Sustainability in Manufacturing Built Materials: Cement Manufacturing Using Alternative Fuel and Raw Material in Cement Kilns

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Abstract

Cement manufacturing has a high impact on the ecological environment from "quarry to lorry". Starting from excavation of limestone, raw material crushing and milling, clinker manufacturing, cement grinding and bulk & bag material transportation demands use of natural resources in the form of material and energy. Driving of sustainability initiatives in the cement industry has gained focus over a period of time and reducing the non-renewable energy usage in the thermal process of clinker manufacturing has been identified as a key area to drive. In the traditional cement manufacturing process, the thermal energy demand of the cement kiln is supplied through the use of fuel such as coal and heavy furnace oil which is a non-renewable energy source. The initiative to replace traditional fuel usage by using alternative fuel derived from the industrial wastes unfolds cement industry to drive sustainability in two aspects. Firstly, through replacing coal and hence conserving a non-renewable energy and secondly through making the cement kilns available under controlled conditions to thermally destruct hazardous and non-hazardous waste and thereby providing an environmentally sound final destination to dispose their waste to the industrial waste generators. The paper discusses how the cement industry in Sri Lanka, specifically the only fully integrated cement manufacturing facility operated by Holcim (Lanka) Ltd. derives this model to deliver sustainability in the cement industry.

Keywords: Co-processing, Sustainability, Geocycle

Abbreviations

PEA	Provincial Environmental Authority
NWP	North Western Province
CEA	Central Environmental Authority
GIHWMR	Guidelines for the Implementation of Hazardous Waste Management Regulations in Sri Lanka
CSI	Cement Sustainability Initiative
AFR	Alternative Fuels and Raw materials
EPL	Environmental Protection Licence
SBU	Strategic Business Unit
BOI	Board of Investment of Sri Lanka

1. Introduction

Cement manufacturing is a highly energy intensive industry and cement companies face the challenge to reduce CO_2 emissions, which results largely due to the thermal process in cement manufacturing. Holcim Ltd., a global leader in the cement industry, adopts the strategy of using waste derived fuels as an alternative fuel in the cement kilns which contributes to reduction of CO_2 emissions. The paper discusses how Holcim (Lanka) Ltd., a subsidiary of Holcim Ltd. used this strategy to contribute to sustainability, environmentally, socially as well as economically.

2. Environmental Impact of Cement Industry

2.1 Cement Manufacturing

Cement industry today produces approximately 3.3 billion tons of cement and 3.1 billion tons of clinker every year as per the Mineral Commodity Summaries (2011) U.S. Geological Survey

The key processes in cement manufacturing consist quarrying, crushing, clinker manufacturing and cement milling.

The main sub process is the chemical process of making clinker which takes place in the cement kilns. Wet and dry cement kilns are used across the world. However, increasingly wet kilns are being replaced by more energy efficient dry kilns across the world.

2.2 The Environmental Impact

The cement industry, in each of its manufacturing process step has an environmental impact. Quarrying results in changes in the landscape and deforestation which impacts on biodiversity, soil, water beds and mineral dispersion in the land. All mechanical processes including crushing limestone, raw milling, cement milling, coal milling and conveyance, packing and finish goods transportation result in fugitive dust emissions and consumption of energy for mechanical activity. The chemical process of pre-heating of the kiln feed and calcinations involve consumption of energy and more importantly use of non- renewable energy in the cement kilns for heat generation. In addition to the combustion process, calcination during clinker manufacturing also results in CO_2.

Overall, cement manufacturing is identified as a high energy intensive process and main contributor to the global CO_2 emissions. Cement industry contributes to 2% of global primary energy consumption and 5% of total global industrial energy consumption. It also contributes to 5% of total global CO_2 as per the World Energy Council (2005).

Cement Industry Environment Report (2003) Cement Industry Federation, Australia provides the breakdown of greenhouse gas emissions of cement industry as 52% resulting from chemical process of making clinker, 36 % from combustion of fossil fuels in the kiln and 12% from indirect emissions from purchased electrical power.

CO_2 emissions in the combustion process is intensified by the use of carbon intensive fuel such as coal as traditional fuel by cement kilns to generate heat in the calcining process.

The specific process CO_2 emission for cement production depends on the ratio clinker/cement and this ratio varies normally from 0.5 to 0.95 as per C.A. Hendriks, E Worrell, D. de Jager, K. Blok, and P. Riemer (2004) Emission Reduction of Greenhouse Gases from the Cement Industry.

