Zero-Carbon Energy for the Asia-Pacific Grand Challenge
Grand Challenge Papers

GCP01-19 Overcoming barriers to solar and wind energy adoption in two Asian giants: India and Indonesia

Paul J. Burke[1]*, Jinnie Widnyana[2], Zeba Anjum[1], Emma Aisbett[3], Budy Resosudarmo[4], Kenneth G.H. Baldwin[5]

[1] ZCEAP Grand Challenge and ANU Crawford School of Public Policy

[2]ZCEAP Grand Challenge and ANU College of Law

[3]ZCEAP Grand Challenge and ANU School of Regulation and Global Governance (RegNet)

[4]ZCEAP Grand Challenge and ANU College of Asia and Pacific

[5]ZCEAP Grand Challenge and ANU Research School of Physics and Engineering

*Corresponding author: paul.j.burke@anu.edu.au

11 April 2019

Overcoming barriers to solar and wind energy adoption in two Asian giants: India and Indonesia

Paul J. Burke*, Jinnie Widnyana, Zeba Anjum, Emma Aisbett, Budy Resosudarmo, Kenneth G.H. Baldwin

Australian National University, ACT 2601, Australia

* Corresponding author, paul.j.burke@anu.edu.au

11 April 2019

Solar and wind electricity generation technologies have become cost competitive and account for a growing share of global investment in new electricity generation capacity. Both India and Indonesia have ambitious targets for adoption of these technologies, and India has an impressive current rate of uptake. Substantial obstacles exist, however, including the entrenched positions of coal and other fossil fuels, regulatory barriers to market access, and weak abilities of electricity utilities to manage intermittent renewables. This paper reviews these obstacles and discusses strategies to overcome them. We focus on the use of reverse auction processes able to deliver low-price solar and wind contracts, as are being successfully employed in India, on tax and subsidy reform options, on regulatory and incentive-design strategies, on approaches to bolster grid management capacities, and on the importance of minimising protectionist barriers. Our analysis covers both small-scale and large-scale systems.

JEL codes: Q42, Q48, O13

Keywords: renewables, electricity, solar, wind, India, Indonesia

Acknowledgements: We are grateful for funding under the Australian National University *Zero-Carbon Energy for the Asia-Pacific* Grand Challenge project, comments from colleagues and during peer review, and discussions with stakeholders.

1. Introduction

Solar and wind accounted for more than half of all net additions to global electricity generation capacity in 2017. In net terms, more solar capacity was installed than fossil fuel and nuclear power generation capacity combined (Frankfurt School-UNEP Centre/BNEF, 2018; REN21, 2018).[1] It is likely that countries will increasingly adopt solar and wind generation as these technologies continue to improve and their costs fall, as capacities for managing intermittent electricity generation are enhanced, and as a result of policy efforts to address the environmental consequences of fossil fuel use (International Energy Agency [IEA], 2017a; Bloomberg NEF, 2018).

India and Indonesia – the second- and fourth-most populous countries in the world – provide contrasting case studies on early progress in the adoption of solar and wind energy. India is among world leaders: the 6th-largest producer of solar electricity and 4th-largest producer of wind electricity as of 2017 (BP, 2018). Solar and wind uptake in Indonesia has been much more limited. In other ways, India and Indonesia share notable similarities. Both have large and growing demands for electricity and have made substantial progress in broadening electricity access and improving the quality of electricity supply. Both remain highly reliant on coal for their electricity.

India and Indonesia have ambitious targets for renewables adoption. In 2014 India set the target of 175 gigawatts (GW) of renewable electricity generation capacity by 2022, including 100 GW of solar and 60 GW of wind. In 2018, a target of 275 GW of renewables by 2027 was announced (Central Electricity Authority, 2018). India's Nationally Determined Contribution to the Paris Agreement commits to 40% of its electricity capacity coming from non-fossil sources by 2030, "with the help of transfer of technology and low-cost international finance". Indonesia has a target for renewables and "new" energy to contribute 23% of the primary energy mix by 2025 (Government Regulation 79/2014), and its National Energy Plan (RUEN) has slated 8.3 GW of solar and wind to come online by 2025. Indonesia is not on track to meet its renewables target.[2]

In years gone by, generating electricity using solar and wind typically involved higher direct costs than generating electricity using fossil fuels, especially coal. This is no longer the case. Rapid cost reductions have meant that, in many countries, solar and wind are now able to compete with new-build coal generators, even before considering the external costs of coal-

[1] Note, however, that solar plants typically have lower capacity factors.
[2] As of 2017, the renewables plus "new" share of Indonesia's primary energy mix was recorded at 8% (Bridle et al., 2018; Ministry of Energy and Mineral Resources, 2018). This is lower than that reported by the IEA (2018a), whose data include use of primary biomass. Solar plus wind capacity was less than 0.1 GW.

fired generation (IRENA, 2017a). Some new solar and wind projects are now also able to undercut the *operating* costs of coal-fired power stations (Das et al., 2017; KPMG, 2017).

Both India and Indonesia have substantial untapped solar potential. While wind endowments are more modest, there is nevertheless the potential to develop onshore and offshore wind resources (IRENA, 2017b, 2017c; Liebman and Foster, 2019). The two countries also have many sites that could be used for pumped hydro energy storage, which could play a key role in balancing renewables-dominated grids (Blakers et al., 2018). Battery costs are falling (Bloomberg NEF, 2018). In terms of technologies and endowments, the two countries have the opportunity to vastly transform their electricity systems over coming years.

Nevertheless, uptake of solar and wind faces many challenges in India and Indonesia. These range from entrenched subsidies for fossil fuels and on-grid electricity, to weak electricity grids, regulatory barriers, and protectionist initiatives. This paper reviews these challenges and discusses strategies to facilitate rapid adoption of solar and wind. Some key challenges are currently more acute in Indonesia than in India, although the challenges faced in reaching high levels of intermittent renewables are large in both countries.

A feature of India's recent success has been its use of reverse auctions to secure low-price contracts for solar and wind electricity generation (Shrimali et al., 2016). One of our conclusions is that there is scope for Indonesia to launch a special round of large-scale procurement auctions of its own. An appropriate facilitating framework would be needed for low-range prices to be achieved. India's solar mission-based approach, and the establishment of government-led solar parks, provide a potential model.

Our paper employs an informal comparative research design (Lijphart, 1971), analysing data and policies from two key countries in terms of the potential for a transition from fossil fuels to zero-carbon energy technologies. Our choice of India and Indonesia is motivated by the fact that these are large and important countries, both with large endowments of coal. A comparative perspective is particularly useful because India has to date achieved much faster adoption of solar and wind than Indonesia, so there are likely to be insights from India that are of high relevance in the Indonesian context. The two countries are experiencing similar energy-sector transition challenges to those being faced in other key countries, such as Vietnam, the Philippines, and South Africa. As a result, our analysis and conclusions are of broad international relevance.[3]

[3] We do not include China among the country case studies in order to maintain a sharp focus on the India/Indonesia comparison, which provides useful insights. For a recent overview of solar and wind policy issues in China, see Zhang (2018).

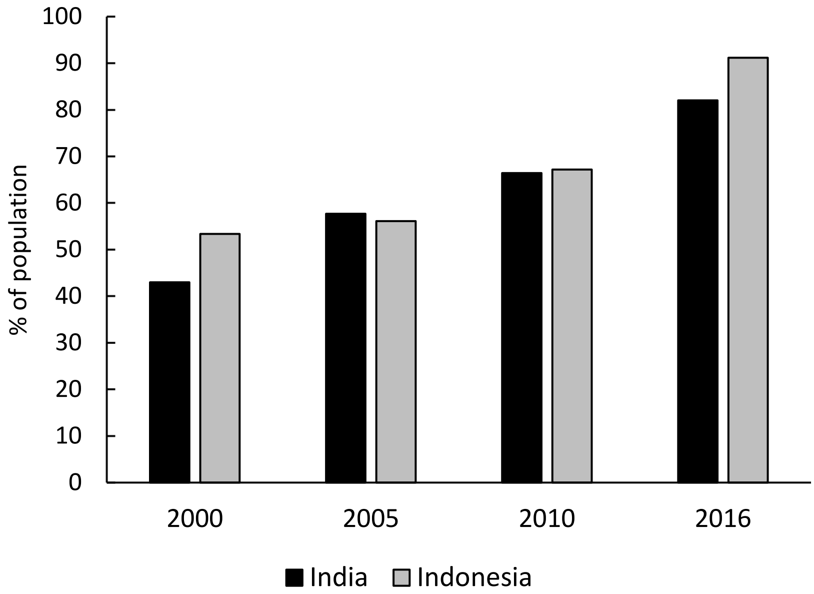
The paper proceeds as follows. Section 2 provides an overview of India and Indonesia's electricity sectors. Section 3 reviews the two countries' records on uptake of solar and wind. Section 4 identifies key barriers to solar and wind adoption. Section 5 discusses strategies for overcoming these barriers. The final section concludes.

2. The electricity sectors of India and Indonesia

2.1 Electrification, electricity quality, and interconnectivity

India and Indonesia – both lower-middle income economies (World Bank, 2018a) – have experienced impressive progress in expanding electricity access. According to IEA data, residential access reached 91% of Indonesia's population and 82% of India's by 2016, well up on the shares recorded at the turn of the century (Figure 1). This includes households with off-grid access or limited connections.

Figure 1: Residential electrification rate, 2000–2016



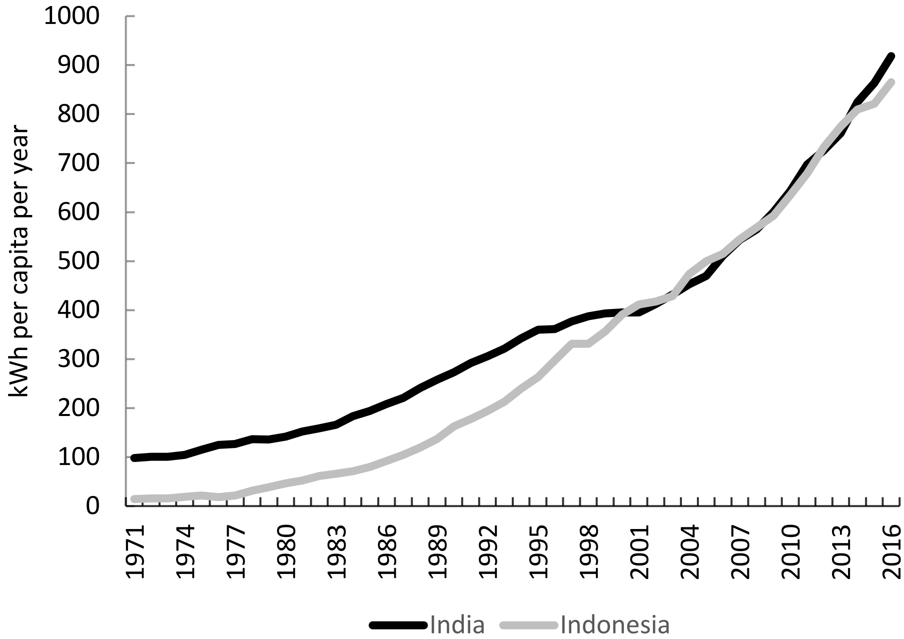
Source: IEA (2017b).

Driven by economic growth and improved access to electricity, per capita electricity consumption grew at averages of more than 5% per annum in both countries over 2000–2016 (Figure 2). The per capita electricity use trajectories of the two countries have been remarkably similar, with electricity use equalling around 0.9 Megawatt hours (MWh) per person per year in 2016. This remained well below the world average of 3.1 MWh per person (IEA, 2018a). Strong growth in electricity demand is expected to continue over coming years.

