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Differential electricity pricing and energy efficiency in South Africa

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ABSTRACT

By international standards the economy of South Africa is extremely energy intensive with only a few countries having higher intensities. SA's primary energy use per unit of GDP is amongst the highest in the world. The high energy and electricity intensity of the economy partly reflects SA's resource endowments (in particular the abundance of coal) but is also a function of the historical under-pricing of coal and electricity by the authorities. South African mining & industrial electricity efficiency is particularly concerning and considerably lower than the global average. This paper sets out to fill a significant gap in the South African energy literature by highlighting the importance of incorporating electricity demand factors as part of the country's energy policy and electricity planning horizon. The paper focuses its attention on modelling the electricity consumption of SA's industrial and mining sectors given these account for the lion's share of electricity demand. A differential electricity pricing policy which targets electricity intensive industrial and mining activities (as practised in China since 2004) is viewed by the author to be a superior policy to blanket electricity price increases administered by authorities in an effort to encourage electricity savings and improve energy efficiency in South Africa.

1. Introduction

By international standards the economy of South African is extremely energy intensive with just a handful of countries notably Iceland, Russia and China having higher intensities. South Africa's primary energy use per unit of GDP is amongst the highest in the world standing at 0.13 toe (tonnes of oil equivalent) per thousand 2005 US dollars of GDP in 2010 calculated using purchasing power parities. This compares with values of other energy intensive economies like Iceland (0.25), Russia (0.22) and China (0.16) and averages of 0.09 and 0.15 respectively for OECD and non-OECD countries. According to energy statistics published by the [23] there has been a reduction in South Africa's energy use per unit of GDP in recent years but this compares unfavourably with larger average reductions for both OECD and non-OECD countries.

The high energy intensity (and in the case of this paper specifically the electricity intensity) of the economy partly reflects South Africa's natural resource endowments in particular the local abundance of coal and other mineral resources but is also a function of the domestic under-pricing of coal and electricity by the authorities for a long period of time. Historically, the country has followed a heavily capital and electricity-intensive development trajectory largely based on the use of coal. In 1991, Eskom (the national electricity provider) proposed a price agreement with government to reduce the real price of electricity to benefit electricity-intensive activities within South Africa and place them in a stronger position to compete on international markets.

Given the country's history of low and stable electricity prices, South African electricity efficiency is substantially lower on average than in other countries and improvements to date have been small by international standards. Although under-emphasised in the IRP (Integrated Resource Plan) which sets out South Africa's plan for electricity generation over the next 20 years, one of the main triggers (identified by market commentators) to encourage improvements in South Africa's electricity efficiency is to allow energy prices to rise to fully cover operating and capital costs and to properly value electricity production, transmission and distribution externalities. Related research by Ref. [26] in the case of China has indicated that artificially low electricity tariff's need to be replaced by a system that better reflects the capital costs of power generation and transmission in order to encourage local & foreign investment and efficiency improvements in power generating capacity. This paper sets out to fill a significant gap in the South African energy literature by highlighting, as in research conducted in the case of China and reported in Energy by Wang et al. (2010), the importance of incorporating electricity demand factors as part of South Africa's energy policy and electricity planning horizon. The paper focuses its attention on modelling electricity consumption for South Africa's industrial and mining sectors given these two

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sectors account for the lion's share of the country's electricity demand. Our research sets out to support claims in Energy by Ref. [22] that differentiated electricity price policies are required if South Africa is to create an effective energy efficiency policy. Finally, our study estimates long-run output and price elasticities of electricity demand for the various South African industrial sub-sectors similar to research by Ref. [21]. It does so however by employing different econometric techniques and by analysing a longer and more recent time period: 1989–2009 in an attempt to establish which sectors would be the best target candidates of a proposed differential electricity-pricing scheme. A differential electricity pricing policy (as that practised in China since 2004) and critically reviewed in Energy by Ref. [28] is viewed by the author to be a superior policy to blanket electricity price increases administered by authorities in an effort to encourage electricity savings and improve energy efficiency in South Africa.

The remainder of the paper is set out as follows. Section 2 provides a review of the relevant energy efficiency and energy demand literature whilst section 3 sets out the empirical methodology and data employed in the current study. Section 4 reports the econometric results of South African industrial electricity consumption. Section 5 briefly presents international experiences with industrial energy efficiency policies, Section 6 sets out our conclusions and policy recommendations.