The total CO_2 emission during the cement production process depends mainly on, the type of type of production process (efficiency of the process and sub-processes), the fuel used (coal, fuel oil, natural gas, petroleum coke, alternative fuels) and the clinker/cement ratio (percentage of additives).

Thus, in order to reduce adverse environmental impact, it is necessary industry focuses on reducing CO_2 emissions.

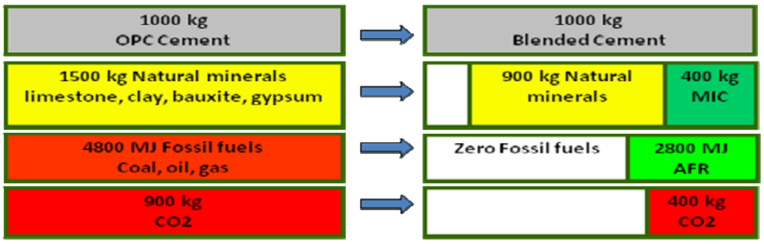
3. Strategies for Reducing CO_2 in Cement Industry

Traditional strategies to reduce the CO_2emissions in the cement industries can be identified as below by C.A. Hendriks, E Worrell, D. de Jager, K. Blok, and P. Riemer (2004)

- Applying lower clinker/cement ratio by increasing additives and producing blended cements.
- Replacing fuel emitting high CO_2 to the ones which produce lower CO_2
- Use of alternative raw material and replace traditional raw material extracted
- Improvement of the energy efficiency of the process to reduce the resultant CO_2 from the same output
- Changes in technology to shift towards a more energy efficient process (e.g. from wet process of cement making to dry process)
- Removal of CO_2 from the flue gases

Use of alternative fuels and raw materials has been identified as a key initiative to bring out a significant CO_2 reduction in the cement industry. This initiative is also endorsed by the Cement Sustainability Initiative (CSI) and the World Business Council for Sustainable Development (WBCSD).

Using a combination of strategies (a), (b) and (c) , an estimation of CO_2 reduction is diagrammatically explained below in moving towards blended cement.



AFR: Alternative Fuels and Raw materials
MIC: Mineral components
OPC: Ordinary Portland Cement
MJ: Mega Joule

Figure 1: CO_2 emissions in cement production

The use of waste derived fuel instead of fossil fuel could reduce CO_2 emissions by about 20% to 40%. On average blended cements are identified to reduce carbon emissions by about 20%.

4. Co-processing of Waste Derived Fuel in Cement Kilns

Cement industry, in general uses coal, heavy furnace oil, petroleum coke and natural gas in producing heat for combustion which are typically considered as traditional fuel used in the combustion process in the cement kilns. Due to high operating temperatures, and the residence times, the cement kilns have the required characteristics and conditions to use alternative fuels derived out of waste, including organic and hazardous waste, effectively to produce heat without detrimental impacts on the environment causing harmful emissions. This technology is referred to as co-processing in cement kilns.

Co-processing is primarily defined as two processes occurring simultaneously. While clinker is produced in the cement kiln by calcination, thermal destruction of the waste (coming via waste derived fuels) takes place simultaneously in the cement kiln.

4.1 Co-processing

Operational conditions and characteristics of co-processing as mentioned below enable it to be used effectively in cement kilns to thermally destruct waste derived fuels, including hazardous waste.

- High flame temperature (1,800 - 2,000°C)
- 5 to 6 seconds of residence time above 1,200°C
- Excess of oxygen during and after combustion
- Complete destruction of organic compounds
- Total neutralization of acid gases, sulphur oxides and hydrogen chloride, by the active lime in the kiln load, in large excess to the stoichiometry
- Embedding of the traces of heavy metals in the clinker structure with very stable links (metallic silicates formation)
- No production of by-products such as ash or liquid residue from gas cleaning

- Total recovery of energy and mineral content of waste (raw material and fossil fuel saving)

4.2 Dual Role of Co-processing

The cement kiln requires a uniform quality fuel mix to have stability in the combustion process in the kiln. Use of waste derived fuel imposes the challenge to the process engineers and production managers to supply a homogeneous fuel mix, derived out of different waste types with varying quality. To face this challenge and to ensure environmental and regulatory compliance in co-processing, it is critical for the cement companies carrying this activity to have a dedicated unit to perform the below two main roles.

