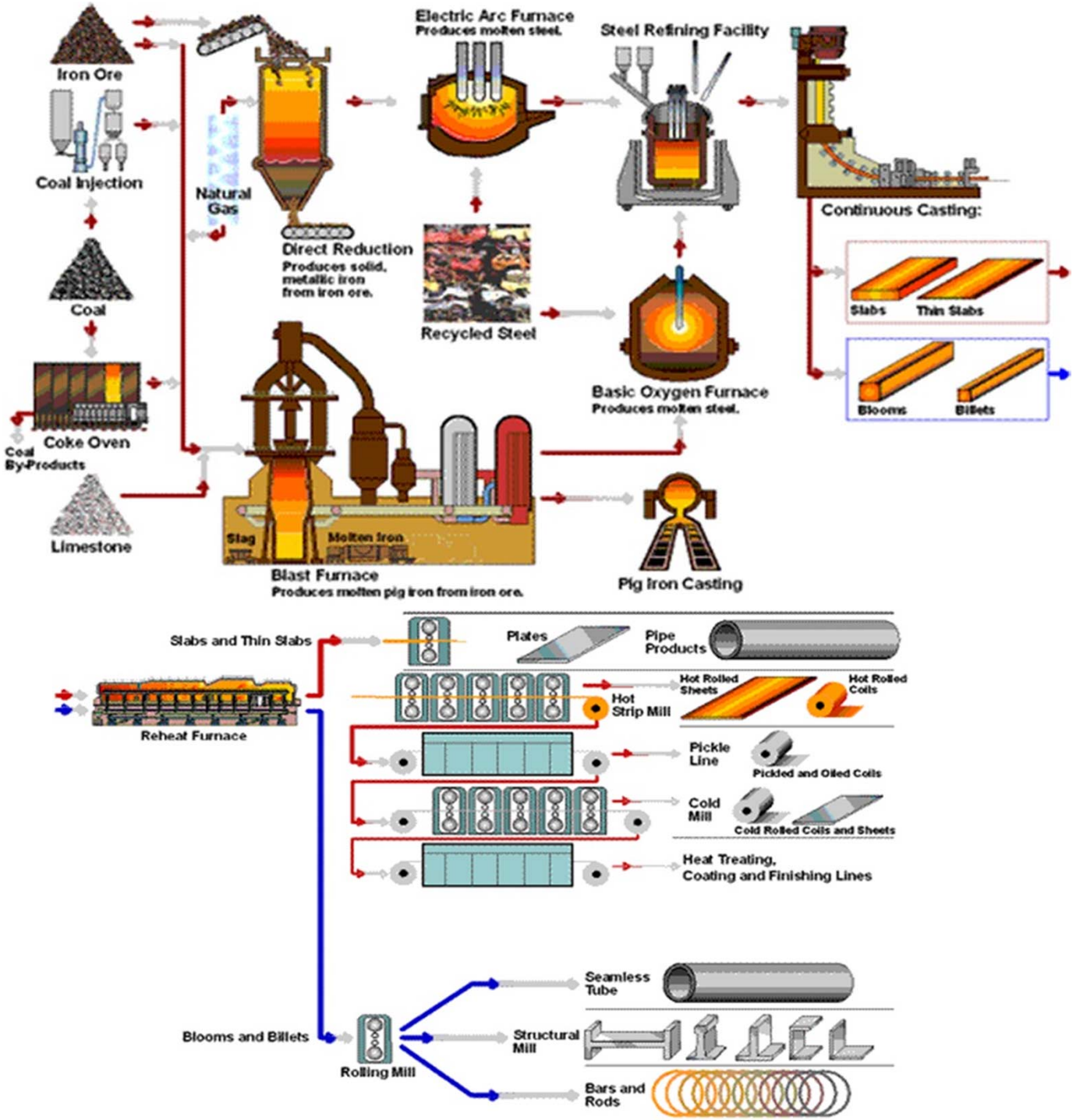
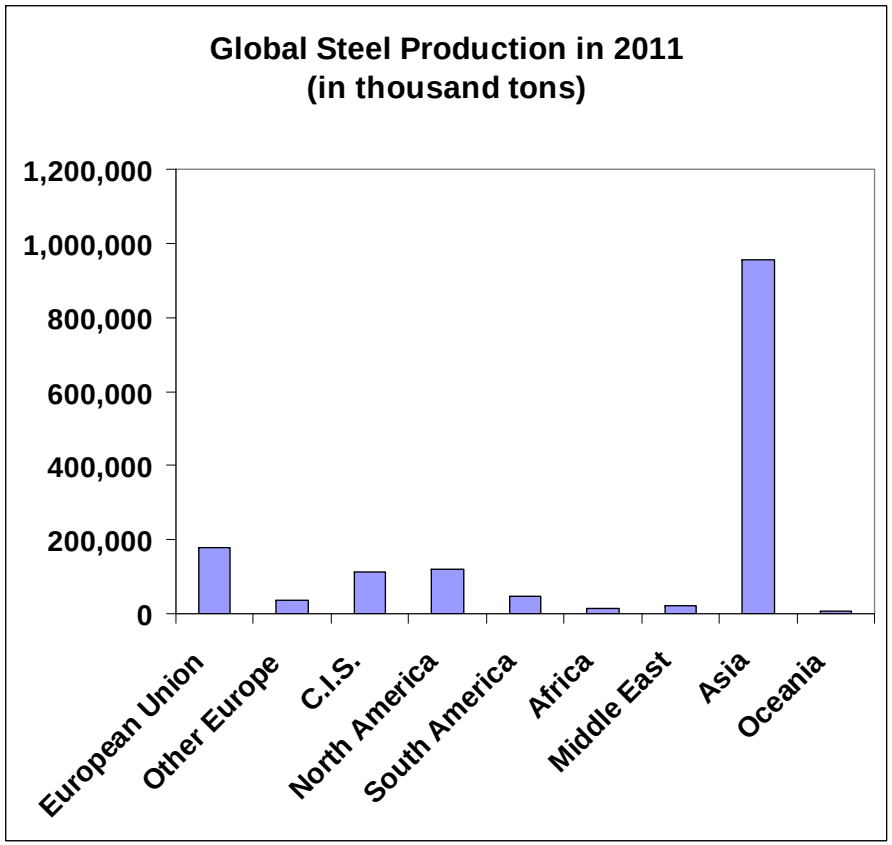
Sustainable Steel Production

