INTERNATIONAL CONFERENCE ON

ENERGY GENERATION AND CONSERVATION FOR MEETING INDIA'S FUTURISTIC NEEDS

MANORANJAN RAM

March 22, 2014

Introduction of Manoranjan Ram

- Manoranjan Ram has multifaceted management experience of more than 20 years in Iron and Steel Industry. He has vast experience in Integrated Steel Plant Operations, Maintenance, Strategy and Market Development, Project Appraisal and Project Controls.

- He spent first 15 years of his career in Steel Authority of India Limited (SAIL); 10 years in line functions on shop floor and 5 years in staff functions in the office of Managing Director of SAIL, Rourkela Steel Plant. He was closely associated with the turnaround process of Rourkela Steel Plant.

- He joined ArcelorMittal in June 2008 and was associated with multiple international assignments and due diligence of Merger and Acquisition opportunities in India and Southeast Asia. He was also a key member in finalization of industrial configurations along with investment estimates for ArcelorMittal steel projects in India. In Oct 2011, he was elevated to the level of General Manager and was deputed to ArcelorMittal Jubail, Saudi Arabia on an international project assignment.

- Currently he is working as Head of Sales and Marketing in Paul Wurth India, SMS group and is also responsible for new technology interventions in Iron making areas of integrated steel plants.

- His academic qualification is B.Tech (Hons.) in Electrical Engineering and PGDM.

What is Energy

- The word “energy” comes from the Greek word *“energia” i.e. vigour of expression, activity*
- *In India the concept of energy as “shakti” has been the focus of metaphysical thoughts since Vedic times*
- *However, we realised the need for external (to man) source of energy as the mankind progressed from a primitive to a civilized state*
- *Factors of Production => Capital, Labour, Energy and Materials - Indispensable for any productive activity*

"Energy is a critical part of boosting prosperity and eradicating poverty."

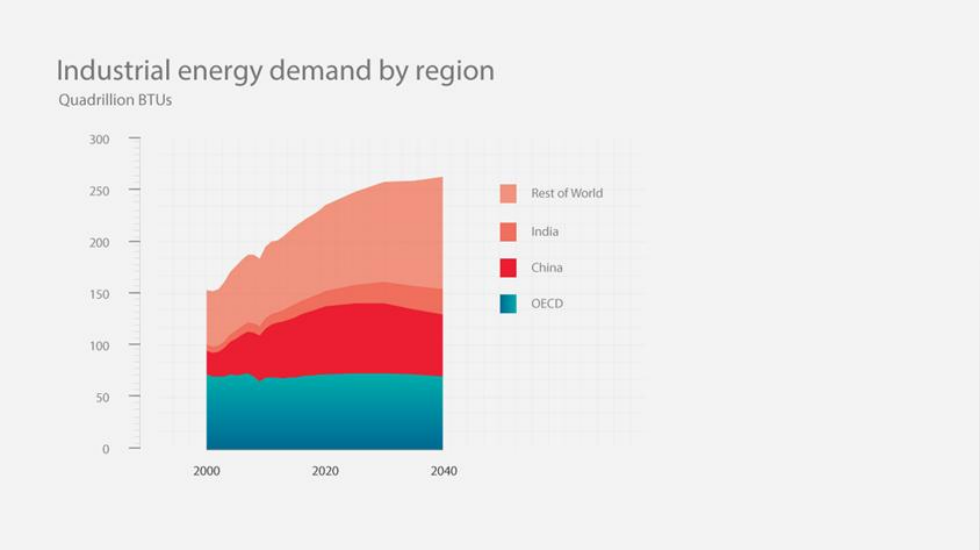
Jim Yong Kim, President, World Bank Group

"Energy powers the movement of goods and people across borders. Without energy, there is no international trade."

Pascal Lamy, former Director-General, World Trade Organization

Energy Demand Drivers

- The industrial sector is a major consumer of energy, accounting for about half of all the electricity consumed around the world
- Urbanization and rising living standards continue to drive industrial demand for energy
- Global industrial energy use also is driven by the chemicals sector, where demand for energy is rising about 50 percent faster than overall energy demand.
- What is perhaps the biggest driver of energy demand: the human desire to sustain and improve the well-being of ourselves, our families and our communities.



By 2040, China's industrial energy demand is expected to be just 25 percent higher than in 2010; in contrast, India's will be about 2.5 times the 2010 level.

Source: Exxon Mobil Energy outlook 2040

INDIA - Energy Scenario

It is certain that India will see an increased escalation of energy demand, the question that surrounds India is at what scale and speed India's energy generation will expand and which fuels and technologies it will use.

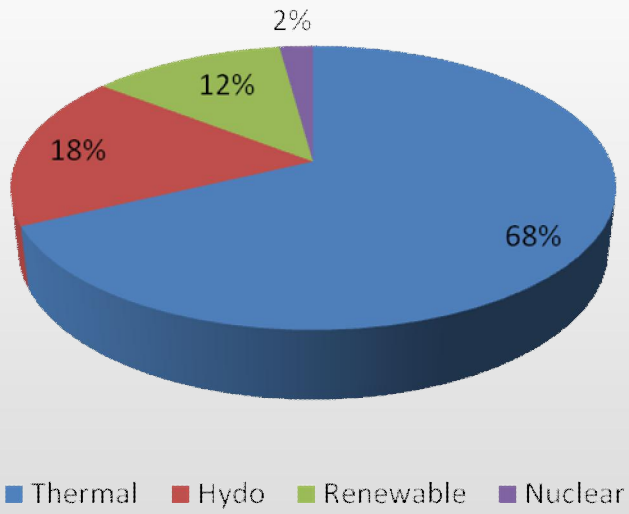
- During the 12th five-year Plan, import dependence on crude oil is expected to increase to ~80% in FY17 and import dependence on natural gas is expected to increase to ~35% in FY17

- India has low proven hydrocarbon reserves with reserve to production ratio of ~18 years for oil and ~26.9 years for gas as per the current production levels.

