



INFINITE OPPORTUNITIES | GERMANY + INDIA
2011-2012

Workshop Report

“Steel Industry in India: Potentials and Technologies for Reduction of CO₂ Emissions”

Wednesday, 7th December, 2011

Hotel Leela Palace, New Delhi



Introduction

India is fourth biggest steel producer in the world, with an annual steel production rate of 68 million tonnes. About 60% of steel is produced through secondary processing, which indicates a good recycling rate of scrap material in the country. Nevertheless, the applied technology for primary and secondary processing offers various options to reduce CO₂ emission in an estimated range of 20-30%. As the Indian steel industries are increasing their production capacity by 5-10% annually, any improvement in the steel industry will contribute to a significant absolute reduction of greenhouse gas emissions.

GIZ-ASEM engaged a study to analyse the potential for the reduction of CO₂ emissions in the steel industry in India. The study focused on identifying relevant technologies for reduction of emissions as well as to identify potential technology providers. It was envisaged to bring about an exchange of information and technology partnerships between India and Germany that could help to accelerate opportunities to increase energy efficiency in the Indian steel sector.

The study was carried out for GIZ-ASEM by AMCG Unternehmensberatung GmbH, International Management Consultants from Germany, and Paradigm Inc., from India. A workshop was held on December 7th, 2011 at the Hotel Leela Palace, New Delhi to present the findings of the study to different stakeholders. The programme details and the list of participants are attached. The report of the workshop is given below.

Objectives:

The overall objective of the study was to identify CO₂ reduction potentials in the Indian steel industry. The objective of the workshop was to engage in a consultation process with the stakeholders' in order to elicit inputs before finalizing the report.



Proceedings:

a) Inaugural Session:

The workshop began with the inaugural session. In his opening address, Dr. Dieter Mutz, Director, GIZ-ASEM, explained the objectives for the workshop focusing on steel sector and drew the attention of the delegates on the significance of the day by pointing out the fact that the ministers and decision makers are discussing in Durban on the climate change. He mentioned that GIZ chose to work in this sector because if India has to achieve the 8% GDP target, then Cement and Steel sectors should have to grow at a fast pace, which may bring about greater environmental stress due to these sectors. He said that in order to reduce CO₂ emissions in India, the public and the private sectors should join hands together. He emphasized that the discussions from the workshop could facilitate modernization of the steel sector while reducing CO₂ emissions.



Addressing the delegates, Mr Bernd Dunnzlaff, Head of Economic Cooperation and Development of the German Embassy in India, mentioned that the Advisory Services in Environmental Management (ASEM) Programme had been one of the flagship programmes of the Indo-German Co-operation, and that one of the first technology enhancement initiatives undertaken by Germany was in the Rourkela Steel Plant some 50 years back. He said that this workshop demonstrates that steel still remains a key sector, albeit with a slight change over the years that care for the environment has become an area of priority in the sector. He mentioned that India has development co-operation funds to the tune of almost 500 million Euros per year with about 50 projects in GIZ on climate relevance. The study on "CO₂ Reduction in the Steel Industry of India" was one of them.



Dr. G.V. Subrahmanyam, Advisor from the Ministry of Environment & Forests (MoEF), Government of India, in his address stressed the need for sustainable development and quoted that Japan and other developed countries have been able to achieve reduction in CO₂ due to technological advancements. He said that for India we need to look for breakthrough technologies. He stated that there is enabling legislative framework in the country and that there are several National Policies on Climate Change already in place. He highlighted that the Research Division at MoEF undertakes applied research to promote innovative technologies and said that he would be



eager to know the outcome of this workshop, particularly to explore if the ministry could assist in demonstration of the findings of study for steel sector in cooperation with GIZ.

b) Technical Session:

The inaugural session was followed by the technical session wherein the key findings of the study undertaken by them for steel sector were presented by Mr. Christoph Genter/AMCG and Mr Pradip Nadkarni/Paradigm. The topics covered included processes in the global steel industry, CO₂ emissions from steel sector and goals for reduction with special focus on CO₂ emissions of the steel industry in India, technologies for the reduction of CO₂ emissions, co-processing of waste in steel industry, a bird's eye view on technology providers and reduction potential of CO₂ emissions in the steel industry in India. A few case studies were also discussed. A copy of the presentation is given at Annexure III.



Highlights of the observations from the presentation are given below.

- Steel and cement industry are the major sources for CO₂ emissions in India. The emission intensity of the steel industry is one third above global average.
- The steel industry in India is highly fragmented with a broad variety of process routes and hundreds of small mills.
- The apex of the steel industry in India is 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.
- India has numerous mini blast furnaces (with high emissions) and usage of reducing agents in blast furnaces is well above global average value.
- Further drivers for the high CO₂ emissions are the growing production by coal based DRI and EIF as well as the low continuous casting rate.
- Gujarat and Maharashtra are the states with large scale DRI plants. The remaining facilities are small scale in most cases.
- EIFs are small shops founded and operated all over India by local entrepreneurs.
- Re-rolling mills are small shops (with a few exceptions) active all over India, driven by low market penetration of continuous casting.
- Steel production in India will double by 2020. Without actions, the CO₂ emissions will take the same development.

- Numerous technologies are commercially available as well as under development for reduction of CO₂ emissions.
- The potential to cut CO₂ emissions are approx. 100 mill. tons in 2020 and if the industry goes for advanced technologies, the reduction of CO₂ emission intensity will be by 38 % (from 2.4 to 1.5 t CO₂ / t steel).
- For the fragmented industry sector, a cluster approach is necessary.
- Guidelines for the future use of steel making technologies, e.g. BAT – best available technologies need to be specified.

This session was followed by a Question and Answer session. Important questions raised by the delegates are summarized below.

1. Why the study did not focus on use of slag from the furnace, which is a good potential for reduction of CO₂, which is undertaken by the cement industry?
2. As per the findings of the study, India has 36% more of consumption of reducing agents as compared to world average. What would be the CO₂ reduction potential if the conventional reducing agents are replaced with plastic waste? Can all kinds of plastics be used – say municipal sourced plastic waste?
3. Why does the study focus on integrated steel plants and not on SMEs? Under a UNDP project, a study of rerolling mills with 25 pilot plants and usage of all kinds of fuel, viz. bio-mass, pulverized coal etc. were studied.
4. What about social impacts from modernization of steel sector?
5. What about use of non-coking coal and gasification process?
6. Important issue is how to address the small scale industry which is a highly unorganized sector where pollution potential is directly linked to energy efficiency. Can cluster approach be adopted especially for the small and medium sector?"
7. Consider the raw material used by the steel industry – Indian industry is using E&F grade of coal, which poses technological challenge.
8. Carbon fund - what are the monitoring mechanisms and how are they monitored?

c) Statements of Stakeholders:

The technical session was followed by the session with presentations from a few stakeholders wherein they provided their view points on the subject.

- **TATA Steel Limited:** The innovations adopted by TATA Steel were shared by Mr Shibojyoti Dutta, head of the Climate Change & Strategic Planning Services. He informed that the TATA Steel, Jamshedpur has been working on Energy Conservation since late 1970s and on Climate Change since late 1990s through modernization of

infrastructure, participation in Worldsteel Association's Life Cycle Assessment exercise and joint initiative of WBCSD & WRI that culminated in the development of GHG Protocol. He said Tata Steel has been monitoring department-wise energy consumption since middle 1980s, CO₂ emissions from the overall site since middle 1990s and has started measuring department-wise CO₂ emissions since 2008-09. Process-wise gap analysis and benchmarking exercises have been taken up and the potential areas for the CO₂ emission reduction are thus identified. Some reduction needs paradigm shift through the development of breakthrough and innovation in process and technologies e.g. alternate iron making without carbon as reducing agent, recovery of heat from slags, use of a high volume of low grade heat e.g. from cooling water etc.

He informed about the actions/investments of the company related to CO₂ reduction in the past and those proposed for the future for operational efficiency and CO₂ reduction/energy saving plants/processes. He shared his experiences on waste processing undertaken at Tata Steel and informed that it was not very encouraging due non availability of the right kind of plastics. Mr Dutta highlighted some of the barriers as actions on 'Climate Change' being not yet a mandate in India, high costs of technology, high cost of capital and that matching the world's benchmarks are challenging especially with the quality of indigenous raw materials, scrap quality etc. He also highlighted that at its current efficiency, renewable energy (solar or wind energy) does not appear to hold potential for large scale deployment. He said that his company is ready to play a decisive and leading role.

- **AllIFA – All India Induction Furnaces Association:** At the invitation of AllIFA, presentation was made by Dr. (Mrs) Malti Goel (former advisor to Department of Science & Technology, Government of India). She said that steel comprises of 85% of all metals produced and the basic steel making technologies in India consists of blast furnace/basic oxygen furnace (41%), scrap electric furnace (25%), direct reduction process (31%) and non-coking coal based DRI (COREX) (3%). She said that the steel industry contributes to 15% of the total industrial emissions and 4% of CO₂ emissions. She said that over the years the energy consumption in steel production has reduced up to 30-35%; and that several CO₂ reduction technologies including top gas recycling blast furnace, photo-bioreactor for enhanced CO₂ fixation, chemi-absorption of CO₂ in metal slag etc. In her concluding remarks, she pointed that the Indian steel industry has high CO₂ intensity compared to global levels and enhancements in technology can lead not only to lowering of CO₂ emissions but also will enable production of high strength steel.
- **The Indian Institute of Metals:** Presentation was made by Mr Neeraj Gupta (from Delhi Chapter). He emphasized the role of secondary steel production in India, especially due to the fact that about 80% of domestic steel consumed in India, for construction of homes comes from this sector. He mentioned that the urgent need is to provide innovative and cost effective solutions for this sector. He also reiterated the importance of metals in the coming years due to its nature of being a non-renewable resource.



Mr Shibojyoti Dutta,
Tata Steel Ltd.

Dr. (Mrs) Malti Goel, Former
Advisor, Deptt. of Science &
Technology, Govt. of India

Mr. Neeraj Gupta
Indian Institute of Metals

- **Outotec:** Presentation was made by Mr Stefan Mehl. Speaking about the sources of CO₂ generation in steel industry in the sintering process, he mentioned that Combustion and Calcination are the critical points. Speaking about the technology which Outotec can offer for the sinter plants, he gave an account of the “Recirculation Gas System” which can bring about Emission Optimized Sintering (EOS). This technology, according to Mr Mehl, will substantially reduce overall emissions and minimize waste gas volume by 40-50%. As this technology can lead to savings in coke, it will bring about direct reduction of CO₂. Another important feature of this technology is that only simple retrofitting is needed for existing plants with minimum interruptions of production.
- **Paul Wurth India Pvt. Ltd.:** Presentation was made by Mr. S. Dipak (Deputy General Manager- Sales & Marketing). He informed that Paul Wurth has launched a program with the focus to improve the energy efficiency and the carbon footprint in the iron making industry. He said that beyond the improvement of existing technologies, new energy saving and energy recuperation technologies are under development. He illustrated various technologies available with Paul Wurth that bring about CO₂ reduction such as ‘BOF Cooling Hood with Energy Recovery’, ‘CDQ System with Electric Power Production’ and ‘Hot Stove Plant with a Heat Pipe Heat Recuperator’. Additionally he mentioned that a modern blast furnace should be equipped with a Bell Less Top charging system, a pulverized coal injection system and a modern automation system like Paul Wurth’s BF Xpert, in order to establish safe and productive blast furnace operation, as a precondition for energy efficiency and low CO₂ emission rates.
- **Siemens VAI Metals Technologies Pvt. Ltd.:** Presentation was made by Mr Pradip Chaudhuri. (General Manager – ET & IR). He illustrated the sources of CO₂ emissions from a typical steel mill and CO₂ emissions from a Top Gas Recovered (TGR) BF steel mill. He explained about environmental improvements, both by end-of-pipe and primary process technology, using Siemens MT green solution examples. A few examples of Siemens green solutions are dry gas cleaning, MEROS, DENOX, EPOSINT, wet gas cleaning, SVAI CONE, Pulse-Jet-Filters, Residual treatment of Pelletizing / Briquetting, Recycling like CONTOP. He mentioned that typical customer benefit that can be ensued due to the use of SIMETAL Gimbal are: Top Blast Furnace charging which can reduce fuel rates 15-25 kg/thm, increase production > 5%, improve service life, improve gas

utilization > 50%, reduce heat load and increase furnace campaign > 40%. Additionally, by use of BOF Gas Recovery, which enables to cut energy costs by utilization of steel making gas, the customer benefits would be in the form of energy savings of 0.57 GJ/t steel, reduction of energy costs, higher degree of efficiency and short pay-back time.



Mr Stefan Mehl,
Outotec

Mr. S. Dipak,
Paul Wurth India Pvt. Ltd.

Mr. Pradip Chaudhuri,
Siemens VAI Metals
Technologies Pvt. Ltd.

- **Karnataka State Pollution Control Board (KSPCB):** Mr M.D.N. Simha, CEO, Karnataka State Pollution Control Board, in his address mentioned that focus should be given to improve the SME sector especially the Sponge Iron Units as they lack awareness and they need support from external sources. According to him, large steel sector industries are committed and have technology know-how and will implement it. However, the smaller industries need attention. He assured the forum that KSPCB will extend all support in this area to agencies which help in improving the steel sector. He also requested GIZ to help the Board to identify best available technologies in this field so that it enables the Board in proper decision making especially during issuing of new licenses to upcoming industries.
- **Tamil Nadu Pollution Control Board (TNPCB):** Mr Vijay Bhaskar, Senior Environmental Officer, Tamil Nadu Pollution Control Board mentioned that such initiatives by GIZ are welcome and mentioned that TNPCB looks forward to conducting a stakeholder consultation with the steel industries in Tamil Nadu to understand the ways and means of bringing about a change. He requested GIZ to help TNPCB in this area.

d) Feedback Session/Discussions:

The stakeholder account was followed by discussions, which was led by the following two questions:

1. What are the most promising potentials and technologies for, a) Large scale steel sector; and b) for MSME steel sector?

2. What are roles by industry and other stakeholders?

The session was moderated by Mr Raghu Babu, Senior Technical Advisor from GIZ (ASEM). The delegates were given cards to express their initial impressions or views with up to three answers to each of the above questions. The summaries of points from the cards written by the delegates are given below.



