WORLD ECONOMIC FORUM

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Industry Agenda

The Future of Electricity in Fast-Growing Economies

Attracting Investment to Provide Affordable, Accessible and Sustainable Power

January 2016

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In collaboration with Bain & Company

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Preface

Roberto Bocca, Senior Director, Head of Energy Industries, World Economic Forum

The World Economic Forum is pleased to present the second *Future of Electricity* report – a set of recommendations for policy-makers, regulators and businesses to attract investment to the electricity sector in fast-growing economies.

In January 2015, the World Economic Forum, in conjunction with Bain & Company, published *The Future of Electricity*, examining how mature economies would continue to attract the investment needed to meet their energy goals. The 2016 report builds on the previous year's work by examining the electricity sectors in fast-growing economies.

The electricity landscape is undergoing a significant transformation, becoming more complex than ever before with rapidly evolving technologies, declining costs, shifting regulatory landscapes and, in fast-growth economies, rising demand. The Forum has established the Future of Electricity platform to help countries, companies and societies learn and reflect as they undergo this transformation: a space for fact-based, yet informal dialogue on the transition to a new electricity landscape among the key stakeholders involved.

The initiative was launched at the World Economic Forum Annual Meeting 2014 in Davos-Klosters, Switzerland. Subsequent discussions involved stakeholders from industry – incumbent utilities, renewable developers, supply and demand equipment manufacturers – and beyond, including policy-makers, regulators, academics and investors. The spirit of multistakeholder collaboration is underscored throughout this report, seeking to develop a holistic understanding of the evolving electricity landscape with recommendations focused on achieving energy policy objectives which balance the energy trilemma of energy access and security, economic development and environmental sustainability.

As in 2015, the World Economic Forum and Bain & Company have identified successful policies, regulations and business and investment models that can help markets attract the investment capital required to achieve their energy goals. This adds to the Forum's efforts aimed at understanding and shaping industry transformation across all sectors through Global Challenge initiatives.

Letter from the Chairs

Ignacio S. Galán, Chairman and Chief Executive Officer, Iberdrola, Spain

Steve Bolze, President and Chief Executive Officer, GE Power, USA

To continue unlocking economic potential and improving living standards, the world's fast-growing economies must deliver electricity in an accessible, affordable, reliable and sustainable manner. To do so, they will need to unleash a new level of capital and human resources to move the energy system towards more efficient business models with the least environmental impact. While some see this as a challenge, we see it as an opportunity for these countries to optimize their energy options, using lessons learned and technological progress to shift towards a cleaner and more affordable generation and distribution system.

At the World Economic Forum Annual Meeting 2015, global leaders discussed how these countries can attract $13 trillion in necessary investment through 2040. Several recommendations outlined in last year's *The Future of Electricity* report on mature markets are also applicable to this case. These include pursuing supply and demand-side "no regret" investments, ensuring a level playing field that recognizes the full value and cost of different technologies, and leveraging innovative financing.

At the same time, differences emerge. Fast-growing economies have the opportunity to pursue more efficient pathways to desired policy outcomes. They are less restricted by existing infrastructure, and therefore can develop an optimal balance of central and distributed, conventional and renewable resources. They will begin to generate more electricity from renewable technologies, and this will require new storage and back-up solutions, as well as smarter grids and more interconnections. To this end they can ride the technology cost curve, taking advantage of declining costs and more efficient generation. In addition, they can implement financial measures and transparent market mechanisms to drive down the cost of capital. And with emerging digital technology, all of us can chart together new paths for electricity system design and operation.

This report highlights how fast-growing economies can attract the necessary investment to achieve universal access to secure, sustainable and competitive power. It also presents a detailed analysis of the progress that India and Mexico have made in evolving their electricity systems, as well as making recommendations for further progress. We hope it will help guide discussion and decisions among relevant stakeholders as they seek to define their country's energy agendas.

Executive Summary

Electricity markets in fast-growing economies face different challenges than those in more mature markets. Mature markets with stable demand for electricity are transitioning to a more sustainable mix of power generation technologies while continuing to support economic growth with affordable and secure power. Fast-growing markets are trying to serve voracious new demand for electricity as their economies grow, as more customers are connected to the grid and as per capita consumption grows.

This report recognizes the need for policy to balance the objectives in the Forum's energy architecture triangle: security and accessibility, short- and medium-term affordability, and environmental sustainability. The fact that 1.2 billion people lacked access to electricity in 2012, combined with the scale of poverty, will inevitably focus attention on accessibility and affordability. But even as they make progress on achieving reliable universal access, fast-growing markets will need to develop roadmaps that take advantage of new technologies to make their power affordable while increasing environmental sustainability.

Meeting the electricity demands of residential, commercial and industrial consumers in these fast-growing economies will require an unprecedented level of investment in fuel supply, centralized and distributed generation, and networks across the whole value chain. Much of the new capacity in fast-growing countries will come from renewables, which requires large capital investments upfront and correspondingly lower operational costs.

The combined effects of growing demand for electricity and rising capital intensity will mean that non-OECD countries will have to double their investments in electricity from about $240 billion[1] annually to $495 billion annually between 2015 and 2040 – $13 trillion in total – to satisfy growing demand and meet energy policy objectives, outspending OECD countries by 2 to 1.

Where debates in these growing markets used to focus on importing commodities to fuel conventional power stations, today's discussions focus on importing capital to build renewable power alongside conventional power, as captured in the Intended Nationally Determined Contributions (INDCs) submitted for the Conference of the Parties hosted in Paris in December 2015. This is also fully in line with UN's Sustainable Development Goals.

Unfortunately, fast-growing economies have a very mixed record of attracting private capital, with volatile returns in many of the largest markets and significant concerns among long-term investors about the transparency and reliability of policies and regulations, particularly where policy-makers have shorter-term political priorities.

Although 60% to 70% of the investment in electricity infrastructure in non-OECD markets has derived historically from governments or state-owned utilities, the scale of the investment necessary in the future will force policy-makers to look to private investors to fund most of the investment.

1 This report uses the International Energy Agency's New Policies Scenario from the World Energy Outlook 2015, which assumes "continuation of existing policies and measures as well as the implementation (albeit cautiously) of policy proposals, even if they yet to be formally adopted" (IEA WEO 2015).

To attract the necessary capital, fast-growing economies will need to improve the viability of investment in their power sectors. Eight recommendations have been identified for policy-makers, regulators and businesses to do this, just as the 2015 *The Future of Electricity* report focused on improving the investment climate in OECD countries.

Policy-makers

Pursue the most efficient pathway to policy objectives

Policy-makers have an important role to play in encouraging the electricity sector to pursue the most efficient paths to achieve energy goals. They should develop roadmaps that balance generation sources among conventional and renewable, and also across centralized and distributed models. They should catalyse "no regrets" investments in infrastructure that move fast-growing economies closer to universal access. By encouraging the adoption of energy-efficiency technologies, both on the demand side (for example, more efficient equipment and buildings) and on the supply side (by upgrading inefficient power plants), they help reduce the need for investments in new generation capacity. Through all these measures, policy-makers support economic competitiveness while reducing the risk of policy instability due to adverse fiscal or stakeholder pressure.

Develop integrated policies that ensure parallel development of the power value chain

Policies need to be integrated across the power value chain to ensure that development of the upstream fuel supply, generation assets, transmission and distribution develop in harmony and investors are not left with fully operational but stranded assets that cannot earn a return due to lack of fuel supply or lack of customer access. Integrated policies need to consider not only the operational aspects such as planning regulations, but also the economic ones such as import duties and regulated tariffs that impact the viability of various participants in the value chain.

Take advantage of declining technology cost curves

As costs decline, non-OECD countries will add 34% more non-hydro renewables capacity than the OECD countries between 2015 and 2040. Moreover, the increasing digitization of energy assets offers the potential to improve operational efficiency and reliability, thus reducing both the delivered cost of electricity and emissions. Policy-makers should take advantage of declining technology cost curves driven by the rapid rates of global deployment and avoid the urge to promote unique technologies that will likely remain at high cost due to a lack of scale. On the demand side, policy-makers should also take advantage of new technologies to improve energy efficiency.

Regulators

Provide a level playing field for technologies, reflecting carbon abatement and security of supply appropriately

Regulators should structure power markets in ways that recognize the full value and costs of technologies, including carbon pricing. Regulations should be technology agnostic, taking into account issues including flexibility, reliability,

carbon-abatement properties, land use and the cost of securing fuel supply. This may also mean removing fuel subsidies that support specific conventional generation technologies. In special circumstances, regulators might support new technologies that show promise in their particular market but only if there is a credible plan for the technology to become competitive in the medium term, and subsidies phased out.

Ensure technically and financially viable operations across value chain

Regulators can ensure the viability of the value chain by keeping it clear of financial obstacles. They should work with suppliers to reduce losses from non-metered supply and ensure that tariff subsidies or progressive tariff structures are fully funded. They should ensure that the viability of generators is not threatened by fuel tariffs that can distort margins or raise demand for electricity beyond their capability to provide it.

Business and investors

Create effective public-private partnerships to attract private sector capital

Private sector – businesses and investors – should engage with policy-makers and regulators to make the governance and regulations around public-private partnerships clear, transparent and independent in order to ensure that investors can be confident in committing long-term capital.

Nurture favourable investment environment

The private sector together with the public sector should put measures in place to reduce risk and decrease the cost of capital, allocating risks to the most appropriate market participants. The private sector should proactively engage with the public sector to align expectations for power sector profitability. Innovative financing schemes and a balanced approach to local content requirements will also help encourage investment.

