THE ECONOMIC IMPACT OF ELECTRICITY PRICE INCREASES ON THE POTATO INDUSTRY IN SOUTH AFRICA

by

Casparus Gerhardus Troskie

A thesis submitted in partial fulfilment of the requirements for the degree

MCom (Agricultural Economics)

in the

DEPARTMENT OF AGRICULTURAL ECONOMICS, EXTENSION AND RURAL DEVELOPMENT

FACULTY OF ECONOMIC AND MANAGEMENT SCIENCES
UNIVERSITY OF PRETORIA

November 2012

DECLARATION

I, Casparus Gerhardus Troskie, hereby declare that the thesis, which I submit for the degree MCom Agricultural Economics at the University of Pretoria, is my own work and has not been submitted for a degree at any other tertiary institution.

SIGNATURE: …….. DATE: November 2012

ACKNOWLEDGEMENTS

First and foremost, I would like to thank our heavenly Father who bestowed on me the talents and blessings to complete this dissertation. Without His heavenly love and grace, this dissertation would not have been possible. All the glory and praise to Him.

To Prof Johann Kirsten, I wish to express my sincere appreciation for his guidance and supervision during the time of this study. I am grateful for the time and effort as well as the positive criticism I received that made it possible for me to complete this study.

To Dr Ferdi Meyer and the Bureau for Food and Agricultural Policy team, I am deeply appreciative of their valuable inputs and the role that they played in the success of this study. I further want to thank the staff members of the University of Pretoria, specifically the Department Agricultural Economics, Extension and Rural Development for their guidance during the time of my studies.

The study would also not have been possible without the determination of Pieter van Zyl and Potatoes South Africa; I received unwavering support while collecting the appropriate data from their representative potato farmers.

To Neels Bezuidenhout and Julian Theron, Energy Advisors at Eskom, thank you for the valuable time and effort that was shared through providing the appropriate data and expertise.

To my parents, Casper and Isabel, I will forever be grateful for the opportunities you provided me with and your never ending support, love and guidance. A special thank you goes to my brother, Francois, sister, Karlien and family for their support during my studies.

Lastly, I would like to express my deepest love and appreciation to my wife, Elizabeth for her never ending love, support and motivation. Without your love this would have been a worthless journey.

ABSTRACT

THE ECONOMIC IMPACT OF ELECTRICITY PRICE INCREASES ON THE POTATO INDUSTRY IN SOUTH AFRICA

by

C.G. Troskie

Degree: MCom (Agricultural Economics)
Department: Agricultural Economics, Extension and Rural Development
Study Leader: Prof J.F. Kirsten

At the start of 2010, the National Energy Regulator of South Africa (NERSA) announced that electricity tariffs would increase at an average rate of 25 percent per year over a three year period (Njobeni, 2010). This raised fears within the economy and specifically within the agricultural sector that these increases would negatively impact the agricultural sector. Various stakeholders within the agricultural sector also raised opinions on what the true impact will be on agricultural production and market prices. The main objective of this study was to quantify the true impact of higher electricity tariffs on production and market prices within the potato industry.

The study focused on the potato producing regions of the Sandveld, Limpopo and South Western Free State. On-farm data were collected in an attempt to capture the electricity consumption and costs associated with potato farming in these specific regions. An effort was also made to calculate and capture production costs in these three regions which, together with the collected electricity costs, formed the basis of the analysis.

The study applied a supply response model developed by the Bureau for Food and Agricultural Policy to evaluate the impact of increased electricity tariffs on potato production and prices in South Africa. The supply response model used is a standard econometric recursive dynamic model that has the purpose to model policy analysis,

with short, medium and long term projections on an annual baseline basis (van Tongeren *et al*, 2000). However, in order to conduct analysis on electricity tariff increases, this supply response model required adaptation and improvement in order to incorporate electricity costs. Before this adjustment, the model applied the producer price / fertilizer price ratio as a proxy for production costs. Since detailed production costs (including electricity costs) were acquired through this study it was now possible to alter this ratio to a producer price / production costs ratio which included the electricity costs.

To illustrate the impact of the electricity price increase the electricity cost component in production cost was shocked to reflect an increase at the set rate of an average of 25 percent per annum for the 2010, 2011 and 2012 production years. The results demonstrated that these three regions will see a decrease in hectares planted over the period between 2013 and 2020 as a result of the increased electricity tariffs, but that this decrease in hectares planted will be very small. The Sandveld region had the highest impact as it was calculated that on average, over the period between 2013 and 2020, a total of 35 hectares of potato production will be lost due to this higher electricity tariff. It can further be expected that the market price in the Sandveld region would increase slightly by 52c/10kg over the same period. The South Western Free State region was least effected by the higher electricity tariffs as a mere 1.6 hectares of potato production land could be lost due to the higher electricity tariffs which will lead to an increase of around 36c/10kg in market prices over the period between 2013 and 2020.

The study further introduced a cost saving technique that farmers can use to counter the higher electricity tariffs. The majority of farmers consume electricity under the Landrate and Ruraflex tariff structure. It is this Ruraflex tariff structure that farmers can use to their advantage by consuming electricity during specific periods of the day that would result in a lower c/kWh cost. By reviewing the irrigation scheduling and activities of farmers the study established that most farmers pay far too much for electricity since their peak usage are during the periods of the day where higher rates apply. The study calculated that farmers, by applying this technique, could save between R190 and R455 on electricity costs per hectare in the Sandveld region.

The study concluded that the impact of higher electricity tariffs on potato production and market prices in the Sandveld, Limpopo and South Western Free State regions are of a small nature which will most likely be absorbed by the farmers. The claims by various industry participants that the potato industry would be adversely negatively impacted were unfounded in this study. Nevertheless, in the event that electricity tariffs continue to increase in the future, farmers have to their disposal a cost saving technique that will aid them in countering some of the negative effects of electricity price hikes.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

LIST OF ABBREVIATIONS

Abbreviation	Meaning
ARC	Agricultural Research Council
ASGISA	Accelerated and Shared Growth Initiative – South Africa
BFAP	Bureau for Food and Agricultural Policy
CGE	Computable General Equilibrium
DAFF	Department of Agriculture, Forestry and Fisheries
DoE	Department of Energy
ECM	Error Correction Model
FAPRI	Food and Agricultural Policy Research Institute
FAO	Food and Agriculture Organization
GrainSA	Grain South Africa
IO model	Input-Output model
kWh	Kilowatt hour
NERSA	National Energy Regulator of South Africa
NAMC	National Agricultural Marketing Council
NPK	Nitrogen, Phosphorous & Potassium
PSA	Potatoes South Africa
SARB	South African Reserve Bank
SVAR model	Structural Vector Auto-Regression model
USDA	United States Department of Agriculture

CHAPTER 1

SETTING THE SCENE

1.1 INTRODUCTION AND PROBLEM STATEMENT

The South African agricultural sector has been identified as a key contributor to rural development and employment creation (National Planning Commission, 2012). The potato subsector contributed 3.4 percent to the gross value of the South African agricultural sector in the 2009/2010 production season (DAFF, 2012). The potato industry further represents 13.4 percent of South African horticulture (DAFF, 2012) while R13.802 billion private consumption expenditure was allocated to the purchase and consumption of potatoes in 2010 (DAFF, 2012). More importantly, the potato industry provides livelihoods to farmers and labourers and is a staple food for many South Africans (NAMC, 2007). In the context of job creation and economic opportunities in many rural areas it would therefore be important to ensure the long term sustainability of the potato industry in South Africa. The sustainability of the industry depends on the profitability of the various stakeholders within the industry.

A serious threat to the overall sustainability of the potato industry is the ever increasing production costs. Over the past decade, from 1997 to 2008, production costs of potato farmers increased by 141.8 percent (NAMC, 2009). The major contributors to this increase in production costs were fertilizer and fuel cost, increasing by 376.7 percent and 379.2 percent respectively between the period 1997 to 2008 (NAMC, 2009). These input price increases resulted in 8 000 hectares of land taken out of potato production in the 2009 production season (BFAP, 2009). It can therefore, to some extent, be assumed that the potato industry is somewhat supply elastic suggesting thus that increases in the cost of potato production will lead to a decrease in the level of potato production.

An added threat that has been faced by the potato industry in the recent few years is the increase of electricity tariffs. Potato production is very dependent on irrigation as the majority of potato farmers make use of irrigation scheduling (PSA, 2010a).

Electricity prices have increased by approximately 94 percent from 2000 to 2009, with further electricity price increases looming in the future for South Africa. Eskom announced that electricity prices would increase on average by 25 percent for the next three years from the year 2010. Figure 1.1 below shows the average increase in electricity tariff prices from 2000 to 2010 as well as the announced increases in the tariff prices for the 2010 (24.8 percent), 2011 (25.8 percent) and 2012 (25.9 percent) seasons.

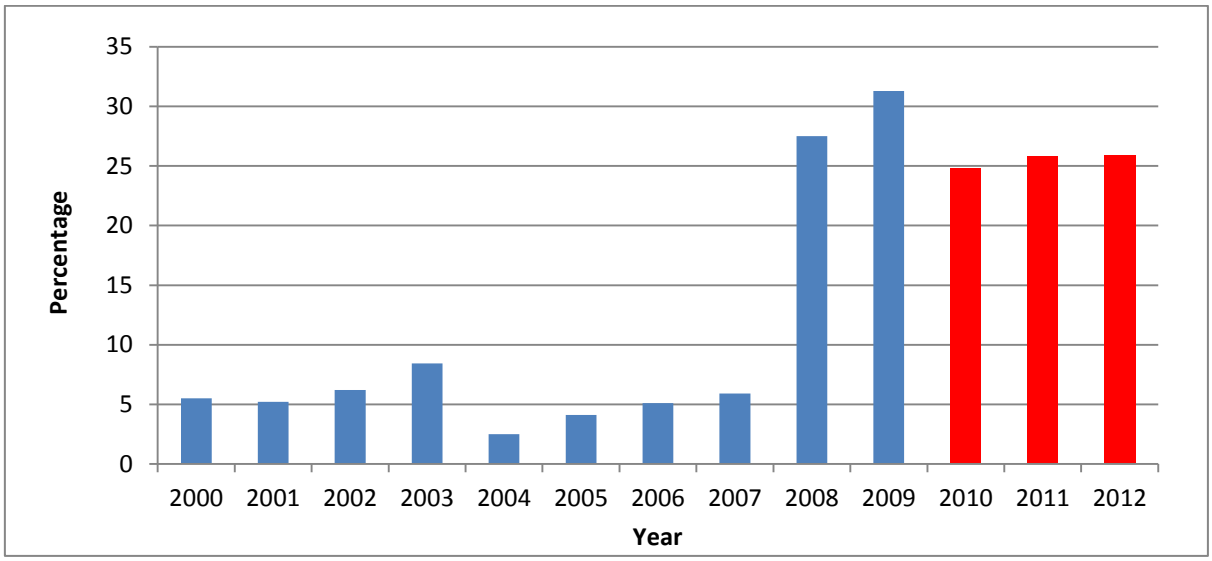


Figure 1.1: Increase in electricity tariff prices, 2000 to 2012.

Source: Eskom (2010)

This continued increase in electricity prices will further pressurise the production costs of potato farmers in the future. At the end of the 2012 season, electricity tariff will have increased by about 298 percent from 2000 (Eskom, 2010). This is much the same increases as was seen in the fertilizer and fuel costs from 1997 to 2008 in which 8 000 hectares were unengaged from potato production. The elastic supply tendency of potato farmers therefore entices one to believe that the announced increase in electricity prices will have a negative effect on the level of potato production. The concern for the potato industry is how much the increase in electricity tariffs will impact the South African potato industry in terms of the level of production.

The increase in the price of electricity will therefore form the specific focus of the study and an effort will be made to assess the impact of this increase in electricity prices on the potato industry regarding the level of potato production. An integral part of the study is to analyse and calculate the electricity usage and the associated costs thereof on potato farming. The study furthermore determines the decrease in hectares of potato production associated with the increase in electricity costs by altering the Bureau for Food and Agricultural Policy (BFAP) potato supply response model to include an electricity costs component.

1.2 PURPOSE STATEMENT

The main purpose of the study therefore is to evaluate the short to medium term impact of the recent announcement that electricity tariff prices will increase over the next three years on the level of profitability and sustainability of the potato industry. The nature of the study follow a short to medium term perspective by assessing the impact of the electricity price increases on the potato industry over a 10 year period. In an era which is characterised by high rates of unemployment and uncertainties on food security, policy makers should understand the impact of policy decisions. At present, the short to medium term effects of the announced increases in electricity prices have not been evaluated. A level of uncertainty exists within the potato industry regarding the impact of electricity tariff price increases on the industry. Therefore, the main purpose of the study is to determine and calculate the on-farm electricity usage and costs associated with potato production. The derived electricity costs will be used in a partial equilibrium model developed by the Bureau for Food and Agricultural Policy (BFAP) to identify the possible loss in potato production and the effect thereof on market prices that might be a result of the increased electricity costs. The study will alter the BFAP partial equilibrium supply response model to accommodate the increased production costs as a result of higher electricity tariffs.

1.3 RESEARCH OBJECTIVES

In order to address the problem of high electricity prices facing the potato industry, the following specific research objectives are addressed in this study:

- To analyse the electricity tariff structure as set out by Eskom.
- To determine the electricity usage (kilowatt hour) on farm level under potato production.
- To determine the associated costs of electricity usage on farm level to calculate the electricity cost per hectare of potato production in a specific region.
- To adjust the potato supply response model as developed by BFAP in a way that will incorporate production costs at farm level in a much more detailed manner.
- To use this adjusted BFAP model to determine the potato production response in a specific region as a result of the increased electricity tariffs.
- To answer the question of uncertainty that is present in the industry about whether the increased electricity price tariffs will lead to lower potato production in South Africa.
- Lastly, to provide recommendations on how to reduce electricity costs on farm level despite Eskom's announcement of electricity tariff increases over the next three years.

1.4 STATEMENT OF HYPOTHESIS

The statement of hypothesis can be formulated as follows:

Increases in electricity prices for the next three years will subsequently lead to a decrease in the level of potato production which will further lead to higher market prices for potatoes as a result of production costs increasing substantially.

In essence the study establishes whether electricity costs make up a substantial share of total production costs in potatoes and therefore could negatively impact the

profitability of potato production. Low profits and margins could lower the area under potatoes and thus reduce the supply on the market and thereby introduce higher prices to the consumer.

1.5 IMPORTANCE AND BENEFITS OF THE PROPOSED STUDY

The question that is addressed by this study necessitated the refinement of one of the supply modules in the existing BFAP family of agricultural commodity models. By analysing detailed farm level data the study thus improved the existing BFAP model by including more thorough production costs. At the same time the study also intends to make a practical contribution to the potato industry. With the increase in electricity price tariffs, uncertainty exists within the industry in terms of what the true impact of the increases in electricity prices will be on the short to medium term sustainability of the industry. The proposed study will therefore answer the question on how the industry will be affected in terms of the level of potato production in South Africa. It was also discovered that no real effort has been made previously to determine the true electricity usage and costs on potato farm levels. Currently, Potatoes South Africa (PSA) makes use of an estimated figure in their production costs calculation. The study therefore will determine the electricity usage and costs in an effort to answer the specific research question of the study.

1.6 DELIMITATIONS AND ASSUMPTIONS

1.6.1 Delimitations of the study

The proposed study has several delimitations related to the structure and context of the study. First, the proposed study only focuses on the impact of electricity price increases on potato production and market prices in South Africa.

Second, the study only focuses on commercial potato farmers within the provinces of Limpopo, South Western Free State and the Sandveld region. These three regions are the top three potato producing regions and represent 51 percent of South Africa's potato production (PSA, 2010b). All the potato production within these regions is under irrigation, except for the South Western Free State where 11 percent of

production is under dry land conditions (PSA, 2010b). As mentioned earlier, irrigation farmers are more exposed to the electricity price increases. The study therefore focuses only on irrigation farmers within these regions and the possible impact of electricity price increases on their levels of production.