Most promising potentials and technologies for large scale Steel Sector

- Dry slag granulation with heat recovery (Paul Wurth)
- EOS/ EOS + waste gas heat recovery for sintex plant (Outotec)
- L.D. slag usage for cement making
- Hydrogen based/ electrolyte based reduction of iron ore

- Use of DRI in BF
- Increased injection in BF
- Reduction in ingot casting

- Corex for iron making
- Improved blast furnace control systems
- Coke dry quenching

- Dissemination of information, technology
- Contributing in R&D efforts (finance and manpower)

- Injection of pulverized coal
- Use of metal slag for CO₂ capture
- Top gas recovery turbine

- Technology for energy recovery- waste Heat Recovery
- Use of slag in Cement Kiln
- Recirculation of CO in the sintering process

- Gasification of coal

- EOS in sinter plant
- Raw material preparation

- Gas based sponge Iron technologies
- Coal beneficiation process
- Dry gas clearing technology

- Energy recovery and auxiliary fuel use in blast furnace
- Use of natural gas/ H2 based/biomass based new technologies
- Use of TSC-Rolling to avoid reheating

- COREX technology shall be used
- Large size blast furnace
- Rolling in continuation of casting of steel

- Off gas and CO2 reduction in sintering plants even with an increasing amount of fines processed in India
- Energy efficiency
- Heat recuperation

- Processing of fines
- Energy efficiency and optimization
- Effective usage of Coal

- Integrated steel making through blast furnace route
- Waste heat recovery system in the stove flue gas
- Power generating through top recovery turbine using a mocker gas cleaning plant to optimize the gas pressure requirement
- Direct injection of alternate fuel to coke in the blast furnace

- Technology provided by Outotec for sintering plants.

- Beneficiation of iron ore, coal washing control of moisture in coal
- Waste heat recovery

- FINEX technology
- Large size BFs
- Large size modern EAFs

- Top gas recovery
- EOS
- Green field expansion and closing legacy plants

- Increase in Energy efficiency
- Waste usage maximization
- Domestic action to reduce CNG/ energy consumption
- Adoption of clean technology

- Dry Dedusting in BOF (Siemens VAI)
- Meros in sinter making (Siemens VAI)

- Power generation in arc furnace (Siemens VAI)
- Use of Gimbal Top (Siemens VAI)

- Energy recovery shall be made compulsory.

Most promising potentials and technologies in MSME Steel Sector:

- Lower energy consumption i.e. specific heat consumption in reheating furnace
- Use hot billets as inputs to re-rolling mills
- Economic fuel to be used

- Close down less than 50ton capacity sponge iron units
- Use plastic waste as reducing agents

- Waste heat recovery
- Strict compliance of statutory norms

- Energy efficiency improvement
- Rapid melting techniques

- Improve efficiency in reheating furnaces
- Heat recovery from flue gases in EAFs
- Water cooled panels/ Pre heating of scrap in EAFs

- Regenerative burners
- Hot- charging
- Use of coal bed methane gas
- Use of Bio-mass as briquette through gasifier
- Power reduction in induction furnaces (UNDP/GEF Project – steel)

- Best practices for EIF sector.
- Mandatory installation of pollution control equipment
- Development of syn gas based DRI process

- Coal gasification for DRI
- Fuel/Air/Ore ratio control in DRI/ Rerolling Mills
- Power Consumption in IF

- Which is best process technology for sponge iron unit and the minimum size of the unit (scale of operations) which is beneficial from both pollution and CO2 point of view?

- Preheating of raw material in steel Rolling mills will be useful.

- Use of Biomass
- Flue Gases heat recovery
- Improving operational efficiency

- Processing of Fines
- Opex reduction

- Processing of fines
- Effective usage of thermal energy
- Remove CAPEX bottleneck by focusing on OPEX

- Gasification of coal
- Waste heat recovery for DRI
- Development of nuclear utilities to decarbonize power for EAF/IF

- Consolidation of Bio-mass
- Cluster approach for energy improvement in furnaces/mills

- Capacity building for technology sharing/updation
- Increase in energy efficiency

Roles by industry and other stakeholders:

- There is need for concrete steps in, a) monitoring of CO₂, b) knowledge sharing & collaboration in research, c) organizational aspects on carbon sequestration for training and awareness.

- Training / technology transfer is required for SME sector through active participation of associations and cluster approach
- Industry Fund should be created to support new pilot project/ innovation

- MoEF should organize training or a seminar in Tamil Nadu to disseminate various technologies available along with the rough cost or investment and financial returns the industry may get.

- Increase R&D expenditure of industries to 2% of turnover
- Invest in pollution control technologies
- Government should give incentives for increasing R&D expenditure
- Government should give tax incentives for energy saving /pollution control technologies

- Need for developing some alternative, cost effective green solutions

- Need for technological development to utilize waste heat recovery
- Need for development of techno-economic viable alternate technology

- MoEF should take up pilot project or power consumption reduction in induction furnace
- MoSteel should continue the on-going project on re-rolling mill for at least 2-3 years

- GIZ should disseminate these info/findings to SPCBs
- Take up demonstration project

- Cluster approach for energy improvement in induction furnaces

- Steel Development Fund should be created to take a time bound project to take forward H₂/Electrolysis based steel making; economical solution to have BOF slag usage

- Capacity building measures by government for adoption of new technologies by industries
- Bilateral projects with Indian and international agencies

What we can do in our industry?

- Adopt prioritized solutions like BOS, dry slag granulation with waste heat recovery
- Use of alternate fuel in blast furnace replacing some part of coke
- Waste heat recovery for hot plant waste gas
- As Engineering & Consulting Co., we shall propose the technologies requiring low energy consumption
- Develop the technologies to minimize waste of energy
- Ask large mills in Karnataka to consider the options presented today by the technology providing companies
- TNPCB is planning to address about 60 identified industries to have a dialogue and we want to impose a condition in the consent order
- Operational discipline
- Waste reuse maximisation
- Adoption of clean technology
- CDP - we can provide examples of best practices by companies in environment and energy management from around the world
- Explore further areas of energy optimization to reduce raw material input
- Develop substitutes for existing raw material inputs

After writing the feedbacks on the cards provided, discussions took place based on the points raised by the delegates. Mr. Genter and Dr Mutz, as panellist addressed the discussions.

e) Concluding Session:

In the concluding session, Dr. Dieter Mutz summarized the following points:

- Large steel industries can deliver as there is pressure for increase in production while there is great potential for reduction of CO₂ emissions.
- There is a need to differentiate between small and big companies. Secondary steel sector needs a lot of focus for India.
- CDM is not suitable; we need to look for better options/mechanisms.
- Various technological options, expensive and non-expensive, simple and sophisticated, are available.

- GIZ could facilitate information dissemination especially among small industries and through its PPP scheme, support new technology demonstration. KfW green credit line would be beneficial for individual companies.

This was followed by the GIZ (India) Country Director; Mr Stefan Helming's concluding remarks. Mr Helming stressed the need for this very high level of technical deliberations to be taken forward. He mentioned that from the day's discussions, he feels that there is high level of potential for reduction of CO₂ in this sector. He also mentioned that the SME sector should be promoted in reducing the CO₂emissions. He stressed that usage of better technology is the need of the hour. He mentioned that he looks forward for larger impact from the Indo-German Development Cooperation with necessary capacity building taking place.



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Workshop

Steel Industry in India: Potentials and Technologies for Reduction of CO₂ Emissions

Wednesday, December 7, 2011, 9:00 AM – 2.30 PM
Hotel Leela Palace, Chanakyapuri, Diplomatic Enclave, New Delhi

Agenda

- | | |
|---------------------------|--|
| 9:00 - 9:15 AM | Registration |
| 9:15 - 10:00 AM | Inaugural Session <ul style="list-style-type: none">▪ Introduction by Dr. Dieter Mutz, Director, GIZ(ASEM)▪ Address by Mr. Bernd Dünzlaff, Head of Economic Cooperation and Development, German Embassy▪ Address by Dr. G.V. Subrahmanyam, Advisor, Ministry of Environment & Forests, Government of India |
| 10:00 - 10:45 AM | Results of the Study, Potential Actions – Presentation by Mr. Christoph Genter/ AMCG, Mr. Pradip Nadkarni/Paradigm |
| 10:45 – 11:00 AM | Q&A |
| 11:00 - 11.15 Noon | Coffee Break |
| 11:15 - 12:15 Noon | Statements of stakeholders <ul style="list-style-type: none">▪ Karnataka State Pollution Control Board▪ Tamil Nadu Pollution Control Board▪ TATA Steel Limited▪ AIIFA – All India Induction Furnaces Association▪ The Indian Institute of Metals▪ Outotec▪ Paul Wurth▪ Siemens VAI |
| 12:15 - 12:45 Noon | Discussions <ul style="list-style-type: none">▪ What are the most promising potentials and technologies – a) large scale sector, b) MSME sector?▪ What are roles by industry and other stakeholders? |
| 12:45 – 1:00 PM | Closing Session <ul style="list-style-type: none">▪ Wrap-up by Dr. Dieter Mutz, Director, GIZ (ASEM)▪ Concluding Remarks by Mr. Stefan Helming, Country Director, GIZ |
| 1:00 - 2:30 PM | Lunch |

Participant List of the Workshop on “Steel Industry in India: Potentials and Technologies for Reduction of CO2 Emissions”

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25	Paul Wurth India Pvt. Ltd.	The Mira, Corporate Suites, Block F-1, First Floor, 1 - 2, Old Ishwar Nagar, Okhla Crossing, Mathura Road	New Delhi - 110 065	S.Dipak	Deputy General Manager (Sales & Mktng)	s.dipak@paulwurth.com	
26	SAIL Steel Authority Of India Limited	Ispat Bhawan, Lodi Road	New Delhi - 110 003	Sunil Singal	Asst. General Manager	sunil.singal@live.com	
27	Siemens VAI Metals Technologies Pvt. Ltd.	I MT BE, Infinium Digispace, Block CP, Plot 15, Sector V, Salt Lake	Kolkata - 700 091	Pradip Chaudhuri	Steel Making	pradip.chaudhuri@siemens.com	Tel: +91-33-3017 1003 Fax: +91-33-3017 1274
28	SIMA Sponge Iron Manufacturers Association	1501, Hemkunt Tower, 98 Nehru Place	New Delhi 110019	Er. Deependra Kashiva	Executive Director	dkedsima@gmail.com	+91-2629 4492, +91-4161 9204 Fax: +91-2629 4491 Mob.: 9899571963
29	TATA Steel Limited	Room No.205, 2nd Floor, Environment Management Department, Fuel Management Building, Jamshedpur Steel Works, Mail Box W-151 (Tata Steel)	Jamshedpur - 831001 District - East Singhbhum, State - Jharkhand, INDIA	Shibojyoti Dutta	Head, Climate Change & Strategic Planning Services Environment Management	shibojyoti@tatasteel.com	+91(657)66-40362, cell # +91 9234560684
30	Steel Furnace Association of India			Arjun Kumar Jain	Exe. Director	sfaidel@yahoo.com	

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34	GIZ – IS	S-35 A, Panchsheel Park, New Delhi - 110017, India		Dr. Juergen Bischoff		Juergen.Bischoff@giz.de	Tel: +91 11 - 47773500, Fax: +91 11 47773555 Mob: 8527100422
35	GIZ-ASEM	2nd Floor, B 5 / 2, Safdarjung Enclave New Delhi 110029	New Delhi	Dr. Dieter Mutz	Dierctor, ASEM Project	Dieter.mutz@giz.de	T +91 11 49495353 Fax: ++91 11 49495391
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37	GIZ-ASEM	3rd Floor, B 5 / 2, Safdarjung Enclave New Delhi 110029	New Delhi	Mr. Enrico Rubertus	Advisor	enrico.rubertus@giz.de	
38	GIZ-ASEM	3rd Floor, B 5 / 2, Safdarjung Enclave	New Delhi	Preeti Negi		Preeti.negi@giz.de	

Participant List of the Workshop on “Steel Industry in India: Potentials and Technologies for Reduction of CO2 Emissions”

		New Delhi 110029					
Special Guests							
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40	German Embassy	Economic Cooperation and Development German Embassy 6/50 G, Shantipath, Chanakyapuri	New Delhi 110021	Mr. Bernd Dunzlaff	Counsellor for Economic Cooperation	wz-1@newd.auswaertiges-amt.de	
41	GIZ India	B5/2, Safdarjung Enclave	New Delhi - 49	Mr. Stefan Helming	Country Director	stefan.helming@giz.de	+91-11-49495353, 49495300

Presentation report

Steel industry in India: Potentials and technologies for reduction of CO₂ emissions

– Report –

prepared for

GIZ – Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, Germany

Munich, December 15th, 2011

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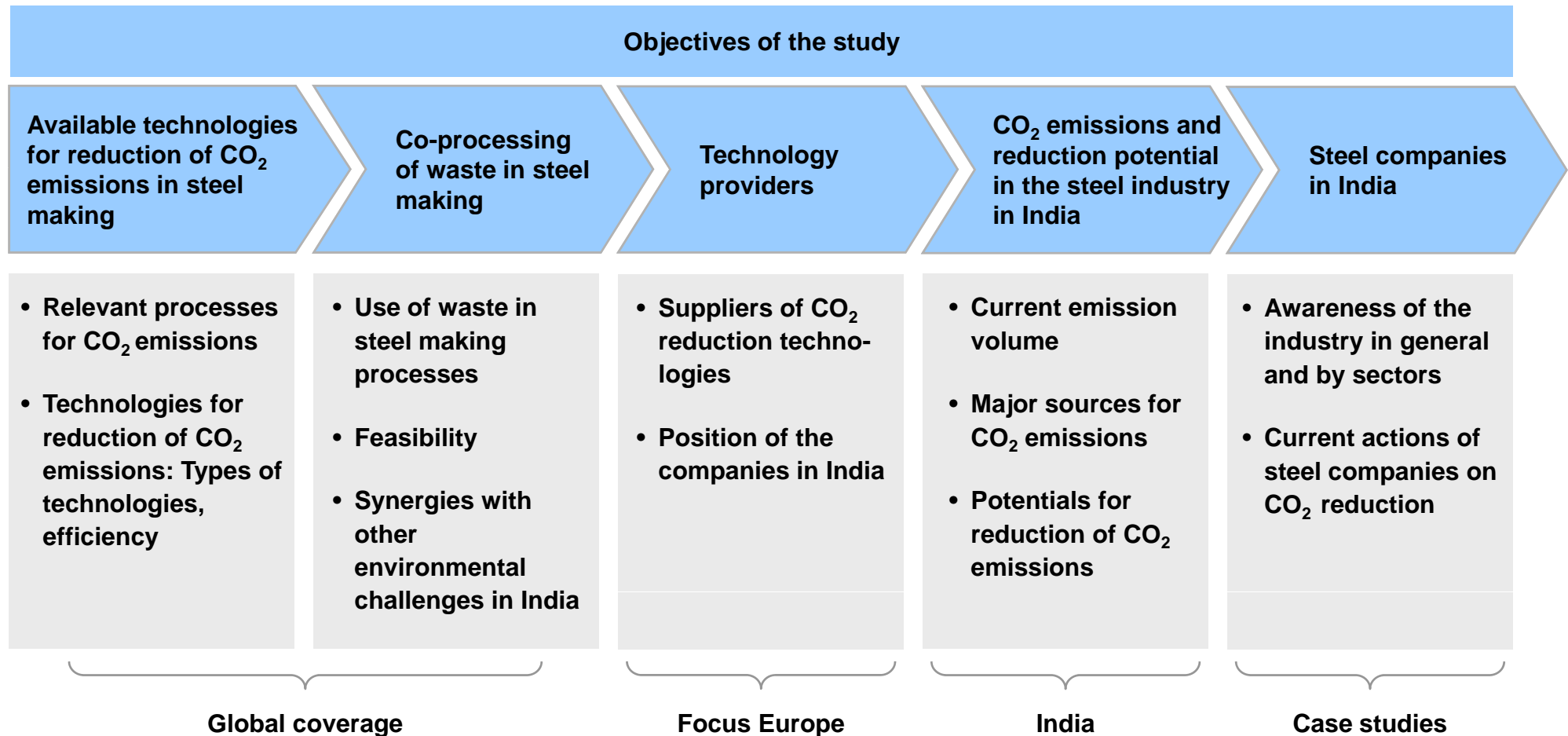
AMCG

