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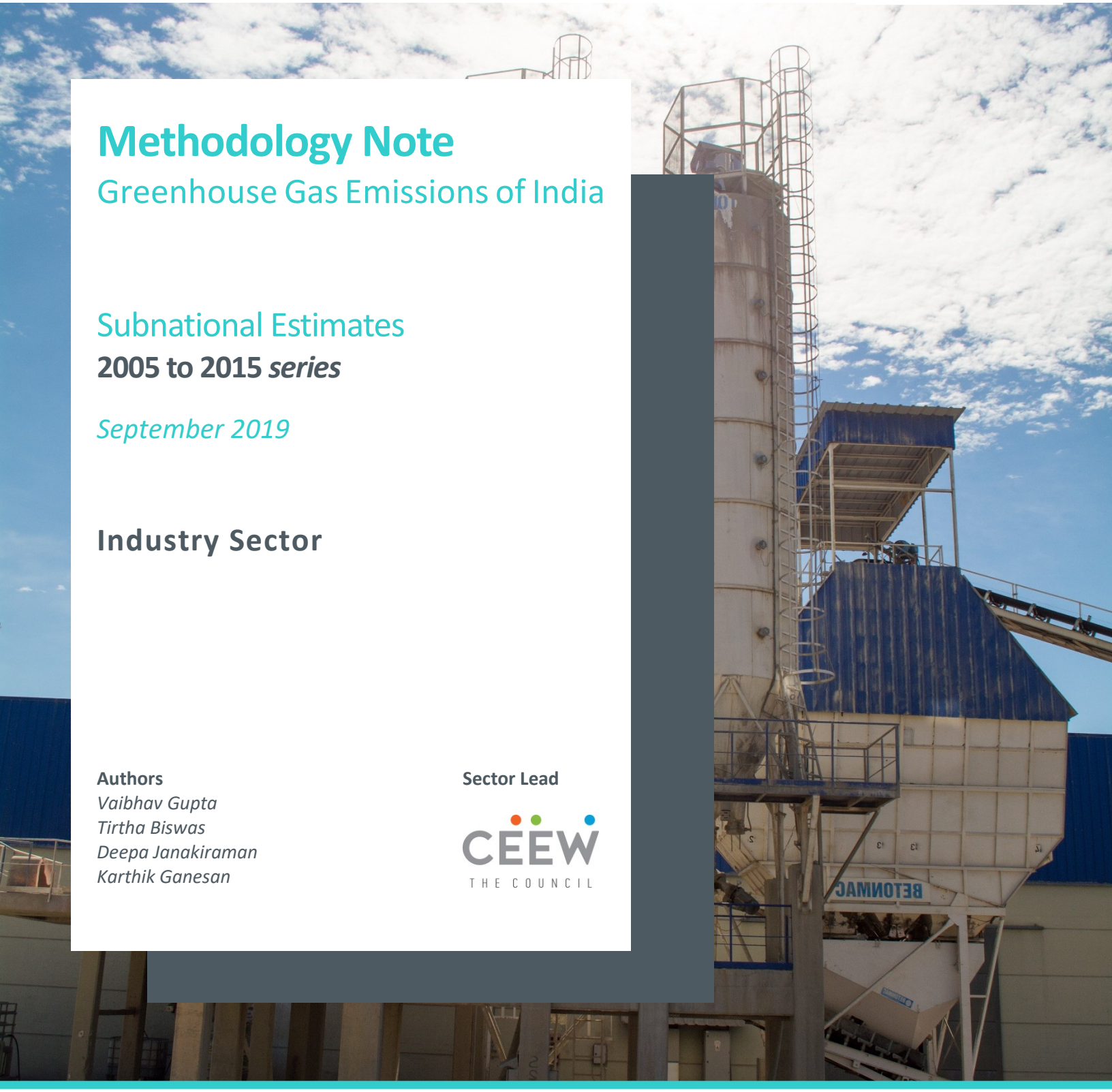

Methodology Note

Greenhouse Gas Emissions of India

Subnational Estimates

2005 to 2015 *series*

September 2019

Industry Sector

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Version information / Revision history

Version	Date	Brief description on changes from previous version
1.0	25 September 2019	This methodology note includes an estimation and analysis of India's annual state-level GHG emissions from the Manufacturing Industries in India: 2005 to 2015, prepared by CEEW under the GHG Platform India initiative (www.ghgplatform-india.org). This document is undergoing a peer review process, however, any changes that may be made further will not have an impact on the figures and estimates. Once the review process is completed, the final document will be uploaded and the same shall be updated in this section.

Foreword

On December 2015, the international community took a significant step to address the global challenge of climate change by endorsing the Paris Agreement at the 21st session of the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change. The milestone Paris Agreement will serve as a foundation for concerted international action to address the threat posed by climate change.

It is now more than evident that climate change is not the responsibility of national governments only. It impacts every aspect of society, and therefore, and thus comes into focus the role of non-state actors. Non-state actors like civil society organizations and research organizations can inform and help national governments devise robust climate actions and strategies. The first step in this is to generate greenhouse gas (GHG) emission estimates of all relevant economic sectors from recent years.

To generate these estimates a few research organizations came together to form the GHG Platform - India. It is a civil society initiative providing independent estimation and analysis of India's GHG emissions. The platform's intention to assist the national government by helping address existing data gaps and data accessibility issues that extend beyond the scope of national inventories, and increasing the volume of analytics and policy dialogue on India's GHG emission sources, profile, and related policies.

The platform hosted GHG estimates for all key economic sectors for the period of 2005 – 2013 accounting for carbon dioxide, methane and nitrous oxide emissions at the national and subnational. In the present edition, the time series has been extended and the methodology note now presents GHG estimates for the period 2005 – 2015/16 across all key economic sectors. The note also highlights the trend in GHG emissions across the sectors and transparently documents all the assumptions, activity data and emission factors that were used to arrive at the estimates.

The GHG estimates presented in the note follow 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for national GHG inventories and associated good practice guidance. Further, the note has been through a rigorous peer review and independent technical review process to ensure accuracy, transparency, consistency, completeness and relevance. On behalf of the platform, we hope that the note will be useful to all relevant stakeholders.

Credits

Led and coordinated by

Vaibhav Gupta
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Deepa Janakiraman
Karthik Ganesan

Peer reviewer

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We would like to acknowledge the constant feedback and critical inputs received from the partner institutes at the GHG Platform India, during all the review meetings hosted by the Secretariat, Vasudha Foundation.

We thank the Ministry of Statistics and Programme Implementation (MoSPI) for promptly responding to our feedback and queries on their Annual Survey of India (ASI) statistics, which is a cornerstone of our estimation methodology. We would also want to thank the Indian Bureau of Mines (IBM) for providing us with relevant information.

CEEW would like to recognize the cooperation of several individuals, organizations, and government departments in providing useful insights and information that, helped us in arriving at meaningful estimates. We deeply appreciate the time they have spent to share their knowledge, experience, and perspectives with the research team.

Last, but not the least, we express our appreciation to WRI India for a comprehensive review of this study at par with standard IPCC guidelines.

Contents

Executive summary

Key Highlights

- The manufacturing sector (energy-use and IPPU) emissions grew at a CAGR of 6.4% between 2005 and 2015. In absolute terms, manufacturing emissions rose from 341 million tonnes (MT) of carbon dioxide equivalent (CO_2e) in 2005 to 635 $MTCO_2e$ in 2015. The emissions from energy use constituted ~ 70% of total emissions during the period.
- CO_2 is the major contributor to manufacturing emissions (energy-use and IPPU), representing a share of nearly 98%. The other greenhouse gases are (CH_4 and N_2O).
- Over the same period, the manufacturing sector's Gross Value Added at basic prices (at 2011-12 constant prices) grew at a CAGR of 8% (MOSPI 2018), thus indicating an emissions intensity reduction of 14% when compared to 2005 levels (refer to Annexure 1).
- Iron and steel, non-metallic minerals, petroleum refining and non-ferrous metal sectors together represent a share of 80% in total energy use emissions for 2015. Odisha, Gujarat, Chhattisgarh, Karnataka and Jharkhand were among top five emitters representing more than 50% of the fuel derived emissions in 2015. Coal and lignite continue to drive 75% to 80% of the overall energy-use emissions.
- IPPU emissions increased from 101 $MTCO_2e$ to 175 $MTCO_2e$ at a CAGR of about 5.6% between 2005 and 2015. Cement, ammonia and iron & steel production together contributed to more than 80% of process emissions in 2015. Gujarat, Rajasthan, Andhra, Uttar Pradesh and Maharashtra were among the leading emitters at the sub-national level in 2015. Cement production alone represents 60% of the total IPPU emissions throughout the time series.

ES 1. Background information of GHG emission estimates

The GHG emissions from the manufacturing sector in 2015 is 635 $MTCO_2e$. Out of which, energy use emissions represented 460 $MTCO_2e$ and IPPU represented 175 $MTCO_2e$. Table ES 1 below provides a gas wise emission break-up of the numbers.

Table ES 1: Snapshot of total GHG emissions from gases and sector

IPCC ID	Key Source category	GHG Emissions (2015)			
		$MTCO_2$	$MTCH_4$	MTN_2O	$MTCO_2e$
1A	**Fuel combustion activities**	**458**	**0.01**	**0.01**	**460**
1A1	**Energy industries**	**61**	**0.00**	**0.00**	**61**
1A1b	Petroleum refining	53	0.00	0.00	53
1A1ci	Manufacture of solid fuels	2	0.00	0.00	2
1A1cii	Other energy industries	6	0.00	0.00	6
1A2	**Manufacturing industries and construction**	**397**	**0.00**	**0.01**	**399**
1A2a	Iron and steel	193	0.00	0.00	194
1A2b	Non-ferrous metals	46	0.00	0.00	47
1A2c	Chemicals and fertilisers	37	0.00	0.00	37
1A2d	Pulp, paper and print	13	0.00	0.00	13
1A2e	Food processing, beverages and tobacco	9	0.00	0.00	9
1A2f	Non-metallic minerals	74	0.00	0.00	74

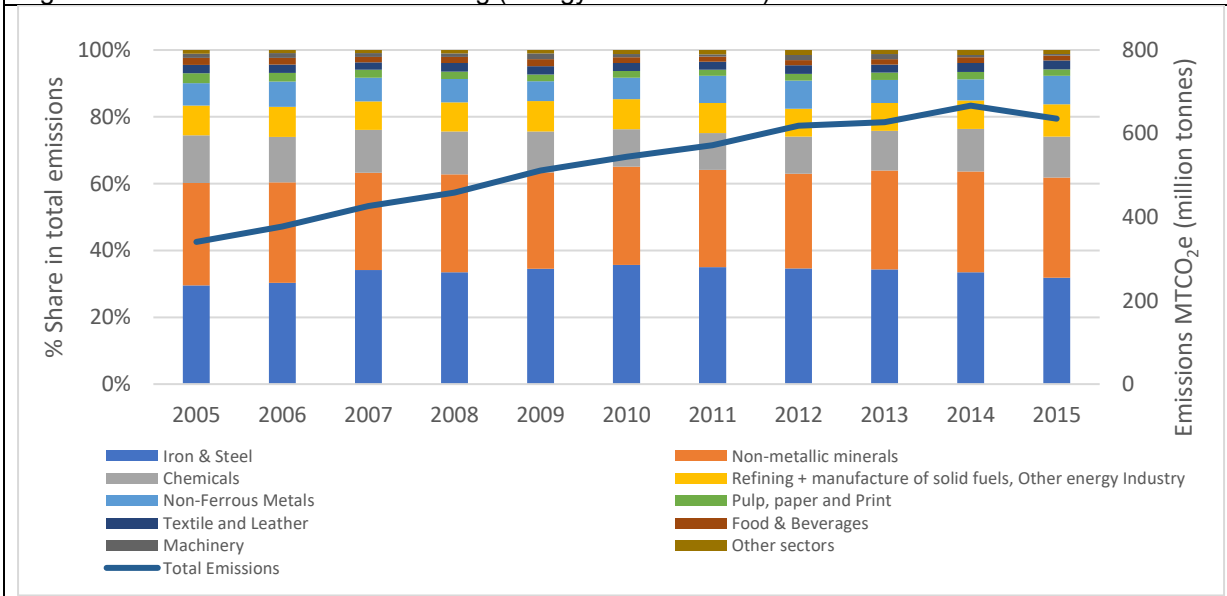
1A2g	Transport equipment	2	0.00	0.00	2
1A2h	Machinery	3	0.00	0.00	3
1A2i	Mining and quarrying	0	0.00	0.00	0
1A2j	Wood and wood products	0	0.00	0.00	0
1A2k	Construction	0	0.00	0.00	0
1A2l	Textile and leather	16	0.00	0.00	17
1A2m	Non-specified industry	3	0.00	0.00	3
2	**IPPU**	**167**	**0.38**	**0.00**	**175**
2A	Mineral industry	116	0.00	0.00	116
2B	Chemical industry	33	0.38	0.00	41
2C	Metal industry	12	0.00	0.00	12
2D	Non-energy products from fuels and solvent use	6	0.00	0.00	6

Source: Authors' analysis

ES 2. Summary of GHG sources and sinks

A closer look at the GHG emission trends over a period of ten years (2005 to 2015) indicates that the share of emissions from the various sub-sectors remained constant. Energy-use and IPPU emissions from iron and steel (32%), non-metallic minerals, dominated by cement manufacturing (30%), chemical and fertilizers (12%), refining, other energy industry and solid fuel manufacturing (10%), non-ferrous metals (9%), and textile and leather industry (3%) represented 95% of the manufacturing emissions denoting them as key categories within the manufacturing sector emissions (Figure ES 1).

Figure ES 1: Overview of manufacturing (energy-use and IPPU) emissions between 2005 and 2015



Source: Authors' analysis

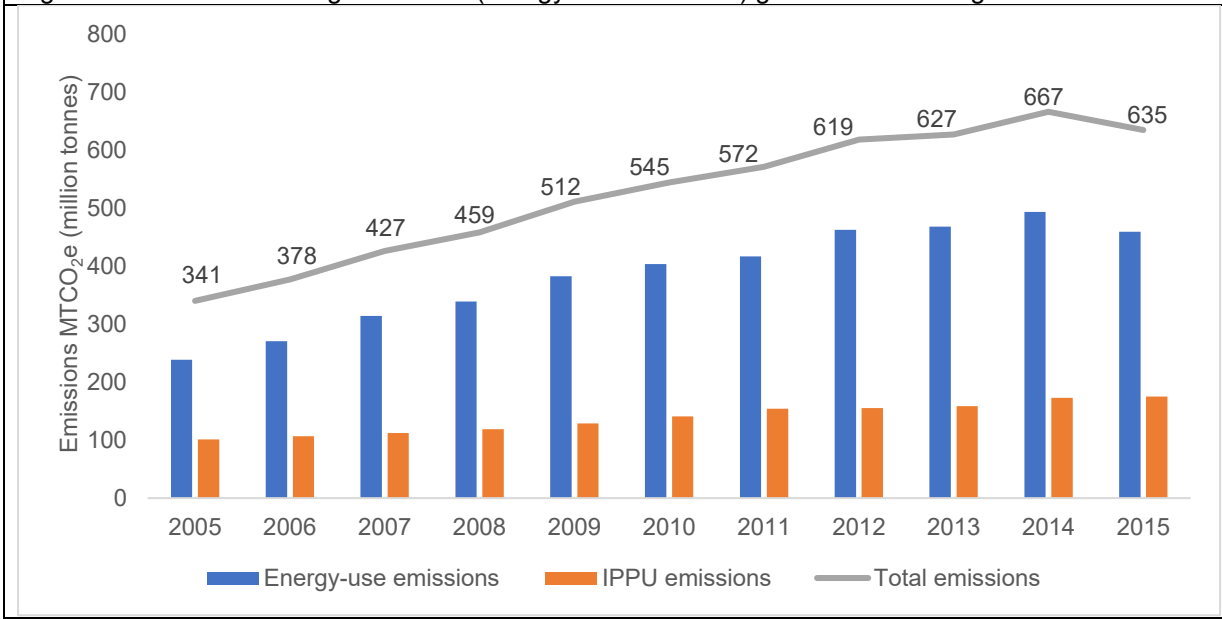
Both, cement and steel manufacturing embody an energy intensive process, and are largely reliant on coal for process heat requirements. Further, these sectors are anticipated to have a

strong growth outlook in the future as the present per-capita consumption levels from these two sectors still remain low when compared to the global averages. The per capita steel consumption in India is very low at 65kg compared to the world average of 214kg (World Steel Association 2018). Similarly, India's per capita cement consumption is very low at 190kg compared to world average of 350kg (IBEF 2017).

ES 3. Summary of GHG trend

The overall manufacturing sector (combined energy use and IPPU) emissions increased from 341 $MTCO_2e$ in 2005 to 635 $MTCO_2e$ in 2015 at a CAGR of 6.4%. While, energy use emissions alone increased at a CAGR of 6.8%, IPPU emissions increased at a CAGR of 5.6%. Energy use emissions consistently contributed to more than 70% of the total emissions throughout the time period. Figure ES 2 below, shows the disaggregation of total emissions into energy use and IPPU emissions between 2005 and 2015.

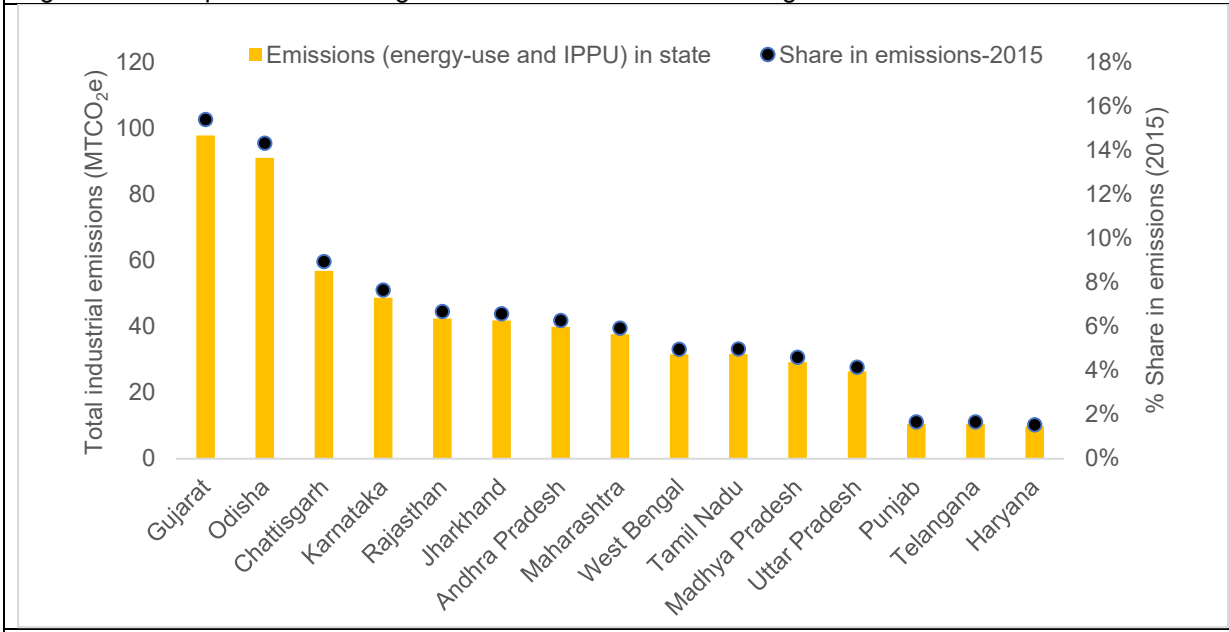
Figure ES 2: Manufacturing emissions (energy-use and IPPU) growth trend during 2005 to 2015



Source: Authors' analysis

Manufacturing activities are not uniformly spread across the states. It is largely a function of resource proximity, energy price, land availability and states' policies towards doing business. Figure ES 3 illustrates the major states in terms of GHG emissions from manufacturing sector for 2015. Comparing these recent numbers with the earlier estimates (2005 to 2013 series) show that the top emitters have remained the same, with Gujarat leading the emission charts.

Figure ES 3: Top emitters among states in terms of manufacturing GHG emissions for 2015 data



Source: Authors' analysis

1. Introduction and background

1.1 Context

The objective of this methodology note – in continuation to our previous estimates (2005 to 2013 series)[1] – is to provide an updated and improved analysis of India's GHG emissions arising out of manufacturing sector. This study contributes to the broader mission of the *GHG Platform India,* a civil society-led initiative, of presenting independent research and analysis on India's GHG emissions and inform the policy discourse around it. The ultimate vision is to establish a transparent and independent source of credible information which would assist policy planners in identifying and optimizing efforts to mitigate GHG emissions across economic activities.

