# INVESTIGATION FOR POTENTIAL OF DIRECT USE OF GEOTHERMAL ENERGY IN MAGADI, KENYA

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## Abstract

Kenya is endowed with abundant geothermal energy resources in a number of prospects, mainly situated in the Rift Valley. Of the mapped-out prospects, only four are being exploited for direct utilization and for electricity leaving out the other ten prospects. Currently main use is in generation of electricity at Olkaria and Eburru, while Menengai is being developed for the same. Only a few of the prospects are for direct use currently. These include: Eburru (drying of farm produce, harnessing of water), Olkaria (Oserian Development Corporation – flower farming, Kengen – spa) and Ndogo (harnessing of water). Considering the large geothermal potential, it is possible to use this form of energy in industrial processes. Industries require high energy needs to sustain their processes, but these energies which include: Coal and fossil fuels are not clean, hence leading to pollution of the atmosphere and depletion of the ozone layer.

This study sought to analyse the energy use in the Tata Chemicals new plant at Magadi, Kenya and suggest opportunities for direct utilization of geothermal energy in the processing of soda ash to cut down on emissions and also reduce on the expenditure used on the Heavy Fuel Oil (HFO). An energy audit was done in the soda ash processing plant with the aim of introducing the use of geothermal energy directly in the processing plant. The eight processes, from dredging of trona to packaging of the processed ash were analysed taking note of the energy needs of every process.

It was concluded that, the introduction of direct geothermal energy to reduce the moisture content of the Crushed Refined Soda (CRS) to 6% just before milling would in turn lead to an increase in the ash produced per litre of heavy fuel oil used. Also the geothermal fluids can be used at the monohydrate drying section to reduce the moisture content of the ash to 4.5% leading to a reduction on the quantity of steam used.

**Keywords:** geothermal energy, energy resources, industrial processes

## Introduction

Magadi area is located at the Kenya Rift Valley southwest of Nairobi city, in southern Kenya. Magadi is northeast of Lake Natron in Tanzania, bounded by latitude 1o53’ and longitude 36o18’. Magadi soda ash processing plant is located a few meters from the shores of Lake Magadi where trona is mined.

Smith and Mosley (1993) defined the geology of Lake Magadi as being made up of mostly Achaean to early Palaeozoic crystalline basement rocks and rifted related volcanic and sediments. Magadi area was classified into three formations by Baker (1963) namely, Precambrian metamorphic rocks, Plio- Pleistocene volcanics, the Holocene to Recent Lake and fluvial sediments. In the southern and northern ends of the Lake Magadi area, there is a deposition of irregular interbedded chert rocks which consists of silicified bedded clays on top of Alkali trachytes (Atmaoui & Hollnack, 2003; Sequar, 2009).

A dense network of grid faults affects the area. These faults, especially the north-south trending fault scarps, control the occurrence of geothermal manifestations (Riaroh & Okoth, 1994).

