Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Presentation report

Steel industry in India:
Potentials and technologies for reduction of CO_2 emissions

– Report –

prepared for

GIZ – Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, Germany

Munich, December 15th, 2011

AMCG Unternehmensberatung GmbH International Management Consultants
Landshuter Allee 49, D-80637 Munich, Phone +49-89-130757-0, Fax +49-89-130757-50, e-mail: christoph.genter@amcg.de

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Table of contents

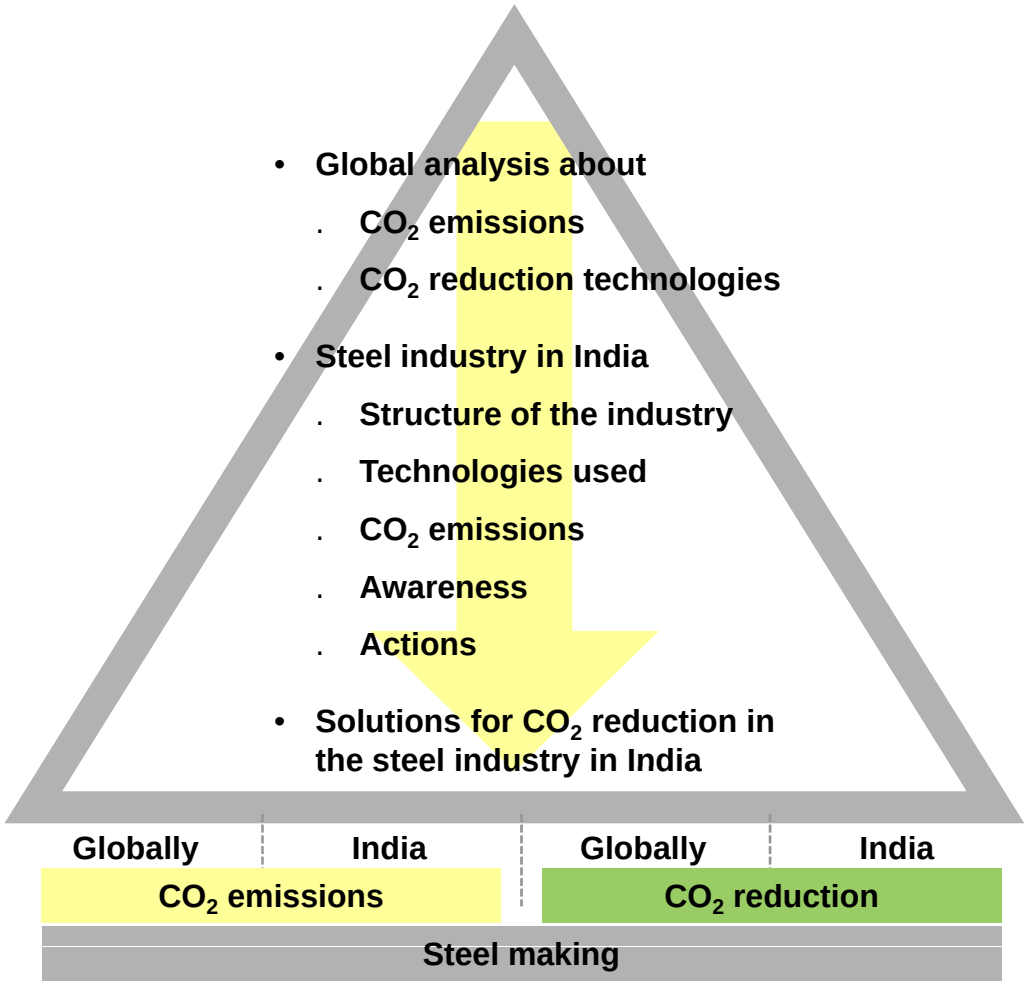
1. Objectives and methodology

The objective of the study was to identify CO_2 reduction potentials in the Indian steel industry.

Objectives of the study

Available technologies for reduction of CO_2 emissions in steel making	Co-processing of waste in steel making	Technology providers	CO_2 emissions and reduction potential in the steel industry in India	Steel companies in India
• Relevant processes for CO_2 emissions • Technologies for reduction of CO_2 emissions: Types of technologies, efficiency	• Use of waste in steel making processes • Feasibility • Synergies with other environmental challenges in India	• Suppliers of CO_2 reduction techno-logies • Position of the companies in India	• Current emission volume • Major sources for CO_2 emissions • Potentials for reduction of CO_2 emissions	• Awareness of the industry in general and by sectors • Current actions of steel companies on CO_2 reduction
Global coverage		Focus Europe	India	Case studies

The study was conducted by a top-down approach, based on meetings with the various stakeholders.



Data sources

- Meetings with stakeholders in India and Europe
- Desk research
  - Policy papers
  - Reports
  - Studies etc.

  from India and globally

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Time schedule

Working packages	2011									
	October			November				December		
Week	42	43	44	45	46	47	48	49	50	51
Potential for reduction of CO_2 emissions in the steel industry in India										
Technologies for the reduction of CO_2 emissions										
Processing of waste material in steel making processes										
Position of Indian steel companies for the reduction of CO_2 emissions										
Potential technology providers for CO_2 reduction										
Workshop in New Delhi								▲ December 7th, 2011		

In the course of the project meetings with 30 stakeholders in India took place.

Europe

- Engineering companies
- Steel industry congress on low emission steel making processes

India

- Industry associations (steel, in general)
  - CII – Confederation of Indian Industry
  - CII-ITC – Centre of Excellence for Sustainable Development
  - FICCI – Federation of Indian Chambers of Commerce and Industry
  - AIIFA – All India Induction Furnaces Association
  - AISRA – All India Steel Rerollers Association
  - IIM – The Indian Institute of Metals
  - SIMA – Sponge Iron Manufacturers Association
- Ministries, environmental organizations
  - Ministry of Steel
  - Joint Plant Committee
  - CPCB – Central Pollution Control Board
  - BEE – Bureau Energy Efficiency
  - Karnataka State Pollution Control Board
  - Tamil Nadu Pollution Control Board
- Steel industry
  - SAIL – Steel Authority Of India
  - TATA Steel
  - Jindal Steel & Power
  - Mukand
  - Adhunik Metaliks
  - Allied Holdings
  - Kalyani Steels
  - Remi Metals/Welspun
- Engineering companies
  - Danieli Corus
  - Mecon
  - Paul Wurth
  - Siemens VAI
- R&D
  - Indian Institute of Technology, Department of Humanities and Social Sciences
  - IRADe – Integrated Research and Action for Development

Policy papers, reports, studies etc. from India as well as global sources were used.

Policy papers from India

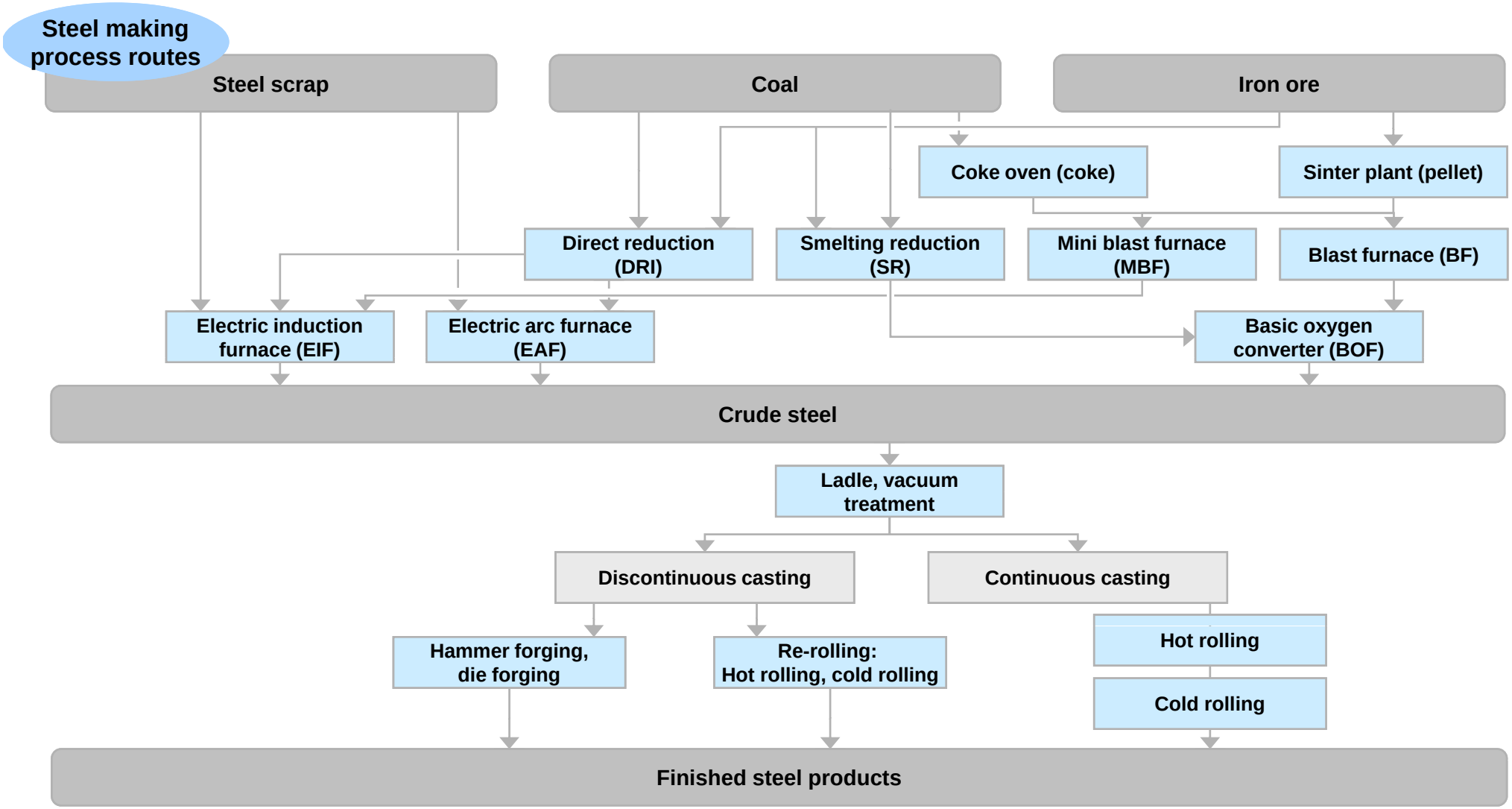
- Low Carbon Strategies for Inclusive Growth. Planning Commission, Government of India, May 2011
- Faster, Sustainable and More Inclusive Growth. An Approach to the 12th Five Year Plan. Planning Commission, Government of India, August 2011 (draft)
- National Action Plan on Climate Change. Prime Minister's Council on Climate Change, Government of India