Despite significant progress, electricity poverty remains a major challenge. Around 239 million people remained without residential access to electricity in India in 2016, and 23 million in Indonesia (IEA, 2018b). Many others have only modest access. Sustainable

Development Goal 7 targets universal access to affordable, reliable, sustainable, and modern energy. It is highly desirable that uptake of solar and wind should accelerate, rather than compromise, progress towards this goal.

Figure 2: Electricity consumption per capita, 1971–2016



Note: Electricity consumption is across all sectors. Source: IEA (2018a).

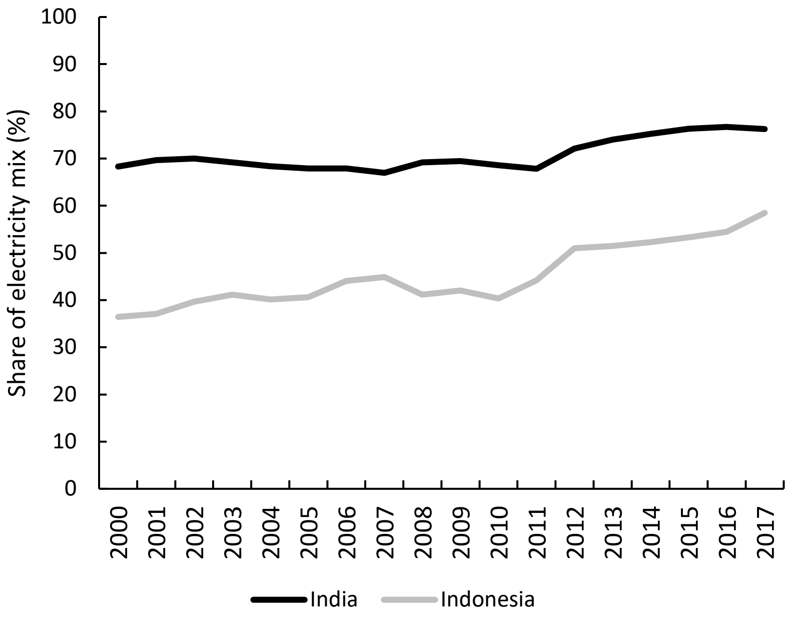
There have been considerable achievements in improving the quality of electricity supply in both countries. Transmission and distribution losses as a share of electricity output fell from 27% and 12% in India and Indonesia in 2000 to 19% and 9% in 2014 (World Bank, 2018b). Electricity theft remains a particular problem in India, although it has reduced in severity (Gaur and Gupta, 2016). While blackouts and grid instability remain serious issues, India received an improving score – from 3.1 out of 7 in 2007 to 4.7 in 2017 – in the World Economic Forum (2018) quality of electricity supply measure, based on surveys of executive opinion. Indonesia's score increased from 4.0 to 4.4. On average, electricity consumers experienced 19 hours of electricity outages in 2017 in Indonesia, with supply issues acute in outer islands (PLN, 2017).

One notable difference between India and Indonesia is the degree of interconnectivity of their electricity systems. Indonesia, an archipelago of around 6,000 inhabited islands, has eight major networks and around 600 isolated grids (Asian Development Bank, 2016; PwC Indonesia, 2017a). India has greater – albeit still underdeveloped (Tongia et al., 2018) – national grid interconnectivity, which is being further improved under the *One Nation-One Grid* initiative (Power Grid Corporation of India, 2018) and a Green Energy Corridor scheme. The advantage of a more interconnected grid is that it can access solar and wind projects sited in high-resource locations, and enable more effective routing of supply between distributed generation and demand centers. Geographical spread also helps to mitigate risks associated with poor solar or wind conditions in any region at any time. Relative to Indonesia, India is also advantaged by greater land availability in regions that are well suited to solar power generation (e.g. arid areas).

2.2 Electricity mix

Coal dominates the electricity mixes of India and Indonesia. The coal shares of their electricity mixes have generally been increasing, although India's has flattened out during the last several years. Coal contributed 76% of India's electricity mix in 2017 and 58% of Indonesia's (Figure 3). Other fossil fuels also make important contributions, with natural gas contributing 20% of Indonesia's electricity mix in 2017 (5% in India) and oil 9% (1% in India). Diesel generators are commonly used to generate electricity in Indonesia's outer islands. In 2015, Indonesia announced a 35 GW capacity expansion program, 20 GW of which was to come from coal. Progress in this program has been slower than planned.

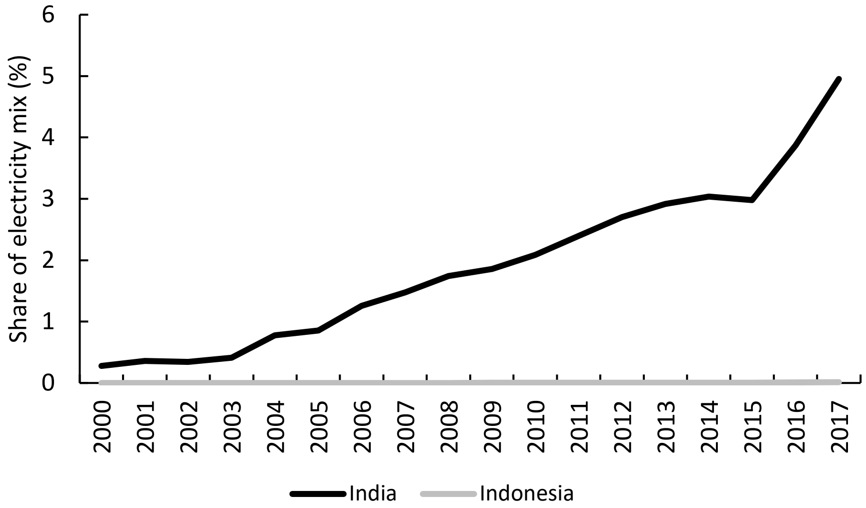
Figure 3: Coal share of electricity generation, 2000–2017



Source: BP (2018).

Among non-fossil sources, hydro accounted for 9% of India's electricity generation in 2017, and 7% of Indonesia's (BP, 2018). Indonesia generates around 4% of its electricity from geothermal resources, with its geothermal generation ranking third in the world, behind the United States and the Philippines (IEA, 2018a). Solar and wind remain small contributors, although there is a rapid rate of increase in India (Figure 4). The solar plus wind share of India's electricity mix reached 5% in 2017. More than two-thirds of this was wind. As can be seen in Figure 4, solar and wind electricity generation remains nascent in Indonesia.

Figure 4: Solar plus wind share of electricity mix, 2000–2017

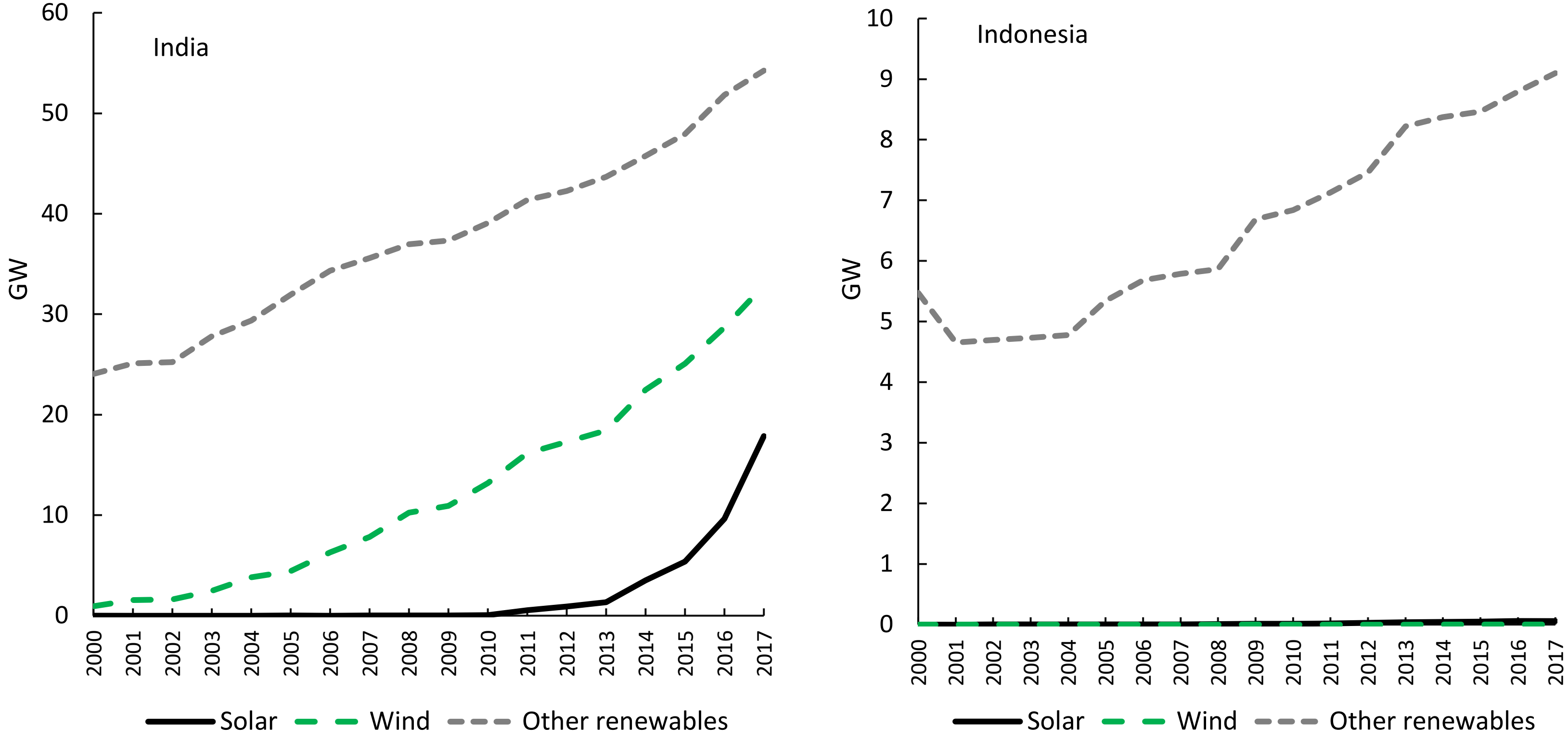


Source: BP (2018). Indonesia's line is equal to, and then more recently close to, zero.

Figure 5 shows India and Indonesia's solar and wind generation capacities over time. For context, the generation capacity of other renewables is also shown.[4] A rapid expansion in India's solar and wind generation capacities is observable, with wind capacity reaching 33 GW in 2017 and solar 18 GW. New solar and new wind installations each exceeded new coal installations for the first time in 2017 (Prabhu, 2018). In contrast, solar plus wind generation capacity remained below 0.1 GW in Indonesia. Indonesia's largest solar installation is the 5 MW solar installation in Kupang, East Nusa Tenggara (IRENA, 2017b). Inaugurated in 2015, this project has been plagued by grid and maintenance issues (Kennedy, 2018). In March 2018, Indonesia opened its first utility-scale wind farm, the 75 MW Sidrap Wind Farm (Phase 1) in South Sulawesi.

[4] Note that capacity factors are not considered. IRENA (2017b, 2017c) assumes capacity factors of 16% and 25% for utility-scale solar PV and onshore wind in Indonesia in 2030. For India, these are 19% and 26%.

Figure 5: Electricity generation capacity: solar, wind, and other renewables, 2000–2017



Note: *y*-axis scaling differs for each country. "Other renewables" is mostly hydro. It also includes bioenergy (both countries) and geothermal (Indonesia only).
Source: IRENA (2018a).

2.3 Operational aspects

Energy is a concurrent power under India's constitution, meaning that states and the central government have dual jurisdiction. State utilities are responsible for the distribution and sale of electricity. New electricity generation is typically procured using multi-year power purchasing agreements (PPAs). Day-ahead and real-time electricity delivery markets exist, but remain underdeveloped (Central Electricity Regulatory Commission [CERC], 2018).