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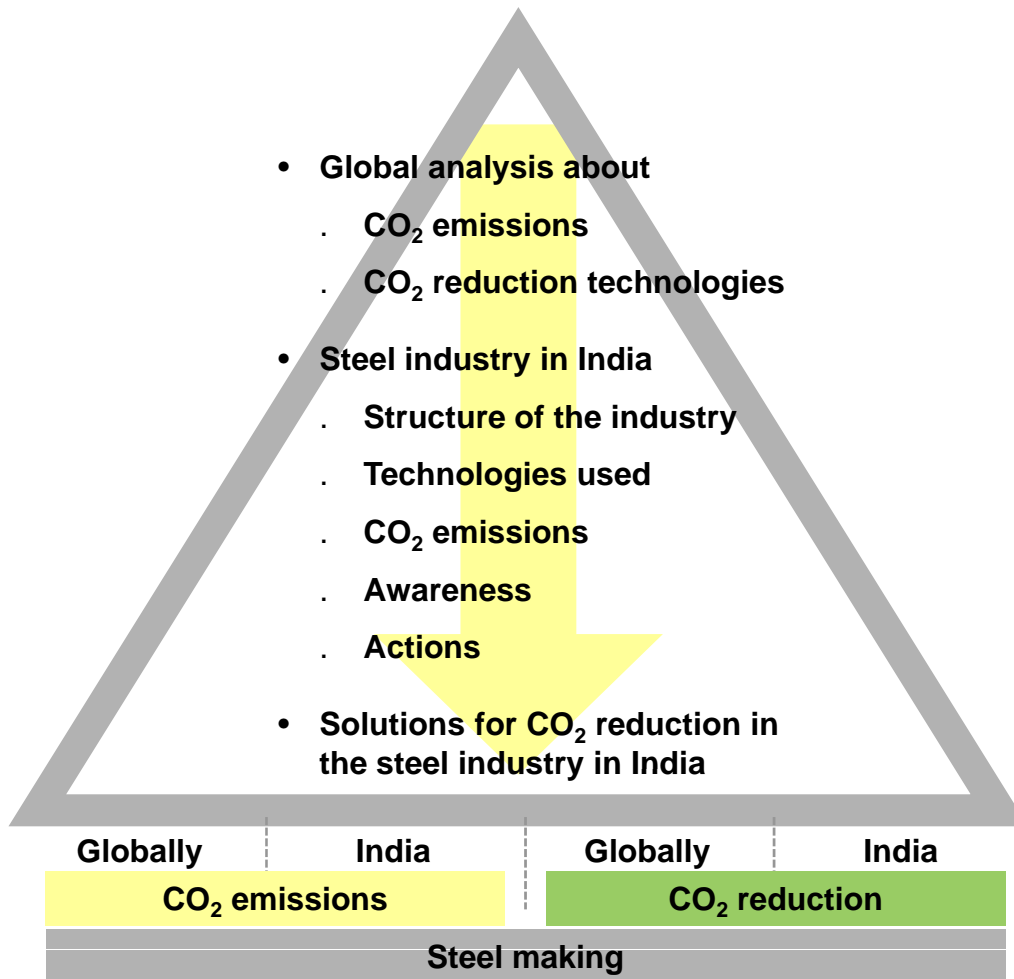
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4. Technologies for the reduction of CO₂ emissions, co-processing of waste in steel making, technology providers	25
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1. Objectives and methodology

The objective of the study was to identify CO₂ reduction potentials in the Indian steel industry.



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

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

- | | | | |
|---|---|--|---|
| <ul style="list-style-type: none"> • Industry associations (steel, in general) <ul style="list-style-type: none"> · 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 | <ul style="list-style-type: none"> • Ministries, environmental organizations <ul style="list-style-type: none"> · 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 | <ul style="list-style-type: none"> • Steel industry <ul style="list-style-type: none"> · SAIL – Steel Authority Of India · TATA Steel · Jindal Steel & Power · Mukand · Adhunik Metaliks · Allied Holdings · Kalyani Steels · Remi Metals/Welspun | <ul style="list-style-type: none"> • Engineering companies <ul style="list-style-type: none"> · Danieli Corus · Mecon · Paul Wurth · Siemens VAI • R&D <ul style="list-style-type: none"> · Indian Institute of Technology, Department of Humanities and Social Sciences · IRADe – Integrated Research and Action for Development |
|---|---|--|---|

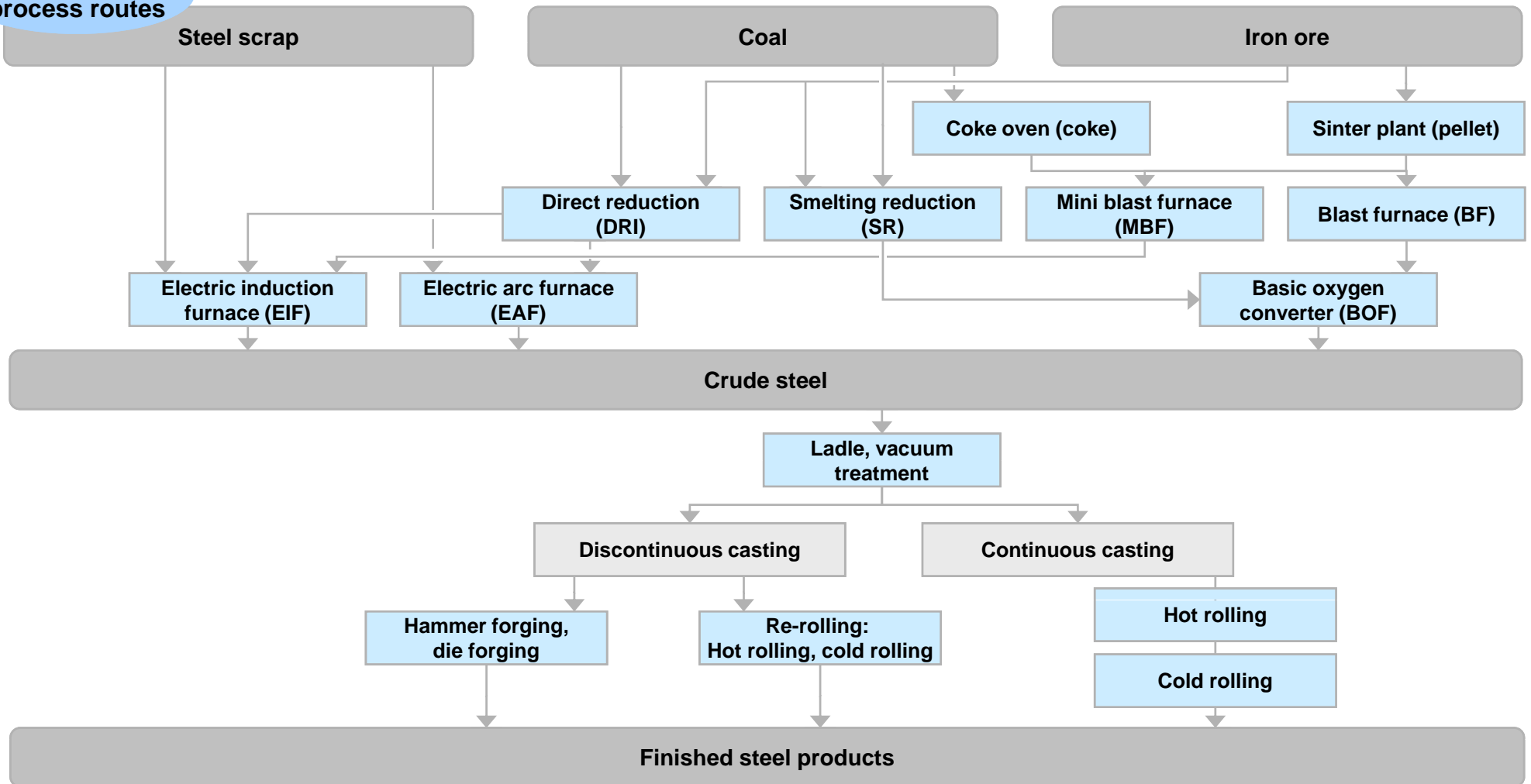
Policy papers, reports, studies etc. from India as well as global sources were used.

Policy papers from India	Steel technology sources	
<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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 CO₂ Emissions. International Energy Agency, 2007 • CO₂ 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 	<ul style="list-style-type: none"> • 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 CO₂ Reduction in the Steel Industry. • Major global programs for new steel technologies with CO₂ reduction <ul style="list-style-type: none"> · ULCOS (Europe) · COURSE50 (Japan) · POSCO (Korea) · AISI (USA)

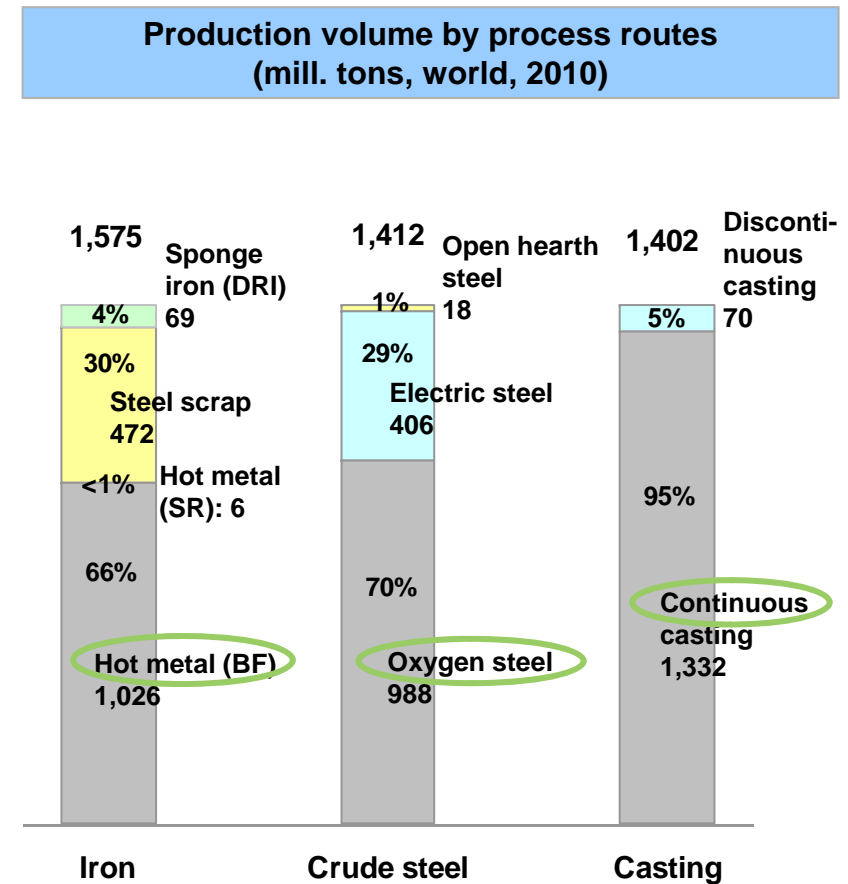
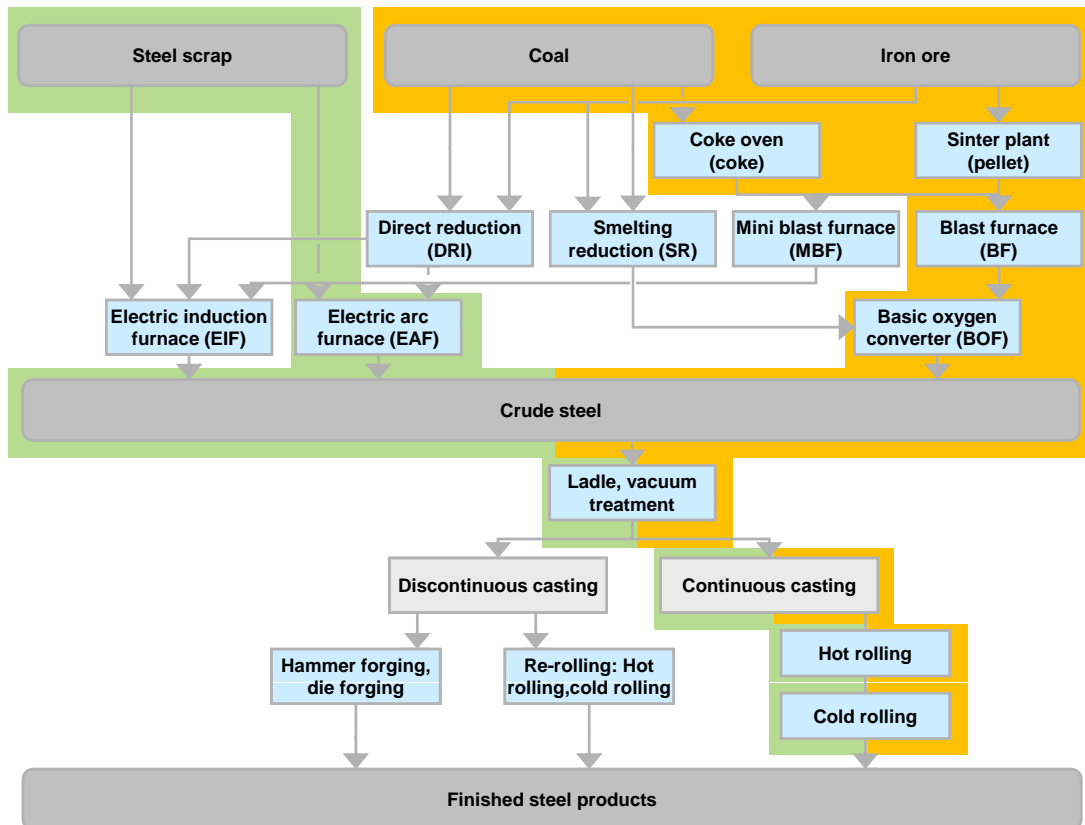
2. Global steel industry: Processes, CO₂ emissions and goals

Steel making is based on various process routes.