Currently, INDIA accounts for around 4.6 % of total global annual energy consumption

Overview of Indian Power Sector – Fourth largest in the world

Installed Power Generation Capacity at the end of FY'13 – 223 GW



- Fourth largest Power Generation Capacity in the world; Top 4 countries are USA, China, Japan and India
  - Installed capacity as on March 31, 2013 –> 223 GW
- Transmission and Distribution network third largest in the world
- Per capita power consumption ~ 880 KWH; World average ~ 3,500 KWH
- Captive Power generation ~ 50 GW"
- Capacity addition planned in Twelfth Plan (2012 – 2017) ~ 107 GW
  - In FY'13, approx. 23 GW capacity has been added in the system
- Peak demand in FY 2012 -13: 135 GW; Peak generation: 123 GW; Deficit 9.0%
- Energy requirement in FY 2012 – 13: 998 MU, Energy availability - 911 MU; Shortage 8.7%

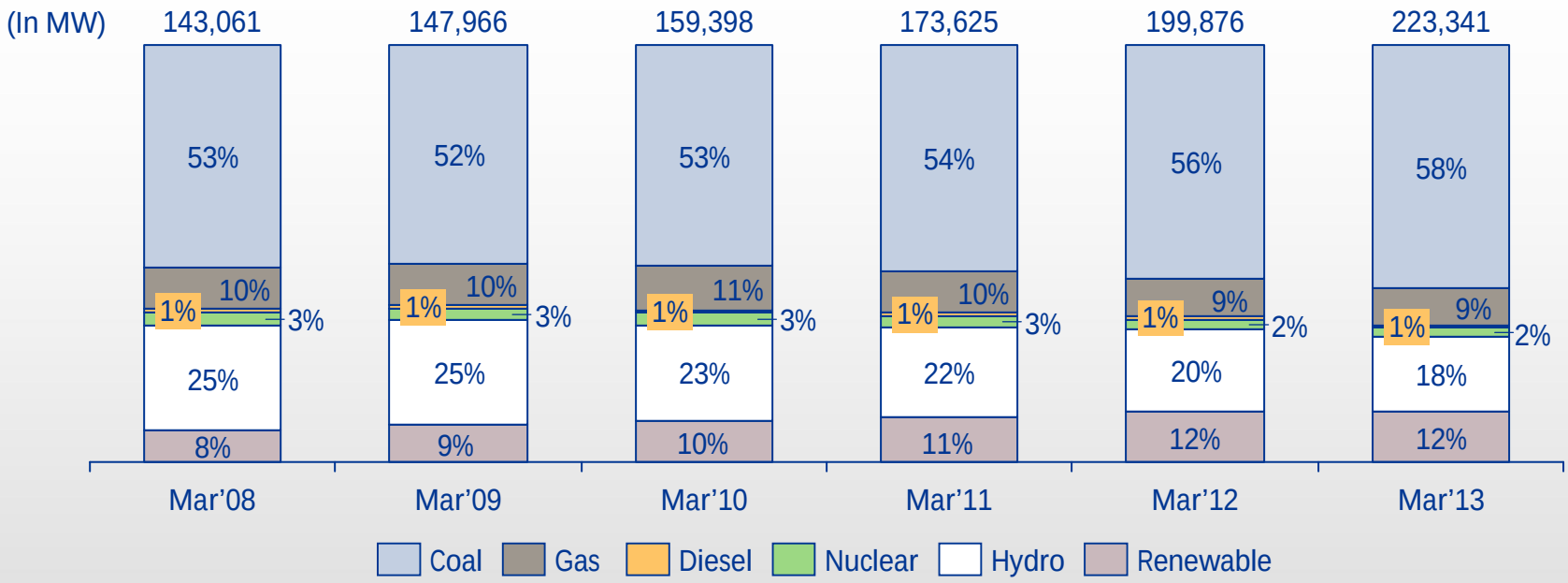
Source: CERC , International Energy Statistics and Published reports

Mainstay of Indian Energy Sector - > COAL

- India's coal demand increased at CAGR of 8.5% while CIL's domestic production increased at a CAGR 4.6% only in 11th five year plan
- Additional coal requirement for new thermal power plants would be unlikely met through CIL (Coal India Limited)
  - Coal as a sector is monopolistic and remains virtually closed to private sector participation except end use cases
- India's coal imports have more than doubled over the last five years
  - Constraints of Coal Import:
    - » Lack of supporting infrastructure
    - » Changing regulations in source countries
    - » Huge price difference between imported and domestic coal

Indian thermal power plants are facing capacity utilization issues due to coal supply constraints

Installed Power Generation capacity has increased by 9.3% CAGR in last 6 years



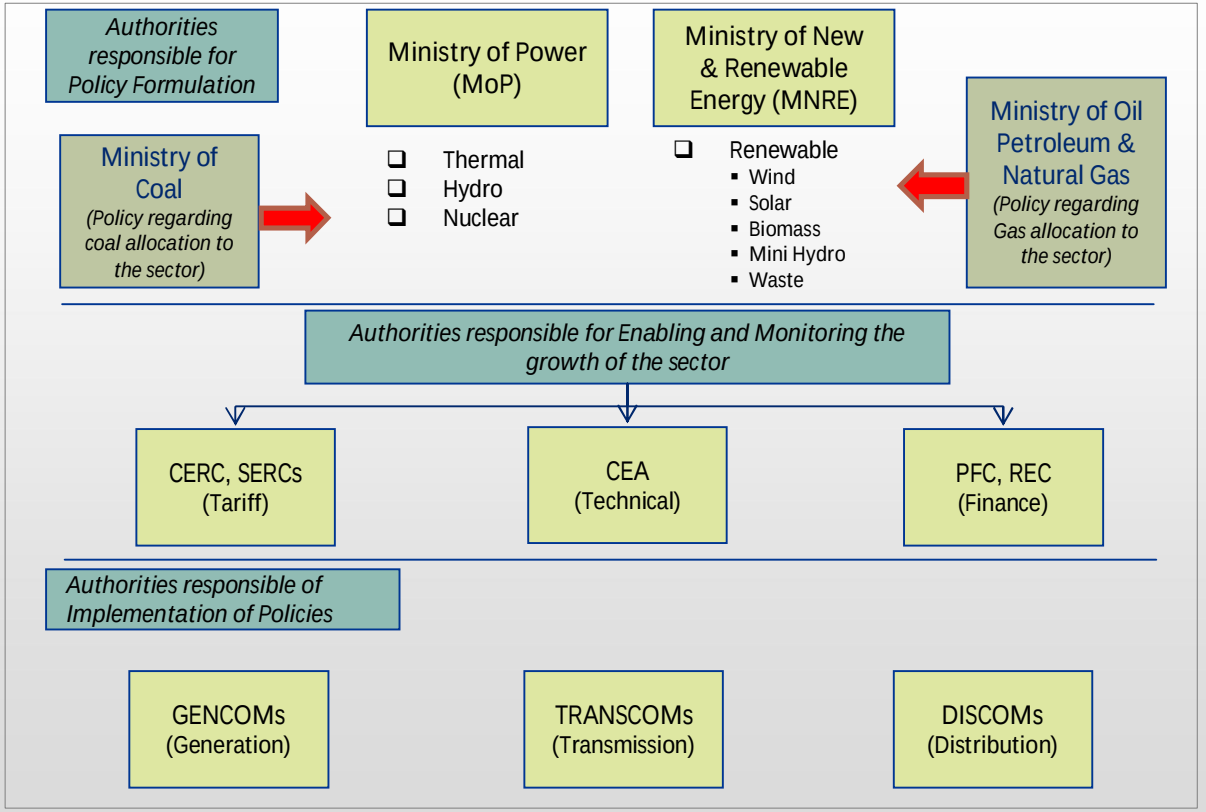
- Share of Thermal Power has increased from 64% in FY'08 to 68% in FY'13 – Coal based power is the biggest contributor
- Share of Renewable has also increased significantly from 8% to 12% in last 6 years – Wind power is the biggest contributor
- Share of NG based power has been on a decline due to non-availability of domestic NG to power sector

