ENERGY TRANSITIONS COMMISSION INDIA

The ROCKEFELLER FOUNDATION

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Creating Innovative Solutions for a Sustainable Future

Sustainable Action Dialogue New York

Leadership Coalition on Energy and Industry Transition

24 September, 2019

WSDS

SECOND INTERNATIONAL PRE-EVENT OF THE

WORLD SUSTAINABLE DEVELOPMENT SUMMIT 2020

29 - 31 January, 2020 I New Delhi, India

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PREFACE

Hosted annually since 2001 by TERI, the World Sustainable Development Summit (WSDS) is one of the largest international events dedicated to accelerating the pursuit of sustainable development. The WSDS has continued the legacy of the erstwhile Delhi Sustainable Development Summit (DSDS) which was initiated in 2001 with the aim of making 'sustainable development' a globally shared goal. The Summit series has over the years brought together 47 heads of state and government, 13 Nobel laureates, ministers from 64 countries, 1700 business leaders, 1900+ speakers and over 13,000 delegates from across the world.

The 2020 edition of the WSDS is scheduled from January 29-31, 2020, in New Delhi, India and will be held under the broad rubric, 'Towards 2030 Goals: Making the Decade Count'.

Possibly the sole Summit on global issues taking place in the developing world, WSDS now strives to provide long-term solutions for the benefit of the global community by assembling the world's most enlightened leaders and thinkers on a single platform.

Each year, in the run-up to the Summit, a series of international and national pre-events are held in the form of 'Sustainable Action Dialogues'. These pre cursor events intend to extend the degree and goal of the Summit. The first 'Sustainable Action Dialogue' was hosted this July in Monaco, followed by two Regional Dialogues in New Delhi and Kolkata.

The international dialogue in New York is being held by TERI as part of the ETC India work programme. Titled 'Leadership Coalition on Energy and Industry Transition', the session is being held with the support of The Rockefeller Foundation. The special session is being hosted on the margins of the Climate Action Summit and the 74th United Nations General Assembly. It will focus on the themes of 'Accelerating the Decarbonization of Electricity in India' and 'Enabling the Decarbonization of Indian Industry'. Deliberations from this dialogue will be brought forward to the main Summit stage in January next year.

Leadership Coalition on Energy & Industry Transition

Sustainable Action Dialogue: New York

A World Sustainable Development Summit (WSDS) 2020 International Dialogue

24 September, 2019 | 3.00 – 6.30 p.m.

Venue: TDR, 23rd floor, The Rockefeller Foundation, 420 5th Ave, New York, NY 10018, USA

Tentative Agenda

Time	Session
2.00 p.m. onwards	Registration
3.00 – 3.30 p.m.	**Inaugural Session** **Welcome and presentation on WSDS (3 minutes film)** **Dr Annapurna Vancheswaran,** Senior Director, TERI **Setting the theme** **Dr Ajay Mathur,** Director General, TERI **Special Address (Invited)** • **Ambassador Luis Alfonso de Alba,** Special Envoy for the 2019 United Nations Secretary-General's Climate Action Summit • **Ambassador Syed Akbaruddin,** Permanent Representative, Permanent Mission of India to the UN • **Ms Isabella Lövin,** Deputy Prime Minister, Sweden **Inaugural address** • **Mr Prakash Javadekar,** Hon'ble Indian Union Minister of Environment, Forest and Climate Change
3.30 – 4.40 p.m.	**Accelerating the Decarbonization of Electricity in India** This session will provide an update of the progress, prospects and challenges with the transition to a low carbon power system in India. It will examine the opportunities and challenges to the growth of renewables, including the need to significantly increase the flexibility of the power system in order to integrate variable renewables. It will discuss policy initiatives that have aimed at supporting the growth of variable renewables. It will summarize various projections for the growth of zero carbon power in the Indian mix by 2030, and draw implications for the implementation of India's NDC.

	Chair: Mr Nigel Topping, CEO, We Mean Business **Session Theme presentation: Mr Thomas Spencer,** Fellow, TERI **Panelists** • **Ms Kate Hampton,** CEO, Children's Investment Fund Foundation • **Mr Nick Mabey,** Chief Executive and Founder Director, Third Generation Environmentalism • **Mr R R Rashmi,** Distinguished Fellow & Programme Director, Earth Science and Climate Change, TERI • **Mr Sumant Sinha,** Founder, Chairman & Managing Director, ReNew Power • **Mr Vivek Subramanian,** Executive Director, Fourth Partner Energy
4.45 – 5.55 p.m.	**Enabling the Decarbonization of Indian Industry** This session will outline the importance of achieving emissions reduction in Indian industry in the longer term. The focus of the session will be on the main 'harder-to-abate' sectors in India, including iron & steel, cement and petrochemicals. It will discuss the present status and the current policies in place to promote energy efficiency in large industries. This session will then cover the main options for decarbonisation, covering near-term actions such as energy efficiency, increasing share of renewable electricity and increased material circularity, as well as longer-term actions, which will require collaborative R,D&D, such as the use of hydrogen and/or carbon capture, utilisation and storage (CCUS). **Chair: Mr Andrew Prag,** Head, Environment and Climate Change Unit, International Energy Agency **Session Theme presentation: Mr Will Hall,** Associate Fellow, TERI **Panelists** • **Mr Siddarthan Balasubramania,** Senior Adviser- Strategy, ClimateWorks Foundation • **Ms Frances Beinecke,** Former President, NRDC • **Mr Girish Sethi,** Senior Director - Energy, TERI • **Mr Mahendra Singhi,** Managing Director & CEO, Dalmia Cement (Bharat) Limited • **Dr Sébastien Treyer,** Executive Director, IDDRI
5.55 – 6.30 p.m.	**Concluding Session** • **Mr Tomasz Chruszczow,** Special Envoy for Climate Change, Poland • **Dr Ajay Mathur,** Director General, TERI
6.30 – 7.30 p.m.	**Reception** Venue: Board Room, 23rd Floor, The Rockefeller Foundation

ABOUT ENERGY TRANSITIONS COMMISSION

The Energy Transitions Commission (ETC) brings together a diverse group of individuals from the energy and climate communities: investors, incumbent energy companies, industry disruptors, equipment suppliers, energy-intensive industries, non-profit organisations, advisors, and academics from across the developed and developing world. Their aim is to accelerate change towards low-carbon energy systems that enable robust economic development and limit the rise in global temperature to well below 2°C. The ETC is co-chaired by Lord Adair Turner and Dr Ajay Mathur. The ETC members agree on the importance of cutting carbon emissions, and share a broad vision of how the transition to a low-carbon energy system can be achieved.

VISION AND ROLE OF ETC IN INDIA TO ENABLE DECARBONISATION

ETC India aims to foster the adoption of low carbon pathways in India through intense and informed discussions between Indian partners, key policymakers and others concerned with technology options and investment opportunities for evolving policy. ETC India is led by TERI as the secretariat. In its first year, ETC India focused on decarbonising the power sector. Whilst that work is still continuing, in the second year, ETC India has initiated research on decarbonising industrial sectors, with a particular focus on the 'harder-to-abate' sectors such as iron and steel, cement and petrochemicals. In this work, we will liaise with industry representatives to understand the challenges with decarbonising Indian industry. Future decarbonisation strategies for industry will need to adopt a 'clean growth' approach, whereby economic growth, competitiveness, and job creation go hand-in-hand with a low carbon transition.

This document contains two thematic papers, which provide a summary of the work carried out in these areas to date. The first paper covers India's electricity sector and the transition to renewables, whilst the second outlines the status of India's heavy industry sectors and the possible options for emissions reduction.

Acknowledgements and Disclaimer

TERI would like to express its gratitude to the ETC India project partners, Climate Policy Initiative (CPI), and the National Renewable Energy Laboratory (NREL). We would also like to acknowledge the valuable inputs of our knowledge partner, the Power System Operation Corporation (POSOCO). The contributions and insights from our corporate partners, Siemens, NTPC, BRPL, Giriraj Renewables, and CLP, have been invaluable.

