



GHG
Platform
INDIA



Green House Gases Emission Estimates for India – Industry subsector (Time-series: 2007 to 2012)

Research team:

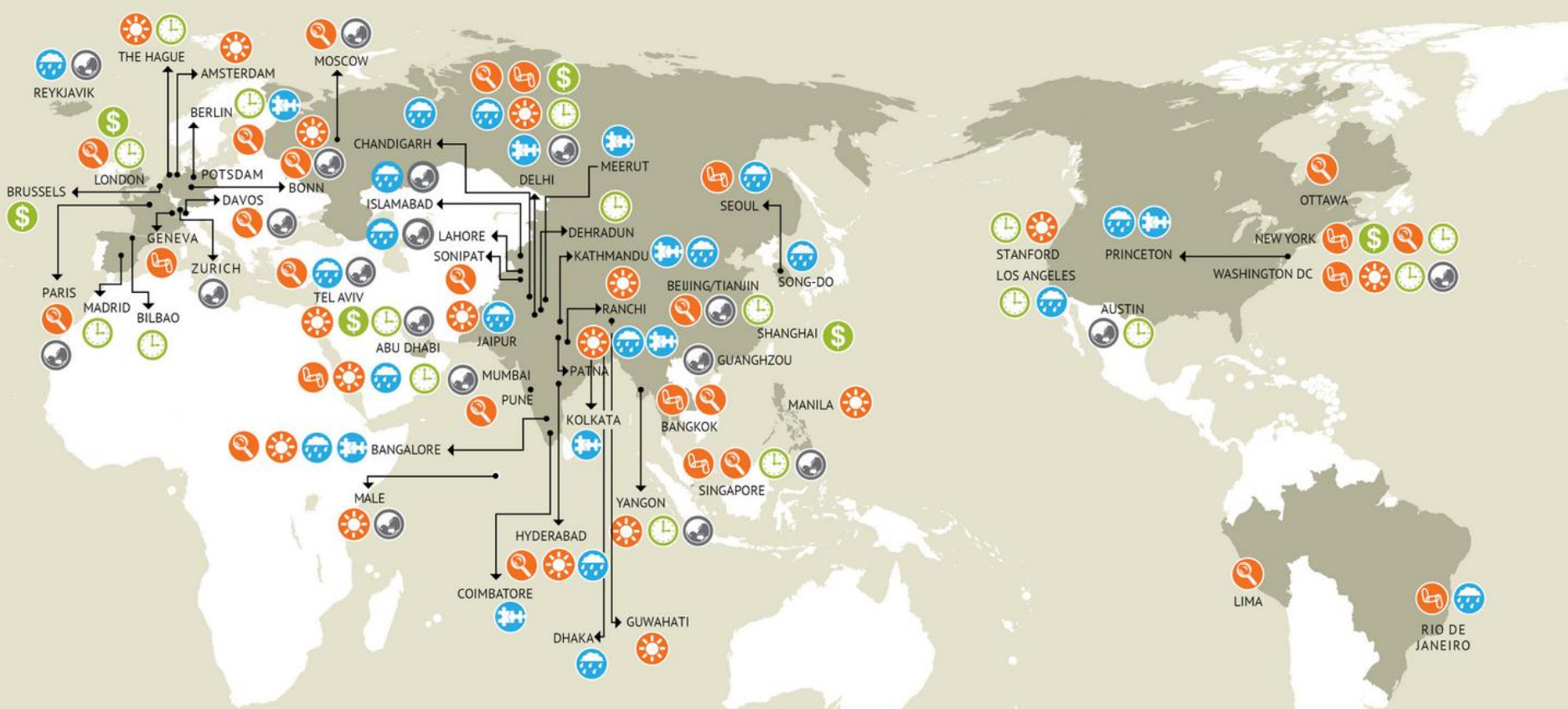
Vaibhav Gupta, Tirtha Biswas, Karthik Ganesan
Council on Energy, Environment and Water

Kolkata, 3 February 2017

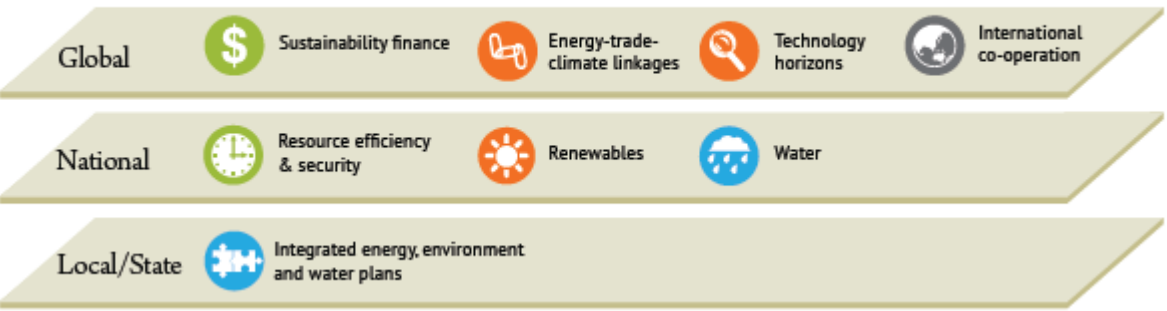
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Introduction

The GHG emissions from Industry covers emissions from fuel use, process and product use (but excludes emissions from captive electricity generation)

Objective:

To streamline the emission reporting process by making full use of existing data sources and reporting

- Use the Annual Survey of Industries (ASI) database representing more than 2 lakh registered industrial units across India
- Activity data is at the unit level and has been aggregated. Represents more than 100 different type of fuels, feedstock, input materials(carbonaceous) and various products

Scope of activity data (as per IPCC guideline)

- A. Energy Industries:** Petroleum refining – 1A1b; Manufacturing of Solid fuels – 1A1ci; Mining & Hydrocarbon extraction – 1A1cii
- B. Manufacturing industries and Construction** – 1A2a to 1A2m
- C. Industrial processes and product use emissions** – (2A, 2B, 2C, 2D & 2H)

