

ADOPTION OF SOCIABLE GREEN ENGINEERING FOR SUSTAINABLE DEVELOPMENT

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Abstract

India is striding ahead to become a world leader in manufacturing of ferrous metals & alloys. Rapid globalization has driven up-gradation to its ultra-modern infra-structure. It has contributed to India's sustainable industrial growth in auto, infra, mining, petrochemicals, and power sectors. Hence over the decade, its per capita consumption of ferrous products has vastly increased. Existing units of iron and steel manufacturing industries emit the greenhouse gases (GHG) with variable life span with multiple and Global Warming Potential (GWP). These are responsible for the global climate changes. Global Warming & negligence of integrated impact of enviro-socio-human-economic factors while achieving technological progress has today become the greatest challenge to the human endeavor for its continued and dignified existence on this planet. Clean Development Mechanism (CDM), which is multistage knowledge process is one of the ways identified under the KYOTO Protocol, for developed countries to offset their carbon emissions, is fast becoming the preferred way. Moreover, KYOTO protocol based market driven generation, registration, valuation of carbon credit and its subsequent trading leads to penalize the polluting and reward the clean industries. Consequently, authors have attempted to create awareness among the ferrous metal manufacturing industries to minimize the hazardous impact of GHG by investing in modernization of various sections, machineries and process of the integrated plants by discussing a few case studies and methodologies adopted to translate controlling carbon emission into a profit churning venture. Implementing alternative, appropriate, innovative, resource conserving, safe & green technology will lead to sustainable development.

Keywords: GHG, GWP, Carbon credit, Kyoto, CDM, Sustainable

Indian Steel Industry Overview

Consumption of heavily embedded chemicals enriched unhealthy agricultural produce, greed of business tycoons to acquire overnight fame & richness, subsurface support of politicians, nexus of criminals in mining resources, scrap, import of unsafety, obsolete, overpriced, energy inefficient raw materials & technology, never ending overseas dependency on fossil fuel and associated skyrocketed cost of logistic, moral corruption of governing authorities, lack of knowledge of quality consciousness, standards, best practices etc. among consumers who compromise on cheaper product and services etc. are some of the vital parameters leading to catastrophic industrial disaster, uncontrolled epidemic diseases, impairing human DNA & inviting life style diseases, creating a superficially rosy but illusive picture of growing economy. However, the said parameters and lack of global efforts to address those issues will severely affect wellbeing of the entire mankind. India a nation with its rich spiritual, cultural heritage, unity with diversity of masses, functioning democracy, enterprising skills of its majority hardworking honest common man who is also equipped with rocket science knowledge can certainly play a visionary's role as torch bearer to save the world from anarchy by all the aforesaid stake holders.

India in its quest to achieve the status of 'developed' nation by 2020 needs to maintain its current golden growth rate which is surging has driven demand for coal, oil, electricity and water. However, on the darker side, uncontrolled, unplanned usage of them is alarming higher emission of green house gases, quantum jump in production of waste, and sinking level of water table. Hence, as per the National Action Plan on Climate Change (NAPCC), Indian industrialist, NGOs, academicians, Private Public Sectors, Government *i.e.* the stake holders in India's success story have to work in co-ordination towards 'Mission of Sustainable Growth (MSG)'. Only this approach will enable India to conserve its natural resources, maintain bio-diversity, decrease carbon foot prints and implement higher discharge standard. Futuristic green certified products will have to be manufactured in "Green Factory" in strong compliance with universally approved Green Process Standard using Green raw materials. Accordingly, manufacturing of steel, polymers, ceramic, rubber, glass, paper, textiles, composite material etc. will undergo sea changes.

India has about 140 million tonne steel capacity, projected by the year 2016-17. During the current year the three Public Sector Units: SAIL, RINL and NMDC have planned to invest nearly Rs. 15,000 plus crore in their ongoing capex and plant modernization projects.

In the 3rd quarter of the FY 2014-15, Globally India stands 4th amongst steel producing nations [1]. Steel is crucial to the development of any modern economy and is considered to be the backbone of the human

civilization. The level of per capita consumption of steel is treated as one of the important indicators of socio-economic development and living standard of the people in any country. It is a product of large and technologically complex industry having strong forward and backward linkages in terms of material flow and income generation. All major industrial economies are characterized by the existence of a strong steel industry and the growth of many of these economies has been largely shaped by the strength of their steel industries in their initial stages of development.

