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Analysis of the South African Industrial sector's energy consumption profile

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ABSTRACT

Energy generation and consumption is one of the most significant concerns for South Africa's growing economy. Efforts to monitor the country's overall energy consumption revealed that the industrial sector consistently consumes the highest energy at just under 60%. Policies are informed by an understanding of the current consumption across sectors and also the ability to predict future consumption. It is therefore important to understand the energy consumption of the highest energy user.

This research investigates the characteristics of industrial sector energy consumption, and how it has evolved between the years 1992 and 2018. The findings show that the total industrial consumption is still increasing. Contrary to global behavior, the local industrial consumption is still dominated by Coal; Electricity; Gas and Petroleum products respectively. High intensity industries are still heavily reliant on fossil fuel, regardless of the carbon footprint and GHG effect. This points to cost and availability influence on consumption. Although there is great potential in renewable energy, it is only low-intensive industries that are shifting to new non-conventional energy sources. Further work is required to define non-specified industrial subsectors as they contribute more than 10% to the total industrial consumption, compared to less than 5% in international consumption trends.

Keywords: renewable energy resources, Industrial sector, Energy consumption, Disaggregated consumption, South Africa

1. INTRODUCTION

Energy consumption in literature, is evaluated mostly with economic output, population growth, impact to the environment and options for sustainable renewable energy use. The Department of Minerals and Energy in [1]; has defined energy consumption in industry as the use of a unit quantity of energy per economic output (or GDP). From this definition industry especially, Mining were found to be the highest energy consumers in the country, contributing about 59% to the total energy consumption [2]. For this reason, more focus was given to Industry to harness opportunities in energy consumption efficiency. The country's steady development translates to increased industrialization, this coupled with the initiative to electrify all households, has caused steep energy demand since 1994 [3]

The government's efforts to secure energy supply require a good understanding of the national demand and accuracy in demand predictions. Available data focuses on energy consumed compared per type or category of energy, however the characteristics of the trends over time have not been analysed. This gap in our literature imposes a vulnerability to the effectiveness of our energy policies and their applications.

The objective of this study is to formulate a comprehensive view on the industry's energy profile, through analysis of energy balances and evaluating factors affecting trends observed within the industrial sector. The research will also seek to make comparisons with global industries and what learnings can be used for improved or advanced consumption profiles.

2. THEORY

2.1 Literature review

Global energy consumption is driven by a number of factors such as; energy prices, fuel availability, economic development, population growth, efficient energy use technologies, development and use of renewable energy, environmental and emission standards and regulations, politics etc. Forecasting of energy consumption can be complicated by the existence of

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data for the mentioned factors and as such each region requires intensive investigations and relevant data, in order to ensure robust forecasting [4].

2.1.1 Global Energy Demand trends and energy outlook

The consumption trends for international economies is still on the rise however there is more appetite for increasing renewable energy in order to limit or even reduce the negative impact to the environment. The commitment to reduce the negative environmental impact was such that, in 2016 the European Union committed to the 20-20-20 plan. The plan entailed that by 2020, the GHG (Green House Gases) emissions would be reduced by 20%; the renewable energy final consumption will be increased by 20% and a 20% improvement on the overall energy efficiency [5].

Many countries are evaluating their consumption and researching on substituting most of the supply with renewable energy with less or no carbon footprint.

2.1.2 The energy demand and outlook in the African continent

[6] evaluated the energy demand for the African continent across sectors. The study also mentions how the African energy sector faces a number of challenges such as inefficiency; poor performance; supply shortages; poverty and inequity in energy access; high and rapid demand for electricity etc. The mentioned challenges limit the ability of modelling and forecasting of energy demand for the continent. The major differentiating factors between developed and developing countries are the following: social barriers to capital flow; technology diffusion; as well as frequent energy policy changes. Developed countries have lower social barriers to capital flow and technology diffusion is easier, this makes policy changes more realistic to implement as compared to developing countries. There is a growing interest in African economies to begin incorporating renewable energy to future plans and policies. Literature mentions great potential in sustainable supply of energy from renewable sources, by combining the types of renewables instead of choosing one.

2.1.3 South African energy demand characteristics

South Africa began to evaluate existing energy policies and also generating new policies as more studies were conducted on the nature of energy supply in the country and continent. The major push for initiating and developing such policies was in light of the "increased" envisaged demand from residential sectors to industrial sectors.