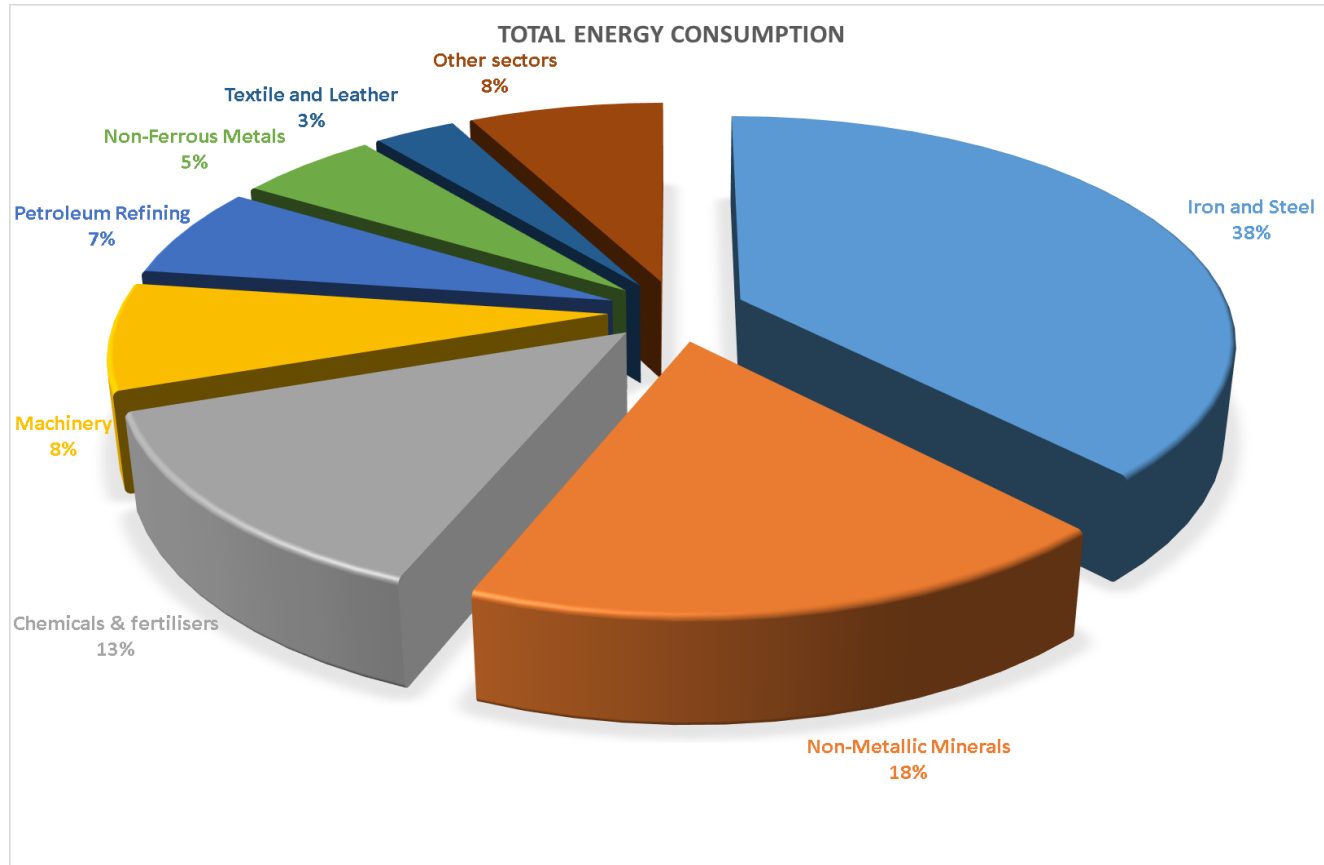
Tiers of emission factor reporting

- **Tier I** : Using global/regional average values
- **Tier II** : Using national level understanding on fuels and general industrial processes
- **Tier III** : Most granular form of information available at the level of individual factory level.

Emission = activity data x emission factors
(follows IPCC 2006 guidelines)

What's in for Industries.....? (1/2)

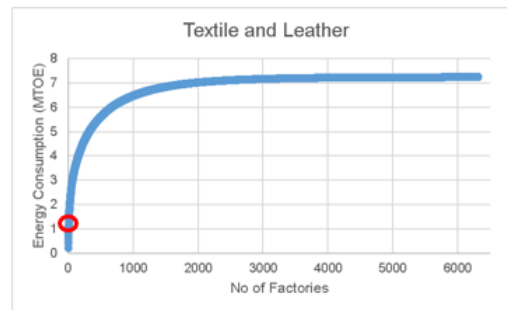
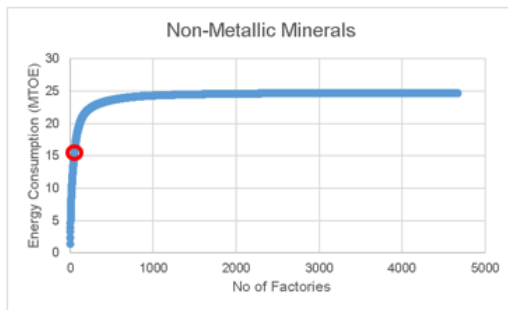
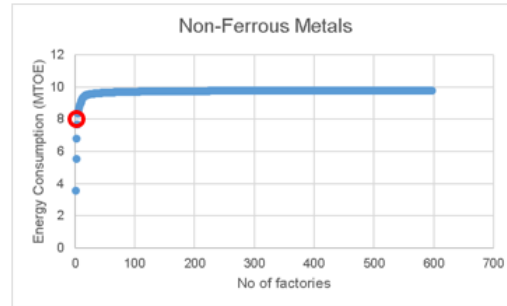
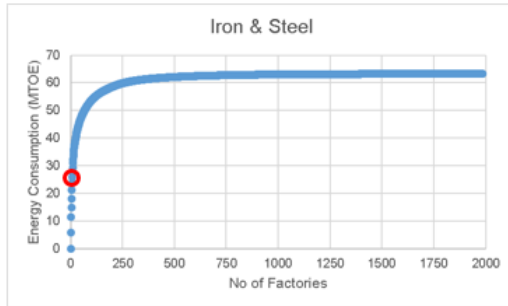
- India in its NDC commitments to the UNFCCC (COP21, 2015) aims to reduce emissions intensity of its GDP by 33 to 35% by 2030 (from 2005 levels)



