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The effect of GHG emission on climate change due to inefficient usage of energy in South African steel foundries

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ABSTRACT

Mitigation of CO_2 emission is the Lessing of CO_2 produced that have or could have a serious threat on climate change. South Africa is known to have a coal addiction. This paper attempts to identify the major opportunities for climate change mitigation through foundry energy efficiency. It does so by analysing key areas of carbon and energy efficiency policy in South Africa. The report further considers a number of important areas concerning future carbon and energy efficiency policy development in the country. Electricity generation and renewable energies are clearly discussed with their advantages and dis advantages in the operation of foundry industry; furthermore it highlights the effect of burning of coal on climate change raising regulation such as carbon tax to be proposed to reduce the growth of CO_2 emission. Mitigation of CO_2 through foundries by using best energy efficiency practices is highlighted as part of assisting in fighting excessive CO_2 emission.

Key words: Co_2 emission, Climate change, Steel foundries,

INTRODUCTION

South Africa is a significant contributor to greenhouse gas emissions as it was listed in 2009, the highest emitter of carbon dioxide in the world by the International Energy Agency. Coal is excessively used for energy generation as compared to other sources of energy because of its abundance in the country. The dependency of South African energy supply on hydrocarbons as a traditional and affordable supply options, has serious consequences in terms of climate change. The role played by CO_2 in global warming is becoming a major concern for energy intensive industries, particularly due to factors that could impact upon business models such as the introduction of a proposed carbon tax and other regulatory mechanisms which could be introduced in an attempt to reduce emissions.

Due to inefficiency of South African industries, introduction of regulations such as carbon tax are proposed to try to mitigate the CO_2 emission and indirectly force the industry to move toward being energy efficient. The carbon tax, although not in place as yet but was proposed, Its primary aim is to achieve GHG emissions reductions and its planned to do so in three main ways that is: changing producer and consumer behaviour; contributing to mitigation and adaptation being taken into account in investment decisions and creating incentives for low-carbon technologies. Many authors have clearly stated and indicated that in foundries the potential of energy savings is in the melting department. Melting units consumes a lot of energy and most of energy wastage lies in there. Energy efficiency can be improved by improving the melt foundry process, thus helps in mitigation of CO_2

GENERATION OF ELECTRICITY IN SOUTH AFRICA

There are various ways of generating electricity in South Africa. This country has a well-developed energy supply and production system. The country is well endowed with large resources of coal. Natural gas and crude oil production are very limited and consequently the bulk of South Africa's crude oil is imported. Figure 1 Shows the Primary energy supply in Terajoules (TJ) 2003–2004 [3].Coal is excessively used as compared to other sources of energy because of its abundance in the country, while hydro energy is hardly used because of the rainfall limitations.

Renewable energy plays a limited but a significant role, particularly large hydroelectric power generation. The country generally has a low rainfall, which limits the exploitation of this form of energy [7]. Greenhouse gas that is commonly found and relevant to the world steel industry is carbon dioxide (CO_2). On average of 1.9 tonnes of CO_2 are emitted for every tone of steel produced. The International Energy Agency states that, the iron and steel industry accounts for approximately 4-5% of total world CO_2 emissions.

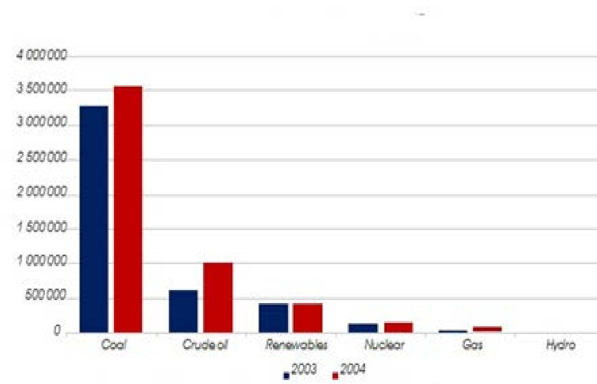

Figure 1: Primary energy supply in Terajoules (TJ) 2003–2004) [3]

The electricity sector is currently the main contributor to CO_2 emission in South Africa and is a key factor in moving toward a low carbon economy.