Most studies have only concentrated on energy consumption in the residential sector, as it was one of the key deliverables, to improve living conditions for the majority of the population of the country [7]. Evaluations stated that the state's energy consumption is dominated by the industry sector. Mining and iron are the highest consumers within the industrial sector [3].

3. METHODOLOGY

The study will seek to evaluate the trend of energy consumption within the local industrial sector, how it has evolved over time and the characteristics of this consumption. The methodology will have the following structure and will involve the following:

- Evaluation of the consumption evolution
- Analysis of the key characteristics influencing the consumption
- Evaluate the changes post 2008 and possible factors behind this change

The information will be taken from the statistical data reports published annually by different energy organizations locally and globally[4][3][8]. The primary source of data will be taken from local Consolidated aggregated historical energy balances, reported for each commodity ad on an annual basis.

4. RESULTS

Data from energy balances from 1992 were collected and evaluated as aggregated consumption and disaggregated consumption[3][2]. The below trends illustrate the consumption trends for major commodities across the industrial sector

4.1 Aggregated consumption

The aggregated consumption evaluates grouped energy commodities, as a first level analysis on energy consumption. It provides an overview of consumption in commodities and is illustrated in the trends below:

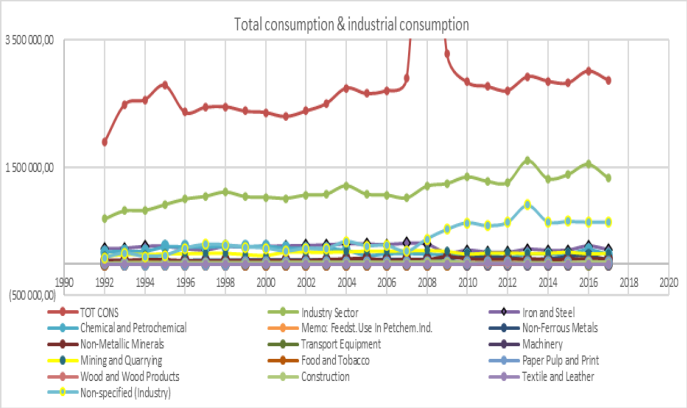

Figure 8: Total Consumption and Total Industrial trends in South African industry contributions[1]

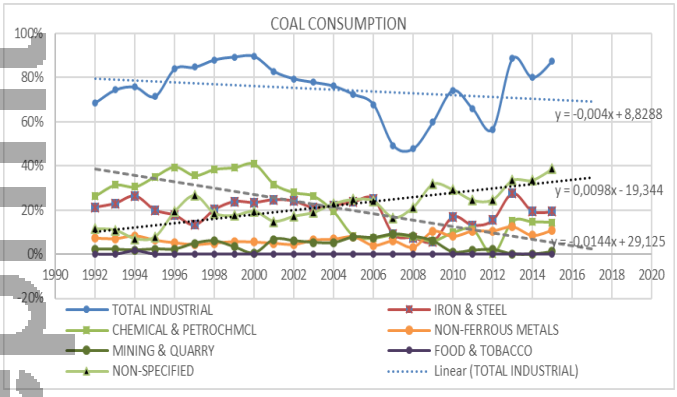

Figure 1: Coal Consumption trends in South African industry

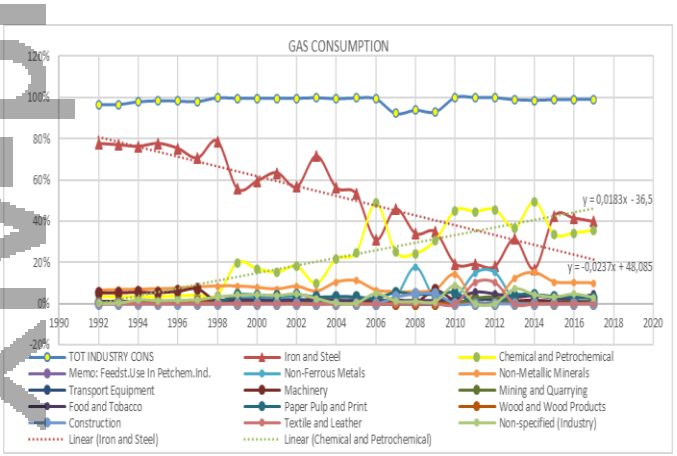

Figure 2: Gas Consumption trends in South African industry

[1]*The total consumption trend was truncated due to escalated residential consumption*

