since the 1990s. Because of its abundance, coal production has more than trebled over the last decade, and currently more than 80% is exported.

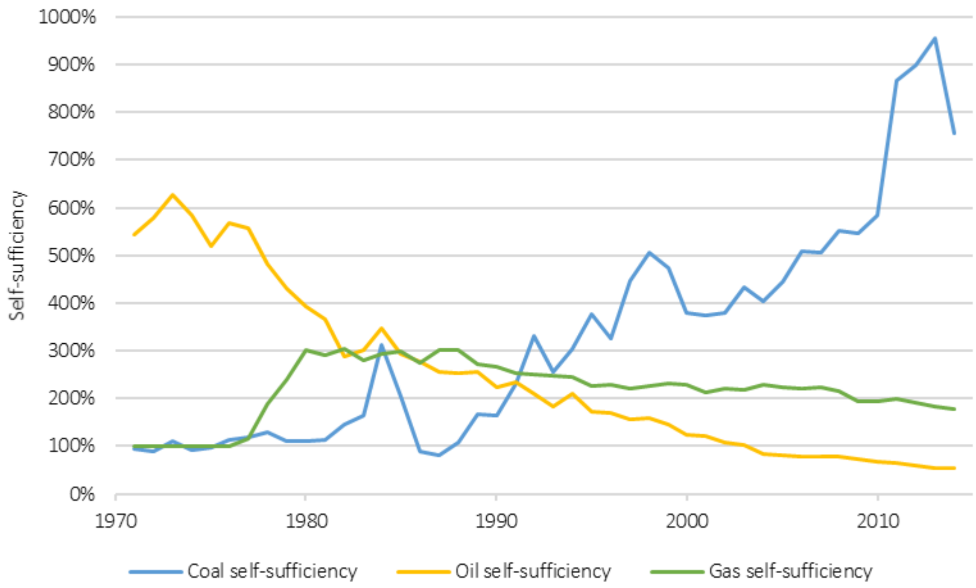
Figure 16: Primary Energy Production by Resource in Indonesia, 1970–2014



Source: International Energy Agency. 2018. Energy Statistics.

Indonesia is self-sufficient in coal and natural gas, but it is now dependent on imported oil (Figure 17). This dependency has been increasing and current oil production can only supply around half of domestic demand. Natural gas production is almost twice the level of domestic demand, but steady production and growing domestic demand are leading to a decrease in self-sufficiency for this resource. Growing coal production is now more than seven times the level of domestic demand, although the availability and low relative price of this resource are leading to a growing domestic use of coal, mainly for electricity generation.