- Industry represents diverse set of manufacturing streams and almost **accounts for 25% of India's total GHG emissions!**
- There is a **need and the opportunity for deep decarbonization of Indian industry**

What's in for Industries.....? (2/2)

- **Schemes like Perform, Achieve and Trade (PAT)** are aimed at improving **industrial energy efficiency** through market based mechanisms
- Over the course of the first year of the PAT cycle 1 scheme a decline in energy intensity by 3.8% per year has been seen
 - Even in the pre-PAT regime, a decline of 3% was seen



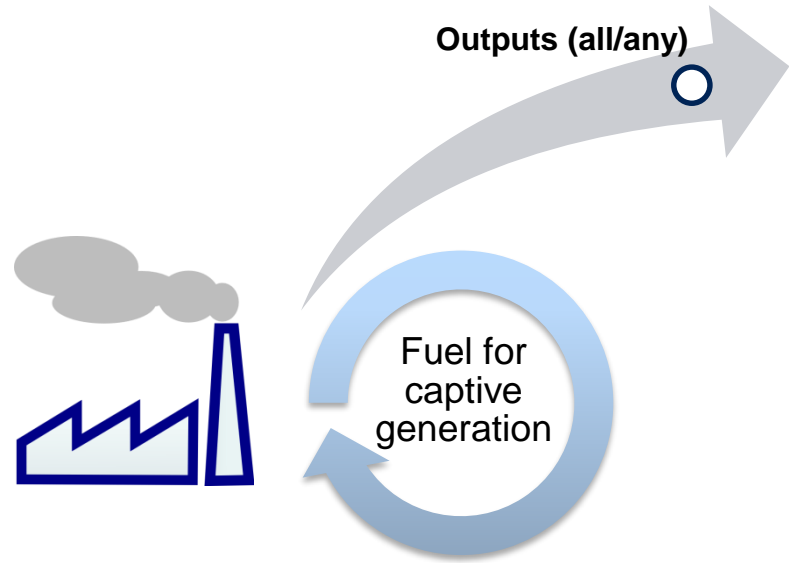
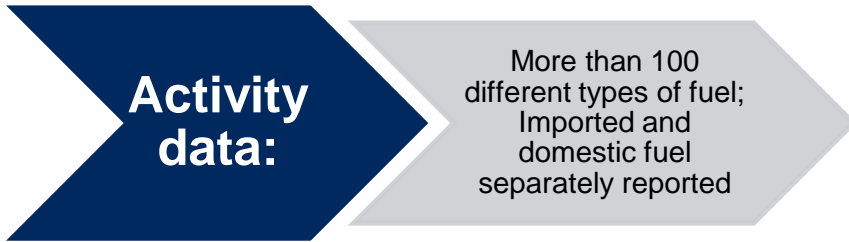
- Before asking how to bring more industries within the fold of efficiency (and emissions intensity) improvements, we need better estimates from a comprehensive set of factories/ units

Methodology (1/3)

- **ASI is the primary data source:** Information on fuel consumption (for energy) and carbonaceous material (for IPPU) is available for over 2 lakh individual factories across the sectors.
 - Covers all factories registered under the factories act section 2m(i) & 2m(ii)
- Each factory follows ***National Industry Classification (NIC)*** system at the most detailed 5 digit level.
- Each input/output fuel or material follows ***National Product Classification for Manufacturing Sector*** (NPCMS) system (previously known as Annual Survey of Industries Commodities Classification)

Methodology (2/3)

Accounting Energy emissions



Reported fuel types	% Expenditure
Coal & lignite	23%
Coal & lignite Products	13%
Natural gas	4%
Petroleum fuels	4%
Other energy use gases	9%
Unspecified coal and lignite	24%
Unspecified liquid fuels	23%

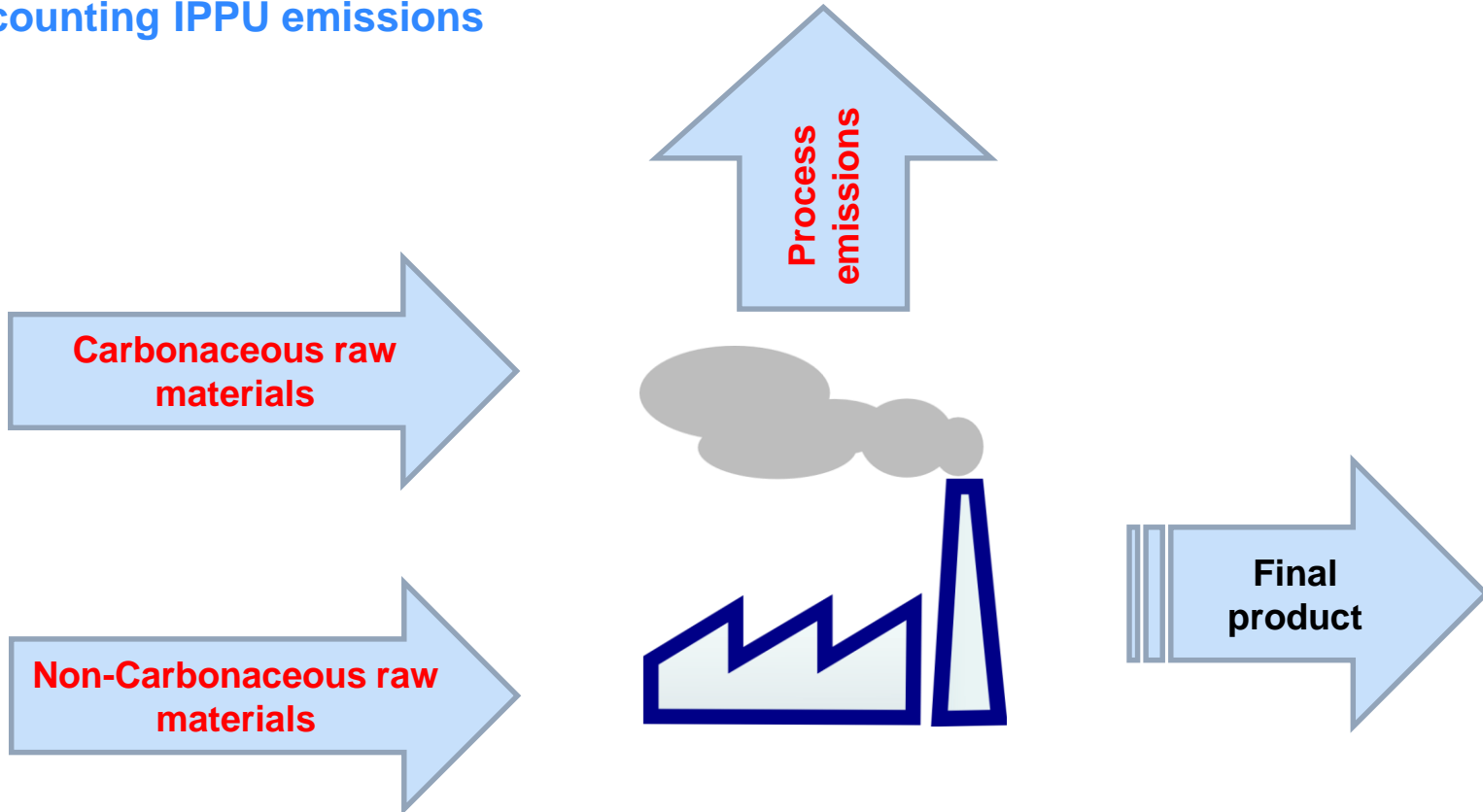
- Inputs for **secondary fuel manufacturing** is **not considered** to avoid double count of energy use
- Captive generation is deducted to avoid overlaps with Energy use output (within scope of C-STEP)

