Innovate UK
KTN

Online Global Expert Mission
Transforming Foundation Industries in India
March 2022

Contents

1.0 Overview

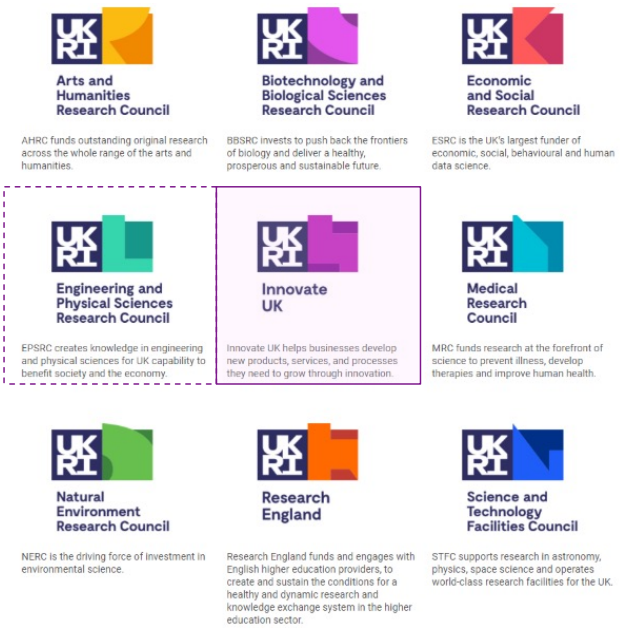
1.1. Innovate UK, UKRI, Innovate UK KTN and Global Expert Missions

Innovate UK is the UK government's innovation agency and is part of UK Research and Innovation (UKRI), the organisation that brings together research and innovation funding.

The function of Innovate UK is to help businesses identify the commercial potential of new technologies and turn them into new products and services that will generate economic growth and increase productivity. With a strong business focus, Innovate UK drives growth by working with companies to de-risk, enable and support innovation.

HOW DO WE FIT INTO UKRI?

- The Challenge Fund sits within Innovate UK which funds business and research collaborations across the economy
- The Transforming Foundation Industries Challenge works closely with EPSRC – the Engineering and Physical Sciences Research Council



UK Research and Innovation

As innovation is increasingly a global endeavour and the ambition of UK businesses to become truly international enterprises is at its highest, Innovate UK established its Global Expert Missions (GEM) Programme in 2017. Delivered by Innovate UK KTN in partnership with the UK Science and Innovation Network (SIN) and Department of International Trade (DIT), the Expert Missions help further Innovate UK's global strategy by providing the evidence base for where it should invest and by providing opportunities for UK businesses to build partnerships and collaborations with key economies.

UKRI India plays a key role in enhancing the research and innovation collaboration between the UK and India. Since 2008, the UK and Indian governments, and third parties, have together invested over £330 million in co-funded research and innovation programmes. This investment has brought about more than 258 individual projects. The projects were funded by over 15 funding agencies, bringing together more than 220 lead institutions from the UK and India. These research projects have generated more than £450 million in further funding, mainly from public bodies but also from non-profit organisations and commercial entities, attesting the relevance of these projects.

www.ukri.org/india

UK Research and Innovation
India
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Built around UK business, policy and research representation, an Expert Mission's objectives are:

1. Informing UK businesses and government
   The findings and opinions of experts on the topic of the GEMs are made available to UK businesses and government departments. These inform UK businesses about opportunities for innovation in the country and the UK government on how it can help UK businesses make the most of those opportunities.
2. Building international collaborations
   The expert insights will help inform how Innovate UK can best help UK businesses find and exploit the opportunities for innovation partnerships. The GEM creates connections with key organisations and people that will deepen and widen the collaboration with the partner country to the benefit of UK business.
3. Sharing UK capabilities
   During the mission, the delegation of experts will use the opportunity to promote and share the UK's innovation strengths.

1.2 Industrial Strategy Challenge Fund

The Industrial Strategy Challenge Fund is delivered by Innovate UK, funding business and research collaborations across the economy. The fund addresses some of the biggest societal challenges faced by businesses today, with one of the four key themes being "Clean Growth".

The Clean Growth theme has eight identified challenges: transforming Foundation Industries; industrial decarbonisation; transforming construction; transforming food production; manufacturing made smarter; smart sustainable plastic packaging; prospering from the energy revolution; low cost nuclear.

1.3 Overview of Transforming Foundation Industries Challenge

Situated in the UK's industrial heartlands, these Foundation Industry (FI) sectors include metals, ceramics, glass, chemicals, paper and cement, producing 28 million tonnes of material per year, and are worth £45 billion annually to the UK economy but in doing so are by far the UK's biggest industrial polluters: around 50 million tonnes of CO_2 per year, or 10% of the total CO_2 emitted by UK homes and businesses.

If the UK is to meet its Paris Climate Change Agreement to reduce CO_2 emissions by 80%, transformational changes are needed by these industries in how materials are sourced and processed, and the types of products manufactured. Developing more resource and energy-efficient Foundation Industries will also help anchor production in the UK through increased competitiveness.

The ultimate aim of the Transforming Foundation Industries Challenge is to transform the UK Foundation Industries so that they are internationally competitive in manufacturing products vital for our economy in an environmentally sustainable way.

THE FOUNDATION INDUSTRIES

Ceramics
Together

Glass
We

Cement
Form

Metals
The

Paper
Foundation

Chemicals
Industries

Worth **£45bn**/yr to the UK and employing **500,000 people**, through their supply chains

Challenges:

- Generate 10% of all UK's CO2 emissions
- MUST be environmentally sustainable in the long term
- Capital intensive making it difficult to change rapidly

India is also home to these six core FI sectors. Addressing sustainability challenges within these FIs requires a global dialogue on how to encourage long-term transformations. There is a clear understanding from the UK government and industry leaders that addressing the immense sustainability challenges facing FIs, which still have a high dependence on using fossil fuels in most of the existing plants, requires a global dialogue on how to encourage and finance long-term transformations to address climate change by significantly reducing greenhouse gas emission, particularly CO_2.

During 2021 and into 2022, the Transforming Foundation Industries Challenge is exploring opportunities for collaboration with India. In February 2022, Innovate UK, Innovate UK KTN and UKRI India, working in partnership with DIT and UKRI India, hosted and facilitated a virtual Transforming Foundation Industries (TFI) Global Expert Mission to better understand the FI landscape in India, compare and benchmark against UK capabilities and look for areas of future collaboration in innovation to more viably deliver the climate change and long-term sustainability commitments given by the respective governments in both countries faster. Alongside this, a lab-to-lab programme has allowed UK research organisations to build networks in India relevant to their areas of research and to scope out collaborative projects of interest to both nations at a research level.

2.0 Aims and Objectives

2.1 Mission Aims

The aim of the mission was, firstly, to explore and obtain a better understanding of the FI ecosystem in India. Secondly, the mission aimed to identify areas of common needs and challenges in FIs and to assess the potential to build collaborations between the UK and India to address the shared environmental challenges facing FIs, as well as socioeconomically benefiting both nations.

2.2 Principal Areas of Focus

Principal areas of focus:

1. Resource efficiency – including waste utilisation, industrial symbiosis and design for a circular economy. The Foundation Industries require large volumes of raw materials in a mixture of virgin and recycled forms alongside other inputs such as water and produce a number of process by-products. As we move towards a UK circular economy, with a focus on net-zero waste, how can some of these input and output streams become connected and extract the best value from these valuable commodities? Discussions covered the barriers to recycling some of these products and opportunities for innovation and development in the utilisation of green feedstocks.

2. Energy efficiency – including process optimisation, heat recovery and utilisation. Foundation Industries are energy-intensive processes, and increasing energy efficiencies will be pivotal to developing a sustainable future. Opportunities to increase energy efficiency can be through process optimisations and the use of technologies, new equipment, new materials and heat recovery. For example, capturing waste heat can reduce energy costs by using the heat in other processes, or by generating electrical power. Although the energy-efficiency technologies and principles can be well understood, they can often be seen as impractical or not cost effective. Discussions considered the innovation opportunities for energy efficient technologies, products and processes.