Indonesia's electricity sector is dominated by the national state-owned utility PT *Perusahaan Listrik Negara* (Persero) (PLN). This is true at the retail and transmission/distribution levels, and also the generation level, as more than two-thirds of Indonesia's electricity generation capacity is owned by PLN and its subsidiaries (PwC Indonesia, 2017a). Independent power producers (IPPs) also participate in electricity generation, with procurement of new supply typically occurring via PPAs for periods of up to 30 years. Indonesia does not have an independent electricity system operator.

3. Initiatives for solar and wind uptake

3.1 India

India has developed a strong institutional platform for renewables, including through the establishment of a Ministry of Non-Conventional Energy Sources in 1992, the world's first such ministry (IRENA, 2017c). This became the Ministry of New and Renewable Energy (MNRE) in 2006. The Indian Renewable Energy Development Agency (IREDA) was established in 1987, with the aim of extending financial assistance to renewables and energy conservation projects. Its loans have returned dividends to the central government (Thapar et al., 2016). A National Institute of Solar Energy (NISE) and National Institute of Wind Energy (NIWE) carry out research, development, testing, and data provision.

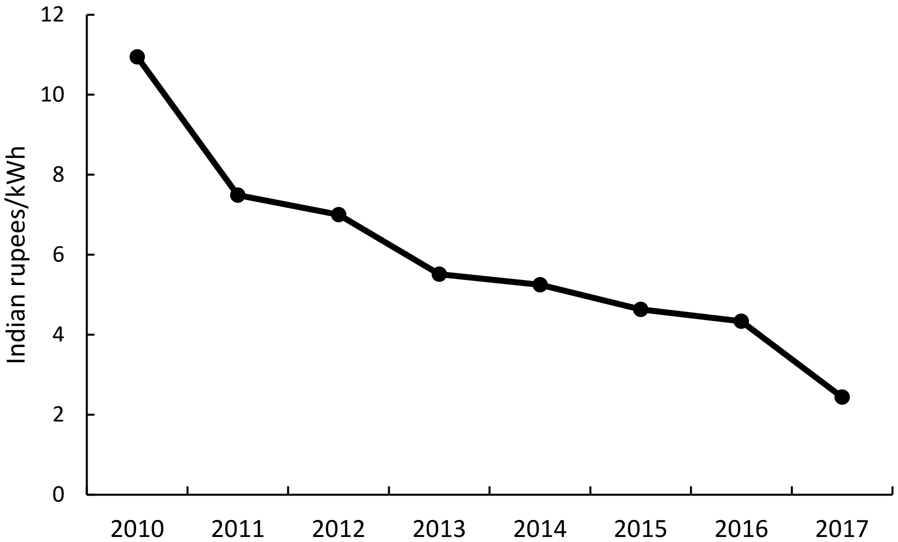
In 2010, India launched the Jawaharlal Nehru National Solar Mission (JNNSM; here called "Solar Mission") with the aim of deploying 20 GW of solar by 2022. Under the Solar Mission, India established the Solar Energy Corporation of India (SECI) in 2011. SECI was tasked with a range of initiatives for promoting solar, including procurement.

In the early phase of the Solar Mission, an innovative approach was used to encourage solar power and improve its affordability for off-takers: solar power received a relatively high feed-in tariff, but was bundled with unallocated "reserve" power from India's Ministry of Power. This made solar available to utilities at a competitive price (World Bank, 2013; Thapar et al., 2016; Moallemi et al., 2017). Following strong interest from project developers, India then moved to a reverse auction system of solar procurement. Reverse auctions involve project developers lodging bids for long-term PPA contracts, with the lowest bids being selected. States also commenced running their own reverse auctions.

India's reverse auctions for solar have seen strong competition and remarkable reductions in prices (Figure 6). In 2017, the minimum reverse auction price for utility-scale solar photovoltaics (PV) fell to as low as 2.44 rupees (US$ 0.037) per kilowatt-hour (kWh) for a project in Rajasthan. India has established one of the world's most competitive solar markets and has some of the world's largest solar plants currently in operation and under construction (Buckley and Shah, 2018).

Rapid reductions in reverse auction prices for solar partly reflect technological improvements and economies of scale in global solar cell production, predominantly in China. They also reflect a de-risking of the investment environment in India, which has helped to reduce financing costs.[5] The low prices are notable given that PPA tariff rates are in nominal local-currency terms, with no adjustments for inflation or exchange rate movements (Bloomberg NEF, 2017). Low prices (2–5 rupees per kWh) have also been achieved in reverse auctions for rooftop solar PV on government buildings, although these have been assisted by direct subsidies (Bloomberg NEF, 2017).

Figure 6: India's reverse auction price history:
Minimum price for utility-scale solar PV installations, by year



Source: Bloomberg NEF (2017). The minimum price in 2017 was 2.44 Indian rupees per kWh. This is equivalent to US$ 0.037 per kWh, using the exchange rate from the World Bank (2018b).

A key means of reducing risk exposure for individual solar projects in India was the government-led establishment of solar parks. Reverse auctions have been held in which winning bidders have been able to lease land in a park, and sell electricity according to long-term PPA contracts under what has been called the "plug and play" model (Chawla et al.,

[5] By no means have India's auctions been totally de-risked. Observed risks include utilities delaying payments (Shrimali and Reicher, 2017; Chawla et al., 2018), utilities attempting to renegotiate prices during the project development and operation phases (Kenning, 2017a), and land access and transmission delays facing solar parks (Asian Power, 2018).

2018; Dobrotkova et al., 2018). Environmental impact assessments and other project pre-requisites have also been handled by the government, which has reduced cost duplication. The overall model has helped to reduce, although not eliminate, uncertainties over land access and transmission connections. Private solar parks have also been developed. As of mid-2018, India had more than 30 solar parks in operation or under development (Sinha, 2018).

Procurement of wind power in India has a much longer history, with the first wind farm opening in the 1980s. State Electricity Regulatory Commissions (SERCs) historically set fixed feed-in tariffs for wind projects, with wind investors benefitting from accelerated depreciation allowances (Chaudhary et al., 2015; Thapar et al., 2016). Following the success of the reverse auctions for solar, in 2017 the Ministry of Power released guidelines for competitive bidding for wind. SECI and the states of Gujarat and Tamil Nadu then held several wind auctions, with prices falling to as low as 2.43 rupees per kWh (Chandrasekaran, 2018). Reverse auctions have consequently now become the principal mechanism for procuring new wind projects in India.

The trend towards reverse auctions for renewables projects has also been global, with auctions in countries such as Chile and the United Arab Emirates delivering low long-term procurement prices (IRENA, 2017d; Frankfurt School-UNEP Centre/BNEF, 2018; REN21, 2018). The lowest prices for utility-scale solar PV have been in locations with low land costs, good solar insolation, and de-risked investment environments (IRENA, 2017a; Dobrotkova et al., 2018).[6] The use of reverse auctions differs from the early phase of solar adoption in developed countries such as Germany and Australia, where the focus was on incentivising small-scale solar through premium feed-in tariffs. A feature of India's use of reverse auctions has been ongoing experimentation and learning over time.[7]

Another feature of India's renewables policy has been the use of renewable purchase obligations (RPOs). The 2003 Electricity Act mandated that State Electricity Regulatory Commissions (SERCs) specify the share of renewables in the electricity bundles of obligated entities, including distribution companies, open-access consumers, and captive power producers. India's 2008 National Action Plan on Climate Change (NAPCC) prescribed that a minimum of 5% of electricity should come from non-hydro renewable sources in financial year 2009–2010 (Comptroller and Auditor General of India, 2015). This was to increase by a percentage point a year, to reach 15% in 2020. In 2010, the MNRE initiated a renewable

[6] Globally, some solar/wind PPA auction prices have fallen to US$ 0.03 per kWh and below (IRENA, 2017d).

[7] Small test auctions were run by SECI prior to moving to larger-scale auctions. The rules and designs of auctions have evolved to address loopholes and achieve evolving objectives (Altenburg and Engelmeier, 2013).

energy certificate (REC) mechanism to allow inter-state purchases of renewable electricity under RPO compliance requirements (Das and Roy, 2018).

The performances of India's RPO and REC mechanisms have been underwhelming. Most SERCs have set targets below the levels prescribed under the NAPCC, and a lack of penalties has led to widespread non-compliance (Shrimali and Rohra, 2012; Chaudhary et al., 2015; Hairat and Ghosh, 2017; Rathore et al., 2018; Sarangi, 2018; Tongia and Gross, 2018). Nevertheless, the RPO and REC mechanisms did help to place renewables on the agendas of states and territories.

India is targeting 40 GW of grid-connected solar rooftop by 2022 (Central Electricity Authority, 2018). Despite rapid growth in rooftop installations, the country is not on track to meet this target (Bloomberg NEF, 2017; Trivedi et al., 2018; Rathore et al., 2019). Challenges include delays in disbursements of rooftop solar subsidies (Prateek, 2018).

A number of other mechanisms have been used to support solar and wind investments in India. Individual states have run their own feed-in tariff schemes and other initiatives (World Bank, 2013; Chaudhary et al., 2015; Kar et al., 2016; Dawn et al., 2016; Das et al., 2017). The central government has provided a generation-based incentive for wind projects – in effect a direct subsidy (Chaudhary et al., 2015; Shrimali et al., 2017). Solar projects have been able to access viability gap funding and a payment security mechanism to reduce off-take risk (World Bank, 2013).

3.2 Indonesia

The solar and wind sector in Indonesia has been the subject of much less concerted policy focus. Indonesia is yet to adopt an RPO scheme or have a successful round of large-scale auctions. Renewables are also supported by a much weaker institutional architecture. There is a Directorate General of New, Renewable Energy and Energy Conservation under the Ministry of Energy and Mineral Resources (MEMR), but it has to date not been strongly positioned to drive rapid uptake of renewables (Bridle et al., 2018). Until recently, Indonesia offered premium feed-in tariffs for renewables, but resistance from the cash-strapped PLN to projects involving premium prices led to little uptake. Indonesia's renewables efforts have principally focused on geothermal energy, but progress has been slower than planned due to challenges in land access, government approval processes, and negotiations with PLN, among other reasons (Burke and Resosudarmo, 2012; IEA, 2015).

In 2013, considerable industry excitement was generated when the MEMR announced reverse auctions for 140 MW of solar PV across 80 locations. However in 2014 the Constitutional Court ruled that the practice of allowing foreign-partnered investors to tender for projects using solely imported components was unconstitutional. The MEMR closed the tender (Cahyafitri, 2015; Devine et al., 2015).

Even before the Court's decision, several issues impeded the effectiveness of the 2013 solar auctions. First, they were limited to projects of 5 MW or below, too small to achieve the scale economies required for competitive costs. Second, international developers could only participate via a joint venture with an Indonesian partner (Law 25/2007 concerning Capital Investment). This remains the case throughout Indonesia's electricity sector. Given thin domestic solar expertise, competition was limited (Dobrotkova et al., 2018). There was a lack of information on development sites, limited grid capacity in tendered regions (contributing to off-take risk), and a window of only two weeks for developers to prepare their bid documentation. Some of the auctioned locations attracted only a few bids (Kruse, 2014).

In 2017 PLN invited developers to pre-qualify for a 168 MW solar PV auction in Sumatra (under MEMR Regulation 12/2017). The pre-qualification process attracted substantial interest. However, the announcement of the outcome was substantially delayed, with participants left wondering what had happened. This type of practice undermines investor confidence in the sector in Indonesia.