As per the survey and news report:

- *The Indian steel industry have entered into a new development stage from 2005-06, riding high on the resurgent economy and rising demand for steel. Rapid rise in production has resulted in India becoming the 2nd largest amongst Asian producer of steel [2].*
- *It has been estimated by certain major investment houses, such as Credit Suisse[3] that, India's steel consumption will continue to grow at nearly 16% rate annually, till 2012, fuelled by demand for construction projects worth US\$ 1 trillion. The scope for raising the total consumption of steel is huge, given that per capita steel consumption is only 40 kg – compared to 219 kg across the world and 545 kg in China.*
- *The National Steel Policy [4] has envisaged steel production to reach 110 million tons by 2019-20. However, based on the assessment of the current ongoing projects, both in Greenfield and Brownfield, Ministry of Steel has projected that the steel capacity in the country is likely to be 140 million tonne by 2016-17. Further, based on the status of MOUs signed by the private producers with the various State Governments, it is expected that India's steel capacity would be nearly 293 million ton by 2020.*
- *India, has become the 4th largest producer of crude steel in the world, it is also net exporter of pig iron and finally it is the world's largest producer of sponge iron with a host of coal based units [5]*

Green House Gases (GHG)

Currently along with the economic slowdown, crisis of trust and cross-border terrorism overshadowed a big challenge faced by the governments of various nations around the globe. Climate change is affecting fluctuation in Monsoon based Indian economy, increase in sea water level, periodic and severe shift in season, spreading of infectious diseases *etc.* However, climate change is as much a business issue as it is an issue for the Government and civil society. Corporations worldwide control more than half of the means of anthropogenic GHG emissions. Dual Challenge of each country are (a) Decrease GHG emissions from their exponential growth curve (b) Easing of impact of climate change

Greenhouse gases (GHGs) are trace gases that control energy flows in the Earth's atmosphere by absorbing infra-red radiation leading to global warming. Now if we talk about the Emission pattern from the different scopes, the sector-wise Green House Gases (GHG) e.g. CO₂, CH₄, N₂O, Hydroflorocarbons (HFCs), Perflorocarbons (PFCs), Sulphur Hexafluoride (SF₆) [6] emissions in India are as follows: Thus, steel industry is one of the energy intensive sectors and also a big emitter of GHGs, almost 15% of the total emissions counted by this sector [7].

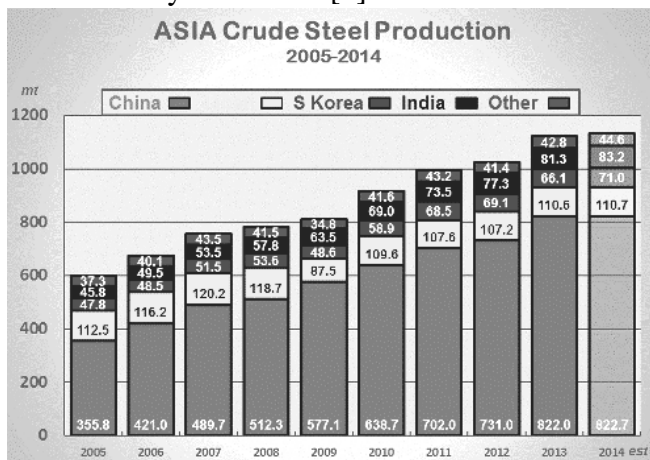


Figure 1: The production of steel in India for the past decade [5],

Table 1: Statistic of Production, Import & Export of Steel – Indian Scenario

Production of steel (Million tons) in India						
Category	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15*
Pig Iron	5.88	5.68	5.371	6.870	7.950	6.081 (5.868)
Sponge Iron	24.33	25.08	19.63	14.33	18.20	13.276 (13.413)
Total Finished Steel (alloy + non alloy)	60.62	68.62	75.70	81.68	87.67	65.197 (64.190)
Indian steel industry: Imports (in million tons)						
Total Finished Steel (alloy + non alloy)	7.38	6.66	6.86	7.93	5.45	6.492 (4.122)
Indian steel industry: Exports (in million tons)						
Total Finished Steel (alloy + non alloy)	3.25	3.64	4.59	5.37	5.98	4.066 (4.355)