3. Digital technologies for resource/energy efficiency – the use of sensors to capture live plant data is becoming more commonplace in the foundation and manufacturing industries, but there is still a large amount of untapped potential. Discussions included what data capture is still required, how it could be captured, and how it can be used most efficiently to increase resource and energy efficiency. Discussion explored all stages of this process from sensor technology to data storage and management, and controls and process hardware, such as drives and burners, to fully embed digitalisation within the industries and move towards automated process management.

2.3 Mission Objectives

The objectives of this mission were:

1. To help determine how Innovate UK can best support UK businesses more effectively and efficiently when considering partnerships with India in the FIs.
2. To provide insights into where there are synergies between the two countries in FIs and determine whether there is an appetite for further collaboration.
3. To identify and showcase key market opportunities for innovative products and services to UK businesses who may be interested in collaborating with India.
4. To capture key UK R&I and market opportunities/challenges when considering collaboration with India.

3.0 Overview of Mission Discussion Meetings

The five-day virtual mission was conducted over consecutive days, timed to accommodate the 4.5-hour time difference between delegates in the UK and India.

The mission was well attended for each session, with a total of 31 UK and 33 Indian delegates participating in the various sessions. The sessions covered the business and technology opportunities and challenges faced by respective sectors, focusing on resources, energy and carbon emissions. There was active participation and open discussion between Indian and UK Foundation Industry delegates during both the single-sector and cross-sector meetings.

Considerable pre-mission preparation was evident in the quality of the information presented by each of the sector representatives, using contributions from respective UK and India sector delegates involved. This enabled constructive, in-depth discussions based on detailed sharing of the current status and challenges faced by respective FIs in both countries.

3.1 Single-Sector Focus Meetings

Six single-sector meetings were held over the first three days of the mission. As the concept of cross-sector working and the term “Foundation Industries” is unfamiliar in India, this provided a focused forum for delegates within an individual sector to share information about their industry and compare challenges and opportunities on common ground. Discussions included industry size, structure, output, sales, process technologies and energy sources, government legislation, policies and incentives and the opportunities and the technical, financial and regulatory challenges facing the sector to make transformative changes to be sustainable and globally competitive.

3.2 Cross-Sector Focus Meetings

Over the last two days of the mission, cross-sector meetings were held to discuss and explore where there was overlap and potential for cross-sector technology sharing and symbiosis to address shared challenges. This could include sharing transferable new technology plant and processing innovations, new energy, storage and supply chain requirements to reduce overall costs and accelerate development and implementation.

The cross-sector discussions focused on identifying possible collaboration areas with respect to infrastructure, recycling, turning waste into a by-product, reducing and recovering plant waste heat, using renewable and next-generation clean energy sources for existing plants, and greater use of digitisation technologies as part of Industry 4.0 to improve plant efficiency and reduce materials usage and emissions.

Alongside considering major collaboration project areas, mission delegates also identified areas where it could be beneficial to look at best practice sharing between the two countries at either single or cross-sector levels.

4.0 Overview of FI Business Sectors

Both the UK and Indian Foundation Industries have a clear need to reduce emissions, improve resource and energy efficiencies, and, longer term, to transition from using fossil fuels to clean future energy sources, such as syngas and green hydrogen. A key challenge for both countries is to ensure the reliable provision of sufficient clean energy sources to address emissions targets, while at the same time meeting the energy needs of industry alongside the projected growth in commercial and consumer demands for more electricity.

4.1 UK FI Sector Overview

The UK Foundation Industries are a long established and vital part of the UK economy. The sustainability challenges facing all sectors, but particularly metals, glass, ceramics and cement, which are very high energy users and emissions generators, are significant given the age of existing capital equipment and replacement costs. More detail on the UK Foundation Industries barriers to innovation can be found here.

4.2 India FI Sector Overview

The Foundation Industries in India play an even bigger role in the domestic economy, directly employing around 1.6 million people. All sectors have been experiencing growing local demand, coupled with the increase in public sector investment in buildings and infrastructure across India. The sustainability challenges facing Indian companies are similar to the UK. Indian FIs have a high dependence on fossil fuels, particularly coal and coke, to power the majority of plants; with ongoing investments regionally in solar, biomass, wind energy and clean electricity generation. For individual Indian FI sector overviews – see Appendix 3.

5.0 Opportunities and Challenges for UK and India Foundation Industries

Flags under the India and UK column indicate a priority raised by representatives of each nation.

5.1 Resource Efficiency – Opportunities and Challenges

Resource opportunities and challenges **Ceramics sector**	India	UK
Alternative raw materials, waste/by-product utilisation A shared objective is to reduce virgin clay reliance by developing alternative raw materials (e.g. synthetic feldspar) and ways to reprocess and use end-of-life products e.g. construction waste and process wastes from polishing lines. A shared key challenge is the consistency of waste quality. India faces additional challenges due to limited local recycling facilities and high transportation costs between regions.	✓	✓
New standards Replacing composition-based standards with performance-based standards was highlighted as a key transformational "game-changer" for the sector. To achieve this, collaboration is needed between industry and R&D institutes to develop and create a new international database.	✓	✓
Low energy sintering Developing new low energy sintering (100-200°C) materials, methods and applications was a shared opportunity. Development work is already ongoing in the UK, but this is a new area for India, with an appetite to find out more.	✓	✓
Product lightweighting and dematerialisation Product redesign to reduce product weight (e.g. thinner wall tiles produced in India), while also lowering processing times and energy consumption, was highlighted to investigate further. Benefits are seen across the supply chain to reduce emissions, production costs, scrap and end-of-life recycling.	✓	

Resource opportunities and challenges **Glass sector**	India	UK
Cullet quality and waste glass recycling An area of common interest in the UK and India is to reduce reliance upon virgin raw materials, whilst also lowering the energy required to produce glass. Also interested in finding an added-value outlet for cullet and fine glass waste, which cannot be used in glass processing but could be used in other FI applications. Current recycled glass quality issues limiting use include colour purity, contaminants and recycled glass size control to avoid furnace life issues if too fine (<1mm). Better collection, sorting and reuse of clear and coloured waste glass are mutual areas of interest. The UK has more expertise in recycling, with India currently only capturing 35–40% of glass. It is thought this may need incentives and regulatory support to increase the adoption of more sustainable practices.	✓	✓
Product design and lightweighting Highlighted as a single-sector collaboration area to investigate the lightweighting of glass products to reduce material and energy requirements.	✓	✓
“Lab-to-Lab” R&D project collaborations For single/cross-sector opportunities needing R&D support, the use of lab-to-lab project collaboration between the UK and India is considered an option to explore further how it could be funded and set up in practice.	✓	✓

Resource opportunities and challenges **Metals sector**	India	UK
Offcuts and recycled scrap utilisation Highlighted as a major opportunity to investigate further. The UK metals sector creates a large volume of off-cuts and end-of-life scrap which need value applications in other FIs as process limitations and contamination currently restrict the use of greater scrap levels in metal production. UK steel producers are actively looking at better scrap segregation and purity to increase scrap usage, particularly for clean-energy-powered electric arc furnaces, but implementation needs a collaborative approach involving the recycler, metal producers and the supply chain to attain benefits. Interest in sharing UK technologies and expertise from Indian producers looking to increase the current 13–14% scrap utilisation levels in steelmaking. Consensus that an integrated “across supply chain” approach is needed collaboratively, in conjunction with the use of digital technologies to help optimise scrap collection and usage.	✓	✓

Resource opportunities and challenges **Metals sector**	India	UK
Waste/by-product utilisation Two key areas highlighted were the reduction of waste production in processing metals and finding added-value uses for non-metallic by-products (from slag, dust, ore sludge) in other FIs, e.g. extracting rare metals, such as platinum and lithium, from bag filter cakes and fly-ash waste for use by the glass sector. A cross-sector approach is needed to improve viability. A number of waste projects are ongoing in the UK with cement, glass and ceramics.	✓	✓
Standards and specifications Need to work with end markets to widen existing high material purity specifications to enable greater utilisation of scrap, to create performance-based product standards. UK research programmes e.g. EPSRC-funded Sustain are already looking at this but would welcome a more international approach.	✓	✓
R&D funding Practical ways to collaborate between the countries need to be investigated to make the best use of private and public sector funding and resources, supported by government grants and incentives. Alternative R&D funding models are needed for future UK-India collaborations.	✓	✓