The MEMR and PLN frequently run tenders for the provision of off-grid electricity in eastern Indonesia and other locations. Village-level hybrid solar-diesel installations are among projects that have recently received funding. Given Indonesia's geography and lack of national interconnectivity, some regions are highly suited to localised use of distributed electricity generation options such as small-scale solar PV.

4. Key barriers

This section reviews barriers to the large-scale adoption of solar and wind in India and Indonesia.

4.1 Market position of coal and other fossil fuels

A key barrier to uptake of solar and wind in India and Indonesia is the entrenched market positions of coal and other fossil fuels. There are powerful political-economy forces seeking to maintain and grow the markets for fossil fuels, including state-owned enterprises. PLN and its subsidiaries, for example, own the majority of Indonesia's fossil fuel-based electricity generation capacity (Bridle et al., 2018). In India, up to half a million people work in the coal industry, and the railways and banks have business models that are closely intertwined with coal (The Economist, 2018; Tongia and Gross, 2018). The fossil fuel industry is an important source of government revenue and political support in both countries (Vishwanathan et al., 2018). As Byrne and Rich (1983) noted, one reason energy transitions tend to be protracted affairs is that incumbent players do not yield quickly to new entrants.

In the context of fossil fuel lock-in (Erickson et al., 2015), the existence of long-term PPAs for coal-fired power stations creates a challenge for the quick rise of renewables. A fairly large number of PPAs for coal-fired power stations have already been signed in both countries. These typically compensate generators via both fixed (i.e. capacity) and variable (linked to electricity generation quantities) payments over a period of around 25–30 years (Chung, 2017). The fixed payments should be considered sunk, and hence not influence dispatch decisions. Coal-fired generators have a strong interest, however, in ensuring off-take of their electricity to receive the variable payments. They may also believe that off-take will consolidate their ability to continue to collect the fixed payments.

4.2 Resistance from utilities

Electricity utilities in India and Indonesia can be hesitant to support solar and wind, for several reasons:

- Solar and wind generation competes directly with existing generation assets.
- Generation for self-use is a direct source of competition for on-grid electricity sales, eating into revenue collections.
- Intermittent power supplies introduce grid management challenges.
- Renewables projects are often located away from existing transmission lines, requiring considerable investment in transmission infrastructure. Utilities often do not have appropriate incentives to invest in this infrastructure. Indeed, utility-scale solar and wind projects have received exemptions from paying inter-state transmission charges in India (Deloitte, 2018).
- Electricity utilities often have large debts and operate at a financial loss (Ghosh and Ganesan, 2015; Atal et al., 2018; Tongia and Gross, 2018), constraining their ability to pursue renewables investments that in some (but not all) instances involve cost premiums, especially once transmission and grid management costs are considered. This issue also contributes to off-take risks.

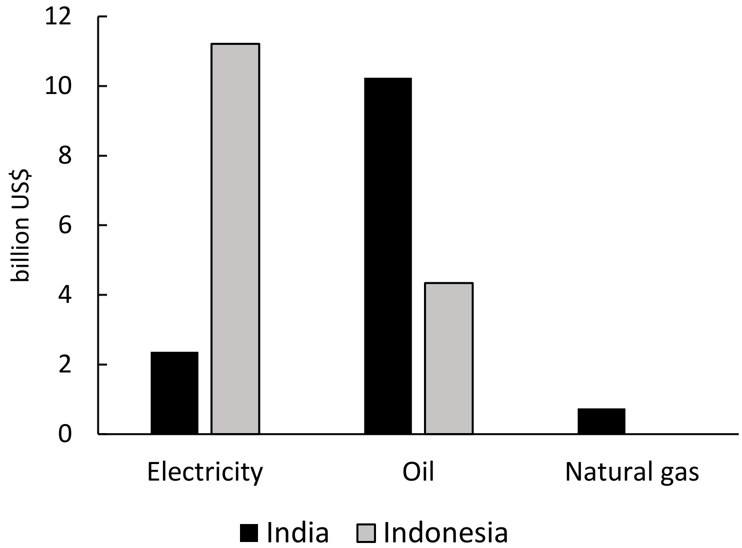
In both countries, resistance from utilities has contributed to difficulties in obtaining net meters for rooftop solar, including delays of up to several months (Trivedi et al., 2018; Rathore et al., 2019). Utility-scale solar and wind projects have also been delayed or had their power curtailed due to transmission issues (World Bank, 2013; Viswamohanan and Aggarwal, 2018).

4.3 Prices: an uneven playing field

4.3.1 Electricity and fossil fuel subsidies

A key obstacle in India and Indonesia is that in some settings solar and wind must compete against (a) subsidised fossil fuels, and (b) subsidised on-grid electricity.[8] Figure 7 shows estimates of fossil fuel consumption subsidies, including for fuels used in the generation of electricity. These subsidies – totalling US$13 billion in India and US$16 billion in Indonesia in 2016 – are the result of consumers being able to purchase energy products such as electricity, gasoline, diesel, and natural gas at below-cost prices. Access to below-cost on-grid electricity reduces the attractiveness of direct investments in rooftop solar. In Indonesia, access to below-cost gasoline and diesel reduces the attractiveness of electric vehicles (a complementary technology to solar and wind electricity generation).

Figure 7: Fossil fuel consumption subsidies, 2016



Note: These are subsidies in the form of below-cost provision of fossil fuels consumed directly by end-users or as inputs to electricity generation. None were recorded for coal. Producer subsidies, for example capital injections into state-owned enterprises, are not included. Source: IEA (2017c).

Indonesia's domestic market obligation for coal is an example of an intervention that facilitates below-cost access to fossil fuels. The obligation requires 25% of domestic coal production to be reserved for domestic electricity generators, at a price capped at US$70 per tonne or below (depending on the coal type). This artificial suppression of the domestic coal price undermines the competitiveness of solar and wind. Separately, the fossil fuel industries of both countries are beneficiaries of production assistance in the form of tax breaks and subsidies. Attwood et al. (2017) estimated this assistance at US$0.6 billion in Indonesia in 2015, mostly as a result of preferential royalty and tax rates for coal mines. Tax incentives,

[8] In other settings, taxes apply. For instance, in India gasoline and diesel are subject to excise duty and value-added tax.

including accelerated depreciation allowances, also exist for renewables projects (Telang, 2015; Thapar et al., 2016; PwC Indonesia, 2017a; Sarangi, 2018).

There has been some success in reducing fossil fuel and electricity subsidies in both India and Indonesia. For instance, Indonesia's government reduced electricity subsidies during 2013–2017 in a reform that appeared to contribute to improvements in the efficiency of electricity use (Burke and Kurniawati, 2018). However in 2018 it was announced that key electricity and fuel prices in Indonesia would be frozen until after the 2019 presidential election (Singgih, 2018).

4.3.2 Overseas support for coal-fired power stations

Another price-based distortion in Indonesia has been the availability of subsidised finance for new coal-fired generators from the export credit agencies and bilateral development banks of China, Japan, and South Korea. This support has typically been tied to the technologies and expertise of the donors (Market Forces, 2017).

4.3.3 Under-priced externalities

Fossil fuels are a source of negative externalities in the form of greenhouse gases and local pollutants, causing major health and other economic costs (Khilnani and Tiwari, 2018). Indian cities are among the world's most polluted, with Balakrishnan et al. (2019) estimating that outdoor particulate matter pollution from fossil fuels and other sources led to around 670,000 deaths in India in 2017. Attwood et al. (2017) estimated that the externality costs of local and global pollutants from coal-fired electricity generation in Indonesia are around US $0.06 per kWh.[9]

Ideally, external costs would be incorporated into prices to ensure that the economic system properly considers all costs (Burke, 2014; Parry et al., 2017). Externality pricing is, however, very limited in both India and Indonesia.[10] Instead, subsidies for fossil fuel use in effect serve as a *negative* price. Best and Burke (2018) found that countries that do not have a price on carbon are less successful in the adoption of solar and wind power.

An exception in terms of externality pricing has been India's clean energy cess: a levy on production and imports of coal, lignite, and peat that was introduced in 2010. The cess aimed to penalise coal and promote the use of clean energy. Revenue went into a National Clean Energy Fund (NCEF) to finance clean energy initiatives, although in practice most of the funds have not been used in this way (Comptroller and Auditor General of India, 2016). The cess was initially 50 rupees (US $0.76) per tonne of coal. It was increased to 400 rupees

---

[9] Residential use of primary biomass also leads to sizeable negative externalities.
[10] Indonesia considered (Ministry of Finance, 2009), but is yet to adopt, a carbon tax.

(around US $6) by 2016. The cess was then merged into India's new goods and services tax (GST) in 2017. Remaining funds in the NCEF were diverted to a GST compensation fund.

4.3.4 A price cap on renewables in Indonesia

In 2017, Indonesia capped feed-in tariffs for new solar and wind projects (among others) at 85% of the regional average cost of electricity generation (*biaya pokok penyediaan pembangkitan*), termed "BPP" (MEMR Regulation 50/2017). This applies in regions where the regional BPP is higher than the national BPP. In regions where regional BPP is less than or equal to the national average, developers are able to negotiate with PLN. The regulation was motivated by the observation of low solar and wind prices in procurement processes overseas (Kennedy, 2018). Official BPP calculations are an underestimate of the true costs of electricity generation, as they exclude capital subsidies and below-cost access to fossil fuels such as coal. The effect of MEMR Regulation 50/2017 is thus that, in many settings, new renewables projects must *outcompete* established incumbents.

4.3.5 Lack of dynamic pricing

Another issue affecting the competitiveness of solar and wind in both India and Indonesia is a lack of dynamic pricing. Real-time electricity markets are thin, making it challenging to manage grids with increasing shares of intermittent renewables as there are often inadequate real-time signals to incentivise rampable generation. Retail prices are also typically set in a rigid way that does not reflect temporal variation in the scarcity of electricity. This leads to, for example, consumers facing a dampened incentive to install rooftop solar, which is able to generate electricity at times that coincide with relatively high electricity demand (e.g. hot afternoons).

4.4 Disadvantageous regulatory settings

New electricity-sector investors – including solar and wind investors – face numerous regulatory hurdles in Indonesia. One recently-introduced barrier is the requirement for all new utility-scale, grid-connected projects to operate on a build-own-operate-transfer (BOOT) basis. The "transfer" obligation means that projects must be handed over to PLN at the expiry of their PPA (MEMR Regulation 50/2017), and was introduced following a 2016 Constitutional Court decision that clarified requirements for public control in the electricity sector.[11] It is understood that even project land must be transferred, although this could perhaps be on a leased basis. While BOOT requirements also apply to fossil fuel-based plants, they form a greater disincentive – and add to uncertainty and contracting costs – for relatively space-intensive projects such as solar and wind, especially when they are closely

[11] Putusan Mahkamah Konstitusi Nomor 111/PUU-XIII/2015 [Constitutional Court Decision no. 111/PUU-XII/2015; final decision 14 December 2016] (Indonesia).

embedded with existing assets such as industrial parks or plantations (PwC Indonesia, 2018). A broad-based BOOT requirement thus risks impeding the dynamism of the sector.[12]

Other regulatory barriers also exist. PLN is typically required to receive a share, in some cases a majority share, of equity in electricity-sector investments (Bridle et al., 2018). There are restrictions on transfers of ownership during the project development phase (MEMR Regulation 49/2017; PwC Indonesia, 2017a). The obligation for PLN to operate renewable plants up to 10 MW in size (the "must run" obligation; MEMR Regulation 50/2017, art 4(3)) does not apply to larger plants. A requirement for PLN to "take or pay" under PPAs (Regulation 10/2017, art 16) explicitly excludes intermittent renewables.

