Aluminium & Green House Gases (GHG):
Mitigation & Capture

Workshop on Awareness and Capacity Building in Carbon Capture, Storage and Utilization: Recent Advances in CO_2 Capture Technology and Its Sectoral Application

ACBCCS 2018

Climate Change & Research Institute, India

New Delhi 31st August 2018

ACBCCS 2 0 1 8

Presentation Layout

1 GHG: Global, Indian & Aluminium Scenario

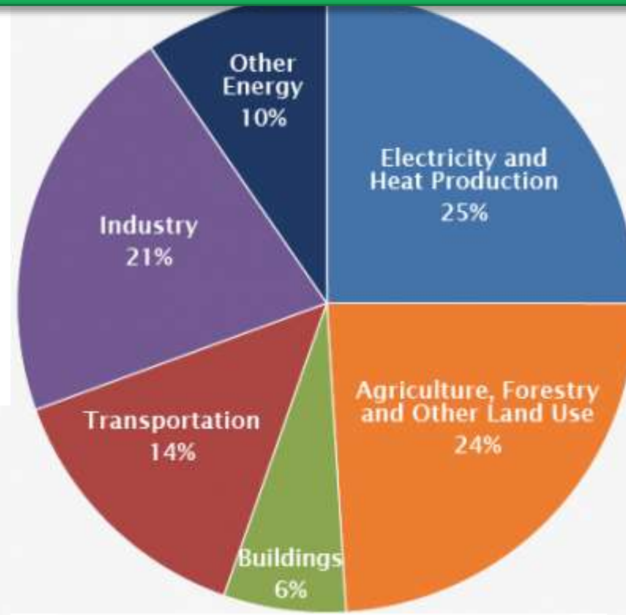
2 Aluminium & Industry Policy

3 Aluminium for Climate & Resource Efficiency

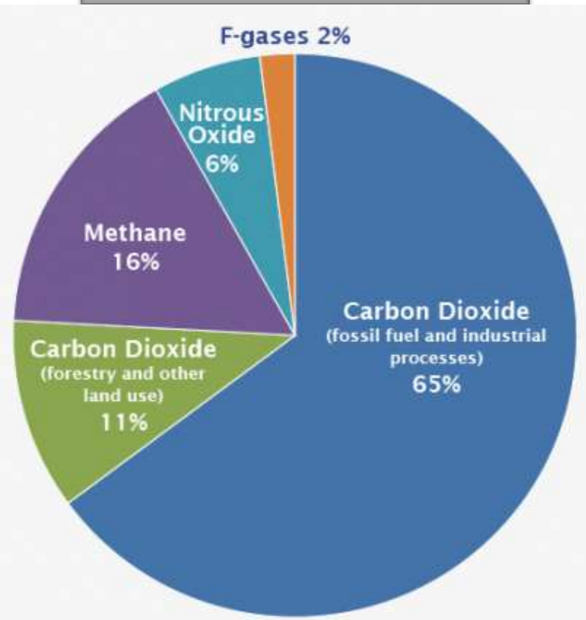
4 Energy in Aluminium

Green House Gas
Global, Indian & Aluminium Scenario

Greenhouse Gas Emissions
-Gas/Sector/Country-

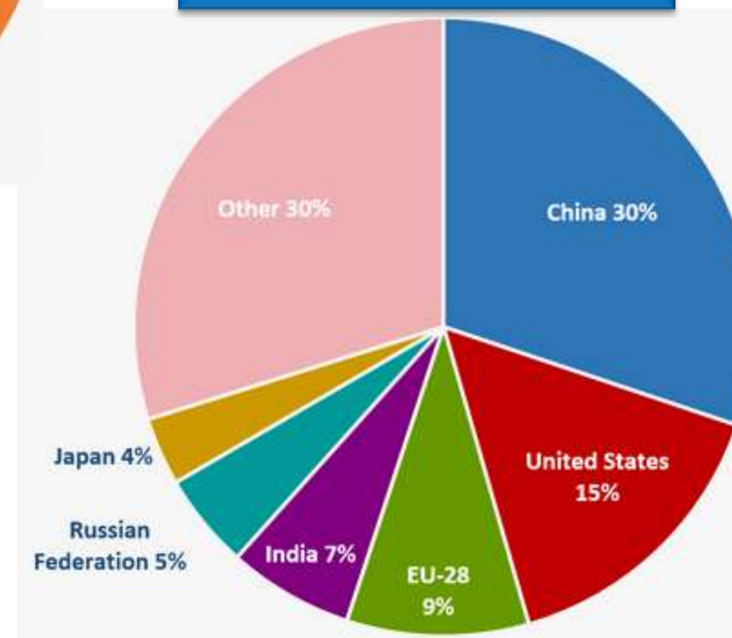


Gas



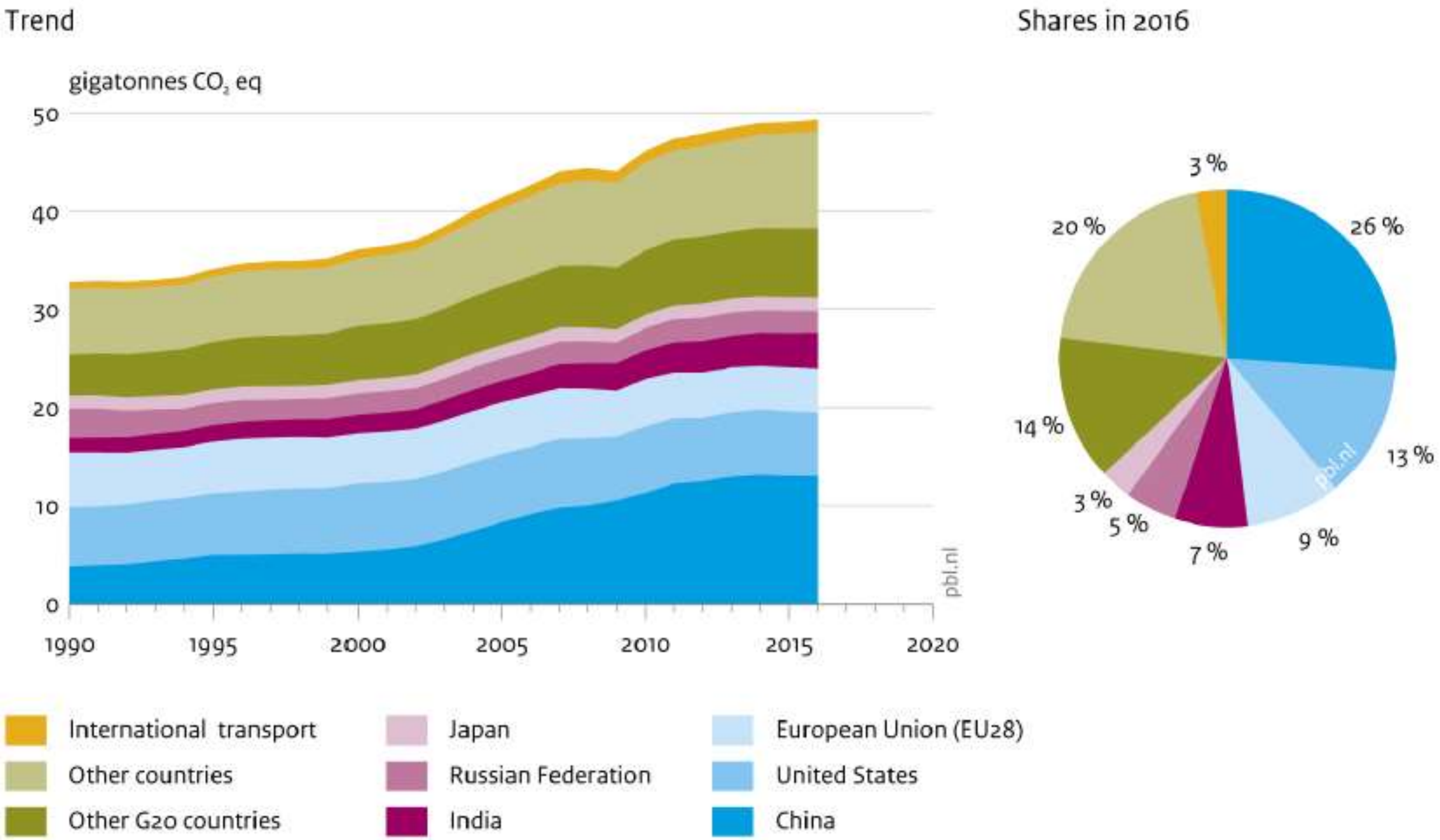
Economic Sector

Country



Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). National CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2014, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, doi 10.3334/CDIAC/00001_V2017.

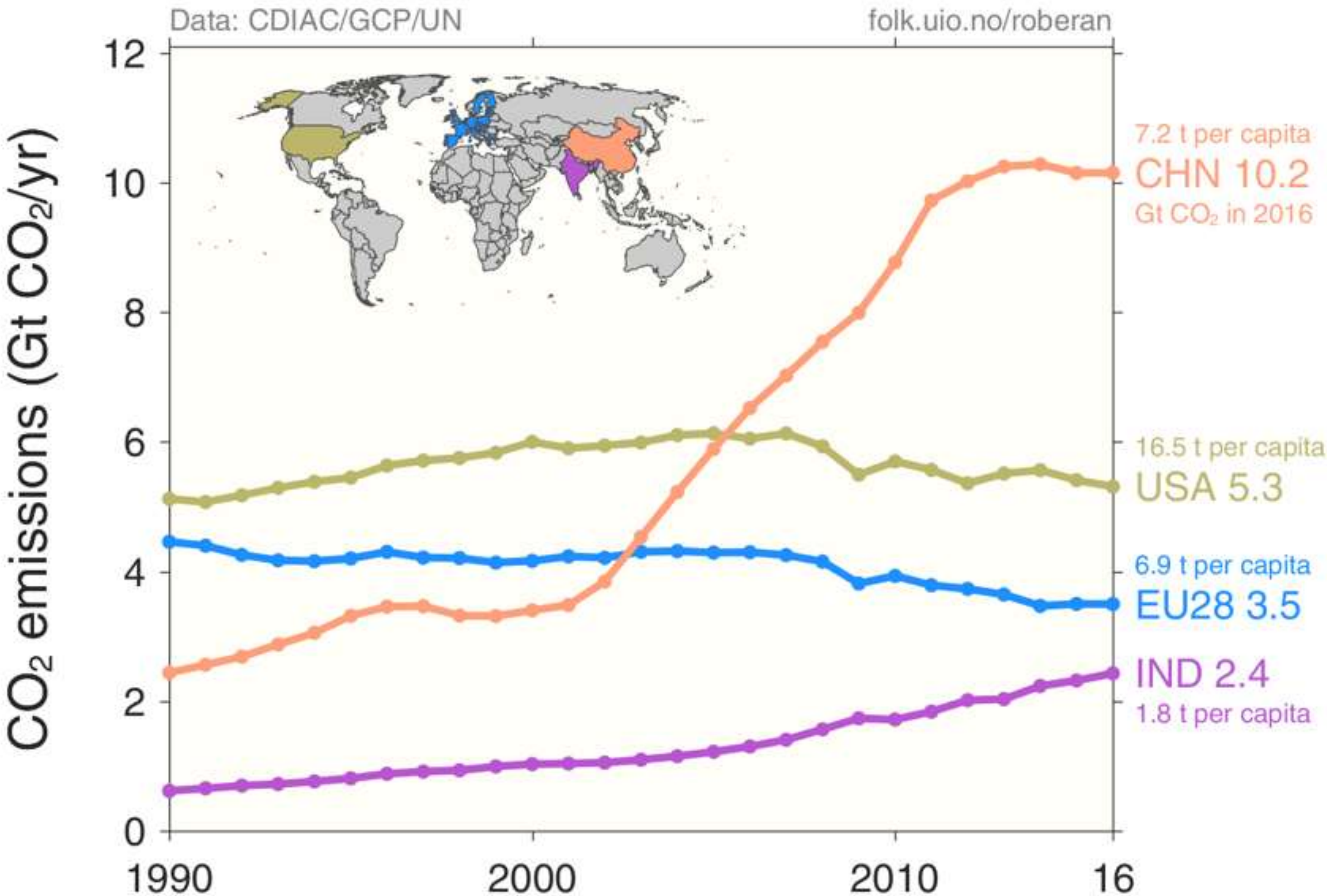
GHG Country & Region



Emissions do not include those from land use, land-use change and forestry and forest and peat fires (LULUCF)