The reported estimates communicate annual manufacturing emissions starting from 2005 till 2015 on a calendar year basis. Appropriate improvements have been introduced in the present assessment approach, including an update in emission factors for key categories sourced from India's second Biennial Update Report (BUR). Hence, recalculations for the previously reported phase has been performed and reported through this update.

This methodology note, in continuation of its previous versions provides the most comprehensive and detailed outline of emission trends over a period of time across the states and sub-sectors within the manufacturing sector.

1.2 GHG coverage

This study covers three key greenhouse gases, namely - carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These three gases collectively account for a large share of anthropogenic emissions from India. 2006 IPCC guidelines for the national GHG inventories cover many more gases (or group of gases) having relatively very high global-warming potential (GWP), such as: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6), etc. (collectively known as *F-gases*). This study does not cover *F-gases*, as their total contribution is known to be very small (or unmeasured) in India for the period under investigation. The Global Warming Potential (GWP) of the above-mentioned gases have been taken from IPCC's second assessment (SAR) and fifth assessment (AR5) reports. Table 1.2 A below lists the GWP values as per the two reports used for our analysis.

Table 1.2 A: Global warming potential as per IPCC assessment reports

Name of the gas	**Formula**	**Global Warming Potential (GWP)**	
		SAR	**AR5**
Carbon dioxide	CO_2	1	1
Methane	CH_4	21	28
Nitrous oxide	N_2O	310	265

Source: (IPCC-AR5 2018) (IPCC-SAR 2018)

[1] Refer GHG Platform India for previous versions at: http://www.ghgplatform-india.org/industry-sector

1.3 Key economic sectors covered

Majority of GHG emissions from manufacturing is from combustion of fuels, both for process heating, as well as power generation for self-consumption (captive power production). Non-energy use of fuels (as feedstock or raw material) can also result in GHG emissions from specific manufacturing processes. Here, chemical or physical transformation of materials, result in the emission of GHGs. Such emission sources are commonly referred to as 'Industrial Process and Product Use (IPPU)'. The entire reporting on manufacturing emissions follows the hierarchy as reported in IPCC 2006 guidelines for national GHG inventories barring few limitations that arises from the lack of, or access to adequate information on activity data.

The overall scope of this study covers - manufacturing industries and construction (1A2)[2]; energy industries for petroleum refining and manufacturing of solid fuels (1A1b & 1A1ci); mining and hydrocarbon extraction (1A1cii); and, industrial process and product-use emissions (2A, 2B, 2C, 2D)[3]. IPPU emissions arising from 2B9, 2B10, 2D3, 2E, 2F, 2G, and 2H categories[4] from the IPCC classification have been excluded from the scope as little or no information is publicly available for such manufacturing activities, many of which has not even existed in India until 2010-11.

1.4 Boundary of GHG estimates

This note illustrates a bottom-up accounting approach, providing a detailed overview of manufacturing emissions at the sub-national as well as sub-sectoral level. The Annual Survey of Industries (ASI) unit level database is the primary source of information that is maintained and disseminated by the Ministry of Statistics and Programme Implementation (MoSPI). ASI reportedly covers only the formal sector manufacturing activity in India, as defined under the Factory Act, 1948 and represents about 75% of the energy consumption in the entire manufacturing sector. This represents all states and union territories in India except Mizoram and Lakshadweep due to unavailability of underlying industrial activity data. All forms of primary energy (including both direct thermal application and further conversion) are considered for energy-use emission estimates. Similarly, carbonaceous materials' consumption and production output (in physical units) as reported by the factories, are considered for IPPU estimates.

1.5 Reporting Period

The reported estimates communicate annual manufacturing emissions starting from 2005 till 2015 on a calendar year basis. 2005 is the base year identified by India in its first Nationally Determined Contributions (NDC) for post 2020 emission reduction targets; whereas, 2015 was the latest year for which activity data is available from the annual survey of industries database during the time of the study.

1.6 Outline of GHG estimates

This study provides an in-depth assessment of greenhouse gas (GHG) emissions from the manufacturing sector (including construction) in India. Manufacturing here refers to the firms coming from the formal sector only, i.e. registered under sections 2m(i) and 2m(ii) of the Factories Act, 1948. This methodology note provides information on activity data collection sources and

[2] The representation within parentheses refers to the IPCC classification of these sectors and emissions categories
[3] 2A: Mineral Industry, 2B: Chemical Industry, 2C: Metal Industry, 2D: Non-Energy Products from Fuels and Solvent Use; No information is available on industryspecific solvent use (2D3), hence not accounted
[4] 2E: Electronics Industry, 2F: Product Uses as Substitutes for Ozone Depleting Substances, 2G: Other Product Manufacture and Use, 2H: others.

proxies, assumptions and correction measures undertaken on the activity data to improve its quality. Further, it lists the tier approach followed for every IPCC category depending on the availability of emission factors. It provides a detailed methodology used to arrive at emissions estimates. The study lists the source and quality of the activity data for every IPCC category. It further details the uncertainties, if any, in the estimation processes; measures undertaken for quality control; details on difference in calculation of emission estimates as compared to previous (Phase 2) estimates; recommendations for policy-makers on improving the quality of data; and finally, a comparison with available national level emission estimates.

1.7 Institutional information

The Council on Energy, Environment and Water (CEEW) (https://www.ceew.in/industrial-sustainability-competitiveness) leads the estimation and reporting of the manufacturing sector emission estimates. A team of four researchers at CEEW, alongside support staff, were responsible for the entire effort behind estimating manufacturing-sector emissions. A brief description of their roles and responsibilities is provided below:

Vaibhav Gupta
Vaibhav is an environmental engineer and policy specialist, who examines and analyses the manufacturing sector via the lens of climate change, energy, and resource security. He was the principle investigator for the industry sector emissions and developed the bottom-up estimation approach in consultation with other team members.

Tirtha Biswas
Tirtha is a policy analyst, working on the development of sustainable and competitive pathways for Indian industries to support its low-carbon growth aspirations. In this effort, he played a very crucial role of translating the approach into feasible outcomes by testing out several scenarios and logics using statistical tools and excel based models.

Deepa Janakiraman
Deepa works as a research analyst at CEEW. She is an economist by training. In this research, she assisted the team with data analysis and drawing emission trends across sectors and states for valuable policy insights.

Karthik Ganesan
An engineer by training, Karthik leads The Council's work on the Power Sector and Industrial Sustainability and Competitiveness in his capacity of Research Fellow. In this research, he supervised the entire set of activities, managed resources and ensured quality of final outcomes through an internal review and assessment process.

1.8 Data collection process and storage

Annual Survey of Industries (ASI) conducted by the Ministry of Statistics and Programme Implementation (MoSPI) forms the core activity data of this research. It is a mix of census (for large firms) and sample survey covering the formal manufacturing sector in India. It is by-far the most exhaustive and periodic data set available for Indian manufacturing on a yearly basis. The prime objective of the ASI data set is to provide insights into the economic aspects of the manufacturing sector by capturing attributes of factories/ units such as value addition, employment, capital investments, etc. However, it also captures information on energy-use by industries, though not in a manner that is entirely suitable for the purposes of this study. The data

has been procured from MoSPI by paying an administrative fee. Annexure 2 provides a quick view of the activity-wise data sources availed for presented estimates.

A transparent inventory process requires an effective data management process to enable users to reproduce emission estimates from the scratch. This needs a systematic data-archiving system. In this case, ASI datasets form the backbone of the entire estimation procedure as an underlying activity data. MoSPI follows a sound practice of recordkeeping and archiving, which makes data available, from early as the 1980s at any point of time upon request to the ministry. All the other sources of information, such as Indian Bureau of Mines (IBM), Cement Manufacturers Association (CMA), Ministry of Coal (MoC), etc. also provide archived information through the publications available on their website. Further, CEEW has a robust archiving and version control process for the estimates made using the activity data. We maintain a separate directory having separate folders and additional backups for each year covered in the analysis. The updates made to the methodology and estimates are done using a version control to enable tracking of the updates or a roll back to a previous version. As mentioned earlier a comprehensive disclosure on the correction measures made by CEEW through this publication and supporting datasheets to enable reproduction of this analysis independently by the users.

1.9 Quality control (QC) and quality assurance (QA)

Since the estimation of GHG emissions from economywide sectors is undertaken by different partners at the platform, ensuring quality control becomes one of the key factors to make the published datasets reusable. The aim of the platform is to provide activity data as well as emission estimates in a form that can be interpreted and used by audiences fairly easily. For this purpose, the platform undertakes certain quality control measures. Some of them are as follows:

- Standardized worksheets containing emission estimates and activity data across the sectors.
- Transparency in reporting all conversion factors used to arrive at emission estimates.
- Uniform abidance to the IPCC 2006 guidelines for the estimation of emissions.
- Citation of all external data used along with source links.
- Providing estimates using GWP numbers from both SAR as well as AR5.
- Multiple checks of activity data to ensure consistency of results.
- Providing detailed methodology to facilitate recalculation of emissions by end user.
- Ensuring consistency in units of reporting across fuel categories throughout the process of estimation.
- Transparent disclosure of recalculations (from previous estimates) and reasons for variation in estimates.
- Proper archiving of all estimates to keep the data accessible.
- Making the data easily accessible through distinct sector pages on the platform’s website.

Quality Assurance is maintained through a thorough peer review process undertaken by the platform. This review is done by personnel not involved in the estimation process. The review analyses the entire estimation process and reverts with improvements and suggestions that are then addressed by the relevant partners. Further, the platform meets at regular intervals to ensure communication and information sharing among all partners.

In continuation to previous efforts, authors of this methodology note have standardized a process incorporating suitable checks and correction measures in the raw (unit level) data obtained from the Ministry. As quality check, all such correction measures have been duly discussed with renowned statisticians and MoSPI officials over the past two years.

Where necessary, alternative sources of information (activity data) were used to substantiate the assumptions and fill information gaps within the ASI datasets. For most years, IPPU related activity data was found to be sparsely available from the ASI, especially with cement, construction and ferro-alloys production activities.

1.10 General assessment of completeness

Since the method of estimating GHG emissions from formal manufacturing enterprises is primarily dependent on the ASI dataset and other reliable government data sources, certain categories have been excluded from the estimation either because little or no data was available for the same. A list of these categories can be found in Table 1.10 A. Further, the analysis covers three main greenhouse gases: CO_2, CH_4 and N_2O and does not cover these F-gases, as their total contribution is known to be very small (or unmeasured) in India for the period under investigation.

Table 1.10 A: Details of key source categories excluded from present GHG estimates

Sector	IPCC ID	Category description	Reason for exclusion
Energy	1A1a	Main Activity Electricity and Heat production (utility + captive)	Beyond current scope
	1A3	Transport	Beyond current scope
	1A4	Other sectors	Beyond current scope
	1A5	Non-specified	Beyond current scope
IPPU	2B9	Fluorochemical Production	Limited information
	2B10	Other	Limited information
	2C2	Ferroalloys Production	Limited information
	2E	Electronics Manufacturing	Limited information
	2F	Product Uses as Substitutes for Ozone Depleting Substances	Limited information
	2G	Other Product Manufacture and Use	Limited information
	2H	Other	Limited information

Source: Authors' compilation

2. Trends in GHG emissions

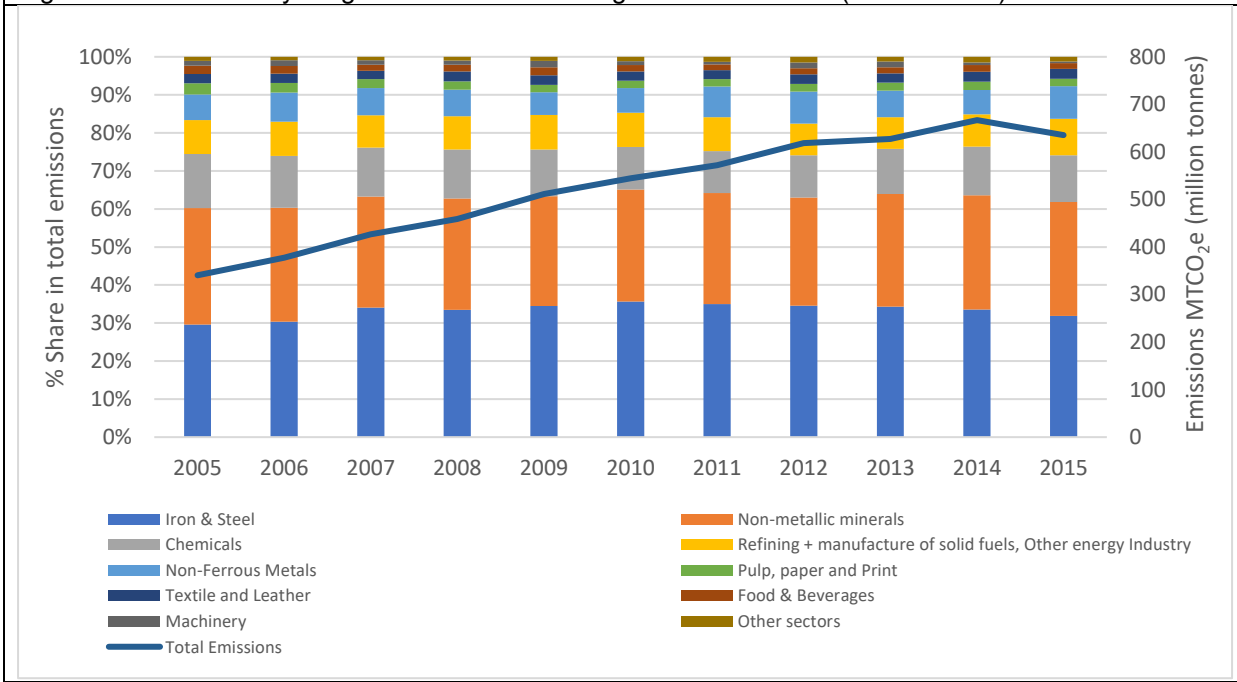
2.1 Trend in aggregated GHG emissions (energy-use and IPPU)

This section illustrates trends across the manufacturing sectors, states and fuel categories associated with the estimated emissions for the period 2005 - 2015.

Figure 2.1 A shows India's manufacturing sector GHG emission estimates in terms of carbon dioxide equivalent (secondary axis). Overall emissions have grown linearly at a CAGR of 6.4%. A slight dip in the terminal year (2015) is a reflection of insufficient activity data and is not the impact of decarbonisation measures taken up by manufacturing units as part of a policy drive or voluntarily. A dip in energy expenditure was observed across a majority of the enterprises in the ASI dataset, whereas their output increased when compared to the previous year. However, this trend can only be validated once the data for the subsequent year is analysed.

At the sectoral level, combined emissions from iron and steel and non-metallic minerals (primarily cement manufacturing) represents almost 60% of the overall manufacturing sector emissions, as shown by the primary axis of Figure 2.1 A.

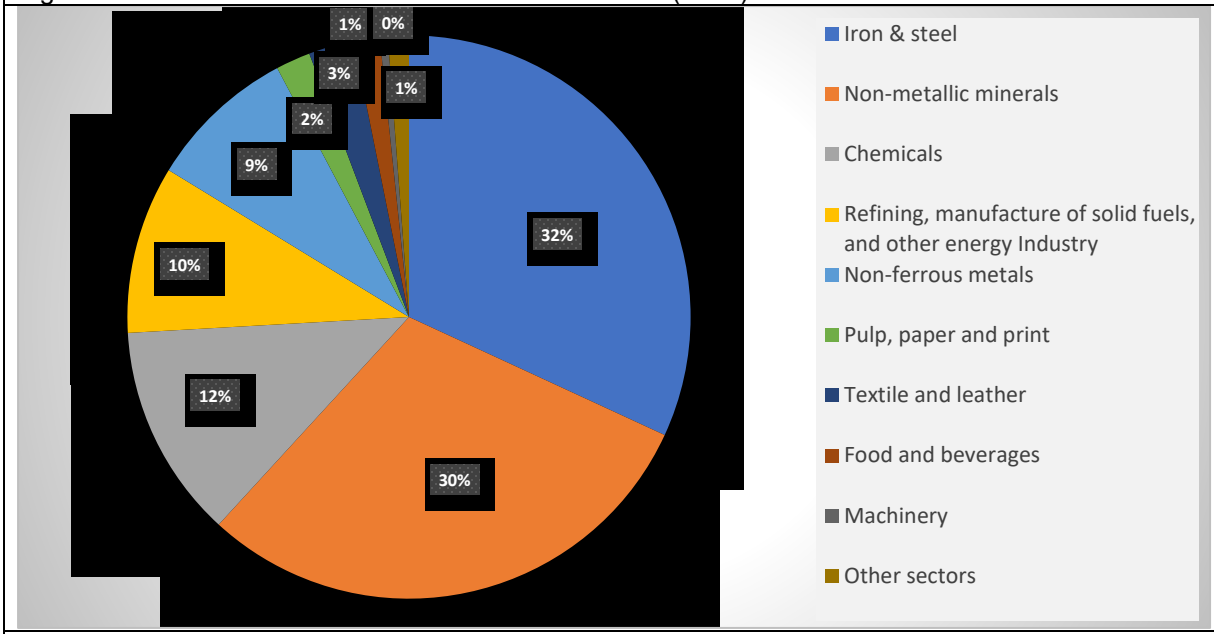
Figure 2.1 A: Year-on-year growth of manufacturing sector emissions (2005 – 2015)



Source: Authors' analysis

Figure 2.1 B shows how different sectors contributed to the overall emissions in 2015. The contribution of iron and steel and non-metallic minerals (mainly cement production) in terms of both energy-use and process emissions accounted for more than 60% of the total emissions.

Figure 2.1 B: Share of sub-sectors in overall emissions (2015)



Source: Authors' analysis

Total emissions grew by 87% from 341 $MTCO_2e$ in 2005 to 635 $MTCO_2e$ in 2015. The absolute growth of energy use emissions (92%) was more than that of IPPU emissions (72%). Also, the annual growth rate of total manufacturing sector emissions was much higher between 2005 and 2010 (10%) than between 2010 and 2015 (3%). Table 2.1 A shows the percentage increase in manufacturing sector emissions at three different points in the time series compared to baseline emissions in 2005.

Table 2.1 A: Total national GHG emission estimates from the manufacturing sector

Category	**GHG emissions ($MTCO_2e$)**				**%increase**		
	2005	**2007**	**2010**	**2015**	**2005-2007**	**2005-2010**	**2005-2015**
Energy-use	239	314	404	460	31%	69%	92%
Industrial Processes & Product Use	101	112	141	175	10%	38%	72%

Source: Authors' analysis

2.2 Trend in GHG emissions by type of GHG

Emissions from carbon dioxide (CO_2) constitute majority of the emissions in both energy-use and IPPU estimates. While CO_2 contributed to 99% for energy-use emissions, it contributed to 95% of IPPU emissions in 2015. Among the other gases, methane (CH_4) and nitrous oxide (N_2O) contributed to 0.03% and 0.4% of energy-use emissions in the same year. In case of IPPU emissions, CH_4 contributed to 4% of the emissions while N_2O contributed to 1% of the emissions. However, the IPPU emissions arising from CH_4 and N_2O are primarily from the chemical industries. Table 2.2 A below displays share of emissions from the three gases in total emissions for both energy-use and IPPU for the year 2015.

Table 2.2 A: Distribution of GHG emissions (energy-use and IPPU) contribution from major gases (2015)

Category	Without AFOLU		
	$\%CO_2$	$\%CH_4$	$\%N_2O$
1. Energy use	99.57	0.03	0.40
2. Industrial Processes & Product Use	95.28	4.58	0.14

Source: Authors' analysis

2.3 Key drivers of the emission trends in various sectors

Energy-use:

- The major sectoral drivers for energy emissions are from iron and steel, non-metallic minerals, petroleum refining and non-ferrous metals. Together they contributed to about 80% of the emissions in 2015, with iron and steel alone representing a share of 42%. The emissions from the sub-sector has more than doubled in the time period from 95 $MTCO_2e$ to 194 $MTCO_2e$.

- At the national level, coal (use) continues to be the dominant source of energy across the sectors. Hence, its share in the energy derived emissions grew from 180 $MTCO_2e$ in 2005 to 366 $MTCO_2e$ in 2015; i.e. nearly 80% of the total energy-use emissions.

IPPU:

- The major driver for industrial processes and product use is the emissions arising from cement production. It has consistently contributed to about 60% of the total IPPU emissions between 2005 and 2015. It has increased from 58 $MTCO_2e$ to 113 $MTCO_2e$, representing an absolute increase by 95% during the period.

- The other drivers of IPPU emissions are ammonia production and iron and steel production.

