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POTENTIAL CLIMATE CHANGE MITIGATION OPPORTUNITIES IN INDUSTRY SECTOR IN VIETNAM

Background Paper

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Abbreviations and Acronyms

BFG	Blast furnace gas
BOF	Basic oxygen furnace
CCM	Climate Change Mitigation
CDM	Clean Development Mechanism
CDQ	Coke dry quenching
CER	Certified Emission Reduction
CH4	Methane
CHP	Heat and Power Cogeneration
CO2	Carbon dioxide
GHG	Greenhouse Gas
GSO	General Statistics Office
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resource and Environment
tCO_2-e	ton CO_2 equivalent
TOE	tons oil equivalent
N2O	Nitrous oxide
TMP	Thermo-Mechanical Pulping
KTOE	Thousand Tons Oil Equivalent
TPM	Total Productive Manufacturing
VABM	Vietnam Association of Building Materials
VICEM	Vietnam Cement Industry Corporation
VSBK	Vertical Shaft Brick Kiln
VSC	Vietnam Steel Corporation
WB	World Bank
WHPG	Waste Heat Power Generation

Brief description of the industry sector

One of the major engines for economic growth in Vietnam over the past 15 years has been industry. Since 1990 the industrial sector has grown an average of 10 percent per year and over that time its share of GDP has grown from 25 to 41 percent. The growth of this sector is led by the “non-state” industries, which have been growing as much as 20 percent annually and foreign invested companies which are growing at 15.3 percent per year. State owned industries are also growing but less significantly.

In addition to the rapid growth rate, it is the largest energy consuming sector, making up 36 percent of the total energy use in 2000. Coal accounts for 57 percent of the energy consumption while electricity accounts for 21 percent. Forecasts indicate the growth rate in energy consumption from industry will be on average 7.1 percent per year (2001 – 2025) and coal is expected to maintain itself as the main fuel source over time with a projected share of 46 percent in 2020.

Table 1 - Energy consumption in the industry sector (2000 – 2025 period)

	2000	**2010**	**2015**	**2020**	**2025**
Energy consumption (MTOE)	4.36	15.77	21.68	29.1	36.7
Share (%)	36%	33%	33%	35%	38%

Source: MOIT, 2007

With the large energy demand and high reliance on fossil fuels, the industrial sector is one of the most significant greenhouse gas emitting sectors. The most energy consuming industry sub-sectors are construction materials including cement and brick (44 percent of industrial energy use), iron and steel (22 percent) and pulp and paper (8 percent), which together emit over 31 million tCO2-e per year which is 21 percent of the GHG emissions in Vietnam in 2005. This report will focus on the potential GHG reduction in these four industry sub-sectors.

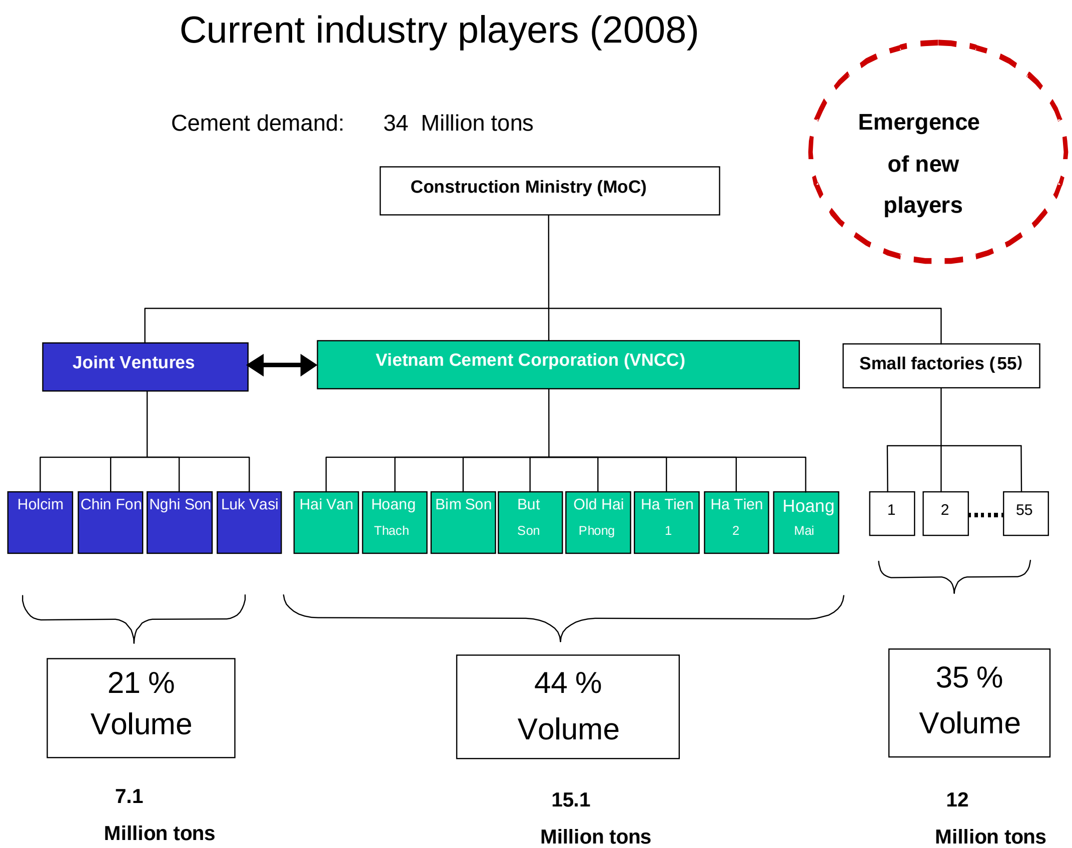
Table 2 - Estimated volume of GHG emissions by industry sub-sector in 2004/2005

Industry	**Production**	**Estimated volume of GHG (thousand tCO_2-e)**
Cement	22,000,000 tons	19,890
Iron and steel	657,000 tons steel billet 1,033,000 tons rolled steel	6,093
Brick	16,000 (million bricks)	4,080
Paper	805,000 tons	1,634

(RCEE, 2005) Calculated based on the energy demand forecast data from Institute of Energy and emission factor from IPCC 1999

Cement industry

The Vietnam cement industry produced an estimated 22,000,000 tons of cement in 2005 and production is growing at an average rate of between 10 percent and 14 percent per year. Demand forecasts indicate this growth rate is expected to continue between 2006 and 2010 and to decrease thereafter, to an estimated 7 percent in 2015 and 3 percent in 2020.
Statistical data from the Technical Department of Vietnam Cement Industry Corporation, 2008; Diagram adapted from Ernst and Young, 2003.



Vietnam National Cement Corporation (VNCC) which is a state general corporation is the major player in the country, with nine member enterprises that produce cement, accounting for 44 percent of production in Vietnam in 2008. The remainder of the cement production is supplied by joint venture companies (21 percent) and small cement plants (35 percent).

Table 3 - Cement demand projection up to 2020 in Vietnam

Items	2004	2005	2006	2007	2008	2009	2010	2015	2020
Growth rate, %	14	13	12	12	10	10	10	5-8	2,5-3
Demand (mil. tons)	25,7	29,1	32,6	36,5	40,1	44,2	48,6	63-65	68-70
Production (mil. tons)	18,8	22,0	27,95	35,3	42,0	47,6	49,8	62,8	68

(MONRE, 2005) According to the Vietnam Cement Development Plan up to 2010 and prospective to 2020

Technologies:
The basic process of cement production consists of 3 steps[1].

Raw material preparation: Limestone – the main raw material - is extracted from the quarry then blended with other raw materials (clay/shale/sand) and crushed. Depending on the technology used, crushed raw material can be either grinded dry into a fine powder

[1] *Adapted from Ernst and Young, 2003b*

(raw meal) in the raw material mill (with Dry Process technology), or be grinded with water to form a slurry (with Wet Process technology). This process uses both electricity and fuel for heat.

Clinker making: The raw materials are then fired in a kiln to form clinker. Raw meal is pretreated by heating to approximately 900 degrees Celsius before being fed into a kiln. Slurry is processed differently. It is pumped in the upper end of the kiln without preheating. Inside the kiln, the cement clinker is produced by a chemical reaction at a temperature of 1450 degrees Celsius. This process relies on large quantities of fuel for heat.

Cement making: Clinker from the kiln is cooled in the clinker cooler, then grinded into powder in cement mill. During the milling, clinker is mixed with additives to form cement. This process relies on electricity.

