KPMG

The electric future

and its implications for India

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Foreword

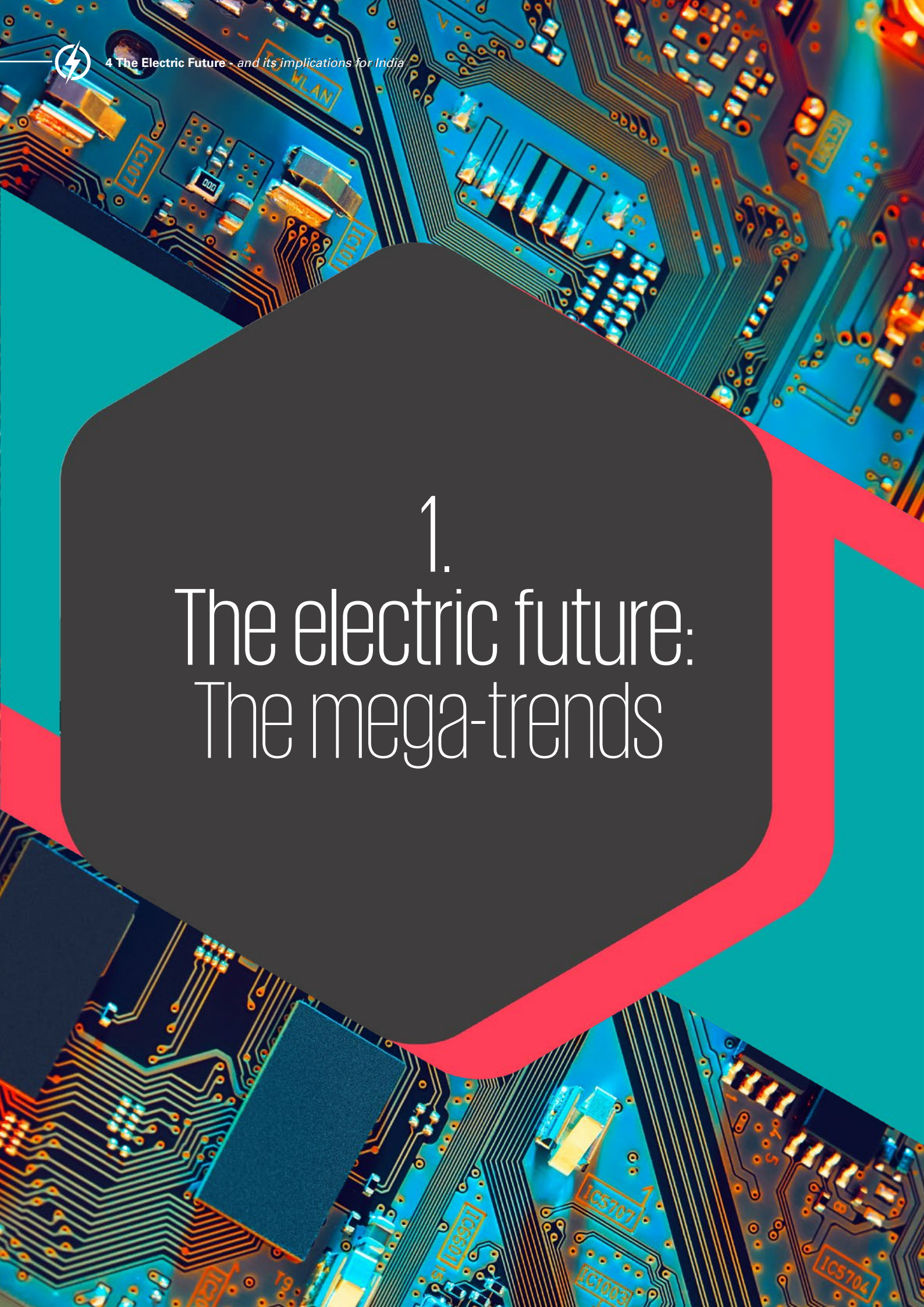
The objectives of this thought paper are to identify the core trends that are likely to influence the structure and operations of the energy and natural resources (ENR) sector globally and in India in the coming decades, assess the potential impact and implications for the Indian nation, and point to a few specific calls for action from the government, industry and other key stakeholders.

India is a large young nation with distinct demographics, resource base and economic trajectory. With more than a sixth of humanity residing in the country, India's actions in the ENR sector has global implications in this carbon constrained and environmentally sensitive world. Its actions also massively influence the hugely populous neighborhood, especially when it comes to energy. At a time when there are massive and simultaneous changes to the demand and supply side dynamics, the choices made will have long term implications, especially since these decisions have a long period of influence.

We are clearly in midst of a global energy transition to cleaner sources of energy, accelerated by climate concerns as well as cost trends. A few trends that are defining this transition include (a) renewable energy scale-up (b) acceleration in energy efficiency (c) decentralisation of resources (d) consumer empowerment and (e) electrification across the board. The characteristics of this new energy paradigm are often radically different from the past. Yet it is also equally true that the new depends on the crutches of the 'old' electricity paradigm to grow. Renewables must be balanced by conventional resources including fossil fuels; distributed generation can scale rapidly when it is grid interactive. ***Navigating the energy transition***, the theme of ENRich 2019, is hence of great importance.

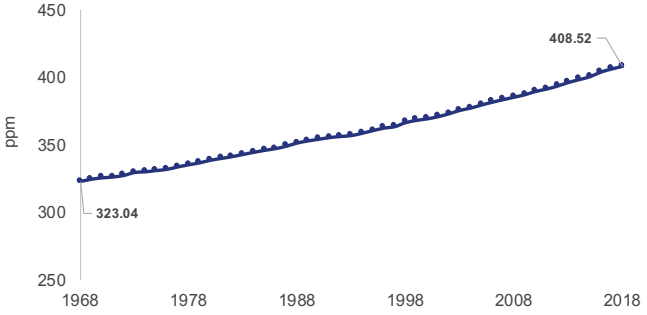
Technology evolves in ways that are unpredictable, hence making it impossible to foresee beyond the horizon. Development cycles are shortening rapidly. However, the near to medium term future does point to accelerated electrification. Indications are that the overall energy sector is headed towards 'The electric future'. This thought paper brings out the various facets of that future and how those facets are intricately linked to each other and to the global priorities around decarbonisation, efficiency in resource use and evolving a virtuous circular economy. I do hope that this conveys thoughts and actions as it is intended to do.

Anish De
Partner and National Head
Energy and Natural Resources, KPMG in India

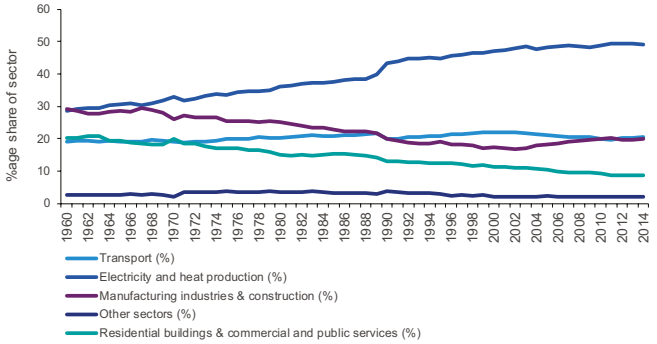


1. The electric future: The mega-trends

Present global CO2 emissions are estimated at 34 Gt per annum[1]. To meet the Paris climate goals and keeping the temperature rise to well below 2 degree above pre-industrial levels, carbon emissions need to fall by around 45 per cent from present levels by 2040. This is in the backdrop of global economic growth where due to increased prosperity, global Gross Domestic Product (GDP) is expected to double in this period. It is thus not just about slowing or containing carbon addition even as the world economy grows, but about reversing the direction of carbon accretion. For this, electrification is an imperative.



Data Source: Our World in data



Source: International Energy Agency via The World Bank

Broad trends across the globe point to rapid electrification of consumption being underway already, driven by efficiency, cost and climate considerations. The ecosystem is already gearing around this future through accelerated deployment of renewables, new age storage solutions and conversion of the energy applications space to electricity in transport, household applications, food production storage and supply, etc. Electrification in a myriad ways is also aiding the convergence of demand and supply sides, improving conversion efficiencies and bringing in an element of seamlessness.

The pace of electrification of transport has now started to pick up globally. Massive investments are going into electric mobility in public and private transport and associated technologies (particularly battery technology) and infrastructure. The dual benefits in terms of likely reduction in local and global emissions are very large. With such massive dual benefits at a time when environment and climate have become the greatest concerns for humankind and with already comparable costs, the juggernaut is rolling.

This is not just about electrification of mobility. Even static applications of energy are turning electric at a rapid pace in industries and households. Case in point is the expanding electricity access across South Asia and Africa where a large proportion of population will have access to commercial energy for the first time and will contribute to electrification of the global economy.

In this section, we discuss the global energy transition around the following propositions:

1. Where and how energy is consumed is set to change massively
2. The pick-up of renewable energy has just about started
3. Storage will start evolving in tandem with renewables.

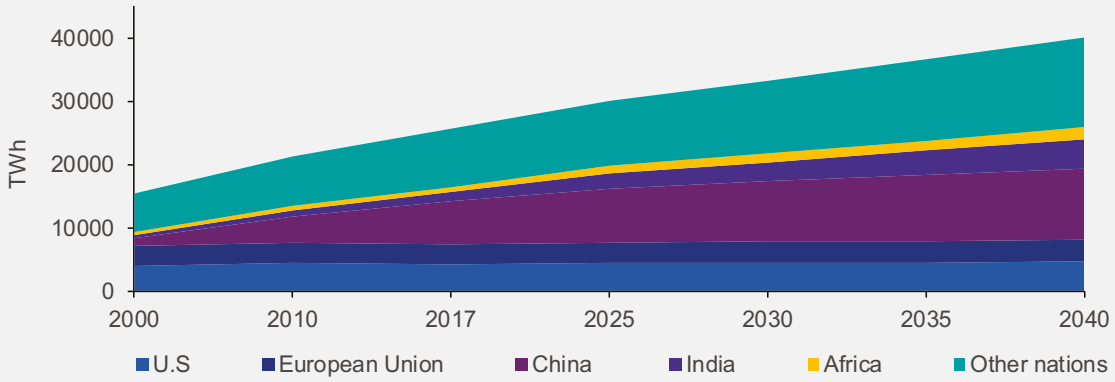
The section concludes by laying out the implications for India, which are then detailed out in the subsequent section.