Source: CERC

Three tier regulatory structure exists in Indian power sector

CERC: Central Electricity Regulatory Commission
SERC: State Electricity Regulatory Commission
CEA: Central Electricity Authority
PFC: Power Finance Corporation
REC: Rural Electrification Corporation
GENCOM: Generation Company
TRANSCOM: Transmission Company
DISCOM: Distribution Company

Regulatory Structure of Indian Power sector



Various strong policy initiatives have been taken by the Ministry in last decade to enable faster growth of the Indian power sector

IPP: Independent Power Producer
AT&C – Aggregated Technical and Commercial

Policy initiatives in Indian Power sector

Indian Power Sector is governed by Electricity Act, 2003

Key policy initiatives under Electricity Act, 2003

Growth in installed capacity, Higher plan to achievement Ratio	▪ Installed generation capacity has almost been doubled within a decade from 105 GW in 2001 – 02 to 199 GW in 2011 – 12 ▪ Plan to achievement ratio has been increased from 47% in 9th plan to almost 85% in 11th plan
Increased share of Renewable power and Private participation	▪ Share of renewable power in the overall installed capacity has increased from 8% in FY 2007 – 08 to 12% in FY 2012 - 13 ▪ Share of IPPs has increased from 14% in FY 2007 – 08 to 25% in FY 2012 - 13

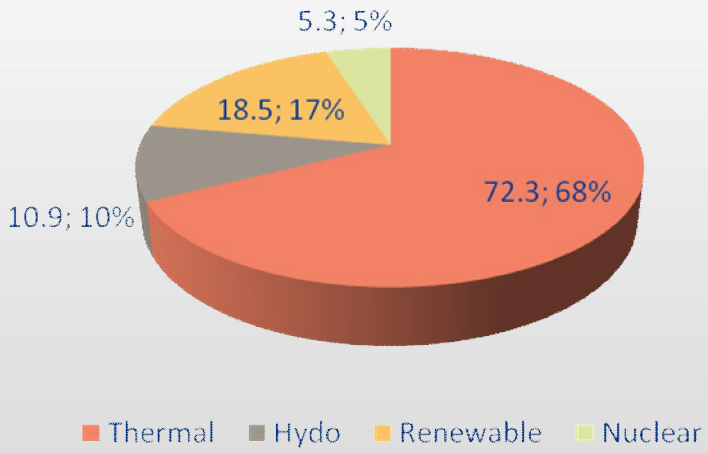
RAPDRP (Restructured Accelerated Power Development and Reforms Program)	▪ The program has been initiated to
	  ▪ To achieve in actual reduction in AT&C losses on sustainable basis
	  ▪ To establish reliable and automated systems for sustained collection of accurate base line data
	  ▪ Adoption of Information Technology in the areas of energy accounting

Ultra Mega Power Projects (UMPPs)	▪ Each Ultra Mega Power Projects will be of 4,000 MW ▪ 12 such projects have been envisioned by the Power Ministry ▪ 4 projects have already been awarded to the developer and 800 MW unit of one UMPP has already become operational
Jawaharlal Nehru National Solar Mission (JNNSM)	▪ Key targets of the mission is to create an enabling policy framework for the deployment of 20,000 MW of solar power by 2022 ▪ Other targets are to deploy 20 Mn solar lighting systems by 2022

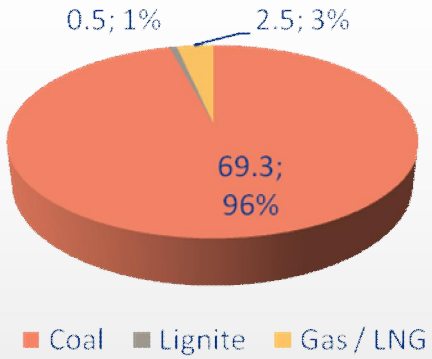
Other key policy initiatives include development of secondary power market, rural electrification, Open access to bulk consumers etc.

During 12th Plan, 107 GW generation capacity has been planned to be added in the system

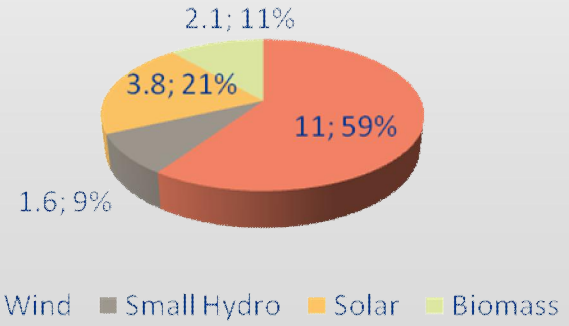
Capacity Addition Plan during 12th Plan Period (2012 – 2017) – 107 GW