Electricity generators in Indonesia that wish to sell their electricity to the grid require an electricity business supply license (IUPTL; Electricity Law 2009, articles 10 and 19). This is only available for operations that have a PPA with PLN (Government Regulation 14/2012 article 13(4)). As a result, it is infeasible for small and medium installations (the size range of many possible renewables projects) to generate revenue from selling to the grid.

A new solar rooftop regulation – MEMR Regulation 49/2018 – has established a clearer framework for on-grid PLN customers to use solar PV to offset their electricity bill (as "prosumers"). Under the regulation, the size of PV systems can be up to 100% of the total inverter capacity of the prosumer's connection to PLN (article 5). However, the per-kWh value of exported electricity is limited to 65% of PLN's applicable tariff (article 6), so net metering is not on a 1:1 basis. Some prosumers continue to have to pay "parallel operation" charges, including a connection charge and a normal energy use charge.[13] Industrial prosumers are subject to capacity and emergency energy charges for their solar energy systems, which reduce the attractiveness of installing.

Other issues in Indonesia include the frequency of regulatory changes and the opaqueness of procurement processes (Bridle et al., 2018; PwC Indonesia, 2017b, 2018). There have been several major changes to solar PV procurement regulations since 2013, and developers often need to restructure their projects to comply with new rules. Negotiations with PLN often proceed on a project-by-project basis, involving uncertainties and delays. Multiple overlapping regulations exist, often with ambiguous definitions and seemingly conflicting provisions (IEA, 2015).[14] PPA contract conditions are not made fully transparent. In India,

---

[12] BOOT requirements can be more appropriate in some project-specific settings, for example projects in a solar park. India's solar parks typically use the BOOT approach.

[13] Normal energy use occurs while the parallel plant is operating under normal conditions as set out in the operational plan, and thus is a generation charge. The rate is based on prevailing tariff regulations (MEMR Regulation 1/2017, Article 6).

[14] In a positive reform, the MEMR has recently revoked a series of regulations in an effort to minimise regulatory overlap (MEMR Regulations 7 and 9 of 2018).

implementation of policy and procedures for net metering of small-scale solar PV has been slow (Das et al., 2017; Trivedi et al., 2018).

India and Indonesia perform relatively well in the "Getting Electricity" category of the World Bank's (2018c) *Ease of Doing Business* rankings, with India ranking 29th out of 190 countries in 2018 and Indonesia 38th. This is based on the time for a standard warehouse to obtain an electricity connection, connection costs, paperwork requirements, electricity quality, and the transparency of electricity tariffs. Both perform poorly on other indicators, including enforcement of contracts (164th and 145th), registering property (154th and 106th), and dealing with construction permits (181st and 108th). Governance issues can create major challenges for solar and wind developers. India easily outperforms Indonesia in the World Bank's (2018d) *Regulatory Indicators for Sustainable Energy*, ranking 37th among 111 countries. Indonesia places 67th, performing poorly in terms of counterparty risk, network connections and pricing, financial and regulatory incentives, and carbon pricing.

4.5 Grid management challenges

Managing intermittent energy supplies introduces technical challenges that often exceed current grid management capacities. Solar and wind generation has often been curtailed as a result. Caps on the share of intermittent renewables on the local grid, and on rooftop solar PV connection sizes, are also enforced. Neither country has developed comprehensive real-time markets, including in ancillary services such as frequency control. In Indonesia, construction of the country's first pumped-hydro facility – the 1,040 MW Upper Cisokan project – has been delayed by land and other issues (Haryanto, 2018; World Bank, 2018e). Major improvements in grid management are required for a large-scale transition to intermittent power resources.

4.6 Protectionism

The solar markets of both countries are dominated by imports, predominantly from China.[15] Domestic solar module production capacities are relatively limited (Dwivedi and Rosencranz, 2018) and domestic panels tend to be more expensive and of lower quality than some of the panels available on the international market (Clover, 2017). Protectionism is pushing up project costs, adversely affecting installation companies, utilities, and consumers.[16] This section provides a review of protectionist interventions, with a focus on solar.

[15] Imported panels account for more than 90% of solar installations in India (Press Trust of India, 2018).
[16] For a discussion of the costs of solar protectionism, see Shum (2017).

4.6.1 India

100% foreign equity in solar and wind installations is possible in India (Moallemi et al., 2017). However, under Phase I of the Solar Mission, the MNRE required projects to use minimum quantities of domestic components. In Phase II, tenders were split into "open" and "domestic content requirement" (DCR) categories (Kumar, 2014). To qualify under the DCR category, solar cells and modules need to originate in India.

In 2014, the US requested the establishment of a World Trade Organization (WTO) dispute resolution panel to hear its complaints concerning India's domestic content requirements. The panel considered whether the requirements breached the *Agreement on Trade-Related Investment Measures* (1994) (TRIMs). It found that they fell within article 1(a) of the TRIMS Illustrative List, which lays out trade-related investment measures that are inconsistent with a country's obligations under the *General Agreement on Tariffs and Trade* 1947 (GATT). An important question was whether the DCR measure was "mandatory" and "enforceable". Several considerations influenced affirmative findings. First, failure to comply with domestic content requirements within 180 days of signing a PPA attracted the forfeiture of any monetary deposit. Second, PPAs issued under the first two phases of the Solar Mission contained "conditions subsequent", which included the fulfilment of domestic content requirements. Non-fulfillment could trigger sanctions and penalties.

The panel also found that India had breached GATT article III – the "national treatment" obligation – which prohibits discrimination between imported products and "like" domestic products. Further, it found the measure was not government procurement, and therefore did not fall within a GATT exemption from the national treatment obligation. It also found that the measure was not covered by other GATT exemptions or justifications. India appealed to the Appellate Body, which upheld the panel's findings (WTO, 2016).

The US argued that India had not complied with the WTO ruling, and in 2017 requested authorisation from the Dispute Settlement Body to suspend concessions and other WTO obligations it would otherwise owe India (WTO, 2017). The matter was referred to arbitration. India's experience demonstrates that countries risk protracted and expensive legal battles, and possible retaliation, if they pursue renewables-sector policies inconsistent with obligations under the WTO.

Adding to cost pressures, in January 2018 India completed a WTO safeguards investigation that found that solar modules from countries including China and Malaysia caused, or threatened to cause, serious injury to domestic manufacturers. The investigation recommended a 70% *ad valorem* duty for 200 days. In the end, a lower duty of 25%, falling to 15% over two years, was imposed on solar imports from China, Malaysia, and developed countries (WTO, 2018). The duty dampened investor interest (Stacey, 2018) and undermined the viability of recently-auctioned projects (Gokhale and Thakurta, 2018). For projects under MNRE schemes, a recent decision also requires criminal proceedings against officials and state-run enterprises that misstate the domestic content of their components (MNRE, 2018).

4.6.2 Indonesia

Indonesia levies a 5% tariff on imported solar panels. The Electricity Law of 2009 also requires electricity generators that supply the public (IUPTL holders) to prioritise local content. This includes those exporting electricity from rooftop PV generators to PLN's grid. Current requirements are for 40.68% of goods and service inputs to grid-connected solar PV projects to be local content (Ministry of Industry Regulation 5/2017 amending Ministry of Industry Regulation 54/2012 article 13A). The requirement is slightly higher for off-grid installations (articles 12 and 13). For government-procured projects, a 40% local content requirement and a "company benefit value" standard apply (Presidential Regulation 16/2018), with the latter based on companies' investment in and contribution to the nation. Tenders have also offered premium prices for projects using local content (Dobrotkova et al., 2018). Indonesia's local content requirements have yet to be tested for WTO consistency.

Indonesia has a variety of other protectionist restrictions.[17] Foreign investors are limited to owning 49% of high-voltage electricity projects between 1–10 MW, and are excluded from small scale (< 1 MW) projects (Presidential Regulation of the Republic of Indonesia no. 44/2016, appendix III.D no. 143, 142).[18] Regulations require that solar installations are developed by local engineering, procurement and construction (EPC) companies (Ministry of Industry Regulation 54/2012).

4.7 Underwhelming political support in Indonesia

International experience shows that top-level political support is a prerequisite for large-scale investment in capital-intensive energy-sector facilities (Sovacool, 2012; Cherp et al., 2017). India's Prime Minister-level prioritisation of renewables has been fundamental to the comparative success of the sector. In Indonesia, dedicated champions of solar and wind have been lacking. While the country has an ambitious renewables target, in practice solar and wind have tended to be given low priority, and there is a broad assumption that the target will not be met (Bridle et al., 2018). Indeed, an examination of PLN's list of planned capacity

[17] Patunru (2018) provides an overview of economic nationalism and protectionist tendencies in Indonesia.
[18] For projects over 10 MW, 95% foreign participation is allowed, or 100% for public–private partnerships during the concession period (appendix III.D no. 145).

additions (RUPTL) reveals much more modest plans for solar and wind than are set out in the National Energy Plan (RUEN).[19]

4.8 Land access

Land access challenges are a key impediment to solar and wind projects and the development of transmission and distribution infrastructure in both India and Indonesia, with complications arising from overlapping permits, fragmented ownership, and unregistered land (World Bank, 2013; Dutu, 2016; IRENA, 2017b). Long lead times for land procurement often reflect a lack of agreement between community members, land owners, and the government over issues such as rightful ownership and the land's fair price. Some delays represent genuine concerns, while others reflect bureaucratic delays or opportunistic, rent-seeking behaviour (Fitzpatrick, 2008). In some instances, land issues have led to the cancellation of projects. An example is a proposed 50 MW wind farm in Yogyakarta, Indonesia (Wicaksono, 2017).

5. Strategies to facilitate solar and wind use

We now discuss potential strategies for boosting solar and wind uptake in India and Indonesia. We focus primarily on Indonesia, drawing lessons from India's relative success.

5.1 High-level political commitment and ambitious targets

India's mission-based approach for solar – which accords with the argument for mission-based sectoral development advanced by Mazzucato (2015) – has underpinned its solar boom. Given the highly political nature of energy and the substantial government involvement in the coal and electricity sectors, there is a case for a similar government-facilitated approach in Indonesia. This would require strong leadership from the President and the Minister for Energy and Mineral Resources, and support from other key actors. On issues such as electrification, slowing deforestation, and integrated pest management, Indonesia has shown that quite rapid progress can occur when there is sufficient institutional and political backing (Burke and Resosudarmo, 2012; Resosudarmo, 2012).

5.2 An attractive investment environment

Ideally, the electricity grid would become more like an open-access carrier, with regulatory requirements and disincentives to supply-side investment in solar and wind generation capacity being minimised. Enhancing the overall attractiveness of the investment environment for solar and wind is a multi-faceted challenge, and involves reducing regulatory uncertainty and removing or relaxing the most unattractive barriers to investment, including

[19] The RUPTL (2018–2027) includes only around 1 GW and 589 MW of new solar and wind capacity over the period 2018–2025 (p. III-10).

some of those discussed in section 4. A simple reform in the case of Indonesia would be to introduce more transparency over the terms of PPA contracts.

5.3 From fossil fuel subsidies to emissions pricing

Reductions in consumer and producer subsidies for fossil fuels and consumption subsidies for on-grid electricity, together with the adoption of explicit prices on carbon and other negative externalities, would help zero-emissions technologies compete on a more level playing field in both countries. One option is the use of coal levies, together with complementary measures to support low-income consumers and affected workforces. Parry et al. (2017) concluded that increasing India's coal cess could make a major contribution to reducing deaths from pollution, and generate net benefits for the economy.

While such reforms can be politically challenging, experience shows that well-communicated reforms, linked to tangible benefits, can secure popular acceptance (Rentschler and Bazilian, 2017). One strategy is to ensure that reforms are visibly coupled with reductions in existing taxes, or priority expenditure initiatives. Both India and Indonesia have mechanisms that can be used to target benefits to low-income households (Burke, 2014; Parry et al., 2017). There is growing potential for the use of environmental taxes in Indonesia following the introduction of Government Regulation 46/2017 on environmental economic instruments and Presidential Regulation 77/2018 requiring the establishment of a public service agency for environmental fund management.

