CLIMATE GROUP

A spotlight on decarbonising heavy industry in India

Narratives on iron and steel, cement, and chemicals

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Organisation: The Climate Group drives climate action. Fast. Our goal is a world of net zero carbon emissions by 2050, with greater prosperity for all. We focus on systems with the highest emissions and where our networks have the greatest opportunity to drive change. We do this by building large and influential networks and holding organisations accountable, turning their commitments into action. We share what we achieve together to show more organisations what they could do. We are an international non-profit organisation, founded in 2004, with offices in London, New Delhi and New York. We are proud to be part of the We Mean Business coalition. Follow us on Twitter @ClimateGroup.

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Executive summary

The hard-to-abate sectors, mainly iron and steel, cement and chemicals are growing at a fast pace given rapid urbanisation and economic growth globally. Since these are among the most energy intensive, their growth and demand is bound to impact the already high emissions from these sectors.

The abundance of infrastructure and developmental projects rolled out and in the pipeline by the Government of India, necessitates a deliberate mitigation of rising emissions from these sectors by both government and businesses.

With huge mitigation and investment opportunities, the heavy industry sector could potentially be the renewable sector of the 2030s. Governments, companies and civil societies alike are focusing on these industries – mainly in two broad focus areas:

1. **What is possible to achieve through best available technologies and how far will that take us till about 2030?**
2. **What could be the next-gen technologies that can help achieve deep decarbonisation and what do we need to do now to ensure a seamless transition?**

With some sectoral nuances, the steel, cement, and chemical sectors all reflect the same patterns. All three sectors understand that the best available technologies on improving energy efficiency, demand management and material circularity are beneficial for the bottom line with short break-even cycles.

There is a push by the national government through initiatives such as the Perform Achieve and Trade Scheme (PAT) to encourage large emitters to adopt these practices. As per studies, all these have been helpful in curbing emissions and could potentially reduce emissions by 40%.

Investment in Research, Development and Demonstration (RD&D) still accounts for a miniscule share of the overall budget of large companies. To scale up new technologies such as hydrogen fuel, Carbon Capture, Use and Storage (CCUS), etc, this is a significant barrier and merits a collaborative approach from both private and public stakeholders to explore innovative business models. Additionally, there are policy barriers that are decelerating the transition in India along with the challenge of COVID-19 pandemic that has slowed economies worldwide.

This report is part of a heavy industry scoping study in three sectors – iron and steel, cement, and chemicals. The report draws key insights from extensive literature review, stakeholder and expert interviews with both businesses and civil society and two virtual workshops held between September and December 2020. These activities present the current state of play in heavy industry decarbonisation in India and the potential opportunities and way forward.

Introduction

The heavy industry sector has been a key player in ensuring job security and enabling India to become one of the fastest growing economies in the world[1]. The sector has contributed significantly to the socio-economic development and urbanisation in the country, due to which energy demand in India has been on the rise.

The power and heavy industry sectors globally accounted for around 60% of annual emissions from existing infrastructure in 2019, while iron and steel, cement and chemical industries combined generated around 11% of total energy system CO_2 emissions (including industrial process emissions). In line with this trend, the increase in energy demand has resulted in a significant rise in greenhouse gas (GHG) emissions in the country, particularly from the heavy industry sectors such as – iron and steel, cement, and chemicals.

Globally we have witnessed an increase in demand for these materials. The demand for cement and steel has more than doubled and a key product in the chemical sector. Plastics has increased by more than 90% since the start of the millennium[2]. This trajectory is likely to continue since demand for the products manufactured from Iron and steel, cement and chemicals are needed for a sustainably developed world as well.

Given this reality, it is imperative for these sectors to set out clear pathways and roadmaps for decarbonisation.

As one of the fastest growing economies in the world, India is poised to achieve sustainable socio-economic development by setting and achieving serious targets towards decarbonising the heavy industry sectors. However, at present there are no concrete plans and targets set in place from the government. Moreover, the Nationally Determined Targets (NDCs) does not mention decarbonisation in the short, medium, or long term.

Both from a policy perspective and from an industry perspective there seems to be a gap in recognising roles of who will lead India's transition towards decarbonisation. The nexus between socio-economic growth and sustainable development needs to be decoupled from the increase in GHG emissions. Collaboration between industries, civil society and the Government is essential to achieve decarbonisation, consequently resulting in sustainable growth.

[1] https://www.investopedia.com/insights/worlds-top-economies/#:~:text=India%20is%20the%20fastest%2Dgrowing,the%20United%20Kingdom%20and%20France.
[2] https://www.iea.org/reports/the-future-of-petrochemicals

Indian iron and steel sector

Overview

The iron and steel sector are the backbone of the Indian economy. Rapid urbanisation and growth in key sectors in India such as building construction and infrastructure development, railways, machinery, automobiles, etc. have catalysed the growth of iron and steel in recent decades.

The last five years has seen continuous growth in the volume of iron and steel production in the country, rising from 90.98 MT (million tonne) in FY2016 to 116.52 MT in FY2020[3], making it the world's second-largest producer of crude steel. India is also the third largest consumer of finished steel globally behind China and the US. The sector contributes nearly 2% to country's GDP and employs over six hundred thousand people[4].

Being energy intensive sectors, this demand trajectory is going to considerably impact greenhouse gas emissions. Therefore, strategic interventions through policy, technology and investment support is imperative to curb emissions while simultaneously meeting the growing steel demand in the country.

Demand and growth scenario

India allows for 100% foreign direct investment (FDI) under the automatic route. This has facilitated significant investments in India's steel sector by foreign countries, primarily in technology and state-of-the-art machinery. This is complemented by strong support from private companies who have significantly expanded their footprint globally.

The global steel production volume is estimated to reach 2175 million tonnes in 2024, growing at a CAGR of 4.50% between 2020 and 2024[5]. This growth is the result of two major trends: a shift from ore-based to scrap-based steel and from BF-BOF (Blast Furnace-Basic Oxygen Furnace) to Electric Arc Furnace (EAF) production, with major differences by country and region.

[3] https://www.ibef.org/download/Manufacturing-August-2020.pdf
[4] https://www.makeinindia.com/article/-/v/steel-sector-achievement-report#:~:text=The%20steel%20sector%20contributes%20nearly,infrastructure%20enablement%20in%20the%20sector.&text=Related%20Posts%3A,National%20Digital%20Health%20Mission
[5] https://www.businesswire.com/news/home/20201022005637/en/Global-Steel-Industry-2020-to-2024---Insights-Forecast-with-Potential-Impact-of-COVID-19---ResearchAndMarkets.com#:~:text=The%20global%20steel%20production%20volume,spanning%20from%202020%20to%202024.

The graph above depicts the growth in steel production in India in the last five years[6]. The main production routes in India are BF-BOF (45%), Electric Arc Furnace (26%) and Induction Furnace (29%)[7].

Focusing in on production pathways, India is the world's largest producer of sponge iron, owing to the widespread use of direct reduced iron (DRI), EAF and induction furnace routes in the country. In India, steel production capacity reached 142 MT in 2018–19, with an average capacity utilisation factor of 75-80%.

The low utilisation factor, however, can be attributed to sub-optimal demand in recent years. Further, as per the World Steel Association, output of Indian steel production was 24% lower in the first half of 2020 compared to the first half of 2019, due to the COVID-19 pandemic. The National Steel Policy 2017, however, envisions to build a globally competitive industry with a crude steel capacity of 300 MT by 2030-31 and increase per capita steel consumption to 160 Kgs (Kilograms) by 2030-31.

Energy demand and emissions scenario

Growing iron and steel demand in India is has come at the cost of environmental degradation and emissions. Due to the nature of production in India, heavy dependence on coal as fuel and DRI furnaces, the Indian iron and steel industry is considered as one of the most energy intensive sectors in the world.

The iron and steel sector, being predominantly coal dependent (85% of energy inputs), holds the largest share of total industrial energy demand in India. Currently the steel industry consumes final energy of around 70 MT of oil equivalent (MTOE), representing almost 23% of total energy inputs to the industrial sector[8]. As per the International Energy Agency, emissions from the steel sector now accounts for the largest share at 30% (252 MT of CO2) in 2019, corresponding to more than 9% of India's total energy-related CO2 emissions.