[1] Data in this paragraph is from BP Energy Outlook, 2019. Paris climate goals refer to the goals set at twenty-first Conference of Parties (COP 21) in Paris in 2016.

Where and how energy is consumed is set to change massively

Global GDP is expected to double by 2040, led primarily by non-OECD[2] countries in Asia-Pacific and Africa[3] with an expected 33 per cent growth in energy demand. Developing economies will account for the largest share of new energy demand, driven by rapid economic and population growth and the need for more goods and services.

Global electricity generation by region



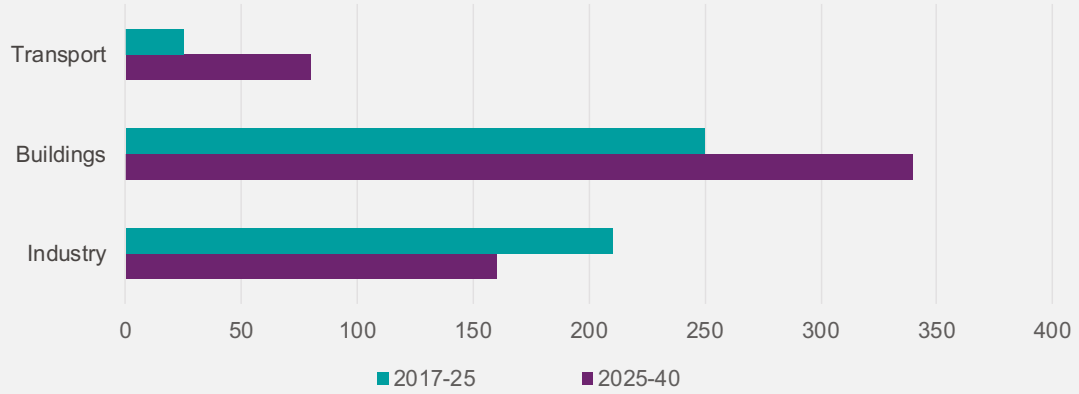
Source: Data for New Policies Scenario, World Energy Outlook 2018, IEA and KPMG in India Analysis

[2] Organisation for Economic Co-operation and Development

[3] BP Energy Outlook, 2019

According to BP's Energy Outlook 2019, around three-quarters of the increase in primary energy demand will be absorbed by the power sector. This is a forecast with inevitable unknowns and uncertainties. In practice, the pace of change may well vary from forecasts, but the direction is clear. For a relatively short period of time this kind of change within a single generation in a mature sector like energy is indeed remarkable.

Average annual increase in electricity consumption by sector



Source: World Energy Outlook 2018, IEA

On the demand side, this change will be largely driven by increasing use of electricity in industry, buildings as well as transportation. Buildings are the largest source of demand for electricity. However, considering the current policy push and evolution of technology, transport is expected to experience the fastest growth in electricity consumption. As per Global EV Outlook 2019, electric vehicle (EV) sales (excluding two/three-wheelers) are expected to reach nearly 23 million in 2030, about 30 per cent of present-day global car sales[4], with China accounting for almost 50 per cent of this number. As history has demonstrated, China is very capable of making rapid modal switches for economic and environmental reasons.

It is anticipated as per BP Energy Outlook, 2019 edition, that electricity will power about 25 per cent of passenger vehicle kilometres by 2040. Globally, electricity demand from EVs is projected to reach almost 640 terawatt-hours (TWh) in 2030[5] and 2333 TWh by 2040[6], marking a rapid scale-up in a decade once the ecosystem for EVs settles in. Given that the decisions on energy production assets that will be in their mid-life in 2040 are being made, now the implications are significant.

India's stated policy is very EV friendly. EV technology itself is advancing fast and the ecosystem is developing rapidly. In the coming decades, the total number of EVs in India is expected to increase sharply from under two million[7] at present. India is also moving rapidly towards enhancement of public transport; particularly metro rail which will move energy demand from petrol and diesel to electricity, apart from relative reduction in energy consumption levels. While the pent-up transport demand in the country is large, such shifts inevitably impact status quo.

[4] "World Car Sales Will Fall More Than 4 Million In 2019", Forbes, by Neil Winton, dated 12th June 2019
[5] Global EV Outlook 2019- Scaling-up the transition to electric mobility
[6] BNEF EV Outlook 2019
[7] EV Market Scenario India, Society of Manufacturers of Electric Vehicles (SMEV) – This data includes two, three and four wheelers

Electrification: Dramatic pick-up

The electricity sector is witnessing its most dramatic transformation since its birth more than a century ago

Dr Fatih Birol,
IEA Executive Director

Source: International Energy Agency

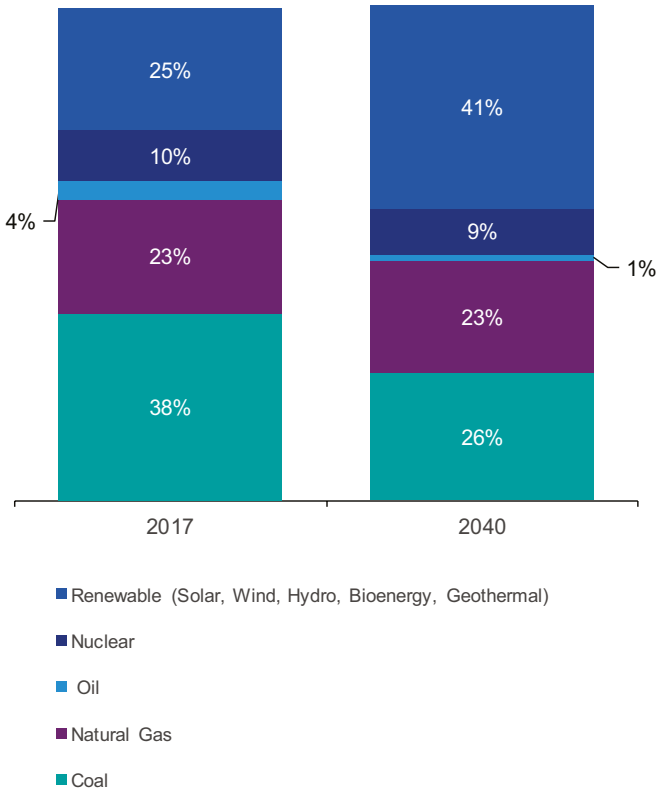
The pick-up of renewable energy has just about started

There is still a debate on the trajectory of growth of EV population on the roads, not so much because of the technology itself, but more for the infrastructure needed for them to flourish, and the cost trends. There is a vibrant ongoing debate on battery charging and swapping infrastructure, which has more real estate than electric dimensions. There is no such debate on the future of coal. New coal fired plants at scale are just not financeable in many parts of the world. Gas fired plants are expanding, but only where there is cheap natural gas available on tap, as it is in United States and some geographies. In contrast, wind and solar economics have improved rapidly.

According to the BP Energy Outlook 2019, renewable energy accounts for the fastest growing energy sector, which is estimated to grow at 7.1 per cent annually. Its share in global primary energy is expected to grow almost fourfold to 15 per cent by 2040 from its current share of 4 per cent. In terms of contribution to the electricity generation basket, renewables are set to grow above 40 percent, reversing positions with coal[8].

[8] BP Energy Outlook, 2019

Share of fuel in world electricity generation



Source: World Energy Outlook, 2018, International Energy Agency

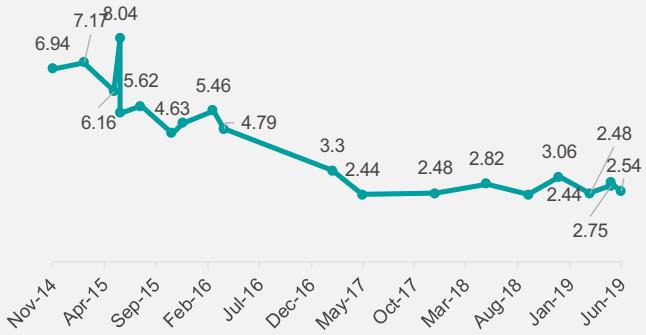
In the recent past, investments in renewable energy have been led by the European Union. The EU expects to meet over half of its power requirement through renewable energy (RE) by 2040. Emerging economies such as Brazil and India are also accelerating deployment of RE in power generation. Brazil, one of the leading energy consumers, has the highest share of renewables, which account for an approximate 45 per cent[9] of country's total energy consumption. China plans on generating 35 per cent of its electricity consumption from renewables by 2030. The major oil exporting nations in the Middle East are also making investments in renewable energy. The recent downturn in oil prices has prompted investors to turn towards renewable energy projects as an investment avenue. Saudi Arabia is expected to invest about USD1.5 trillion in the country's renewable energy sector. By the end of next decade, the country plans to generate 60 GW[10] from renewable sources[11].

In India, the new targets for RE by 2030 could be in the order of 350 to 500 GW[12]. Coal is expected to continue as the major fuel source for electricity generation in India. However, the share of electricity generated from coal is expected to decline and the share of electricity generated from renewables is expected to increase from about 16 per cent in 2017 to 38 per cent in 2040[13]. Less than a decade ago, this would have been considered a fantasy. Agencies, including KPMG in India, in its 2012 publication, 'The Rising Sun', laid out the construct for the rise of solar power, and that eventually solar would overtake conventional power in commercial attractiveness. That eventuality has happened. India has been witnessing a rapid fall in prices that have hovered for the past year in the stable range of INR 2.44 – 2.89 per kWh. More countries are increasingly committing to elimination of fossil fuels and providing

[9] International Energy Agency
[10] Gigawatts
[11] Published media articles, KPMG in India Analysis
[12] Energy Storage System- Roadmap for India: 2019-2032 by ISGF and IESA.
[13] World Energy Outlook, 2018, International Energy Agency (IEA)

a stable predictable market for renewables. Market stability, coupled with low interest rates, makes all the difference in capex heavy and opex light renewable projects.