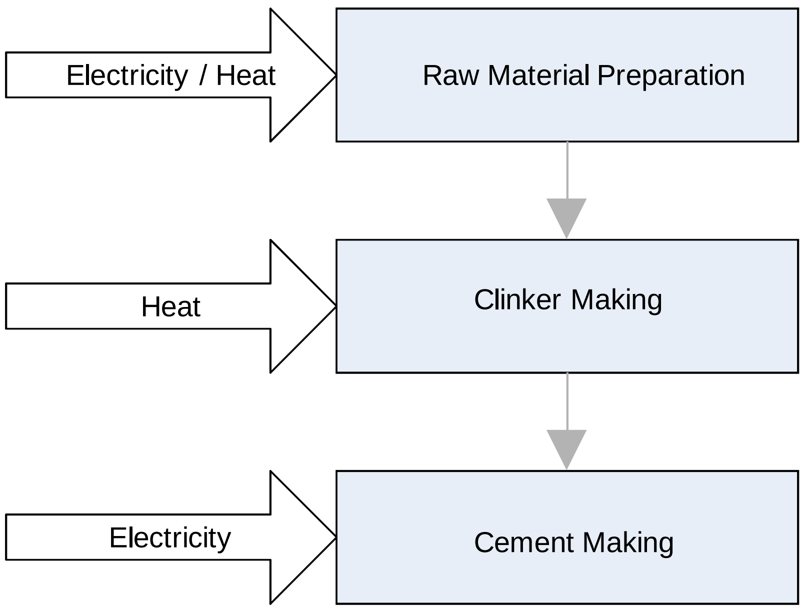


Figure 1 - Flow chart of energy use in cement production

Kiln technologies in Vietnam: While many plants are converting to more modern kiln technology, older less efficient kilns are widely in use. In particular, many plants employ wet kiln technology that relies on wet or semi wet raw materials and therefore require more energy for evaporation; and vertical shaft kilns which is an outdated technology that produces lower quality cement and is difficult to operate in an energy efficient manner. Over the past 10 years plants have been converting to a variety of modern kiln technologies that improve energy use efficiency relative to these older technologies. These include rotary kilns and semi wet, semi dry, dry or combined wet-dry processes; and also pre-heater and pre-calciner technology.

Table 4 - Number of cement plants and clinker production capacity by type in Vietnam

No.	Technology	No. of plants	Total production capacity (million tons/year)
1	Rotary kiln	19	24.2
2	Vertical kiln	47	2.7
3	From vertical to rotary (under	8	3.1

	process)		
4	From vertical to rotary (proposed)	9	4.1

(RCEE, 2007) Statistical data from Vietnam Cement Industry Corporation

Cement blending in Vietnam: The cement industry in Vietnam produces predominantly PCB30 quality cement and also the higher quality PCB40. PCB30 quality allows up to 40 percent blending with additives according to standards from the Vietnam Association of Building Materials (VABM). At present, the ratio of additives in cement product is only 18-20 percent and therefore the clinker content and associated energy requirements in its production is higher than may be necessary.

Energy consumption: The cement industry uses both fuel and electricity. The largest energy consuming processes are raw material treatment and clinker production which account for 80 percent of the energy consumption and clinker grinding which accounts for around 20 percent of energy consumption[2]

Table 5 Comparison of energy efficiency in two plants with different kiln technologies in Vietnam

Cement plant and technology	Energy use	World comparison (# of samples)
Bim Son cement plant Wet kiln technology	144 kwh/ton 7704 KJ/ton	104 kwh/ton (86 cement factories) 3669 KJ/ton (150 kilns) 6313 KJ/ton (30 wet kilns of similar capacity)
Huang Thach cement plants Pre-calciner technology	98.8 kwh/ton 3967-4010 KJ/ton	104 (86 cement factories) 3669 KJ/ton (150 kilns of all technologies) 3460 KJ/ton (44 pre-calciner kilns)

Ernst and Young, 2003.

Average energy consumption estimates for this sector as follows[3]:

- Heat consumption: 950 kcal/kg of clinker (3.98 GJ/ton of clinker)
- Electricity consumption: 100 kWh/ton of cement
- Electricity consumption for clinker grinding: 40 kWh/ ton of clinker

Table 6 - Energy consumption forecast for cement production (kTOE)

	2010	**2015**	**2020**
Electricity	407	513	555.6
Fuel	3,276	4,132	4,473.8
Total	3,683	4,645	5,029.4

Source: MONRE, 2004

[2] (MONRE, 2004).

[3] *Data source: Assessment of the demand for GHG reduction technology in industry sector in Vietnam, 2005, MONRE*

Greenhouse gas emissions**:** The cement industry emits an estimated 19.9 million tCO2-e per year from a combination of energy consumption (fuel and electricity) and emissions of carbon dioxide from the chemical reactions in the cement processes. Emissions are projected to grow 25 percent per year.

Table 7 - GHG emission in the cement industry (thousand tCO_2-e), 2002 – 2020

	2002	**2005**	**2010**	**2015**	**2020**
Emission from fuel	4,640	7,750	13,490	17,010	18,420
Emission from electricity	1,480	2,100	4,050	5,100	5,520
Emission from processing	7,300	10,040	22,730	28,660	31,030
Total emission	**13,420**	**19,890**	**40.270**	**50,770**	**54,970**

(RCEE, 2005) Calculated based on the energy demand forecast data from Institute of Energy and emission factor from IPCC 1999

In addition to the rapid growth of the industry, the major reasons for the high emissions are:

- Reliance on coal for raw material treatment and clinker production;
- Reliance on fossil fuel based electricity grid for the clinker grinding;
- Continued use of vertical kilns and wet kilns in many plants.
- Blending of cement is well below industrial standards and therefore clinker content and production is higher than necessary.
- Low energy efficiency of many facilities.

Brick making

As with the cement industry, rapid growth of the construction sector, the production of bricks, increased dramatically over the last 10 years with the volume of baked brick produced expected to reach 25 billion pieces in 2010 and 42 billion pieces in 2020[4]. The brick industry is dominated by small scale manufacturers including over 10,000 traditional brick kilns that utilize coal or firewood.

Table 8 - Baked brick production and consumption/demand in Vietnam (million pieces)

	2000	**2001**	**2002**	**2003**	**2004**	**2005**
Production	9,087	8,981	11,365	12,810	14,501	16,000
Consumption/ Demand	8,500	9,500	11,300	12,800	14,300	15,700

Source: GSO,2007 and survey data from the Market and Price Scientific Research Institute

Technologies:

Brick making involves the following steps:

Mixing: clay is mixed with water by hand or by auto-machine;

Forming: Bricks are formed using a brick machine;

Drying: The bricks are then dried to make them hard and durable using sunlight or by heat in drying room;

Firing: The bricks are then fired in kilns.

[4] *VABM, 2007*

Kiln technologies in Vietnam: The majority of the energy used is in the firing of the bricks in kilns. In Vietnam 65 percent of the total of bricks and tiles are produced in traditional kilns. These technologies are batch processes largely dependent on coal and firewood. Approximately 30 percent of the bricks are produced in tunnel or blast furnaces which are more efficient than the traditional kilns but like the traditional kilns use coal as the major source of energy. In recent years, the vertical shaft brick kiln (VSBK) was disseminated through donor and government support. These kilns while still dependent on coal, use an estimated 56 percent of the energy for production. The degree of adoption is estimated to be 5 percent and has experienced some popularity where it as been promoted. Higher investment cost and stricter operator skill requirements are the main barriers for the adaptation of the new technology.

Energy consumption: The energy consumption for brick production in Vietnam varies from 0.88 – 2.2 MJ/kg, depending on the type of kiln and clay. The energy consumption of VSBK is lower than for traditional brick kilns.

Table 9 - GHG emissions in the brick industry

Items	Unit	2002	2005	2010	2015	2020
Total brick production	million	11,010	13,601	19,345	27,515	39,135
Total emission	thousand tCO_2-e	3,303	4,080	5,804	8254.5	11740.5

(MONRE, 2004) Assume that conventional technology is applied until 2010, vertical shaft brick kiln will be applied thereafter. Emission factor: conventional technology 0.3 tCO2/1000 units, VSBK 0.161 tCO2/1000 units

Greenhouse gas emissions**:** The brick making industry emits an estimated 4.1 million tCO2-e per year from energy consumption. Based on continued use of current technologies this would grow at 23 percent per year until 2010 and 42 percent per year thereafter. Studies have indicated that with the introduction of more efficient technologies the emissions from 2010 to 2020 could reduce by nearly half (4,431 and 6,302 tCO2-e in 2015 and 2020, respectively)[5].