5.4 Openness to international trade and investment

Countries benefit from the ability to employ the lowest-cost and highest-quality technologies available on the world market, and the lowest-cost sources of finance. To achieve this, it is vital that protectionist barriers are minimised. There are alternative ways to encourage local employment in solar and wind industries, including by having a healthy installation sector and targeted investments in research and development (OECD, 2015). The importance of openness to trade also extends to cross-border trade in electricity. Ideally, solar, wind, and energy storage facilities would be located at the best possible sites, which may be across international borders.[20] Trade and investment liberalisation may be undertaken via unilateral policy changes or international agreements.[21]

[20] There is a proposal to develop an Asian Renewable Energy Hub (AREH) that would supply solar- and wind-powered electricity and hydrogen from Australia to Indonesia and beyond. See https://asianrehub.com/.

[21] See Aisbett et al. (2018) for a recent discussion of public international economic law supporting international electricity trade and investment in the region.

5.5 Large-scale reverse auctions and solar parks in Indonesia?

In Indonesia, a major new round of reverse auctions would have the potential to provide a sizeable impetus to the adoption of solar and wind. While legal issues surrounding foreign participation form constraints that will tend to place upward pressure on prices, the country could seek to establish a facilitating environment that is as encouraging as possible to investors, within legal constraints.

One way to seek to facilitate low auction prices would be to pursue India's solar park concept. Government facilitation of land procurement is justifiable given that land titling and other issues create real challenges for the private sector, pushing up project costs. The solar park model could also help to alleviate challenges associated with a shortage of data on grid capacity, solar resources, and flooding frequency at installation sites, as data could be provided. Such data are important for securing low-cost finance. Government procurement of land could also help to counteract the disincentive effects of Indonesia's BOOT requirement. Instead of having to obtain, and subsequently hand over, land for solar installations, project developers could focus on their comparative advantage relative to the government – namely sourcing and installing the systems.

A challenge is site selection for solar parks. Java, where electricity demand is highest, is densely populated and has high land prices. Interconnections with other islands would potentially allow solar parks to be sited elsewhere and still access the Java market, although would be expensive and take years to build.[22] Degraded agricultural land (Fargione et al., 2008) or former mining land may provide suitable solar park siting locations.[23] To ensure compatibility with sustainable development goals, it is important that existing land users are fairly compensated – regardless of whether they possess formal land title. Otherwise, the renewables industry could risk political opposition over "land grabs".[24]

5.6 An Indonesian Clean Energy Agency?

Indonesia has the potential to adopt aspects of the institutional architecture for renewables utilised by India, perhaps through the establishment of an Indonesian Clean Energy Agency. Responsibilities of this agency (or multiple new agencies) could include:

- Managing renewables procurement, including reverse auctions.
- Establishing and administering solar parks.

[22] A Java-Sumatra undersea transmission cable has been proposed, but has faced delays (Prakoso, 2017).
[23] There is also substantial rooftop space. Another potential is floating solar (Kenning, 2017b).
[24] This issue has received much attention in the case of large-scale land acquisitions for agriculture. This is particularly so in Africa, where governments have been accused of supporting foreign investors at the expense of marginalised local populations. See, for example, Zoomers (2010).

- Administering an RPO.
- Planning.
- Capacity building.
- Securing and utilising international concessional finance.
- Investing in research and development.
- Data provision.

Several sources of international finance could possibly be harnessed by such an agency, including the Green Climate Fund.[25] It is important to note, however, that a new agency may be ineffective in achieving key responsibilities in the absence of broader improvements in sectoral governance (Jarvis, 2012). Any new agency would need strong backing from the President and a design suited to overcoming procedural bottlenecks. The strengthening of institutions for renewables development is often recommended as a pre-requisite for strong renewables uptake (e.g. Dulal et al., 2013).

5.7 Renewable purchase obligations in Indonesia?

A potential reform to increase the likelihood of Indonesia meeting its renewables target would be the introduction of an RPO scheme. Under an RPO, renewables projects would generate "green certificates". PLN could be required to acquire a certain number of these certificates each year so as to meet the national renewables target. While the implementation of India's RPO scheme has been imperfect, implementation should be somewhat easier in Indonesia given the more centralised governance that exists for the sector. One strategy would be for RPO compliance to be listed among the key performance indicators of PLN's Board of Directors. This would ensure that incentives to meet targets exist at the individual as well as the institutional level.

5.8 Incentivising utilities

Altered financial models could be used to align the incentives of utilities with the rapid adoption of modern renewables. For example, governments could reward utilities for the successful procurement, transmission, distribution, and utilisation of solar and wind.[26] In Indonesia, funds for such payments could possibly be redirected from existing budget lines

[25] Some overseas concessional finance is already being accessed. For example, the Sidrap Wind Farm (Phase 1) was assisted by a long-term loan from the US Overseas Private Investment Corporation (OPIC). A new central agency might be able to deliver better overall results in terms of accessing concessional finance.

[26] An example of this type of approach is India's Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI) scheme, which financially rewards utilities (and others) for achieving rooftop solar targets.

for fossil fuel and electricity subsidies.[27] Another possibility is for utilities to be encouraged to enter the rooftop solar installation market themselves (Bloomberg NEF, 2017). By improving the financial positions of electricity utilities, a move to cost-reflective retail electricity prices would also help to reduce off-take risks for solar and wind investors (Shrimali and Reicher, 2017). Off-grid solutions that side-step utilities also have potential in some rural and remote settings (see USAID and Clean Energy Access Network, 2018).

5.9 Grid management

Sizeable investments in grid management will be required to achieve a large-scale transition to intermittent generation sources (IEA, 2015).[28] Priorities include larger roles for system planning, forecasting, real-time markets, and energy storage, as well as improved "visibility" of intermittent renewables so as to facilitate real-time grid management (NITI Aayog, 2015; Palchak et al., 2017; Pierpont and Nelson, 2017; CERC, 2018; Buckley et al., 2019). Improved interconnectivity via high-voltage, direct current (HVDC) cables would greatly boost Indonesia's ability to move to high reliance on solar and wind. Ideally, transmission/distribution infrastructure would be planned to suit distributed energy resources, and be ready in advance of capacity installations (Deloitte, 2018).

There are substantial opportunities for international sharing of lessons and experiences in managing solar and wind on the grid. The International Solar Alliance (ISA), headquartered in India, could play a role in this type of knowledge exchange.

5.10 Enhanced research capacity

A large-scale transition to renewables will require significant investment in technical capacity and innovation (IRENA, 2018b). India has stronger energy-sector research capacity than Indonesia, especially in The Energy and Resources Institute (TERI) and policy-focused think tanks. There is considerable scope for additional investment in research capacity in Indonesia, with a focus on intermittent renewables and grid management.[29]

5.11 Private-led solutions

Private enterprises are increasingly seeking to procure solar and wind electricity, both to reduce electricity bills and meet social responsibility objectives. Procurement can occur via direct investment, business-to-business (B2B) contracts, or purchases of renewable

[27] To meet legal requirements, such support would need to be framed as being support to PLN rather than IPPs.
[28] Note that coal-based electricity expansion would also require substantial investments in infrastructure, including ports, rail lines, and transmission lines.
[29] Indonesia launched a Centre of Excellence (CoE) for Clean Energy in Bali in 2016, but this has yet to get off the ground.

certificates (Telang, 2015). Internationally, more than 100 companies – including India's Infosys and Tata Motors – have pledged to go 100% renewable in their energy use (http://there100.org). In the context of growing demand, it is important that regulatory settings provide attractive platforms for the supply-side of the renewables market to function.

Innovative financing and business models are likely to be important for rooftop solar and other segments of the renewables market (Kuldeep et al., 2018). The third-party model – where an enterprise retains ownership of rooftop solar installations and shares the benefits with rooftop owners via financial payments or lowered electricity prices – is worth pursuing. This model has been employed in India, although for only a minority of solar rooftop installations (Rathore et al., 2019).

5.12 Additional issues

Additional issues of high importance for the large-scale adoption of solar and wind energy in India and Indonesia include:

- Ensuring *project quality*, especially for solar. It is important that contracts and markets reward only genuine provision of electricity generation and/or generation capacity. If so, investors will have an incentive to ensure project quality and maintenance.
- The *operation and maintenance* of projects in remote areas, some of which have fallen into disrepair due to problems in disbursing funds and other reasons. IRENA (2017b) recommended that Indonesia establish an entity responsible for operations and maintenance that engages local communities in the task.
- *Human capital*. There is scope for governments to boost training in key skills in project maintenance and grid management (Gabriel, 2016). Sovacool (2012) concluded that capacity building is vital for the success of renewables projects.
- Policies for a *phase-out of coal* and other fossil fuels. There is scope for work on strategies to facilitate a just transition for workers and communities who might be adversely affected by the rise of alternative energy technologies.

6. Conclusion and policy implications

India and Indonesia have ambitious targets for the adoption of solar and wind, and India has made impressive progress, with a boom in new installations facilitated by large-scale reverse auctions. Indonesia has also taken early steps, such as the opening of its first wind farm. Substantial potential exists for uptake of solar and wind energy, although there are sizeable barriers to overcome before they can take on a major role in the electricity mix. A key challenge is the need to establish an investment environment suited to unlocking the vast opportunities in the sector.

This paper has identified barriers to solar and wind uptake in India and Indonesia. Some involve direct disincentives for investors; for example, Indonesia's BOOT requirement that projects must be handed over to the utility at the end of the PPA term, even when they are closely embedded with existing assets. Others are structural issues, such as the weak financial positions of transmission and distribution utilities and their underdeveloped capacities to manage intermittent power sources. India's approach of using large-scale reverse auctions and solar parks serves as an attractive model for Indonesia.

We have proposed a number of other possible reforms for Indonesia, including an RPO scheme and the establishment of an Indonesian Clean Energy Agency. We also recommend avoiding the temptation to pursue infant industry protection for nascent solar and wind component manufacturing industries. Total employment in the renewables industry is likely to be best served by having a vibrant and growing installation industry that is able to access quality inputs at the lowest costs (OECD, 2015). Trade openness will also help to ensure least-cost energy for millions of households and commercial consumers alike.

Our focus on solar and wind was motivated by the growing prominence of these technologies and their falling project costs. Other renewable electricity generation options, such as geothermal in Indonesia, also have potential. Ideally, policy settings would ensure that electricity generation technologies are able to compete on a level playing field, and one that incorporates externality costs.

Large expansions in electricity generation capacity will be required to keep up with electricity demand in India and Indonesia. If a share of this investment is in coal-fired power stations, it would risk creating stranded assets due to escalating competition from renewables (Gray et al., 2018; Liebman and Foster, 2019). Indeed, a number of planned coal-fired power stations have already been cancelled in both India and Indonesia, and some existing coal-fired power stations are operating at reduced capacity factors (Woods, 2017; Buckley, 2018; Vishwanathan et al., 2018). Governments in both countries have the chance to play major roles in steering their energy systems to a lower-emission future.

References

Aisbett, E., Prest, J. Soutter, G. and Widnyana, J. 2018. Public international law and private involvement in cross-border renewable electricity trade and investment in the Asia Pacific. Mimeo. Australian National University.

Altenburg, T. and Engelmeier, T. 2013. Boosting solar investment with limited subsidies: Rent management and policy learning in India. *Energy Policy* 59, 866–874.

Asian Development Bank. 2016. *Indonesia Energy Sector Assessment, Strategy, and Road Map*. Manila.

Asian Power. 2018. Is India hurting from self-inflicted solar burn? *Asian Power*. 30 March. https://asian-power.com/power-utility/in-focus/india-hurting-self-inflicted-solar-burn#.