One is to provide waste management solutions by operating at the front end to secure waste sources to be directed to the cement kiln and to provide a service to the waste generators by undertaking to provide a solution to the waste. This part of the organization operates as a service organization in the waste management/ environmental industry focusing on the needs and wants of the waste generator.

Two is to provide an alternative fuel to the cement kilns by preparing a waste derived fuel, which can be substituted in the cement kilns as an alternative fuel and supply a uniform quality alternative fuel source to the cement kilns. It is required to maintain facilities to pre-process waste to bring them to a homogenous quality and to work closely with the cement plant to supply a fuel mix meeting their specifications.

4.3 Key steps in Co-processing

Considering the total life cycle of co-processing a waste derived fuel in the cement kilns, the following key processes are required to be carried out by the organization mentioned above.

a) Testing and pre-qualification
   The candidate waste sample needs to undergo testing and pre-qualification. A technical feasibility analysis is done prior to accepting a waste, assessing mainly the possible combustion products and pre-processing required for the bulk waste load. The cement plant sets the specifications for acceptance for the waste following pre-qualification analysis.
b) Permitting and approval
   Environmental approval to collect, transport, store and treat the waste is required from the relevant authorities. The approval need to be sought jointly by the waste generator and the treatment facility and given with conditions both parties have to comply with.
c) Commercial terms and agreement
   The waste generator and the relevant treatment facility needs to agree on the commercial terms and conditions on treatment and disposal before the physical movement of the waste happens. As hazardous waste is subject to stringent regulatory criteria, typically an agreement is signed between the parties prior to shipping the hazardous waste with specific details about the transfer of the ownership of waste.

d) Testing and finger-print analysis

Prior to physical transfer of the waste happens or before acceptance at the treatment facility, a sample of waste the bulk waste load is checked to identify whether the characteristics of the waste fall within the pre-agreed criteria.

e) Collection

The waste load is prepared for transportation, which may include packing, repacking, transferred to safe containment in the case of liquid waste, covering and sealing. Labeling is particularly required if hazardous waste is transported.

f) Storage

The waste may have intermediate storage and needs to be stored under appropriate conditions specified.

g) Pre-processing

Pre-processing involve preparation of the waste material to be fed and used as a waste derived alternative fuel, based on the specifications required by the cement plant. For solid wastes such as textile and polythene, shredding into small pieces may be required. For hazardous wastes, chemical treatment such as neutralization, decontamination of containers, mixing and dilution may be required.

h) Transportation

The waste needs to be transported to the treatment facility.

i) Handling, storage and conveyance

The waste needs to be handled, may be stored, and need to be conveyed to the cement kilns via the appropriate feeding mechanism. Some wastes have dedicated feeding lines.

j) Co-processing

The waste is destroyed under controlled conditions.

k) Compliance monitoring

The gases of the combustion process are monitored on a continuous basis to ensure that the emissions are within the permissible limits set for the cement manufacturing process.

5. Holcim's initiative on Co-processing

5.1 Co-processing as a Global Sustainability Initiative

Holcim has been a pioneer in identifying and developing concept, technology and know-how on co-processing in the cement industry over the last three decades. In 2008, all intermediary business units and companies carrying out co-processing and operating in the waste management industry were given a common identity, Geocycle across the group. Presently Holcim has more than 30 such service oriented business units/ companies across the group.

5.2 Holcim (Lanka) Ltd. and Geocycle

Hoclim (Lanka) Ltd. is a fully owned subsidiary of Hoclim Ltd., Switzerland which has a presence in over 80 countries worldwide. Holcim (Lanka) Ltd. produces 1.3 million MT of cement and approximately 640,000 MT of clinker annually. It has Sri Lanka's only fully integrated cement plans with two rotary dry kilns, each with capacity 1100 MT/day in Puttalam and a grinding station in Galle. Sri Lanka's annual demand of cement sold is about 5.9 million MT and Holcim Lanka is a leading player in the cement market in Sri Lanka with approximately 38% market share.

Holcim Group set up a dedicated unit to carry out co-processing activities, with a separate identity called Geocycle, worldwide. In Holcim (Lanka) Ltd., Geocycle functions as a Strategic Business Unit (SBU), under the same legal entity operates as its waste management arm.

Holcim (Lanka) Ltd. operates Sri Lanka's only fully integrated cement plant, which consist of two dry kilns with four stage suspension pre-heaters, located in Palavi, Puttalam. Each kiln has capacity of 1100 MT/ day. The kilns operate as rotary, counter current plug flow reactors and have operating temperatures in the range of 900 C and 1450 C at the material entry and exit ends.

