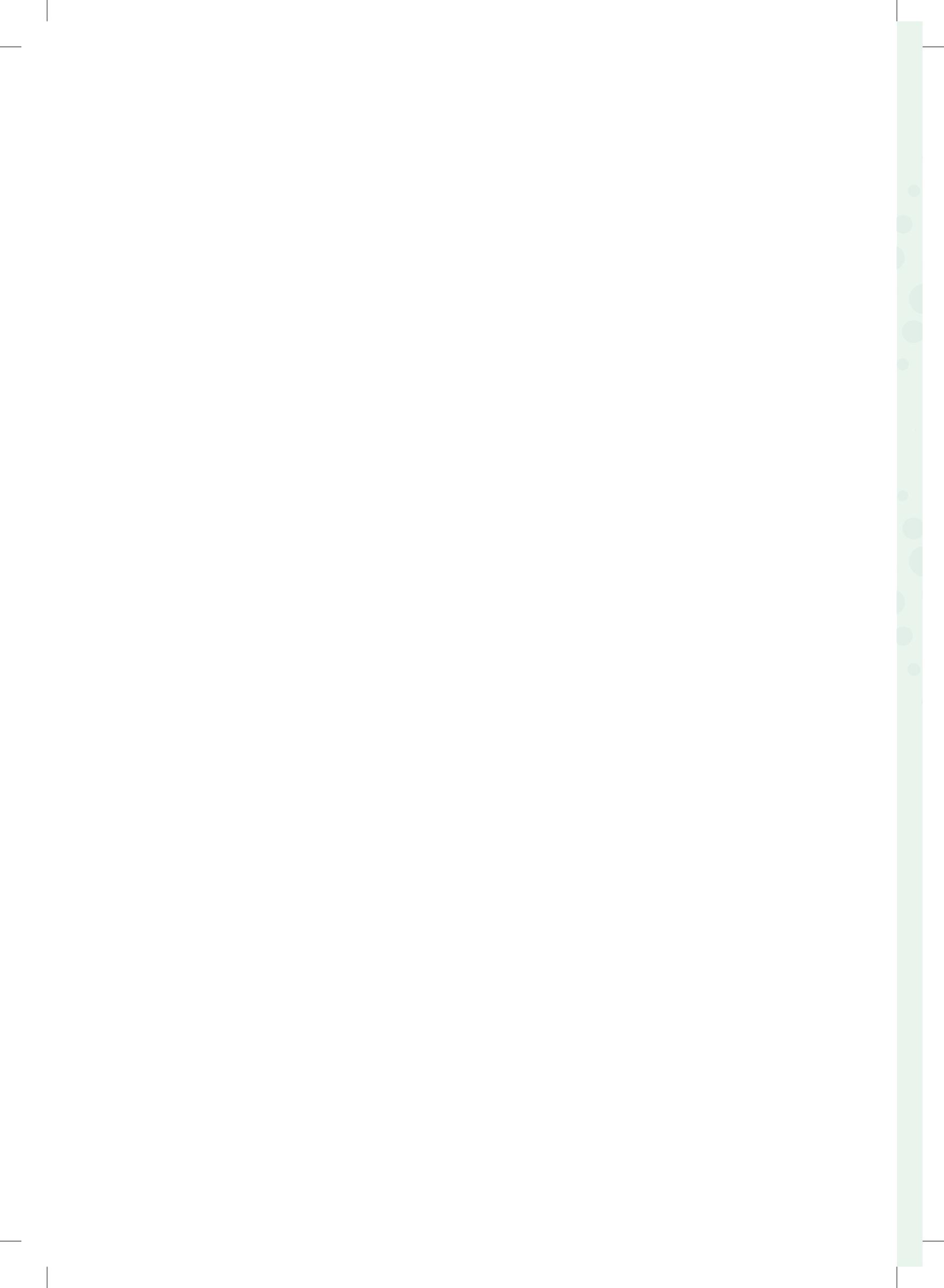




Report of the Inter-Ministerial Committee on Low Carbon Technologies

Under Sustainable Growth Pillar of India-US Strategic
Clean Energy Partnership





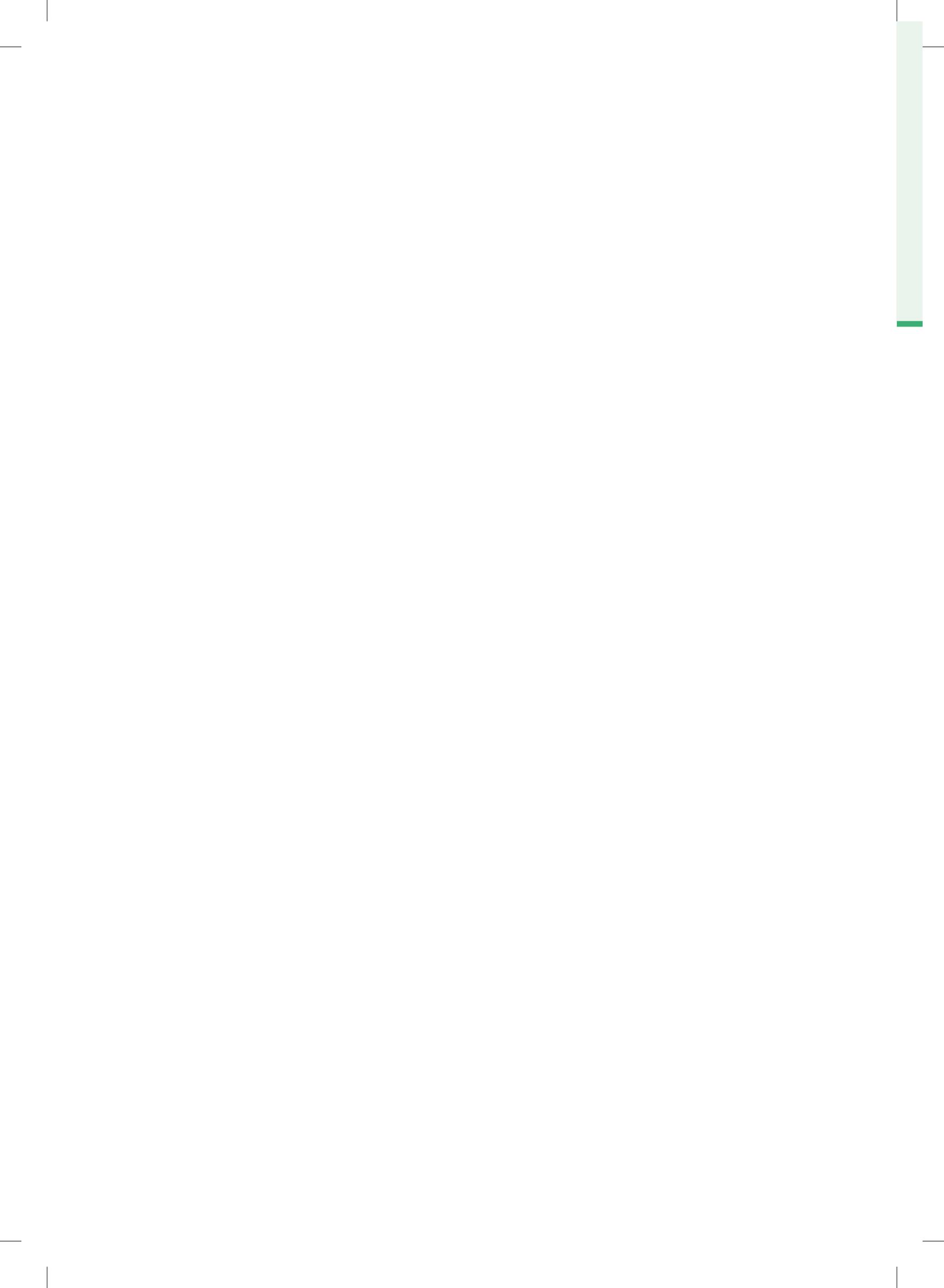


NITI Aayog



Report of the Inter-Ministerial Committee on Low Carbon Technologies

Under Sustainable Growth Pillar of India-US Strategic
Clean Energy Partnership



COMPOSITION OF THE INTER-MINISTERIAL COMMITTEE



Sl. No.	Name and designation	Position
1.	Sh. Neeraj Sinha, Sr Adviser (S&T), NITI Aayog	Chairman
2.	Ms. Rasika Chaube, Additional Secretary, Ministry of Steel	Member
3.	Sh. Sudhendu Jyoti Sinha, Adviser (Transport), NITI Aayog	Member
4.	Sh. BP Pati, Joint Secretary, Ministry of Coal	Member
5.	Sh. BN Mohapatra, Director General, National Council for Cement and Building Material	Member
6.	Dr Ashok Kumar, DDG, Bureau of Energy Efficiency	Member
7.	Representative from the Department of Heavy Industries	Member
8.	Sh. Nirvik Banerjee, ED, Steel Authority of India Limited	Member
9.	Sh. Ashok Kumar Rajput, Chief Engineer (RT&I), Central Electricity Authority	Member
10.	Sh. Rajib Kumar Paul, Director, National Institute of Secondary Steel Technology	Member
11.	Sh. Anil Kumar, Scientist D, Ministry of New and Renewable Energy	Member
12.	Dr Ajay Arora, GM (Fuels), R&D Centre, Indian Oil Corporation Limited	Member

13.	Sh. Prabodh Acharya, Chief Sustainability Officer, Jindal Steel	Member
14.	Sh. SAurabh Kundu, Chief Process Research, TATA Steel	Member
15.	Sh. Prashant K Banerjee, Executive Director (Technical), Society of Indian Automobile Manufacturers	Member
16.	Sh. Priyavrat Bhati, CSTEP	Member
17.	Sh. Raju Goyal, Chief Technical Officer, UltraTech Cement Ltd	Member
18.	Sh. Ashwani Pahuja, Chief Sustainability Officer, Dalmia Cement (Bharat) Ltd	Member
19.	Sh. Philip Mathew, Holcim, Head - Cement Manufacturing Excellence Asia	Member
20.	Prof Prodip Sen, IIT Kharagpur	Member
21.	Ms Apurva Chaturvedi, Sr Clean Energy Specialist, USAID	Member
22.	Ms. Sha Yu, Senior Scientist, Pacific Northwest National Laboratory (PNNL)	Member
23.	Mr David Palchak, Group Manager, National Renewable Energy Laboratory	Member
24.	Mr Nikit Abhyankar, Scientist, Lawrence Berkely National Laboratory	Member
25.	Sh. Manoj Kumar Upadhyay, Deputy Adviser (Energy), NITI Aayog	Member Convener

FOREWORD



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वरिष्ठ सलाहकार
NEERAJ SINHA
Senior Adviser



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Foreword

India has taken some giant strides with respect to its clean energy transition, with some bold policy moves that are reflected in its Nationally Determined Contributions (NDCs). Under that vision, India has committed to Net Zero emissions by the year 2070. The low carbon technologies will play a critical role in the fulfillment of that vision. The Inter-Ministerial Committee on Low Carbon Technologies has, accordingly, examined the various options available to decarbonize the hard to abate sectors (such as the steel and the cement sectors).

The Committee explored various decarbonization options for industries, including the demand side measures, energy efficiency improvements, electrification of heat, hydrogen usage, biomass usage, carbon capture, Advanced Ultra Supercritical Technology and other innovations. Based on those options, a detailed road map for decarbonisation of the steel and the cement sectors has been worked-out. That road map identifies the various types of interventions required such as policy interventions, technological interventions and the incentives required. The Ministries / Departments for undertaking those interventions, and the corresponding time period required for their implementation (short/ medium/ long term), have also been identified.

The Committee witnessed the participation of a wide range of stakeholders, including the concerned Ministries / Departments, academic institutions, think tanks, the industry and US labs under the Sustainable Growth Pillar of the India-US Strategic Clean Energy Partnership. Their valuable inputs have formed the basis of the report.



(NEERAJ SINHA)
23/9/2022





CONTENTS

<i>Composition of the Inter-Ministerial Committee</i>	<i>iii</i>
<i>Foreword</i>	<i>v</i>
About the Sustainable Growth Pillar under the India-US Strategic Clean Energy Partnership	1
1. Introduction	2
2. Decarbonization of Industries	3
3. Technologies Enabling Decarbonization - Example of Waste Heat Recovery	6
4. Decarbonization of Cement Industry	8
5. Decarbonization Options for Steel Industry	17
The Way Forward	18
6. Annexure I	26
7. Annexure II	28