Solar tariff trend in India



Source: Published media articles, KPMG in India Analysis

Market innovation is also helping reduce risks and prices of renewables. Recent solar bids in Portugal, Brazil and Saudi Arabia have returned auction prices of as low as USD17.5/MWh[14]. Companies which bid for solar in these nations were allowed a flexible, gestation period up to 36 months and contract tenures (15 years for Portugal and 20 years for Brazil) which allowed Independent Power Producers (IPPs) to benefit from open market sale.

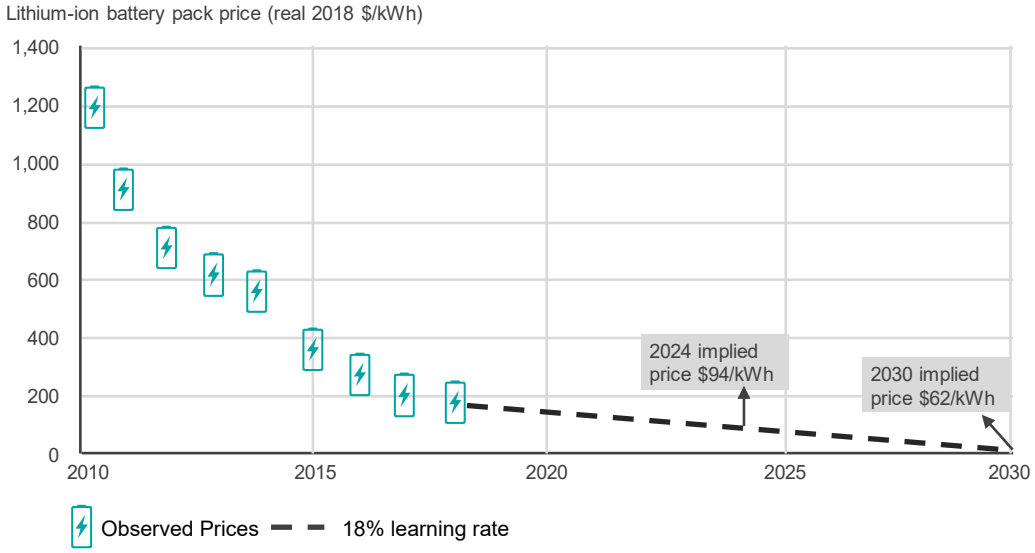
The bottom in terms of prices of renewables is yet to be seen. Dimming prospects of hitherto mainstream conventional resources are pulling in further capital into renewables and enhancing the faith of the market in these technologies. Further advancements in material sciences and manufacturing methods are imminent. The available scale is spawning further innovation in products, production, supply chain and in business models.

[14] Article on "Brazil A-4 auction signs 211 MW of solar for record-low price of $0.0175 kWh", PV-Magazine, dated July 1, 2019

Storage and new energy technologies will start evolving in tandem with renewables

The biggest challenge for, and from renewables, is in grid balancing because the main RE technologies are inherently intermittent. However, the world is coming to terms with the intermittency of renewables and is now finding more ways of managing the intermittency through flexing conventional generators, balancing through the power markets and finally through storage. This is already happening. Denmark already generates more than half of its electricity from variable renewable energy sources. In 2017, Costa Rica's electricity was generated entirely from renewable energy for 300 days. For several days in the past year, the power systems of Germany, Portugal and Denmark were able to run entirely on renewables[15].

Lithium-ion battery price outlook



Source: BloombergNEF

As per a special issue on the future of storage in India published in the 11th International Renewable Energy Storage Conference, IRES 2017, Düsseldorf, Germany, "The Demand For Storage Technologies In Energy Transition Pathways Towards 100 per cent Renewable Energy For India"[16], the authors have established through an hourly resolved simulation model that 100 per cent RE penetration is possible in India subject to low cost support of batteries.

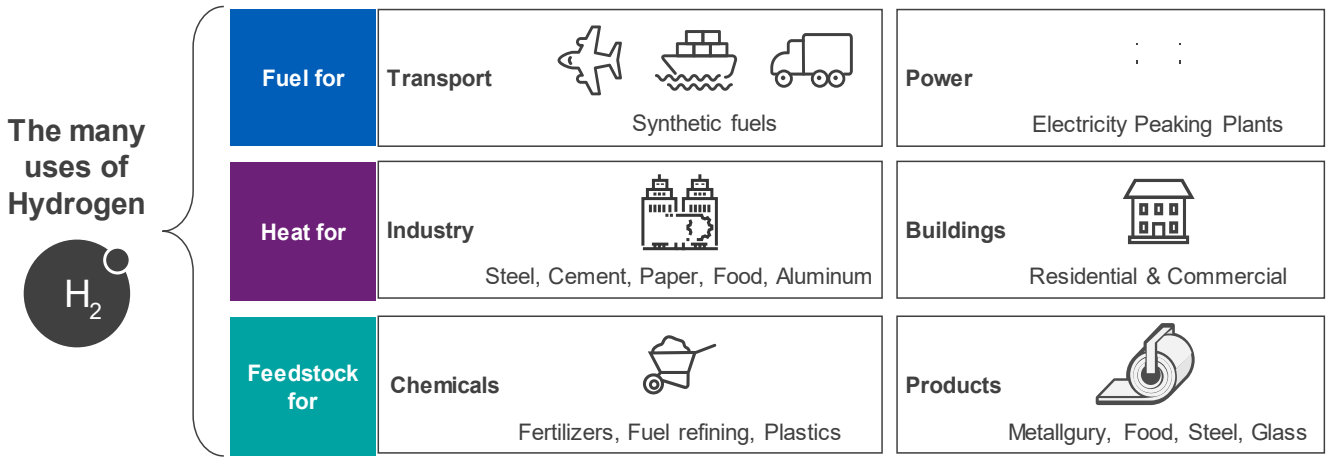
A modelling exercise by KPMG in India for several leading RE states indicates that RE penetration of 30-40 per cent (in energy terms) is eminently possible by 2025. India's large synchronously operated electricity grid inherently allows for great resilience and flexibility. As RE penetration increases, there will be need for storage requirements (battery, pumped hydro, other alternative forms), the extent of which will be known in the years to come and will be greatly linked to the cost of storage. It is variously foreseen that costs of battery storage systems, in particular, will continue to decline as shown in the adjacent graphic[17]. It also indicates that there is a strong case to promote battery storage with a firm policy and the right set of incentives. There is a window for India to seize the opportunity for batteries early and integrate back into

[15] Renewables 2019 Global Status Report, REN21

[16] "The demand for storage technologies in energy transition pathways towards 100% renewable energy for India", ScienceDirect, Energy Procedia 135 (2017), 37-50 by Ashish Gulagi, Dmitrii Bogdanov and Christian Breyer

[17] Article on "A Behind the Scenes Take on Lithium-ion Battery Prices", BloombergNEF by Logan Goldie-Scot, Head of Energy Storage, dated 5th March 2019

the research and manufacturing ecosystems. Pumped hydro also had a significant role to play in the current as well as evolving energy systems. Depending upon the characteristics of storage required by the system (say, for example, the Energy to Peak ratio, which determines the specific role suited for the resource in electricity grid management), several states have shown interest in pumped hydro storage technologies as the least cost storage option. India is looking to add hydro capacities of about 12 GW[18] in various forms encompassing storage, pumped storage hydro and run of the river projects with limited pondage.



Source: BloombergNEF

An important storage technology that deserves consideration is hydrogen, which has the potential to play a transformational role, especially when produced from renewables and operating in tandem with natural gas in the interim before it becomes mainstream for various applications. Bloomberg NEF predicts that the cost of producing hydrogen gas with renewables is likely to plummet 80 per cent by 2030, making one of the most radical technologies for reducing greenhouse gases economical[19].

There are other advancements in new energy technologies like carbon neutral nuclear fusion power reactors which may prove to be a resilient and an efficient alternative in the future. A group of start-up companies intends to capitalize on the nuclear fusion technology and wants to commercialize fusion by 2030s to meet growing demand of energy while tackling climate change in the most effective manner. A new private company named Commonwealth Fusion Systems (CFS) in collaboration with MIT has already attracted an investment of USD 115 million[20] for development of this technology with the objective to produce a working pilot plant within 15 years. One of the investors of CFS is Breakthrough Energy Ventures (BEV), an investment consortium worth USD1 billion led by Bill Gates and supported by global high net worth individuals including Mukesh Ambani, Jeff

[18] Ministry of Power, Government of India
[19] Article on "Hydrogen's Plunging Price Boosts Role as Climate Solution", Bloomberg, by Will Mathis and James Thornhill, dated 22nd August 2019
[20] Article on "Commonwealth Fusion Systems Closes $115M Series A, Makes Our Inner Sci-Fi Nerds Happy", Crunchbase news, by Alex Wilhelm and Mary Ann Azevedo, dated 28th June 2019

Bezos, Richard Branson, Jack Ma and Masayoshi Son with the objective of bringing climate friendly technologies to scale that can potentially reduce annual global greenhouse emissions by at least 500 million metric tons[21]. BEV has also invested in new innovative technologies in the fields of clean energy, energy storage, carbon capture, nuclear energy, waste to wealth across the globe and is also focused on sectors with high carbon footprints, including agriculture, transport, buildings and industries. In order to balance growth with sustainability, impact investing in high potential technologies by global investors like BEV is of utmost importance, which can successfully scale up the technologies from the lab to the masses.