Figure 17: Indonesia – Self-Sufficiency in Fossil Fuels,[a] 1970–2014



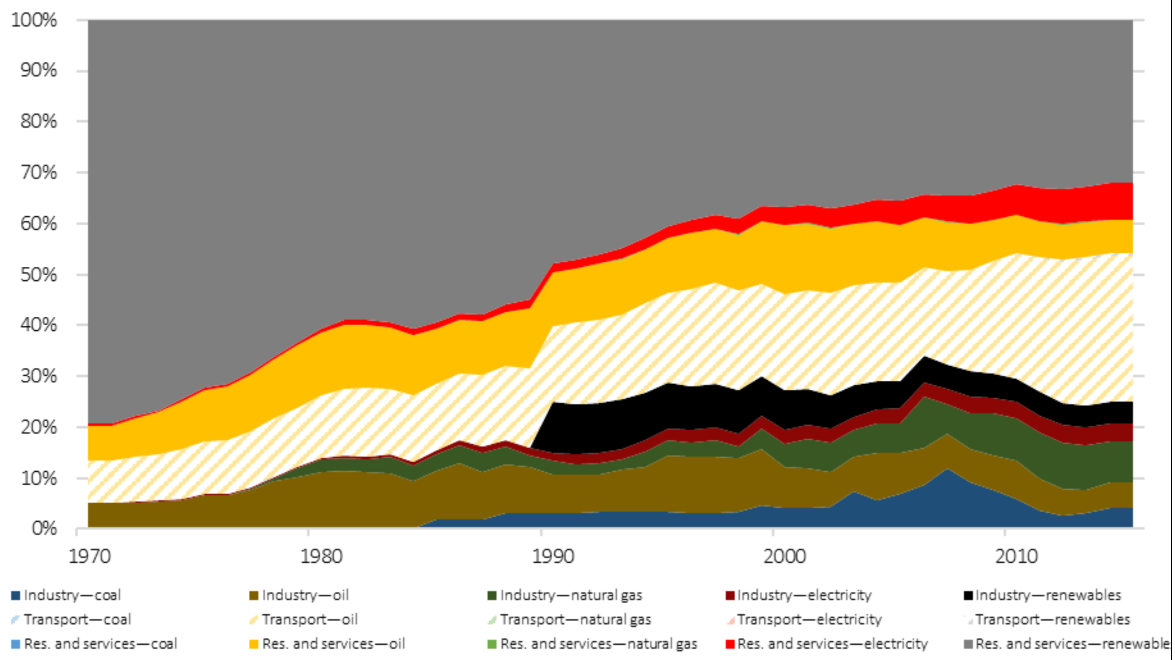
Note: a) Self-sufficiency is defined as the ratio of primary energy production to primary energy supply. A country is self-sufficient if self-sufficiency is equal to or greater than 100%, in which case the excess production can be traded.

Source: International Energy Agency. 2018. Energy Statistics.

Energy Demand

Almost all of the natural gas and coal is used for electricity generation and in the industrial sector. Oil products are mostly used in the transport sector, almost exclusively as petrol for vehicles. Residential and commercial energy uses account for 50% of energy demand. Biomass has historically been the most used energy product in this sector, but recently the demand for electricity has been increasing (Figure 18).

Figure 18: Indonesia – Energy Demand by Sector and Product, 1970–2014

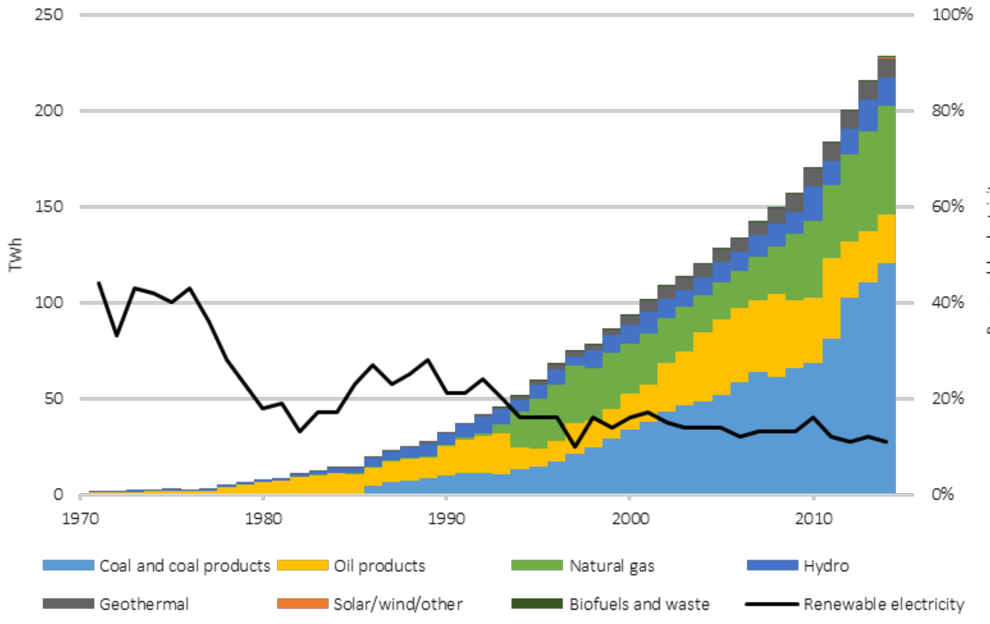


Source: International Energy Agency. 2018. Energy Statistics.

