PROMOTING RESOURCE EFFICIENCY ALONG THE SUPPLY CHAIN OF KEY SECTORS

Institute for Industrial Productivity

Promoting Resource Efficiency along the Supply Chain of Key Sectors: Stimulating Knowledge Partnership in South Asia

Over exploitation of natural resources for various manufacturing processes can impact its availability in the long run along with severe negative social and environmental externalities. To deal with this critical issue, there is a need to better understand the nexus between poverty, environment degradation and resource intensive growth and optimise conservation where possible. This needs to be complimented with effective policies to incentivize greening of production processes along the supply chain of important sectors. The primary producers and Small & Medium Enterprises (SMEs) have a crucial role in this, as they, provide substantial proportion of raw materials, subassemblies and finished products for larger industries and are acknowledged as being vehicles of economic growth, while providing livelihood to a large population in many South Asian countries. However their energy and environment performance is extremely poor and offers substantial scope for resource conservation along the supply chain of industries.

To tap in to this potential, Institute for Industrial Productivity (IIP) has initiated a Greening Supply Chain project in India, which has resulted in positive impacts with high replication potential. As a first step in the direction of scaling up the learning's drawn from IIP's pilot initiative and realising the potential for resource efficiency in South Asia, an analysis of three case studies from India is presented in this document. Each of these case studies have been carefully chosen to demonstrate the value of resource efficiency in different stages of supply chain in the key sectors that are relevant from the point of view of; (i) high resource consumption and environmental impacts (ii) relevance to local economy (iii) willingness of local government, industry associations, and corporate houses, and (iv) replication potential. By presenting these case study analysis, the report offers industry, policy makers and analysts a guide to anticipating and shaping the future of economic growth and poverty reduction in the region, specifically by, (i) helping better understand the extent to which these key sectors are vulnerable to unsustainable resource use (ii) understand how resource constraint will impact the supply chains of large Corporates; (iii) what investments and policies are needed to make these supply chains more resilient, and (iv) assist primary producers and SMEs to sustain their operations and grow by managing the environmental impact of their operations, improving their bottom line and by developing products that meet the needs of a greening market.

Resource Conservation at Industry Level: an Imperative

Rapid development coupled with high population growth in South Asia has led to unsustainable use of natural resources resulting in serious environmental and social problems. These problems may constraint growth in the production and manufacturing industry, which is critical for the development of the region's economy, especially for feeding its growing population and for pulling millions out of poverty. There is a pressing need to reverse this trend by introducing sustainable practices that are less resource intensive.

Resource Stress set to Increase with Growing Population

South Asia is one of the most densely populated regions of the world. Although, the per capita consumption of natural resources in many countries of the region is significantly lower than in many developed countries, in absolute terms, South Asia is already consuming beyond its own resource capacity. With around 15 kilograms of resource use per day, Asia is consuming around twice the biological resource capacity available on the continent on account of resource intensive economic development. Sustaining an estimated population of 9 billion by 2050 will require at least 40 percent more food, 30 percent more water and 50 percent more energy than is being consumed now. These challenges will be acutely felt in South Asia, where over 420 million people live on less than a dollar a day, and will lead to an intense struggle for land, energy and water.

Sustainable Economic Growth: Being 'less' wasteful and 'more' resourceful

Over exploitation of natural resources can impact the sustainability of supply along with severe negative environmental and social externalities in the long run. The World Bank estimates that air and water pollution alone costs India an equivalent of 5.7 percent of country's Gross Domestic Product (GDP) and is responsible for more than 100,000 deaths a year. Therefore, economic and industrial development without resource efficiency policies and practices will aggravate the water and energy security concerns, and escalate environmental degradation-local as well as global.

A better understanding of the deep links between environmental degradation, resource intensive growth and poverty is necessary to provide a sound basis for developing policies that will support the greening of industrial production and manufacturing processes along any value chain. The concept of greening would encompass all technologies and processes that reduce water, energy and material use- encourage waste reuse, mitigate CO_2 emissions, etc.

Greening of Industry: 'Small' Partners can make a 'Big' Difference

Large industry and corporate entities alone cannot bring about transformation in resource efficiency as the producers, suppliers and vendors of raw material comprising farmers and SMEs, contribute to a major portion of industrial output. They are a crucial part of the supply chain, providing raw materials, subassemblies and finished products to larger companies and are acknowledged as being vehicles of economic growth. It is estimated that the vendor base of large industries that includes the SMEs contribute half of Bangladesh's industrial GDP and provides employment to about five million people[i], or 82 percent of the total employment in the industrial sector[ii]. In Nepal, it account for 96 percent of the total number of industrial establishments, and accounts for 83 percent of employment generated[iii,iv] by the industrial sector, and 80 percent of the industrial sector's contribution to GDP[v]. The SME sector also occupies a position of prominence in the Indian economy. The sector contributes to 8 percent of the country's GDP and 45 percent of the manufacturing output[vi]. They provide raw material and finished/ semi-finished goods for local and international markets; many multinational companies source their products from SMEs in the South Asia region. In India, SMEs account for 40 percent of exports and this figure for Bangladesh is about 76 percent[vii]. SMEs also contribute substantially to exports, but not so much directly as indirectly-through forward linkages with large firms. This is especially true of the textile and clothing sector, agro-food and herbal medicines. Therefore, in order to bring about any significant improvement in resource efficiency at industry level, any intervention will need to be initiated at the level of the SME/farmers/producers and worked upwards. Working with SMEs however, present significant challenges as well as opportunities as highlighted below:

Technology Obsolescence

Some of the major challenges faced by the SME sector in South Asia are related to technological obsolescence, poor product quality, information deficiency, non-availability of credits and inadequate management systems[viii]. The competitiveness of most of these enterprises is based only on the low cost of labour and not because products, technologies or skills are better. The energy, resource and environment performance of these units are extremely poor[ix] with high potential for saving.

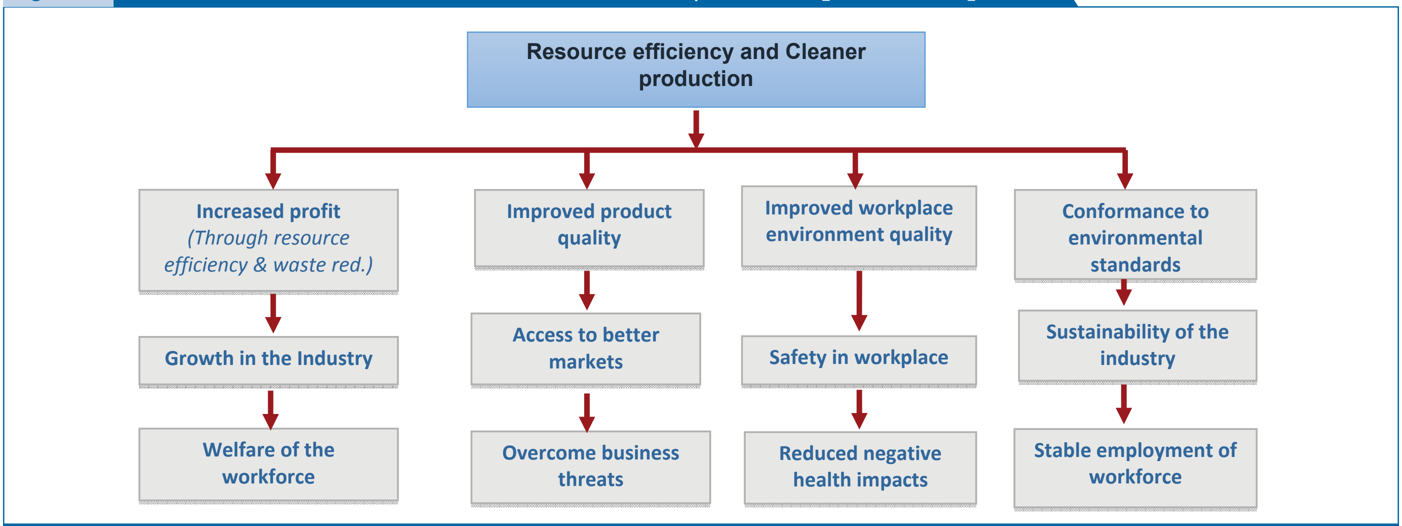
Potential for Transformational Impact

In India, Bangladesh and Pakistan, SME operations tend to cluster naturally. Within a cluster, there is a high degree of similarity across units in terms of the level of technology being employed, operating practices and even trade practices. This makes intervention at a cluster level very attractive as improvements demonstrated in one unit is most likely to be replicated and mainstreamed in others.

The enhanced resource efficiency, waste minimization etc. directly impacts the profitability and competitiveness of SMEs through reduced costs of energy and raw material and improvements in the product quality. Such interventions also have many co-benefits in the form of improved workplace environment, safety at the workplace, reduced negative health impacts, stable employment of workers employed by the units and significant GHG mitigation.

The direct and co-benefits of promoting cleaner technologies are shown in Figure 1. Although the benefit streams apply to industries of any size the effects are more pronounced in the SME sector.

Figure 1: Some co-benefits associated with Resource Efficiency & cleaner production options



Pilot Initiative for Enhancing Resource Efficiency in Supply Chains

In order to address the challenge of resource scarcity and to capitalise on the potential and opportunity that exists for enhancing resource efficiency along the supply chain (comprising SMEs and primary producers) in key sectors, the Institute for Industrial Productivity[1] (IIP) has initiated a Greening Supply Chain project in partnership with IKEA[2] to promote cleaner technologies across their vendor base in India. IIP entered in to a Memorandum of Understanding (MoU) with IKEA to work on this initiative.

To help IKEA's vendors, detailed energy and environmental assessments were carried out for representative units in India. These assessments were then used to develop a prioritised action plan to improve the efficiency of resource (water, energy, raw material) use and reduce their carbon footprint. In the first phase of the exercise a blue-print was prepared for greening the production and manufacturing facilities of selected vendors and technical support provided to help them in implement the recommended measures. This resulted in substantial saving of material, water and energy, and reductions in the quantities of waste produced. IKEA has acknowledged the benefits of this initiative and is in the process of scaling it up.

The success of the India pilot has paved the way for scaling up the demonstrated approach, first in the South Asia region and subsequently at a global level through environmentally and socially conscious corporate entities and industry associations.

Stimulating Knowledge Partnership in South Asia

As a first step towards realising the potential for resource efficiency in South Asia and scaling up the learnings drawn from IIP's pilot initiative, an analysis of three case studies from India has been presented in this document to highlight the potential of resource efficiency along the supply chain. Each of these case studies has been carefully chosen to demonstrate the value of resource efficiency at different stages of the supply chain in the key sectors that are relevant from the point of view of; (i) high resource consumption and environmental impacts (ii) relevance to the local economy (iii) willingness of local government, industry association, corporate houses and vendors, and (iv) replication potential.

These case studies also show how important different drivers are in promoting resource efficiency in the supply chain. (i) The case study of the textile sector shows how the corporate policy of a multi national corporations (MNCs) can help to stimulate sustainability not just along its vendor base, but also cause a multiplier effect by pushing its competitors to follow suit; (ii) the case study of brick industry shows how pro-active government policies can help in promoting an innovative technology that has the ability to transform the industry from being resource extractive to becoming environment friendly, making productive use of hazardous wastes from other polluting industries; and (iii) the case study on the steel re-rolling sector highlights the value of engaging with an industry association in saturating a cluster with resource efficient technology.

The report offers industry, policy makers and analysts a guide to anticipating and shaping the future of economic growth and poverty reduction in the region, specifically by, (i) helping governments better understand how vulnerable their key sectors are to unsustainable resource use impacts (ii) Showing large industries and MNCs how resource constraint will impact their supply chains; (iii) what investments and policies could be put in place by government and industry to make these supply chains more resilient, and (iv) assisting producers and SMEs to survive and grow by managing the environmental impact of their operations, improving their bottom line and by developing products that meet the needs of a greening market.

1 IIP is an independent non-profit organization that operates globally as a Best Practice Network for promoting low carbon growth and works closely with the private sector and government for promoting sustainable models of resource efficiency.

2 IKEA is a leading multinational brand that sells home furnishing products, accessories and appliance.

Summary: Case Study 1
Sustainable Textile Production

Sector

Textile sector has high relevance for the South Asian economy, providing direct employment to more than 55 million people and to nearly 90 million indirectly, while generating an export volume of over USD 37 billion. While the sector offers substantial resource conservation opportunities, such interventions can also make a significant impact on poverty eradication and in improving the living conditions of its vast workforce.

Resources Inefficiency and Environmental Problem: While the sector is extremely important for fostering economic development and for livelihoods generation, it is also confronted with a variety of problems that range from low resource efficiency (water, energy and chemicals) and significant pollution which impairs the sustainability of the very inputs on which this sector thrives.

Supply chain intervention

Like other South Asian economies, the Indian textile industry has long suffered from inefficiency and low productivity at both ends of the supply chain – low farm yields affecting cotton production, and inefficiency in the garment sector leading to high environmental and social externalities. This case study focuses on how resource efficiency has been achieved in the textile sector along the supply chain of IKEA, a leading multinational brand. Starting from the farm level, the case study emphasizes the measures that led to reduced use of water and pesticide for cotton production on one end to increase in resource efficiency and productivity for textile manufacture. While these measures resulted in improving the bottom line for farmers and SME entrepreneur, it also impacted the larger sustainability issues as highlighted under the impact section.

Impacts Achieved

- About 6000 farmers linked with 'Better Cotton Initiative' in Aurangabad, Maharashtra, got benefitted by way of 38 percent less pesticide use, 24 percent less water use and 29 percent less fertilizer use. All this led to a 45 percent increase in gross profit margins compared to conventional farmers. Apart from these direct benefits, the farm level intervention also focused on issues like child labour, health and safety, and employment conditions for farm workers. Better earnings have increased the farmers' ability to send their children to school, access to better health care facilities and provide a better quality of life to their families.
- Small vendors involved in spinning, weaving, cutting, sewing operations could improve their bottom line through financially viable resource conservation efforts. The vendor partner could save 51 million litres of water and 13015 Gcal energy, equivalent to annual monetary savings of INR 308 Million (USD 5 Million) in a year and greenhouse gas (GHG) mitigation to the tune of 3800 tCO_2. The other co-benefits include reduced pollution of surface and ground water sources and the associated damage to the nearby agricultural fields. Less emission of harmful gases and fumes, better ventilation, enhanced natural lighting through use of acrylic sheets in factories and worker's quarter and clean drinking water has helped in improving the living and working conditions of the workforce. Better compliance of environmental guidelines and regulations has helped in providing stable livelihoods to the workers, by avoiding shutdown threats.
- Large brands like IKEA benefitted by way of creating a green image for themselves by reducing their overall water, energy and GHG footprint.

Replication potential

Apart from environmental and social issues, the sustainability of industry in the region is also threatened by global competition demanding technological up gradation. The model demonstrated in India has great scope for replication in other South Asian countries as the textile sector bears a lot of similarity in cultivation and production processes, technologies and operational practices. With an estimated 5500 textile units in Bangladesh accounting for 45 percent total industrial workforce and in Pakistan with textile contributing to 11 percent of GDP and 40 percent of total industrial workforce, the India experience holds enormous potential for scale up through effective regional collaborations around knowledge transfer, which can help in enhancing the competitiveness of this sector and in increasing their market share in the world.