[21] Article on "Bill Gates-led $1 billion fund expands its portfolio of startups fighting climate change", Quartz, by Akshay Rathi, dated 26th August 2019

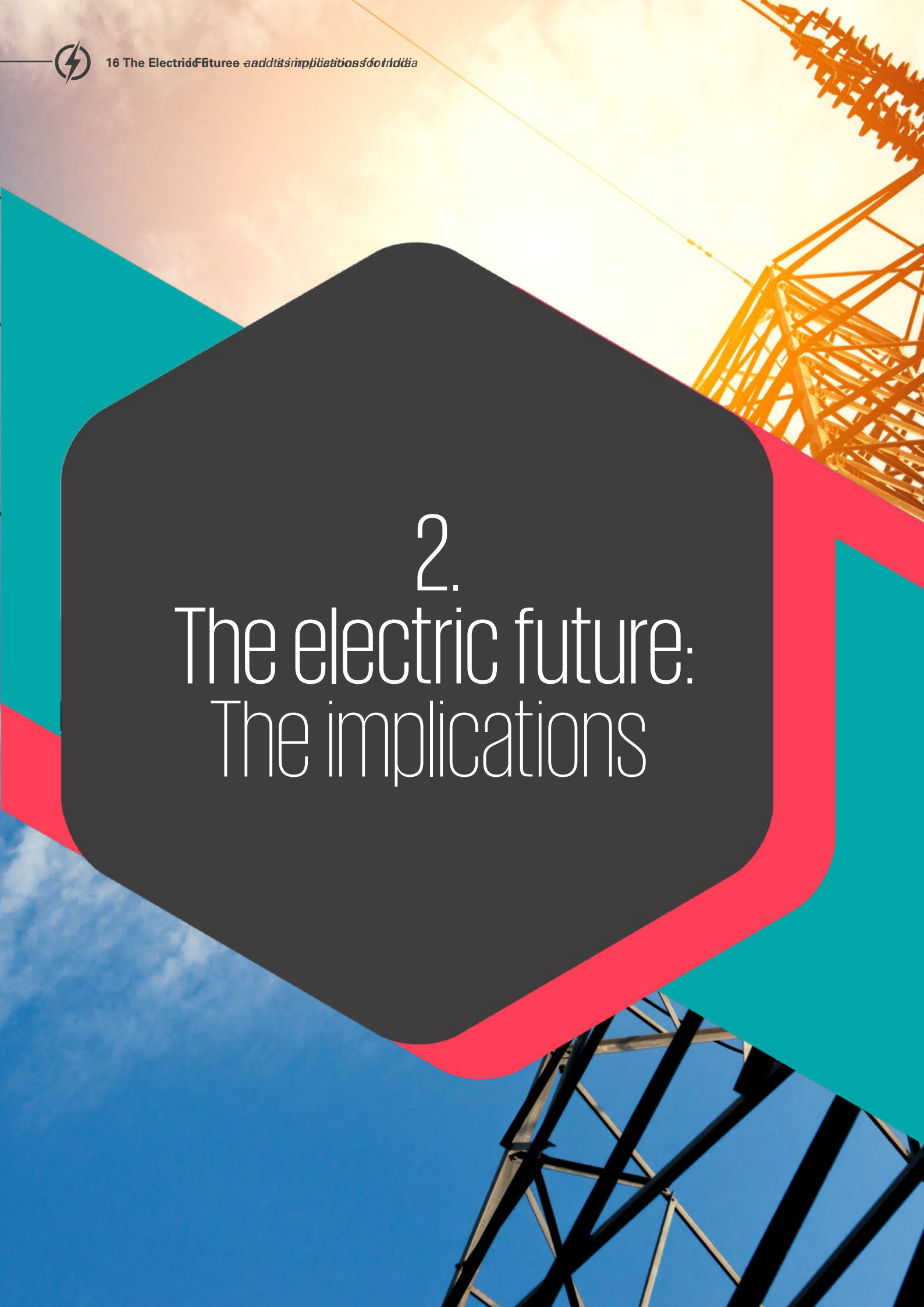
The implications of the transition for India have many dimensions

No rapid change comes without some adversities and consequences. Clear directional trends towards low carbon electric future, ushered in by a range of technologies operating in tandem are apparent. It will inevitably cause upheavals. Coping strategies would be needed on these aspects, thoughts around which are included in the document to engender a vibrant discussion. Like most radical changes the shift can lead to adversities but could well be converted to large scale opportunity. It is critical that the key imperatives are understood and appropriate strategies are adopted by stakeholders.

In the ensuing sections, we have chosen seven critical imperatives, which we believe need to be discussed and debated upon:

- Coal fired plants will need to become flexible
- A new wave of energy efficiency measures will be needed
- Circular resources economy will need to evolve simultaneously rather than as afterthought
- Businesses within and outside energy sector will be impacted and will need to transform
- New institutions capable of delivering change will have to evolve
- Governments will need to work to facilitate energy financing
- Macro-economic impacts on imports, remittances, employment, taxation structures will need attention

As India is set to become the most populous nation in the world, there are challenges related to employment, value addition, standards of living, technological leadership, environmental responsiveness, etc. However, the challenges can be converted to opportunities and propel the country to global energy leadership. In this paper, we argue that India will have to think and do differently to ensure that we do not miss the proverbial electric bus.



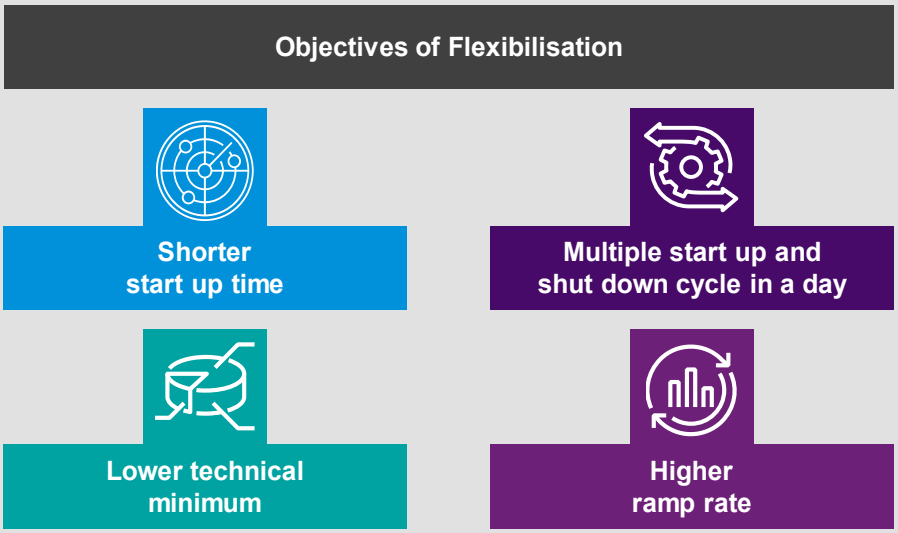
2. The electric future: The implications

Implication 1: Coal-fired plants - the elephant has to dance

Increased penetration of RE in the electricity system will lead to duck curve effects[22], requiring flexibilisation of conventional power plants. As per KPMG in India analysis, even a scenario with 130 GW of renewables instead of the planned 175 GW by 2022 could result in plant load factor (PLF) dropping to 35-40 per cent for many coal plants. Some may have to be seasonally shut down or mothballed.

Flexibilisation of conventional coal-fired plants was for a while resisted by existing operators on the premise that cycling and stop-start operations impair asset life and reliability. That is undoubtedly the case. If the option is between mothballing the plants versus operating the plants with technical, operational and commercial modifications, the latter option is surely preferable. Flexibilised coal-fired generation's new role will be akin to storage, having energy content available on tap for balancing grid variability when the need arises rather than its erstwhile role of being the bulwark of supply.

Flexibilisation of coal plants involves retrofitting of components and modifying operational processes for increasing cycling flexibility of thermal power plants so as to achieve lower technical minimum, reduce the start-up time, increase ramp rates and enable multiple cycles of start-up and shut down in a day.



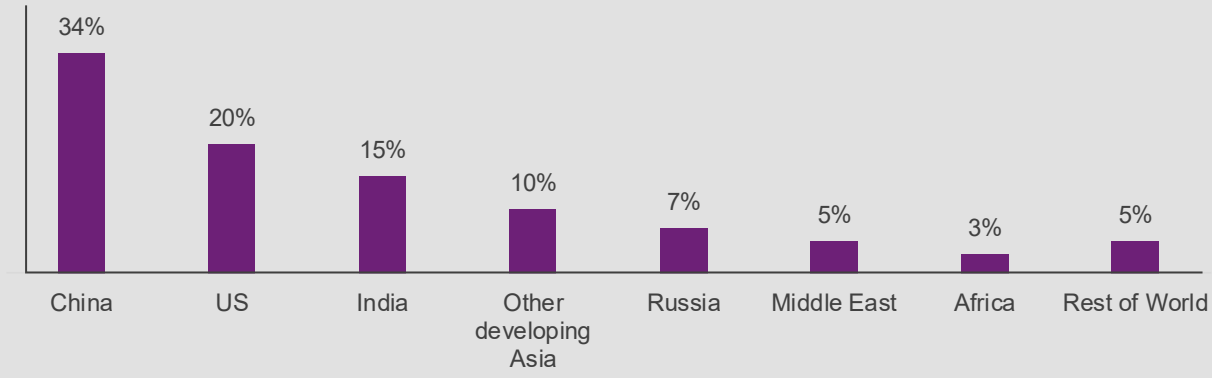
It is possible to typically reduce the minimum technical limits to 40 per cent in Indian conditions. However, this would require some amount of retrofitting of plant equipment and instrumentation along with extensive changes to operating practices and human competencies to safely manage cycling operations that feature frequent start-stop and ramping up and down of plants. Going substantially below 40 percent (as is done in Germany where plants go down to 20-25 per cent) would require coal quality to be improved and controlled and would also require significantly more capex. In many cases, the overall costs of retrofit may not be justified, especially for assets in the later parts of their life cycle.

[22] The Duck Curve refers to the phenomenon in the electricity grid where due to high solar generation system demand net of solar falls during the day but peaks sharply in the evening hours.