In addition to the rapid growth of the industry, the major reasons for the emissions trends are:

- Large dependence (65 percent) on inefficient traditional kilns:
- Dependence on coal as fuel.

Iron and steel industry

Vietnam produces 6,633,000 tons of steel products per year including 3,656,000 tons of “long products” such as bars, rods, rails and other elongated forms of steel and 2,977,000 tons of pipes and “flat products” such as flattened sheets and strips. The steel used to manufacture these products is both produced domestically and imported. For domestic steel production, seventy-seven percent of the raw material supply comes from domestic and imported scrap metal (693,000 tons per year) which is further refined into steel and the remainder (202,000 tons per year) comes from domestic iron ore extraction and iron production facilities which is processed from pig iron to steel. Steel is imported in the form of billets (2,158,000 tons per year) and flat products (2,958,000 tons per year), which along

[5] *MONRE 2004.*

with the domestically produced steel is then rolled, shaped or coated in Vietnam to manufacture the final steel products[6].

The largest player in iron and steel production is the Vietnam Steel Corporation (VSC), accounting for nearly 50 percent of the iron and steel production[7]. VSC is comprised of 14 local members and 14 joint ventures with foreign companies that cover steel production, rolling, surface coating, secondary processing, distribution and research and development. VSC includes the follow facilities:

- 21 electric steel manufacture kilns with a capacity of 180 tons of product, with a total annual output of 500,000 tons of steel;
- 17 steel rolling lines, with a yearly output over 1,600,000 tons of a combination of laminated steel and construction steel products;
- 7 manufacturing facilities with main products such as galvanized iron, black steel pipe and galvanized steel pipe, with a yearly output above 100,000 tons;
- 2 blast-furnaces for iron production (about 50,000 tons per year of pig iron of different types);
- 8 mines supplying millions of tons of raw materials to the sector each year.

Since Doi Moi, larger private enterprises and foreign invested firms other than those under VSC have emerged as players in the country. It is estimated that in 2004 these firms accounted for 40 percent of the rolling capacity in the country and 20 percent of the electric arc furnace steel manufacturing.[8]. Additionally, small metal processing enterprises (about 160-170[9] in total also produce a variety of steel products and were estimated to account for 16 percent of the long product capacity in 2001[10].

Technologies: As the sector is largely dependent on scrap steel as a raw material, the steel production is predominantly in the form of "mini-mills" that utilize steel scrap, combined with produced steel in an electric arc furnace to produce steel that is then rolled into long products. Although some have been proposed, large-scale fully integrated systems that are commonly found in other countries are not common in Vietnam. These systems normally rely on pig iron produced in a blast furnace combined with steel production in open hearth or basic oxygen furnaces. Rather in Vietnam where iron ore is available typically a smaller hybrid system is used where the iron produced is processed along with scrap in an electric arc furnace process. The sector also uses imported flat products along with cold rolling technologies, pipe fitters and various coating technologies to product pipes and flat products. In general, the subsector technologies can be characterized as being largely based on old technologies with some upgrading and modernization. The most rapidly modernizing part of the subsector surrounds the expansions and construction activities of the joint venture companies (in VSC and outside). The older facilities are also undergoing upgrading but rely on older equipment and the very small traditional metal processing facilities are the least modern. Below is a brief overview of the technologies used.
Iron making: Vietnam is not heavily dependent on domestically produced iron accounting for only 23 percent of the raw materials for steel production. The existing iron production facilities rely on old blast furnace and coke plant technology that has undergone some

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[6] Production numbers based on SEAISI (2006a and 2006b) as compiled and reported in Kawabata (2007).
[7] VSC, 2005
[8] Kawabata (2007)
[9] VSC, 2005
[10] Ernst and Young, 2003

upgrades. Some energy saving techniques has been adopted including the use of sintered coal, and the installation of top pressure recovery power.

Steel making: Steel making is largely done using electric arc furnaces. The electric arc furnaces in use in Vietnam include older furnaces that were constructed 10 years or more ago and the more modern ones that have been upgraded or constructed as part of the recent surge in steel making capacity led by VSC joint ventures and other large private companies. The more modern plants are more energy efficient and commonly employ continuous casting which saves energy in reheating the steel.

Rolling: Rolling technologies vary by the enterprise with the most modern rolling technologies in the country being adopted by VSC and non-VSC foreign joint venture companies.

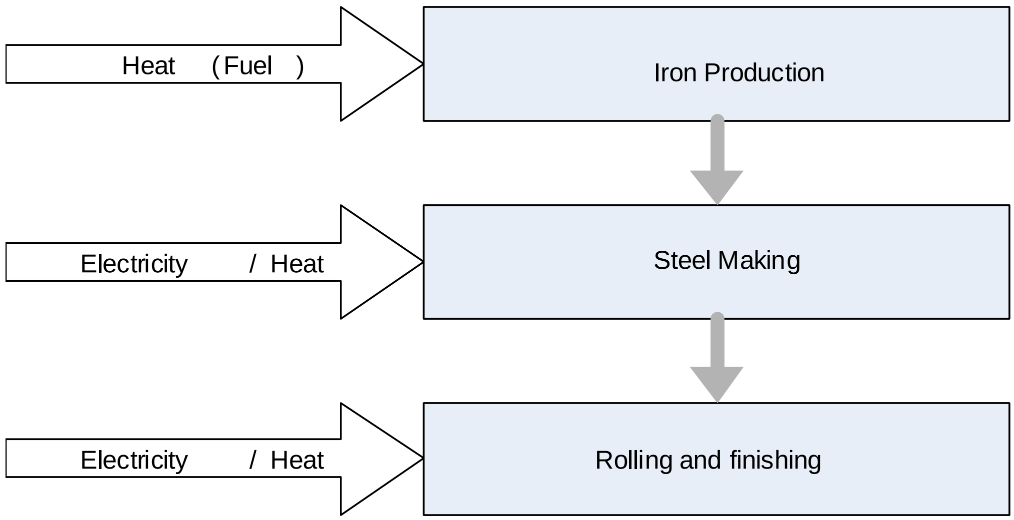

Figure 2: Flow chart of energy use in the iron and steel industry

Energy consumption: Energy consumption in the Vietnam iron and steel industry is higher than international benchmarks. For example, iron production has been estimated to consume 3 Gcal per ton of iron produced in Vietnam while in Japan it consumes 5.85 Gcal per ton[11] (MoIT CPI project). For steelmaking using electric arc furnaces, electricity use ranges from 600-900 kwh/ton[12] of steel while typical values internationally range from 350-700 kwh/ton. Electricity use in rolling mills in Vietnam ranges from 90 to 150 kwh/ton[13]. At the same time, energy intensity is reducing with the new technologies and upgrades as evidenced by the reduction in electricity use by VSC in steel making and rolling since 2000.

Table 10 - Steel production and energy consumption of VSC for the 2000–2004 period

Items	**2000**	**2001**	**2002**	**2003**	**2004**
1. Steel billet production, Kwh/ton	752	732	725	620	600
2. Steel rolling, Kwh/ton	112	112	107	103	100

Source: VSC, 2005

Greenhouse gas emissions: The sources of GHG emissions in iron and steel include emissions from the process itself and from the energy used by the processes in the form of

[11] *MoIT Cleaner Production Initiative Project "Cleaner Steel Production Desired"*
[12] *Based on data from Ernst and Young, 2003 and VSC, 2005.*
[13] *Based on data from Ernst and Young, 2003 and VSC, 2005.*

electricity and fossil fuel. The process related emissions are largely from the iron production process during the combustion of coal and coke; the reactions involved with the removal of carbon impurities in the iron ore; and the reactions between magnesium impurities in the iron ore and limestone. Though smaller in magnitude, steel production also has process related emissions including carbon dioxide emissions from the removal of carbon impurities and the use of carbon electrodes in electric arc furnaces. In Vietnam the sub-sector overall emitted an estimated 6.1 million tCO2-e per year in 2005, a value that is expected to grow to 10.5 million tCO2-e in 2010 due to the growth in the industry and low energy efficiency.

Table 11 - GHG emissions in the iron and steel industry

Items	Unit	2002	2010	2015	2020	2025
Total production[14]	thousand tons	2,100	10,500	17,000	27,000	34,000
Total emission[15]	thousand tCO_2-e	3,356	16,780	27,168	43,149	54,335

The major factors contributing to the amount of GHG emissions from this sector are:

- Reliance on fossil fuel based electricity, fuel oil and coal for these processes.
- Low energy efficiency plants in the older technologies.
- Lack of iron production in the sector reduces overall emissions footprint.
- Slow adoption of more energy efficient technologies.