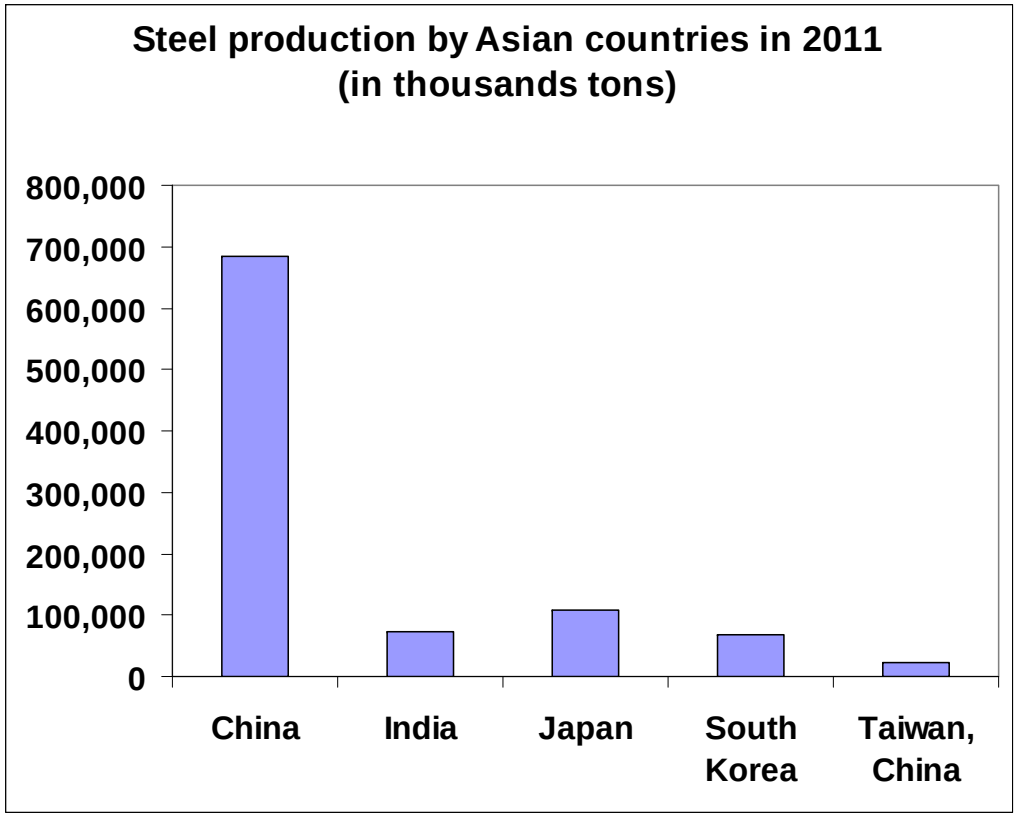

Iron Ore
Coal Injection
Natural Gas
Direct Reduction
Produces solid, metallic iron from iron ore.
Electric Arc Furnace
Produces molten steel.
Steel Refining Facility
Continuous Casting:
Slabs
Thin Slabs
Blooms
Billets
Recycled Steel
Basic Oxygen Furnace
Produces molten steel.
Coal
Coke Oven
Coal By-Products
Limestone
Slag
Molten Iron
Blast Furnace
Produces molten pig iron from iron ore.
Pig Iron Casting
Slabs and Thin Slabs
Plates
Pipe Products
Reheat Furnace
Hot Strip Mill
Hot Rolled Sheets
Hot Rolled Coils
Pickle Line
Pickled and Oiled Coils
Cold Mill
Cold Rolled Coils and Sheets
Heat Treating, Coating and Finishing Lines
Blooms and Billets
Rolling Mill
Seamless Tube
Structural Mill
Bars and Rods

Keys challenges which steel industries face today

- **Depleting resources of quality raw materials and their increasing cost.**
- **Environmental protection laws forcing steel industries to generate low CO2 emissions.**
- **Shortage of land to accommodate the huge amount of waste generated by steel industries.**
- **Increasing cost of coal and electricity making it further difficult to maintain enough profit margins.**
- **Pressure to minimize energy consumption (Since energy cost itself is 30-40% of total cost and more important if energy source itself is responsible for generation of CO2)**
- **Production of steel with stringent specifications having special properties.**

Energy consumption  **CO2 emissions**





Asia produces more than 66% of total world steel production.

India + China alone contribute 50% of world steel production. This figure may rise above 80%, if India attains the same level of production as China in future.

Energy and CO2 status for steel industry

Table I. Actual, Practical Minimum, and Theoretical Minimum Energy Consumed in Various Processes, Energy (GJ/t Product)

Process	Actual	Practical Minimum	Theoretical Minimum
Hot metal	13 to 14	10.4	9.8
Steelmaking (BOF)	0	(0.5)	(1.0)
Steelmaking (EAF)	2.1 to 2.4	1.6	1.3
Hot rolling	2.0 to 2.4	0.09	0.03
Cold rolling	1.0 to 1.4	0.2	0.02

( ) Indicate energy available.

Table II. CO_2 Emissions for Various Steelmaking Processes CO_2 Emissions (kg/t)

Process	Typical	Practical Minimum	Theoretical Minimum
Hot metal	1500	1160	1090
Steelmaking (BOF)	200	144	144
Steelmaking (EAF)	380	280	225
Rolling	320	60	10