Invest in education and R&D to close knowledge and human capital gaps

The private and public sector should work together to foster the development of universities and research institutes that produce the talent which will innovate, develop and manage the power sector in the decades ahead.

Each country will prioritize these recommendations differently based on its energy policy objectives across energy access and security, economic development and environmental sustainability. Prioritization depends on its economic and natural resources, the maturity of energy markets, and its policy objectives. In particular, this report looks closely at two fast-growing economies, India and Mexico, both at critical points in the development of their power markets:

- India's rapidly growing economy has fuelled an intensifying demand for electricity with which supply has struggled to keep pace. Where investment in the past has come from government sources, in the future India's policy-makers want to attract the majority of funding from private investors, which means addressing some of the structural issues such as unprofitable distribution companies, along with fuel issues and regulatory obstacles. Recognizing these challenges, India's government has embarked on a series of progressive reforms, including integrated policies to ensure even development through the value chain, addressing losses that hinder the viability of the transmission and distribution businesses, nurturing a more favourable investment environment by decreasing finance costs, and recognizing the important role of renewables.
- Mexico's economic growth over the last decade has been held back in some cases by the regulatory structure of some key sectors, including telecommunications, financial services and energy. To address these barriers and encourage the country's economic development, Mexico has launched a series of reforms. In electricity, the reforms are guiding a transition from a state-owned electricity system to a new model that opens the door for private investment and multiple players in power generation selling into an efficient wholesale market. To ensure the viability of investment, Mexico is pursuing an integrated approach that supports development across the entire value chain and improves the flow of funds through the power value chain. Mexico will also need to ensure that the new market functions smoothly, enables appropriately attractive returns to investors and attracts the required scale of investment in conventional and renewable power.

Growth in Electricity Shifts to Fast-growing Markets

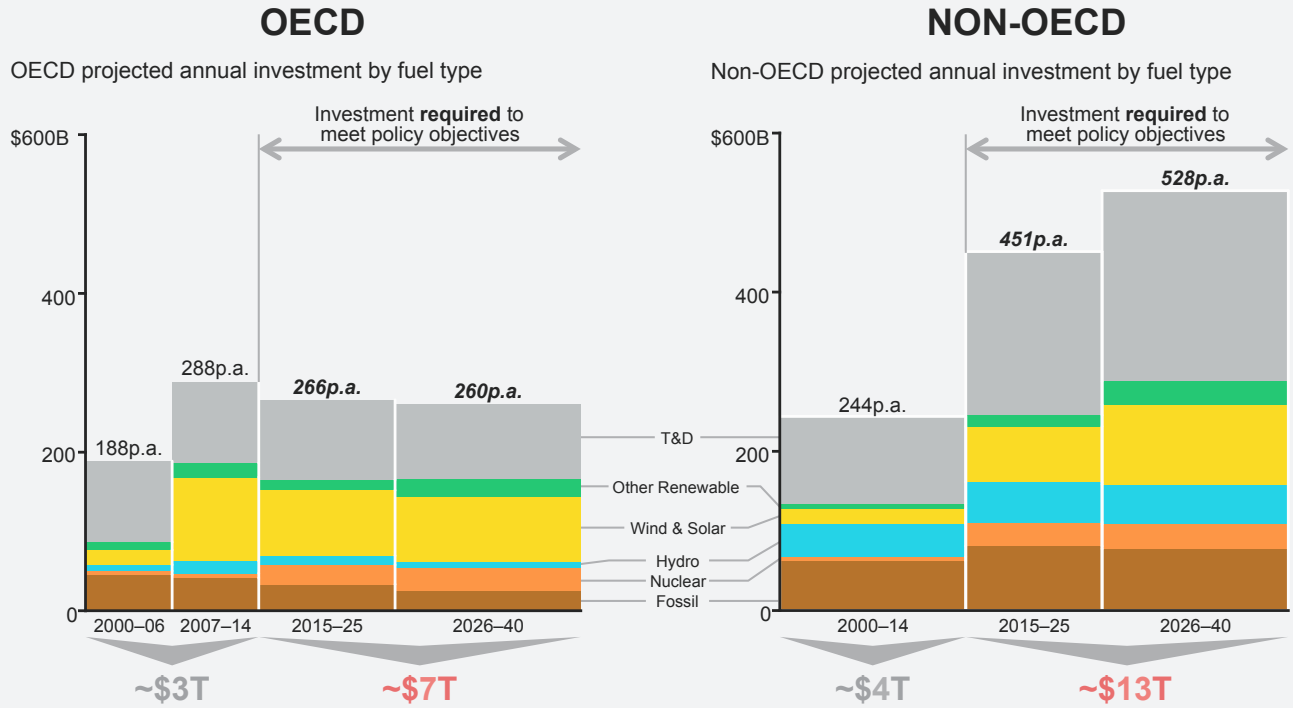
Electricity markets in fast-growing economies face different challenges than those in more mature markets. Mature markets with stable demand for electricity are transitioning to a more sustainable mix of power generation technologies while continuing to support economic growth with affordable and secure power. Fast-growing markets are trying to serve voracious new demand for electricity as their economies grow, as more customers are connected to the grid and as per capita consumption grows.

This report recognizes the need for policy to balance the objectives in the Forum's energy architecture triangle: security and accessibility, short- and medium-term affordability, and environmental sustainability. The fact that 1.2 billion people lacked access to electricity in 2012, combined with the scale of poverty, will inevitably focus attention on accessibility and affordability. But even as they make progress on achieving reliable universal access, fast-growing markets will need to develop roadmaps that take advantage of new technologies to make their power affordable while increasing environmental sustainability.

Meeting the electricity demands of residential, commercial and industrial consumers in these fast-growing economies will require an unprecedented level of investment in fuel supply, generation and networks across the entire value chain. Moreover, much of the new capacity in fast-growing countries will come from renewables which, although increasingly competitive with conventional generation over its lifetime, needs a robust commitment from the regulatory authorities to make possible the intensive capital investments these technologies require.

The combined effects of growing demand for electricity and rising capital intensity will mean that non-OECD countries will have to double their investments in electricity across the value chain from about $240 billion annually to $495 billion annually between 2015 and 2040 – $13 trillion in total – to satisfy growing demand and meet energy policy objectives, outspending OECD countries by 2 to 1 (see Figure 1).

Figure 1. Investment in non-OECD markets will double over next few decades, rising to 1.9 times the investment levels of OECD markets.



Note: 2014 investments assumed to be equal to average annual investments in 2007-2013 for OECD and 2000-2013 for non-OECD
Source: IEA World Energy Outlook 2015

Transmission and Distribution (T&D) investment in non-OECD markets is expected to reach $5.8 trillion – much higher than investment within OECD countries, which will invest $2.5 trillion. Similarly, fossil fuel generation still accounts for a large share of investments in non-OECD countries, about $2.1 trillion, compared to only $750 billion in the OECD from 2015 through 2040. In the same period non-hydro renewables – wind, solar, biomass and others – will total $2.9 trillion in non-OECD countries, about 10% higher than in the OECD.

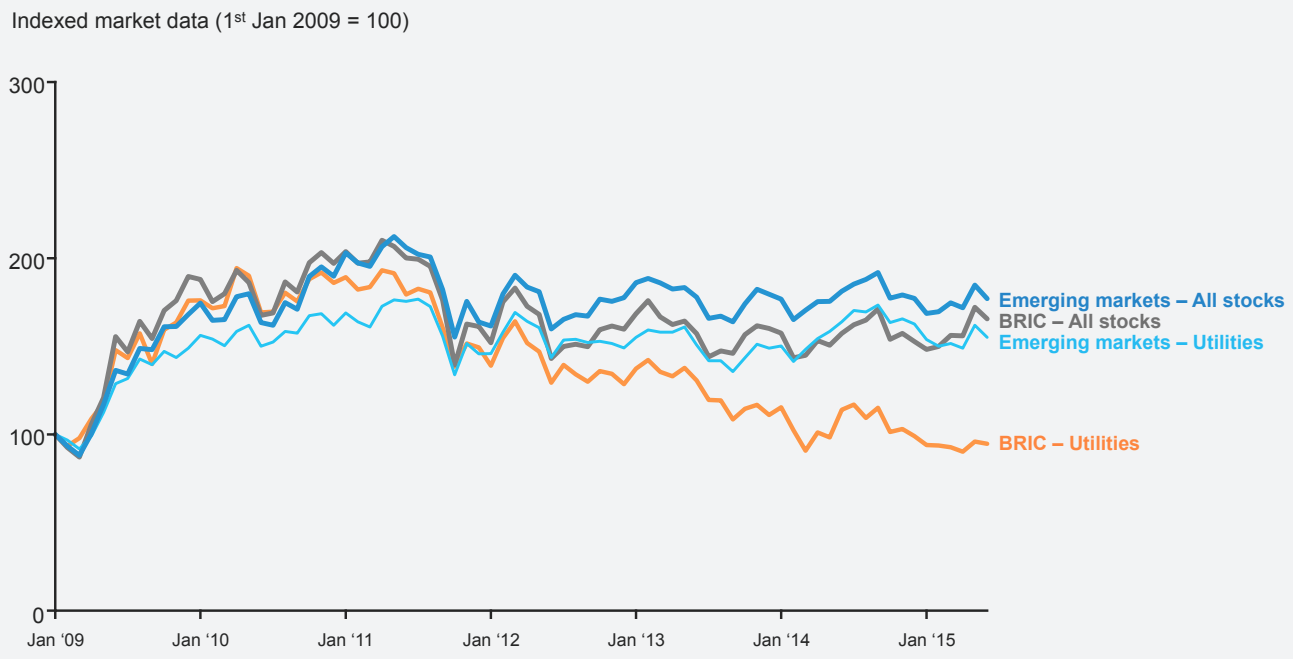
Where debates in these markets used to focus on importing commodities to fuel conventional generating stations, today's discussions focus on importing capital to build renewable power alongside the conventional.