Considering the rapid economic development and growth in demand segments such as buildings and infrastructure, automobiles, machinery, railways, MSMEs, etc, the total emission is projected to reach around 837 MT CO2 by 2050.

Existing policies for the iron and steel Sector

To address the issue of emissions, air pollution and other harmful impacts from industries and simultaneously enhance energy efficiency, the Government of India has taken bold steps through policy and regulatory measures.

Perform, Achieve and Trade (PAT)	A market-based mechanism incentivising heavy emitting industries including iron and steel, cement, thermal power plants, aluminium, etc to improve energy efficiency. PAT cycle I (2012-15) achieved an energy saving of 8.67 MTOE against the targeted energy saving of 6.68 MTOE, equivalent to monetary savings of approx. INR 9500 crore. Currently PAT cycle IV is underway.
National Resource Efficiency Policy 2019	Aims to enhance resource efficiency and promote the use of secondary (i.e. recycled) raw materials. The policy includes the goal to eliminate scrap imports by 2030 (at 20-25% today), increase the steel recycling rate to 90% and increase the slag utilisation rate to 50% by 2025 and 85% by 2030[9].

[6] https://www.ibef.org/download/Manufacturing-August-2020.pdf
[7] https://www.teriin.org/sites/default/files/2020-03/Towards%20a%20Low%20Carbon%20Steel%20Sector%20Report.pdf
[8] https://webstore.iea.org/download/direct/4208
[9] http://moef.gov.in/wp-content/uploads/2019/07/Draft-National-Resourc.pdf

Steel Scrap Recycling Policy	To promote 6Rs principles of Reduce, Reuse, Recycle, Recover, Redesign and Remanufacture through scientific handling, processing, and disposal of all types of recyclable scraps including non-ferrous scraps and lead to resource conservation and energy savings[10].
National Steel Policy[11]	The National Steel Policy 2017 aims to augment steel production in the country by facilitating faster growth and development of steel industry. The policy projects crude steel capacity of 300 MT, production of 255 MT and a robust finished steel per capita consumption of 158 Kgs by 2030-31, as against the current consumption of 61 Kgs.

Key emerging technologies

Achieving deep decarbonisation will only be possible by completely moving away from fossil fuel-based energy generation and explore innovative and breakthrough clean technologies. As highlighted in an extensive recent study by TERI, the industry needs to now think beyond transitioning technologies such as coal gasification and those based on natural gas and begin large scale use of the below emerging technologies:

- **CCUS – Carbon Capture, Use and Storage**
  CCUS technology is still in a nascent stage in India, with only a few, small-scale projects currently underway. Studies have identified that CCUS has significant potential to mitigate emissions from the iron and steel sector, should carbon storage be located nearby. A leading technology is the use of the HIsarna process being currently piloted by Tata Steel in five locations in Europe, along with CO_2 capture. This technology can potentially reduce emissions by 20% thereby allowing the raw materials which is injected in a powdery form to be directly converted into liquid iron.

- **Hydrogen as the next generation fuel**
  Hydrogen is currently being hailed as the fuel for the future. In 2016, a Swedish steel company SSAB teamed up with LKAB (mining company) and Vattenfall AB (energy company) and launched a project aimed at investigating the feasibility of a hydrogen-based sponge iron production process with fossil-free electricity as the primary energy source: HYBRIT (Hydrogen Breakthrough Ironmaking Technology). The three companies SSAB, LKAB and Vattenfall AB aim at creating the first fossil-free value chain from mining to finished steel by 2026[12]. If supplied with zero-carbon hydrogen and combined with an electric arc furnace supplied with zero-carbon electricity, this has the potential to reduce emissions by over 94% compared with conventional technologies[13]. The potential scale of hydrogen use in India is huge, increasing between three and 10 times by 2050.

- **Recycling and process innovation**
  A report named ‘The Circular Economy: A powerful force for climate mitigation’, has spelt out the potential to reduce the demand for all major industrial materials in Europe. Commissioned by the Energy Transitions Commission, this work was then replicated at a

[10] https://steel.gov.in/sites/default/files/Steel%20Scrap%20Recycling%20Policy%2006.11.2019.pdf
[11] https://steel.gov.in/national-steel-policy-nsp-2017#:~:text=Consumption%20of%20steel%20in%20the%20country%20reflects%20the%20prosperity%20of%20its%20economy.&text=The%20policy%20projects%20crude%20steel,current%20consumption%20of%2061%20Kgs.
[12] https://group.vattenfall.com/press-and-media/pressreleases/2020/hybrit-ssab-lkab-and-vattenfall-to-start-up-the-worlds-first-pilot-plant-for-fossil-free-steel
[13] https://www.teriin.org/sites/default/files/2020-06/Hydrogen-Policy-Brief.pdf

global level. In total, they estimate that global annual carbon emissions from steel production could be reduced by 37% relative to business as usual by 2050 (and 52% by 2100) through enhanced recycling practices.

- **Coke Dry Quenching (CDQ):** This is a heat recovery system in which heat of the red-hot coke from a coke oven is recovered and utilised for power generation or as steam used for other purposes. It can deliver up to 40% energy consumption reduction. In 2017, Tata Steel established India's largest CDQ facility in their Kalinganagar Steel Plant[14].

- **Ore-based steel production could potentially be fully decarbonised in four ways –**
  (1) Using hydrogen as a reduction agent
  (2) Retrofitting CCUS in existing BF-BOF
  (3) Biomass usage – using charcoal instead of coal in blast furnaces and
  (4) Electrolysis

- **Internal Carbon Pricing**
  In India, 20 companies were reported to have set up the Internal Carbon Pricing (ICP) mechanism, with 31 planning to adopt this mechanism. These include two steel companies. The overall Indian average ICP was found to be INR 1549.1 per tCO2 (~$US 23), with the steel companies, being INR 1172 per tCO2 (~$US 17[15]).

Key commitments by companies

Steel Authority of India Limited (SAIL): The Environment Management Division (EMD) in SAIL has set a target of achieving specific carbon-dioxide emission of 2.30 tonnes per tonne of crude steel production by 2030. This will amount to a 23% reduction in emissions from 2007-08 level. In FY 2018-19, it was able to achieve reduction of 11.7% in CO_2 emission. In Addition, afforestation is a major activity under its climate actions[16].
Tata Steel: Tata Steel was recognised as the Climate Disclosure Leader in 'Steel category' by CDP in 2017 and a leader in the Dow Jones Sustainability Indices for three years in a row. Tata Steel has won several awards including the Lighthouse recognition for its Kalinganagar Plant – a first in India. In 2019, Tata Steel's European business announced its intent to become carbon neutral by 2050 through a range of technological interventions. In our discussion with Tata Steel, they said that they can take on several smaller projects at different plants. However, their challenge lies in transformative actions (such as those done at Kalinganagar), throughout its operations and within the current regulatory and policy frameworks. A significant limitation is lack of support from green finance.
JSW Steel: JSW are prioritising resource utilisation, for which it has invested in and implemented a range of iron and steel making technologies. This includes Corex, Blast Furnace, DRI and Twin Shell ConArc[17]. The company is focusing on encouraging internally driven climate initiatives. JSW have established a cross-functional 'climate action group' for

[14] https://www.tatasteel.com/media/newsroom/press-releases/india/2017/indias-largest-coke-dry-quenching-cdq-facility-at-tata-steel-kalinganagar-reaffirms-commitment-to-a-resource-efficient-circular-economy/#:~:text=In%20its%20continuous%20journey%20towards,Kalinganagar%20Industrial%20Complex%20in%20Jajpur
[15] https://www.teriin.org/sites/default/files/files/low-carbon-pathway-iki-report.pdf
[16] https://www.teriin.org/sites/default/files/files/low-carbon-pathway-iki-report.pdf
[17] https://www.teriin.org/sites/default/files/files/low-carbon-pathway-iki-report.pdf

project planning, as well as a Board level Business Responsibility Reporting Committee which regularly reviews the sustainability parameters and impact of the company's CSR spending.

Decarbonisation: Challenges and emerging narratives

To rapidly drive decarbonisation in Indian heavy industries, the following aspects need to be purposefully looked at:

Financing

Ramping up investment and financing

Companies see value in decarbonisation projects because these add to the bottom line. Since most decarbonisation initiatives already have this impact, external funding is not required for pilot projects.