3. Industrial energy-use and IPPU

3.1 Overview of the sector

Between 2005 and 2015, Greenhouse gas emissions (GHG) from the manufacturing activities in India have increased at a rate of 6.4% (CAGR); i.e., rising from ~ 341 $MTCO_2e$ in 2005, to ~ 635 $MTCO_2e$ in 2015. The emissions estimates include emissions arising from captive power generation for all the manufacturing sectors. An overview of the GHG emissions is shown in the Table 3.1 A.

Table 3.1 A: Comparison of GHG emissions estimates between base year and current year ($MTCO_2e$)

IPCC ID	Source Category	GWP – SAR			GWP – AR5		
		2005	2015	% change	2005	2015	% change
1A	**Fuel combustion activities**	239	460	92%	239	459	92%
1A1	**Energy industries**	30	61	102%	30	61	102%
1A1b	Petroleum refining	26	53	107%	26	53	107%
1A1ci	Manufacture of solid fuels	1	2	273%	1	2	273%
1A1cii	Other energy industries	4	6	43%	4	6	43%
1A2	**Manufacturing industries and construction**	209	399	91%	208	398	91%
1A2a	Iron and steel	95	194	103%	95	194	103%
1A2b	Non-ferrous metals	19	47	142%	19	47	142%
1A2c	Chemicals and fertilisers	17	37	121%	17	37	121%
1A2d	Pulp, paper and print	10	13	27%	10	13	27%
1A2e	Food processing, beverages and tobacco	7	9	29%	7	9	29%
1A2f	Non-metallic minerals	45	74	65%	45	74	65%
1A2g	Transport equipment	2	2	32%	2	2	32%
1A2h	Machinery	4	3	-30%	4	3	-30%
1A2i	Mining and quarrying	0	0	230%	0	0	230%
1A2j	Wood and wood products	0	0	13%	0	0	13%
1A2k	Construction	0	0	0%	0	0	0%
1A2l	Textile and leather	8	17	95%	8	17	95%
1A2m	Non-specified industry	1	3	252%	1	3	252%
2	**IPPU**	101	175	73%	103	178	73%
2A	Mineral industry	59	116	95%	59	116	95%
2B	Chemical industry	32	41	29%	33	44	32%
2C	Metal industry	7	13	81%	7	13	81%
2D	Non-energy products from fuels and solvent use	3	6	77%	3	6	77%

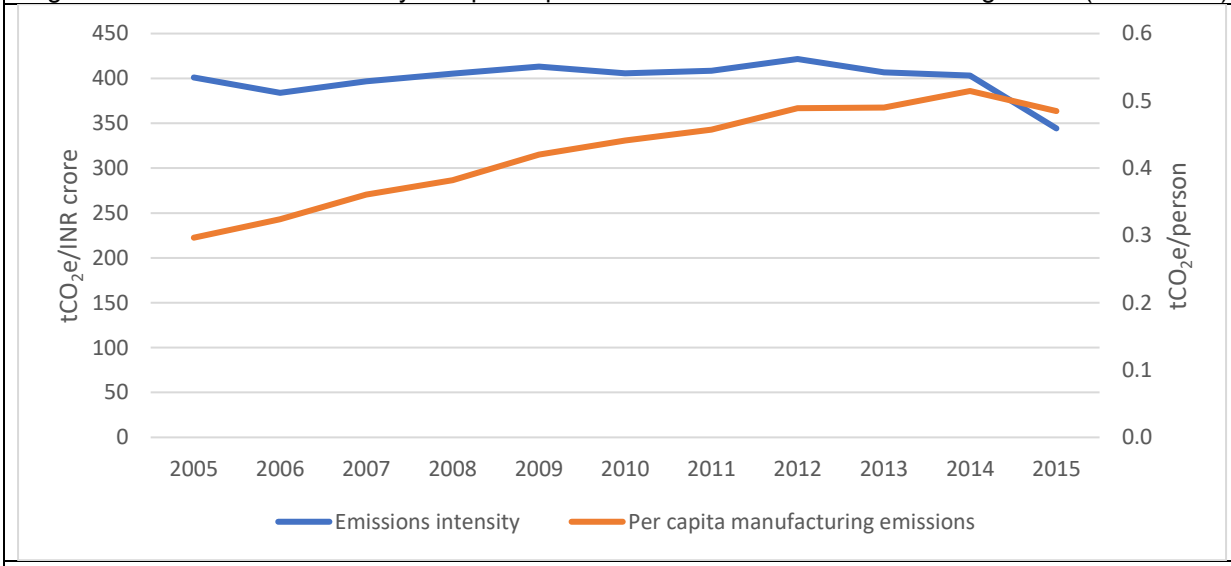
Source: Authors' analysis

The AR5 values for GWP of gases are from the fifth assessment report of IPCC which SAR values are from the second assessment report. Throughout the document, emissions calculated using the SAR values have been used for trend analysis and other analysis.

3.2 Analysis of sectoral emissions

The per capita manufacturing emissions have witnessed an increase of 5% annually over the time period. A comparison with the gross value added of India further reveals a negligible reduction in emissions intensity of the manufacturing sector, decreasing with a rate of 2% annually. Figure 3.2 A displays the trends in manufacturing emissions intensity and per capita emissions between 2005 and 2015.

Figure 3.2 A: Emissions intensity and per capita emissions from the manufacturing sector (2005-2015)



Note: Data for population sourced from (Planning Commission 2014) and GVA from (MOSPI 2018)

Source: Authors' analysis

A sectoral breakdown of emissions (energy-use and IPPU) from the manufacturing sector is provided in Table 3.2 A below.

Table 3.2 A: Sectoral breakdown of manufacturing emissions (2005 to 2015) in $MTCO_2e$ using IPCC SAR

IPCC codes	***Sector/Subsector - as per IPCC, 2006 classification***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***
1A1	**Fuel Combustion Activities > Energy industries**	**30**	**34**	**36**	**40**	**46**	**49**	**51**	**52**	**52**	**57**	**61**
1A1a	Main activity electricity and heat production (utility + captive)	**Reported Elsewhere (Refer: GHG Platform India)**										

1A1b	Petroleum refining	26	30	32	36	41	43	46	45	45	50	53
1A1ci	Manufacture of solid fuel	1	0	1	1	1	1	1	1	2	2	2
1A1cii	Other energy industry	4	4	4	4	4	5	5	5	5	5	6
1A2	**1A2: Manufacturing industries and construction**	**209**	**237**	**278**	**299**	**337**	**355**	**366**	**412**	**417**	**437**	**399**
1A2a	Iron and steel	95	109	140	147	170	187	186	201	207	216	194
1A2b	Non-ferrous metals	19	24	26	27	25	29	40	46	38	36	47
1A2c	Chemicals and fertilisers	17	19	22	27	29	24	24	30	36	46	37
1A2d	Pulp, paper and print	10	10	10	10	10	11	11	12	14	15	13
1A2e	Food processing, beverages and tobacco	7	8	7	8	11	9	9	10	10	12	9
1A2f	Non-metallic minerals	45	50	56	60	66	71	74	81	82	84	74
1A2g	Transport equipment	2	1	2	2	2	2	3	4	3	3	2
1A2h	Machinery	4	5	5	5	9	5	4	9	9	5	3
1A2i	Mining (excluding fuels) and quarrying	0	0	0	0	0	0	0	0	0	0	0
1A2j	Wood and wood products	0	0	0	0	0	0	0	0	0	0	0
1A2k	Construction	0	0	0	1	0	0	0	0	0	0	0
1A2l	Textile and leather	8	9	10	12	13	13	13	16	15	17	17
1A2m	Non-specified industry	1	1	1	1	2	2	2	3	3	3	3
2A	**Mineral industry**	**59**	**64**	**68**	**74**	**82**	**90**	**93**	**95**	**104**	**116**	**116**
2B	**Chemical industry**	**32**	**32**	**33**	**33**	**35**	**37**	**39**	**39**	**39**	**39**	**41**
2C	**Metal industry**	**9**	**10**	**10**	**12**	**12**	**12**	**20**	**20**	**14**	**14**	**16**
2D	**Non-energy products from fuels and solvent use**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**4**	**3**
Emissions (energy-use and IPPU, excluding electricity)		**341**	**378**	**427**	**459**	**512**	**545**	**572**	**619**	**627**	**667**	**635**

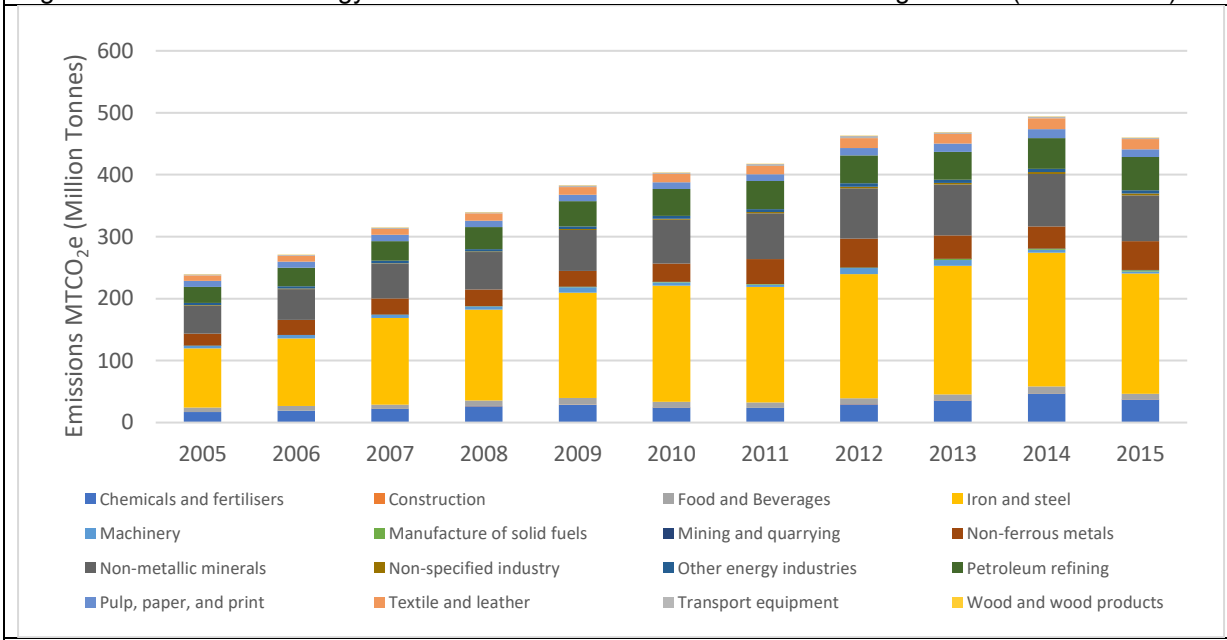
Source: Authors' analysis

Energy-use emissions

Energy-use emissions are the major contributor to the manufacturing sector emissions. Between 2005 and 2015, energy use emissions contributed ~ 70% of total sectoral emissions. At the sub-sector level, iron and steel production was the single largest contributor, representing a share of 44% in the total energy use emissions. It is followed by non-metallic minerals (17%), petroleum refining (10%), non-ferrous metals (8%), and chemical and fertilisers (7%). Figure 3.2 B portrays

sector wise split across energy use emissions, which has remained almost constant (in terms of sectoral share) over the assessment period.

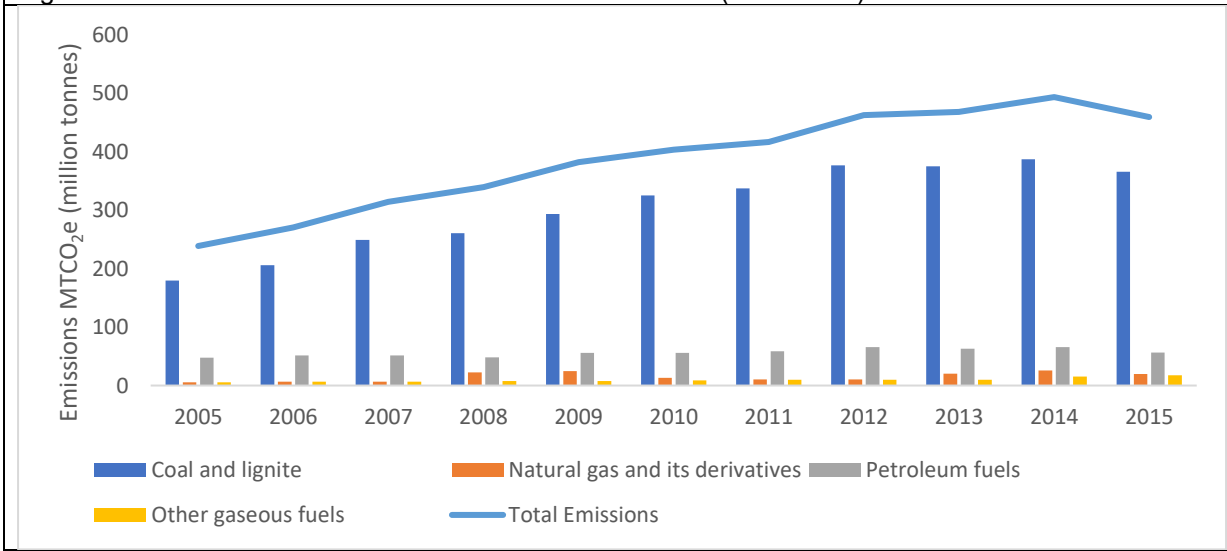
Figure 3.2 B: Trend of energy-use emissions across end-use manufacturing sectors (2005 – 2015)



Source: Authors' analysis

At the national level, coal (use) continues to be the dominant source of energy across the sectors. Hence, its share in the energy derived emissions grew from 180 $MTCO_2e$ in 2005 to 366 $MTCO_2e$ in 2015; i.e. nearly 80% of the total energy-use emissions. Figure 3.2 C shows the energy-use emissions from consumption of different fuels. It is observed that, the increase in India's manufacturing emissions is primarily driven by increase in coal consumption. This is also evident from the fact that the fuel mix of manufacturing industries has remained relatively constant during the period.

Figure 3.2 C: Emissions from combustion of industrial fuels (2005-2015)



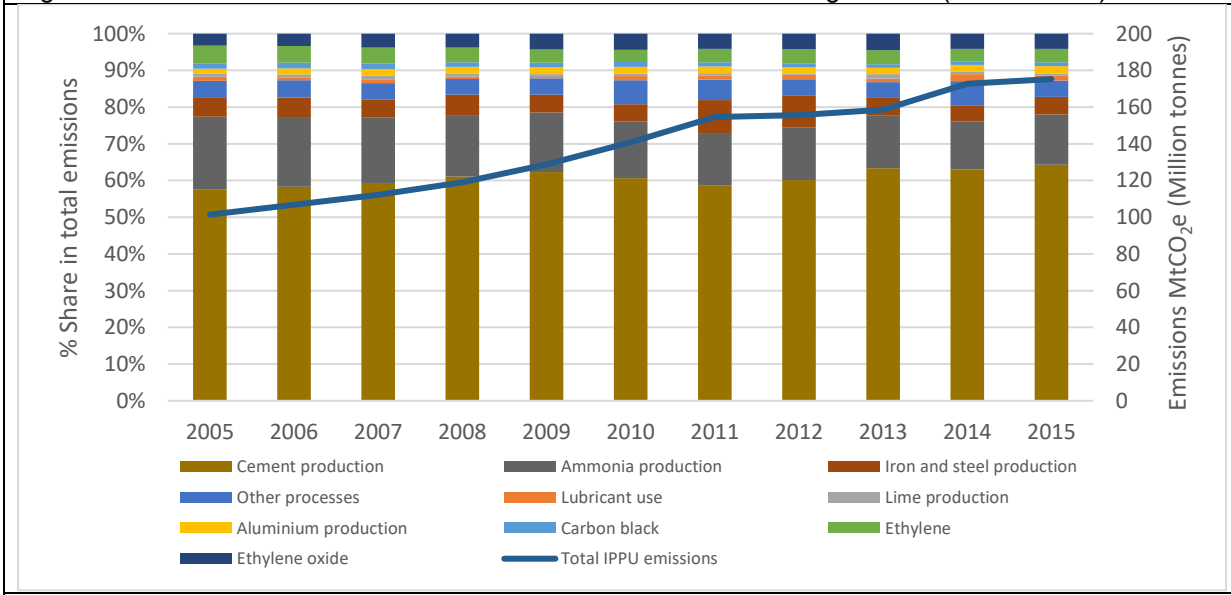
Source: Authors' analysis

Iron and steel and non-metallic industries (mainly cement) are heavily dependent on coal. National statistics indicate the iron & steel and cement manufacturing to be the second and third major consumers after thermal power generation (MoSPI 2018). Among all states, for their manufacturing operations (including captive power generation), Odisha has the largest share of coal-based emissions at 22% of country's total coal derived manufacturing emissions in 2015. It is followed by Chhattisgarh (13%), Gujarat (11%), Jharkhand (9%), and Karnataka (9%) for the same year.

IPPU emissions

Similarly, IPPU emissions are largely driven by cement production process (Figure 3.2 D). Cement manufacturing consumes more than 90% of total limestone/dolomite produced in the country (IBM 2015) and as a result contributes to more than 60% of total IPPU related emissions through most years.

Figure 3.2 D: Trend of IPPU emissions across end-use manufacturing sectors (2005 – 2015)



Source: Authors' analysis

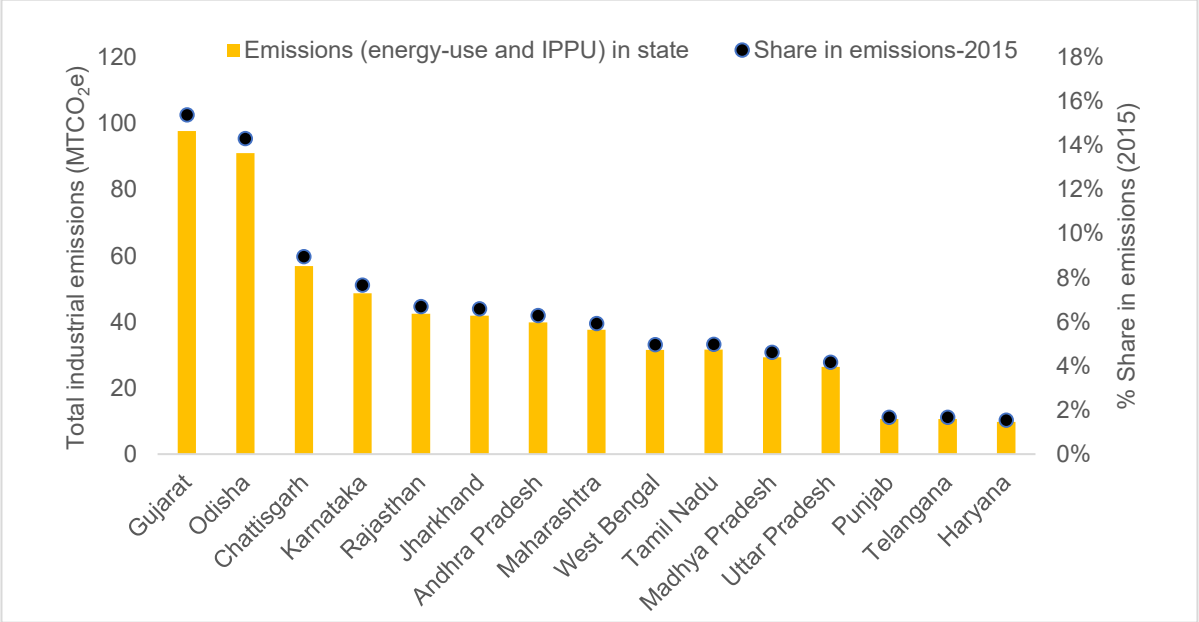
India ranks second globally in absolute consumption of nitrogenous fertilizers (FAO 2009) and on account of this, the production of fertilizer accounts for a large share of emissions. For the year 2015, fertilizer production (read as ammonia production) contributes to around 14% of total IPPU emissions.

Although, the specific requirement of carbonaceous material in iron and steel production is less than cement production, ever increasing demand of steel in India has driven the emissions from this sector to be the third largest. Process emissions from iron and steel contribute nearly 5% of overall IPPU related emissions in 2015.

3.3 State-wise analysis of emissions

State level GHG emission accounting suggests that ~82% of manufacturing emissions (including process emissions) comes from only ten states, i.e. Gujarat (15%), Odisha (14%), Chhattisgarh (9%), Karnataka (8%), Rajasthan (7%), Jharkhand (7%), Andhra Pradesh (6%), Maharashtra (6%), West Bengal (5%) and Tamil Nadu (5%). Figure 3.3 depicts absolute emissions from the top emitting states (primary axis) and the order of their share in emissions (secondary axis).