Utilities in the largest fast-growing economies have had difficulty attracting private investors as utility stocks have performed below the average market (see Figure 2). The power sector is capital intensive with long-term investment horizons. Long-term investors are particularly concerned about the transparency and reliability of policies. Their concerns stem from policy-makers' short-term political priorities, the stability of market design and regulation, mitigation of financial risks such as currency and debt market volatility and the participation of state owned enterprises.

Historically, 60% to 70% of the investment in the power sector of non-OECD countries has come from the public sector compared to 45% in the European Union, 25% in Japan and 20% in the US. Private investment is likely to play a more significant role over the next few decades. For example, India's five-year plans through 2017 aim to increase the private sector share of capacity from 13% in 2007, to 27% in 2012 up to 43% in 2017. In the future, the scale of the investment necessary will impose a strong need for policy-makers to look to private investors to fund most of the investment.

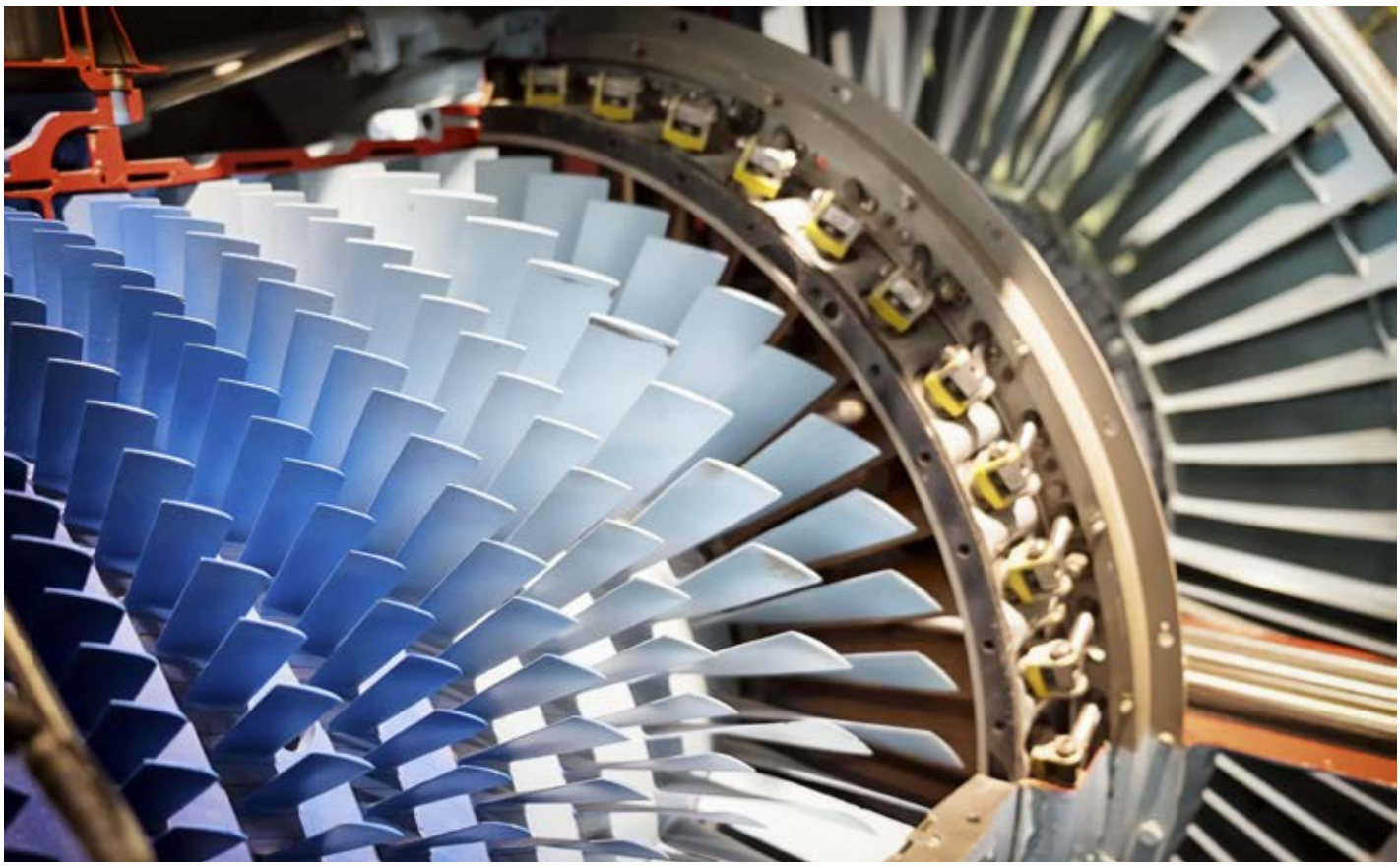
As the power sector seeks to attract ever increasing amounts of investment it will have to compete with markets that are more predictable, transparent and friendly to investors – both in other sectors within fast-growth economies and in the power sector within mature markets.

Figure 2: Power companies in the BRIC countries have struggled to match the performance of broader markets. Utilities in smaller developing countries have performed better.



Note: BRIC – All Stocks: MSCI BRIC index; BRIC – Utilities: BRIC electric utilities index (X4BIUC$); Emerging market – All stocks: MSCI Emerging Market Index; Emerging Markets utilities index - Bloomberg M1EF0UT Index
Source: Datastream; Bloomberg

Best Practices across Fast-growing Markets



To become more competitive in global capital markets and attract the investments needed to achieve their energy goals, fast-growing markets need to improve the investment viability of their electricity markets, learning from success stories around the world. Towards that goal, examples from 20 of the largest fast-growing electricity markets have been identified that have successfully improved the security, affordability and access to electricity, or that have improved the sustainability of power generation. Based on lessons from these markets, eight recommendations have also been identified for policy-makers, regulators and businesses and investors to improve the attractiveness of the power sector in developing markets, just as the 2015 *The Future of Electricity* report focused on improving the investment climate in OECD countries.

Policy-makers

Pursue the most efficient pathway to policy objectives

Policy-makers have an important role to play in encouraging the electricity sector to pursue the most efficient paths to achieve energy goals. They should develop roadmaps that balance generation sources among conventional and renewable, and also across centralized and distributed models. They should catalyse "no regrets" investments in infrastructure that move fast-growing economies closer to universal access. By encouraging the adoption of energy-efficiency technologies, both on demand-side and on the supply side by upgrading inefficient power plants, they help reduce the need for investments in new generation capacity. Through all these measures, policy-makers support economic competitiveness while reducing the risk of policy instability due to adverse fiscal or stakeholder pressure.

As highlighted in the 2015 report on OECD power markets, power prices are a critical driver of economic competitiveness and an important policy issue for residential customers. Policy-makers are expected to develop long-term roadmaps that take advantage of a country's natural resources – to both fossil fuels and renewables – and low cost imports, whether via interconnection or by importing fossil fuels.

For example, Mexico has long been dependent on fuel oil for power generation resulting in industrial electricity prices that have been 77% higher than in the US. Recently, Mexican energy policy has recognized the extensive gas reserves domestically and in the US, as well as excellent wind and solar resources across the country (solar in the west, wind in the south and along the Caribbean coast). By prioritizing investments in gas and electricity transmission from the north to the south of the country, combined with new efficient conventional and renewable generation, Mexico has already been able to reduce its wholesale electricity prices by 33%, closing the gap with the US by 58% – providing a significant stimulus to the economy.

The most efficient pathways will vary depending on the particular needs and advantages of each country. Indonesia, for example, must develop new power sources to sustain its continued economic growth and address electrification challenges across its archipelago. Its recent commitment to add 35 gigawatts (GW) will use a range of sources, including large central gas and coal power plants, gas reciprocating engines, and barge-mounted power. The large centralized plants will supply low cost electricity to the population centres in Java, while smaller, mobile distributed solutions will provide power in remote and less populated areas throughout the archipelago. Such an approach seeks to minimize expensive transmission and distribution construction, take advantage of local fuel sources, and ensure affordable access to all.

Indeed, providing universal access to power is a substantial challenge faced by all fast-growing markets. The required investment in transmission and distribution infrastructure represents nearly 45% of the projected capital expenditure over the next 25 years and roughly two times the level of investment in the OECD. Executing on the priority to provide universal access remains a challenge for many fast-growing markets, but the experience of Brazil in the 2000s illustrates the impact when well executed. After privatizing the power sector in the 1990s, Brazil invested about $7 billion in the 2000s to expand the grid, through its "Light for All" programme, which connected 3 million Brazilian households over the decade and moving connection rates in rural areas from 73% in 2002 to 97% by 2012.