Resource opportunities and challenges **Paper sector**	India	UK
Waste by-product utilisation More economically viable by-product utilisation, especially for smaller mills, is a priority in India due to significant transportation costs across regions. Cross-sector FI collaboration could help to identify viable uses further afield. Sharing of best practices and technologies would be beneficial.	✓	✓
Waste recycling Knowledge transfer of UK pulp and paper recycling methods and best practices could improve the less developed waste recycling in India, but need to be implemented alongside new government regulations, policies, incentives and support to create a better national recycling infrastructure. Single-sector collaborations and sharing UK best practices with India is seen as beneficial covering: pulp and paper products; use of non-wood fibres and straw pulping; designing paper products for end-of-life and circular economy within a global market.	✓	✓
Water utilisation and recovery A major area of interest for the Indian paper industry is to find ways to optimise/reduce water use and improve drying efficiencies. Evaporation, bio and microfiltration are possible new technologies to clean liquid discharge waste and recover fibres and water to produce uncontaminated recycled discharge water that meets environmental quality standards. Collaborations in specific new technologies areas, such as closed-loop recycling in paper mills and alternatives to using potable water, are mutual UK and India areas of interest.	✓	✓
Paper machines and process knowledge sharing Cooperation is seen as beneficial, sharing real-time processing experience operating paper mill machines, which are of a very similar design and technology globally. Best practice areas highlighted were equipment; optimising chemistries in mills; paper production optimisation.	✓	✓
Improving fibre properties and quality Knowledge transfer and collaborative R&D innovation technology sharing for improving fibre material properties is seen as an area that would benefit both the UK and India paper sectors. Product innovations ongoing to improve fibre strength and quality, such as microfibrillated cellulose (MFC) and nanofibrillated cellulose (NFC), are highlighted to investigate further.	✓	✓

Resource opportunities and challenges **Paper sector**	India	UK
Digital control and twinning The use of existing and future emerging digitalisation technologies to improve paper processing and energy management is seen as very important, especially for older mills and equipment. The UK and India are at different adoption levels, with larger paper producers in India being more advanced, already using sophisticated process data analysis and predictive modelling. The UK can benefit from Indian mill best practices. Collaboration is seen as highly beneficial within the sector to share existing best practices in data analysis and interpretation, and to explore emerging AI and machine learning to improve current mills and test new processing innovations. Collaboration should accelerate development and improve commercialisation viability.	✓	✓

Resource opportunities and challenges **Cement sector**	India	UK
Plant process improvements Process benchmarking of implemented sustainability improvements and knowledge transfer exchange on the latest technologies are of interest for further improving plant efficiencies and reducing waste.	✓	✓
Waste/by-product utilisation R&D investigation into the possible uses of cement waste instead of disposal, either as a by-product material or as a fuel energy source is an area of interest to explore opportunities for collaboration.	✓	✓
Blended cement utilisation The use of more blended cement in the Indian public sector and a preference for site-based supplementary cementing materials (SCMs) to ordinary portland cement (OPC) instead of procuring blended cement, are both seen as key sustainability challenges for cement producers in India. Finding ways to change current local practices are needed.	✓	
Carbon capture, storage and utilisation A global challenge for all cement plants, which generate several thousand tonnes of CO_2 per day. Known carbon capture (CC) practices highlighted included: Indian UREA CC project; use of algae for CC that is a food by-product; using captured CO_2 to accelerate curing of steel-slag-based construction products.	✓	✓
Standards and specifications Changing current cement standards highlighted as a shared single-sector collaboration area to focus on, requiring big data analysis and innovative mix design R&D to develop new sustainable cement blends beyond existing building codes. New product innovations are constrained due to the current international standard on cement (e.g. LC3 norm). There is European-level support to move to performance-based specifications for alkaline-activated cement and new cement standards. Changing concrete standards need (costly) long-term testing. The conclusion was that this is a key collaborative topic area, requiring broader global concrete industry involvement across the supply chain, ideally supported by international legislation.	✓	✓

Resource opportunities and challenges **Cement sector**	India	UK
R&D funding Indian cement sector challenge to secure sufficient funding for CAPEX under existing cement pricing constraints. Finance partnerships are needed for R&D and trials using Indian-developed technologies. The UK cement sector also needs more R&D innovation funding and financing to meet transformational objectives, so see benefits in collaboration to develop sector-specific optimal solutions, with higher success probability and return from a single-sector focus.	✓	✓
Parent-company level collaboration As most cement production companies operating in the UK have subsidiaries in the Indian cement market, sharing best practices and exploring new development collaborations via parent companies was highlighted as likely to benefit both countries.	✓	✓

Resource opportunities and challenges **Chemicals sector**	India	UK
Waste reduction, recycling and utilisation The chemicals sector produces considerable amounts of waste that is not being used, with hazardous waste materials a particular issue. Interest from India in identifying ways to collaborate with the UK and share best practices to enable more chemical recycling in the future. Plastic waste is a key focus area, looking for added-value use rather than low-grade recycled applications. Both plastic waste reduction and increasing the use of recycled materials into monomers are major opportunity areas for collaboration. India sees plastic waste segregation as a big challenge at the municipal level, where the UK has made good progress and India could learn from.	✓	✓
Captured carbon utilisation (CCU) A high priority area with numerous applications, which could be an area to explore collaboratively.	✓	✓
Biomass for speciality chemicals The UK sees opportunities to use biomass for the production of added value speciality chemicals e.g. green-based epoxides. Sharing UK case studies of successful projects could spark new collaboration project areas with India. Additionally, the sector could benefit from using its collective pre-competitive knowledge to evaluate commercially-viable supply chains for biorefineries, biofuels and chemicals.	✓	✓
PCPIR sector support The Government of India has approved 4 Petroleum, Chemical and Petrochemical Investment Regions (PCPIRs) in Andhra Pradesh (Vishakhapatnam), Gujarat (Dahej), Odisha (Paradeep) and Tamil Nadu (Cuddalore and Nagapattinam) to promote sector investment and industrial development. Each PCPIR is a specifically delineated region, having an area of about 250 sq km, where 40% of the area must be for processing activities. *Source: https://www.investindia.gov.in/sector/chemicals*	✓	