CASE STUDY 1
Sustainable Textile Production

The importance of the textile sector for the South Asia region cannot be overstated providing as it does direct employment to more than 55 million people and indirectly to nearly 90 million while generating an export volume of over US$ 37 billion (in 2008). The importance of the sector to the region is also reflected by its share in total exports. South Asia's share in global trade is around 4.4 percent while the region's share in global exports is around 7.7 percent with the value touching US$ 45.7 billion in 2007[xi]. The textile sector constitutes around 80 percent of Bangladesh's total exports providing direct employment to 3 million people; the corresponding figure for Sri Lanka are 45 percent and more than 1.8 million; 55 percent and 15 million people in Pakistan, in India around 12 percent of exports are from the textile sector and it employs more than 38 million[xii].

The data above clearly indicates that the textile sector is a key contributor to the South Asian economy, and its performance can contribute to a rise or fall in poverty. While the sector has a positive impact on economic development it is associated with a range of problems such as, high pollution, impairing the sustainability of the very inputs on which this sector thrives.

- The textile sector has high relevance for the South Asian economy with potential for eradicating poverty and improving health
- The sector has a complex value chain, including agricultural products
- Resource intensive sector with high use of energy, chemicals and water causing negative environmental impacts
- Potential for resource efficiency is high-broad range of technological interventions possible to reduce energy and water use, minimize wastage, and enhance operational efficiency
- Large potential for replication and knowledge sharing

Resource Inefficiency and Environmental Problems

The main problems associated with the textile industry are typically those associated with high water pollution caused by the discharge of untreated effluents, high energy and chemical use, GHG emissions and associated issues of workplace safety.

Water: The textile industry uses large volumes of water throughout its operations, from cultivation to bleaching, dyeing and the washing of finished products. On an average, approximately 200 litres of water are required to produce l kg of textiles. Of all the steps involved in textiles processing, wet processing creates the largest volume of waste water. It has been estimated that for a simple cotton shirt, an average of 2700 litres of water is needed[xiii]. Cotton products therefore have a particularly high 'water footprint'.

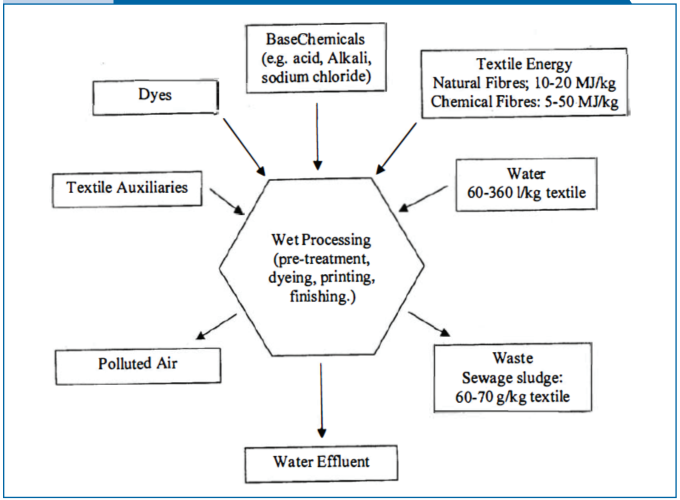
Energy: Fossil fuels (oil, gas and coal) are used in the production of textiles, especially during wet processing. A large amount of energy is used to run machines in different stages of the production cycle. The are significant opportunities for energy saving and CO_2 mitigation in the sector.

Chemicals: The textile sector is extremely chemical intensive. Cotton growing involves extensive fertilizer use in farm lands that causes soil depletion and contaminates surface and ground water. Textile manufacture, specifically the dyeing, printing and finishing processes use chemicals extensively, most of which are hazardous.

Air Pollution: Gaseous emissions are the largest pollution problem (after water pollution) in the textile industry. This includes both local as well as global emissions. Apart from local emissions from the use of fossil fuels in utilities, processes such as dyeing, printing, fabric preparation involve emissions of hydrocarbons, formaldehyde and other volatile compounds.

Solid Waste: Solid waste includes scraps of fabric and yarn, off-specification yarn fabric and packaging waste. There are also wastes associated with the storage and production of yarns and textiles,

Figure 2: Input output process of textile manufacture



Source: Chavan, R.B., Indian Textile Industry- Environmental issues

such as chemical storage drums, cardboard reels for storing fabric and cones used to hold yarns for dyeing and knitting.

Resource efficiency along the supply chain of textile sector is an attractive approach to enhance productivity and tackle environmental and social problems.

The following case study provides details of various resource efficiency measures along the textile sector's supply chain, the economics, impacts achieved and replication potential. The case study in based on a joint initiative by IIP and IKEA undertaken in India.

The Indian Textile Sector: An Overview

India is the world's third largest producer of cotton, with China and the USA in the first two places, and the largest cotton consumer after China. It contributes about 14 percent of industrial production, 4 percent to India's GDP, 20 percent to the foreign exchange earnings and directly employs more than 35 million people[xiv], making the sector the largest provider of jobs after agriculture. The textiles sector also creates a large volume of indirect employment, both in traditional industries (like production of cotton and other natural fibers) and modern industries (like textile design and fashions)[xv,xvi].

The textile and apparel supply chain[xvii] comprises essentially of farmers, ginning facilities, spinning processes, processing sector, weaving and knitting factories and garment manufacturing facilities that supply to an extensive distribution channel. This supply chain is perhaps one of the most diverse in terms of the raw materials used, technologies deployed and end products. Cotton remains the most significant raw material for the Indian textile industry with a production of 5 billion kg per year making up for 22 percent of the world's share. Cotton grows mostly in western and central India and cotton cultivation provides direct livelihoods to 6 million farmers[xviii].

However, cotton production in India relies on the intensive use of hazardous pesticides and chemical fertilizers. Data suggests that Cotton cultivation in India consumes 44.5 percent of the total pesticides used in the country. In addition, cotton is a water intensive crop and around 6 percent of the water for irrigation in India is used for cotton cultivation[xix].

There are about 65,000 garment units in the organized sector, of which about 88 percent make woven cloth while the remainder make knits. The weaving and knits sector lies at the heart of the industry. Weaving, using powerlooms, was traditionally done by composite mills that combined it with spinning and processing operations. Over the years, government incentives and demand for low cost, high volume and standard products moved the production towards powerloom factories.

The Indian textile industry has long suffered from inefficiency and low productivity at both ends of the supply chain – low farm yields affecting cotton production and inefficiency in the garment sector leading to high environmental and social externalities. This case study focuses on how resource efficiency has been achieved in the textile sector in India.

Supply Chain Intervention

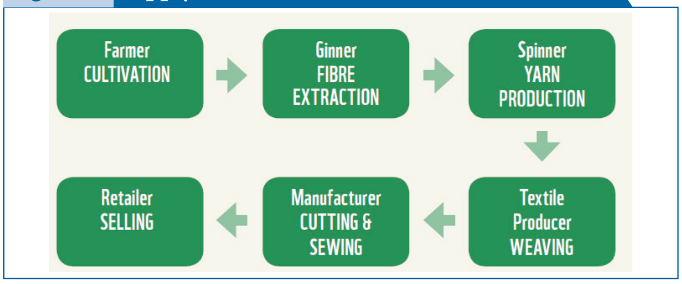
The supply chain intervention in this case study, as shown in Figure 3, covers resource efficiency issues at the cotton farmers' level as also at the level of production facilities or textile mills. At the farm level, reducing water and pesticide use was emphasised, while the focus at the manufacturing facilities was to enhance the efficiency of production.

The following section briefly outlines the intervention at different stages of the supply chain, the approach followed and benefits achieved. For ease of understanding, the interventions have been presented in two sections: at the farmer's level and at the level of fabric production.

Enhancing Resource Efficiency for Cotton Growers

The cotton producing area covered is the Aurangabad region of Maharashtra, where IKEA interventions have helped farmers adopt sustainable production approaches. Inefficient crop

Figure 3: Supply chain of textile sector



Source: WWF & IKEA Project Report, April, 2014 management practices are a leading cause of water loss and this is compounded by cyclic drought every 3-5 years, impacting the livelihoods of farmer in a big way. Freshwater resources in the area have been degraded, leading to soil erosion and biodiversity loss. Moreover, cotton growing is characterised by intensive and indiscriminate use of pesticides and fertilizers, contributing to serious environmental, social and economic problems also because most cotton is grown and picked by hand on small farms, exposing the farmers to health risks. Most cotton growers in Aurangabad are smallholders with lack of access to credit facilities, information and extension services. Overcoming these obstacles has been the central element of strategy for increasing yields and providing economic benefits to farmers.

FACTS ABOUT COTTON

- 2.5 percent of the worlds cultivated land is used to grow cotton
- Cotton accounts for up to 10 percent of global pesticide use
- Cotton is grown in around 80 countries around the world
- The largest producers are China, India, USA, Pakistan, Brazil and Uzbekistan
- Some 300 million people work in the cotton industry
- On average, 10,000 litres of water is used to grow one kilogram of cotton, but it can require three times as much if farming practices are poor
- Nearly half of all textile production is based on cotton

Source: www.waterfootprint.org

Approach

The basic philosophy was to enhance the capacity of smallholders by developing their skills through participatory approaches of Farmer Training and Farmer Field School (FFS) to develop site-specific better crop management practices to reduce the use of pesticides, fertilizers and water in cotton production; enhance productivity; improve livelihoods; and reduce environmental and social impacts. This was done through sustained interaction with a few farmers at first, so as to motivate them to adopt the new approach and provide hands-on training in cultivation practices. The initial hook for the farmers was more in terms of money savings and not as much about mitigating the environmental or social issues. The initial results were very encouraging and inspired other farmers to join the initiative. To scale up the effort:

- Farmers and their families were made aware of the Better Cotton Initiative (BCI) and the benefits linked to it.
- Farmers Field Schools and farmers were organized into learning groups to provide practical training
- Expert agronomists were brought in to guide at every stage
- Continuous monitoring was carried out and farmers were provided timely feedback by experts

DETAILS OF BCI

BCI exists to make global cotton production better for the people who produce it, better for the environment it grows in and better for the sector's future. It works with adverse range of stakeholders to promote measurable and continuing improvements for the environment, farming communities and the economies of cotton-producing areas. BCI aims to transform cotton production worldwide by developing Better Cotton as a sustainable mainstream commodity.

Source: www.bettercotton.org

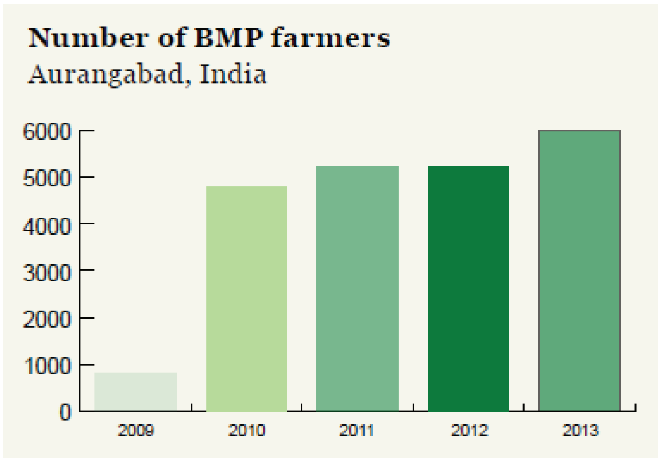
- Farmers were trained to use and handle plant protection chemicals safely
- Links to banking channels for farmers were facilitated
- Street plays and awareness campaigns on social issues such as child labour, health and safety, and employment conditions were organized.

Impact of BCI[xx]

Currently about 6000 farmers are linked with this initiative in Aurangabad, Maharashtra; they are promoting better farm management practices and techniques ensuring sustainable production. The scale and impact of the BCI initiative is captured in Figures 4 and 5. An impact assessment carried out by WWF in this region shows that:

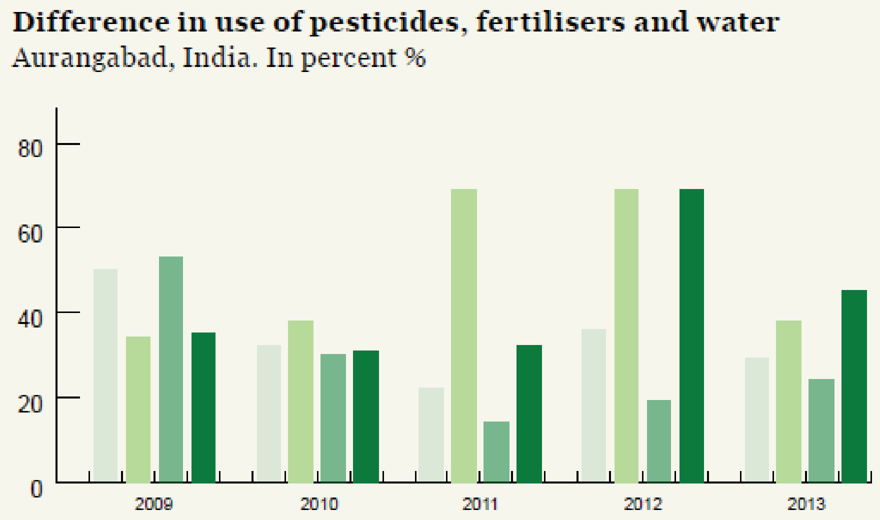
- Farmers now use 38 percent less pesticides than before
- Efficient irrigation practices have helped farmers use 24 percent less water which means less stress on the already scarce surface and ground water resources.
- Farmers now use 29 percent less fertilizers in cultivation thus helping preserve soil health and preventing chemical pollution.

Figure 4: Farmers engaged with BCI Initiative



Source: WWF & IKEA Project Report, April, 2014

Figure 5: Impact of BCI Initiative



Source: WWF & IKEA Project Report, April, 2014

- By applying better farming practices, farmers have got quick results in terms of increased crop yields and have reduced water usage while saving money. All this led to a 45 percent increase in gross profit margins of the farmers as compared to conventional farmers.
- Apart from these direct benefits, the farm level intervention also focused on issues like child labour, health and safety, and employment conditions for farm workers. Better earnings have increased the farmers' ability to send their children to school, access to better health care facilities and provide a better quality of life to their families.

Cotton is an important raw material for IKEA, and the company uses around 0.6 percent of the world's cotton production every year; they are therefore keen to promote sustainably produced cotton in their supply chain. IKEA currently uses 34 percent BCI cotton, but aims to use only sustainably produced cotton by the end of 2015.

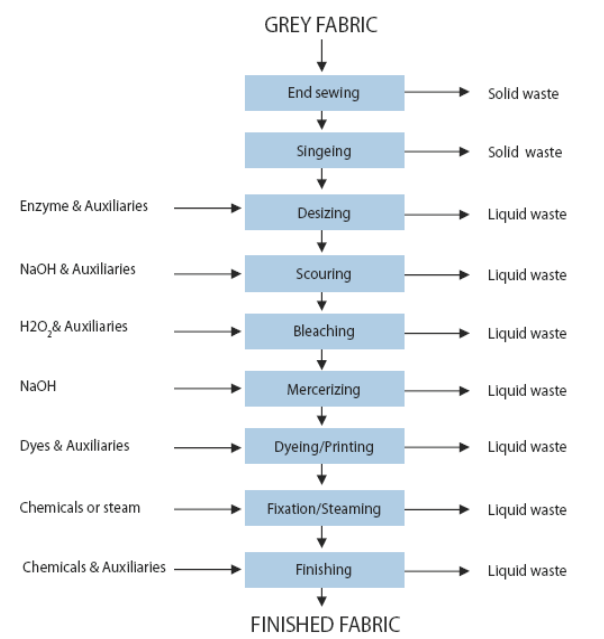
Promoting resource efficiency in Textile Production

To complement the BCI's efforts to promote greener cotton, the sustainability effort was extended up the supply chain associated with textile production. Detailed investigations and technical backstopping support were provided by IIP to enhance resource use efficiency in one textile production unit in Erode district of Tamil Nadu, one of the most important textile producing clusters in India. Handlooms, powerlooms, textile products and readymade garment industries contribute to the economy of the city leading to its nicknames, 'Textile City' and 'Loom City'.