Figure 3.3 A: Major states in terms of manufacturing GHG emissions for 2015 data



Source: Authors' analysis

Interestingly, among top five emitters, coal dominates industrial energy-use emissions with more than 75% share in each of them, except Gujarat (61%) which is the top emitter. This shall be explained by the highest share of natural gas derived emissions in Gujarat (33% of national) alongside of highest emissions from liquid fuels (at 32%) and third highest share of coal-based manufacturing sector emissions (12% of country's total).

3.3 Sectoral quality control (QC) and quality assurance (QA)

The entire process of preparation, assessment, and reporting of GHG emission inventory for manufacturing sector involves procurement of data/information from several ministries largely made available in the public domain. Indeed, across various data sources, there are numerous challenges such as data consistency, timeliness/periodicity, quality of information, coverage of sectors, etc. Hence, a quality control (QC) approach was developed and followed over a period of time. It is largely based on experiences gathered from previous reporting and subsequent feedback from national experts. The QC approach involves cross validation of information from alternative sources, expert consultations on assumptions and extrapolations, comparison with other independent estimates, etc. Sector specific QC was performed through expert consultations, regional workshop and interactions with relevant ministries.

Further, other quality control measures such as ensuring consistency in conversion factors throughout the estimation process and across manufacturing sub-sectors, proper archiving of data, transparency in disclosure of emissions factors and other conversion factors used,

disclosing detailed methodology and good practices methodology from IPCC 2006 guidelines have been followed.

Quality assurance (QA) was performed was performed through in-house experts who are not involved in the estimation process. This also includes feedback and interactions with the MoEFCC during the preparation of India's formal GHG inventory estimates. Moreover, consistency with emission estimates and periodic consultations with reviewers over the last two years has provided depth to the QA process.

3.4 Key source category [1A1b, 1A1c, 2A: energy-use emissions]

3.4.1 Category description

Key category analysis is very useful to identify the emission sources having significant impact on the total emissions represented by each broader category. It helps in prioritizing key sectors for application of higher tiers, as well as adding stringent quality control (QC) and quality assurance (QA) measures. Hence, lead to reduction in uncertainties in the overall emission estimates (MoEFCC 2018).

Table 3.4 A features key source categories for the activity data used in the energy-use emission estimations. It further highlights the indicative quality of the data sources referred for each category. Refer Annexure 2 and Annexure 3 for detailed information of data sources and emissions factors used across the manufacturing sources.

Data quality has been marked high/medium/low depending upon consistency, accuracy, and completeness of the information. Wherever, the data is consistent (temporal variation) and complete throughout the reported period (2005 – 2015), it has been assigned 'high' quality impression. If the data is found inconsistent over the analyzed timeframe, or is modelled using suitable assumptions, it is considered to be of 'medium' quality. Wherever, average representative factors were used to derive activity data, quality is considered to be 'low' to reflect a further scope of improvement.

Table 3.4 A: Category wise source and quality of activity data for energy-use emissions

IPCC ID	GHG Source and Sink Categories	Type	Quality	Source
1	**Energy**			
1A1	**Fuel Combustion Activities**			
1A1b	Petroleum refining	Secondary	High	MoP&NG
1A1ci	Manufacture of solid fuel	Secondary	Medium	ASI
1A1cii	Other energy industry*	Secondary	Low	MoP&NG, SCCL Annual Reports
1A2	**Manufacturing Industries and Construction**			
1A2a	Iron and steel	Secondary	High	ASI

1A2b	Non-ferrous metals	Secondary	High	ASI
1A2c	Chemicals and fertilisers	Secondary	High	ASI
1A2d	Pulp, paper and print	Secondary	Low	ASI
1A2e	Food processing, beverages and tobacco	Secondary	Medium	ASI
1A2f	Non-metallic minerals	Secondary	High	ASI
1A2g	Transport equipment	Secondary	High	ASI
1A2h	Machinery	Secondary	High	ASI
1A2i	Mining (excluding fuels) and quarrying	Secondary	Low	ASI
1A2j	Wood and wood products	Secondary	Medium	ASI
1A2k	Construction	----	-----	ASI
1A2l	Textile and leather	Secondary	High	ASI
1A2m	Non-specified industry	Secondary	Medium	ASI

*: Includes emissions from energy use in coal mining and oil & gas extraction

Source: Authors' analysis

Most of the 'low/medium' quality source categories in Table 3.5 A are known to be contributing incomparably lower emissions than the high-quality source categories for energy-use emissions. Moreover, data quality issues arise predominantly due to certain fuel types (example: poor reporting of natural gas in the earlier years) across all sectors. Total share of energy-use emissions represented by low to medium quality categories is 7% contributed by pulp, paper and print; and, food processing, beverages and tobacco, wood products, mining, manufacturing of solid fuels, and non-specified industry categories.

3.4.2 Methodology

The simple manner of calculating the emissions is multiplying activity data with the associated emission factor. The emissions factors are driven by attributes such as calorific value, carbon content associated with fuels, extent of combustion, etc. whereas, activity data is a function of energy used for combustion process, and/or the amount of carbonaceous material entering a system. These could be directly specified or computed based on overall production or input materials consumed.

In this study, the energy-use emission estimates find activity data at the unit level of manufacturing establishments, as captured by the ASI every year. In IPPC terminology, activity data sourced from ASI shall be designated as Tier-3 level of information, which is the most accurate understanding of any manufacturing operation. IPCC lists out three level of tiers for the activity data, and emission estimation methodology. Each tier differs from the other based on the origin and quality of underlying information. Tier-1 methodology employs the default emission factors and other parameters as provided by IPCC, whereas Tier-2 represents an average country specific representation of the various fuel characteristics and prevalent technologies. Tier-3

represents greater level of details with more complex and site-specific data. Emission factors could either be country specific, or as per the prescription of IPCC guidelines. Table 3.4 B indicates the choice of tiers made for arriving at the emission estimates. Segregated information on the use of imported vis-à-vis domestic fuel across a wide-range of fuel-types is an additional advantage bringing more accuracy with the choice of emission factors, and hence improved emission accounting. Unit-level information is used to generate aggregate emissions at the sectoral, state and the national level.

Table 3.4 B: Tier approach followed for the manufacturing sector emission (Energy-use and IPPU) category

IPCC ID	GHG source & sink categories	CO2		CH4		N2O	
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1A1	**Energy industries**						
1A1b	Petroleum refining	T2	CS, D	T2	CS, D	T2	CS, D
1A1ci	Manufacture of solid fuels	T1	D	T1	D	T1	D
1A1cii	Other energy industries	T1	D	T1	D	T1	D
1A2	**Manufacturing industries and construction**						
1A2a	Iron and steel	T2	CS, D	T2	CS, D	T2	CS, D
1A2b	Non-ferrous metals	T2	CS, D	T2	CS, D	T2	CS, D
1A2c	Chemicals	T2	CS, D	T2	CS, D	T2	CS, D
1A2d	Pulp, paper and print	T2	CS, D	T2	CS, D	T2	CS, D
1A2e	Food processing, beverages and tobacco	T2	CS, D	T2	CS, D	T2	CS, D
1A2f	Non-metallic minerals	T2	CS, D	T2	CS, D	T2	CS, D
1A2g	Transport equipment	T2	CS, D	T2	CS, D	T2	CS, D
1A2h	Machinery	T2	CS, D	T2	CS, D	T2	CS, D
1A2i	Mining (excluding fuels) and quarrying	T2	CS, D	T2	CS, D	T2	CS, D
1A2j	Wood and wood products	T2	CS, D	T2	CS, D	T2	CS, D
1A2k	Construction	T2	CS, D	T2	CS, D	T2	CS, D
1A2l	Textile and leather	T2	CS, D	T2	CS, D	T2	CS, D
1A2m	Non-specified industry	T2	CS, D	T2	CS, D	T2	CS, D

Notations: T1: Tier 1; T2: Tier 2; T3: Tier 3; CS: Country-specific; PS: Plant-specific; D: IPCC default

Source: Authors' analysis

Activity data and emission factor(s)

In this study, across the three major fuel groupings (solid, liquid, gaseous) more than 80 variants/distillates have been considered as reported by the sector through ASI unit level data.

Annexure 3 depicts each and every fuel variant considered for the emission estimates. ASI allows industries to report 'biomass' within the 'other fuel' category, unless they choose to specify its reporting in the major fuel categories. Any use of biomass is considered to be commercial in nature and hence *carbon-neutral* due to offsetting properties. All the 'material transit' related fuel is considered beyond the scope of industry reporting, as it shall be considered elsewhere as per the IPCC guidelines.

Each fuel variant corresponds to a specific calorific value (energy content per unit mass) and emission value (tonnes of carbon dioxide equivalent per unit of energy content). Annexure 3 highlights all fuel variants alongside of corresponding calorific value and emission factors. These values may vary for domestic and imported source of origin as identified by India and suggested by IPCC guidelines. For instance, Table 3.4 C illustrates coal specific variations with calorific value and emission factor according to the choice of source and process within manufacturing sector.

Table 3.4 C: Distinct emission factors and calorific values adopted for coal as per the process and source of origin

Fuel Type	Calorific value (TJ/Gg)	Emission factor CO2 (T/TJ)	Source	Conversion factor source
Coal	18.26	93.68	Domestic	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal (electricity)	17.09	96.76	Domestic	
Coal (cement)	20.15	95.63	Domestic	
Coal (fertilizer)	20.4	95.55	Domestic	
Coal (non-ferrous metals)	18.17	96.36	Domestic	
Coal (pulp, paper and print)	18.35	96.29	Domestic	
Lignite	9.8	105.97	Domestic	
Coal	25.8	94.6	Imported	IPCC 2006 guidelines
Lignite	9.69	106.51	Imported	

Note: 1) CEEW compilation based on India's Second Biennial Update Report and IPCC 2006 default values for emission factors
2) Please refer to the chapter 2 (Stationary combustion) of IPCC 2006 guidelines for detailed information on the emissions factors.

Source: (MoEFCC 2018), (IPCC 2007)

It is important to understand the input use of a fuel for 'energy' and/or 'non-energy' purposes. This may vary across specific manufacturing segments for a same type of fuel. Essentially, only the energy use of an input fuel contributes to the direct GHG emissions. Any other non-energy use – be it feedstock, or interconversion of one form to other – does not contribute to the energy-use emissions.

The current form of manufacturing sector reporting in India, across various information channels (including ASI), does not elucidate the end use of input fuels within the factory premise. This is indeed challenging as well for all point sources to keep a record in a disaggregated manner. Hence, a user can not differentiate a specified quantity of fuel-use for heating purpose, captive power generation, and/or as a feedstock for non-energy uses. To overcome this challenge to a certain degree, palpable assumptions have been made on the basis of desktop research and expert consultations. These are similar to what has been assumed in the previous series (2005-2013) of GHG estimates reporting available at the GHG Platform India. Annexure 4 provides all

such assumptions on non-energy use of input fuels adopted for certain manufacturing activities. For example:

a) Coal transformation into coking coal, especially within coke manufacturing units of integrated steel plants, is considered as a non-energy practice to avoid under-estimation or over-estimation of emissions within the manufacturing operation. In such event, emissions are directly attributed to use of secondary forms (coke) by manufacturing units, and any sale of coke outside the premises has been deducted from the emissions accounting.

b) Similarly, transformation of crude oil into refined petroleum products has not been considered for emissions, except for 'energy used' to carry out such activity. This is to avoid double-accounting of liquid fuel emissions from refined products and to ensure appropriate distribution of emissions into diverse manufacturing sub-sectors.

c) Natural gas and/or naphtha is notably known for its non-energy use in fertilizer manufacturing (for urea manufacturing). Hence no emissions considered from such use.

d) Certain manufacturing products use forms of fuel as an ingredient for its physical and chemical properties, hence does not necessarily results in emissions due to combustion. For instance, kerosene is used as solvent by paints, dying and varnishing industries. Any such kind of fuel consumption is treated as a feedstock and hence dropped from energy-use and emission accounting.

Methodology

The characteristic quality of input hydrocarbon fuels, and associated consumption determines the energy use emissions for manufacturing sector. The basic equation adopted to determine manufacturing energy-use emissions is mentioned below:

Basic Equation:

$$Egas = Afuel * C.Vunit * C.Vfuel * E.Fgas * GWPgas$$

Where:
$Egas$: Emission of greenhouse gas(es) in tonne
$Afuel$: **Activity data** of fuel (in litres/kg/tonne etc.)
$C.Vunit$: Conversion factor(s) to convert other reported units of fuel to a set of standard units chosen in the exercise (please refer to Annexure 5.)
$C.Vfuel$: Calorific value of fuel (tonne of energy in Tera Joule per tonne of fuel)
$E.Fgas$: **Emission factor** of GHG gas due to combustion of the fuel (tonne of gas /TJ of energy input)
$GWPgas$: Global warming potential of gas

The scope of energy use emission accounting is limited to 'manufacturing industries and construction (1A2) in addition to coverage of petroleum refining (1A1b), manufacturing of solid fuels (1A1ci), and other energy industries (1A1cii). Any emissions that arises due to purchase of electricity from the grid is attributed to electricity generation (1A1ai), which is beyond the scope of reporting. However, generation of captive power by the manufacturing units and the associated emissions are attributed to their respective sub-sectors (discussed above) falls under the scope of this accounting exercise. This section details out choice of methodology (tiers and approach), activity data, and emission factor variants used for major IPCC categories within the purview of manufacturing reporting.

Manufacturing industries and construction (IPCC 1A2)
This category further includes almost the entire range of manufacturing activities, as highlighted in **Error! Reference source not found.** (from 1A2a to 1A2m). ASI is the prime source of activity data for each of the sub-category where the fuel-use information is available at the unit level (Tier-3). However, emission factors for the input fuels represents national average for the major fuel, measured and updated by India for domestic sources. All the imported fuel types reflect IPCC default emission factor values. Hence, the study reports emissions at Tier 2 level for this category.

Petroleum refining (IPCC 1A1b)
The choice of methodology for this sector is Tier-2 using both country specific and default calorific values and emission factors of fuels consumed. There is a paucity of quality information on activity data from petroleum refineries. The Ministry of Petroleum and Natural Gas (MoPNG) provides total energy consumption by the refinery enterprises (at sub-national level), without any clarity on various fuel types associated as energy inputs. Assuming that most refineries operate with similar basket of fuels for crude transformation, fuel-wise activity data from Indian Oil Corporation Limited (IOCL) is extrapolated for the entire sector, which has remained constant over time. Country specific emission factors were used for specific fuel-types (wherever available), while default values were used for the others.

Manufacturing of solid fuels (IPCC 1A1ci)
This category involves reporting of emissions that arises from conversion of coal into coke, barring non-energy use of coal for this transformation process. Steel sector is the biggest consumer of coke as a reducing agent as well as source of energy in its blast furnaces. Hence, majority of coke production is integrated within steel units, which is difficult to separate out for reporting purpose. Thus, a major share of emissions from this category is included within manufacturing of steel (IPCC 1A2a), while the standalone coke manufacturing plants have been reported for their limited share in total emissions. It follows Tier 2 level of reporting.

Other energy industries (1A1cii)
This category involves a wide range of activities. In this methodology note, scope is limited to upstream oil and gas extraction activities alongside of emissions from coal mining activities. Consumption of diesel constitute activity data for coal mining activities, which is derived on the basis of 'specific consumption statistics (diesel per unit of coal produced) made available by Central Coalfields Limited (CCL) for its operations. Total emissions in terms of CO_2 equivalent (CO_2e) are reported at Tier 2 level with country specific emission factors (wherever reportedly available from public sources).

Proxies, assumptions and correction measures

1. **Unspecified fuel reporting in ASI**

   Several manufacturing units report a sizable amount of fuel-use only in terms of expenditure, not as quantity. In certain cases, manufacturing units provide only a generic description of fuel (as solid, liquid, gaseous) instead of specific form or distillate. This poses considerable challenges in arriving representative calorific value and emission factors for such reporting, especially with liquid fuels where the emission factor ranges between 63.1 Tonnes CO_2/TJ to as high as 107 Tonnes CO_2/TJ.

Measures adopted

To arrive at a proximate value of emissions from unspecified fuels, the actual fuel use pattern over a period of time was captured from units who reports energy inputs in a very specific manner. This may vary with geographical location of the unit and with each type of manufacturing sub-sector. The former is a factor of 'resource proximity and transport infrastructure' while the latter is largely determined on the basis of technology adopted. Hence, varying fuel use patterns were considered at state level and with each sub-sector type. This adjustment also helps in translation of reported fuel expenses into a determined fuel quantity for emission accounting. Table 3.4 D provides a 2015-16 snapshot of sector wise (at two-digit NIC level, see column) distribution of liquid fuel consumption (expressed as a share of quantity) adopted by Manufacturing units. This has largely stayed constant over the assessment period at each fuel category level. A detailed illustration is provided through Annexure 6.

Table 3.4 D: Manufacturing sub-sector wise preferences for liquid fuel distillate in 2015-16

Row Labels	10	11	13	15	17	18	19	20
Diesel	0.00%	0.47%	0.03%	13.19%	0.00%	0.00%	0.00%	0.04%
Fuel oils n.e.c	0.00%	0.00%	0.31%	0.00%	0.00%	0.00%	0.09%	0.06%
Fuel, aviation turbine	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Furnace oil	93.89%	99.53%	99.34%	0.00%	0.00%	0.00%	0.01%	79.15%
Gas oils	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
High speed diesel	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
Kerosene	0.00%	0.00%	0.00%	0.00%	0.00%	1.03%	0.00%	0.22%
Kerosene n.e.c	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%
Light petroleum oil	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Liquidified petroleum gas (LPG)	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	99.87%	19.80%
Medium petroleum oil, n.e.c.	0.00%	0.00%	0.00%	0.00%	0.00%	98.97%	0.00%	0.00%
Other light petroleum oils and light oils obtained from bituminous minerals n.e.c	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Petroleum coke	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.07%
Petroleum coke calcined	0.00%	0.00%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%
Petroleum products obtained from bitumen n.e.c.	6.11%	0.00%	0.00%	86.81%	0.00%	0.00%	0.00%	0.01%
Shale Oil	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.61%
Superior kerosene	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Note: Percentages indicate the share of quantities of liquid fuels by type within each industrial sector.

Source: Authors' analysis

2. Erroneous reporting by manufacturing units

The information collection template under ASI is smartly designed to collect a wide range of information around material and energy consumption; form and quantum of output products; expenditure on various activities; manpower involved, etc. Since, energy/emission estimation is not a defined mandate for the exercise, it incorporates a very broad level of scrutiny and quality checks, largely limited to expenditure records. It was observed that in few cases, factories end us feeling perplexed with the extent of reporting, resulting in apparent mix-up between 'unit of measurement' and 'reported rates' of energy inputs. For instance: coal inputs see a wide (possibly erroneous) range of rates, starting from INR 196/tonne to as high as INR 49,508/tonne. This makes a substantial difference in the input fuel quantity for such industries, and can be largely explained as a mix-up between 'per tonne' and 'per kg' of reported unit. Rates may vary within a certain range considering the cost of transportation and differing tax structure.

Measures adopted

- As a primary step, different units of measurement (UoM) adopted by certain factories has been standardized to a common UoM for each fuel type across industries over the assessment period.
- Factories which are common over a period of time, mostly the bigger operations, and are consistent with reported rates and UoMs have been considered to arrive at a median rate for each fuel type. These median rates are further used to define permissible bounds for the outlier values when the entire dataset is analysed. Common factories within two different time frames (2004-05 to 2009-10, and, 2010-11 to 2015-16) were considered for defining median rates to ensure any new additions, closure or expansion of manufacturing activities.
- To mimic the heterogeneity with manufacturing process across the country, median rates were defined considering three distinct layers: (a) median rates at a sector level; (b) median rates at state level; and, (c) median rates at the national level. The choice of defining bounds is suitably made after considering adequate number of representative industries within each state.
- A generous variation of 50% (in either side) is allowed between the reported rate and the representative median value for each fuel type as a scrutiny measure. This is to accommodate higher costs incurred on transporting fuels for certain geographic locations.

3.4.3 Recalculation

GHG Platform India adopts a process of publishing independent and most recent inventory estimates for each economic sector on a periodic basis. It is natural that any such effort undergoes systemic changes over time due to improvements in capacity of information providers and assessors; data quality and availability; methodological change; refinement in assumptions, etc. All such changes are important and brings accuracy with the estimates. In order to draw trends for measuring improvements over time, it is necessary that user follows similar (preferably most recent) approach for the entire time-series to ensure comparability and completeness. IPCC recommends 'Recalculation' of emission estimates through its good practice guidelines for such purpose.

In case of energy use emissions, this version follows a few advancements with methodology and assumptions, as described below:

Revision of calorific values and emissions factors

In December 2018, MoEFCC issued an update on country specific emission factor for selected fuels and key processes through its second BUR (please refer to Table 3.4 C). Hence, the present analysis (2005 – 2015 series) is based on updated emission factors including recalculation for previous years.