More than 60% of electricity is currently used by the residential and services sector. From 2010 to 2014 the share of the population with access to electricity increased from 68% to 84%, but the levels of electrification are highly variable across the country, with the Eastern provinces lagging behind. The level of electrification is still among the lowest in Asia, with an annual consumption of only 814 kWh per capita, far behind China (3938 kWh per capita), but also behind the current average for all other Asian countries (947 kWh per capita).

Electricity generation doubled over the last decade, largely as a result of the expansion of coal power plants (Figure 19), but generation growth has been slower than electricity demand, leading to power shortages and low reliability in accessing the power grid. Renewable electricity accounts for only 10% of power generation. A growing geothermal capacity currently accounts for 40% of renewable electricity, and hydroelectricity accounts for the remaining 60%. Wind and solar photovoltaic power are still in very early stages of deployment, accounting for only 0.05% of power generation.

Figure 19: Indonesia – Electricity Generation in Indonesia and Share of Renewable Electricity, 1970–2014



Source: International Energy Agency. 2018. Energy Statistics.

Immediate Challenges

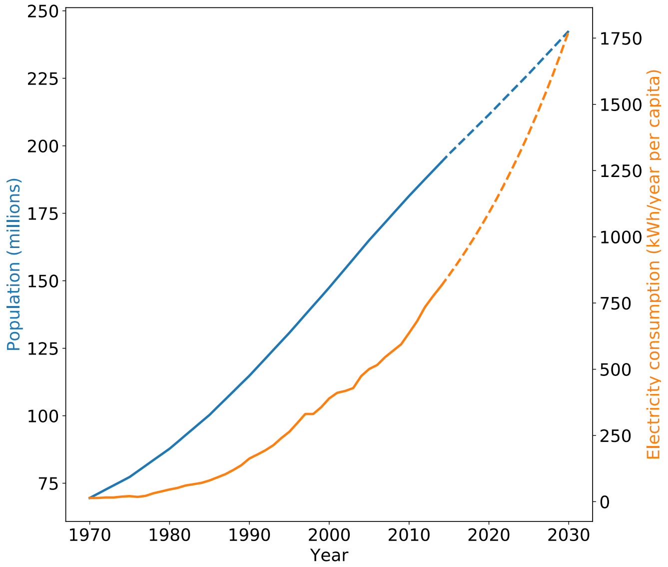
Indonesia is the fourth most populous country on Earth and the ninth in terms of population growth projected until 2050. This continued growth population will imply further growth in energy demand over the next decades. Electricity demand is likely to increase more than other energy products, because of the combined effect of the growth in population and electrification, as Indonesia has yet to catch up with the levels of electrification of other Asian countries (Figure 20).

Indonesia has access to substantial reserves on a variety of energy resources, namely, geothermal energy and natural gas, but has not been able to exploit them fully. Regulatory uncertainty and inadequate investment led to a reduction in oil production and to the current dependency on imported oil products. Current energy policies aim to reorient energy production from serving primarily export markets to meeting Indonesia's growth domestic energy demand.[119] Current policies aim to reduce dependency on oil by expanding the use of coal, natural gas, and renewable sources, and simultaneously achieve 23% of renewable electricity generation by 2025.[120]

Recent trends show a coal-dominated energy sector, with continuous growth in coal uses. Meeting existing targets on renewable electricity will require further investments in the deployment of renewables. Geothermal energy is largely undeveloped, but it has the greatest potential for deployment in Indonesia – natural geothermal reserves could be used to generate 29 GW, which accounts for 40% of the global geothermal potential. Although there is limited potential for deploying wind power, the use of solar photovoltaic power is also largely underdeveloped, and it could contribute to facilitating access to electricity and reducing dependency on fossil fuels.