5.2 Energy Efficiency – Opportunities and Challenges

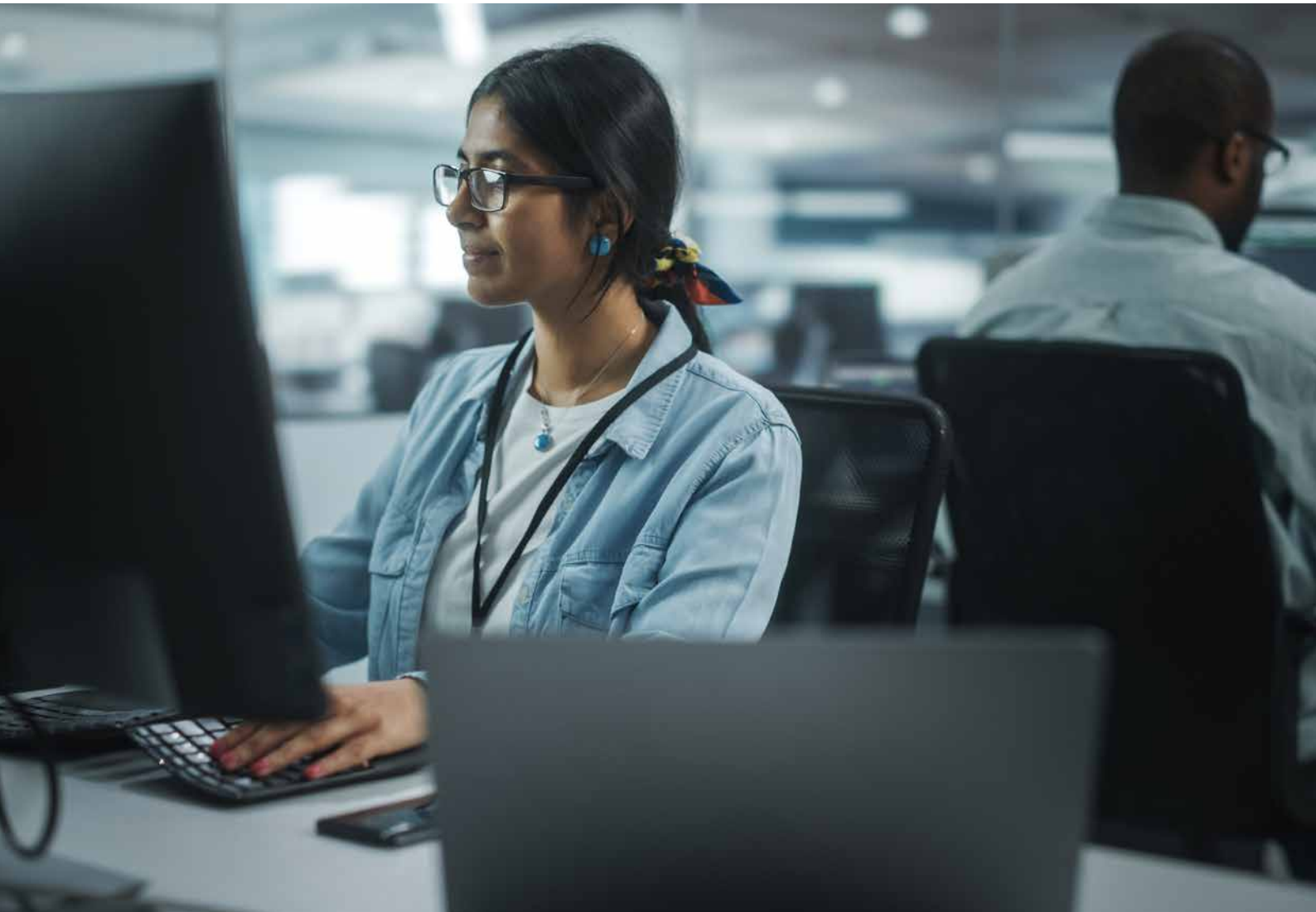
Energy opportunities and challenges Ceramics sector	India	UK
Drying efficiency and waste heat recovery Both the UK and India are looking to reduce emissions, improve drying efficiencies and reduce overall plant energy use. A shared interest in developing heat exchangers in kiln stack exhaust systems and lower temperature recovery technologies, which can be retrofitted to existing plants.	✓	✓
Sintering technologies Flash sintering or pulse hybrid sintering new technologies may be areas to look into that are more energy efficient and can use clean electric energy (link to cold sintering resource opportunity).	✓	✓
Kiln firing temperatures Alternative kiln and firing temperature technologies to improve efficiencies, alongside material formulation projects, are considered a key collaboration area.	✓	✓
Alternative fuels A shared need to understand the plant corrosion impact of alternative green hydrogen and syngas and what upgrades will need to be made to existing plants.	✓	✓
Automation The majority of Indian ceramics production is very workforce intensive. Looking long term to invest in fully automated machines to replace semi-automatic and manual systems to increase efficiency and use less energy. High CAPEX is a barrier.	✓	✓
Digital technologies The use of advanced digitalisation analysis, data twinning, artificial intelligence (AI) and machine learning to improve process control and plant efficiencies and to save energy are seen as key to upgrade existing plants. A cross-sector approach is seen as the best option, learning from best practices in other sectors.	✓	✓
Funding innovation A key challenge for the Indian ceramics industry is funding innovations and technology upgrades. Currently internally-funded CAPEX and business payback financing, with very limited R&D funded support from the Department of Science & Technology (DST) or the Council of Science & Industrial Research (CSIR).	✓	

Energy opportunities and challenges **Glass sector**	India	UK
Waste heat recovery Developing viable waste heat recovery systems, such as kiln stack heat exchangers to recover heat from dirty hot air, plus improving furnace insulation is a common need in both the UK and India. In India, waste heat recovery projects already progressed, with feasibility work done on the use of organic rankine cycle (ORC) technology, identified for float glass as one of the best energy recovery solutions for lower grade heat recovery. ORC highlighted as a single/cross-sector collaboration area to investigate further that could mutually benefit future investment and payback viability.	✓	✓
Digitisation, Artificial Intelligence (AI) and Industry 4.0 Both the UK and India are interested in using digital technologies, including AI, to reduce energy use and improve existing plant processing productivity and efficiency. A mutual short term need, linked to exploiting the benefits of Industry 4.0. In the medium/long term, digitisation is seen as a key part of next-generation glass processing technologies and production monitoring, using new clean energies. The Indian glass sector has made considerable progress in adopting digitisation and "future logic" and has expertise and key talent in using data and AI. This expertise could help the UK glass sector via collaborative knowledge transfer and sharing. Digitisation is seen as a major focus area opportunity, which can be used to justify the financing of plant upgrades and new technologies to reduce energy use.	✓	✓
Furnace/burner control and design Both the UK and India see the importance of furnace efficiency (improved process control) and new furnace designs to support green fuels. Future NOx regulations: new, cost effective hi-tech advanced burner technologies are also needed to meet more stringent future NOx regulations being drawn up.	✓	✓

Energy opportunities and challenges **Metals sector**	India	UK
Alternative clean energy Reducing CO_2 and other greenhouse gas emissions is a priority in India, where coal and coke are still extensively used for metal production. Indian blast furnace plants are fairly new and will transition to hydrogen gas, once a mainstream energy source. As hydrogen energy is still a long-term possibility, the Indian metals sector's short-term focus is on wind and solar. The UK has an early-stage project initiative ongoing for hydrogen fuel usage. Financing new technologies and plant CAPEX to use clean energy is a major UK and India sector challenge, with current limited incentives, funding or policy support to enable by 2030.	✓	✓
Waste heat recovery and utilisation Heat recovery is a major challenge to retrofit in old technology foundries, especially in lower temp (~700°C) SME metal processes. Opportunity is seen to utilise recovered waste heat from higher temperature plants (~1500°C) by local/regional commercial/industrial users. Interest from India in organic ranking cycle (ORC) for recovery of 80–100°C waste heat to generate electricity, which is a technology that has been investigated by the European Investment Casting Federation for smaller micro-electric power plants.	✓	✓
Carbon capture and utilisation The high use of fossil fuels makes reducing CO_2 emissions to achieve net zero a major challenge in both countries. Sharing technologies on carbon capture and utilisation is seen as an important collaboration area.	✓	✓
Digitalisation and AI technologies Use of digital technologies implemented and ongoing in India, which is looking for further process and efficiency improvements using emerging AI and machine learning digital platforms, linked to Industry 4.0. Digitalisation technologies are already implemented in the UK metals sector to reduce energy. Best practices, learnings and techniques should be transferable.	✓	✓

Energy opportunities and challenges **Cement sector**	India	UK
Plant efficiency and waste heat recovery Significant energy savings can be made from a cement plant, which can throw out ~25MW from the stack. The Indian cement sector has installed a number of waste heat recovery systems (WHRS), providing a 30–40% reduction in National Grid power demand from some plants, alongside new technologies, new equipment and more efficient electrical machines, achieving global best practice. Waste capture and reuse systems are being used in the UK, with nearly 15% waste-derived fuels now used in UK cement kilns. A combination of organic cycle and heat pipe recovery technologies in one plant has achieved 25–27% waste heat conversion. Plant efficiency and waste heat recovery discussions highlighted considerable synergies between the UK and India.	✓	✓
Alternative energy sources In India the major players have made advances in the use of developed renewable energy, mainly solar power and wind energy. A few plants have achieved up to 30–32% traditional solid fuel replacement, but the sector average is only ~5%, so seen as a key area where India could benefit from collaboration with the UK. Longer-term alternative energy (syngas/green hydrogen) development is a collaboration area of interest for new technology developments such as tertiary air duct plasma burners and hydrogen-powered kilns for the main burners, or biomass. India has an ongoing 500MW hydrogen (H2) fuel power generation project.	✓	✓
The Global Cement and Concrete Association (GCCA) – was recommended to approach to explore how it could support international collaboration projects on hydrogen kiln technology and materials development as part of its Sustainability Charter.	✓	✓
Funding new technologies Securing finance is a major challenge for both the Indian cement sector, especially for smaller regional cement companies, which need economic incentives to invest in sustainability projects, and for the UK.	✓	✓