Steel technology sources

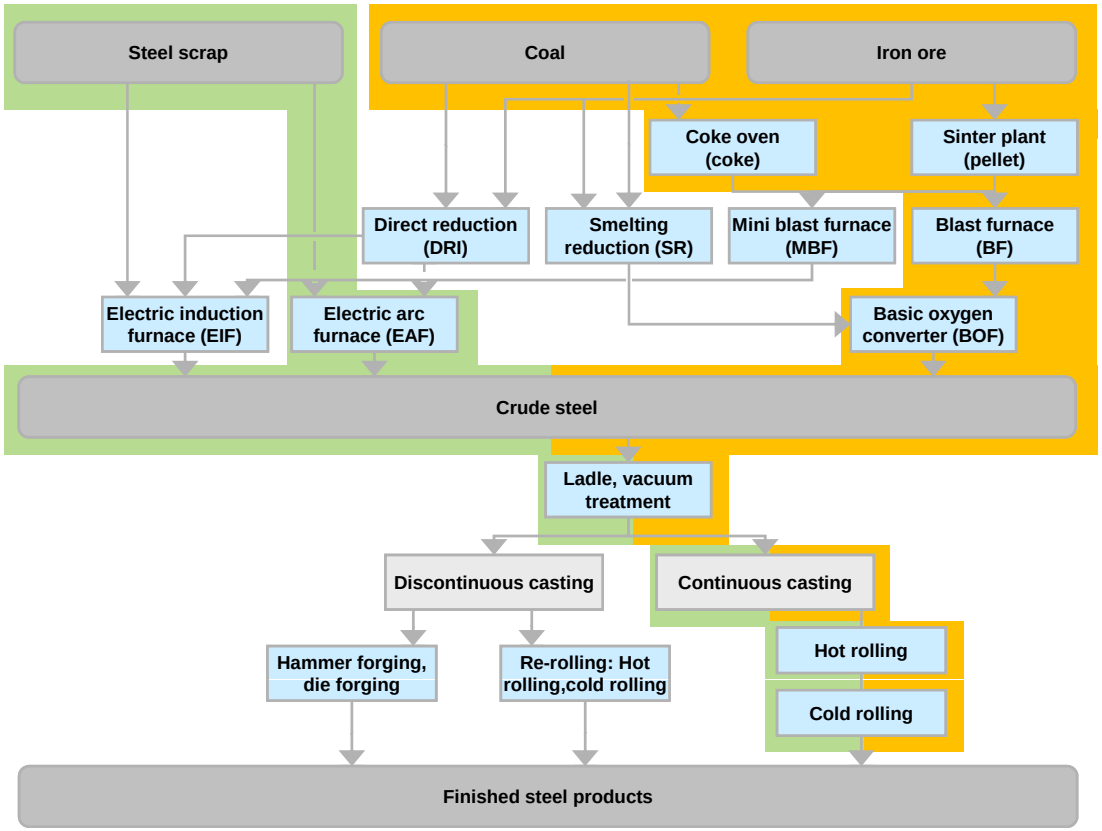
- Best Available Techniques (BAT) for Iron and Steel Production. European Commission, June 2011 (draft)
- Best Available Techniques in the Ferrous Metals Processing Industry. European Commission, December 2001
- Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Iron and Steel Industry. U.S. Environmental Protection Agency, October 2010
- The State-of-the-Art Clean Technologies (SOACT) for Steelmaking Handbook. Asia Pacific Partnership for Clean Development and Climate, December 2010
- Energy Transition for Industry: India and the Global Context. International Energy Agency, January 2011
- Tracking Industrial Energy Efficiency and CO_2 Emissions. International Energy Agency, 2007
- CO_2 Emission Reduction Potential of Large-Scale Energy Efficiency Measures in Heavy Industry in China, India, Brazil, Indonesia and South Africa. Hamburg Institute of International Economics (HWWI), 2005
- Methodology for the Free Allocation of Emission Allowances in the EU ETS post 2012 – Sector Report for the Iron and Steel Industry. European Commission, November 2009
- Worldsteel Association, Fact Sheets
- Best Practices in Energy Efficient Industrial Technologies – Iron and Steel Industry. Institute for Industrial Productivity, October 2011
- Efficiency Improvement Solutions in the Steel Industry. VDEh – German Association of the Steel Industry, September 2010
- EECR Steel 2011 – 1st International Conference on Energy Efficiency and CO_2 Reduction in the Steel Industry.
- Major global programs for new steel technologies with CO_2 reduction
  - ULCOS (Europe)
  - COURSE50 (Japan)
  - POSCO (Korea)
  - AISI (USA)

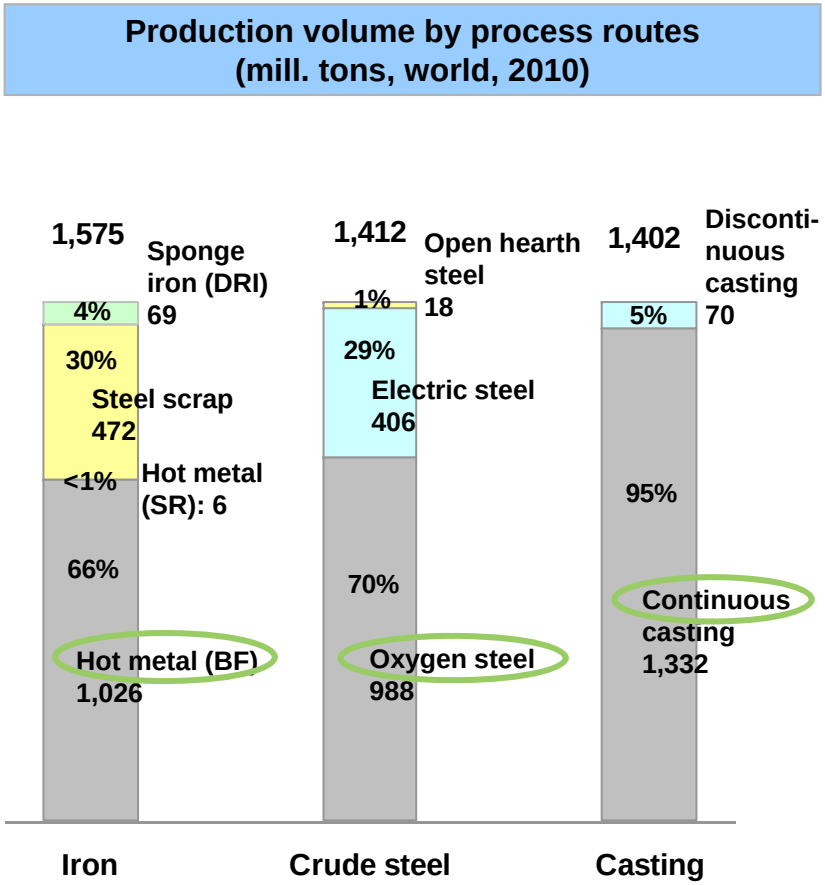
2. Global steel industry: Processes, CO_2 emissions and goals

Steel making is based on various process routes.



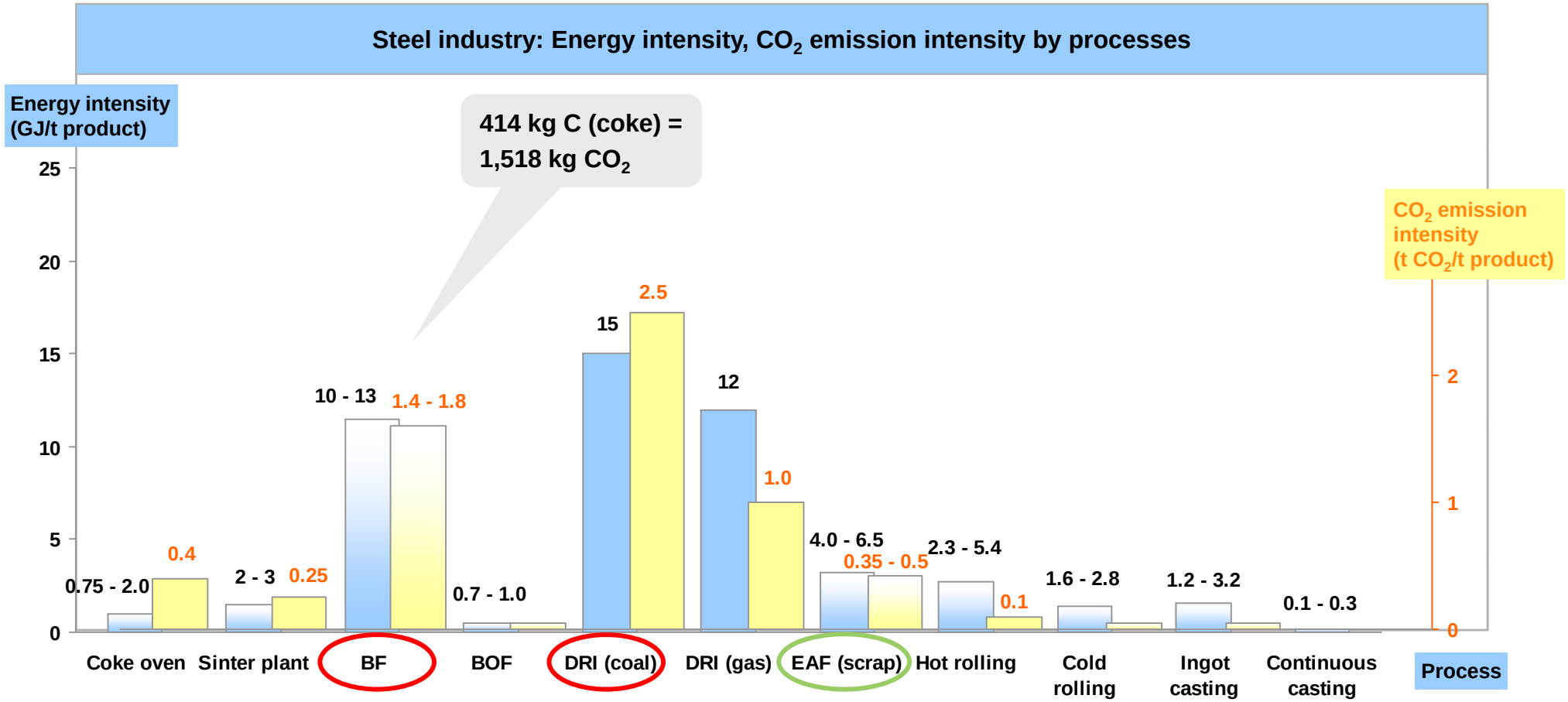
On a global level dominating routes are blast furnace/BOF and electric arc furnace with continuous casting.





Source: Worldsteel , ThyssenKrupp

The blast furnace is the major source of CO_2 emissions due to its need on reducing agents (= coke).



Source: IEA, VDEh, HWWA

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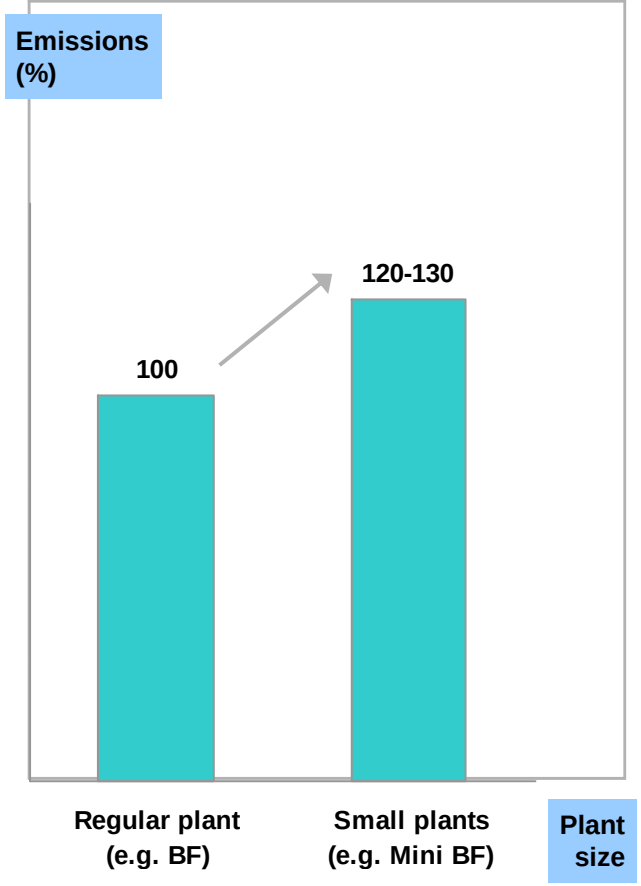
CO_2 emissions of primary raw material based process routes are higher compared with secondary raw material using EAF. Heat losses and efficiency of small scale plants are lower in most cases.