Basic equation:

$E_{gas} = \text{Activity data (tonne)} * \text{calorific value of fuel} * \text{emission factor} * \text{Global warming potential of gas}$

Methodology (3/3)

Accounting IPPU emissions



Basic equation:

$E_{gas} = \text{Activity data (tonne)} * \text{emission factor} * \text{Global warming potential of gas}$

Data sources used across different sectors

Energy use emissions

- **Petroleum refining** – Indian PNG stats (2006-13)
- **Solid fuel manufacturing** – ASI (2006-13)
- **Other energy industries**
 - Natural gas extraction – Indian PNG stats (2006-13)
 - Coal mining – using specific diesel consumption from CIL annual report 2006-07
- **Fuel consumption in manufacturing industries** – ASI (2006-13)

IPPU emissions

- **Cement production** – CMA (2006-08); IBM Mineral Yearbook (2008-13)
- **Lime and glass production** – ASI (2006-13)
- **Ammonia and nitric acid production** – ASI (2006-13)
- **Other chemicals production** – Annual Report-Ministry of chemicals and fertilizers (2006-13)
- **Iron & Steel and ferro alloys production** – ASI (2006-13)
- **Aluminium production** – MCX India (2006-09); IBM Mineral Yearbook (2009-13)
- **Lead & Zinc production** – IBM lead & zinc market survey report (2006-08); IBM Mineral Yearbook (2008-13)
- **Non-energy product use**
 - Lubricant use – ASI (2006-13)
 - Paraffin use – ASI (2006-13)

Methodological Assumptions for energy use emissions (1/4)

Annual survey of Industries do not separate hydrocarbons into fuel and feedstock

Desktop research and discussions with industrial experts has helped us to assign specific use of certain hydrocarbons for non-energy purpose.

Manufacturing Industry	Hydrocarbons considered as feedstock
Manufacture of coke products	Coal, peat and lignite; Coal & Lignite Products; Coal ash; Coal for carbonisation; Coke and semi-coke of coal, of lignite or of peat; retort carbon n.e.c; Benzol; Coal tar peat
Manufacture of cement	Coal ash
Manufacturing of rubber and plastic products	Coal for carbonisation; Coke and semi-coke of coal, of lignite or of peat; retort carbon n.e.c; Coal tar peat
Manufacturing of chemicals and chemical products	Benzol
Manufacturing of pharmaceutical products	Benzol
Manufacturing of electrical equipments	Coal tar peat
Bottling of LPG/CNG	Natural gas/CNG; LPG
Manufacturing of urea and other fertilizers	Natural gas/CNG
Manufacturing of plastics and synthetic rubber products	Natural gas/CNG
Manufacturing of paraffin wax and other petroleum products n.e.c	Light petroleum oils; Kerosene and kerosene products; Fuel oils, gas oils and other medium petroleum oils; Shale oil; Furnace oil; Petroleum coke; Other petroleum products obtained from bitumen n.e.c.
Manufacturing of pesticides and other agrochemicals	Kerosene and kerosene products
Manufacturing of paints, varnishes, printing inks and similar coatings	Light petroleum oils; Kerosene and kerosene products; Fuel oils, gas oils and other medium petroleum oils;
Manufacturing of soap and detergents	Shale oil; Furnace oil; Petroleum coke; Other petroleum products obtained from bitumen n.e.c.
Printing and allied services	Kerosene and kerosene products
Production of liquid and gaseous fuels, illuminating oils, lubricating oils or greases or other products from crude petroleum or bituminous minerals	Shale oil; Other petroleum products obtained from bitumen n.e.c.
Manufacturing of rubber tyres, tubes and similar products	Shale oil; Petroleum coke
Manufacture of graphite products other than electrical articles	Petroleum Coke
Manufacturing of aluminum and aluminium products	Petroleum Coke

Methodological Assumptions for energy use emissions (2/4)

Industries often report only the expenses of total liquid fuel consumption

- Applied Similar breakdown into different fuel categories as reported by other factories in the same industry
- Wherever consumption is reported in terms of expenditure, normative rates were used to translate them into an equivalent physical quantity