Energy opportunities and challenges **Cement sector**	India	UK
Digitalisation Major players in the Indian cement sector are extensively using digital technologies to improve energy efficiency and looking to do more as a next stage by adopting technologies such as machine learning and artificial intelligence (AI), linked with future automation upgrades to further reduce energy consumption. Likewise, the increased use of digital technologies to improve plant energy utilisation and efficiency is seen as an important area in which the UK can benefit from collaboration with India, which is more advanced in digitalisation.	✓	✓



Energy opportunities and challenges **Paper sector**	India	UK
Renewable/alternative energy UK paper mills are relatively small, ageing and not energy efficient, and are gradually being converted from coal to natural gas. The Indian paper sector is largely still using conventional coal energy, but actively looking to switch to new cleaner energy technologies. India is looking at solar and locally-grown biomass materials. Natural gas is less attractive as it must be imported, so India is more interested long-term in new clean energy technologies, such as syngas and hydrogen fuel. Agreement that this topic is of interest to explore as part of a future cross-sector collaboration project.	✓	✓
Mill process efficiency and waste heat recovery Improving existing mill processing efficiencies and heat recovery are identified as key areas to investigate collaboratively. Energy from waste is being increasingly used in UK paper mills and across Europe, but needs more efficient, affordable electric heat pumps to dry paper; current options very expensive to install and run. Both UK and Indian paper mills have similar production challenges, also faced by mills worldwide. Agreement that it would be beneficial to find a way to share best practices without giving up competitive advantage.	✓	✓
Digital technologies The Indian paper sector is already very engaged in the use of digital technologies, data collection, analysis and predictive modelling. The ongoing development of digital technologies is growing rapidly, with more Indian engineering graduates working in emerging new digital technology providers and consulting companies. This was highlighted as an opportunity for the UK paper sector to learn best practices from India. Digitisation is a definite collaboration area to explore further both single and cross-sector.	✓	✓

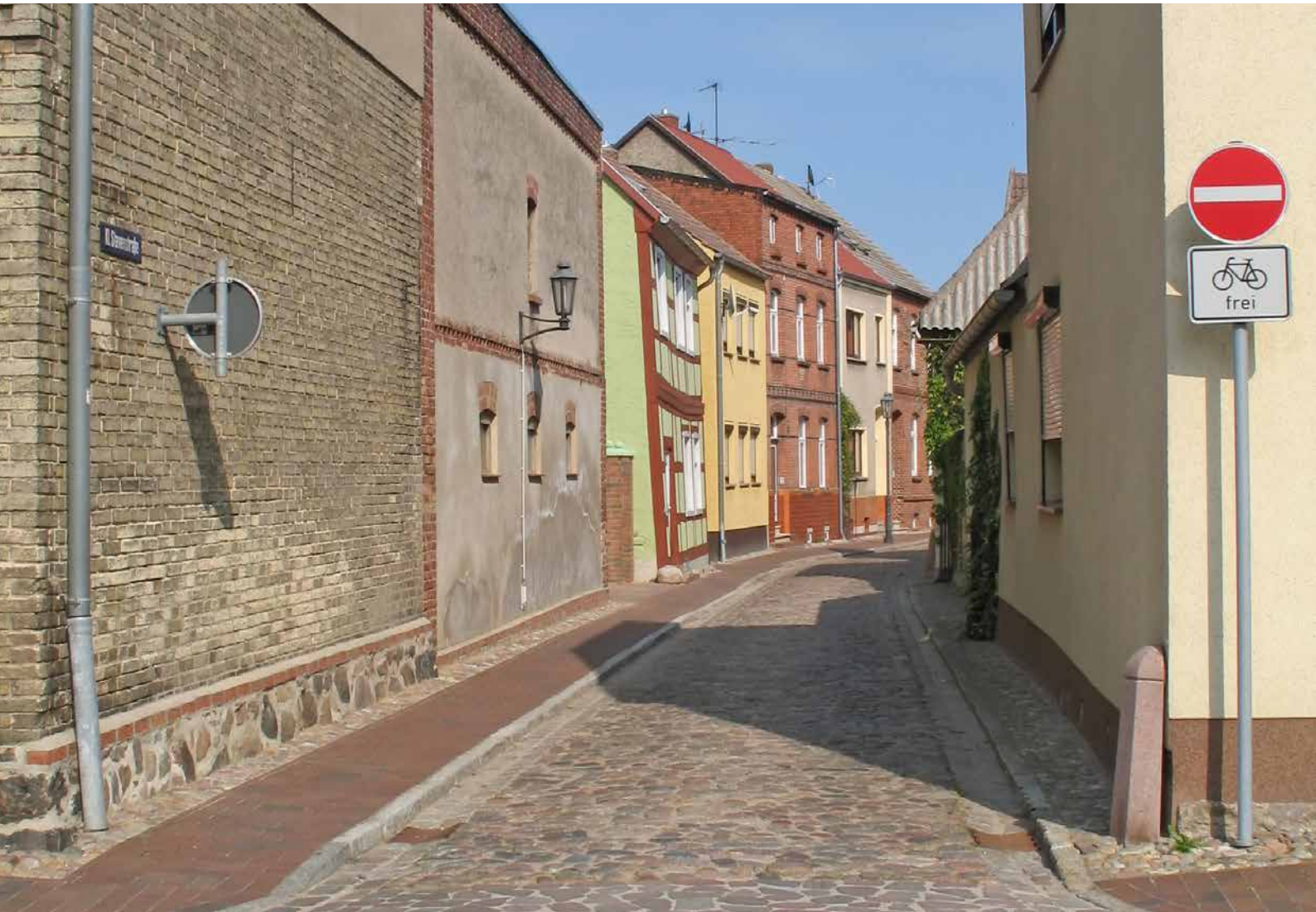
Energy opportunities and challenges **Chemicals sector**	India	UK
Improving plant and energy efficiency Most equipment in the UK chemicals industry is 30–50 years old, so not energy efficient. In the immediate future many of the existing plants will not be replaced, but improvements to energy efficiency to reduce energy consumption and greenhouse gas emissions are needed. This is a major sector challenge. Both the UK and India are interested in developing plant/equipment upgrades, such as retrofitting more energy-efficient burners, boilers and pumps, so see collaboration benefits.	✓	✓
Renewable/alternative energy and storage Short-term interest from the UK and India in using more existing renewable energy options. India focused on biomass power generation and PV solar, with interest in new high-temperature solar. The UK focused more on biomass and wind. Storage of renewable/alternative energy is a key focus area as socioeconomic demand for clean electricity grows. The UK has already done some energy storage projects with China. Longer-term strong interest from the UK and India in the development of blue and green hydrogen gas, identifying the infrastructure and plant adaptations/upgrades needed (e.g. avoiding pipe corrosion issues) and the provision of a reliable source of alternative clean energy options to FI clusters and remote, stand-alone plants. Agreement that cross-sector collaboration is needed on new innovative energy technologies and storage.	✓	✓
Carbon capture and utilisation (CCU) Both the UK and India are interested in capturing, storing and using CO_2 from existing plants. The UKRI-funded circular economy R&D centre for the chemicals sector was highlighted as a possible collaboration resource for CCU projects. Methanol fuel was highlighted by India as a collaborative area for CO_2 utilisation.	✓	✓
Digitalisation and AI India has a growing digital engineering workforce. This is not the case in the UK, which needs more and better qualified chemical engineers able to apply digital technologies to improve processing efficiencies and reduce energy use. Strong agreement that it would be beneficial for India to share best practices and explore cross-sector collaboration opportunities between the UK and India.	✓	✓

6.0 Possible Areas for UK–India Collaboration

Discussions about possible areas of future collaboration covered a wide range of topics including: R&D innovations; alternative material formulations and waste by-product utilisation; next-generation clean energy sources; plant efficiency and waste heat utilisation; using digitisation to improve plant processing efficiency; financing new technologies; new standards; government policies and legislation.

As a minimum from this mission, both UK and Indian delegates expressed an interest in finding a practical way to share best practices and knowledge transfer without compromising competitive advantages.