Source: R.J. Fruehan

- **Steel industry contributes 20% to total global energy consumption and 30% to total global CO2 emissions.**
- **Energy consumption by BF-BOF route is 18-22 GJ/ton and CO2 generation is 2000-2500 kg/ton.**
- **Iron making process step consumes maximum energy and generates maximum CO2. There is greater scope for energy/CO2 reduction at this step.**
- **Maximizing the steel production by Scrap/DRI-EAF route could result in energy as well as CO2 reduction in substantial way.**

Scope of research for sustainable steelmaking

- **Reduction of CO2 emissions by iron and steelmaking processes by making them more energy efficient.**
- **Using alternate energy sources like Hydrogen, Nuclear energy, solar energy, wind energy, tidal wave energy….where the source of energy does not contain carbon.**
- **CO2 sequestration.**
- **Development of new technologies for iron production which are based upon direct reduction and smelting reduction consuming non-coking coal.**
- **Development of technologies which can utilize lean quality raw materials.**
- **Development of technologies for beneficiation of lean quality iron ores.**
- **Maximization of waste and scrap recycling**
- **Recycling of heat energy contained in waste materials and gases.**

Research topics leading to CO2/Energy reduction during iron and steelmaking

- Development of automation control systems for optimized control of iron and steelmaking processes.
- Recovery of sensible heats of high temperature waste gas and slag produced during iron and steelmaking processes.
- Geological sequestration of CO2 by carbonate formation utilizing CaO/MgO containing slag.
- Recycling of waste slag/oxides, waste carbon containing materials like plastics, tires etc. in blast furnace.
- Development of sensors for prediction of online metal and waste gas composition during BOF/EAF steelmaking process.
- Optimization of post combustion during BOF/EAF steelmaking process.
- Reduction of iron ores using hydrogen in fluidized bed reactor.
- Increase in PCI (pulverized coal injection) to blast furnace process and reduction of coke consumption.
- New Iron making process which does not utilize coking coal.
- Conversion of non-coking coal into coking coal.
- Beneficiation of lean/fine iron ore to be used for iron making.
- Development of technologies which can use mine wastes.