As the demand for energy increases, wind is seen as one of the key future sources of electricity generation. Electricity produced by wind is generated with significantly lower lifetime CO_2 emissions than the global average for electricity production.This helps to mitigate an impact on climate change as stated by the Global Wind Energy Council in 2008. The environmental impact of the wind system is relatively low. Besides this type of energy, solar or hydro-electric energy is strongly conditioned by climatic conditions and their availability is unpredictable [7]

In general, it is believed that small hydro energy is on the rise in the country, but not more than 100MW will be possible to develop. South Africa is said to be a very flat country, with height differences only being available in certain parts of the country. At the same time, this country is also very dry. The combination of these two factors results in very little hydro power being available for development as stated by Nuplanet clean energy in 2011.

South Africa's commitment to nuclear power as a mitigation action is clear. Nuclear power is considered a risky technology and given the high capital costs and high level of uncertainty surrounding the technology, the need for this form of electricity generation is even more questionable. The Integrated Resource Plan (IRP) assumes that nuclear power and renewable technologies have zero emissions. The emissions reduction from 9,6GW of installed capacity is 109Mt of CO2, against the baseline, over the period to 2030 [4]

Mr Davies,CEO SAIF stated that alternative ways of generating power require high capital costs upfront and once in operation, if they are no longer viable, the foundry cannot return the product. He mentions that, while alternative power sources, such as solar and wind energy is available for generating power, these options are not always reliable [2]. For instance, in Gauteng, the use of wind energy will be impossible, as there is insufficient wind to sustain the full 24-hour operation of foundries. This form of energy will have to be used in conjunction with other forms of energy, which is said to be too costly. Solar energy is also seen as a challenge, as it also needs to be provided in conjunction with other energy forms to be viable, and this limits the production and functionality in steel industries.

Coal on the other hand is used for generation of power due to its abundance and reliability. Global warming and other environmental concerns are beginning to constrain further local coal-based investment decisions. The figure below illustrates the amount of coal used by the service provider such as Eskom and Sasol [7].

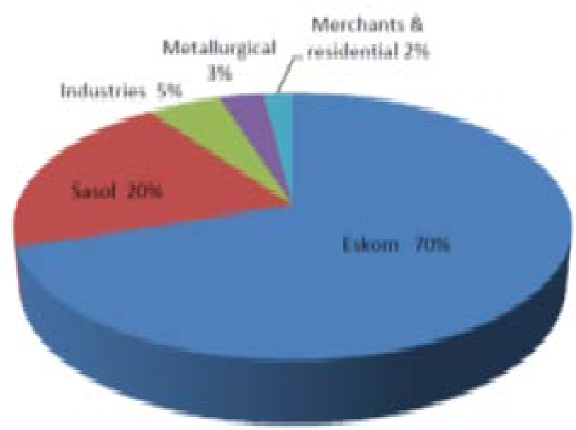

Figure 2: Coal usage by different subsectors [7]

EFFECT OF BURNING COAL ON CLIMATE CHANGE DUE TO ENERGY INEFFICIENCY BY INDUSTRY

South Africa is one of the most energy intensive countries in the world. This energy intensity is due to reliance on coal for producing electricity, liquid fuels and because of the structure of the economy. Cheap energy especially low cost electricity has been an emphasis of government and business throughout the industrialisation of South Africa. Cheap energy is considered to be a comparative advantage for South African industry. However, there are a number of costs to society related to the production and consumption of cheap energy. The figure below illustrates the greenhouse gas emission by 2030 in South Africa.