In addition to developing new capacity, fast-growing markets will continue to optimize the operations of their existing installed base. In many cases, upgrading the existing generating fleet is the fastest and lowest-cost way to generate more power sustainably. Upgrading gas turbines, for example, can improve efficiency, reduce emissions and limit the need for new fuel supplies. Often, the incremental power comes online in a few months rather than years, making it a very efficient way to increase a country's installed capacity. Improving energy efficiency, through new and existing technologies, will also reduce the need for investment in power generation.

Policy-makers also have a critical role to play in balancing between conventional generation and renewables, taking advantage of the natural resources available to each country – for example gas and wind in Mexico, or hydro, wind and solar in Brazil – as well as the right balance between centralized and distributed generation, as in Indonesia. By monitoring how technologies are deployed around the world, policy-makers can make better bets on the technologies that are likely to reach scale, and they can pursue "no regrets" investments that align with policy objectives and offer the quickest payback for investors.

Develop integrated policies that ensure parallel development of the power value chain

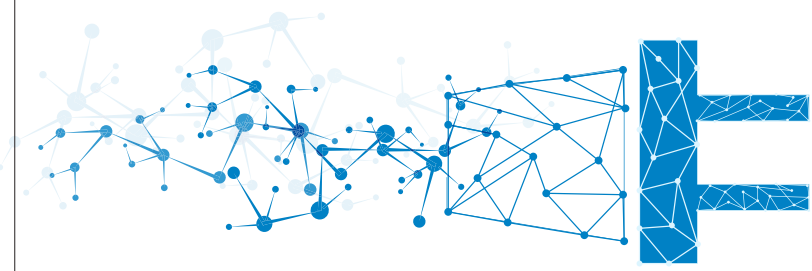
Policies need to be integrated across the power value chain to ensure that upstream fuel supply, generation assets, transmission and distribution develop in harmony and investors are not left with fully operational but stranded assets that cannot earn a return due to lack of fuel supply or lack of customer access. Integrated policies need to consider not only the operational aspects such as planning regulations, but also the economic ones such as import duties, regulated tariffs that impact the viability of different participants in the value chain.

One of the unique challenges of fast-growing markets is ensuring that investment occurs at a similar rate across the full value chain, avoiding potential obstacles that could constrain growth. In turn, this will ensure that investors of one asset class are not left without an opportunity to recover their investment because of constrained growth in another part of the value chain. At the end of the day, the rate at which energy policy priorities are delivered is only as fast as the slowest point in the chain.

The development of the China power sector over the past decade is a good example. With economic growth around 10% annually, demand for electricity has grown at a comparable rate, about 12% each year from 2002 to 2012 with per capita consumption of electricity nearly tripling over this period. To meet this demand, China implemented an integrated energy strategy that started with a plan for domestic fuel production, diversifying the fuel mix while also locking in long-term supply agreements for fuel imports. Between 2004 and 2014, China has also added 911 GW in generation, including 175 GW of hydro and 151 GW of renewables (wind, solar, biomass), more than any other country to date. The country also intends to add substantial amounts of nuclear capacity from 17 GW in 2013 to 145 GW in 2040. Although China historically struggled to connect wind farms to transmission lines, it made large investments in T&D, comprising 29% of all non-OECD investments in T&D and 31% of total power investments in China between 2000 and 2013. As a result of its integrated policy, China increased access to electricity from 94% in the 1990s to 100% in 2012, with the quality of supply rank improving from 81st to 56th from 2007 to 2015, according to the World Economic Forum Global Competitiveness report.

Countries such as Mexico and Turkey are also good examples of the transformational impact of integrated energy policies. Mexico is seeking to tap into the North American shale gas revolution and the natural wind and solar resources in the country. To exploit these resources, Mexico is spending $11 billion on gas transmission pipelines (2011-2018) and $33 billion on power transmission and distribution lines (2015-2029). Similarly, Turkey is looking to exploit its pivotal position for multiple gas trade flows and significant potential in renewables like wind generation. To ensure a secure electricity supply, it aims to diversify its gas supply, triple its gas storage capacity, increase the share of renewables in its energy mix to 30% and add coal generation capacity.

Given the fast growth of power demand in these markets and the need for investment across the value chain, policy-makers need to have a clear and integrated view of the factors necessary to deliver not only on fuel supply, generation, storage and T&D infrastructure, but also the supporting infrastructure – cranes, tools and instruments, construction and project management capabilities – and the regulatory frameworks in areas such as carbon, wholesale power trading and planning permits. By adopting integrated policies that allow for balanced development along the value chain, policy-makers can ensure that no group of investors are left stranded at one point along the value chain while other points are left under developed.



Take advantage of declining technology cost curves

As costs decline, non-OECD countries will add 34% more non-hydro renewables capacity than the OECD countries between 2015 and 2040. At the same time, there will be significant investment in conventional generation, which is becoming more efficient and producing fewer emissions. Moreover, the increasing digitization of energy assets offers the potential to improve operational efficiency and reliability, thus reducing both the delivered cost of electricity and emissions. Policy-makers should take advantage of declining technology costs curves driven by the rapid rate of global deployment and avoid the urge to promote unique technologies that will likely remain high cost due to a lack of scale. On the demand side, policy-makers should also take advantage of new technologies to improve energy efficiency.

Over the next 25 years, non-OECD countries will add about 1.7 terawatts of non-hydro renewable capacity, 34% more than in the OECD. China leads the world in deploying renewable generation, investing $84 billion in non-hydro renewables in 2014 alone to grow renewable capacity to 433 GW more than the entire capacity of the European Union's renewables including hydro. This rate of global deployment is rapidly driving down the cost of renewables, by 6% each year for wind and 20% for solar photovoltaic over the last five years. Further decline of the levelized cost of electricity (LCOE) for solar PV is estimated at 4% to 5% annually, and for onshore wind at 1% to 2% annually over the next decade.

In India, domestic fuel resources cannot satisfy the growing demand for electricity, so it depends on fossil fuel imports for about 30% of its primary energy supply, with projections to reach 40% by 2040. But India has extensive wind and solar resources available, with high wind speed locations and average irradiation on par with the best locations in Spain and Italy – two of Europe's sunniest countries. In 2015, it is already cheaper in many parts of India to generate electricity from solar panels than from diesel generators, even without subsidies. So India's government has set an ambitious plan to deploy 100 GW of solar generation by 2022, taking advantage of the declining cost of solar technology, alongside its 260 GW of thermal and nuclear generation and 62 GW of hydro capacity. To encourage investment in solar, the government is considering incentives such as accelerated depreciation, purchase incentives and obligations for distributors and industrial users, and feed-in tariffs to allow solar users to sell supply back into the grid. The Ministry of Finance estimates that over the next five years India will require renewables investments worth $160 billion. Additionally, according to IEA estimates, India will invest about $845 billion in T&D networks between 2015 and 2040 to ensure universal access to power for customers.

Similarly Brazil is investing in wind power to complement hydro generation and satisfy growing demand. Wind generation is complementary to hydro as rain and wind seasons occur at different times. Brazil has large wind resources currently estimated at nearly 300 GW, of which only 6 GW is currently installed. To encourage development of wind generation Brazil has established a framework of centralized capacity auctions, initially technology specific and later allowing wind to compete with other technologies. Competitive auctions, technology advances and improvements in supporting infrastructure (tools and instruments, local capabilities) have driven the price of wind power down – and at nearly $60/MWh in 2017-2019, very close to low cost hydro generation at $41-$47/MWh. Brazil plans to invest $71 billion in wind and add 40 GW in between 2015 and 2040.

In addition to improved efficiencies and lower costs for thermal and renewable technologies respectively, fast-growing countries should consider deploying digital technologies to help optimize electricity delivery. For example, using digital solutions like integrated hardware and software, fast-growing countries can reduce power system operating costs, thus generating a higher return on investment. The software can proactively identify maintenance issues across energy assets, adjust operating parameters to maximize output and reduce emissions given a specific fuel input, and ensure minimal outage time and reliable electricity delivery. Kenya will be using digital technology to site and operate wind farms that will generate 20% more output on average than farms without software. Meanwhile, Pakistan will be installing advanced thermal plants that will use software to adjust operating parameters to maximize efficiency while providing valuable grid services.

Beyond improving operational efficiencies and asset performance management to lower delivered electricity cost and emissions, digital technology can help reshape the energy system in fast-growing economies. Software can help determine the optimal location and improve operations of central and distributed generation. When combined with demand-side management tools (including demand-side hardware and software, energy efficient buildings, lighting and appliances) these measures can help balance demand with the most affordable, reliable and sustainable supply.

Few markets have sufficient scale to go it alone with a new technology, deploying enough capacity to make it cost competitive. Instead, policy-makers will need to follow the deployment decisions of mature and fast-growing markets to understand the likely cost reductions in different technologies over the next few decades so they can identify the right mix for their country. By using proven low-cost hardware and emerging digital solutions, policy-makers can minimize the capital required.

Regulators

Provide a level playing field for technologies, reflecting carbon abatement and security of supply appropriately

Regulators should structure power markets in ways that recognize the full value and costs of technologies, including carbon pricing. Regulations should be technology agnostic, taking into account issues including flexibility, reliability, carbon-abatement properties, land use and the cost of securing fuel supply. This may also mean removing fuel subsidies that support specific conventional generation technologies. In special circumstances, regulators might support new technologies that show promise in their particular market but only if there is a credible plan for the technology to become competitive in the medium term, and subsidies phased out. Recent capacity auctions in Latin America have demonstrated how technology-agnostic processes can bring down overall costs and avoid distorting the market.