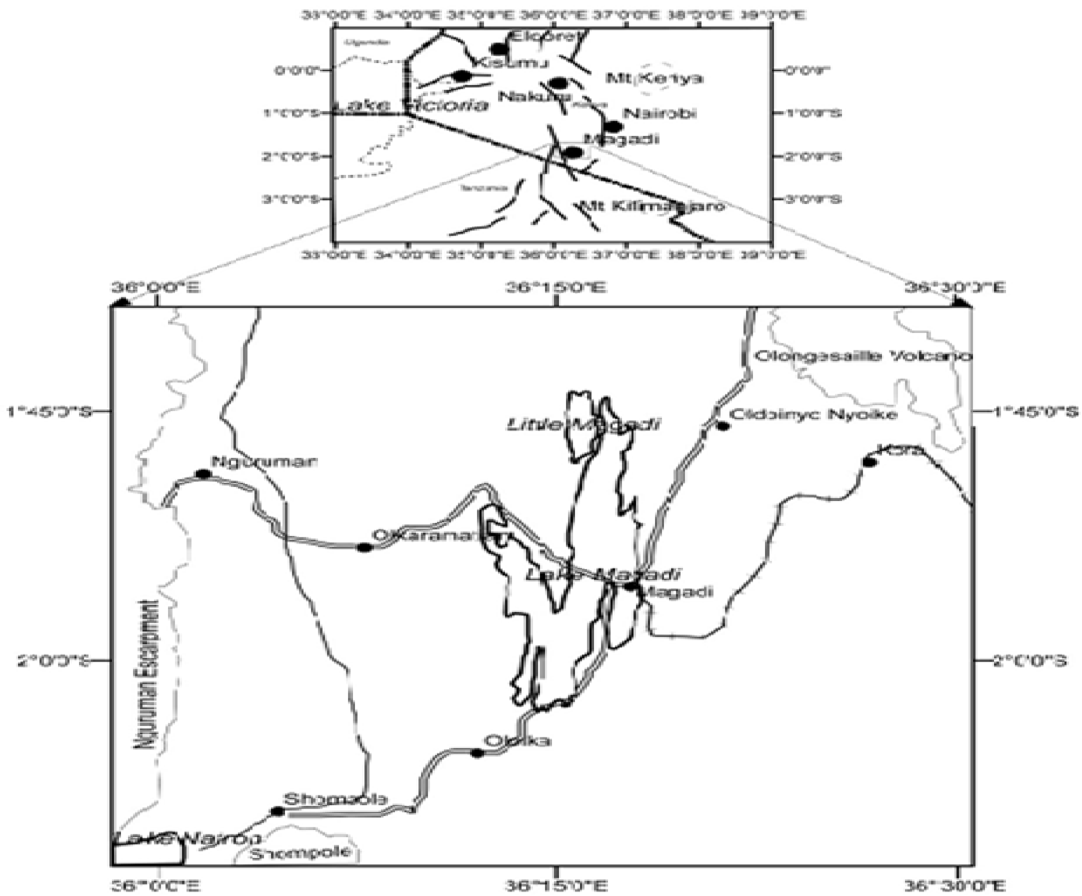


*Figure 2*. Magadi map

**Overview of Soda Ash Processing**

The processing of soda ash is energy intensive and requires energy from dredging to packaging of the finished product. There are eight processes involved in the processing of soda ash (figure 2). These includes: Dredging, washing, milling and calcining, crystallization, monohydrate drying, product screening, product storage & load and utilities.