Third, only farmers that focus mainly on potato production will be included in the study. Some farmers have a diverse farming business in which different commodities are produced each year. They therefore will be excluded from the study which will result in a more accurate and precise study of electricity usage and costs on potato farm level.

Lastly, only the supply response model as developed by BFAP will be used to determine the effect of increased electricity costs on potato production in South Africa. Although the BFAP model will be altered to incorporate production costs in a broader sense, the altered model will only be used to determine the electricity costs increases on potato production in the specific regions under study.

1.6.2 Assumptions of the study

The assumptions of the study can be summarised as follows:

- The analyses of the study are based on the assumption that the electricity prices in South Africa will increase for the next three years at an average rate of 25 percent per annum.
- The weather patterns, although very important in an irrigation study, will be assumed to not change drastically from the historic weather patterns during the period of the study.
- The same farmer will be farming in the same region and the farmer will more importantly make use of the same managerial decisions during the period of the study.
- It is further assumed that the farmer will make use of the same irrigation scheduling system during the period of investigation.

- The irrigation system and management used by farmers will stay constant throughout the period of investigation.
- The sampling plan used in the study will be a true reflection of electricity usage and costs on potato production within the three regions under investigation.
- Lastly, it was assumed in collecting the data, that the other on-farm electricity use components (for example, storage and packaging facilities and human electricity consumption) will not substantially add to the electricity usage and costs per hectare. In other words, the vast majority of the electricity usage and costs as calculated by the study are related to potato production on farm level.

1.7 RESEARCH DESIGN AND METHODS

1.7.1 Description of the inquiry strategy and broad research design

In order to analyse the impact of electricity price increases on the South African potato industry, it is essential to follow the correct research approach or methodology. Finding the correct research approach or methodology is encapsulated in the specific inquiry strategy that the proposed study will be following. The nature of the study can be summarised as an impact, outcome or effect study. It is therefore most appropriate to follow the inquiry strategy design of evaluation research: experimental and quasi-experimental outcome study (Mouton, 2001).

The mentioned inquiry strategy design aims to answer the specific question of whether an intervention (programme, policy or strategy) has been successful or effective and whether the intended (and unintended) outcomes of the intervention have materialised, whether in the short or long term (Mouton, 2001). The main focus of the study is to quantify the impact of the recent announcement that electricity tariffs will increase over the next three years in terms of the level of potato production in the three regions under study. The study therefore applied an experimental and quasi-experimental strategy inquiry design.

In order to conduct an accurate evaluation research study, the proposed study will be applied. The study is empirical and quasi-experimental in nature by collecting primary and secondary, quantitative, cross-sectional and longitudinal data that enables a detailed evaluation of the impact of electricity price increases on the level of potato production in South Africa.

1.7.2 Sampling plan

In an effort to analyse the increase in electricity prices on the potato farm level, primary as well as secondary data were collected. The primary data was obtained through a survey amongst a sample of potato farmers in order to determine the on-farm electricity usage and the associated costs thereof. The study area was restricted to the potato producing regions of the Sandveld, Limpopo and South Western Free State. It was decided to focus on these three regions for the reason that the potato farmers in the three regions farm under irrigation which is essential in an electricity impact study. However, some farmers in the Western Free State produce potatoes under dryland conditions, and it must be noted that these farmers were excluded from the survey. Additionally, these three regions collectively produce 51 percent of South Africa's potato production (PSA, 2010b) which therefore suggests that the coverage is sufficient to make sound conclusions regarding the impact on the South African potato industry as a whole.

The collection of electricity usage and costs on farm level is a vital component of the study as data on this is not widely available. Although farmers and PSA have a rough estimate of electricity costs on farm level, no real effort has been made to calculate and analyse electricity usage and costs on potato farm level. Secondly, the rough estimates that PSA uses in their production cost estimates is only an estimate and needs to be updated to more recent data as the tariff structure by Eskom has changed over the last few years.

Ultimately, the researcher was faced with two main decisions as far as the sampling plan was concerned. Firstly, the researcher could make use of a sampling plan that used the cluster sampling method whereby the population is divided into clusters. This approach would be considered an appropriate method as the electricity usage

on farm level would be influenced by the scale of production and would therefore need to be divided into groups (clusters).

However, in making use of this sampling method a few problems came to the fore. Firstly, the difference between the largest potato producing farmer and the smallest potato producing farmer is very high. For example, in the Limpopo region the largest potato farmer produces 734 hectares of potatoes, while the smallest producing potato farmer only has 4 hectares under potato production (PSA, 2010b). This vast difference in production scale would result in the cluster sampling being skewed which the researcher admits will not result in a sample that represents the population accurately. For example, in the Limpopo region, according to the cluster sampling method, 12 out of the 15 large scale farmers will have to be interviewed, 1 out of 46 medium scale farmers will have to be drawn and 1 out of 31 small scale farmers must be interviewed. This explains the severity by which the difference in production scale skews the sample.

The second problem identified was that only farmers that have potato production as their dominant enterprise were included in the study due to the complexity in calculating electricity usage and associated cost on farm level (fully explained in Chapter 3). By focusing on farmers that only produce potatoes and no other commodity on farm, it makes it difficult to define the final population. Although PSA knows all farmers that produce potatoes, they do not know what other commodities these farmers produce. Identifying the final population from where a sample could have been drawn was therefore difficult and would require unnecessary costs and time to determine.

The second sampling plan option was to make use of the already established study groups identified by PSA. PSA makes use of potato farmers that they have identified and who they feel represent potato farming in a specific region. By making use of these study groups, certain advantages were identified. First, the secondary data that this study uses was collected from these PSA study groups. Therefore, if the researcher makes use of these study groups, the primary and secondary data can be collected from the same group of farmers which make the comparisons between

farmers more realistic and precise. The second advantage is that these farmers were willing to make accurate data and information available to the researcher.

Third, PSA has interactive sessions with these farmers whereby they discuss the results and findings of data and information that was shared by them to PSA. The researcher therefore has an added advantage whereby the results of the study can be shared with the farmers in formal and informal discussions. This ensured the accuracy of the data collected as well as provided more information about the differences between the farmers in terms of the electricity usage and costs.

Lastly, by focusing on these farmers, the study imparts knowledge that can be used by the farmers in terms of the analysis of electricity costs and usages. It was identified that electricity usage and costs are overshadowed by other threats on farm level and that the farmers do not recognise or understand the threat that electricity price increases pose to the potato farmer and industry in the specific regions.

After a careful analysis of the different sampling plans, it was decided to make use of and collect data from the farmers as identified by PSA in their study groups. This ensured and verified the data and information from the farm level which resulted in an accurate and precise study that represented electricity usage and cost on farm level.

Following this approach, in total 13 out of 20 study group farmers in the Sandveld region, eight out of 10 study group farmers in the South Western Free State and seven out of 12 study group farmers in the Limpopo region were interviewed and included in the study.

The secondary data used by the study are the data that was collected by BFAP to develop the supply response model that is used in the study. The study also uses the already collected and calculated production cost budget as collected by PSA. Both these sources of data are accurate and are already in use to make sound strategic decisions.

1.7.3 Data collection plan

As previosuly stated, data on electricity usage and costs on potato farm level needs to be collected. Developing an accurate data collection plan therefore is vitally important to the study. This section is dedicated to the data collection plan that was used in the study.

1.7.3.1 Potential problems in accessing and collecting primary and secondary data

The nature of the primary and secondary data requirements have been discussed in detail in the above sections. It is important to acknowledge the fact that access and collection of the required data may be restricted or even out of boundaries. This section describes some of the potential problems that occurred while collecting the needed primary data.

From the outset of the study it was clear that collecting the primary data (electricity usage and costs on farm level) would be difficult for various reasons. Firstly, the tariff structure as set out by Eskom is complicated and differs from one region to another, from one farm to another, from one month to another, from one day to another and even from one hour within a day to another. Farmers therefore will need to know exactly when (during which day and exactly at which hour) irrigating took place and how many kilowatts were used. Details on Eskom's tariff structure are discussed in detail in Chapter 3. Lastly, the on-farm irrigation scheduling and systems differs from one farm to another, depending on how the farm is set up. This made it difficult to develop a structured questionnaire that encapsulated all the required questions to calculate the electricity usage and cost on farm level.

The second potential problem was found in the collection of primary data from the various potato farmers within the three regions under investigation. There was the risk that farmers were unable, unavailable and unwilling to provide access to accurate data concerning their input cost structures and electricity usage on the farm. This problem could have potentially derailed the research efforts.

However, as mentioned previously, the above mentioned problems in accessing and collecting the data were overcome due to the fact that the researcher made use of the farmers already involved in the PSA study groups.

1.7.3.2 Data collecting techniques

Collecting data and information on electricity usage and costs on farm level are potentially difficult due to the complexity of Eskom's tariff structure and the vast differences between one farm and another. It was therefore decided to only collect the electricity accounts from each farm as these accounts clearly stated how many kilowatts were used and what the total electricity account for the specific month was.

Data on the actual planting and harvesting dates was collected as well as an indication of the other on-farm activities also covered on the specific electricity account. PSA indicated that they would collect the mentioned data from the farmers, which made the data collection speedier due to their trusted relationship with the farmers.

1.7.4 Data analysis plan

All the accounts on a specific farm were added, irrespective of whether a component of the account supplied electricity to other on-farm activities not directly associated with potato farming (for example, household electricity), and was divided by the total potato hectares planted in the 2010 season. A total electricity cost per hectare and kilowatts used per hectare were calculated for each specific farm. A weighted average electricity cost per hectare for a specific region was calculated by using these collected and computed electricity cost per farm averages. This was completed for all three areas under investigation.

Due to the nature of the sampling and data plan, the study managed to ensure accurate and complete data by making use of the following:

- The farmers as mentioned are involved in the PSA study groups in the specific regions. They therefore have already indicated their willingness to share accurate and complete data and information.
- Secondly, the data was collected by PSA from the farmers. These two parties have trusted relationships which ensure accurate data.
- By collecting the actual electricity account for the specific farms under investigation, the study ensured that the true on farm electricity costs were captured.
- Although PSA and other stakeholders have rough estimates about what the electricity usage and costs on farm level are, the calculated costs and usage as calculated by the study should not differ immeasurably.

1.7.5 Assessing and demonstrating the quality and rigour of the proposed research design

The purpose of this section is to describe the techniques and criteria that were used to access and demonstrate the quality of the research efforts (Kotze, 2010). The study draws a conclusion on the impact of electricity tariff price increases on the level of production and market prices in the potato industry. Various external factors could potentially harm the quality and outcome of the research efforts. It is therefore important that a criteria be developed that provides evidence of the quality, credibility and rigour of the research efforts.

There are basically two important aspects of the study that could harm the quality and rigour of the research efforts. Primarily, the study must clearly indicate that the majority of the on-farm electricity usage and costs are directly related to the production of potatoes and; then, the study must clearly indicate that the calculated change in the level of potato production is a direct result of the increase in the electricity prices.

As aforementioned, the study analysed the on-farm electricity accounts. As a result, the collected data could potentially include on-farm activities that are not directly related to the production of potatoes but are still included in the electricity accounts. The researcher acknowledges this but has limited this impact by only collecting data from farmers that only farm with potatoes and do not have any other commodities. The only activity therefore that can be included in the electricity analysis is private consumption. According to Eskom representatives, private on farm consumption accounts for less than five percent of the total electricity costs. Private consumption therefore represents a small percentage of the electricity account and will consequently not significantly change the electricity costs from the actual costs. In short, the majority of the calculated on-farm electricity costs are directly related to the production of potatoes. These activities include irrigation of the potato land, washing and packing of potatoes and the on-farm storage facilities.

The researcher also must clearly indicate that the change in the level of potato production is a direct result of the increase in the electricity prices. To overcome this problem, the study has altered the partial equilibrium supply response model developed by BFAP. This econometric model enables the researcher to hold external forces constant. This has ensured that the decrease in production as calculated by the model is a direct result of the shock imposed on the electricity cost weight, taking external forces out of the equation. Secondly, the BFAP model has the added advantage to model the change in production and market conditions over a 10 year period. In the first year, prices are provided but in the second year and third year prices change according to the change in production levels of the previous year as a result of the increase in electricity prices. This is a partial comprehensive analysis as the changes in prices are directly associated with the increase in electricity prices. The prices received by potato farmers are therefore only influenced by the electricity price change with no other factors influencing the market price. These other factors that potentially can influence the market price are held constant during the period under investigation by the BFAP model.

1.8 OUTLINE OF DISSERTATION

Chapter 1 has provided a sound background, research objectives and hypothesis to the current study. The remainder of the study serves to analyse the impact of higher electricity tariffs on potato production in South Africa. However, before the empirical work of the study can be presented, it is paramount to conduct a review of the available literature that will provide the foundation from where the study can be performed. Literature regarding the impact of energy price shocks as well as studies about supply response models will be researched in Chapter 2. Chapter 3 of this study is dedicated to the analysis and data collection of electricity consumption and costs in the Sandveld, South Western Free State and Limpopo regions. Eskom electricity tariff structures are also reviewed which is critical to the study. The refinement of the BFAP supply response model as well as the impact of higher electricity tariffs are discussed in detail in Chapter 4. The results and recommendations are summarised and concluded in Chapter 5, forming the final concluding remarks of the study.

CHAPTER 2

MEASURING THE IMPACT OF INPUT PRICE SHOCKS: A REVIEW OF AVAILABLE LITERATURE

2.1 INTRODUCTION

The main purpose of the study is to analyse the impact of electricity price increases on the level of potato production in South Africa. In order to conduct a study that is consistent and adds value to the industry and stake-holders involved, a critical review of the available literature must be performed. Saunders, Lewis and Thornhill (2009) explain that the main purpose of a critical review of the available literature is to provide a foundation on which a research study can be performed as well as to develop a good understanding into relevant previous research studies and the applicable trends that have emerged. This chapter can mainly be divided into two sections. The first section focusses on the nature of energy and input price shocks in the agricultural industry and the second section reviews literature on modelling techniques that can be performed to answer the specific research objectives of this study.

There exist numerous studies in the global literature domain focussing on changes in a specific industry brought about by exogenous shocks or influences. These influences can range from changes in government policies to rising commodity prices that have a negative influence on a specific industry. The next section concentrates on the methods used by different studies to quantify the impact of these shocks.

2.2 STUDIES MEASURING THE IMPACT OF ENERGY PRICE SHOCKS

The effects of energy and input prices shocks received wide attention from researchers from as early as the 1970s after the first energy price shock hit the world in 1973 (Kilian, 2007). Numerous studies were conducted on the high level of volatility seen in oil prices and the threat it posed to agricultural industries world-wide.

In a broader economic sense, a study was conducted by Kilian (2007) about the economic effects of energy price shocks. The main purpose of the study was to address a number of vital issues including determining what energy price shocks are, how responsive energy demand is to changes in energy prices, how do consumer expenditures patterns evolve in response to energy price shocks, how do energy price shocks affect real output, inflation, stock markets and the balance of payments and most importantly why do energy price increases seem to cause recessions (Kilian, 2007). The study emphasised the above questions and accentuated the effect that energy price shocks would have on the broader economy. Although from a broader economic sense, an agricultural intensive country would also be negatively impacted by higher oil prices through reduction in agricultural output and higher food prices.

A study by Hanson, Robinson and Schluter (1993) was conducted on the sectoral effects that a world-wide oil price shock might have on the economy wide linkages to the Agricultural sector in the United States of America. The study acknowledged that agricultural production techniques in the United States are energy intensive and that raising energy prices should lead to higher production costs which would lead to lower output and ultimately lower farm income. The study made used of an input-output model to analyse the direct and indirect linkages between energy and other sectors of the economy. The study went beyond the use of the Input-Output (IO) model and used a Computable General Equilibrium (CGE) model to analyse the sectoral effects under three different macro adjustment scenarios. The study concluded that although the agricultural industry is energy intensive, this level of intensity varied from one agricultural commodity to another. The study further concluded that based on costs analysis in the Input-Output framework, the agricultural industry should experience higher costs when there is an oil price shock (Hanson, *et al.* 1993). This study introduced the researcher to the modelling technique of an Input-Output model, even though this model analyses economies on a sectoral linkage method.