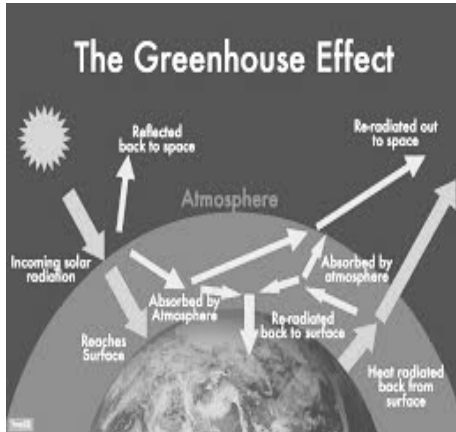


Figure 2: Green House Gas Effect

Table -2 Industry Wise GHG

Sr.	Industry	% GHG
1	Power	51
2	Steel	15
3	Transport	13
4	Cement	03
5	Chemicals	03
6	Others	15

Therefore it really draws attention to find some scopes in the Steel industry to take measures for energy efficiency and thereby reducing its GHG emission.

Every greenhouse gas has a Global Warming Potential (GWP), a measurement of the impact that particular gas has on 'radiative forcing'; that is, the additional heat/energy, which is retained in the Earth's ecosystem through the addition of this gas to the atmosphere. This allows the greenhouse gases regulated under the Kyoto Protocol to be converted to the common base reference unit of CO₂ equivalent valid for the next 100 years [8].

Table -3 Global Warming Potential (GWP) of Various GHG

Sr. No.	Green House Gas (GHG)	Lifetime (years)	Global Warming Potential (GWP)
1	Carbon dioxide (CO ₂)	Variable	1
2	Methane (CH ₄)	12-15	21
3	Nitrous oxide (N ₂ O)	120	310
4	Hydrofluorcarbons (HFCs)	100	150 –11700
5	Perfluorcarbons (PFCs)	12.1	6500 –9 200
6	Tetrafluoromethane (CF ₄)	50000	5700
7	Sulphur hexafluoride (SF ₆)	3200	23 900

Carbon Credits

Carbon credits [9] are a measure devised by the Kyoto Protocol [10] which is an agreement made under the United Nations Framework Convention on Climate Change (UNFCCC) [11] to reduce world Greenhouse Gas emissions (5.2% compared to the year 1990), and hence

fight climate change. Through the carbon market and by means of a provision of the Kyoto protocol called the "Clean Development Mechanism," people, companies and states can claim to reduce their emissions by investing in carbon-friendly projects in poorer countries [11-12]

CDM gives carbon credits or certified emission reduction (CER) units to clean energy projects in a developing country. These credits can be sold to companies in industrialized countries. The National CDM Authority is a single window clearance for such projects. One carbon credit or CER is equivalent to one tonne of GHG emission reduced and will approximately fetch Rs.1000 in Indian market [13].

CDM Opportunities in Iron & Steel Industry

Clean Development Mechanism (CDM), one of the ways identified under the Kyoto Protocol, for developed countries to offset their carbon emissions, is fast becoming the preferred way over other carbon offsetting mechanisms. CDM is an arrangement under the Kyoto Protocol that allows developed countries to invest in emission reducing projects in developing countries when they are unable to reduce them in their own countries. A project in India which helps in reduction of GHG emission could be a potential CDM project and CERs generated from such project could be traded in the international market.

Concerning with the GHGs emissions, all the steel industries are now looking for efficient operations in production. Various technologies are now in hand to go with energy saving measures and efficiency improvement. With the implementation of such new technologies it becomes possible to conserve energy as well as to reduce the conventional emissions from the industry. But in taking such measures towards the environment benefits and help mitigating the global climatic issues, huge investments are required. Therefore financial support towards implementing new efficient technology is a core need for such industries. In this regards Carbon credits supports from CDM can provide them a new roadway to adopt new technology and thus to help mitigating the global emissions [14-15].