5.3 Implementation and Key Milestones

Co-processing was started in Holcim Lanka in 2002. Rice husk and saw dust were the key alternative fuel used. There was a change in strategic direction to move from agricultural waste to industrial waste, especially hazardous waste and a dedicated business unit was formed in 2004 to carry out co-processing. A detailed survey on waste generation was done focusing especially on hazardous waste during the same year and the first waste marketing plan was formulated to make entry in to the hazardous waste market.

In 2005, industrial waste co-processing started and the first load of pharmaceutical waste was co-processed with the approval of the Provincial Environmental Authority (PEA) of the North Western Province (NWP) and the Central Environmental Authority (CEA) . Geocycle also took steps to apply for a generic permit to co-process waste by submitting a detailed project proposal to the PEA of NWP as a prescribed project. To win acceptance for co-processing among its focused stakeholders, Geocycle launched a long term communications strategy, also in 2005.

By 2006, the total industrial customer base consisted of 22 and to gain generic permit for hazardous waste co-processing Geocycle started the Environmental Impact Assessment (EIA) study, while continuing to provide solutions for non-hazardous waste and obtaining permits for hazardous wastes on case by case basis.

Taking another development in its strategy, in 2007, Geocycle started supplying total solutions to Colombo Dockyard PLC, a large scale generator of industrial waste building up a partner network to handle wastes not diverted to co-processing. Geocycle adopted the global identity during the same year and also started operations of its first pre-processing facility in Peliyagoda.

In October 2008, cement kilns operated by Holcim Lanka demonstrated its ability to thermally destruct hazardous waste to a Thermal Destruction Efficiency (TDE) exceeding 99.9999% which is considered to be the acceptable global standard. The kilns' TDE was assessed using wastes containing Polychloro Biphenyl (PCB), monitored by an independent group including Environmental Authorities of Sri Lanka.

In 2008, Geocycle obtained the first Environmental Protection License (EPL) for hazardous waste co-processing in cement kilns to a list of wastes, enabling it to accept a large range of hazardous waste. It also expanded its operations to provide a solution to the waste of 84 companies in the Katunayake Export Processing Zone (KEPZ) and signed a contract with the BOI. Expanding its capacity Geocycle constructed and opened for operations the first fully fledged pre-processing plant to process hazardous waste in the KEPZ. By 2010 the total customer base consisted of 194 and Geocycle was able to co-process more than 40,000 MT of waste.

6. Contribution towards sustainability

6.1 Sustainability

Sustainable development was defined by the United Nations World Commission on Environment and Development in the 1987 Brundtland Report as "those paths of social, economic and political progress that meet the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainability described using the triple bottom line concept as below by Gilbert, Stevenson, Girardet, Stren in 1996, generally the following requirements.

- Environmental sustainability requires that natural capital remains intact
- Social sustainability requires that the cohesion of society and its ability to work towards common goals be maintained.
- Economic sustainability occurs when development, which moves towards social and environmental sustainability, is financially feasible.

6.2 Contribution to Environmental Sustainability

Co-processing contributes to environmental sustainability in two ways mainly;

a) Reduction of CO_2 by using alternative low carbon intensive fuels and avoiding the emissions of CO_2 and other gases as combustion products by incorporating them under the combustion products for clinker manufacturing
b) Diverting the industrial waste to an environmentally sound final destination for treatment and thereby avoiding the detrimental impact to the environment otherwise

6.3 Environmental Sustainability – CO_2 Reduction

The CO_2 reduction due to co-processing can be derived using the following methodology using life cycle cost analysis basis