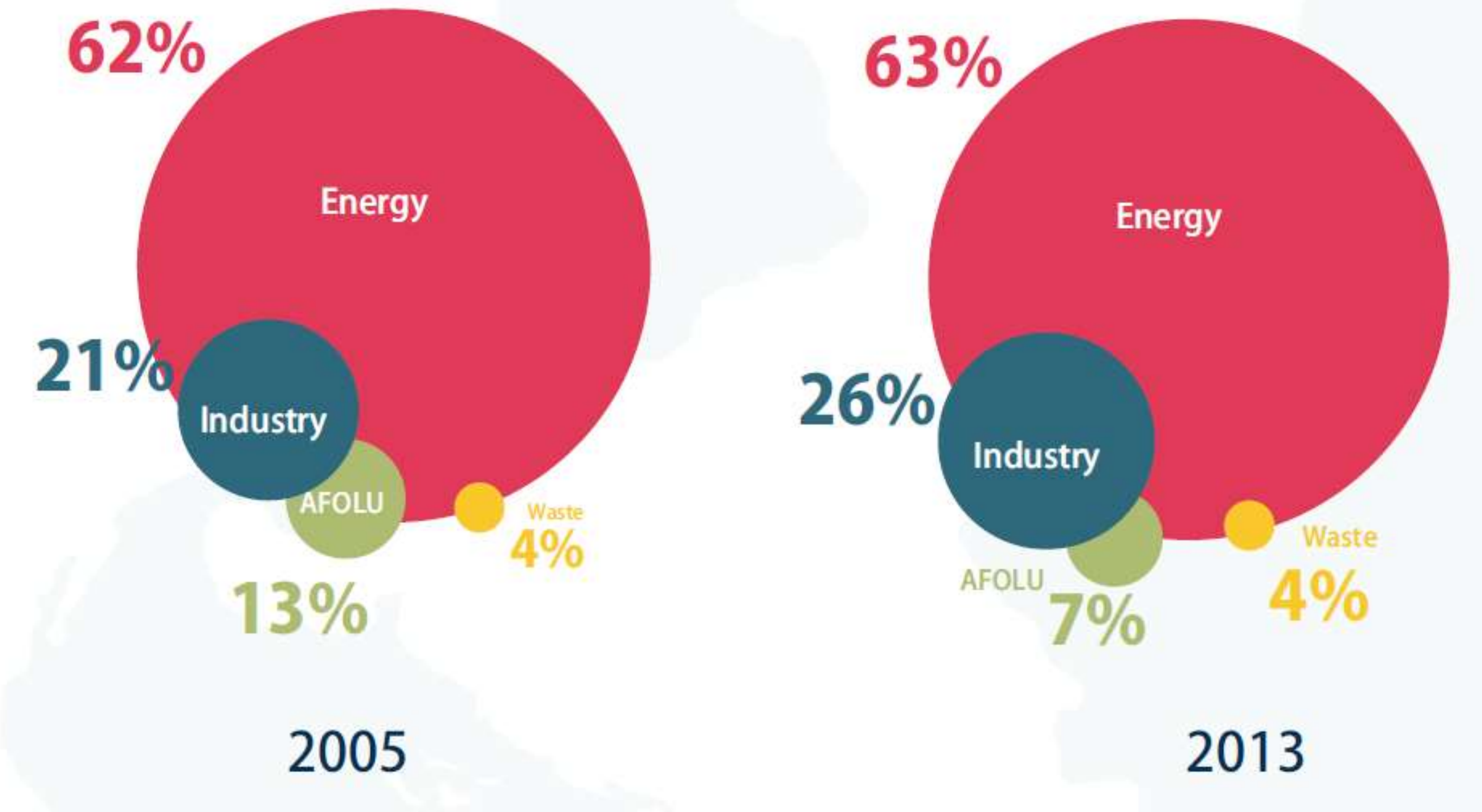
Bron: EDGAR v4.3.2 (EC-JRC/PBL 2017)

GHG & India



India has the world's **fourth highest CO_2 emissions**, but its emissions per person are very low. **World-average per capita emissions** were **4.2 tonnes in 2016**. Source: CDIAC, Global Carbon Project, and UN.

India: Sectoral Share of Emissions

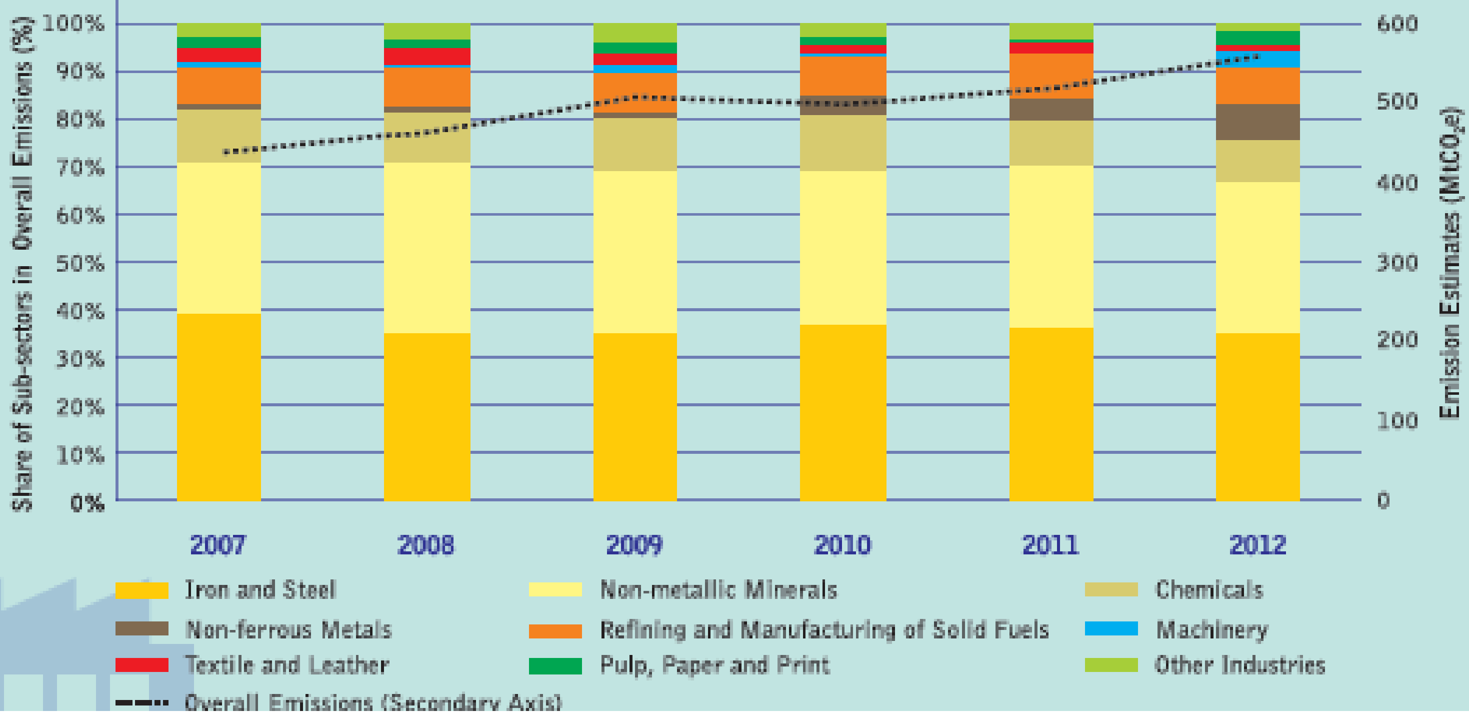


Indian Industry

Industrial Fuel Combustion***	Industrial Process and Product Use (IPPU)

Industry sector represents ~25% of the overall national estimates for the greenhouse gas emissions. As per our estimates, GHG emissions from industries grew at a CAGR of approximately 4% between 2007 and 2012.

Trend of Greenhouse Gas Emissions by Various Industrial Sub-sectors



Fuel use by industries contributes 69% to 74% of overall Industry emissions, while rest comes from the IPPU activities. Manufacturing of iron and steel contributes the largest share of emissions (35% to 39%) closely followed by non-metallic minerals (primarily cement).

*Compound Annual Growth Rate

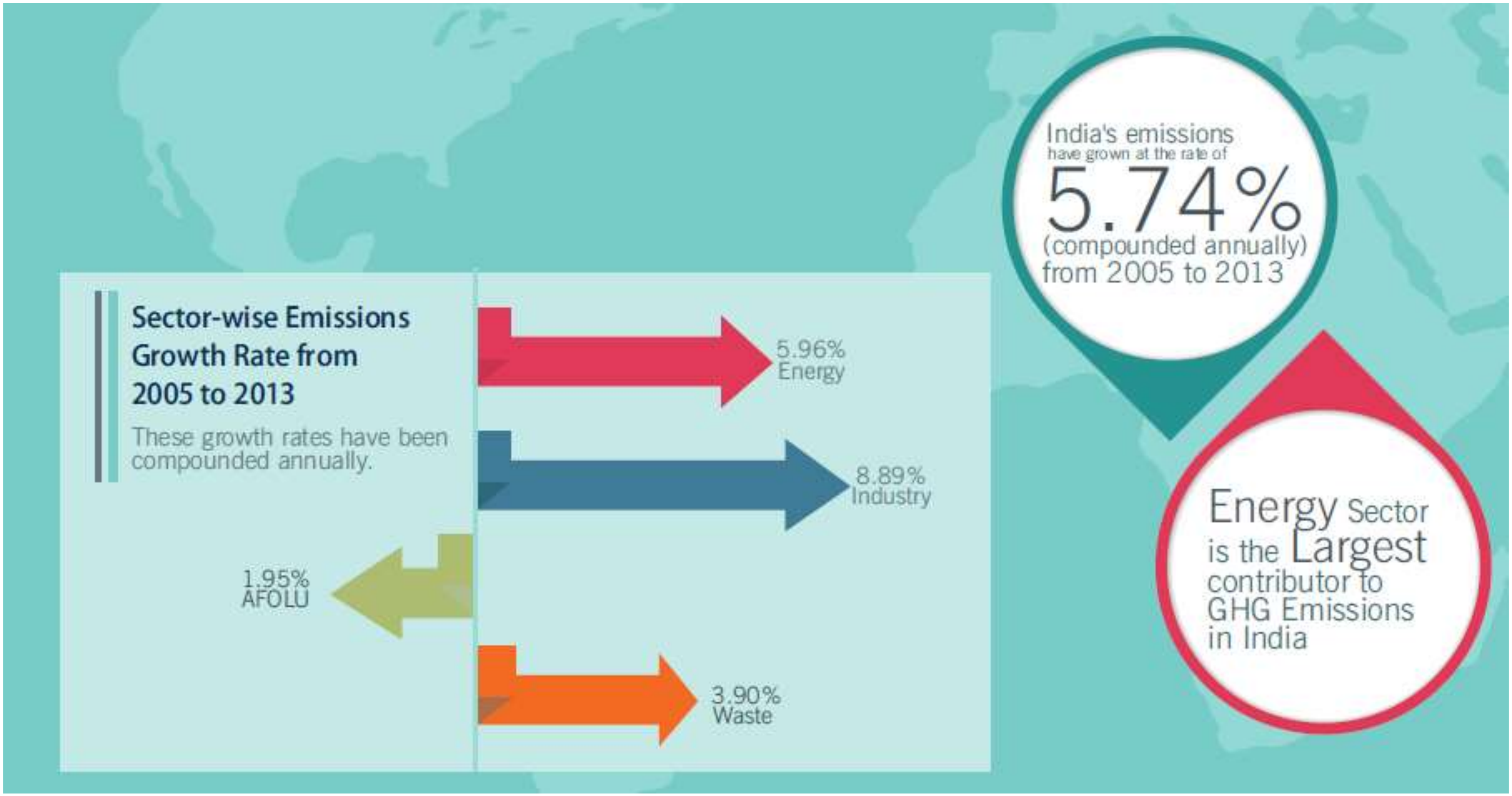
**Captive generation is known to be more inefficient and its rising share in electricity emissions is concerning