Inclusion of emissions from captive power generation

In this series, emissions attributed to captive power generation (within manufacturing sector) are being reported alongside manufacturing emissions. This is a significant improvement in the methodology as it follows IPCC guidelines for auto-producers. In the previous series, captive emissions were part of 'electricity sector emissions,' which is now being shifted rightfully to manufacturing sector reporting. Hence, appropriate recalculation has been performed for the previous estimates as well.

Control measure on incremental fuel rates reported by factories

This note adopts modest assumptions on 'fuel rates' adjustments for certain factories wherever there is lack of clarity. Such adjustments follow median rates of fuel reported by similar operations at sector and state level. However, a certain degree of deviation is still observed as sudden rise/fall in evaluated fuel rates, especially where assessment points are limited to a few factories for median calculations. In order to prevent abrupt changes, 20% limit has been imposed to make room for annual increment in adjusted rates, unless all the major factories for a specific fuel reports higher degree of change. This additional check measure further helps in bringing down uncertainties with incomplete data points.

Table 3.4 E presents the overall impact of methodological differences on previous year estimates through recalculations. It varies between 3% to 24% mostly with an upside trend. Major deviation is observed for the base year and following year, which may certainly impact the discussion around intensity improvement targets of India over a period of time. One must take note of expanded scope of manufacturing estimate reporting via inclusion of captive emissions in the presented note, which was included elsewhere in the 2005 – 2013 series of reporting.

Table 3.4 E: Comparison between energy-use emissions estimates (Phase 2 and Phase 3)

Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
GHG emission estimates (2005 – 2013 series)	205	219	283	298	352	381	402	447	481
GHG emission estimates (2005 – 2015 series)	239	271	314	340	383	404	417	463	469
% difference between estimates	16%	24%	11%	14%	9%	6%	4%	4%	-3%

Source: Authors' analysis

3.5 Key source category [2A, 2B, 2C, 2D: Industrial Process and Product Use emissions]

3.5.1 Category description

Table 3.5 A features key source categories for the activity data used in IPPU emission estimations. It further highlights the indicative quality of the data sources referred for each category. Refer Annexure 2 for detailed information of data sources used across the manufacturing sources.

Data quality has been marked high/medium/low depending upon consistency, accuracy, and completeness of the information. Wherever, the data is consistent and complete throughout the

reported period (2005 – 2015), it has been assigned 'high' quality. If the data is found inconsistent over the analyzed timeframe, or is modelled using suitable assumptions, it is considered to be of 'medium' quality. Wherever, average representative factors were used to derive activity data, quality is considered to be 'low'. It reflects scope of improvement (please refer to Annexure 7 for a detailed list of emission factors).

For IPPU emissions, since the activity data is directly sourced from public agencies without making any significant extrapolation or assumptions to capture the reported timeframe, most of the categories have 'high' quality of information. Hence, less than 2% of the IPPU emissions are derived from 'low' to 'medium' quality sources.

Table 3.5 A: Category wise sources and quality of activity data for the IPPU emissions

IPCC ID	GHG source & sink categories	Type	Quality	Source
2	**Industrial processes and product use**			
2A	**Mineral industry**			
2A1	Cement production	Secondary	High	CMA, IBM
2A2	Lime production	Secondary	High	ASI
2A3	Glass production	Secondary	High	ASI
2A4a	Ceramics		High	
2A4b	Other uses of soda ash	Secondary	High	ASI
2A4c	Non-metallurgical magnesia production	Secondary	High	ASI
2A4d	Other uses of carbonates	Secondary	High	ASI
2B	**Chemical industry**			
2B1	Ammonia production	Secondary	High	Annual Report, Ministry of Chemicals and Fertilizers, Exports-Imports database

2B2	Nitric acid production	Secondary	High	ASI
2B3	Adipic acid production^			Annual Report, Ministry of Chemicals and Fertilizers, Market research
2B4	Caprolactam, glyoxal and glyoxylic acid production	Secondary	High	
2B5	Carbide production	Secondary	High	
2B6	Titanium-dioxide production	Secondary	High	
2B7	Soda ash production	Secondary	High	
2B8a	Methanol production	Secondary	High	
2B8b	Ethylene production	Secondary	High	
2B8c	Ethylene dichloride and vinyl chloride monomer production	Secondary	High	
2B8d	Ethylene oxide production	Secondary	High	
2B8e	Acrylonitrile production	Secondary	High	
2B8f	Carbon black production	Secondary	High	
2C	**Metal industry**			
2C1	Iron and steel production	Secondary	High	ASI
2C2	Ferroalloys production*			
2C3	Aluminium production	Secondary	High	MCX, IBM Mineral Yearbook, USGS
2C4	Magnesium production*			
2C5	Lead production	Secondary	High	IBM market survey report & Mineral Yearbook
2C6	Zinc production	Secondary	High	

2C7	Other- emissions from carbonates usage in copper production	Secondary	High	ASI
2D	**Non-energy products from fuels and solvent use**			
2D1	Lubricant use	Secondary	Medium	ASI
2D2	Paraffin wax use	Secondary	Medium	ASI
2D4	Other – lubricant use in coal mining activities	Secondary	Low	SCCL Annual Reports

^: Official data indicates absence of production
*: Not estimated due to unavailability of reliable production data

Source: Authors' compilation

3.5.2 Methodology

Simple manner of calculating the emissions is multiplying activity data with the associated emission factor. The emission factors are driven by attributes such as calorific value, carbon content associated with fuels, extent of combustion, etc. Whereas, activity data is a function of energy used for combustion process, and/or the amount of carbonaceous material entering a system. These could be directly specified or computed based on overall production or input materials consumed.

IPPU estimates find a mixed approach, using both top-down (supply side) as well as bottom-up (consumption based) activity data sourced from diverse publications. In IPPC terminology, activity data sourced from ASI shall be designated as Tier-3 level of information, which is the most accurate understanding of any manufacturing operation. IPCC lists out three level of tiers for the activity data, and emission estimation methodology. Each tier differs from the other based on the origin and quality of underlying information. Tier-1 methodology employs the default emission factors and other parameters as provided by IPCC, whereas Tier-2 represents an average country specific representation of the various fuel characteristics and prevalent technologies. Tier-3 represents greater level of details with more complex and site-specific data. Emission factors could either be country specific, or as per the prescription of IPCC guidelines. Table 3.5 B indicates the choice of tiers made for arriving at the emission estimates. Segregated information on the use of imported vis-à-vis domestic fuel across a wide-range of fuel-types is an additional advantage bringing more accuracy with the choice of emission factors, and hence improved emission accounting. Unit-level information is used to generate aggregate emissions at the sectoral, state and the national level.

Table 3.5 B: Tier approach followed for the IPPU emission

IPCC ID	GHG source & sink categories	CO2		CH4		N2O	
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
2A	**Mineral industry**						
2A1	Cement production *	T1	CS, D	T1	CS, D	T1	CS, D
2A2	Lime production	T2	CS	T1	CS	T1	CS
2A3	Glass production	T1	D	T1	D	T1	D
2A4a	Ceramics	T1	D	T1	D	T1	D
2A4b	Other uses of soda ash	T1	D	T1	D	T1	D
2A4c	Non-metallurgical magnesia production	T1	D	T1	D	T1	D
2A4d	Other	T1	D	T1	D	T1	D
2B	**Chemical industry**						
2B1	Ammonia production	T1	D	T1	D	T1	D
2B2	Nitric acid production	T1	D	T1	D	T1	D
2B3	Adipic acid production	T1	D	T1	D	T1	D
2B4	Caprolactam, glyoxal and glyoxylic acid production	T1	D	T1	D	T1	D
2B5	Carbide production	T1	D	T1	D	T1	D
2B6	Titanium-dioxide production	T1	D	T1	D	T1	D
2B7	Soda ash production	T1	D	T1	D	T1	D
2B8a	Methanol production	T1	D	T1	D	T1	D
2B8b	Ethylene production	T1	D	T1	D	T1	D
2B8c	Ethylene dichloride and vinyl chloride monomer production	T1	D	T1	D	T1	D
2B8d	Ethylene oxide production	T1	D	T1	D	T1	D
2B8e	Acrylonitrile production	T1	D	T1	D	T1	D
2B8f	Carbon black production	T1	D	T1	D	T1	D
2C	**Metal industry**						
2C1	Iron and steel production	T2	CS, D	T2	CS, D	T2	CS, D
2C2	Ferroalloys production	T1	D	T1	D	T1	D
2C3	Aluminium production	T1	D	T1	D	T1	D
2C4	Magnesium production	T1	D	T1	D	T1	D
2C5	Lead production	T1	D	T1	D	T1	D

2C6	Zinc production	T1	D	T1	D	T1	D
2C7	Other	T1	D	T1	D	T1	D
2D	**Non-energy products from fuels and solvent use**						
2D1	Lubricant use	T1	D	T1	D	T1	D
2D2	Paraffin wax use	T1	D	T1	D	T1	D
2D4	Other	T2	CS, D	T2	CS, D	T2	CS, D

Notations: T1: Tier 1; T2: Tier 2; T3: Tier 3; CS: Country-specific; PS: Plant-specific; D: IPCC default

Source: Authors' analysis

Activity data and emission factor(s)

IPPU emissions are largely associated with the manufacturing activities using non-fossil carbonaceous material (such as limestone, carbon electrodes, dolomite, etc.) as a process input, and/or from non-energy use of fossil fuels and their derivatives. In addition, GHG emissions arising from certain product categories such as leakages of refrigerant gases (having high global warming potential) from air-conditioning also attribute to IPPU emissions.

For IPPU emissions, activity data largely comprises of product output and/or consumption of carboniferous material which leads to emissions during the process. For instance – consumption of graphite electrodes leads to process emissions within the steel sector; similarly, burning of limestone (calcium carbonate) during cement production leads to IPPU emissions due to oxidation of carbonates into carbon dioxide.

IPPU related emission factors are based on either input carbonaceous material or represents emissions per unit of a product output. A detailed list of the emissions factors along with their source of information are presented in Annexure 7.

Unlike a comprehensive coverage of input energy fuels with each manufacturing unit, information on output from manufacturing units is poorly captured by the ASI. Alternative data sources were referred to such cases, especially for aluminium, zinc, lead and chemical manufacturing sub-sectors. Hence, all the information is secondary in nature obtained mainly from public sources. To maintain completeness of information, following assumptions have been maintained throughout the assessment period:

a) Natural gas is conventionally used as a source of fuel as well as feedstock in the ammonia/urea manufacturing process, therefore separate accounting of the energy and IPPU based GHG emissions is not possible. Hence, overall emissions from fertiliser manufacturing (energy-use and IPPU) gets reported jointly under the IPPU head.

b) Use of lubricants, solvents, and paraffin wax for machinery and other processes also contributes to IPPU emissions. Emissions from all such product use (including mining activities) are illustrated in supporting excel workbooks (Refer GHG Platform India website: http://www.ghgplatform-india.org/methodology-industry-sector). Activity data for mining sector is partially available through the ASI data sets.

Methodology

Accounting of IPPU emissions require a slightly different approach from the energy-use estimation process. The basic equation illustrated below captures the characteristic property of input

materials and/or output products as an activity data to bind with corresponding emission factors prescribed by IPCC 2006 guidelines.

Basic equation:

$$Egas = Amat * C.Vmat * E.Fgas * GWPgas$$

Where:

$Egas$: Amount of greenhouse gas in tonne

$Amat$: **Activity data** of material (carbonaceous) input or product output (expressed in tonne/kg/litre/unit etc.)

$C.Vmat$: Conversion factor to activity data units in tonne

$E.Fgas$: **Emission factor** of gas emitted in the process (tonne of gas per unit of carbonaceous material input or product output)

$GWPgas$: Global warming potential of concerned gas

In this methodology note, assessment of IPPU emissions is limited to major IPCC categories, namely – mineral industry (2A); chemical industry (2B); metal industry (2C); and, non-energy products from fuels and solvents used (2D). Due to constraints with other categories, IPPU emissions has not been calculated for electronics industry (2E) and product uses as substitute for Ozone Depleting Substances (ODS). A brief description of adopted approach with reported categories is as follows:

Mineral industry (IPCC: 2A)

This category includes cement, lime and glass production as major activities alongside of other process use of carbonates such as – ceramics, use of soda ash, and non-metallurgical magnesia production.

- *Cement production (2A1)*
  - The data for cement production (2A1) has been obtained from Cement Manufacturers' Association (CMA) from 2004 to 2009 (CMA) and from Indian Bureau of Mines' annual publication (IBM Yearbook) for 2010 onwards.
  - Country-specific clinker factors have been used to compute the emissions (Table 3.5 C).
  - The latest state-wise share of cement manufacturing is available for 2010-11 (source: Lok Sabha), which further remained invariant for the latest years. Annexure 8 features the state-wise share of cement production.
  - CMA is the prime source of information on various types of cement production within the country. However, the data is available till 2007-08. For the remaining years, constant share of cement types has been maintained for the overall production data obtained from IBM.

Table 3.5 C: Clinker factors for types of cement

Clinker Stock	O.P.C.	P.P.C.	P.B.F.S.	S.R.C.	IRST 40	Others	Total Cement
1	0.95	0.68	0.6	0.95	0.95	0.95	0.77

O.P.C = Ordinary Portland Cement, P.P.C. = Portland Pozzolana Cement, P.B.F.S. = Portland Blast Furnace Slag Cement, S.R.C. = Sulphate Resistant Cement, IRST 40 = Indian Railway Specification No. T-40

Source: Authors' analysis

- *Lime production (2A2), glass production (2A3) and other process use of carbonates (2A4)*
  - ASI is the prime source of information on all these activities

- The A_{mat} for this category is the total production number, the $C.V_{mat}$ is the conversion factor based on the unit of reporting of the mineral and $E.F_{gas}$ is the emission factor for the mineral.
  Example: In the year 2015-16, certain factories in Andhra Pradesh reported lime production of 29385 tonnes. The conversion factor is 1 and the emission factor is 0.75 tCO2/tonne of product. Hence the emissions CO_2 will be multiplication of emission factor with quantity which gives us 22,039 tonnes of CO_2 and CO_2e (since GWP of CO_2 is 1 as per SAR).
- Country-specific emission factor of CO_2 is used in case of lime production. The emission factor has been estimated based on stoichiometric equation using the grade as reported by Indian Bureau of Mines (IBM 2016).
- For all the other categories under the sector, default IPCC conversion factors are used for calculation of emissions. A detailed list of emission factors can be found in the Annexure 7.

Chemical industry (2B)

This category covers manufacturing of a wide range of chemical products, namely – ammonia, nitric acid, adipic acid, caprolactam, glyoxal, glyoxylic acid, carbide, titanium dioxide, soda ash, petrochemicals, carbon black, etc.

- IPCC default emission factors have been used for all the sub-categories under this category (refer Annexure 7)
- 'Chemical and Petrochemical statistics at a Glance' released by the Ministry of Chemicals and Fertilizers (Department of Chemicals and Petrochemicals 2019) is the prime source of activity data.
- Export-import database (EXIM database 2019) is used for information on net ammonia imports, whereas domestic information is derived from urea production statistics obtained from the Ministry of Chemicals and Fertilizers.
- The state-wise production of various chemicals has been estimated by using secondary literature, plant level capacity installation data and official reports. A detailed list of all chemicals under this manufacturing category, with their state shares can be found in Annexure 9.
- Information on activity data associated with fluorochemical production is barely available and hence has been kept out of coverage from this report.

Metal industry (2C)

This category is mainly represented through the production of iron and steel; ferroalloys; aluminium; magnesium; lead; zinc; etc.

- Tier 2 methodology is adopted for iron and steel due to advantage with country specific emission factors. Rest of the sub-categories follows Tier 1 method by using IPCC default emission factors.
- ASI is the prime source of information on input carbonaceous material within iron and steel and other metal production.
- The data for aluminium (2C3), zinc (2C5) and lead (2C6) production has been taken from IBM data. (IBM 2017)
- The data for aluminium production for the initial years was collected from United States Geological Survey (USGS 2019) and Aluminium MCX India (Aluminium - MCX India 2019)
- The state-wise share of production for aluminium, zinc and lead have been taken from the Indian Bureau of Mines' Minerals Yearbook, as represented in Annexures 10, 11 and 12.

Non-energy products from fuels and solvent use (2D)

This category predominantly includes product-use emissions arising from lubricants, paraffin wax and solvents.

- Tier 1 methodology is followed for estimating emissions from lubricants (2D1) and paraffin wax (2D2) consumption with default IPCC conversion factors. Whereas, emissions from lubricant use in coal mining activity reported under 'others (2D4)' follows Tier 2 methodology due to country-specific factors. The value of specific fuel consumption 2D4, is derived using specific fuel consumption per tonne of coal produced (taken from Central Coalfields Limited) and the total coal and lignite production (taken from the coal directory).
- Data for 2D1 and 2D2 is sourced from ASI.
- Annexure 13 highlights the state-wise production quantities of coal and lignite in India, which is used to determine coal mining-related emissions under 2D4.

3.5.3 Re-calculation

Re-calculation of IPPU emissions from the chemical industry has been carried out. The state-wise production information of various chemicals has been sourced from secondary literature sources instead of ASI database. This is because a majority of these chemicals are used as intermediates, and ASI does not provide complete information on their production/consumption. Please refer to section 3.6.2 for detailed information on the methodology. Table 3.5 D highlights the difference in emission estimates from the chemicals sector when compared to the earlier phase 2 estimates for the top 5 states in terms of emissions from the chemical sector. A detailed table of emissions can be found in the workbook associated with IPPU emissions.

Table 3.5 D: Comparison of IPPU emissions from the chemicals sector (Phase 2 and Phase 3)

State	Phase	2005	2006	2007	2008	2009	2010	2011	2012	2013
Gujarat	II	19	15	13	14	19	22	12	15	9
	III	13	13	14	14	15	16	17	17	18
Uttar Pradesh	II	1	1	1	0	1	1	15	7	2
	III	6	6	6	6	6	6	6	6	7
Rajasthan	II	0	0	0	0	0	0	1	0	0
	III	3	4	3	3	4	4	4	4	4
Maharashtra	II	4	11	13	14	13	13	12	12	22
	III	3	3	3	3	4	4	5	4	4
West Bengal	II	1	1	1	0	0	0	0	0	0
	III	3	3	3	3	3	3	4	4	4

Source: Authors' analysis

3.6 Uncertainty

In this study, uncertainty with estimated emissions may arise due to variation in activity data and associated emission factors. Such variation occurs during direct measurement or as a result of assumptions-based accounting. Since, this study is largely based on secondary data obtained from public sources, uncertainties could emerge out of three major reasons:

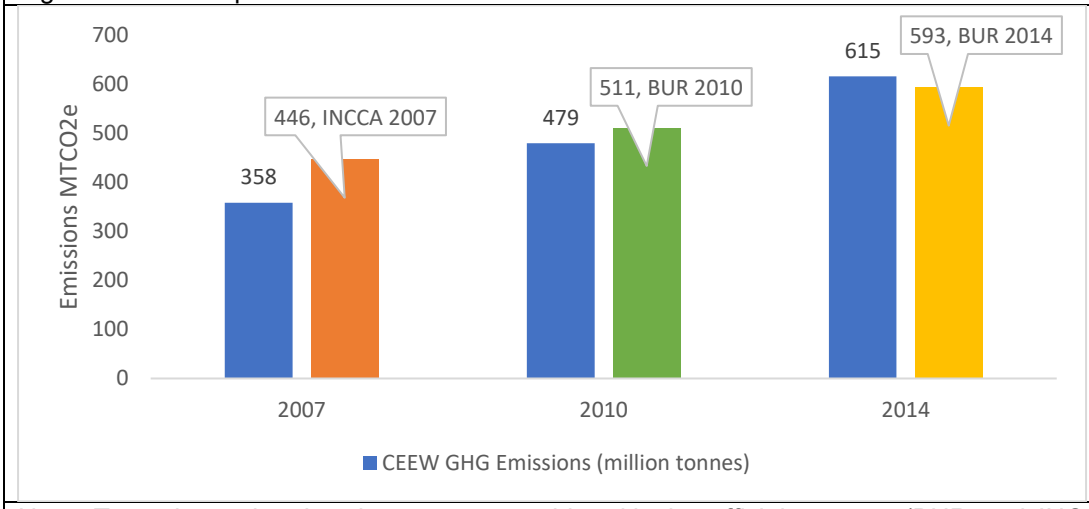
- **Coverage:** The activity data (obtained from ASI) does not cover unregistered/informal sector activities, and represent only the formally registered firms under the section 2(m)(i) and 2(m)(ii) of the Factories Act. Within the formal sector reporting, it seemingly covers all the sectors well, except mining and construction activities, where data is highly sparse.