Break up of Thermal Power



Break up of Renewable Power

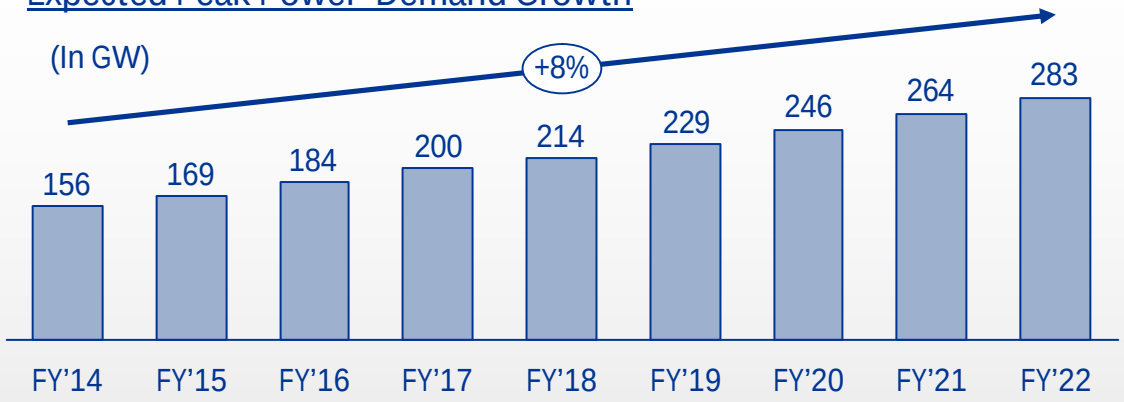


12th Plan Capacity Addition Trend

Source: CERC

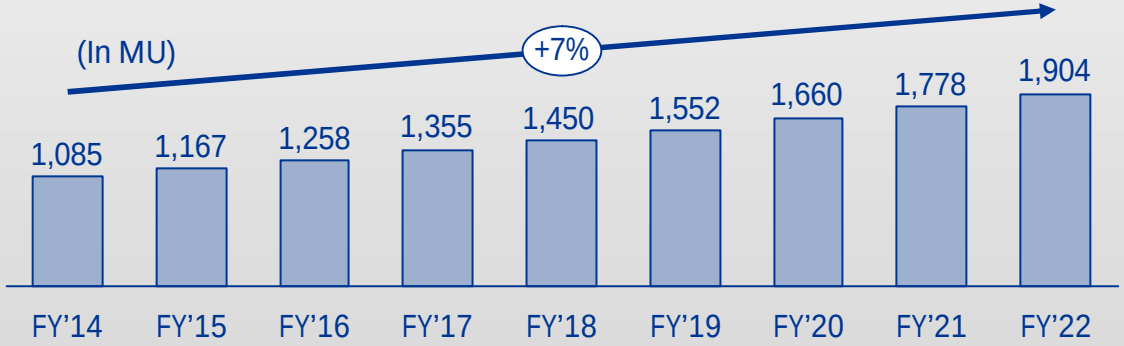
Peak Demand and Energy Requirement is expected to grow at 8% and 7% CAGR respectively

Expected Peak Power Demand Growth



- As forecasted by CERC, peak power demand of the country is expected to grow at 8% CAGR till FY'22
- By FY'17, peak demand of the country will reach 200 GW while installed generation capacity may touch approx. 300 GW
- Peak deficit of the country was hovering at approx. 10% mark during eleventh plan however in FY'14, peak deficit has gone down below 4% due to poor demand from the industries and due huge capacity addition

Expected Growth in Energy Requirement



- As forecasted by CERC, energy requirement of the country is expected to grow at 7% CAGR till FY'22
- By end of 12th five year plan, energy requirement of the country is expected to reach 1.35 BU
- In FY'13, energy deficit in the country was recorded at 8.7% however deficit is expected to go below 5% during FY'14

Peak Demand and Energy Requirement Trend

Source: CERC, Report on Eighteenth Electric Power Survey in India

Comparative Figures for Power Plants in INDIA

Energy Cost from different fuel based power plant

Coal based power plant	INR 3.5 / Kwh
Gas based power plant	INR 5.0 / Kwh
Hydro based power plant	INR 2.0 / Kwh
Nuclear power plant	INR 2.5 / Kwh

Capital Investment for per Megawatt

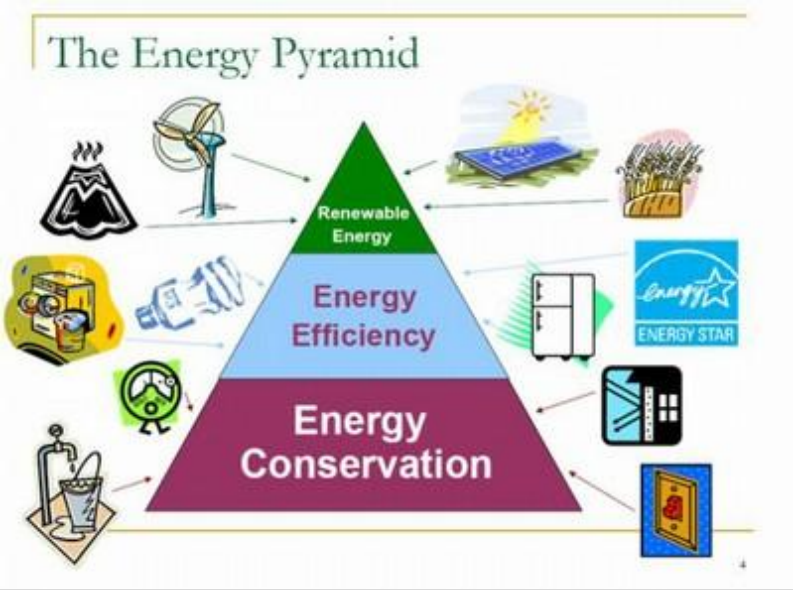
Coal based power plant	INR 4.5 crores
Gas based power plant	INR 4.0 crores
Hydro power plant	INR 6.0 crores
Nuclear power plant	INR 7.0 crores

The above opex and capex numbers are indicative only

Overview of Energy Conservation Related Activities in India

“We do not inherit the earth from our parents, we borrow it from our children”-

Chief Seattle



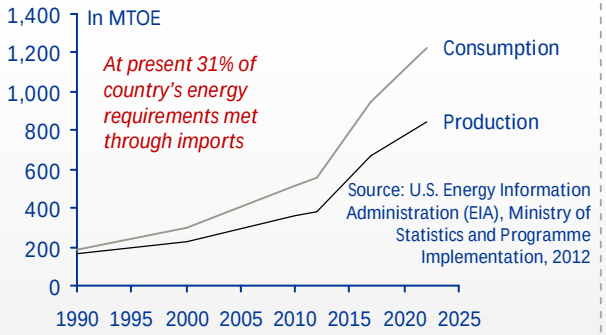
What is Energy Conservation

- The demand for energy is a derived demand
- Energy itself is not that which is of value
- It is what is accomplished with energy inputs determines the demand for energy
- Therefore, the task accomplished rather than the energy consumed which provides the economic welfare
- Energy conservation is not a reduction per se but a rationalization of use and increase in energy efficiency
- An often unrecognized sign of technology's progress over time is dramatic energy efficiency gains.
  - For example, a steam engine in the year 1800 at 6 percent efficiency pales in comparison to a modern combined-cycle gas turbine with about 60 percent efficiency.