Implication 2: Efficiency in consumption - greater possibilities need to be tapped into

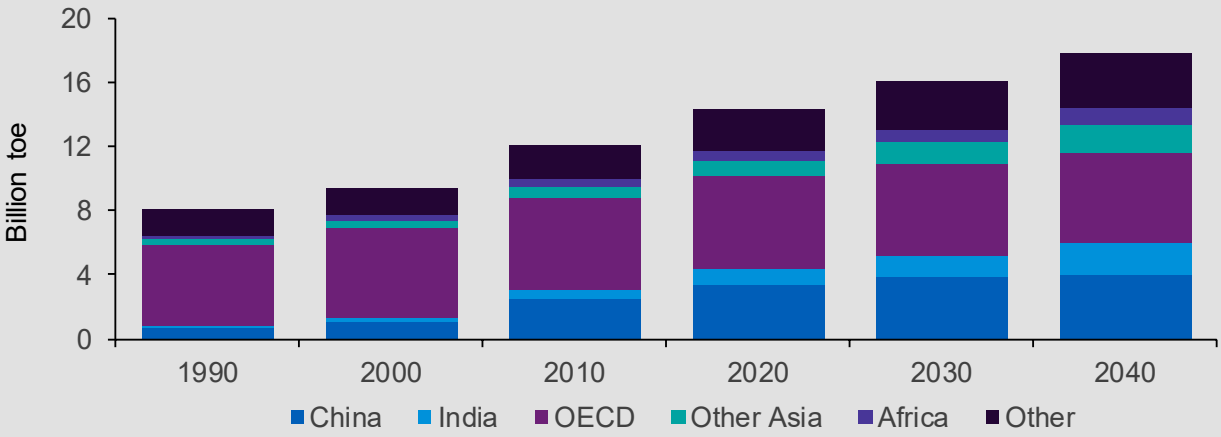
Improving energy efficiency in many large energy consuming countries has led to a decoupling of energy consumption with growth in output. Global primary energy demand is forecast to grow at 1 per cent[23] a year in the period to 2040, representing less than a third of the growth in GDP. However, with robust growth in population, coupled with rapid urbanisation and growth in middle class, this GDP/energy growth equation is not representative for developing countries. India will face a massive demand for energy, making the country, the highest contributor to the growth in primary demand in the world. BP Energy Outlook estimates a 156 per cent growth in primary energy demand in India between 2017 and 2040.

Contribution to primary energy growth in 2018



Source: BP Statistical Review of World Energy, 2019

Primary energy consumption by region



Source: BP Energy Outlook, 2019

[23] BP Energy Outlook, 2019

India needs to make an informed set of decisions to propel its development through a long-term balanced approach. Enhancing resource efficiency through energy efficiency measures, promoting circular use of resources to derive higher value with usage of lesser resources are some of the key imperatives for ensuring that the trade-offs between environmental goals and growth can be minimised. India has already made the commitment. PM Narendra Modi has said,

"*The respect for nature, the judicious use of resources, reducing our needs and living within our means have all been important aspects of both our traditions and present-day efforts. Need, not greed, has been our guiding principle*".[24]

Turning intent to practice involves a series of actions. In the energy efficiency theatre, India has made several strides through programmes that have helped it achieve 10 GW[25] of avoided generation capacity till about FY 17, such as implementation of LED bulbs under the Unnat Jeevan by Affordable LEDs and Appliances for All (UJALA) scheme, Perform, Achieve and Trade (PAT) schemes for industries, standards and labelling for equipment and appliances, Energy Conservation Building Codes (ECBC) for buildings, demand side management in agriculture/municipalities, etc. Areas such as transportation offer huge opportunities for energy eficiency through electrification and improvements in Intenral Combustion Engines (ICE) vehicle efficiency. Transportation contributes to 14 per cent to India's primary energy demand and the sector is witnessing rapid growth[26] as India modernises. In such a scenario, electrification of transport offers significant means to manage the growth in energy demand for India.

Similarly, there are higher efficiencies to be achieved in residential and commercial sectors through embracing digital technologies which deploy sensors, IOT and ICT platforms to facilitate analysis and consumption optimisation for energy management. It is estimated that smart energy management coupled with innovative financing can result in rapid savings in high consumption sectors. These form the basis of further interventions under the ROSHANEE[27] and other programmes of Bureau of Energy Efficiency to build on the considerable past successes that the country has had in this area.

Agriculture requires a large amount of energy. Unfortunately, due to its politically sensitive nature, it has proved difficult to bring about energy and water use efficiency in agriculture. Recent steps on solarisation coupled with devices like Brushless Direct Current (BLDC) pumpsets are positive moves. The potential to improve energy consumption, water usage and prevention of environmental degradation while improving agricultural productivity remains large.

[24] Speech by PM Narendra Modi while addressing the United Nations Climate Action Summit in New York

[25] Ministry of Power, Government of India

[26] BP Energy Outlook, 2019

[27] Roadmap of Sustainable and Holistic Approach to National Energy Efficiency (ROSHANEE)

Implication 3: Circular economy - need to evolve in tandem

The transition from take-make-waste model of virgin, non -renewable sources across all strata, needs to be redesigned from a circularity hierarchy perspective to bring in resource efficiency. The entire theme of a circular economy is gaining currency as resources become scarcer and environmental consciousness takes roots. Therefore, the circular resources economy needs to evolve simultaneously rather than as an afterthought.

> We need to adopt a new model of energy conservation based on a circular economy and way of life - not merely reducing waste, but also decreasing the need for raw materials
>
> *Claudio Descalzi, Eni CEO*
>
> Source: The future is round by Mike Scott, Eniday

The basic philosophy of circular economy is 6R – Reuse, Recycle, Reduce, Redesign, Recover and Remanufacture. The cycle seeks to preserve, restore and regenerate, thereby enhancing the productivity of resources, promoting long-term sustainability and security and reducing risks to the system.

Till date, continued investments in linear business models and infrastructure have hindered the transition into circular economy. With an aim to become a USD5 trillion economy by 2024, India is focused on increasing its domestic manufacturing capability and resource consumption, and this is the right time to integrate circularity in planning approaches. A step in this direction has been taken with the issue of the draft National Resources Efficiency Policy by the Ministry of Environment, Forest and Climate Change which seeks to create a facilitative and regulatory environment to mainstream resource efficiency across all sectors[28].

A key sector that the policy focuses on is solar. A 100 GW of solar capacity entails an estimated demand of ~7 Mn tonnes of materials including glass, aluminum, silicon, silver, etc. which can be retrieved and recycled, reducing the stress on resources[29]. Also, solar panel disposal at the end of the useful life of 20-25 years needs close attention. Under the proposed policy, an 85 per cent recovery rate of discarded PVs is proposed through interventions such as setting up recycling infrastructure that can manage large volumes of PV modules disposed in future, access

[28] Draft National Resource Efficiency policy, 2019 by Ministry of Environment, Forest & Climate Change
[29] KPMG in India Analysis based on data provided in Draft National Resources Policy

to finance for such facilities, reverse logistics and dismantling, etc.

With the advent of EVs and batteries, India also needs to plan for issues around conserving natural resources and addressing end of life issues for batteries. Several large corporates have announced plans to set up battery recycling facilities. However, clearer policy initiatives towards EV, batteries and effective disposal of waste will be critical. Almost 30-40 per cent of li-ion battery's weight is from valuable cathode materials. However, the current recycling rate of batteries even in advanced economies is less than 5 per cent at present[30]. This not only lends to a less economical use of valuable resources but also contamination of soil and groundwater if the batteries are disposed in landfills. Countries such as the U.S. and U.K. have taken the lead in research by establishing battery recycling R&D centres/programmes. Department of Energy of the US Government has also launched prize money for encouraging innovation in this field.

The case studies below, focus on the burning issues governing circular economy in energy highlighting innovations from around the world.

Recycling of materials Lithium ion battery

American Manganese Inc.

A critical metals company focusing on the recycling of lithium-ion batteries

- The company has patented a process, RecycLiCo for recycling cathode materials in li ion batteries
- The process provides high extraction of lithium, cobalt, nickel, manganese, and aluminum at battery grade purity, with minimal processing step
- A recent pilot has demonstrated a purity of 99.94 per cent from materials recovered
- This would eliminate waste from landfills thus addressing issues of
  1. Contamination
  2. Reduce stresses caused by mining
  3. Recycling of critical metals

Source: Official website of American Manganese Inc.

Carbon use

LanzaTech

A tech start up converting carbon to sustainable alcohol

- The company uses anaerobic bacteria to ferment waste emissions from industry to make ethanol
- Ethanol can then be used as a low carbon fuel and can be converted downstream to jet fuel, diesel, and household products
- The approach addresses the planet's climate crisis on two fronts.
  1. Incentivises companies to capture the emissions driving global warming
  2. The process stands to reduce demand for energy resources

Source: Official website of LanzaTech, Published media article

Utilization of residues from industrial processes

Hamburger Containerboard

A leading brown containerboard paper manufacturers in Europe

- The company has an on - site power plant that utilises residues from paper recycling
- 95% of the waste generated during production is recovered and a majority of the waste is utilized in the power plant which has a multi fuel boiler for energy generation
- This has helped the company achieve
  1. Reduction in procurement of grid electricity
  2. Avoid waste disposal in landfills

Source: Official website of Hamburger Containerboard

The economics of recycling are in turn dependent on the core commodity prices. For example, a reduction of solar PV module prices could render recycling of solar PV modules uncompetitive. Thus, conventional wisdom on low prices creating demand for products/ commodities does not quite hold true in a circular economy. For the eventual greater good circular economy has to scale up, but conventional levers of the economy and some of the key players could well be disrupted. At the minimum, planning approaches need to take adequate cognisance of the circular economics and help create the circular ecosystem through mandates and incentives.

[30] Article on "It's time to get serious about recycling lithium-ion batteries", Chemical & Engineering News (c&en), by Mitch Jacoby, dated 14th July 2019

Implication 4: Businesses transformation – time to pick momentum

Businesses along the energy value chain by the energy transition will need to transform rapidly and radically. In the wave of a rapid switch to a low carbon economy, traditional major energy providers have begun to plan their strategic response to the growth potential in the renewable energy sector. Conventional power utilities were quick to anticipate the trend and have been adopting strategies to help them diversify to green power for the last 4-5 years. The realisation within the big oil companies has just begun to dawn and after many stops and starts renewables and the circular economy is increasingly on their radars.

In India, the trend is also being witnessed in both traditional power generation companies as well as Indian oil and gas industry. Companies such as NTPC, Indian Oil Corporation and GAIL have made large plans to invest in green energy projects, including solar, wind power, bio-fuels plants, and EV charging stations[31]. However, despite access to capital, technological know-how and project management capabilities, investing in new energies poses challenges around risk- return tradeoffs and agility in decision making. This needs to be addressed through organisation realignment, culture shifts and a strategy which focusses on leveraging strengths but redefining protocols to up the game.