Energy intensity by steel processing routes

	Energy intensity (GJ/t product)
• **Blast furnace (BF) – basic oxygen converter (BOF)**	
· Ingot casting – hot rolling	22.6
· Continuous casting – hot rolling	20.6
· Thin slab casting	17.3
• **Smelting reduction (SR) – basic oxygen converter (BOF)**	
· Ingot casting – hot rolling	22.4
· Continuous casting – hot rolling	20.4
· Thin slab casting	17.1
• **Direct reduction (DRI) – electric arc furnace (EAF)**	
· Continuous casting – hot rolling	23.3
· Thin slab casting	20.0
• **Electric arc furnace (EAF) (scrap)**	
· Continuous casting – hot rolling	9.3
· Thin slab casting	6.0

CO_2 emissions by plant size



Source: IEA, VDEh, HWWA

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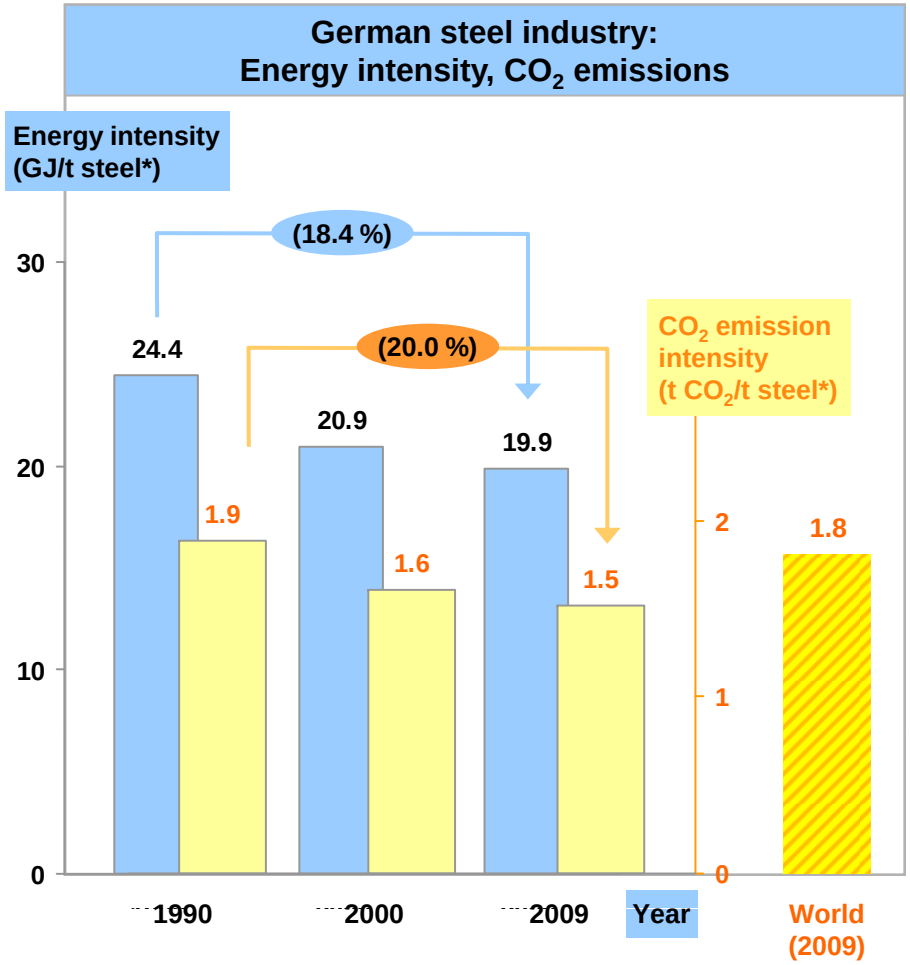
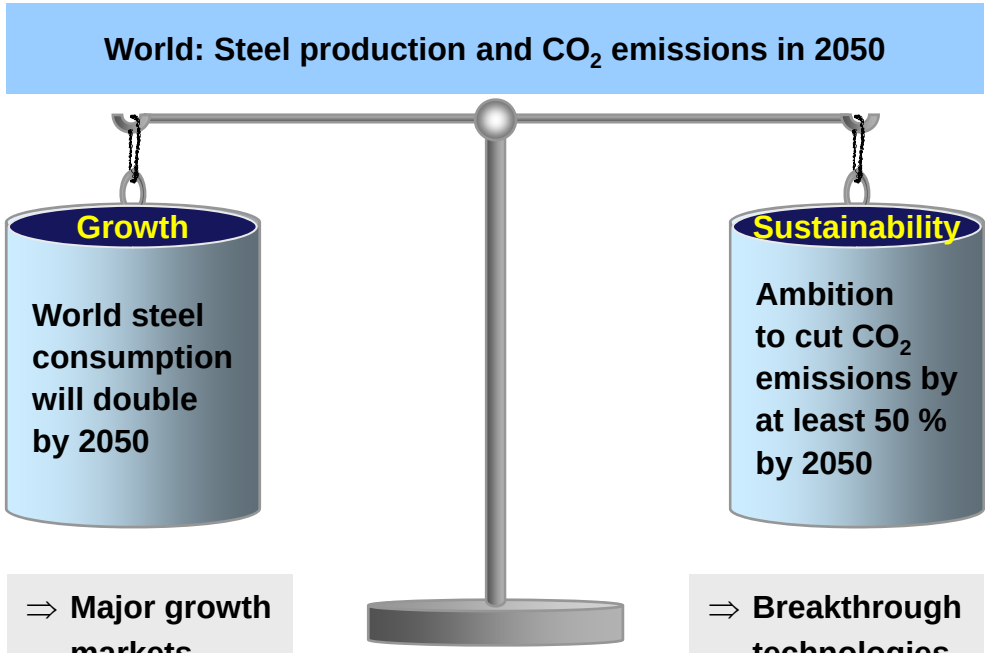
The steel industry has cut energy intensity/CO_2 emissions substantially in the past. The goal is further improvement by breakthrough technologies.



* finished product

Source: VDEh, Worldsteel



⇒ Major growth markets
India
China
Brazil
Russia

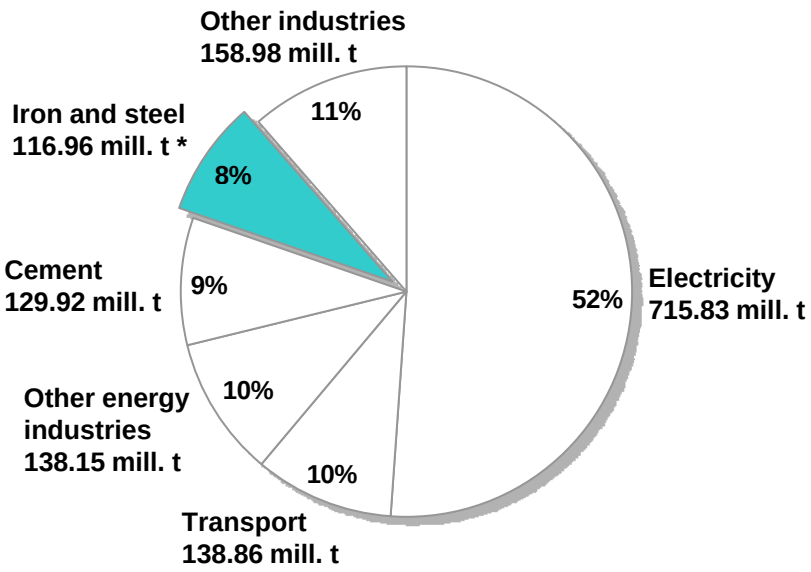
⇒ Breakthrough technologies necessary

3. CO_2 emissions of the steel industry in India

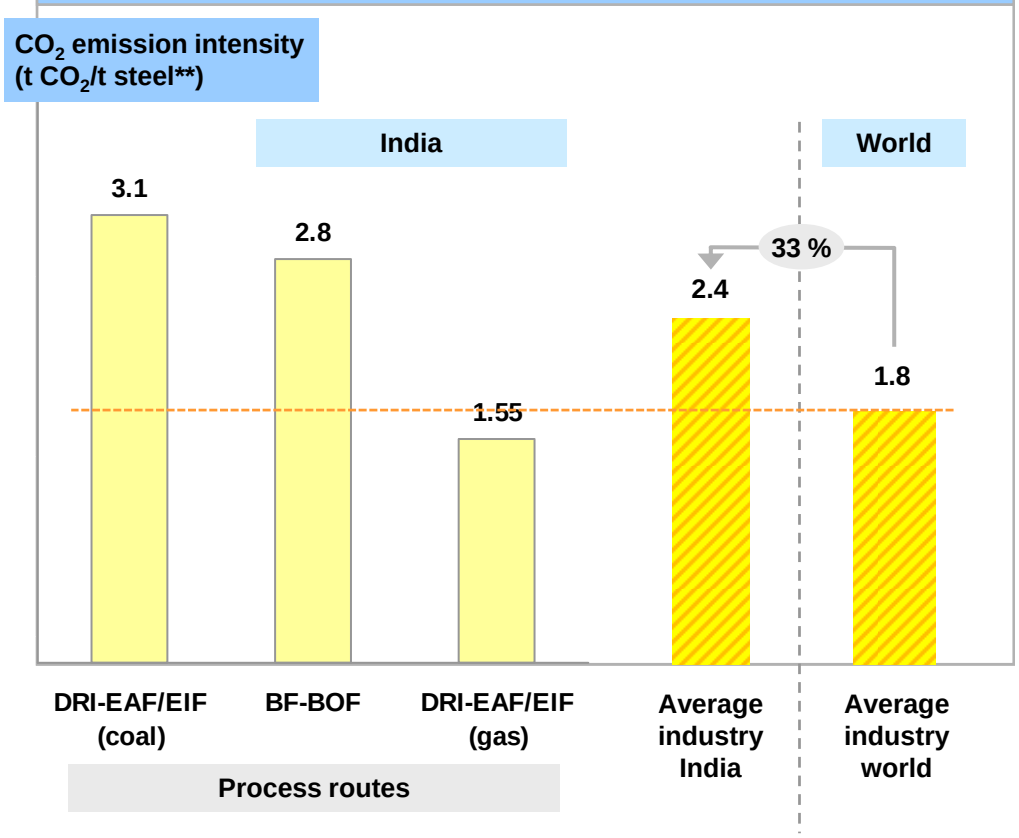
Steel and cement industry are the major sources for CO_2 emissions in India. Emission intensity of the steel industry one third above global average.

India: CO_2 emissions Total: 1,398 mill. tons (2007)

– by sectors –



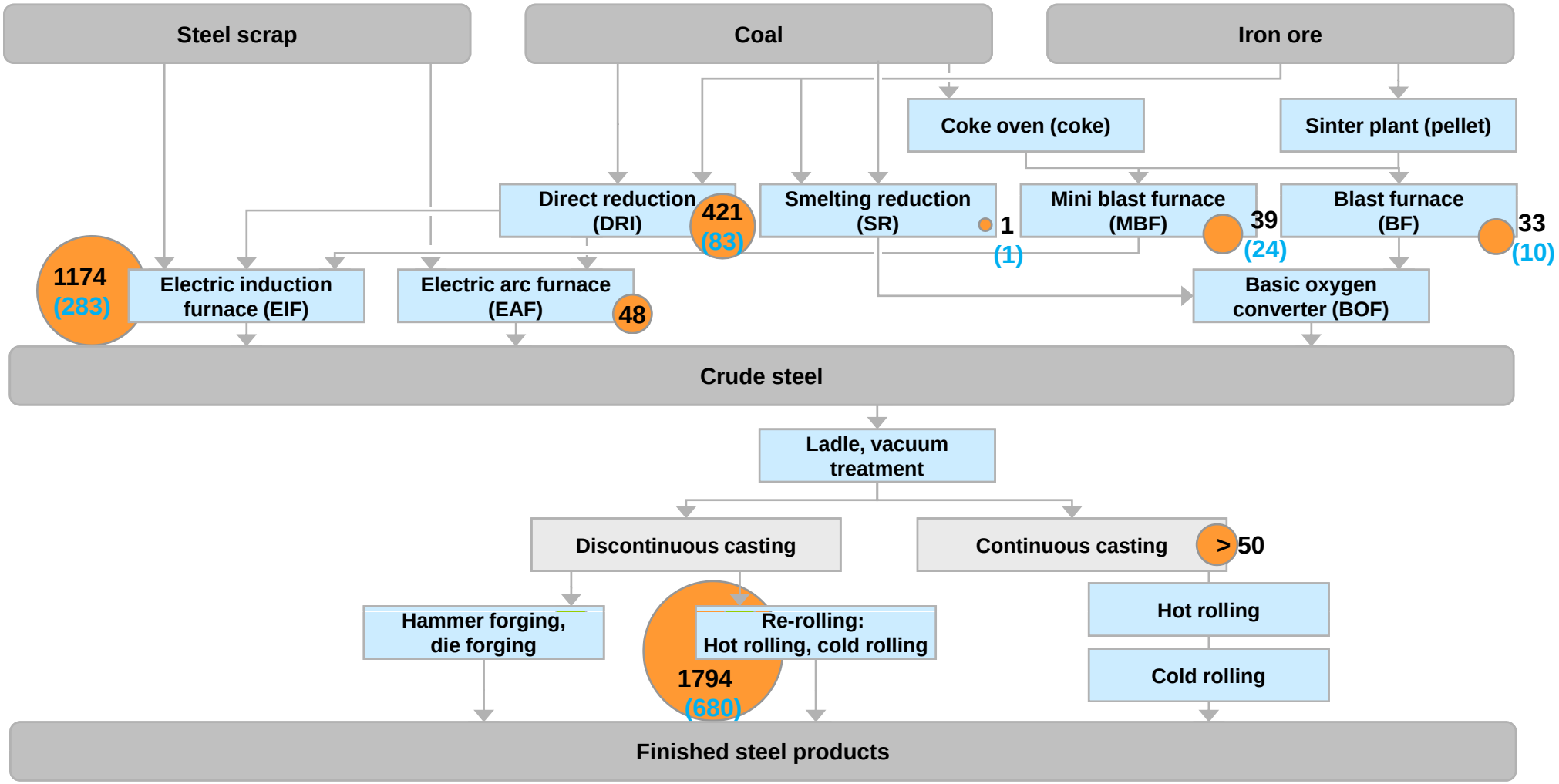
Steel industry: CO_2 emission intensity by process routes



* IEA-reports 151 mill. t ** finished product

Source: Planning Commission, Government of India; Centre for Science and Environment

The steel industry in India is highly fragmented with a broad variety of process routes and hundreds of small mills.