The vendor studied is one of IKEA's largest Indian suppliers and houses all the important stages of textile production. The unit produces textiles for various IKEA products with all its raw material coming from farmers producing cotton under the Better Cotton Initiative. A major drawback of the textile industry in Erode is low level of investment in technology upgradation and modernization. The use of obsolete and outmoded machinery results in low efficiencies, high energy consumption and excessive water use. Effluent management is another significant challenge; Erode is located in a dry, water-scarce region, but the rapid expansion of the textile industry has been unplanned with no accompanying development of supporting infrastructure or institutional capacity. This has led to the depletion of groundwater reserves and a serious deterioration in environmental quality of both, surface and ground water. Large quantities of salt are used in the dyeing process leading to highly saline wastewater contaminated with a variety of chemicals. Owing to the absence of fresh water sources nearby, water is brought in by trucks from ground water sources as far as 50 km away at an enormous cost. The typical water consumption in Erode is 200 to 400 litres/kg of finished product, compared with the international norm of 120 to 150 litres/kg. Most of the bleaching and dyeing units in Erode are located in clusters along the banks of the Rivers Cauveri and Bhavani, into which they discharge the effluent. Industrial effluents stagnate in the riverbeds and percolate into the groundwater, polluting it. The bleaching and dyeing processes are the main sources of the pollutants comprising of caustic soda, hydrochloric acid, sodium hydro sulphate and peroxides. Contaminated water quality has in turn polluted the soil, with crop productivity falling drastically in the nearby agricultural belt. It is not impossible to foresee that as time passes, pollutants will percolate into the soil and groundwater causing irreversible environmental damage.

The approach to resource efficiency was therefore to focus on minimizing the water and energy footprint as also reducing waste and discharges of effluent. The unit selected for the pilot study is a medium sized wet processing mill, manufacturing a wide range of cotton and blended home textile products. The activities of the mill include sizing and warping of yarn, weaving, wet processing, printing and specialized finishing. In addition to its own production the unit undertakes job orders from global

Figure 6: Process flow diagram of the pilot unit



customers such as IKEA. The products manufactured include bleached, dyed, printed fabrics and bleached and dyed yarns.

Figure 6 depicts the process flow chart along with the input and output at each stage of fabric processing. Large amounts of energy are used in the unit along with water, directly, as well as in the form of steam for different wet processing stages.

Energy: Electricity and firewood are the primary sources of energy in the mill. The plant uses around 4 million units of electricity and 18000 tonnes of wood annually. Electricity is used to power equipment and machinery for drying, pumping, lighting, and office equipment (Figure 7).

Firewood is used in boilers to generate steam and for thermic fluid heaters. Diesel is used in the generator sets, which are standby power sources. The forms of energy and their use in the plant are summarized in Table 1.

Figure 7: Electricity use by different departments (KWh, percent)

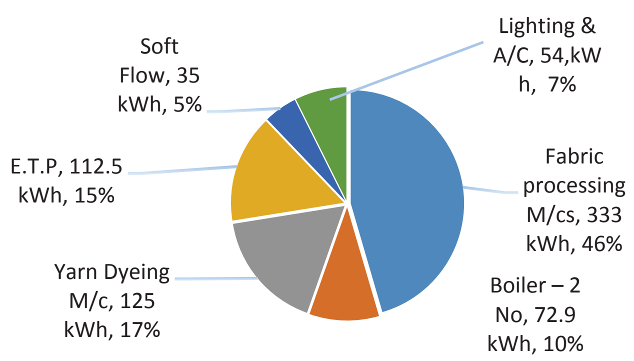


Table 1: Different forms of energy & water used in the Plant

Energy & Water form	Description of use
Process Steam (Direct steam)	Steam is distributed through pipelines to the fabric/baths during some wet processing stages such as chemical desizing, scouring, bleaching, mercerizing, and steam fixation of dyes and prints.
Heating Steam (Indirect steam)	Steam distributed through pipelines and indirectly applied to process and used for heating purposes such as drying cylinders, kiers, soft flow dyeing M/cs, yarn dyeing, and caustic evaporator plant.
Thermic fluid (Oil)	Used in stenters, printers for indirectly heating air which in turn is used for drying or heat setting.
LPG	Direct flame use for singeing

Water: Since the plant is a wet processing mill, large quantities of water are used at almost every stage of the production process. The main source of water is an open well. As per the zero discharge regulations applicable to the textile industry, the plant's treated effluent has to be diverted back to the well for recharging. The recharging is facilitated by an RO system. Table 2 shows section/ equipment wise water consumption in the plant.

The amount of water consumed varies widely and depends on the following factors:

- **Type of fabric being processed:** water consumption in textile operations varies with the fabric being processed. Typically, between 50 and 100 m^3 of water is used in processing woven fabric per tonne of production depending upon the operating sequence.
- **Management and work practices:** improper management and work practices also contribute to excessive water

Table 2: Water consumption in the plant

Equipment or Section	Total Water Consumption, KLD
Kiers	126
Jiggers	288
Padding Mangle	7.4
Rotary screen Printing	183.15
Print washer	80
Yarn dyeing	303
Mercerizing	25
Soft flow dyeing	279
TOTAL	**1291.55**

consumption. About 5-10 percent savings in water consumption can be achieved by applying good housekeeping measures and adopting efficient practices.

- **Type of process:** water consumption in textile operations vary widely between different equipment for the same process. Some dyeing methods consume large quantities of water (for example jiggers) while others have very low water consumption (such as pad-batch).
- **Machine type:** water consumption in different textile processing machines depends on the bath or liquor ratio (weight of bath water divided by weight of fabric).
- **Process control:** lack of adequate process controls (such as flow and level controls) also leads to avoidable water loss.

Waste and Effluent discharge: Almost all the chemicals and dyes used are carried over into the wastewater except the chemicals picked up by the fabric and yarn. Hence the wastewater from the pre-treatment washing and dyeing operations contains substantial pollution loads characterized by a high biological load, suspended solids (e.g. fibers and grease), dissolved solids and colours (i.e. dyes).

The Biological Oxygen Demand (BOD) level in the effluent varies between 1500-4000 ppm and the Total Dissolved Solids (TDS) vary from 7000 ppm to over 10000 ppm. Some of the chemicals released into the wastewater are highly toxic and hazardous posing a threat to human health and aquatic life. All the wastewater from the plant is collected in tanks and sent to a primary clarifier. Aeration tank takes care of BOD and Chemical Oxygen Demand (COD). Turbidity is removed in a tertiary clarifier; the next steps are ultra filtration and reverse osmosis (RO). TDS gets removed and the permeate is collected from all three stages of RO. The final reject from the RO is sent to an evaporator and the resulting salt slurry is stored in a shed. The solid waste arising from the primary clarifier is separated from the liquid in a filter press. The sludge is dried in an open bed and packed and stored under a closed roof. The sludge from primary treatment amounts to about 480 kg/day.

Towards resource efficient and cleaner production

In order to deal with the existing resource inefficiency and ensuing environmental issues, a thorough resource audit was carried out in the unit followed by developing a 'greening' action plan detailing the various measures. This action plan was presented to the unit, and using a consultative process involving the plant personnel and senior management, a prioritization exercise was carried out.

The plant was given technical backstopping support to implement the recommendations. An impact assessment was subsequently carried out to gauge the impacts of interventions implemented by the unit, those in progress and proposed.

Details of impact of some of the resource saving measures already implemented by the unit are as follows:

Insulation of Boiler Feed water tank

Annual reduction in firewood consumption = 134 Tonne

Annual savings = USD 6800

Investment = USD 4600

Simple payback = 8 months

Annual GHG reduction = 100 Tonne of CO_2

Variable Frequency Drive for Calendar Machine

Annual Electricity Savings = 20130 kWh

Annual savings = USD 2310

Investment = USD 2950

Simple payback = 15 months

Annual GHG reduction = 16.9 Tonne of CO_2

Single Shot Dyeing and Printing

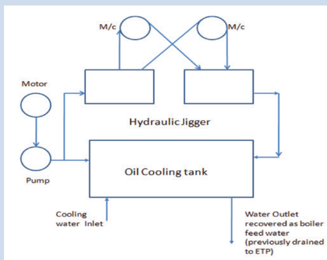
Annual thermal energy savings = 16.5 Gcal
Annual electricity savings = 7015 kWh
Annual savings = USD 22295
Investment = USD 33770
Simple payback period = 18 months
Annual GHG reduction = 6 Tonne of CO_2

Replacement of Surface Aerator with Diffused Aerator

Annual electricity savings = 108098 kWh
Annual savings = USD 9738
Investment = USD 34426
Simple payback period = 42 months
Annual GHG reduction = 101 Tonne of CO_2

Cooling Water Recovery from Hydraulic Jiggers

Annual water savings = 5.49 Million Litres
Annual electricity savings = 32105 kWh
Annual savings = USD 3672
Investment = USD 820
Simple payback = 3 months
Annual GHG reduction = 26.9 Tonne of CO_2



Recycling of Wash Water in Rotary Screen Printing

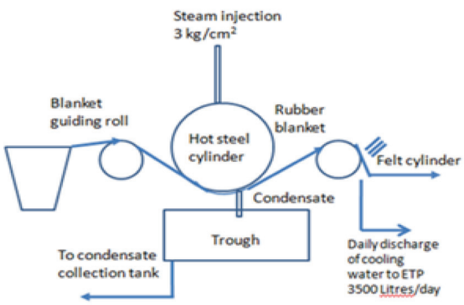
Annual water savings = 3.95 Million Litres
Annual electricity savings = 23040 kWh
Annual savings = USD 2623
Investment = USD 410
Simple payback = 2 months
Annual GHG reduction= 10.4 Tonne of CO_2

In addition to these, the plant also implemented the measures such as: energy saving in AC utilisation, insulation of bare steam line, worn out bearing used as wheel in yarn dying, VFD for screw compressor, boiler duct pipe work and Yarn dying feed water motor change. The cost of these additional measures was USD 6550, yielding an annual saving of USD 11,721 to the plant.

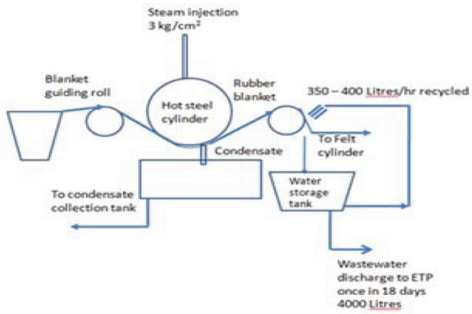
Cooling Water and Condensate Recovery from Pre-shrinking Range

Annual water savings = 0.86 Million Litres
Annual savings in water cost = USD 1803
Annual savings in electricity = 5005 kWh
Annual GHG reduction = 4 Tonne of CO_2

Net annual savings = USD 2393
Investment = USD 819.6
Simple payback = 4 months

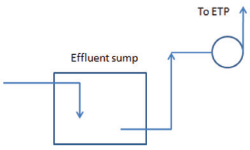


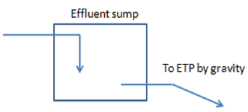
Before implementation

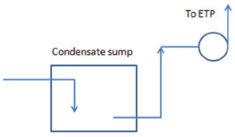


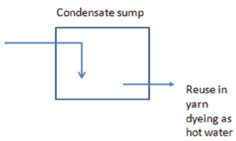
After implementation

Improvements in Yarn Dyeing Section







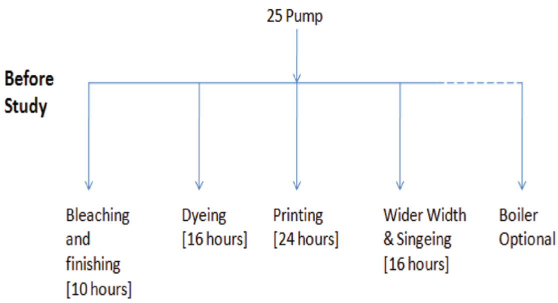


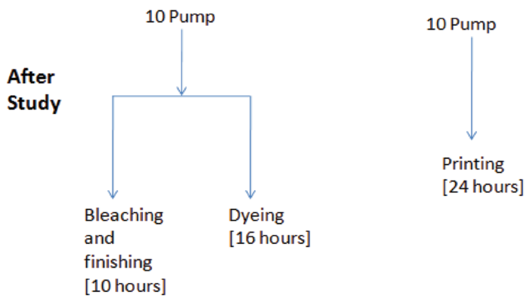
Before: Effluent pumped to ETP along with condensate

After: Effluent to ETP by gravity and condensate recycled in yarn dyeing as hot water

Annual electricity savings = 16331 kWh
Annual reduction in water (RO) consumption = 1.83 Million Litres
Annual cost savings = USD 5770
Investment = USD 2950
Simple payback period = 6 months
Annual GHG reduction = 8.9 Tonne of CO_2

Optimizing Well Water Pumping Energy





Annual reduction in water consumption = 30.5 million Litres
Annual electricity savings = 2857 kWh
Annual savings = USD 3115

Investment = USD 5328
Simple payback period = 21 months
Annual GHG emission reduction = 2.4 Tonne of CO_2

Table 3 summarizes additional resource conservation measures identified, which are yet to be implemented. For each of the measures, the table also provides information about energy savings, material savings, implementation cost, payback period and the corresponding CO_2 mitigation.

The vendor partner could save 51 million liters of water and 13015 Gcal energy, equivalent to annual monetary savings of INR 308 Million (USD 5 Million) in a year and greenhouse gas (GHG) mitigation to the tune of 3800 tCO2. The other co-benefits include reduced pollution of surface and ground water sources and the associated damage to the nearby agricultural fields. Less emission of harmful gases and fumes, better ventilation, enhanced natural lighting through use of acrylic sheets in factories and worker's quarter and clean drinking water has helped in improving the living and working conditions of the workforce. Better compliance of environmental guidelines and regulations has helped in providing stable livelihoods to the workers, by avoiding shutdown threats.