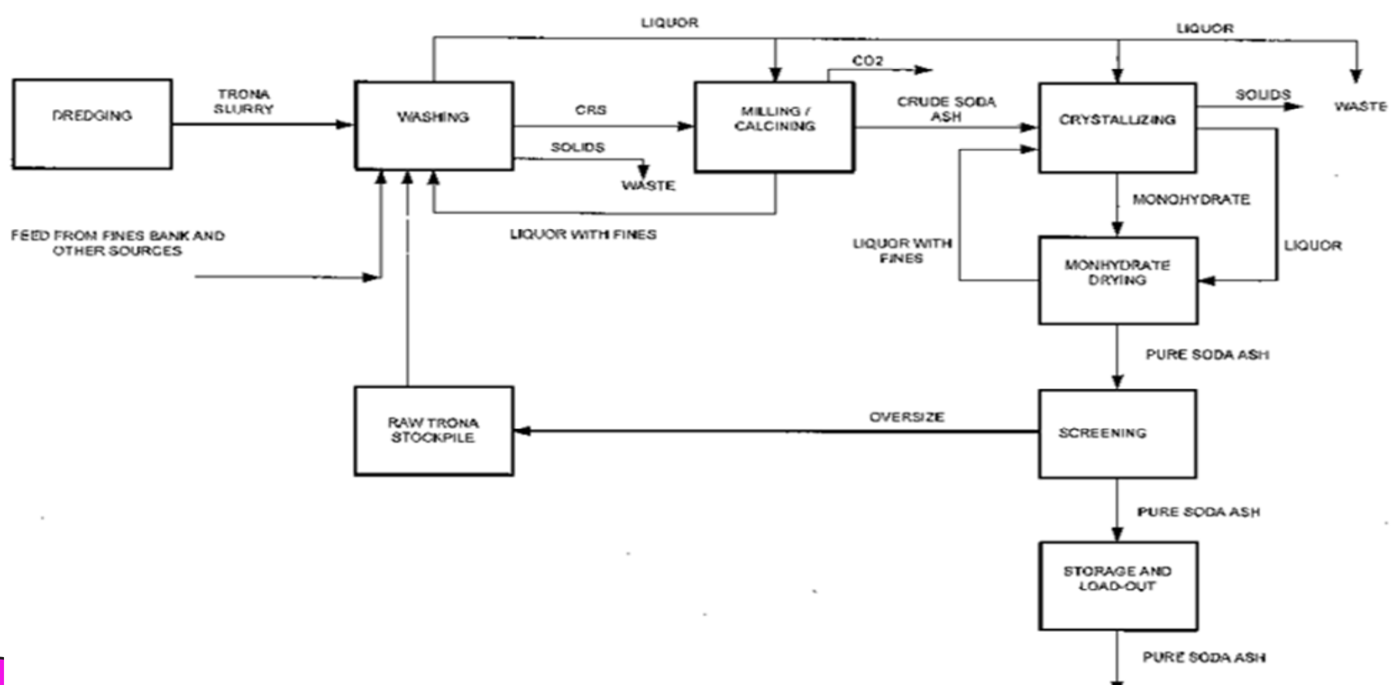


*Figure 2*. Overview of soda ash processing

The trona is mined from the lake bed by a dredge and transported, in pipes, in form of slurry after mixing with the lake waters to the washery section. The energy that is used in the dredging process is predominantly electricity.

The aim of passing the trona through the washery, is to remove insoluble impurities. Here the trona is sieved, that which is less than 8mm is transported to the milling and calcining section while that which is more than 8mm is sent to the crusher where it is crushed to 8mm or less for easier processing. From the washer, the trona now in solid form is conveyed to the milling and calcining section. The energy used in the washery is predominantly electricity.

In this section, the CRS from the washery is ground by the miller then calcined to purify it. HFO and electricity are used to power the milling and calcinations process. 35.838 litres of HFO is used in the furnace per minute (average for three years assuming the plant operates non-stop for the whole year) to heat flue gas which is used for the calcination . From the calciner, the CRS is conveyed to the crystallizer. Electricity in this section is used to power the roller mill, the cyclone and the motors rotating the conveyer belts.

Table 1

*HFO Usage and TCO2 Emitted in 2010*

| Month | LITERS OF HFO USED IN 2010 | Mass of HFO USED IN 2010 | $tCO_2$ emission | Ash produced in 2010 |
|---|---|---|---|---|
| ***JANUARY*** | 1,444,715 | 1377102.338 | 4263.509 | 10,639 |
| ***FEBRUARY*** | 1,407,229 | 1341370.683 | 4152.884 | 10,218 |
| ***MARCH*** | 1,655,098 | 1577639.414 | 4884.372 | 10,131 |
| ***APRIL*** | 1,730,073 | 1649105.584 | 5105.631 | 10,776 |
| ***MAY*** | 1,198,216 | 1142139.491 | 3536.064 | 9,147 |
| ***JUNE*** | 1,919,790 | 1829943.828 | 5665.506 | 14,020 |
| ***JULY*** | 2,043,202 | 1947580.146 | 6029.708 | 16,583 |
| ***AUGUST*** | 2,062,458 | 1965934.966 | 6086.535 | 14,799 |
| ***SEPTEMBER*** | 1,638,756 | 1562062.219 | 4836.145 | 13,031 |
| ***OCTOBER*** | 1,560,971 | 1487917.557 | 4606.593 | 12,700 |
| ***NOVEMBER*** | 2,100,320 | 2002025.024 | 6198.269 | 20,328 |
| ***DECEMBER*** | 2,272,064 | 2165731.405 | 6705.104 | 18,074 |
| **Total** | **21,032,892** | **20,048,553** | **62,070** | **160,446** |

The crystallization section serves to remove impurities from milled calcined soda ash (Bourne et. al., 1972). The ground calcine is expected to contain 95.4% sodium carbonate, 3.0% sodium fluoride, 0.26% sodium chloride, 0.84% sodium sulfate, and 0.5% insoluble material.

The monohydrate dryer has a fluid bed dryer which comprises three baffled compartments containing heat exchanger tube bundles. In the first compartment surface moisture is removed, and the monohydrate is heated to about 85 to 90°C.The first section is a well mixed deep bed for receiving and drying the wet feed material. Dehydration is not desired in this first compartment, as it results in a fragile, low hardness final product and can lead to excessive heat bundle scaling.

In the second compartment the solids temperature is increased to 150°C, and dehydration is performed. The second section is for dehydration and has a plug flow design. In the third compartment ambient temperature fluidizing air and circulating water supplied from a cooling tower are used to reduce the product temperature to 80°C. Anhydrous product containing less than 0.1 % moisture will discharge through an airlock to the dryer product conveyor feeding the screening.

Fluidizing air will be indirectly steam heated to 180°C prior to delivery to the first two dryer compartments. Air for the first compartment is supplied by a dryer air fan, preheated with condensate in a dryer air preheater and heated with steam in a dryer air heater. Air for the second compartment is supplied by a dryer air fan, preheated with condensate in dryer air preheater and heated with steam in dryer air heater. The majority of the heat for drying and dehydration is supplied by the steam heated pipe bundles inside the fluid bed. Product screening section, product storage section and utilities section all rely entirely on energy from electricity.