2. Background

2.1. Electricity efficiency and intensity

Energy efficiency according to the IEA (International Energy Agency) and the WEC (World Energy Council) involves a reduction in the energy input of a given service (such as heating/cooling, etc.) or level of economic activity. The resulting reduction in energy consumption whilst usually associated with technological changes can also come about as a result of better organisation and management or improved economic conditions in the sector under investigation. Electricity efficiency which is the focus of this research paper is measured as the change recorded in electricity intensity in order to account for its quantitative nature. A common definition of electricity intensity adopted in studies by Refs. [30,44] and [20] measures this intensity in terms of electricity consumption per national production unit such as the J (joule) per US$ of GDP. In this paper we follow this approach and measure the electricity intensity of industrial sectors as the electricity consumption to output contribution of that sector. Improving the electricity efficiency of production processes is generally regarded as a low cost and effective way of curbing energy demand in an economy.

2.2. Electricity intensity: the South African case

Energy statistics published by the [23] indicate that South Africa's electricity intensity has been rising at an alarming rate and by 2010 stood at 0.451 GWh per 2005 US million dollars comparable to values for China (0.371), Russia (0.362) and far in excess of the OECD and non-OECD average ranges of 0.249–0.253 and 0.196–0.277 over the review period 1971 to 2010 respectively (see Table 1 for details).

The high overall electricity intensity of the South African economy when compared internationally is the result of a heavily capital and electricity-intensive development path that has been driven by the extraction of resources and a set of inter-connected economic activities termed the 'Minerals–Energy Complex' [13]. This Complex is primarily based on mining, and limited mineral beneficiation that is underpinned by the provision of cheap electricity. Eskom (the national electricity provider) has been of fundamental significance to the Minerals–Energy Complex through its electricity price fixing agreement with government. This agreement has reduced the real price of electricity since the early 1990s to benefit electricity-intensive activities within the economy. South Africa has thus enjoyed electricity prices amongst the lowest in the world and – although prices started rising sharply in 2008 after a series of power outages – by 2011 South Africa still had extremely low electricity tariffs compared to other countries (see Fig. 1). Whilst statistics for China are not included in this figure, it is noted that the fare charged by the State Grid for 2010 stood at 0.16 yuan (US$26) per GWh. Eskom estimates that current South African electricity prices are still only about two thirds of the level needed to cover total costs, even though average prices have more than doubled in real terms since 2007 (see Fig. 2).

Table 1
Electricity intensity: South Africa and Rest of World (GWh/PPP adj. $ million).

	1971	1980	1990	2000	2010	Change
OECD	0.249	0.269	0.267	0.264	0.253	1%
EU-27	n/a	n/a	0.223	0.211	0.204	−8%
Non-OECD	0.196	0.220	0.272	0.264	0.277	42%
China	0.360	0.443	0.345	0.301	0.371	3%
Russia	n/a	n/a	0.442	0.483	0.362	−18%
South Africa	0.258	0.383	0.493	0.553	0.451	75%

Source: Own calculations based on [23].

The alarming rate of increase in South Africa's electricity-intensity for the period 1971–2010 implies that South African economy wide electricity efficiency compares poorly internationally (for details on this refer back to the percentage changes indicated in Table 1). Ref. [48] suggests that South African industrial electricity efficiency is particularly concerning and considerably lower than global averages. In particular, industrial activities linked to the Minerals–Energy Complex account for most of the country's electricity consumption whilst contributing far less to South Africa's GDP. According to the SA Department of Energy, industry and mining consumed 54% of the electricity produced in the country in 2010 which has only slightly changed from the 66% consumed in 1989 (see Table 2).

Our estimates of South Africa's industrial electricity intensity for the period 1989–2010 are presented in Table 3. Related research by Ref. [20] found South Africa's primary minerals extraction and processing industries linked to the 'Minerals Energy Complex' to be extremely electricity-intensive by OECD standards.

Whilst the reported estimates in themselves do not prove that South African industry is inefficient it does suggest that large quantities of electricity are used (per unit value produced) in the country's industrial processes. Information on electricity intensity/efficiency is essential to energy policy makers in understanding how a country's demand for electricity changes when the economy undergoes changes in its economic structure. This takes on added significance in a country facing critical energy supply constraints as has been the case in South Africa since the major electricity blackouts of 2008.

Although now relatively dated, the 1998 White Paper [5] forms the back-bone for all energy related policy in South Africa. In terms of the energy efficiency of South Africa's industrial and commercial sectors, the White Paper, commits government to the following:

- Promotion of energy-efficiency awareness;
- Encouragement of the use of energy-efficiency practices;
- Establishment of energy-efficiency standards for commercial buildings; and
- Monitoring the progress

In 2005 the Department of Minerals and Energy released South Africa's first Energy Efficiency Strategy [6]. A national target of 12%