Table 3: Greening action plan to be implemented

Greening measure implemented	Investment (USD)	Annual Savings (USD)	Pay-back period (month)	Annual Fuel (thermal energy) Savings (Gcal)	Annual Electricity Savings ('000 KW)	Annual Water Saving (ML)	Annual CO_2 emission reduction (tonne)
Indirect steam use in Jiggers (under trial)	8606	5820	18	309	-	-	86
VFD for ID fan of boiler	820	1785	6	-	25.92	-	22
Insulation of drying cylinders (under trial)	1640	3212	6	169	-	-	47
VFD for ID fan of thermic fluid heater	574	1090	6		15.84	-	16
Maximizing condensate recovery	1640	3598	5	160.65	-	-	43
AFBC boiler with multi-fuel capability in place of exisiting firewood fired-boiler	24590	11917	25	5500	-	-	1700
Waste heat recovery from yarn dyeing machine	22950	10926	25	-	-	-	156
VFD for Stenter exhaust fan	1147	436	32	-	6.336	-	5
Centralized compressed air system in place of distributed system with piping size modification	14754	7304	24	-	111.39	-	94
VFD for thermic fluid circulation pump	820	718	14	-	10.426	-	9
Adopting Continuous Scouring and Bleaching Range and phasing out post-mercerized activities in jiggers	40983	20492	24	5.9	1453	10 -15 Litres/ kg	1221
Rain water harvesting plan (proposed)	5737	17550	-	-	-	8.235	

Table 4: Benefits expected from textile vendors of IKEA

Indicator	Over 3 to 5 years*
CO_2 mitigation achieved/opportunities identified (tCO_2)	188450
Policy changes catalysed	IKEA adopts 'greening of supply chain' policy as part of their sustainability protocol
Total Energy savings (Gcal)	650750
Water savings (million litre)	580
Energy savings (monetary terms) in million USD per annum	13.5
Total resource saving (monetary terms) in million USD per annum	308
Investments catalyzed (in million USD)	310
Partnerships being forged	With financial institutions (SIDBI) for loan facilitation

* The estimated benefit assumes reaching out to 80% of IKEA vendors in India

Scaling up Resource Conservation Measures

The supply chain greening approach in the textile sector represents a win-win situation. For the SME vendor and farmers involved in cotton growing, it means improved resource productivity, reduced wastages and higher profit margins. For a socially and environmentally conscious company like IKEA, it means a reduced carbon footprint for its operations. The co-benefits by way of social and environmental impacts are a bonus.

This successful demonstration has encouraged IKEA to internalize this approach with all its Indian vendors. IKEA has already set sustainability targets for its vendors for energy, water and raw material use as well as for the use of renewable energy. To motivate other Indian vendors to adopt project approaches in the textile sector, IKEA organized a 'Sustainability' workshop in which all major IKEA vendors were encouraged to follow similar approaches, where the benefits achieved by the participating unit were showcased.

This initiative holds the potential to reduce 0.12 million tonnes of CO_2 by 2015-16 by way of adopting the resource and energy efficiency models in about half of IKEA vendors located in India and may lead to the GHG mitigation of up to 0.32 million tonne by the year 2020, by expanding this initiative to their entire vendor base located in South Asia. The benefit streams of the IKEA model are captured in the table 4, highlighting the positive impacts not just on account of carbon mitigation but also on resource conservation.

Replication Potential

Every country in the South Asia region has a demonstrated comparative advantage in the textiles and clothing sector. They contribute to the core exports of these countries, are leading earners of foreign exchange and contribute significantly to manufacturing, employment and output. Despite this comparative advantage, South Asia's textile industry faces major sustainability issues with regard to degradation of its water resources from the discharge of polluted effluents; GHG emissions, and high energy use. All these threaten the existence of the sector in the long run. The industry is also threatened by global competition demanding technological upgradation as the South Asia textile sector is gradually losing its edge in profit margins due to cheap labour. Many global textile and clothing brands are becoming increasingly conscious of the water, energy and carbon footprint of their products in developing countries, demanding 'cleaner and greener' products.

The model demonstrated with IKEA in India has great scope for replication in other South Asian countries. Bangladesh, India, Pakistan and Sri Lanka, in particular, can take advantage through effective regional collaborations around knowledge transfers, and enhance the competitiveness of this sector, increasing their market share in the world.

Summary: Case Study 2

'Greening' the Brick Industry

Sector

South Asia's brick industry makes up for a major share in the global brick production. India, Pakistan, Bangladesh and Nepal along with China and Vietnam are among the top six brick producing countries of the world. The brick industry in South Asian countries also provides a very important source of livelihood for large number of rural poor during the dry summer months, when crop production yields little income. , The sector provides livelihood to around ten million people in India and about a Million each in Pakistan and Bangladesh.

Resources Inefficiency and Environmental Problem: The brick manufacturing as practiced in South Asia, is highly resource intensive and polluting owing to the prevalence of inefficient kilns and poor operating practices, with energy accounting for 35 to 45 percent of the total brick production cost. The other major problem is associated with massive use of top soil from fertile agricultural belt (annually, around 1145 million tonne of soil is used for making of bricks in South Asia) that threatens the food security of the region. With poor working conditions, occupational safety and health, drudgery, seasonal employment, children and gender issues, the sector is an ideal candidate for such interventions, offering tremendous scope for not only resource conservation but also for addressing far reaching social and environmental concerns.

Supply chain intervention

The case study highlights a climate-friendly fly ash brick (FaL-G) technology that produces bricks without using top soil and coal and completely eliminates carbon emissions. The technology patented in India also holds the promise of gainfully utilizing certain industrial hazardous wastes. To encourage its widespread adoption, the inventors of FaL-G are providing their technology without invoking the patent. Entrepreneurs who choose this technology are provided assistance with production techniques, training for workers, and advice on the marketing of bricks.

Impacts Achieved

- Over 16,000 FaL-G brick plants were in operation by March 2012 throughout the country, up from just 100 enterprises in 2000, producing bricks and blocks equivalent to over 48 billion standard bricks, generating a turnover of over INR 12000 crore annually (USD 1970 Million).
- FaL-G bricks have contributed to total savings of about 67 million M^3 of agriculture soil, equivalent to 7200 ha of fertile agriculture land with exploitative depth of 1m together with coal saving of 9.6 million tonne and gainful use of over 20 million tonne of fly ash which would otherwise have created serious health and pollution problem and got dumped as hazardous ash mounds and ponds. It has also resulted in abatement of over 11,520,000 tonne of CO_2.
- Stable year-round employment for over 200,000 workers nearer their homes, allowing their children to attend regular school (instead of seasonal, migratory employment in clay brick units). A sizeable number of women entrepreneurs are setting up FaL-G brick manufacturing plants (with low investment of INR 3 to 3.5 lakh or USD 5500).
- Assessment of 108 FaL-G brick plants shows that about 12 percent of revenues was allocated for improving the lives and working conditions of FaL-G plant labourers. Workers are covered by health and accident insurance, provided with protective gear for use at the workplace. They were also provided with toilets, showers, and drinking water facilities in the residential area along with awareness campaigns on HIV.

Replication potential

The manufacture of clay bricks is becoming increasingly unviable in South Asia given the spiralling costs of the clay (land) and fuel. On the other hand, ample opportunities exist for the growth of FaL-G brick technology with fly ash output bound to go up as a result of increase in coal-fired power plants already operational and those planned in the near future. Technology like FaL-G can help in dealing with the imminent threat of fly ash pollution while protecting agricultural land from getting converted in to barren infertile land. Policies initiated by the Government of India for promoting fly ash use in the brick industry will also find applicability in these countries grappling with similar conditions. For a country like Bangladesh (having more than 6000 brick kilns) which is embarking into a major coal based power plant drive, the timing of introducing this technology is just right. In Pakistan, with over 16000 kilns in operation, part substitution by FAL-G offers tremendous potential in terms of the benefits as outlined above.

CASE STUDY 2
'Greening' the Brick Industry

The brick industry has a prominent position in the South Asian economy. Rapid urbanization and high economic growth throughout the region has led to an increase in infrastructure development and therefore, a rise in the demand for construction and building material. In Bangladesh, the brick industry has grown at an average rate of 6 percent, and contributes to 1 percent of country's GDP[xxi], in Nepal it is growing at a rate of 7 percent and contributes to 1.41 percent of the GDP. In India, the brick industry is expected to grow at a rate of 6.6 percent till 2030, by when it is expected to become five times its current size[xxii]. South Asia's brick industry also contributes a major share to the global brick production. India, Pakistan, Bangladesh, and Nepal along with China and Vietnam are among the top six brick producing countries of the world. These six countries also represent 75 percent of Asia's population and are home to almost 60 percent of world's poor[xxiii] (Figure 8).

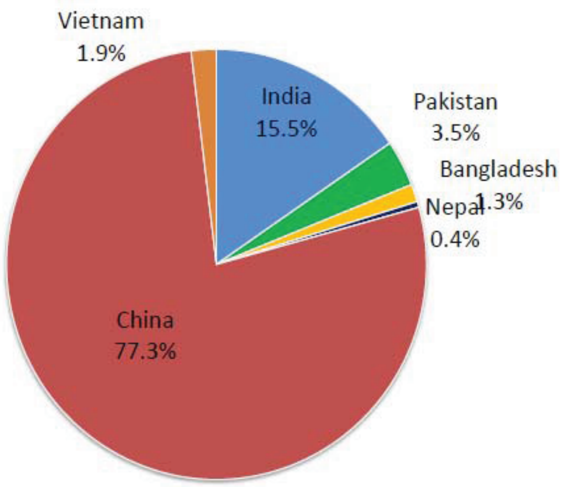
The brick industry in South Asian countries is a very important source of livelihood for large numbers of the rural poor during

- High growth rates in South Asia are driving infrastructure growth and demand for building materials like bricks
- Brick sector is important for supporting growth and generated livelihoods, but it is highly polluting with negative social and environmental impacts
- Highly resource inefficient (excessive use of soil, water and coal): between 35 and 45 percent of the cost of brick production is due to energy. Massive use of top soil from fertile agricultural belts threatens food security
- Social issues linked to brick making are occupational safety and health, drudgery, seasonal employment, child and gender issues
- Potential for promoting alternative technologies reducing the use of fertile top soil, energy use, minimizing emissions and enhancing operational efficiency
- High replication and knowledge sharing potential

Figure 8: Global Brick production & share of Asian countries

Total estimated global brick production = 1500 billion bricks per year

Country	Billion bricks/year
China	1000
India	200
Pakistan	45
Vietnam	25
Bangladesh	17
Nepal	6
Total Asia	**≈1300**

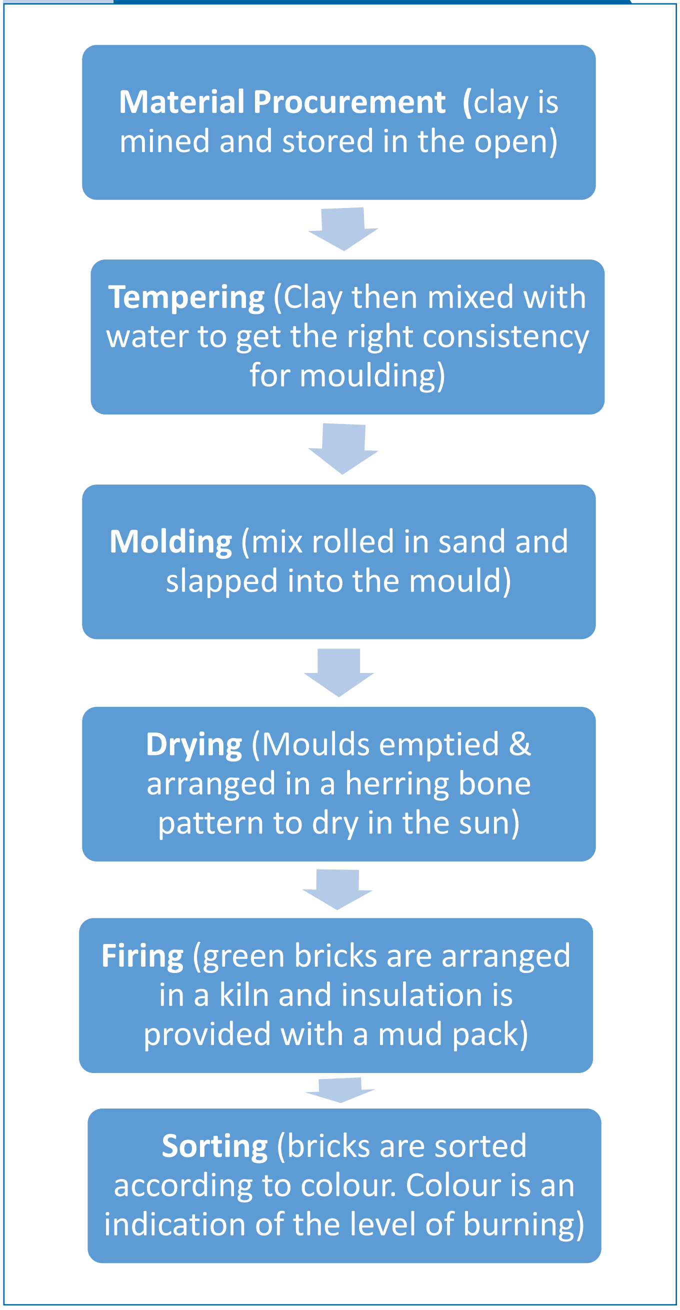


Source: India: GKSPL Estimate, Pakistan: Estimate based on CIWCE report Lahore, Bangladesh: ESMAP & World Bank Report, China: Bangladesh ESMAP & World Bank Report, Vietnam: Ministry of Construction, Vietnam the dry summer months, when crop production yields little income. In India, around eight and ten million people work in brick kilns and in Bangladesh brick kilns employ an estimated one million people.

But these facts about the brick industry in South Asia are overshadowed by the fact that they are highly resource intensive and polluting owing to the prevalence of inefficient kilns, and have far reaching social, environmental and economic consequences. The brick making clusters are sources of local air pollution that affect local populations; they destroy agricultural soil and vegetation and, at a global scale they also contribute to climate change.

The brick sector in South Asia is characterized by traditional firing technologies; reliance on manual labour and low mechanization rates; dominance of small-scale brick kilns with limited financial, technical and managerial capacity; dominance of a single raw material (clay) and product(solid clay brick); and a lack of institutional capacity for the development of the sector. The most commonly used kiln in South Asia is the Bull's trench kiln (BTK), which uses very simple technologies that are extremely resource inefficient and highly polluting. Nevertheless, this kiln is commonly used because of the high profit margins associated with its operation and low initial investment. In the context of social and environmental issues, the brick industry has been a largely overlooked sector in South Asia and there is room for significant action.

Figure 9: Typical brick making process



Resource Inefficiency, Social and Environmental Problems

Inefficient Resource Utilization

The brick making process is highly dependent on natural resources such as soil, water, coal and biomass, and cheap access to these resources has resulted in their over exploitation. The scale of abuse of some of these resources and the resulting damage is described below:

Soil

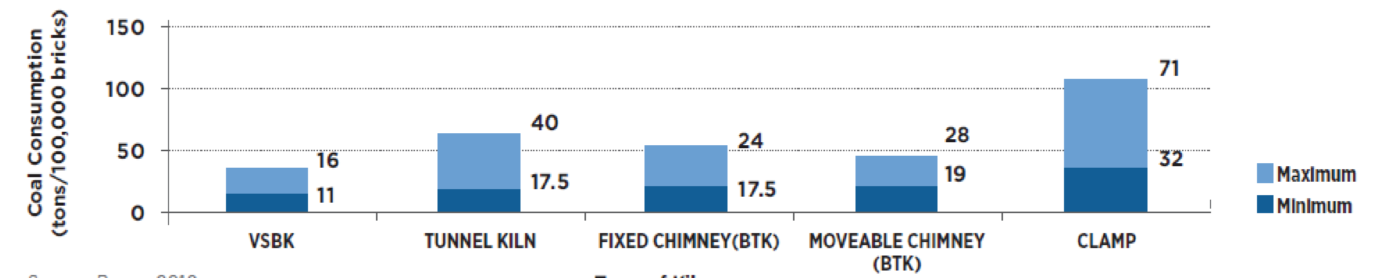
The primary raw material for the brick industry in South Asia is clay which is derived from top soil, mostly in the fertile agricultural belts. On average, 1145 million tonnes of soil is used for making bricks in South Asia, and this figure is expected to rise with growth in the construction sector. The brick industry therefore competes with agriculture for resources; the depletion of arable land due to brick making is a matter of concern for food security of growing population in the region.