Row Labels	10	11	12	13	14	15	16	17	18	19	20
Bituminous oil	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Bituminous or oil shale and tar sands n.e.c	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%
Diesel	17%	0%	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%
Fuel, aviation turbine	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Furnace oil	76%	0%	0%	99%	100%	0%	0%	0%	0%	2%	4%
Glancepitch	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%
High speed diesel	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Kerosene	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
Kerosene n.e.c	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%
Liquid or liquid gas fuel for lighter	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Liquidified petroleum gas (LPG)	0%	0%	0%	0%	0%	0%	0%	0%	0%	98%	2%
Medium petroleum oil, n.e.c.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Motor spirit (gasolene), including aviation spirit n.e.c	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Oil, Coal tar	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%	1%
Paraffin incl wax	5%	0%	100%	0%	0%	2%	92%	100%	0%	1%	92%
Petroleum coke	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Petroleum coke calcined	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Petroleum jelly	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Petroleum oils and oils obtained from bituminous minerals, crude	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
Petroleum products obtained from bitumen n.e.c.	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Propane and butanes, liquefied, n.e.c.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Shale Oil	0%	0%	0%	0%	0%	27%	0%	0%	0%	0%	0%
Spirit type (gasolene type) jet fuel	0%	96%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Superior kerosene	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wax chlorinated paraffin	0%	0%	0%	0%	0%	67%	0%	0%	0%	0%	0%
Wax polythene	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Grand Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Methodological Assumptions for Energy Emissions (3/4)

Discounting emissions from captive electricity generation

- Using CEA default emission factors and share of gas, hydro and thermal for captive generation across the industries , specific emission factors have been determined from 2006-07 to 2012-13

Emission Factors (kgCO ₂ /KWh)		2006-07				
		IPCC Codes	Description	Captive generation (Kwh)	E.F (kgCO ₂ /KWh)	Emissions from Captive (tCO ₂)
2006-07	0.92	1A1b	Petroleum Refining	8146690000	0.92	7506016
2007-08	0.85	1A1ci	Manufacture of Solid Fuels	23684276.95	0.92	21822
2008-09	0.95	1A1cii	Other Energy Industry	0	0.92	0
2009-10	0.94	1A2a	Iron and Steel	15718594671	0.92	14482449
2010-11	0.94	1A2b	Non-Ferrous Metals	15938294155	0.92	14684871
2011-12	0.93	1A2c	Chemicals & fertilisers	16092422236	0.92	14826878
2012-13	0.93	1A2d	Pulp, Paper and Print	4516116055	0.92	4160959
Average	0.92	1A2e	Food Processing, Beverages and T	5618222533	0.92	5176393
		1A2f	Non-Metallic Minerals	7631431662	0.92	7031279
		1A2g	Transport Equipment	1081723818	0.92	996655
		1A2h	Machinery	2226614767	0.92	2051509
		1A2i	Mining and Quarrying	716438.5151	0.92	660
		1A2j	Wood and wood products	26409831.31	0.92	24333
		1A2k	Construction	67951.23176	0.92	63
		1A2l	Textile and Leather	4092033679	0.92	3770227
		1A2m	Non-specified Industry	686727926.4	0.92	632722

Methodological Assumptions for Energy Emissions (4/4)

Adjustment made for entities having erroneous reporting for fuel prices against unit of measurement for input fuels

		ASI Reported Data					
	Product	Unit	Example Rate	Min reported rate	Max reported rate	Std Dev of the reported rate	Corresponding New Rate
				2007-08	Hard Coke	tonne	
	Pitch Hard/Medium	tonne	19.48	19.48	53511.45	18510.80	19480.00
	Coal Tar Pitch	tonne	18.82	18.82	22759.41	8092.05	18820.00
	Kerosene	k litres	42.03	24.00	29883.39	11597.96	42030.00
	HSD	k litres	38.62	30.44	20281.86	9044.48	38620.00
	Diesel	k litres	38.35	27.22	30094.67	10818.69	38350.00
	Petrol/Motor Spirit	k litres	48.00	25.00	38855.51	18300.96	48000.00
	Light Petro Oils	tonne	36.51	27.24	27648.79	24329.33	27240.00
	LPG	kg	35264.07	9.49	37722.79	14373.12	35.26
	Propanes & Butane liquified	tonne	37.85	37.85	33730.17	15970.15	37850.00
	Product	Unit	Example Rate	Min reported rate	Max reported rate	Std Dev of the reported rate	Corresponding New Rate
2006-07	Coal	tonne	7.00	5.00	9735323.00	662594.90	7000.00
	Coke Breeze	tonne	5.00	5.00	44307.00	6511.18	5000.00
	Lignite, Hot Agglomerate	tonne	3.00	3.00	10125.00	3824.72	3000.00
	Coal Tar, Pitch	tonne	16.00	6.00	36956.00	9847.32	16000.00
	Pet Coke	tonne	15.00	15.00	72000.00	14537.11	15000.00
	Kerosene	k litres	35.00	20.00	32028.00	13006.44	35000.00
	HSD	k litres	34.00	28.00	33962.00	13473.08	34000.00
	Light Petro Oil	tonne	37.00	23.00	20773.00	6905.00	37000.00

Methodological Assumptions for IPPU Emissions

Process emissions are calculated for a mix of inputs, outputs and intermediate products

- **Input material** – Only carbonaceous materials are responsible for emissions e.g. limestone , dolomite etc.
- **Intermediate material** – ASI only reports final products, activity data is taken from government sources (e.g acrylonitrile) or is equivalent quantity is calculated from final product (ammonia produced is calculated from total urea output)
- **Final product** – Final products sold or moved out of factory gate. Often difference from national production is found due to running stocks. In such scenarios data is supplemented from national statistics

		Quantity (000 tonnes)	
Year	Product	ASI reported statistics	Officially reported statistics
2007-08	Cement	212585	168310
	Lead	458	58
	Zinc	593	457
2012-13	Cement	363348	235110
	Lead	187	118
	Zinc	502	704

Data reliability (1/2)

Comparison between ASI inputs and national statistics provides variation at the fuel specific level, but, overall energy consumption matches within close proximity