**Geothermal Energy Utilization**

Geothermal energy can either be utilized for electricity generation or for direct heat utilization Electricity generation is the most common mode of utilization of high enthalpy fluids. However, with the use of binary power plants it is possible to produce electricity from geothermal fluids at lower enthalpies. Currently main use in Kenya is in generation of electricity at Olkaria and Eburru, while Menengai is being developed for the same.

Direct heat applications utilize geothermal fluids from the low and medium enthalpy resources. There are several applications for utilizing geothermal energy directly and they depend to a large extent on the energy content of the fluid as described by Lindal (Figure 4). These are classified as agricultural applications, aquaculture, space conditioning, industrial applications and bathing and swimming.

Only a few of the prospects in Kenya are currently using geothermal energy directly. These include: Eburru (drying of farm produce, harnessing of water), Olkaria (Oserian Development Corporation – flower farming, Kengen – spa) and Ndogo (harnessing of water).

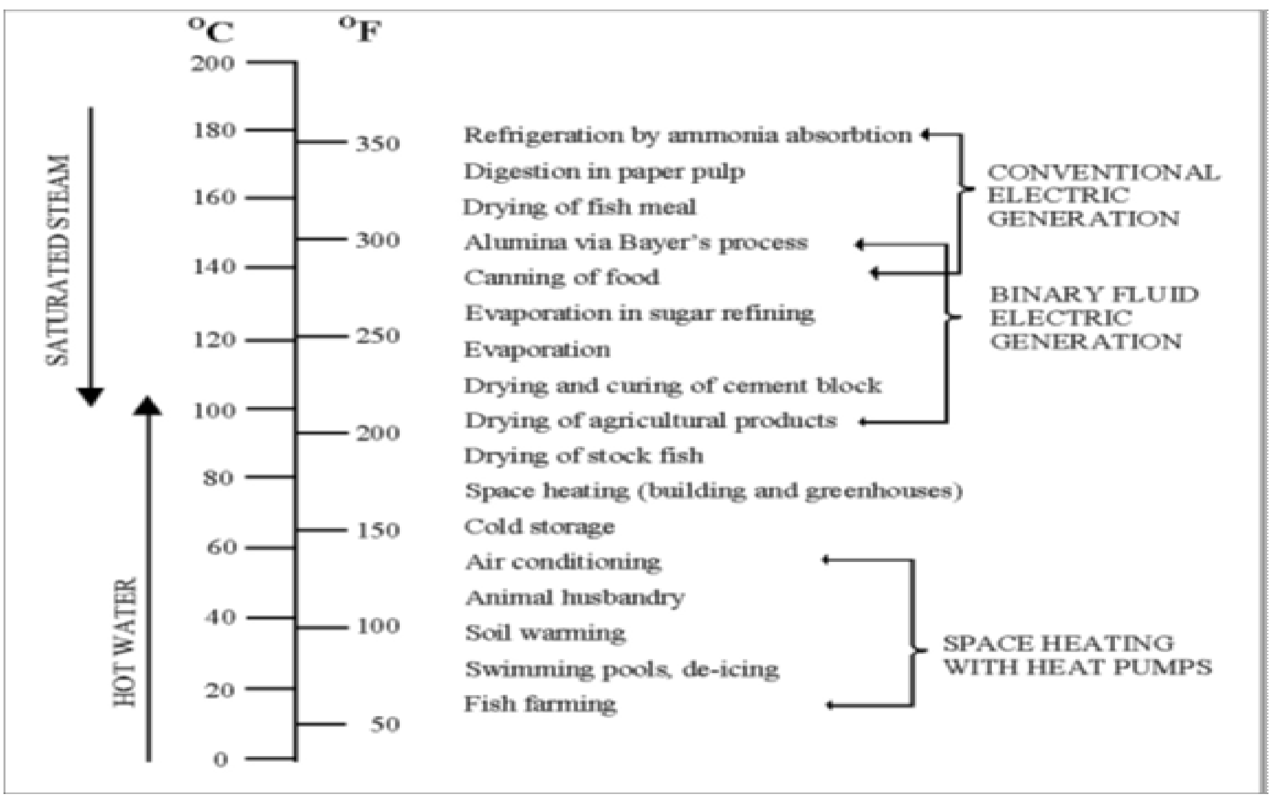


*Figure 4.* The Lindal diagram (Fridleifsson, 1998)

**Potential for Direct Use in the TATA Chemicals New Plant**

Geothermal energy is usually utilized close to the location where it is found. This is because transporting the fluids over long distances results in temperature and pressure losses and high capital costs. However, with proper designs and cost analysis, the fluid can be transported for long distances.