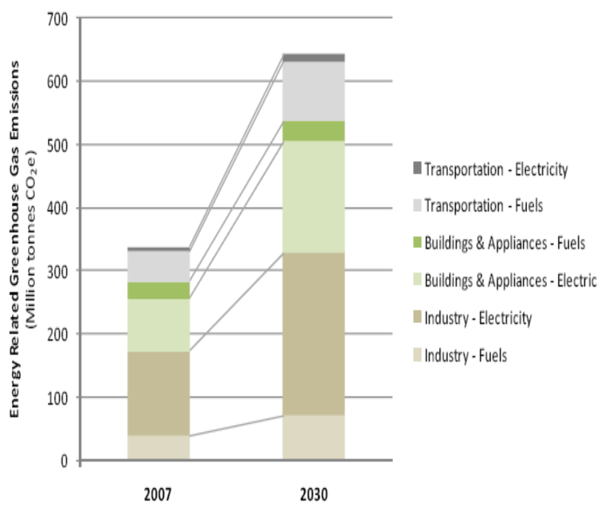

Figure 3: Projected Baseline Energy-sector Greenhouse Gas Emissions in South Africa in 2030 [6]

The dependency of South African energy supply on hydrocarbons as a traditional and affordable supply options, has serious consequences in terms of climate change. Industry is the most user and emitter of CO_2 as shown in figure 4. The role played by CO_2 in global warming is becoming a major concern for energy intensive industries, particularly due to factors that could impact upon business models such as the introduction of a proposed carbon tax and other regulatory mechanisms which could be introduced in an attempt to reduce emissions [1].

Below are some common ways to reduce the carbon footprint associated with the manufacture and use of steel. This frame was suggested by world steel [8]. The framework consists of four building blocks, this include:

1. The development and application of new steels to improve the energy efficiency of steel-using products in society.

2. The need for major expenditure on research and development to identify breakthrough steelmaking technologies with potential to reduce steel's CO_2 emissions associated with steel production.

3. The importance of enabling all steel plants to move up to the level of performance of the best, in terms of current available technology through benchmarking and technology transfer.

4. The establishment of a common measurement and reporting system for steel plant CO_2emissions that can be used by all steel companies around the world for benchmarking and to identify the scope and priorities for their own improvement programs.

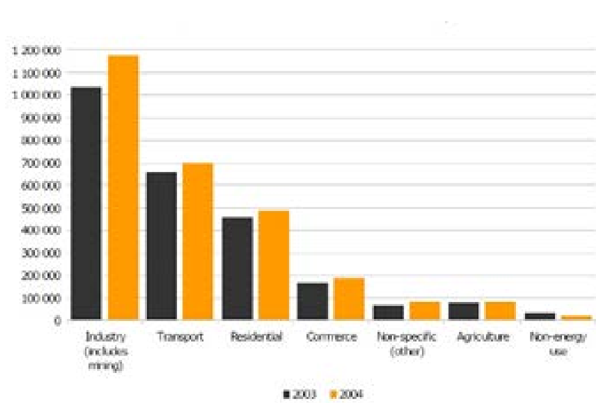

***Figure 4: Final sectorial consumption of energy in TJ, 2003–2004* [3]**

Most of South Africa's greenhouse gas emission is related to the production and consumption of energy. Total emissions of CO_2, CH_4 and N_2O were said to be 379 842 Gg CO_2 equivalents [17]. The energy sector, including energy production and use, contributed 78% of GHG emissions (297 564 Gg CO_2 equivalent). Comparing the three GHGs, carbon dioxide contributes by far the most i.e. 83.2%. Methane contributed 11.4% and nitrous oxide 5.4% respectively. Figure 5 presents the gas emitted, CO_2 being the highest and nitrous oxide is the lowest.