A different method was used by Lambert and Gong (2010) in a study where the objective was to measure the degree of farm responsiveness to energy price changes in the United States of America. The method used by Lambert and Gong

(2010) included using a dynamic cost function model that was estimated to derive short and long run adjustments within the United States' agriculture to changes in relative input prices. Miranowski (2005) indicated that the demand for direct energy inputs is price inelastic meaning that should there be adverse increases in energy input prices; farmers may absorb these shocks as they have limited substituting possibilities available to energy inputs. This statement by Miranowski (2005) might also be true for this research study as potato farmers have little substitution possibilities for electricity inputs as well. One can therefore assume that due to the little availability of alternative electricity sources to potato farmers in South Africa that electricity inputs are price inelastic.

A more recent attempt was conducted by Wang and McPhail (2012) with the aim to analyse the impact of energy shocks on the US agricultural productivity growth and food prices. Unlike the above mentioned studies which used the Input-Output, CGE modelling approaches and the dynamic cost function model, this studied made use of a Structural Vector Auto-Regression Framework (SVAR) model with five variables to capture the impacts of an energy shock on United States agricultural productivity growth as well as on fluctuations in food prices. The results obtained from the study indicated that in the short run an energy shock account for 10 percent in the volatility of food prices. However this percentage increased to a 16 percent contribution in the medium term. The study therefore concluded that energy shocks are an important factor in explaining the rapid increase in food prices.

The impacts of higher energy prices on Agriculture and Rural economies were researched by Sands and Westcott (2011) in a published report by the United States Department of Agriculture (USDA). The importance of energy in the agricultural sector was reviewed, with a further report on the results of a case study on the economic implications for the farm sector in the event of energy price increases. The analysis focused more on relatively short term adjustments to higher energy related costs. The study found that in the crops sector, the overall planted acreage would decline as higher energy costs would lead to lower on-farm producer net returns. Due to lower acreage, prices for most crops would increase as a consequence. Looking at the wider agricultural industry, higher crop prices would lead to higher feed prices

which would also negatively affect the livestock production which in turn will lead to higher livestock prices.

The impact of energy price shocks is not bound to agriculture in the United States. In a study by Tewari and Rao (1989) energy use in the Indian agricultural industry was modelled using a sectoral approach. The main objective of this study was to describe the various types of long run changes that can be expected in the Indian Agricultural industry due to rising energy prices. The study further needed to develop an empirical model that could estimate the impact of rising energy prices on the Indian Agriculture. It was recommended that a sectoral quadratic programming model with detailed specifications be developed that could be used in assessing and analysing the impact of increasing energy prices.

The long and short run impacts of food and energy price shocks were also researched by Aye (2012) with specific reference to Nigeria. A link between food prices and various other interconnected factors were modelled with the purpose to quantify the current and future poverty impacts due to rising energy and food prices. In attempting to answer the specific research objective, Aye (2012) reverted to developing a dynamic system of equations comprising of both short and long term variables of interest. The long term behaviour was modelled using the method of cointegration while the short term behaviour included using the Granger Error Correction Model (ECM). The study concluded that in general, food and oil prices do have a high increasing effect on consumer price inflation and poverty in Nigeria and following the findings of the study urged policy makers to develop policies that would improve agricultural productivity in Nigeria.

Eggerman, McMahon, Richardson and Outlaw (2006) conducted a study on the impact of fuel price increases on Texas crops in the USA. This study had the primary objective to estimate the effect of increased fuel prices on economic indicators while also having a secondary objective to estimate short and intermediate-term impacts on the Texas economy. To estimate the impact of increases in fuel prices on crop producers in Texas, a state-level model that projects net farm income for crops was used. The researcher made use of the state-level model developed by Food and Agricultural Policy Research Institute (FAPRI) as the basis to develop a model

needed to solve the hypothesis of the study. This study by Eggerman *et al.* (2006) served as a good basis for the current study as it has similarities to this specific research objective. In much the same way, this study also answered specific questions related to higher production costs and the effect thereof on farm production and market prices. The study by Eggerman *et al.* (2006) further added value by introducing the research institute of FAPRI which make use of modelling techniques that could be beneficial to the researcher.

FAPRI were involved in a study, which has some similarity to this research effort, called “The American Clean Energy and Security Act of 2009”. This study researched the effect of higher energy prices as a result of this passed legislation and the impact thereof on production costs (FAPRI, 2009). The analysis used the 2009 production cost budget of selected farmers as the base year and extrapolated these to production costs in 2020, 2030, 2040 and 2050 assuming that these production costs only increased as a result of the higher energy costs (FAPRI, 2009). The study concluded that producers use high levels of energy inputs and that the direct impact of higher energy prices will be to reduce farmers’ net returns on farm level (FAPRI, 2009).

The studies discussed in here applied a variety of modelling techniques that included:

- Input/Output Models
- Computable General Equilibrium Models
- Dynamic Cost Function Models
- Sectoral Quadratic Programming Models and;
- Structural Vector Auto-Regression Framework Models

Not one of the studies reviewed here applied a supply response model which is fundamentally important to this study due to its characteristic in quantifying a supply driven hypothesis. The section that follows introduces the supply response model and the manner in which this model can be used in this study.

2.3 DETERMINING THE IMPACT OF INPUT COST INCREASES ON PRODUCTION AT FARM LEVEL: A SUPPLY RESPONSE MODEL TECHNIQUE

In reviewing the available literature concerning supply response models, it is important to first understand the applied methods that are available in a global context. Van Tongeren, van Meijl and Surry (2000), completed a comprehensive study that provides an assessment on the present state of applied modelling in the area of agricultural policies. The study provides a comparative assessment of applied modelling which considered partial and general equilibrium models. In an effort to find the applicable model to quantify the change in output as a result of the increase in electricity prices, the study by van Tongeren *et al.* (2000) provided valuable insight. According to van Tongeren *et al.* (2000) "…The choice of theoretical framework, the extent of regional and sectoral desegregation and the choice of datasets and estimation methods determine the domain of applicability of the model."

Figure 2.1 below provides a structured classification of the global applied models as defined by van Tongeren *et al.* (2000). These models are widely used to examine the global changes in agricultural policies. This structure therefore provides valuable insight into the applicable applied models that have aided this study in quantifying the change in supply as a result of increases in electricity prices.

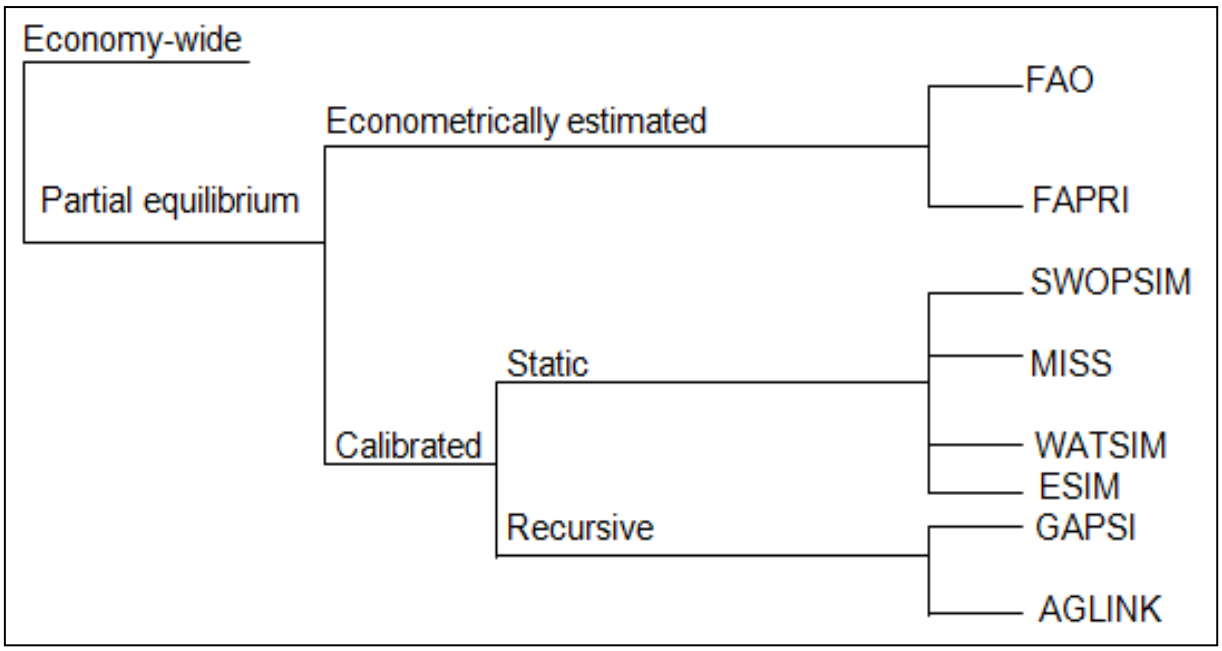


Figure 2.1: A structured classification of global applied models

Source: van Tongeren *et al.* (2000)

The first distinction van Tongeren *et al.* (2000) make is between economic-wide and partial equilibrium applied models. According to Meyer (2002), an economic-wide model provides a representation of national economies and the inclusion of factor movements between sectors in the economy. A partial equilibrium model can be defined as a model that considers the agricultural system to be closed with no linkages to the rest of the economy (Meyer, 2002). The standard partial equilibrium model captures supply and demand equations which determine a set market price.

The partial equilibrium model based on the Food and Agricultural Policy Research Institute (FAPRI) is of particular interest to this study as the model used in this study was based on the model of FAPRI. The FAPRI model is a standard econometric recursive dynamic model that has the purpose to model policy analysis, with short, medium and long term projections on an annual baseline basis (van Tongeren *et al*, 2000).

According to Meyer (2002) “standard” implies that the basic principle of constant return to scale, homothetic preferences and perfect competition underlies the model. A dynamic model has the ability to estimate adjustment processes of time which implies that lagged independent variables can also be used by the model (Meyer,

2002). To incorporate these dynamic features, the model has to specify a recursive sequence of equilibrium which implies that for each time period an equilibrium is solved by the model (Meyer, 2002). The last distinction made by Figure 2.1 above is between econometrically and calibrated models. Econometric models have the ability to simultaneously estimate equations, with these estimated parameters that can be used to calculate elasticities. This is the method that is used by the FAPRI model. Calibration models use the initial elasticities that were estimated by the econometric model and adjust certain parameters to the equilibrium dataset (Meyer, 2002).

The FAPRI model is used today to conduct numerous research studies and forms an integral part of policy analysis in the United States of America. On an annual basis, FAPRI presents a world agricultural outlook which incorporates baseline projections on dairy, grains, livestock, oilseed and sugar (FAPRI, 2011). The Bureau for Food and Agricultural Policy (BFAP) was developed on much the same principles as the FAPRI model and were developed to perform baseline projections on the South African agricultural industry. BFAP each year also launches a South African baseline that provides an outlook on the South African grain, dairy, livestock, oilseeds and other agricultural sectors which include wine, sugar, horticulture and potatoes. It is this ability of the BFAP model to perform analysis on the South African potato industry that is of particular interest to this study. Studies on the BFAP model exist that will be briefly explained.

The study by Meyer (2002) had the purpose and objective to make baseline projections that would enable policy makers to conduct accurate policy analyses (Meyer, 2002). The study aimed to apply econometric analysis to the market structure of the wheat board. The developed model consists of a supply block, a demand block and a price linkage block and consists also of behaviour equations and identities (Meyer, 2002). The supply block of the model consists of an area harvested and import equation, whereas the demand block consists of domestic use and ending stock equations (Meyer, 2002). The price linkage block consists of a price linkage equation (Meyer, 2002).

In a study by Mhlabane (2011) a simulation model for the South African potato industry was developed on a regional level. This study by Mhlabane (2011) had the

main objective of developing a system of equations that have the ability to simulate the dynamic interaction between production and consumption on a regional level in the potato industry. As with the study by Meyer (2002), the Mhlabane (2011) study also consists of a supply, demand and a price linkage block while also consisting of behavioural equations and identities. The study by Mhlabane (2011) formed the basis of the supply response component of this study. Both these two studies are based on the same principles as explained at the beginning of this section in that they are standard econometric recursive dynamic models.

For the purposes of this study, the area harvested equation and price linkage equation are used to quantify an electricity price increase shock on the potato farmer in South Africa. The area harvested equation of the BFAP model is mainly used to quantify the decrease in the level of potato production in South Africa as a result of the increase in electricity prices. The price linkage equation is used to determine the market prices for potatoes in the following year as a result of the decrease in the level of potato production from the previous year.

An important dimension of this study is to refine the BFAP sector model in order to ensure that it can accommodate the electricity cost component of potato farmers. At present, the supply block of the BFAP model consists of a general input cost index. By refining the input cost index with a more detailed summary of all the associated costs in potato farming, future input costs analysis on the potato farmer can be simplified. For the purposes of the study, a detailed summary of the input costs of potato farmers with special emphasis on the electricity cost component enables the researcher to alter the electricity cost component by the increases in the electricity tariffs, while holding all other input costs and external changes constant. It is therefore worth noting that an effort has been made by the study to refine the BFAP sector model with a more detailed input cost component. This will be explained in more detail in Chapter 4 of this study. With the above two sections focusing on the impact of external driven shocks on a specific industry and with the explanation of the applicable methods that were used, it is worth reviewing literature on the economics of on-farm electricity usage.

2.4 THE ECONOMICS OF ELECTRICITY USAGE ON FARM LEVEL

The vital component to the overall success of the proposed study lies in the determination of electricity usage on farm level and the associated costs thereof. It is therefore important to review studies that have been conducted around irrigation management and systems in the South African agriculture sector with special emphasis on the potato industry. However, it is important to note that at present no studies were found on irrigation systems and management in the South African potato industry.

There is however an article that was written for Grain SA with the purpose of indicating the impact on the profitability of irrigation farmers, should Eskom increase its costs by 45 percent per annum for a period of three years (Reinders, 2009). The study only focused on pivot irrigation since this irrigation system has been very successful over the years (Reinders, 2009). The electricity usage of this type of irrigation system is a function of flow tempo (amount of water pumped per hour) and the pressure against which it is being delivered (Reinders, 2009). The electricity costs are further influenced by the tariff structures of Eskom and the time of day that irrigation takes place (Reinders, 2009). The tariff structure of Eskom is further divided into a peak, standard and off-peak time (Reinders, 2009). The tariff can differ from 191c/kWh in peak times and only 26c/kWh in the non-peak hours (Reinders, 2009). Should Eskom increase its tariffs by 45 percent per annum for three consecutive years, tariffs in the peak and non-peak times would increase to 573c/kWh and 78c/kWh respectively (Reinders, 2009). This article is valuable for the proposed study because it identified the factors that influence the cost of electricity usage by farmers.

In a study by Shock, Pereira and Eldregde (2007) it was found that if best management practises on potato irrigation is done it will lead to maximum economic use of resources while at the same time minimising environmental disturbances. The study indicated the effect on profitability of potato farmers if small errors occurred in the management of irrigation (Shock *et al*, 2007:29). It is worth referencing this study in terms of the impact on profitability of potato farmers if the management of irrigation is not sound.

BFAP (2010) also completed a study on the effect of electricity costs on irrigation farming. This study focused on the effect of the announced increase in electricity tariffs by NERSA on a typical grain irrigation farm in the Northern Cape province of South Africa. The study found that due to the higher electricity tariffs, farmers could expect to see their electricity costs component of total production costs to increase from eight percent to more than 20 percent in 2014 and 2015. The study concluded that these farmers would have realised a higher Net Farm Income of R300 000 and more in 2010 should NERSA not have increased electricity tariffs (BFAP, 2010). This study by BFAP provided some insight into the effect of the higher electricity tariffs on farm level which indicated that higher electricity tariffs would also negatively impact potato farmers in South Africa.