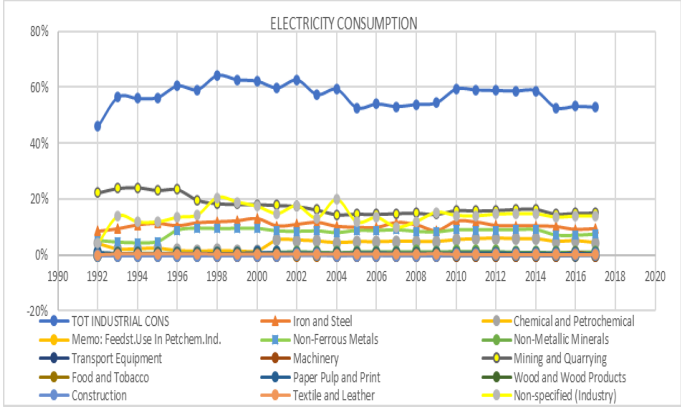

Figure 3: Electricity Consumption trends in South African industry

4.2 Disaggregated consumption

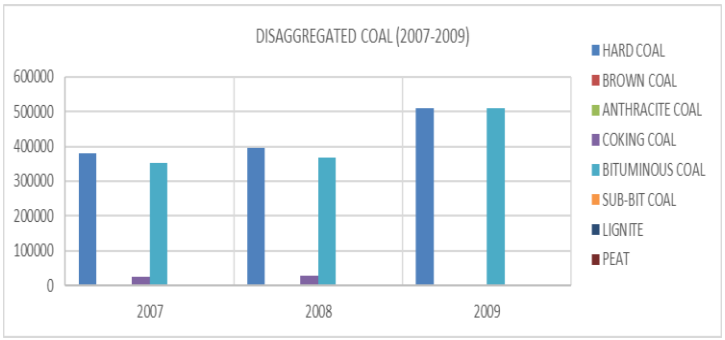

Figure 4: Disaggregated Coal Consumption trends in South African industry

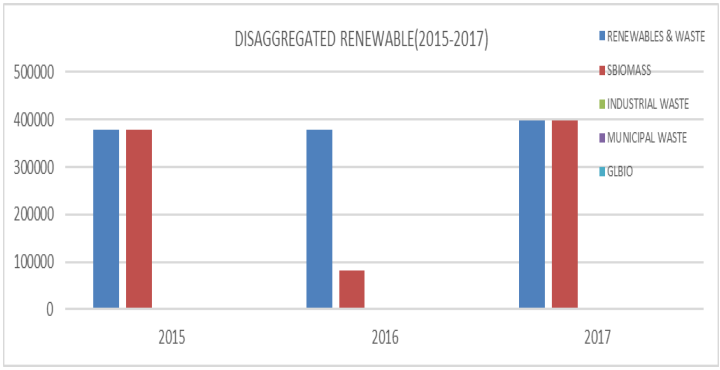

Figure 5: Disaggregated Renewables Consumption trends in South African industry

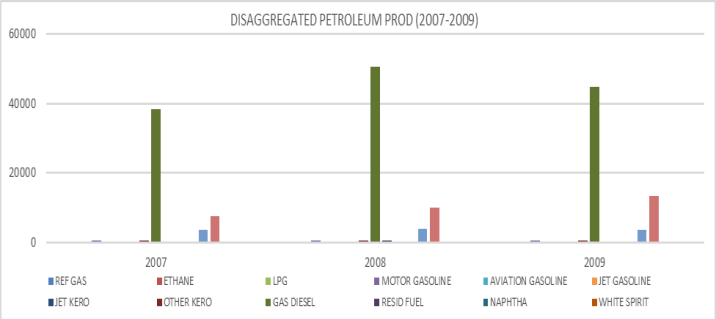

Figure 6: Disaggregated Petroleum Consumption trends in South African industry

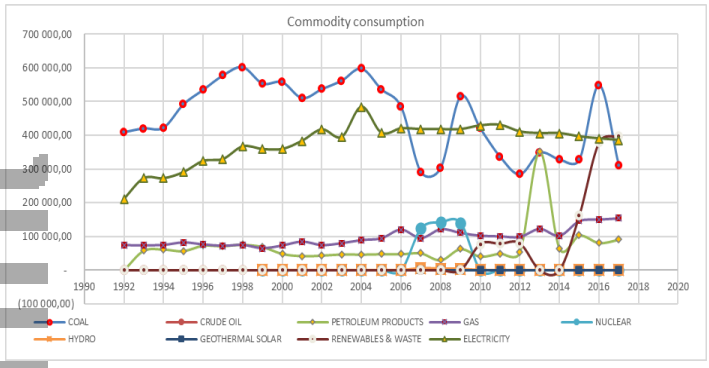

Figure 9: Aggregated Commodity consumption comparison

4.3 Discussion

The coal consumption as shown within Figure 1 was steady prior to 2008. However, during and post the economic decline of 2008 the coal consumption showed a decline and became erratic. This was not the case with gas and electricity consumption, which was steadier before and after the economic decline of 2008. The biggest consumers of coal in industry are chemical and petrochemical industries followed by the Iron and steel and non-specified industries. With time petrochemical and steel industries are displaying a reduction in consumption of coal. Recent publications have cited two major factors that may affect these industries namely demand and carbon footprint [9][10]. The factors appear to impact the same industries in a similar manner globally. When consumption of these two major industries (chemical & petrochemical and iron & steel) declined, the non-specified sub-sector showed an increasing consumption trend. Non-specified industry is a grouped industry sub-sector that can be defined in general terms as a manufacturing consumption where no further breakdown to specific sub-sector can be achieved. For most countries this sector contributes no more than 2% of the total consumption, and therefore deemed insignificant [11]. In South Africa however we observe that this sector can contribute more than 2% percent consumption to the total consumption, more so in other commodities.

The two industries that are major contributors to the consumption of gas in the industrial sector are Iron & Steel and Petrochemical & Chemical industries, as showed in Figure2. The Iron & Steel industry has a declining trend from 1998, again pointing to external factors such as demand reduction nationally or globally. The consumption trend for the Petroleum industry however is showing a favourable but steady growth from 2003.