[119] US Energy Information Administration. 2015. *Indonesia: International energy data and analysis.*
[120] Directorate General of Electricity, Ministry of Energy and Mineral Resources of the Republic of Indonesia. 2017. *Country Report "Electricity sector in Indonesia".*

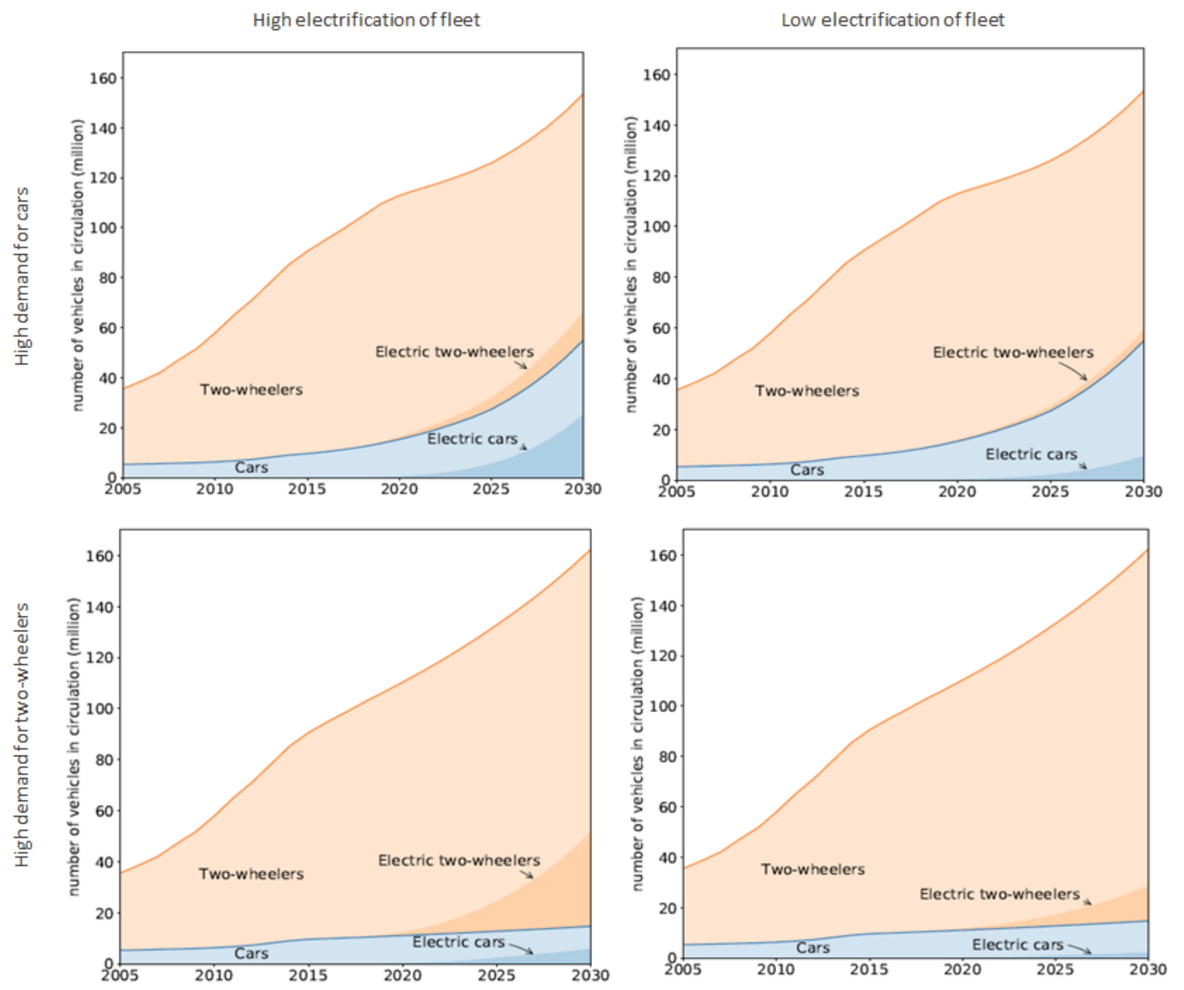
Figure 20: Indonesia – Population Estimates and Rate of Electricity Consumption, 1970–2030