Civil society feel the need for investment in R&D on new and emerging technologies from both businesses and government. Spending needs to be ramped up to make technologies such as hydrogen and CCUS affordable. A revenue neutral market-based mechanism like the PAT programme could help push adoption of alternative fuels such as biofuels, biomass, hydrogen with a set cut-off date akin to the approach adopted by the government for Bharat Stage (domestic) regulations for vehicles.

Internal carbon pricing or ICP could additionally help create a fund that is accessible to companies. Here carbon, as a commodity, can be traded in the market to generate additional revenue.

MSMEs

Green and clean supply chain including Micro, Small and Medium Enterprises (MSMEs)

Large industries do a lot of outsourcing of their products which means that MSMEs involved in the supply chains contribute directly or indirectly to the overall carbon emissions from the sector. For example, auto companies, where many companies have become aggregators and almost 60 to 70% of the vehicle parts are outsourced.

Most of these outsourced MSMEs either use legacy technologies or are not aware of the long term economic and environmental benefits of using clean fuels and energy efficient technologies. This is both a significant barrier as well as a huge opportunity for the large companies to mitigate sectoral emissions through efforts at the MSME levels.

Demand and economic recovery

The role of civil society will be key to push the agenda of green and just economic recovery

Civil society could continue playing a leading role in pushing the agenda for the need for a green, clean, and just economic recovery, both in government and industry spheres. However, the hesitancy and immediate priority of businesses to follow 'business-as-usual' measures to recover from the losses inflicted by the on-going pandemic poses a significant challenge to this.

More than half of the relief package announced by the government for SMEs have already been utilised – the bulk of it being utilised to take loans for working capital. In Europe, a green deal has been announced recently to drive a sustainable and green economic recovery. Similar leadership needs to come from the government.

Policy

Clear roadmap and policy support from government

The government's key driver to bring in any policy changes will be around energy consumption. Given that Indian industries are in line to meet these targets in the near term, any stricter policy is not expected to be introduced soon. Emissions trading or carbon trading could play a key role in the future. Meanwhile, many large companies already have their own internal carbon pricing.

There is a need for clarity on the government's long-term strategy on decarbonisation, and a need for businesses to engage with government to share their expectations. A forum for businesses and government to ideate and address barriers could be helpful at this juncture.

A recent policy brief published by The Energy and Resources Institute (TERI) suggested a National Mission on Hydrogen along with effective public-private partnerships driving demand-supply of hydrogen will be pivotal in scaling up hydrogen adoption by the industry and other sectors[18].

A new report by the Energy Transitions Commission shows that reaching net-zero carbon emissions from heavy industry and heavy-duty transport can be done through policy, innovation, and investment, with minimal cost to the global economy. Carbon capture (combined with use or storage) will potentially be required to capture process emissions from cement and may also be the most cost-competitive decarbonisation option for other sectors in several geographies.[19]

[18] https://www.teriin.org/sites/default/files/2020-06/Hydrogen-Policy-Brief.pdf
[19] https://www.cmaindia.org/key-areas/environment/#:~:text=to%20achieve%20them.-,The%20sustainability%20engine%20of%20the%20industry%20has%20reduced%20CO2%20emission,0.719%20per%20tonne%20in%202017.

Indian cement sector

Overview

The Indian cement sector accounts for approximately 8% of global cement production, the sector being the fifth largest contributor to the Indian economy. The Cement Manufacturers Association (CMA) in India estimates that cement production in India will reach 1.360 billion tonnes annually by 2050[20] as a result of increasing urbanisation and related demand for infrastructure provision such as housing and real estate, transport infrastructure and industrial development.

There are immense opportunities for the sector due to the national government's aspirations on GDP growth and associated flagship programs such as Smart Cities, Housing for All, and schemes pertaining to dedicated freight corridors, ports, and metro rail.

Given the growth potential of the sector and carbon intensive processes involved with manufacturing of cement, it is pertinent to include cement in the narrative around heavy industries decarbonisation even when India fares well on this front already. This is attributed to efforts made by some of the top Indian cement producers.

In the cement industry CO2 is emitted from both the chemical process and energy consumption associated with the manufacturing of cement[21]. Indirect emissions from the burning of fossil fuels used to heat the kiln account for about 40% of emissions from cement. Finally, electricity used to power additional machinery and the transportation of cement account for 5-10% of the industry's emissions.

Demand and growth scenario

National initiatives such as Housing for All, the dedicated freight corridors and ports project, the metro rail, and smart cities, significantly contribute to the growth of the industrial sectors and are the key drivers and opportunities for the cement sector in India.

The infrastructure sector, which will influence the demand for cement, has become a priority area for the Government of India. India plans to spend $US 1.4 trillion on infrastructure during 2019–23 via sustainable pathways.

India is expected to become the world's third largest construction market by as early as 2022[22].The Union Budget (2020-21) of the Government of India has extended benefits under Section 80 - IBA of the Income Tax Act till March 31, 2020 to promote affordable housing in India. The Union Budget has allocated Rs 139 billion ($US 1.93 billion) for the Urban Rejuvenation Missions: AMRUT and Smart Cities Mission.

The Government's infrastructure push combined with Housing for All, Smart Cities Mission and Swachh Bharat Abhiyan has the potential to boost cement demand in the country. The move is expected to boost the demand of cement from the housing segment as well. As per the Union Budget 2019-20, the government has planned to upgrade 125,000 km of road length over the next five years. Besides this, an outlay of INR 27,500 crore ($US 3.93 billion) has been allotted under the Pradhan Mantri Awas Yojana in the Union Budget 2020-21.

Only 24% of national highway systems in India are four lane roads, thereby presenting immense opportunities for the road sector boom in the coming years. There have been increasing investments in the construction sector with construction and infrastructure sector receiving FDI

[20] Indian Cement Sector SDG Roadmap, WBCSD published 24th June 2019
[21] https://www.teriin.org/sites/default/files/files/low-carbon-pathway-iki-report.pdf
[22] https://www.ibef.org/industry/infrastructure-sector-india.

amounting to $US 25.66 Billion and $US 16.84 Billion respectively between April 2019 and March 2020. FDI in the industries related to manufacturing cement and gypsum products reached to $US 5.28 Billion between April 2019 and March 2020.[23]

Cement demand is expected to grow at a Compound Annual Growth Rate (CAGR) of 5.6% between FY2016 and FY2020. The per capita consumption for cement in India stands at 235 KGs in 2019. Long term cement demand is estimated to grow at 1.2 times of the current GDP growth rate. Due to the increasing demand in various sectors such as housing, commercial construction and industrial construction, the cement industry is expected to reach 550-600 million tonnes per annum (MTPA) by the year 2025.

Emissions scenario

The Indian cement industry is on track to meet its 2030 carbon emissions intensity-reduction objectives set within the Low Carbon Technology Roadmap (LCTR) [24]. The sector has achieved this through various initiatives, efforts, and investments.

The World Business Council for Sustainable Development (WBCSD)[25], estimated that direct CO_2 emission intensity fell by 5% in 2017 in the Indian cement sector compared to the 2010 baseline.

Data from 2017 suggests that the sector reduced its direct CO2 emission intensity by 32 kg CO2 per tonne of cement to 588 kg CO2 per tonne in 2017 alone. A report on "Low Carbon Roadmap for Indian Cement Industry; Status Review 2018[26]" showed that domestic industries achieved the 2020 performance objectives for carbon emissions intensity reduction three years ahead of schedule.

In Addition, Indian cement companies topped the Carbon Disclosure Project (CDP)[27] assessments figures as they were able to reduce carbon footprint in their cement production process over the years.

The cement sector is a significant player in the Bureau of Energy Efficiency's (BEE) ongoing Perform, Achieve and Trade (PAT) scheme for energy savings and is one of the best performing sectors in energy efficiency. The sector has achieved the PAT Cycle Reduction target by about 1.81 times by reducing 1.48 MTOE (million tonnes of oil equivalent) compared to the target of 0.815 MTOE. The sector has already met 80% of the targets of the government's PAT scheme making it one of the most energy-efficient globally.

Emission reductions have also been made possible through increased use of alternative fuels and blended cement production, improved energy efficiency in operations, a reduction in the clinker replacement factor and improved heat recovery with the use of cooler hot air recirculation technology. The alternative fuels thermal substitution rate (TSR) increased five-fold in cement manufacturing between the year 2010 and 2017[28].