- **Sampling:** The activity data does not cover each firm individually for specific reporting. It covers only the bigger firms, and follows a sampling design for the rest of the firms – assigning a representative multiplier to each reporting firm. The Ministry estimates errors and variance related to the sample design, and approves only the acceptable limits, however probability of uncertainty cannot be ignored. Multipliers may not be the best representation for the employment, productivity, and energy/resource use altogether for the sample survey firms. Nevertheless, the overall energy use represented by census units (larger firms) is almost 90% of the total activity data, which is consistent over the years.

- **Measurement:** The activity data (for energy use) provides an exhaustive reporting on fuel use by each firm covering more than 80 fuel types. However, lack of mandate on energy reporting allow users to dilute this information and club energy-use reporting under unspecified categories in expenditure terms. A few firms reflect mismatch between reported rates (of fuel) and its unit of measurement. Overall, such firms represent approx. 13% of the total emission estimates. A scientific approach is adopted to identify and correct 'units/rates' of erroneous entries, whereas expenditure-based reporting is approximated by mimicking trends from past reporting of the same or similar firms in each sector.

IPCC good practice guidelines (2006) suggests three approaches to estimate uncertainties: (a) comparison of results with independent data, (b) comparison from alternative models, and (c) expert judgement related to magnitude of uncertainties. In this case, quantification of the magnitude of uncertainties is difficult to achieve as: (a) no alternate source of information provides the desired level of granularity, and (b) ASI is lesser known for its utility to derive GHG estimates, hence lack of expert judgement at this point. A very high-level comparison with the official GHG estimates is possible for 2007 (INCCA),2010 (BUR) and 2014 (BUR-2), as can be noticed from **Error! Reference source not found.**. It suggests marginal deviations, which are unverified and unquantifiable due to insufficient clarity.

Figure 3.6 A: Comparison with official GHG estimates



Note: To make authors' estimates comparable with the official sources (BUR and INCCA), captive emissions within manufacturing has not been considered as latter report captive emissions in a different

category. For 2014 comparison, CEEW estimates includes captive emissions for the Iron and Steel sector only, so as to match the scope and coverage of BUR-2 estimates.
Source: Authors' analysis

Figure 3.6 A shows that except the comparison between INCCA (2007) and CEEW estimates, where INCCA is not an official submission by the Government of India; overall deviation between CEEW estimates and the official numbers from BURs is under 5%. This confirms a low uncertainty in the presented estimates. Further to this, few representations of 'low' and 'medium' activity data quality in 'key category analysis' (in the following section) also supports this conclusion.

3.7 Recommended improvements

This exercise has resulted from continual improvements through expert consultations, enhanced capacity and improved data quality for the recent years. This section recommends further improvements, and identifies how the published information could be used by a wide range of stakeholders including policy planners from state and central government(s); industry and their associations; research community; academicians, etc.

Proposed improvements

- **Frequency** of energy data published by the government agencies needs to be improved over time. Currently there is a lag of at least three to four years between the published date and reported year for energy statistics.

- **Lack of quality of information** is another barrier for improved understanding on GHG emissions. Most agencies do not collect (or publish) energy consumption records from industry units due to administrative challenges. This dilutes our understanding of the supply side perspective.

- In most cases, activity data information is made available by central agencies at an aggregated level. It is recommended that states plan for their own statistics to understand and address local level policy issues in a more scientific manner.

- Coverage of reported information is also a prominent area of improvement. For instance, ASI covers only the registered/formally operating units within the country. By excluding the informal/unregistered sector, often leaves an open space for interpretation and assumptions on the left out unregistered economy of the country. General perceptions suggest that the unregistered sector is highly energy inefficient due to lack of scale and sophisticated equipment. Thus far, not focusing on this sector is certainly a missed opportunity for India's policy planners to roll out measures towards decarbonisation.

Recently, NITI Aayog has constituted a working group on 'Energy Data Management' in India to address such challenges along with other prominent issues.

Recommended use of these estimates

- This effort is already assisting the MoEFCC, Government of India in reconciling their official estimates and seeking consultations with the authors and other experts as a quality control process. Continuation of such arrangement would be a strong indicator of success for this reporting under the collaborative effort of GHG Platform India.

- In India, each state government and Union territory has received a mandate to come up with their own State Action Plans on Climate Change (SAPCC). Thus far, 34 SAPCCs have been

received by the MoEFCC and further revision is in process to establish this as a periodic exercise. Since this reporting is a first-of-its-kind of independent effort attempted by civil society organizations to arrive at a sub-national understanding of emissions, it opens doors for extensive deliberations with state policy planning units to strengthen their climate planning and monitor the impact of such measures. At present, GHG Platform India is collectively assisting the state of Madhya Pradesh with their SAPCC revision exercise.

- Industry and their associations must take note of granular information provided in this methodology note to understand the scope and opportunities of decarbonisation before making long-term capital investments into existing and inefficient processes of manufacturing.

- Academicians and the research community could take forward this exercise for further improvements. Disaggregated information on industry estimates should be a perfect nudge to the research community to come up with more process and state-focused research outcomes.

4. Comparison with national inventories

A comparison of our GHG emissions estimates have been done with the two reference points available from India's official reporting to UNFCCC. i.e., (a) first Biennial Update Report to UNFCCC (for 2010) (MoEFCC 2015), and (b) second Biennial Update Report to UNFCCC (for 2014) (MoEFCC 2019). Table 4 A shows the comparison across different estimates:

Table 4 A: Source category wise details of deviation in GHG estimates ($MTCO_2e$) between GHGPI and official inventories published by Government of India

Consolidated comparison		***INCAA 2007***	***CEEW 2007 ****	***% difference***	***BUR 2010***	***CEEW 2010 ****	***% difference***	***BUR 2014***	***CEEW 2014 ****	***% difference***
Sl. No.	***Sector Descriptions***	***$MTCO_2$ eq***	***$MTCO_2$ eq***		***$MTCO_2$ eq***	***$MTCO_2$ eq***		***$MTCO_2$ eq***	***$MTCO_2$ eq***	
1	Iron and steel	117	129	**-10%**	96	179	**-86%**	155	224	**-44%**
2	Chemicals	33	44	**-32%**	36	51	**-40%**	30	77	**-153%**
3	Ferro alloys	2	0	**100%**	4	0	100%	2	0	100%
4	Non-ferrous metals	3	16	**-445%**	24	25	-1%	29	37	-31%
5	Non-metallic minerals	131	116	11%	145	150	-3%	174	189	-8%
6	Non-energy products from fuels	1	1	-52%	2	2	-19%	2	4	-71%
7	Refining	34	28	**4%**	42	40	6%	50	43	15%
8	Manufacturing of solid fuels		1		18	1	95%	7	1	81%
9	Other energy industry @		4		N.R	5		N.R	5	
10	**Mining^, #**	1	0	**99%**	4	0	**#**	3	0	**#**
11	Textile and leather	2	6	**-219%**	3	9	-253%	4	12	-246%
12	Food and beverages	28	3	**90%**	N.R	5		N.R	6	
13	Pulp, paper and print	5	6	**-16%**	7	8	-18%	4	12	-204%

14	Transport equipment	N.R	1		N.R	2		0.42	2	-259%
17	Machinery	N.R	4		N.R	2			3	
15	Wood and wood products	N.R	0		N.R	0		N.R	0	
16	Construction #	N.R	0	#	N.R	0	#	N.R	0	#
18	Manufacturing n.e.c, $	N.R	0		N.R	1		N.R	1	
19	Non specific industries	88	N/A		130	N/A		129	N/A	
20	Other (Pulp and paper)							3		
	Grand Total (energy-use and IPPU)	***446***	***358***	***20%***	***511***	***478***	***6.4%***	***593***	***615***	***-3.6%***
	Difference level		**20%**			**6.41%**			**-3.65%**	

Source: Authors' analysis

At an aggregated level, the deviation between our estimates and national reporting is within 7% - our estimates are 6% lower in 2010, and 4% higher in 2014. However, when analyzed at the sectoral level, it can be seen that the official estimates at the sectoral level are significantly lower compared to the CEEW estimates. One plausible explanation to the under-reporting of sectoral emissions is because they are reported under the '***non specified industries'***. The share of emissions reported under this sector was 27% in 2010 and 21% in 2014.

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List of Abbreviations

ATF	Aviation Turbine Fuel
BESCOM	Bangalore Electricity Supply Company Limited
BMTC	Bangalore Metropolitan Transport Corporation
CAGR	Compounded Annual Growth Rate
CEA	Central Electricity Authority
CEEW	Council on Energy, Environment and Water
CH_4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon dioxide
EF	Emission Factor
FO	Furnace Oil
GAIL	Gas (India) Limited
GDP	Gross Domestic Product
GGGI	Global Green Growth Initiative
GHG	Greenhouse Gas
GoI	Government of India
kT	Kilo Tonnes
HSDO	High Speed Diesel Oil
IISD	International Institute for Sustainable Development
INCCA	Indian Network on Climate Change Assessment
IPCC	Intergovernmental Panel on Climate Change
LDO	Light Diesel Oil
LPG	Liquefied Petroleum Gas
LSHS	Low Sulphur Heavy Stock
$MTCO_2e$	Million tonnes of Carbon dioxide equivalent
MOSPI	Ministry of Statistics and Programme Implementation
N_2O	Nitrous Oxide
NDC	Nationally Determined Contribution
NSSO	National Sample Survey Office
OC	Open Cast
PCMC	Per Capita Monthly Consumption
PNG	Piped Natural Gas
SAPCC	State Action Plan on Climate Change
T	Tonnes
TJ	Tera Joule
TCO_2e	Tonnes of Carbon dioxide equivalent

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Annexures

Annexure 1 Manufacturing sector GVA and emissions intensity (of GVA) trends

Financial Years (values in INR crores)													CAGR (2005 to 2015)	% Change (2005 to 2015)
Description	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16		
Manufacturing Sector GVA	793308	867475	1021780	1093106	1144085	1269564	1367258	1409986	1486873	1560709	1683938	1898790		
Calendar Years (values in INR crores)														
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015			
Manufacturing Sector GVA (Values In INR Crores)	848933	983204	1075275	1131340	1238194	1342835	1399304	1467651	1542250	1653131	1845077		8%	
Emissions (values in Million tonnes CO2eq AR2)	341	378	427	459	512	545	572	619	627	667	635		6%	
Emissions Intensity (values in Million tonnes CO2eq AR2/INR crores)	0.000402	0.000384	0.000397	0.000406	0.000414	0.000406	0.000409	0.000422	0.000407	0.000403	0.000344		-2%	-14%

Source: (MOSPI 2018)*; Please refer to Statement 3.2 for the detailed information on GVA from the manufacturing sector*

Annexure 2 Data sources for the energy and IPPU activity Data

Table 8: Activity data sources		**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
IPCC codes	***Sector/Subsector - as per IPCC, 2006 classification Data Sources Used for Emission Estimation***												
1A1	**Fuel Combustion Activities > Energy industries**												
1A1a	Main Activity Electricity and Heat production	Beyond current scope											

	(utility + captive)	
1A1b	Petroleum refining	MoP&NG
1A1c	Manufacture of Solid Fuels and other Energy Industries	
1A1ci	Manufacture of Solid Fuel	ASI data
1A1cii	Other Energy Industry	Specific fuel consumption CIL annual reports, MoPNG
1A2	**1A2: Manufacturing Industries and Construction^^**	
1A2a	Iron and Steel	ASI Data
1A2b	Non-Ferrous Metals	
1A2c	Chemicals and Fertilisers	
1A2d	Pulp, Paper and Print	
1A2e	Food Processing, Beverages and Tobacco	
1A2f	Non-metallic Minerals	
1A2g	Transport Equipment	
1A2h	Machinery	
1A2i	Mining (excluding fuels) and Quarrying	
1A2j	Wood and Wood Products	
1A2k	Construction	
1A2l	Textile and Leather	
1A2m	Non-specified Industry	
1A3	Transport	Beyond current scope
1A4	other sectors	

1A5	Non-specified					
2A	**2A Mineral Industry**					
2A1	Cement Production	Cement Manufacturing Association	IBM 2009-13	IBM 2014	IBM 2016	IBM 2017
2A2	Lime Production	ASI Data				
2A3	Glass Production					
2A4	**Other Process Uses of Carbotes**					
2A4a	Ceramics					
2A4b	Other Uses of Soda Ash					
2A4c	Non-Metallurgical Magnesia Production					
2A4d	Other					
2A5	Other					
2B	**Chemical Industry**					
2B1	Ammonia Production	ASI Data- Ministry of chemicals and fertilizers				
2B2	Nitric Acid Production	ASI Data				
2B3	Adipic Acid Production	Chemicals and Petrochemicals statistics 2014, 2015, 2016, 2017 (Ministry of chemicals and fertilizers)				
2B4	Caprolactam, Glyoxal and Glyoxylic Acid Production					
2B5	Carbide Production					
2B6	Titanium Dioxide Production					
2B7	Soda Ash Production					
2B8a	Methanol					
2B8b	Ethylene					

2B8c	Ethylene Dichloride and Vinyl Chloride Monomer								
2B8d	Ethylene Oxide								
2B8e	Acrylonitrile								
2B8f	Carbon Black								
2C	**Metal Industry**								
2C1	Iron and Steel Production	ASI Data							
2C2	Ferroalloys Production								
2C3	Aluminium Production	USGS	Aluminium MCX India	IBM mineral yearbook 2012	IBM mineral yearbook 2013	IBM mineral yearbook 2014	IBM mineral yearbook 2015	IBM Mineral Yearbook 2016	IBM Mineral Yearbook 2017
2C4	Magnesium Production	NE							
2C5	Lead Production	IBM Data	IBM Data	IBM mineral yearbook 2013	IBM mineral yearbook 2014	IBM mineral yearbook 2015	IBM Mineral Yearbook 2016		IBM Mineral Yearbook 2017
2C6	Zinc Production								
2C7	Other	ASI Data							
2D	**Non-Energy Products from Fuels and Solvent Use**								
2D1	Lubricant Use	ASI Data							
2D2	Paraffin Wax Use								
2D3	Solvent Use	NE							
2D4	Other	Lubricant use in Coal Mining							

Source: Authors' compilation

Annexure 3: Detailed topology of fuel wise (a) emission factors, (b) calorific value

			Emissions Factor (T/TJ)			
Fuel CODE	Source	Calorific Value (TJ/Gg)	CO2	CH4	N2O	Source
Anthracite (raw coal)	Domestic	19.63	95.81	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury

Coal	Domestic	18.26	93.6833	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal (Electricity)	Domestic	17.09	96.76333	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal (Cement)	Domestic	20.15	95.62667	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal (Fertiliser)	Domestic	20.4	95.55333	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal (Non-Ferrous Metals)	Domestic	18.17	96.36	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal (Pulp, Paper and Print)	Domestic	18.35	96.28667	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal (under sized)	Domestic	19.63	95.81	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Coal ash	Domestic	9.69	106.51	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Coal compressed (middlings)	Domestic	19.63	95.81	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Coal for carbonisation	Domestic	23.66	96.36	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal slack	Domestic	9.69	106.51	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Coal, not agglomerated, n.e.c.	Domestic	19.63	95.81	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Briquettes, coal, coal dust	Domestic	9.69	106.51	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Briquettes and similar solid fuels manufactured from coal, n.e.c.	Domestic	19.63	95.81	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Peat, hard/medium	Domestic	9.76	106	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Peat, other than hard/medium	Domestic	9.76	106	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Peat, n.e.c.	Domestic	9.76	106	0.001	0.0015	Determination of carbon dioxide emission factor from coal combustion - Ashim Choudhury
Lignite, not agglomerated	Domestic	9.8	105.9667	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Lignite, agglomerated	Domestic	9.8	105.9667	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)

Petroleum oils and oils obtained from bituminous minerals, crude	Domestic	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Fryon Gas	Domestic					IPCC 2006 Guidelines
Gas compressed natural	Domestic	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
liquified petroleum gas	Domestic	47.3	63.1	0.001	0.0001	IPCC 2006 Guidelines
natural gas	Domestic	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
Gas, n.e.c	Domestic	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
Asphalt (Gilsonite)	Domestic					IPCC 2006 Guidelines
Glancepitch	Domestic	38.1	73.3	0.003	0.0006	IPCC 2006 Guidelines
Shale Oil	Domestic	38.1	73.3	0.003	0.0006	IPCC 2006 Guidelines
Bituminous or oil shale and tar sands n.e.c	Domestic	8.9	107	0.001	0.0015	IPCC 2006 Guidelines
Asphalt natural	Domestic					IPCC 2006 Guidelines
Asphalt Rock	Domestic					IPCC 2006 Guidelines
Bitumen	Domestic					IPCC 2006 Guidelines
Bitumen, blown	Domestic					IPCC 2006 Guidelines
Bitumen, h.g.	Domestic					IPCC 2006 Guidelines
Bitumen and asphalt, natural; asphaltites and asphaltic rock; n.e.c	Domestic					IPCC 2006 Guidelines
Crude mineral	Domestic	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Lignite briquettes	Domestic	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Atomic energy	Domestic					IPCC 2006 Guidelines
Biogas energy	Domestic					IPCC 2006 Guidelines
Hydro-electricity	Domestic					IPCC 2006 Guidelines
Kinetic energy	Domestic					IPCC 2006 Guidelines
Other non conventional electricity	Domestic					IPCC 2006 Guidelines
solar energy	Domestic					IPCC 2006 Guidelines
steam energy	Domestic					IPCC 2006 Guidelines
Thermal electricity	Domestic					IPCC 2006 Guidelines
Wind energy	Domestic					IPCC 2006 Guidelines
Electrical energy, n.e.c	Domestic					IPCC 2006 Guidelines

Coal gas	Domestic	38.7	44.7	0.001	0.0001	IPCC 2006 Guidelines
Mafron gas	Domestic					IPCC 2006 Guidelines
Other gaseous hydrocarbons	Domestic	38.7	44.7	0.001	0.0001	IPCC 2006 Guidelines
Other than petroleum gas	Domestic	38.7	44.7	0.001	0.0001	IPCC 2006 Guidelines
Water gas	Domestic	38.7	44.7	0.001	0.0001	IPCC 2006 Guidelines
Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons;n.e.c	Domestic	38.7	44.7	0.001	0.0001	IPCC 2006 Guidelines
Briquettes, coke	Domestic	28.2	107.06	0.001	0.0015	IPCC 2006 Guidelines
Coal rejects	Domestic	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coal washed	Domestic	19.63	95.81	0.001	0.0015	IPCC 2006 Guidelines
Coke breeze	Domestic	38.7	44.7	0.001	0.0001	IPCC 2006 Guidelines
Coke cp	Domestic	28.2	107.06	0.001	0.0015	IPCC 2006 Guidelines
Coke dust	Domestic	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke hard	Domestic	28.2	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke mixed	Domestic	28.2	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke peat	Domestic	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke seme	Domestic	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke soft	Domestic	28.2	106.51	0.001	0.0015	IPCC 2006 Guidelines
Lignite briquettes	Domestic	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke and semi-coke of coal, of lignite or of peat; retort carbon n.e.c	Domestic	28.2	106.51	0.001	0.0015	IPCC 2006 Guidelines
Benzol	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar by-product	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar crude	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar Oil	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar peat	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar processed	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar product	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Tar from Coal or Lignite	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines

Fuel, aviation turbine	Domestic	44.3	69.3	0.003	0.0006	IPCC 2006 Guidelines
Petrol / motor spirit/ gasoline	Domestic	44.3	69.3	0.003	0.0006	IPCC 2006 Guidelines
Motor spirit (gasolene), including aviation spirit n.e.c	Domestic	44.3	69.3	0.003	0.0006	IPCC 2006 Guidelines
Spirit type (gasolene type) jet fuel	Domestic	44.3	69.3	0.003	0.0006	IPCC 2006 Guidelines
Light petroleum oil	Domestic	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Other light petroleum oils and light oils obtained from bituminous minerals n.e.c	Domestic	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Kerosene	Domestic	43.8	71.9	0.003	0.0006	IPCC 2006 Guidelines
Superior kerosene	Domestic	44.1	71.6	0.003	0.0006	IPCC 2006 Guidelines
Kerosene n.e.c	Domestic	43.8	71.9	0.003	0.0006	IPCC 2006 Guidelines
Kerosene type jet fuel	Domestic	44.1	71.6	0.003	0.0006	IPCC 2006 Guidelines
Diesel	Domestic	43	74.1	0.003	0.0006	IPCC 2006 Guidelines
High speed diesel	Domestic	43	74.1	0.003	0.0006	IPCC 2006 Guidelines
Medium petroleum oil, n.e.c.	Domestic	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Gas oils	Domestic	43	74.1	0.003	0.0006	IPCC 2006 Guidelines
Fuel oils n.e.c	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Furnace oil	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Grease, petroleum etc.	Domestic	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Oil lubricating used in spindle/ spinnings the like	Domestic	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Oil used for tempering	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil used in leather	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil used in transformer	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, base	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, c.p.w	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, cuttings	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, middle	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, mineral white	Domestic	40.4	73.3	0.003	0.0006	IPCC 2006 Guidelines
Oil, solvent	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, used in hydrolic machine	Domestic	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines

Para cresol	Domestic	44.5	73.3	0.003	0.0006	IPCC 2006 Guidelines
Lubricating pet	Domestic	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Compressed natural gas (CNG)	Domestic	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
Gas natural	Domestic	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
Liquid or liquid gas fuel for lighter	Domestic	40.4	73.3	0.003	0.0006	IPCC 2006 Guidelines
Liquidified petroleum gas (LPG)	Domestic	47.3	63.1	0.001	0.0001	IPCC 2006 Guidelines
Propane and butanes, liquefied, n.e.c.	Domestic	47.3	63.1	0.001	0.0001	IPCC 2006 Guidelines
Butadiene	Domestic					IPCC 2006 Guidelines
Butylene	Domestic					IPCC 2006 Guidelines
C-4 Raffinate	Domestic					IPCC 2006 Guidelines
Ethylene	Domestic					IPCC 2006 Guidelines
Isobutylene	Domestic					IPCC 2006 Guidelines
N-butene	Domestic					IPCC 2006 Guidelines
Polyisobutylene, PIB	Domestic					IPCC 2006 Guidelines
Propylene	Domestic					IPCC 2006 Guidelines
all gases, except natural gas n.e.c	Domestic					IPCC 2006 Guidelines
Bituminous oil	Domestic	8.9	107	0.001	0.0015	IPCC 2006 Guidelines
Paraffin incl wax	Domestic	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Petroleum coke	Domestic	32.5	97.5	0.003	0.0006	IPCC 2006 Guidelines
Petroleum coke calcined	Domestic	32.5	97.5	0.003	0.0006	IPCC 2006 Guidelines
Petroleum jelly	Domestic	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Tarfelt	Domestic	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Wax chlorinated paraffin	Domestic	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Wax polythene	Domestic	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Petroleum products obtained from bitumen n.e.c.	Domestic	8.9	107	0.003	0.0006	IPCC 2006 Guidelines
Ammonia gas	Domestic					IPCC 2006 Guidelines
Ammonia liquid	Domestic					IPCC 2006 Guidelines
Coal tar processed	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines

Coal tar, crude	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar, pitch	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Oil, coal tar	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Pitch other than hard/medium	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Pitch, hard/medium	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Other coal tar oil pitch products, n.e.c.	Domestic	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Urea	Domestic					IPCC 2006 Guidelines
Urea, others	Domestic					
Ammonium sulphate	Domestic					
Ammonium nitrate	Domestic					
Emulsifier / batching oil (excl. wax emulsifier	Domestic					
Emulsifier agents (non-photo sensitive)	Domestic					
Paint	Domestic					
Painting oil	Domestic					
Paints (paste) other than alum paste	Domestic					
Paints epoxy, Epoxy powder and liquid	Domestic					
Paints, bituminious/ coal tar	Domestic					
Paints, enamels	Domestic					
Paints, plastic emulsion	Domestic					
Liquefied petroleum gas (LPG) cylinders of on and steel	Domestic					
Coal consumed	Domestic	18.26	93.6833	0.001	0.0015	India's Second Biennial Update Report (BUR) to United Nations Framework Convention on Climate Change (UNFCCC)
Coal consumed (Electricity)	Domestic	17.09	96.76333	0.001	0.0015	
Coal consumed (Cement)	Domestic	20.15	95.62667	0.001	0.0015	
Coal consumed (Fertiliser)	Domestic	20.4	95.55333	0.001	0.0015	
Coal consumed (Non-Ferrous Metals)	Domestic	18.17	96.36	0.001	0.0015	
Coal consumed (Pulp, Paper and Print)	Domestic	18.35	96.28667	0.001	0.0015	
Petrol, diesel, oil, lubricants consumed	Domestic			0.003	0.0006	IPCC 2006 Guidelines

Gas consumed	Domestic	0	0	0.001	0.0001	IPCC 2006 Guidelines
Other fuel consumed	Domestic	0	0	0	0	IPCC 2006 Guidelines
Anthracite (raw coal)	Import	26.7	98.3	0.001	0.0015	IPCC 2006 Guidelines
Coal	Import	25.8	94.6	0.001	0.0015	IPCC 2006 Guidelines
Coal (under sized)	Import	19.63	95.81	0.001	0.0015	IPCC 2006 Guidelines
Coal ash	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coal compressed (middlings)	Import	26.7	98.3	0.001	0.0015	IPCC 2006 Guidelines
Coal for carbonisation	Import	28.2	94.6	0.001	0.0015	IPCC 2006 Guidelines
Coal slack	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coal, not agglomerated, n.e.c.	Import	26.7	98.3	0.001	0.0015	IPCC 2006 Guidelines
Briquettes, coal, coal dust	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Briquettes and similar solid fuels manufactured from coal, n.e.c.	Import	26.7	98.3	0.001	0.0015	IPCC 2006 Guidelines
Peat, hard/medium	Import	9.76	106	0.001	0.0015	IPCC 2006 Guidelines
Peat, other than hard/medium	Import	9.76	106	0.001	0.0015	IPCC 2006 Guidelines
Peat, n.e.c.	Import	9.76	106	0.001	0.0015	IPCC 2006 Guidelines
Lignite, not agglomerated	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Lignite, agglomerated	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Petroleum oils and oils obtained from bituminous minerals, crude	Import	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Fryon Gas	Import					
Gas compressed natural	Import	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
liquified petroleum gas	Import	47.3	63.1	0.001	0.0001	IPCC 2006 Guidelines
natural gas	Import	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
Gas, n.e.c	Import	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
Asphalt (Gilsonite)	Import					
Glancepitch	Import	38.1	73.3	0.003	0.0006	IPCC 2006 Guidelines
Shale Oil	Import	38.1	73.3	0.003	0.0006	IPCC 2006 Guidelines
Bituminous or oil shale and tar sands n.e.c	Import	8.9	107	0.001	0.0015	IPCC 2006 Guidelines
Asphalt natural	Import					

Asphalt Rock	Import					
Bitumen	Import					
Bitumen, blown	Import					
Bitumen, h.g.	Import					
Bitumen and asphalt, natural; asphaltites and asphaltic rock; n.e.c	Import					
Crude mineral	Import			0.003	0.0006	IPCC 2006 Guidelines
Lignite briquettes	Import			0.001	0.0015	IPCC 2006 Guidelines
Atomic energy	Import					
Biogas energy	Import					
Hydro-electricity	Import					
Kinetic energy	Import					
Other non conventional electricity	Import					
solar energy	Import					
steam energy	Import					
Thermal electricity	Import					
Wind energy	Import					
Electrical energy, n.e.c	Import					
Coal gas	Import			0.001	0.0001	IPCC 2006 Guidelines
Mafron gas	Import					
Other gaseous hydrocarbons	Import			0.001	0.0001	IPCC 2006 Guidelines
Other than petroleum gas	Import			0.001	0.0001	IPCC 2006 Guidelines
Water gas	Import			0.001	0.0001	IPCC 2006 Guidelines
Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons;n.e.c	Import			0.001	0.0001	IPCC 2006 Guidelines
Briquettes, coke	Import	28.2	107.06	0.001	0.0015	IPCC 2006 Guidelines
Coal rejects	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coal washed	Import	25.8	94.6	0.001	0.0015	IPCC 2006 Guidelines
Coke breeze	Import	38.7	44.7	0.001	0.0001	IPCC 2006 Guidelines

Coke cp	Import	28.2	107.06	0.001	0.0015	IPCC 2006 Guidelines
Coke dust	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke hard	Import	28.2	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke mixed	Import	28.2	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke peat	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke seme	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke soft	Import	28.2	106.51	0.001	0.0015	IPCC 2006 Guidelines
Lignite briquettes	Import	9.69	106.51	0.001	0.0015	IPCC 2006 Guidelines
Coke and semi-coke of coal, of lignite or of peat; retort carbon n.e.c	Import	28.2	106.51	0.001	0.0015	IPCC 2006 Guidelines
Benzol	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar by-product	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar crude	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar Oil	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar peat	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar processed	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar product	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Tar from Coal or Lignite	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Fuel, aviation turbine	Import	44.3	69.3	0.003	0.0006	IPCC 2006 Guidelines
Petrol / motor spirit/ gasoline	Import	44.3	69.3	0.003	0.0006	IPCC 2006 Guidelines
Motor spirit (gasolene), including aviation spirit n.e.c	Import	44.3	69.3	0.003	0.0006	IPCC 2006 Guidelines
Spirit type (gasolene type) jet fuel	Import	44.3	69.3	0.003	0.0006	IPCC 2006 Guidelines
Light petroleum oil	Import	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Other light petroleum oils and light oils obtained from bituminous minerals n.e.c	Import	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Kerosene	Import	43.8	71.9	0.003	0.0006	IPCC 2006 Guidelines
Superior kerosene	Import	44.1	71.6	0.003	0.0006	IPCC 2006 Guidelines
Kerosene n.e.c	Import	43.8	71.9	0.003	0.0006	IPCC 2006 Guidelines
Kerosene type jet fuel	Import	44.1	71.6	0.003	0.0006	IPCC 2006 Guidelines
Diesel	Import	43	74.1	0.003	0.0006	IPCC 2006 Guidelines

High speed diesel	Import	43	74.1	0.003	0.0006	IPCC 2006 Guidelines
Medium petroleum oil, n.e.c.	Import	42.3	73.3	0.003	0.0006	IPCC 2006 Guidelines
Gas oils	Import	43	74.1	0.003	0.0006	IPCC 2006 Guidelines
Fuel oils n.e.c	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Furnace oil	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Grease, petroleum etc.	Import	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Oil lubricating used in spindle/ spinnings the like	Import	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Oil used for tempering	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil used in leather	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil used in transformer	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, base	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, c.p.w	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, cuttings	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, middle	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, mineral white	Import	40.4	73.3	0.003	0.0006	IPCC 2006 Guidelines
Oil, solvent	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Oil, used in hydrolic machine	Import	40.4	77.4	0.003	0.0006	IPCC 2006 Guidelines
Para cresol	Import	44.5	73.3	0.003	0.0006	IPCC 2006 Guidelines
Lubricating pet	Import	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Compressed natural gas (CNG)	Import	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
Gas natural	Import	48	56.1	0.001	0.0001	IPCC 2006 Guidelines
Liquid or liquid gas fuel for lighter	Import	40.4	73.3	0.003	0.0006	IPCC 2006 Guidelines
Liquidified petroleum gas (LPG)	Import	47.3	63.1	0.001	0.0001	IPCC 2006 Guidelines
Propane and butanes, liquefied, n.e.c.	Import	47.3	63.1	0.001	0.0001	IPCC 2006 Guidelines
Butadiene	Import					
Butylene	Import					
C-4 Raffinate	Import					
Ethylene	Import					
	Import					

N-butene	Import					
Polyisobutylene, P	Import					
Propylene	Import					
all gases, except natural gas n.e.c	Import					
Bituminous oil	Import	8.9	107	0.001	0.0015	IPCC 2006 Guidelines
Paraffin incl wax	Import	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Petroleum coke	Import	32.5	97.5	0.003	0.0006	IPCC 2006 Guidelines
Petroleum coke calcined	Import	32.5	97.5	0.003	0.0006	IPCC 2006 Guidelines
Petroleum jelly	Import	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Tarfelt	Import	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Wax chlorinated paraffin	Import	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Wax polythene	Import	40.2	73.3	0.003	0.0006	IPCC 2006 Guidelines
Petroleum products obtained from bitumen n.e.c.	Import	8.9	107	0.003	0.0006	IPCC 2006 Guidelines
Ammonia gas	Import					
Ammonia liquid	Import					
Coal tar processed	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar, crude	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal tar, pitch	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Oil, coal tar	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Pitch other than hard/medium	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Pitch, hard/medium	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Other coal tar oil pitch products, n.e.c.	Import	28	80.7	0.001	0.0015	IPCC 2006 Guidelines
Coal consumed	Import	25.8	94.6	0.001	0.0015	IPCC 2006 Guidelines
Petrol, diesel, oil, lubricants consumed	Import	0	0	0.003	0.0006	IPCC 2006 Guidelines
Gas consumed	Import	0	0	0.001	0.0001	IPCC 2006 Guidelines
Other fuel consumed	Import	0	0	0	0	

Source: Authors' compilation

Annexure 4: Classification of hydrocarbons as feedstock

	Treat as feedstock (if output NPCMS/ASICC is matching as fuel/non-energy product form this list)	
Detailed description of fuel material	**NIC-08 codes (to be treated as a feedstock and later have to perform mass balance)**	**NIC-04 codes (to be treated as a feedstock and later have to perform mass balance)**
Anthracite (raw coal)	191, 35	231, 40
Coal	191, 35	231, 40
Coal (under sized)	191, 35	231, 40
Coal ash	191, 35,2394	231, 40, (new: 2694)
Coal compressed (middlings)	191, 35	231, 40
Coal for carbonisation	191, 35, 22	231, 40, 25
Coal slack	191, 35	231, 40
Coal, not agglomerated, n.e.c.	191, 35	231, 40
Briquettes, coal, coal dust	191, 35	231, 40
Briquettes and similar solid fuels manufactured from coal, n.e.c.	191, 35	231, 40
Peat, hard/medium	191, 35	231, 40
Peat, other than hard/medium	191, 35	231, 40
Peat, n.e.c.	191, 35	231, 40
Lignite, not agglomerated	191, 35	231, 40
Lignite, agglomerated	191, 35	231, 40
Gas compressed natural	19203, 35, 20121, 20122, 20123	23203, 40, 24123, 24124, 24122, 24121
liquified petroleum gas	19203,35	23203, 40
natural gas	19203, 35, 20121, 20122, 20123	23203, 40, 24123, 24124, 24122, 24121
Gas, n.e.c	19203, 35, 20121, 20122, 20123	23203, 40, 24123, 24124, 24122, 24121
Shale Oil	19201, 19202, 19209, 35, 2022, 2023, 2211	23201, 23202, 23209, 40, 2422, 2424, 2511
Lignite briquettes	191, 35	231, 40
Coal gas	191, 35	231, 40
Other gaseous hydrocarbons	19203, 35	23203, 40
Briquettes, coke	191, 35	231, 40
Coal rejects	191, 35	231, 40
Coal washed	191, 35	231, 40
Coke breeze	191, 35	231, 40

Coke cp	191, 35	231, 40
Coke dust	191, 35	231, 40
Coke hard	191, 35	231, 40
Coke mixed	191, 35	231, 40
Coke peat	191, 35	231, 40
Coke seme	191, 35	231, 40
Coke soft	191, 35	231, 40
Coke and semi-coke of coal, of lignite or of peat; retort carbon n.e.c	191, 35, 22	231, 40, 25
Benzol	191, 35, 20, 21	231, 40, 24, 2423
Coal tar by-product	191, 35	231, 40
Coal tar crude	191, 35	231, 40
Coal tar Oil	191, 35	231, 40
Coal tar peat	191, 35, 22, 27	231, 40, 25, 31
Coal tar processed	191, 35	231, 40
Coal tar product	191, 35	231, 40
Tar from Coal or Lignite	191, 35	231, 40
Fuel, aviation turbine	19202, 19209, 2021, 2022, 2023, 1811	23202, 23209, 2421, 2422, 2424, 2221
Light petroleum oil	19202, 19209, 2022, 2023	23202, 23209, 2422, 2424
Other light petroleum oils and light oils obtained from bituminous minerals n.e.c	19202, 19209, 2022, 2023	23202, 23209, 2422, 2424
Kerosene	19202, 19209, 2021, 2022, 2023, 1811	23202, 23209, 2421, 2422, 2424, 2221
Superior kerosene	19202, 19209, 2021, 2022, 2023, 1811	23202, 23209, 2421, 2422, 2424, 2221
Kerosene n.e.c	19202, 19209, 2021, 2022, 2023, 1811	23202, 23209, 2421, 2422, 2424, 2221
Kerosene type jet fuel	19202, 19209, 2021, 2022, 2023, 1811	23202, 23209, 2421, 2422, 2424, 2221
Medium petroleum oil, n.e.c.	19202, 19209, 2022, 2023	23202, 23209, 2422, 2424
Gas oils	19202, 19209, 2022, 2023	23202, 23209, 2422, 2424
Fuel oils n.e.c	19202, 19209, 2022, 2023	23202, 23209, 2422, 2424
Furnace oil	19202, 19209, 2022, 2023	23202, 23209, 2422, 2424
Compressed natural gas (CNG)	19203, 35, 20121, 20122, 20123	23203, 40, 24123, 24124, 24122, 24121
Gas natural	19203, 35, 20121, 20122, 20123	23203, 40, 24123, 24124, 24122, 24121
Liquid or liquid gas fuel for lighter	19203,35	23203, 40

Liquidified petroleum gas (LPG)	19203, 35	23203, 40
Propane and butanes, liquefied, n.e.c.	19203, 35	23203, 40
Petroleum coke	23994, 24202, 19202, 19209, 35, 2022, 2023, 2211	26994, 27203, 23202, 23209, 40, 2422, 2424, 2511
Petroleum coke calcined	23994, 24202, 19202, 19209, 35, 2022, 2023, 2211	26994, 27203, 23202, 23209, 40, 2422, 2424, 2511
Petroleum products obtained from bitumen n.e.c.	19201, 19202, 19209, 2022, 2023	23201, 23202, 23209, 24124, 24122, 24121
Coal tar, crude	191, 35	231, 40
Coal tar, pitch	191, 35	231, 40
Oil, coal tar	191, 35	231, 40
Pitch other than hard/medium	191, 35	231, 40
Pitch, hard/medium	191, 35	231, 40
Other coal tar oil pitch products, n.e.c.	191, 35	231, 40
Gas consumed	19203, 35, 20121, 20122, 20123	23203, 40, 24123, 24124, 24122, 24121

Source: Authors' compilation

Annexure 5: Conversion factors used for different fuel types

Description	Conversion Factor
Anthracite (raw coal)	1
Benzol	1
Briquettes and similar solid fuels manufactured from coal, n.e.c.	1
Briquettes, coal, coal dust	1
Briquettes, coke	1
Coal	1
Coal (under sized)	1
Coal ash	1
Coal bed Methane	1
Coal compressed (middlings)	1
Coal consumed	1
Coal for carbonisation	1
Coal gas	1

Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons;n.e.c	1
Coal rejects	1
Coal slack	1
Coal tar by-product	1
Coal tar crude	1
Coal tar Oil	1
Coal tar peat	1
Coal tar processed	1
Coal tar product	1
Coal tar, crude	1
Coal tar, pitch	1
Coal washed	1
Coal, not agglomerated, n.e.c.	1
Coke and semi-coke of coal, of lignite or of peat; retort carbon n.e.c	1
Coke breeze	1
Coke cp	1
Coke dust	1
Coke hard	1
Coke mixed	1
Coke peat	1
Coke seme	1
Coke soft	1
Diesel	0.837520938
Fuel oils n.e.c	0.9765625
Fuel, aviation turbine	0.798722045
Furnace oil	0.000976563
Gas compressed natural	0.000711238
Gas consumed	0.000711238

Gas oils	0.856164384
Gas, n.e.c	1
High speed diesel	0.826446281
Kerosene	0.798722045
Kerosene n.e.c	0.798722045
Kerosene type jet fuel	1
Light petroleum oil	0.862068966
Lignite briquettes	1
Lignite, agglomerated	1
Lignite, not agglomerated	1
Liquid or liquid gas fuel for lighter	1
Liquidified petroleum gas (LPG)	1
Liquified natural gas	0.00045
Medium petroleum oil, n.e.c.	0.825082508
Motor spirit (gasolene), including aviation spirit n.e.c	0.734214391
natural gas	0.000711238
Oil, coal tar	1
Other coal tar oil pitch products, n.e.c.	1
Other gaseous hydrocarbons	1
Other light petroleum oils and light oils obtained from bituminous minerals n.e.c	0.862068966
Other than petroleum gas	1
Peat, hard/medium	1
Peat, n.e.c.	1
Peat, other than hard/medium	1
Petrol / motor spirit/ gasoline	1
Petrol, diesel, oil, lubricants consumed	
Petroleum coke	1
Petroleum coke calcined	1
Petroleum products obtained from bitumen n.e.c.	1
Pitch other than hard/medium	1