Various macroeconomic situations are driving Energy Conservation activities in India

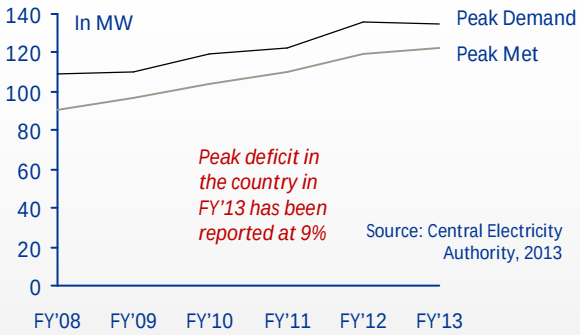
Energy Consumption

India is the fourth largest energy consumer in the world – after USA, Russia and China; ever increasing energy production vs. consumption gap prevalent in the country



Power Deficit

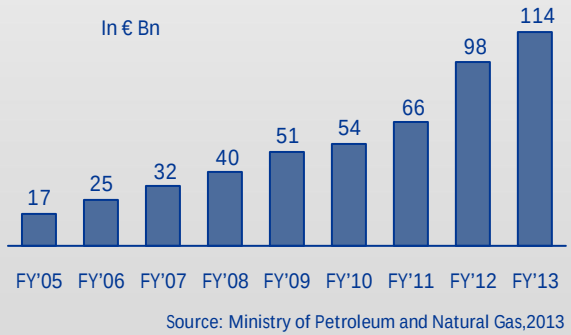
The country has seen the highest ever capacity addition during 11th plan - Present installed capacity 230 GW but peak deficit hovering around 10% mark since last many years



Drivers for Energy Conservation in India

Crude Oil Bill

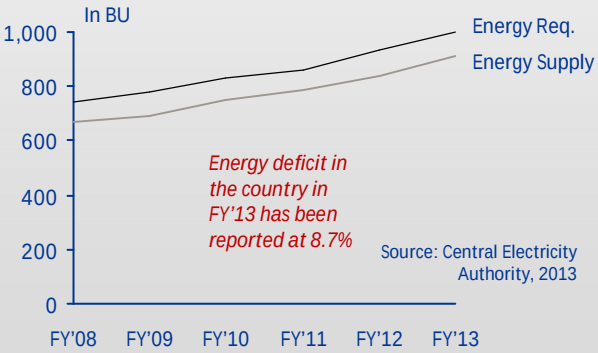
India is one of the largest importers of Crude oil in the world; Spending on Crude oil imports has increased manifold in the last 8 years – the situation is worse with the recent rupee depreciation



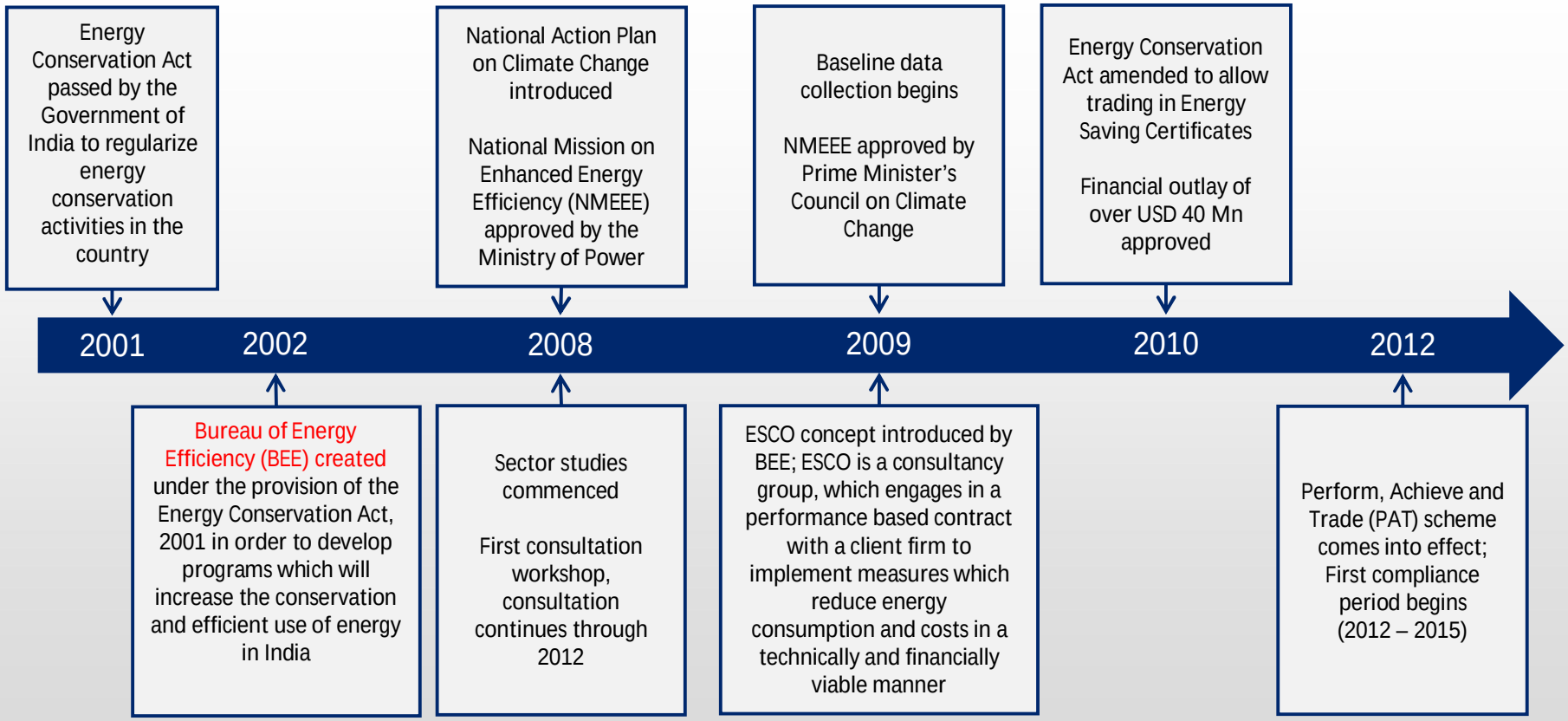
Source: Ministry of Petroleum and Natural Gas,2013

Electricity Consumption

Energy requirement of the country has steadily grown @ 6% CAGR over last 6 years – From 739 BU in FY'08 to 998 BU in FY'13 – Energy deficit has always been close to the 10% mark