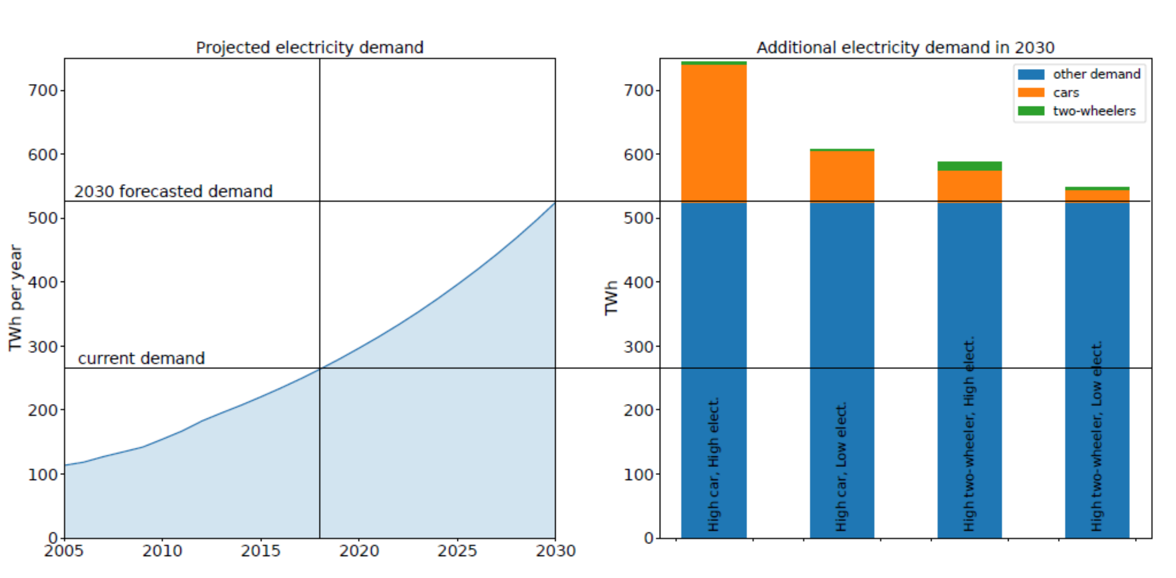
Source: United Nations. 2018. World Population Prospects 2017; International Energy Agency. 2018. Energy Statistics.

Box 1: Case Study – Electric Vehicles: Opportunities and Challenges for Indonesia

Electric car sales have been increasing rapidly in China and in some European countries, which are scaling up production and reducing the cost of batteries. This has spill-over effects across other modes of transport, particularly on the deployment of electric motorcycles. China already has 200 million electric two-wheelers deployed and it is expected that 39% of all two-wheelers in the world will be electric by 2030.[a] Currently, two-wheelers account for almost 90% of the fleet of low-duty passenger vehicles in Indonesia. There is roughly one two-wheeler for every three people, while the ownership of cars is just one per every twenty-seven people (much lower ownership than in China – nine people/car; or Western economies such as the United Kingdom – two people/car). The figure below shows the projected size and composition of the fleet until 2030 for two strategies of vehicle ownership in scenarios of high and low rates of electrification of the fleet.[b] The two strategies assessed (fostering car or two-wheeler ownership) anticipate growth of the fleet to around 150–160 million vehicles by 2030, but with different market shares of cars and two-wheelers. This offers great potential for the deployment of electric vehicles. With the right incentives, high levels of adoption of electric vehicles can occur, as verified in China or Norway. However, even if there is fast adoption of electric vehicles, the shift in the composition of the fleet from internal combustion engines to electric is slow, because of the slow rate of replacement of vehicles. Even if 80% of new sales in 2030 were electric vehicles, it is expected that only one fourth of the fleet should already have been converted to electric drivetrains. However, the expected increase in the number of vehicles contributes to a substantial increase in energy demand for transportation, which may produce substantial additional electricity demand to supply new electric vehicles.