Source: Steel Associations India, Joint Plant Committee

.. Number of plants
.. (Number of companies)

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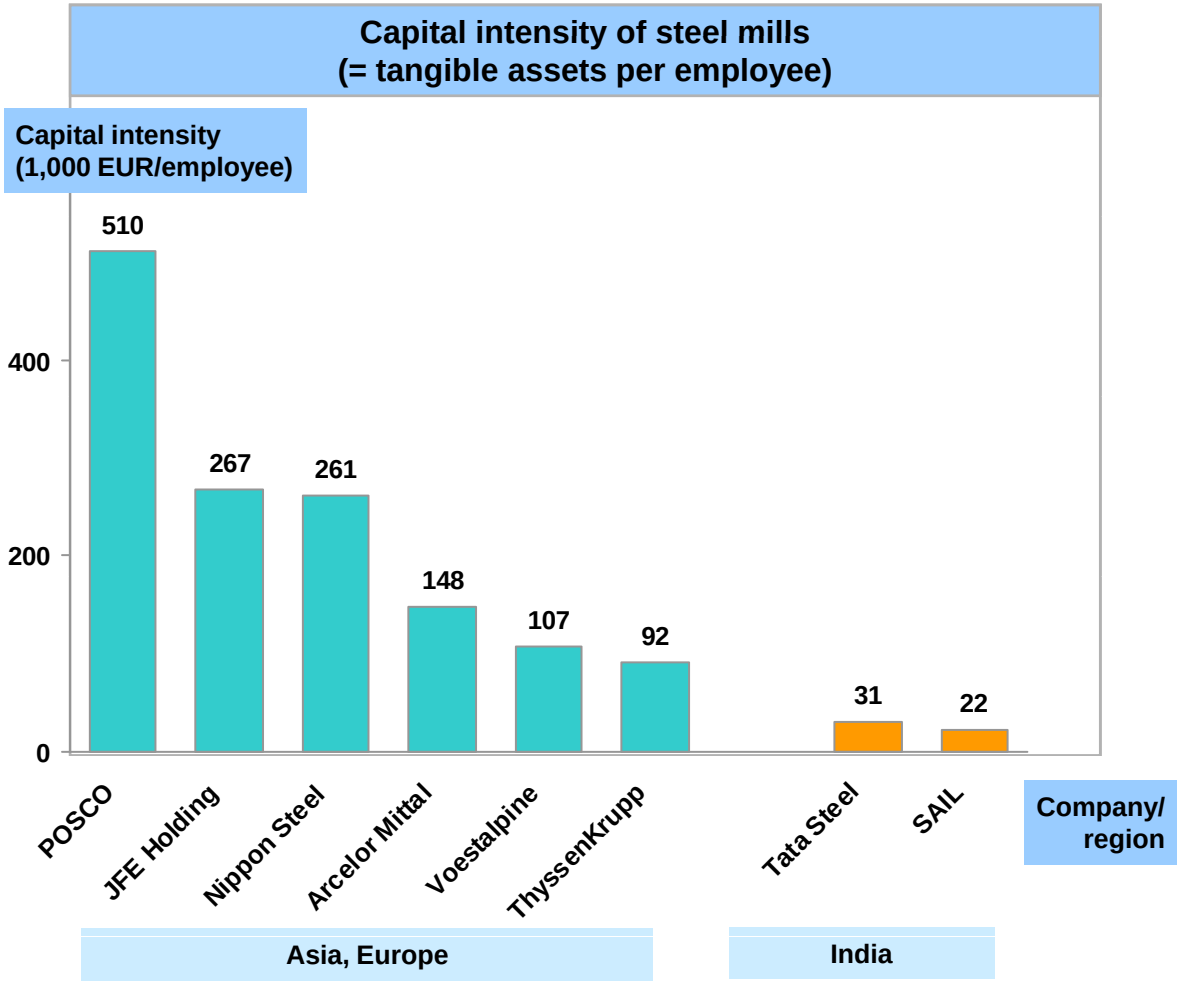
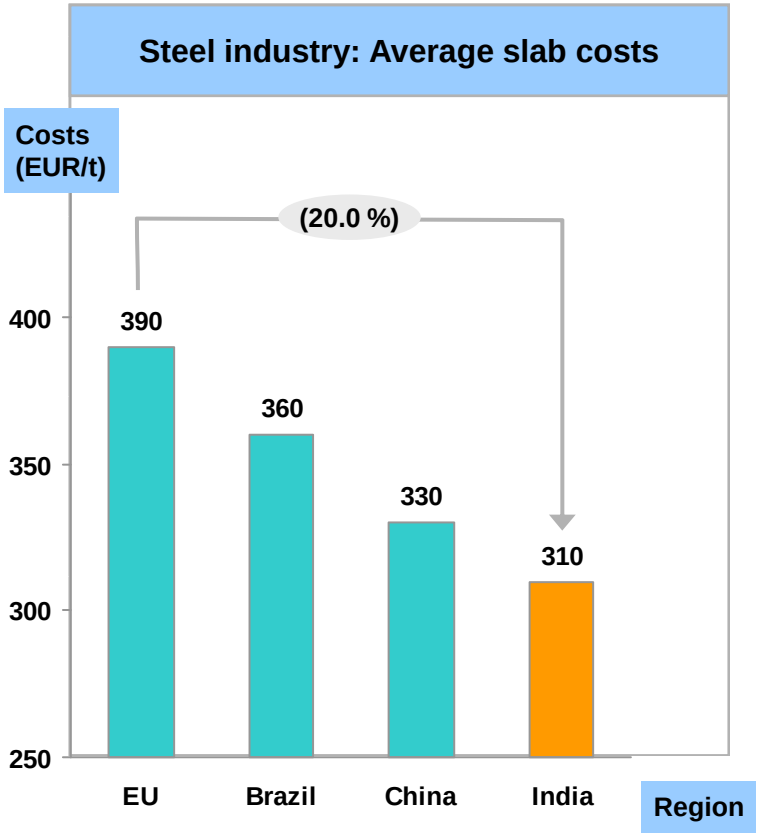
The capex of the steel industry in India are lower compared with the global industry due to the trend towards small scale plants. Hence, also cost/price level for steel products is lower in India.



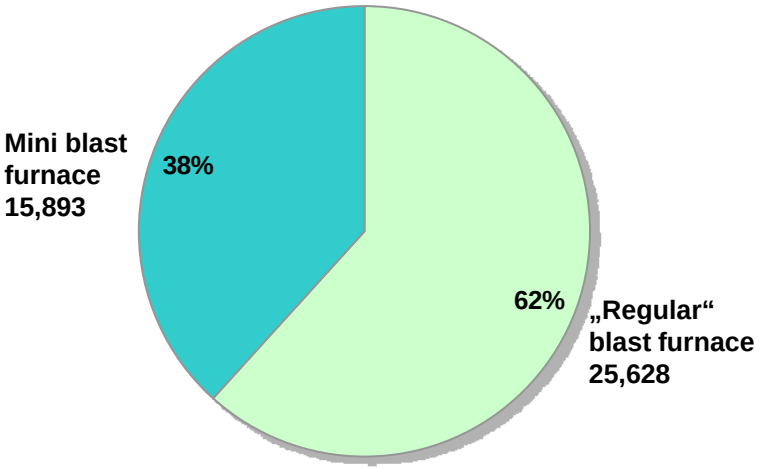


Source: Annual reports, Tata Steel

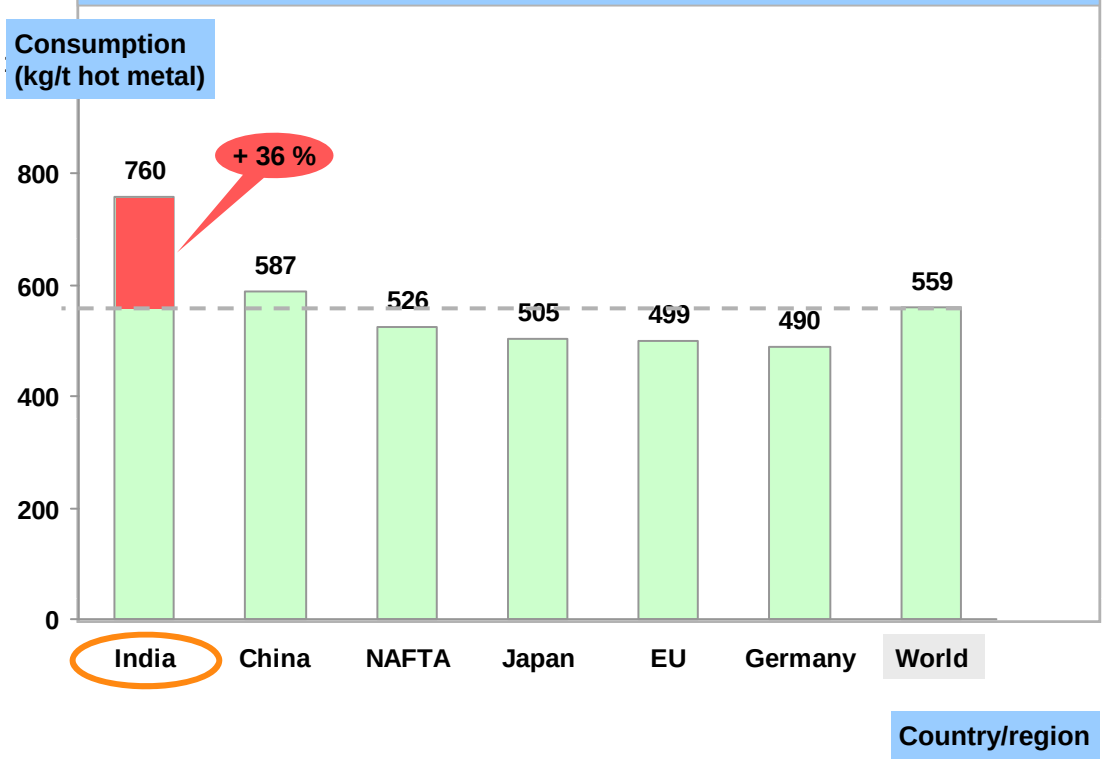
India has numerous mini blast furnaces (with high emissions) and reducing agent consumption in blast furnaces is well above global average value.

India: Hot metal production
Total: 41,521 (1,000 tons, 2010)

– by type of mill –



Blast furnace: Consumption of reducing agents (2009)



Source: Joint Plant Committee, VDEh

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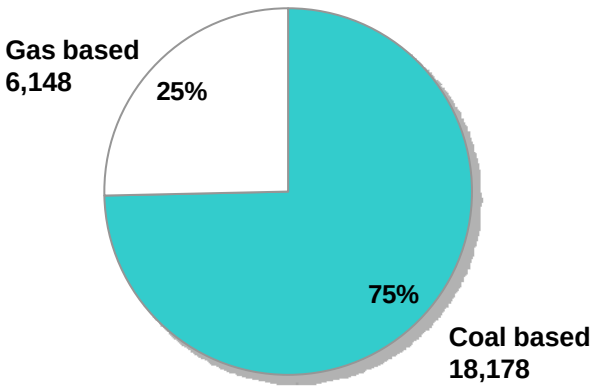
Further drivers for the high CO_2 emissions are the growing production by coal based DRI and EIF as well as the low continuous casting rate.