Traditional kilns occupy 3-4 ha of land area which is subjected to high temperatures making it unfit for agricultural activities after the site is abandoned (operational life of 8-12y). Areas with large concentrations of brick kilns also suffer from other types of land degradation, which can affect the ecology of the area and adversely affect human health and vegetation[xxiv]. Brick-making alters the physicochemical properties and habitats of nearby soils by destroying nutrients in the top soil and soil biota, which are likely to impact species diversity and the biomass structure of the neighbouring plant communities.

Coal

With an average consumption of 180 tonnes of coal per million bricks, the brick sector in South Asia consumes about 47.50 million tonnes of coal per year. In addition, it also consumes several million tonnes of biomass fuels. The share of energy in

Figure 10: Coal consumption by Kiln Type



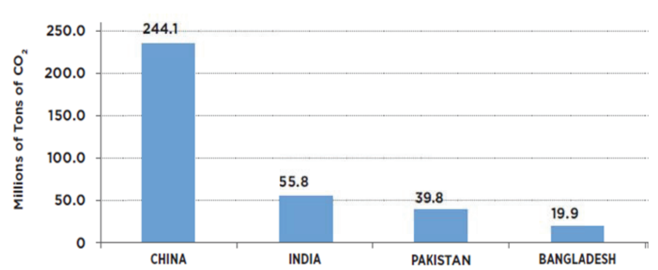
Source: Baum, 2010.

total cost of brick production is 35-45 percent. But, significant coal savings can be realized through better kiln design and better control of kiln operation.

Air Pollution

With unabated increase in the price of coal and high costs of transportation, the brick industry has had to resort to using poor grades of coal. The combination of poor coal and inefficient combustion technologies causes high levels of air pollution in terms of carbon monoxide (CO), sulphur dioxide (SO_2), oxides of nitrogen (NOx) and suspended particulate matter (SPM). Brick making is a major source of SPM emissions in South Asia. While the emission standards for SPM range between 750 mg/Nm^3 and 1000 mg/Nm^3, the actual emissions exceed the norm by a huge margin[xxv]. Large amounts of environmentally damaging bottom ash residue also result from coal use in brick firing. Apart from these local pollutants, brick making also contributes significantly to global pollution as can be seen from Figure 11, which shows CO_2 emissions in major brick producing countries.

Figure 11: CO_2 emissions from Brick Industry



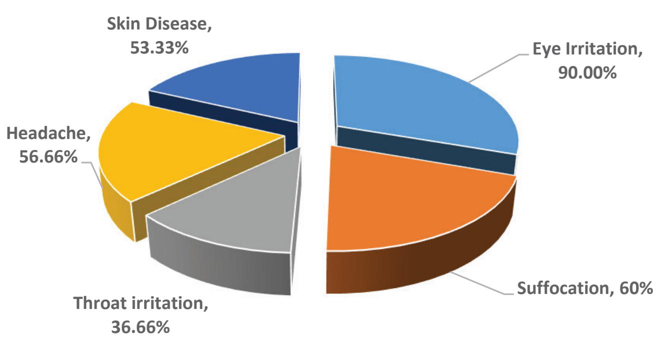
Poor Living Conditions

The brick market operates on tight margins and when this is coupled with rising costs of energy, the result is poor remuneration for most workers. The families of workers also face poor living conditions since children accompany their parents to the workplace, usually located away from settlements, instead of attending school[xxvi]. Families, including young children therefore work and live in harsh conditions lacking access to clean drinking water and sanitation.

Health Impact and Occupational Hazards

Brick workers are exposed to high concentrations of Respirable Suspended Particulate Matter (RSPM). Brick making also involves use of crude techniques causing considerable worker drudgery. Brick workers, especially moulders, are exposed to the sun for long hours. They are exposed to high concentrations of dust when breaking coal. Workers run the risk of exposure to dust (from bottom ash spread on the kiln) and open fires during manual coal feeding. The workers have to walk on hot surfaces (on top of the furnace) while monitoring and regulating the fire. Even though brick workers are exposed to these occupational hazards, coverage under any sort of insurance or medical facilities is not present[xxvii]. A research survey done in Parbhani District (Fig: 12) in India shows that 30 to 90 percent brick kiln workers suffer from a variety of health problems.

Figure 12: Percentage people suffering from health problems in brick kilns*



*Based on research carried out to study the environmental impact of brick kilns in Jintur area of Parbhani district (Pawar Vijay Kumar B. et.al)

Seasonal Livelihood

Due to the seasonal nature of the brick industry, its workforce is employed for a limited period of six months each year, closing down in the peak summer and monsoon. During this period, workers must to look for other ways of earning money, usually as labourers in agricultural fields. When the next brick making season arrives, they are not sure of employment in the same kiln. Therefore this community has to look for a job twice a year. The brick worker is typically brought in by a contractor. Since they

TRADITIONAL BRICK KILN TECHNOLOGIES

Brick Kilns can be classified as intermittent and continuous. The continuous kilns are more efficient as they have heat recovery features from both the heat in fired bricks and flue gases unlike the intermittent ones.

Intermittent Kilns: The oldest technology is the clamp. Clamps are temporary constructions made of green bricks or clinker. Certain brick makers use permanent clamps made of refractory bricks. Two basic variations of kilns are the updraft and the downdraft kilns. The updraft ones have flues running through the floor of the kiln with spaces between the stacks of bricks to allow heat to circulate, while the top is covered for insulating the kiln. The downdraft ones are circular with the flue running from the floor to the chimney stack. The hot air is then directed downwards from the dome through the stacks of bricks.

Continuous Kilns: Continuous Kilns can be based either on the principle of moving fire or on moving ware. The Hoffman, BTK and Zig-zag work on the principle of moving fire. In the Tunnel and VSBK, the firing zone remains constant while the bricks move.

- **Hoffman's Kilns:** The circular arched tunnel surrounding the chimney has various chambers where green bricks are placed and the fuel is added via vents in the roof.
- **Bull Trench Kiln (BTK):** Bricks to be fired are arranged in a trench and tall movable metal chimneys are placed on the brick setting. They are moved as the firing progresses. This is now being increasingly replaced by fixed chimney BTKs.
- **Habla Zig-Zag Kiln:** The bricks are arranged such that hot flue gases move between them in a zig-zag manner resulting in better heat utilisation and energy efficiency.
- **Vertical Shaft Brick Kiln (VSBK):** The kiln consists of one or two shafts in a rectangular structure insulated with agriculture residue and clay. The shaft is loaded from the top in a pre-determined pattern. After being fired in the shaft they are removed batch wise from the bottom via an unloading tunnel.

are not on the payrolls of the kiln owner, they are not covered under the prevalent labour laws, such as the Minimum Wages Act[xxviii].

Governments have often tried to clamp down on the industry for its impact on agricultural land and the environment but were never successful because no alternative, cleaner technologies with the potential for widespread adoption were available. One improved technology, the VSBK, developed in China and piloted in Nepal, was promoted in the South Asia region, but did not meet much success. A number of technical problems encountered in Nepal dissuaded the scale up of this technology. It was later piloted in Bangladesh, where it faced similar technical problems. In Pakistan it did not succeed because the quantum of production from a VSBK was much lower than that from a BTK and therefore it did not get established as an alternative to the BTK or Clamp[xxix]. In India, the VSBK technology has been successful in some areas but has also not been able to make a mark for itself.

Two Indians have invented a climate-friendly fly ash brick technology that produces bricks without using soil and coal and completely eliminates carbon emissions. It also helps in effectively dealing with hazardous waste produced in other industries. The following case study details this innovation, which has the potential to effectively deal with all the environmental and resource efficiency issues in the South Asian brick industry. Although this green option cannot replace traditional brick making completely, it has the potential to work as a substitute in selected pockets. The case study is based on an initiative of the Institute for Solid Waste Research & Ecological Balance (started by the inventor of fly ash brick technology), which has also been supported by the World Bank.

Indian Brick Sector: An Overview

The construction industry contributes to about 10 percent of India's GDP, registering an annual growth of about 6-7 percent. Clay fired bricks form the backbone of the construction industry valued at approximately US$ 70.8 billion. The brick sector in India, although unorganized, is huge in size and spread. India is the second largest brick producer (China dominates with a 54 percent share) in the world. It is continuously expanding on account of a rapid increase in demand in the infrastructure and housing sectors. In order to meet this demand, over 100,000 brick units have come up in the country, providing direct employment to around 10 million workers[xxx].

India produces around 200 billion bricks per year, consuming, in the process, around 520 million tonnes of fertile agricultural soil. Considering that the majority of the bricks produced will be burnt clay bricks, this volume of production will require about 270-280 million m^3 of agricultural soil. This is equivalent to around 30,000 hectares of fertile agricultural land, with the exploited depth being 1 m. Such exploitation will have a tremendous impact on national food security.

As per the widely adopted technique for brick making, bricks are fired to a temperature of 700-1100 °C, requiring a large amount of fuel. Brick kilns are estimated to consume roughly

25 million tonnes of coal per year, thus making them among the highest industrial consumers of coal in the country[xxxi]. The total carbon dioxide emission from brick production is estimated to exceed 50 million tonnes, accounting for 4.5 percent of total GHG emissions in India[xxxii].

The large amounts of coal used are also responsible for high SPM emissions. Overall, it is estimated that brick making in India accounts for about 60 percent of black carbon emissions from the industrial sector, and 9 percent of black carbon emissions from all Indian emissions sources[xxxiii]. Thus the Indian brick industry has a highly resource inefficient supply chain right from excavation of top soil used as a raw material to the processing technology that uses large amounts of coal and water, having far reaching social and environmental impacts.

While dealing with the issue of land degradation and other environmental issues associated with the brick industry, India also faces problems with fly ash disposal. About 72 percent of India's present power generation capacity is coal-based. Indian coals are characterized by a high ash content (35 to 48 percent) and low calorific value (3,500 to 4,000 Kcal/Kg), and its use is accompanied by a number of problems including that of fly-ash generation. In 2011, 131 million tonnes (mT) of ash was generated from 407 million tonnes of coal[xxxiv.] This fly ash is dumped on large parcels of land, damaging both the environment and the health of populations around power plants. However, on a promising note, this fly ash can be used for making a variety of building materials such as bricks, blocks, cellular concrete, tiles, and Portland pozzolana cement.

This case study demonstrates how a conducive policy environment an alternative technology based on fly ash utilization can make the brick industry resource efficient and eliminate the use of top soil and energy, while having a positive social and environmental impact.

An Innovative Supply Chain Intervention for Greening the Brick Industry

Although the use of fly ash in brick making is not new, two Indians, Dr N Bhanumathidas and N Kalidas, have invented a new climate-friendly technology that produces bricks without using coal. The new method, known as FaL-G or Fly ash-Lime-Gypsum has the potential to completely eliminate carbon emissions from India's large brick-making industry which burns huge amounts of coal and emits millions of tonnes of carbon dioxide each year[xxxv].

Another significant benefit of the new technology is that unlike clay bricks that use valuable top soil as raw material, the new method uses fly ash, an environmental menace that currently occupies over 125,000 acres of land. Putting fly ash to productive use thus reduces water, air, and soil pollution and respiratory problems of the populations living near thermal power plants.

The productive use of fly ash becomes particularly important in light of India's plans to use coal to expand power production. With this, the generation of fly ash is set to increase while the availability of top soil is bound to decrease. A further advantage is that fly ash bricks can be produced in a variety of strengths and sizes. This means that apart from their conventional use in building walls, etc., fly ash bricks can also be used for the construction of a variety of infrastructure projects such as roads and pavements, dams and bridges. This technology can be used to produce bricks throughout the year eliminating the problem of seasonality of employment for the workers engaged in brick making[xxxvi].

Given the numerous benefits of the new fly ash brick technology, the inventors are allowing its use without invoking the patent. Recognizing the importance of restricting the excavation of top soil for manufacture of bricks and promoting the use of fly ash in brick making, the Government of India has taken several measures to promote it.

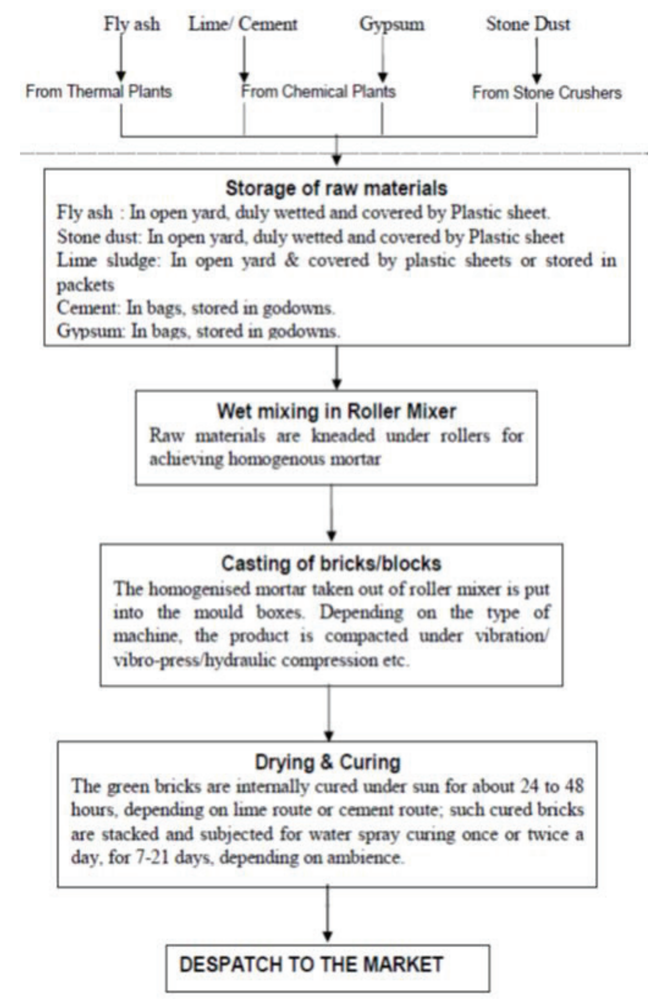
GOI DIRECTIVE ON USE OF FLY ASH FOR BRICK PRODUCTION

In order to protect environment, conserve top soil and prevent the dumping and disposal of fly ash discharged from coal or lignite based thermal power plants on land, a notification S.0.763 (E) was published in September, 1999. It restricts the excavation of top soil for manufacture of bricks and promotes the utilisation of fly ash in the manufacture of building materials and in construction activity within a specified radius of fifty kilometres from the thermal power plants. The notification was further modified in November 2008 (S.O. 2623 (E)) such that all construction activity within 100 km shall use only fly ash based products. Exemption of excise duty on all products using Fly ash and phosphogypsum resulted in widely scattered production of flay ash and gypsum based bricks/blocks.