Atal, V., Shrimali, G. and Singh, V.P. 2018. Addressing off-taker risk in renewable projects in India: A framework for designing a payment security mechanism as a credit enhancement device. Technical Paper. Climate Policy Initiative.

Attwood, C., Bridle, R., Gass, P., Halimanjaya, A.S., Laan, T., Lontoh, L., Sanchez, L. and Christensen, L.T. 2017. *Financial Supports for Coal and Renewables in Indonesia*. International Institute for Sustainable Development.

Balakrishnan, K. et al. 2019. The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017. *Lancet Planetary Health* 3(1), e26–e39.

Best, R. and Burke, P.J. 2018. Adoption of solar and wind energy: The roles of carbon pricing and aggregate policy support. *Energy Policy* 118, 404–417.

Blakers, A., Stocks, M., Lu, B., Anderson, K. and Nadolny, A. 2018. *International Pumped Hydro Sites*. http://re100.eng.anu.edu.au/research/re/for/.

Bloomberg NEF. 2017. *Accelerating India's Clean Energy Transition: The Future of Rooftop PV and Other Distributed Energy Markets in India*.

Bloomberg NEF. 2018. *New Energy Outlook 2018*. https://about.bnef.com/new-energy-outlook.

BP. 2018. *BP Statistical Review of World Energy*. http://www.bp.com/statisticalreview.

Bridle, R., Gass, P., Halimajaya, A., Lontoh, L., McCulloch, N., Petrofsky, E. and Sanchez, L. 2018. *Missing the 23 Per Cent Target: Roadblocks to the Development of Renewable Energy in Indonesia*. International Institute for Sustainable Development.

Buckley, T. 2018. India is bringing the coal era to an end. *Asia Times*. 26 June. http://www.atimes.com/india-is-bringing-the-coal-era-to-an-end/.

Buckley, T. and Shah, K. 2018. *Solar is Driving a Global Shift in Electricity Markets: Rapid Cost Deflation and Broad Gains in Scale*. Institute for Energy Economics and Financial Analysis. May.

Buckley, T., Gupta, A., Garg, V. and Shah, K. 2019. *Flexing India's Energy System: Making the Case for the Right Price Signals Through Time-Of-Day Pricing*. Institute for Energy Economics and Financial Analysis. January.

Burke, P.J. 2014. Green pricing in the Asia Pacific: An idea whose time has come? *Asia & the Pacific Policy Studies* 1(3), 561–575.

Burke, P.J. and Kurniawati, S. 2018. Electricity subsidy reform in Indonesia: Demand-side effects on electricity use. *Energy Policy* 116, 410–421.

Burke, P.J. and Resosudarmo, B.P. 2012. Survey of recent developments. *Bulletin of Indonesian Economic Studies* 48(3), 299–324.

Byrne, J. and Rich, D. 1983. Energy markets and energy myths: The political economy of energy transitions. In Byrne, J., Callahan, M. and Rich, D. (eds) *Technology and Energy Choice*. University of Delaware. 124–160.

Cahyafitri, R. 2015. Solar power projects up in the air. *Jakarta Post*. 10 February. http://www.thejakartapost.com/news/2015/02/10/solar-power-projects-air.html.

Central Electricity Authority. 2018. *National Electricity Plan*. Volume 1: Generation. January. Ministry of Power, Government of India.

Central Electricity Regulatory Commission. 2018. Discussion paper on re-designing real time electricity markets in India. No RA-14026(11)/2/2018-CERC. July. New Delhi.

Chandrasekaran, K. 2018. Wind energy capacity addition reduces under auction regime. *Economic Times*. https://economictimes.indiatimes.com/industry/energy/power/wind-energy-capacity-addition-reduces-under-auction-regime/articleshow/63621845.cms.

Chaudhary, A., Krishna, C. and Sagar, A. 2015. Policy making for renewable energy in India: Lessons from wind and solar power sectors. *Climate Policy* 15(1), 58–87.

Chawla, K., Waldron, M., Dutt, A., Aggarwal, M., Toril, A. and Nobuoka, Y. 2018. *Clean Energy Investment Trends: Evolving Landscape for Grid-Connected Renewable Energy Projects in India. CEEW - IEA Report*. June.

Cherp, A., Vinichenko, V., Jewell, J., Suzuki, M. and Antal, M. 2017. Comparing electricity transitions: A historical analysis of nuclear, wind and solar power in Germany and Japan. *Energy Policy* 101, 612–628.

Chung, Y. 2017. *Overpaid and Underutilized: How Capacity Payments to Coal-Fired Power Plants could lock Indonesia into a High-Cost Electricity Future*. Institute for Energy Economics and Financial Analysis.

Clover, I. 2017. The weekend read: Will duties ADD doubt to India's solar growth? *pv magazine*. 24 November. https://www.pv-magazine.com/2017/11/24/the-weekend-read-will-duties-add-doubt-to-indias-solar-growth/.

Comptroller and Auditor General of India. 2015. *Report of the Comptroller and Auditor General of India on Renewable Energy Sector in India*. Report No. 34 of 2015.

Comptroller and Auditor General of India. 2016. *Report of the Comptroller and Auditor General of India for the year 2015-2016*. No. 34 of 2016.

Das, N., Gambhir, A., Sarode, J. and Dixit, S. 2017. *175 GW Renewables by 2022*. Version 2.0. Prayas (Energy Group).

Das, N. and Roy, J. 2018. Making Indian power sector low carbon: Opportunities and policy challenges. In Gautam A., De S., Dhar A., Gupta J. and Pandey A. (eds) *Sustainable Energy and Transportation*. Springer. 163–183.

Dawn, S., Tiwari, P.K., Goswami, A.K. and Mishra, M.K. 2016. Recent developments of solar energy in India: Perspectives, strategies and future goals. *Renewable and Sustainable Energy Reviews* 62, 215–235.

Deloitte. 2018. *Variable Renewable Energy Sources Integration*. February.

Devine, L., Sastrawijaya, K., Kurniawan, F. and Sungkono, A. 2015, Indonesian Supreme Court revokes solar power regulation. *Global Compliance News*. 3 September. https://globalcompliancenews.com/indonesian-supreme-court-revokes-solar-power-regulation.

Dobrotkova, Z., Surana, K. and Audinet, P. 2018, The price of solar energy: Comparing competitive auctions for utility-scale solar PV in developing countries. *Energy Policy* 118, 133–148.

Dulal, H.B., Shah, K.U., Sapkota, C., Uma, G. and Kandel, B.R. 2013. Renewable energy diffusion in Asia: Can it happen without government support? *Energy Policy* 59, 301–311.

Dutu, R. 2016. Challenges and policies in Indonesia's energy sector. *Energy Policy* 98, 513–519.

Dwivedi, V. and Rosencranz, A. 2018. Why solar energy use has declined in India. *The Statesman*. 12 September. https://www.thestatesman.com/opinion/solar-energy-use-declined-india-1502683631.html.

Erickson, P., Kartha, S., Lazarus, M. and Tempest, K. 2015. Assessing carbon lock-in. *Environmental Research Letters* 10, 084023.

Fargione, J., Hill, J., Tilman, D., Polasky, S. and Hawthorne, P. 2008. Land clearing and the biofuel carbon debt. *Science* 319(5867), 1235–1238.

Fitzpatrick, D. 2008. Beyond dualism: Land acquisition and law in Indonesia. In Lindsey, T. (ed), *Indonesia: Law and Society*. Federation Press. 2nd ed. 224–246.

Frankfurt School-UNEP Centre/BNEF. 2018. *Global Trends in Renewable Energy Investment 2018*. Frankfurt.

Gabriel, C.A. 2016. What is challenging renewable energy entrepreneurs in developing countries? *Renewable and Sustainable Energy Reviews* 64, 362–371.

Gaur, V. and Gupta, E. 2016. The determinants of electricity theft: An empirical analysis of Indian states. *Energy Policy* 93, 127–136.

Ghosh, A. and Ganesan, K. 2015. Rethink India's energy strategy. *Nature* 521, 156–157.

Gokhale, N. and Thakurta, P.G. 2018. Safeguard duty throws India's solar sector into confusion and chaos. *Newsclick*. 6 August. https://www.newsclick.in/safeguard-duty-throws-indias-solar-sector-confusion-and-chaos.

Gray, M., Kok, I., Ljungwaldh, S. and Watson, L. 2018. Economic and financial risks of coal power in Indonesia. Briefing. Carbon Tracker Initiative. October.

Hairat, M.K. and Ghosh, S. 2017. 100 GW solar power in India by 2022 – A critical review. *Renewable and Sustainable Energy Reviews* 73, 1041–1050.

Haryanto, A. 2018. Target operasional PLTA Upper Cisokan Molor, ini penyebabnya. *SINDONEWS.com*. 20 October. https://jabar.sindonews.com/read/2142/1/target-operasional-plta-upper-cisokan-molor-ini-penyebabnya-1540015827.

International Energy Agency. 2015. *Indonesia 2015: Energy Policies Beyond IEA Countries*. Paris.

International Energy Agency. 2017a. *Renewables 2017: Analysis and Forecasts to 2022*. Paris.

International Energy Agency. 2017b. *Energy Access Outlook: World Energy Outlook 2017 Special Report*. Paris.

International Energy Agency. 2017c. *World Energy Outlook 2017*. Paris.

International Energy Agency. 2018a. *World Energy Statistics and Balances*. Paris.

International Energy Agency. 2018b. *Energy Access Database*. https://www.iea.org/energyaccess/database/.

IRENA. 2017a. *Renewable Power Generation Costs in 2017*. Abu Dhabi

IRENA. 2017b. *Renewable Energy Prospects: Indonesia, a REmap analysis*. Abu Dhabi.

IRENA. 2017c. *Renewable Energy Prospects: India, a working paper based on REmap*. Abu Dhabi.

IRENA. 2017d. *Renewable Energy Auctions: Analyzing 2016*. Abu Dhabi.

IRENA. 2018a. *Renewable Energy Statistics 2018*. Abu Dhabi.

IRENA. 2018b. *Innovation Priorities to Transform the Energy System*. Abu Dhabi

Jairaj, B., Martin, S., Ryor, J., Dixit, S., Gambhir, A., Chunekar, A., Bharvirkar, R., Jannuzzi, G., Sukenaliev, S. and Wang, T. 2016. *The Future Electricity Grid: Key Questions and Considerations for Developing Countries*. World Resources Institute.

Jarvis, D.S.L. 2012. The regulatory state in developing countries: Can it exist and do we want it? The case of the Indonesian power sector. *Journal of Contemporary Asia* 42(3), 464–492.

Kar, S.K., Sharma, A. and Roy, B. 2016. Solar energy market developments in India. *Renewable and Sustainable Energy Reviews* 62, 121–133.

Kennedy, S.F. 2018. Indonesia's energy transition and its contradictions: Emerging geographies of energy and finance. *Energy Research & Social Science* 41, 230–237.

Kenning, T. 2017a. India's solar PPA troubles: negotiating with Discom 'cowboys'. *PV-Tech*. 31 October. https://www.pv-tech.org/editors-blog/indias-solar-ppa-troubles-negotiating-with-discom-cowboys.

Kenning, T. 2017b. Masdar and Indonesian power giant to build world's largest floating solar plant, *PV-Tech*. 28 November. https://www.pv-tech.org/news/masdar-and-indonesian-power-giant-to-build-worlds-largest-floating-solar-pl.

Khilnani, G.C. and Tiwari, P. 2018. Air pollution in India and related adverse respiratory health effects: Past, present, and future directions. *Current Opinion in Pulmonary Medicine* 24(2), 108–116.