Various Stages in CDM Process

- (a) Project Design Document (PDD) and Monitoring Plan preparation
Cost: 15,000 Euro (with approved methodology) Cost: 45,000 Euro (new methodology)
Host country approval
Cost: 4,000-25,000 Euro
- (b) Validation
Cost - 7000-15,000 Euro
- (c) Verification

- (d) Approval of Baseline Methodology by CDM –EB/Meth Panel
- (e) Project Registration
- (f) Monitoring and verification
- (g) Issuance of CERs

Figure 3 provides estimate on the time each step of the project cycle consumes. It is based on work of the World Bank Prototype Carbon Fund. It therefore includes extra steps like the negotiations with the project entity and a slightly different wording [16].

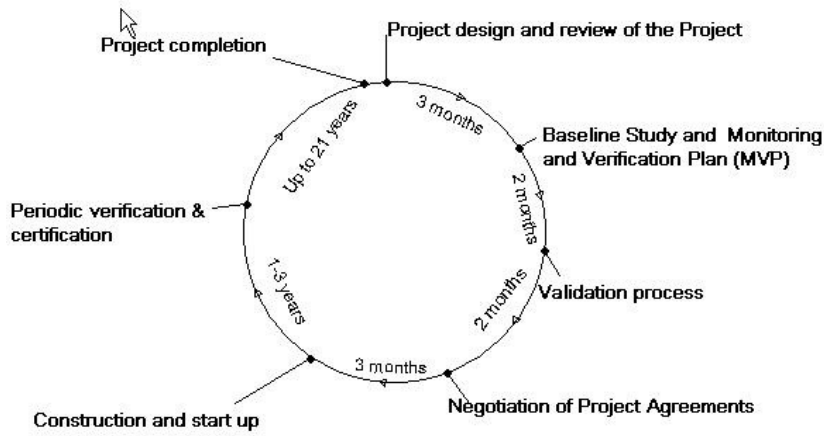


Figure 3: Time line for various stages to acquire carbon credit certificate

Opportunities for emission reduction

India's per capita greenhouse gas (GHG) emission, the main cause of global warming, continues to be less than the global average and even in 2031 it will be below the world average of 2005,

- **Energy efficiency improvement:**
 - (a) Energy efficiency improvement through power factor improvement,
 - (b) Steam system efficiency improvement,
 - (c) Batch casting replaced by continuous casting,
 - (d) Optimization of motor size,
 - (e) Variable Frequency Drive installation,
 - (f) Lighting system efficiency improvement,
 - (g) Optimization of material handling system,
 - (h) Cooling tower efficiency improvement etc.
- **Fuel switch**
Fuel switchover from fossil fuel to renewable fuel, in CPP
- **Waste heat recovery**

The highest possibility of bringing down the emissions from this industry is to enhance the recovery of the gases and utilize them in the captive power generation.

This would replace the electricity from the fossil fuel based grid electricity. Hence capture of the waste gas from these plants become a very feasible measure to bring about emission reductions. Also the temperature of these gases go upto 950 °C. This temperature can be used to meet the heat requirements of the plant for steam generation.

Potential CDM Areas in Ferrous Industry

As the agreement builds for comprehensive reductions in greenhouse gas (GHG) emissions across international boundaries and industries, there is a growing need to understand the role that materials play in achieving a low carbon society. Companies are designing the innovative economically sustainable business model.

Steel industry has made significant reductions in its energy usage and is committed to take positive action to achieve further reductions in CO₂ emissions.[17]. Through the use of eco-products it has also guided other sectors to tackle the problem of rising GHG emissions.

New Steel Grades in Vehicles

New grades of Advanced High-Strength Steel (AHSS) have replaced conventional steels for a vehicle's body structure or body-in-white (BIW), resulting in typical weight savings of 25%.[18]. This corresponds to an estimated total vehicle weight reduction of 9%, with an impressive reduction in fuel consumption. One example is the introduction of lighter components for vehicles using higher strength grades of steels.