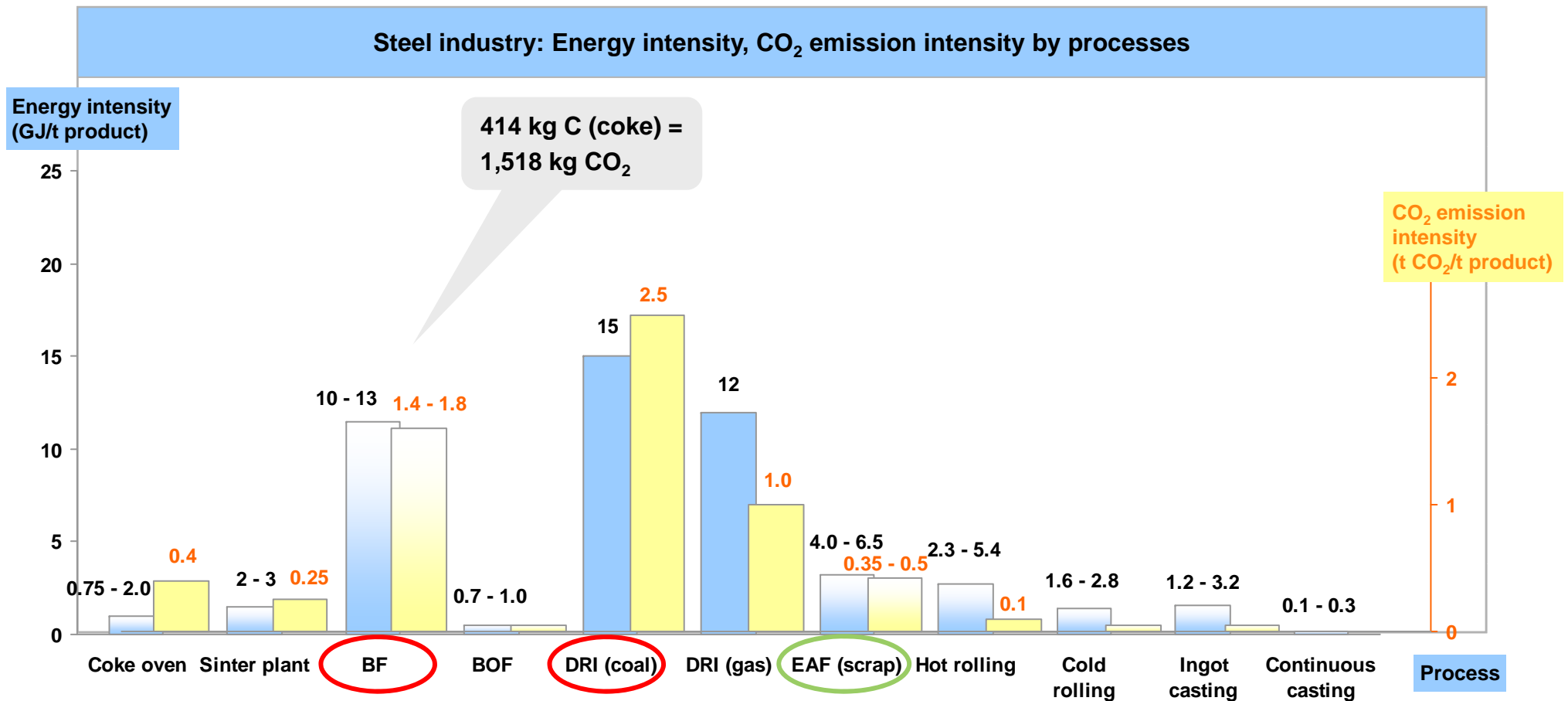
Steel making
process routes



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



The blast furnace is the major source of CO₂ emissions due to its need on reducing agents (= coke).

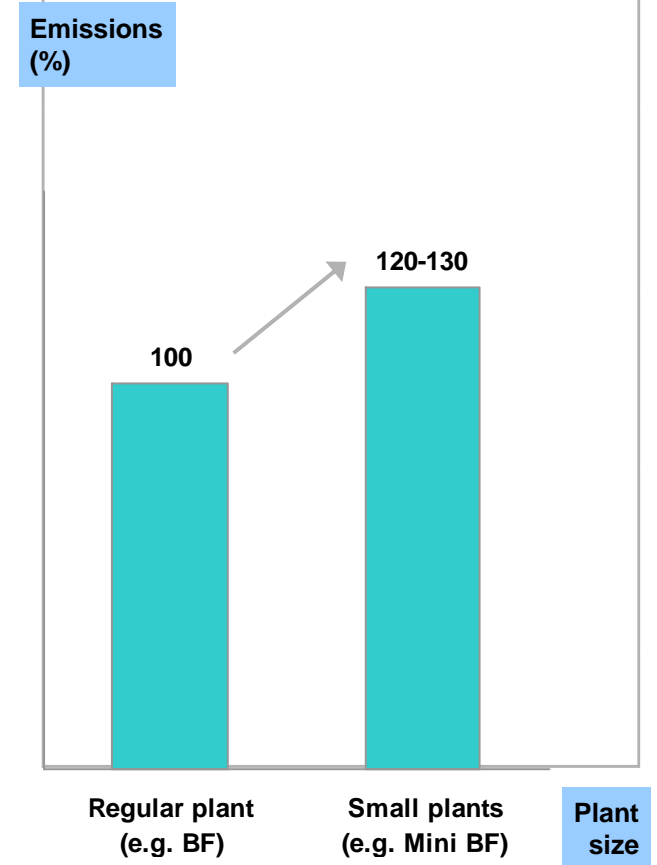


CO₂ emissions of primary raw material based process routes are higher compared with secondary raw material using EAF. Heat losses and efficiency of small scale plants are lower in most cases.

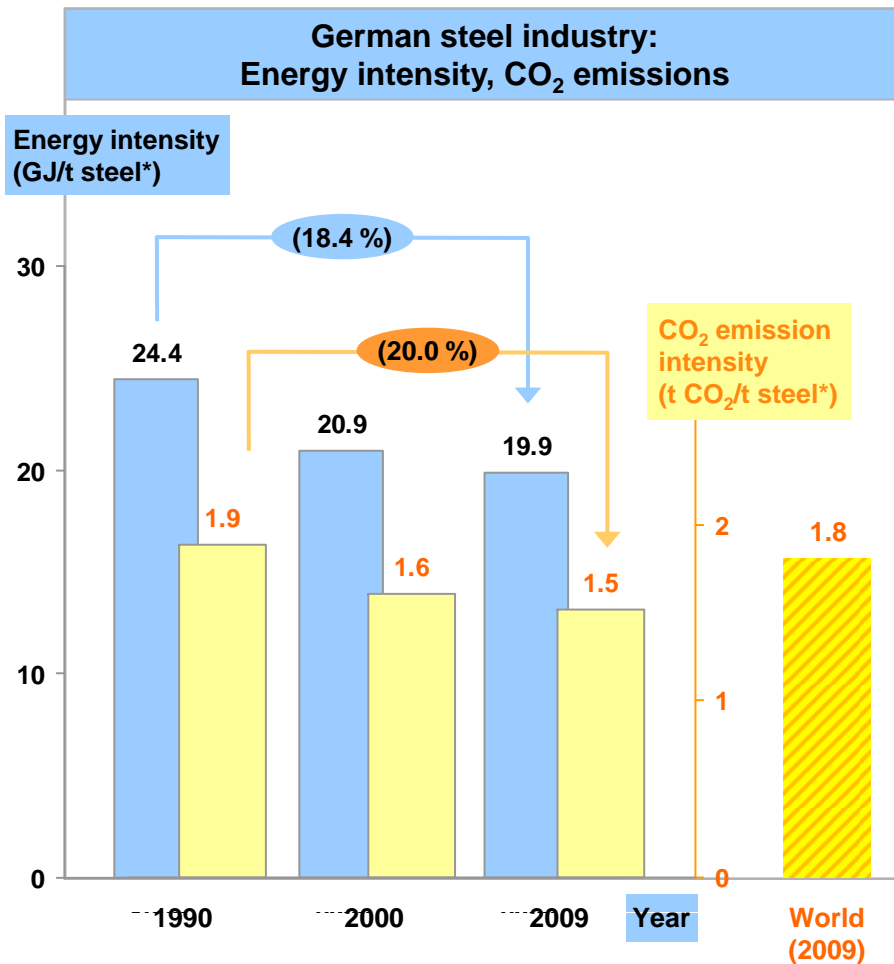
Energy intensity by steel processing routes

	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

CO₂ emissions by plant size

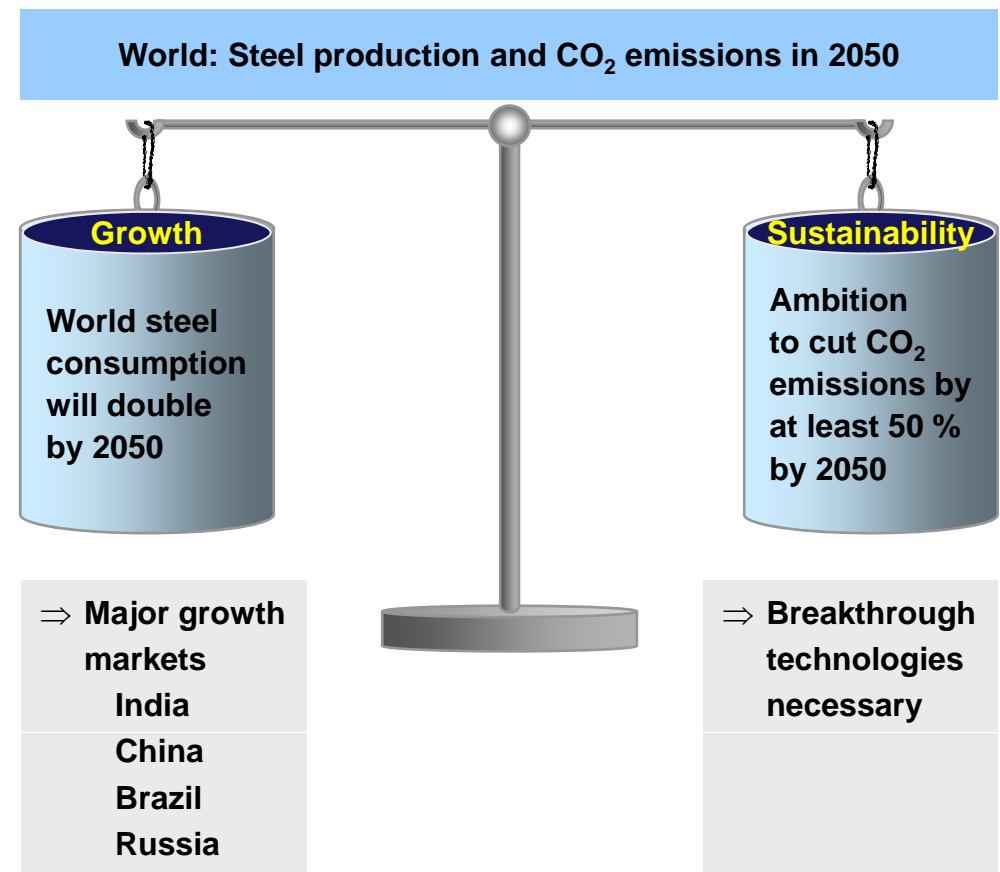


The steel industry has cut energy intensity/CO₂ emissions substantially in the past. The goal is further improvement by breakthrough technologies.



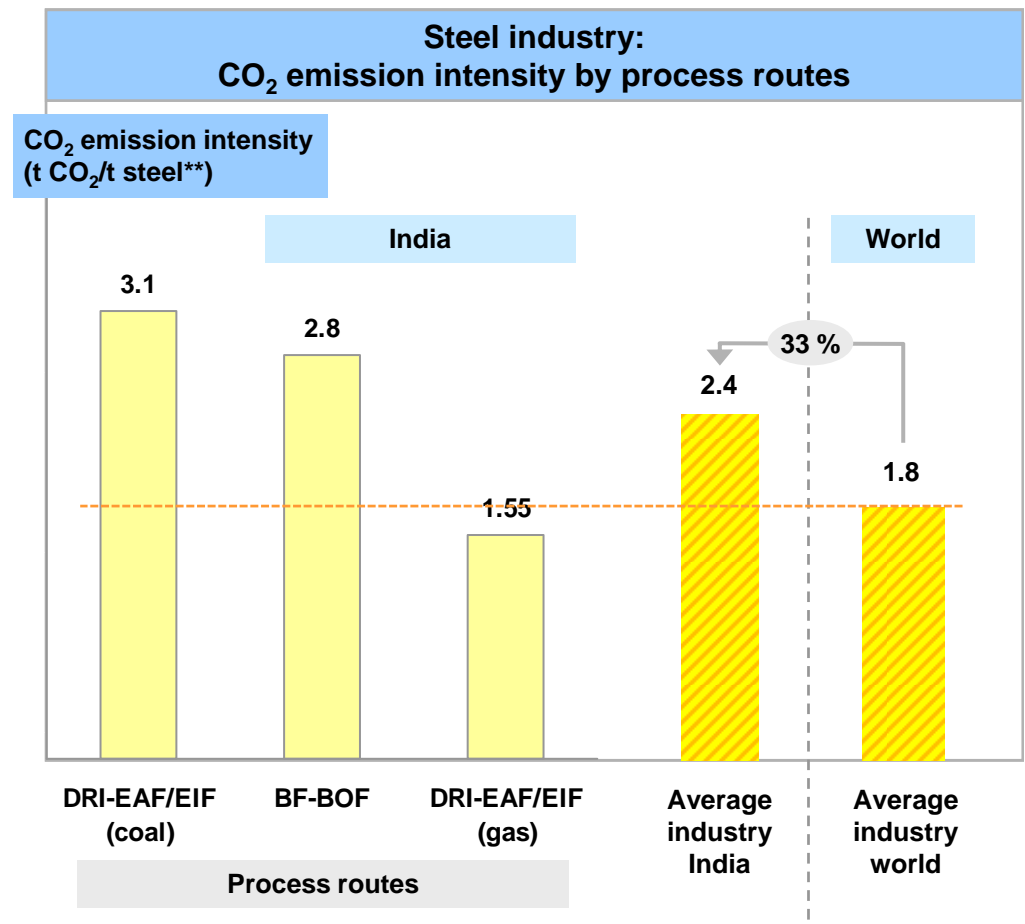
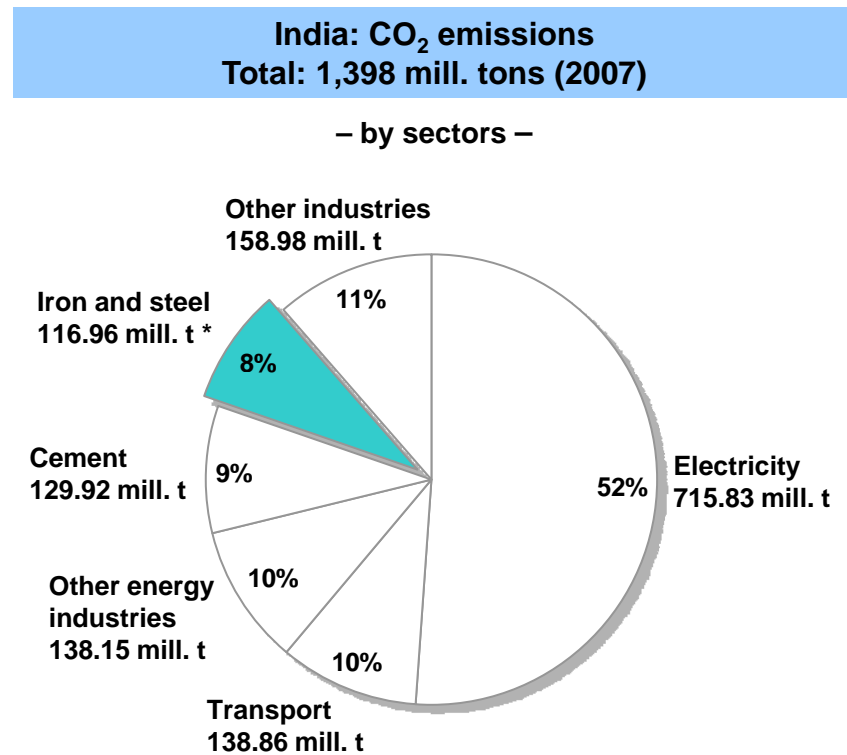
* finished product