A World Bank Project is helping to promote the new method by enabling entrepreneurs to earn carbon credit revenues to offset some of their initial costs.

Fly Ash bricks are being promoted effectively as an alternative to burnt clay bricks in India's construction sector. Fly ash is mixed with two other ingredients available as industrial by-products: lime from the acetylene industry, and gypsum from chemical plants. This is proving to be a revolutionary invention that produces bricks without the sintering process and consequently, no greenhouse gases are emitted. Fly ash bricks are now gaining popularity with builders and engineers because of their high strength, uniform quality and the lower requirement of mortar plastering; they are also seen as being eco-friendly.

Figure 13: Typical supply chain of FaL-G brick



Source: PDD: India FaL-G Brick and Blocks Project No.6

The process flow chart for making Fal-G bricks is shown in figure 13. These bricks are available in serval load bearing grades and reduces plastering costs by 30 percent and brings down the consumption of cement mortar by 60 percent[xxxvii]. Their high compressive strength eliminates breakages/ wastages during transport and handling. The cracking of plaster is also reduced because joints are less thick and plaster and basic material of the bricks are more compatible with cement mortar.

Fly ash is a mixture of silica, aluminium, iron oxides, calcium, magnesium, arsenic, mercury, and cadmium, and poses serious environmental and health hazards to large population. However, in the form of bricks, fly ash changes into a non-toxic product when mixed with lime at ordinary temperatures (as calcium silicate hydrates) and forms a dense composite inert block. The relative advantages of these bricks over the conventional clay types are shown in Table 5.

However, the wider adoption of FaL-G brick technology is proving to be a challenge. Clay brick production remains a popular family business in India, with no incentives to innovate or modernize. Moreover, manufacturers still have to bear the cost of transporting fly ash to their production sites. In contrast, top soil for making clay bricks is easily available around production sites.

To encourage the widespread adoption of this environment friendly technology, the inventors of FaL-G are providing their technology without invoking the patent. For entrepreneurs opting for this technology are provided assistance with production techniques, training and advice on the marketing of bricks. Though the Bureau of Energy Efficiency (BEE), under the Ministry of Power encourages use of eco-friendly construction materials such as fly ash bricks, its guidelines are voluntary. Experts feel that if BEE's green building regulations become mandatory the annual demand for fly ash bricks would be about 370 million units, which would increase the production of fly ash brick by 1.5 to 2 times[xxxviii].

Success in Mainstreaming Fal-G Technology[xxxix]

The inventors' decision not to invoke the patent to facilitate the diffusion of FaL-G technology has paid off:

Table 5: Advantage of FLY ASH Bricks over CLAY Bricks

Clay Bricks	Fly Ash Bricks
Varying colour as per soil	Uniform pleasing colour like cement
Uneven shape as hand made	Uniform in shape and smooth in finish
Lightly bonded	Dense composition
Plastering required	No plastering required
Heavier in weight	Lighter in weight
Compressive strength is around 35 Kg/cm^2	Compressive strength is around 100 Kg/cm^2
More porous	Less porous
Thermal conductivity 1.25–1.35 W/m^2 ^{o}C	Thermal conductivity 0.90-1.05 W/m^2 ^{o}C
Water absorption 20-25 percent	Water absorption 6-12 percent
Causes local and global pollution	Eliminates pollution in brick making
Uses top soil and fossil fuel	Eliminates the use of top soil and fossil fuel

- Over 16,000 FaL-G brick plants were in operation by March 2012 throughout the country, up from just 100 enterprises in 2000 producing bricks and blocks equivalent to over 48 billion standard bricks, generating a turnover of over INR 12000 crore annually (at a conservative average of INR 3 per brick) and resulting in the abatement of over 11,520,000 tonne of CO_2.
- Fly ash bricks account for about one sixth of India's annual brick production.
- FaL-G bricks have contributed to total savings of about 67 million M^3 of agriculture soil, equivalent to 7200 ha of fertile agriculture land with exploitative depth of 1m together with coal saving of 9.6 million tonne and gainful use of over 20 million tonne of fly ash which would otherwise have created serious health and pollution problem and got dumped as hazardous ash mounds and ponds.
- The timely flow of carbon revenues through the World Bank project has helped in increasing the participation of microenterprises.

CONTRIBUTION PER MILLION FaL-G BRICKS

- Conservation of top soil : 3500 tonne
- Conservation of coal : 200 tonne
- Abatement of CO_2 : 270 tonne
- Net profit ratio : 15 percent
- Average Rate of return : 38 percent

- FaL-G technology is providing workers a stable year-round income nearer their homes and allowing their children to attend regular school, giving them reason not to migrate to a city.
- Assessment of 108 FaL-G brick plants shows that about 12 percent of revenues was allocated for improving the lives and working conditions of FaL-G plant laborers. Workers are covered by health and accident insurance, provided with protective gear for use at the workplace. They were also provided with toilets, showers, and drinking water facilities in the residential area along with awareness campaigns on HIV.
- Stable year-round employment for over 200,000 workers nearer their homes, allowing their children to attend regular school (instead of seasonal, migratory employment in clay brick units). A sizeable number of women entrepreneurs are setting up FaL-G brick manufacturing plants (with low investment of INR 3 to 3.5 lakh or USD 5500).

Replication Potential

The need for establishing linkages among our scarce resources and development is more fundamental now. These challenges will be acutely felt in South Asia, where land and water are already under intense pressure and demand for food is increasing - the average farm size in South Asia has decreased from 2.2 Ha in the 1970s to 1 Ha today. As the brick sector is growing there will be competing demand for agricultural land, which is expected to tilt in the favour of brick industry due to the prevalent political economy and powerful contractors managing the industry. This may severely impact the food security of the rising population in the region.

Besides, the manufacture of clay bricks is becoming increasingly unviable in South Asia given the spiraling costs of the clay (land) and fuel. On the other hand, ample opportunities exist for the growth of FaL-G brick technology with fly ash output bound to spiral as a result of South Asia's planned increase in coal-fired power plants. The countries in the region are grappling with the issue of safe disposal of fly ash generated by thermal power plants and other industries. In Bangladesh, it is estimated that the generation of fly ash would reach an alarming level of 9.5 million cubic feet by 2018 once all its planned thermal power plants become operational[xli]. Pakistan, generates 55680 m^3/hr of fly ash[xlii]. Technology like FaL-G can help in dealing with the imminent threat of fly ash pollution while protecting agricultural land from getting converted to barren un-fertile land. Policies initiated by the Government of India for promoting fly ash use in the brick industry will find applicability in these countries grappling with similar conditions. For a country like Bangladesh (having more than 6000 brick kilns) which is embarking into a major coal based power plant drive, the timing of introducing this technology is just right. In Pakistan, with over 16000 kilns in operation, part substitution by FaL-G offers tremendous potential in terms of the benefits as outlined above.

Summary: Case Study 3
Greening the Steel Re-Rolling Sector

Sector

The steel re-rolling in this region largely dominated by small and medium enterprises, employing a huge workforce. Currently, there are around 2500 steel re-rolling mills of various sizes operating in the region providing livelihoods to millions of people both directly and indirectly along its supply chain. In Bangladesh, it caters to 80 percent of the country's steel needs and provides direct employment to 30,000 and indirect employment between 100,000 and 200,000 people. In Pakistan steel re-rolling industry accounts for up to 15 percent of Pakistan's steel production. The case study, which is based on a scrap based re-rolling industry cluster sourcing its raw material from ship breaking yard is unique in many ways and would find a direct application for similar clusters in neighbouring countries.

Resources Inefficiency and Environmental Problem: The steel re-rolling sector in the region is characterized by high specific energy use and poor environment performance because of outmoded and badly designed furnaces, poor operating practices and lack of technical manpower. In addition to high fuel usage, the units also end up wasting large amounts of raw material on account of high scale losses. The workers are exposed to very harsh and difficult working conditions not only in the re-rolling plants but also in ship breaking yards that provide raw material for these rolling mills. The industry is in desperate need for solutions that not only conserve energy and raw material, thereby improving profitability and productivity, but also to tackle environmental issues by way of improving the workplace environment and addressing the local pollution concerns.

Supply chain intervention

The initiative focuses on enhancing energy and resource efficiency in the Steel Re-rolling cluster of Bhavnagar, in India. The raw material for the industry is sourced from the nearby Alang ship breaking yard. With a capacity of about 4.58 million tonne per year, Alang is one of the biggest ship breaking yards in Asia. The intervention focused on effective disposal of hazardous waste generated through ship dismantling by using it as a fuel in place of coal in cement production leading to resource saving as well as avoiding potential health and social impacts for the workers and the nearby community. At the level of steel re-rolling unit, the intervention was focused on demonstrating an energy efficient reheating furnace that saves coal and steel through improvement in thermal efficiency and reduction in scale losses respectively.

Impacts Achieved

- Safe handling and disposal potential for 3285 tonne per annum of hazardous wastes produced from ship breaking activity by blending it along with municipal solid waste generated in Bhavnagar municipal area which otherwise can cause damage to land, water and biodiversity along with health impacts by co-processing in cement manufacture .
- The participating small steel re-rolling mill benefitted from coal saving of 22 kg per tonne of steel produced, which is equivalent to 330 tonne of coal annually. Along with this, the oxidation loss reduction of 1.6 percent resulted in savings of 240 tonne of steel annually.
- Training of workers on safe handling of hazardous waste helped in reducing the number of accidental deaths.

Replication potential

The small steel re-rolling units have mostly mushroomed in clusters in the South Asia region with a great deal of similarity between the units within a cluster in terms of the level of technology, operating practices and even trade practices. This allows the possibility of developing standard solutions which enhances the chances of replication/scale up. The Bhavnagar experience, where the raw material is being sourced from Alang ship breaking yard, is of direct relevance to large number of small and medium sized steel re-rolling mills in Bangladesh and Pakistan, where the raw material is sourced from ship breaking yards in Chittagong and Gidani respectively.

CASE STUDY 3
Greening the Steel Re-Rolling Sector

The steel re-rolling sector holds an important position in South Asia, firstly because of its raw material supply chain from ship-breaking, for which this region is the largest hub with 70 percent of the global market share. Secondly because the steel re-rolling industry caters to the majority of the steel demand in these countries and supports infrastructure growth and construction industry.

India has one of the world's largest ship-breaking industry in the world with 40 percent of ships dismantled in 2012 (497 ships); Bangladesh scrapped 230 ships in 2012, or 18 percent of the global activity while Pakistan dismantled 124 ships, or 10 percent[xliv]. Re-rolling of ship scrap is done by the steel re-rolling industry to produce a variety of finished products. With the economy booming and the construction industry in particular accounting for almost 10 percent of GDP in the South Asia region, the scope of the steel re-rolling industry is huge. Currently, there are around 2500 steel re-rolling mills of various sizes operating in the region providing livelihoods to millions of people both directly and indirectly along its supply chain. For example, in Bangladesh, the steel re-rolling industry depends greatly on the Sitakund ship-breaking yard in Chittagong, caters to 80 percent of the country's steel needs, and contributes to the production of other industries such as cement and construction materials[xlv]. According to local reports, the industry provides direct employment to about 30,000 people and indirect employment between 100,000 and 200,000 in Bangladesh[xlvi]. The Gadani ship breaking yard in Pakistan has an output of 500,000 tons per year and the steel re-rolling industry accounts for up to 15 percent of Pakistan's steel production. The Alang ship-breaking yard in India supplies raw material to SMEs engaged in steel re-rolling that provides direct employment to 35,000 people. These SMEs constitute an important link in the overall supply chain of steel, contributing more than 57 percent of steel produced and 65 percent of long steel products in India.

Table 6: No. & tonnage of ship dismantled in South Asia & China (2008)

Country	No. of vessels	Tonnage (in '000 GT)
Bangladesh	170	4,178
India	198	2,548
China	38	928
Pakistan	25	374

Source: Lloyd's Register, 2008. Ships size coverage: 100 gross tonnage and over

- The steel re-rolling sector is a key link in the supply chain of iron and steel production.
- It is an important sector in India, Bangladesh and Pakistan. Most units belong to the small and medium industry category employing a huge workforce, both directly and indirectly.
- There are tremendous opportunities for saving fuel and raw material through technology modernization. This would also lead to lower pollution loadings (local as well as global) and improved workplace environment.
- The case study, which is based on a scrap steel rolling cluster sourcing the raw material from a ship-breaking yard would find a direct application in Bangladesh and Pakistan.

Although steel re-rolling is an important sector in the region, they are characterized by high energy usage, GHG emissions, resource intensive processes, and the use of poorly designed furnaces, that lead to very poor energy and environmental performance. The ship breaking industry in South Asia has been under pressure because of alleged abuse of the environment and occupational health hazards. It is seen as a polluting industry that has adverse effects on ecosystems.

VALUE OF DISMANTLED SHIP

When broken, a ship yields nearly 70 percent of its light displacement tonnage (LDT) as re-rollable steel scrap. Another 6 to 10 percent of its LDT weight constitutes melting scrap. There is a weight loss of 10 percent due to rusting and other wear and tear. Of the remaining 10 percent, about 1 percent is furniture, 5 percent is machinery (generators and appliances), 1 percent is non-ferrous scrap, about 0.6 percent is used diesel oil, and 0.5 percent is other waste material.

Source: Iron Steel Scrap and Ship Breakers' Association of India (ISSAI), Mumbai, 2006

Resource Inefficiency and Environmental Issues

A large segment of this sector belongs to the category of small industries and represents an ideal situation wherein substantial improvement in resource use efficiency can be realized through properly designed interventions.

Low efficiency of energy use and highly polluting: Steel re-rolling mills have grown haphazardly, utilizing outdated technologies, and are characterized by high production costs and low investments in upgrading technologies. The specific thermal energy consumption in oil-fired furnaces is in the range of 45 to 85 litres per tonne of finished product. In coal fired furnaces, it is in the range of 125 to 400 kg. The specific electrical energy consumption is in the range of 100 to 300 kWh per tonne of finished product. This is quite high in comparison to the energy usage in re-rolling mills of developed countries. The energy consumption in Indian steel rolling mills using fuel oil is 1.8 times, and, in mills using coal, 3 times that of such mills abroad. The corresponding CO_2 emissions in India are estimated to be 3 times higher than those in developed countries such as Japan.

Raw material wastage: Rolling mills in the region are generally wasteful of raw material; losses result from high scale or oxidation losses. The main reason for this loss of raw material (which can be as high as 6 percent after the reheating operation) is uneven heating of the raw material because of poorly designed reheating furnaces and lack of furnace control. This represents a significant material loss and also loss of revenue for the mill owners.

Hazardous working condition: Steel re-rolling mills have very harsh (excessive heat and high temperatures) and difficult working conditions. Accidents are common as workers generally don't use protective gear. A large number of women are engaged in this industry, especially in Bangladesh, and face hazardous working conditions. The physical hazards associated with ship breaking are also very high. The biggest causes of accidents are fires and chemical explosions. The other causes of major accidents are falling objects and people slipping on oil spills. Workers in Bangladesh and Pakistan are at even higher risks because facilities and use of protective gears are limited. Such accidents are however seldom reported. The Government of Bangladesh has no statistics or reliable records for ship breaking yards, and yard owners are reluctant to give any information. It is estimated that about 40 people die in explosions and fires every year at the Chittagong ship breaking yard.