Pulp and paper industry

The total pulp and paper production in Vietnam in 2006 was 370,000 and 960,000 tons, respectively. Additionally, Vietnam imports 63 percent of its pulp and 39 percent of its paper as domestic demand cannot be met by the existing capacity. Much of the production is for printing and writing papers for domestic use while the major export product is carton boxes and other packaging. In 2001, printing paper production accounted for 34 percent of the total paper production, while newsprint paper made up 12 percent[16]. The growth of the industry has been rapid with paper production tripling between 2000 (350,000 tons per year) and 2006 and a current average annual growth rate of 16 percent (newsprint 35 percent, printing & writing paper 20 percent, and packaging paper 16 percent).

Table 12: Pulp and Paper Production

	2000	2006	2010
Paper (tons/yr)	455,000	960,000	1,400,000
Pulp (tons/yr)	200,200	370,000	600,000

Based on actual production in 2000 and 2006 and projected for 2010 based on targets of VPC.

There are over 300 paper manufacturing facilities, 28 of which are state owned. Vinapimex is the largest player accounting for nearly 38 percent of the paper production capacity and 57 percent of the pulp production capacity in the country in 2000 and possessing most of the larger scale facilities in the country. Otherwise the sector is dominated by smaller scale facilities that primarily produce lower quality paper products such as newsprint and writing paper. Since 2000, there has been shift toward more investment in larger facilities including most recently, plans of the Ministry of Industry to invest US$1.1 billion in order to scale up production to meet targets.

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[14] *The forecast data on steel production is taken from the Master plan of steel development, VSC*

[15] *Due to the unavailability of forecast emission data, the emission factor of steel production was estimated at 1.6 ton CO2/tons of product (VSC, 2005)*

[16] *Ernst and Young, 2003*

Table 13 - Number of pulp and paper mills by size in Vietnam

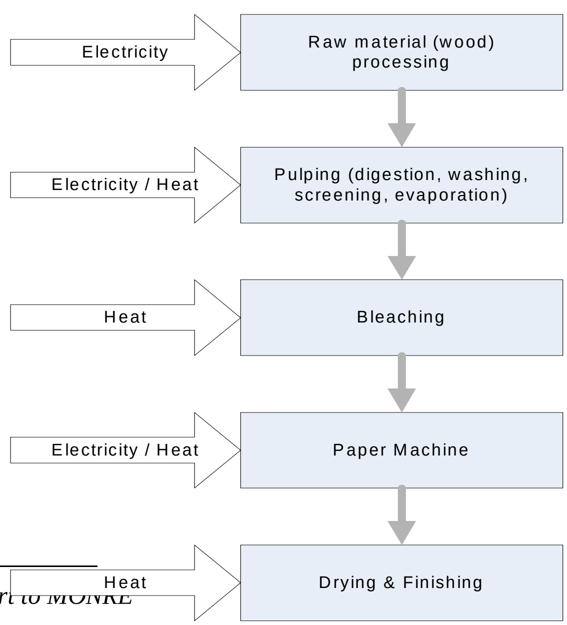
No.	**Capacity** (tons/year)	**No. of plants**	**% of total production**
1	Large scale (□20,000)	5	47.9
2	Medium scale (□5,000)	20	24.3
3	Small scale (□1,000)	75	20.3
4	Very small scale (< 1,000)	200	14.3

(RCEE, 2005) Data from Annual Report of Vietnam Paper Corporation 2002

Technologies: Pulp production is a process that takes wood normally in the form of chips and separates the fibers from the remainder of the wood components by using chemical or mechanical processes. The fibers can then be bleached with chorine-based compounds or using other chemicals as in the case of more modern chlorine free process technologies. As discussed above only a portion of the pulp used in Vietnam is produced in the country while the remainder is imported normally in solid form. Paper is then produced from the pulp by spreading it in liquid form in an even layer, evaporating the water and drying. Chemicals can be added during various stages of this process to adjust the content of the paper or provide a coating.

In Vietnam, much of the sector is dependent on technologies that are 10-30 years old, only some of which have been upgraded. There are only a few plants that can be considered to use up-to-date technologies, although the recently proposed investments may improve the technologies present in the country. Within the spectrum of technologies employed in Vietnam, 27 percent of the pulp and 36 percent of the paper production employs more advanced technologies involving the use of synchronous motors, automated process lines and more recently manufactured equipment. Approximately 47 percent[17] of the pulp and paper production uses outdated and minimally upgraded technologies employing asynchronous motor technology and domestically produced equipment and with no raw material cleaning systems or pulp purifying systems. The technology in the older plants are significantly less energy efficient as globally the industry has made large technological advances in saving both electrical and steam use over the last few decades. Additionally cogeneration using pulp and wood wastes is only employed in some plants and technologies for waste heat recovery and reuse are not fully exploited.

Figure 3 - Flow chart of energy use in the paper industry



[17] *RCEE, 2005: final report to MONRE*

Energy consumption: The energy needs of pulp and paper in Vietnam is predominantly derived from electricity and coal, accounting for 52 percent and 30 percent of total energy consumption respectively. The major heat energy using processes are the drying process in paper production and the production of the steam used in evaporators in chemical based pulp production processes. Electricity is used for a variety of tasks including chipping, pumping, air handling and lighting. Additionally, when mechanical pulping is employed, it uses large quantities of electricity. In some plants, the steam is powered by waste wood and pulp as a form of cogeneration and heat for drying is also sourced from waste heat. Overall the pulp and paper industry is a high energy consuming industry accounting for 7 percent of electricity use and 9 percent of coal consumption in industry. In 2002, the industry consumed 597 million kWh of electricity, 350,000 tons of coal, 11,200 tons of diesel and 87,000 tons of fuel oil. The energy efficiency is low due to the use of an old technology and there is also limited exploitation of energy recovery and reuse systems such as waste heat recovery and co-generation.

Table 14 - Energy consumption projection in pulp and paper industry (2010 – 2030)

Fuel type	2010	2012	2020	2030
Gasoline (tons)	96	108	172	308
Fuel Oil (tons)	192909	221730	386996	776354
Diesel (tons)	20084	23038	39880	79187
Coal (tons)	594532	684503	1132126	2290297
Electricity (MWh)	862378	1009607	1896577	4171028

(RCEE, 2005) Forecast data from Institute of Energy. No forecasting method mentioned in the report.

Greenhouse gas emissions:

The sources of greenhouse gas emissions from the pulp and paper industry are from the energy use and process emissions. Energy use produces GHG emissions from fossil fuel based electricity used in the production process and coal and other fossil fuels used to produce steam for the pulping process, paper drying, and power other processes depending on the facility. Process emissions include those from the reaction of carbonate based chemicals used in the pulping process and methane produced from the wastewater and solid waste during disposal. In 2000, the total CO2 emissions were 1.2 million tons, was just under 1.4 million tons in 2002 and is anticipated to grow to 2.5 million tons in 2010. [18] The CO2 emission projections in the pulp and paper industry are given in Table .

Table 15- GHG emission projections in the pulp and paper industry (2010 – 2030)

	2010	2012	2020	2030
Total emission (thousand tCO_2-e)	2,592	2,994	5,162	10,622

The major factors contributing to these emissions trends are:

- Reliance upon fossil fuels for energy including electricity from grid (52%); coal (30%), fuel oil (17%) and gasoline and diesel (1%).
- Reliance on old, energy intensive technologies and slow adoption of newer technologies.
- Lack of heat recovery and cogeneration systems
- Lack of methane recovering wastewater systems.