Without the support of our Foundation Partners, Bloomberg Philanthropies, Hewlett Foundation, Oak Foundation, Shakti Foundation, Growald Family Fund, and Children's Investment Fund Foundation, this project would not have been possible. We are deeply grateful.

All findings and views expressed herein, and any eventual errors or omissions, are those of TERI alone.

ETC-INDIA PARTNERS

Project Partners

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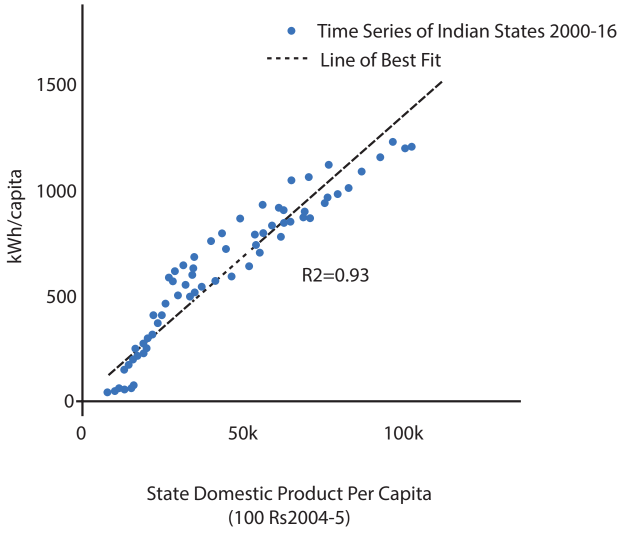
UNDERSTANDING INDIA'S ELECTRICITY SECTOR TRANSITION TO RENEWABLES

THOMAS SPENCER, FELLOW, TERI

Electricity is Crucial to India's Development

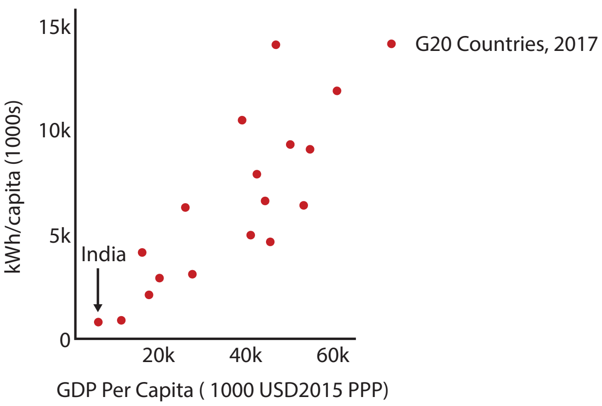
Reliable and affordable electricity supply is a prerequisite for India's development. Electricity increases household welfare and productivity, as well as the productivity and competitiveness of manufacturing. For India's large agricultural sector, access to affordable electricity has become essential for pumping groundwater, increasing farm productivity and income resilience, although with negative consequences in terms of excessive, inefficient groundwater withdrawal. The strong relationship between electricity consumption and state-level GDP per capita in India is shown in Figure 1. The poorest states in India have much lower levels of electricity consumption per capita than the richer states. Here there is clearly a dual causality. Low incomes prevent affordability of reliable electricity supply; lack of reliable electricity supply depresses economic opportunity and keeps incomes low. Figure 2 also shows that India's electricity consumption per capita is extremely low in an international perspective.

Figure 1: State-level GDP per capita versus electricity consumption per capita, India, 2000–16



Source: TERI, based on data from (CEA, n.d.; Reserve Bank of India, 2019)

Figure 2: G20 countries GDP per capita versus electricity consumption per capita



Source: TERI, based on data from (IEA, 2019; World Bank, 2019)

India's electricity consumption will continue to grow as India develops its economy.

THE INDIAN ELECTRICITY SECTOR HAS SIGNIFICANTLY INCREASED ITS PERFORMANCE IN RECENT YEARS

For decades after Independence in 1947, the Indian electricity sector was playing catch up on the very low level of development at Independence. In 1947, India's electricity consumption per capita was only 12 kWh, compared to 75 kWh in the United States as early as 1902, and 25 kWh per capita in Great Britain and Germany as early as 1910. At Independence, therefore, India's electricity sector was essentially at the level of those of the developed countries near the turn of the previous century (see Table 1). After Independence, India's growth in electricity generation, consumption and electrification was relatively rapid, compared to the rates achieved in the developing countries at the dawn of their electricity sectors. Growth in generation output per capita was almost 10% per year in the first few decades of India's independence (CEA, 2018).

Table 1: Electricity consumption per capita in major economies in a historical perspective

Country	Year	Per Capita Consumption (kWh)
United States	1902	75
Germany	1910	25
United Kingdom	1910	25
Russia	1913	13
India	1947	12

Source: TERI based on data from (Byatt, 1979; Carter et al., 2006; CEA, 2017; Coopersmith, 1992; Rahlf, n.d.)

However, for a number of decades heading into the 2000s, the performance of the Indian electricity sector still left much to be desired. For several decades since 1980, the annual energy deficit (i.e. unmet demand due to inadequate or unavailable generation resources) averaged about 10%, while the peak deficit was as high as 15-20% (CEA, 2018). In 1999 the rural electrification rate was only 49% and the increase in the rural electrification rate was showing clear signs of stagnating (Aklin, Harish, & Urpelainen, n.d.).

However, since the mid-2000s, India's electricity sector has made significant progress. The energy and peak deficits have declined to less than 1%. Rural electrification has advanced tremendously, with the country approaching 100% household electrification (Ministry of Power, 2019b). An important programme of largely coal-fired capacity addition occurred in the years 2010-2015, largely from the private sector spurred by the liberalization of electricity generation under the Electricity Act, 2003. This substantially increased available generation resources, and the energy and peak deficits fell to less than 1% in recent years.

DESPITE THIS PROGRESS, THE PERFORMANCE OF THE ELECTRICITY SECTOR IS STILL TO BE IMPROVED IN A NUMBER OF AREAS

Despite these important steps forward, there are a number of areas where the performance of the Indian power sector still requires improvement. The financial foundations of the sector are still shaky, with a pervasive yet incomplete cross-subsidy on tariffs from high-paying industry and commercial consumers to tariffs from low-paying agricultural and residential consumers. In order to plug the gap in the tariff subsidy, state governments also provide direct budgetary support to electricity distribution companies. State government subsidies to electricity distribution companies in just six states amounted to INR 361 billion in the fiscal year 2017 (USD 5.2 billion, 0.2% of GDP) (Das, Dabadge, Chirayil, & Manabika Mandal, 2019).[1] Yet the gap in the tariff subsidy is not fully made up for by such fiscal subsidies from state governments, leaving distribution companies with large accumulated and still growing losses. As of June 2019, about 674 billion in dues were outstanding from distribution companies to generators, equating to USD 9.6 billion or 0.4% of GDP (Ministry of Power, 2019a). Outstanding dues from renewable energy generators amounted to about INR 68 billion in August 2019. All this is after a bailout of distribution company debt to the tune of INR 2.32 trillion under the Uday scheme (1.3% of GDP).[2]

While supply has improved and the energy deficit has come down significantly, many parts of India still face unreliable supply with rural areas still facing typically more than 20-30 interruptions per month. Aggregate technical and commercial losses in the electricity sector have also come down, but at about 18.7% they remain very high in an international comparison, and there is evidence that the actual number is higher still (Spencer & Awasthy, 2019). Electricity markets are still under development in India, with the vast majority of generation tied up in long-term, capacity-based contracts, and electricity exchanges accounting for only a tiny proportion of electricity transactions (6%). End-user prices are distorted by the cross-subsidy, with an aggregate gap between cost of supply and revenue realization still of about 0.26 Rs/kWh (Ministry of Power, 2019c). This implies, at a rough calculation, an annual revenue shortfall, which must eventually be made up from somewhere including state subsidies, of about INR 326 billion (0.19 % of GDP every year, or 1.6% of the total annual tax intake). The end-user price distortion promotes wasteful consumption in subsidized segments (notably agriculture, where it leads to ecologically harmful and wasteful consumption of groundwater), and undermines the economic competitiveness of high-tariff consumers notably manufacturing.