	Coal & Lignite		Nat Gas		Petroleum Fuels		Total Energy Consumption (MTOE)		
	ASI	National	ASI	National	ASI	National	ASI	National	Diff
2006-07	65.9	59.2	0.2	4.6	20.0	21.2	86.1	85.0	-1%
2007-08	75.5	63.3	0.3	4.2	15.1	23.6	90.9	91.1	0%
2008-09	79.1	68.2	4.5	6.9	7.7	24.0	91.3	99.1	8%
2009-10	88.8	76.6	1.8	3.5	10.3	24.4	100.9	104.5	3%
2010-11	82.1	79.0	6.7	3.3	26.2	25.0	115.0	107.3	-7%
2011-12	84.9	81.3	6.6	3.7	24.9	25.5	116.4	110.4	-5%
2012-13	92.3	86.6	4.4	3.2	21.4	26.7	118.1	116.4	-1%

Sensitivity analysis on assumptions (on rates) using maximum and minimum commodity purchase rates

Year	Baseline	With Maximum Rates	With Minimum Rates
% Variation			
2007		-2%	0%
2008		-4%	1%
2009		-1%	2%
2010		-2%	5%
2011		-6%	13%
2012		-4%	1%

Data reliability (2/2)

A question may arise that why there is reasonable fuel balance while product quantum does not match (aggregated ASI numbers vs nationally reported statistics)

A look at unregistered entities offers some explanation

<i>4th MSME census unregistered units (2006-07)</i>	
Category	Percent units
No power needed	38.6%
Coal	1.8%
Oil	5.3%
LPG	0.6%
Electricity	48.2%
Non-conventional Energy	0.3%
Traditional energy/firewood	2.0%
Others	3.3%

- Majority of the firms rely on electricity, which is anyway accounted for on the generation side
- They consume little amount of other fossil fuels. This was validated using the confirmed with NSSO 62nd round as well (~ 6 MT of coal consumption by unorganized sector units)
- Petroleum based fuels and natural gas show some variation and more research is needed to explain these differences

Results: A comparison with national estimates (1/2)

Consolidated Comparison		National estimate 2007 (million tonnes)	CEEW 2007 (million tonnes)	% difference	National estimate 2010 (million tonnes)	CEEW 2010 (million tonnes)	% difference
Sl no	Sector Descriptions	CO2e	CO2e		CO2e	CO2e	
1	Iron & Steel	117	173	-48%	96	185	-92%
2	Chemicals	33	50	-51%	36	58	-60%
3	Ferro Alloys	2	2	35%	4	3	18%
4	Non-Ferrous Metals	3	3	-3%	5	18	-259%
5	Non-metallic minerals	131	141	-7%	145	161	-11%
6	Non-Energy products from fuels	1	4	-392%	2	5	-195%
7	Refining	34	24	-2%	42	32	24%
8	Manufacturing of solid fuels		1	18	1	96%	
9	Other Energy industries		10	N.R	12		
10	Mining[^], #	1	0	#	4	0	#
11	Textile and Leather	2	14	-660%	3	10	-296%
12	Food & Beverages	28	4	84%	N.R	2	
13	Pulp, paper and Print	5	9	-63%	7	8	-22%
14	Transport Equipment	N.R	0		N.R	0	
15	Wood & wood products	N.R	0		N.R	0	
16	Construction #	N.R	0	#	N.R	0	#
17	Machinery	N.R	4		N.R	1	
18	Manufacturing n.e.c	N.R	2		N.R	2	
19	Non specific industries	88	N/A		135	N/A	
	Grand Total (Energy + IPPU)	446	441	1%	497	498	-0.3%

The ASI dataset does not cover this sector exhaustively

[^] . IBM reporting is being explored

Results: A comparison with national estimates (2/2)

- A significant amount of emissions (88 MT in 2007 and 135 MT in 2010) remains **unaccounted** in the national reporting – No clarity is available from national sources
 - This leads to deviation in sectors with relatively smaller emissions. Part of it may/must be coming from ‘unaccounted’ emissions

- **Deviation in the Iron & steel and ferro-alloys sectors**
 - CEEW estimates includes emission from solid fuel manufacturing (within integrated plants), as it is difficult to separate the quality
 - National accounting doesn’t report on IPPU emissions from limestone and dolomite usage
 - National estimates do not report emissions from manufacture of ferro-manganese
 - INCCA (2007) and BUR (2010) show a dip in emissions, despite increase in production!

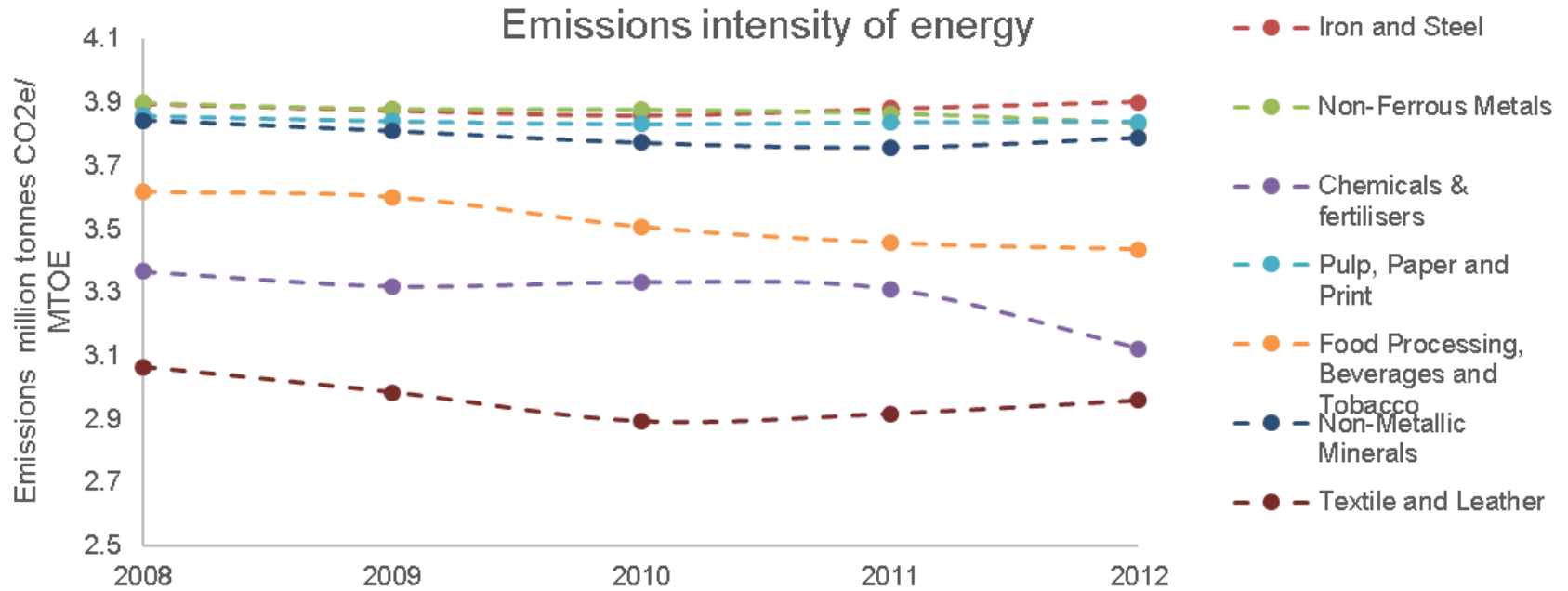
- Deviation in emissions from the food & beverages sector as compared to INCCA 2007
 - Less clarity is available on activity data from food & beverages from national records
 - BUR submission doesn’t even report any emissions due to lack of information
 - Comparison between CEEW analysis (from ASI) and national Input-output table records on fuel expenditure shows better convergence, however I-O table is available only for 2007-08.