The Indian cement sector is the largest consumer of fly ash produced by India's thermal power plants annually and consumes almost 100% of slag produced by India's steel plants. In addition,

[23] https://www.ibef.org/industry/cement-india.aspx
[24] https://www.wbcsd.org/Sector-Projects/Cement-Sustainability-Initiative/News/Indian-cement-industry-on-track-to-meet-2030-carbon-emissions-intensity-reduction-objectives
[25] World Business Council for Sustainable Development (https://www.wbcsd.org/Overview/About-us)
[26] Based on the milestones set in the International Energy Agency (IEA)'s 2013 low carbon technology roadmap
[27] https://www.cdp.net/en/articles/investor/Cement-companies-must-more-than-double-efforts-to-meet-paris-climate-goal
[28] : https://beeindia.gov.in/node/166

the sector plans to use waste as a resource through the substitution of alternative fuels and raw materials (AFRs) over the coming years. Apart from the large-scale use of wastes such as fly ash and slag in cement manufacturing, AFRs include the use of various hazardous and non-hazardous wastes[29].

The CMA estimates the waste heat recovery (WHR) potential of the Indian cement sector at 800 MW (megawatt) and the present installed capacity at approximately 307 MW [30]. The sector is enhancing resource efficiency efforts for blending and the use of alternative fuels, as well as the implementation of waste heat recovery systems. The sector also benefits from newer and more efficient cement plants driven by high market growth in the region.

Key commitments by companies

Nine companies, including ACC, Ambuja Cements, CRH India, Dalmia Cement (Bharat), Heidelberg Cement India, Orient Cement, Shree Cement, UltraTech Cement and Votorantim Cimentos as well as the Cement Manufacturers' Association of India developed a Low-Carbon Technology Roadmap for the Indian Cement sector in 2013 as part of the WBCSD's Cement Sustainability Initiative (CSI) India program. This group was formed as the Cement Sustainability Initiative (CSI) in India in 2009.

As of 1 January 2019, the CSI program moved to the Global Cement and Concrete Association (GCCA). These nine sustainability leaders represent more than 60% of the production capacity in the world's second largest cement market. These companies have come together once more to develop the first country-specific sectoral roadmap based on the WBCSD's SDG Sector Roadmap Guidelines framework.[31]

Of the 20 companies who have set up the Internal Carbon pricing mechanism, five are cement and concrete companies. The average ICP for the cement companies was found to be INR 2032.2 per tCO2 (~$US29). Among companies, Ambuja Cement, was found to have the highest ICP of around $US 30 per tCO2.

Dalmia Cement has the lowest carbon emissions per tonne**e** of cement produced globally. **The company** achieved this by increasing the percentage of renewables in its overall electricity consumption (with a target of 100% RE by 2030)[32], in addition to undertaking energy conservation and experimenting with carbon capture and Use (CCU) technology at one of its plants in Tamil Nadu.

The company is working with the UK based Carbon Clean Solutions Limited (CCSL), a company engaged in the low-cost carbon dioxide separation technology. This would be the largest-scale CCU demonstration project in the cement industry. The project will have

[29] http://knowledgeplatform.in/wp-content/uploads/2015/09/IIP_AFR_Booklet.pdf
[30] https://www.ifc.org/wps/wcm/connect/f0394a25-3645-4765-8291ea33d9f09594/IFC+Waste+Heat+Recovery+Report.pdf?MOD=AJPERES&CVID=kqgTRfZ
[31] As per WBCSD – "This Roadmap reflects the broader actions – supported with key performance indicators – that will guide the sector to achieve its strategic priorities, mission and vision while contributing to achieving the SDGs. The Roadmap presents the interconnected nature of the sector's activities and the common goals on which the sector is and will be working. The articulation of the key impact opportunities and actions highlighted in this report is the first step on the road to continued SDG engagement."
The roadmap outlines initiatives/measure that help achieve SDG 7 – "Affordable and Clean Energy", SDG – 11 – "Sustainable Cities and Communities" and SDG – 13 – "Climate Action" amongst others – Hence taking a more holistic approach to the industry roadmap where focus on climate and decarbonisation remains a key priority
[32] https://www.dalmiabharat.com/press_release/dalmia-cement-becomes-first-cement-company-to-commit-to-100-renewable-power/

multiple utilisation streams, has a capacity of 500,000 tonnes, will be critical for the company to achieve its climate goal.[33]
Ultratech Cement has undertaken numerous initiatives to increase the share of renewable energy, switch from fossil fuels to alternative materials, reduce clinker ratio, improve energy efficiency, and scale up investments in the development of innovative products and services[34]. In 2019, the company announced its intent to increase contribution of green energy from 10% of its total power consumption in 2019 to 25% of its total power consumption by 2021, to enable it to reduce its carbon emissions by 25% (from 2005-06 level) by 2021[35]

Decarbonisation: Emerging narratives

Technology deployment and access

By nature, the cement manufacturing processes need to use fossil fuels. Since renewable electricity does not seem to be a feasible option to generate heat at extreme temperatures (essential for cement manufacturing), the carbon capture and storage technologies will need to be deployed and made accessible to the companies. This can be conducted by proper market strategies and technology transfer mechanisms. In terms of available decarbonisation technologies, CCUS is what the industry is most hopeful about. However, there are also other technologies such as hydrogen and low temperature clinker to name a few.

Demand management

There are potential opportunities to be explored around the demand management side. This is especially relevant access to waste and waste management. The concept of a circular economy is the ideal way to manage and reuse waste, however we are still at the nascent stage of adopting this waste management model. However, despite the waste management regulations currently in play, they are not utilised due to the failure of formal mechanism in place.

Besides this, India can facilitate blending by using fly ash as a substitute for clinker. However, with India's ambition of 175 GW of renewable power, conventional power facilities will cease to exist– leading to lesser availability of fly ash. There is also a limitation to steel plant slag and how much of it would be available for the cement industry. In the next five to 10 years, cement demand will double to more than 800 MT of cement and it will need over 150 MT of fly ash.

In addition, some of the CSO interviews suggested that there is a case to be made in considering the entire life cycle of the value chain on CO2 emission from the cement sector. Cement is an intermediate product and concrete is the final product (used in building constructions). To calculate CO2 emission, we must look at it in its entirety.

To do this, the different ways in which cement can be converted to concrete depending on the proportion of cement mixed has to be considered. For example, CO2 could be calculated as volume of CO2 emitted in cubic metre of built environment and not as volume of CO2 emitted in 1 tonne of cement produced. The volume of CO2 emitted at a manufacturing stage is high, but over the life cycle of usage in built material etc, it gets somewhat neutralised and hence

[33] https://www.prnewswire.com/in/news-releases/dalmia-cement-bharat-limited-globally-ranked-no-1-by-cdp-for-lowest-carbon-footprint-684550771.html#:~:text=DBL%20produces%20one%20of%20the,on%20water%20conservation%20and%20harvesting.
[34] https://www.ultratechcement.com/about-us/sustainability/sustainability-framework/climate-change
[35] https://www.ultratechcement.com/about-us/media/press-releases/ultratech-cement-to-exceed-25-per-cent-green-energy-contribution-to-total-energy-consumption-by-2021

important to take a lifecycle perspective. However, this view of accounting for CO_2 emissions tends to discount the emission intensity of the sector and cannot be an excuse to reduce intensity of carbon emissions or decarbonise at every stage of production and operation.

Developed countries have lower per capita consumption for cement. This is because most of the infrastructure is already built. India's growth projections support immense investment in new infrastructure and hence the overall demand for cement will only increase; thereby highlighting the strong case to decarbonise the sector fast.

Most of the decarbonisation initiatives thus far in the sector have been company driven. For example, Ultratech has signed up to SBTi, EP100 and has its own internal targets on alternate fuels, carbon market simulation etc. Initiatives such as these initiate collaborations, competition and provide appropriate platforms to facilitate deployment of decarbonisation measures in a structured campaign and target-based fashion.

Financing

The sector is looking at investments of between INR 2 trillion ($US 30 billion) and INR 3.8 trillion ($US 50 billion) to achieve the CO_2 emission reduction target envisaged for 2050.