It is expected that population growth and an improvement in the levels of electrification in Indonesia will lead to a doubling of the electricity demand by 2030 from current levels (see figure below – left). Electric vehicles will create additional electricity demand, depending on the market share of electric vehicles and development of the composition of the fleet. The figure below – right – shows an estimate of the additional electricity demand caused by electric vehicles for the strategies compared in the previous figure. Fostering car ownership may lead to an additional 40% demand for electricity by 2030 for high levels of deployment of electric vehicles. By 2030 this would be almost as much as the current electricity demand used for electric cars alone, which would require drastic deployment of power generation capacity and distribution infrastructure. This would probably be accomplished by the rapid deployment of coal power plants, given the current low costs and high availability of this resource, which could delay the development of renewable power sources and would partially offset the environmental benefits of electric cars. However, two-wheelers require much less energy to travel the same distances; thus, fostering two-wheeler ownership would result in a minimal increase in electricity demand – only +3% electricity by 2030 for high levels of deployment of electric vehicles, which is equivalent to two new natural gas power plants.



Indonesia is well placed to promote two-wheeler ownership as an alternative to cars and to support the deployment of electric two-wheelers, resulting in minimal stress to the electricity grid. In large cities with high population density, short-range and frequent trips favour the use of electric two-wheelers, and reliable electricity supply would be easier to provide in urban areas. The deployment of electric two-wheelers in Indonesia also has spill-over effects. Most two-wheelers are manufactured locally, which provides an opportunity to create regional leadership in the development of new electric two-wheeler technology, fostering local economic activity. Electric two-wheelers are much more efficient than the internal combustion engine equivalent, and thus electrification would contribute to a 20–30% decrease in dependency on oil, reducing greenhouse gas emissions and noise, and improving air quality in big cities. Typical transportation requirements in big cities cover short-range distances and have high annual mileage, resulting in low costs for developing the infrastructure for charging electric two-wheelers in most urban areas. However, the deployment of new electric two-wheelers could only be enabled if more investment were made in the power generation sector. Only a reliable electricity grid and a power sector capable of supplying a fast-growing demand for electricity would enable the deployment of electric vehicles in Indonesia.

[a] International Energy Agency. 2018. Global EV Outlook 2018 – Towards cross-modal electrification.
[b] Two strategies are considered: fostering car ownership, doubling the growth rate of new car registrations, and maintaining current ownership for two-wheelers; and fostering two-wheeler ownership, maintaining current car ownership, and continuing the recent increasing trend of two-wheeler registrations.
High electrification scenario: it is assumed that 80% of new vehicle sales in 2030 will be electric. Low electrification scenario: it is assumed that 30% of new vehicle sales in 2030 will be electric.

IMPLICATIONS OF DISRUPTIVE TECHNOLOGIES FOR INDONESIA

Disruptive technologies offer potential opportunities to develop new businesses, but almost all result in increased electricity demand, which may hinder their deployment in Indonesia, where growth in electricity demand has not been matched by developing the capacity for power generation. However, some disruptive technologies, such as the deployment of electric motorcycles combined with microgeneration from intermittent renewable energy sources, may contribute to the transformation of the energy sector with spill-over effects in the environment and economic activity.

Historically, periods of fast electrification in other countries were associated with rapid economic growth, because new and more efficient activities become available.[121] Indonesia could benefit from higher levels of access to electricity if the power generation capacity were developed. Electricity demand has been growing rapidly in Indonesia, although current levels of electrification are still below average for Asian countries (excluding China). Population growth and increasing access to electricity are likely to double electricity demand by 2030 from the current levels. This will require a clear and continuous investment schedule to expand power generation capacity and to improve the reliability of the electricity grid. This effort is all the more challenging given the geographical constraints – Indonesia is an archipelago comprising thousands of islands, which is a major hindrance to reliable interconnectivity of the grid among islands. Currently, increased electricity demand is being supplied through increased use of coal power plants, but Indonesia has access to undeveloped potential on geothermal energy and natural gas. These resources could contribute to meeting existing targets for renewable electricity and the expected increase in demand for electricity. It is critical to develop the electricity sector in Indonesia to enable the deployment and potential opportunities of new disruptive technologies. These could simultaneously reduce the dependency on oil imports, while retaining Indonesia's global leadership as an exporter of coal and natural gas.