[31] Article on "Indian Oil Corporation to invest Rs 25,000 Cr in green energy", Economic Times, dated 19th August 2019

Businesses will often have to restructure to unlock value. Globally, trends have been witnessed where traditional utility businesses are restructuring to unlock value and enhance competitiveness. With the energy sector in deep transition affecting fortunes, large utilities are employing innovative strategies to forge forward. A case in point is the asset swap deal between EON and RWE which saw two of the largest utilities in Germany with similar vertically integrated businesses optimally combine to focus on either upstream or downstream activities based on their strengths. This followed individual restructuring initiatives by each company where they sought to unlock value by entirely separating their "clean" businesses.

While the transformation will have many dimensions, two are especially noteworthy. The first is the business model transformation where traditional energy infrastructure players will have to transform to service driven models (often through subscription) as the distinction between products and services merge and there is a shift towards consumption-based models where users pay for the utility they derive rather than the product they buy. The second is on digital transformation where energy companies have to rapidly turn digital to cope with the new players who emerge to tap into the convergence and the new consumer trends. This will often be a tortuous process where traditional players will struggle to balance between retention of their traditional advantages while seeking to serve the new age consumer markets and preferences. Incumbents who fall behind the curve on these aspects stand to imperil themselves.

Orsted, a Danish traditional energy player transformed from DONG Energy to **go fully green** with RE share at 80% today (from 17% in 2006) and is targeting **zero emissions by 2025**

Vattenfall, Swedish electricity utility with sales of USD 10 bn aims to become "**fossil-free within one generation**".

Equinor (erstwhile Statoil), a USD 80 bn oil & gas major, **is focusing strongly on new energy**, with 1.25 TWh RE generation

Implication 5: New institutions with new capabilities have to evolve

As traditional boundaries of the energy sector disintegrate, value chains get disrupted and new technologies gain center stage in the future energy paradigm, new institutions capable of delivering and managing change will have to evolve. Organisations will also need to develop capabilities and up-skill their employees to survive and grow in an exceedingly complex business environment. A key area of innovation in future power systems is in system operations as distributed energy resources (DER) scale up. Such DERs would need to be supported in their integration in the local grid as well as leveraged for flexibility services, optimisation of network spends, etc. Here, distribution system operators (DSO) could play a pivotal role by providing system integration services including forecasting, real time monitoring, and procurement of DER for grid services as well as establishing local market places when regulations permit.

Globally, the increasing role of DSOs is gaining prominence. The U.S. and EU countries are front-runners in expanding DSO responsibilities. The European Union's draft Electricity Regulation requires DSOs to facilitate the integration of distributed energy resources. In a similar initiative, the Open Networks project in the U.K. lays the foundation for the transition of distribution network operators to the role of distribution system operators.

The new arrangements are also spawning new forms of innovation as the energy grid moves closer to the user. UK Power Networks, a DSO operating in the U.K., aims to create London's first virtual power plant (VPP). A technology trial led to reduced peak evening demand by 60 per cent[32].

Apart from the DSOs, the role of utilities and regulators will also need to mature to accommodate the transition. In general, there should be more openness to innovation and market forces along with a change in mindset by the institutions which can act as enablers of the transition.

In the Indian context, all of the above are relevant. As DERs become mainstream and their management as well as leveraging their potential for grid services become a necessity, DSOs will need to evolve. India could plan ahead by having the frameworks in place at the centre which envisage the expanding role of the utilities and lay down the regulatory and market changes that need to accompany such a transition.

[32] Article on "Electricity network plan to launch London's first 'virtual power station", UK Power Networks, dated 22nd June 2018

DSO - moving closer to the user

Firstly, the regulatory framework needs to define clear roles and responsibilities for DSOs and to incentivise innovation.

Secondly, there is a need to standardise the collection and sharing of data by DSOs as this will be crucial in providing value added services to consumers, as well as enabling successful system operation and management.

Lastly, smart hardware backed by communication infrastructure is needed to facilitate complex interactions betweenDSOs and DERs.

Report on "Future Role of Distribution System Operators" by IRENA

Implication 6: Financing will require government reassurance

In a rapidly disrupted environment accentuated by climate change, investments risks will be high and reliable returns could be difficult to come by. Yet the quantum of finance required will be high, especially in growth economies like India. As per an analysis done by Observer Research Foundation, a public policy think tank, India's transition needs stand at USD2.3 trillion in climate action through 2030. This is apart from regular infrastructure financing for new assets and maintenance of existing assets which will require significant sums as the economy grows and the infrastructure deficit is sought to be addressed as the country modernises.

The requirements also need to be seen in the context of the prevailing political economy that has deep influence on private investments. Even as renewable energy has emerged as one of the most competitive sources of energy attracting USD42 billion flows into Indian renewable energy sector over the last four years[33], there are significant challenges. The country and the sector have been struggling with (a) curtailment of generation (b) financial dues from procurers and (c) threats of contract reneging which is choking the flow of investments into this space. Areas such as solar roof top, which have a huge potential in India and can also address grid challenges posed by large scale projects, have not been

Kelkar committee: select recommendations for public private partnerships (PPP)

1. Trust and partnership to be fostered in long duration relationships
2. Risks may not have been contemplated during contracting. Objective renegotiation should be permitted
3. Independent regulators need to be set up for sectors going into PPP

[33] Over $42 Billion Invested in Renewable Energy Sector in India in 4 Years, ETEnergyworld.com dated June 05, 2018

able to gain traction owing to discomfort of financiers around scale of project, transactions costs and counter party risks. Additionally, financiers have been skeptical in lending for emerging solutions like battery storage owing to technology risks, lack of regulatory clarity and uncertain pay back periods.

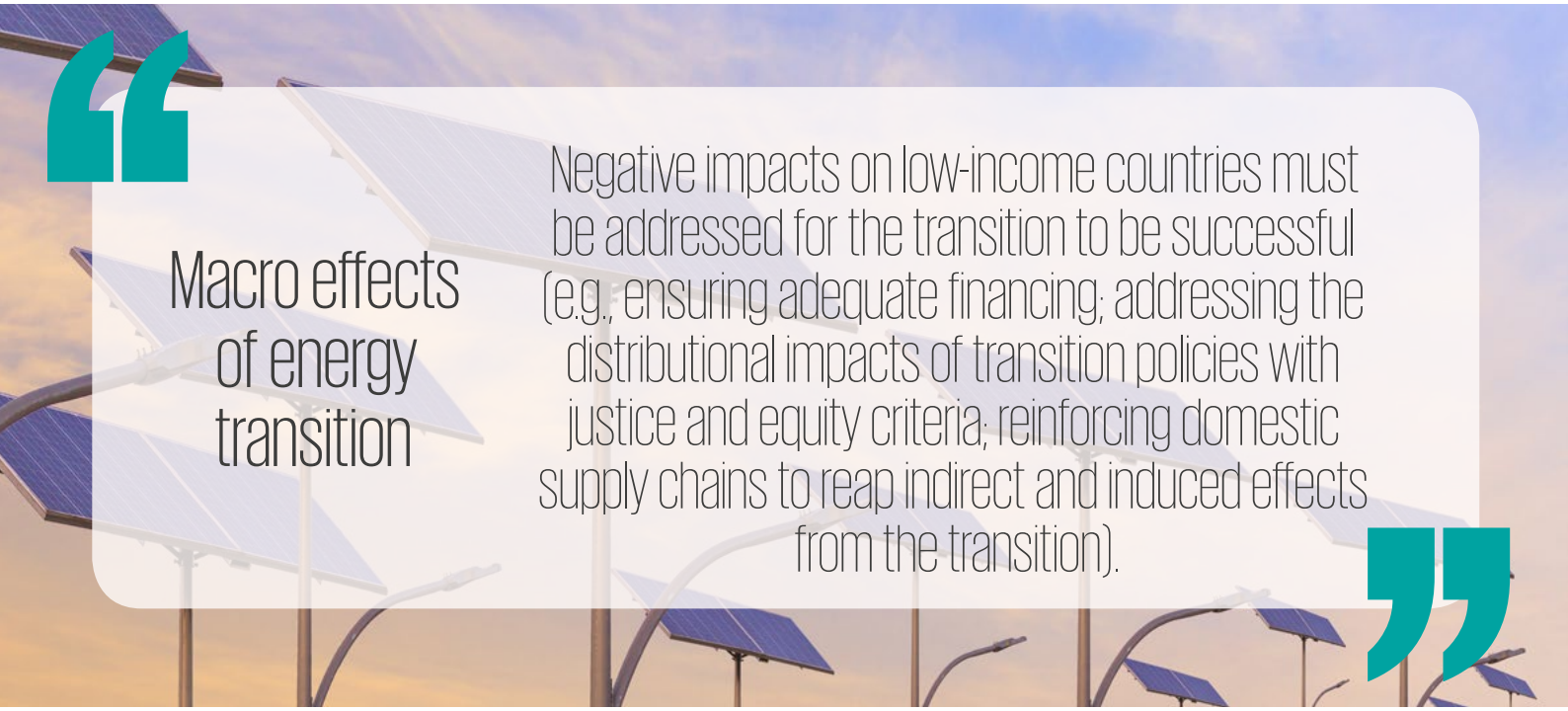
For India to successfully move forward on its path towards energy transition, financing would be a key enabler which would need to be addressed through investment-friendly regulatory framework conditions, innovations in products which encourage financing in new technologies and government support to encourage broader societal inclusion. This will be a journey and the foremost measure that will be required is to ensure policy stability, not changing the rules of the game post-facto and recognising that legitimate risks will have to be priced in. For those that cannot be priced in, or can cause the pricing to be astronomical, governments would have to step in directly to finance the projects or evolve guarantee arrangements to ensure that risks which private capital cannot bear are not passed on to them through one-sided contracts. Finally, in a disrupted world there will be unforeseen events and disputes around them since no contract can take into account the eventualities of a 25-30 year contract term. Credible mechanisms for resolving challenges and disputes need to be put in place for such eventualities.