Due to the occasionally reckless expansion of coal-fired generation capacity in the period 2010-2015, there is now a substantial capacity of coal-fired plants that are stranded or stressed assets. About 54 GW of coal-fired capacity, and 7 GW of natural gas-fired capacity, are stranded or stressed assets. About INR 1 trillion of loans to the thermal power sector have gone bad, equating to a whopping 18% of total outstanding loans to the power sector or 0.6% of GDP. The causes of these stranded assets were the imprudent capacity expansion that occurred in the period 2010-15; demand growth slowdown after 2012; and upstream (coal linkages) and downstream (PPA tie-ups) challenges in the power sector value chain. It is not true, as of yet, that the growth of renewables has caused the stranded asset issues, although the future growth of competitive renewables may make the turnaround of these stranded projects unviable.

Thus, despite all its progress, the Indian power sector still faces a highly challenging context of incomplete markets and distorted price signals; lower technical capacities; and a pervasive, pernicious yet socially and politically unavoidable large-scale subsidy to huge swathes of the lower income population and agriculture.

It is in still this challenging context that the transition to renewable electricity is occurring.

1 Page three of the above-quoted source provides details on the data and methodology, as well as the limitations thereof. Suffice it here to quote a few relevant sentences: "This report, thus, has to refer to several sources other than regulatory documents, such as reports of the Comptroller and Auditor General (CAG), government notifications and documents and DISCOM audit reports. Efforts have been made to use audited data where available. Subsidy details are also reported in periodic reports published by the Power Finance Corporation (PFC) on the performance of state power utilities. There are several substantial discrepancies between data from the PFC and that from regulatory documents…". The study should thus be understood as the best possible effort to shed light on an un-transparent issue.

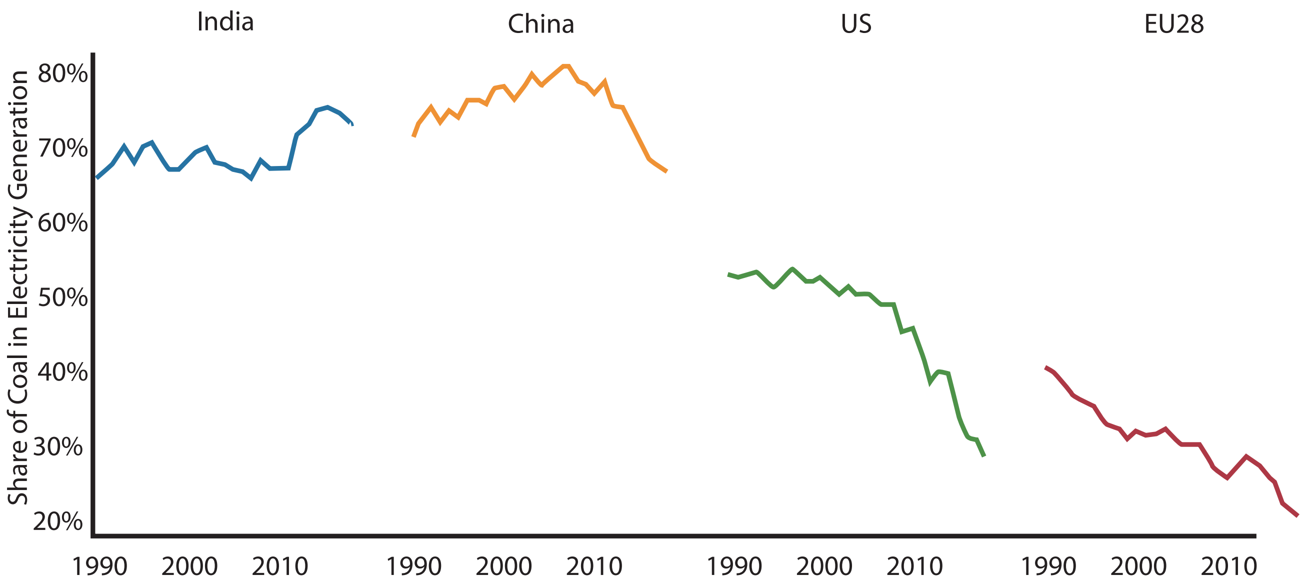
2 Taken to be the total amount of bonds issued by state governments to taken on DISCOM accumulated debt. According to the Uday Portal (Ministry of Power, 2019c), a total of 2.32 trillion Rupees worth of bonds have been issued.

RENEWABLES ARE BY FAR THE CHEAPEST SOURCE OF NEW GENERATION

India has long experience with the exploitation of renewable energy, with the Ministry of New and Renewable Energy being established as early as 1992. However, the sector received a real boost in 2010 and then 2015, with the adoption respectively of the Jawaharlal Nehru National Solar Mission and the 175 GW target for renewable energy capacity by 2022. At the time of the adoption of the 175 GW target, solar PV tariffs typically ranged between INR 6 and INR 8/kWh and wind between INR 4 and INR 6/kWh (Prayas, 2019). Today, competitive auctions for solar and wind range between INR 2.5 and INR 3.0/kWh. This is significantly cheaper than the modelled cost of new coal, and cheaper even than the short-run marginal cost of a very substantial part of the existing coal fleet (Spencer, Pachouri, Renjith, & Vohra, 2018).

Driven by the government's strong push, capacity expansion in renewables has accelerated significantly. On the back of this, the growth of renewable generation has allowed the share of coal generation to peak and start to decline. Figure 3 shows that the share of coal in India's electricity generation has peaked in 2015, at a level lower than China and certainly lower than that of major European countries at comparable levels of development (in 1920, coal accounted for 99.56% of the energy input into electricity generation in the UK). India thus has the potential to peak and decline its share of coal in electricity at a far earlier stage of development that was achieved by either the early industrialisers or the catch-up industrialisers (China).

Figure 3: Share of coal in electricity generation, India, China, US and European Union (EU28)

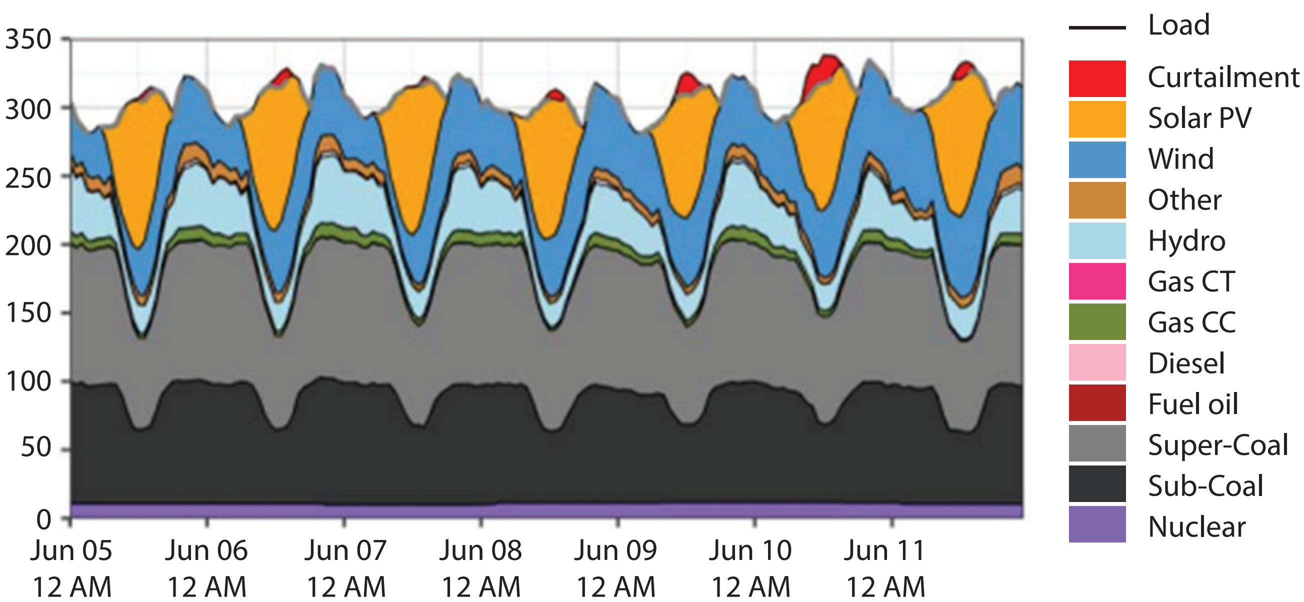


Source: TERI, based on data from (IEA, 2019)