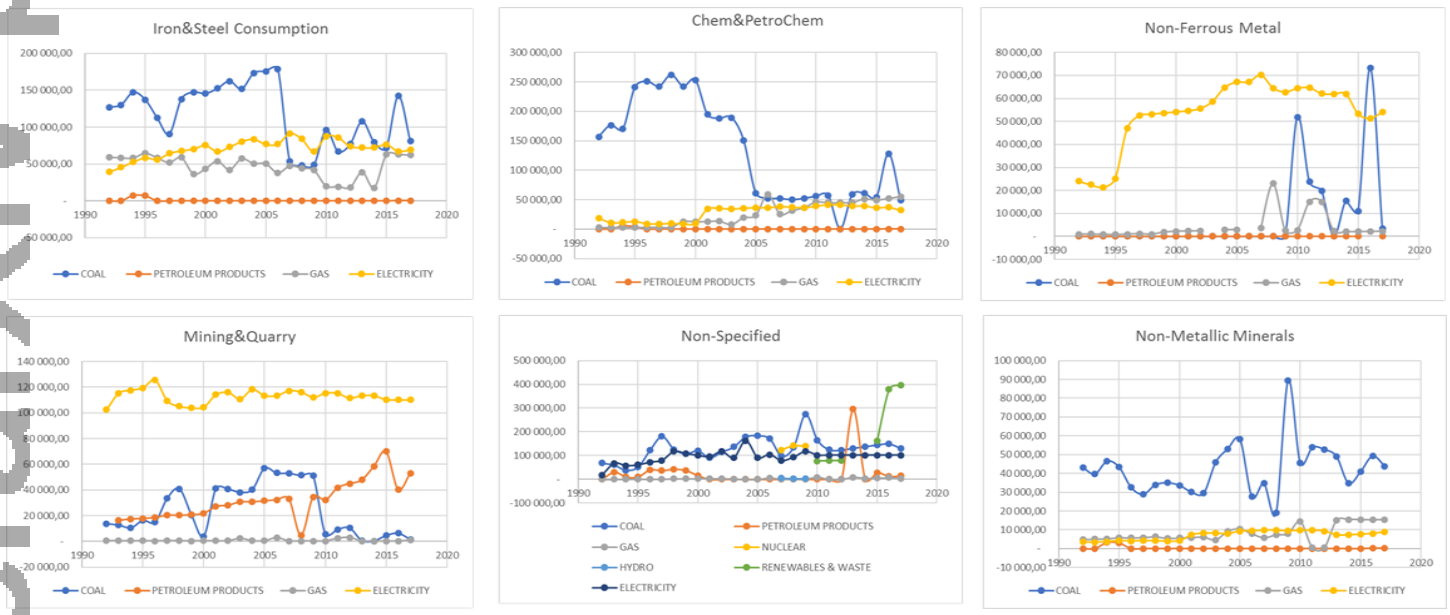

Figure 7: Dominant commodities per subsector

Figure 3 shows the electricity aggregated consumption. Electricity is one of the most widely used sources of energy. Despite the changes in energy policies in recent years, which impacted the cost of electricity sales, the consumption of electricity has remained relatively steady. There is a noticeable drop in consumption in the mining industry from the year 1996, after which the consumption was steady. There seems to be no indication of major changes to the consumption.

Most subsectors have a dominant commodity of energy source, the major consumers often display this characteristic, this can be observed in Figure 7. The dominance of a commodity can be significant, such as in the iron & steel; chemical & petrochemical; and the non-ferrous metals sub-sector. The dominance seems to be related to the sector's process energy needs, as these sectors are said to be energy intensive industries. It is interesting to note that the dominant energy sources for these industries are electricity and coal. A different characteristic is observed on non-specified industry from 2005, where nuclear and renewable energy are included in the energy sources. The non-specified industry shows an ability to diversify energy sources.

The disaggregated consumption reveals the preferred sub-commodity of energy source and can reveal, among many things, the availability of the sub-commodity; the quality vs. cost of the commodity and also the growth plans of the respective industry.

Coal consumed is divided into eight types of coal produced, however it is observed that only three are mostly used. This could be due to availability; however, it is also true that the coal types have differing calorific and contaminants qualities. The two mostly used types are hard coal/anthracite and bituminous coal. Hard coal is known for higher heat qualities or higher calorific values and lower sulphur content. This may be the reason for higher consumption on the evaluated period. Lower consumption was experienced, possibly due to reduced production from the financial crisis of the time, it can be observed as well that the consumption is inclusive of coking coal. Coking coal is similar to hard coal, with a lower cost.