Automotive GHG Emissions

Active legislation relevant to the automotive sector has focused on the need to reduce use phase (tailpipe) emissions during the driving life of vehicles, and this is commonly achieved through mass reduction. However, tailpipe emissions do not tell the complete story, and competitive materials selected for use phase emissions reduction may not be the optimum choice for reducing overall energy use and the impact on the environment.

The Life Cycle Benefits Of AHSS

Life Cycle Assessment (LCA) has been adopted by the steel industry as a means to comprehensively evaluate material choices, and their effect on life cycle GHGs. Major Automakers are also adopting LCA as a tool for design and material selection decisions. LCA models developed by the University of California at Santa Barbara have enabled comparisons of

automotive materials and their associated GHGs across all phases of the vehicle life cycle.[19]. From these models, we have determined that:

- *For every 1 Kg of AHSS used in the vehicle there is a total life cycle saving of 8 Kg CO₂ equivalents.*
- *If all vehicle bodies produced globally were fabricated with AHSS the annual emissions savings is estimated to be 156 million tones of CO₂.*
- *Material choice becomes more significant for vehicles using advanced power trains and fuel sources.*

Other Steel Solutions

The use of AHSS in vehicles is just one example of where steel is contributing to a reduction in the use of fossil fuels. An efficient transport infrastructure is also heavily dependent on steel bridges and rail networks to reduce transport times and distances without compromising fuel consumption. Renewable energy technologies, such as wind turbines, benefit from the strength of steel to reach heights where there are greater wind speeds and, as a consequence, produce more wind power[20].

- *Energy used in the construction of a wind turbine is typically recovered within six to nine months of the turbine operating.*
- *The weight of steel towers has been reduced by 50% over the last 10 years.*

Green Manufacturing of Steel

Steel production process uses carbon feedstock as thermo-reduction agents in the form of coke. Globally it, is obtained by dry distillation of coal which is one the most carbon intensive fossil fuels. The Brazilian steel sector, however, it is the only one globally that uses charcoal as a reducing agent. Given that charcoal is a renewable fuel source, the charcoal-based steel can therefore be considered ‘carbon neutral’[21].

V & M Tubes is the only steel pipe manufacturer in the world to use 100% renewable energy for the production of pig iron and steel. Its forestry division, V & M Florestal, is responsible for the production of all charcoal required by its mills. The project consists of investments to ensure the use of sustainably-produced charcoal for steel manufacture in Brazil, avoiding the use of coal. It is estimated that this will result in the reduction of 45 million tonnes of CO₂ emissions during the next 27 years. V&M tubes projects plan to adapt their existing carbonization kilns to incorporate best available technology to avoid the emissions of methane and particulate.

Cosipar, a private Brazilian company producing 330,000 million tones of pig iron in the state of Pará, in Northern Brazil has an objective to establish plantation forests to produce its charcoal needs, as opposed to other

companies in the Amazon region that are either using charcoal from unsustainable degradation of natural rainforests, or are moving to coke.

The study conducted by energy management cell of UNDP explored various measures for implementation and to reduce industrial electricity consumption as detailed below.

- *Installation of new Energy Efficient Pushers type furnace equipped with new set of burners, high efficiency recuperator, and blower, oil heating pumping unit, pusher, ejector, flue line & chimney, damper and PLC control combustion.*
- *Replacement of existing spindles & couplings by universal type spindles/couplings*
- *Replacement of existing roll neck fabric bearings with anti-friction bearings*
- *Adoption of Flat belts in place of existing V-belts*
- *Installation of new roughing mill having anti-friction bearing, tilting tables, stationary wall tilters centralized lubrication system*

Some of the main opportunities available for SME's in steel sector are energy efficiency measures by way of saving in fuel and electrical energy. Major savings are expected in fuel – furnace oil and coal [22].