ABOUT THE SUSTAINABLE GROWTH PILLAR UNDER THE INDIA-US STRATEGIC CLEAN ENERGY PARTNERSHIP



The long history of energy cooperation between the United States and India have powered lives and livelihoods. On the margins of the April 2021 Leaders Summit on Climate, President Biden and Prime Minister Modi announced the launch of a new bilateral partnership to advance shared climate and clean energy goals. The U.S.-India Climate and Clean Energy Agenda 2030 Partnership includes the Strategic Clean Energy Partnership (SCEP) which was earlier established as the Strategic Energy Partnership in 2018 and had replaced the U.S.-India Energy Dialogue, the previous intergovernmental engagement for energy cooperation. The revitalized SCEP will continue to advance energy security and innovation with greater emphasis on electrification and decarbonization of processes and end uses, scaling up emerging clean energy technologies, while finding solutions for hard-to-decarbonize sectors. Engagement with the private sector and other stakeholders will remain a priority.

The Sustainable Growth (SG) Pillar under the U.S.-India Strategic Clean Energy Partnership takes a broader role in advancing low-carbon development and improving inclusive and sustainable economic growth through climate responsive strategies, long-term plans, and energy data management. India is well on its way to leverage its expanding and diverse economy, capitalize on its demographic dividend and benefit from its rapid urbanization. The country's growth could be further enhanced with addressing energy issues along with ensuring financial and environmental sustainability as a climate responsible country. India is prioritizing strategies which could improve energy security, reliability, and affordability, universal energy access, and resiliency of energy systems to cyber-attacks and extreme weather events. As part of the agenda of the Pillar for 2021-22, three committees were formed on important issues of energy data management, low carbon technologies and just transition from coal.

1. INTRODUCTION



- 1.1** The challenge of climate change has created an urgent requirement to adopt clean and environment friendly technologies. Goal 9 of the Sustainable Development Goals has increased resource use efficiency and greater adoption of clean technologies and industrial processes as one of its targets. Industry emits about 28% of global greenhouse gas (GHG) emissions of which 90% are carbon dioxide emissions.
- 1.2** In the Indian context industries contribute approximately one-fourth of India's total GHG emissions. Within industry half of the emissions are from iron and steel and cement sector - either through energy use or industry process emissions. In order to meet the targets aimed at addressing climate change there is a need for addressing hard to abate sectors.

2. DECARBONIZATION OF INDUSTRIES



2.1 Some of the challenges faced in decarbonization of industries are as follows:

1. The processing of feedstocks generates about 45 percent of CO₂ emissions in the focus sectors. These emissions can only be reduced by changing feedstock's or processes, rather than changing to low-carbon energy sources.
2. Sectors such as steel and cement have a large demand for high-temperature heat (in the focus sectors the high temperature heat demand ranges from 700 °C to over 1,600 °C which generates 35 percent of CO₂ emissions). To replace the fossil fuel for heat generation with electricity or hydrogen requires a significant change in the production process and development of alternative furnace designs. Up to ~1,000 °C, adaptation and scale up of electric furnace technology is needed. For temperatures above ~1,000 °C, such as required for cement production, research is required to develop industrial-scale electric furnaces.
3. Steel is traded globally (cement is not). Companies or countries that increase their costs of production by adopting low-carbon processes and technologies will find themselves at a cost disadvantage to industrial producers that do not.
4. The products made from the steel or iron industry are basically commodities for which cost is the decisive consideration in purchasing decisions. Companies in the these sectors therefore compete mainly on price, so implementing decarbonization options that increase the cost of production will put them at a disadvantage.

2.2 Industrial companies can reduce CO₂ emissions in various ways, with the optimum local mix depending on the availability of biomass, carbon-storage capacity and low-cost zero-carbon electricity and hydrogen, as well as projected changes in production capacity.