In Chile, where demand for electricity has grown at 4% to 5%, most of the fossil fuels for generation are imported, resulting in volatile and high prices. To reduce the cost of electricity and secure a steady supply, the Chilean government adopted new policies that aim to develop renewables, which will also improve the country's energy security. The government also launched capacity auctions structured to allow different technologies to compete with each other, taking into account the total costs of each technology. At these auctions, renewable generators won bids with prices 7% below competing bids from conventional generators.

Similarly in Brazil, with relatively high electricity prices and good wind load factors, wind energy has been able to compete in recent years with conventional generation without subsidies or feed-in tariffs. As a result, the contracted electricity prices at auction fell from $84/MWh to $60/MWh between 2009 and 2011.

Regulators should seek to level the playing field in power generation by ensuring that subsidies, carbon pricing or tax mechanisms appropriately reflect the value of decarbonization and do not unnecessarily distort markets, thereby undermining economic competitiveness. The IEA estimated that in 2013 fossil fuel subsidies for electricity generation amounted to about $130 billion and subsidies for renewable generation amounted to about $121 billion globally. The regulators also need to set grid prices appropriately. Equally customers who generate much of their own electricity, but still rely on the grid for backup electricity need to pay an appropriate fee to the grid to reflect the value of access to reliable backup electricity and thereby ensure the ongoing viability of the grid.

A critical component of a level playing field is the mechanism for valuing decarbonization. Carbon pricing is gaining increasing support in fast growing countries, with China launching regional pilot programmes for emission trading in 2014, with plans to roll out nationally in 2017. Mechanisms such as carbon taxes have also been deployed in markets such as Japan and Chile to provide a clear signal to the power sector and industry to

decarbonize. Clarity and certainty in the carbon pricing signals is critically important in the power sector with long investment time horizons. By limiting the effects of subsidies and using other tools like grid standing charges, feed-in tariffs and carbon pricing mechanisms regulators can ensure that artificial measures do not distort capital allocation, thus ensuring that investors have a level playing field to achieve a competitive level of returns on their investments.

Ensure technically and financially viable operations across value chain

Regulators can ensure the viability of the value chain by keeping it clear of financial obstacles. They should work with distributors to reduce losses from non-metered supply and ensure that tariff subsidies or progressive tariff structures are fully funded. They should ensure that the viability of generators is not threatened by fuel tariffs that distort margins or security of supply.

The integrated nature of the value chain affects not only the physical flow of electricity but also the financial flows. If there are obstacles preventing the flow of funds from customer to companies to other stakeholders (including investors) then future investment will also stall. Historically, the obstacles have occurred when there are substantial physical non-technical losses in the system or where regulatory interventions squeeze the viability of particular industry participants and funds do not flow properly.

Reducing distribution losses is an important step in ensuring financial viability of an electricity system. Losses vary greatly across fast growing markets from 2% to 50% largely as a result of unmetered supplies and exempt categories of customers. Across fast-growing markets, there are a range of examples where countries or states have systematically attacked non-metered supply with impressive results – and significant improvements in attracting further investment in the system.

China reduced losses over two decades from 10% in 1989 to 6% in 2012 through constant improvements in payment discipline and, in recent years, through a systematic programme installing smart metres. Some Indian states, including Gujarat, Madhya Pradesh and Andhra Pradesh, have also made improvements, with state distribution companies reducing their distribution losses from almost 40% down to 25% to 30% in just a few years, with continued reductions expected.

In Colombia, Codensa, the country's largest electricity distributor in terms of number of customers, launched an extensive programme to reduce its losses through non-metered supply, cutting them in half in just three years, from 22% of supply to only 12% in 2000, and eventually to 7% in 2013 – close to the average rate across the OECD. Codensa inherited an ineffective distribution network when in 1997 it was created by unbundling a state-owned vertically integrated utility. To reduce the theft of electricity, Codensa developed an integrated approach across all company activities: work with authorities on regulation, commercial and technical management, staff training, community management, IT upgrades and law enforcement. The reduction in distribution losses had two major positive effects on the utility – increased collection of payments and a permanent decrease in power demand. Efforts like these give investors confidence that distribution systems will be able to recover their costs to ensure viability.

Business and investors

Create effective public-private partnerships to attract private sector capital

The private sector – businesses and investors – should engage with policy-makers and regulators to make the governance and regulations around public-private partnerships clear, transparent and independent in order to ensure that investors can be confident in committing long-term capital.

In some fast-growing markets, businesses are more susceptible to interventions by governments and regulators than they are in OECD countries. These risks are particularly acute in long-term, highly capital intensive sectors such as power generation, transmission and distribution. Investors need to engage with policy-makers and regulators to agree on appropriate governance, regulatory and contractual mechanisms to mitigate these risks.

From 2002 to 2012, Brazil's economy and its demand for electricity both grew at about 4% annually. To attract private capital to build the required capacity, in 2004 Brazil adopted new regulations on public-private partnerships that defined the rules of engagement with private investors in infrastructure and power projects. The public-private partnership framework defined rules for competitive bidding and contracting private suppliers at the federal and state levels, while also appropriately allocating risks between public and private stakeholders (for example, a dedicated fund guaranteeing government financial obligations under

public-private partnership agreements). Clearly, defined rules of public-private partnerships and financing support provided by the Brazilian Development Bank (BNDES) – a government institution used for investments in the Brazilian economy – enabled the large-scale addition of generation capacity and a decrease in the cost of electricity, until the rules changed in 2012. In the five years following the adoption of the public-private partnership framework Brazil was able to attract $118 billion for more than 172 public-private partnerships across industries.

Similarly, South Africa has recently made substantial progress in attracting private investment into its wind and solar sector. By carefully structuring public-private partnerships – defining a responsible independent government authority to manage auctions and providing government guarantees for signed public purchase agreements – the South African regulator has attracted nearly $16 billion in investment from 2012-2014 into these sectors.

Nurture favourable investment environment

The private sector together with the public sector should put measures in place to reduce risk and decrease the cost of capital, allocating risks to the most appropriate market participants. The private sector should proactively engage with the public sector to align expectations for power sector profitability. Innovative financing schemes and a balanced approach to local content requirements will also help encourage investment.

In recent years, countries have witnessed an expansion in the range of financial instruments that they can use to finance investments in the power sector. As in mature markets, good governance and contractual mechanisms can mitigate some of these risks and attract long-term, low-risk capital, such as pension, sovereign wealth and insurance funds.

The Brazilian Development Bank has offered low-cost funding to finance about 60% of the power projects there, amounting to a $35 billion loan portfolio for electricity and gas in 2014 or about 17% of its portfolio. This disciplined approach has attracted $42 billion of capital in addition to BNDES financing from 2003 to 2012, and has achieved higher or comparable returns on assets and returns on equity than for peer banks in other markets.

International development institutions like the World Bank, Inter-American Development Bank and the Asian Development Bank are among other sources of low-cost financing for power markets. Engagement with these institutions is especially important for large projects in fast-growing markets.

National governments can help reduce credit risks by offering sovereign guarantees for power purchases where appropriate. South Africa was able to trigger investments of around $16 billion in renewables from 2012 to 2014 by launching a Renewable Energy Independent Power Producer Procurement programme with government-guaranteed power purchase agreements that serve as a reliable source of long-term cash flow. As a result, three bid rounds attracted investments from both local (86%) and global players (14%), including banks, insurance companies, utility companies and such development institutions as the International Finance Corporation (IFC).

Similarly, investors can engage with domestic or international institutions to seek support for power projects in fast-growth countries through export financing and export credits to support deployment of technology, or risk insurance to help reduce the cost of credit.

Another important factor that affects investor returns in fast-growth economies is exchange rate risk. To address this, countries are coming up with innovative schemes, such as the US dollar-denominated solutions in Mexico, ensuring

that revenue of power companies is not affected by currency depreciation risk. Similarly, India recently launched several initiatives to address exchange risk. One of these is a foreign currency-denominated tariff plan for solar to protect investors from currency fluctuations. Another recent development is the launch of country-specific bonds sold to offshore buyers to fund specific projects, such as green power projects. For example, India's so-called "masala bonds" are rupee-denominated and backed by an IFC AAA rating.

Invest in education and R&D to close knowledge and human capital gaps

The private and public sector should work together to foster the development of universities and research institutions that produce the talent which will innovate, develop and manage the power sector in the decades ahead.

The scale of investment required in the power sector over the next 25 years in the non-OECD markets is unprecedented and will require an equally large deployment of human capital across the power sector value chain in construction, operations and maintenance. Mature markets have also faced a shortage of engineers, project managers and other skilled talent in the power sector, and these gaps are being addressed by promoting education in this field. Similarly, in fast-growing markets industry and government will need to work together to ensure that the knowledge and human capital gap is closed.