Ship breaking is highly polluting: End-of-life vessels often contain toxic materials like polychlorinated biphenyls (PCB), polyaromatic hydrocarbons (PAH), tributyl tin (TBT), polyvinyl chloride (PVC), tin, lead, heavy metals and various other substances such as sulphuric acid, halogens, and asbestos. Therefore, ship dismantling can affect the environment, if not properly handled. Toxins mixed with sea water can adversely affect the marine ecosystem. They may also contaminate air and surface water. According to the Central Pollution Control Board of India (CPCB), the disposable waste a ship contains may not constitute more than 1 percent of its weight. Of this, only 30 percent can be hazardous and 70 percent must be non-hazardous.

The issues associated with the industry that are in need of being addressed are improvement of workplace environment, local pollution and carbon emissions. The present case study provides details of resource and energy efficiency measures undertaken in a steel re-rolling cluster in India, their impacts and scale up potential. This is an initiative that IIP has undertaken in partnership with Sihor Steel Re-rolling Mills Association in the state of Gujarat.

Table 7: Status of existing rules & regulations in ship breaking in South Asia

Parameters	India	Bangladesh	Pakistan
Specific Rules for ship breaking	Yes	No	No
Cargo Free Certificate	Yes	Yes	Yes
Gas Free Certificate	Yes	No	No
Waste Disposal Facility	Yes	No	No
Labour Insurance	Yes	No	No

Source: Ship Dismantling: A status report on South Asia, EU-India Action Plan Support Facility

Steel Re-Rolling Sector in India: an Overview

Steel re-rolling is one of the most important segments of the steel industry in India. Starting its journey way back in 1928, the Indian steel re-rolling industry has come up a long way with an estimated 1800 mills presently operating in various clusters.

The industry provides employment to more than 68000 people. In spite of the global and domestic recession in the steel industry, the sector has recorded a decent growth rate. The sector is dominated by small and medium enterprises (SMEs) to an extent of 75 to 80 percent; these units have a competitive edge over the large producers due to their flexibility in production for meeting low tonnage requirements in various grades, shapes and sizes to serve niche markets. However, their operating efficiencies are dismally low leading to not only huge energy losses but also significant wastages of raw material. The process of re-rolling comprises heating the raw material in the form of ingots or billets and then rolling the heated stock in a rolling mill so as to shape it into thermo mechanically treated (TMT) bars or structural steel parts such as angles, plates, channels, rounds. The direct energy use in this sector includes heating fuels (furnace oil, natural gas, and coal), and electrical energy. Indirect energy use is accounted by the use of energy intensive raw materials. The energy losses would thus comprise direct losses as well as indirect losses through scale loss and low yields. The direct energy costs in the re-rolling mill sector are estimated at 25-30 percent of the overall production cost. The production process followed in a typical re-rolling unit is shown in Figure 14.

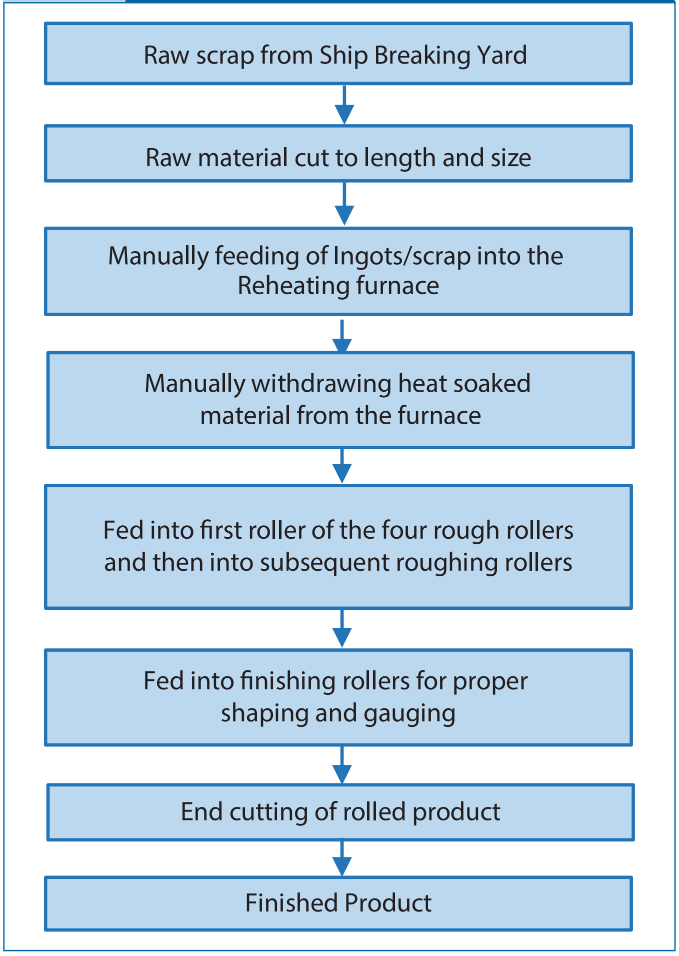
The steel re-rolling sector in India is further characterized by the following:

- Outdated technologies and practices.
- Low information and awareness levels.
- Lack of experience in accessing external funds.
- Lack of delivery system at the cluster level.

Supply Chain Intervention

This initiative focussed on enhancing energy and resource efficiency in the steel re-rolling cluster of Bhavnagar, which is a medium sized town in the Indian state of Gujarat, located approximately 200 km from the state capital Gandhinagar. The town assumes great importance from an industrial perspective since it is a big energy intensive hub comprising a number of steel re-rolling mills. The raw material for the industry, ingots, is obtained by melting steel scrap obtained from the nearby Alang ship-breaking yard. More than 90 percent of ship dismantling in India is carried out at the Alang yard. Its maximum capacity is about 4.58 million tonnes per year, which makes it one of the biggest ship breaking yards in Asia. The ingots are heated in a reheating pusher type coal fired furnace up to a temperature

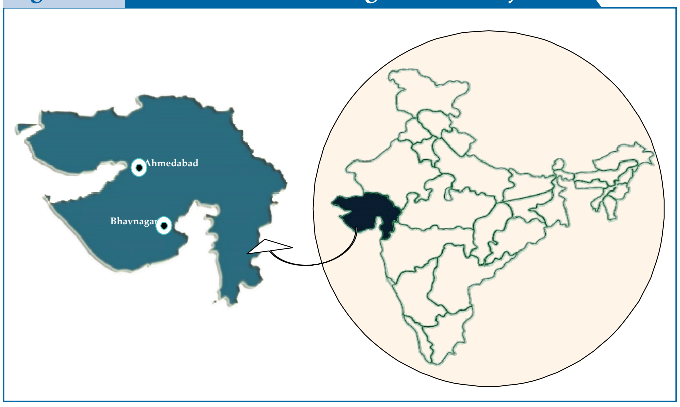
Figure 14: Typical production process in steel re-rolling sector



of around 1,200°C. Red hot ingots are then repeatedly passed through rollers to obtain the final product.

There are tremendous opportunities for energy savings, material savings and corresponding CO_2 mitigation potential in steel re-rolling. This potential was assessed for replacing a conventional furnace with an energy efficient furnace for a typical small scale steel re-rolling mill.

Figure 15: Location of Re-rolling units in Gujarat



Resource Saving Potential of Steel Re-rolling Sector

Capacity of the unit: 4 tonnes per hour (tph)

Annual production: 12000 t

Specific coal consumption of the old furnace: 110kg/t of product

Specific coal consumption in improved furnace: 80kg/t of product

Reduction of oxidation losses in new furnace: 3%

Coal savings per tonnes of product

- On account of increased furnace efficiency: 30 kg
- On account of handling less product: 3.3 kg

Material savings per ton of product: 30 kg

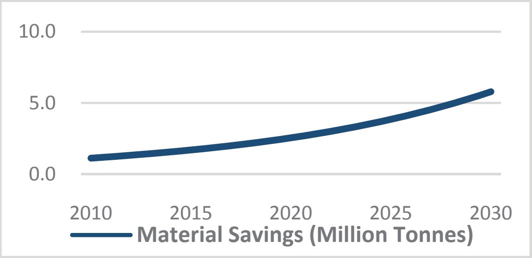
Emission factor for coal (t CO_2/t coal): 1.816

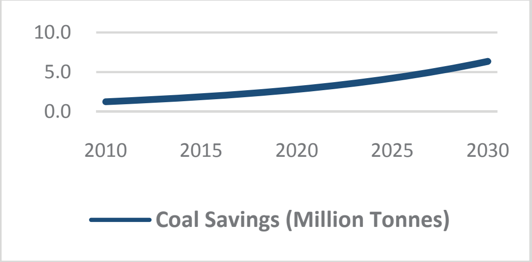
CO_2 savings/tons of product (due to coal Savings alone): 0.060t

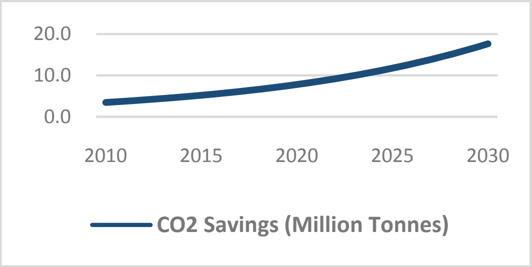
Emission factor for raw steel production: 2.7t CO_2/t product

- CO_2 savings/tonnes of product (due to reduced oxidation loss): 0.081 tonnes
- Total CO_2 savings on account of improved furnace: 0.141 t/t of product

Annual growth rate of sector: 8.5%.







Cleaning of Operations in Ship Breaking

The ship recycling industry can generally be considered green and eco-friendly as the emissions and resource use per tonne of steel production from ship-breaking is far less compared to that used for primary steel making. However, the Alang ship breaking yard generates waste which poses serious environmental hazards due to its potential to contaminating air and surface water and ultimately the ecosystem. This waste can be broadly divided in two parts. 1) non-hazardous waste (land fillable waste) and 2) hazardous waste. As per the estimates of the Gujarat Maritime Board, a typical list of materials generated as waste from ships demolished at Alang is provided in Table 8.

Incinerable hazardous wastes, which constitute about 30 percent of the total waste, pose serious health and environmental hazards and require sound and sustainable waste management practices for their disposal. This waste is currently being sent to Surat (340 km from Bhavnagar) for disposal as incinerators are not available in Bhavnagar or Alang. Disposal of hazardous waste in incinerators is an energy intensive process as it employs additional fossil fuels.

The best way to use this waste is as a resource, taking advantage of its high calorific value while ensuring that its burning does not lead to harmful emissions. IIP has undertaken research in this area, which shows that these wastes can be used as a

Table 8: Generation of Hazardous and Non-Hazardous waste from Ship Breaking

Hazardous Material	Tonne per annum		Non Hazardous	Tonne per annum
Asbestos	175			
Glass wool	2000		Fiber Glass	40
Rubber	40		Iron Scales	900
Rexine	50		Cardboard & Packing	35
Plastics & Cables	20		Glass	175
Sludge residue	800		Municipal Solid Waste for Landfill	5000
Contaminated Material	200		Cement Tiles	10000
Total	**3285**		**Total**	**16150**

Source: Data of Gujarat Maritime Board fuel in cement plants in place of coal. Using this waste as an alternate fuel in cement kiln, therefore, represents a win-win situation in terms of waste management and also coal savings in cement manufacture. Co-processing hazardous waste in cement kilns at high kiln temperatures would ensure that it is completely destroyed and no harmful emissions result. In order to explore the option of waste utilization, such as hazardous waste and municipal waste in cement plants, IIP launched a multi stakeholder initiative to develop a detailed action plan for dealing with the technical, policy and regulatory and financial issues. This was based on a detailed literature survey, field level techno economic feasibility studies to further the existing knowledge on the subject and extensive engagement and interaction with a range of stakeholders that includes the regulators, industry, technology suppliers as well as civil society.

In order to identify and resolve any regulatory and policy issues related with usage of hazardous wastes in cement plants, a Forum of Regulators was created with high level representation from State Pollution Control Boards of major cement producing states in India. The Forum met regularly to deliberate on the key policy and regulatory bottlenecks and developed a series of White Papers/Policy Briefs. These White Papers/ Policy Briefs were based on the inputs of the members of the state pollution control boards, technical experts, industry representatives and with references from international best practices, journals and research documents. Some of the relevant White Papers developed include:

- Amendment of the Hazardous Waste Management Rule under the Environment Protection Act to include co-processing in cement plants as a disposal option
- Emission standards for co-processing of alternate fuel and raw material in cement kilns including Hazardous Wastes, along with emission monitoring methodology
- Guidelines for transportation and storage of hazardous waste
- Technical Guidelines on environmentally sound pre-processing facilities to prepare homogenous waste mix suitable for co-processing in cement kilns

These policy and regulatory changes can give impetus to use of hazardous wastes in cement kilns and create a favourable situation by safe disposal of hazardous waste on one hand and coal savings for cement plant on the other hand.

Using incinerable hazardous waste generated during ship-breaking as an alternative fuel in cement industry would help in (1) avoiding the fuel usage in its incineration and environmental penalty associated with the transport of waste from Alang to the incinerator site at Surat, (2) avoiding fossil fuel usage in incinerator (which are not equipped with energy recovery features), and (3) possibility of any illegal dumping.

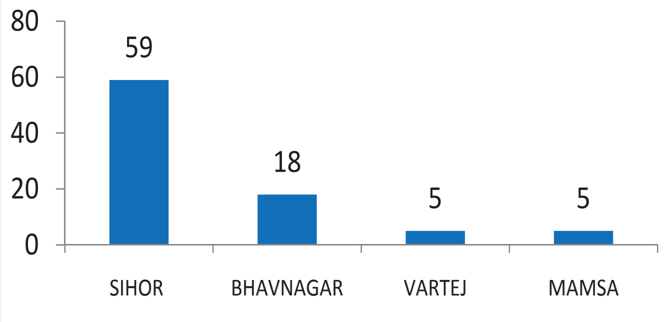
Realising this potential, the Bhavnagar Municipal Corporation has already approached a major cement producer to explore the possibility of using municipal solid waste (MSW) of the city (and its adjacent cities including Alang) as an alternative fuel in their cement plant situated around 80 km from Bhavnagar. One of the barriers to the use of MSW lies in its low calorific value. This problem could be partly overcome by blending it with hazardous waste from Alang having a high calorific value. This possibility is being explored. If this model succeeds, cement manufacture will be greener and the ship- breaking yard will be rid of hazardous waste.

Promoting Resource Efficiency in Re-rolling Units

The re-rolling industry of Bhavnagar is one of the biggest rolling mill clusters in Gujarat. Most of the mills in Bhavnagar produce round bars that are used in building structures. Almost all the mills are manually operated and the normal working hours are 10 hours a day. There are a total of 87 units under the Shihor and Bhavnagar Steel Re-rolling Association. The number of industries at different locations is shown in Figure 16.

Pulverised coal is the major source of fuel in the cluster. The cluster offers significant opportunities for CO_2 saving because of high scale (material) loss and high specific coal consumption on account of poor furnace design. Thus, like most of the SME clusters across the country, the Bhavnagar re-rolling mill cluster is characterized by very poor energy and environment performance because of outdated technologies leading to high local pollution and an unhealthy working environment for workers. They also face a series of market failures with constrained access to finance technology and market related information that can help improve their energy/ production efficiency.