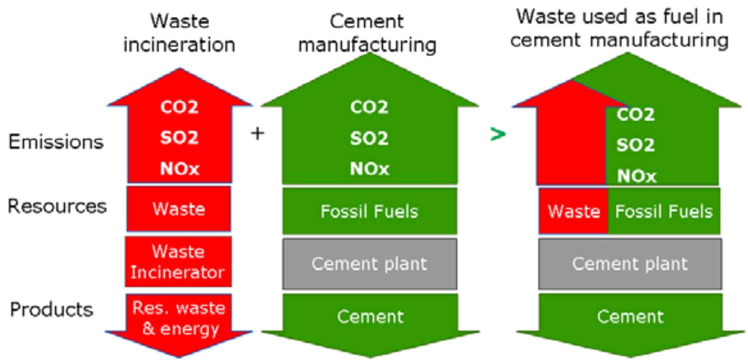


Figure 2: Net saving of CO_2

a) The CO_2 avoided by replacing combustion of coal includes CO_2 emissions resulted by coal quarrying, crushing, transportation (Includes land transportation within the country of origin, sea transportation across country boundaries and land transportation in the country of use in the context of Sri Lanka) , coal milling and handling and conveyance. The CO_2 resultant from the combustion of waste derived fuel includes CO_2 resultant from waste transportation, pre-processing and handling and conveyance. The net effect of replacement needs to be considered by addition the above two.

b) The CO_2 avoided by the thermal destruction of the waste in the next best available thermal process outside cement kilns (e.g. incinerator) including CO_2 emitted in the operations and the supply chain of waste.

The net effect of (a) and (b) is the CO_2 saved by co-processing.

6.3.1 Environmental Sustainability – Waste Management

Co-processing contributes to environmental sustainability via establishing environmentally sound waste management practices and solutions, by diverting the waste to a sustainable end destination.

As per the waste management hierarchy which ranks the waste management solutions based on sustainability, co-processing is regarded as a recovery solution as material and energy recovery takes place during co-processing. It contributes to sustainability by elevating a waste stream to a more sustainable solution. Taking the life cycle impact of the waste, future environmental liabilities resulting from the waste is avoided as complete thermal destruction takes place inside the kiln, without wastes or additional by products.

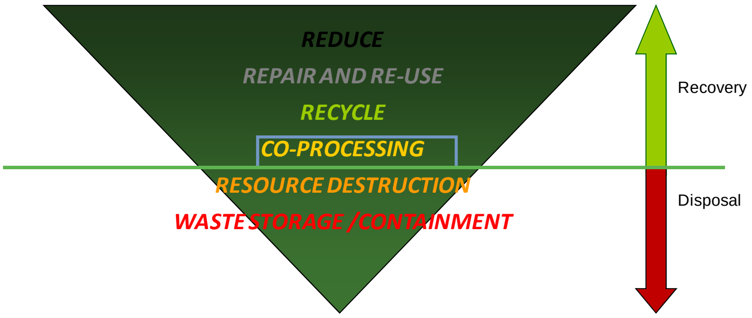


Figure 3: Waste management hierarchy

6.4 Contribution of Geocycle to Environmental Sustainability

6.4.1 Environmental Sustainability – CO_2 Reduction

Waste volume grew from about 6,000 MT to about 40,000 MT from 2004 to 2011. Out of the total thermal energy requirement of the cement kiln, the thermal energy supplied by the waste derived fuel increased from 6% to 30% from 2004 to 2011 (estimated).

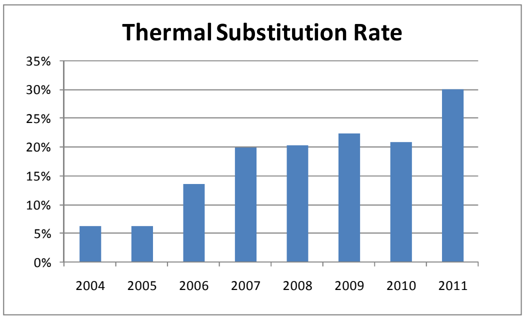


Figure 4: Thermal substitution rate

6.5 Diverting Waste to a Sustainable End Destination

The main environmental benefit in the case of Sri Lanka by co-processing is making the services of the cement kilns available to provide a final destination to industrial waste, especially hazardous waste, which would have otherwise caused significant environmental problems over its life cycle.

In Sri Lanka generation of hazardous waste was estimated to be about 66,000 MT in 2006 out of which a large percentage can be co-processed in cement kilns as identified in the Environmental Impact Assessment for the proposed co-processing of schedules wastes in kiln of cement plant at Holcim Cement Works –Puttalam.

The hazardous waste material is defined based on the constituents it contains under the "Guidelines for the implementation of hazardous waste management regulations of Sri Lanka" (GIHWMR) published the Central Environmental Authority of Sri Lanka. The GIHWMR recognizes co-processing in cement kilns as a solution to treat hazardous waste in Sri Lanka.