The highlights and conclusions from the mission's discussion meetings detailed in this section cover the areas identified for possible cross-sector collaborations between the UK and India.



UK-India FI cross-sector collaboration topic area	Timeline	Collaboration stakeholders	
Alternative clean energy and utilisation technologies		Industry	R&D
All FIs in the UK and India need alternative low or zero-emission fuels, such as green hydrogen, in addition to clean renewable energy/electricity, for which collaboration has clear benefits. There is a common need to understand the possibilities and implications of using syngas, Corex and green hydrogen gas and by-product fuels on existing plants, and to develop new future plant technologies, with the option for new plants (depending on type/location) to use multiple energy sources.	Medium/ long term	✓	✓
The development of a storage, handling and transportation infrastructure for new alternative energy sources was identified as a critical success factor for adoption by industry, particularly where Foundation Industries operate more remotely using a combination of local/private/cluster power generation plants and the national grid.	Medium/ long term	✓	✓
Examples of knowledge transfer/best practices			
Major cement players in India are now using developed clean renewable energy, mainly solar power and wind energy. A few plants have achieved up to 30-32% traditional solid fuel replacement.			
The UK has an early-stage hydrogen fuel initiative, and India has a 500MW H2 fuel power generation project.			
Improving plant waste heat recovery and thermal efficiency		Industry	R&D
Waste heat recovery is of particular interest for collaboration projects at both research and industry levels. Examples of collaboration areas include low temperature/pressure heat and steam utilisation; more efficient high and low-temperature heat pumps. Organic ranking cycle (ORC) waste heat recovery is potentially applicable to all sectors.	Short/ medium term	✓	✓
Collaboration projects on furnace/burner control and new designs of kiln and furnace exhaust heat exchangers. New, cost-effective hi-tech advanced burner technologies are needed not only to improve burner efficiencies, but also to meet future NOx regulations.	Medium/ long term	✓	✓

Improving plant waste heat recovery and thermal efficiency		Industry	R&D
R&D innovation is needed to develop novel materials for refractories to reduce heat loss and new technologies for furnaces and burners, regenerators, emissions reduction and coatings.	Medium/ long term		✓
Using existing and more advanced digitisation technologies is seen as vital, in conjunction with new waste recovery and thermal efficiency systems retrofitted to existing plants, as well as for new plant and equipment. *[See Digitisation Technologies section overleaf]*	Short/ medium term	✓	

Examples of knowledge transfer/best practices
Indian cement sector has made significant advancements in waste heat recovery systems (WHRS).
The Indian paper sector has developed lower temperature waste heat recovery technologies.
A combination of organic cycle and heat pipe recovery technologies are achieving best practice efficiencies of 25–27% heat recovery conversion in the UK cement sector.

Carbon capture storage and carbon utilisation (CCS and CCU)		Industry	R&D
All FI sectors see a need for CCS and CCU. An immediate need is to develop and retrofit the capabilities to capture and store CO_2 generated by existing plants; a high priority for FI sectors running high-temperature furnaces and kilns producing dirty waste gases. Innovation projects are ongoing to develop carbon capture and storage technologies.	Short/ medium term	✓	
Chemical sector process technology areas were highlighted to utilise captured CO_2 emissions such as methanol to olefins (MTO) and methanol to propylene (MTP); methanol to gasoline (MTG) feedstocks; xylene to polyethylene terephthalate (PET). Seen as an interesting area to explore further collaboratively and investigate available technologies.	Short/ medium term	✓	✓
There is a shared interest in collaboration to find added-value uses for captured CO_2 in preference to disposal, which has a cost. Investment in developing the technologies to do this on existing plants and equipment is needed. The challenge for all FIs is how to make the economics of carbon capture, storage and utilisation viable in practice.	Medium term	✓	✓

Carbon capture storage and carbon utilisation (CCS and CCU)		Industry	R&D
The conclusion from discussions was that developing new CCS and CCU options for FIs has a higher chance of success if relationships with partners are built both single-sector and cross-sector across the supply chains to identify viable innovations and to gain economies of scale to support investments in the new technologies and infrastructure.	Medium/ long term	✓	✓

Examples of knowledge transfer/best practices

Knowledge transfer about two carbon capture pilot plants currently running in India, due to report later in 2022, could be part of future cross-sector collaboration.

Examples of current best practice CCU projects highlighted included: urea based on CCU; use of CO_2 for algae food production; accelerating curing of steel slag-based construction products; chemicals sector producing calcium carbonate from captured CO_2 from cement and metals sectors.

Digitisation technologies and Industry 4.0		Industry	R&D
Application of existing digitalisation systems identified as a cross-sector opportunity to make shorter-term transformational changes to upgrade and improve the performance and efficiency of existing plants and equipment to reduce emissions, energy use and waste.	Short term	✓	✓
Improving furnace energy control by using more advanced digitisation to optimise energy consumption, along with using AI, machine learning and emerging new digital technologies to further improve process and combustion control, both key areas highlighted to improve thermal efficiency and enable new waste heat recovery systems.	Short/ medium term	✓	✓
Using digitisation is seen as vital to maximise the benefits of Industry 4.0 for FIs across the broader supply chain and future circular economy.	Medium term	✓	✓
Sharing best practices and cross-sector collaboration of emerging new digitalisation technologies is seen as key to accelerate new developments, test innovations and improve commercial viability of digital start-ups.	Medium/ long term	✓	✓

Examples of knowledge transfer/best practices
The development and use of digital technologies is growing rapidly in India, with more engineering graduates working for emerging digital technology providers and consulting companies. This allows the UK paper sector to learn best practices from India.
Digitalisation technologies already implemented by the UK metals sector to reduce energy. Best practices, learnings and techniques should be transferable.
Larger paper producers in India already use sophisticated process data analysis and predictive modelling. The UK can benefit from shared best practices with India.

Recycling and waste/by-product utilisation		Industry	R&D
Across all FI sectors there is a shared need for higher quality recycled scrap and waste materials that can be used to replace a proportion of virgin materials. Recycling is nationally lower and less developed in India compared with the UK. Opportunities seen for Indian FIs to benefit from sharing best practices and learning more about UK activities and infrastructure for recycling of industrial, commercial and domestic waste streams, but is seen as a significant challenge for India to create more recycling facilities, needing government incentives and policy support.	Short term	✓	✓
Reducing process waste and finding added value by-product uses for current FI waste (e.g. extracting rare metals materials, such as platinum and lithium, from bag filter cakes, or using waste as fuel source) are seen as an opportunity by all FIs to explore collaboratively to provide single and cross-sector symbiosis. The costs of transportation, handling and storage are key challenges to going beyond only using by-products locally. Cross-sector collaboration could identify added-value uses further afield.	Short/ medium term	✓	✓
Product behaviour and developing alternative performance-based standards to existing (barrier) standards to incorporate recycled and waste by-products were highlighted by several FI sectors as a major opportunity area. Single-sector collaboration focus will be needed at both industry and research institute levels to conduct practical research to develop new standards, involving end-market customers and applications. In some cases, this will also require new international standards and specifications.	Medium/ long term	✓	✓

Examples of knowledge transfer/best practices
The UK metals sector has several waste projects ongoing with cement, glass and ceramics FIs.
The UK paper sector has expertise and a long-established paper collection recovery (PfR - paper for recycling) and recycling ecosystem, with developed products that have "built-in" recyclability.
Nationally, the UK has made good progress in plastic waste sorting, but still needs more development to increase the amount of usable waste plastic, with mixed plastic packaging waste a key challenge.

Technology start-ups and incubation hubs		Industry	R&D
Focused initiatives to tap into the innovation start-up ecosystems that exist in both countries identified as an important cross sector collaboration area to investigate further. Collaboration should enable greater speed and agility to develop and implement new technologies (especially clean energy) more cost effectively to meet demanding emissions and sustainability government objectives and timescales.	Medium/ Long term	✓	✓
Shared funding of spin-off start-up businesses from lab-to-lab project collaborations between the UK and India is an area to consider in the future, given the R&D funding challenges faced by all FIs.	Medium/ Long term	✓	✓

Examples of knowledge transfer/best practices
India indicated that it could benefit from Innovate UK KTN start-up experience and expertise in new technology scouting and incubation hubs to set up a similar system in India to drive new innovations for FIs.