2.3 There exist the following decarbonization options for industries:

1. **Demand-side measures:** Decreasing the demand for an industrial product should lead to lower production and CO₂ emissions. For example, light-weighting can reduce the demand for steel, and cement could be replaced by materials such as wood. In addition, increasing the circularity of products, e.g., by increasing recycling or reuse of plastics and steel, would lessen CO₂ emissions by reducing the production of virgin materials.
2. **Energy-efficiency improvements:** Increases in energy efficiency can economically cut fuel consumption for energy use by 20 to 40 percent across sectors. Potential gains in energy efficiency will differ between sectors and facilities. Using less fossil energy to make industrial products will lower CO₂ emissions.
3. **Electrification of heat:** Emissions from the use of fossil fuels to generate heat can be abated by switching to furnaces, boilers, and heat pumps that run on zero-carbon electricity. Electrifying heat can involve a change in the production processes. For example, to electrify ethylene production, companies need to install both electric furnaces and electrically driven compressors.
4. **Hydrogen usage:** Emissions from the consumption of fossil fuel for heat and emissions from certain feedstocks can be abated by changing them for zero-carbon hydrogen. Hydrogen is generated by using zero-carbon electricity for the electrolysis of water. For example, ammonia production can be decarbonized by replacing the natural gas feedstock with zero-carbon hydrogen.
5. **Biomass usage:** Like hydrogen, sustainably produced biomass can be used in place of some fuels and feedstocks. Depending on the fuel or feedstock required, biomass in a solid (wood, charcoal), liquid (biodiesel, bioethanol), or gaseous (biogas) form can be used. For example, steel producers in Brazil use charcoal as a fuel and feedstock instead of coal, and chemical producers in several European countries experiment with bionaphtha in chemicals production.
6. **Carbon capture:** With carbon-capture technology, CO₂ can be collected from the exhaust gases produced by an industrial process and prevented from entering the atmosphere. The CO₂ can be stored underground (CCS) or used as a feedstock in other processes through carbon capture and usage (CCU).

7. Advanced Ultra Supercritical Technology
 - a. On being sanctioned by the Government of India, the implementation of an R&D project for the development of the Advanced Ultra Supercritical (AUSC) technology for thermal power generation – jointly by a Consortium of the Indira Gandhi Centre for Atomic Research (IGCAR), Department of Atomic Energy (DAE), Kalpakkam; the Bharat Heavy Electrical Limited (BHEL) and the NTPC Limited – had commenced on the 1st of April, 2017 and has ended successfully on the 31st of December, 2020. The entire implementation of that project was, very proactively, led by a Mission Directorate set-up by the Department of Heavy Industry (DHI), Government of India, in Noida, Uttar Pradesh. A high-level committee – called the Over-arching Committee (OAC) – has contributed significantly in guiding the said project to its successful completion. The OAC was chaired by the Principal Scientific Adviser to the Government of India, with the members being the Member (S&T), NITI Aayog; the Secretary, DAE; the Secretary, Ministry of Power; the Secretary, DHI and the Secretary, Department of Expenditure. The AUSC Mission Director was the Member-Secretary to that Committee.
 - b. The successful completion of the project was despite the challenges faced by the Consortium in the completion of the indigenous design of the steam turbine (viz. the rotor and the casing) of the AUSC project. ***That design, incidentally, is a global first, along with several other such global firsts.***
 - c. Based on the successful R&D work already done, the Consortium, with the support of the Government of India, is planning to set-up the world's 1st AUSC thermal power plant, of 800 MWe capacity, in Sipat, Chhattisgarh.
8. **Other innovations:** Besides the decarbonization options listed above, other techniques for carrying out industrial processes could lead to CO₂ emission reductions. For example, alternatives to limestone feedstock could reduce process emissions in cement production. High-temperature chemical processes can also be replaced by electrochemical processes, in which electricity, rather than heat, drives reduction and oxidation reactions. CO₂ to methanol and Molten Carbonate Fuel Cell as a CO₂ concentrator while generating power can also be examined as options for decarbonization.

3. TECHNOLOGIES ENABLING DECARBONIZATION - EXAMPLE OF WASTE HEAT RECOVERY



- 3.1** One of the prime measures to decarbonize industries, especially steel and cement is to improve efficiency of the overall process. In this regard, Waste Heat constitutes a substantial amount of energy in many core sectors such as iron and steel, cement and power plants. Waste Heat Recovery (WHR) is a method of recycling and re-using the heat that is escaping the industrial processes after useful work is accomplished. The Government is promoting energy conservation under the ambit of Electricity Conservation Act. In order to support efforts towards a sustainable growth of economy, reuse of waste heat generated by industries for electricity generation has tremendous potential. It is estimated that 20-50% of input energy is lost into the environment in the form of hot gases, hot air, hot water, etc, due to process inefficiencies and technical limitations. These energy losses cannot be recovered fully but may be reduced partially by improving efficiency of processes/equipment as well as by deploying Waste Heat Recovery (WHR) Systems.
- 3.2** US support is required in development and deployment of industrial processes powered by electricity produced from clean energy sources as a vital pathway in achieving decarbonization across the industries.
- 3.3** Substantial amount i.e. 20% to 50% of energy input being used by industry is wasted as heat into environment in form of exhaust gases, waste streams of air and liquids leaving industrial facilities. The industrial sector accounts for about 45% of total electricity being consumed in India. Even considering 30% of this energy input being wasted by industry accounts to 160 billion KWh annually or equivalent to 20000 MW of coal based power generation capacity. This huge amount of waste heat is caused due to equipment inefficiencies and thermodynamic limitations of the equipment/processes. Hence industrial facilities can reduce these losses by installing Waste Heat Power systems to improve overall equipment/process energy efficiency. Therefore waste heat power (WHP) generation will reduce the energy consumption per unit of production for Indian industries. Also WHP will

result in savings of fossil fuels like Diesel/high grade coal/furnace oil, etc. mainly used for captive power generation and thereby reducing nation's GHG emissions.

3.4 Waste heat in the industry is generated during fuel combustion or chemical reactions, and can be utilised in Waste Heat Recovery (WHR) boilers to generate steam. The increasing use of WHR systems in industries such as refineries, paper and pulp, cement, heavy metals, petrochemicals and chemicals for preheating, steam generation and power generation purposes is expected to drive market growth in the coming years.

3.5 Benefits of WHP are the following:

1. Installation of waste heat power systems for captive power generation can cater up to 20-40% of power consumption for a given industry and electricity generated from waste heat power can displace power from sources that generate emissions i.e. coal based thermal power plants.
2. Waste heat power plant reduces its consumer's reliance on fossil fuel based power generation.
3. Generation of electricity from WHP does not add any carbon dioxide or heat in the atmosphere. Emission/temperature levels remains almost same even with increased generation capacity of electricity without using fossil fuels.

4. DECARBONIZATION OF CEMENT INDUSTRY



- 4.1** Cement manufacturing releases CO₂ through two main activities: energy use and calcination reactions. Energy-related emissions (30–40% of direct CO₂ emissions) occur when thermal fuels, most commonly coal, are used to heat a precalciner and rotary kiln. The other primary source of direct CO₂ emissions (“process emissions”) come from a chemical reaction that takes place in the precalciner, where limestone (largely calcite and aragonite, with chemical formula CaCO₃) is broken down into lime (CaO) and carbon dioxide (CO₂). The CO₂ is released to the atmosphere, while the lime is used to make clinker, one of the main components of cement.
- 4.2** Cement production has substantial environmental impacts. Globally, cement and concrete are responsible for 8–9% of GHG emissions, 2–3% of energy demand, and 9% of industrial water withdrawals. Further, the selection of fuels for cement kilns, and in part the kiln materials used, currently lead to notable air pollutant emissions. It is critical to select mitigation strategies that can contribute to reduced CO₂ emissions while lowering other environmental burdens. This is especially true considering the high near-term projected future demand for cement. These factors must be taken into consideration when evaluating strategies to decarbonize cement production, one of the most difficult industries to decarbonize, due to the need for high temperatures, the generation of CO₂ process emissions, and the large quantity of cement demanded globally.
- 4.3** To reduce energy-related emissions from cement (e.g. from the fuel used to heat the precalciner and kiln), the main options are improving the thermal efficiency of cement-making equipment, fuel switching, electrification of cement kilns, and carbon capture and sequestration (CCS).
- 4.4** Reducing the moisture content of input materials improves energy efficiency, as less energy is needed to evaporate water. This can be achieved by using a dry-process kiln and ensuring the kiln has a precalciner and multi-stage preheater. Recovered heat can be used to pre-dry input materials. A grate

clinker cooler is better at recovering excess heat than planetary or rotary-style coolers. The extent to which these upgrades can reduce energy use depends on the age and efficiency of the technology already in use. Most modern kilns incorporate this processing stage, which is reflected in the high-producing regions that recently expanded cement production capacity.