- *Replacing/retrofitting to blowers, motors and rolling mills*
- *Redesigning the furnace for increasing the productivity and efficiency*
- *More efficient furnace oil burners*
- *Change of insulation*
- *Switch to fuels with lower carbon content, e.g. from coal to fuel oil*
- *Optimizing of air fuel ratio*
- *Heat recovery from exhaust gases*

Where as in integrated Steel plant where coal, limestone, iron ores, steel scraps are processed to make, coke, pig iron, hot metal in coke ovens, blast furnaces, ladle /electric arc furnace to manufacture ingot, billets, bloom, plates, I/V-section, rail, wire rope etc has ample scope to bring down the emission of GHG as shown in Table-3

- Coal dust, hot oxygen & tar injection in blast furnace can be done to reduce coke rate, operation cost, energy consumption
- Waste Gases from blast furnace / Corex Units can be use to generate electric power – steam – boiler
- Waste heat recovery from DRI/Midrex can be adopted to manufacture sponge iron
- Russian Romelt: is a single-stage continuous *iron-making* technique meant for recovery of valuable from metallurgical wastes - EAF dust *etc.* It uses iron bearing wastes in its natural form without any

preparation using only ordinary non-coking coal and burnt lime for process conversion. Currently being adopted by NMDC in India.

- Hydrogen annealing can be done to reduce H₂ in a material to prevent H₂ embrittlement (long exposure at 200 °C). It is mainly used immediately after welding or galvanizing of the parts [23-24].

Methodology for GHG Reductions

- (a) Reducing waste heat energy release into the atmosphere and recovery of waste heat to generate steam
- (b) Generating Electricity for in-house consumption and exporting surplus power to grid thereby reducing the electrical energy load on the regional grid
 - i. Reducing GHG emission at the thermal power stations
 - ii. Conserving the non-renewable natural resource like coal
 - iii. Making coal available for other utilizations
- (c) Contributing to a small increase in the local employment in the area of skilled jobs for
- (d) Operation and maintenance of the equipment [25].

Scope of Registered Projects with CDM

There is approved baseline and monitoring methodology under the CDM section of Kyoto protocol as given by UNFCCC for such project related to Iron & Steel industries.

The methodology mainly used is **ACM 0012 - “Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects --- Version 3.1[11]”**

More than 30 projects have already been registered with CDM in India with this scope. These projects are mainly the waste heat recovery projects which helps reducing the GHGs by the efficient use of energy, replacement of Grid connected power or combined heat and power

Table – 4 Various Units with minimization of their GHG Potential

Unit	Potential Areas
Coke Ovens	<ul style="list-style-type: none"> • <i>Coke Dry Quenching (CDQ)</i> • <i>Tall and Wider Ovens</i>
Sinter Plant	<ul style="list-style-type: none"> ➤ <i>Waste Heat Recovery</i> ➤ <i>Installation of Multi-slit Burners</i>
Blast Furnace	<ul style="list-style-type: none"> ☐ <i>Coal Dust Injection / Coal Tar Injection</i> ☐ <i>Top Pressure Recovery Turbine (TRT)</i>
SMS	<ul style="list-style-type: none"> ❖ <i>Replacement of Open / Twin Heath Furnace by BOF</i> ❖ <i>Recovery of LD Gas (CV : 1680 KCal/m³)</i> ❖ <i>Continuous Casting and thin slab casting</i>

Rolling Mills	<ul style="list-style-type: none"> ▪ <i>Installation of Walking Beam type Reheating Furnaces with computerized combustion system</i> ▪ <i>Strip/ Slab charging at higher temperature (online)</i>
EAF	<ul style="list-style-type: none"> ○ <i>Scrap pre-heating</i> ○ <i>Oxygen lancing(ALARC),supersonic nozzle design</i>
Power Plant	<ul style="list-style-type: none"> • <i>Fuel Switching [12]</i>

Some Case Studies of Registered Projects

So far, quite a number of projects have been registered under this type. As mentioned earlier, the major scope of developing a project activity under CDM in the steel industry would fall under the energy efficiency category. A glance at the *registered projects in India would show that a majority falls under the waste heat recovery type*. The different kinds of projects developed under different possible methodologies are:

Title: “Waste Heat Recovery project at Saraikela, Kharsavan, Jharkhand by M/s Kohinoor Steel Private Limited”

- ✓ Date of registration: 28 May 2008
- ✓ Applied Methodology: ACM0002
- ✓ Emission Reductions (CERs): 56,176
- ✓ Project Activity: Installation of a 10MW Captive Power
- ✓ Plant (CPP) for generation of electricity by utilizing sensible heat of waste gases emanating from the Direct Reduction Kiln.
- ✓ Project Location: Kharsavan, Jharkhand