Implication 7: Macro-economic impact on imports, remittances, employment, taxation structures will need attention

The transition to a low-carbon global economy is a system-wide change which will impact most countries significantly. Countries like India with high oil and gas import bills will obviously stand to gain with electrification and a shift to renewables. India today imports ~84 per cent of its oil requirements spending USD112 billion on oil imports, nearly 4 per cent of its GDP[34]. Conversely, taxation on hydrocarbons is among the largest sources of tax revenues. The central excise collection from oil and gas been in the order of INR 2-2.5 lakh crore for the last few years contributing 1 per cent to the country's GDP[35]. State taxes on oil is a principal source of budgetary revenues for the states. In contrast electricity is much more difficult to tax as compared to hydrocarbons. The ability to compensate the loss of taxes due to the energy transition is limited since electricity tariff is a sensitive matter.

A critical sector that would be impacted with the energy transition is the auto segment, which provides jobs to 1.9 crore people directly or indirectly and accounts for 7.1 per cent of the country's GDP. As the sixth largest auto producer in the world, India has emerged as a global supplier and been among the few success stories of Indian manufacturing. The net impact on the employment on account of transition to EVs needs to be contained by bringing in self-sufficiency in EV technologies. If India does not get its manufacturing story right, it could spell a double whammy. On the one hand, India would lose the opportunity to substantially rebalance the fiscal deficit equation, while on the other, the country could face a severe GDP and employment loss.

India and South Asian countries in general, rely heavily on remittances from oil producing nations in the Middle East. Countries exposed to stagnation and fall in fossil fuel production will likely restrict employment opportunities for overseas citizens. Even more than the overall value of the remittances for the countries, a greater concern is the extent of dependence of individual households on remittances. Indians count among the largest working diaspora in foreign countries at about 16 million. United Arab Emirates (UAE), USA and Saudi Arabia are the top



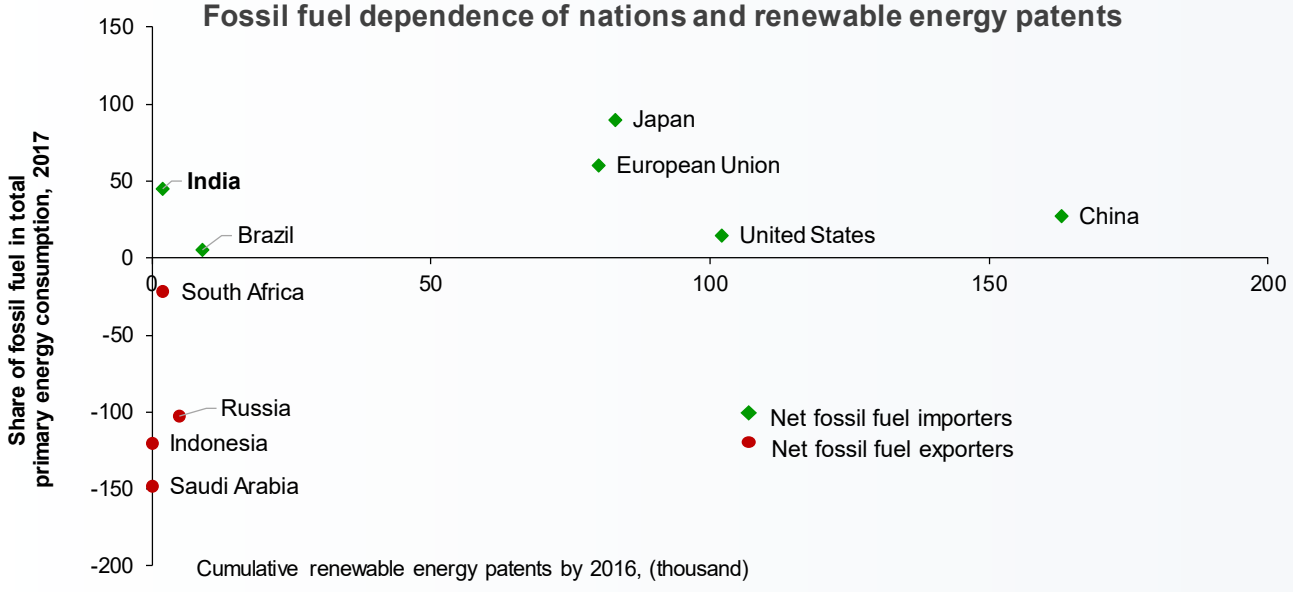
[34] Oil ministry's Petroleum Planning and Analysis Cell, GDP data from World Economic Outlook (April 2019 data)

[35] KPMG in India Analysis based on Petroleum Planning & Analysis Cell (data as on September 1, 2019), GDP data from World Economic Outlook (April 2019 data)

three source countries for India remittances. Currently, remittances account for 3.3 per cent of India's Gross Domestic Product (GDP). In countries like Nepal this is as high as 25 percent. History has demonstrated that an economic slowdown in oil-gas rich countries can negatively impact remittances. For example, when oil prices dropped from more than USD100 per barrel in June 2014 to as low as USD27 by mid 2016, the remittances to India dropped from USD71 billion in 2014 to USD63 billion in 2016[36]. Future drops could be sharper.

Some hydrocarbon-rich countries are showing resilience and are likely to strengthen their long-term growth prospects by diversifying their economies thereby somewhat mitigating the impact on employment and remittances. In recent years, several oil exporting countries have developed economic diversification plans to increase their resilience. For example, in its New Vision 2035, Kuwait has announced plans to becoming a regional financial and commercial hub for the northern Gulf. The Saudi Vision 2030 envisions creating the world's largest sovereign wealth fund, improving government efficiency, etc. Despite these measures, replacement of fossil fuel revenues for these nations in entirety is unlikely.

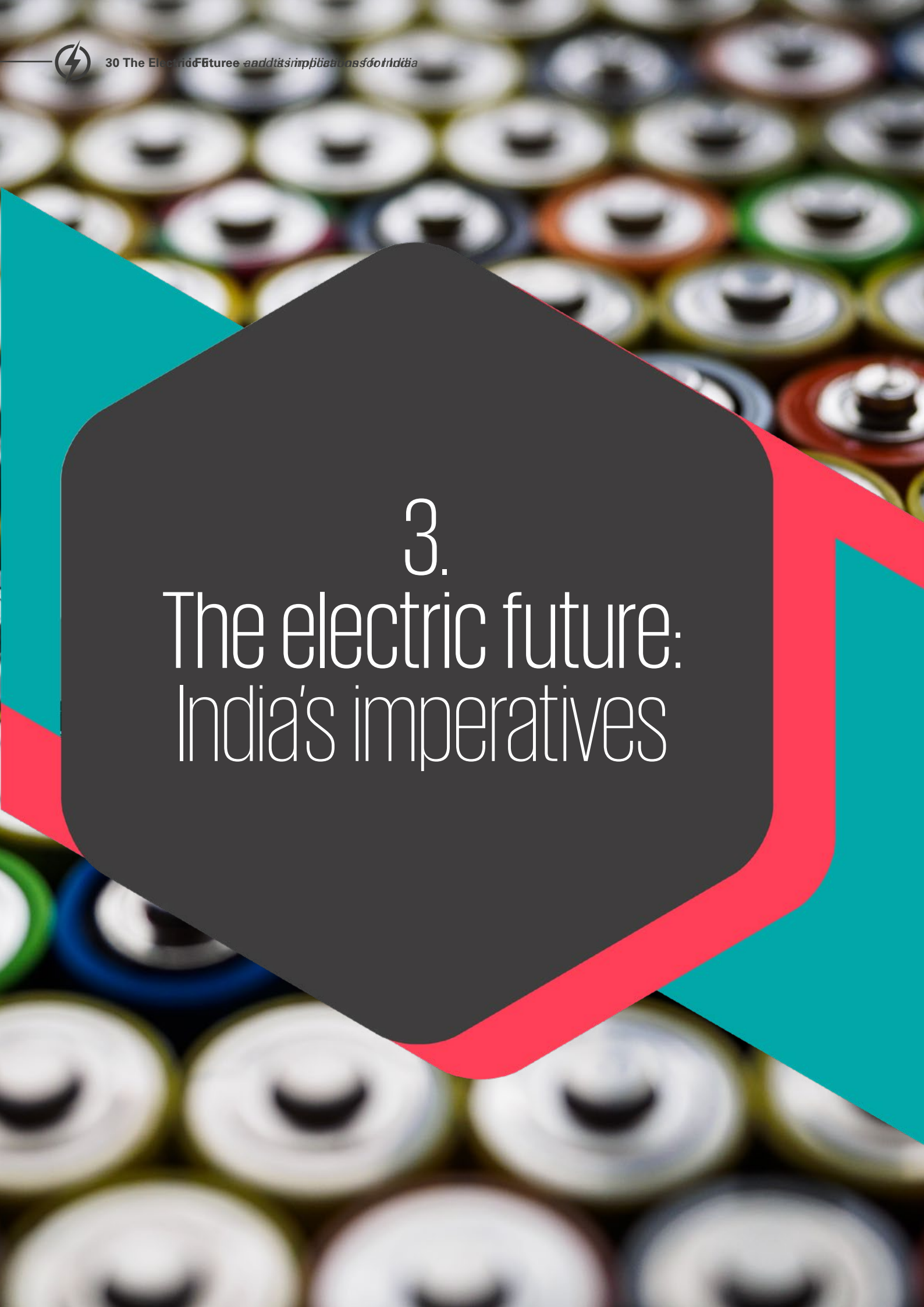
From economic development and employment perspectives India needs to plan for her own response to this change in the energy landscape. India's greatest strength is the large consuming economy, and this gives the country global clout. At the same time the capability to consume comes only when human resources are productive. The country has 5 – 7 million youth entering the workforce every year[37] and the education levels on the average have improved tremendously. Making this youthful and talented workforce productive is an imperative. The road to that starts with technological leadership and manufacturing base. India has hitherto been behind the curve in the past decade during the transition to renewables. The nation cannot afford to miss the opportunity as the country and the world step into the broader electric future.