7. Conclusions

The mission has undoubtedly identified a number of key transformation change areas where collaboration in research and innovation, start-up emerging technologies and at industry levels across supply chains would be beneficial to the UK and Indian economies if they can be achieved in practice.

There is a need to take a broader, more holistic, cross-sector approach across the supply/value chains for each sector to address challenges that no one sector can tackle in isolation, such as new national and regional infrastructure needs; domestic and commercial waste material recycling and reprocessing facilities. Having a reliable supply of better quality recycled materials from process waste is doubly beneficial, particularly for scarce materials, such as precious metals, reducing the need for virgin raw material sourcing, which helps to reduce the overall supply chain carbon footprint of manufactured products.

An international approach is also needed to make radical changes to long-established regulatory standards and specifications for FI products currently manufactured, such as cement, concrete, glass and steel, based on performance, that could open up opportunities to reformulate and use alternative by-product materials from another FI sector that is currently waste.

Industry 4.0, big data, digitisation and the use of sensors and control systems with rapidly emerging new advanced digital technologies, such as AI and machine learning to generate predictive data and improve existing plant efficiency, is a major short to medium-term cross-sector collaboration opportunity. A number of Indian FIs are more advanced digitally than the UK, benefiting from a strong digital talent pool.

Other short to medium-term collaborative areas identified that could benefit multiple FI sectors were around existing and emergent technologies to reduce carbon emissions, use more process waste as an added value by-product, and provide process efficiency improvements on existing plants. There was consensus that sharing technologies and knowledge about energy efficiencies has cross-sector benefits where there are similar needs and challenges for different FI plants, such as refractory technologies, process and burner design efficiency, reheating kilns and furnaces to maximise on-time power versus dead time.

Developing more efficient furnaces, burners, boilers and waste heat recovery systems that can be retrofitted to existing plants and equipment is seen as critical in the immediate future to meet sustainability objectives. Retrofit designs are needed as existing plants will not be replaced in the short to medium term due to the very high CAPEX requirements and the timescales to develop and deliver new clean energy alternatives.

For the longer term, all FIs see a need for affordable clean electricity and reliable non-fossil-fuel-based energy supply sources, such as syngas and green hydrogen, to ensure that furnaces, kilns and high energy-consuming processing plants can be guaranteed sufficient energy supply 24/7, with future plants ideally able to operate using a combination of clean energy sources.

The development cost and expected timescales to develop and implement clean energy is a major shared challenge, with agreement that this long-term development work needs to run in parallel alongside shorter-term collaboration areas, such as digitisation, carbon capture storage and utilisation, and waste heat recovery and utilisation. Involving FIs early in the development stage will enable faster implementation of new clean energy sources, like hydrogen, once available, avoiding additional development time.

Linked to increasing renewable and clean energy use is how FI sectors will be able to eventually transition from old plants (closure and dismantling) to new technology plants. Developing independent industrial FI cluster energy sources to supplement the national power grid is seen as increasingly important as domestic homes, consumers and businesses gradually switch away from carbon-emitting vehicles, power and gas boilers to using electricity and alternative clean energy options for heat and light.

Underpinning all FI cross-sector transformational change is the key question of who and how these changes will be funded. The need for government involvement with respect to supporting FIs with policies, permits, legislation, funding and incentives is recognised as key for FIs to play their part in helping the UK and India meet legislation standards and post COP 26 climate change 2030 and 2050 net carbon zero objectives.

The overall conclusion from the mission is that finding ways to share transferable technology solutions to solve common challenges faced by multiple sectors will benefit FIs in the UK and India. Collaboration can provide the opportunity to accelerate development and maximise investment returns from private and public funding in R&D and CAPEX by avoiding duplication of efforts for common sustainability and circular economy goals, intellectual property, international standards and globally competitive market forces notwithstanding.

Appendix 1: List of UK Stakeholder Participants

The following UK stakeholder companies, industry bodies and R&D organisations participated in the mission.

Ceramics sector
Applied Materials Research, Innovation & Commercialisation Company (AMRICC); Basis Bricks–Vesuvius UK; The British Ceramic Confederation (BCC); WB Group.

Glass sector
Encirc (Vidrala Group); Glass Futures Ltd; Glass Technology Services; The NSG Group (including former Pilkington plc).

Metals sector
Cast Metals Federation (CMF)/UK Metals Council; Constellium; Materials Processing Institute; Tata Steel UK; UK Steel; Vesuvius UK.

Cement sector
Breedon Cement Ltd (Breedon Group); Hanson Cement; Innovandi Global Cement and Concrete Research Network Association (GCCA); London Concrete (Aggregate Industries UK/Holcim); University of Sheffield Department of Materials Science and Engineering.

Paper sector
The Confederation of Paper Industries; DS Smith plc; Kimberly-Clark Corporation; The Paper Industry Technical Association (PITA); Saica Paper UK (Sasia Group).

Chemicals sector
Centre for Process Innovation (CPI); Chemical Industries Association (CIA); Green Lizard Technologies Ltd (GLT); Johnson Matthey; Unilever.

Appendix 2: List of Indian Stakeholder Participants

The following Indian stakeholder companies, industry bodies and R&D organisations participated in the mission.

Ceramics sector
Asahi Glass; Hindustan Sanitaryware (HSIL); H&R Johnson Division–Prism Johnson Ltd; Simpolo Vitrified Ltd/Simpolo Ceramics; Somany Ceramics; Varmora Granito Pvt. Ltd.

Glass sector
AGI Glaspac (Packaging Products Division HSIL Ltd); Asahi India Glass Ltd; Borosil Renewables Ltd.

Metals sector
Adani Copper (Adani Group); Hindalco Industries; JSW Steel; Tata Steel.

Cement sector
Ambuja Cements Ltd; Birla Cement/Birla Corporation Ltd (M.P. Birla Group); Dalmia Cement; Ultratech Cement.

Paper sector
Andhra Paper Ltd; ITC Paper; JK Paper; Orient Paper & Industries Ltd.

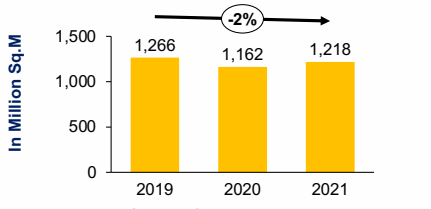
Chemicals sector
DCM Shriram Ltd; Eternis Fine Chemicals Ltd; Laxmi Organic Industries Ltd (LOIL); The Lubrizol Corporation (a Berkshire Hathaway Company).

Appendix 3: Indian Foundation Industries – Sector Overviews

Indian Ceramics Sector

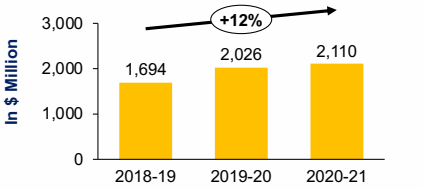
Ceramic: India is 6th Largest Exporter of Ceramic Products and 4th Largest Exporter of Ceramic Tiles

Domestic Production of Ceramic Tiles



Source: Ceramic World Review, Lucintel

Export of Ceramics and Allied Products from India



Source: DGCIS

Key Insights

- 2nd largest producer as well as consumer of ceramic tiles and sanitary ware.
- 80% of tiles produced is consumed domestically whereas 20% is exported.
- 70% of total output in India comes from Gujarat alone.

Key Indian Players

Kajaria, RAK CERAMICS, SOMANY, CERA, AGL TILES – Asian Granito India Ltd.