- 4.5 Certain mineral compositions can lower the temperature at which input materials are chemically transformed into clinker, and less fuel is needed to reach a lower temperature. However, some of these alternatives can alter cement performance, so testing and certification of alternative cement chemistries will be important. Another approach is to react fuel with oxygen-enriched air, so less heat is lost in the exhaust gases. Oxy-combustion also has the benefit of reducing the concentration of non-CO2 gases in the exhaust stream, making carbon capture easier.
- 4.6 Today, 70% of global thermal fuel demand in the cement industry is met with coal, and another 24% is met with oil and natural gas. Biomass and waste fuels account for the last 6%. Biomass and waste fuels typically have lower CO2-intensity than coal, though they may have other drawbacks, such as a higher concentration of particulates in the exhaust.
- 4.7 To completely decarbonize heat production for cement, electrification of cement kilns or CCS may be necessary. The best route may vary by cement plant, as it will be influenced by the price and availability of zero-carbon electricity, as well as the feasibility of carbon capture and storage at the plant site. Due to the ability for hydrated cement to carbonate, and in doing so uptake CO2, some work has started to quantify potential carbon capture and storage through using crushed concrete and fines at the end-of-life.

Table 1

Challenges	
<p>Cement manufacturing is Hard to Abate Sector</p>	<ul style="list-style-type: none"> ◆ Process emissions : 50 - 55 % of the CO2 emissions attributable to process (de-carbonation of limestone) where mitigation is only possible through CCU ◆ Combustion of fossil fuels : 30 - 35 % emissions attributable to thermal energy needed in pyro-processing ◆ Emissions related to electricity use : 8 - 10 % of total CO2 emissions ◆ Onsite vehicular and equipment emissions : 2 - 5% from liquid fossil fuels consumption

Challenges	
Decarbonization Roadmap for Cement Sector	
Scope 1	
Reducing Carbon Footprint of Electrical Energy	<ul style="list-style-type: none"> ◆ Improving efficiency through energy efficient equipment ◆ Renewable & Waste Heat ◆ Optimize Waste Heat Recovery System ◆ Waste Heat Recovery generation may be granted the status of Renewable Energy, which are operating with actual waste heat available ◆ Recovery power generation from chlorine bypass system ◆ Digitization and Industry 4.0
Reducing Carbon Footprint of Thermal Energy	<ul style="list-style-type: none"> ◆ Improving heat efficiency through efficient pyro technology ◆ Innovation in Pyro-processing Technology ◆ Alternative green fuels (including green hydrogen) and Sustainable Biomass (Bamboo energy plant) to switch fossil fuels ◆ Artificial intelligence and Industry 4.0 in pyro-processing ◆ Heat Electrification from Renewable Power ◆ Solar Calcination/Clinkerisation ◆ New clinker systems
Enhancing use of Supplementary Cementitious Materials	<ul style="list-style-type: none"> ◆ Enhancing the use of Blended Cements from the existing 73% to 100%, replacing Ordinary Portland Cement (OPC) with Portland Pozzolana Cement (PPC), Portland Slag Cement (PSC), Composite Cement (CC). ◆ Flyash based cements ◆ Enhancing the fly ash % in from the existing BIS limit of 35% to 40%. ◆ GGBF Slag Cements ◆ Limestone based cements ◆ Calcined clay/Natural Pozzolana based cements ◆ Multi-blend cements
Reducing Process Emissions	<ul style="list-style-type: none"> ◆ Carbon Capture and Utilisation ◆ New Novel Cements with Low Carbon/No Carbon raw material
Reducing Emissions from On-site Vehicles and Equipment	<ul style="list-style-type: none"> ◆ Electric, Plug-in Hybrid, Fuel Cells or Pure Battery

Challenges
Scope 2
Emissions reduction by use of Renewable Energy
Scope 3
Emissions reduction by : <ul style="list-style-type: none"> ◆ Concrete recarbonation during product use ◆ Use of electric vehicles in logistics operations ◆ Offsetting business travel ◆ Green procurements

4.8 Suggestions for faster industry transition:

1. Switching from fossil fuel to sustainable biomass such as Agro waste/ Bamboo etc. and target setting for compulsory use of biomass as alternative fuel.
2. Transition to Industry 4.0.
3. Target setting for adaptation of efficient pyro-process technology and monitoring mechanism for its effective implementation.
4. Transitioning to 100% renewable power (RE 100):
 - ✦ **Policies regarding amendments** should be done at central level and should not be not State Specific in order to promote the RE projects,
 - ✦ **ISTS charges:** Waiver of ISTS charges for Inter State Open Access Wheeling (Impact of Rs. 0.5/unit),
 - ✦ **Electricity Duty:** Waiver of Electricity duty on Captive consumption from Solar (Impact of Rs.0.10/unit to Rs.0.6/unit),
 - ✦ **Scheduling and Settlement of Power:** For Captive Wheeling, Scheduling of power should be allowed on monthly TOD basis and not in 15 minute time block basis,
 - ✦ **Banking of power:** Banking provision should be provided for captive consumers wherein Yearly Banking of power should be allowed on RTC(round the clock) basis and shall be allowed even for Inter State transaction and Balance Power if any after the Financial Year shall be Procured by DISCOM on APPC Rate,
 - ✦ **Capacity Restriction:** There should not be any Capacity restriction based on Grid contract Demand on captive consumers for Installation of Solar or other Renewable projects.

- ✦ **Contract Demand reduction:** Grid Contract Demand reduction on average basis equivalent to the RE capacity,
 - ✦ **Cross Subsidy Surcharges:** Cross subsidy surcharges should be waived off for Intra and Inter State Open access transactions (Third Party and GTAM) as an Incentive,
 - ✦ **Additional Surcharges:** Non applicability of Additional Surcharges for GTAM, 3rd Party or Group captive Consumers (levied in Maharashtra, KN, TN, GUJ),
 - ✦ **Evacuation Facilities:** Evacuation Facilities from RE Project to Consumer premises should be provided by DISCOM for Intra State Consumers,
 - ✦ **Net Metering:** Net Metering should be allowed with no restriction on grid CD capacity,
 - ✦ **REC:** REC should not be restricted to one State. In case of group units in different States, REC generated in one State should be allowed to comply RPO of other States.
5. **Wastes to Circularity Renewable biomass and waste to replace fossil fuel use in cement kiln:**
- ✦ Facilitate availability of waste land for sustainable biomass plantation/ Carbon sink creation in wastelands of India (26 million Ha. announced, 97 million Ha. actual waste landmass in India). Bamboo planted in wastelands can have huge potential for fossil fuel replacement in a big way.
 - ✦ Introduce landfill tax/polluter to pay policy to promote circular economy models of greater waste utilization
 - ✦ Create Waste Generation Database (WGD), controlled by a Central Body) for wastes, both legacy and daily generation
 - ✦ Creation of Municipal Solid Waste (MSW) pre-processing facilities by all Municipalities for converting MSW to Refuse Derived Fuel (RDF)
 - ✦ Create Micro-level Government-Industry-Private Entity (G-I-P) partnership enterprise to facilitate transfer of processed waste material from Source (Industry [processed waste]/Private Entity [waste processor]) to Consumer (Cement Industry)