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[18] *CO2 emissions are calculated based on energy emissions only using the following emission factors (ton CO2/tons fuel): Coal: 2.31; Fuel oil: 3.24, Diesel: 3.16, Gasoline: 2.58. For electricity: 0.615 tons CO2/MWh.*

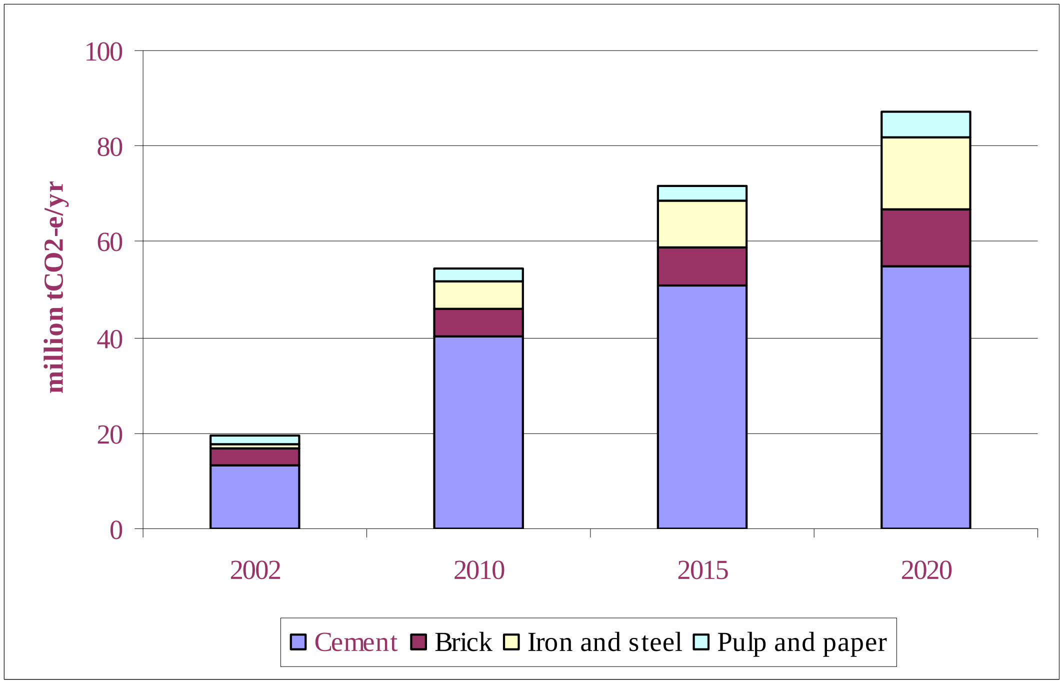

Figure 4 Trends in GHG emission from major industrial sub-sectors

Climate Change Mitigation Opportunities in the Industry Sector for 2010 to 2015

A list of potential typologies of interventions were evaluated to understand their potential for sector wide reductions in emissions of GHGs. Based on the sector potential and the relative challenges of implementing the typology in a portion of the sector, potentially feasible interventions were characterized based a set of criteria important to their implementation potential including estimates of potential emission reductions, in-roads institutionally, and methodology and additionality issues. While all interventions are believed to have potential as “win-win” or “no-regrets” interventions under the CDM, considerations on the related co-benefits and financial cost (if any) related to the intervention was also included in the evaluation and as summarized in the Annexes. All calculations of the emission reduction potentials were based on the sector structure over the time span of 2010 and 2015 and used CDM and IPCC methodologies where available and local emission factors where available.

Overview of the potential

As GHG emissions from the industrial sub-sectors are mainly from fuel and electricity consumption, the solutions for GHG emission reduction consist in technology optimization and upgrading, aiming at fuel and electricity savings.

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Typologies of potential CCM projects in the sector

To understand the options for the sector, for each industry typologies of likely projects were assessed. The typologies explored are listed below.

Table 16: Typologies considered

Industry	Typology of Intervention		Description
Cement	C1	Fuel switching:	Substituting coal by biomass (rice husk, saw dust).
	C2	Cement blending:	Increasing the blending of other materials (ash, etc) to reduce the clinker content and production.
	C3	Waste heat power generation:	Recovery of waste heat from the pre-heater and clinker cooler in steam boilers for power generation in condensing turbines.
	C4	Energy efficiency.	Improving energy efficiency in existing and new plants.
Brick industry:	B1	Energy efficiency improvement	Replacement of traditional kilns with vertical shaft brick kilns.
Iron and Steel Industry:	S1	Waste heat recovery,	coke dry quenching, top pressure recovery turbine; utilization of furnace gas.
	S2	Improvement in energy efficiency	Variety of energy efficiency interventions
Pulp and Paper:	P1	Cogeneration/Combined Heat and Power	Cogeneration of wood and paper wastes.

Cement industry

a.Project type C1: Fuel Switching in Cement Industry

(i) Project Technologies and Activities

The cement industry in Vietnam currently relies on fossil fuel based energy. No utilization of waste (tyres, plastic, etc.) and biomass (rice husk, saw dust, etc.) have been reported. Therefore there is a very significant CO2-saving potential from such solutions, which are already widely applied internationally. Surveys on biomass in Vietnam show large amounts of unused rice husk, wood fuel and other biomass that could be used in the cement industry. As most cement plants are situated along river banks, waste and biomass can be easily transported to the plants. A 20 percent utilization of biomass or waste at 2 production facilities could save as much as 175,000 tons of CO2 per year. However, most facilities in Vietnam have not yet considered such options.

(ii) Baseline and Additionality Issues

The baseline scenario considers that all cement plants use traditional technology and coal as a fuel. The alternative scenarios consider the utilization of waste and biomass. They can be used in the existing plant to replace coal or in new plants. At present, so few projects have been invested in cement industry that it would not be difficult to demonstrate additionality. New lines with higher production represent large investments. Consequently, limited investment capabilities are used for current system improvement. Furthermore, so far there is no financial support from the Government to cement companies to encourage them to invest in energy efficiency projects.

(iii) Assessment of Applicable CDM methodologies

There is an approved methodology by CDM Executive Board in the area named AC M 0003: Fuel switch substituting coal with waste, biomass, etc.

(iv) GHG Emission Reduction Potential

The GHG emission reduction by applying fuel witching solution- substituting 13 percent coal in all 41 cement plants by biomass- the GHG emission reduction is 2.155 million tCO2-e/yr.

% sector covered	Cumulative Emission reduction (tCO2-e/yr)
2.4%	162,899
4.9%	311,835
7.3%	442,154
9.8%	572,473
12.2%	642,287
14.6%	707,447
17.1%	772,606
19.5%	828,457
22.0%	870,346
100.0%	2,154,920

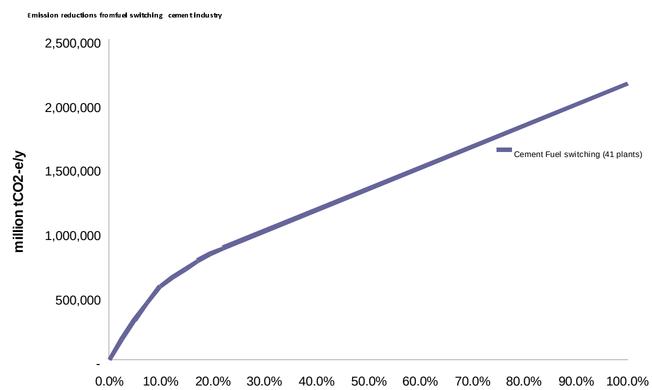

Figure 5 GHG emission reduction from fuel switching in cement industry

(v) <u>Examples of potentially feasible sector-wide interventions:</u>

Intervention	**Potential structure and in-roads**	**Estimated GHG reduction**	**Estimated CDM Revenues**
Fuel switching from coal to biomass (13%) for 9 plants of VNCC	Work with 1 company and 9 plants New World Bank counterpart	870,346 tCO2-e/yr (2% emission from cement industry)	$ 8.7 million per year (about $1 million per plant)

b. Project type C2: Blending

<u>(i) Project Technologies and Activities</u>

The cement industry in Vietnam primarily produces cement of the PCB30 quality, which allows blending of 40 percent additives according to standards from the Vietnam Association of Building Materials (VABM). PCB40 is also produced, which is of a higher quality and allows lower degree of blending At present, the ratio of additives in cement product is only 18-20 percent, thus there is a very significant CO2-saving potential by reducing the clinker content of PCB30. However it requires a higher quality of clinker to ensure the quality of the final product.

<u>(ii) Baseline and Additionality Issues</u>

The baseline scenario considers that all cement plants use traditional blending ratios. The alternative scenarios take into account increased blending. In term of barriers, the same challenges are met as in the fuel switching typology.

Blending represents a huge opportunity in CDM potential, however, this solution is widely applied in Vietnam and it is difficult to register as CDM project. Experience from Chinese CDM projects indicates difficulties in registration of projects of this type if blending results in increased production capacity.

(iii) Assessment of Applicable CDM methodologies

An approved methodology is ACM0005: Blending of clinker to cement with CO2-free additives. However this methodology is current on hold by the CDM Executive Board.