The industry itself is already responding to the need for funding decarbonisation initiatives as well as in early investments to pilot new technologies. More and more companies have adopted an internal carbon pricing mechanism. This has generated a funding pool within companies that is being directed towards decarbonisation efforts.

Companies see value in decarbonisation projects aimed at improving energy efficiency or improving material circularity because these directly impact the bottom line. Since cement is a commodity, intense competition exists on price, cutting down costs is a primary lever to meet competition. The cost of the product is 30% to 40% and is directly attributable to fuels and energy required, hence energy saved or avoided (leading to reduced emissions) is a margin improved.

The above rationale does have a negative impact as competition intensifies between local producers of cement v/s bigger players in the sector. In order to be competitive some of the decarbonisation ambitions run the risk of being ignored particularly from the side of the local mid-level industries where there is no immediate economic benefit within line of sight.

There is acknowledgment within individual companies of the need to invest in pilot technologies that in the long run have the potential to decarbonise the entire sector. Hence the sector is exploring through its association with Global Cement and Concrete Association India (GCCA – India) by investing in innovative pilot concepts and projects that could be potential deep decarbonisation solutions in the future and can be adopted across the board.

Internal carbon pricing has the potential for assessment of funds. Carbon can be sold in the market and some revenue could arise from that. Furthermore, investments in CCUS could help avoid regulatory costs in the future. There may not be a bottom-line incentive for companies to invest in CCUS projects now. However, if the government comes up with a cap on CO_2 emissions and companies must borrow allowances from the market, resulting in a cash outflow, to meet the norms, then there will be a more direct financial incentive to invest in CCUS. Investments in CCUS could hence avoid regulatory costs for companies in the long run.

There is an ongoing recognition for the need of innovation in products and technology to meet our climate objectives. In the light of this, Global Cement and Concrete Research Network has established Innovandi. Innovandi is an ambitious industrial academic research network focused

on lowering the CO_2 footprint of cement and concrete, and already has 30 companies and 40 leading academic institutions from around the world as its members and partners[36].

MSMEs

Large industries depend on outsourcing which means there is both a direct way in which MSMEs impact carbon emission, and an indirect way. For example, auto companies, where many companies have become aggregators wherein almost 60% to 70% of the vehicle parts are outsourced. MSME is the biggest employer in India and in the current economic scenario, MSME is struggling. As a result, the primary focus now should be to allow MSMEs time to recover from the economic slowdown to then take up sustainable pathways.

One of the leading cement companies that engages over 30,000 suppliers (mostly MSMEs) has designed a program with ~150 of its key suppliers to engage on ESG (Environmental, Social and Governance) parameters. While the focus is on cost reductions, carbon and energy are indirectly impacted. Despite being one of the first movers in engaging supply chain on sustainability parameters in a formal way, this may be happening across other companies as well. This approach remains one of the most robust and reliable methods to include MSMEs in the decarbonisation regime.

Policy

A new report by the Energy Transitions Commission shows that reaching net-zero carbon emissions from heavy industry and heavy-duty transport can be achieved through policy, innovation, and investment, with minimal cost to the global economy. Carbon capture (combined with use or storage) will likely be required to capture process emissions from cement and consequently, be the most cost-competitive decarbonisation option for other sectors in several geographies.[37]

However, to do this there is a need for a common framework dictated by a policy that can help build an ecosystem that facilitates decarbonisation and create a healthy market environment around it. There is a need for appropriate, standardised regulations for uniformity across pathways/practices for companies across the heavy industry sector.

Finally, regulations around construction and demolition waste that allows recycling waste is essential. This has the potential to generate fresh concrete for use in construction.

Re-carbonatisation

Cement manufacturing is a carbon intensive process and therefore concrete is a carbon intensive product. However, concrete also absorbs CO_2 throughout its lifecycle – a process called recarbonatisation. The GCCA is currently undertaking research to calculate the potential of CO_2 absorption by concrete in the built environment. This will help make an accurate assessment of the impact of concrete on CO_2 emissions throughout its life cycle. Now it is

[36] https://gccassociation.org/wp-content/uploads/2020/09/GCCA_ClimateAmbitionStatement_English_Screen_AW.pdf

[37] https://www.cmaindia.org/key-areas/environment/#:~:text=to%20achieve%20them.-,The%20sustainability%20engine%20of%20the%20industry%20has%20reduced%20CO2%20emission,0.719%20per%20tonne%20in%202017.

estimated that as much as 100% of process CO_2 from the clinker manufacturing process can be re-absorbed by the concrete or mortar during its lifetime[38].

[38] https://gccassociation.org/wp-content/uploads/2020/09/GCCA_ClimateAmbitionStatement_English_Screen_AW.pdf

Indian chemical sector

Overview

The chemical industry is a vast industry and produces materials that trickle down into every other downstream sector[39]. The highest growth in this sector is expected to be in China, Latin America, India, and the Middle East[40].

The Indian chemical industry is ranked 6th largest in the world and 3rd largest in Asia[41], and is one of the oldest industries in the country. India is one of the largest production hubs of chemicals with an output of over 80,000 commercial chemical products[42]. In the next five years the industry is expected to grow by 13-14%[3], projecting major demand increases which would result in emissions increase if the industry carries on with business as usual.

The chemical industry is a significant consumer of the global energy system. The rise in plastics – the most popular petrochemical - is a testament to this, overtaking all other bulk materials such as steel and cement.[43]

The Government of India recognises the chemical industry as one of the key growth players of the Indian economy. The industry contributes approximately 10.5% to the global foreign trade[44]. Furthermore, the government has listed this sector as a priority under the 'Make in India' initiative[45].

For this report we have chosen to focus on the production of ammonia and petrochemicals since they are the most energy and emissions intensive chemical processes, often viewed as essential commodity products for the growth of the country[46].

Demand and growth scenario

Ammonia

India is ranked fourth largest producer for agrochemicals in the world[47]. The largest demand for ammonia emerges from the fertiliser industry[48]as ammonia is needed to produce urea, ammonium nitrate and ammonium phosphate, essential compounds for nitrogen-based

[39] https://www.essentialchemicalindustry.org/the-chemical-industry/the-chemical-industry.html
[40] https://www.globalefficiencyintel.com/new-blog/2018/chemical-industrys-energy-use-emissions
[41] https://www.maiervidorno.com/indian-chemical-industry-accelerating-growth/#:~:text=Numerous%20initiatives%20have%20been%20proposed,more%20intolerant%20towards%20environmental%20pollution.
[42] https://smefutures.com/india-chemicals-2-the-countrys-chemical-industry-is-at-next-phase-of-growth/
[43] https://www.iea.org/reports/the-future-of-petrochemicals
[44] https://economictimes.indiatimes.com/small-biz/sme-sector/a-163-billion-sector-is-fighting-against-a-hazardous-future-chemical-sector-india/articleshow/71716343.cms#:~:text=Environment%3A%20The%20levels%20of%20pollution,of%20the%20chemical%20industry%20clusters.&text=Energy%3A%20The%20Indian%20chemical%20industry%20is%20a%20major%20consumer%20of%20ener
[45] http://visionias.in/beta/sites/all/themes/momentum/files/CA_Important_Issues/Make_in_India.pdf
[46] https://www.ceew.in/sites/default/files/CEEW%20-%20Sustainable%20manufacturing%20in%20a%20low-carbon%20economy%2024Sep19.pdf#overlay-context=
[47] http://ficci.in/events/20563/Add_docs/SectorBrief.pdf
[48] https://www.businesswire.com/news/home/20200102005427/en/India-Ammonia-Market-Study-2019-Trends-Share-Size-Growth-Opportunity-and-Forecast-2020-2025---ResearchAndMarkets.com#:~:text=The%20Indian%20ammonia%20market%20reached,15%20Million%20Tons%20in%202019.&text=Growing%20demand%20of%20food%2C%20owing,growth%20of%20the%20ammonia%20industry.

fertilisers. In India ammonia production is dominated by urea and ammonium phosphate fertilisers accounting for almost 93.8% of the demand in this sector[49].

Fertiliser production in 2020 saw a 2.79% increase than last year, urea production was 8.40% higher compared to 2019 (the highest production of urea[50]).

We are now seeing India on track to becoming the most populated country in the world[51]. As the population grows so will demand for food and agriculture. This growth will catalyse the demand for fertilisers, and consequently the growth of the ammonia industry.