#Despite Renewable Energy generation growing by 34% in the same period

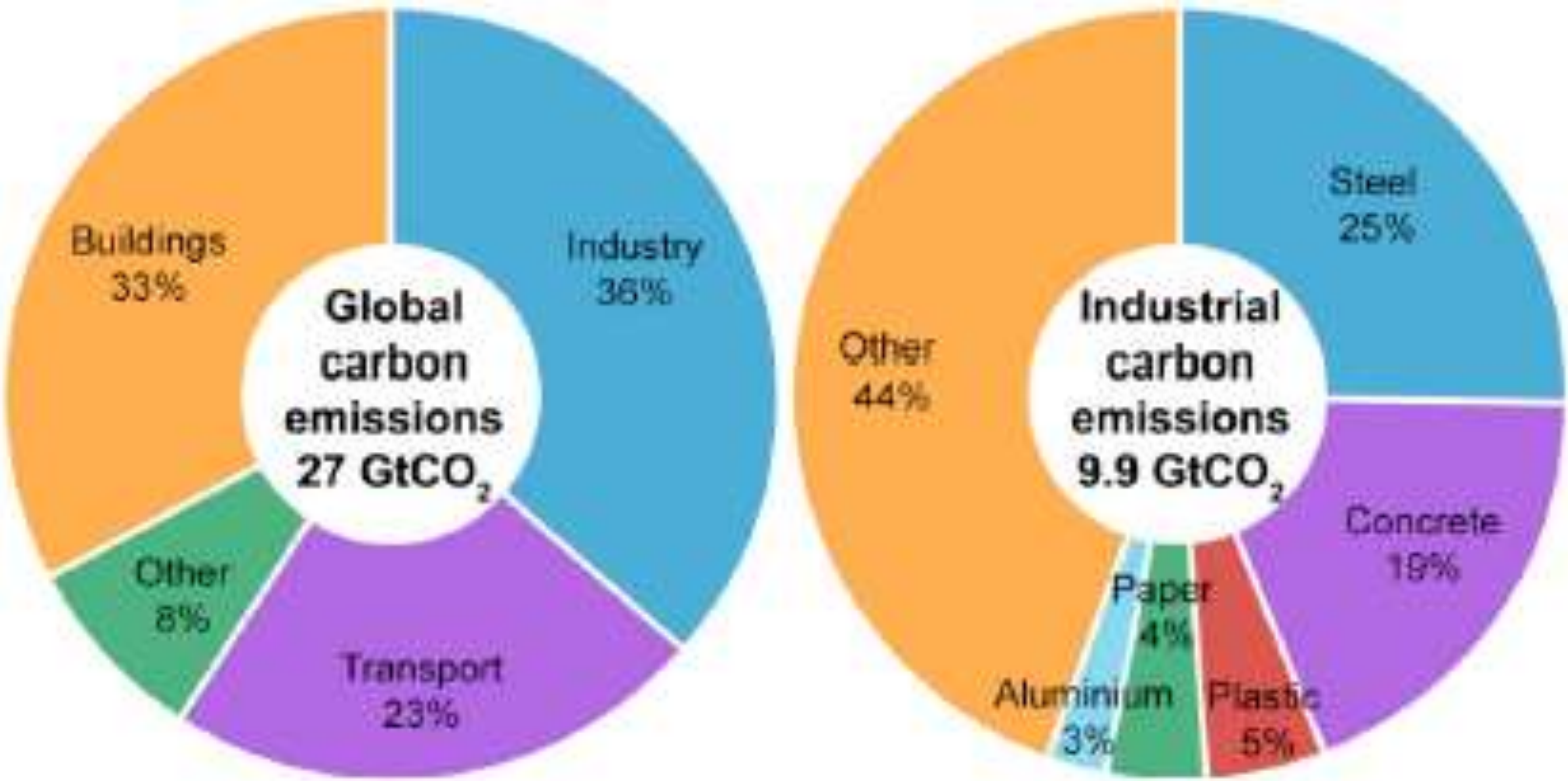
##Low Sulphur Heavy Stock/Hot Heavy Stock

###Fuel combusted for captive electricity generation has not been recorded under industry emissions

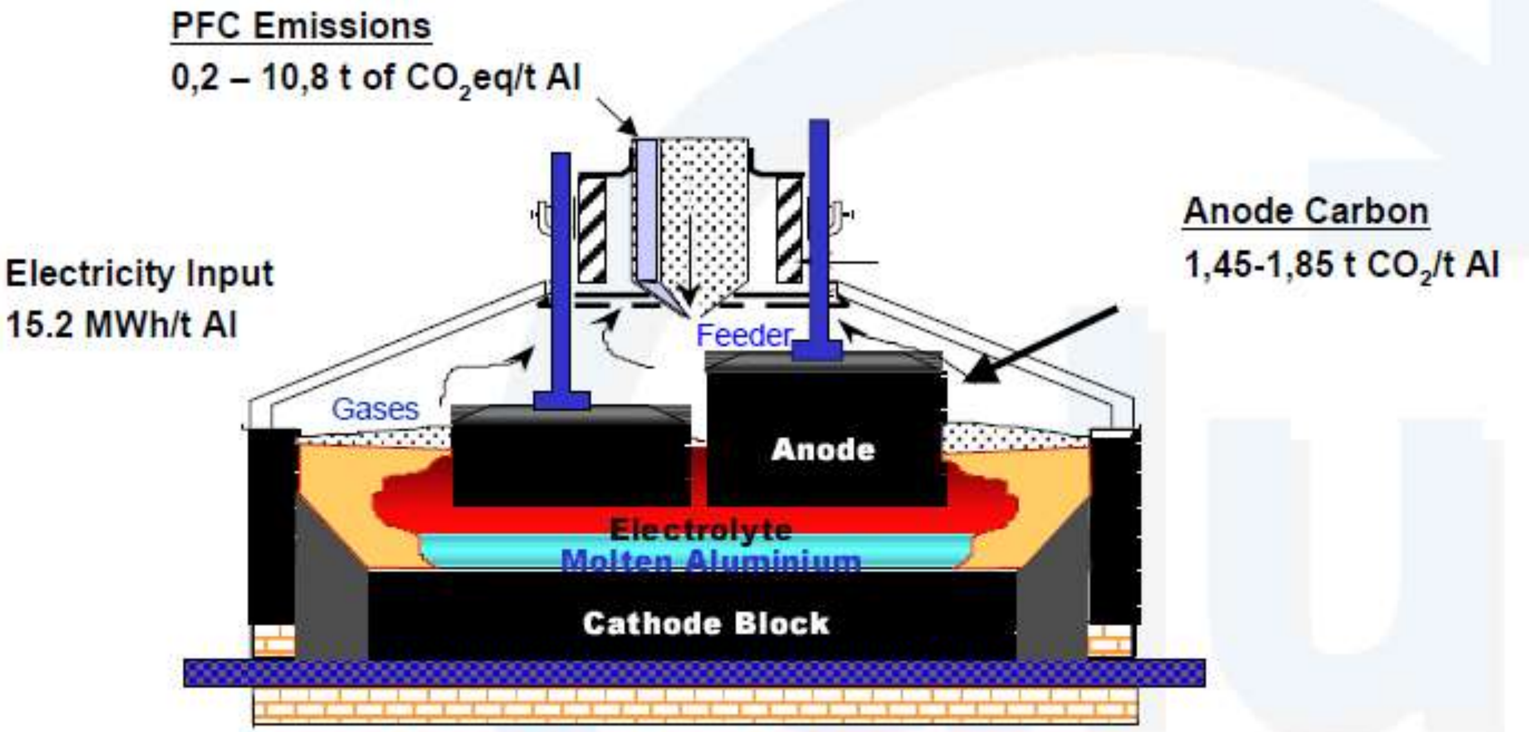
Sector Wise Emission Growth Rate



Global emissions of carbon dioxide (a) by major sector and (b) within industry



GHG from Aluminium

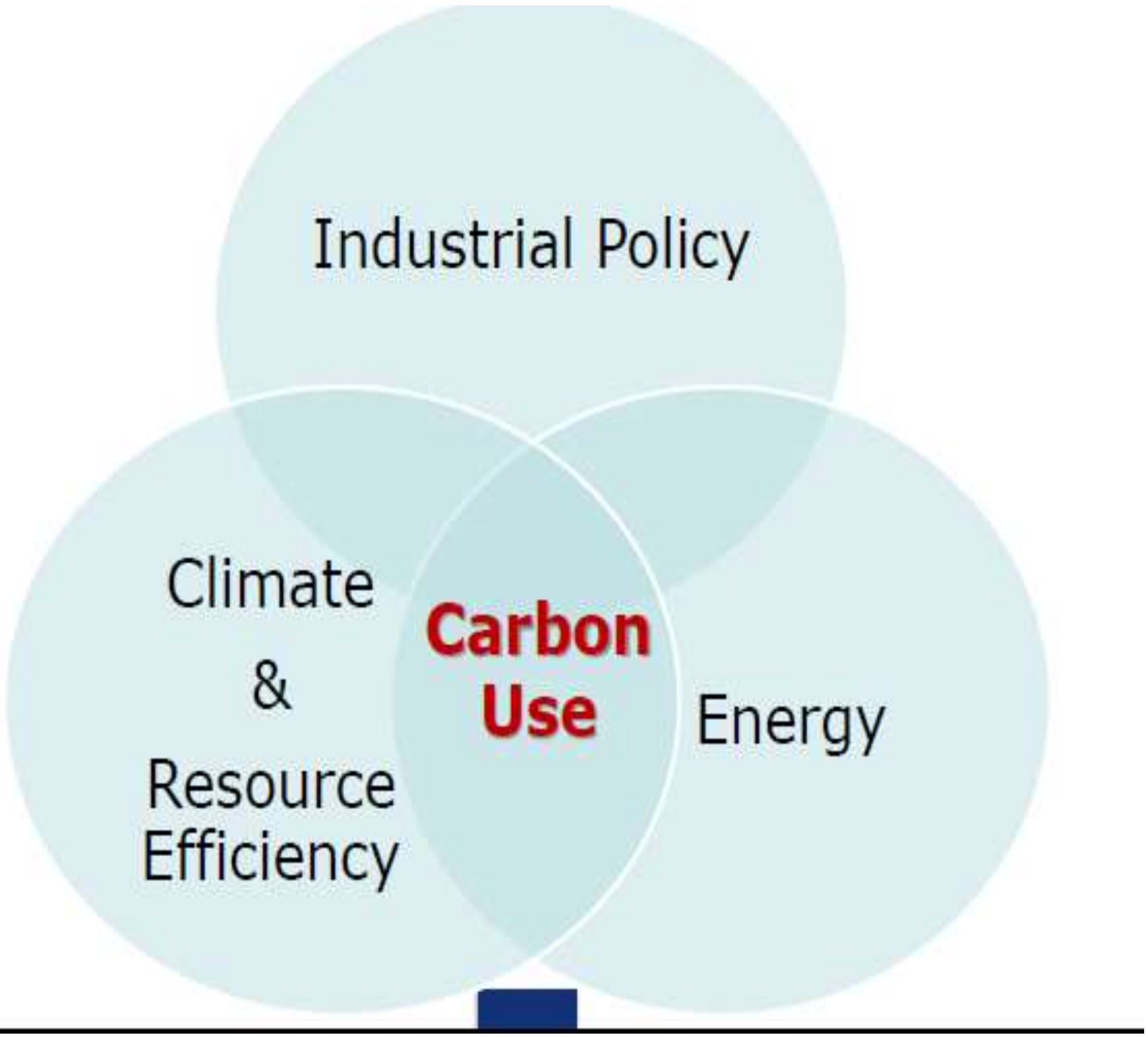


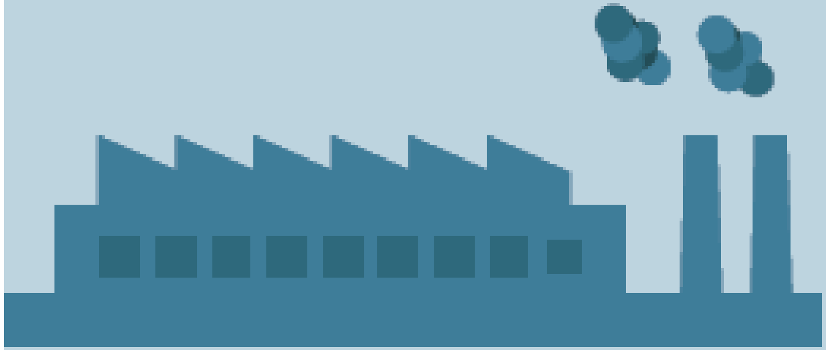
GHG from Primary Aluminium Production

Two PFC (perfluorocarbon compounds - CF_4 and C_2F_6) contribute about 48% of primary aluminium GHG emissions

Carbon Use in Aluminium Industry

Carbon Use


Industrial Policy
Climate
&
Resource
Efficiency
Carbon
Use
Energy



Industry sector represents ~25% of the overall national estimates for the greenhouse gas emissions. As per our estimates, GHG emissions from industries grew at a compound rate of 9% – rising from ~315 Million Tonnes (MT) of Carbon-dioxide equivalent (CO_2e) in 2005, to ~623 MT CO_2e in 2013.