KPMG. 2017. *Solar Beats Coal Costs: Implications*. https://assets.kpmg.com/content/dam/kpmg/in/pdf/2017/09/Solar-beats-coal-cost.pdf.

Kruse, H. 2014. FIT solar auction in Indonesia: Experiences of a local company during bid preparation. Presentation, PEP-Information Workshop. https://www.giz.de/fachexpertise/downloads/2014-en-kruse-pep-infoveranstaltung-netzgeb-pv-indonesien-thailand.pdf.

Kuldeep, N., Saji, S. and Chalwa, K. 2018. *Scaling Rooftop Solar Powering India's Renewable Energy Transition with Households and DISCOMs*. Council on Energy, Environment and Water (CEEW). June.

Kumar, P. 2014. India: Domestic content requirement under JNNSM policy for phase II, batch I. Mondaq. http://www.mondaq.com/india/x/321104/Renewables/Domestic+Content+Requirement+Under+JNNSM+Policy+For+Phase+II+Batch+I.

Liebman, A. and Foster, W. 2019. A Roadmap for Indonesia's Power Sector: How Renewable Energy Can Power Java-Bali and Sumatra. Institute for Essential Services Reform (IESR), Jakarta.

Lijphart, A. 1971. Comparative politics and the comparative method. *American Political Science Review* 65(3), 682–693.

Market Forces. 2017. *Foreign Finance to Indonesian Coal*. https://www.marketforces.org.au/research/indonesia/public-finance-to-indonesian-coal/.

Mazzucato, M. 2015. *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*. Anthem Press.

Ministry of Energy and Mineral Resources. 2018. *Renewable Energy and Energy Conservation – Policies and Regulatory Framework*. Presentation. 18 July. Jakarta.

Ministry of Finance, 2009. *Ministry of Finance Green Paper: Economic and Fiscal Policy Strategies for Climate Change Mitigation in Indonesia*. Ministry of Finance and Australia Indonesia Partnership. Jakarta.

Ministry of New and Renewable Energy. 2018. Penalties for violation of norms of domestic content requirement (DCR) under solar PV power projects under MNRE's schemes/programmes. Office Memorandum No. 283/5/2018-GRID SOLAR. 20 February. New Delhi. https://mnre.gov.in/sites/default/files/webform/notices/OM-Penalties-for-violation-DCR-Under-SolarPV-Power-Projects.pdf.

Moallemi, E.A., Aye, L., Webb, J.M., de Haan, F.J. and George, B.A. 2017. India's on-grid solar power development: Historical transitions, present status and future driving forces. *Renewable and Sustainable Energy Reviews* 69, 239–247.

NITI Aayog. 2015. *Report on India's Renewable Electricity Roadmap 2030: Toward Accelerated Renewable Electricity Deployment*. Government of India.

OECD. 2015. *Overcoming Barriers to International Investment in Clean Energy*. Paris.

Palchak, D., Cochran, J., Ehlen, A., McBennett, B., Milligan, M., Chernyakhovskiy, I., Deshmukh, R., Abhyankar, N., Soonee, S.K., Narasimhan, S.R., Joshi, M. and Sreedharan, P. 2017. *Greening the Grid: Pathways to Integrate 175 Gigawatts of Renewable Energy into India's Electric Grid*. Vol. I—National Study. USAID and Ministry of Power.

Parry, I., Mylonas, V. and Vernon, N. 2017. Reforming energy policy in India: Assessing the options. IMF Working Paper WP/17/103.

Patunru, A.A. 2018. Rising economic nationalism in Indonesia. *Journal of Southeast Asian Economies* 35(3), 335–354.

Pierpont, B. and Nelson, D. 2017. Markets for low carbon, low cost electricity systems. Working Paper. Climate Policy Initiative.

PLN. 2017. *PLN Statistics 2017*. Jakarta.

Power Grid Corporation of India. 2018. *One Nation-One Grid*. https://www.powergridindia.com/one-nation-one-grid.

Prabhu, W. 2018. Solar was the top source of new power capacity addition in 2017 for the first time in India. Mercom India. https://mercomindia.com/solar-top-renewable-source-india-2017.

Prakoso, R. 2017. Java-Sumatra undersea power transmission project revived for 2021. *Jakarta Globe*. 10 April. https://jakartaglobe.id/business/java-sumatra-undersea-power-transmission-project-revived-2021/.

Prateek, S. 2018. Subsidy disbursement delays are hampering growth of residential rooftop solar in India. Mercom India. https://mercomindia.com/rooftop-subsidy-delays-india/.

Press Trust of India. 2018. India's demand for solar equipment import jumps 90% in last three FY: Govt. *Business Standard*. 19 July. https://www.business-standard.com/article/economy-policy/india-s-demand-for-solar-equipment-import-jumps-90-in-last-three-fy-govt-118071900753_1.html.

PwC Indonesia. 2017a. *Power in Indonesia: Investment and Taxation Guide*. 5th Edition.

PwC Indonesia. 2017b. *Powering the Nation: Indonesian Power Industry Survey 2017*. May.

PwC Indonesia. 2018. *Alternating Currents: Indonesian Power Industry Survey 2018*. 2nd Edition. July.

Rathore, P.K.S., Chauhan, D.S. and Singh, R.P. 2019. Decentralized solar rooftop photovoltaic in India: On the path of sustainable energy security. *Renewable Energy* 131, 297–307.

Rathore, P.K.S., Rathore, S., Singh, R.P. and Agnihotri, S. 2018. Solar power utility sector in India: Challenges and opportunities. *Renewable and Sustainable Energy Reviews* 81(2), 2703–2713.

REN21. 2018. *Renewables 2018 Global Status Report*.

Rentschler, J. and Bazilian, M. 2017. Reforming fossil fuel subsidies: Drivers, barriers and the state of progress. *Climate Policy* 17(7), 891–914.

Resosudarmo, B.P. 2012. Implementing a national environmental policy: Understanding the 'success' of the 1989–1999 integrated pest management programme in Indonesia. *Singapore Journal of Tropical Geography* 33(3), 365–380.

Sarangi, G.K. 2018. Green energy finance in India: Challenges and solutions. ADBI Working Paper Series No. 863.

Shrimali, G., Konda, C. and Farooquee, A.A. 2016. Designing renewable energy auctions for India: Managing risks to maximize deployment and cost-effectiveness. *Renewable Energy* 97, 656–670.

Shrimali, F. and Reicher, D. 2017. Instruments to mitigate financial risk in Indian renewable energy investments. Stanford Precourt Institute for Energy.

Shrimali, G. and Rohra, S. 2012. India's solar mission: A review. *Renewable and Sustainable Energy Reviews* 16(8), 6317–6332.

Shrimali, G., Srinivasan, S., Goel, S. and Nelson, D. 2017. The effectiveness of federal renewable policies in India. *Renewable and Sustainable Energy Reviews* 70, 538–550.

Shum, R.Y. 2017. The coming solar trade war: Obstacles to decarbonization from a political-economy conflict. *Electricity Journal* 30(8), 49–53.

Singgih, V.P. 2018. Fuel, electricity prices to remain unchanged until 2019. *Jakarta Post*. 6 March. http://www.thejakartapost.com/news/2018/03/06/fuel-electricity-prices-to-remain-unchanged-until-2019.html.

Sinha, A. 2018. Catching the sun at Bhadla solar park. *Indian Express*. 26 June. https://indianexpress.com/article/india/bhadla-solar-park-rajasthan-catching-the-sun-india-biggest-solar-energy-park-jodhpur-power-plant-hot-winds-sand-storms-4709314/.

Sovacool, B.K. 2012. Design principles for renewable energy programs in developing countries. *Energy & Environmental Science* 5(11), 9157–9162.

Stacey, K. 2018. Clouds gather over India solar energy sector. *Financial Times*. 11 March. https://www.ft.com/content/80bb18c2-1c5b-11e8-aaca-4574d7dabfb6.

Telang, S. 2015. *India: Understanding Market Conditions for Business to go 100% Renewable*. RE100. The Climate Group and CDP.

Thapar, S., Sharma, S. and Verma, A. 2016. Economic and environmental effectiveness of renewable energy policy instruments: Best practices from India. *Renewable and Sustainable Energy Reviews* 66, 487–498.

The Economist. 2018. The black hole of coal: India shows how hard it is to move beyond fossil fuels. *The Economist*. 2 August. https://www.economist.com/briefing/2018/08/02/india-shows-how-hard-it-is-to-move-beyond-fossil-fuels.

Tongia, R. and Gross, S. 2018. Working to turn ambition into reality: The politics and economics of India's turn to renewable power. Paper 4. Brookings.

Tongia, R., Harish, S. and Walawalkar, R. 2018. Integrating renewable energy into India's grid – harder than it looks. Brookings India IMPACT Series No. 112018-01. November.

Trivedi, S., Ray, I., Vulturius, G., Goldar, A., Prakash, J., Paul, S. and Sagar, A. 2018. Scaling up rooftop solar power in India: The potential of municipal solar bonds. Working Paper No. 353. ICRIER.

USAID and Clean Energy Access Network. 2018. *State of the Decentralized Renewable Energy Sector in India*. New Delhi.

Vishwanathan, S.S., Garg, A. and Tiwari, V. 2018. Coal transition in India: Assessing India's energy transition options. IDDRI and Climate Strategies.

Viswamohanan, A. and Aggarwal, M. 2018. *Rethinking Renewable Energy Power Purchase Agreements: Curtailing Renewable Energy Curtailment*. Council on Energy, Environment and Water (CEEW). June.

Wicaksono, P.E. 2017. Terkendala pembebasan lahan, proyek PLTB samas berhenti. *Liputan6*. 2 September. https://www.liputan6.com/bisnis/read/3080227/terkendala-pembebasan-lahan-proyek-pltb-samas-berhenti.

Woods, L.E.J. 2017. Facing oversupply, Indonesia scales back its coal-based electricity plan. *Mongabay*. 11 May. https://news.mongabay.com/2017/05/facing-oversupply-indonesia-scales-back-its-coal-based-electricity-plan/.

World Bank. 2013. *Paving the Way for a Transformational Future: Lessons from Jawaharlal Nehru National Solar Mission Phase I*. Energy Sector Management Assistance Program. Washington DC.

World Bank. 2018a. *World Bank Country and Lending Groups*. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

World Bank. 2018b. *World Development Indicators*. http://databank.worldbank.org.

World Bank. 2018c. *Doing Business*. http://www.doingbusiness.org/.

World Bank. 2018d. *Regulatory Indicators for Sustainable Development*. http://rise.worldbank.org/.

World Bank. 2018e. *Upper Cisokan Pumped Storage Hydro-Electrical Power (1040 MW) Project*. http://projects.worldbank.org/P112158/upper-cisokan-pumped-storage-hydro-electrical-power-1040-mw-project?lang=en.

World Economic Forum. 2018. *Global Competitiveness Report 2017-2018*. http://reports.weforum.org/global-competitiveness-index-2017-2018.

World Trade Organization. 2016. India – Certain measures relating to solar cells and modules. Report of the Appellate Body. WT/DS456/AB/R. 16 September.

World Trade Organization. 2017. India – Certain measures relating to solar cells and solar modules. Recourse to article 22.2 of the DSU by the United States. WT/DS456/18. 20 December.

World Trade Organization. 2018. Notification under article 12.1(B) of the Agreement on Safeguards on finding a serious injury or threat thereof caused by increased imports. WTO document no. G/SG/N/8/IND/31/Suppl.2. 6 August.

Zhang, S. 2018. Wind and solar power in China. In Lester, L. and Thomas, M. (eds) *China's Electricity Sector*. Palgrave Pivot, Singapore. 83–105.

Zoomers, A. 2010. Globalisation and the foreignisation of space: Seven processes driving the current global land grab. *Journal of Peasant Studies* 37(2), 429–447.