THE RATE OF DEVELOPMENT OF RENEWABLES WILL DEPEND ON THE RATE OF INCREASE IN THE FLEXIBILITY OF THE POWER SYSTEM

With cost per kWh of renewable electricity no longer being an issue in India, the primary constraint on the growth of renewables in the future will be the rate at which the power system can be made more flexible to accommodate the variability of renewables. This variability of renewables poses a number of technical challenges and additional costs to power systems, which must balance demand and supply in real time at every location in the grid. Figure 4 shows an output of a simulation of electricity system operation in one week in 2030, under a scenario of high renewables penetration. While high, this scenario for renewables penetration is well within the range considered in current official planning documents (see the following section). Figure 4 shows how the daily variability in renewables, particularly solar, leads to a large need for highly flexible operation of the electricity system, visible, for example, in the daily cycling of the coal fleet (see the variable daily output of the dark grey and light grey series).

Figure 4: Dispatch Simulation of the Indian Power System in 2030 With High Renewables



Source: Palchak, Chernyakhovskiy, Bowen, & Narwade, 2019

Thus, the key constraint to the rate of growth of renewables is the speed with which the Indian power system can be made more flexible to absorb variable renewables.

Dispatchable power plants must be able to vary their output quickly and flexibly to follow the scheduled and unscheduled variations in the output of variable renewables. In addition, electricity demand should be scheduled to the extent possible at times of high renewable energy availability, and consumption avoided at times when renewable energy is not available. There is a large potential for this from shifting agricultural pumping from the night, the current practice, to the daytime when solar electricity is available. In the near future, storage will become competitive with fossil fuels to provide peaking services, for example to meet the peak of electricity demand in the evening (Schmidt, Melchior, Hawkes, & Staffell, 2019). This could avoid substantial new build of expensive coal plant 'peakers', which would run only limited hours in the day. The expansion of transmission capacity between Indian states and regions is also necessary to allow the large-scale transfer of power across the country, from areas where renewables production is high to areas where demand is high.

All these changes in electricity system technology and operations need to be underpinned by the right planning processes, regulatory mandates and price signals, notably from more sophisticated and closer to real-time electricity markets. The Central Electricity Regulatory Commission (CERC) is moving forward on a number of electricity market reforms to introduce this kind of more sophisticated price signal into Indian electricity markets, and increase the depth and liquidity of Indian electricity markets.

Other countries such as the United Kingdom, Denmark and Germany, or subnational jurisdictions like Texas, South Australia or California, have succeeded in having quite a high level of variable renewables in their power systems. However, India presents some important differences which are likely to make it more difficult to integrate variable renewables in the Indian electricity system. Firstly, unlike mature economies, India's electricity and peak demand is growing rapidly. For example, in the United Kingdom peak demand has declined by about 2.8% per year since 2010, whereas it has grown by about 5% per year in India. Adding enough renewables to meet annual electricity demand growth is one issue; adding enough flexible electricity system capabilities (dispatchable capacity, demand response, or storage) to meet rapidly rising peak demand is a proposition that is just as challenging, if not more. Secondly, whereas high renewables electricity systems tend to be more reliant on wind, with a more constant output, India will have to rely to a large degree on solar energy, with a highly variable diurnal cycling of output (visible in Figure 4).

Thus, India's ambitions to transition to renewable energy in the electricity sector should be seen for what it is: an economically and environmentally desirable, yet institutionally and technically difficult process of systemic transition, in an already challenging environment. It will necessitate clear policy, technical and systems innovation, institutional learning, and rapid capacity building.

2030 VISIONS FOR THE POWER SYSTEM

TERI has studied in depth the evolution of the electricity system to 2030 (Pachouri, Spencer, & Renjith, 2019; Palchak et al., 2019; Spencer & Awasthy, 2019; Udetanshu, Pierpont, Khurana, & Nelson, 2019). This section presents the main conclusions of some of this analysis, as well as reflecting on official policy ambitions.

India's electricity demand is projected to grow about 6% per year between now and 2030, reaching about 2040 TWh of grid-based electricity demand.[3] Including projected T&D losses and auto-consumption, the generation requirement would be in the order of 2400 TWh. This growth rate in itself presents a challenge to substantially increasing the share of renewables, requiring an extremely rapid rate of capacity addition to meet incremental demand growth. Within aggregate demand, the growth trajectory of cooling, in particular air conditioning, is expected to be particularly rapid, at about 10% per year (Spencer & Awasthy, 2019). This may present a real challenge to the integration of renewables, as much of India's residential cooling demand falls at night when solar is not available.

Scenarios studying the grid integration of renewables clearly show that the need for power system flexibility is projected to grow significantly under ambitious scenarios for the increase in renewables. While total demand is projected to roughly double by 2030, the need for daily balancing (shifting energy within a day to balance the variability in solar output, notably) is projected to grow six-fold by 2030 (Udetanshu et al., 2019). By the mid-2020s, the available supply of flexibility would be exceeded, posing an absolute constraint on the growth of renewables, unless proactive measures are taken to increase the flexibility of the power system. Nonetheless, India has a large potential to increase the flexibility of its power system, including by demand response, supply-side flexibility, and rolling out storage. A scenario with very high penetration of renewables shows no incremental system costs against a scenario with far more moderate renewables deployment, provided that a cost-effective and comprehensive portfolio of flexibility options is developed (Udetanshu et al., 2019). This portfolio needs to encompass supply-side flexibility from the dispatchable coal, gas and hydro fleet, demand respond and demand shifting, as well as the deployment of storage.

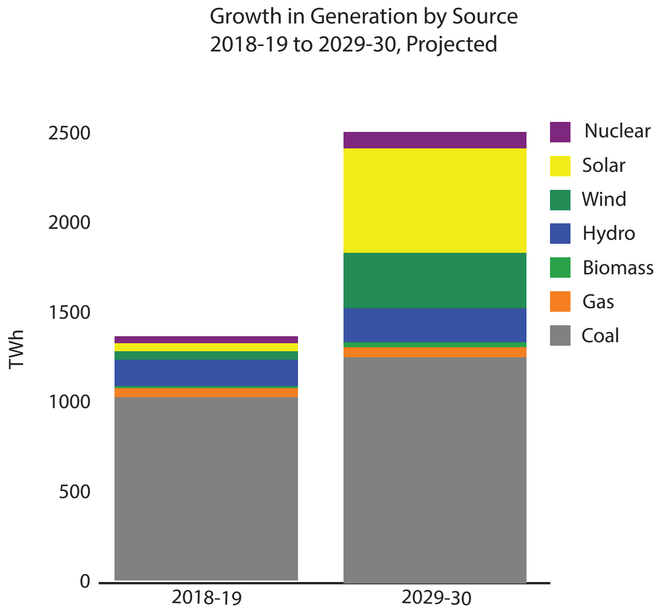
On the supply side, multiple scenarios, including from official sources, have now emerged with a variable renewables penetration of greater than 30% by 2030, the majority of which comes from solar (CEA, 2019;

[3] Grid-based electricity demand excludes captive and off-grid generation. The figure above is for consumption, i.e. exclusive of technical and commercial losses.