Sponge iron production
Total: 24,326 (1,000 tons, 2010)

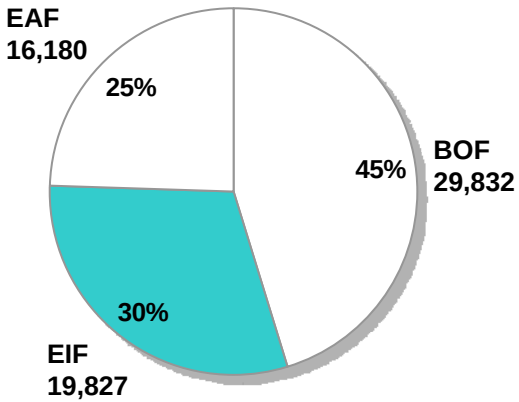
– by fuel –



⇒ Coal based dominating due to local availabilty, high emission intensity

Crude steel production
Total: 65,839 (1,000 tons, 2010)

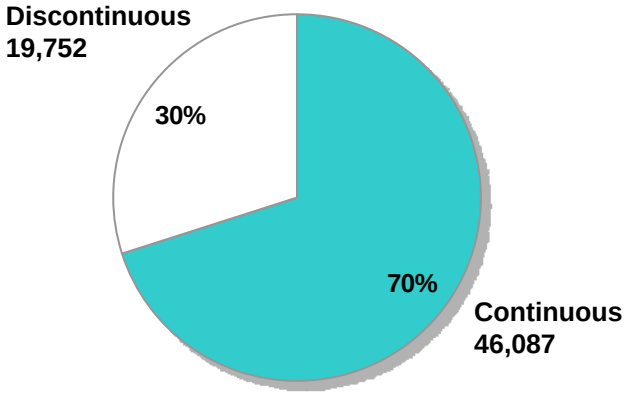
– by routes –



⇒ Small share of EAF due to low scrap production (import of 4 mill. tons scrap)

⇒ High share of EIF with high emission intensity

– by casting processes –

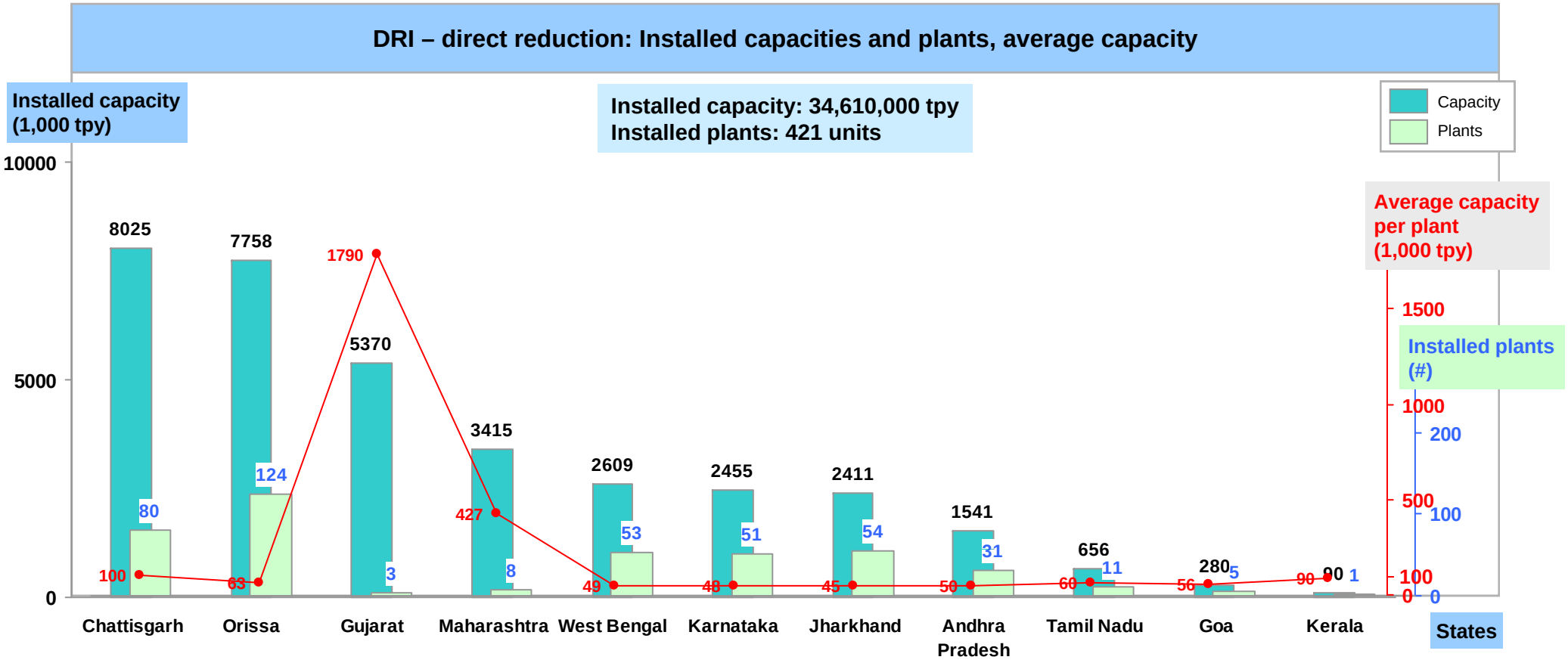


⇒ Low continuous casting rate

⇒ High energy consumption of discontinuous route (re-rolling)

Source: Joint Plant Committee, VDEh

Gujarat and Maharashtra are the states with large scale DRI plants. The remaining facilities are small scale in most cases.



Source: Joint Plant Committee

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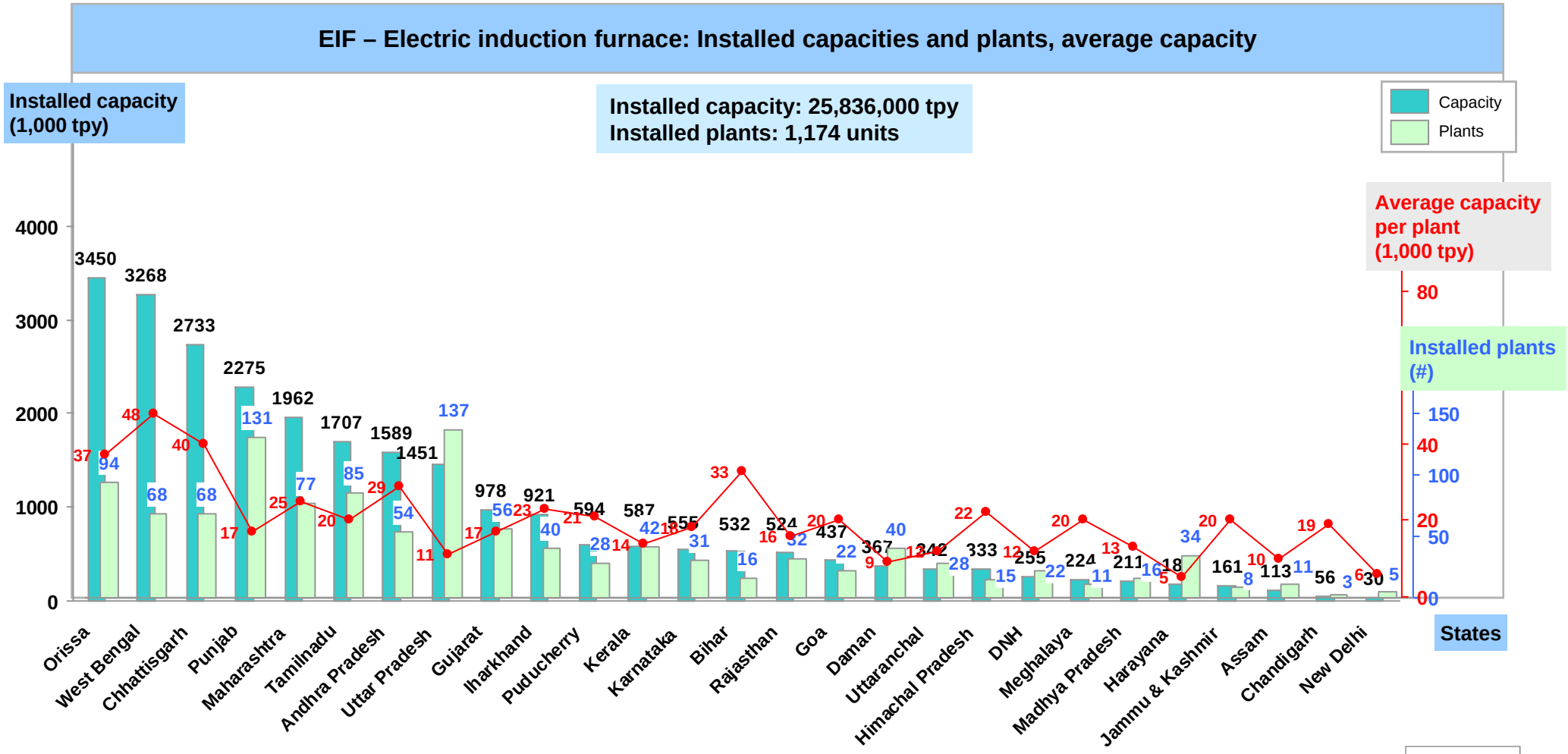
EIFs are small shops founded and operated all over India by local entrepreneurs.



Source: Joint Plant Committee

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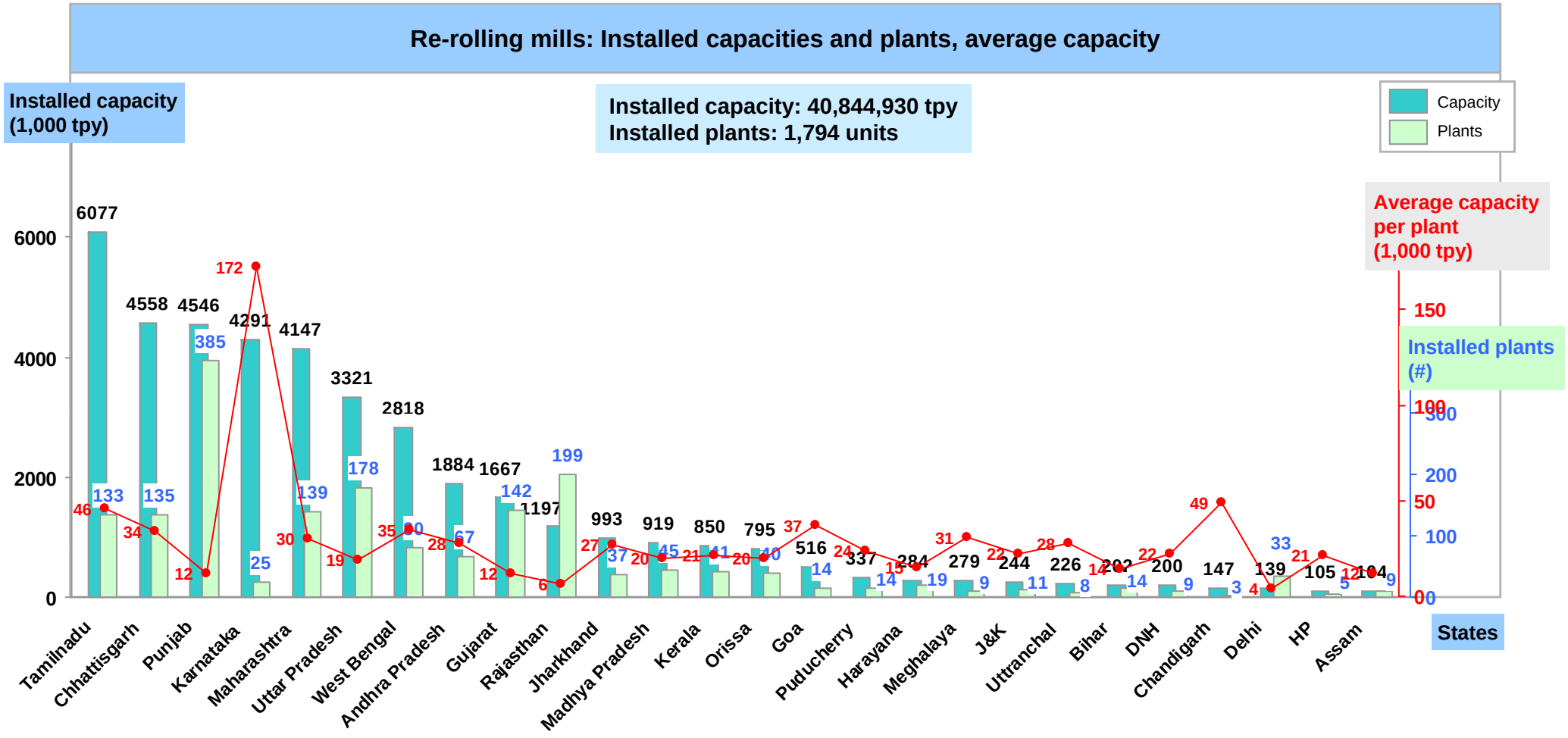
Re-rolling mills are small shops (with a few exceptions) active all over India, driven by low market penetration of continuous casting.