Apart from the fertiliser industry, ammonia is an essential chemical needed for refrigerants. As the country sees rapid urbanisation the demand for refrigerants is expected to increase, in turn impacting the demand for ammonia[52]. Other than the above-mentioned products, ammonia is needed as a building block for various compounds to produce household products, cosmetics, pharmaceuticals, and metal treating, to name a few[53].

Petrochemicals

Petrochemicals is the leader of the chemicals sector; they are the backbone of most raw materials needed for products used by majority of the population[54]. There are two types of petrochemicals: olefins and aromatics[55]. Outputs from both chemical process infiltrate nearly every other industry. They establish the foundations for many sectors such as: pharmaceuticals, textiles, construction, packaging, automotive and many more. Over 95% of products manufactured are directly impacted by this industry[56].

It is estimated that over the next decade India will contribute more than 10% of the global growth in petrochemicals[57] – in the next three years the demand is expected to grow by 8-9% annually[58]. The sector has also seen an increase in international and domestic investments. The demand for plastics is increasing rapidly, the estimated growth by the Indian Department of Chemicals and Petrochemicals is expected to reach 35 million tonnes by 2027-28[59].

Energy demand and emissions scenario

In India 12% of the total manufacturing emissions are from the chemicals sector. Production of ammonia is highly energy intensive and consequently is the third largest emitter of greenhouse gas emissions (after steel and cement)[60].

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[49] https://www.globaldata.com/indias-ammonia-capacity-is-expected-to-witness-double-digit-growth-over-the-next-six-years-says-globaldata/
[50] https://www.financialexpress.com/industry/urea-output-at-record-244-55-lakh-tonne-in-fy20/2032351/
[51] https://ourworldindata.org/india-will-soon-overtake-china-to-become-the-most-populous-country-in-the-world
[52] https://www.businesswire.com/news/home/20200102005427/en/India-Ammonia-Market-Study-2019-Trends-Share-Size-Growth-Opportunity-and-Forecast-2020-2025---ResearchAndMarkets.com#:~:text=The%20Indian%20ammonia%20market%20reached,15%20Million%20Tons%20in%202019.&text=Growing%20demand%20of%20food%2C%20owing,growth%20of%20the%20ammonia%20industry.
[53] https://www.analyticaltechnology.com/analyticaltechnology/gas-water-monitors/blog.aspx?ID=1144&Title=Industries
[54] https://indianpetrochem.com/report/petrochemicalsreport
[55] https://www.britannica.com/science/petrochemical
[56] https://www.researchandmarkets.com/reports/1878608/petrochemicals_industry_in_india
[57] https://www.kearney.in/article/?/a/riding-india-s-petrochemicals-wave#:~:text=With%20demand%20growth%20projected%20at,demand%20(see%20figure%202).
[58] https://energy.economictimes.indiatimes.com/news/oil-and-gas/indias-petrochemical-demand-to-grow-at-8-9-through-2023-crisil/65519205
[59] https://chemicals.nic.in/petrochemicals#introduction
[60] https://www.ceew.in/sites/default/files/CEEW%20-%20Sustainable%20manufacturing%20in%20a%20low-carbon%20economy%2024Sep19.pdf#overlay-context=

Due to India's agrarian economic nature it is heavily dependent on nitrogen-based fertilizers[61]. The chemical industry is not only responsible for a significant amount of CO_2 emissions, but the end use of the products manufactured by ammonia and petrochemicals contribute towards other greenhouse gasses such as methane and nitrogen oxides and is increasing the amount of other GHG emissions of the country[62].

Ammonia

To understand the carbon emission intensity of ammonia production it is important to note the feedstock needed for the process which significantly contributes to the overall GHG make-up of this sector. Large amounts of energy are needed to run an ammonia plant along with the requirement for natural gas or oil as feedstock.

Industrial production of ammonia is based on the steam reforming process. In a conventional ammonia plant natural gas is used and large amounts of energy is required for the overall production of liquified ammonia[63]. Globally 1% of the total world's energy goes into the production of ammonia[64] .

Methane is needed as feedstock to obtain the hydrogen atom which is derived from (usually natural gas) fossil fuels. Around 90% of carbon emissions are emitted during this process[65]. In 2015 urea production accounted for 85% of the total energy consumption from this sector.

Petrochemicals

According to the International Energy Agency, the petrochemical sectors is a blind spot for the overall energy sector[66]. In India this sector is heavily dependent on imported crude oil since naphtha is used to make most of the products making this a heavily oil dependent industry. Within this sector the production of ethylene and propylene is the most emissions intensive process after ammonia.

It is estimated that every tonne of petrochemical production emits approximately two tonnes of CO_2 resulting from the need for thermal energy from the cracking process[67].

Transportation

Globally we are witnessing a shift towards electric vehicles, this shift is going to lower the demand for oil from the transportation sector. However, it is expected that emissions related to crude oil will be related to the production of petrochemicals soon[68].

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61 https://www.natureasia.com/en/nindia/article/10.1038/nindia.2018.83#:~:text=Chemical%20fertilisers%20account%20for%20over,voluntary%20body%20of%20over%20a

62 https://www.iea.org/reports/the-future-of-petrochemicals

63 https://www.aiche.org/resources/publications/cep/2016/september/introduction-ammonia-production#:~:text=While%20most%20of%20the%20global,plants%20are%20located%20in%20China.

64 https://cen.acs.org/environment/green-chemistry/Industrial-ammonia-production-emits-CO2/97/i24#:~:text=Each%20metric%20ton%20of%20ammonia,re%20approximately%20only%2050%25%20efficient.

65 https://royalsociety.org/topics-policy/projects/low-carbon-energy-programme/green-ammonia/

66 https://www.iea.org/reports/the-future-of-petrochemicals

67 https://www.ceew.in/sites/default/files/CEEW%20-%20Sustainable%20manufacturing%20in%20a%20low-carbon%20economy%2024Sep19.pdf#overlay-context=

68 68 https://www.iea.org/reports/the-future-of-petrochemicals

Key steps and commitments by companies

The conventional method of industrial ammonia production uses the Haber-Bosch process. There is limited scope for innovation in this process, however, some companies have incorporated certain energy efficiency measures in their plants.

Research conducted by GlobalData in 2017 found the following companies in India to have the largest ammonia plants: Matix Fertilisers & Chemicals Panagarh Ammonia Plant, Jaypee Fertilizers & Industries Kanpur Ammonia Plant, Yara International Babrala Ammonia Plant, Indo Gulf Fertilizers & Chemicals Corporation Jagdishpur Ammonia Plant and KRIBHCO Hazira Ammonia Plant.

Some of these companies that have adopted energy saving measures:

Matix Fertilisers & Chemicals: This plant produces three million tonnes of urea annually. The company has adopted latest energy efficient technology from industry stewards Kellogg, Brown & Root (KBR) from USA and Saipem, Italy[69].
Jaypee Fertilisers & Industries: Currently, data on the specific ammonia plant is not publicly available. However, the company does list various environmental and energy efficiency targets. The following stand out and could be possibly incorporated within this plant: Operation of industrial plants and infrastructure with modern energy efficient technology which helps in reducing pollution, conservation of energy and have an impact on the company's carbon emissions on a continual basis. Implementation of renewable energy to the extent it is possible.
Yara International Babrala[70]: Yara, an international Norway based ammonia manufacturer, acquired a TATA Chemicals Plant in 2016. Annually 0.7 million tonnes of ammonia and 1.2 million tons of urea is being produced here. In 2016 the Yara plant was said to be the most energy efficient plant in year with energy efficient technology at par with Yara's best international plants.
Indo-Gulf Fertilizers and Chemicals: This is the fertiliser division of the Aditya Birla Grasim Cooperation. They have been named one of the most energy efficient plants in India and the 8th largest urea manufacturer in the country producing 1.2 million tonnes of urea annually.
TATA Chemicals has established an innovation centre with a targeted focus on green technologies for the chemicals sector.

The petrochemicals market on the other hand is an oligopolistic led market, wherein a small number of companies (private and public) govern the rules of the market. The major players in India are: Reliance Industries and Indian Oil Corporation Limited, together they account for nearly 70% of the domestic petrochemicals production[71].