6. **External actions needed to support Carbon Capture and Utilization (CCU) for industry transition:**

- ✦ Government grants/viability gap funding for innovative and disruptive CCU projects
- ✦ Cross sector and cross country collaborations – The cross sector and cross country collaborations to tap advantages of each sector for policy advocacy, technical know-how and disruptive incubations
- ✦ Encouraging green labelling and green procurement policies
- ✦ Facilitating carbon markets

7. **Other Suggestions for faster industry transition**

- ✦ **Incentives for heavy-transport electric mobility:** Provide GST/Toll Tax incentives to the heavy-transport sector
- ✦ **Charging infrastructure:** Develop adequate fast charging infrastructure, every 25 km target
- ✦ **Green Hydrogen for fuel cells and turbines:** Build cost competitive green hydrogen with vast RE resources
- ✦ **Global Carbon Markets Access:** The access to global carbon markets for Indian companies should be ensured
- ✦ **Showcase Indian Industry actions:** Highlight the climate actions of progressive industries in various international and national platforms such as UN General Assembly, COP-26, Leadership Summit, etc.
- ✦ **Waste Heat Recovery:** Waste Heat Recovery based power projects should be given the status and incentives of renewable power

4.9 The Way Forward – Cement Sector

The measures suggested for transition to low carbon technologies in cement sector are discussed in section 4.8. The suggested measures are further classified in terms of short term and long-term measures as well as categorized in terms of policy, incentives and technological interventions. For better coordination and swift implementation of the interventions, the related nodal ministry/departments are also highlighted.

1. Policy Interventions

Sl. No.	Suggested Measures	Nodal Ministry/ Department	Timeline
1.	For Captive Wheeling, Scheduling of power should be allowed on monthly TOD basis and not in 15 minute time block basis	Ministry of Power	Short Term
2.	Banking provision should be provided for captive consumers wherein Yearly Banking of power should be allowed on RTC (round the clock) basis and shall be allowed even for Inter State transaction and Balance Power if any after the Financial Year shall be Procured by DISCOM on APPC Rate,	Ministry of Power	Short Term
3.	No Capacity restriction, based on Grid contract Demand on captive consumers, for Installation of Solar or other Renewable projects.	Ministry of Power/ SEBs	Short Term
4.	Grid Contract Demand reduction on average basis equivalent to the RE capacity	Ministry of Power	Short Term
5.	Evacuation Facilities from RE Project to Consumer premises should be provided by DISCOM for Intra State Consumers	Ministry of Power/ SEBs	Short Term
6.	Net Metering should be allowed with no restriction on grid CD capacity	Ministry of Power/ SEBs	Short Term
7.	Renewable energy Consumption should not be restricted to one State. In case of group units in different States, REC generated in one State should be allowed to comply RPO of other States.	Ministry of Power/ Ministry of New and Renewable Energy (MNRE)	Short Term
8.	Facilitate availability of waste land for sustainable biomass plantation/Carbon sink creation in wastelands of India	Ministry of Environment, Forest and Climate Change (MoEF&CC)	Short Term
9.	Introduce landfill tax/polluter to pay policy to promote circular economy models of greater waste utilization	MoEF&CC	Short Term
10.	Renewable power status for Waste Heat Recovery based power projects	MNRE	Short Term

2. Technological Interventions

Sl. No.	Suggested Measures	Nodal Ministry/ Department	Timeline
1.	Cross sector and cross country collaborations to tap advantages of each sector for policy advocacy, technical know-how and disruptive incubations	Niti Aayog	Short Term
2.	Build cost competitive Green Hydrogen with vast RE resources	Ministry of New and Renewable Energy (MNRE)	Long Term
3.	Development of technology on Solar Thermal Calcination	MoP/DST/MNRE/ DPIIT	Long Term
4.	Development of technology on Electrification of Pyro-processing	DST/MoP/MNRE/ DPIIT	Long Term
5.	Development of Low Cost Technology on Carbon Capture and Utilization	DST/Department of Scientific and Industrial Research (DSIR)	Long Term
6.	Development of Technology for Utilization of Green Hydrogen in Pyro-processing	MoP/MNRE	Long Term
7.	Knowledge Transfer for Transition to Industry 4.0 for reduction in energy consumption	Niti Aayog/DPIIT/ DST/DSIR	Short Term

3. Incentives Required

Sl. No.	Suggested Measures	Nodal Ministry/ Department	Timeline
1.	Waiver of Inter State Transmission Charges (ISTS) charges for Inter State Open Access Wheeling (Impact of Rs. 0.5/unit)	Ministry of Power	Short Term
2.	Waiver of Electricity duty on Captive consumption from Solar (Impact of Rs.0.10/unit to Rs.0.6/unit)	Ministry of Power	Short Term
3.	Waiver of Cross subsidy surcharges for Intra and Inter State Open access transactions (Third Party and GTAM)	Ministry of Power	Short Term
4.	Non applicability of Additional Surcharges for GTAM, 3rd Party or Group captive Consumers (levied in Maharashtra, KN, TN, GUJ),	Ministry of Power/ SEBs	Short Term

Sl. No.	Suggested Measures	Nodal Ministry/ Department	Timeline
5.	Create Waste Generation Database (WGD) , controlled by a Central Body) for wastes, both legacy and daily generation	MoEF&CC	Short Term
6.	Creation of Municipal Solid Waste (MSW) pre-processing facilities by all Municipalities for converting MSW to Refuse Derived Fuel (RDF)	MoEF&CC	Short Term
7.	Develop an ecosystem to promote the use of Alternative fuels and raw materials and incentivize the industry for maximizing the usage.	MoHUA	Short Term
8.	Create Micro-level Government-Industry-Private Entity (G-I-P) partnership enterprise for enhancing utilization of Alternate fuels and raw materials	MoHUA/ULBs	Short Term
9.	Government grants/viability gap funding for innovative and disruptive CCU projects	Niti Aayog	Short Term
10.	Encouraging green labelling and green procurement policies	Ministry of Consumer Affairs	Short Term
11.	Facilitating carbon markets	MoEF&CC	Short Term
12.	Provide GST/Toll Tax incentives to the heavy-transport sector	Ministry of Finance/ Ministry of Road, Transport & Highways	Short Term
13.	Develop adequate fast charging infrastructure for electric vehicles, every 25 km target	Ministry of Road, Transport & Highways	Short Term
14.	Ensuring Global Carbon Markets Access for Indian companies	Niti Aayog/MoEF&CC	Short Term
15.	Showcasing Indian Industry actions to highlight the climate actions in various international and national platforms	Niti Aayog/Ministry of External Affairs	Short Term

5. DECARBONIZATION OPTIONS FOR STEEL INDUSTRY



- 5.1** India is the world's 2nd largest steel producing country, producing more than 100 MTPA and the National Steel Policy anticipates that a crude steel capacity of 300 MTPA will be required by 2030-31 to cater to the projected demand. Steel is also a key component of India's energy system. In addition to being an important input to much of its energy infrastructure, the sector itself is a major energy consumer. The iron and steel sector are responsible for around one-fifth of industrial energy consumption in India, with coal accounting for 85% of its roughly 70 Mtoe of total energy inputs¹. As a result, the sector is highly emissions intensive, contributing almost a third of direct industrial CO₂ emissions, or 10% of the country's total energy system CO₂ emissions. Therefore, a significant fraction of global efforts of low carbon steelmaking are to be driven by Indian steel industry.
- 5.2** Technologically, steel industry in India is quite heterogeneous with several process and input material combination and a wide range of different sized facilities in primary and secondary sectors. With advanced technologies, and under the right circumstances, the Indian steel industry could achieve a transformation in the way it makes steel and reduce its environmental impact. The Indian steel industry should plan to reduce its direct and indirect CO₂ emission by 60 % by 2050 in comparison to 2019-20 levels to be in trajectory for net zero by 2070². However, this change cannot be an instantaneous shift. The key potential deep decarbonization technologies are not yet techno-commercially feasible and hence, emissions reductions till 2030 are expected through series of levers like improvement of process and energy efficiency, energy transition to renewable sources, usage of alternative fuel sources, ensuring the use of improved raw material quality, and enhancing material circularity, etc. Thus, Decarbonization is required to be done in phases:

¹ IEA Roadmap for Iron and Steel Sector – Chapter 3

² IEA Roadmap for Iron and Steel Sector

- ▣ **Phase 1 - (2022-2030):** Emission Reductions in short term
- ▣ **Phase 2 - (2031-2050):** Deep Decarbonisation technologies in the medium to long term.
- ▣ **Phase 3 - (2050-2070):** Offsetting and other interventions post 2050 towards net-zero.