Pachouri et al., 2019). The very high penetration of solar (>20%) would be unprecedented as of today, with no country having achieved a penetration of solar electricity greater than 10% (the penetration of solar electricity in California was 11.4% in 2018).[4] If one includes hydro and nuclear, the share of total zero carbon generation is projected to reach greater than 45%. This is way above India's Nationally Determined Contribution (NDC), which targets zero-carbon generation capacity, not generation share, of 40% (under such scenarios the zero carbon generation capacity would be in the order of 60-65%). The share of coal generation would drop to 50%, although in absolute terms it would still have grown by some 2% per year on the 2018 level. Some very ambitious renewables scenarios see an absolute peak in coal generation attained just before 2030, declining thereafter (Spencer et al., 2018). Thus, while India may be unable to commit to absolute peaking of total emissions, pathways towards a sectoral peak in power generation are emerging.

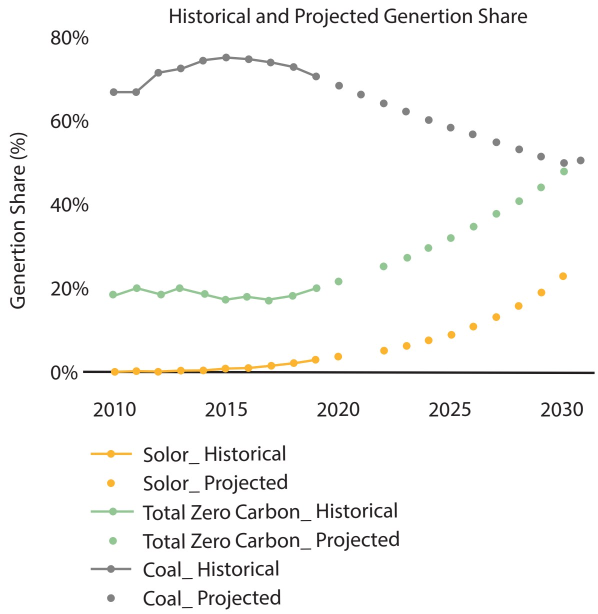
Figure 5 shows the projected generation by source in 2030, according to a recent study by the Government of India (CEA, 2019). The moderate growth in coal from current levels and the huge growth in solar and wind generation can clearly be seen. Figure 6 shows the historical and projected generation shares of coal, total zero carbon sources, and within zero carbon sources, solar. The importance of the dramatic ramp up in the share of solar can be seen. The source for this projection is a recent study from the Government of India (CEA, 2019), which accord quite closely with the analysis done by TERI (Pachouri et al., 2019).

Figure 5: Historical (FY18-19) and projected generation by source



Source: TERI, based on data from (CEA, 2019)

Figure 6: Historical and projected generation shares



Source: TERI, based on data from (CEA, 2019; IEA, 2019)

To summarize this section: ambitious visions are emerging, including from the Government of India, for a power sector that would be substantially transformed by 2030, with a zero-carbon share reaching almost 50% and a solar share reaching of more than 20% - an absolutely unprecedented level as of today.[5] However,

4 The largest global penetrations of solar among major national economies as of 2018 was 8.24% in Italy, 6.79% in Greece, and 6.09% in Germany. A handful of small national power systems have achieved penetrations somewhat above this level.

5 The largest global penetrations of solar among major economies was 8.24% in Italy, 6.79% in Greece, and 6.09% in Germany. A handful of small power systems have achieved penetrations somewhat above this level.

analysis of the grid integration challenge of variable renewables in India clearly show that this transformation will be unachievable unless substantial progress is made in developing a comprehensive portfolio of flexibility options. While not a panacea, cost-effective storage will be crucial before 2030 for meeting evening peak demand, in order to smoothen the daily cycling of solar, and here global deployment efforts in stationary storage deployment matter tremendously to drive down the learning curve. For India, the cost of solar plus storage needs to reach parity with that of coal by the mid-2020s in order to give confidence that the trajectories seen in Figure 5 and Figure 6 are possible.

CONCLUSION: TRANSITION IN A CHALLENGING CONTEXT

The purpose of this paper is to give an overview of the emerging transition of the Indian power sector. Importantly, it is crucial to understand this with the Indian context firmly in mind. India is still a lower middle-income country, and improving the lives of its people means that its economy must grow rapidly. Evidence within India and from cross-country comparison shows that increasing the level of electricity consumption is crucial to this growth. The key question is how to cater to this growing demand, without exacerbating, and if possible, substantially mitigating, the challenges of resource scarcity, import dependence and environmental degradation.

The Indian electricity sector, thanks to the policy push given by the Government of India and the economic competitiveness of renewables, is firmly embarked on a trajectory of transition. However, this transition is occurring in a still-challenging context, where the performance of the electricity sector, while substantially improved, still leaves much to be desired. Improving the technical and financial performance of the electricity sector is important to deal with the challenge of integrating variable renewables securely into the Indian grid. The problems faced in the sector are deeply entrenched in India's political economy, and addressing them will not be easy.

In the future, the pace of the growth of renewables will be determined not by the cost of solar or wind electricity, but rather by the rate at which the operation and installed technology of the electricity system can be made more flexible. There is no quick fix here: cost-effectiveness requires that a portfolio of flexibility options are developed (Udetanshu et al., 2019). While battery storage can be a crucial component of this portfolio, under no reasonable scenario can it be a panacea by 2030. India will still need to improve the flexibility of its coal fleet, activate large scale demand shifting, develop an even more integrated grid infrastructure and operation to support large-scale power transfers across the country, and develop more sophisticated electricity markets. If this can be achieved in the years to come, a substantially lower carbon, cost-effective electricity system would start to emerge by 2030.

REFERENCES

Aklin, M., Harish, S. P., & Urpelainen, J. (n.d.). Global Electrification Database: Datasets and Codebook. Harvard Dataverse. https://doi.org/doi:10.7910/DVN/BZBKJP

Byatt, I. C. R. (1979). *The British Electrical Industry, 1875 to 1914: The Economic Returns to a New Technology.* Oxford: Clarendon Press.

Carter, S. B., Gartner, S. S., Haines, M. R., Olmstead, A. L., Sutch, R., & Wright, G. (2006). *Historical Statistics of the United States Millennial Edition Online.* (G. Wright, Ed.). New York: Cambridge University Press. Retrieved from http://hsus.cambridge.org/

CEA. (n.d.). *General Review.* New Delhi.

CEA. (2017). *Power Sector Dec 2016.* New Delhi.

CEA. (2018). *Growth of Electricity Sector in India 1947 - 2018.* New Delhi. Retrieved from http://www.cea.nic.in/reports/others/planning/pdm/growth_2018.pdf

CEA. (2019). *Draft Report on Optimal Generation Capacity Mix for 2029-2030.* New Delhi.

Coopersmith, J. (1992). *The Electrification of Russia, 1880 - 1926.* Ithica, United States and Londong, England: Cornell University Press.

Das, N., Dabadge, A., Chirayil, M., & Manabika Mandal. (2019). *Elephant in the Room: Implications of Subsidy Practices on DISCOM Finances.* Pune. Retrieved from http://www.prayaspune.org/peg/publications/item/419

IEA. (2019). World Energy Balances. Retrieved May 3, 2019, from http://wds.iea.org

Ministry of Power. (2019a). *Praapti Portal.* New Delhi. Retrieved from https://www.praapti.in/

Ministry of Power. (2019b). Saubhagya Dashboard. Retrieved September 1, 2019, from https://saubhagya.gov.in/

Ministry of Power. (2019c). Uday Portal. Retrieved September 12, 2019, from https://www.uday.gov.in/home.php

Pachouri, R., Spencer, T., & Renjith, G. (2019). *Exploring Electricity Supply-Mix Scenarios to 2030.* New Delhi.

