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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.

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

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THEMATIC PAPER

ENABLING DECARBONISATION OF INDIAN INDUSTRY

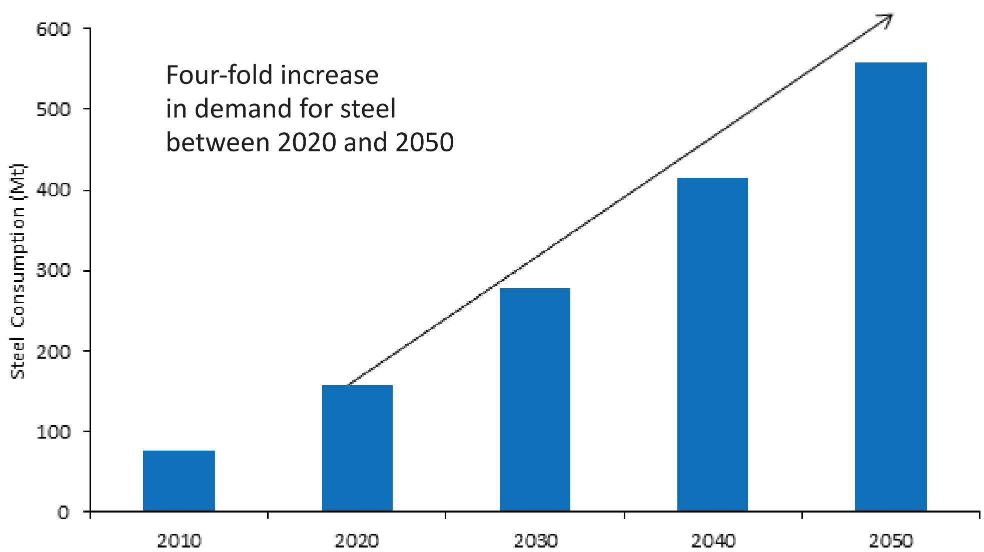
WILL HALL, ASSOCIATE FELLOW, TERI

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).

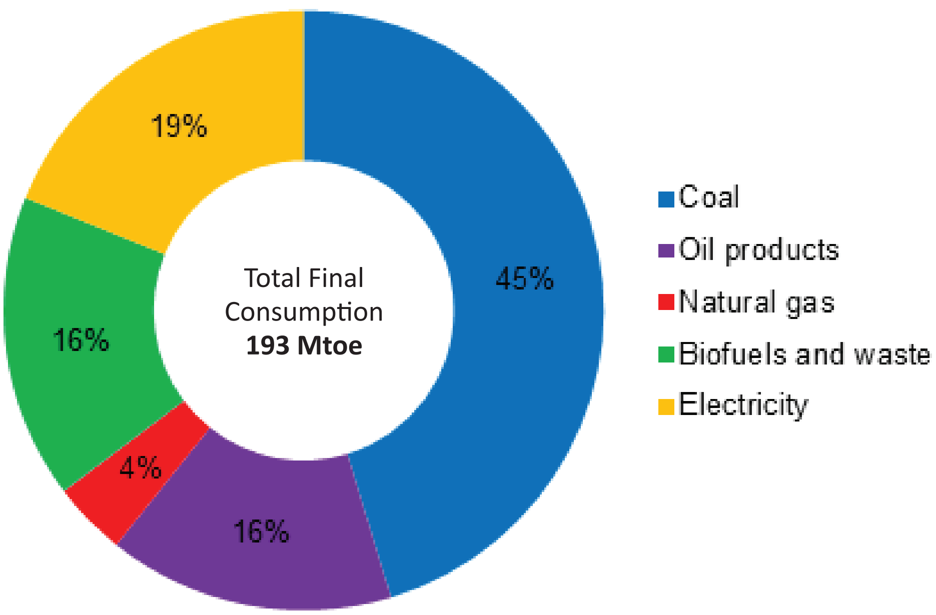
If India is to remain globally competitive and achieve sustainable growth, within the constraints of the environment, future industrial strategy should prioritise greater resource efficiency in the heavy industry sectors. Beyond energy efficiency, these sectors should also consider the adoption of new 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.

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