The hottest spring in the Magadi prospect lies on the shores of little Lake Magadi which is approximately 20 km from the processing plant. Allen (1989) concluded that "the heat source from the springs is probably local and lies to the west of Lake Magadi".

*Milling and Calcination*

To a greater extent, the fuel used in the Milling and Calcination section highly depends on the moisture content of the CRS. If the moisture content is high, the feed rate of the CRS from the washer section to the milling section will be low to allow time for the CRS to be pre-calcined so as to achieve smooth flow of the miller. If the moisture content of the CRS is low, the flow rate will be high since less time will be needed for pre-calcination.

Geothermal energy can be introduced for drying: to reduce the moisture content of the CRS from 6% currently to about 2%. If the CRS is dried to about 0% moisture content, the flow rate would be much higher but the material will be milled to less than 105µm hence more wastage of the material in form of dust.

*Monohydrate Drying*

I n the first compartment of the monohydrate dryer, hot air, heated by the geothermal energy, can be circulated through perforated plates holding the product at depths of several inches. Depending upon the moisture of the product, a Bryair desiccators may be necessary. This will reduce the product's moisture content to the required percentage and reduce greatly the use of steam in the section. This will in return reduce the quantity of HFO needed to super heat water to steam.

## Conclusion

It is possible to reduce the dependence of heavy fuel oil in the processing of soda ash by using direct geothermal energy, leading to the reduction of green house gases emitted to the atmosphere by the fossil fuel. This study suggests that:

1. Before the CRS is channelled to the miller, it should be passed through a geothermal drier that can be built close to the washery.
   This will ensure that the moisture content of the CRS is reduced using this natural energy hence achieving a higher product tonnage using less or the same volume of HFO that would have been used if the moisture content wasn't reduced.
2. Hot air heated by the geothermal energy can be passed through perforated plates in the first compartment of the monohydrate dryer, to reduce the use of steam for drying.

## Recommendations

The following should be looked at before the proposed use of geothermal directly in the new ash plant at TATA Chemicals Magadi Company:

1. Carry out a thorough survey to identify the feasibility of the project.
2. Engage the local communities and the relevant environmental agencies to ensure acceptability of the projects.
3. Assessment of the chemistry of the geothermal fluids from the prospect so as to determine the effect it would have to the quality of ash.