Source: Joint Plant Committee

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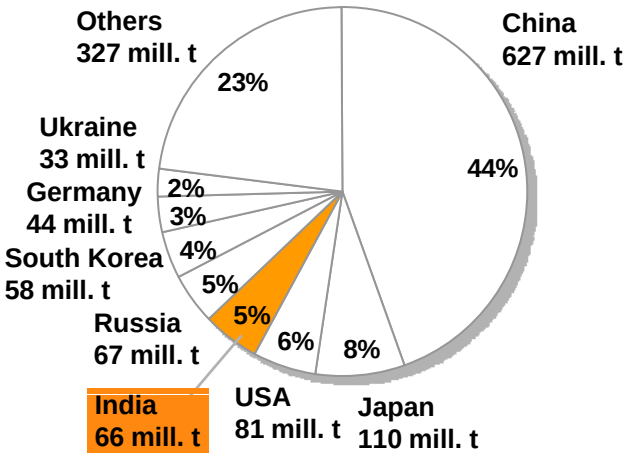
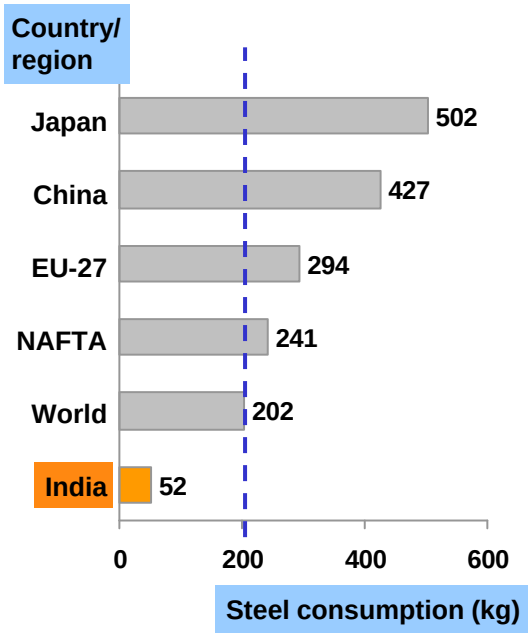
Steel production in India will double by 2020. Without actions the CO_2 emissions will take the same development.

Steel production
Total: 1,413 mill. tons (world, 2010)

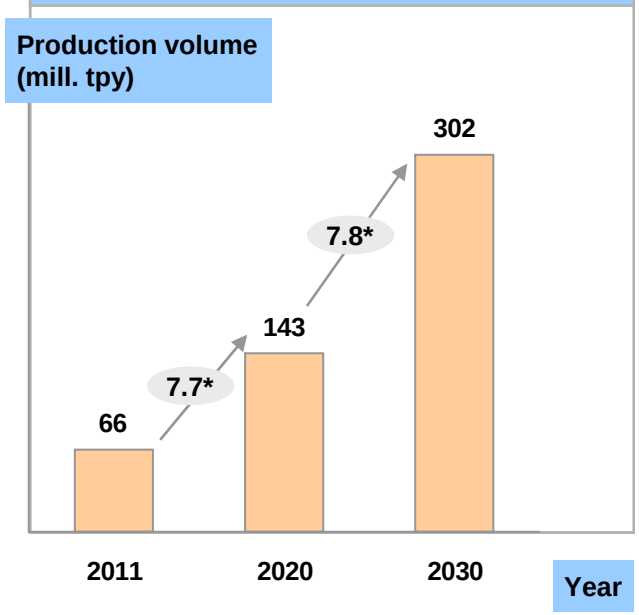
– by countries –



Steel consumption per capita (finished products, 2010)



Steel production in India



⇒ **Conservative forecast**

⇒ **Demand for steel will touch 113 mill. t and crude steel capacity will likely be 149 mill. tpy in 2016/17****

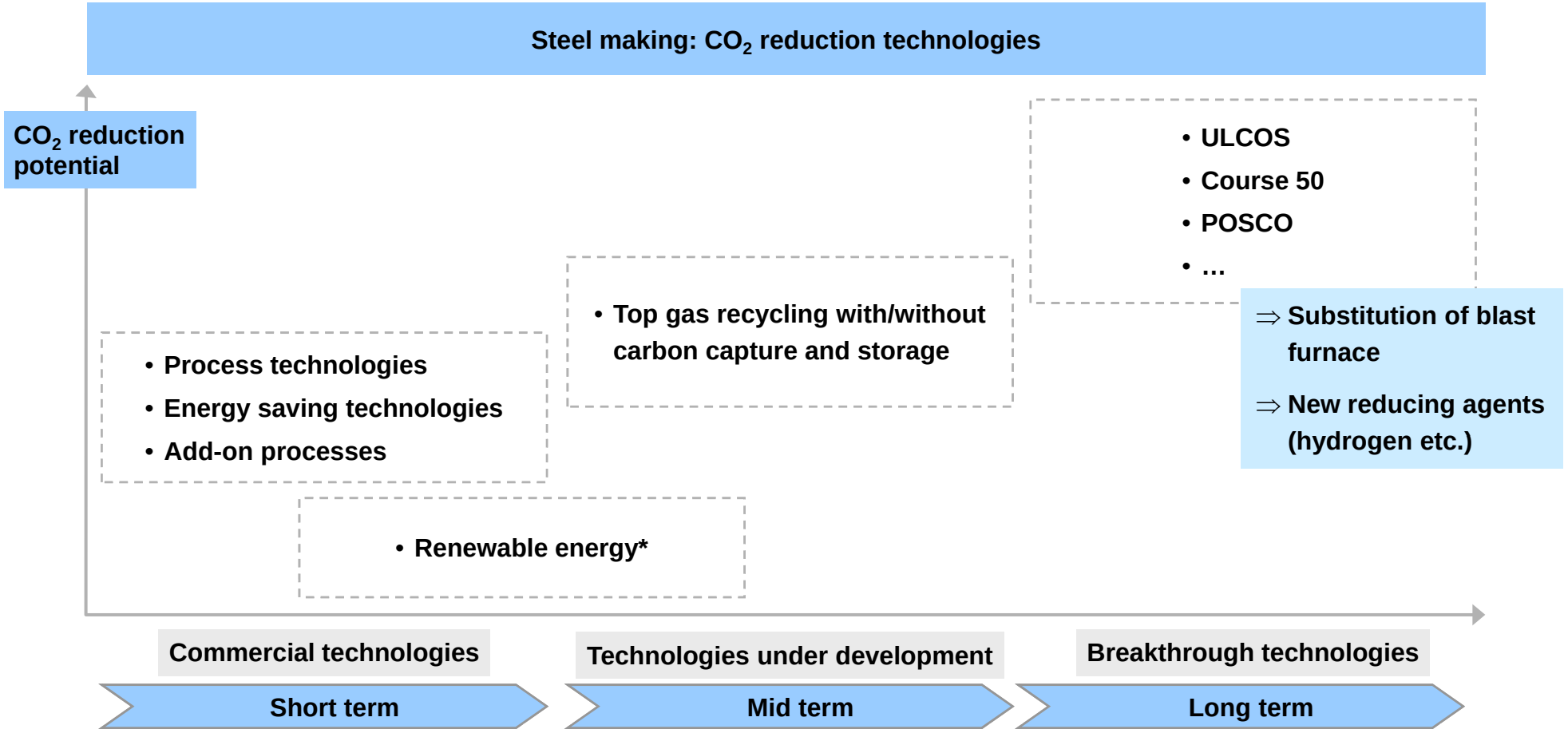
⇒ **Growing steel production in India due to growing demand from automotive, construction, white goods industry**

* CAGR = compound average growth rate ** Planning Commission Report

Source: Worldsteel, Centre for Science and Environment, IEA

4. Technologies for the reduction of CO_2 emissions, co-processing of waste in steel making, technology providers

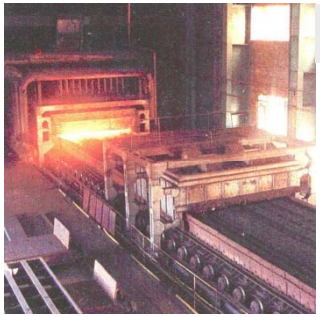
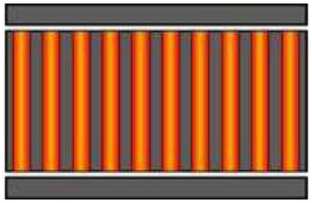
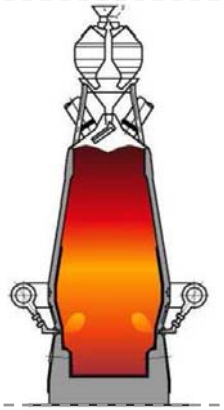
Numerous technologies are commercially available as well as under development for reduction of CO_2 emissions.



* not process technologies but power supply

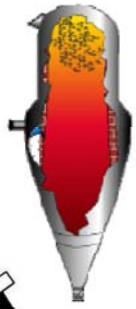
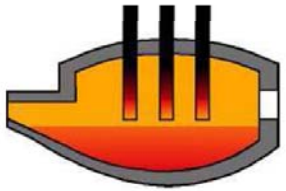
Source: AMCG-research, VDEh congress

Commercial technologies: For the first process steps various reduction technologies are applied.

Process step	CO_2 reduction solution	Reduction potential CO_2 emission intensity *kg CO_2 / t product*
 **Sinter plant**	• Sinter plant heat recovery • Use of waste fuels (e.g. lubricants) in sintering plant	57.2 19.5
 **Coke oven**	• Coke dry quenching	27.5
 **Blast furnace**	• Use of high quality ore • Direct injection of reducing agents . Coal injection, pulverized coal injection . Gas injection, natural gas injection • Improved blast furnace control systems • Hot blast stoves automation • Top pressure recovery turbine	15 - 80 34.7 – 47.0 54.9 24.4 22.6

Source: BAT – Best Available Technologies/European Commission, U.S. Environmental Protection Agency, State-of-the-Art Clean Technologies for Steel Making

Commercial technologies: New smelting technologies and coal gasification for direct reduction are important.