Palchak, D., Chernyakhovskiy, I., Bowen, T., & Narwade, V. (2019). *India 2030 Wind and Solar Integration Study: Interim Report.* Denver, Colorado.

Prayas. (2019). Renewable Energy Data Portal. Retrieved September 1, 2019, from http://prayaspune.org/peg/re.html

Rahlf, T. (n.d.). Zeitreihendatensatz für Deutschland, 1834-2012. Retrieved June 5, 2019, from https://histat.gesis.org/histat/de/project/details/3FAB1077E9F9816F0F3C2CDCE7C371DC

Reserve Bank of India. (2019). RBI-DBIE: Database on the Indian Economy. Retrieved July 30, 2019, from https://dbie.rbi.org.in/DBIE/dbie.rbi?site=home

Schmidt, O., Melchior, S., Hawkes, A., & Staffell, I. (2019). Projecting the Future Levelized Cost of Electricity Storage Technologies. Joule, 3(1), 81–100. https://doi.org/10.1016/J.JOULE.2018.12.008

Spencer, T., & Awasthy, A. (2019). *Analysing and Projecting Indian Electricity Demand to 2030.* New Delhi. Retrieved from https://www.teriin.org/sites/default/files/2019-02/Analysing and Projecting Indian Electricity Demand to 2030.pdf

Spencer, T., Pachouri, R., Renjith, G., & Vohra, S. (2018). *Coal Transition in India. New Delhi.* Retrieved from https://www.teriin.org/sites/default/files/2018-12/Coal-Transition-in-India.pdf

Udetanshu, Pierpont, B., Khurana, S., & Nelson, D. (2019). *Developing a roadmap to a flexible, low-carbon Indian electricity system: interim findings.* London. Retrieved from https://www.teriin.org/sites/default/files/2019-02/Developing a roadmap to a flexible-low-carbon Indian electricity system.pdf

World Bank. (2019). World Development Indicators Database. Retrieved October 3, 2017, from https://databank.worldbank.org/data/reports.aspx?source=World-Development-Indicators#

THEMATIC PAPER

ENABLING DECARBONISATION OF INDIAN INDUSTRY

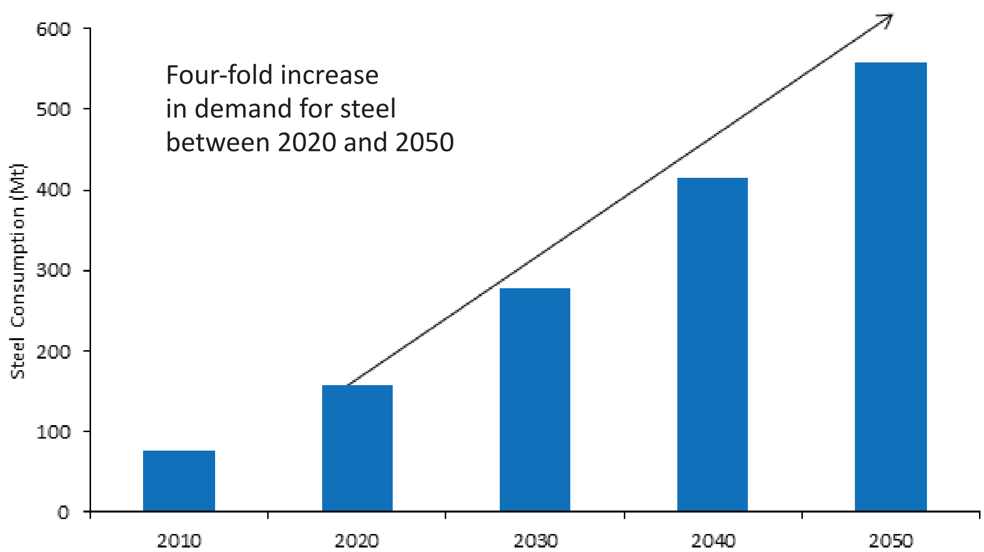
WILL HALL, ASSOCIATE FELLOW, TERI

Heavy industry is at the centre of the Indian economy

The industrialisation of the Indian economy has been responsible for a significant proportion of economic growth since 1947, with strong industrial policy being cited as a key driver for alleviating poverty. Industrialisation in India has been a slow but continuing process, which increased more rapidly with the liberalisation of the Indian economy in the 1990s (Siddiqui, 2015). This experience and the experience internationally, illustrates the centrality of the heavy industry sectors for providing the materials to support a modern economy. These include iron & steel, cement (and concrete), petrochemicals, aluminium, fertilisers, and bricks.

Demand for these materials is set to grow rapidly out to 2050, continuing to drive substantial economic growth. Consumption of these materials is fundamental to delivering the infrastructure improvements that India requires to modernise. Steel consumption, for example, is set to quadruple between 2020 and 2050, as a result of greater demand in the buildings, automobiles, infrastructure, metal goods and industrial equipment end-use sectors.

Figure 1: Forecast Indian steel consumption, 2010–2050



Source: TERI analysis. Projections of material demand based on analysis of data from (World Bank, 2019; World Steel Association, 2018).

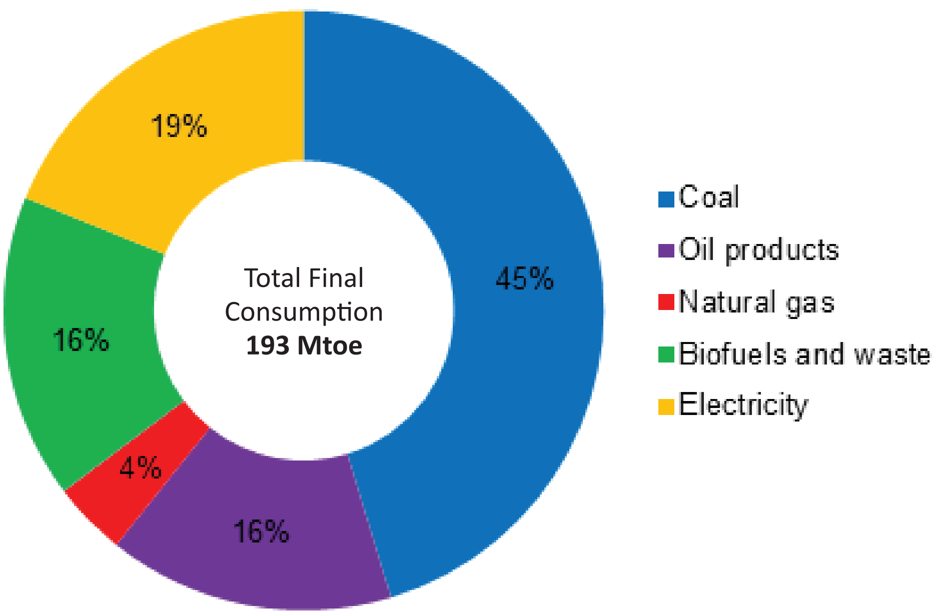
If India is to remain globally competitive and achieve sustainable growth, within the constraints of the environment, future industrial strategy should prioritise greater resource efficiency in the heavy industry sectors. Beyond energy efficiency, these sectors should also consider the adoption of new technologies to further reduce emissions in order to keep temperatures within the limits agreed under the Paris Agreement. Based on research at a global level, it seems technically possible to reduce emissions from these sectors to near zero levels, although many of the technologies require further development to reach commercial scale (ETC, 2018). This paper will lay out the current status of Indian industry, before covering the mitigation options that could reduce emissions out to 2050 and beyond.