There are other players on the list, however, the production and intensity are highest amongst the above-mentioned two. Out of the two, Reliance Industries is a multi-million conglomerate

[69] https://www.kbr.com/en/solutions/technologies/process-technologies/ammonia-fertilizers-technologies
[70] https://www.yara.com/corporate-releases/yara-acquires-tata-chemicals-urea-business-in-india-for-usd-400-million/
[71] https://www.kearney.in/documents/2979345/13598377/Riding+India%E2%80%99s+petrochemicals+wave.pdf/9930dce7-204f-f5f4-a23f-82fdfa3eb3a9?t=1589961719824

worldwide. Below are some energy efficiency and low carbon measures adopted and incorporated by them for their petrochemicals sector:

Reliance Industries[72] has 10 petrochemicals production plants. It uses naphtha and gas-based crackers for the production and feedstock. The company emphasises its use and investment in new energy efficient technologies. They have also stated the importance of environmental regulation and the need to reduce emissions in their latest sustainability report. The company has breakthrough technologies for all its principal business. The company is also venturing into developing a circular economy business model and is the largest recycler of polyethylene terephthalate in India – recycling over two billion bottles annually. The company has implemented continuous emissions monitoring systems in all its petrochemical plants. Reliance Industries is also developing technologies to extract oil from algae and for cleaner fuel, process optimisation and energy management. In 2018 Reliance industries was named the most energy efficient producer of petrochemicals in response to commissioning the largest refinery off-gas cracker which uses refined gas as feedstock to produce petrochemicals[73].
Hindustan Petroleum Corporation[74] **Ltd** has plans to roll out green lubricants developed from renewable feedstock derived from vegetable oils, biomass such as second-generation bioethanol. They also plan to reduce dependence on methane and another traditional fossil-based feedstock. In their latest sustainability report the corporation has funded a start-up to reduce plastic pollution by creating alternatives to plastic straws by organic biodegradable straws.[75]

Going forward: Scaling up decarbonisation

Badische Anilin und Soda Fabrik (BASF) a leading chemicals cooperation has identified three main areas which need to be addressed to decarbonise the chemicals industry:

1. **Process and energy optimisation**
2. **Renewable energy supply**
3. **CO_2 reduction through breakthrough technologies**[76]**.**

Currently the manufacturing process of ammonia produces brown ammonia. However, several studies and now some pilot projects have been conducted which show the benefits of blue and green ammonia[77] – not just as a standalone decarbonised product but as something which could potentially be used as fuel.

Green ammonia not only has the potential to reduce carbon emission but also assists in the energy transition. Green ammonia can be used as a medium to store and transport chemical energy by the decomposition of ammonia to release hydrogen, as a transport fuel, ideally used in the shipping industry as well as storage of thermal energy through the absorption of water.

[72] https://www.ril.com/DownloadFiles/SustainiabilityReports/RILs%20Sustainability%20Report%202017-18.pdf
[73] https://www.icis.com/explore/resources/news/2018/01/02/10179032/india-s-reliance-commissions-refinery-off-gas-cracker-at-jamnagar/
[74] http://ficci.in/sector/7/Project_docs/Chemical-Petrochemical-sector.pdf
[75] http://www.hindustanpetroleum.com/documents/pdf/HPCL%20SR%202019-20%20Cover%20to%20Cover%20PDF_V2_22.9.20_final.pdf
[76] https://www.weforum.org/agenda/2020/01/how-to-build-a-more-climate-friendly-chemical-industry/#:~:text=Transforming%20chemical%20production%20can%20have,greenhouse%20gas%20(GHG)%20emissions.&text=Our%20products%20are%20made%20up,industry%20is%20simply%20not%20possible.
[77] https://royalsociety.org/-/media/policy/projects/green-ammonia/green-ammonia-policy-briefing.pdf

Green ammonia is the transformative technology needed to scale-up decarbonisation in the chemical industry's most energy intensive and high emissions generating sector.

Hydrogen emerged as a champion alternate in conversations with businesses and civil society experts. They envision this fuel to transform the heavy industries across sectors. Production of green ammonia is possible either via carbon capture and use or by the electrolysis of water to produce hydrogen via renewable energy[78].

A policy brief published by the Royal Society in 2020 highlights [79] the immense potential of green ammonia in reaching our collective goal to shift away from fossil fuels as our primary energy source. It is also optimistic to note that the integration of electrolysers to produce green ammonia in technologically possible since only the steam methane reformer would need to be replaced.

Scaling-up decarbonisation in the petrochemicals space has not been explored as much as ammonia in the chemicals sectors. There are a few **technological options** currently at play which reduce the dependency on crude oil as feedstock for petrochemicals such as: Refinery off gas cracker, crude oil to chemicals and oxidative coupling of methanol[80]. However, decarbonisation is not possible with them. A report published by the Council on Energy, Environment and Water (CEEW) in 2019 elucidated the use of green methanol as a possible route towards decarbonising the petrochemicals industry[81].

The production of **green methanol** would need biomass (the use of biomass and biofuels have their own challenges[82]) and would have a negligible carbon footprint during production. Green methanol production would also need green hydrogen as with green ammonia and CO_2 captured and utilised in a carbon capture and storage plant[83].

The **circular economy** is also another solution towards scaling decarbonisation to a certain extent. The main concept of a circular economy is to minimise waste and material inputs by incorporating eco-design by reusing products. This would help in significantly reducing carbon emissions[84].

Decarbonisation: Challenges and emerging narratives

Technology and investment in RD&D

[78] https://www.teriin.org/sites/default/files/2020-06/Hydrogen-Policy-Brief.pdf

[79] https://royalsociety.org/-/media/policy/projects/green-ammonia/green-ammonia-policy-briefing.pdf

[80] https://www.kearney.in/documents/2979345/13598377/Riding+India%E2%80%99s+petrochemicals+wave.pdf/9930dce7-204f-f5f4-a23f-82fdfa3eb3a9?t=1589961719824

[81] https://www.ceew.in/sites/default/files/CEEW%20-%20Sustainable%20manufacturing%20in%20a%20low-carbon%20economy%2024Sep19.pdf#overlay-context=

[82] https://study.com/academy/lesson/carbon-neutral-activity-biofuel.html#:~:text=Biofuels%20are%20said%20to%20be,when%20the%20fuel%20is%20burned.&text=However%2C%20biofuel%20isn't%20truly,processes%20used%20in%20its%20production.

[83] https://www.thyssenkrupp-industrial-solutions.com/power-to-x/en/green-methanol

[84] https://www.ecologic.eu/16978#:~:text=The%20circular%20economy%20aims%20to,recycling%20and%20reusing%20of%20products.

Most of the technologies mentioned above are still in their nascent stage. However, some companies in the west have implemented pilot projects in green ammonia production, green methanol, green hydrogen, CCUS and principles of circular economy[85].

Large investments in Research, Development & Demonstration (RD&D) as well as international and national level collaboration is needed to pilot, demonstrate, commercialise, and finally implement these necessary technologies needed to decarbonise the chemicals industry.

Understanding the cost competitiveness of these new transformative technologies with the current production processes is also important to note and incorporate when creating decarbonisation roadmaps.

The report by CEEW referred to above also states the socio-economic benefits India would reap while on this decarbonisation journey – it is estimated that hydrogen production chain will generate 200,000 jobs by 2050. Incorporating or building new infrastructure is also a possible challenge which would also require large amounts of investment as well as development of new skills to operate the new technology.

Collaboration

Due to the dynamic nature of this industry and its impact on multiple sectors, a collaborative approach would be needed to overcome most of the challenges related to decarbonisation. It is necessary to form partnerships with international, national, states and business organisations.

Possible decarbonisation initiatives taken within the industry would be essential as well as intra sector collaboration both by businesses, institutions, and government bodies.

Futuristic research is still absent in India, even influential companies that are viewed as leaders in taking forward sustainability in the heavy industry sector have made little headway towards decarbonisation in the chemicals industry.

MSMEs

Micro, small, and medium enterprises (also known as the informal sector in India), lack the funds, and vison to prioritise decarbonisation in their business models. This is where large companies need to take ownership and steer the chemicals industry towards decarbonisation. Greening the supply chain is essential to obtain overall decarbonisation. Thus, large corporations have the funds and influence to bring about this change by investing in technological updates needed to transition to a low carbon and energy efficient pathway.