(iv) GHG Emission Reduction Potential

The emission factor for clinker production is 0.5071 tCO2/ton clinker[19]. In the project, the ratio of additives in blending is increased by 5 percent from 20 percent to 25 percent. The GHG emission reduction potential is 923,537 tCO2-e/yr if the solution is applied for all 41 cements plant.

% sector covered	Emission reduction (tCO2-e/yr)
2.4%	69,814
4.9%	133,644
7.3%	189,495
9.8%	245,346
12.2%	275,266
14.6%	303,191
17.1%	331,117
19.5%	355,053
22.0%	373,005
100.0%	923,537

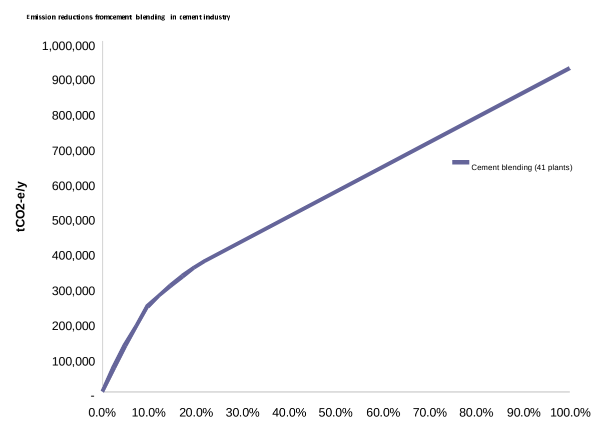

Figure 6 GHG emission reduction from blending solution in cement industry

(v) Examples of potentially feasible sector-wide interventions:

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Blending solution for 9 plants of VNCC (22% numbers of plants)	Work with 1 company and 9 plants New World Bank counterpart	373,000 tCO2-e/yr (0.9% emission from cement industry)	$ 3.7 million per year (about $0.4 million per plant)

c. *Project type C3: Waste Heat Power Generation (WHPG)*

(i) Project Technologies and Activities

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[19] *Data taken from IPCC (1996)*

Thanks to the waste heat recovery system, recuperation of waste heat from the pre-heater and clinker cooler in steam boilers can be used for power generation in a condensing turbine. This power production can be consumed by the process or delivered to the grid whenever possible. The power consumption from the public grid will be reduced. So will GHG emissions.

(ii) Baseline and Additionality Issues

The baseline scenario considers that all cement plants use traditional technology. The alternative scenarios take into account the utilization of waste heat for generation.

There are the same barriers as for project type C1 and C2.

One project was implemented in Vietnam in the Ha Tien 2 plant (NEDO funding). The capacity is 3 MWe. The project is a demonstration project for energy consumption reduction, not a CDM project.

(iii) Assessment of Applicable CDM Methodologies

The methodology is approved by CDM Executive Board:

AM0024: Cogeneration from waste heat from the kiln

(iv) GHG Emission Reduction Potential

The GHG emission reduction by utilizing waste heat for power generation in all 40 cement plants by biomass- the GHG emission reduction is 640,426 tons CO2-e/yr.

% sector covered	Emission reduction (tCO2-e/yr)
2.5%	50,033
5.0%	95,778
7.5%	135,805
10.0%	175,831
12.5%	195,844
15.0%	215,858
17.5%	233,012
20.0%	245,878
100.0%	640,426

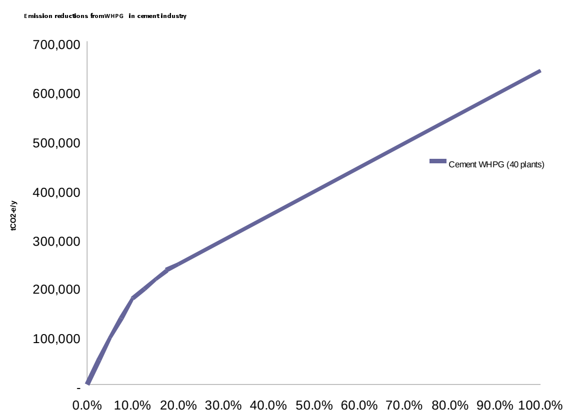


Figure 7 GHG emission reduction from WHPG in cement industry

(v) Examples of potentially feasible sector-wide interventions:

It is expected that such solution can be applied for most of the 14 existing large kilns as well as for most of the 20 large kilns planned to be implemented. VICEM considers this technology as interesting and is presently planning to carry out feasibility studies at 8 major production facilities in order to assess its technical and economical feasibility. An intervention covering all the existing and planned kilns would result in emission reductions of 245,878 tCO2e per year.

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Waste heat power generation solution for 8 plants of VNCC	Work with 1 company and 8 plants New World Bank counterpart	245,878 tCO2-e/yr (0.6 % emission from cement industry)	$ 2.5 million per year (about $0.3 million per plant)

d. Project type C4: Energy efficiency

(i)Project Technologies and Activities

There are CDM-methodologies for energy saving projects in the cement industry. The solutions applied to improve energy efficiency include:

- Replace ball grinder by roller grinder in grinding raw material (limestone, coal).
- Replace ball grinder by roller grinder in grinding clinker.
- Use high efficient mechanical classifier to separate over-size material (limestone, clinker) to back to grinder.
- Improve pre-heaters.
- Improve efficiency in lighting.
- Improve efficiency in fan system.
- Apply inverters for motors

Such projects (Improvement of grinders/clinker mills projects; improvement of pre-heaters projects; improved control of fans projects) have been applied internationally.

(ii) Baseline and Additionality Issues

The baseline scenario considers that all cement plants use traditional technology. The alternative scenarios take into account the improvement in energy consumption and therefore, enhance the energy efficiency in the plants.

In Vietnam a number of plants apply open type ball mills while newer plants apply closed ball mills with a higher efficiency. It is even more efficient if roller grinder is used. It is expected that such a solution will be relevant for a large number of cement kilns in Vietnam. The principle will however not be relevant in all cases if the waste heat can instead be used for power generation according to AM0024 above. It should be clarified whether the improvement of pre-heaters also increases production capacity of the cement plants.

(iii) Assessment of Applicable CDM methodologies

The methodology approved by CDM Executive Board.

AMS-II.D: Energy savings optimizing mills, pre-heaters and fans etc.

(iv) GHG Emission Reduction Potential

The GHG emission reduction by improving energy efficiency by 15 percent for electricity and 26 percent for fuels in all 41 cement plants by biomass- the GHG emission reduction is 6.2 million tCO2-e/yr.

% sector covered	Cumulative Emission reduction (tCO2-e/yr)
2.4%	465,426
4.9%	890,957
7.3%	1,263,298
9.8%	1,635,638
12.2%	1,835,106
14.6%	2,021,277
17.1%	2,207,447
19.5%	2,367,021
22.0%	2,486,702
100.0%	6,156,915

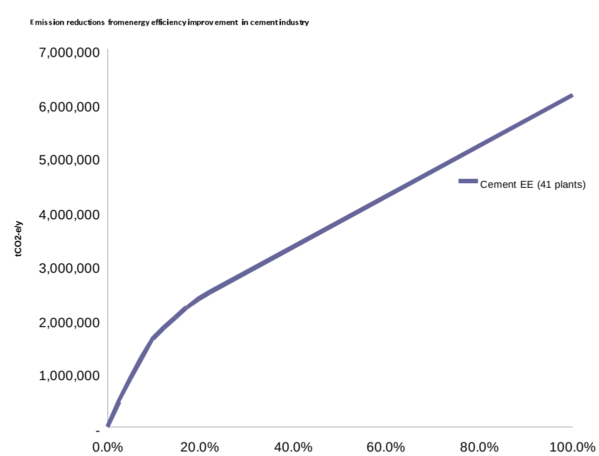


Figure 8 GHG emission reduction from energy efficiency improvement solution in cement industry

(v) Examples of potentially feasible sector-wide interventions

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Energy efficiency improvement solution for 9 plants of VNCC (22% numbers of plants)	Work with 1 company and 9 plants New World Bank counterpart	2,486,702 tCO2-e/yr (6% emission from cement industry)	$ 25 million per year (about $2.7 million per plant)

Brick making

Project type B1: Replacement with vertical shaft brick kiln

(i) Project Technologies and Activities

The vertical shaft brick kilns have better energy efficiency and higher productivity than traditional kilns.

Replacement of the old traditional kilns with the vertical shaft brick kilns (VSBK) are expected to reduce the energy consumption and to offer a potential of CO2 emission reduction. This replacement can save up to 50 percent of the fuel consumption.