Source: VDEh, Worldsteel



3. CO₂ emissions of the steel industry in India

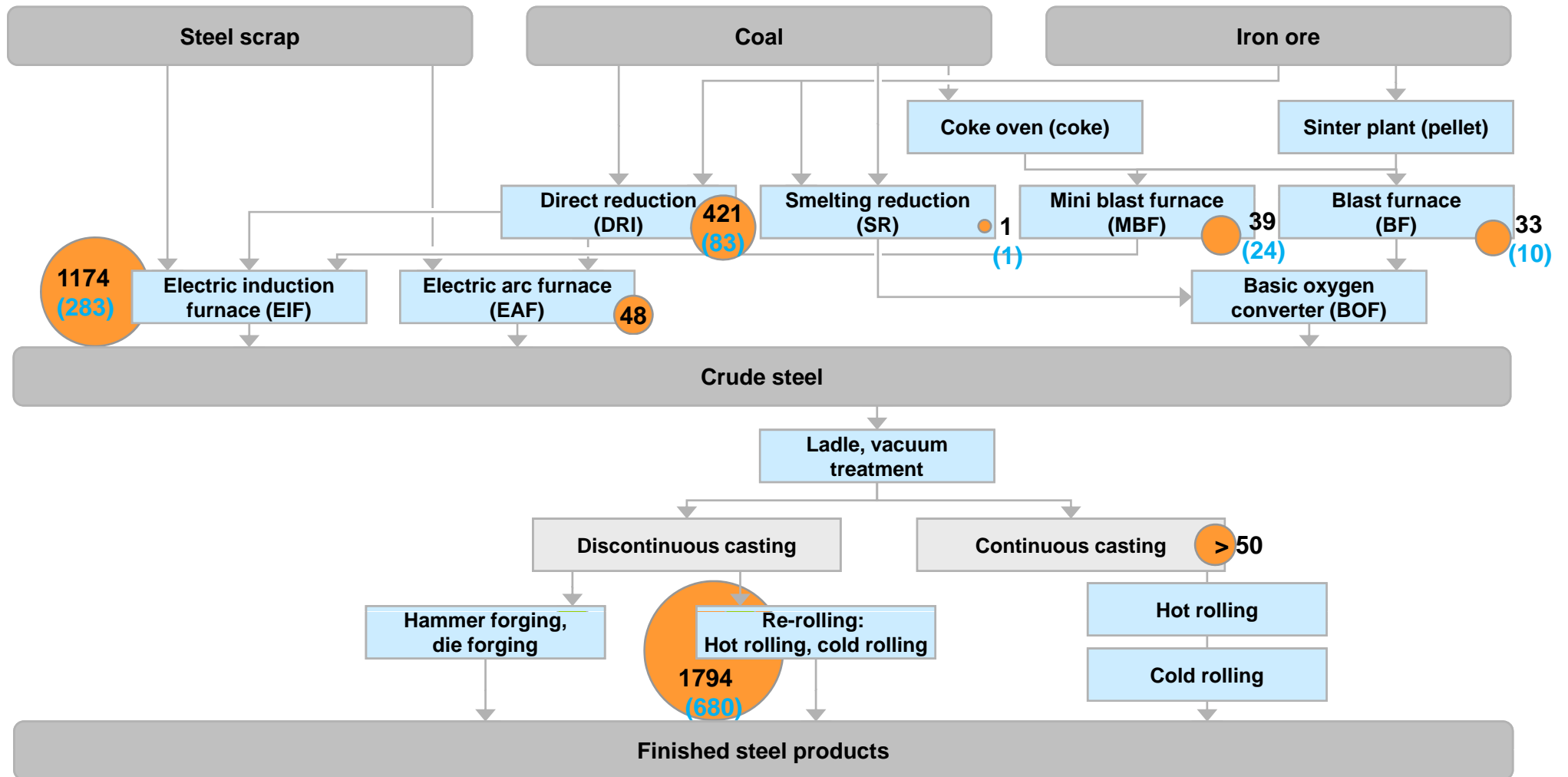
Steel and cement industry are the major sources for CO₂ emissions in India. Emission intensity of the steel industry one third above global average.



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

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

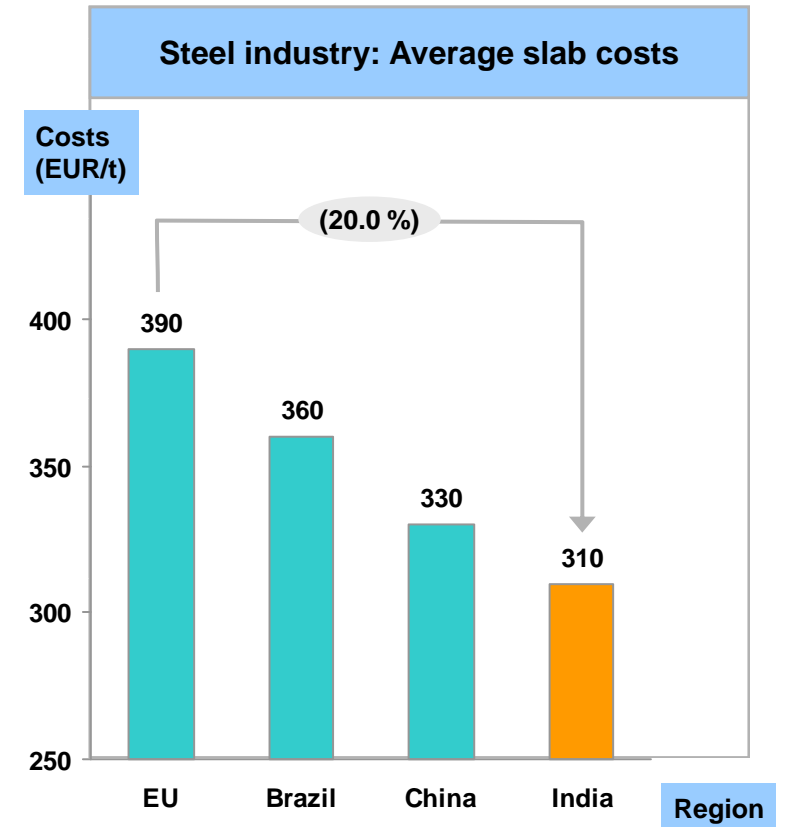
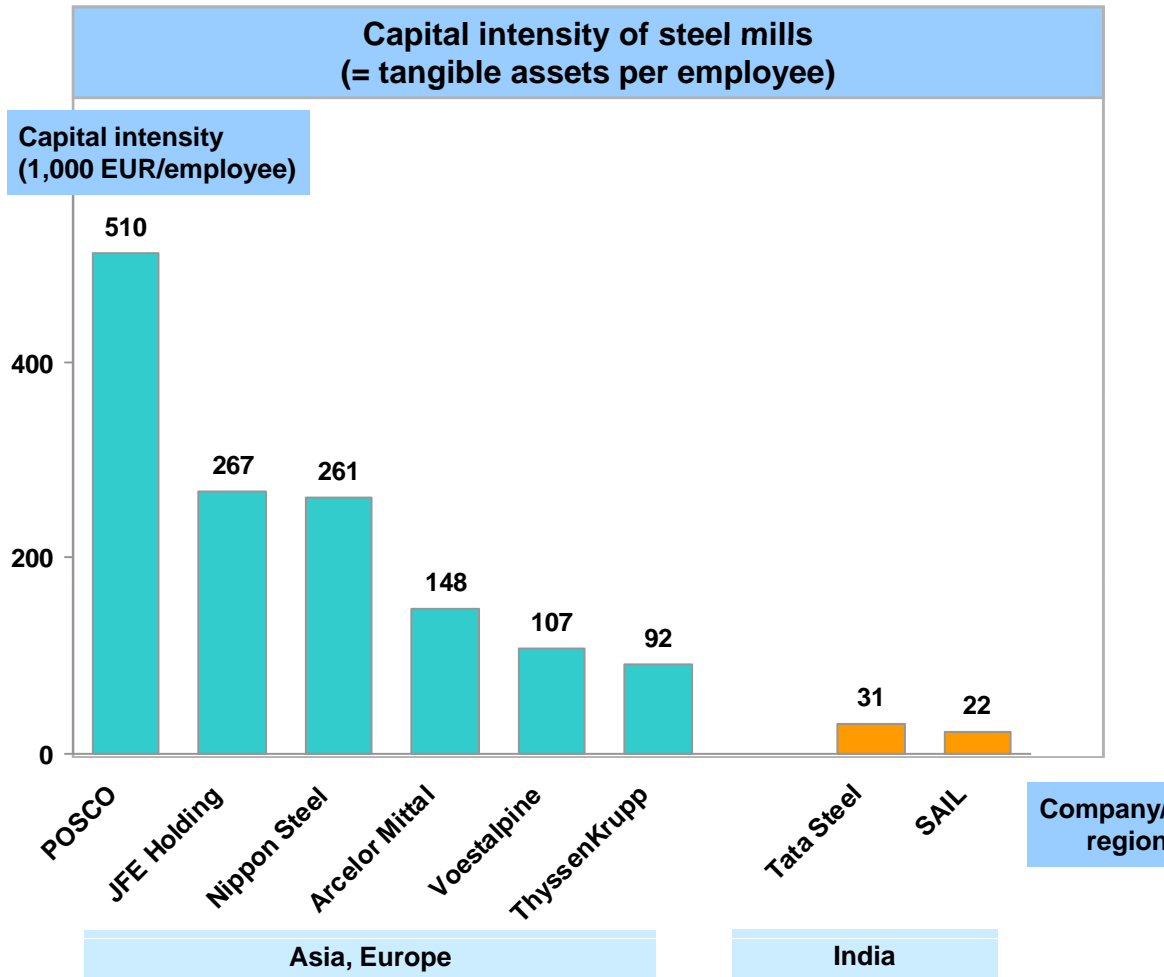
The steel industry in India is highly fragmented with a broad variety of process routes and hundreds of small mills.



Source: Steel Associations India, Joint Plant Committee

● Number of plants
● (Number of companies)

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.

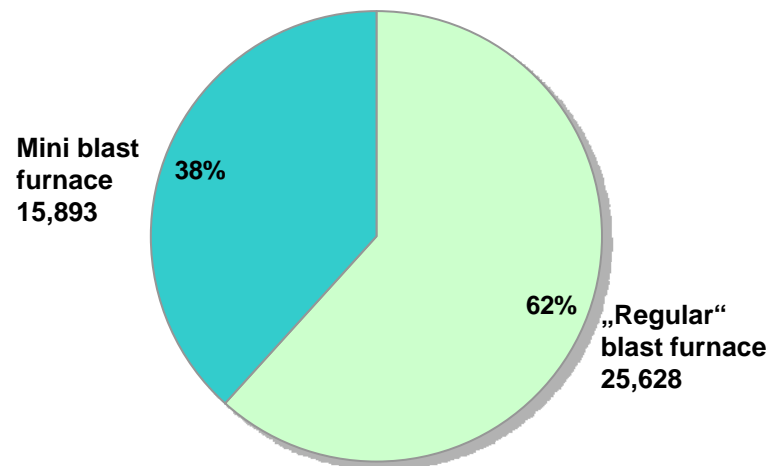


Source: Annual reports, Tata Steel

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

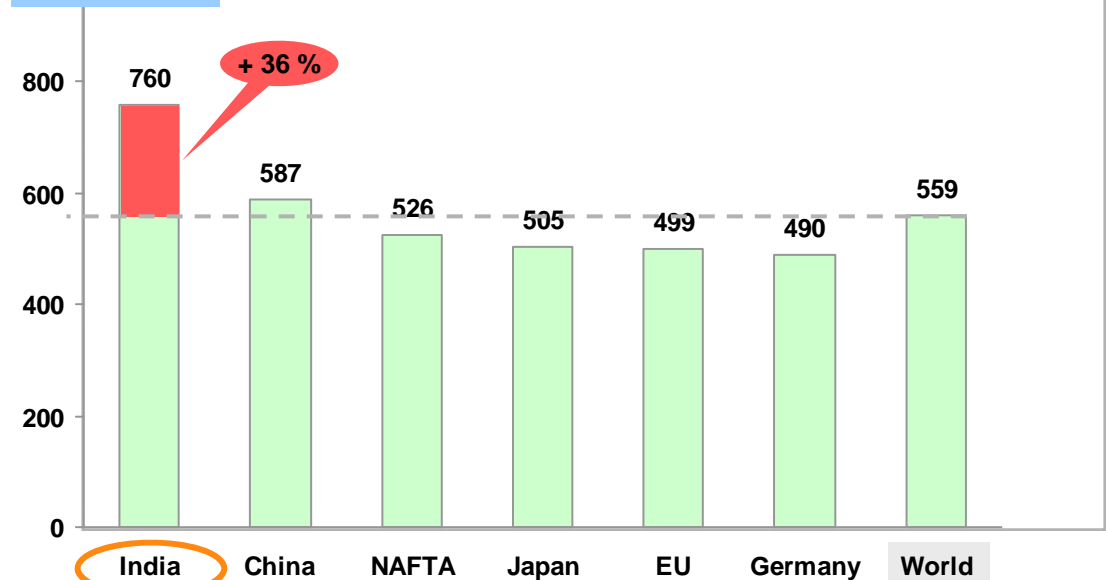
India: Hot metal production
Total: 41,521 (1,000 tons, 2010)

– by type of mill –



Blast furnace: Consumption of reducing agents (2009)

Consumption
(kg/t hot metal)

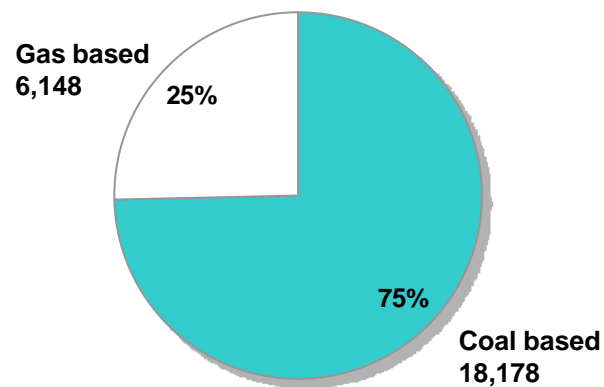


Country/region

Further drivers for the high CO₂ 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)