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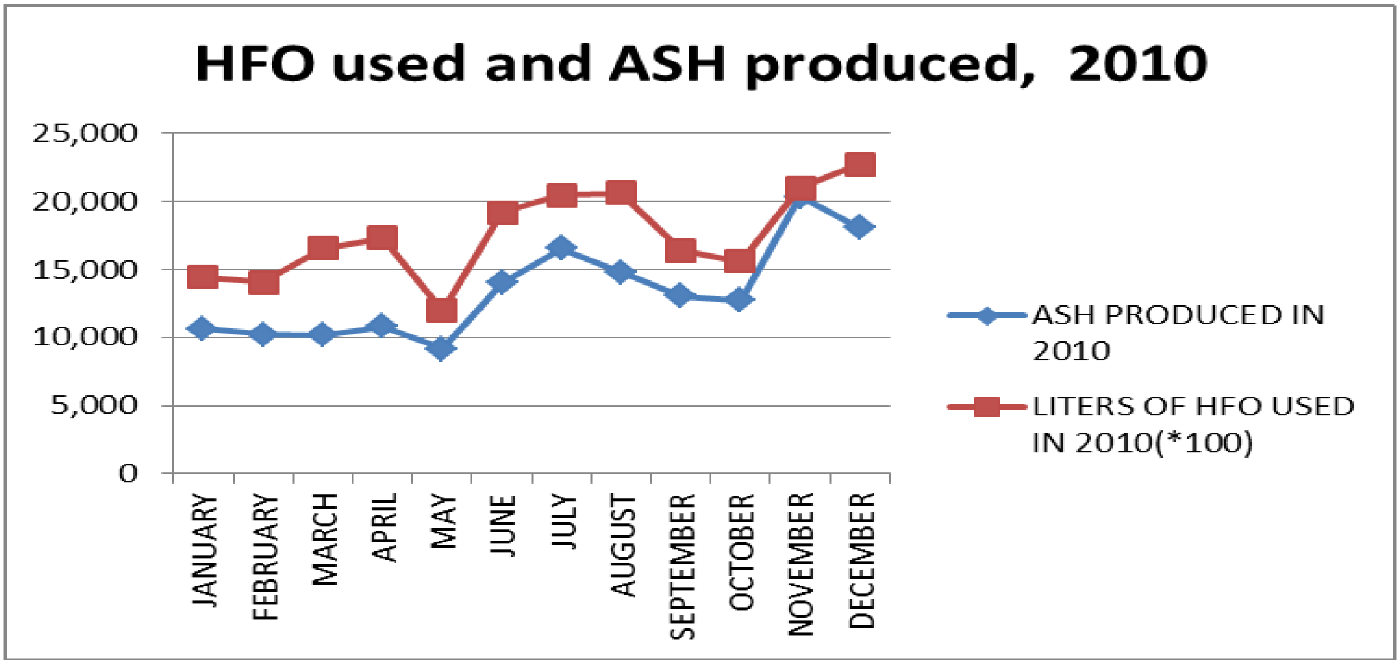
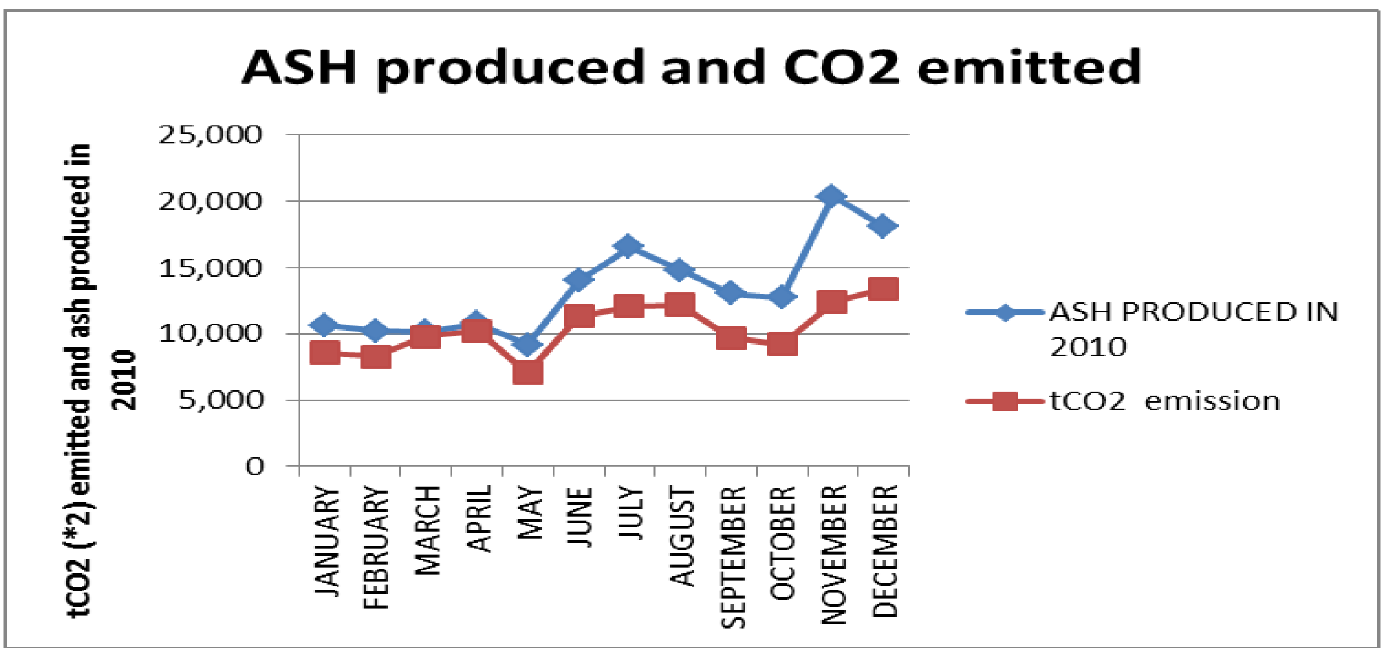
**APPENDIX**




In 2010,

Ash production was 160,446 tonnes
$tCO_2$ Emitted to the atmosphere was 62,070.32
$tCO_2$/tonne of ash was: 62,070.32/160,446 = 0.3868
For every tonne of ash produced in 2010, 0.3868 tonnes of $CO_2$ were released to the atmosphere due to combustion of HFO