Figure 6 shows the disaggregated consumption for petroleum products. It can be observed that gas diesel is the most consumed product in industry. It was observed that there was increased consumption in 2008, during the economic recession. This could be due to the changes in electricity costs, which encouraged the use of diesel as an alternative energy source in some industry.

Of interest is the disaggregated consumption of renewable energy as showed in Figure 5. Renewables consumption only began in the early 2000s. The more popular renewables are renewables; waste and Sbiomass (which is inclusive of solid agricultural material).

Figure 8 and 9 show a high-level view of total consumption vs total industrial consumption, as well as aggregated commodity consumption respectively. Figure8 clearly illustrates the significantly high consumption of the non-specified subsector within industry post 2008. Figure 9 on the other hand hammers the view that electricity remains the energy commodity of choice for the industry sector. The renewables have only taken off from 2014 with plans to increase consumption in all sectors, by enforcing policies[12][13]

5. CONCLUSION

The observed trends show very sharp reactions on the consumption of most of the commodities to external factors. The most vivid factors for local industries are energy costs against production, environmental influences that usually stem from policy changes and changes in energy availability. It would be naive to not recognise the possibility of internal structure changes within industries as contributing factors; however more visible impact is often felt from external factors. Electricity as an energy source, though unreliable, remains the energy source of choice. Coal remains the most affordable source of energy to this day; however environmental effects have hampered global consumption greatly. Trends on local coal consumption however seem to hint a continued and even slight increase to the consumption in 2018 to 2020. The local industrial sector may need to pursue ways of reducing energy intensity. This may promote energy savings and allow for the use of renewable energy as alternative sources.

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