As per the GIHWMR, hazardous waste generated needs to be identified at the point of generation by the generator. Proper segregation needs to be carried out to avoid mixing of hazardous waste with non-hazardous waste, as the slightest contamination makes the non-hazardous waste stream also hazardous, requiring stringent regulated disposal. Geocycle has been able to establish best practices in managing hazardous waste contributing to environmental as well as social sustainability.

Holcim Lanka obtained approval from the PEA of NWP to use the cement kilns operated by the Puttlam Cement Plant as a hazardous waste co-processing facility under environmental monitoring by the PEA of NWP. This is accompanied by an approval covering collection, storage, transportation and pre-processing operations by PEA of NWP and the CEA.

The table highlights the incremental impact on the environment by adopting a more sustainable solution for waste management as per the waste management hierarchy.

Table 1: Environmental impact by the waste with the next commonly practiced solution

Waste type	***Form of waste***	***Co-processing methodology***	***Next best alternative commonly available or practiced***	***Detrimental impact to the environment avoided***
Rice husk	*Solid*	*Co-processing*	*Dumping, Open burning*	▪ *Material accumulating creating adverse health & environmental impacts*
Saw dust	*Solid*	*Co-processing*	*Dumping , Open burning*	▪ *Pollution of river water, Material accumulating at river banks creating adverse health & environmental impacts*
Waste oil	*Liquid*	*Co-processing*	*Used in brass / metallic cottage industries for heat generation under uncontrolled conditions,* *Used for unauthorized adulteration of lubricant oil,* *Dumped in the sea in the case of waste lubricants from ships*	▪ *Heat generation by combustion : Contaminants in the oil may emit harmful gases including dioxins and furans (carcinogen) at low temperatures due to heat loss during open burning* ▪ *Adulteration : The bulk lubricant oil quantity become hazardous, Uncontrolled contamination by a hazardous waste harmful to health and environment* ▪ *Dumping in sea : Pollution of sea water, Adverse effects on marine environment*
Petroleum sludge with suspended solids	*Sludge*	*Impregnation with saw dust and co-processing*	*Dumping, unregulated land filling, Storage*	▪ *Dumping & land filling : Constituent hazardous elements polluting soil and underground water sources, Effects on fauna and flora, hazardous constituents could create bio-accumulative effects*

Hazardous chemical waste (e.g. paints and solvents, agrochemical wastes)	*Liquid*	*Mixing and co-processing*	*Dumping, unregulated land filling, Storage, Open burning*	▪ *Dumping & land filling : Constituent hazardous elements polluting soil and underground water sources, Effects on fauna and flora, hazardous constituents could create bio-accumulative effects* ▪ *Open burning : Hazardous gas emissions under uncontrolled conditions including dioxins and furans (carcinogen)* ▪ *Serious adverse health impacts due to wrong handling*
Pharmaceutical waste in solid form	*Solid*	*Shredding of containers and co-processing*	*Dumping, unregulated land filling, Storage, Open burning*	▪ *Dumping & land filling : Constituent hazardous elements polluting soil and underground water sources, Effects on fauna and flora, hazardous constituents could create bio-accumulative effects* ▪ *Open burning : Hazardous gas emissions under uncontrolled conditions including dioxins and furans (carcinogen)* ▪ *Serious adverse health impacts due to wrong handling*
Mixed industrial solid waste with textile, plastic & paper in solid form	*Solid*	*Shredding and co-processing*	*Dumping, unregulated land filling, Storage, Open burning*	▪ *Dumping and land filling : Material accumulation mixed with unknown material causing adverse health and environmental problems, contamination of soil and underground water sources* ▪ *Open burning : Burning of polythene causes emission of dioxins and furans (carcinogen) at low temperatures*

The graphs below show the waste volume increase over the years the types of wastes co-processed in 2010.

Figure 5: Waste quantity increase

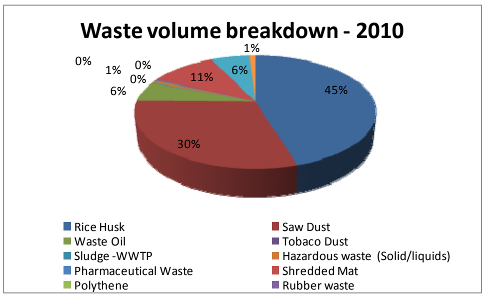


Figure 6: Waste volume breakdowin in 2010

6.6 Contribution to Economic Sustainability

Cement kiln co-processing is economically feasible and the internal economic value addition is reflected as the economic performance of the business unit.