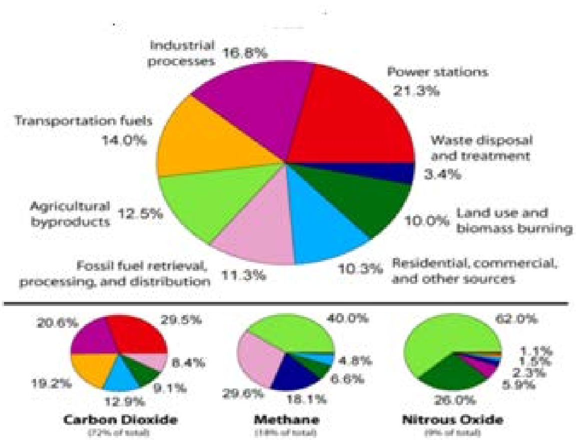

Figure 5: Annual greenhouse gas Emission by sector [7]

The energy sector is a key source of emissions, which include a number of critical energy-related activities. Global greenhouse gas emissions are broken down by the economic activities that lead to their production and it is shown in the below Figure [9].

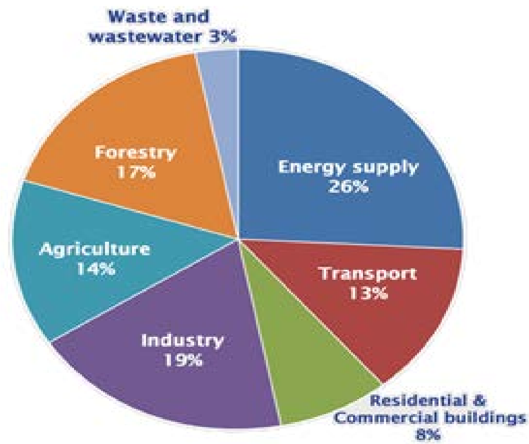

Figure 6: Green gas house emission by source [9].

Energy Supply -26% of 2004 global greenhouse gas emissions. The burning of coal, natural gas, and oil for electricity and heat is the largest single source of global greenhouse gas emissions.

Industry -19% of 2004 global greenhouse gas emissions. Greenhouse gas emissions from industry primarily involve fossil fuels burned on-site at facilities for energy. This sector also includes emissions from chemical, metallurgical, and mineral transformation processes not associated with energy consumption.

Land Use, Land-Use Change, and Forestry -17% of 2004 global greenhouse gas emissions from this sector primarily include carbon dioxide (CO_2) emissions from deforestation, land clearing for agriculture, and fires or decay of peat soils.

Agriculture -14% of 2004 global greenhouse gas emissions. Greenhouse gas emissions from agriculture mostly come from the management of agricultural soils, livestock, rice production, and biomass burning.

Transportation -13% of 2004 global greenhouse gas emissions. Greenhouse gas emissions from this sector involve fossil fuels burned for road, rail, air, and marine transportation. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel.

Commercial and Residential Buildings -8% of 2004 global greenhouse gas emissions. Greenhouse gas emissions from this sector arise from on-site energy generation and burning fuels for heat in buildings or cooking in homes. It is now evident that Development and population growth have an effect on CO_2 emission, in that the more energy inefficient the world becomes, the more electricity demands increases directly increasing the CO_2emission.

INTRODUCTION OF EXTERNAL REGULATION DUE TO EXCESSIVE GHG EMISSION

Due to energy inefficiency of South African industries, introduction of regulations such as carbon tax are proposed to try to mitigate the CO_2emission and indirectly force the industry to move toward being energy efficient. The carbon tax, although not in place as yet but was proposed. Its primary aim is to achieve GHG emissions reductions and it's planned to do so in three main ways that is: changing producer and consumer behaviour; contributing to mitigation and adaptation being taken into account in investment decisions and creating incentives for low-carbon technologies [5].

There are numbers of issues that are relevant to the proposed carbon tax. These include global carbon pricing developments, emission reduction potential and the development of emission reduction plans, as well as the impact carbon pricing will have on a variety of businesses in the South African economy [14]. There are key designs elements that form the carbon tax policy, that upon implementation of this policy they will serve as a guide line and are as follows [4]

Tax rate: The nominal rate is R120 / t CO_2-eq. in order to understand the effective tax rate, several factors need to be considered such as tax-free thresholds, increase in the tax rate over time, off-sets, and adjustments to reward good practice within sectors [16].