Pitch, hard/medium	1
Propane and butanes, liquefied, n.e.c.	1
Re-gasified LNG	0.000711238
Shale Oil	1
Spirit type (gasolene type) jet fuel	0.8
Superior kerosene	0.778210117
Tar from Coal or Lignite	1
Water gas	1

Source: Authors' compilation

Annexure 6: Distribution of liquid fuel consumption across manufacturing sectors

	NIC 2008 codes at 2-digit level																		
Fuel Type	10	11	13	15	17	18	19	20	21	22	23	24	25	26	27	28	29	30	32
Diesel	0%	0%	0%	13%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fuel oils n.e.c	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	3%	0%
Fuel, aviation turbine	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%
Furnace oil	94%	100 %	99%	0%	0%	0%	0%	79%	100 %	0%	58%	99%	100 %	98%	83%	0%	94%	0%	0%
Gas oils	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
High speed diesel	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	97%	0%	0%	0%
Kerosene	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Kerosene n.e.c	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Light petroleum oil	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Liquidified petroleum gas (LPG)	0%	0%	0%	0%	100 %	0%	100 %	20%	0%	76%	0%	0%	0%	2%	16%	0%	2%	97%	100 %
Medium petroleum oil, n.e.c.	0%	0%	0%	0%	0%	99%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Other light petroleum oils and light oils obtained from bituminous minerals n.e.c	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Petroleum coke	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%	1%	0%	0%	0%	0%	0%	0%	0%
Petroleum coke calcined	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%
Petroleum products obtained from bitumen n.e.c.	6%	0%	0%	87%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Shale Oil	0%	0%	0%	0%	0%	0%	0%	1%	0%	16%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Superior kerosene	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Grand Total	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

Source: Authors' analysis

Annexure 7: Emission factors for IPPU emissions

Metal/Chemical/Mineral	Emission Factor (CO_2)	Emission Factor (CH_4)	Emission Factor (N_2O)	Unit
Cement	0.537			tCO_2/tclinker
Ammonia	1.76715			tCO_2/tproduct
Nitric Acid			0.01	tCO_2/tproduct
Adipic Acid			0.3	tCO_2/tproduct
Caprolactum			0.009	tCO_2/tproduct
Glyoxal			0.0052	
Calcium Carbide	1.1			tCO_2/tproduct
Titanium Dioxide	1.385			tCO_2/tproduct
Soda Ash	0.138			tCO_2/tproduct
Methanol	0.67	0.023		tCO_2/tproduct
Ethylene	1.73	0.003		tCO_2/tproduct
Ethylene Dichloride	0.296			tCO_2/tproduct
Vinyl Chloride	0.47	0.00226		tCO_2/tproduct
Ethylene Oxide	0.863	1.79		tCO_2/tproduct
Acrylonitrile	1	0.18		tCO_2/tproduct
Carbon Black	2.62	0.06		tCO_2/tproduct
Aluminium	1.65			tCO_2/tmetal
Lead	0.52			tCO_2/tmetal
Zinc	0.53			tCO_2/tmetal
Lubricant Use in Coal mining	73			tCO_2/tonne

Source: Authors' compilation

Annexure 8: State-wise production of cement

State	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Haryana	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%
Punjab	3%	3%	3%	3%	0%	3%	2%	2%	2%	2%	2%	2%
Rajasthan	14%	14%	14%	15%	16%	16%	16%	17%	17%	17%	17%	17%
Himachal Pradesh	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Delhi	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Jammu & kashmir	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Uttarakhand	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%
Assam	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Meghalaya	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Bihar	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Jharkhand	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Odisha	2%	2%	2%	2%	3%	2%	3%	2%	2%	2%	2%	2%
West Bengal	2%	2%	2%	2%	2%	3%	3%	3%	3%	3%	3%	3%
Chattisgarh	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Andhra Pradesh	14%	14%	15%	15%	16%	15%	14%	13%	13%	13%	13%	13%
Tamil Nadu	10%	10%	11%	11%	11%	11%	10%	10%	10%	10%	10%	10%
Karnataka	7%	7%	7%	6%	7%	7%	7%	7%	7%	7%	7%	7%
Kerela	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gujarat	10%	10%	10%	9%	8%	8%	8%	9%	9%	9%	9%	9%
Maharashtra	8%	8%	8%	8%	8%	7%	6%	7%	7%	7%	7%	7%
Uttar Pradesh	3%	3%	3%	3%	3%	4%	5%	5%	5%	5%	5%	5%
Madhya Pradesh	12%	12%	12%	12%	11%	11%	10%	10%	10%	10%	10%	10%

Due to unavailability of data source after 2011-12, the share is kept same as observed in 2011-12

Source: Authors' compilation, Loksabha XIV Question 3596, Lokshabha XV Question 4062

Annexure 9: State – wise production of chemicals covered under IPPU emissions

IPCC Sector	*Description*		*Production (000 MT)*											
2B	***Chemical Industry***		***2004-05***	***2005-06***	***2006-07***	***2007-08***	***2008-09***	***2009-10***	***2010-11***	***2011-12***	***2012-13***	***2013-14***	***2014-15***	***2015-16***
2B1	Ammonia Production	Total Production	11480.85	11387.35	11507.13	11252.34	11286.56	11961.50	12397.65	12455.14	12790.79	12869.88	12796.10	13866.98
	Gujarat	Prod. Capacity	32.64%	32.64%	32.64%	32.64%	32.64%	32.64%	32.64%	32.64%	32.64%	32.64%	32.64%	32.64%
		Production	3747.35	3716.83	3755.93	3672.76	3683.93	3904.23	4046.59	4065.36	4174.91	4200.73	4176.65	4526.18
	Uttar Pradesh	Prod. Capacity	25.19%	25.19%	25.19%	25.19%	25.19%	25.19%	25.19%	25.19%	25.19%	25.19%	25.19%	25.19%
		Production	2892.03	2868.47	2898.65	2834.46	2843.08	3013.10	3122.97	3137.45	3222.00	3241.92	3223.34	3493.09
	Rajasthan	Prod. Capacity	16.95%	16.95%	16.95%	16.95%	16.95%	16.95%	16.95%	16.95%	16.95%	16.95%	16.95%	16.95%
		Production	1946.00	1930.16	1950.46	1907.27	1913.07	2027.47	2101.40	2111.15	2168.04	2181.44	2168.94	2350.45
	Andhra Pradesh	Prod. Capacity	3.34%	3.34%	3.34%	3.34%	3.34%	3.34%	3.34%	3.34%	3.34%	3.34%	3.34%	3.34%
		Production	383.46	380.34	384.34	375.83	376.97	399.51	414.08	416.00	427.21	429.85	427.39	463.16
	West Bengal	Prod. Capacity	10.24%	10.24%	10.24%	10.24%	10.24%	10.24%	10.24%	10.24%	10.24%	10.24%	10.24%	10.24%
		Production	1175.64	1166.06	1178.33	1152.24	1155.74	1224.86	1269.52	1275.41	1309.78	1317.88	1310.32	1419.98
	Maharashtra	Prod. Capacity	7.45%	7.45%	7.45%	7.45%	7.45%	7.45%	7.45%	7.45%	7.45%	7.45%	7.45%	7.45%
		Production	855.32	848.36	857.28	838.30	840.85	891.13	923.63	927.91	952.91	958.81	953.31	1033.09
	Kerala	Prod. Capacity	4.19%	4.19%	4.19%	4.19%	4.19%	4.19%	4.19%	4.19%	4.19%	4.19%	4.19%	4.19%
		Production	481.05	477.13	482.15	471.47	472.91	501.19	519.46	521.87	535.93	539.25	536.16	581.03
2B2	Nitric Acid Production	Total Production	Not Available											
2B3	Adipic Acid Production	Total Production	Not Available											
2B4	Caprolactam, Glyoxal and Glyoxylic Acid Production													

	Caprolactum	Total Production	122	117	121	86	84	123	123	118	99	85	87	86
	Kerala	Prod. Capacity	41.70%	41.70%	41.70%	41.70%	41.70%	41.70%	41.70%	41.70%	41.70%	41.70%	41.70%	41.70%
		Production	50.874	48.789	50.457	35.862	35.028	51.291	51.291	49.206	41.283	35.445	36.279	35.862
	Gujarat	Prod. Capacity	58.30%	58.30%	58.30%	58.30%	58.30%	58.30%	58.30%	58.30%	58.30%	58.30%	58.30%	58.30%
		Production	71.126	68.211	70.543	50.138	48.972	71.709	71.709	68.794	57.717	49.555	50.721	50.138
	Glyoxal	Not Available												
	Glyoxalic Acid													
2B5	Carbide Production													
	Calcium Carbide	Total Production	52.73	64.64	91.95	97.41	66.55	22.02	44.7	66.39	70.98	78.78	87.18	83.47
	Rajasthan	Prod. Capacity	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Production	52.73	64.64	91.95	97.41	66.55	22.02	44.7	66.39	70.98	78.78	87.18	83.47
2B6	Titanium Dioxide Production	Total Production	57.56	60.29	62.92	59.15	53.28	61.32	64.02	52.14	50.14	52.78	47.88	58.83
	Kerala	Prod. Capacity	77%	77%	77%	77%	77%	77%	77%	77%	77%	77%	82%	82%
		Production	44.3212	46.4233	48.4484	45.5455	41.0256	47.2164	49.2954	40.1478	38.6078	40.6406	39.2616	48.2406
	Tamil Nadu	Prod. Capacity	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	18%	18%
		Production	13.2388	13.8667	14.4716	13.6045	12.2544	14.1036	14.7246	11.9922	11.5322	12.1394	8.6184	10.5894
2B7	Soda Ash Production	Total Production	2287.24	2298.24	2078.06	2005.51	1989.05	2058.34	2298.76	2410.82	2437.79	2392.17	2462	2583.01
	Gujarat	Prod. Capacity	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%
		Production	2195.7504	2206.3104	1994.9376	1925.2896	1909.488	1976.0064	2206.8096	2314.3872	2340.2784	2296.4832	2363.52	2479.6896
	Kerala	Prod. Capacity	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
		Production	91.4896	91.9296	83.1224	80.2204	79.562	82.3336	91.9504	96.4328	97.5116	95.6868	98.48	103.3204

2B8	Petrochemical and Carbon Black Production													
2B8a	Methanol	Total Production	392.2	386.76	396.23	351.73	237.12	330.83	374.53	359.93	254.91	307.26	209.83	162.62
	Gujarat	Prod. Capacity	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%
		Production	188.256	84253.44	37367.04	31257.6	37935.36	39356.16	63225.6	64504.32	61804.8	44897.28	39498.24	40492.8
	Maharashtra	Prod. Capacity	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%
		Production	168.646	75477.04	33474.64	28001.6	33983.76	35256.56	56639.6	57785.12	55366.8	40220.48	35383.84	36274.8
	Assam	Prod. Capacity	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
		Production	35.298	15797.52	7006.32	5860.8	7112.88	7379.28	11854.8	12094.56	11588.4	8418.24	7405.92	7592.4
2B8b	Ethylene	Total Production	2645	2719	2683	2810	2639	2515	2665	3320	3315	3346	3192	3727
	Gujarat	Prod. Capacity	51%	51%	51%	51%	51%	51%	51%	51%	51%	51%	54%	51%
		Production	1352.35	1390.18	1371.78	1436.71	1349.28	1285.88	1362.57	1697.46	1694.91	1710.76	1720.84	1905.56
	Maharashtra	Prod. Capacity	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	9%	8%
		Production	221.87	228.08	225.06	235.71	221.37	210.96	223.55	278.49	278.07	280.67	290.50	312.63
	Uttar Pradesh	Prod. Capacity	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	11%	10%
		Production	264.13	271.52	267.92	280.61	263.53	251.15	266.13	331.54	331.04	334.13	345.83	372.18
	West Bengal	Prod. Capacity	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	8%	13%
		Production	353.93	363.84	359.02	376.01	353.13	336.54	356.61	444.26	443.59	447.74	242.08	498.72
	Haryana	Prod. Capacity	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	19%	17%
		Production	452.72	465.39	459.22	480.96	451.69	430.47	456.14	568.25	567.40	572.70	592.75	637.91
2B8c	Ethylene Dichloride and Vinyl Chloride Monomer													
	Ethylene Dichloride	Total Production	593	263	220	267	277	445	454	435	316	278	285	277

	Gujarat	Prod. Capacity	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Production	593	263	220	267	277	445	454	435	316	278	285	277
	Vinyl Chloride Monomer	Total Production	541	308	280	289	303	674	672	689	669	735	718	791
	Gujarat	Prod. Capacity	71.10%	71.10%	71.10%	71.10%	71.10%	71.10%	71.10%	71.10%	71.10%	71.10%	71.10%	71.10%
		Production	384.651	218.988	199.08	205.479	215.433	479.214	477.792	489.879	475.659	522.585	510.498	562.401
	Maharashtra	Prod. Capacity	28.90%	28.90%	28.90%	28.90%	28.90%	28.90%	28.90%	28.90%	28.90%	28.90%	28.90%	28.90%
		Production	156.349	89.012	80.92	83.521	87.567	194.786	194.208	199.121	193.341	212.415	207.502	228.599
2B8d	Ethylene Oxide	Total Production	79	88	96	114	117	154	164	169	172	191	185	188
	Uttarakhand	Prod. Capacity	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%
		Production	0.02	0.03	0.03	0.03	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06
	Maharashtra	Prod. Capacity	17.88%	17.88%	17.88%	17.88%	17.88%	17.88%	17.88%	17.88%	17.88%	17.88%	17.88%	17.88%
		Production	14.13	15.73	17.16	20.38	20.92	27.54	29.32	30.22	30.75	34.15	33.08	33.61
	Gujarat	Prod. Capacity	82.09%	82.09%	82.09%	82.09%	82.09%	82.09%	82.09%	82.09%	82.09%	82.09%	82.09%	82.09%
		Production	64.85	72.24	78.81	93.58	96.05	126.42	134.63	138.73	141.19	156.79	151.87	154.33
2B8e	Acrylonitrile	Total Production	39	33	37	39	30	39	38	38	33	37	34	2
	Gujarat	Prod. Capacity	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Production	39	33	37	39	30	39	38	38	33	37	34	2
2B8f	Carbon Black	Total Production	381.26	395.1	422.47	426.96	371.4	419.43	452.44	447.67	404.02	406.41	444.35	469.56
	West Bengal	Prod. Capacity	30.35%	30.35%	30.35%	30.35%	30.35%	30.35%	29.11%	29.11%	29.11%	29.11%	29.11%	29.11%
		Production	115.71	119.91	128.22	129.58	112.72	127.30	131.71	130.32	117.61	118.31	129.35	136.69
	Gujarat	Prod. Capacity	27.73%	27.73%	27.73%	27.73%	27.73%	27.73%	26.59%	26.59%	26.59%	26.59%	26.59%	26.59%
		Production	105.72	109.56	117.15	118.40	102.99	116.31	120.30	119.04	107.43	108.06	118.15	124.86

	Kerala	Prod. Capacity	9.90%	9.90%	9.90%	9.90%	9.90%	9.90%	9.50%	9.50%	9.50%	9.50%	9.50%	9.50%
		Production	37.74	39.11	41.82	42.27	36.77	41.52	42.98	42.53	38.38	38.61	42.21	44.61
	Tamil Nadu	Prod. Capacity	4.28%	4.28%	4.28%	4.28%	4.28%	4.28%	8.21%	8.21%	8.21%	8.21%	8.21%	8.21%
		Production	16.32	16.91	18.08	18.27	15.90	17.95	37.15	36.75	33.17	33.37	36.48	38.55
	Uttar Pradesh	Prod. Capacity	14.45%	14.45%	14.45%	14.45%	14.45%	14.45%	13.86%	13.86%	13.86%	13.86%	13.86%	13.86%
		Production	55.09	57.09	61.05	61.70	53.67	60.61	62.71	62.05	56.00	56.33	61.59	65.08
	Maharashtra	Prod. Capacity	8.99%	8.99%	8.99%	8.99%	8.99%	8.99%	8.62%	8.62%	8.62%	8.62%	8.62%	8.62%
		Production	34.28	35.52	37.98	38.38	33.39	37.71	39.00	38.59	34.83	35.03	38.30	40.48
	Punjab	Prod. Capacity	4.28%	4.28%	4.28%	4.28%	4.28%	4.28%	4.11%	4.11%	4.11%	4.11%	4.11%	4.11%
		Production	16.32	16.91	18.08	18.27	15.90	17.95	18.60	18.40	16.61	16.70	18.26	19.30
	Urea (used for calculating emissions from ammonia)	Total Production	20263	20098	20310.00	19860.00	19920.00	21112.00	21881.00	21984.00	22575.00	22715	22585	24475
	Ammonia Production(via urea)	Total Production	11482.37	11388.87	11509.00	11254.00	11288.00	11963.47	12399.23	12457.60	12792.50	12871.83	12798.17	13869.17
	Ammonia Import	Total	1.52	1.52	1.87	1.66	1.44	1.97	1.58	2.46	1.71	1.96	2.07	2.19

Source: Authors' analysis

Annexure 10: State-wise share of aluminium production

State	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	Source
Orissa	55%	55%	55%	55%	55%	55%	59%	60%	62%	61%	55%	54%	IBM Mineral Yearbook (Metals review)
Chhattisgarh	17%	17%	17%	17%	17%	17%	16%	15%	14%	15%	16%	14%	
Uttar Pradesh	27%	27%	27%	27%	27%	27%	25%	25%	23%	24%	20%	17%	
Madhya Pradesh	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	9%	14%	

Source: Authors' compilation

Annexure 11: State-wise share of lead production

Year	Production(tonnes)	State	Share
2004-05	15657	Rajasthan	100%
2005-06	23817	Rajasthan	100%
2006-07	44627	Rajasthan	100%
2007-08	58246	Rajasthan	100%
2008-09	60323	Rajasthan	100%
2009-10	64319	Rajasthan	100%
2010-11	57294	Rajasthan	100%
2011-12	92100	Rajasthan	100%
2012-13	118317	Rajasthan	100%
2013-14	122595	Rajasthan	100%
2014-15	127142	Rajasthan	100%
2015-16	145257	Rajasthan	100%

Source: Authors' compilation

Annexure 12: State-wise share of zinc production

Year	State	Quantity	Source
2015-16	Rajasthan	758944	IBM yearbook 14
2015-16	Kerala	0	
2014-15	Rajasthan	732792	
2014-15	Kerala	0	
2013-14	Rajasthan	749168	
2013-14	Kerala	17362	
2012-13	Rajasthan	676921	
2012-13	Kerala	27307	
2011-12	Rajasthan	758717	IBM yearbook 12
2011-12	Kerala	24930	
2010-11	Rajasthan	712471	
2010-11	Kerala	27931	
2009-10	Rajasthan	578411	http://www.mrai.org.in/site/assets/files/5229/pugazhenty.pdf

2009-10	Kerala	35352	
2008-09	Rajasthan	551724	
2008-09	Kerala	30443	
2007-08	Rajasthan	426323	
2007-08	Kerala	31903	
2006-07	Rajasthan	354423	lack of available literature; used the last available production shares
2006-07	Kerala	26522	
2005-06	Rajasthan	275392	
2005-06	Kerala	20608	
2004-05	Rajasthan	222360	
2004-05	Kerala	16640	

Source: Authors' compilation

Annexure 13: State-wise production of coal and lignite

Fuel	States	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Coal	Andhra Pradesh	9%	8%	8%	8%	8%	9%	9%	9%	9%	0%	0%	0%
	Arunachal Pradesh	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Assam	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Chhattisgarh	17%	17%	18%	18%	19%	19%	20%	20%	20%	21%	20%	19%
	Jammu & Kashmir	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Jharkhand	19%	20%	19%	19%	18%	19%	19%	19%	18%	19%	19%	18%
	Madhya Pradesh	13%	13%	13%	14%	14%	13%	12%	12%	13%	12%	13%	16%
	Maharashtra	8%	8%	8%	7%	7%	7%	7%	7%	6%	6%	6%	6%
	Meghalaya	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	1%
	Odisha	16%	16%	18%	18%	19%	19%	18%	18%	18%	19%	19%	20%
	Telangana										8%	8%	9%
	Uttar Pradesh	4%	4%	3%	2%	2%	2%	3%	3%	3%	2%	2%	2%
	West Bengal	6%	6%	5%	5%	4%	4%	4%	4%	4%	5%	5%	4%
Lignite	TamilNadu	5%	5%	5%	4%	4%	4%	4%	4%	4%	4%	4%	4%
	Gujarat	2%	2%	2%	2%	2%	2%	2%	3%	2%	2%	2%	1%

	Rajasthan	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%	2%	1%

Source: Authors' compilation