5 GENERAL CONCLUSION

5.1 Restating the main purpose and objectives

The main purpose of this study was to propose a market-based solution promoting demand-side management towards the improvement of electricity efficiency in South Africa. Before doing so, the electricity consumption and efficiency status quo of the country was examined at aggregate and sectoral levels. This thorough analysis showed what the main factors are that determine the trends of electricity consumption in the country; how important electricity efficiency is; which economic sectors are the most and least electricity intensive and why; and finally, how the country performed compared to other countries.

The following specific objectives guided the study:

- To conduct an extensive local and international literature review on electricity efficiency related matters
- To examine and analyse the South African electricity sector and its unique characteristics
- To estimate the price elasticity of electricity both at aggregate and sectoral levels, as well its evolution through time
- To examine the role of electricity efficiency in the evolution of the country's electricity consumption, and investigate how significant the role of the structure of the economy is

- To compare the country's total and sectoral electricity intensity with a group of developing and developed economies and conclude if South Africa is following international standards

- To design the proposed electricity efficiency benchmark-and-trade system and make recommendations on how this market should function and what the limits of the intervention should be in order for this market to be considered successful

5.2 Outline of the study

After the general introduction, the second section of the study reviewed the necessary introductory literature on the case of South Africa, energy (electricity) efficiency matters and cap-and-trade models. More specifically, the presentation of the South African case included an analysis of the key players and their role as well as policies and regulations implemented in the country. Also, it provided a graphical representation of indicative data and information to illustrate the overall picture of the country.

Next, the study proceeded to the definition of energy efficiency as well as its main measuring methods. In addition, it discussed a number of international and local policies towards the improvement of energy efficiency.

Subsequently a brief presentation of the cap-and-trade system was provided followed by a discussion on international applications and an evaluation of the system. The next section provided empirical evidence and aimed to fulfil all the requirements of a complete understanding of the electricity sector in order to proceed with a proposed solution.

First the aggregate price elasticity of electricity demand in South Africa was discussed. An econometric technique known as the Kalman filter was employed in order to estimate the evolution of the sensitivity of electricity consumption to changes in price and output. Next, by using panel data techniques, different behavioural responses of a number of economic sectors to changes in the sector-specific prices and output were examined; while the following section employed decomposition analysis to analyse the role of the structure of the economy, electricity intensity and output to the country's increasing trend of electricity consumption both at an aggregate and a sectoral level. Finally, a comparative analysis of the South African total and sectoral electricity intensities to the OECD countries was presented in the last section.

The fourth part of the study presents the proposed benchmark-and-trade system in order to change the picture of electricity efficiency in South Africa. It explains in detail the mechanisms as well as the policy implications of the model. Finally, the last section provides a general conclusion of the study.

5.3 Important findings

The study's major concluding points can be summarised as follows.

From the first econometric exercise, the Kalman filter, it was found that the price elasticity of aggregate electricity demand has been changing over the years. It was also shown that the higher the electricity price, the higher the sensitivity of consumers to price fluctuations. These results can explain the lack of reaction to price

changes in the past and maybe assist the policy-makers in 'predicting' future behaviour after the recent and future price hikes.

Next, focus was given to the price elasticity at a sectoral level and the question of whether or not all the sectors' price sensitivity is the same was answered. Over the study period, only the industrial sector (in total) behaved as expected by economic theory; the price coefficient was shown to be negative and statistically significant. Also, economic output was a positive contributing factor to electricity consumption only for the industrial and commercial sectors (positive and statistically significant coefficients); while for the other three sectors ('agriculture', 'transport' and 'mining') the production was not a statistically significant factor.

Having established that in the past South African consumers were not sensitive to price fluctuations (the situation that might change in the future due to the price reform) the analysis turns to identify other reasons that contributed to the increase in electricity consumption. The changes in production were the main factor that increased electricity consumption, while efficiency improvements during the period were a driver in decreasing consumption. Not surprisingly, the examined sectors presented a different picture regarding its contributing factors. According to the results, the electricity efficiency was the only contributing factor to the decreasing side of electricity consumption at an economy-wide level. Hence, its improvement might prove to be the desired solution towards the decrease of electricity consumption without neglecting the importance of the country's economic growth.

Taking the significance of efficiency into account, the analysis proceeds to indicate whether there is scope for improvement on a national level from a South African

perspective and also do so at a disaggregated sectoral level. The country's total electricity intensity more than doubled in the study period and its weighted growth was higher than the majority of the OECD member countries by a considerable margin. In addition, the vast majority (nine of the thirteen) of the South African industrial sectors were more intensive than their OECD counterparts.

Given these results, a benchmark-and-trade system was proposed to improve the electricity efficiency of the country. This market-based approach promotes the trading of credits among sectors after comparing their electricity efficiencies with the benchmark chosen for each phase. The benchmarks are subject to the equivalent sectors of the OECD countries. An important finding was that depending on the chosen benchmark, the price of the credits differs. Also, the price or cost of technology plays an important role in the decisions the participants make on whether they should trade or change their technology (and hence, efficiency) in order to reduce their electricity consumption.

Finally, the proposed system and a carbon tax both aspire to reduce the GHG emissions but employ different methods. The carbon tax 'penalises' the consumption of energy and aims to thus decrease the electricity (energy) consumption; while the benchmark-and-trade system gives financial incentives to the successful performers to improve their electricity (energy) efficiency. A comparison showed that the benchmark-and-trade system's superiority is highly dependent on the choice of the appropriate benchmark. However, under the proposed system, some sectors will make profits by being better off than the benchmark and supplying the market with credits. However, all the sectors will have to increase their expenses after a carbon tax is imposed.

5.4 Recommendations for further research

The international interest on the consequences of climate change resulting from extensive energy use and GHG emissions as well as the local crisis at the beginning of 2008 have made energy research imperative for the South African policy environment. As Pouris (2008) states, the South African publications on energy have been increasing substantially but from a low basis and focus more on research specialties such as chemical engineering, mechanics and mechanical engineering. However, the severe economic consequences of the 2008 crisis show that energy should also be examined from an economic and environmental point of view. Thus, this study provides the foundation for further research on electricity/energy efficiency in the country.

The main predicament in energy research is the quality and availability of data. Although steps have recently been made, data is still a major problem. Additional work should be undertaken in order to improve the accuracy of the collection of energy data. More importantly, data on a more disaggregated level will be useful in better understanding the way in which companies and households make decisions on consumption and efficiency of energy (electricity).

Moreover, baseline studies of different types of energy at both an economy-wide and a sectoral level should be conducted for two reasons. First, that the South African policy authorities can then be aware of the current situation and second, that the efforts for improvement can have certain targets based on the business-as-usual.

This study also opens new paths for advanced energy research in combination with economic analysis and econometric techniques. Employing panel data and Kalman filter techniques allows researchers to acquire constructive and valuable results with regards to behaviour of sectors and the economy when different factors change. This study sets a precedent for future econometric analysis on different energy types at various levels of disaggregation.

Also, the benchmark-and-trade system can be examined in a *game theory* framework to investigate the participants' decisions on the demand and supply of credits as well as the electricity reductions and economic benefits from the market. Also, a system dynamics model may be of assistance in order to better understand the mechanics of the system.

Finally, the proposition of a benchmark-and-trade electricity efficiency system extends the horizons on future demand-side management policies both for South Africa and other countries. It would be interesting to apply a similar system to other developed and developing economies and compare the results with that of the South African application. Also, more detailed disaggregation as well as inclusion of different types of energy in the system could improve it further.