The Way Forward

Phase 1 - Emission Reductions in Short term till 2030

5.3 The technologies required for emission cuts in the short term are not the low-cost ones (like replacement of conventional lighting with LED or use of Variable Voltage Variable Frequency drives along with high efficiency motors), but the high cost ones, most of which are related to energy efficiency and need a hand-holding by the GoI for its implementation.

5.4 Steel-producing fleet in India is only a little more than one third of the way through its typical lifetime, which is around 40 years on average for these assets. Many more blast furnaces and DRI furnaces will need to be built in India before alternative near-zero emission routes are ready to enter the market, and the country is projected to have a comparatively young fleet in 2030. Therefore, in the near term it is crucial to maximise operational efficiency in existing assets and to minimise additional emissions from new infrastructure by investing in the BAT for commercial production routes until near-zero emission alternatives reach market introduction.

Key Levers	Feasibility and Recommendations
1. Monitoring and Assessment	<p>The beginning of Phase - I of the Decarbonisation will require data collection to categorise Iron and Steel Plants based on</p> <ul style="list-style-type: none"> ◆ Process ◆ Extent of integration ◆ Combination of processes. <p>Most of the MSME steel plants have a coal based DRI and Induction Furnaces which has a much higher rate of CO₂ per ton of steel produced than Integrated ones. Thus, it becomes important to create a centralized monitoring mechanism to step up the efficiency of these MSME steel sector.</p> <p>It is recommended to set up Energy Monitoring Cell to monitor energy efficiency and CO₂ emissions of MSME steel sector. (Ministry of Steel and Bureau of Energy Efficiency, Long term)</p>

Key Levers	Feasibility and Recommendations
<p>2. Energy and Process Efficiency through implementation of Best Available Technologies (BAT)</p>	<p>Around 40% of blast furnaces in India are currently equipped with top-pressure recovery turbines (TRTs), and more than 30% of coke ovens are equipped with coke dry quenching (CDQ), two examples of BAT. Both these shares should rise to around 70% by 2030^{<?>}. These and other measures like waste heat recovery systems, smelting reduction technologies, CONARC technology etc. including those that optimise operational efficiency, considerably improve performance.</p> <p>Perform, Achieve and Trade (PAT) scheme by Gol was one such measure which is driving the energy efficiency in steel plants. Conscious early discontinuation or interim underutilisation of some obsolete steel plant units is already taking place because of introduction of Perform Achieve and Trade (PAT) Mechanism by Bureau of Energy Efficiency (BEE) that makes them uneconomic. In spite of this, in some plants, due to lack of space and logistics, retrofitting of energy efficient equipment like coke dry quenching plant, blast furnace top gas pressure recovery turbines, torpedo ladles, waste heat recovery systems, hot charging in re-heating furnaces, walking-beam type reheating furnaces etc. becomes non-viable.</p> <p>It is recommended to prepare road map for covering the viability gap in introducing such modern technologies in old plants. (Ministry of Steel, Short Term)</p> <p>It is also recommended that schemes like Japan's deployment of industrial energy and environmental technologies through New Energy and Industrial Technology Development Organisation (NEDO), may be deployed for utilization by needy plants. (Ministry of Power, Long Term)</p>
<p>3. Demand reduction through Material Efficiency</p>	<p>This involves various sectors at different stages along the steel value chain starting from transportation sector, buildings, automotive, improving yields during manufacturing etc. With the use of Advanced high strength steels in the value chain, the amount of material consumed can be reduced there by increasing the material efficiency.</p> <p>For example, it is proven that the use of Advanced High Strength Steels (AHSS) can reduce total vehicle weight by 8-10% compared to conventional steel which corresponds to a lifetime saving of 2-3 tonnes of greenhouse gases over the vehicle's total life cycle^{<?>}.</p> <p>Gol has set ambitious target for electric mobility. The expansion of the Electric Vehicles (EV) market is estimated to drive the demand for EV component materials such as high-quality Cold Rolled Non-Oriented (CRNO) electrical steel, which improves energy efficiency by reducing power losses in several applications.</p> <p>It is recommended to create a market and incentivise indigenous manufacturing of such value added high quality and high strength steel to help in reduction of carbon footprint. (Ministry of Steel, Short Term)</p>

Key Levers	Feasibility and Recommendations
4. Reduction in Coke rate using High Iron bearing raw material	<p>As the demand for steel increases to 255 MT in 2030-31, the demand for iron ore is expected to be 437 MT by 2030^{<?>}. With the rapid depletion of natural resources, it will be difficult to receive high grade iron ore in the future. Iron ore pellets are largely characterized by inherent physical and chemical properties of the ore. Alumina and silica play important roles in determining the productivity of a Blast Furnace. This will have a significant impact on the energy consumption and emission intensity of the steel production process by affecting the productivity of a Blast Furnace.</p> <p>It is recommended to promote advanced beneficiation of iron ore and production of high grade pellets for BF feed to minimize coke consumption. (Ministry of Steel, Long Term)</p>
5. Energy Transition	<p>Scope 2 emissions of Indian steel industry stands at 75 Million tonnes of CO₂ for 111 MT of steel production in 2019-20. This amounts to 0.68tCO₂/tcs of indirect emissions in steel industry^{<?>}. An alternative approach to using grid electricity is to harness Renewable Energy and possibly directly in captive installation. Usage of renewable energy during manufacturing process reduces these indirect emissions there by reducing the total emission intensity significantly. Moreover, increased usage of renewable energy is very important to decarbonize the steel sector through production of electrolytic hydrogen which is currently in the R&D stages, targeting to produce green hydrogen economically and also eventually scaling up for industrial levels.</p> <p>Recommendations provided under Section 4.8 of cement sector.</p>
6. Increased utilization of Scrap	<p>Steel plants, mostly integrated ones which produce steel from Iron ore account for 75% of Global steel production, but emit almost 90% of CO₂ emissions due to their high CO₂ intensity of 2.3 ton CO₂ per ton of steel produced. In contrast, Minimills, whose primary feedstock is recycled steel scrap, account for the balance 25% of the global steel production, but only 10% of emissions since they emit 0.6 ton of CO₂/per ton of steel produced. Every tonne of scrap used for steel production avoids the emission of about 1.5 t of CO₂, consumption of natural resources of about 1.4 t of iron ore, 740 kg of coal and 120 kg of limestone, energy consumption by around 2½ Gcal and water consumption by around 40 %. Such scrap based Steel units have the potential to eliminate emissions by using renewable electric power.</p> <p>However, ferrous scrap is not available due to the long service life of steel products, given steel's strength and durability. India, as a developing economy, with very low apparent finished steel use per capita of 64 kg, has limited amounts of domestic scrap to use as a material in steelmaking. Most of the scrap supply in India today happens through unorganised sector. At present, around 7 MT of scrap being imported, provides a potential to harness this from the domestic market itself. This shall require adequate collection centres,</p>