2.5 SUMMARY

It was explained in the introduction of the literature review that a clear understanding of the available literature is needed to conduct a study that is consistent and precise and that will add value to the industry and stake-holders involved. Numerous studies were found that analysed the impact of external driven influences on specific industries which provided valuable insight into the modelling techniques that were used. The review of literature introduced the researcher to the modelling techniques used by FAPRI and BFAP. The modelling techniques by FAPRI and BFAP will be valuable to this study as it provides the researcher with the necessary requirements to analyse the research question of this study. It can therefore be concluded that the current study makes use of a supply driven approach developed by BFAP to estimate the effect of higher electricity tariffs on the potato industry of South Africa. It can also be concluded that the current study will add to the existing body of knowledge as well as provide further valuable insight into the true impact that can be expected as a result of higher electricity tariffs.

CHAPTER 3

ON FARM ELECTRICITY USAGE IN POTATO PRODUCTION

3.1 INTRODUCTION

One of the main objectives of the study is to accurately calculate the electricity usage and costs of potato farming. Prior to this study no real effort was made by potato farmers and Potatoes South Africa (PSA) to analyse and determine the electricity usage and the associated costs thereof by potato farmers in a specific season. The main purpose of this chapter therefore is to focus on the on-farm electricity usage of potato farmers in the areas of the Limpopo province, South Western Free State and Sandveld regions. Special attention is also given to the Eskom tariff structure and its implication for on-farm electricity usage, the manner in which the study attempted to collect the electricity information from farmers, the results obtained from farmers and lastly, the study has determined the average electricity usage and costs of potato farmers in the three areas under investigation.

3.2 ESKOM ELECTRICITY TARIFF STRUCTURE

Understanding the electricity tariff structure as created by Eskom is an important aspect to the study and therefore requires special and specific attention. From the inception of the study it was clear that the tariff structure as created by Eskom to some extent influences the electricity costs of potato farmers in the Limpopo, South Western Free State and Sandveld regions. It was also further identified that the tariff structure is complex to understand and would need some background on how Eskom derived the tariff structures. This section is therefore dedicated to illuminate the complex electricity tariff structure as created by Eskom as this is a vital aspect and objective of the study.

Eskom divides the electricity tariff structure into various categories with different implications on the costs of electricity. Due to the complexity of Eskom's tariff

structure, a graphical representation of the tariff structures is depicted in Figure 3.1 below.

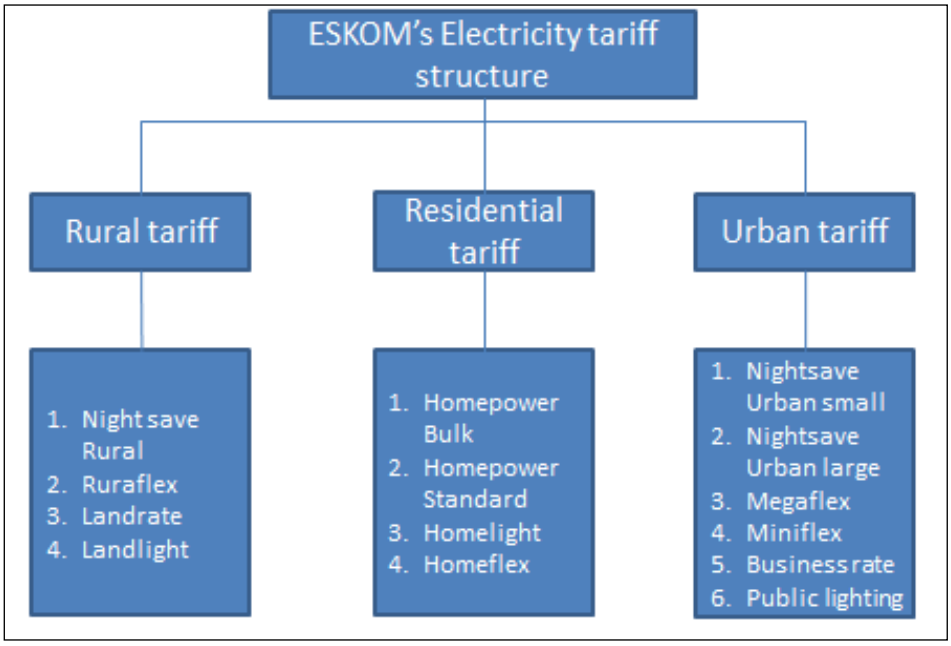


Figure 3.1: Electricity tariff structure

Source: Eskom (2009)

Eskom divides its tariffs into three broad categories which are the Rural, Residential and Urban tariffs. From there, the tariffs are further divided into different tariff structures depending on the specific requirements. All of the tariff structures as listed in Figure 3.1 above have different purposes and serve different clients with different needs. Electricity supply in the agricultural sector is classified under the Rural tariff category. The Rural tariff category is further divided into four tariff structures, meaning that farmers in general have the choice of four different tariff structures. Of these four tariff structures under the Rural category, Landrate and Ruraflex are particularly important as the majority of the farmers' electricity bills are classified into these two tariff structures. This was also found in the study as all the farmers that were included in the study made use of Landrate and Ruraflex tariff structures.

Of the two mentioned electricity tariff structures, the Landrate structure is the most regularly used. This was also the case in the study as the majority of the farmers included in the study were classified in the Landrate tariff structure. This tariff structure is not as complex and in general is easy to understand. This structure

consists of a service charge, a network charge, an energy charge (kWh used) and an environmental levy charge, all depending on the amount of electricity used. This tariff structure is different from the Ruraflex tariff structure in that the time of day in which electricity is consumed does not impact the unit costs of electricity as it does in the case of the Ruraflex tariff structure. To better understand this, the Ruraflex tariff structure is explained in detail in Figure 3.2 below.

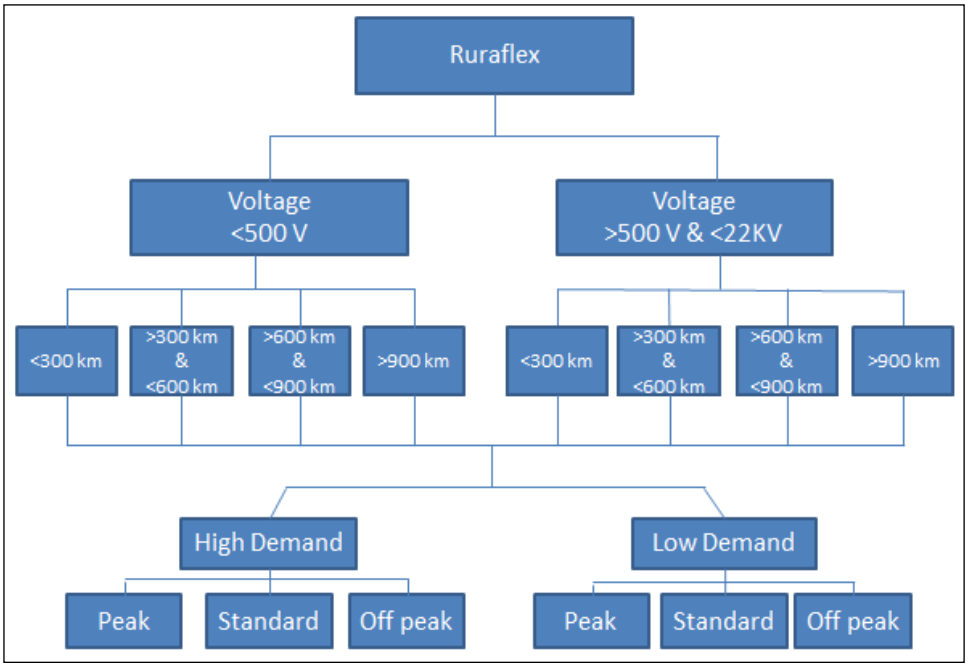


Figure 3.2: Ruraflex tariff structure

Source: Eskom (2009)

The Ruraflex tariff structure is dependent on a few important variables which include the amount of voltage that Eskom supplies to a specific point, how far the supplied transformer is from the transmission point, during which months (high or low demand months) electricity was used and also during which periods of the day and week electricity was consumed. All of these variables lead to a different electricity unit price per farmers. The Ruraflex tariff structure therefore leads to different farmers paying different electricity unit prices depending on their own unique circumstances and farming techniques. Farmers using this electricity tariff structure furthermore pay different unit prices during different times of the day. Eskom has divided this tariff structure into peak, off peak and standard periods. The peak period has the highest per unit price while the off peak has the lowest per unit price. The different times

within the days in which the peak, standard and off peak periods apply are illustrated in Figure 3.3 below.

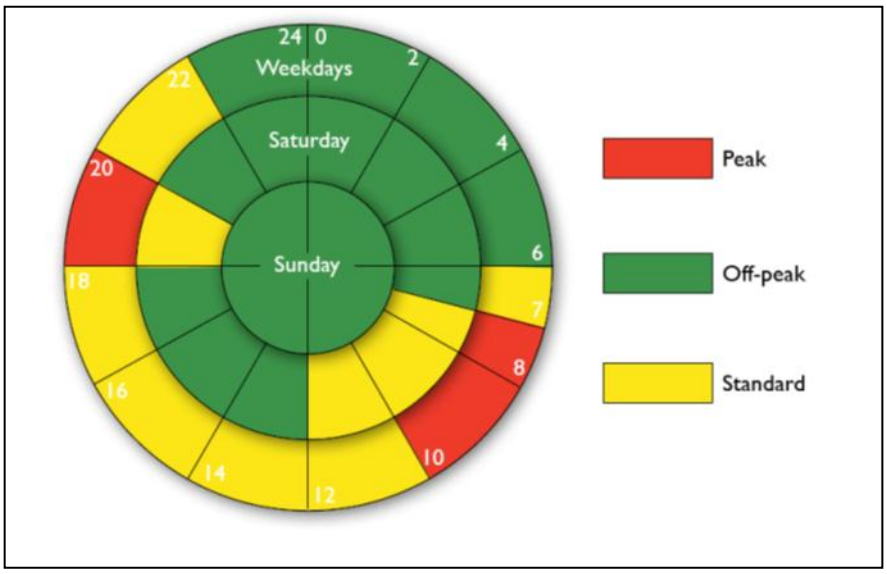


Figure 3.3: Peak, Standard and off peak period within a day

Source: Eskom (2009)

As mentioned, depending on the time of the day (Peak, standard and off peak) a different c/kWh tariff applies. The difference between peak and off peak tariffs, for the Sandveld farmers for example, can vary in the low season by as much as 31 c/kWh and in the high season by as much as 199 c/kWh. This is a way for Eskom to lure farmers out of the peak periods and into the standard and off-peak periods.

Having said this, the Ruraflex has an added advantage in that farmers to some extent can control their electricity costs. According to Eskom advisors, if farmers make use of the Ruraflex tariff structure to their advantage, their electricity bills will be lower under the Ruraflex tariff structure than under the Landrate tariff structure over which they have no control. The general consensus of Eskom advisors were also that farmers would benefit with lower electricity costs from switching their existing Landrate accounts to the Ruraflex structure[1]. This added a new dimension to the

[1] It is worth mentioning that the majority of farms are classified under the Landrate tariff structure as this was the traditional electricity tariff structure available to farmers. The Ruraflex tariff structure was introduced by Eskom to alleviate the national demand during specific periods of the day.

study; is there a way out for farmers in terms of the increase of electricity tariff prices?

The section that follows provides attention to the on-farm electricity usage and associated costs in the three different areas under investigation as well as to answers the specific question - is there a way out of high electricity tariffs for farmers?

3.3 ON FARM ELECTRICITY USAGE AND COSTS

With Eskom's tariff structure well defined and explained, a detailed analysis of farmers in the Sandveld, Limpopo and South Western Free State regions can be performed. It was found that the farmers in the three regions had a high degree of variation in terms of electricity usage and costs due to different weather patterns in the regions and therefore the different irrigation scheduling techniques. The section that follows indicates these differences in electricity usage and costs between the three regions.

3.3.1 Electricity consumption and costs in the Sandveld region

According to PSA (2010b) a total of 96 farmers actively farmed with potatoes in the 2010 production season. Of this total, the study focused and collected data from 13 farmers in the Sandveld region, all of who were potato farmers. As discussed, one of the delimitations of the study was to exclude farmers that made use of double cropping practises. This ensured that the calculated electricity usage and costs can directly be linked to potato farming.

Although the study included potato farmers that are only involved in the cropping of potatoes and no other commodity, it must be noted that the 13 farmers above do to some extent differ in their electricity consumption patterns. The study analysed the on-farm electricity consumption sources. The farmers were asked to indicate whether the electricity consumption and costs as collected by the study included household and storage facilities. Farmers that indicated that household and storage facilities are included in the total electricity consumption and costs as collected by the study would

therefore have a higher electricity cost associated with potato farming. However, it must be noted that household and storage facility electricity consumption and costs have a small contribution to the total electricity cost (approximately five percent, according Eskom representatives). Therefore, for the purpose of the study it was still worth identifying which farmers' electricity bills included household and storage facility consumption.

Of the 13 farmers interviewed in the Sandveld region, eight indicated that the collected electricity account included household and storage facility consumption together with irrigation scheduling. The remaining five farmers indicated that only potato irrigation scheduling were included in the collected electricity accounts.

The size and scale of production of the farmers were the second distinction in terms of electricity consumption and costs that were made. Of the 13 farmers, six farmers produced potatoes on 50 hectares and less. These six farmers were therefore classified as small scale farmers. Another four farmers were classified in the medium scale category as they produced potatoes on between 50 and 100 hectares of land. The remaining 3 farmers for the purpose of the study were classified in the large scale category as more than 100 hectares of land were used in the production of potatoes in the 2010 season.

The study found that the electricity consumption and costs of the 13 farmers in the Sandveld region ranged between 2 000 kWh to over 9 000 kWh consumed on the different farms. As a result of this vast difference between the kWh electricity consumption by the farmers, the electricity costs also ranged between R3 600 per hectare to almost R6 500 per hectare. Figure 3.4 below shows the variation in electricity usage and costs of potato farmers in the Sandveld region.

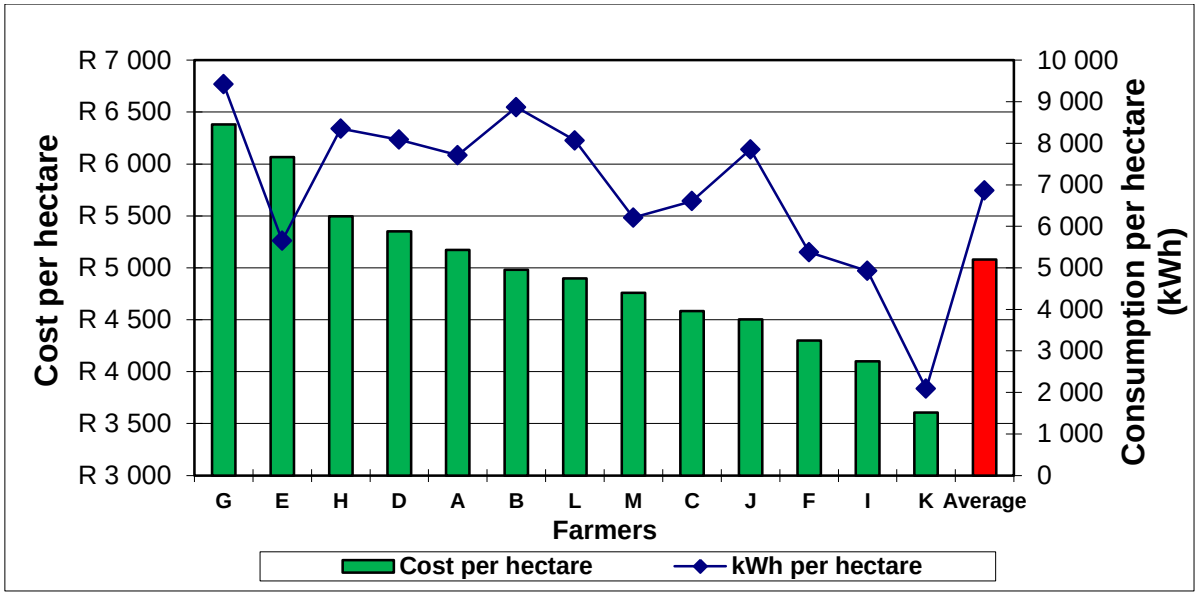


Figure 3.4: Electricity usage and costs of potato farmers in the Sandveld region

Source: Own data calculations from collected Eskom electricity bills

It is evident from the figure above that there is a high degree of variation in the on farm electricity usage and costs of potato farmers in the Sandveld region. The average electricity consumption for the region was calculated at 6 862 kWh per hectare with the weighted average electricity costs calculated at R 5 080 per hectare. Of the 13 farmers, eight farmers were below the average with the remaining five farmers above the average for the region.