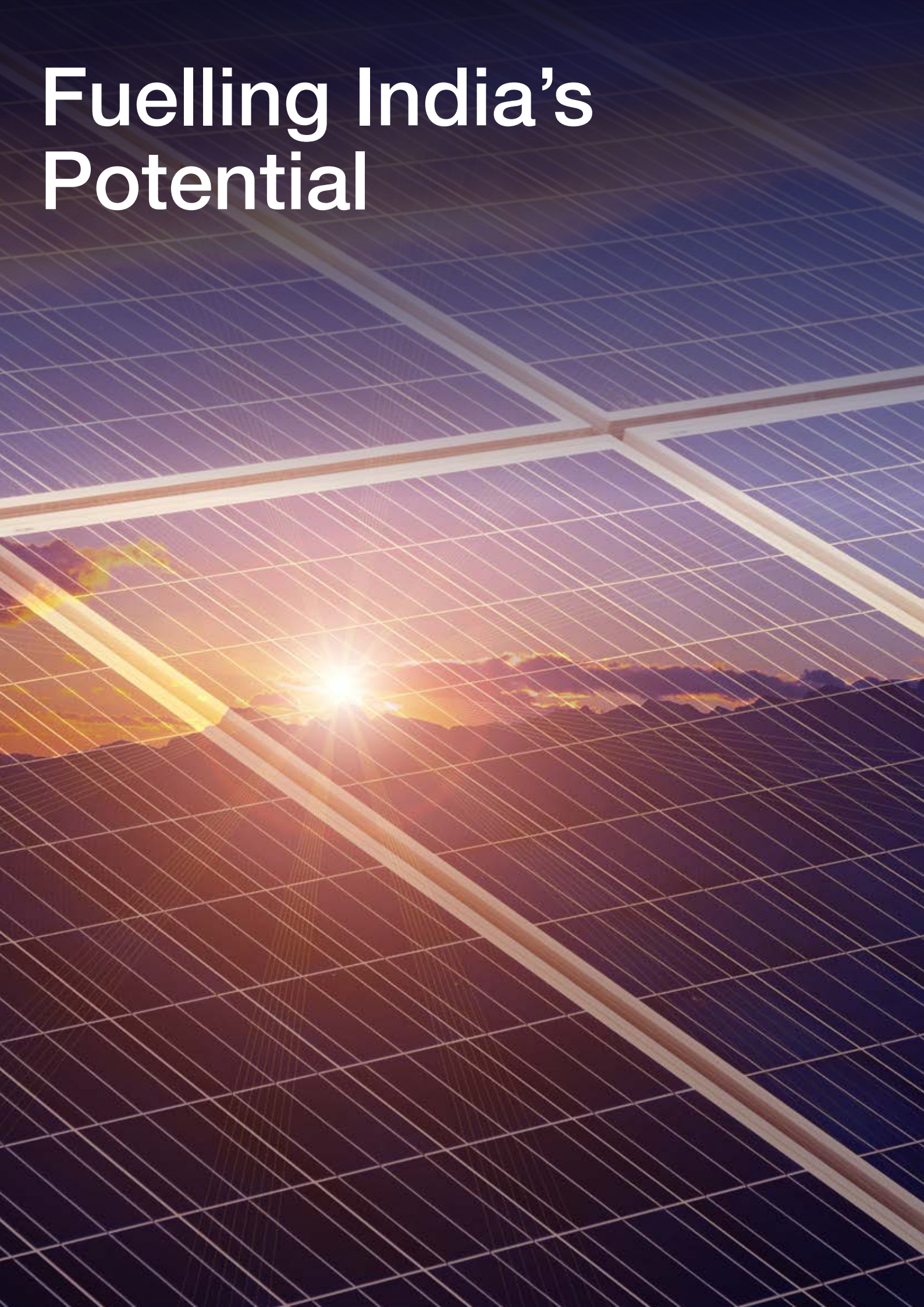
For example, the United Arab Emirates has established the Masdar Institute to funnel investment to the development of researchers and professionals focused on the renewables industry. The UAE has one of the largest carbon footprints per capita worldwide, largely due to the country's electricity generation from fossil fuel. In 2009, the UAE approved policies to diversify its power generation, aiming to generate 15% of its power from renewables by 2030.

To support the renewables initiative, the Masdar Institute is investing to create a domestic pool of talent to drive R&D in renewables. Since its establishment, Masdar has generated six US patents, 54 patent applications, 600 papers in peer-reviewed journals and five start-up companies. The efforts of the institute, along with other initiatives by the UAE to build its knowledge-based economy, has raised the country's global innovation ranking in the World Economic Forum's Global Competitive Index from 52nd place in 2008 to 24th in 2015.

Businesses can also collaborate with local governments and schools to establish educational programmes focused on power management and services, to ensure the availability of local capabilities. For example, in India and Indonesia businesses and educational institutions jointly developed dedicated programmes for power sector employees, focusing on the skills needed to expand access to electricity.

Each country will prioritize these recommendations differently based on its energy policy objectives across energy access and security, economic development and environmental sustainability. Prioritization depends on economic resources, the maturity of energy markets, and the policy objectives.

Fuelling India's Potential



India's power sector is at an inflection point, given the government's conviction that electricity is a critical enabler for economic growth. India's government recognizes the need for private investment in the power sector and is planning to adopt progressive policies on renewables and the sector overall. Alignment between federal and state government objectives is critical, as India devolves significant power to its states.

Recommendations identified in the best practices section of this report are all relevant for India, but there are also four key imperatives that India can focus on to improve the sector's attractiveness to investors.

1. India needs to fix the viability of its distribution system.

– Policy-makers can help by developing and promoting a framework conducive to public-private partnerships in electricity transmission, distribution and generation. In the short-term, basics need to be fixed – for example, separate electricity infrastructure for different industries (feeder segregation), and metering systems and collection systems, all of which require strong political will to execute.

– Regulators can help by ensuring a level playing field for private players that enter the market, and working to stem non-technical losses. They can ensure transparency in overall industry governance and clear separation between policy-makers and regulators. Regulators also can ensure the delivery of open access, which is the ability of large commercial and industrial customers to purchase power from an open market.

– The private players who enter the distribution market will be able to help improve the viability of the distribution network in several ways. They are most likely to introduce new technologies in the grid, such as outage management systems (OMS), distribution management systems (DMS) and demand management systems (including matching power purchase agreements to demand curves), while also helping to accelerate adoption of smart grid and metre technology. Private players can bring the capabilities to develop integrated regional or national systems that will yield substantial benefits in load and supply forecasting. They can also help establish an integrated peak power capacity to stabilize the grid and a national ultra-high voltage (UHV) network.

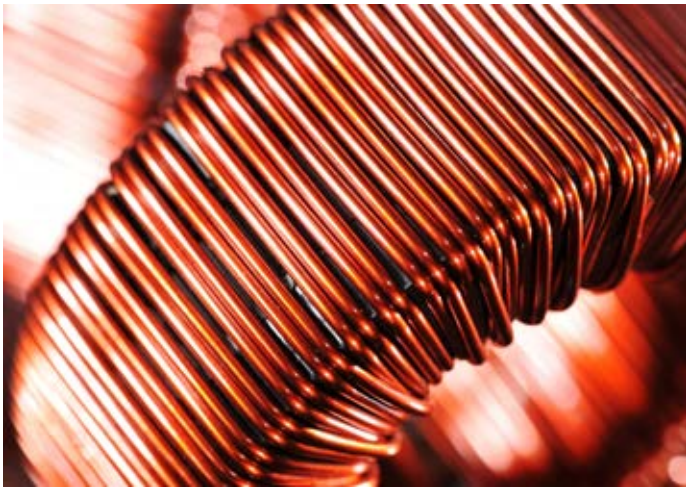
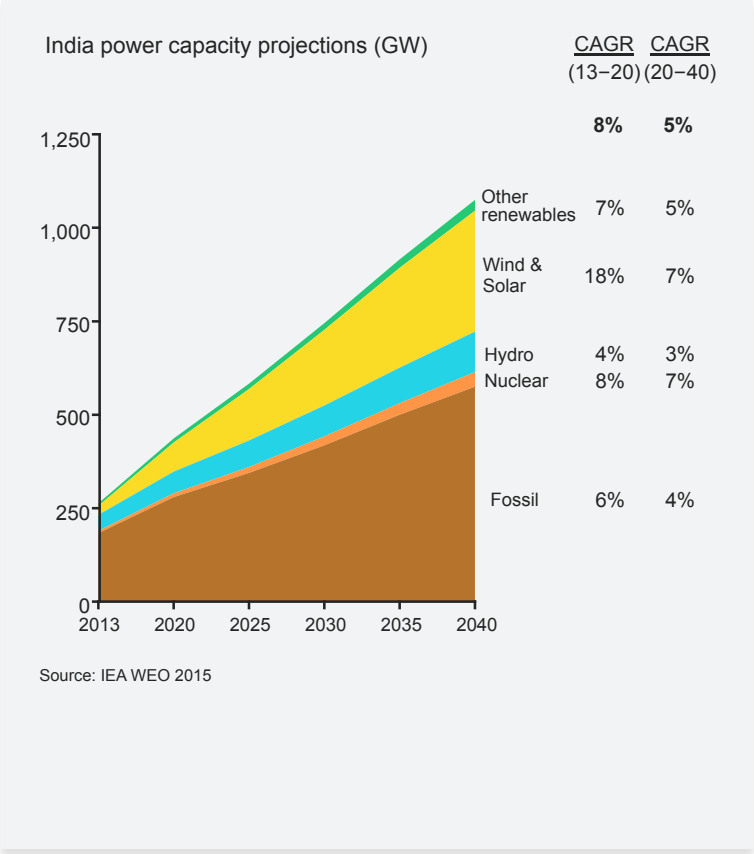


Figure 3: Forecast growth of India's power generation capacity and India power markets stock performance.