Overall emissions from the informal sector accounted for 78% of total emissions of India in 2010[86]. This shows the substantial impact of small and medium enterprises on overall GHG intensity and the need to incorporate them into low carbon and energy efficient roadmaps. A holistic approach needs to be implemented to green the supply chain[87] which will have a ripple effect and significantly contribute towards decarbonisation.

Policy

[85] https://www.marketsandmarkets.com/Market-Reports/green-ammonia-market-118396942.html#:~:text=The%20major%20players%20in%20the,and%20Haldor%20Topsoe%20(Denmark).
[86] http://www.ghgplatform-india.org/Images/Publications/CSTEP_GHG_emission_Informal%20sector.pdf
[87] http://ficci.in/spdocument/20441/knowledge-paper-chem.pdf

Economic growth is one of the biggest priorities for India. However, with the current political climate and India being one of the signatories to the Paris Agreement, economic growth needs to be coupled with environmental prosperity and GHG emissions reduction policies.

Currently, public health and safety is the main priority with regards to policy and regulations within this sector rather than carbon emissions[88]. Nonetheless, the government does see immense merit in implementing schemes which provide the foundations for R&D[89] as well as incentives to produce chemicals which use green chemistry.

Moreover, the government has also initiated setting-up Centres of Excellences which will predominantly focus on the petrochemical industry and the use of sustainable technology to reduce impacts on the environment.

Within the R&D policy for the chemical industry, the government allows weighted tax deduction of 200%. However, even with such policies in place there is still low R&D activity in this sector due to the cost involved.

According to the Federation of Indian Chambers of Commerce and Industry (FICCI), it takes approximately USD 250 million in research and development to launch a new product into the market. The Government of India is a signatory to the Strategic Approach to International Chemicals Management (SAICM)[90] and other international conventions which aim to improve public and environmental health within the chemical industry.

The government also provides incentives for bio-based raw materials which in turn would reduce dependency on (imported) oil and fosters companies to sign up for the responsible care initiative to meet environmental norms[91].

As mentioned above the Indian chemicals industry plans to and is significantly growing. It is estimated that in the next five years it will be a $US 430 billion industry. This growth can only be sustainable through decoupling emissions from this sector via policy intervention, market shifts, technological intervention and a policy-industry collaborative approach which needs to include guidance from international players.

[88] https://www.sgs.com/en/news/2020/11/safeguards-16420-india-releases-latest-draft-chemicals-management-and-safety-rules
[89] https://chemicals.nic.in/sites/default/files/English%20Annual%20Report%20date%2024-2-2020.....pdf
[90] http://moef.gov.in/wp-content/uploads/2019/05/SAICM.pdf
[91] http://ficci.in/sector/7/Project_docs/Chemical-Petrochemical-sector.pdf

Barriers to accelerating decarbonisation in Indian heavy industries

The **multiple stakeholder consultations conducted with government representatives and experts from businesses and civil society organisations** under this project have brought to light the following common barriers hindering decarbonisation in the Indian heavy industries.

No single policy or strategy on decarbonisation for the government

The government of India currently has no dedicated policy as such on heavy industry decarbonisation. Policies and regulations have played a significant enabling role in driving adoption of clean energy and energy efficiency measures among Indian industries. A lack of policy clarity on industry decarbonisation is acting as a major deterrent and a disincentive for the industries to undertake bold and innovative technological interventions.

Cost competitiveness is a key priority for industries

Private iron and steel companies in India currently invest between 0.07% and 0.58% of their sales turnover in R&D projects (compared with up to 1% in China, Japan, and South Korea).

Due to the constant growth in demand for iron and steel in the country, cost competitiveness has become a top priority for Indian industries. This, at times, deprioritise other aspects including exploring newer and innovative cleaner technologies, fuel substitution options, etc. which call for additional investments. This is however not true for few leading companies or the sector as a whole. The Indian cement industry clearly stands out in this aspect and is one of the most efficient industries in the world. On the other hand, the story of iron and steel sector is different and is one of the most energy intensive and heavy emitting sectors in India.

Lack of investment in R&D by both government and industries

Current investment from both public and private players in India is significantly low (see box)[92]. The Steel Research & Technology Mission launched by the Government of India, however, aims to increase the R&D spending of leading steel companies to 1% of their turnover[93]. Deep decarbonisation calls for exploring innovative and pathbreaking technologies to transform the way we produce things. For example, hydrogen is the talk of the town and is termed as 'fuel of the future' by some. But as the technology is new, support through research and pilots is needed before it can be rolled out at an industry scale cost competitively. This calls for large scale investment from both public and private players much more than what is being done today.

Slump in demand due to COVID-19 and industry recovery priorities

The Covid-19 pandemic has inflicted serious damage to economies worldwide and India is no exception. In the backdrop of negative GDP growth rate, the sectors such as iron and steel and cement has experienced severe demand slump due to stalling of construction, real estate, and other developmental projects. Towards recovery, industries are now keen on regaining the lost momentum by focussing on business as usual rather than exploring any new and investment intensive interventions/ strategies which includes decarbonisation approaches.

Lack of accountability and data transparency

[92] https://www.iea.org/reports/iron-and-steel-technology-roadmap
[93] https://www.srtmi.com/index.php/site/about/#objs

Companies are averse to sharing data on emissions and actions they are taking on climate and environment. In 2019, only 59 Indian companies participated in CDP's Disclosure initiative on corporate commitments to science-based targets (SBT)[94].

Conclusion and way forward

As the country is rapidly transforming, the demand for iron and steel is expected to rise significantly. These industries have a major role in India's socio-economic development journey. The need to disassociate economic prosperity from GHG emissions is necessary now more than ever. Therefore, multilevel collaboration, substantial investment in R&D, carbon pricing and implementation of new technologies will pave the way for the steel industry to decarbonise.

We are already seeing major strides by several Indian companies. This especially so now that they value the benefits of decarbonisation and the positive impact it will have on their bottom line.

The Government of India has implemented a few policies and regulations which enable this industry to initiate its decarbonisation trajectory. However, clarity with regards to specific decarbonisation policies is important to convey the necessary market signals to producers and consumers.

The Indian cement sector has taken significant strides towards sustainable production through the Cement Sustainability Initiative (CSI). This initiative has created an inspirational model for other heavy industry sectors – showcasing the need for necessary action within the heavy industry towards green growth.

Initiatives such as the Low Carbon Technology Roadmap and CSI have set the foundations for this sector to pilot and implement solutions towards a zero-carbon industry in India. Investments in decarbonisation technologies and pilot projects is essential along with government intervention which foster market strategies and advancement of said technology adoption.

For the chemical industry, there is still a long way to go to achieve decarbonisation. The major hurdle within this industry is our dependence on the carbon atom as feedstock, and the lack of action taken within India in terms of adopting and piloting technological solutions which would enable decarbonisation. It is important for this sector to collaborate with relevant stakeholders to create a holistic strategy towards decarbonisation, keeping in mind MSMEs as well as new job opportunities. Creating such a strategy would enable the Indian chemical industry to become a leader in stewarding this monumental transformation which will have a positive global impact.

Our discussion with businesses and civil society brought forward the willingness and optimism of these entities. Responses from our interviews and workshops were positive and solution oriented, steering us towards an inspirational and highly insightful direction.

A recent workshop with government and experts from civil society and industries brought to light certain immediate solutions and way forward to accelerate deep decarbonisation in Indian heavy industry. Prominent levels mentioned included the need for a clear-cut policy and a long-term roadmap for industry decarbonisation, increasing the share of hydrogen and alternative green fuels into our energy mix, increased investment in RD&D, labelling of products, benchmarking and carbon pricing, global collaboration on research and demonstration projects, among others.

[94] https://economictimes.indiatimes.com/news/science/india-5th-among-countries-with-corporate-commitments-to-science-based-targets-report/articleshow/73434464.cms?from=mdr

During the workshop, a greater role by the Government in R&D was emphasised by promoting technology innovation in industry as well as R&D amongst large Public Sector Enterprises (PSEs), calling the PSEs as the right test beds for innovation. And finally, for a just and equitable decarbonisation journey, India needs to proactively contribute and engage in the global conversation, while understanding its domestic markets around heavy industry decarbonisation.