It was interesting to note that the two distinctions made by the study, the on-farm electricity consuming sources and the size and scale of production, had different effects on the electricity consumption and costs. Of the eight farmers below the average, five farmers were classified in the small scale category, two farmers in the medium scale and one farmer in the large scale category. It was also found that of these eight farmers, three farmers indicated that household and storage facility consumption were included in the collected electricity bills, with the remaining five farmers indicating that the household and storage facilities were excluded from the collected bills.

Of the five farmers that consumed more electricity than the average, only one farmer fell in the small scale category, two farmers in the medium scale category and two farmers in the large scale category. Three out of the five farmers indicated that

household and storage facility consumption were included in the collected electricity accounts.

Therefore, it seems that the small scale farmers on average were more electricity efficient than their larger scale counterparts. It was also found that farmers that included household and storage facility consumption on average have above average electricity consumption and costs. However, it must be noted that according to Eskom representatives, household and storage facility consumption contribute a small percentage to farmers total electricity consumption and costs. It can therefore be assumed that the majority of the electricity costs were associated with the irrigation scheduling and farming techniques of these farmers.

Apart from the above, there are a number of different reasons for the high degree of variation in electricity usage and costs of farmers in the Sandveld region. These reasons included the difference in on-farm weather patterns (especially precipitation), the differences in irrigation scheduling techniques by farmers, the differences in the distance between the water source and the point at which the actual irrigation took place and the soil texture and moisture to name a few. However, another reason for this high degree of difference in electricity usage and costs that was highlighted by the study could also be the manner in which farmers made use of Eskom's tariff structure to their advantage, especially the Ruraflex and Landrate tariff structures.

Of the 13 farmers interviewed, seven farmers consumed electricity under the Ruraflex tariff structure with the remaining eight farmers consuming electricity under the Landrate tariff structure. Of the seven farmers under the Ruraflex tariff structure, three farmers were above the average electricity cost for the region and the remaining four farmers below the average. As far as the the eight Landrate farmers are concerned, only two farmers' electricity accounts were higher than the average. The remaining six farmers were below the average for the region. It therefore seems that in general, farmers that use electricity under the Ruraflex tariff structure have higher electricity cost than their Landrate counterparts. However, with Eskom's representatives indicating that farmers' that consume electricity under the Ruraflex tariffs structure should have a lower total electricity cost than the farmers under the

Landrate tariff structure, a question was raised about whether the farmers are efficient in using the Ruraflex tariff structure?

An analysis of the farmers' electricity usage and costs, with reference to the Ruraflex tariff structure is analysed in the next section.

3.3.1.1 Using Ruraflex tariff structure to farmers advantage

As mentioned, the Ruraflex farmers, in the case of this study, on average consumed more electricity than the average for the region and their Landrate counterparts. The Ruraflex farmers therefore generally have higher electricity costs than their Landrate counterparts. However, previously mentioned, the Ruraflex farmers have more hands-on flexibility to control their electricity costs without consuming more or less electricity. To explain this point, it is worth analysing the consumption pattern of the seven Ruraflex farmers in the Sandveld. Eskom penalises farmers that consumed electricity in the peak periods of the day while providing more favourable tariffs during the off-peak and standard periods.

Table 3.1 below shows the Ruraflex farmers' cost of consumption during the peak, off peak and standard periods as a percentage of total consumption costs.

Table 3.1: Farmers' electricity consumption under the Ruraflex tariff structure

Farmer	A	B	C	D	E	J	L
Off peak	29%	31%	31%	37%	23%	31%	32%
Peak	**37%**	**34%**	**33%**	**28%**	**38%**	**38%**	**34%**
Standard	34%	35%	36%	35%	39%	31%	34%

Source: Own data calculations from collected Eskom electricity bills

The table above displays the percentage of the farmers' total electricity cost as per tariff period. For example, 37 percent of farmer A's total electricity account are consumed during the peak periods. The higher the percentage in the peak periods the more inefficient the farmer is in consuming electricity in terms of Eskom's electricity tariff structure. Out of the seven farmers, Farmer E therefore is the most inefficient while farmer D is the most efficient in terms of using the electricity tariff

structure to their advantage. Although farmer D is the most efficient of the seven farmers, the peak consumption period still presented 28 percent of the farmers total electricity consumption.

This leads to a two-fold question, firstly how would these seven farmers perform if they are more efficient in terms of consuming electricity during the off peak and standard periods as created by Eskom and, secondly, could this be a strategy for farmers to reduce their on-farm electricity cost, thereby minimizing the effect of the increase in electricity tariffs? As it currently stands, these seven farmers are paying on average almost the same for the peak period as for the off peak and standard periods. This is shown in Table 3.2 below.

Table 3.2: Electricity cost per farmer per Ruraflex period.

	Peak	**Standard**	**Off Peak**
Per Year	1300 Hours	3588 Hours	3848 Hours
Percentage	14.88 Percent (hours)	41.07 Percent (hours)	44.05 Percent (hours)
Farmer A	R135 294.54	R124 968.12	R108 289.43
Farmer B	R68 434.22	R70 862.93	R61 788.35
Farmer C	R110 046.77	R118 044.19	R100 967.73
Farmer D	R67 397.55	R86 075.10	R90 451.99
Farmer E	R126 170.73	R130 292.91	R76 656.98
Farmer J	R29 221.65	R35 500.90	R29 456.34
Farmer L	R88 880.66	R91 235.87	R93 667.32
Average	R89 349.45	R93 854.29	R80 182.59

Source: Own data calculations from collected Eskom electricity bills

Farmer E in the table above was the most inefficient in terms of consuming electricity during the off peak and standard periods. Farmer E pays R126 170 for electricity consumed during the peak periods (which only represent 1300 hours per year) while paying R130 292 during the standard periods (which represent 3588 hours per year). In other words, farmer E almost pays the same for electricity during the peak periods than for the standard periods, even though the standard periods allows the farmer 2288 hours more per year to consume electricity. In much the same way, all the farmers shown in Table 3.2 above are inefficient in terms of consuming electricity.

As mentioned in Chapter 1 of this study, the farmers that formed part of this study is directly involved in the PSA study groups. This created the added advantage that the results obtained in this study could be shared with this group of farmers. All the information that was collected and calculated by the researcher was shared with the farmers in a discussion session. The topic of using electricity more efficiently were also discussed with the farmers. It was clear from the interaction with the farmers that the magnitude to which the farmers could save in electricity costs were not known or explored by the farmers. This showed that farmers were unaware of the cost saving technique that they to some extent can control. However, farmers and industry stake-holders indicated that during some period of the potato growing stages, irrigation needs to take place for the majority of the day which makes it difficult for farmers to make use of this cost saving technique. Nevertheless this is only the case for some potato farmers during the last few stages of the potato growing period. As will be explained below, the researcher does not rule out any consumption during the peak periods but only states that by decreasing consumption during peak periods it will be more financially beneficial to farmers.

To analyse the effect on the electricity costs of farmers by changing the periods in which they consume electricity, the study calculated the seven inefficient farmers' electricity costs with the assumption that the farmers halve the amount of electricity consumption during the peak periods and transfer that halved amount to the standard and off peak periods in equal amounts. Put differently, the farmers still consume the same amount of electricity; however the consumption now takes place during the standard and off peak periods. Table 3.3 below shows the change in consumption percentage per peak, standard and off peak period.

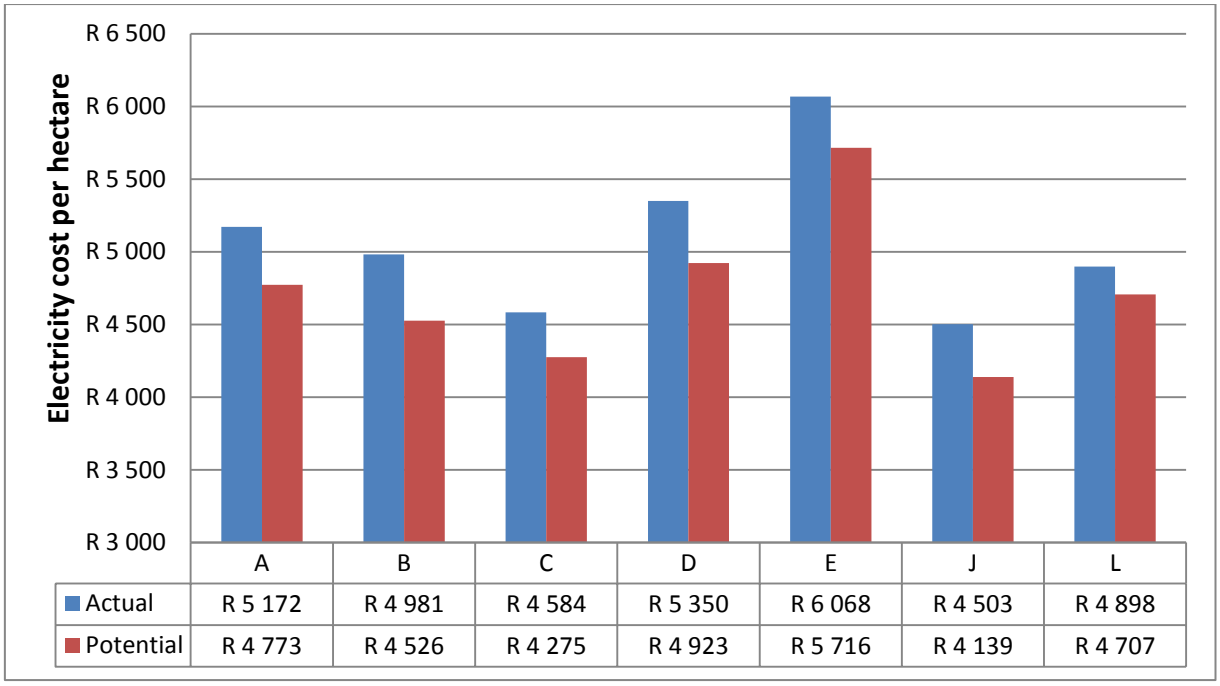
Table 3.3: Change in consumption percentage per peak, standard and off peak periods.

	Off Peak		Peak		Standard	
	Before	After	Before	After	Before	After
Farmer A	29%	35%	37%	23%	34%	42%
Farmer B	31%	37%	34%	19%	35%	44%
Farmer C	31%	37%	33%	19%	36%	44%
Farmer D	37%	43%	28%	16%	35%	42%
Farmer E	23%	29%	38%	22%	39%	49%
Farmer J	31%	37%	38%	17%	31%	46%
Farmer L	32%	45%	33%	15%	34%	40%

Source: Own data calculations from collected Eskom electricity bills

Before any changes to the farmers electricity consumption per Ruraflex period was made, between 28 and 38 percent of the seven farmers' total electricity account were consumed during the peak periods. This changed after the study reduced the amount of electricity consumption during the peak periods and transferred this to the standard and off peak periods. The peak periods as a percentage of total electricity cost changed from the 28 to 38 percent to between 15 and 23 percent after the changes were made.

The net effect of this was that the farmers total electricity costs were reduced per hectare as Figure 3.5 below shows. Figure 3.5 below shows the difference between the actual electricity costs of farmers and the potential estimated electricity costs per hectare in the event that farmers consume electricity more efficiently according to Eskom's tariff structure.



	A	B	C	D	E	J	L
Actual	R 5 172	R 4 981	R 4 584	R 5 350	R 6 068	R 4 503	R 4 898
Potential	R 4 773	R 4 526	R 4 275	R 4 923	R 5 716	R 4 139	R 4 707

Figure 3.5: The difference between the actual electricity cost per hectare and the potential estimated electricity cost per hectare.

Source: Own data calculations from collected Eskom electricity bills

Farmers, by consuming electricity more efficiently according to Eskom's tariff structure, could save on electricity costs as the figure above shows. Farmers could save between R 190 and R 455 per hectare on electricity while using the same amount of electricity. The net result on the overall electricity costs for the region is shown in the figure below. Figure 3.6 below shows the electricity cost per hectare when the Ruraflex tariff structure farmers consume electricity more efficiently.

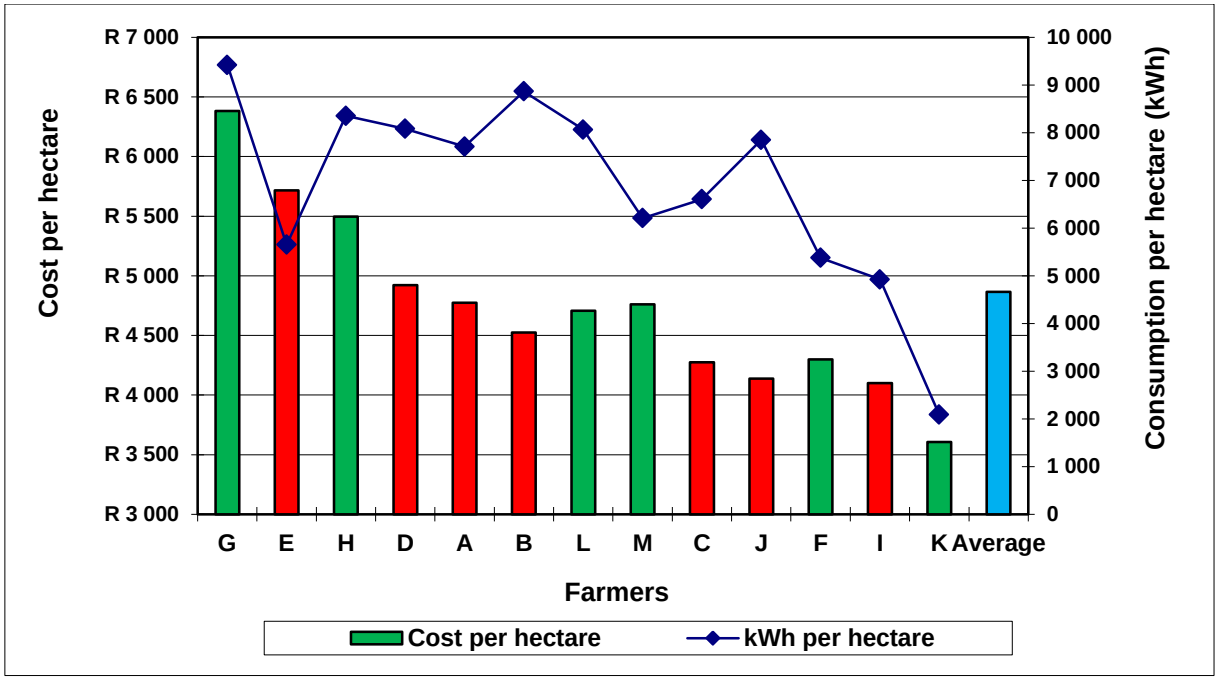


Figure 3.6: Electricity cost per farmer in the Sandveld region after changes to electricity consumption was made.
Source: Own data calculations from collected Eskom electricity bills

The net result of farmers consuming electricity more efficiently according to the Ruraflex tariff structure is that the weighted average electricity cost per hectare for the region decreased from R5 080 per hectare to R4 866 per hectare. Should all the farmers convert to the Ruraflex tariff structure and consume electricity efficiently according to this tariff structure, the study is of the opinion that this weighted average electricity cost per hectare could decrease further. This is in line with the comments by Eskom representatives that farmers could save electricity when consumed wisely. More importantly it provides farmers with a way out of the announced increases in electricity tariffs.

3.3.1.2 The impact of Eskom's announcement that electricity tariffs will increase in the coming three years on the farmers in the Sandveld region.