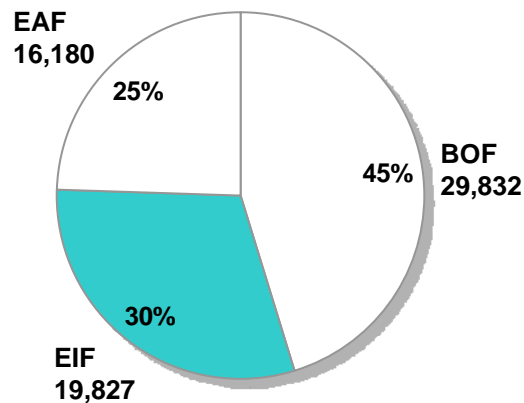
– by fuel –



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

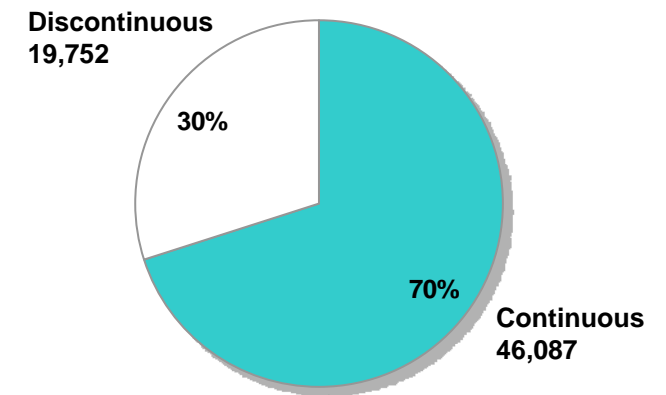
Crude steel production
Total: 65,839 (1,000 tons, 2010)

– by routes –



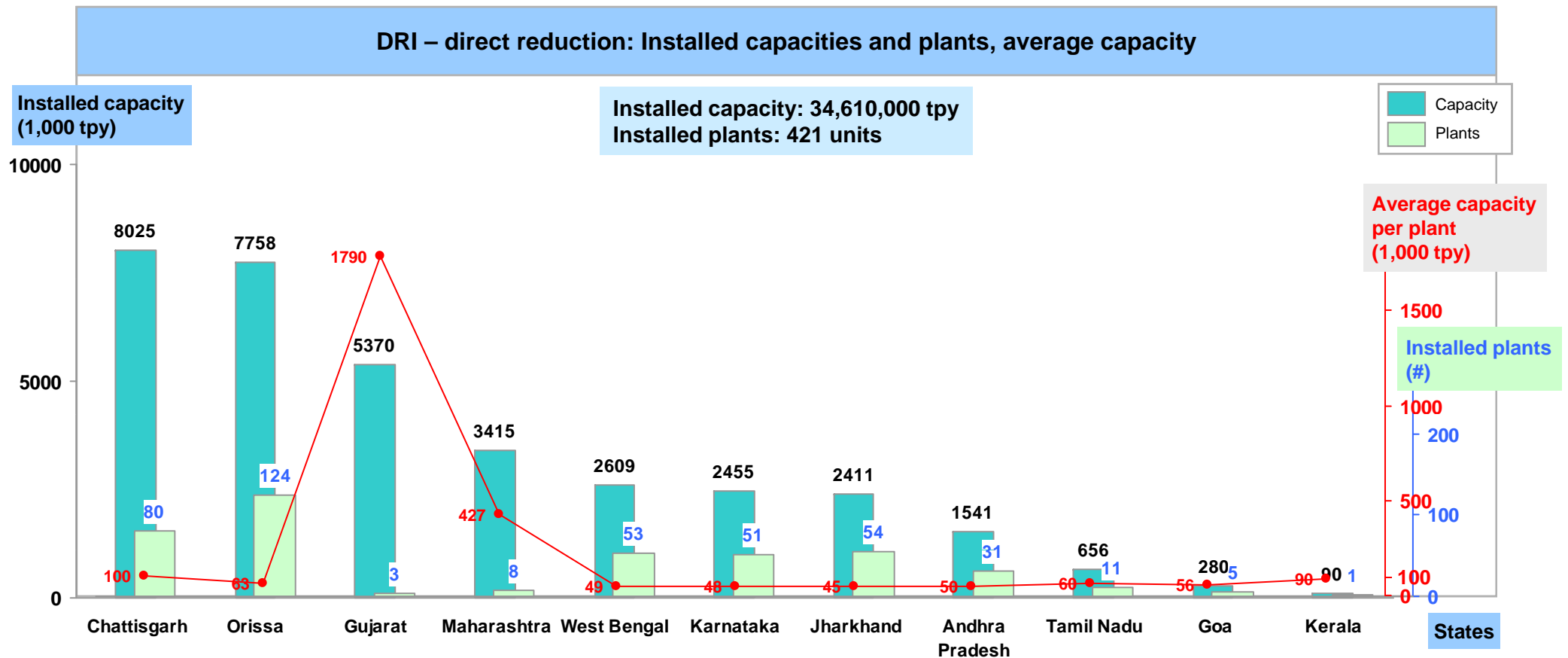
⇒ Small share of EAF due to low scrap production (import of 4 mill. tons scrap)
⇒ High share of EIF with high emission intensity

– by casting processes –



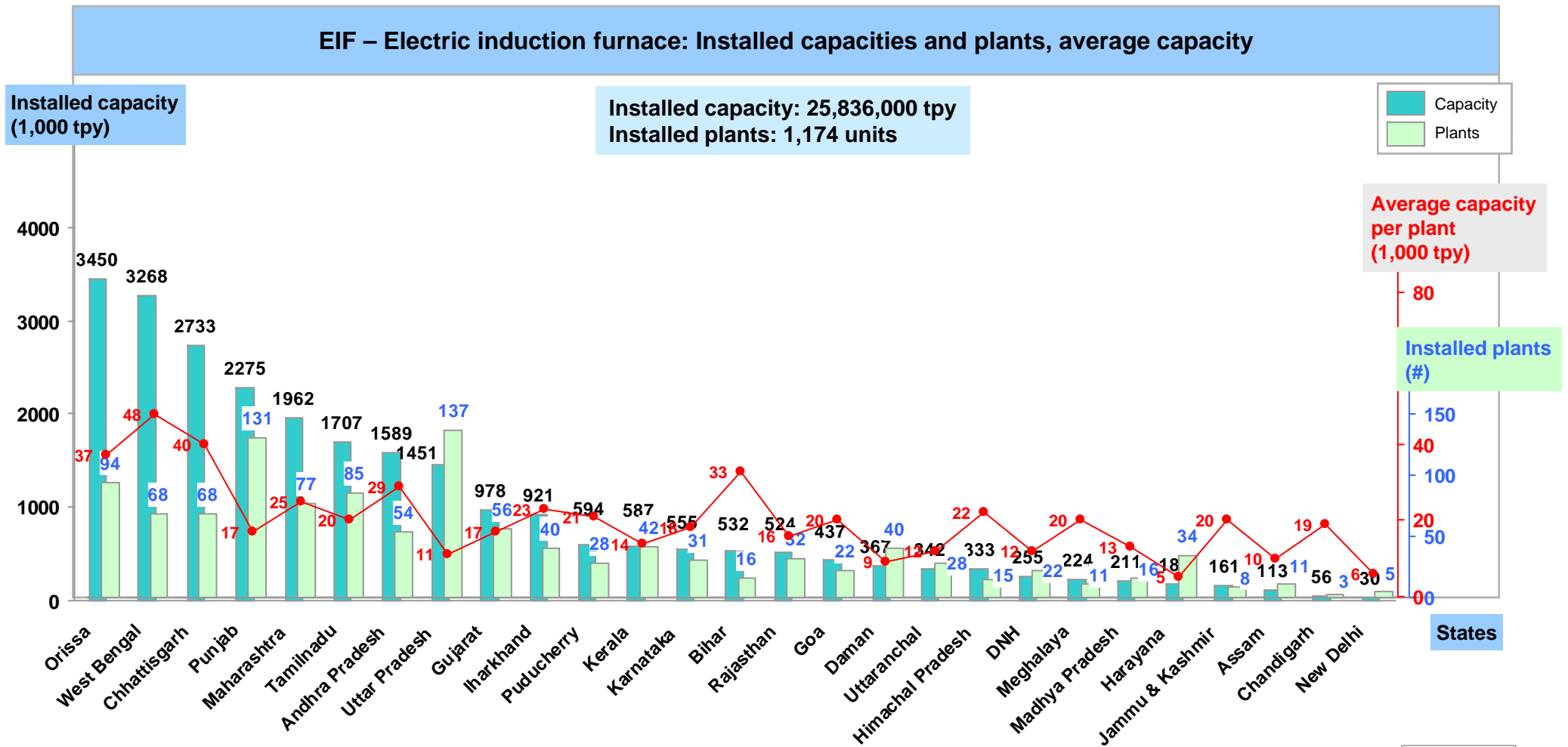
⇒ Low continuous casting rate
⇒ High energy consumption of discontinuous route (re-rolling)

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



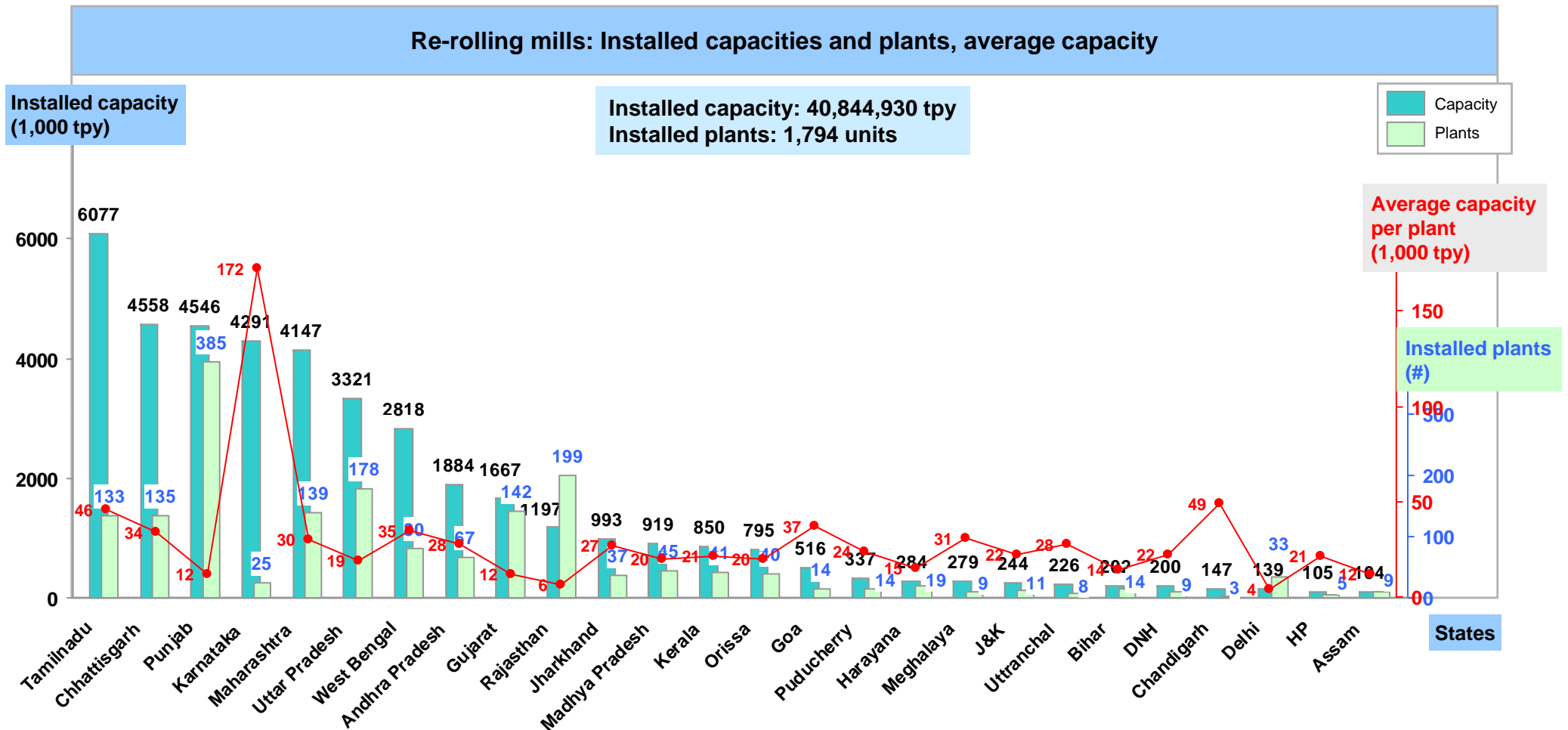
Source: Joint Plant Committee

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



Source: Joint Plant Committee

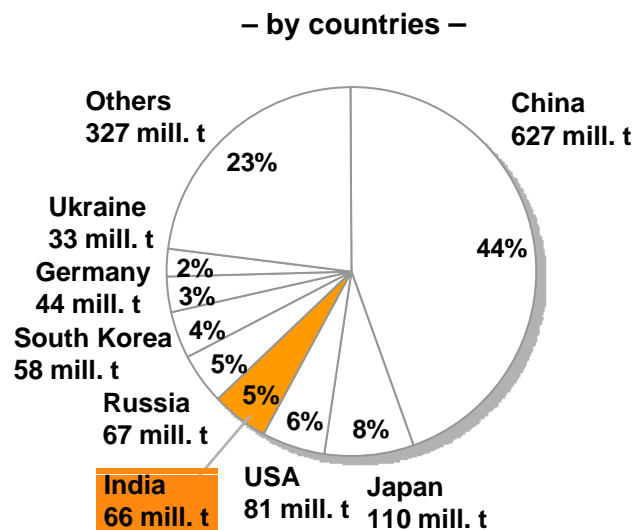
Re-rolling mills are small shops (with a few exceptions) active all over India, driven by low market penetration of continuous casting.



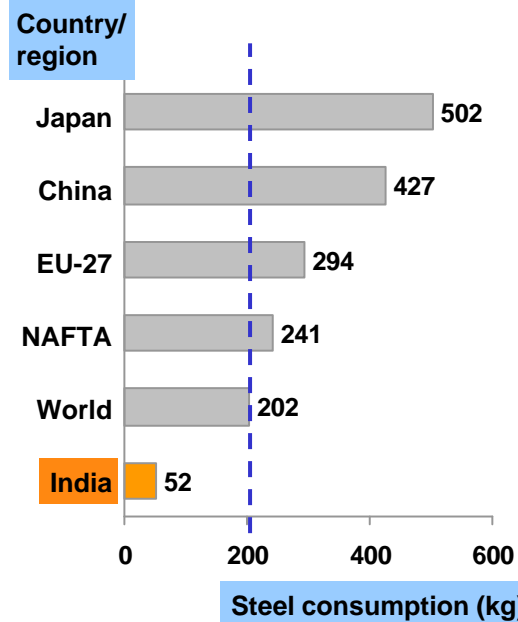
Source: Joint Plant Committee

Steel production in India will double by 2020. Without actions the CO₂ emissions will take the same development.