Tax base: The carbon tax is to be implemented as a fuel input tax i.e. it is levied on coal, crude oil and natural gas inputs (not directly on GHG emissions' nor on energy outputs)·

Increment: The tax rate is said to increase by 10% per year until the end of 2019. The rate of increase for 2020-2025 will be announced in February 2019 at the latest. If the industries continues with emission caused by inefficient energy use and practices, this countries' economy and growth will be in great danger resulting to close down of companies and poverty by society.

The development of domestic carbon pricing systems is one of the biggest international trends of the last past years. Promethium Carbon stated that this was evidenced by the high rate of penetration of regional, national and subnational carbon pricing schemes worldwide [14]. Figure 7 below shows the emissions covered by a variety of carbon pricing schemes by 2015 as implemented or announced by the different administration, while Figure 8 shows the nominal values of the carbon prices.

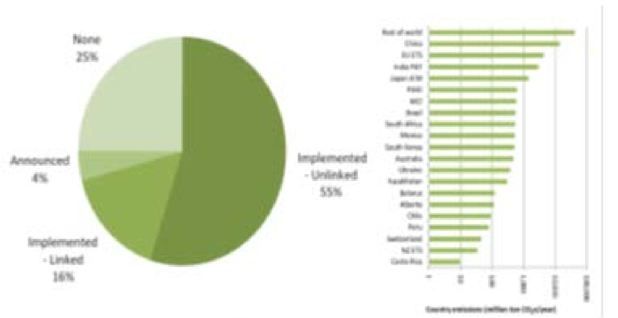

Figure 7: Emissions from regions covered by carbon pricing systems in 2015 [14]

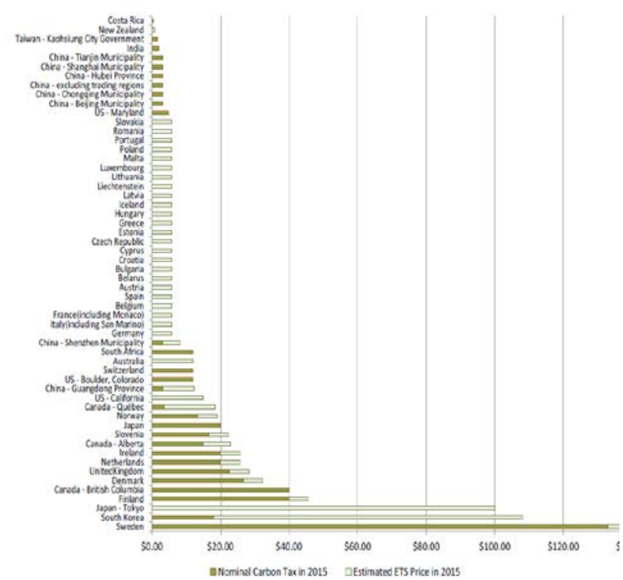

Figure 8: Nominal values of carbon pricing schemes - Estimated for 2015 [14]

The designs of most of the pricing mechanisms worldwide differ in many aspects. They however all have in common that they are putting the infrastructure for carbon pricing in place while delaying the impact of carbon pricing, and thereby shielding their domestic economies, until an effective level of global pricing can be established. The South African proposals are no different in this respect. The relief measures in the proposed tax are designed to shield SA industry from impacts on its global competiveness [14].

The design of carbon pricing schemes in most countries is based on two main drivers; the first being environmental integrity and the second is economic competitiveness. The biggest issue with respect to environmental integrity is the concept of carbon leakage. Carbon leakage occurs when the implementation of a carbon pricing scheme causes emission intensive activities to be moved from the authority where pricing is implemented to the authority with a lesser level of pricing [7]. Economic competitiveness on the other hand, is impacted when the pricing of carbon in one authority makes the businesses in that surrounding less competitive than those in authority without carbon pricing.