Aluminium Industry Policy

National Industrial Policy 2017- A Discussion Paper

- **For ensuring sustainability and responsible industrialisation**
  - "Establishment of a circular economy"
  - "Improvements in energy use efficiency through large scale adoption of smarter technologies"
  - "What are the measures to ensure minimal/zero waste from industrial activities?"

http://pibphoto.nic.in/documents/rlink/2017/aug/p201783006.pdf

Carbon Policy

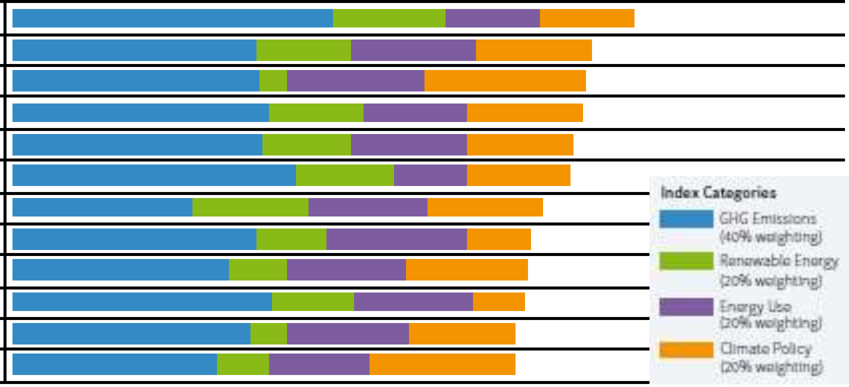
- Globally, negative sentiment about coal (CCC), declining consumption trend in most of major economies, except India
- Excessive Carbon tax of $9.71 a tonne of CO_2 emission (developing country perspective with low per capita consumption of electricity)
  - Obligation to purchase renewable power (2018-19 target is 17%)
  - Unpredictable renewable power needs backup (cost +)
  - coal cess of Rs. 400 a ton
  - the carbon trading system
  - electricity duty on power generation (levied by states)
- Despite having a competitive advantage in coal, India is one of the most expensive places to produce coal-based electricity
- NITI Aayog: Separate energy policy for power-intensive industries like aluminium, a strategic metal critical to infrastructure, automobiles & defence industries

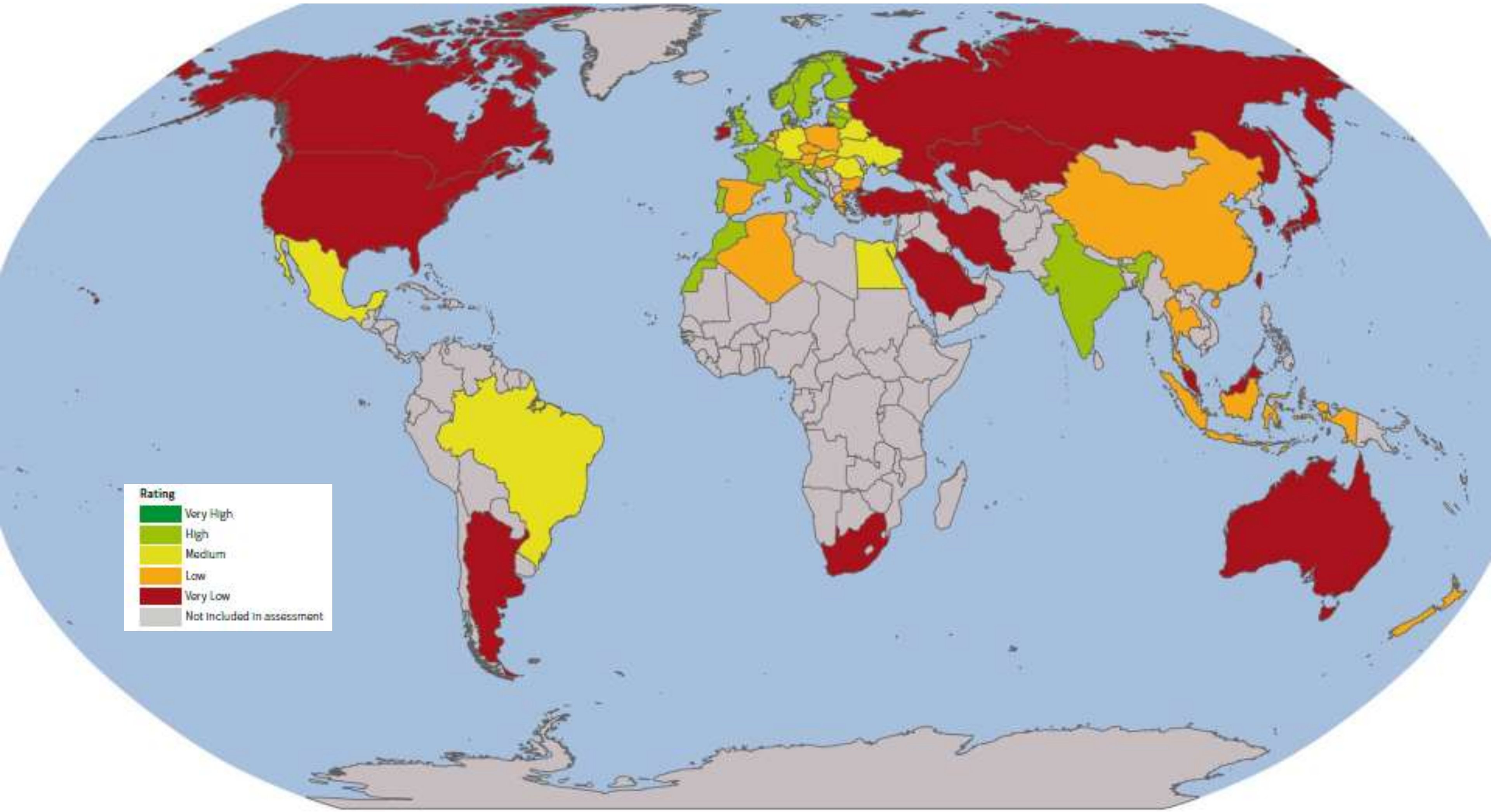
Climate Change Performance Index

- With a high rating in the emissions and energy use categories, India secured 14th place in the ranking
- With its still low per capita emissions, the country’s emissions level is showing compatibility with a well-below-2°C pathway
- Yet emissions over the last years have increased relatively strong
- India ranks medium in the climate policy category with its plans for further promoting renewable
- Despite India‘s significant deployment of renewable, the country should further improve the targets for this category

CCPI 2018

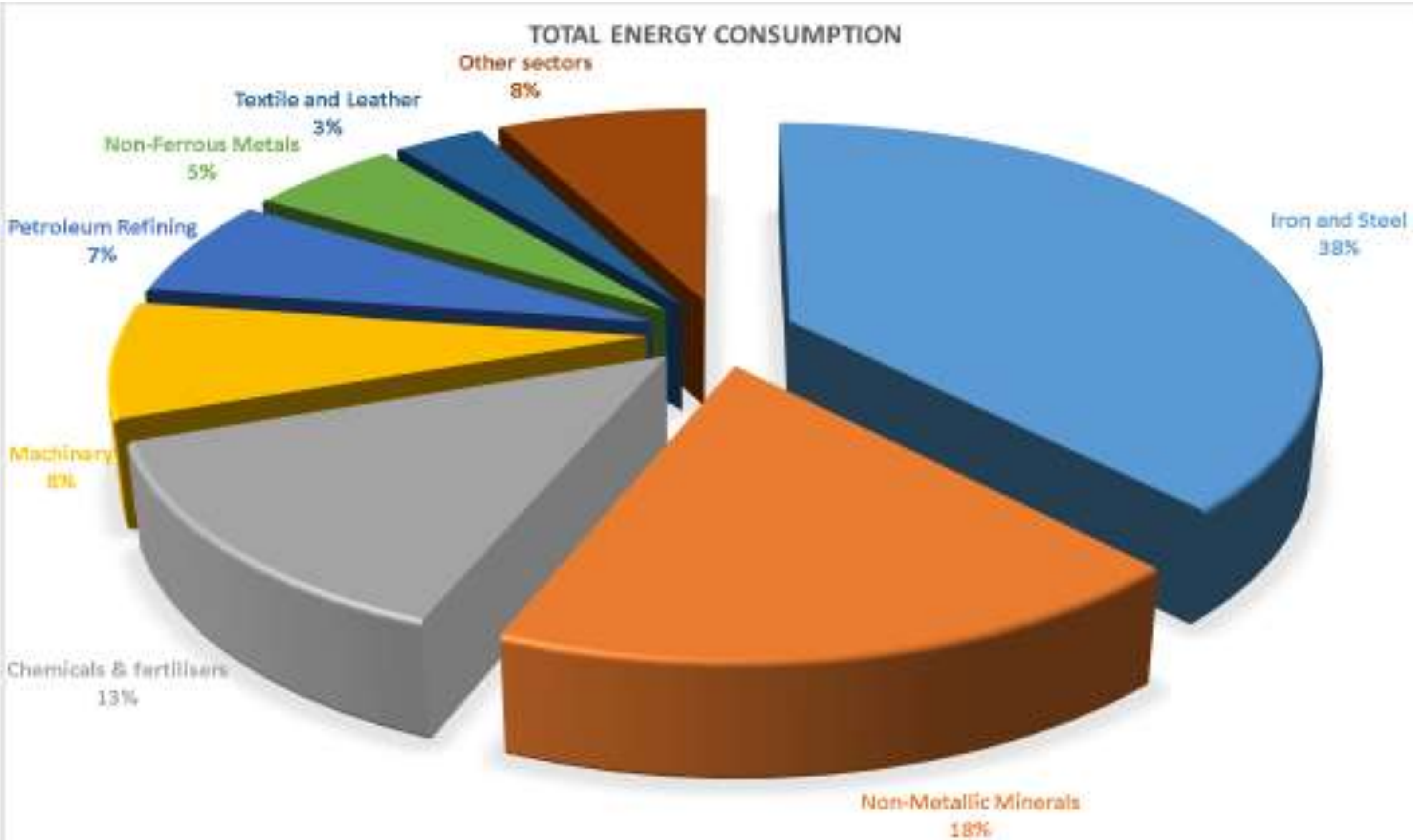
4.	Sweden	74.32
5.	Lithuania	69.20
6.	Morocco	68.22
7.	Norway	67.99
8.	United Kingdom	66.79
9.	Finland	66.55
10.	Latvia	63.02
11.	Malta	61.87
12.	Switzerland	61.20
13.	Croatia	61.19
14.	India	60.02
15.	France	59.80