One of the objectives of the study is to provide an indication about what the impact of Eskom's announcement that electricity tariff will increase in the coming three years (2010 to 2012) will be on the potato farmers in the Sandveld region. This analysis provides insight into the impact of potato production levels in the Sandveld region in terms of the increases in electricity tariffs. Figure 3.4 above showed the farmers total

electricity consumption in the 2010 year as well as electricity costs per hectare of potato production. As previously mentioned, Eskom announced that electricity tariffs will increase in the 2010 year by 24.8 percent, in the 2011 season by 25.8 percent and in the 2012 season by 25.9 percent (Njobeni, 2010). Figure 3.7 below depicts the increase in electricity costs per hectare per farmer in the Sandveld region from 2010 to 2012. The calculation was based on the percentage increase in electricity tariffs as announced by Eskom.

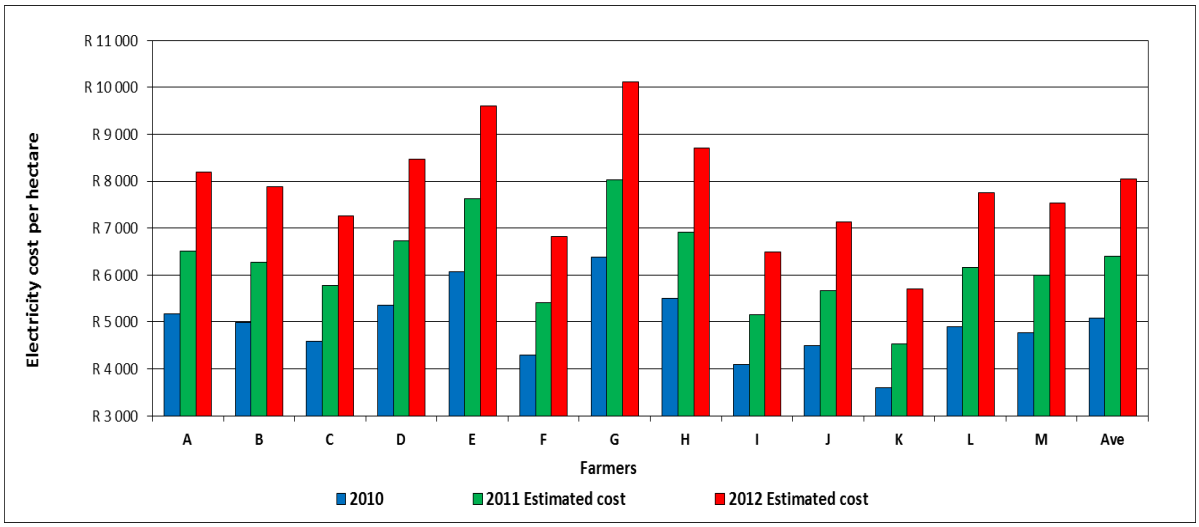


Figure 3.7: Increase in electricity cost per farmer from 2010 to 2012

Source: Own data calculations from collected Eskom electricity bills

Following the increase in electricity tariffs, the per hectare electricity costs for potato farmers will increase from the average of R5 080 to roughly R8 045 at the end of the 2012 year. Farmers E, G and H particularly will see the highest impact on electricity costs as electricity cost per hectare for these three farmers will be between R8 700 and R10 100 at the end of 2012. However, if these farmers make use of the Ruraflex electricity tariff structure, they will have greater flexibility on the tariff that they pay for electricity. Of the three farmers mentioned above, only farmer E makes use of Ruraflex with the other two farmers (G and H) make use of Landrate tariff structure.

Focusing on the seven farmers that consume electricity according to the Ruraflex tariff structure, it is important to understand the amount that these farmers can save if electricity is consumed more efficiently. Table 3.4 below shows the savings per

hectare per farmer on an annual basis from 2010 to 2012 if electricity is consumed more efficiently and according to Eskom's Ruraflex tariff structure.

Table 3.4: Electricity saving per farmer per year by consuming electricity more efficiently.

Farmer	A	B	C	D	E	J	L
2010	R 399	R 455	R 309	R 427	R 352	R 364	R 191
2011	R 502	R 573	R 388	R 537	R 443	R 458	R 240
2012	R 632	R 721	R 489	R 677	R 557	R 577	R 302

Source: Own data calculations from collected Eskom electricity bills

The table above displays the amount that the farmers could save per season based on the electricity consumption in the 2010 season. At the end of the 2012 season, farmers could save between R 302 to R 721 in electricity cost per hectare. On a 100 hectare farm this is equivalent to a total saving of between R30 200 and R72 100 per year. What makes this more interesting is that farmers could save these amounts on electricity by consuming the same amount of electricity. The only actual change is that farmers will be more efficient in terms of consuming electricity according to Eskom's Ruraflex tariff structure.

3.3.1.3 Conclusion on electricity usage in the Sandveld region

After a comprehensive analysis regarding electricity consumption in the Sandveld region, it was found that on average, potato farmers in the Sandveld region consumes approximately 6 900 kWh in a year. This is equal to an electricity account of R5 080 on average per hectare. The announced increase in electricity tariffs by Eskom will further pressure electricity costs of potato farmers with the average set to increase to approximately R8 045 at the end of the 2012 season. Farmers do not have control over these increases but the study found that the Sandveld farmers that use the Ruraflex electricity tariff structure could potentially limit their exposure to the increases in electricity tariffs. Seven Ruraflex farmers were analysed in the study, which led to the conclusion that these farmers, by consuming electricity during the off peak and standard periods, could save on electricity costs. The savings in elelctricity costs was calculated to be between R302 and R721 per hectare for the different farmers at the end of 2012.

Having completed a detailed study on the electricity consumption and costs of potato farmers in the Sandveld region, the focus of the study will shift to the potato farmers in the Limpopo province. The section that follows will therefore be dedicated to the Limpopo region.

3.3.2 Electricity consumption and costs in the Limpopo region

With a detailed analysis of electricity consumption and costs in the Sandveld region, the study shifts its focus to potato farmers in the Limpopo region. Limpopo is the largest potato producing region in South Africa with 92 active potato farmers in the 2010 season. These farmers range from managing 732 hectares of potato land to a mere 4 hectares (PSA, 2010b). With this region being one of the largest producers in the country it is inevitable that analysis on electricity consumption and costs be performed by the study.

In total the study collected data on electricity consumption and costs of seven potato farmers in the Limpopo region as these seven farmers were willing to participate in the study and provide accurate data. Again, as with the Sandveld region, the study made two distinctions in collecting the data. Firstly, the farmers were asked to indicate whether the collected data included or excluded household consumption for reasons mentioned in the previous section and secondly, the size and scale of farmers were identified in an effort to see whether the size of operations had any influence on the consumption and costs of electricity.

Of the seven farmers, five indicated that household consumption was included in the electricity bills with the remaining two farmers' electricity bill only focusing on irrigation pivots and pumps. In terms of the size and scale of operations, three farmers were classified in the small scale category with total production taking place on less than 50 hectares. Three farmers were classified in the medium scale category with total production taking place on more than 50 hectares but less than 100 hectares and one farmer was classified in the large scale category with production of potatoes taking place on more than 100 hectares, 141 hectares to be precise. With these delimitations in mind, the weighted average electricity cost and consumption per hectare for the seven farmers are shown in Figure 3.8 below.

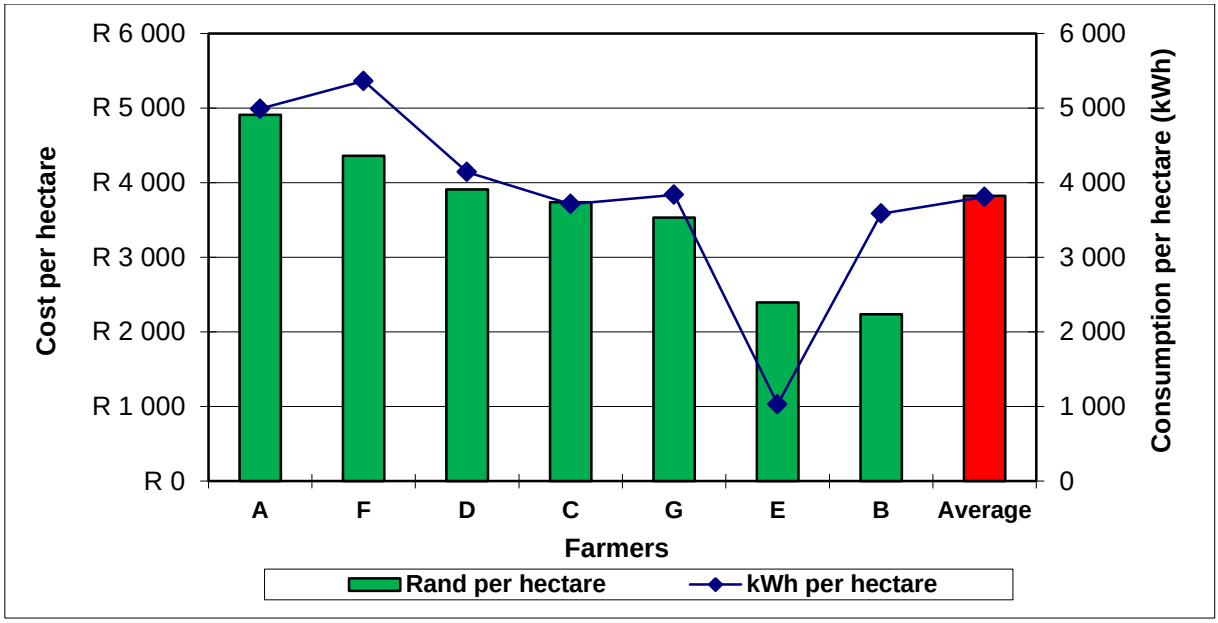


Figure 3.8: Electricity consumption and costs of potato farmers in the Limpopo region.

Source: Own data calculations from collected Eskom electricity bills

The weighted average electricity cost per hectare for farmers in the Limpopo region was calculated at R3 826 per hectare with the average consumption calculated at 3 809 kWh per hectare.

Again, as was the case in the Sandveld region, a high degree of differences from one farmer to another in terms of electricity consumption and costs were identified in the study. These differences ranged from slightly higher than R2 000 per hectare (Farmer B) to just below the R5 000 per hectare (Farmer A). The consumption (kWh) per hectare also showed a high level of discrepancy with farmer F consuming more than 5 000 kWh per hectare and Farmer E slightly higher than 1 000 kWh per hectare. Delving into possible reasons for this high level of discrepancies between farmers, the study again concluded that soil moisture and texture and frequency of rainfall on the different farms were possible reasons for this degree of difference.

Out of the seven farmers, four farmers' total electricity costs were either equal to or higher than the weighted average for the region. The remaining three farmers' total electricity costs were below the weighted average for the region. Of these four farmers that were higher than the weighted average for the region, one farmer was classified in the small scale category, two farmers in the medium scale category and

one in the large scale category. All four farmers' indicated that household consumption was included in the electricity bills collected. In terms of the three farmers below the weighted average for the region, two farmers were classified in the small scale category, with the remaining one farmer classified in the medium scale category. Both the small scale farmers indicated that household consumption was excluded from the electricity bills with the medium scale farmer indicating that household consumption was included.

It is therefore evident that the medium to larger scale farmers and farmers' electricity bills that include household consumption have on the average higher electricity costs than their smaller scale counterparts which excluded their household consumptions. However, the study again questioned the efficiency with which farmers consume electricity according to Eskom's tariff structure. The level of efficiency will be discussed in the next section.

3.3.2.1 Using Ruraflex tariff structure to farmers advantage

To illustrate the above, the study focused on two farmers (Farmer B and C) which consume electricity according to the Ruraflex tariff structure. Keep in mind that the other five farmers consumed electricity under the Landrate tariff structure, which therefore cannot form part of this analysis. Table 3.5 below shows the electricity costs per period under the Ruraflex tariff structure for these two farmers.

Table 3.5: Farmers electricity consumption under the Ruraflex tariff structure

Farmer	**B**	**C**
Off peak	29%	24%
Peak	**38%**	**43%**
Standard	33%	33%

Source: Own data calculations from collected Eskom electricity bills

The two farmers in the table above were analysed as a case study. What is more significant is that these farmers both consume roughly the same amount of electricity per hectare. Farmer B consumes 3 580 kWh, while farmer C consumes slightly more at 3 700 kWh per hectare. With the consumption of these two farmers roughly the

same, one would expect to see the cost per hectare to also be nearly the same. Yet, this is not the case as Farmer B's total electricity cost per hectare is equal to R2 239 per hectare, while farmer C's total electricity bills is equal to R3 737 per hectare. Although there is a number of reasons for the difference in electricity costs, one reason that the study found is that Farmer B is slightly more efficient in terms of consuming electricity costs according to Eskom's Ruraflex tariff structure. Of Farmer B's total ruraflex electricity bill, 38 percent is consumed during the peak periods, 33 percent in the standard period and 29 percent in the off peak period. Farmer C on the other hand is slightly more inefficient with 43 percent consumed in the peak period, 33 percent in the standard period and only 24 percent in the off peak period. As previously discussed, farmers should make an active attempt to move away from cosuming electricity during the peak periods and should consume more during the off peak and standard periods. By using this strategy, farmers could contribute towards saving electricity costs without consuming less electricity.

In an effort to understand the savings that these two farmers can generate by consuming electricity efficiently according to the Ruraflex tariff structure, the study again assumed that the farmers halve the amount of electricity consumption during the peak periods and transfer that halved amount to the standard and off peak periods in equal amounts. Table 3.6 below shows the change in electricity consumption per Ruraflex tariff period.

Table 3.6: Consuming electricity more efficiently

Farmer	B		C	
	Before	After	Before	After
Off peak	29%	36%	24%	32%
Peak	**38%**	**22%**	**43%**	**25%**
Standard	33%	42%	33%	43%

Source: Own data calculations from collected Eskom electricity bills

By using this strategy, the two farmers would drastically reduce consumption during the peak periods and channel this to the standard and off peak periods. The effect of this on their electricity cost per hectare is shown in Figure 3.9 below.

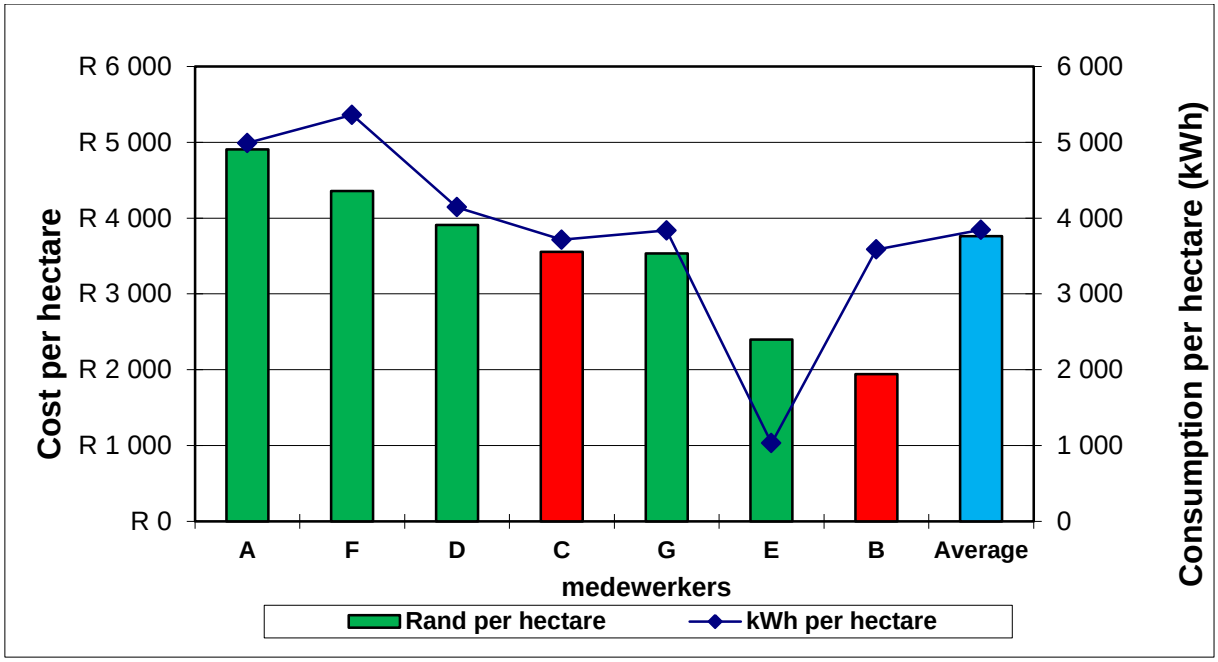


Figure 3.9: Reduced electricity costs per hectare for Farmer B and C due to more efficient electricity consumption

Source: Own data calculations from collected Eskom electricity bills

These two farmers, by consuming more electricity during the off peak and Standard periods, would contribute towards saving electricity costs of between R180 and R300 per hectare. Farmer B, by using this strategy, would lower its electricity cost per hectare from R2239 to R1940, saving roughly R298 per hectare per year. Farmer C's electricity cost would be reduced from R3737 to R3556, saving R182 per hectare. Furthermore, these two farmers together will manage to reduce weighted average electricity costs for the region from R3825 to R3760.