South Africa faces a number of environmental challenges that are likely to be aggravated as the economy grows if natural resources are not properly managed and protected. These include: emissions of local air pollutants that manifest in poor air quality with adverse impacts on society; excessive emissions of greenhouse gases that contribute to global warming (Climate Change) [11] thus moving toward energy efficiency will save the environment and the society.

MITIGATION OF GHG EMISSION BY USAGE OF ENERGY EFFICIENT FOUNDRY PRACTICE

Many authors have clearly stated and indicated that in foundries the potential of energy savings is in the melting department. Melting units consumes a lot of energy and most of energy wastage lies in there. Energy efficiency can be improved by improving the melt foundry process thus helps in mitigation of CO_2. The energy efficient processes are as stated below:

CHARGE PREPARATION

The preparation of the charge is very much of importance because the correct mix of larger and smaller pieces determines whether the electromagnetic field couples to the charge well or not. If the packing density is less than optimal, melting can be a longer process and the energy efficiency is correspondingly less. Type of scrap used has a large impact on the efficiency; scrap containing sand takes longer to melt due to grains of the sand to be melted. To avoid this, shot blasting of sand from scrap or returns should take place [2].

Cleanliness of crap material was also looked at in terms of sheared versus un-shredded scrap and the effect of rusted scrap [2]. Shipley added that the condition of the charge materials can have a significant impact on the energy needed for melting a ton of metal [15]. Generally, greater energy is needed to melt rusty or dirty scrap material. If dirty scrap or unsuitable material is used, the savings in metallic purchases must be weighed against the increased energy costs for melting.

CHARGING

Charging when requested is necessary, estimated 25-50 kwh/t is added on the efficiency due to the influential interruption of 2-4 min. Bridges are also mentioned as one of the inefficient charging practice which will have a negative impact on trying to improve energy efficiency. Furnace lids can be important to conserving energy; badly fitting lids and their unnecessary or prolonged opening increases energy losses [2].

MELTING

The furnace lid should be closed during the melting process whenever possible. This is especially important at the end of the melting period when the crucible is full of melt and the bath surface is free of slag. If the lid is open at that stage, a 12t-crucible furnace loses up to 600 kW heat within 5 min, which means 50 KWh extra energy consumption.

Very little smoke develops during that phase. Consequently, the suction capacity is reduced to keep the heat loss low at that end. Melting schedules should be arranged to reduce the number of cold starts because the refractory lining has a large thermal mass, melting with a cold furnace can require 10 percent more energy than melting with a hot start. Moreover, the capacitors of furnaces in old plants should be tested because capacitor banks deteriorate with age. A poor power factor increases electricity costs and reduces melting rates [15]

POURING

In regulated pouring, the level of liquid metal in the cup is constant during the whole pouring time. The charging of pouring conditions in the cup mainly based on the opposite pressure inside of the cup- should be reproducible from cup to cup [15].

MAINTENACE

Maintenance and good housekeeping are one of the less expensive ways of combating energy consumption. Material and equipment control are indirect ways of maintaining efficiency in the melt shop. In case of induction as a melting furnace, regular coil inspection should be conducted as to make sure no heat escapes. Types and thickness of refractories should be taken in to consideration as they tend to have a great effect on the furnace efficiency. Thick lining reduces furnace volume and hence the metal output resulting high specific energy consumption. Thin lining, though it improves the power density, promotes heat loss from the side wall. Lining material with high thermal conductivity causes more heat loss. Lining material with long sintering cycle time consumes much energy for the first heat to get ready [13]

CONCLUSION

Understanding the impact that CO_2 emission have on the climate change due careless use of energy by foundries serves as an alarm or awareness to South African foundries on the importance of energy saving. This was achieved by analysis of generation of electricity in this country, threat opposed by CO_2 emission on climate change and what can be done by foundries to mitigate CO_2 emission. Therefore, efficient use of energy will save the environment and foundries from external regulations such as the introduction of carbon tax.

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