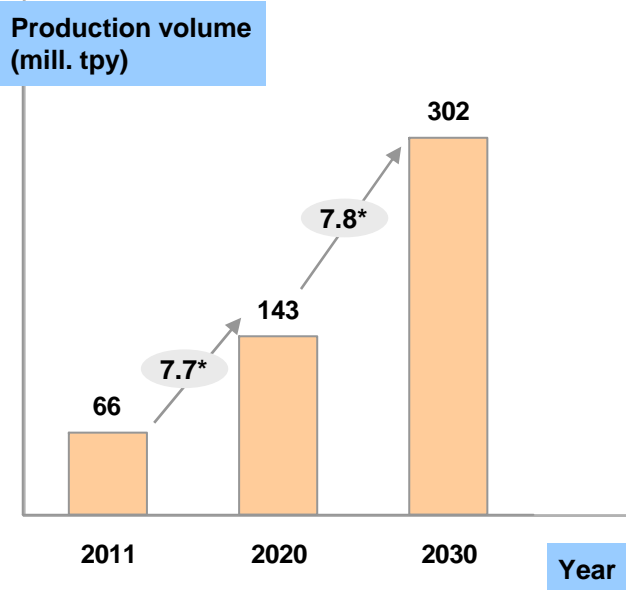
Steel production
Total: 1,413 mill. tons (world, 2010)



Steel consumption per capita
(finished products, 2010)



Steel production in India



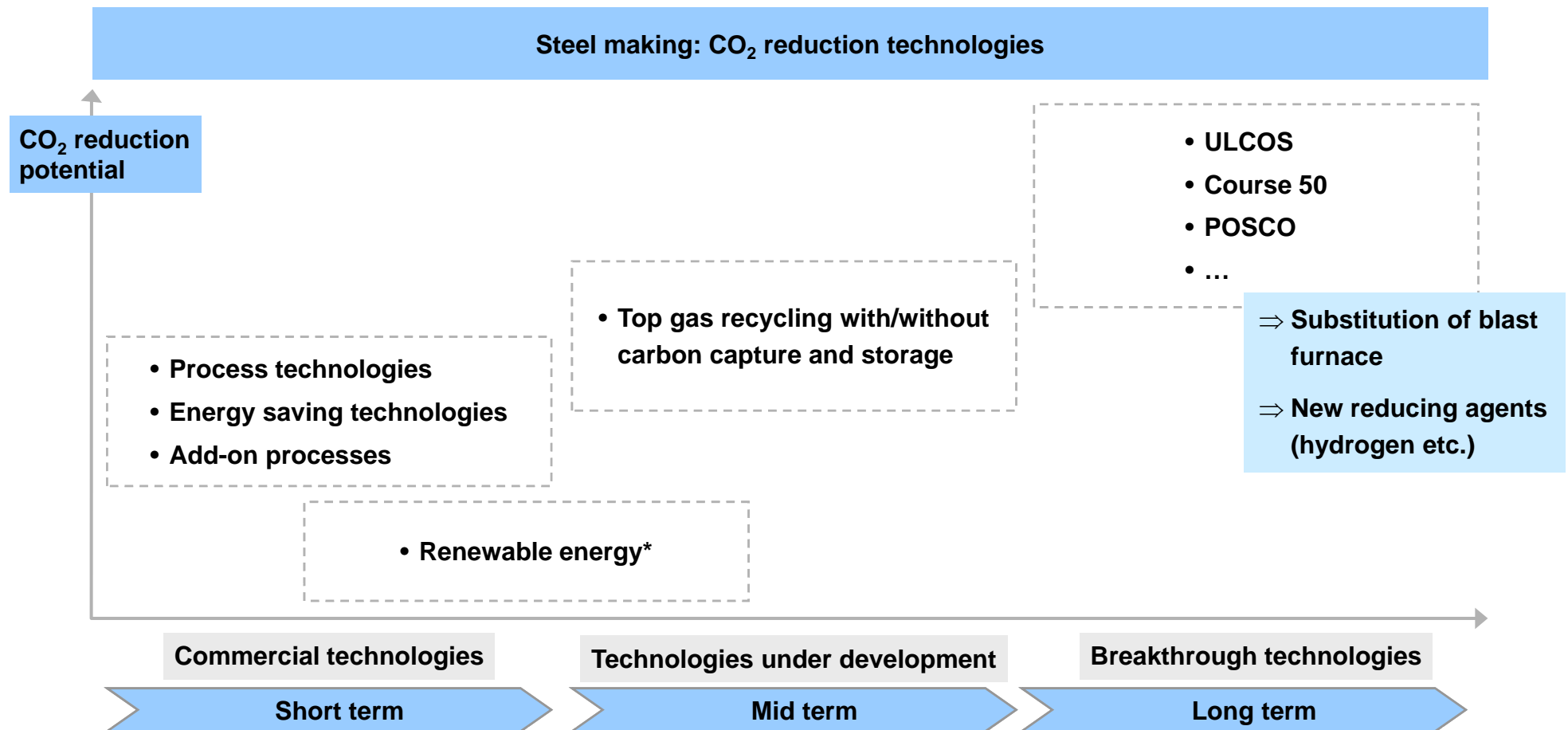
⇒ Conservative forecast
⇒ Demand for steel will touch 113 mill. t and crude steel capacity will likely be 149 mill. tpy in 2016/17**

⇒ **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 CO₂ emissions,
co-processing of waste in steel making,
technology providers**

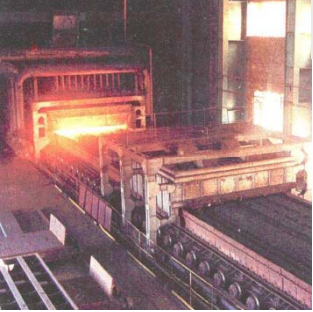
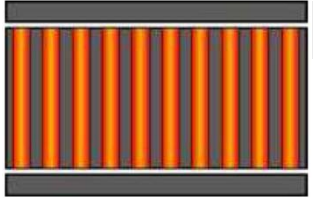
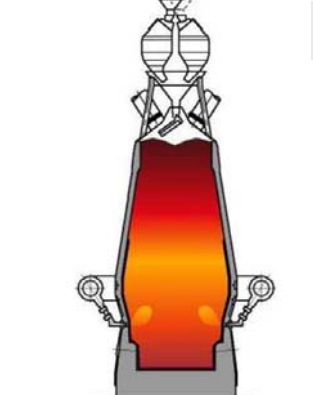
Numerous technologies are commercially available as well as under development for reduction of CO₂ emissions.



* not process technologies but power supply

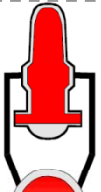
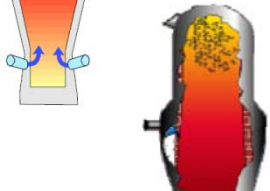

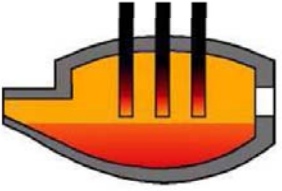
Source: AMCG-research, VDEh congress

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

Process step	CO ₂ reduction solution	Reduction potential CO ₂ emission intensity
 <p>Sinter plant</p>	<ul style="list-style-type: none"> • Sinter plant heat recovery • Use of waste fuels (e.g. lubricants) in sintering plant 	<p><i>kg CO₂ / t product</i></p> <p>57.2</p> <p>19.5</p>
 <p>Coke oven</p>	<ul style="list-style-type: none"> • Coke dry quenching 	<p>27.5</p>
 <p>Blast furnace</p>	<ul style="list-style-type: none"> • Use of high quality ore • Direct injection of reducing agents <ul style="list-style-type: none"> . Coal injection, pulverized coal injection . Gas injection, natural gas injection • Improved blast furnace control systems • Hot blast stoves automation • Top pressure recovery turbine 	<p>15 - 80</p> <p>34.7 – 47.0</p> <p>54.9</p> <p>24.4</p> <p>22.6</p>

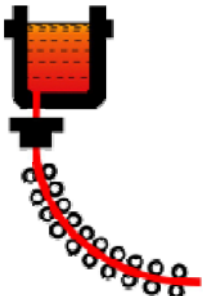
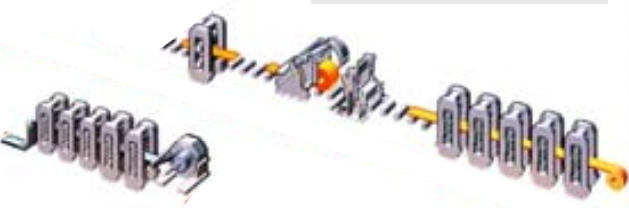
Source: BAT – Best Available Technologies/European Commission, U.S. Environmental Protection Agency, State-of-the-Art Clean Technologies for Steel Making

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
 <p data-bbox="459 470 739 558">Smelting reduction</p>	<ul style="list-style-type: none"> • New processes <ul style="list-style-type: none"> . Finex / POSCO . IT mk3 / Kobe Steel 	<p data-bbox="1960 438 2094 510"><i>kg CO₂ / t product</i></p>
 <p data-bbox="459 694 739 734">Direct reduction</p>	<ul style="list-style-type: none"> • Coal gasification (syngas) 	<p data-bbox="1836 694 1915 734">High</p>
 <p data-bbox="459 917 739 997">Basic oxygen converter</p>	<ul style="list-style-type: none"> • Energy recovery from the BOF gas • Increased energy efficiency by automation 	<p data-bbox="1836 933 1915 965">46.0</p> <p data-bbox="1825 997 1926 1029">15 - 16</p>
 <p data-bbox="459 1204 739 1284">Electric arc furnace</p>	<ul style="list-style-type: none"> • Scrap preheating • Improved process control • Transformer efficiency • Bottom stirring/stirring gas injection 	<p data-bbox="1836 1165 1915 1197">35.2</p> <p data-bbox="1836 1220 1915 1252">17.6</p> <p data-bbox="1836 1276 1915 1308">10.0</p> <p data-bbox="1836 1332 1915 1364">11.7</p>

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

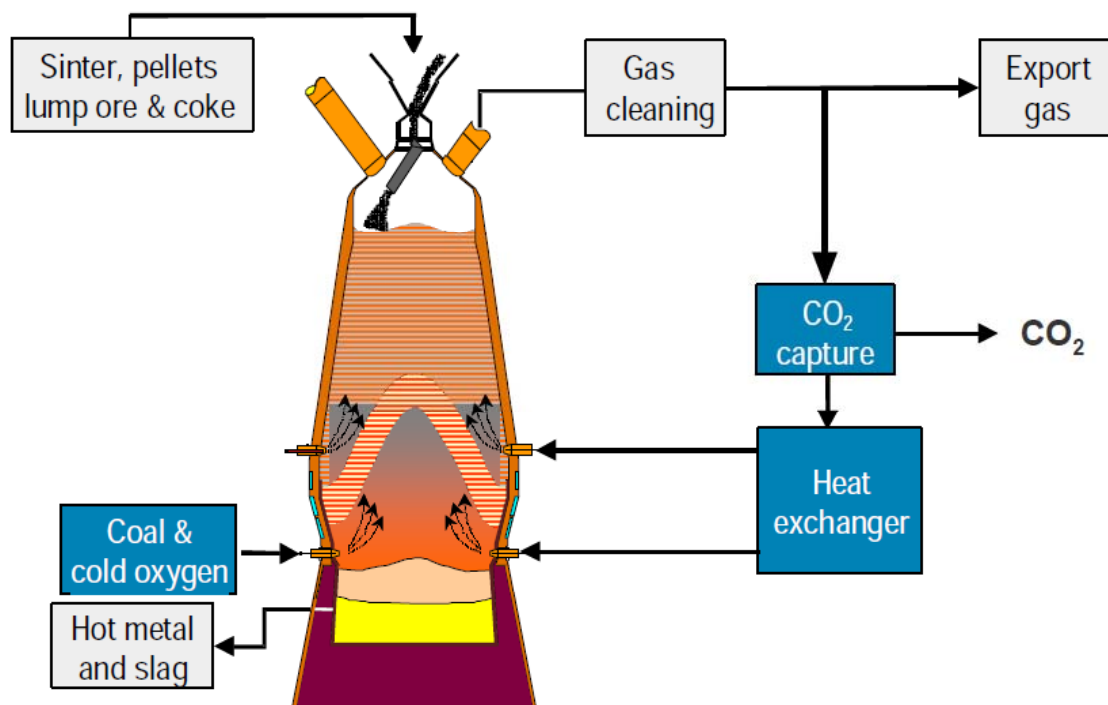
Commercial technologies: Thin slab casting and optimized furnaces are important for casting and rolling.