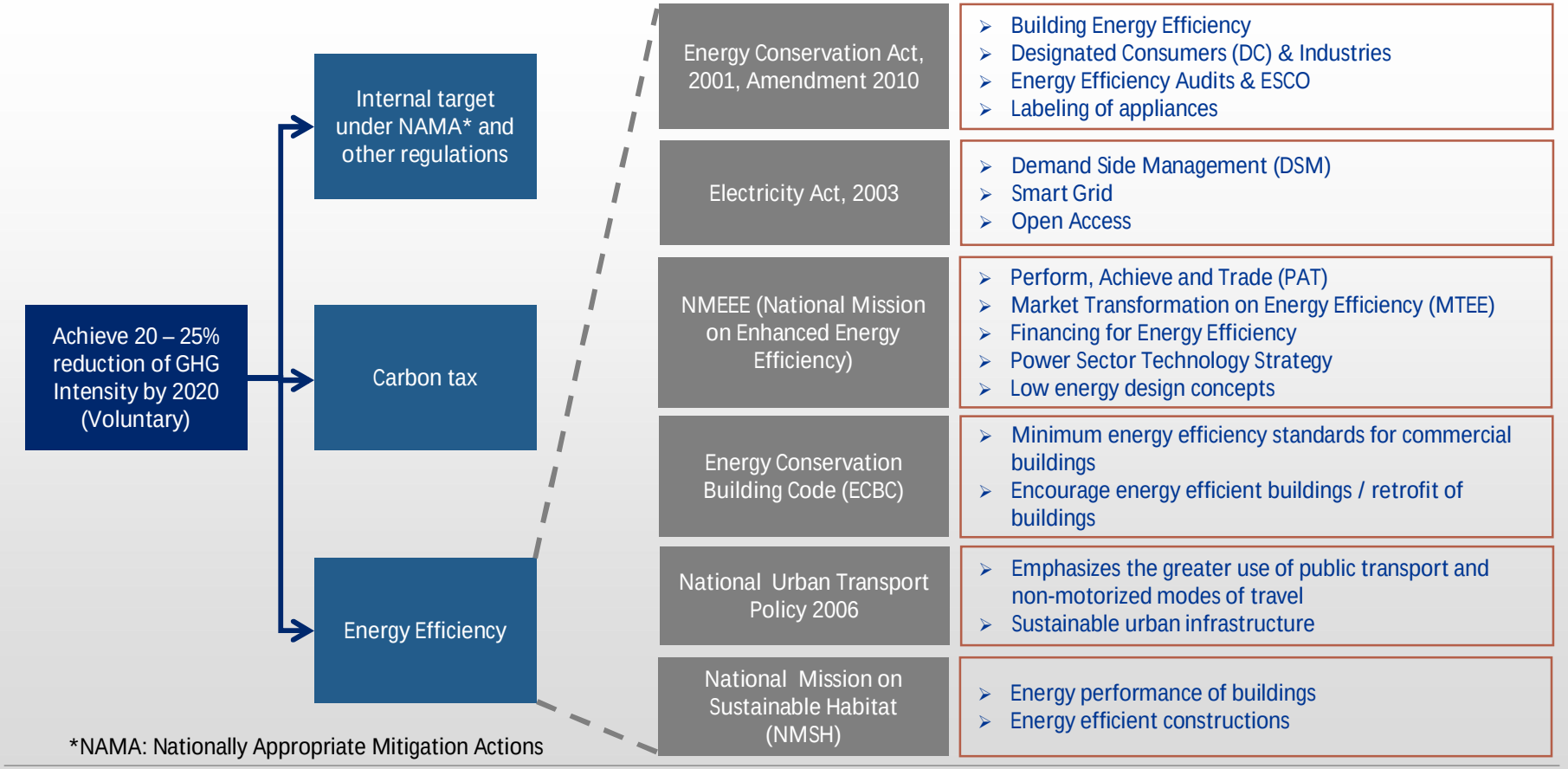


Energy Conservation initiatives began in India in 2001 with introduction Energy Conservation Act, 2001



Source: BEE and various reports published on Energy Efficiency

Energy Efficiency implementation framework adopted by the Indian Government



*NAMA: Nationally Appropriate Mitigation Actions

Energy Efficiency Implementation Framework

Source: BEE 2011

National Mission on Enhanced Energy Efficiency (NMEEE) at a glance

NMEEE - Goal

- Market based approaches to unlock investment in energy efficiency opportunities, estimated at approx. INR 750 Bn (€ 10.7 Bn)
- By 2014 – 15:
  - fuel savings in excess of 23 million tons of oil equivalent (MTOE)
  - Cumulative avoided electricity capacity addition of approx. 20,000 MW
  - CO_2 emission mitigation of 98 MT / Year

Industry Sector	No. of Identified Designated Consumers
Aluminium	11
Cement	92
Chlor-Alkali	21
Fertilizer	22
Pulp & Paper	70
Power	154
Iron & Steel	110
Textiles	197
Railways	8

- Specific Energy Consumption (SEC) reduction targets for the identified Designated Consumers (DC)
- Target would be a percentage reduction of current SEC
- Target setting for the power generation and fertilizer sectors through the existing tariff-setting process
- SEC measurement and verification by BEE through accredited auditors

The Demand Side Management (DSM) and increased electricity end use efficiency can together mitigate power shortages to a certain extent and drastically reduce capital needs for power capacity expansion

Initiative	Estimated Investment (INR Bn)	Fuel Saving in (MTOE)	GHG Emissions saving (MT)	Avoided Capacity (MW)
Perform, Achieve and Trade (PAT)	306	9.78	26.21	5,623
DSM (including Agriculture DSM)	440	13.22	72.75	14,335
TOTAL	746	23.00	98.96	19,958

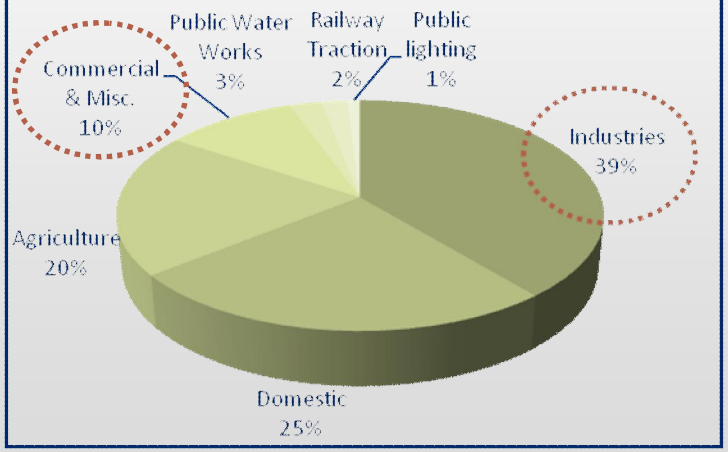
Source: BEE 2011 Presentation on NMEEE

Industry and Commercial Buildings are the key segments where energy efficiency measures will be implemented in a big way in future

Electrical Energy Consumption in India – Sector wise distribution

- Industry, the largest energy consuming sector, consumed approx. 39% of the electrical energy in the country in FY'13
- Commercial & Misc. segments consumed approx. 10% of the electrical energy in FY'13