Limitations

- **ASI only accounts for factories registered under section 2m of factories act**
 - Factories/units not registered under factories act but registered under companies act are left out of the survey
- **ASI under-reports mining, oil/petroleum exploration and construction sectors.**
 - Emissions from coal & lignite mining has been accounted by considering the specific fuel consumption from Coal India Limited annual reports
 - Little or no information is available for the construction processes and upstream oil and gas explorations.
- **A sizeable amount of expenditure is categorized under “other fuels”.**
 - ASI instructions categorise them as biomass based fuels and are hence carbon-neutral
- **For integrated steel plants, coal entering into a factory gate can be used for heating purpose or for captive power generation, or for secondary fuel manufacturing.**
 - Hence a part of emissions from manufacturing of coal based solid fuels (1A1ci) has been accounted alongside emissions from iron & steel industry (1A2a)
- **Natural gas is used both as a fuel and feedstock in ammonia manufacturing units.**
 - Overall emissions from fertilizer industry (energy + process) is reported together in the IPPU category

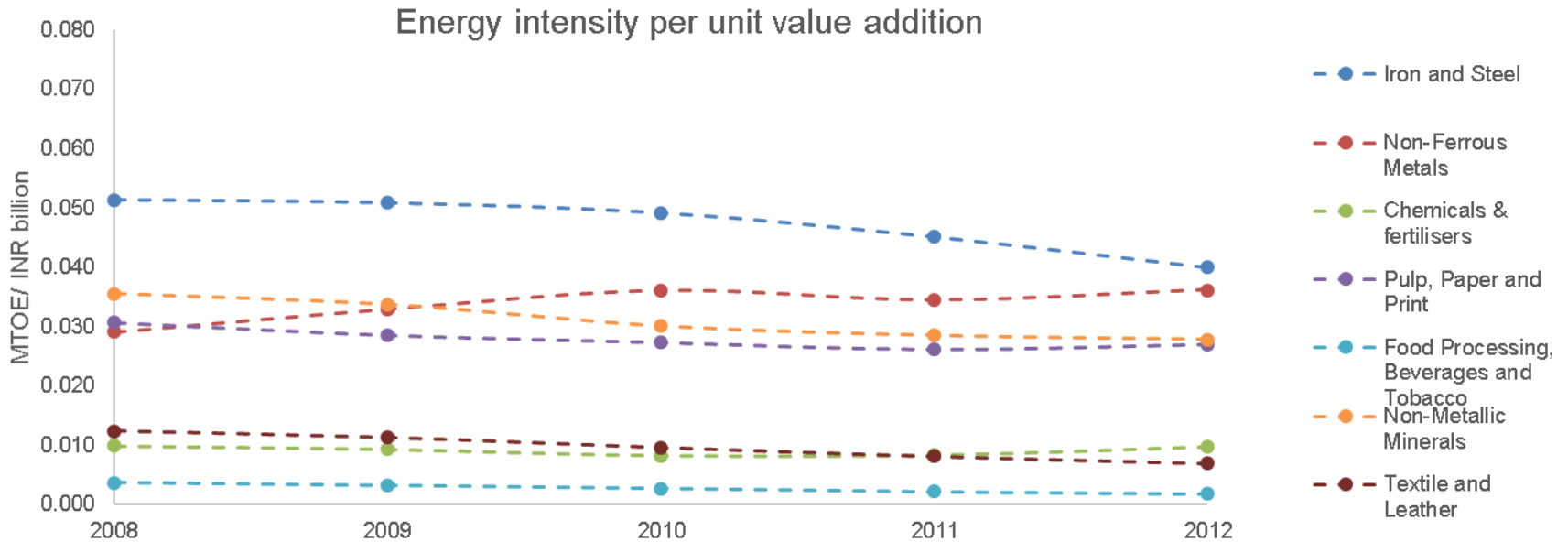
Takeaway: Carbon intensity of industrial energy has remained invariant

- Fuel carbon intensity of major industries has remained unchanged
- A more perceptible shift towards natural gas in chemical and food industries has decreased emissions intensity in the later years
- RE generation grew at 34% CAGR (higher than utilities (6%) and captive (10%)) but, minimal impact is evident in terms of overall decarbonization!