2. India needs to address its fuel supply challenge.

- Policy-makers have an important role to play by moving upstream industries towards the free market and attracting more participation from the private sector. Initiatives such as a streamlined and viable coal auction process, defined risk-reward frameworks to attract global majors with the right technologies and capabilities, and adopting free market driven pricing will all help increase supply.
- Indian regulators can also optimize and scale the model of Mine–Develop–Operate by accelerating the MDO award process, adopting single-window clearance through a coordinated approach across ministries.
- Businesses and investors have an important role to play in improving the operational efficiency of Coal India, Ltd. (CIL) by streamlining processes, improving productivity and implementing more efficient managerial practices. A new long-term strategic model for CIL needs to be adopted with a better capital management and asset strategy, including potentially breaking out parts of CIL. Power infrastructure needs to be optimised with more pithead plants, which generate power from coal at the mines, and UHV lines from coastal locations.
- Private players will likely build much of the additional capacity to alleviate bottlenecks in the coal distribution system at the ports and in the railways. Building rail corridors dedicated to coal, dedicated LNG ships, regasification terminals, and dredging deeper sea berths for larger ships will also be required.
- With potential government support, private players could help build a world-class technology cell to assess and commercialize new technologies (for example underground mining), which could help attract more skilled technological talent to the industry.

3. India's plan to add 175 GW of capacity from renewables by 2022 can succeed only if the relevant stakeholders act in ways that encourage investment in this part of the sector.

- Policy-makers should develop the blueprint for the country's renewable energy capacity by 2022 and provide policy support to foster investment in solar power. They can help attract external capital by reducing borrowing costs through strengthening the state electricity boards. They can also boost the solar industry by simplifying rules and regulations of the construction of distributed solar power across many different types of infrastructure. Similarly, land acquisition regulations should be simplified to accelerate growth of wind and solar power generation.
- Regulators should enable distributed generators to feed excess power into the grid and receive payments or discounts for it. Regulators can enforce the mechanisms underlying renewable purchase obligations (RPOs) and renewable generation obligations (RGOs), while also promoting open access for wind power. Critically, they should ensure long-term tariff consistency with no retroactive changes or flip-flops.

– Investors and businesses can contribute in all areas. There are opportunities to set up large solar and wind power plants on idle land through both bilateral and auction routes, promote rooftop PV through solar leasing models supported by feed-in tariffs and tax benefits, and develop the infrastructure to support new capacity. These will require businesses to incubate new technologies (for example, for wind, higher capacity turbines, gearless generators, offshore masts, central and distributed storage technologies and wind generation forecasting tools) and launch training programmes to create the skills base required for the next wave of investment

4. Even with the huge investments in renewables, most of the electricity consumed in India over the next two decades will be generated by burning fossil fuel, and India can do much to improve the efficiency of the existing power infrastructure.

– Policy-makers should develop an integrated outlook for India's energy, including targets for fuel mix, emissions and sector progress, and set a government body to monitor progress. Tariffs and rates for fuel pricing, costs that are passed through to customers, and peak power policies and pricing should all be transparent and consistent across India's states.

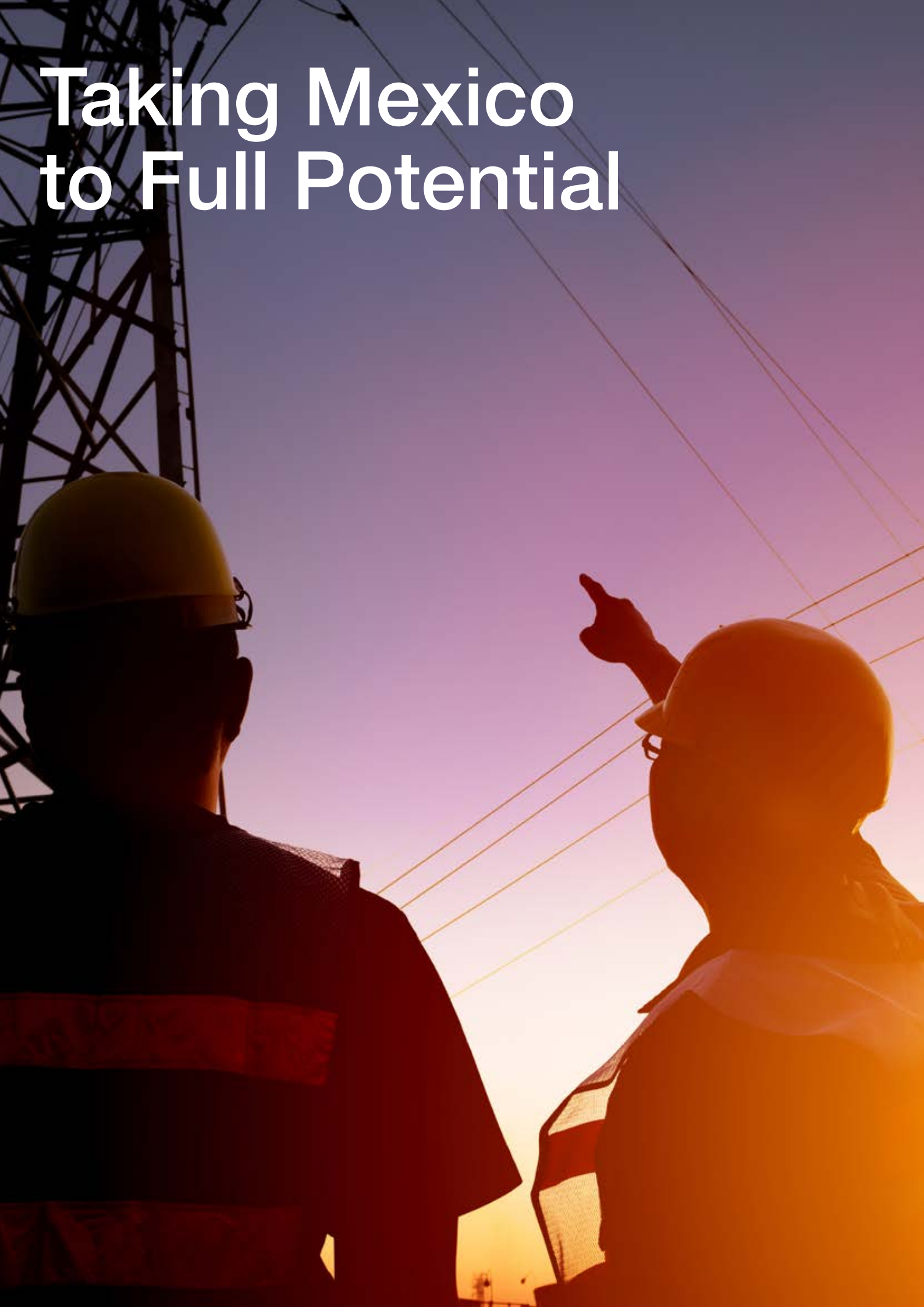
– Policy-makers should continue their work on improving demand-side energy efficiency, extending efforts such as the domestic lighting initiative to include other sectors of the economy.

– Regulators should define clear guidelines for public and private sector participation and develop "single-window clearance" for large projects like Ultra Mega Power Projects (UMPP), assigning to developers only those risks that they can control.

– The private sector is best suited to define blueprints for systems that include large coal and gas plants and the coastal infrastructure to import coal and LNG.

– Businesses also play a critical role in promoting efficient new technologies, such as ultra-super critical boilers, particularly as they become more financially viable. They can also help optimise the use of the coal through coal-to-power system efficiency initiatives such as heat rate optimization, gangue re-use, washed coal and fire minimization. They will also be the training ground for the next generation of skilled workforce for the energy industry.

Taking Mexico to Full Potential



Mexico's energy reforms promote key structural changes that open up new opportunities in the power sector. However, the degree of change will present considerable challenges for policy-makers, regulators and the business and investment communities who will all need to work together to transform the country's electrical ecosystem. The country aims to invest $146 billion by 2029, with most of that going towards generation with natural gas and renewables, gas pipeline infrastructure and strengthening the distribution system (see Figure 4).

To attract the necessary capital, Mexico will need to finalize its plans for the power market and continue to signal policy stability to investors. There are critical roles for policy-makers, regulators and private businesses and investors across the value chain, in upstream roles (fuel, equipment and development), power generation, and transmission and distribution. Most of the eight best practice recommendations above are applicable to Mexico, but in the short term power market stakeholders in Mexico should focus on three key recommendations.