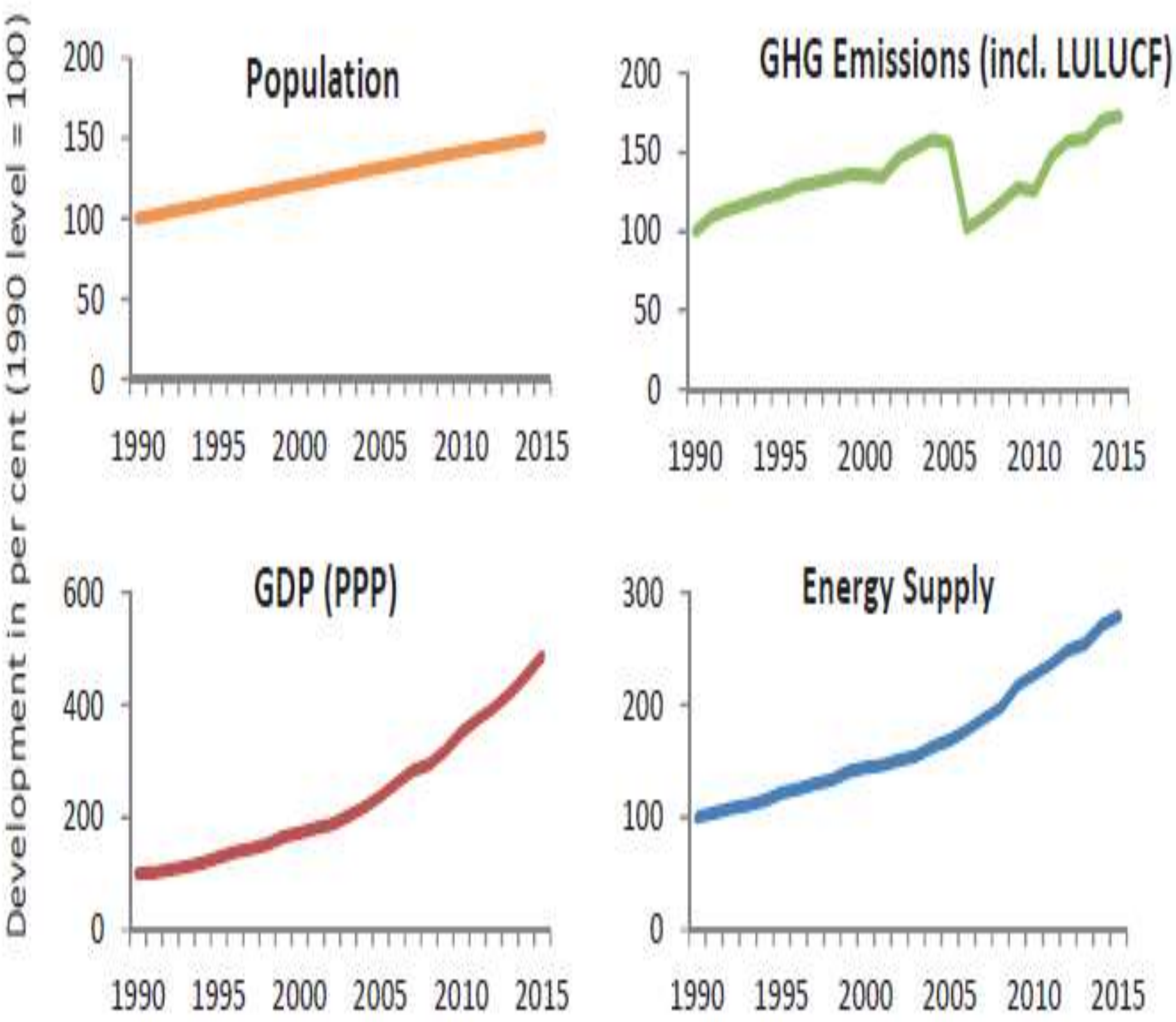
- National Mission on Enhanced Energy Efficiency including Perform Achieve & trade (PAT) Scheme (Industries)
- Zero defect, Zero Effect Scheme (Improve overall efficiency & zero adverse environmental & ecological effect)

Indian Industries GHG Emissions



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 accounts for 25% of India's total GHG emissions!



Key Indicators	2015
Population [million]	1311,10
GDP per capita (PPP) [US$]	5617,27
CO_2 per capita (excl. LULUCF) [t]	1,58
CO_2 per GDP (PPP) [t/1000US$]*	0,90
TPES per GDP (PPP) [MJ/US$]	4,84
CO_2 per TPES [t/TJ]*	57,98
Share of Renewable Energy of TPES	24,99%

GHG = Greenhouse Gases

TPES= total primary energy supply

PPP= purchasing power parity in prices of 2005

LULUCF = Land Use, Land Use Change and Forestry

Source: IEA (2017)

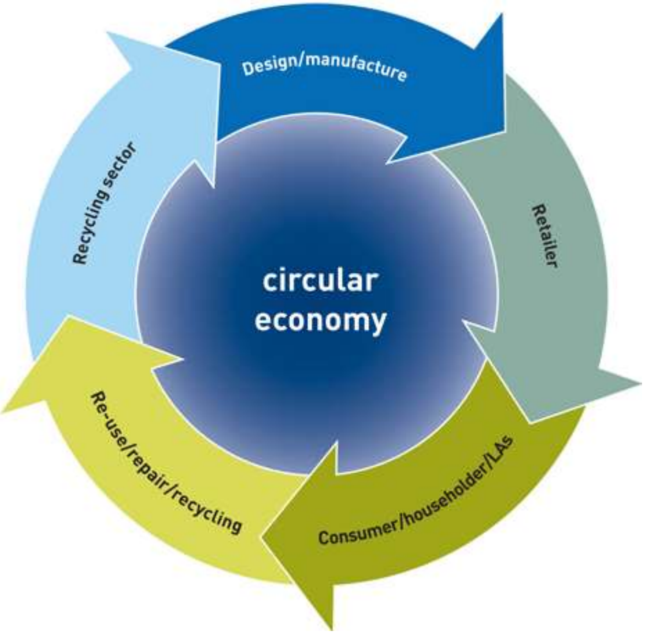
Climate & Resource Efficiency

Aluminium – Resource & Energy Efficient

- Al synonymous with sustainability, climate change prevention & ecological ‘footprints’
- Al production, process & products fit well in to conservation of RE & EE
- RE is apparent in complete LCA from extraction-semi-finished-finished-utilisation-recycling and its life as a new product
- With Al, LC can be repeated indefinitely. More than three-quarters of all Al ever produced is still in use today (recycled many times over)

Circular Economy

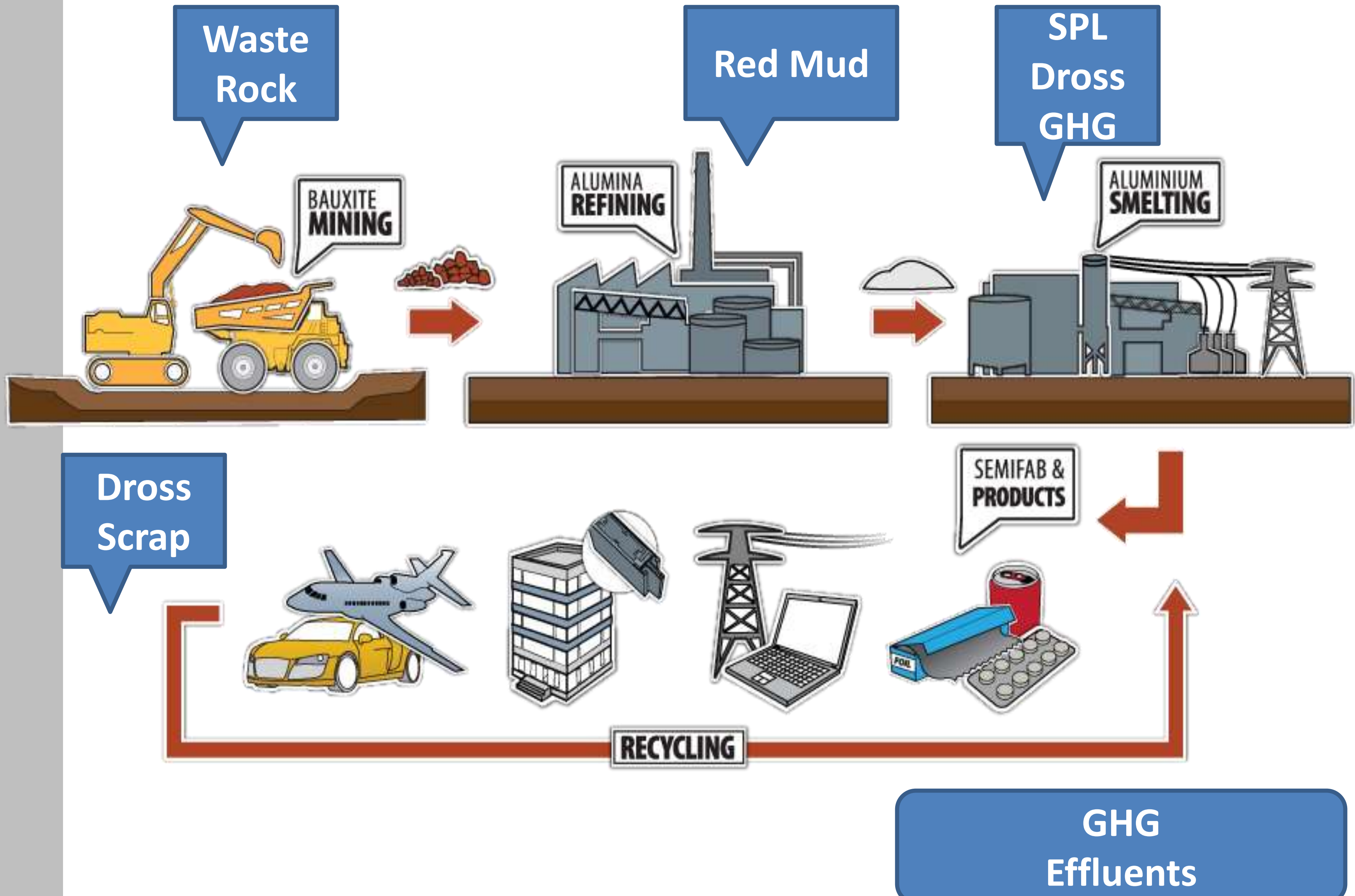
The circular economy aims to eradicate waste—not just from manufacturing processes, as lean management aspires to do, but systematically, throughout the life cycles and uses of products and their components.



Importance of Aluminium circular economy

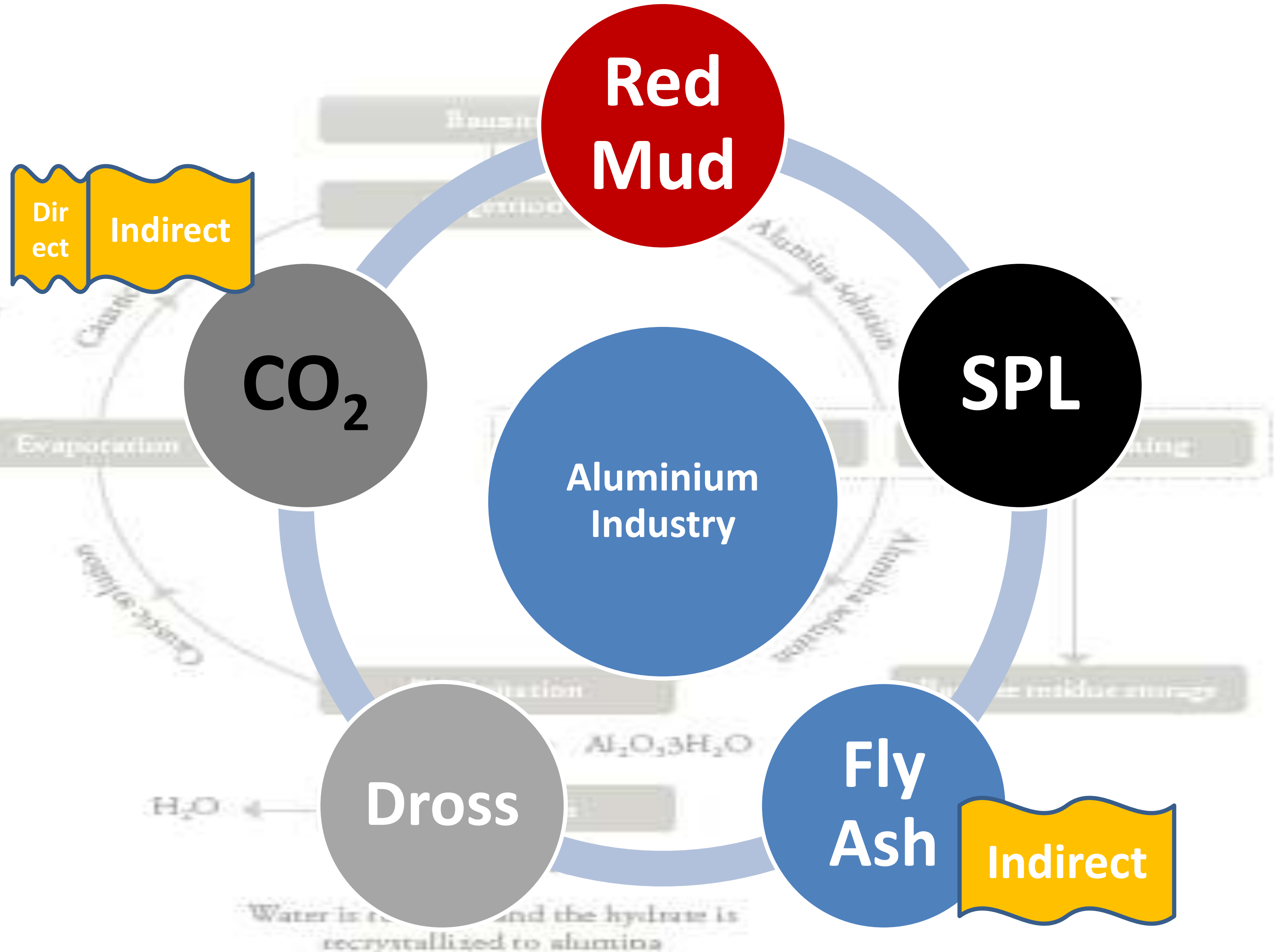
- Creating growth opportunities
- Reduce waste to ZERO
- Deliver competitive economy
- Address resource security/scarcity
- Reduce environmental impacts