Process step	CO ₂ reduction solution	Reduction potential CO ₂ emission intensity
 <p>Casting</p>	<ul style="list-style-type: none"> • Thin slab casting 	<p>(Energy saving 50 % compared with continuous slab casting)</p>
 <p>Hot, cold rolling</p>	<ul style="list-style-type: none"> • Automated monitoring system • Recuperative burners • Hot charging/direct rolling • Heat recovery (annealing line) • Process control in hot strip mill 	<p>kg CO₂ / t product</p> <p>35.3</p> <p>35.2</p> <p>30.2</p> <p>17.5</p> <p>15.1</p>
<p>General</p>	<ul style="list-style-type: none"> • CHP – combined heat and power/cogeneration • Preventive maintenance • Energy monitoring and management system 	<p>82.1</p> <p>35.7</p> <p>9.5</p>

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



- **CO₂ emission reduction**
 - 16 % without CO₂ capture
 - 50 % with CO₂ capture
- **Test runs (commercial scale) at ArcelorMittal**

For further energy savings and reduction of CO₂ 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
 - H₂ based pre-reduction for EAF
- **COURSE50** (Japan)**
 - CO₂ capture systems (CCS)
 - H₂ reduction based ironmaking
- **POSCO (Korea)**
 - Prereduction of, and heat recovery from hot sinter
 - CO₂ absorption using ammonia solution
 - CO₂ fixation using marine bio-slag
 - H₂ 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

** CO₂ 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**

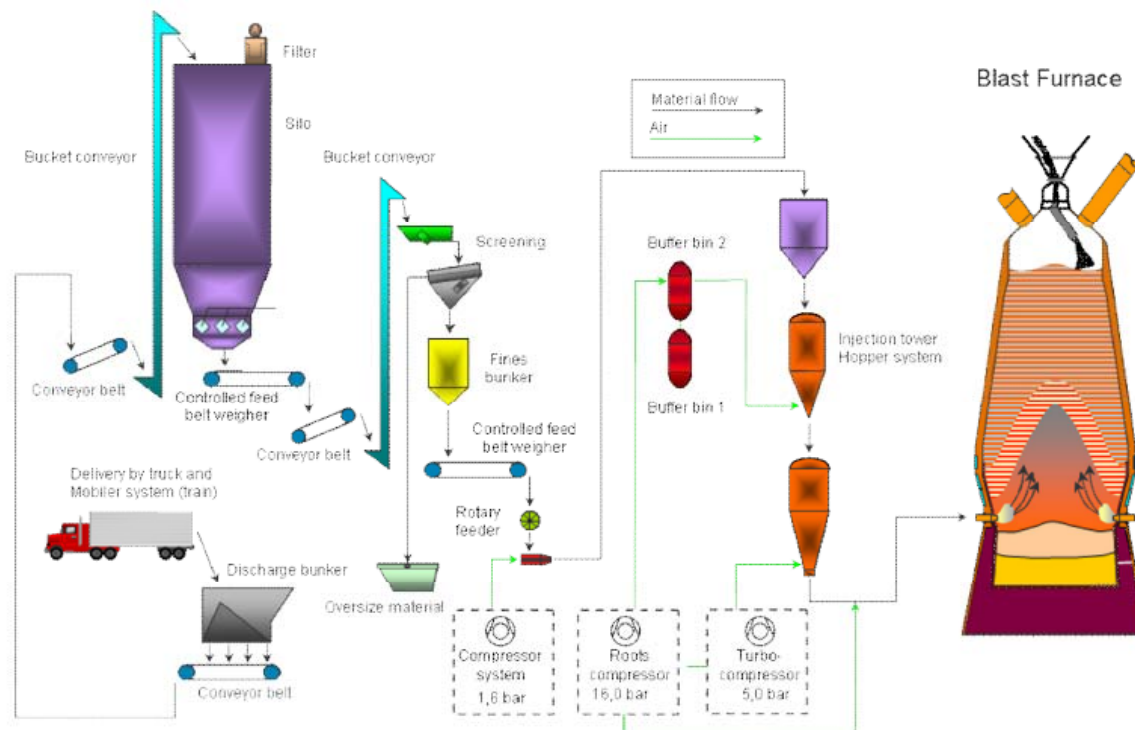
⇒ **Not a steel making specific solution**

⇒ **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)**

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

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.

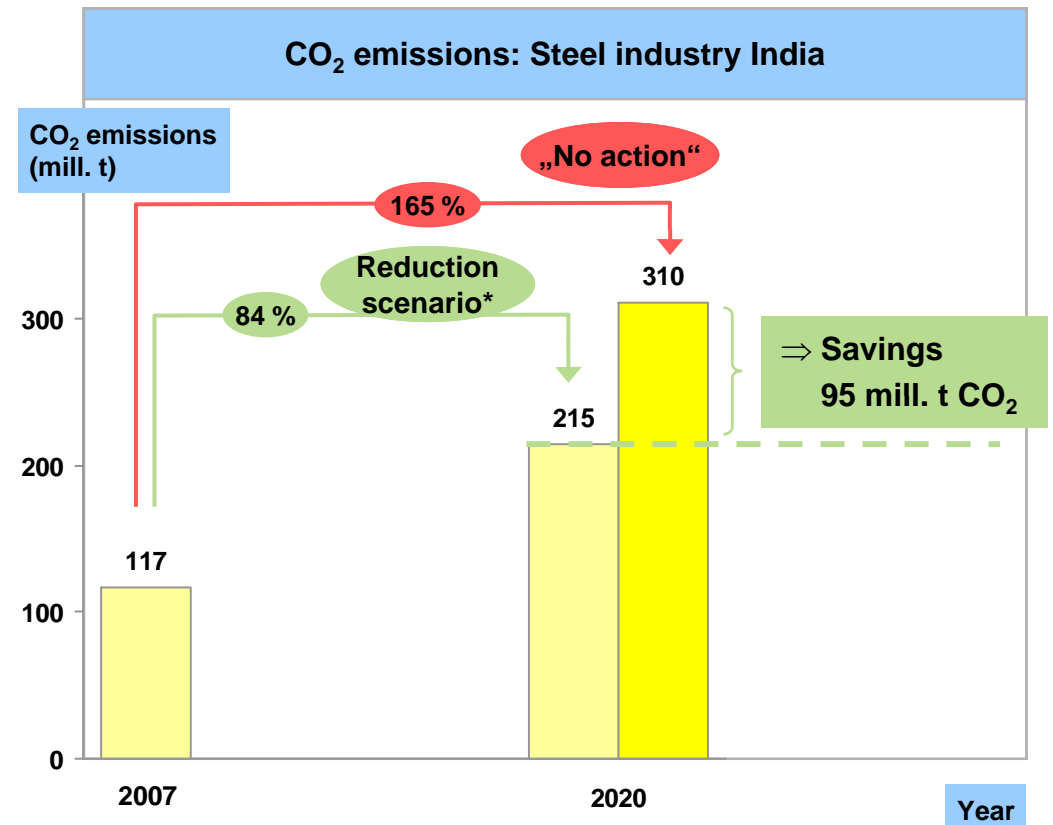
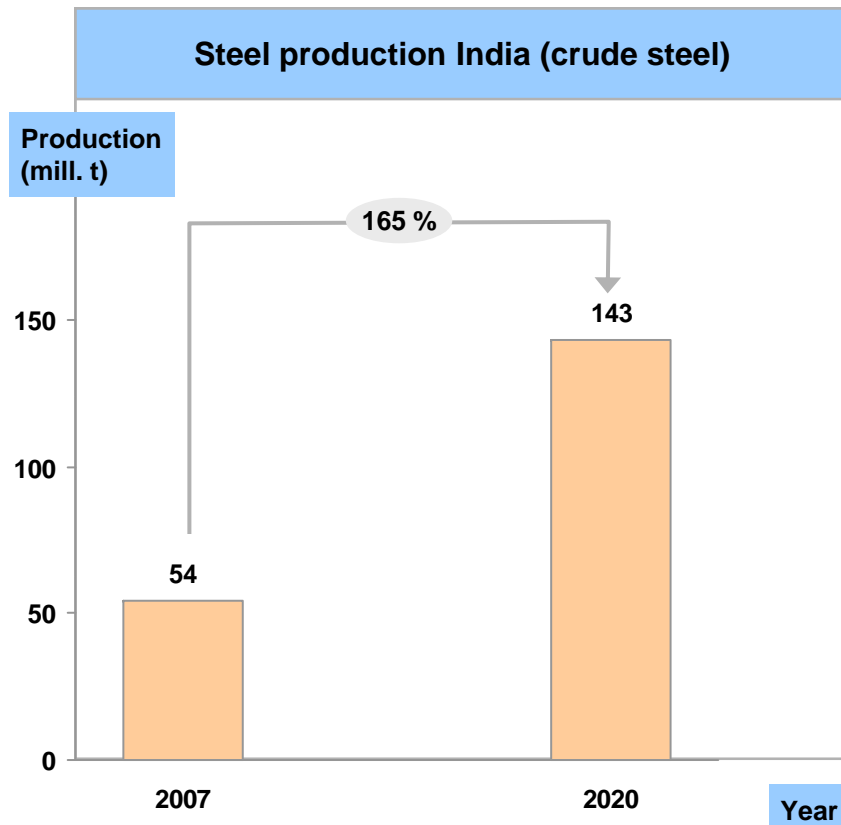
Technology providers for steel making (major players)

- **Danieli Corus**
- **Inductotherm**
- **LOI Italmimpianti**
- **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 CO₂ emissions in the steel industry in India

The potential to cut CO₂ emissions are approx. 100 mill. tons in 2020, if the industry goes for advanced technologies.



⇒ Reduction of CO₂ emission intensity by 38 % (from 2.4 to 1.5 t CO₂ / t steel)

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 CO₂ reduction

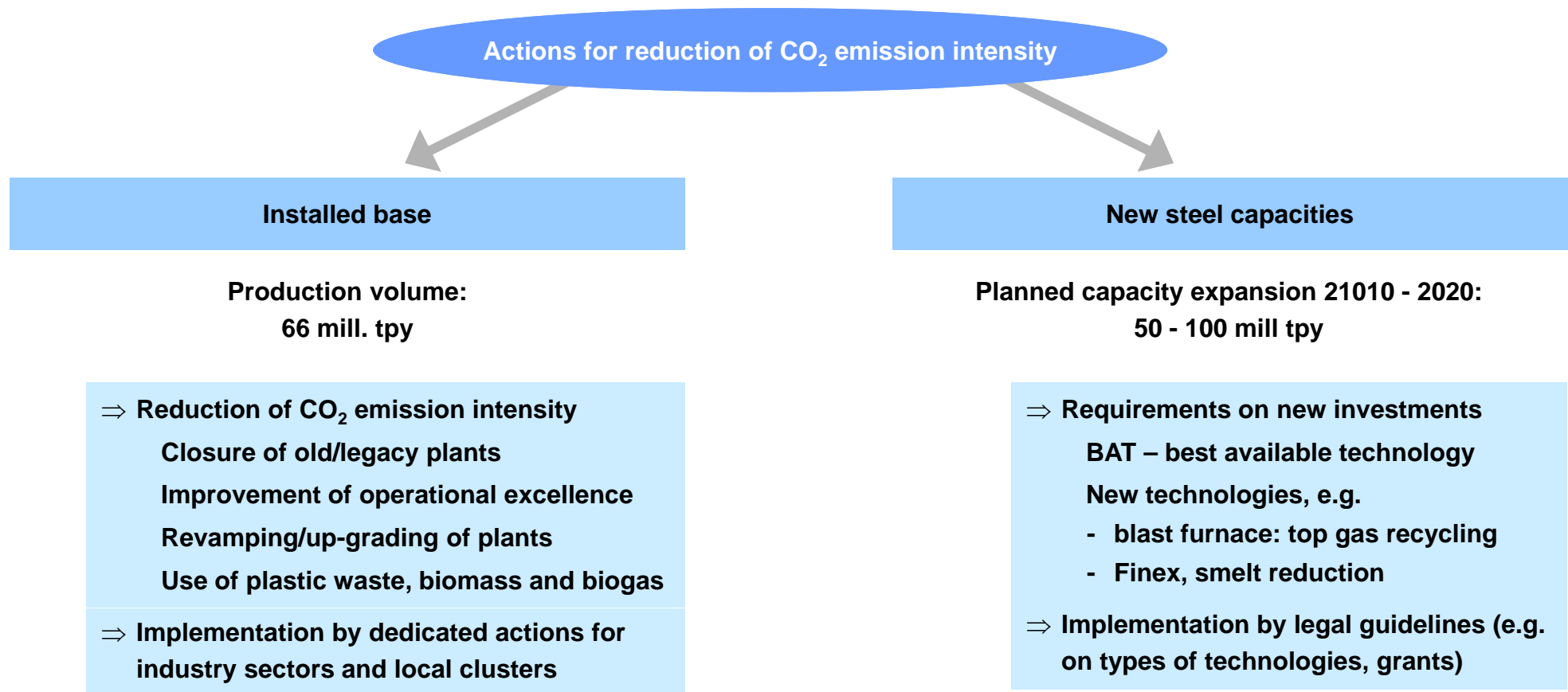
The awareness of the steel industry on CO₂ emissions varies significantly across the industry.

CO₂ ?

Steel industry: Awareness on CO₂ emissions

- Large steel companies (Tata, SAIL, Jindal, Essar etc.) know very well the CO₂ challenge of the global steel industry. Partly these companies have programs to cut CO₂ 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 CO₂ topics.
- The drivers for the companies to cut CO₂ emissions are in most cases efficiency improvement and RoI.
- Currently India does not have an agency/organizational unit for monitoring of CO₂ emissions.

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



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	<ul style="list-style-type: none"> • Up-grading of plants <ul style="list-style-type: none"> · Control systems, reducing agents etc. → See page 27, commercial technologies • Pilot project: Co-processing of plastic waste <ul style="list-style-type: none"> → e.g. Tata Steel, SAIL
Direct reduction	<ul style="list-style-type: none"> • Focus on coal based DRI plants/companies • Revamping, i.e. coal gasification (Syngas)
Electric induction furnaces	<ul style="list-style-type: none"> • Operational excellence programs • Efficiency improvement of furnaces
Re-rolling mills	<ul style="list-style-type: none"> • Operational excellence programs • Efficiency improvement of furnaces (walking beam furnaces) • Fuel: Substitution of coal by coal gasification, biogas

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

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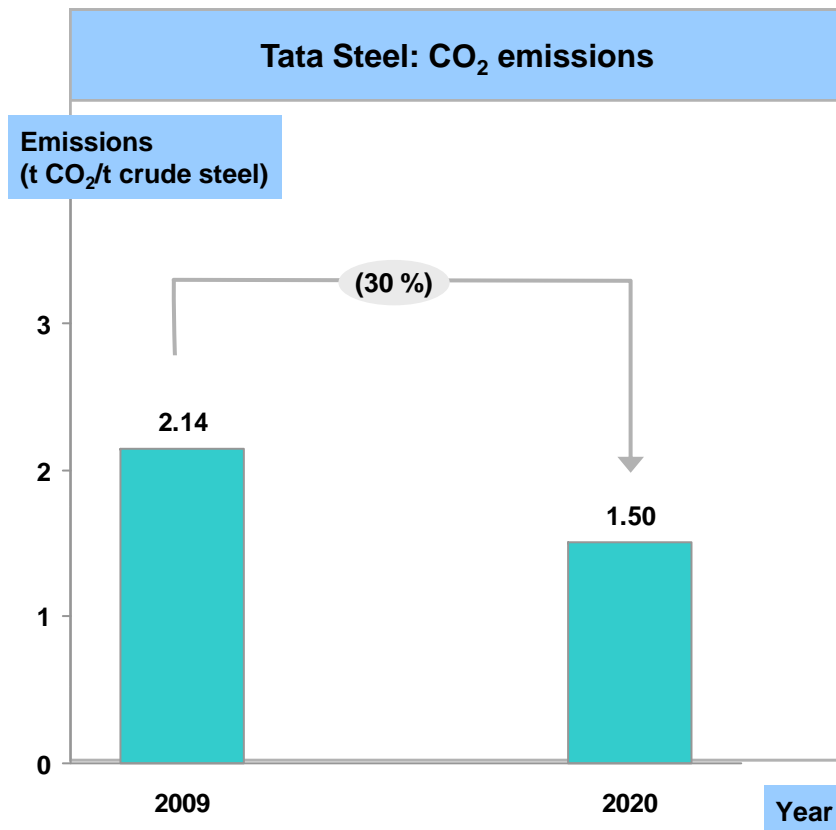
Potential actions on new steel capacities are guidelines on technologies used and support of new technologies.

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 CO₂ emissions by 30 % in the year 2020.

Case study:
Tata Steel



Actions

- Process analysis of the CO₂ emissions
 - 80 % of CO₂ emissions caused by sinter plant and blast furnace
- Actions for CO₂ 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

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 CO₂ emissions**

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**