Key Levers	Feasibility and Recommendations
	<p>dismantling centres which shall work in a hub-spoke model and feed to the scrap processing centres. To produce 7 MT more of scrap, the country shall require 70 scrap processing centres each with the capacity of 1 lakh tonnes; this is without disturbing the existing dismantling centres. The 70 scrap processing centres shall require about 300 collections and dismantling centres on the presumption that 4 collecting and dismantling centres cater to scrap processing centre. In 2030, at a requirement of > 70MT of scrap, India require about 700 scrap processing centres, that is 700 shredders. These shall in turn be fed by 2800-3000 collections and dismantling centres spread all over the country⁶⁷. Through National Resource Efficiency Policy (draft), Government of India is aiming to reduce the import of steel scrap to zero by 2030. Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021 is a significant step in this direction.</p> <p>It is recommended to facilitate and promote metal scrapping centres to ensure scientific processing & recycling of ferrous scrap generated from various sources & from a variety of products along with assurance of availability of ‘quality’ and sized scrap at a price below the cost of hot metal by subsidising scrap recycling industry. (Ministry of Steel, Long Term)</p>
7. Demand Pull for low carbon steel	<p>Since steel is used in large quantities in infrastructure and construction projects, their cost is a critical factor for overall project costs. Unlike energy efficiency or captive renewable energy generation, currently there is no business case from the consumer side towards this end; the primary demand-side issue is that there is no actual prevailing demand for low carbon steel products in the market; i.e, indication on the part of consumers about their willingness to bear part of the burden of additional cost to be incurred for transition towards low-carbon steel. The weak demand can broadly be attributed to two factors: lack of drivers to change consumer preferences and lack of awareness. At present, consumers are largely driven by the cost factor and are choosing the better-known and lower priced product.</p> <p>It is recommended that the Preferential Public Procurement be mandated that the government-funded construction projects source at least a portion of their steel from low-carbon-emitting producers. (Ministry of Steel, Short Term)</p> <p>It is recommended to introduce standards for Green Steel (e.g., GreenPro); establishing Buyer Clubs, etc. Introduction of “Green Steel Inside” sticker. Consumers will probably have to pay a bit more for green steel products - at least at first. Because steel constitutes just a small portion of most products of which it’s a component, that price premium is likely to be small. (Ministry of Steel, Short Term)</p>

Key Levers	Feasibility and Recommendations
8. R&D Collaborations	<p>Promoting research and development including demonstration projects in line with the support being extended by the government in various countries for climate change may boost the transition.</p> <p>It is recommended to evaluate and analyse all available technologies worldwide, Indigenisation and CAPEX requirement for short term and medium term (Phase 1 and 2) reduction of GHG emission. (Ministry of Environment, Forest & Climate Change, Short Term)</p> <p>Create a dedicated research and development fund, jointly funded by the government and industry, aimed at achieving technological breakthroughs and improving the commercial viability of technologies. (Ministry of Steel, Short Term)</p>
9. Access to Finance and Capital	<p>This transition will require significant access to capital.</p> <p>It is recommended to consider setting up a National Decarbonisation Fund to finance the transition of Indian industry to a low carbon economy. The public policy framework and regulations also needs to help facilitate Indian companies to access international capital for a financially feasible transition. (Ministry of Environment, Forest & Climate Change, Short Term)</p>

Phase 2 - (2031-2050): Deep Decarbonisation technologies in the medium to long term.

5.5 For further emissions cuts, efficient energy use must be combined with alternative technologies such as replacement with low-carbon fuel (hydrogen direct reduction) or Carbon Capture Use and Storage (CCUS). The steel sector is willing to undergo the required transformation, but this cannot be done in isolation.

Technology	Feasibility and Recommendations
1. Carbon Capture Usage/ Storage (CCUS)	<p>BF route Iron making process will always require coke (300-450 kg/ton of Hot metal) with attendant CO₂ emissions. So the process requires capturing and sequestering all their CO₂ emissions with Concomitant CAPEX and OPEX implications. Here Cryogenic Oxygen plant equipment supplier can be roped in to separate CO₂. This is a normal process in an Oxygen Plant installed in most Steel Plants.</p> <p>Carbon capture and usage (CCU) concept includes converting steel off-gases to fuels and chemicals. In reference to India's iron and steel sector, this becomes important as National Bio-Fuel Policy 2018 emphasizes on the production of Bioethanol/sustainable advanced fuels using alternate options. As most of the off gases are rich in CO, CO₂ and Hydrogen, these become the obvious choice for producing such chemicals and minimizing emissions considerably. There is a company (now US based) LanzaTech who has a microbe based process (fermentation) which captures carbon-rich waste gases from the steelmaking process and converts them into sustainable fuels and chemicals like Ethanol and 2, 3-Butanediol.</p>

Technology	Feasibility and Recommendations
	<p>It is recommended that Steel Companies evaluate this technology and be provided with fiscal incentives/direct subsidies for the early adopters. (Ministry of Steel, Short Term)</p> <p>The principal long-term CO₂ management options – alongside CO₂ direct avoidance technologies – are either permanent geological storage (CCS), or CCU for products that do not release CO₂ emissions (are not oxidised) during use or at end-of-life. The latter may include closed carbon cycles in which the CO₂ in products produced via CCU are recycled back into the system, such as plastics being gasified and used as fuel in steel plants that then produce plastics through CCU.</p> <p>To move forward with CCS in India, it is recommended to conduct a nationwide assessment of potential storage locations, ideally undertaken by the Geological Survey of India (GSI), before its potential can be understood. Such a study would provide an understanding of the total potential and the relative costs of developing those storage resources. This is vital to understand the costs of CCU networks, which are impacted by the length of pipelines and the number of point sources and storage locations.</p>
2. Carbon Avoidance - Usage of Green Hydrogen as a fuel in Blast Furnace	<p>An alternative to avoid the carbon emissions during the process of steel making is to replace carbon with hydrogen as a reductant. In traditional blast furnaces, by using hydrogen instead of coke for the iron ore reduction process, the by-product is water (H₂O) instead of CO₂. While hydrogen blending serves as a transitional strategy, technical process constraints put an upper limit on the amount of blending that can occur without equipment modifications, particularly for blast furnaces which have a minimum coke requirement.</p>
3. Carbon Avoidance - Usage of Green Hydrogen for DRI	<p>“Hydrogen Direct Reduced Iron” (H₂ DRI) is another technology that substitutes hydrogen for the coal or natural gas used for DRI production. In a DRI furnace, the iron ore is heated but not to the point of melting. Hydrogen then passes over the hot ore, combining with oxygen liberated from the iron oxide to form water and leaving relatively pure iron behind. If the electricity used to produce the hydrogen and run the furnace comes from non-carbon-emitting sources, then the overall process will result in little to no carbon dioxide emissions. Therefore, green steel production will depend on technologies and infrastructure for producing and handling green hydrogen on a commercial scale. It is estimated from the various research studies that the blend of Hydrogen in NG Based DRI can go up to as high as 30% without any major process changes.</p>

Technology	Feasibility and Recommendations
4. Carbon Avoidance - Molten Oxide Electrolysis of Iron Ore	This technology employs electrolysis directly to the iron oxide ore by placing it in an electrolytic cell filled with a mineral-bearing solution. An electric current is run through the solution, heating it up beyond the melting point of iron, and separating oxygen from iron. If the electricity used to power the MOE process comes from clean sources, the steel can be made with virtually no carbon dioxide emissions. However, H ₂ DRI is already proven in Sweden through project called "HYBDRIT" and GoI being very proactive in trying to ensure the availability of green hydrogen usage in industries through National Green Hydrogen Mission, there is a huge scope of its use in steel industry.