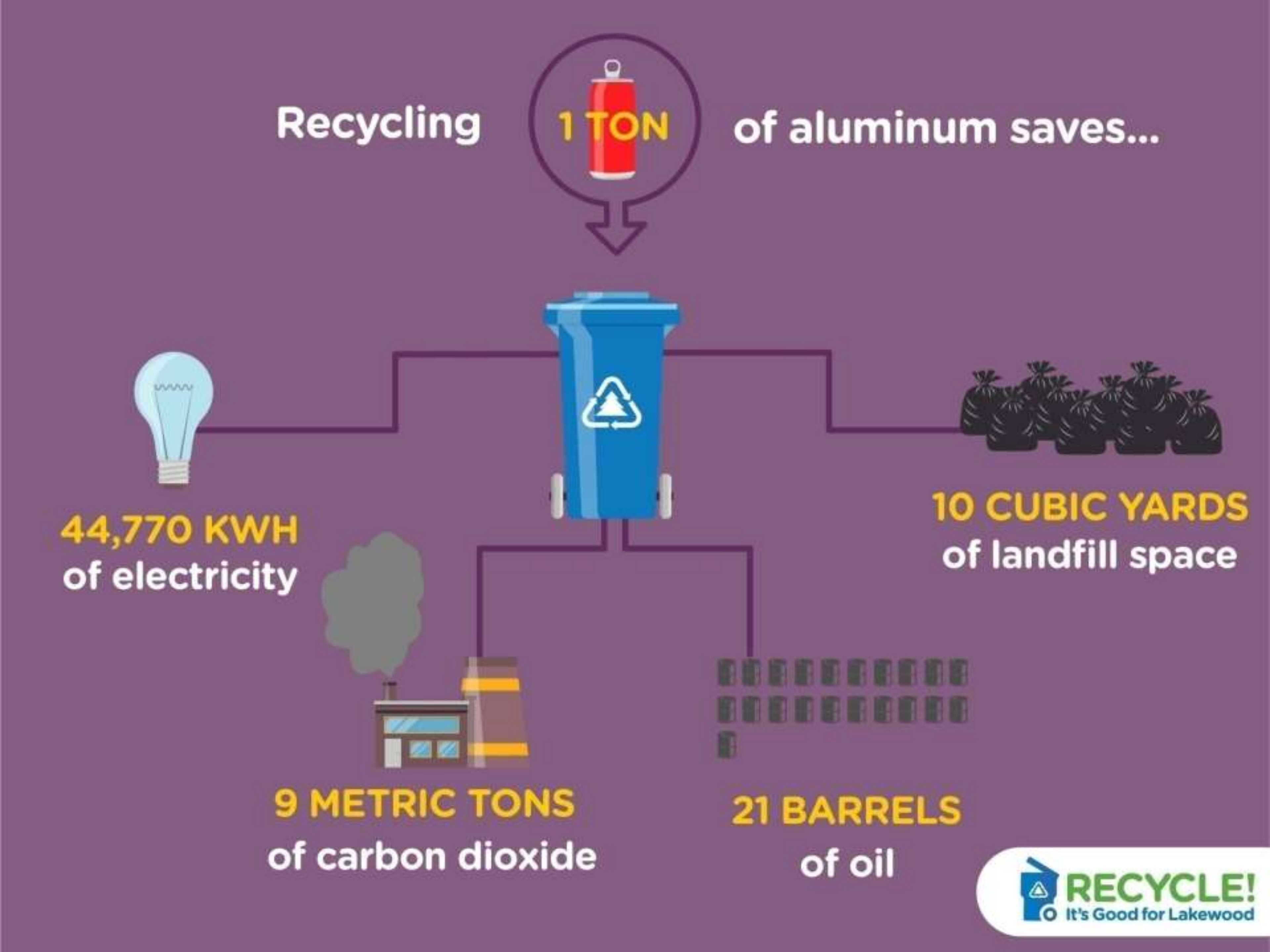
Aluminium Production Schematic



Aluminium Vs Steel: Waste Generation

Waste from Al Industry

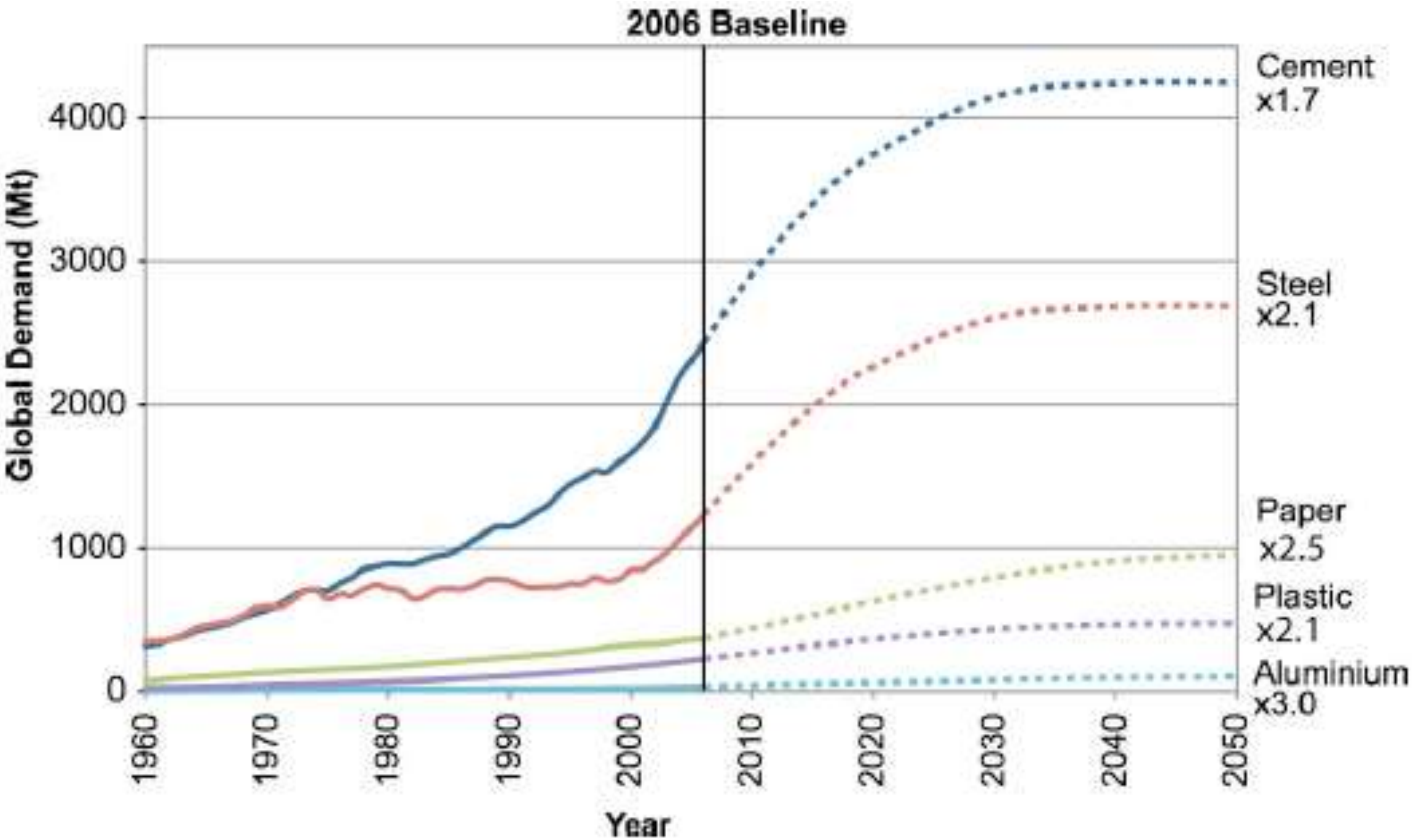




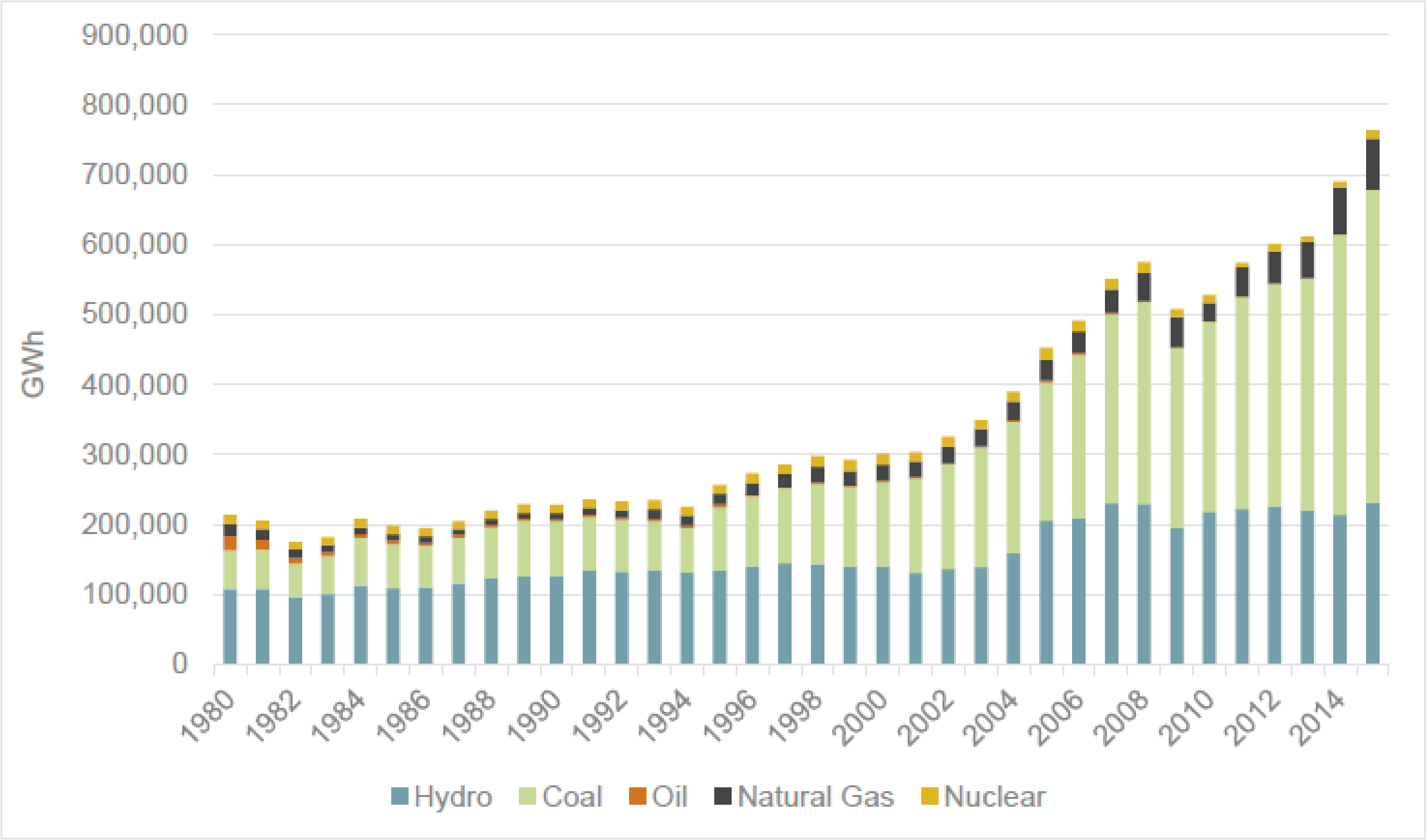
Recycling
1 TON
of aluminum saves...
44,770 KWH
of electricity
10 CUBIC YARDS
of landfill space
9 METRIC TONS
of carbon dioxide
21 BARRELS
of oil
RECYCLE!
It's Good for Lakewood