(ii) Baseline and Additionality Issues

The baseline scenario considers that all bricks are produced by traditional kilns. In the alternative scenario, the vertical shaft brick kilns replace all traditional kilns. The higher investment cost for the construction of the vertical shaft brick kilns is the most prominent barrier as investors are mostly small entrepreneurs.

In 2001, the Small Grant Program Operations (SGP) (UNDP – GEF) supported the Vietnam Association of Thermal Science and Technology and the Institute of Heat Engineering and Refrigeration to implement a project on “Developing a model of vertical shaft brick kiln with high efficiency” to promote the application of vertical shaft brick kilns in Vietnam. This VSBK model was then introduced in the UNDP-GEF program “Promoting Energy Conservation in Small and Medium Enterprises” (PECSME) and achieved some significant results in energy savings and environmental improvement. The technology are rather simple and does not require high investment capital, nor professional labor skills as compared to tunnel technology. However, to the small scale manufacturers, need of financial and technical support as the initial investment represents a large capital outlay for them and the operation of the technology is new to them.

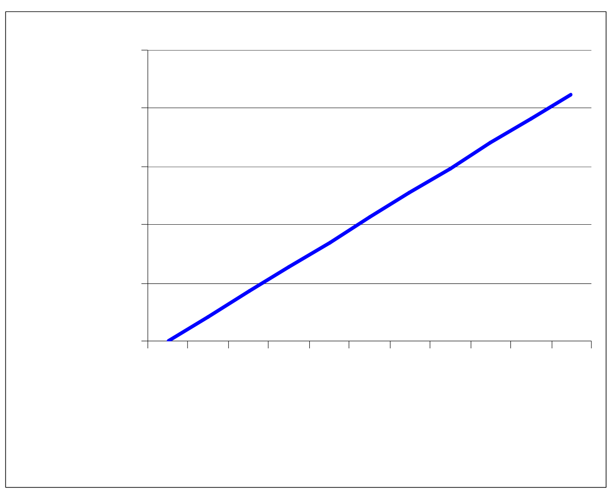
(iii) Assessment of Applicable CDM Methodologies

There is no approved methodology in the area

(iv) GHG Emission Reduction Potential

The potential GHG emission represents around 170 thousand tCO_2-e/yr if 100 percent of traditional kiln is replaced by vertical shaft kiln.

% replacement	Emission reduction (tCO2-e/yr)
10%	17000
20%	34000
30%	51000
40%	68000
50%	85000
60%	102000
70%	119000
80%	136000



90%	153000
100%	170000

Figure 9 GHG emission reduction vs. replacement of traditional kiln by vertical shaft kiln

(v) Examples of potentially feasible sector-wide interventions:

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Introduction of VSBK in 40% of traditional kilns	Through intermediary bank or using mechanism utilized by GEF project	68,0000 tCO2-e/yr	$ 680,000 per year

<u>Iron and steel industry</u>

a. *Project type S1: Waste heat recovery*

(*i*) Project Technologies and Activities
Waste heat recovery in the steel production can be done follow the Blast Furnace's Top Pressure Recovery Turbine (BF-TRT) technology and Basic Oxygen Furnace (BOF) gas recovery technology. BF-TRT can be applied for pig-iron production and BOF is used for billet production.

(ii) Baseline and Additionality Issues
The baseline scenario considers that all steel production facilities use traditional technology. The alternative scenario considers waste heat recovery for saving electricity..
There are some barriers for such kind of project to be implemented:

- Lack of government policy and incentive mechanism to promote the implementation of projects
- Limited awareness of owners

There is no information available about CDM projects under development in iron and steel industry in Vietnam.

(iii) Assessment of Applicable CDM Methodologies
An approved small scale methodologies is as follow:
AMS-III.Q: Waste Energy recovery (gas/heat/pressure) projects

(iv) GHG Emission Reduction Potential
The emission reduction is calculated based on the following assumptions:

- BF-TRT technology is applied for pig-iron production in 1 major plant (Thai Nguyen Iron and Steel Company TISCO), 4 small plants[20] and 9 other plants[21]. The emission reduction is 17.377 tCO2-e/ ton of final production[22]
- BOF is applied for billet production in 3 VSC plants[23] and 4 non VSC plants[24]. The emission reduction is 49.263 tCO2-e/ton of final production[25]

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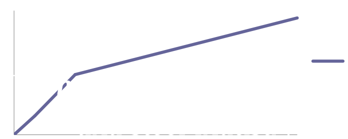
[20] *Nguyen, V. S. (2008)*
[21] *,Ernst & Young (2003)*
[22] *Michaelowa, A. (2005)*
[23] *Ernst & Young (2003)*



% sector covered	Cumulative Emission reduction (tCO2-e/yr)
0%	0
5%	45343.22
26%	84969.47
53%	114768.4
63%	130618.9
100%	182291.5

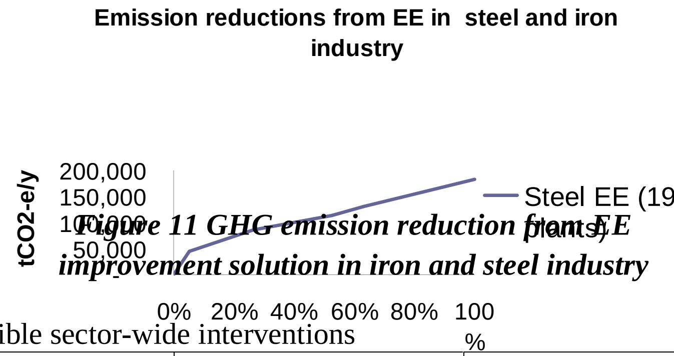


Figure 11 GHG emission reduction from EE improvement solution in iron and steel industry

(v) Examples of potentially feasible sector-wide interventions

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Energy efficiency improvement solution for 5 plants of VSC	Work with 1 company	84,969 tCO2-e/yr (0.5 % emission from iron and steel industry)	$ 0.8 million per year (about $ 0.16 million per plant)

<u>Pulp and paper production</u>

Project type P1: Cogeneration/Combined Heat and Power (CHP)

(i) Project Technologies and Activities

Cogeneration, also know as “Combined Heat and Power” (CHP), is defined as the simultaneous generation of two forms of energy (heat and power) from the same plant using one single primary energy source. All pulp and paper mills use steam and electricity with steam produced using fossils fuels and electricity purchased from the grid.

The main advantage of cogeneration is fuel savings (25-30 percent) when compared to separate generation of electricity and heat. The fuel used in cogeneration can be coal, oil, gas or even biomass in conjunction with energy producing steam turbines, reciprocating engines or gas turbines. As a coal-intensive industry in Vietnam, the pulp and paper industry can largely benefit from cogeneration and offer the high potential of GHG emission reduction.

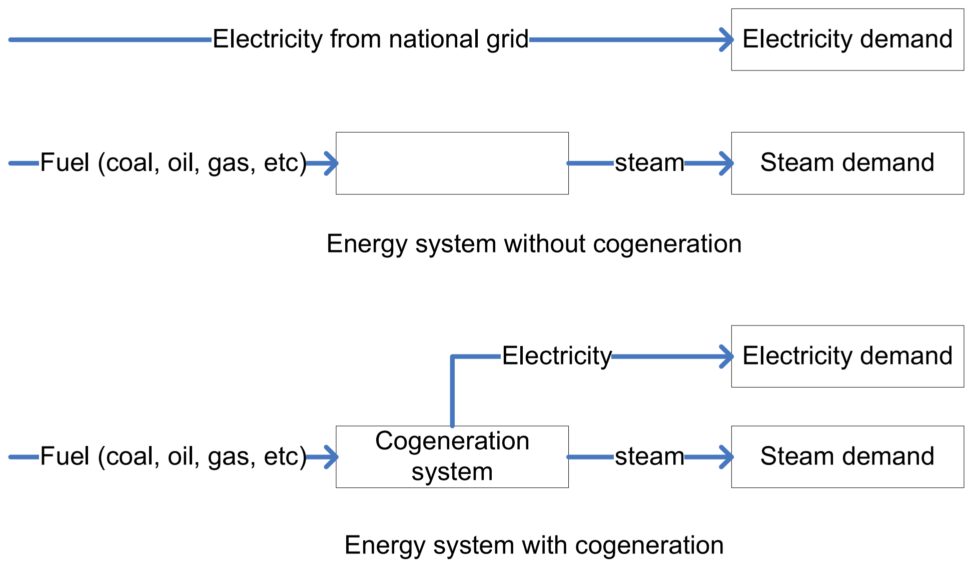


Figure 12 Energy system in pulp and paper mills with and without cogeneration

(ii) Baseline and Additionality Issues

The baseline scenario considers that electricity used in paper mills is supplied from the national grid. In the alternative scenario, a cogeneration plant supplies steam and electricity. The investment cost is around 1200 USD/kW. Efficiency in paper mills will increase, leading to a decrease in fuel consumption and GHG emissions. Combined heat and power is economically cost-effective. Therefore, several cogeneration facilities have already been installed in the pulp and paper industry in Vietnam. However, in recent years, no new investment in cogeneration in this sub-sector was made, mainly due to high investment costs and an increased price of coal. Alternatives to coal can be natural gas or biomass. However, most of the natural gas is presently used for power plants. The feasibility of biomass cogeneration is not very good due to high investment costs and unclear biomass supply sources.