Electricity Energy Consumption in India in FY'13 ~ 765 BU



Source: CEA 2013

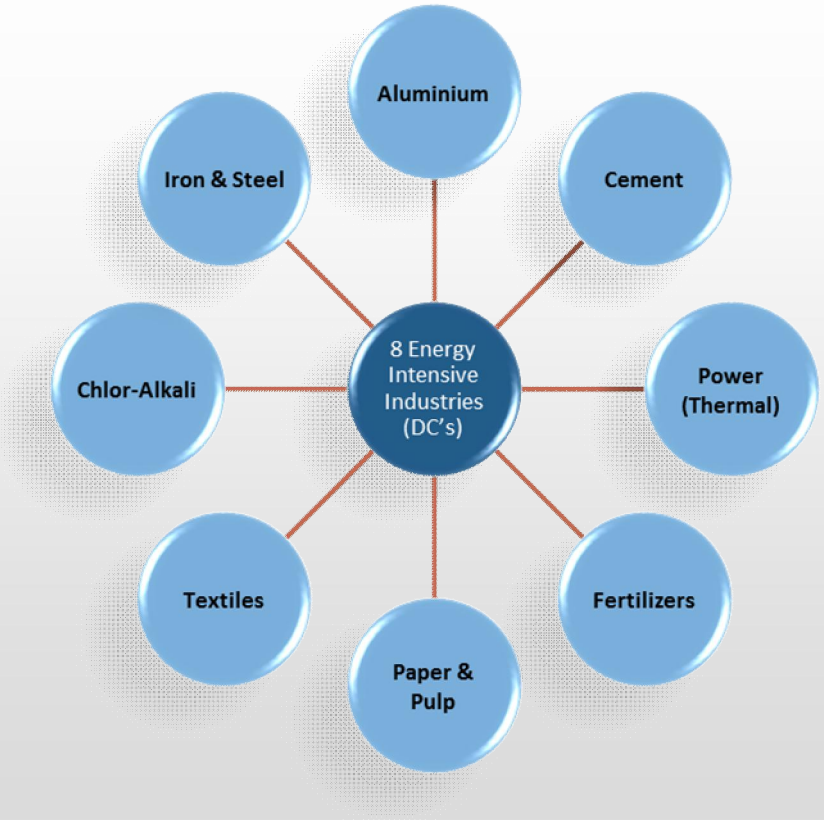
Energy Saving Opportunity

- Economy as a whole: Up to 23%
- Industrial: Up to 25%
- Domestic & Commercial: Up to 20%
- Agriculture: Up to 30%

Source: Primary research with BEE

8 Industries have been identified as the most energy intensive industries by BEE

- Contribute to 25% of the nation's GDP
- Account for 45% of industrial energy use in India
- Wide variance in process energy efficiency among DCs indicating large potential for energy saving (Source BEE study)
- Major drivers - Economic growth and competing energy demand from different end users
- Thermal power will continue to be India's main source of electricity for decades to come
- Infrastructural development and automotive sector drive cement, iron and steel growth



DC => Designated Consumer

Source: BEE

Energy Efficiency opportunities in 479 DCs of 8 energy intensive industries (1/2)

Aluminum (10 DCs)

Opportunities for Energy Saving:
- Secondary Aluminium - Primary heating, Electric Motors, Pumping Systems
- Primary Aluminium - Alumina Refining, Aluminium Smelting

Reported Energy Consumption (MTOE) (2012)	8.00
Expected Energy Reduction after PAT First Cycle (2015)	0.43

Cement (86 DCs)

Opportunities for Energy Saving:
- Grid & Power Management
- Power from waste heat recovery
- Use of alternative fuels

Reported Energy Consumption (MTOE) (2012)	17.20
Expected Energy Reduction after PAT First Cycle (2015)	0.82

Thermal Power (145 DCs)

Opportunities for Energy Saving:
- Electrical & Lighting system
- Equipment Cooling, Auxiliary Cooling Water System
- Compressed air and HVAC system
- Air and flue gas cycle
- Steam, feed water and condensate cycle
- Fuel and ash cycle

Reported Energy Consumption (MTOE) (2012)	154.90
Expected Energy Reduction after PAT First Cycle (2015)	3.19

Fertilizers (29 DCs)

Opportunities for Energy Saving:
- Fuel Switch
- Cogeneration & Renewable energy
- Improved automation products and services

Reported Energy Consumption (MTOE) (2012)	8.15
Expected Energy Reduction after PAT First Cycle (2015)	0.48

Source: Data published by BEE on DCs in 2013

Energy Efficiency opportunities in 479 DCs of 8 energy intensive industries (2/2)

Paper (30 DCs)

Opportunities for Energy Saving:
- Improved capacity utilization
- Waste heat recovery facilities
- Chemical recovery and cogeneration units

Reported Energy Consumption (MTOE) (2012)	2.14
Expected Energy Reduction after PAT First Cycle (2015)	0.11

Steel (68 DCs)

Opportunities for Energy Saving:
- Waste energy recovery
- Top gas recycling blast furnace
- Smelting reduction
- Use of charcoal and waste plastic
- Molten oxide analysis
- Coke dry quenching
- Advanced wet quenching

Reported Energy Consumption (MTOE) (2012)	25.22
Expected Energy Reduction after PAT First Cycle (2015)	1.45

Textiles (89 DCs)

Opportunities for Energy Saving:
- Spinning
- Weaving
- Wet processing

Reported Energy Consumption (MTOE) (2012)	1.20
Expected Energy Reduction after PAT First Cycle (2015)	0.07

Chlor-Alkali (22 DCs)

Opportunities for Energy Saving:
- Process improvement, better energy utilisation
- Switch from Mercury Cell to Membrane Cell Technology

Reported Energy Consumption (MTOE) (2012)	0.89
Expected Energy Reduction after PAT First Cycle (2015)	0.05

Source: Data published by BEE on DCs in 2013

Challenges before Industry

The energy usage pattern varies widely in industries of a particular sector due to various diversities like:

- Scale of Production (Installed Capacities)
- Use of Raw Material
- Process Technology
- Vintage
- O & M Practices
- Type of Product Output etc.