Process step	CO_2 reduction solution	Reduction potential CO_2 emission intensity *kg CO_2 / t product*
 Smelting reduction	• New processes . Finex / POSCO . IT mk3 / Kobe Steel	
 Direct reduction	• Coal gasification (syngas)	High
 Basic ogygen converter	• Energy recovery from the BOF gas • Increased energy efficiency by automation	46.0 15 - 16
 Electric arc furnace	• Scrap preheating • Improved process control • Transformer efficiency • Bottom stirring/stirring gas injection	35.2 17.6 10.0 11.7

Source: BAT – Best Available Technologies/European Commission, U.S. Environmental Protection Agency, State-of-the-Art Clean Technologies for Steel Making

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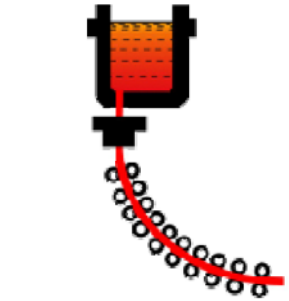
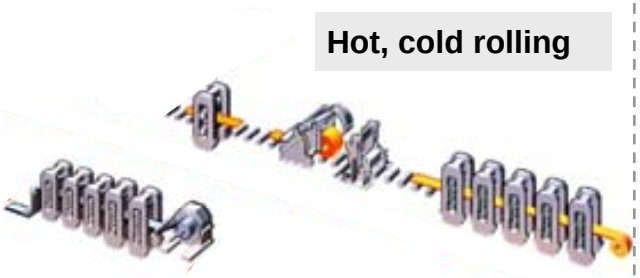
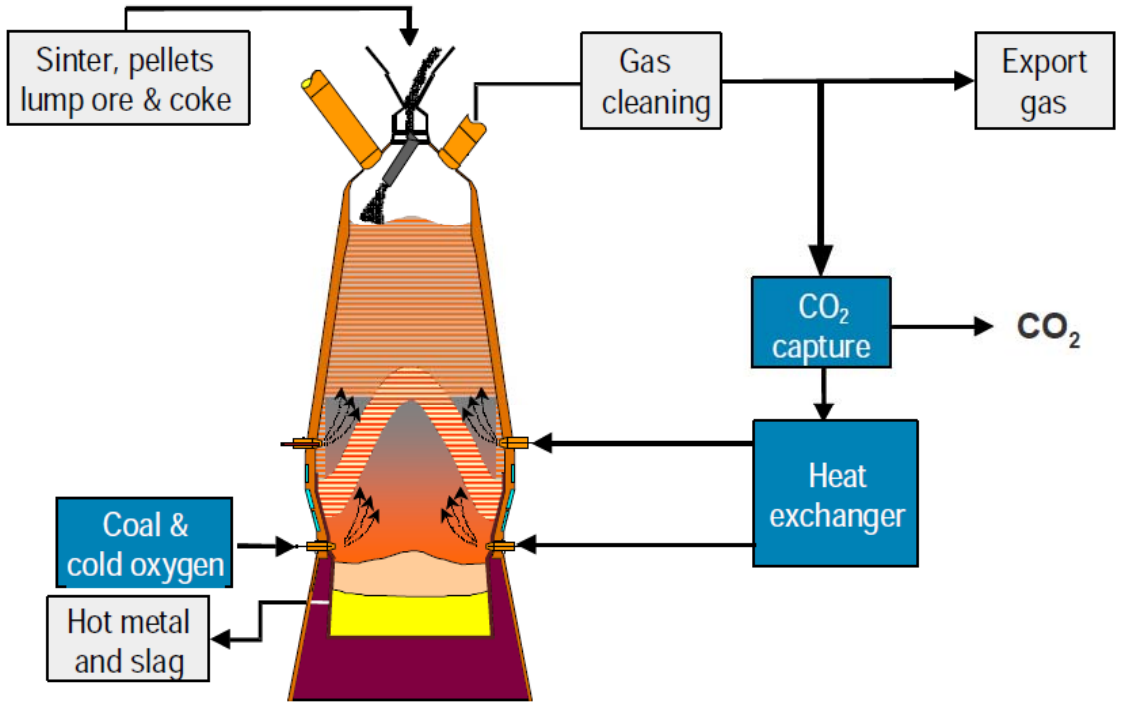
Commercial technologies: Thin slab casting and optimized furnaces are important for casting and rolling.

Process step	CO_2 reduction solution	Reduction potential CO_2 emission intensity	
 Casting	• Thin slab casting	(Energy saving 50 % compared with continuous slab casting)	
 Hot, cold rolling	• Automated monitoring system	35.3	*kg CO_2 / t product*
	• Recuperative burners	35.2	
	• Hot charging/direct rolling	30.2	
	• Heat recovery (annealing line)	17.5	
	• Process control in hot strip mill	15.1	
General	• CHP – combined heat and power/cogeneration	82.1	
	• Preventive maintenance	35.7	
	• Energy monitoring and management system	9.5	

Source: BAT – Best Available Technologies/European Commission, U.S. Environmental Protection Agency, State-of-the-Art Clean Technologies for Steel Making

The top gas recycling process is under development, would reduce emissions drastically.

BF process with top gas recycling



- **CO_2 emission reduction**
  - **16 % without CO_2 capture**
  - **50 % with CO_2 capture**
- **Test runs (commercial scale) at ArcelorMittal**

Source: Voestalpine Stahl, ArcelorMittal

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For further energy savings and reduction of CO_2 emissions new technologies are necessary, available in 10 - 20 years.

Steel making: Breakthrough technologies

Major programmes

- ULCOS* (Europe)
  - HISARNA - direct smelting-reduction of iron ore
  - Electrolysis based steelmaking
  - H_2 based pre-reduction for EAF
- COURSE50** (Japan)
  - CO_2 capture systems (CCS)
  - H_2 reduction based ironmaking
- POSCO (Korea)
  - Prereduction of, and heat recovery from hot sinter
  - CO_2 absorption using ammonia solution
  - CO_2 fixation using marine bio-slag
  - H_2 production and carbon-lean ironmaking process
- AISI*** (USA)
  - Flash smelting of iron ore using hydrogen reduction
  - Steelmaking by molten oxide electrolysis

Major options

- Coal as reducing agent but with CCS
- Hydrogen as a reducing agent (carbon-lean processes, hydrogen necessary)
- Electricity as a reducing agent
- Biomass used for making reducing agents (charcoal****, syngas)
- CCS – carbon capture and storage

* Ultra_Low Carbon Dioxide Steelmaking
** CO_2 Ultimate Reduction in Steelmaking Process by Innovative technology for Cool Earth 50
*** American Iron and Steel Institute **** already applied

Source: IISI, VDEh congress

Plastic waste is used in a few steel mills globally as an reducing agent in the blast furnace.

Steel making: Co-processing of waste

- **Plastic waste (= hydrocarbon) used in the blast furnace as a reducing agent**

⇒ **Partial substitution of coke as a reducing agent**

⇒ **Globally applied in a few furnaces only**

Voestalpine, Austria

JFE, Japan

Nippon Steel, Japan

- **Plastic waste (= hydrocarbon) used in power stations as fuel**

⇒ **Not a steel making specific solution**

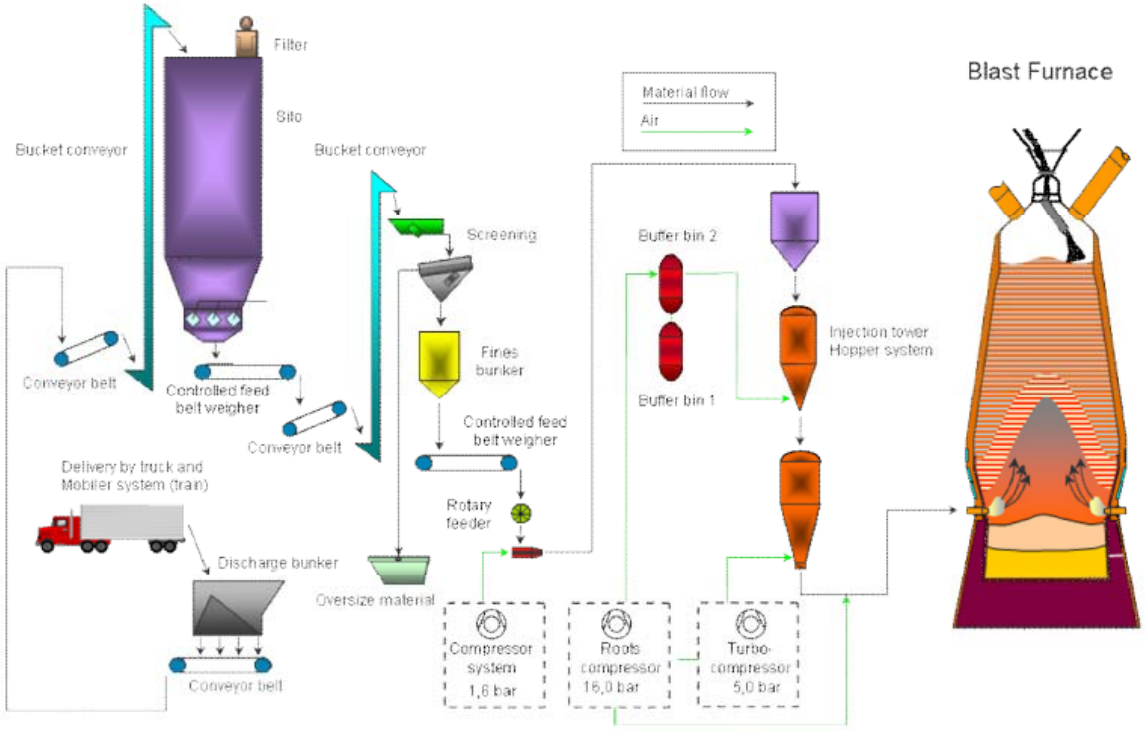
⇒ **Basic option for power stations**

⇒ **The only Indian steel company to have tried is Tata Steel in 2004 (with no encouraging results, see page 42)**

Source: VDEh congress, AMCG-research

The use of plastic waste as a reducing agent requires sophisticated plastic collection and treatment systems.

Voestalpine: Treatment and injection plant of plastic waste for blast furnace



- **Plastic waste as a reducing agent used since 2006 in one blast furnace in Linz, Austria**
- **Consumption of 100,000 tpy plastic waste (= 10 % of total reducing agent demand for one furnace)**
- **Sourcing of waste from Austria and Italy**
- **Complex treatment of waste, defined particle size for waste required**

Source: Voestalpine Stahl

There are well-known global players serving the steel industry with the different processing technologies. Most of the companies are active in India since many years.

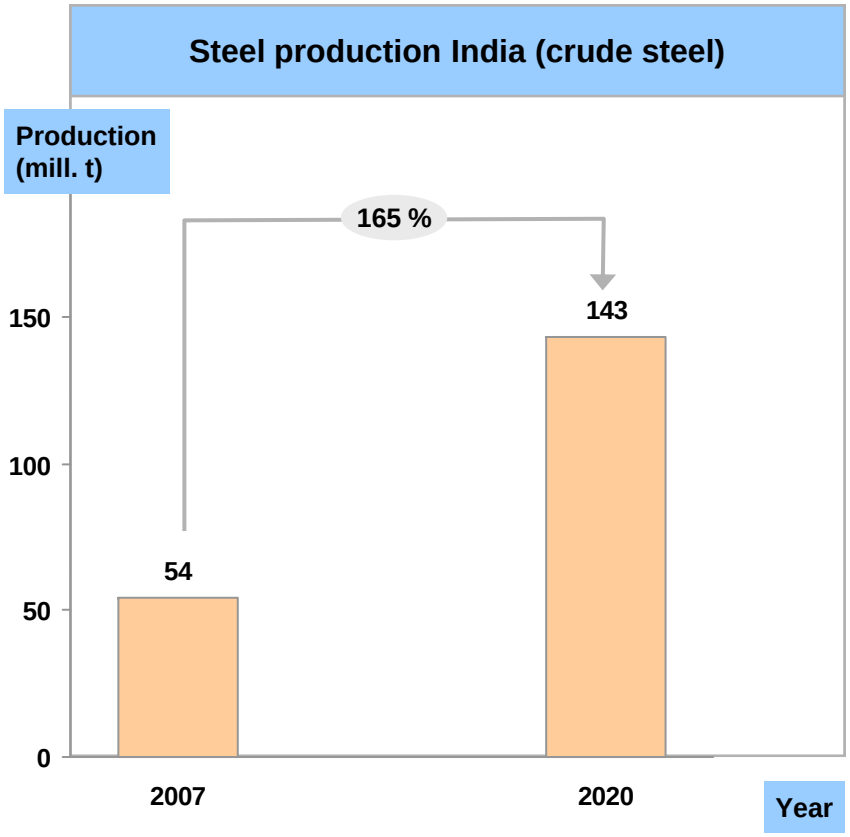
Technology providers for steel making (major players)