Major Drivers

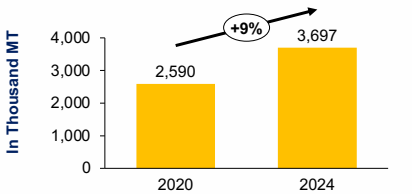
1. Rapid growth in the construction as well as infrastructure development
2. Shift in consumer preferences
3. Push from GOI with "Make in India", "Pradhan Mantri Awas Yojna"
4. Increasing urbanization and increasing disposable income

[Data source Indian FIs: Lucintel LLC]

Indian Glass Sector

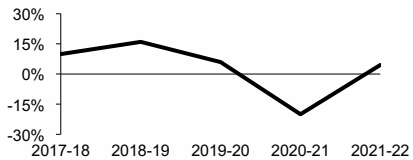
Glass: Glass Container Market in India is Expected to Grow at a CAGR of 9% while Float Glass Market in India will Grow at rate of 5% till 2025

Glass Container Market in India



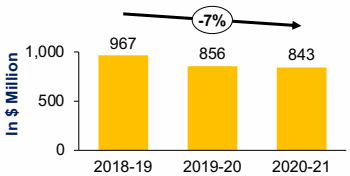
Source: AIGMF

Float Glass Market in India – Growth Trend



Source: AIGMF, Lucintel

Export of Glass and Glassware



Source: DGCIS

Key Indian Players

AIS Asahi India Glass Ltd., SAINT-GOBAIN, MODIGUARD FLOAT GLASS, HNG LEADERS IN GLASS CONTAINERS, Piramal Glass

Key Insights

- Domestic manufacturers are able to fulfill only 70% of total flat glass demand, rest is imported.

Major Drivers

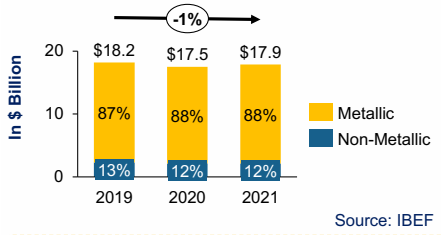
1. Rapid growth in the global construction sector
2. Increased demand from various end use industries like food and beverage packaging, pharma packaging, etc.
3. Change in market dynamics and people becoming more cautious to choose better packaging
4. Increasing urbanization and increasing disposable income

[Data source Indian FIs: Lucintel LLC]

Indian Metals Sector

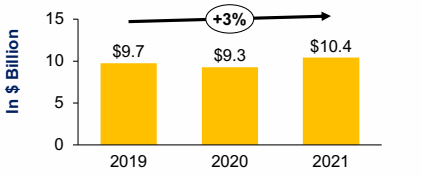
Metal and Minerals: Mineral Production in India was Affected in 2020 due to Pandemic and is in the Path of Recovery

Mineral Production in India



Source: IBEF

Iron and Steel Export from India



Source: IBEF

Key Insights

- India ranks 2nd in crude steel production 4th in world in terms of iron ore production.
- In July 2021, Odisha govt. approved five key industrial projects worth $ 19.60 billion
- These 5 projects are expected to boost capacity of steel production by 27.5 million tonnes.
- Metallic minerals production increased from $ 5.14B in 2016 to $ 6.79B in 2021.

Key Indian Players

TATA STEEL, JSW ESSAR STEEL, HINDALCO ADITYA BIRLA GROUP, SAIL, NMDC, HINDUSTAN ZINC Zinc & Silver of India

Major Drivers

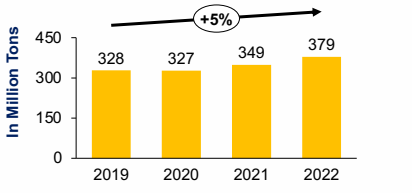
1. Rise in infrastructure development, automotive, power and cement industries aiding growth
2. Reduction in custom duty and import duty of various metallic products, relaxation in FDI norms
3. The National Steel Policy of India aims to boost per capita steel consumption to 160 KGs by 2030-31
4. GOI is encouraging privatization of various metal operations

[Data source Indian FIs: Lucintel LLC]

Indian Cement Sector

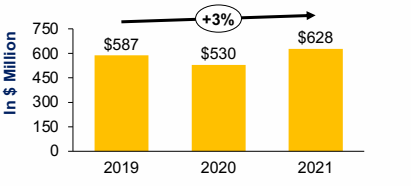
Cement: Cement Consumption increased by 5% during 2019-2022 in India and it is expected to maintain the pace in near future

Cement Consumption in India



Source: IBEF

Cement Export from India



Source: IBEF

Key Insights

- 2nd largest producer in the world
- Expected to add 80 million ton capacity by 2024
- Some of the recent government initiatives like development of 98 smart cities will provide a major boost to the sector.
- Overall production capacity is 545 MT, 98% of which is with private sector.
- Top 20 Companies account for 70% of Cement Production

Key Indian Players

UltraTech CEMENT The Engineer's Choice, BIRLA CORPORATION LIMITED, ACC, Ambuja Cement, SHREE CEMENT LIMITED

Major Drivers

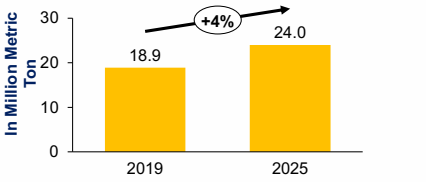
1. Rural housing projects and government's strong focus on infrastructure development
2. "PM Gati Shakti" will bring synergy to create multimodal transport network
3. Increasing FDI inflows
4. Affordable housing schemes and road projects

[Data source Indian FIs: Lucintel LLC]

Indian Paper Sector

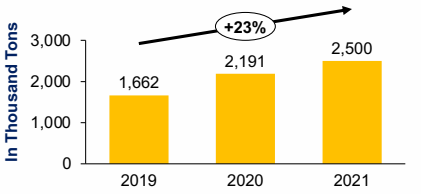
Paper: India Exported Record Level in 2021 with 3 Fold Increase in Export to China

Paper and Paperboard Consumption in India



Source: IPMA

Paper, Paperboard and Newsprint Export from India



Source: IPMA, Lucintel

Key Insights

- Indian paper manufacturers association (IPMA) projects per capita paper consumption to increase to 17 kgs by 2024-25 from 13kg in 2019-20.
- According to CPPRI data (2019-20), India has 861 paper mills with total installed capacity of 27.15 million tonnes.
- There was demand compression due to closing down of educational institutes, commercial establishments and downstream industries during pandemic.

Key Indian Players

JK PAPER LTD. Creating lasting impressions | bilt | ITC Enduring Value PAPERBOARDS AND SPECIALTY PAPERS DIVISION | emami

Major Drivers

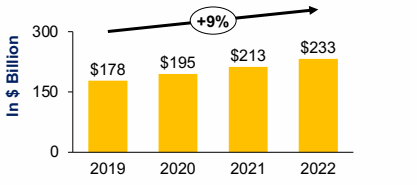
1. Growing demand for paper products, like, tissue paper, tea bags, filter paper, medical grade coated paper, etc.
2. Rising circulation and number of newspapers and magazines
3. Increasing Emphasis on education and literacy rate by GOI
4. Inclination towards sustainability and rising demand for high quality packaging

[Data source Indian FIs: Lucintel LLC]

Indian Chemicals Sector

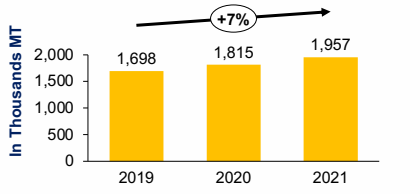
Chemicals: India is 3rd Largest Consumer of Polymers, 4th Largest Producer of Agrochemicals and 2nd Largest Manufacturer and Exporter of Dyes

Chemicals Market in India



Source: IBEF

Chemical Export from India



Source: DGCIS

Key Insights

- Highly diversified with more than 80,000 products.
- Chemical industry in India is de-licensed, only few hazardous chemicals require licensing.
- Expected contribution of >$300B in India's GDP by 2025.
- Specialty chemicals sector holds 22% market share and is expected to grow at a CAGR of 12% during 2021-25.

Key Indian Players

Pidilite | TATA CHEMICALS | UNITED PHOSPHORUS LIMITED | GFL GUJARAT FLUOROCHEMICALS | Reliance Industries Limited

Major Drivers

1. Rise in demand from food processing, personal care, and home care industries
2. PLI schemes to promote domestic manufacturing of agrochemicals
3. PCPIR policies to attract $142 billion investments by 2025
4. Shift in consumer preference towards environment-friendly products is pushing chemical companies to invest and innovate

[Data source Indian FIs: Lucintel LLC]

Connecting for
Positive Change.

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