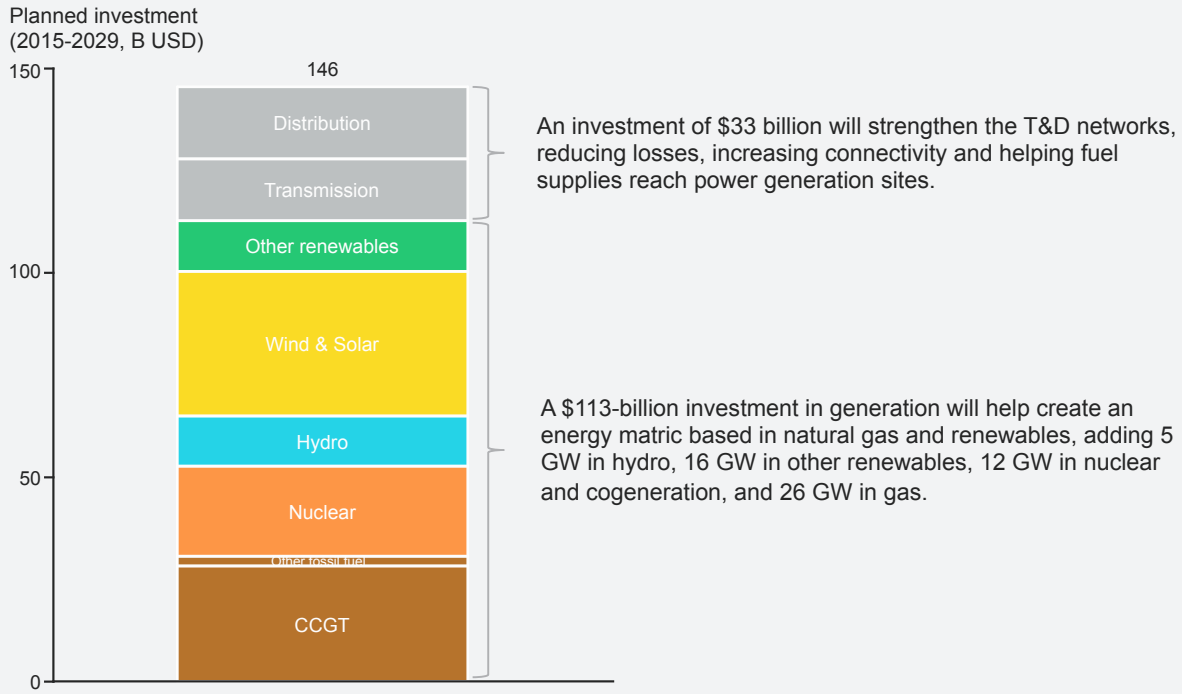
1. In upstream, a viable market in natural gas is required to encourage stability and predictability that will attract the required investment to build out the infrastructure for bringing the supply of fuel to the power generators. The energy reforms allow private companies to build and own their own pipelines, and the private sector will be instrumental in meeting this infrastructure challenge under certain regulatory conditions:

   – Policy-makers will need to create incentives for new infrastructure for gas production and storage. Policies will need to create a truly competitive gas market with multiple producers and suppliers and a secondary gas transportation market.

   – Regulators will need to ensure that the new government agencies regulating and managing the gas market are aligned. In accord with the spirit of energy reform, they should continue to identify and remove redundancies in regulation, promoting simplification and homogenization in regulation. Creating an index of gas prices across Mexico will help create a domestic market in gas and decouple the country's gas prices from the Henry Hub price in the US. Regulators also have a role to play in lining up anchor tenants for new and proposed pipelines, so investors and operators can estimate a predictable cash flow.

   – Policy-makers should encourage the creation of diverse financial instruments to increase the depth, robustness and liquidity of wholesale markets. The private sector should explore long-term contracts to tackle gas price volatility and market liquidity.

Figure 4: Mexico plans to invest $146 billion in the electricity system by 2029.



Source: Mexico Ministry of Energy (SENER) National Power System Development Plan (PRODESEN) 2015-2029

2. In power generation, Mexico should continue working on implementation of energy reform, in particular focusing on the following:
   - Policy-makers need to define clear targets for the generation mix and demand-side management.
   - Regulators should also finalize the outline of a clean energy market, detailing the criteria for clean technologies and specifying detailed bidding criteria before the launch of clean energy certificates that will be issued to renewable energy generators for the power they generate, and which many industry participants will be obliged to buy to support renewable generation.
   - Regulators will need to structure the market and provide stability by setting minimum amounts for capacity and energy from suppliers in long-term contracts, and creating and calibrating the auctions for renewables. Regulators should create new institutions that will be responsible for monitoring the market operations and ensuring policy and regulation stability.
   - Mexico's energy regulator Comisión Reguladora de Energía (CRE) has a large role to play also in eliminating or reducing regulatory barriers to investment in power generation and putting in place governance mechanisms that ensure independence from government and state-owned enterprises

3. As in many other fast-growing countries, Mexico has much work to do restoring the viability of its transmission and distribution systems in order to make it more reliable and efficient while reducing loss:

   – Mexico needs to adopt a “smart follower” strategy on new technologies, encouraging adoption of proven technologies that support its T&D development and are within the scope of the energy system’s financial capability. Policy-makers should also be seeking out and creating opportunities for interconnections with neighbouring countries. They can also help coordinate the efforts of the various relevant government entities working to modernize and improve the country’s regulatory structure, which will also help the T&D network grow. Moreover, policy-makers could help manage demand by developing energy efficiency regulations that would help begin to level out the growth of the country’s energy demand.

   – Regulators have an important role to play in reducing the loss of electricity, both by encouraging the adoption of better technology and setting the precise mechanisms to minimize non-technical losses. They should also encourage sharing of best practices across the T&D network to improve efficiency and reduce operating costs, including higher participation of private players. Regulators can also improve the transparency and clarity of the tariff structure for the private sector.

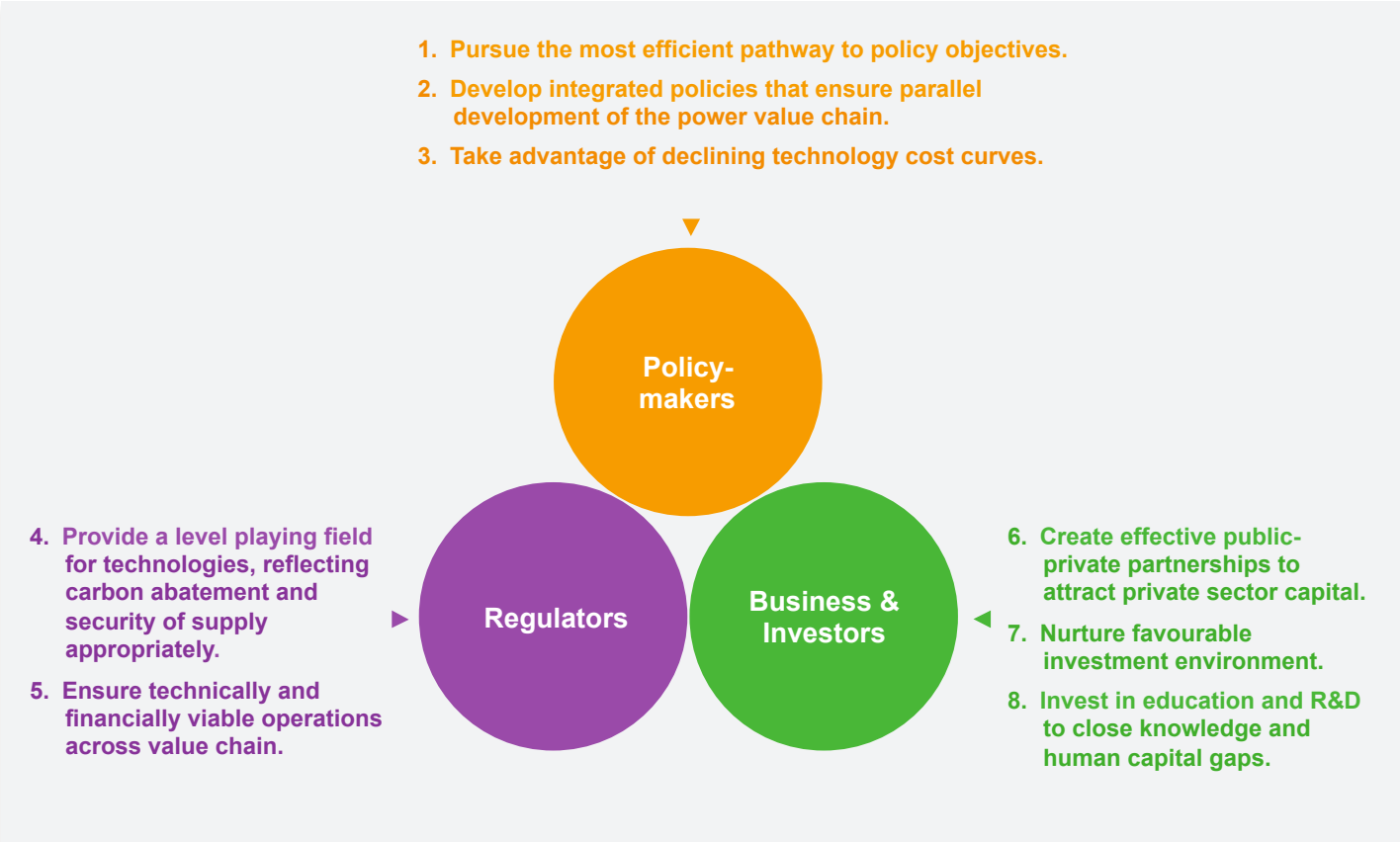
   – Businesses and investors have an important role to play in bringing in fresh capital that will deliver new technology and efficiency to the T&D system. Smart grids and other technologies that manage demand and outages, as well as customer management systems that can help reduce non-technical losses, are prime targets for investment. The private sector can be invited to contribute to Mexico’s T&D sector by engaging in public-private partnerships and other investment vehicles that tap less traditional pools of capital.

   – Regulators need to simplify subsidies frameworks and ensure that they are targeted towards end users that need them the most.

Conclusion

Of all the challenges that fast-growing economies face as they build the electricity sector to power their growth – removing obstacles, stemming losses, ensuring access – perhaps none is greater than the shift in mind-set from acquiring commodity fuels to attracting capital at the scale that will be required. The recommendations set out above will help to improve the investment attractiveness of the power systems of fast-growing economies and help them achieve their social and economic objectives including universal access to reliable and affordable power, and environmental sustainability.

Figure 5: Key recommendations.



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