CURRENT STATUS OF INDIAN INDUSTRY

Total final energy consumption in India in 2016 was 572 Mtoe, with industry demanding 193 Mtoe, or a 34% share (IEA, 2016). Industry's total energy consumption has grown rapidly over the past decade, driven by high levels of economic growth. Despite strong growth in services, heavy industry will continue to be a strong driving force behind the Indian economy over the next decade, growing rapidly out to 2030 and beyond.

In terms of the final energy consumption mix in industry, coal consumption dominates, making up 45% of industrial energy consumption, which is predominantly used in the production of iron & steel and cement, as well as in the large and disparate Medium and Small Enterprise (MSME) sector. The next most commonly used fuels are oil, electricity, biofuels, and waste, which are used throughout the sub-sectors. Other fuels, such as natural gas, are largely restricted to the fertiliser and petrochemical industry and not widely used as a result of their relative cost to coal. However, the use of natural gas in industry is likely to increase in the future as a result of air pollution from the combustion of coal. For example, in large metro areas such as Delhi, which are facing high levels of air pollution, the Government has mandated that industries should switch to natural gas in place of more polluting fuels.

Figure 2: Total final consumption for Indian industry, 2016



Source: (IEA, 2019)

India has a number of policies in place to incentivise greater energy efficiency across the economy. These have been put in place under the National Mission for Enhanced Energy Efficiency (NMEEE), which is a key component of National Action Plan on Climate Change (NAPCC). The main policy affecting the industrial sector is the Perform, Achieve and Trade (PAT) scheme.

The PAT scheme is a regulatory instrument to reduce specific energy consumption across energy intensive industries. It was developed by the Government as a cost-effective way of implementing energy efficiency measures. Large consumers of energy (referred to as Designated Consumers) are given energy reduction targets to be met over a certain time period. The scheme also uses a certification scheme, whereby excess energy savings are translated into tradable instruments, similar to emissions trading schemes found elsewhere around the world. During the first PAT cycle (2012–2015), participating industries over-achieved the target by 30%, saving just under 9 Mtoe of energy, or around 1.25% of India's total primary energy supply. This translates to a CO2 saving of 31 million tonnes, or just under 2% of India's total CO2 emissions.

The scheme is continuing to set new targets for efficiency improvements, drawing in Designated Consumers from a broader set of sectors, including refineries, railways and electricity distribution companies (DISCOMS). In future, it may be necessary to shift from energy efficiency targets to CO2 targets, to facilitate further emissions reduction across these sectors.

CHALLENGES FACING INDIAN INDUSTRY

There are a number of key challenges for the decarbonisation of the heavy industry sub-sectors, which contribute to them being considered 'harder-to-abate'. Some of these challenges are unique to India but many will be experienced by all countries given the nature of the decarbonisation challenge in these sectors.

Table 1: Key Challenges for Decarbonising the HTA Sectors[1]

Challenge	Description
Delivering future infrastructure needs	India is set to continue to achieve high levels of economic growth over the coming decades, which is essential for continued development and the improvement of living standards. This is nevertheless a challenging situation for the HTA sectors, which will need to focus on rapidly increasing production capacity as opposed to improving the quality of production, whether that be increased energy and resource efficiency, or greater levels of RD&D spent on low-carbon technologies.
Maintaining competitiveness	HTA sub-sectors will have to consider the cost of decarbonisation options and the impact that this will have on their competitiveness, both domestically and internationally. Much of the cost-effective abatement has already been achieved, or will be achieved in the near future, including high levels of energy and resource efficiency and the reduction of fugitive emissions. If the HTA sectors are to reduce emissions to very low levels, other options, such as using hydrogen or deploying CCUS technology, will be required. In the absence of international coordination, the incremental costs of these solutions will make it challenging to reduce emissions without forcing industry abroad. This would negatively impact the Indian economy and not help in reducing global emissions.

[1] (CCC, 2019; MoS, 2017; WBCSD, 2018)

Moving to higher quality products	To reduce the impact on the environment, India could produce fewer products of higher quality, which have longer lifetimes. In the steel sector, for example, ultra high-strength steels are increasingly being used in modern construction and automobile manufacture, increasing the lifetime of products and reducing the steel intensity. However, limited supply of domestic high grade manganese or chromite ore mean that lower quality materials are still being relied upon versus the more expensive imports.
Network requirements	Many of the more promising technology solutions require significant infrastructure investment, beyond the means and control of individual organisations or industries. This includes the construction of CCUS networks, as well as the gas infrastructure for hydrogen distribution and storage.
Technology availability	Over and above cost of alternative options, some of the technologies that might be required to decarbonise the HTA sectors are not yet commercially available in India. Unlike in the transport or power sectors, low carbon alternatives to reduce emissions from high-temperature heat processes or the production of process emissions (e.g. from cement production) are in many cases a long way from parity with the incumbent technologies.
Replacement rates	Industrial plants and components tend to have long lifetimes, which make it important to plan emissions reduction strategies in line with replacement cycles. This can be challenging as different components within a single facility can have different lifetimes, although they may need to be switched simultaneously, for example under a conversion to hydrogen. As India is continuing to expand its industrial base, it will become increasingly difficult to retire plants or components that have significant useful lifetime remaining.
Access to capital and low levels of investment	Many of the technology solutions for deep decarbonisation in industry require significant amounts of upfront capital and can have long payback periods. As a result, there will need to be sufficient access to long-term, patient capital. Levels of investment in RD&D are currently low across industry (Firoz, 2014). These will need to increase to support longer-term technological innovation.
Industry awareness	Many organisations, particularly in the MSME sector, are not aware of energy efficiency or low-carbon technologies that will help drive emissions reduction, even when these technologies can deliver significant cost savings or improve product quality.

OPTIONS FOR DECARBONISING INDUSTRY

Despite these challenges, there are several promising technology solutions which could support deeper decarbonisation of the HTA sectors, beyond that of improving energy efficiency or reducing demand. These include the option of 'fuel switching' away from fossil fuels to low or zero carbon fuels, deploying carbon capture and storage (CCS) technology and the use of biomass as a feedstock in the manufacture of petrochemical products. Many of these technologies are yet to be proven commercially at scale and will require sustained support from government and industry to achieve significant levels of deployment.

Table 2: Steps to industrial decarbonisation in India

1.	Energy Efficiency	
2.	Demand Reduction / Product Substitution / Recycling	
3.	Fuel switching / process switching (electricity, hydrogen or biomass)	CCS / CCU

Energy Efficiency

There has been a strong recognition of energy efficiency as a tool to deliver cost-effective energy savings, which can help Indian industry maintain competitiveness within domestic and international markets. Initiatives such as the PAT scheme have been very successful in contributing to increasing the energy efficiency of the Indian industrial sector. Since the late 1980s, the industry sector has recorded greater energy efficiency improvements as compared to any of the other sectors in India (World Bank, 2011). Many units in the harder-to-abate sectors, such as fertiliser and cement plants have adopted state-of-the-art technologies, in line with international benchmarks. Moreover, most new capacity additions are adopting best available technologies, to maintain competitiveness and minimise costs. As a result, the abatement potential from large, centralised industries through further energy efficiency is becoming more limited based on the current technologies. There are however potential 'step-change' energy efficiency technologies, such as 'HIsarna' in the steel sector, which can achieve further efficiency savings. Beyond energy efficiency, the harder-to-abate industries need to explore some of the more innovative technologies discussed below, to continue to reduce emissions. Nevertheless, there are still several significant steps that industries can take to cut energy consumption in other sectors, particularly within MSMEs.