Source: BP, IRENA

[36] World Bank data on remittances, KPMG in India Analysis

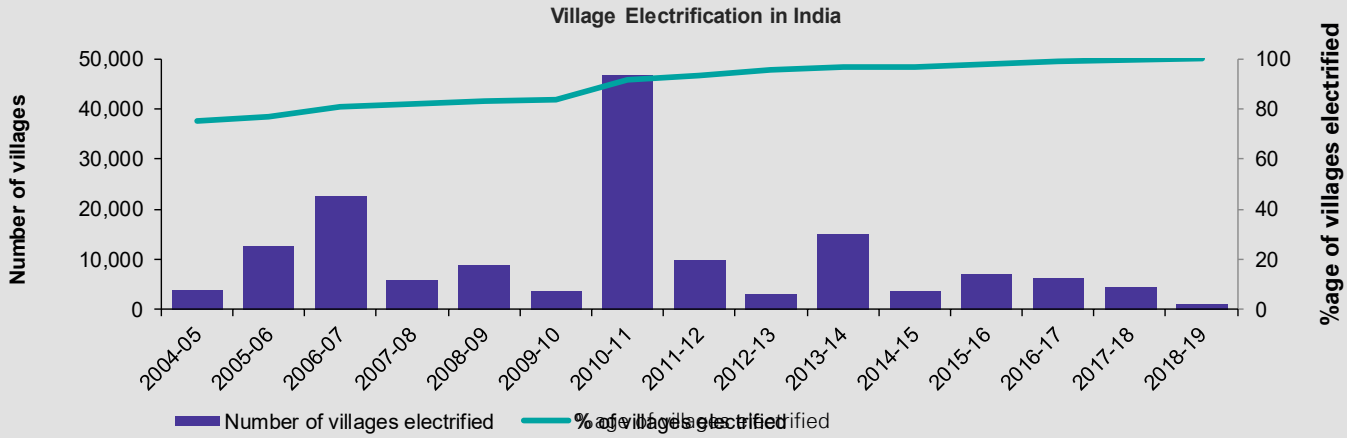
[37] Labour Bureau and World Bank estimates



3. The electric future: India's imperatives

This paper started with the electrification imperatives in a carbon constrained world. The imperatives for India as a country go well beyond carbon. In the end, it comes down to the basics: do we have the right products and services for the market; is the pricing right; are the delivery channels appropriate for the age that we live in. As the country moves towards renewable energy and energy storage from conventional resources, there are massive economic implications of the pathways that we choose for technology development, manufacturing, production, supply and pricing. In many ways, our approach in ushering in the new world of energy will determine the health of the economy and well-being of citizens and the youthful workforce.

India just cannot miss the fact that we need to build a producing economy rather than just being a consumption centre. Large swathes of population still live below acceptable standards of economic well-being. Governmental initiatives in the past few years have transformed energy access. The next wave must focus on economic development using energy, and in particular electricity, as a principal resource lever.



Source: Central Electricity Authority

India needs to garner competitive advantages in production that will help leverage its large consumption base. We identify four imperatives from an energy standpoint for that economic transformation:

1. Energy goods must be substantially produced in India to take advantage of the large consumption base

2. Energy prices for the producing sectors must be lowered and artificial cost build-ups removed

3. Energy services must be modernised to allow for efficiency and innovation in consumption

4. Energy markets must be furthered to allow for flexibility and lowering of transaction costs

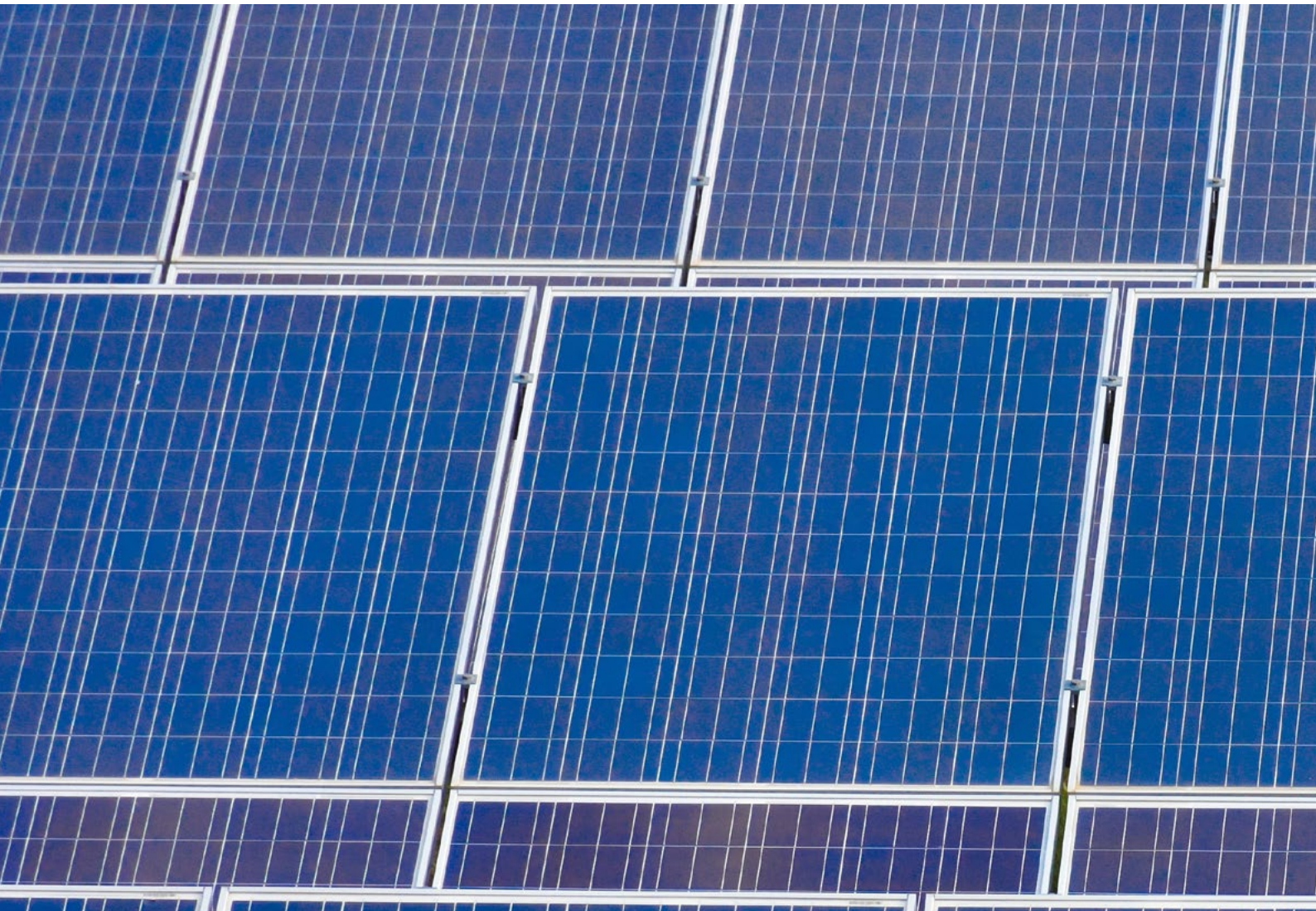
In the coming years the investments required in energy projects will be to the tune of INR 200,000 crores per annum or more[38], through the electricity value chain. Basis current estimates solar energy will have a preponderance among the generation resources in the coming decade. The cost of capital equipment constitutes most of the overall project costs. India imports more than 90 percent of the modules[39] of the required capital equipment, mostly from China. As demonstrated in the previous section, China has taken a huge technological leap in renewable energy, exemplified by the number of patent awards. As new energy products like battery storage and hydrogen come into play, India must **aim for technological leadership ab-initio**. Government's priorities must be clear in this regard, as they are in China.

[38] KPMG in India Analysis based on the data provided in National Electricity Plan, January 2018

[39] Ministry of Commerce and Industry data

Technological leadership, even if achieved, must be nurtured and expanded through **large scale manufacturing**. Here, India is at a disadvantage because infrastructure, including power, is unreliable and expensive, and taxation levels are high. As per the recent developments, the government has brought down the tax rate for new manufacturing units to 15 per cent to enable a better market for domestic manufacturers . Unlike China, through electricity tariffs, India has looked towards the industry to subsidise other sectors. That is not tenable if India wants to look at manufacturing leadership. Industrial electricity tariffs for all producing activity – but especially for identified priority sectors – must be brought down to make manufacturing competitive in areas where the end-use market is large and employment generation and economic multiplier effects are high. To reiterate, *only large-scale manufacturing can sustain technological advantages over time*.

For pricing to be competitive the country needs to throw open retail electricity supply to usher in competition and innovation. That is not possible in an ossified electricity distribution sector. Experience has by now demonstrated that state ownership is a monopoly structure and does not provide incentives for efficient supply and commercial innovation. With increasing options on the supply side in future, electricity will be delivered increasingly as a complete service by the service providers rather than as a rigid product. The supply side of electricity requires competition and innovation for that to happen. Alternative means for that could be franchising, licensing or any other alternate form. Also, even as politically challenging as it is, governments of today and tomorrow must consider privatizing the sector entirely. In a fast-changing world, the legacy



arrangements just don't have the strength to deliver for the country.

Energy markets must be opened up and deepened to allow for greater flexibility and lower the transaction costs. For this there are several asks. The building blocks in terms of Universal Service Obligations (USO), planning regimes, data disclosure, capacity adequacy statements and appropriate penalties for load serving entities for defaults must be in place. These are standard requirements in any modern power system. For a country that features the largest synchronous power system in the world, India is woefully behind the curve on these aspects. The existing Day Ahead Markets (DAM) must be deepened and new product-markets introduced for vibrancy in intra-day trading and ancillary services. Contractual rigidities that have not only affected the power sector but have, in turn, lacerated the financial sector must be dealt with and not allowed to persist. Fuel markets must be liberalised. Vibrant power and fuel markets will go a long way in supporting clean energy and its integration.

The final recommendation of this paper is on **overhauling sector governance.** Authorities in governance and regulatory roles in the sector must define their charters aligning to the overall economic and sector agenda and act accordingly. Energy is and will always remain, a sensitive commodity since it touches ordinary lives very deeply. At the same time energy is also the fuel of economic growth. Just as India has been working to bring its energy products to global standards (especially in hydrocarbons), its energy governance must also measure up to world standards. Presently the gap, especially in electricity, is far too large and unsustainable. To measure up to the asks of a young, growing, vibrant and ecologically responsible economy, India must also radically change the sector ownership arrangements and governance to usher in the electric future.

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