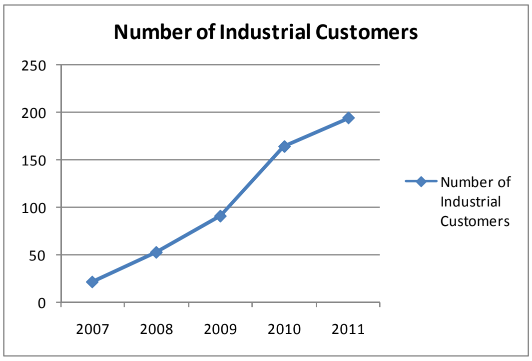
The revenue from co-processing consists of the waste disposal fee obtained from the waste generator and the benefit by replacing coal or traditional fuel. The costs involve mainly the cost of analytical testing, permitting and approval costs, the cost for operations including the cost of collection, storage, transportation and pre-processing and other fixed costs apportioned such as overhead costs for maintaining facilities, finance costs for investments, commercial and administration costs, knowledge acquisition and training costs, compliance monitoring costs etc.

The economic value addition is the net of the cost and the benefit above.

The above assumes that a waste derived fuel mix will not alter the production performance of the kilns, with the assumptions that the combustion characteristics of coal are equal to that of the waste derived fuel. Practically, in the cement kilns, there could be a production loss experienced, especially if the waste contains added moisture and fed purely for the purpose of destruction.

6.7 Contribution of Geocycle to Economic Sustainability

Geocycle has shown steady economic sustainability over the last years. The added value to the business increased by nearly 12 times from 2004 to 2011, while consistent continuous growth of customer base from the commercial front.



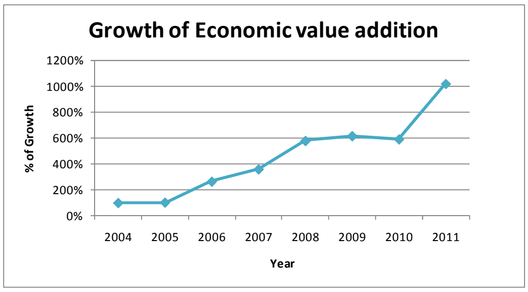


Figure 7: Increase of customers

Figure 8: Growth of economic value addition

6.8 Contribution to Social Sustainability

Co-processing contributes to social sustainability mainly through

1. Help develop and enforcement of regulatory compliance in hazardous waste disposal
2. Establish industry best practices for waste management
3. Development of partner network, employment creation and value addition to social conditions

6.9 Contribution of Geocycle to Social Sustainability

Geocycle initiated changes in the developing waste management industry and the regulatory framework associated with co-processing acting as a catalyst for change. Most of the permits and licences obtained for its operations are the first of that nature in Sri Lanka and Geocycle went through the stringent regulatory process while setting a benchmark for the following industries. These include the licence to operate a co-processing facility, EPL from BOI to operate a pre-processing facility and the E-Waste Management License issued by the CEA.

Geocycle introduced industry best practices including implementation of the six copy waste manifest system to govern control and transfer of hazardous waste. The technology for pre-processing and handling of hazardous waste were developed through research and development and is in par with global best practices

Geocycle developed a partner network along its supply chain and some partners were selected to divert the waste to the most sustainable solution such as virgin material recyclers, paper recyclers. Partners also exist who handle the wastes that cannot be co-processed in the cement kilns, such as electronic waste. The value addition created for the partner network is building up of competencies and promoting of best practices and entrepreneurship in the industry.

Geocycle establishes its health, environmental and safety standards in operations and the improvement of working conditions of more than 200 waste collectors collected waste in the KEPZ open dump yard by bringing them under a sheltered space is one example.
An assessment of the employment created by Geocycle operations in 2010 is approximately 65 full time employees and about 900 indirect employees through channel partners.

7. Conclusions

1. Cement manufacturing is a highly energy intensive process and typically when 1 metric tonne of OPC cement is made, between .8 and 1 metric tonne of CO_2 is emitted to the environment

2. Cement industry uses alternative fuel and raw materials as a strategy to reduce the environmental impact in producing cement and as a strategy to derive economic advantage and reduce dependency on traditional fuel and raw material

3. The alternative fuel mainly consists of waste derived fuel coming from industrial waste.

4. The model enables cement companies to reduce the environmental impact of the operation and to contribute to sustainability, economically, socially and environmentally.

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