In order to achieve the specific energy consumption (SEC) target set for the industry in a sector, the industry has to look for:

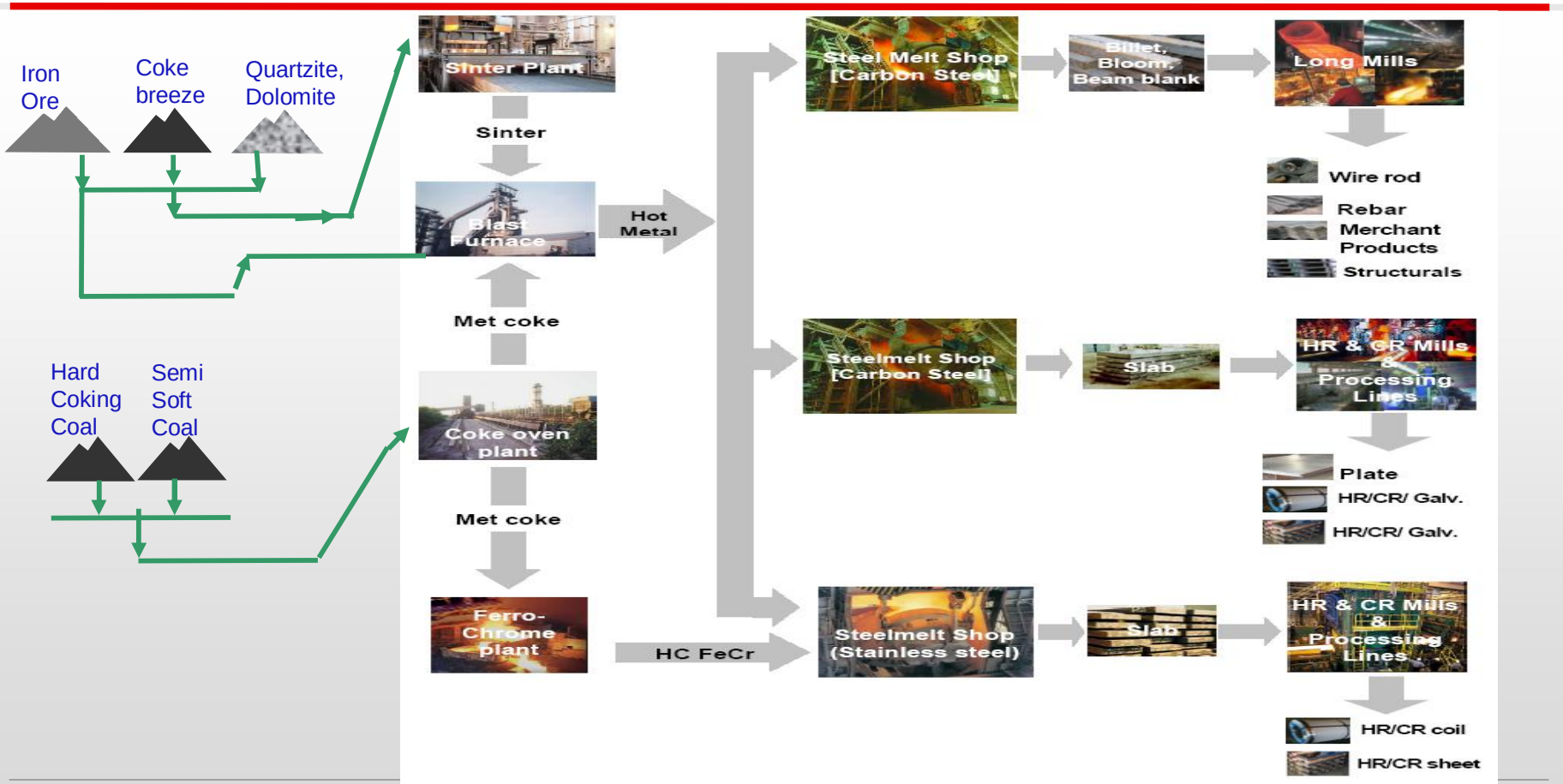
- Efficiency improvement in existing plant through retrofit options
- Introduce of best available technology
- Recovery of Waste Energy

It is necessary to overcome the barrier (High Initial Cost) to make the energy efficient technologies as an attractive option

Energy conservation in Indian integrated steel plant

An overview of possible technological interventions.....

An Integrated Steel Plant (ISP) Process Flow



Energy Balance in an ISP

- Today, a typical 1.5 million tons per annum (MTPA) integrated steel plant (ISP) with the following industrial configuration is self sufficient in its power requirement:-
  - Coke Oven Battery (1.22 MTPA) with Byproduct recovery unit
  - Blast Furnace (1.7 MTPA) with Top Recovery Turbine and Pulverized Coal Injection Plant
  - Sinter Plant (2.46 MTPA)
  - Steel Making Shop (1.55 MTPA)
  - TSCR / CSP (1.5 MTPA Hot Rolled Coil)
  - Waste Gas fired boilers for generating power
- Calorific values of waste gases generated out of metallurgical process units
  - Blast Furnace Gas (870 Kcal/NM^3)
  - Coke Oven Gas (4300 Kcal/NM^3)
  - Gas from Steel melting furnace (2000Kcal/NM^3)
- The surplus waste gases can be gainfully utilized to produce steam and power of around 150 MW for meeting the requirement of the steel plant
- The above industrial configuration makes the ISP independent of external source of electric power and also result in energy conservation and environment protection by way of saving fossil fuels

Top Recovery Turbine (TRT) in Blast Furnace (BF)

TRT technology is a method of generating electrical power by employing BF top gas heat and pressure to drive a turbine generator. Although the pressure difference over the generator is low, the large gas volumes of waste gas can make the recovery economically feasible.

The system comprises dust collecting equipment, a gas turbine, and a generator.

7000 kW of electricity can be generated from a Blast Furnace of 1 Million tonnes/ year capacity

New technology / equipments for ISPs

Primary Areas	Technology Interventions for Energy Conservation
Coke Oven Battery	Coke Dry Quenching (CDQ), new generation charging cars, computerized coke combustion process, taller coke ovens batteries, High Pressure Ammonia Liquor Aspiration (HPLA), Installation of Dry Fog Dust Suppression Systems for Coal and Coke Handling Plants
Sinter Plant	Larger bed, efficient burner design, efficient de-dusting/ dust suppression system, energy recovery from Sinter Cooler and replacement of multi-cyclones by efficient Electro Static Precipitators
Blast Furnace	Cast House Dedusting, Cast House Slag Granulation, Waste Heat Recovery from Stoves, Top Pressure Recovery Turbine, Pulverised Coal Injection
Steel Melting Shop	Energy efficient thin slab castor, efficient De-dusting system to control process emissions and secondary emission control facility

Through new technology interventions ISPs will reduce emissions, enhance heat recovery and **green power generation** and thus can reduce waste

By significant investments in new steelmaking technologies, and through the innovation of the women and men working on the plant floor, America's steel industry has reduced energy intensity per ton of steel shipped by 30 percent since 1990.

American Iron and Steel Institute

The outlook for Energy

By 2040, we expect to see ...

- 2 billion more people on the planet,
- 130 percent larger global economy,
- about 35 percent greater demand for energy – which could have more than doubled without gains in efficiency,
- Non-OECD countries like China and India lead the growth in energy demand,
- about 60 percent of energy demand supplied by oil and natural gas,
- natural gas surpass coal as the second-largest fuel source,
- 90 percent growth in demand for electricity,
- energy-related CO2 emissions plateau and gradually decline.

Source: Exxon Mobil – A view to 2040

Thank You

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