Aluminium & Energy

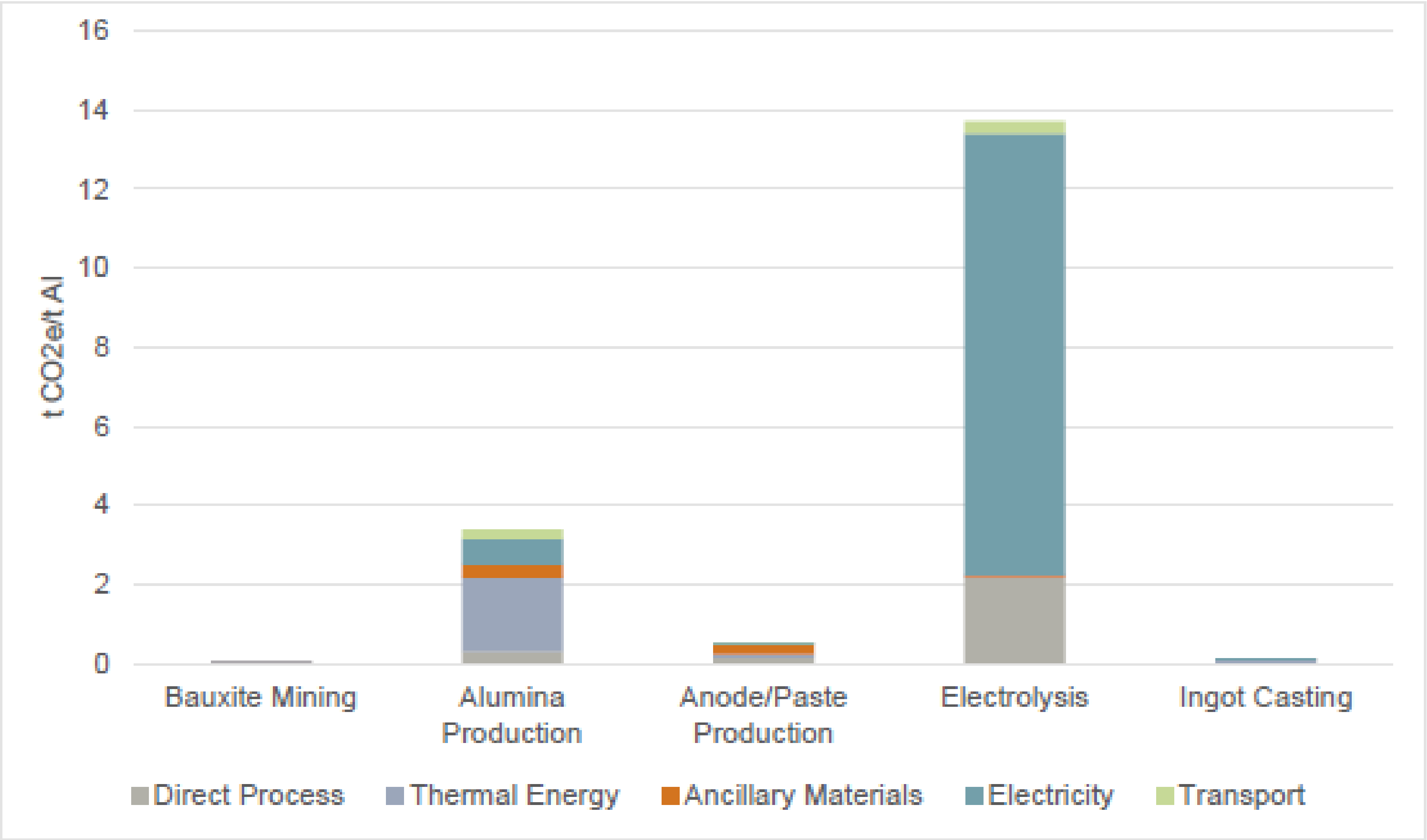
Global demand for the five key materials, historic from 1960 and forecast to 2050



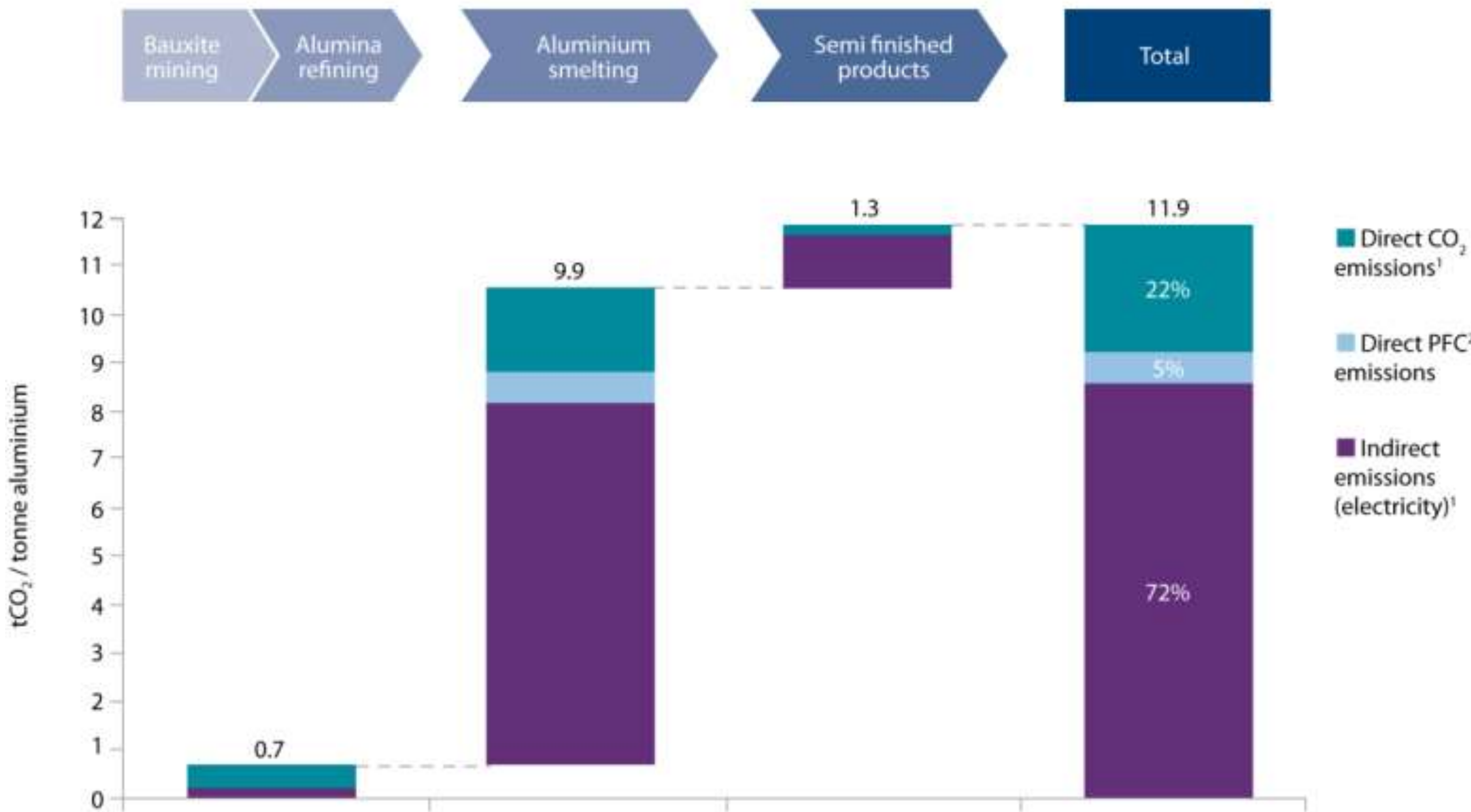
Global Aluminium Industry Powermix (1985-2015)



Global Warming Potential
(unit process & process type)



GHG Emissions During Production of Virgin Aluminium



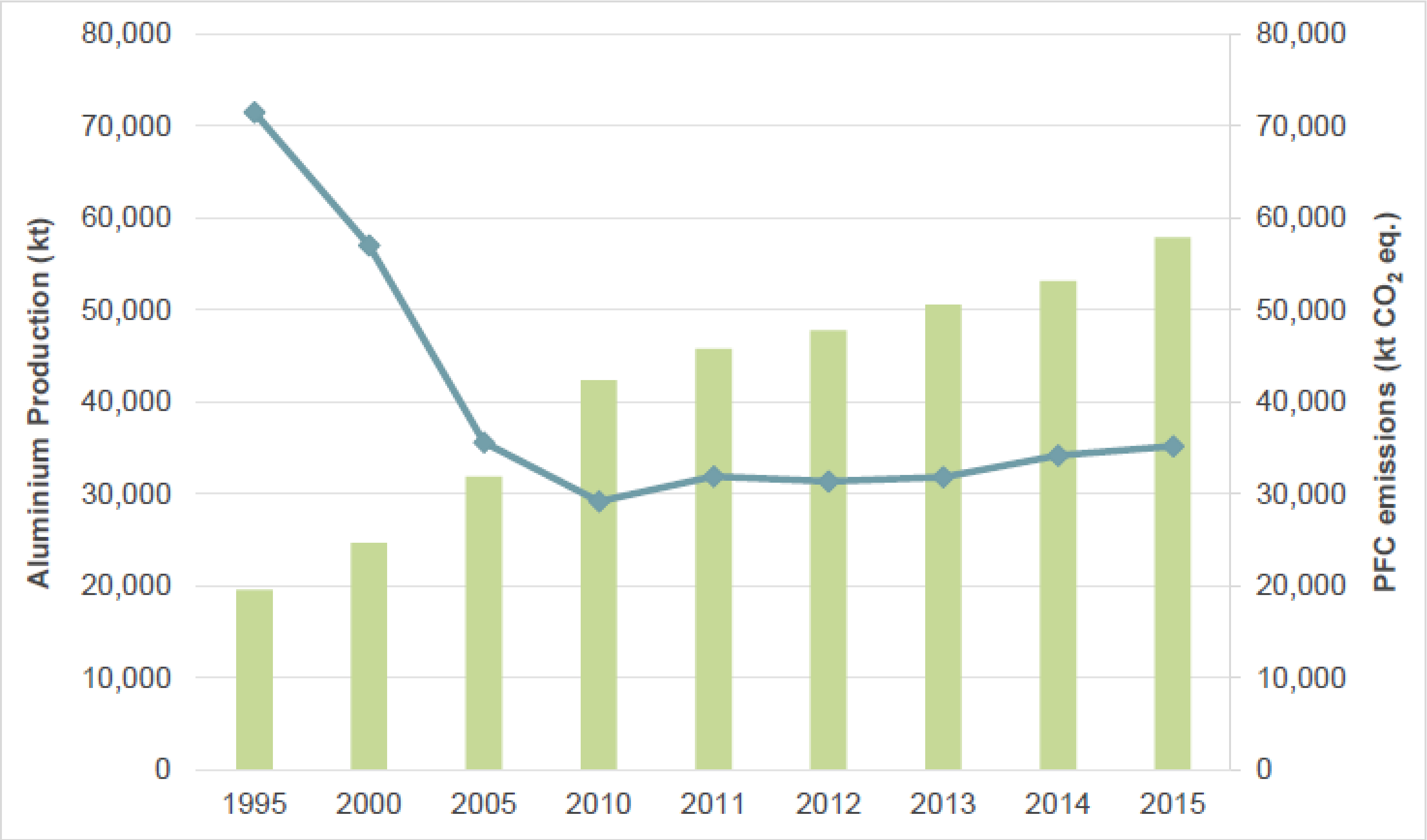
[1] Direct emissions are CO_2 emissions arising from the production process (mainly anode degreadation), whereas indirect emissions are those associated with electricity production.