Title: Waste heat recovery based captive power project in an integrated Iron and steel plant

- ✓ Date of registration: 6 July 2007
- ✓ Applied Methodology: ACM000
- ✓ Emission Reductions (CERs): 8536
- ✓ Project Activity: Increase in waste heat recovery of the LD gas generated from the LD converter process of the integrated steel plant, and utilizing it to meet the captive power requirements
- ✓ Project Location: Rourkela, Orissa

Title: Electrotherm 30MW combined waste heat recovery, coal based captive power plant at Kutch

- ✓ Date of registration: corrections under review
- ✓ Applied Methodology: ACM0012
- ✓ Emission Reductions (CERs): 61386

- ✓ Project Activity: installation of waste heat recovery boilers, in order to generate power from the hot flue gases from the sponge iron kilns at an iron and steel facility.
- ✓ Project Location: Kutch, Gujarat

Apart from these three case studies, there are **more than 30 registered projects** under the CDM EB related to Iron & Steel Industry. A percentage share of registered projects in India has been highlighted here. It shows that almost 7 % of the total registered projects accounts for Iron & Steel Industry. Also such projects carry overall sustainable development in the regions which make them eligible to gain the carbon credits.

Benefits of Acquiring Carbon Credits

1. *Implementation of New technologies*
2. *High investment required*
3. *Contributions to Emission reduction by the efficiency measures*
4. *Overall sustainable development through the infrastructure improvement*
5. *Encouragement for more development and future benefits to the environment.*

Thus considering all the above facts related to the Iron & Steel industry, CDM benefits are seemed to be a better supportive tool for these industries. And the trend of CDM registered projects in the area of Iron & Steel industries has shown us the potential scopes in CDM and its future benefits as well and also encourages the new project proponent to implement such new environment friendly technologies keeping a faith on Carbon credits supports. Therefore a move with CDM is definitely a profitable business for the Iron & steel industries and also a effective measure for GHG emission reductions.

Sustainable Growth

Overall in order to minimize the negative impact of unplanned urbanization, industrialization, it is essential to have a thoughtful approach towards development. Adoption of CDM based green engineering would enforce all the stake holder to optimize usage of natural resource, minimize waste, nurture community values to impart economic prosperity. Hence during planning of any development project apart from the standard right from ecofriendly, ergonomic, safe design, impact on environment, biodiversity, community health, value & risk analysis, logistic, etc. aspects if precisely taken into account then it would certainly be a better sustainable place for tomorrow. Complex problems [26-27] e.g. climate change driven rural to urban migrations creating Syrian civil war, integrated interaction of global, social and human system can be efficiently addressed. This will lead

to a global sustainable production and consumption with human security in a low carbon society.