3.3.2.2 The impact of Eskom's announcement that electricity tariffs will increase in the coming three years on the farmers in the Limpopo region.

A serious threat for farmers is the announcement that electricity costs will increase for three consecutive years. With a detailed analysis of electricity costs per hectare for farmers in the Limpopo region in the previous section, Figure 3.10 below shows the expected increase in electricity costs per hectare for potato farmers in the Limpopo region from 2010 to 2012.

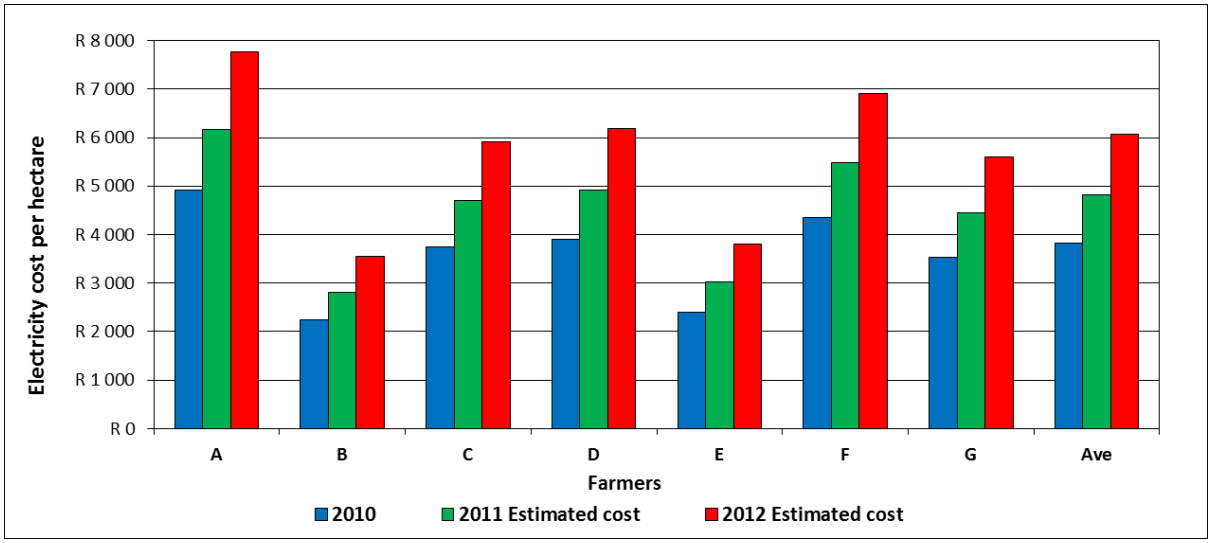


Figure 3.10: Increase in electricity cost per hectare for potato farmers in the Limpopo region from 2010 to 2012

Source: Own data calculations from collected Eskom electricity bills

From the figure above, farmers in the Limpopo region can expect to see average electricity costs per hectare to increase from R3 825 to R6 059, representing a 58 percent increase in electricity costs. Farmer A particularly will see electricity costs per hectare rising to R7 774 per hectare in 2012. Therefore, farmers will need to reduce electricity costs per hectare to counter the increase in electricity tariff rates.

3.3.2.3 Conclusion on electricity consumption and costs of potato farmers in the Limpopo region

Electricity consumption in the Limpopo region was found to be slightly lower than for the Sandveld region. However, the farmers again showed a high level of inefficiency in terms of consuming electricity according to the Ruraflex tariff structures. With the average electricity cost per hectare set to reach over R6 000 per hectare at the end of 2012, farmers will need to lower electricity costs. A possible way out of experiencing electricity increases to the deteriment of potato production is for farmers to consume electricity wisely and according to Eskom's tariff structure. The last region under study is the South Western Free State. The next section is dedicated to this region.

3.3.3 Electricity consumption and costs in the South Western Free State

Having analysed the farmers in the Sandveld and Limpopo region and seeing the high degree of difference between farmers and between regions, it was also important to analyse the potato farmers in the South Western Free State region. The study focused on the electricity usage and costs of these potato farmers in an effort to also identify the impact of the increase in electricity prices on the production of potatoes in this region. It was clear from the outset of the study that these farmers have a different electricity consumption pattern leading to different electricity costs per farmer.

According to PSA (2010b) a total of 31 farmers actively farmed with potatoes in the 2010 season in this region. In total the study collected the electricity consumption and costs of eight potato farmers in the South Western Free State region. As was the case with the previous two regions, an active attempt was made to exclude farmers that farm with other crops and commodities to ensure that the calculated electricity cost and consumption can directly be linked to potato farming.

Although delimitations were made to exclude farmers that also farm with other crops, the eight farmers interviewed differ from one another in terms of the size and scale of farming and the electricity consumption sources (household consumption) that were included or excluded in the collected electricity bills. In terms of the size and scale, farmers in the South Western Free State region on average farm on smaller hectares than the Sandveld and Limpopo regions, with the largest potato farmer in this region producing on 105 hectares and the smallest producing on less than 5 hectares. This compares to 340 hectares for the largest producer and 3 hectares for the smallest producer in the Sandveld region. The largest producer in the Limpopo region produces potatoes on 732 hectares of land and the smallest farmer on 4 hectares. This difference between this region and the Sandveld and Limpopo regions in terms of the size and scales of farmers lead to the eight studied potato farmers in this region being much smaller than the farmers in the Sandveld and Limpopo regions. The size and scale of farming of the eight farmers ranged from 12 to 47 hectares per farmer. In terms of difference in electricity consumption sources, farmers were asked to indicate whether the collected electricity bill included or excluded household

consumption. As previously mentioned, taking active steps to exclude household consumption from the calculation was time consuming and due to the relatively small impact of household consumption on the final electricity cost and consumption calculation was deemed unnecessary. The study therefore made the effort to identify which farmers included and which farmers excluded household consumption in the electricity bills that were collected. Out of the eight farmers, only three farmers indicated that the electricity bills collected included household consumption. The remaining five farmers' collected electricity bills therefore excluded household consumption and only focussed on potato production. Figure 3.11 below shows the electricity usage and costs of the eight farmers in the South Western Free State for the 2010 year.

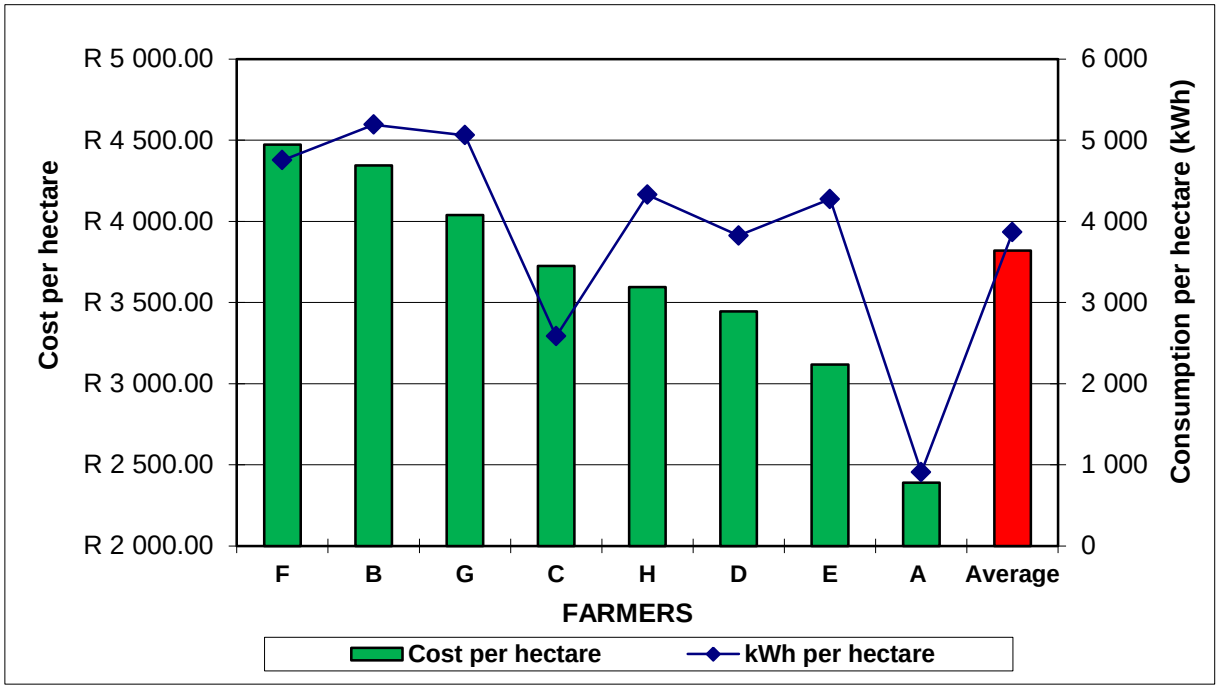


Figure 3.11: Electricity usage and costs of potato farmers in the South Western Free State region

Source: Own data calculations from collected Eskom electricity bills

The weighted average electricity costs per farmer for the eight farmers were calculated at R3 641, with the average consumption calculated at 3 865 kWh. Of the eight farmers, five were below the weighted average and three farmers above the average for the region. As mentioned, a distinction was made between the size and scale of farmers and the electricity consumption sources included in the electricity bills. Of the five farmers below the average, three produced in the smaller scale class

of the eight with the other two producing at the medium scale class. Of the three farmers above the average, two produced at a small scale level with the remaining one farmer classified as a medium scale farmer. It was also interesting to note that of the five farmers below the average, four excluded household consumption from their electricity bills with the remaining one including household consumption. As far as the three farmers above the average are concerned, two farmers included household consumption while the remaining one farmer excluded household consumption.

From the analysis above no clear indication could be derived in terms of the true effect that the size and scale of operation and whether household consumption was included or excluded in the electricity bills would have on the weighted average electricity costs as calculated in the study.

An analysis of Figure 3.11 above, shows that the farmers again had a high degree of discrepancies when compared to one another in terms of electricity consumption and costs. Electricity costs per hectare ranged from R2 390 to R4 471 per hectare whereas the consumption per hectare ranged from 909 kWh to 5 190 kWh per hectare. There were again a vast number of reasons that supported the high level of discrepancy between farmers. The difference in soil moisture and texture, irrigation scheduling and techniques and precipitation received are three possible reasons for this. One farmer (Farmer A), for example, indicated that he only irrigated at night and that he received more than adequate precipitation over the growing season leading to very little irrigation. Hence, this farmer was one of the lowest electricity users and therefore had the lowest cost per hectare as can be seen Figure 3.11 above. With some reasons given for the difference between farmers' electricity cost and consumption, questions were again raised. Do farmers efficiently use electricity according to the Ruraflex tariff structure and could this be a possible reason for the high level of discrepancies between the electricity costs per hectare of the eight potato farmers?

3.3.3.1 Using Ruraflex tariff structure to farmers advantage

As previously mentioned, farmers, by consuming electricity according the Ruraflex tariff structures, could save on electricity costs. Although this again was the case in

the South Western Free State region, only two farmers out of the eight farmers consumed electricity according to the Ruraflex tariff structure. The remaining six farmers make use of the Landrate tariff structure and therefore are excluded for this analysis. The two farmers under analysis are Farmer C and Farmer E. Both these two farmers were below the weighted average for the region. Farmer C's electricity cost per hectare is R3 724 per hectare while Farmer E's electricity cost per hectare is equal to R3 118. It is interesting to note that Farmer C (which electricity cost per hectare is higher that Farmer E) uses less electricity than Farmer E. Farmer C's electricity consumption per hectare is equal to 2 582 kWh whereas Farmer E's electricity consumption is equal to 4 272 kWh. One possible reason for this is the manner in which these two farmers differ in terms of consuming electricity efficiently according to the Ruraflex tariff structure. Farmer E was particularly efficient in terms of consuming electricity during the correct periods of the day, while farmer C was not as efficient. Table 3.7 below shows the differences in electricity consumption according to the Ruraflex tariff structure between the two farmers.

Table 3.7: Farmers electricity consumption under the Ruraflex tariff structure

Farmer	**C**	**E**
Off peak	24%	34%
Peak	**38%**	**24%**
Standard	38%	42%

Source: Own data calculations from collected Eskom electricity bills

The majority of the cost of electricity consumed by Farmer C was in the peak and standard periods, while only 24 percent was consumed during the off peak periods. Farmer E on the other hand consumed more electricity during the standard periods with the least electricity consumed during the peak periods making Farmer E more efficient. Again it was clear that when farmers use the Ruraflex tariff structure to their advantage, electricity costs could be saved without consuming less electricity. Farmer E for example has an above average electricity consumption but has an average electricity cost per hectare of R522 less than the average. Therefore, apart from the reasons stated above, by consuming electricity according to the Ruraflex time periods, Farmer E contributed towards saving electricity costs. Therefore, the study again recognised that when farmers consume electricity in accordance with the

Ruraflex tariff structure, especially when consuming in an efficient manner, farmers saved on electricity costs. To some extent, this provides farmers a way out of the increases in electricity tariffs.

3.3.3.2 The impact of Eskom's announcement that electricity tariffs will increase in the coming three years on the farmers in the South Western Free State region

With the electricity costs for the farmers in the South Western Free State calculated, it is important to analyse these electricity costs of farmers over a three year period in which Eskom announced that electricity tariffs will increase on an annual basis. As mentioned, the weighted average electricity costs for the region were calculated at R3 819 per hectare for the year 2010. This weighted average, over the coming three years, will inevitably increase on a per year basis due to the increase in electricity tariffs as created by Eskom. Figure 3.12 below depicts the expected increase in electricity costs per hectare per farmer for the South Western Free State farmers from 2010 to 2012

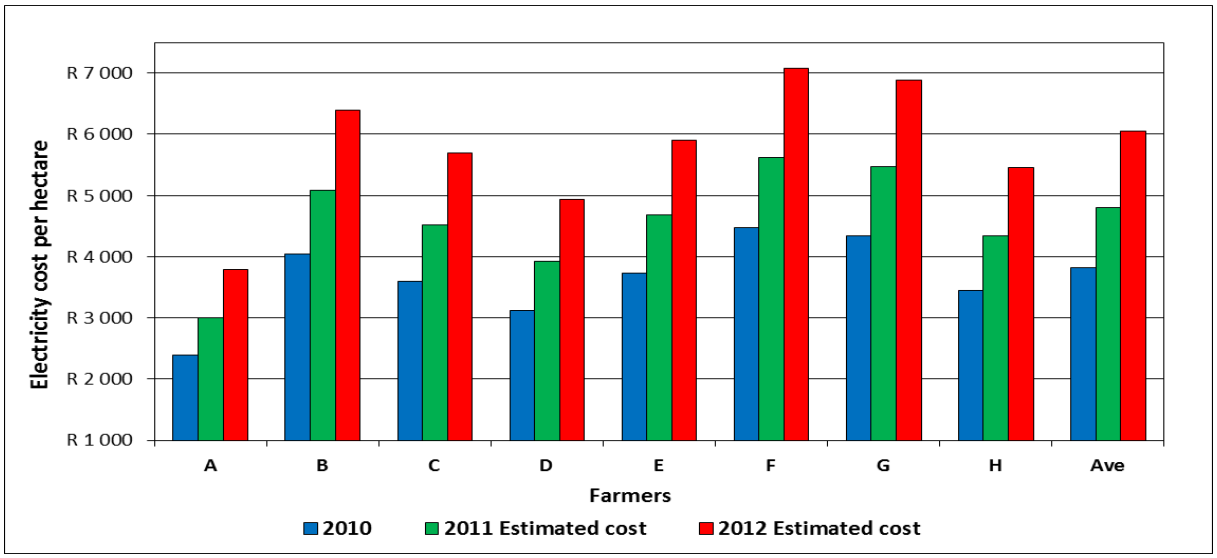


Figure 3.12: Increase in electricity cost per hectare per farmer in the South Western Free State from 2010 to 2012
Source: Own data calculations from collected Eskom electricity bills

Following Figure 3.12 above, potato farmers in the South Western Free State will see an increase in electricity costs on average from R3 819 to R6 049 in 2012. Of the eight farmers, farmers F and G particularly will see large increase in electricity costs,

with an average electricity cost per hectare at the end of 2012 near R7 000 per hectare.