Figure 16: Concentration of units across various towns (in Greater Bhavnagar)



The majority of mill owners are first generation industrialists without any formal technical education and are unable to make informed judgements based on technical criteria. Even the foreman and mill staff do not have formal training but run the operation based on their experience. This situation is compounded by a lack of effective delivery systems for supporting cleaner production uptake at industry level.

Towards Resource Efficient Production

Against this background, IIP initiated an intervention to introduce resource and energy efficiency measures which would gradually percolate through the Bhavnagar cluster and scale up this model in other clusters. IIP targeted the industries with both, retrofit options and as green-field projects.

The intervention attempted a bottom up participatory approach to ensure that the proposals for improving resource use efficiency would be endorsed by the local industry; this is which is crucial to its sustained uptake and mainstreaming.

As a starting point, local buy-in from the industry was ensured so as to be able to use it as a driver for change. To ensure this, IIP signed a MoU with the Shihor Steel Re-rolling Mills Association (SSRMA), which is the registered apex body of re-rolling mills' owner in the Bhavnagar cluster and was established in 1992. The industry association played an important role in promoting/disseminating resource efficient solutions.

To ensure that the project design met the expectations of the local industry, a feasibility study was carried out covering aspects such as: (1) Willingness and readiness of the industry and the association to implement the proven energy efficient technology, (2) analysis of the barriers and risks. An implementation plan was drawn up as the outcome of the feasibility study and was based on the agreement with the local industry. The key elements of the implementation strategy were:

- Since the reheating furnace is the most energy intensive process in a re-rolling mill the focus would be on designing and demonstrating an improved reheating furnace and its controls as detailed below:
    - o To design a furnace that aids uniform heating and heat transfer to the raw material avoiding a situation of heat being carried away by hot flue gases.
    - o To aid fuel turndown, which is difficult in a conventional furnace. This not only saves coal but also helps to keep emissions in check
    - o Zoning of furnaces to increase production rate and significantly reduce air pollution
    - o Improved furnace control including better coal conveying system and air-fuel ratio control, aided by minimum instrumentation.
- Undertake the following accompanying measures to ensure proper management of the demonstrated design and its acceptance amongst the cluster;
    - o Training of the plant operators and supervisors to efficiently operate and maintain the new furnace
    - o Monitor impacts through detailed resource audits to quantify the benefits of the new furnace design and launch sensitization campaigns together with the industry association.

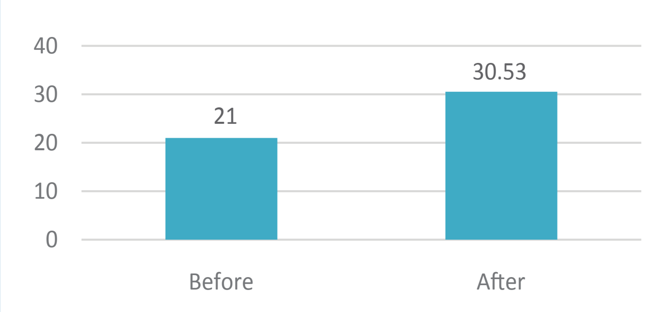
Main features of the energy efficient furnace	
Equipment	Pusher type Re heating Furnaces
Output capacity	3 to 5TPH
No of Zones (three)	1.End fired soaking zone 2 side fired heating zone 3 Unfired pre heating zone
Effective furnace length	14 mtrs (approx)
Inside width of the Furnace	1.8 mtrs (approx)
Furnace temperature.	1250 °C(Max)
Material temperature.	1050 °C 1100 °C
Furnace exhaust Temperature.	About at 400 °C -450 °C during peak production rate of 5T/Hr
Main energy Source	Pulverized coal

- o Assessing the financing needs of the cluster and identifying financing partners.

Resource saving benefits

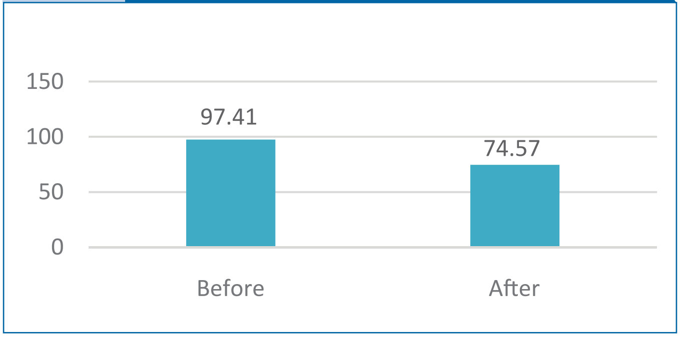
The re-heating furnace was designed to enhance the resource use efficiency by increasing operating efficiency and reducing oxidation or scale losses. The improved re-heating furnace has a flat roof for effective heat utlization; distinct zoning; improvement in the furnace refractory; installation of thermocouples for the entire zone to monitor the furnace temperature; extended furnace length for reduced scale loss and flue gas loss etc. The improved furnace led to improvements in thermal efficiency from a mere 21 percent to 30.5 percent (Figure 17).The improvement in this efficiency level was also reflected in coal and material savings.

Thermal efficiency (percent) of new furnace design



Fuel Savings: As already pointed out, the rolling unit uses pulverized coal as fuel to heat the scrap in the re-heating furnace. The modifications to the reheating furnace reduced the specific fuel consumption of TMT and round bars by 23 percent from 97 to 75 kg per tonnes of product, as shown in Figure 18. The improvement in specific coal use led to a savings of 330 tonnes of coal annually.

Figure 18: **Improvement in specific fuel consumption (Kg of coal per tonnes of product)**



Material Savings: The scale loss (or oxidation loss) study revealed that the improved re-heating furnace reduced the scale loss after the rolling process by 1.6 percent as shown in Figure 19. It may, however, be noted that in a typical unit, this

Figure 19: **Material Savings (percent) Rolled out Product**

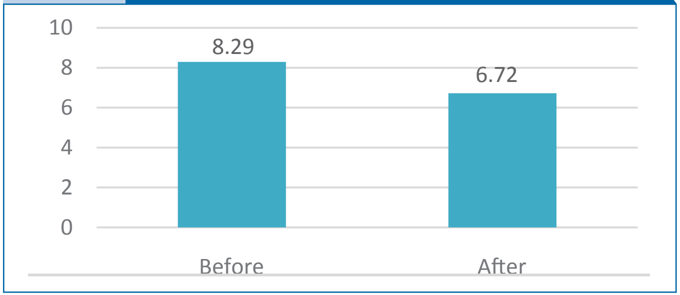


figure would be much higher. The scale loss performance of the demonstration unit was already quite good compared to an average representative unit. With 1.6 percent drop in scale loss, the total material savings for the unit worked out to 240 tonnes annually.

Replication Potential

The present case study, which highlights resource saving opportunities in scrap based steel re-rolling units in India has high replication potential in South Asia. The Bhavnagar experience, where the raw material is being sourced from Alang ship breaking yard, is of direct relevance to large number of small and medium sized steel re-rolling mills in Bangladesh and Pakistan, where the raw material is sourced from Chittagong and Gidani ship breaking yards respectively. There is a need for an integrated solution that deals with the policy, technology, information and market related challenges, which has been effectively dealt by the IIP model in Bhavnagar and offers an effective model for scaling up.

Additionally, the small steel re-rolling units have mostly mushroomed in clusters in the South Asia region with a great deal of similarity between the units within a cluster in terms of the level of technology, operating practices and even trade practices. This allows the possibility of developing standard solutions the would help in quick scale up.

Reference

i. Small and Medium Scale Enterprises as Industrial Development, Sadrul Reza. M. U. Ahmad and Wahiduddin Mahmud, Academic Publishers, 2010

ii. Bangladesh Economic Review, 2003 & 2004, Ministry of Finance, Government of Bangladesh.

iii. Central Bureau of Statistics; Survey of Small Manufacturing Establishments, Nepal

iv. Federation of Nepalese Chambers of Commerce and Industry; Nepal and The World: A Statistical Profile 20082

v. World Bank Group (2003) Small and Medium Enterprise, Growth and Poverty: Cross Country Evidence World Bank Policy Research Working Paper 3178.

vi. Zaman. Arif, South Asian SMEs need to globalise, Commonwealth Business Council, March, 2008

vii. "Bangladesh has emerged as an important supplier of quality readymade garments in the global market. Once heavily dependent on exports of primary products lead by Jute, the economy of Bangladesh is now experiencing almost 76 percent export contribution from readymade garments. The sector has now occupied an important place in Bangladesh national economy."- Nuruzzaman Md. (2007), "Developing Export of RMG products in Bangladesh: Analysing the lead time", Management Trends, Vol.4, No.1, P- 1

viii. SME Finance Policy Guide, World Bank, International Finance Corporation, 2011

ix. SMEs have some highly energy intensive sub sectors like foundry, glass, ceramic, steel re-rolling, lime klins, where the cost of energy forms a sizeable proportion of the total production cost and offers tremendous scope for energy efficiency improvement and GHG mitigation opportunities through technology innovation, up gradation, modernization and through better energy management practices.

x. UN-COMTRADE database, World Integrated Solutions (WITS)

xi. Potential supply chains in the textile and clothing sector in South Asia: An Exploratory Study, United Nations and Common Wealth Secretariat

xii. Potential supply chains in the textile and clothing sector in South Asia: An Exploratory Study, United Nations and Common Wealth Secretariat

xiii. Water footprint of Cotton Consumption, UNESCO-IHE, September, 2005

xiv. Derived from Planning Commission's Employment estimates

xv. Potential Supply Chains In The Textiles And Clothing Sector In South Asia An Exploratory Study, United Nations Conference on Trade and Development (UNCTAD)

xvi. Devaraja., T.S, Indian Textile and Garment Industry- An Overview, Department of Commerce, Post Graduate Centre, University of Mysore, Hassan, India

xvii. Chandra Pankaj., The Textile and Apparel Industry in India, Indian Institute of Management, Ahmedabad, April, 2006

xviii. Chandra Pankaj., The Textile and Apparel Industry in India, Indian Institute of Management, Ahmedabad, April, 2006

xix. Devaraja, T.S., Indian Textile and Garment Industry: An Overview University of Mysore, India

xx. Source: WWF & IKEA Project Report, 2014

xxi. LI, J. (2012). World Bank Experience on Clean Brick Production in South Asia Regio. In: INE Proceedings of the Workshop on public policies to mitigate environmental impact of artisanal brick production. (Session VI. Toward programs and public policies to mitigate environmental impacts). Guanajuato, Mexico, 4- 6th September, 2012. [PowerPoint slides]. InstitutoNacional de Ecología. Available in: http://www.ine.gob.mx/cenica-memorias/1111-taller-ladrilleras-2012-eng.

xxii. McKinsey & Company, 2009. Environmental and Energy Sustainability: An Approach for India. McKinsey & Company, Mumbai, India.

xxiii. Baum,E.(2012). Present Status of Brick Production in Asia. In: INE Proceedings of the Workshop on public policies to mitigate environmental impact of artesanal brick production. (Sesión I. Overview in each region). Guanajuato, Mexico, 4-6 th September, 2012. [PowerPoint slides]. InstitutoNacional de Ecología. Available in: http://www.ine.gob.mx/cenica-memorias/1111-taller-ladrilleras-2012-eng.

xxiv. Gupta, Sachi.,&Narain, Rup., Brick kiln industry in long-term impacts biomass and diversity structure of plant communities, CURRENT SCIENCE, VOL. 99, NO. 1, 10 JULY 2010

xxv. REDUCING BLACK CARBON EMISSIONS IN SOUTH ASIA: Low Cost Opportunities, US Environment Protection Agency

xxvi. Environment & Social Report for VSBK, A Guidance document for Entrepreneurs and Project Auditors, Development Alternatives, December, 2005

xxvii. Environment & Social Report for VSBK, A Guidance document for Entrepreneurs and Project Auditors, Development Alternatives, December, 2005

xxviii. Environment & Social Report for VSBK, A Guidance document for Entrepreneurs and Project Auditors, Development Alternatives, December, 2005

xxix. Heierli. Urs.,andMaithel. Sameer., Brick by brick: The Herculean task of cleaning up the Asian Brick Industry

xxx. Maithel, Sameer, 2003. Energy Utilization in Brick Kilns. PhD Thesis. Energy Systems Engineering, Indian

xxxi. Institute of Technology, Bombay.

xxxii. Brick Klins Performance Assessment: A Road map for cleaner brick production in India, Greentech Knowledge Solutions, April, 2012

xxxiii. Brick Klins Performance Assessment: A Road map for cleaner brick production in India, Greentech Knowledge Solutions, April, 2012

xxxiv. REDUCING BLACK CARBON EMISSIONS IN SOUTH ASIA: Low Cost Opportunities, US Environment Protection Agency

xxxv. Report on Fly Ash Generation at Coal/Lignite Based Thermal Power Stations and its Utilization in the Country, Central Electricity Authority, New Delhi, December, 2011

xxxvi. Fly Ash Bricks Reduce Emissions: The FaL-G Brick Technology and Carbon Finance Project, World Bank and Ministry of Finance, 2012

xxxvii. Fly Ash Bricks Reduce Emissions: The FaL-G Brick Technology and Carbon Finance Project, World Bank and Ministry of Finance, 2012

xxxviii. Bhanumathidas., N, &Kalidas., N., Concrete in India – Need for Rapid Transition,

xxxix. Institute for Solid Waste Research & Ecological Balance

xl. Chakravartty., Anupam., Ban paves the Way, Center for Science and Environment, December, 2012

xli. Fly Ash Bricks Reduce Emissions: The FaL-G Brick Technology and Carbon Finance Project, World Bank and Ministry of Finance, 2012

xlii. Mittal, S. and Sethi, D. (2009) Food Security in South Asia. Issues and Opportunities. Indian Council for Research on International Economic Relations, New Delhi; FAO (2009), State of Food Insecurity; ADB (2010) Building a Climate Resilient Agriculture Sector; Jones and Hossain, 2009. Situational Analysis. DFID internal paper and Gulati, A (2009) Making the case for Asia: USAID Food Security meeting; 2008 Revision Population database: http://esa.un.org/unpp/p2k0data.asp.

xliii. Mir MdTamim, ArindamDhar, Md. Shahadat Hossain, Fly Ash in Bangladesh: An overview

xliv. Shaheen Aziz, Suhail A. Soomro, A. H. Tunio, Imran Nazir, K. M. Qureshi and Razia Begum, Environmental & Health Hazards of Fly Ash &SOxfrom FBC Power Plant at Khanote, Pak. J. Anal. Environ. Chem. Vol. 11, No. 2 (2010) 56 ñ 62

xlv. Source: Shipbreaking Platform for the year 2012

xlvi. Kanwar Muhammad Javed Iqbal and Patrizia Heidegger, Pakistan Shipbreaking Outlook:The Way Forward for a Green Ship Recycling Industry –Environmental, Health and Safety Conditions, Brussels / Islamabad, October 2013

xlvii. Ship breaking in Bangladesh, YPSA Report, 2004

xlviii. Richard Bradley, Battleship Beach, BBC, 1989

xlix. GMB calculation on labour force

l. The Human Cost of Ship Breaking – an investigation in Bangladesh - Greenpeace

li. Report by YPSA on Chittagong ship breaking yard, 2005

lii. Inventory of hazardous waste on end-of-life-vessels, Greenpeace, 2001

liii. GPCB and GMB report to Supreme Court of India

liv. Indian Ship Breakers' Association