[2] Perflourocarbon emissions from electroyte.

Note 1: Emissions are based on a global average. Actual emissions vary from 3-20t CO_2e per tonne of aluminium depending on electricity supply

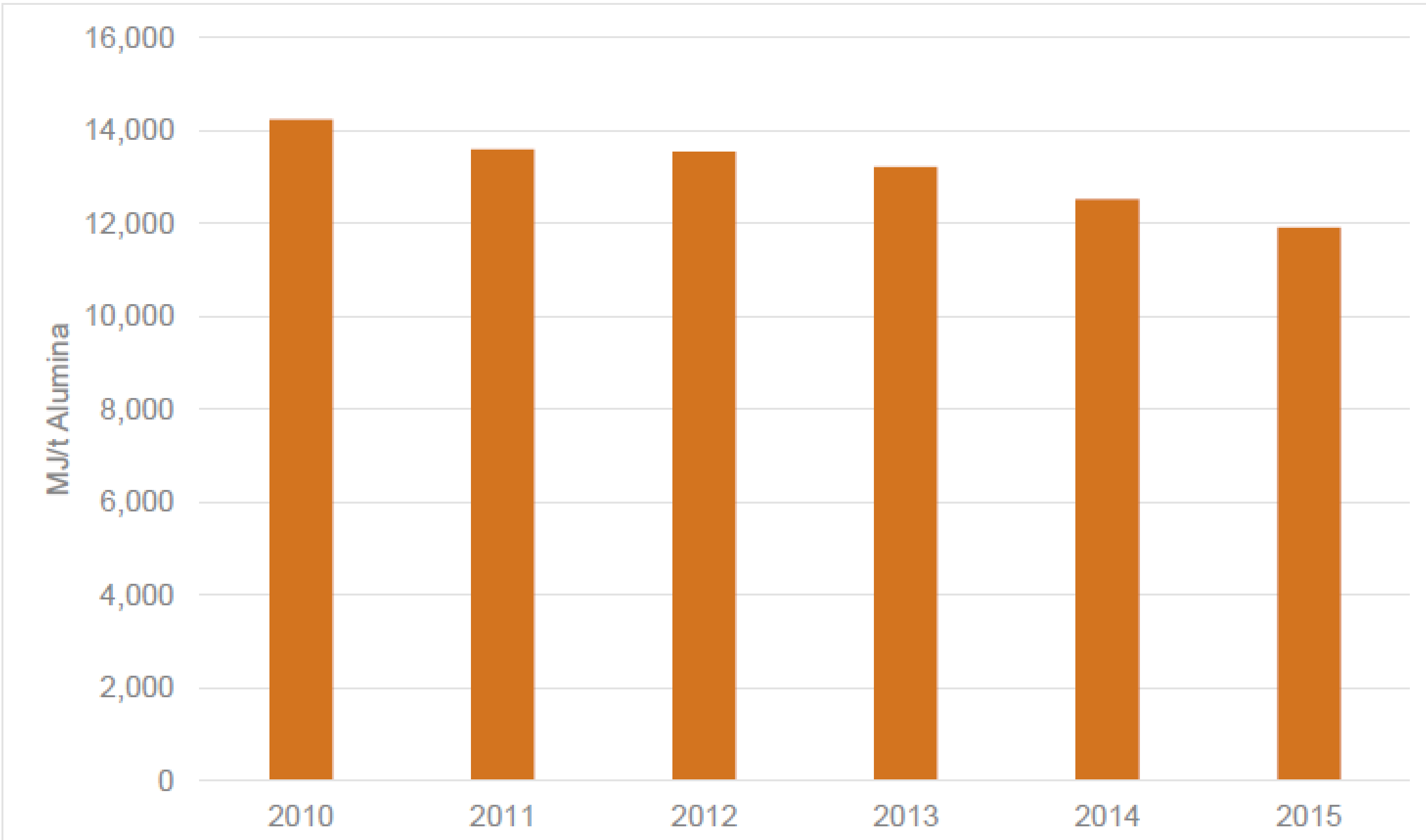
Source: BCG Analysis; Data from James F. King; Energy Report (IEA 2007); Sustainability Report (IAI, 2008).

Total global aluminium industry perfluorocarbon emissions against global production



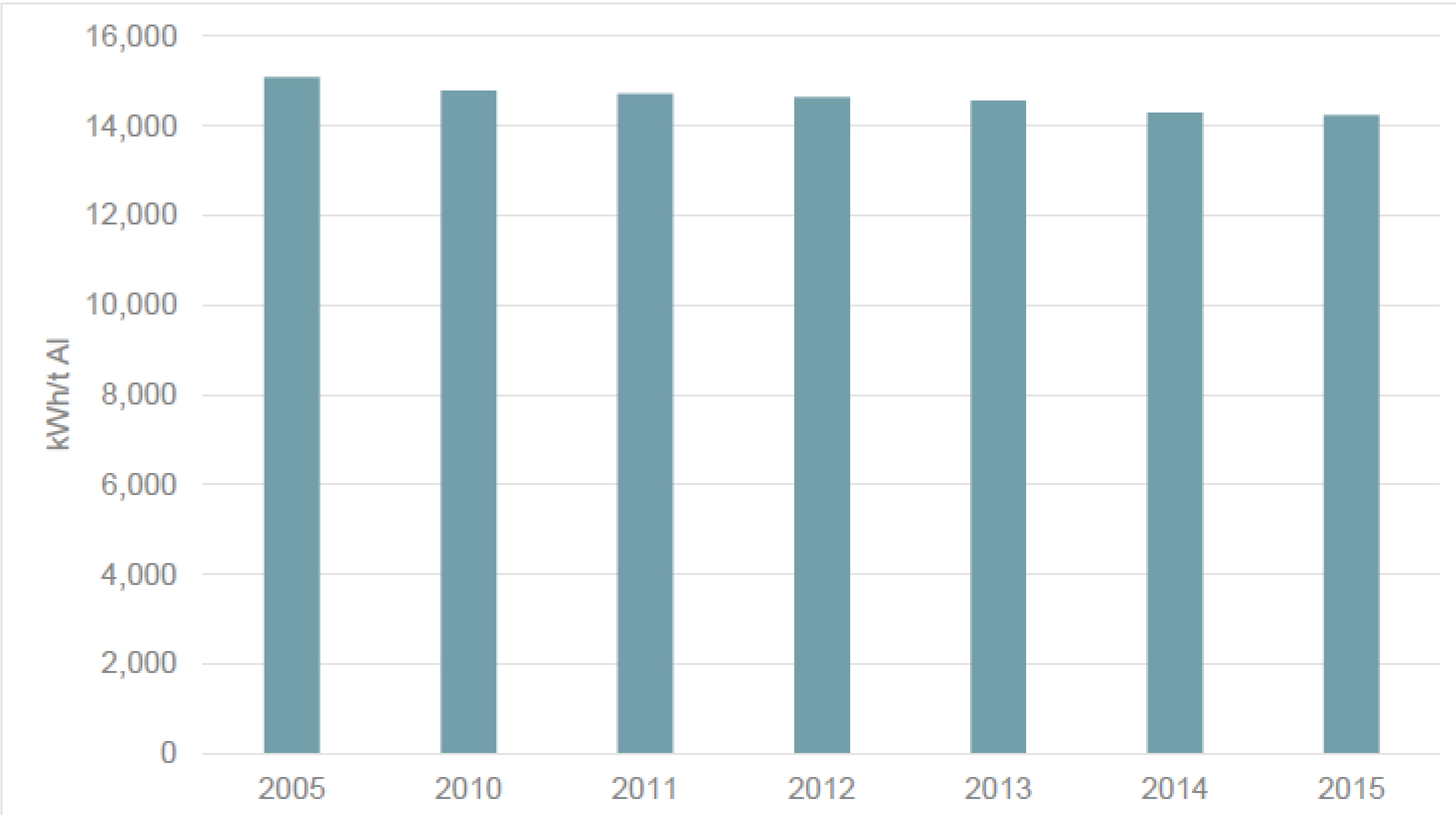
http://www.world-aluminium.org/media/filer_public/2018/02/19/lca_report_2015_final_26_june_2017.pdf

Global energy intensity of the alumina production process for years 2010 – 2015



Source : **Life cycle inventory data and environmental metrics for the primary aluminium industry June 2017**(world-aluminium.org)

Global aluminium smelting electrical energy intensity for years 2005 – 2015



Source : **Life cycle inventory data and environmental metrics for the primary aluminium industry June 2017**(world-aluminium.org)

Global Aluminium Industry Power Mix

% power mix	Africa (AFR)	Asia (ex China) (OAS)	Canada (CAN)	China (CNA)	Europe (EUR)	GCC (GCC)	North America (NAM)	Oceania (OCA)	Russia & Other Europe (ROE)	South America (SAM)	World (GLO)
Hydro	57	14	100	10	68	0	74	27	98	72	30
Coal	43	86	0	90	10	0	24	73	2	0	59
Oil	0	0	0	0	1	0	0	0	0	0	0
Natural Gas	0	0	0	0	5	100	1	0	0	27	9
Nuclear	0	0	0	0	16	0	1	0	0	0	2
Total	100	100	100	100	100	100	100	100	100	100	100

http://www.world-aluminium.org/media/filer_public/2018/02/19/lca_report_2015_final_26_june_2017.pdf

Strategies for Low Carbon

- Dissemination of best practice, further process efficiencies (introduction of inert anodes, wet and drained cathodes and carbothermic reduction in aluminium) and increased recycling
- Increased use of de-carbonised electricity, including renewables, nuclear power and ‘clean coal’ for electrolysis in aluminium production, and eventually steel.
- Claiming credit for emissions reductions in other sectors – for instance if aluminium is substituted for steel in car making and the resulting lighter car is more fuel efficient.

Sequestration of carbon dioxide (CO_2) using red mud

- In Bayer process of obtaining alumina from bauxite, the insoluble product generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure is known as “red mud” or “bauxite residue.”
- It is an alkaline residue with a high pH of 10.5–12.5.
- In this view, a pH-reduction processing step is incorporated to ameliorate the red mud by sequestrating it with CO2. By mixing carbon dioxide into the bauxite residue, the compound’s pH level can be reduced to levels normally found in alkaline soil.
- It was seen that full neutralization of red mud takes place following CO2 carbonation, but the pH rebound of carbonated mixtures takes place and the pH drifts upward to a value of 9.4–9.7 with time when solution and solid remains in contact. Chemical, mineralogical, and morphological analysis of neutralized red mud is also studied in the paper.

At last…

- Globally, a third of oil reserves, half of gas reserves and over 80 % of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2°C
- At least a 50 % chance of keeping warming below 2°C throughout the 21st century
- However, the cumulative carbon emissions between 2011 and 2050 need to be limited to around 1,100 gigatonnes of carbon dioxide (Gt CO_2)

(Christophe McGlade and Paul Ekins (2015) in Nature)

Thank You

Anupam Agnihotri

Director

Jawaharlal Nehru Aluminium Research Development & Design Centre, Nagpur

director@jnarddc.gov.in

+91 7104220763

+91 9404084435

www.jnarddc.gov.in

सत्यमेव जयते

Ministry of Mines

Government of India