Electric vehicles could help the transition to an electricity grid with a higher share of renewables, using electricity generated from intermittent renewable sources at times of low demand. Wind energy is often the preferred choice of renewable electricity to be deployed with electric vehicles, given the potential synergies created in the daily management of electricity availability – wind energy is often available at night, when electricity demand is low, thus creating the possibility of battery charging at night. However, this option is limited for Indonesia, given the reduced potential for deploying wind energy, but the development of microgeneration with solar energy could be exploited. More investment in geothermal energy, along with increased exploitation of natural gas, should enable an additional electricity supply. Indonesia is particularly well placed to deploy electric two-wheelers, which offer an opportunity to mitigate air pollution and congestion in big cities, while promoting economic activity and enabling regional leadership in electric two-wheeler manufacturing, without being a substantial burden to the electricity grid.

Recent policies have issued tax cuts for car engines below 1000 cm^3, which has driven car sales. Although cars with small engines require less energy to travel the same distances, having more petrol engines on the roads is contributing to worsening dependency on imported oil, and to deteriorating congestion, noise, and air quality in cities. Small electric cars could mitigate some of these problems, but if growing demand for these cars continues, it would be very challenging to meet the required additional electricity demand. Besides, the affordability of electric cars over their petrol equivalents is only favoured if fuel prices are high. However, the economic case for electric two-wheelers is strong for any reasonable range of annual mileage, and battery costs for two-wheelers are likely to fall 50%–60% more than for electric cars.[122]

The opportunity to enable the deployment of new technologies, in particular electric two-wheelers and smart grids, to manage microgeneration, would require new incentives and policies. Besides reorienting recent incentives from car purchasing to two-wheeler ownership, Indonesia could set clear targets to aim for high market shares of electric vehicles, for example, following recent similar policies in India – whose government announced the aim of having all-electric new vehicle sales by 2030. Fiscal incentives and public procurement schemes could foster the use of electric vehicles (particularly two-wheelers), demonstrating the technology to the public and thus increasing their levels of acceptance.

[121] Serrenho et al. 2016. Structure and dynamics of useful work along the agriculture-industry-services transition: Portugal from 1856 to 2009. *Structural Change and Economic Dynamics*. 36. Pp. 1–21.
[122] International Energy Agency. 2018. *Global EV Outlook 2018 – Towards cross-modal electrification.*

Clear incentives are required to develop the power grid, when electricity demand is expected to rise faster than ever before. This would also require new policies to facilitate simple integration of electric vehicles in power grid operations. Any synergies between transport electrification and variable renewable sources could be maximized if changes in regulations and grid operations enabled non-utility stakeholders to access the grid and to enter the charging business market.

New technologies pose challenges but also offer new opportunities. Electric vehicles are the most disruptive technology for Indonesia, given the low levels of electrification, but electric two-wheelers in particular offer clear opportunities. China and India are already investing in the deployment of electric vehicles, particularly two-wheelers. These countries are investing in the creation of know-how to support a switch to electric motorcycles. These practices are also applicable to Indonesia and could promote a transition of existing local two-wheeler manufacturing to electric motorcycles and charging infrastructure development and maintenance. However, a delay in joining other regional leaders may limit the potential to fully exploit the business opportunities arising from deploying electric vehicles.

Only a reliable electricity grid and a power sector capable of supplying a fast-growing demand for electricity will enable the deployment of new technologies. The energy sector in Indonesia has undertaken profound transformations in recent decades, but priority focus should be given to developing the power sector. A delay in doing so would hinder or even inhibit the deployment of new technologies and their potential benefits. Additionally, a fast-growing demand for electricity is enabling an increasing number of new services; thus, the inability to supply electricity demand could have drastic social and economic effects.