There is a project in Phong Khe village involving the construction of a cogeneration system with a steam capacity of 60 ton per hour and electricity capacity is 6.4 MW. Total CO2 emission reduction is 74,717 tCO2-e/yr.

(iii) Assessment of Applicable CDM Methodologies

Several CDM methodologies can be applied to these types of projects, depending on the fuel type and use of energy.

(iv) GHG Emission Reduction Potential

The GHG emissions reduction by cogeneration solution for all pulp and paper industry, including about 150 plants, is 381,250 tCO2-e/yr.

% sector covered	Cumulative Emission reduction (tCO2-e/yr)
0.0%	0
0.7%	80,874
1.3%	155,927
2.0%	174,908
2.7%	191,667
3.3%	198,708
4.0%	203,237
4.7%	207,352
100.0%	381,250

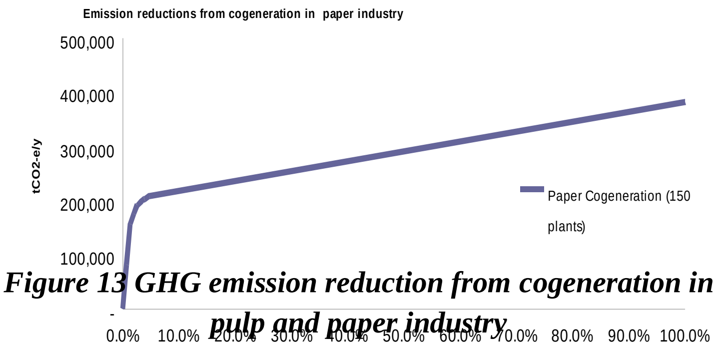


Figure 13 GHG emission reduction from cogeneration in pulp and paper industry

(v) Examples of potentially feasible sector-wide interventions

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Cogeneration solution for 7 plants of Vinapimex	Work with 1 company	207,352 tCO2-e/yr (7% emission from pulp and paper industry)	$ 2 million per year (about $ 0.3 million per plant)

Annex 1: References

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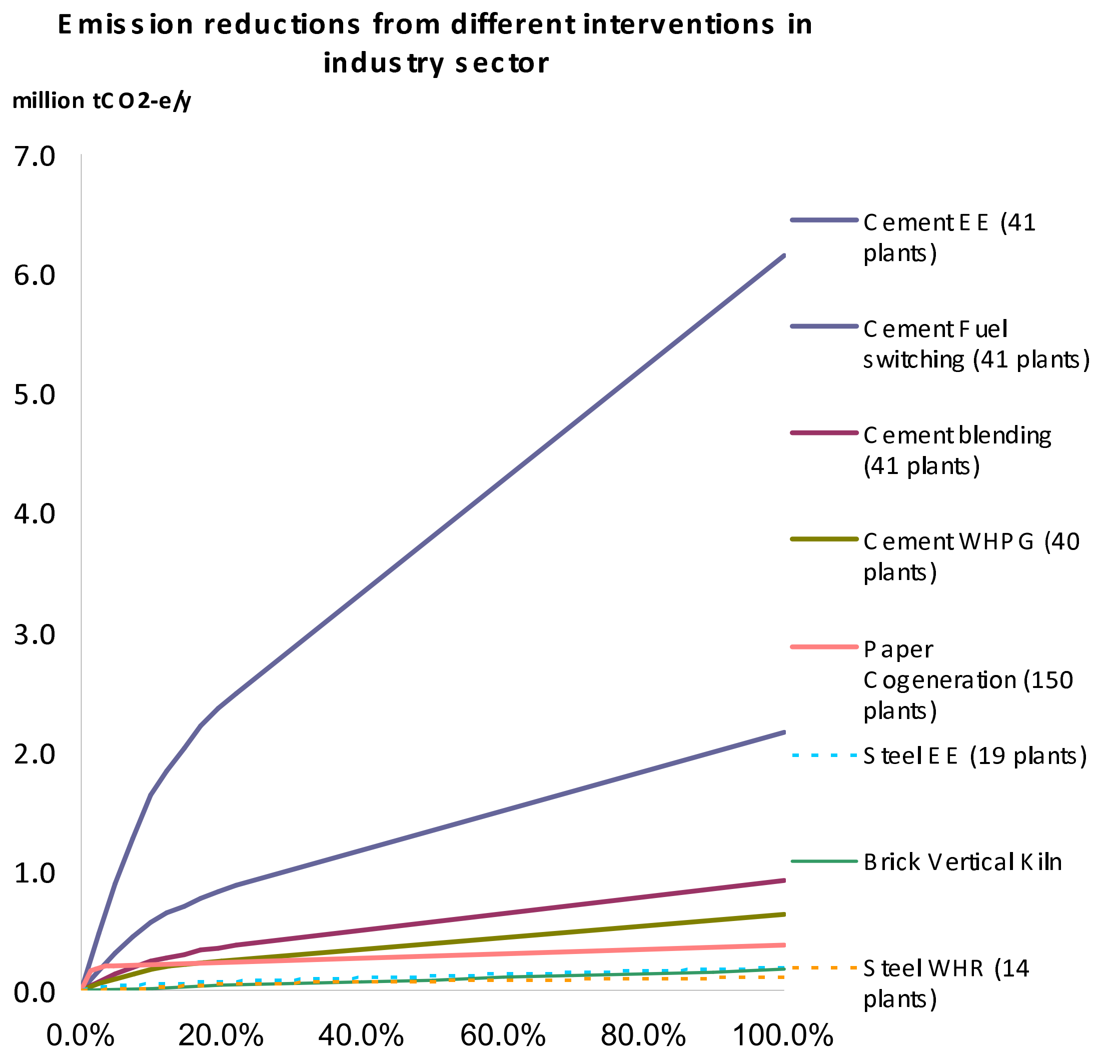
Annex 2: Summary of potential emission reductions from interventions in industry



Note: Estimates based on annual reductions during 2010-2015

Annex 3: Summary of potentially feasible sector-wide interventions in industry

	Sector	Program Intervention	GHG emissions in 2010 (million tCO2-e)	GHG reduction potential (2010 to 2015)		
				Total Potential (million tCO2-e/y)	For program idea (million tCO2-e/y)	Co-benefits and Financial C
	Industry		**40.3**	**10.7**	**4.4**	
C1	Cement	Applying fuel switching in 9 cement factories of VICEM		2.2	0.87	Fuel savings; reduced air polluti Typically profitable with CDM
C2	Cement	Increased blending of cement for 9 cement factories of VICEM		0.92	0.37	Fuel savings; Typically profitable CDM
C3	Cement	Recovery of waste heat in 9 cement factories of VICEM for power generation		0.64	0.246	Fuel savings; reduced air polluti Typically profitable with CDM
C4	Cement	Energy efficiency improvement for 9 plants if VICEM		6.1	2.5	Fuel savings; reduced air polluti Typically profitable with CDM
B1	Brick	Replacement of traditional kilns with Vertical Shaft Brick Kiln for 40% of traditional kilns		0.17	0.068	Fuel savings; reduced air polluti Typically profitable with CDM
S1	Iron and Steel	Recovery of waste heat in 3 iron and steel factories belonging to VSC for power generation or heating		0.113	0.058	Fuel savings; reduced air polluti Typically profitable with CDM
S2	Iron and Steel	Improving energy efficiency in 5 iron and steel plants belonging to VSC		0.182	0.085	Fuel savings; reduced air polluti Typically profitable with CDM
P1	Pulp and Paper	Cogeneration/Combined Heat and Power in 7 pulp and paper plants belonging to Vinapimex		0.381	0.207	Fuel savings; reduced air polluti Typically profitable with CDM