Demand mitigation, product substitution and recycling

For the harder-to-abate sectors, it will be important to increase resource efficiency through different strategies of demand mitigation, product substitution, and recycling. For example, in the cement sector, better building codes and industry education could substantially lower the cement use in buildings. Another route to demand mitigation is the use of clinker substitutes such as fly ash and steel blast furnace slag. However, the scope of increasing traditional clinker substitutes is limited, but emerging options such as combinations of calcined clays and ground limestone could potentially replace large amounts of clinker in cement (Scrivener, John, & Gartner, 2018). Maximising the recycling of steel has the potential to replace large amounts of primary steel production, substantially lowering emissions from the iron and steel sector, given the lower emissions intensity of secondary steel production. In terms of end-use product substitution, cross-laminated timber or bamboo can be used to replace steel and/or cement structures in buildings.

Fuel switching

One of the main options for deep decarbonisation in the HTA sub-sectors is the switching of fuels away from current sources, predominantly coal, towards low or zero carbon alternatives. This can include electrification (using renewable sources), the use of (low carbon) hydrogen, or the use of biomass (solid or gaseous). Some electrification of industrial processes is already underway in India. There is substantial potential for different forms of electrification to provide different grades of process heat (McMillan, Boardman, McKellar, Sabharwall, Ruth, & Bragg-Sitton, 2016). However, for electrification of industry in India the reliability and cost-effectiveness of electricity supply will be a significant barrier.

For some processes, particularly those requiring large amounts of high-temperature heat and/or process inputs such as a hydrogen feedstock or reacting agent, hydrogen may be a better low carbon route. The HYBRIT project being run in Sweden is investigating the potential of using hydrogen for direct reduction of iron ore (SEI, 2018). Using hydrogen in this way also has the potential benefit of being able to provide demand-side flexibility, through the storage of hot iron briquettes and/or the storage of hydrogen. This would be beneficial for India, which is forecast to require large amounts of flexibility in future as the share of renewable electricity generation increases (Udetanshu, Pierpont, Khurana, & Nelson, 2019). However, for hydrogen steel to be cost-effective and truly low-carbon would require significant cost reductions in electrolysers and an abundance of low cost, renewable electricity (SEI, 2018).

Biomass can also be used as a substitute for coal across the harder-to-abate sectors, either through direct combustion or via conversion into biofuels. In the steel sector, for example, biomass can be used to substitute coal in the blast furnace basic oxygen furnace (BF–BOF) route. This is already used in countries with abundant access to biomass resources, such as Brazil, where small blast furnaces use 100% charcoal instead of coke (Fick, Mirgaux, Neau, & Patisson, 2014). The main barrier to the wide-scale adoption of biomass use in India is the cost and availability of biomass, whilst ensuring sustainable land management practices (Mandova, Gale, Williams, Heyes, Hodgson, & Miah, 2018). A comprehensive assessment of competing biomass uses (e.g. biofuel for aviation) will need to carried out before the potential of biomass use in industry can be understood.

Carbon capture, usage and storage (CCUS)

Deploying CCUS is likely to be a vital technology in abating emissions within the HTA sub-sectors, particularly for cement. It is most cost-effective when used to capture CO2 from large industrial sources, as this reduces the requirement to build out significant pipeline infrastructure, i.e., building fewer, larger pipelines, instead of more, smaller pipelines. There is also the potential to use some of the captured carbon in this process, known as carbon capture and use (CCU). Carbon can be used to produce renewable methanol, for mineral carbonation, to produce polymers or in existing commercial industrial uses (e.g. EOR, drinks, horticulture) (Element Energy, 2014).To improve the business case of CCUS networks, it may be possible for several different users to share the cost of the infrastructure in 'industrial clusters'. For example, a large cement plant could share a CCUS network with a hydrogen production facility, where some of the carbon is captured and used in the production of basic chemicals. India is at an early stage of developing domestic CCUS expertise and infrastructure but pilot projects are beginning to be established, primarily in the oil and gas (for EOR) and fertiliser sectors (Gupta & Paul, 2019).

CONCLUSION: FUTURE FRAMEWORK FOR DECARBONISING INDIAN INDUSTRY

This paper has set out the current status of Indian industry and its need to transition to resource efficient, sustainable and low carbon production in order to support future growth. We then discuss a number of challenges that need to be overcome for the HTA sectors, which are specific to the Indian context. The paper then outlines the steps that can be taken to reduce emissions in these sectors, covering energy efficiency, increased material efficiency and step-change technologies, such as hydrogen and CCUS.

To conclude, the policy framework in the harder-to-abate sectors, to facilitate an industry transition, must focus on:

- Continued improvements in energy efficiency, whether that be near-term international benchmarks or future step-change technologies;
- Achieving a high degree of material circularity, understanding scope for material substitution and reducing material intensity where possible and;
- Developing longer-term technology roadmaps and collaborative RD&D programmes at the global scale for the HTA sectors and associated technologies.

REFERENCES

CCC. (2019). *Net Zero Technical Report*. Retrieved from https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf

Element Energy. (2014). *Demonstrating CO2 capture in the UK cement, chemicals, iron and steel and oil refining sectors by 2025*. Retrieved from http://www.element-energy.co.uk/wordpress/wp-content/uploads/2017/06/Element_Energy_DECC_BIS_Industrial_CCS_and_CCU_final_report_14052014.pdf

ETC. (2018). *Mission Possible.* Retrieved from http://www.energy-transitions.org/sites/default/files/ETC_MissionPossible_FullReport.pdf

Fick, G., Mirgaux, O., Neau, P., & Patisson, F. (2014). Using biomass for pig iron production: a technical, environmental and economical assessment. Waste and Biomass Valorization, 43-55.

Firoz, A. (2014). *Long Term Perspectives for Indian Steel Industry.*

Gupta, A., & Paul, A. (2019). Carbon capture and sequestration potential in India: A comprehensive review., (pp. 848-855).

IEA. (2016). *Energy Balances of Non-OECD Countries.* Retrieved from https://www.iea.org/statistics/relateddatabases/energybalancesofnon-oecdcountries/

IEA. (2019). *World Energy Balances.* Retrieved from Retrieved May 3, 2019, from: http://wds.iea.org

Mandova, H., Gale, W., Williams, A., Heyes, A., Hodgson, P., & Miah, K. (2018). Global assessment of biomass suitability for ironmaking - Opportunities for co-location of sustainable biomass, iron and steel production and supportive policies. Sustainable Energy Technologies and Assessments, 23-29.

McMillan, C., Boardman, R., McKellar, M., Sabharwall, P., Ruth, M., & Bragg-Sitton, S. (2016). Generation and Use of Thermal Energy in the US Industrial Sector and Opportunities to Reduce its Carbon Emissions. Retrieved from https://www.nrel.gov/docs/fy17osti/66763.pdf

MoS. (2017). *National Steel Policy.* Retrieved from Ministry of Steel: https://steel.gov.in/national-steel-policy-nsp-2017

SEI. (2018). *Hydrogen steelmaking for a low-carbon economy.* Retrieved from https://www.sei.org/publications/hydrogen-steelmaking/

Siddiqui, K. (2015). Challenges for Industrialisation in India: State versus Market Policies. R*esearch in World Economy, 6*(2).

Udetanshu, Pierpont, B., Khurana, S., & Nelson, D. (2019). *Developing a roadmap to a flexible, low-carbon Indian electricity system: interim findings.* Retrieved from https://www.teriin.org/sites/default/files/2019-02/Developing%20a%20roadmap%20to%20a%20flexible-low%E2%80%90carbon%20Indian%20electricity%20system.pdf

WBCSD. (2018). *Low Carbon Technology Roadmap for the Indian Cement Sector: Status Review.* Retrieved from https://www.wbcsd.org/Sector-Projects/Cement-Sustainability-Initiative/Resources/Low-Carbon-Technology-Roadmap-for-the-Indian-Cement-Sector-Status-Review-2018

World Bank. (2011). *Energy Intensive Sectors of the Indian Economy.* Retrieved from http://documents.worldbank.org/curated/en/753461468041481044/pdf/546070ESW0WHIT00India0LC0FullReport.pdf

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