- 5.6** Green Hydrogen is expected to increase traction in India to fast track the decarbonization efforts in hard-to-abate sectors like fertilizers, refineries, steel, etc. Electrolysers used for green hydrogen production have extremely limited capacity in India and need enormous focus to scale up the manufacturing capacity. **It is recommended to support the nascent industry in the initial years to realise its true potential. (MNRE/DPIIT/Ministry of Micro, Small and Medium Enterprises, Short Term)**
- 5.7** Projects on hydrogen in Sweden and Germany are heavily supported by Government and private funding institutions. In India, industries can take up bold large-scale trials/projects with funding support and there must be incentives required to take up work on hydrogen till the process becomes mature enough for economic merit. **It is recommended to incentivize the process of setting up pilot plants projects and products which can create faster sustainable solutions. (MNRE/DPIIT/Ministry of Micro, Small and Medium Enterprises, Short Term)**
- 5.8** A detailed modelling exercise may be undertaken which would simulate the emissions trajectory, required reduction with respect to various steel sub-sectors and consequently identify technologies required. As an example, for a given level of steel production of 100 Million Tons, (hot metal, DRI and scrap quantities used for production of steel), it is appropriate to work out the fractional feeds for production of 1 ton of crude steel. It is necessary to allocate a sectoral emission value to hot metal production (say, 1.7 tCO₂/tHM with partial sequestration) and DRI (say 1.5tCO₂/t DRI). DRI production would involve EAF use and a consequential emission of 0.28t CO₂/t DRI (450kWh/t steel and 0.8 kg CO₂/kWh). For a HM: DRI: scrap ratio of 0.5: 0.25:0.25, the net sectoral emission attributable is 1.48 t CO₂/t steel assuming energy intensity of 350 kWh/t steel for scrap re-melting. Once the target requirements are pre-fixed, it may be necessary

to enlist the technologies to be sought under collaboration for achieving the targets for HM production emission and DRI production emission. Subsequently, integration with carbon based smelting processes can be planned. **(NITI Aayog/Ministry of Steel, Short Term)**

ANNEXURE I



Abbreviations used in the report

APPC	Average Power Purchase Cost
AUSC	Advanced Ultra Supercritical
BAT	Best Available Technologies
BEE	Bureau of Energy Efficiency
BF	Blast Furnace
BIS	Bureau of Industrial Standards
CC	Composite Cement
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilization
CD	Contract Demand
CDQ	Coke Dry Quenching
CRNO	Cold Rolled Non-Oriented
DAE	Department of Atomic Energy
DISCOM	Distribution Company
DPIIT	Department for Promotion of Industry and Internal Trade
DRI	Direct Reduced Iron
DSIR	Department of Scientific and Industrial Research
DST	Department of Science and Technology
EV	Electric Vehicles
GGBF	Ground Granulated Blast Furnace Slag
GHG	Greenhouse Gas
GSI	Geological Survey of India
GTAM	Green Term Ahead Market

ISTS	Inter-State Transmission System
MNRE	Ministry of New and Renewable Energy
MOE	Molten Oxide Electrolysis
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MoP	Ministry of Power
MSME	Micro, Small and Medium Enterprises
MSW	Municipal Solid Waste
MSW	Municipal Solid Waste
NEDO	New Energy and Industrial Technology Development Organisation
NG	Natural Gas
OAC	Over-arching Committee
OPC	Ordinary Portland Cement
PAT	Perform Achieve Trade
PPC	Portland Pozzolana Cement
PSC	Portland Slag Cement
RDF	Refuse Derived Fuel
RE	Renewable Energy
REC	Renewable Energy Certificate
RPO	Renewable Purchase Obligation
RTC	Round the Clock
SCEP	Strategic Clean Energy Partnership
SEB	State Electricity Board
SG	Sustainable Growth
TOD	Time of Day
TRT	Top-pressure Recovery Turbine
ULB	Urban Local Body
WGD	Waste Generation Database
WHR	Waste Heat Recovery

ANNEXURE II



File No. P-11026/20/2015-pet(P&E)

NITI Aayog
Energy Vertical

NITI Bhawan, Sansad Marg
New Delhi, Dated :23rd September 2021

OFFICE MEMORANDUM

Subject – Constitution of the committee on Low Carbon Technologies

The undersigned is directed to convey that a meeting of the Sustainable Growth Pillar under the India-US Strategic Partnership was held on 12th July 2021. Both sides deliberated on the enhanced cooperation in the fields of Energy Data Management, Low Carbon Technologies, Carbon Markets and Just Transition in Coal Sector. It was decided that four committees of Indian and US counterparts would be formed in these fields.

2. Accordingly, with the approval of the competent authority, it has been decided to form the committee on Low Carbon Technologies with the approval of the Competent Authority as per the following composition;

Sl. No.	Member	Position
1	Sh. Neeraj Sinha, Sr. Adviser, S&T NITI Aayog	Chairman
2	Ms. Rasika Chaube, Additional Secretary, Ministry of Steel	Member
3	Sh. Sudhendu Jyoti Sinha, Adviser (Transport), NITI Aayog	Member
4	Sh. BP Pati, Joint Secretary, Ministry of Coal	Member
5	Sh. BN Mohapatra, Director General, National Council for Cement and Building Material	Member
6	Dr Ashok Kumar, Deputy Director General, Bureau of Energy Efficiency	Member
7	Representative from the Department of Heavy Industries	Member
8	Sh. Nirvik Banerjee, ED, Steel Authority of India Limited	Member
9	Sh. Ashok Kumar Rajput, Chief Engineer (RT&I),	Member

	Central Electricity Authority	
10	Sh. Rajib Kumar Paul, Director, National Institute of Secondary Steel Technology	Member
11	Sh. Anil Kumar, Scientist D, Ministry of New and Renewable Energy	Member
12	Dr Ajay Arora, GM (Fuels), R&D Centre, Indian Oil Corporation Limited	Member
13	Sh. Prabodh Acharya, Chief Sustainability Officer, Jindal Steel	Member
14	Sh. Saurabh Kundu, Chief Process Research, TATA Steel	Member
15	Sh. Prashant K Banerjee, Executive Director (Technical), Society of Indian Automobile Manufacturers	Member
16	Sh. Priyavrat Bhati, CSTEP	Member
17	Sh. Raju Goyal, Chief Technical Officer, UltraTech Cement Ltd	Member
18	Sh. Ashwani Pahuja, Chief Sustainability Officer, Dalmia Cement (Bharat) Ltd	Member
19	Sh. Philip Mathew, Holcim, Head-Cement Manufacturing Excellence-Asia	Member
20	Prof Prodip Sen, IIT Kharagpur	Member
21	Representative from USAID	Member
22	Representative from Department of Energy	Member
23	Representative from Pacific Northwest National Laboratory	Member
24	Representative from Lawrence Berkely national Laboratory	Member
25	Representative from National Renewable Energy Laboratory	Member
26	Sh. Manoj Kumar Upadhyay, Deputy Adviser (Energy), NITI Aayog	Member Convener

3. The broad terms of reference of the committee are as follows;
- i. Identifying the roadmap to deploy low-cost technologies for decarbonization of industries (particularly steel and cement), suited to India.
 - ii. Collaborations on the supply of necessary components for making high quality and low-cost batteries in Indian circumstances
 - iii. Scaling the use of best technology for battery storage.
 - iv. Any other ToR the committee may suggest
4. The Committee is required to submit its report within two months from its first meeting.

Kamil Bhullar

(Kamil KPS Bhullar)
Research Officer
Tel-011-23042462

To,

1. The Secretary, Department of Heavy Industries (with request to nominate suitable officer)
2. Ms. Rasika Chaube, Additional Secretary, Ministry of Steel
3. Sh. Sudhendu Jyoti Sinha, Adviser (Transport), NITI Aayog
4. Sh. BP Pati, Joint Secretary, Ministry of Coal
5. Sh. BN Mohapatra, Director General, National Council for Cement and Building Material
6. Dr Ashok Kumar, Deputy Director General, Bureau of Energy Efficiency
7. Sh. Nirvik Banerjee, ED, Steel Authority of India Limited
8. Sh. Ashok Kumar Rajput, Chief Engineer (RT&I), Central Electricity Authority
9. Sh. Rajib Kumar Paul, Director, National Institute of Secondary Steel Technology
10. Sh. Anil Kumar, Scientist D, Ministry of New and Renewable Energy
11. Dr Ajay Arora, GM (Fuels), R&D Centre, Indian Oil Corporation Limited
12. Sh. Prabodh Acharya, Chief Sustainability Officer, Jindal Steel
13. Sh. Saurabh Kundu, Chief Process Research, TATA Steel
14. Sh. Prashant K Banerjee, Executive Director (Technical), Society of Indian Automobile Manufacturers
15. Sh. Priyavrat Bhati, CSTEP
16. Sh. Raju Goyal, Chief Technical Officer, UltraTech Cement Ltd
17. Sh. Ashwani Pahuja, Chief Sustainability Officer, Dalmia Cement (Bharat) Ltd
18. Sh. Philip Mathew, Holcim, Head-Cement Manufacturing Excellence-Asia
19. Prof Prodip Sen, IIT Kharagpur
20. Apurva Chaturvedi, USAID (with request to coordinate with US members of the committee)





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