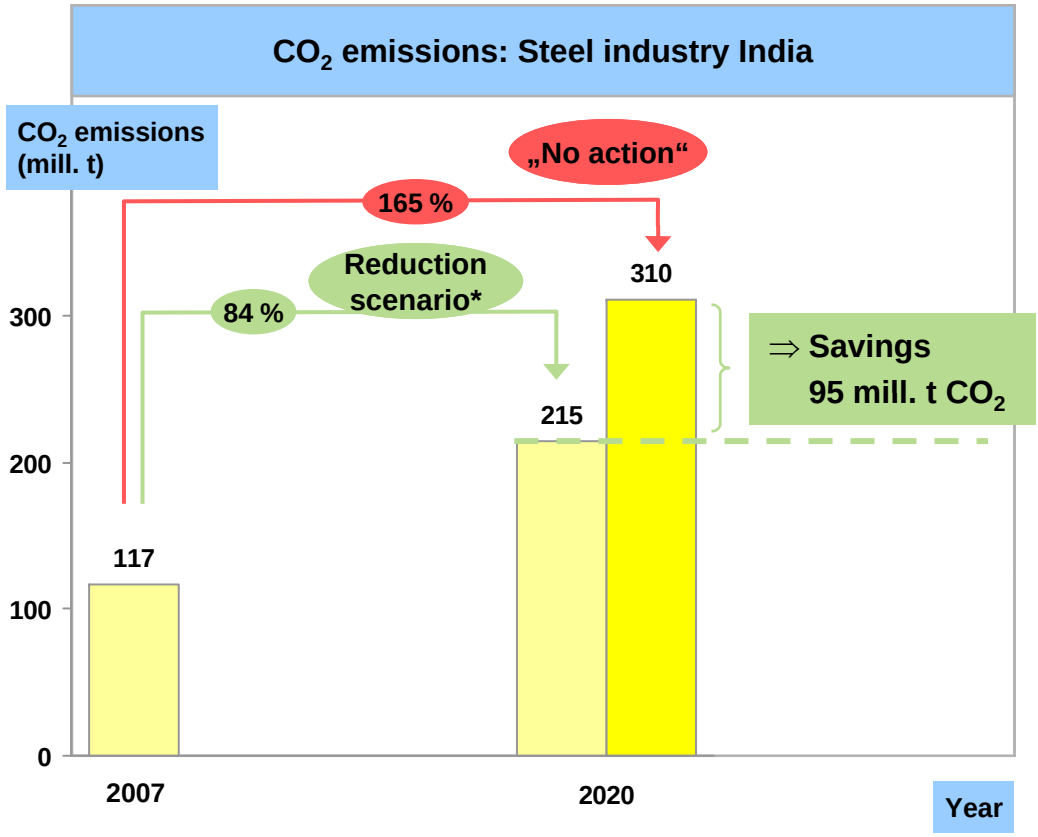
- Danieli Corus
- Inductotherm
- LOI Italimpianti
- Midrex
- Paul Wurth
- Outotec
- Siemens VAI
- SMS Siemag
- Tenova
- …

⇒ **After numerous mergers and acquisitions the engineering industry is a consolidated industry**

5. Reduction potential of CO_2 emissions in the steel industry in India

The potential to cut CO_2 emissions are approx. 100 mill. tons in 2020, if the industry goes for advanced technologies.





⇒ Reduction of CO_2 emission intensity by 38 % (from 2.4 to 1.5 t CO_2 / t steel)

Source: Joint Plant Committee, Centre for Science and Environment, AMCG-research

AMCG

Indian steel industry is facing many key challenges.

Indian steel industry: Current crucial issues

- **Availability of iron ore**
- **Availability of good quality coke**
- **Slow down in economy (global and domestic)**
- **Very high interest costs**
- **MMDR act – additional very high burden**

⇒ **In spite of these, managements of progressive companies are engaged in addressing energy enhancement and indirectly CO_2 reduction**

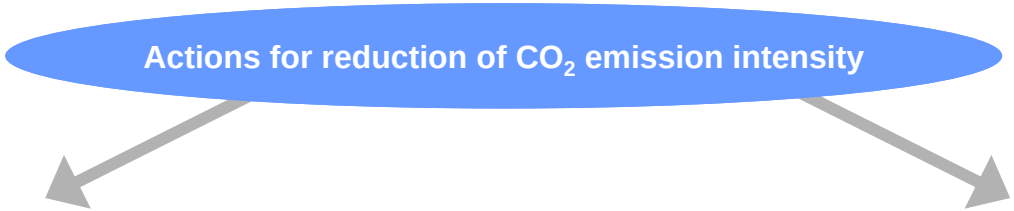
The awareness of the steel industry on CO_2 emissions varies significantly across the industry.

CO_2 ?

Steel industry: Awareness on CO_2 emissions

- Large steel companies (Tata, SAIL, Jindal, Essar etc.) know very well the CO_2 challenge of the global steel industry. Partly these companies have programs to cut CO_2 emissions as well as to improve energy efficiency.
- Some large and medium-sized steel companies know the PAT scheme and are actively engaged in discussions with BEE.
- The hundreds of small steel companies (re-rollers, operators of small DRI/EIF plants) are entrepreneurs and hardly experienced in CO_2 topics.
- The drivers for the companies to cut CO_2 emissions are in most cases efficiency improvement and RoI.
- Currently India does not have an agency/organizational unit for monitoring of CO_2 emissions.

Actions are required to optimize installed production base as well as requirements on technologies for new capacities.



Installed base

Production volume:
66 mill. tpy

- ⇒ **Reduction of CO_2 emission intensity**
  - **Closure of old/legacy plants**
  - **Improvement of operational excellence**
  - **Revamping/up-grading of plants**
  - **Use of plastic waste, biomass and biogas**
- ⇒ **Implementation by dedicated actions for industry sectors and local clusters**

New steel capacities

Planned capacity expansion 21010 - 2020:
50 - 100 mill tpy

- ⇒ **Requirements on new investments**
  - **BAT – best available technology**
  - **New technologies, e.g.**
    - **blast furnace: top gas recycling**
    - **Finex, smelt reduction**
- ⇒ **Implementation by legal guidelines (e.g. on types of technologies, grants)**

Source: AMCG-research

For the installed base different actions by industry sectors/processes can be conducted.

Installed base: Actions by industry sectors	
Industry sectors/process routes	**Actions**
Blast furnace	• **Up-grading of plants** · **Control systems, reducing agents etc.** **→ See page 27, commercial technologies** • **Pilot project: Co-processing of plastic waste** **→ e.g. Tata Steel, SAIL**
Direct reduction	• **Focus on coal based DRI plants/companies** • **Revamping, i.e. coal gasification (Syngas)**
Electric induction furnaces	• **Operational excellence programs** • **Efficiency improvement of furnaces**
Re-rolling mills	• **Operational excellence programs** • **Efficiency improvement of furnaces (walking beam furnaces)** • **Fuel: Substitution of coal by coal gasification, biogas**

Source: AMCG-research

For the fragmented industry sectors local clusters are necessary.

Installed base: Local clusters

States / Industry sectors	Installed plants (#)																									
	Andhra Pradesh	Assam	Bihar	Chandigarh	Chattisgarh	Daman	DNH	Goa	Gujarat	Harayana	Himachal Pradesh	Jammu & Kashmir	Jharkhand	Karnataka	Kerala	Iharkhand	Madhya Pradesh	Maharash-tra	Meghalaya	New Delhi	Orissa	Puducherry	Punjab	Rajasthan	Tamilnadu	Uttar Pradesh	Uttranchal	West Bengal
Direct reduction	31				80			5	3				54	51	1			8			124				11			53
Electric induction furnace	54	11	16	3	68	40	22	22	56	34	15	8		31	42	40	16	77	11	5	94	28	131	32	85	137	28	68
Re-rolling mills	67	9	14	3	135		9	14	142	19	5	11	37	25	41		45	139	9	33	40	14	385	199	133	178	8	80
Total	152	20	30	6	283	40	31	41	201	53	20	19	91	107	84	40	61	224	20	38	258	42	516	231	229	315	36	201
					3																4		1	5		2		

Potential actions on new steel capacities are guidelines on technologies used and support of new technologies.

New steel capacities: Actions

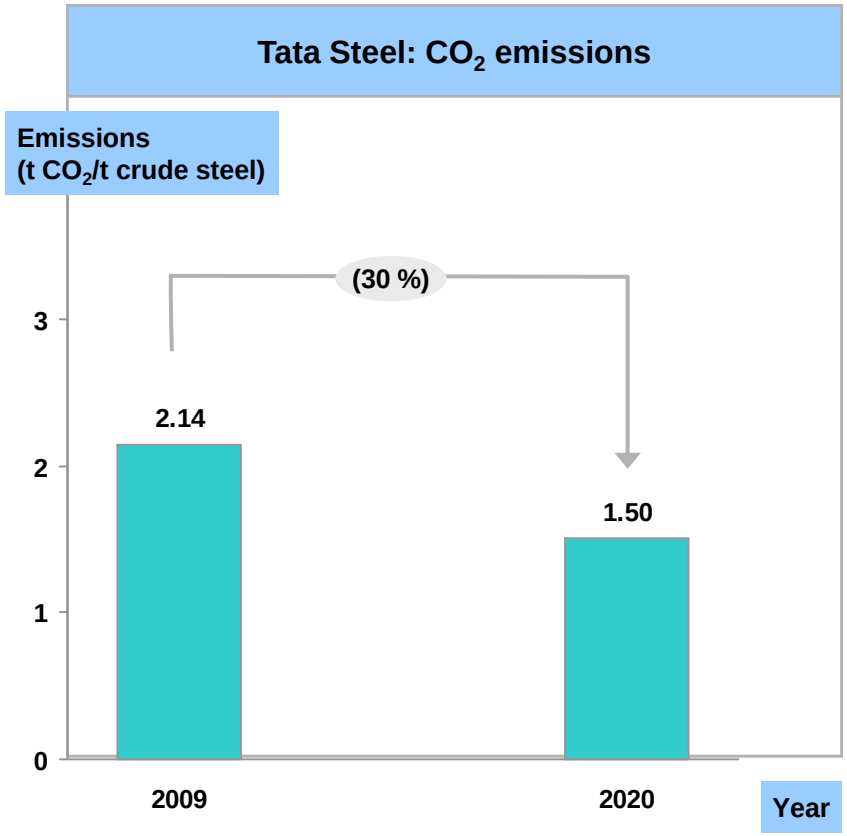
- **Guidelines for the future use of steel making technologies, e.g. BAT – best available technologies**

  → Goal to improve efficiency of technologies used (e.g. for re-rolling, EIF, blast furnaces, direct reduction)

- **Support of market introduction and penetration of new technologies**
  - **Blast furnace: Top gas recycling, CCS, use of biomass for reducing agent**
  - **Smelt reduction and direct reduction technologies (due to the quality of raw materials available in India)**

Tata Steel has the goal to cut CO_2 emissions by 30 % in the year 2020.

Case study: Tata Steel



Actions

- Process analysis of the CO_2 emissions

  → 80 % of CO_2 emissions caused by sinter plant and blast furnace

- Actions for CO_2 reduction
  - Blast furnace: One new large scale furnace in 2012 combined with closure of four small furnaces
  - Agglomeration: Pellet plant being installed
  - Coke oven: Coke try quenching
  - Waste co-processing: In 2004 Tata Steel tried to use plastic waste, another trial is currently on

    → Tata Steel open for support in this area

Source: Tata Steel

AMCG

SAIL is modernizing and expanding to reach world class level.

Case study: SAIL

SAIL: Actions

- **Addition of 12 mill. tons of world class capacity, shutting down of four mill. tons of legacy capacity**

  → Total capacity by 2013 will be 20 mill. tons (from existing 12 mill. tons)

- **Current mix of 67 % continuous casting route plus 33 % ingot casting route**

  → Almost 100 % continuous casting by 2013

- **Target to reduce energy intensity by 20 % in the next 2 - 3 years**

  → Similar reduction in CO_2 emissions

Source: SAIL

Jindal is the first company in India using coal gasification in its direct reduction plant.

Case study: Jindal

Jindal: Actions

- Direct reduction (coal based)
  - New plant with coal gasification (syngas) from mid of 2012 on
  - Waste heat recovery
- Blast furnace
  - Waste heat recovery
- Coke oven
  - Coke oven gas used for DRI

Source: Jindal