Takeaway: A marginally decrease in industrial energy intensity

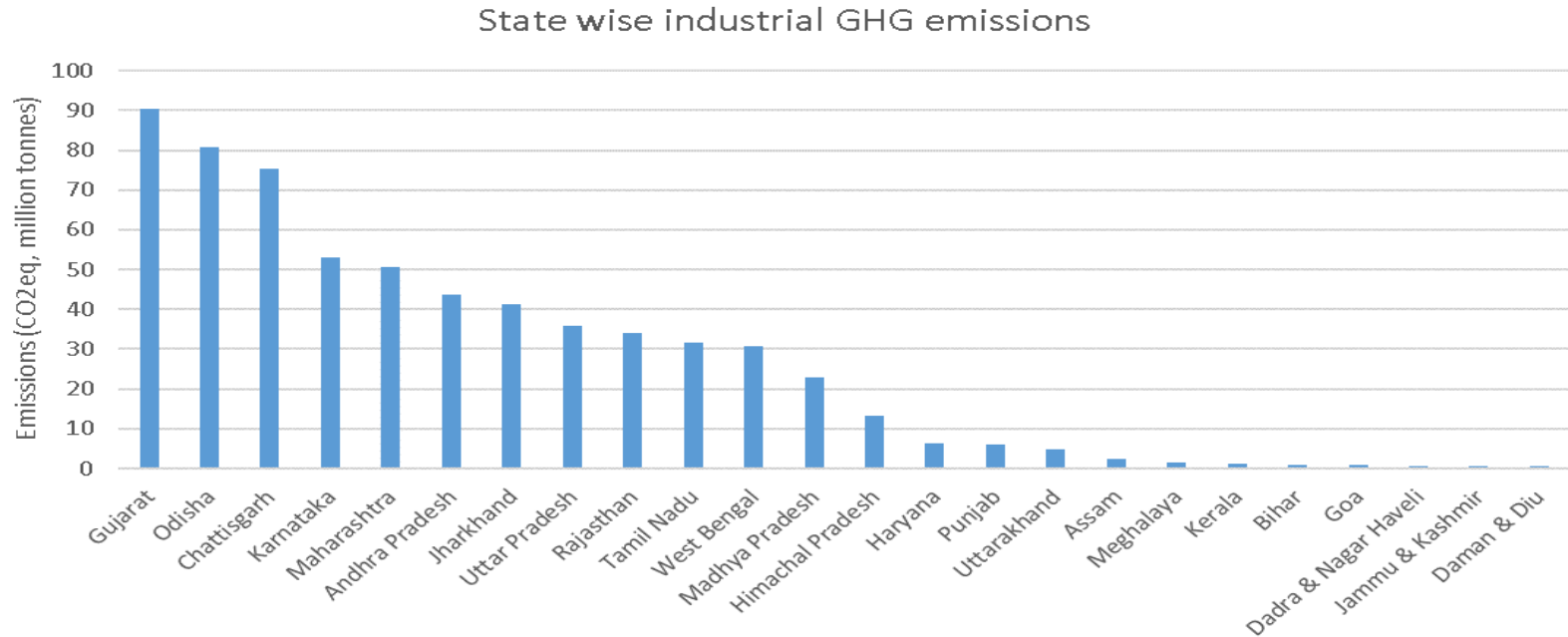
The decrease in emissions intensity is a result of gradual improvement of energy efficiency (through market competitiveness) while retaining the same fuel-mix over the years.



What's next?

Breakdown of national estimates (sector wise) at the State level

- Preliminary analysis* has been carried out for 2012-13, but data challenges on material output at the state level does exists!
 - National reports provides information at the national level at most of the times
 - Suitable proxies have been be used for apportionment at the state level, where exact breakdown is not available



*Subject to verification and review

Guiding questions for the deliberation session

- **Comprehensiveness of ASI dataset**
 - We are in the process of creating an economy wide energy balance by including emissions from NSSO and MSME census survey. This should be able to further verify our analysis!
 - Explore the use of MCA 21 returns to be filed by industries at 'Ministry of Corporate Affairs for any additional information on fuel/energy use
 - Prime source of energy by informal sector players is electricity, which is already accounted for. Any further insights on fuel use by the informal sector [national estimates registers only formal sector]?

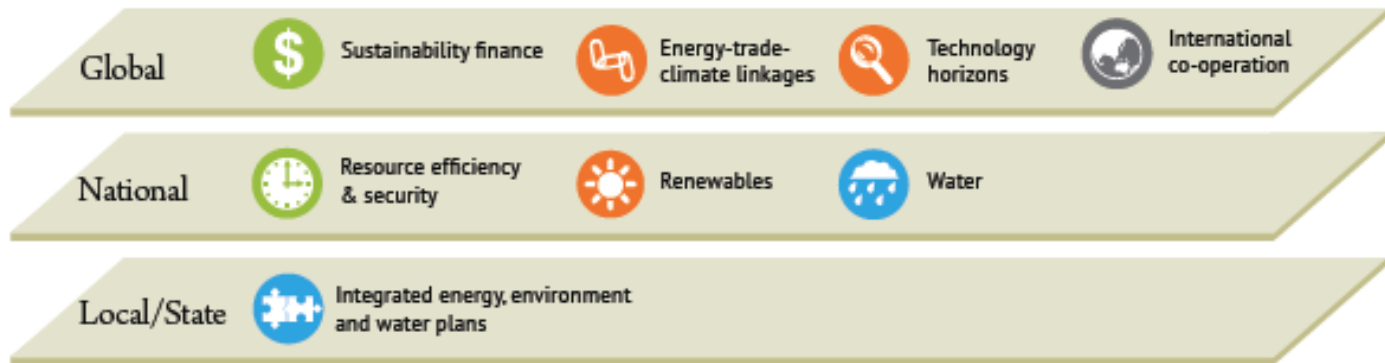
- **Discussion on methodology and assumptions**
 - We will be circulating a template on (a) fuel: feedstock ratio, (b) overall fuel mix.
 - Can industry associations/industry verify it and provide feedback?

- **Improvements in existing information collection mechanism under the ASI or MCA**
 - Monitoring of emissions is inevitable in the foreseeable future.
 - Do we need dedicated surveys (new) to capture energy related inputs or can ASI and other NSSO surveys adapt to the changing requirements of the new MRV regimes that are being instituted for monitoring energy consumption and emissions.

THANK YOU

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