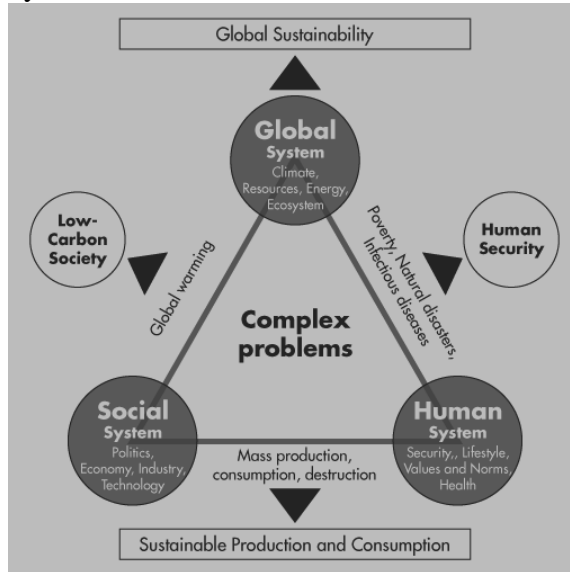
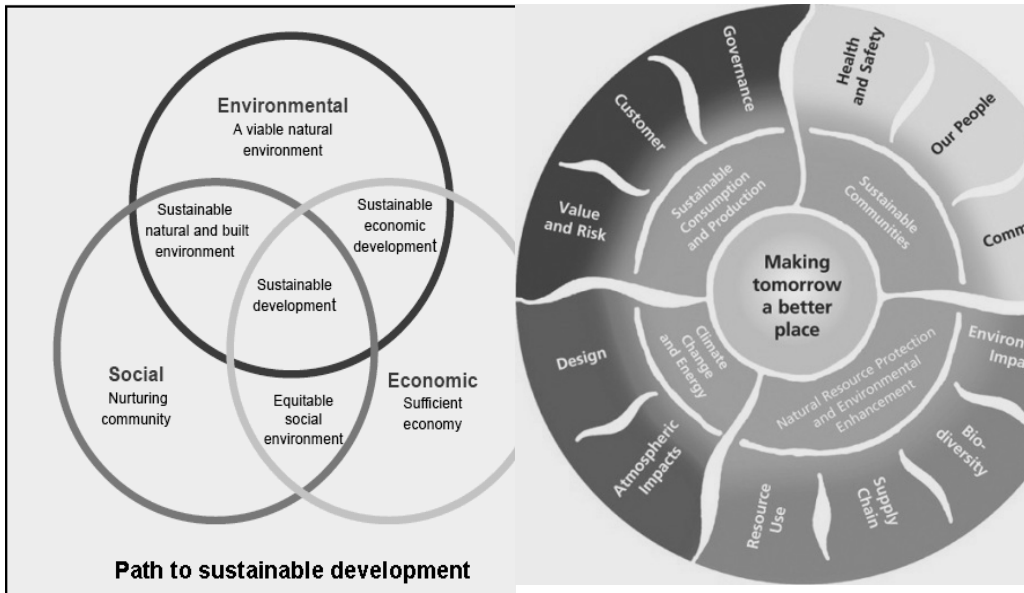


Figure 4: Matrix to addressing complex problems



(a)

(b)

Figure 5: Plan to sustainable develop for better tomorrow

Conclusion

- (a) Futuristic green certified products will have to be manufactured in “Green Factory” in strong compliance with universally approved Green Process Standard using Green raw materials.
- (b) Rapid industrialization, globalization, liberalization and privatization along with its mineral rich resources, economical skilled manpower and visionary steel tycoons have lead India to improve its ranking as one of top key player in iron and steel manufacturing sector.
- (c) The green house gases emitted from various units of iron and steel manufacturing industries are responsible for the global climate changes.
- (d) The GHG has several ill effects threatening to inter & intra country migration and also survival of the human race on this planet.
- (e) India being part of 1997 *Kyoto* Protocol signatory has enormous potential in the emerging carbon based economy. It can offer effective risk management for companies with emission constraints and opportunities to sponsor green house gas emission reduction projects.
- (f) Clean Development Mechanism being one of the healthy routes to acquire a carbon credit against per tone of reduction in GHG emission. It is a multistage and lengthy process where domain experts in specialized field can guide industries with suitable methodologies to minimize the emission by managing their energy resources..
- (g) Usage of Advanced High-Strength Steel (AHSS), Life Cycle Assessment (LCA) tool & Renewable energy technologies proved vital in bringing down carbon foot prints.
- (h) Modernization of raw material yard, alternative fuels, their pre and post treatment, various melting units, metal working process, power plants etc are the sectors where there is scope to reduce GHG and save the planet.
- (i) The carbon credit thus sought can be internationally traded to boost the revenue of the vibrant Indian economy. It can lead to sustainable growth if it can adopts customized Green Technologies (with their due diligence) which will offer flexibility in burden to produce wider, economic, quality product range in iron and steel vertical.
- (j) Achieving sustainable development in a low carbon society is feasible if all the stake holders of any development project give

due justice to various parameters ranging from biodiversity to economics.

- (k) Green products and services if given certain tax holidays by government will lead to healthy industrial boom bringing harmony & joy among human giving them opportunity to truly taste the fruits of sustainable growth.
- (l) Green Engineering if practiced perfectly will facilitate all of us to pass on this beautiful conserved & gifted planet by our ancestors in a same or eco-friendly state to the generation next for their sustainable growth.

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