3.3.3.3 Conclusion on electricity consumption and costs of potato farmers in the South Western Free State region

To conclude, electricity costs in the South Western Free State will, as was the case with the other two regions, see electricity cost increase exponentially between the 2010 and 2012 periods. It was again found that farmers, by consuming electricity according to Eskom's Ruraflex tariff structure, could save on electricity costs. With this in mind, the weighted average electricity costs per potato farmer in the South Western Free State region was calculated at R3 819 with consumption equal to 3 865 kWh. This weighted average electricity costs is set to increase over the next three years and will be equivalent to approximately R6 049 at the end of 2012 if the same amount of electricity is consumed.

3.4 SUMMARY

The main purpose of this chapter was to identify the electricity costs and consumption of potato farmers in the Sandveld, Limpopo and South Western Free State regions. A total of 28 farmers' electricity information was collected to identify and calculate the electricity cost and consumption of potato farmers in the three regions.

The results obtained from the three regions differed from one region to the other and from one farmer to the other. It was clear that these differences stem from the fact that farmers have different irrigation scheduling techniques, that the soil moisture and textures from farms differ and that some farmers received more precipitation over the growing season of potato farming than the other farmers.

Table 3.8 below summarises the weighted average electricity cost per hectare and the average electricity consumption per hectare of farmers in the three regions.

Table 3.8: Weighted Average electricity cost per hectare and consumption per hectares of farmers in the three regions

Region	Average electricity cost per hectare	Average electricity consumption per hectare
Sandveld	R5 080.00	6862 kWh
Limpopo	R3 826.00	3809 kWh
South Western Free State	R3 641.00	3865 kWh

Farmers in the Sandveld region were found to have the highest electricity cost per hectare than the other two regions. These farmers also consumed the most electricity per hectare which supports this high electricity cost per hectare for the region. It must be noted that farms in the Sandveld region has a sandy soil texture, they have a much windier environment and that precipitation over the growing period is far less than the other two regions. These are reasons for the high electricity cost and consumption per hectare for the Sandveld region. The other two regions were found to be much the same in terms of electricity consumption and cost with Limpopo region edging the South Western Free State in the weighted average cost per hectare, even though Limpopo consumes slightly less than the South Western Free State.

While performing the analysis, the study also concluded that farmers were inefficient in terms of consuming electricity according to the Ruraflex tariff structure. Case studies were performed in the three regions that indicated this high level of inefficiency. With this in mind and the fact that electricity costs per hectare are set to increase over the 2010 to 2012 period, this chapter concludes that farmers do have a way out in terms of the increase in electricity tariffs. The solutions lies in farmers' abilities to consume electricity efficiently according to the Ruraflex tariff structure as created by Eskom.

CHAPTER 4

THE IMPACT OF ELECTRICITY PRICE INCREASES ON POTATO SUPPLY AND PRICES IN SOUTH AFRICA

4.1 INTRODUCTION

With a detailed analysis of electricity costs and usage calculated and defined in the preceding chapter, an important answer to one of the main questions and objectives to the study can be concluded in Chapter 4. From the inception of the study it was important to determine and define the true impact that the announced increase in electricity prices would have on potato production in South Africa with reference to the production areas of the Sandveld, Limpopo and South Western Free State regions. Chapter 4 therefore concentrates on this true impact and seeks to quantify this impact by using a supply response model developed by the Bureau of Food and Agricultural Policy (BFAP). Due to the nature of the study, the BFAP model has received some alterations and refinement to enable the model to perform electricity price supply response modelling. This refinement is addressed in the first section of this chapter. The second section of this chapter focuses on estimating the electricity price shock on potato production and prices due to the increased electricity prices. Chapter 4 concludes by providing an indication about what the price and supply response will be of potato farmers with improved farming practices. This will in some manner quantify the role that farmers can play in reducing the impact of electricity tariff hikes on potato prices and supply.

4.2 REFINING THE BFAP POTATO SUPPLY RESPONSE MODEL BY INTRODUCING DETAIL PRODUCTION COSTS

4.2.1 Introducing the BFAP supply response model

The BFAP modelling approach plays an integral part to the success of this study as it equips the researcher with vital modelling techniques that enables accurate study results. It is therefore important to introduce the BFAP model to form an idea regarding how the model is structured, what results can be obtained from the model

and more importantly what the delimitations of the model are in terms of modelling techniques.

In the literature that was reviewed in Chapter 2 of this study, a comprehensive overview of possible modelling techniques was introduced. Given this researched literature, the modelling technique that best suited the study is a partial equilibrium modelling technique. For this reason the BFAP supply response model, which uses a partial equilibrium technique, is used in this study to determine the necessary supply and demand responses to changes in the price of electricity. In a study by Mhlabane (2011), the partial equilibrium regional potato BFAP model was introduced with the main objective "…to develop a system of equations that have the ability to simulate the dynamic interaction between production and consumption on a regional level for potato producers…". The model more importantly has the ability to simulate external shocks on both a regional and national potato industry level (Mhlabane, 2011).

The model consists of three behavioural equations, namely a production equation, a consumption equation and an implicit price equation. Together, these three equations work interchangeably which result in the cobweb phenomenon whereby a change in either supply and or demand results in a corresponding change in the commodity price and vice versa. Total supply consists of total production and imports. Total demand consists of potato consumption and exports and lastly, the price equation provides the interrelationship between regional and seed potato prices (Mhlabane, 2011).

Due to the significance of the supply and demand equations to this study, it is important to address these equations as it currently is being used by the BFAP model. The supply equation in the BFAP model consists of production and imports. The production equation in turn is a function of the area planted and the yield. The area planted is determined by the lagged potato area harvested, potato prices, input factors, price of substitutes and/or complements and the weather. The yield is a function of cultivars utilised and the rainfall experienced (Mhlabane, 2011).

Mathematically, the production equation can be written as follows (Mhlabane, 2011):

Equation 4.1: The potato area harvested equation

$$PAHR = f(PAHR_{t-1,} P_{p,t}/P_{i,t}, P_s, Rain)$$

Where:

PAHR is the potato area harvested
$PAHR_{t-1}$ is the area harvested during the previous period
P_{pt} is the potato producer price (R/t)
P_{it} is the price of the cost of inputs (R/ha) which is denoted by fertiliser prices
P_s is the price of complements or substitutes (R/t)
Rain is the rainfall per annum

The potato yield equation mathematically looks as follows (Mhlabane, 2011).

Equation 4.2: The potato yield equation

$$PYLDR = f(C, Rain)$$

Where:

PYLDR is the potato yield on a regional level
C is the cultivars used
Rain is the rainfall per annum

These two equations together form the potato production equation in the model. Mathematically it is illustrated as follows (Mhlabane, 2011):

Equation 4.3: Potato production equation

$$PPRODR_t = PAHR \times PYLDR$$

Where:

$PPRODR_t$ is the potato production per region

The demand equations in turn consist mainly of local consumption and exports. The consumption function in the BFAP model is a function of consumer prices, the price of substitutes and/or complements and household income. It is important to note that unlike the production equation which focuses on a regional level and then aggregates these regional equations into a national equation, the demand equation only focuses on a national level (Mhlabane, 2011).

Mathematically, the potato consumption equation can be written as follows:

Equation 4.4: Potato per capita consumption equation

$$PPCC = f(Ppt, Pst, INC)$$

Where:

PPCC is the per capita consumption of potatoes
Ppt is the consumer price
Pst is the price of complements and/or substitutes
INC is the disposable household income

The model further focuses on four consumption types which are the fresh formal consumption, fresh informal consumption, potatoes for processing and the seed potato consumption. The aggregate consumption in the model is the sum of all four consumption types. The demand function for fresh formal consumption can be written as follows (Mhlabane, 2011):

Equation 4.5: Fresh formal potato consumption

$$FFPOTCONS = f(Ppt, Pst, TREND, PCGDP)$$

Where:

FFPOTCONS is the fresh formal potato consumption
TREND is the consumption pattern change over time
PCGDP is the per capita Gross Domestic Product

With both the supply and demand equations as used in the BFAP model briefly introduced in the preceding section, focus can shift to introducing the production costs to the BFAP model. It must further be noted that this section was a brief explanation on the BFAP model and serves as only an introduction to the BFAP model. Should anymore explanation be needed on the complexities of BFAP model, the Mhlabane 2011 study should be reverted to.

4.2.2 Introducing production costs to the BFAP supply response model

It is evident from the preceding section that the BFAP supply response model was not equipped to perform electricity price shocks as the model only made use of a fertilizer/price ratio to represent production costs to the model. In order to perform electricity price shocks, the BFAP model needed to be altered to incorporate potato production costs to the model. This altered model enabled the researcher to perform electricity price shocks to the model which answered questions about whether production would decrease and / or increase as a result of the increased electricity tariffs. More importantly, by incorporating potato production costs to the BFAP supply response model, future study on changes in production costs of potato farmers can more easily be done as the main framework to the model will be constructed in this section. However, before any alterations to the model can be made, it is first important to determine the production cost of potato farmers in the three regions under study.

4.2.2.1 Determining potato production cost per region

The study collected production costs data for the three regions for the 2010 production season. This data was made available by Potatoes South Africa (PSA) which collected the data from the same group of farmer study groups used in collecting the electricity cost and usage data. However, as with any supply response modelling technique it is important to collect data over a time series basis. That meant that data regarding production since 1997 needed to be collected in order for an accurate supply response model to be developed. With no availability of production costs data before 2010 from any of the important agricultural institutions (Potatoes South Africa or Abstract of Agricultural Statistics) it was clear that collecting potato production cost data would be time consuming. The study therefore needed to make use of a different technique in collecting the data.

The researcher made use of calculating the production cost per year by making use of indexes to capture a trend for a specific cost element over a period. The collected production costs data for the 2010 production season was used as a base year. From this base year production costs for the preceding seasons were calculated by using important indexes that best represented a specific production cost in the overall production cost structure. By identifying these important production costs indexes, production costs for the period between 1997 and 2009 can more accurately be determined and calculated. This technique of extrapolating the data before 2010 by using the 2010 production season as a base year was the best technique available to the researcher and more importantly represented a technique that is limited in terms of consuming time but unlimited in attracting more accurate data. The first step in this technique was to identify the production costs of potato farmers for the three regions for the base year 2010. Table 4.1 below shows the production cost per hectare for potato farmers in the Sandveld region for the 2010 production season.

Table 4.1: Total production costs of potato farmers in the Sandveld region for the 2010 production season

RAND TERMS	2010
Potato seed costs	R 14 500.00
Fertilizer	R 21 077.00
Herbicides	R 540.00
Pesticides	R 9 981.00
Contractors (including transport to and from farm)	R 2 030.00
Seasonal labour	R 2 043.00
Fuel & Diesel	R 1 972.00
Repair & Maintenance	R 3 008.00
Irrigation (Electricity)	R 5 080.00
Labour	R 3 420.00
Admin & other fixed costs	R 2 739.00
Interest on production credit	R 2 215.00
General provisions	R 3 559.00
TOTAL PRODUCTION COST PER HECTARE	**R 72 164.00**

Source: PSA (2010c)

As the table above indicates, the total production costs for potato farmers in the 2010 production season was estimated and calculated by Potatoes South Africa to be R72 164 per hectare. The major contributors to the total production costs were seed costs (R14 500) and fertilizer costs (R21 077). A cost that is of particular importance to this study is irrigation costs which represented R5 080 per hectare. For the purpose of this study it will be important to see the tendency with which electricity costs increases over the years. More insight into this will be discussed later in this section.

Shifting focus to the production costs of potato farmers in the Limpopo region, Table 4.2 below indicates that the production costs in the Limpopo region is almost the same as farmers in the Sandveld region.

Table 4.2: Total production costs of potato farmers in the Limpopo region for the 2010 production season

RAND TERMS	**2010**
Potato seed costs	R 23 950.00
Fertilizers	R 13 613.00
Herbicides	R 245.00
Pesticides	R 5 175.00
Contractors (including transport to and from farm)	R 1 900.00
Seasonal labourers	R 4 680.00
Fuel & Diesel	R 2 472.00
Repair & Maintenance	R 2 982.00
Irrigation *(Electricity)*	R 3 826.00
Salaries	R 5 606.00
Admin & other fixed costs	R 3 032.00
Interest on production credit	R 2 334.00
General provisions	R 3 567.00
TOTAL PRODUCTION COST PER HECTARE	**R 73 382.00**

Source: PSA (2010c)

Total production costs per hectare were calculated to be R73 382 by Potatoes South Africa. Again seed (R23 950) and fertilizer costs (R13 613) stood out as the major contributors to the total production costs per hectare. Electricity costs in this region was, as discussed in Chapter 3, calculated to be lower than for the farmers in the Sandveld region. Electricity costs were calculated to be R3 826 per hectare.

Analysing the third region, the South Western Free State, it was interesting to note the differences in total production costs of the preceding two regions to this region. Table 4.3 below shows the total production costs for the South Western Free State region for the 2010 season.

Table 4.3: Total production costs of potato farmers in the South Western Free State region for the 2010 production season

RAND TERMS	2010
Potato seed costs	R 16 315.00
Fertilizers	R 10 050.00
Herbicides	R 144.00
Pesticides	R 6 958.00
Contractors (including transport to and from farm)	R 585.00
Seasonal labourers	R 4 093.00
Fuel & Diesel	R 1 752.00
Repair & Maintenance	R 2 450.00
Irrigation *(Electricity)*	R 3 641.00
Salaries	R 2 010.00
Admin & other fixed costs	R 2 682.00
Interests on production credit	R 1 860.00
General provisions	R 3 130.00
TOTAL PRODUCTION COST PER HECTARE	**R 55 670.00**

Source: PSA (2010c)

Total production costs in the South Western Free State were calculated to be much lower than the preceding two regions. Total costs were calculated by Potatoes South Africa to be around R55 670 per hectare. It was clear that seed and fertilizer costs were much lower but still represented the largest share in production costs for the region. Electricity costs were calculated to be slightly lower than the Limpopo region, at R3 641 per hectare.

With the production costs for the year 2010 for all three regions determined and defined, focus can shift to the indices and the manner in which these indices could extrapolate production costs for the 12 production seasons preceding the base year 2010. Firstly, it is important to identify the correct indices for a specific production cost element. The identified indices should have a strong correlation with the specific production cost element. The section that follows introduces each production cost element and the specific indices used to extrapolate the data to the 1997 production season. From the outset, it must be noted that an assumption was made that the quantity for each specific cost element was constant during the period between 1997 and 2010.

The first production cost element to the overall production costs structure was the potato seed prices. Data on seed prices for the three regions were collected by PSA from the year 1997 onwards. The precise movement in seed prices and exact costs per year were therefore ready to be used. This time series was used for seed prices and the data incorporated into the overall production cost model.

Data on fertilizer costs for potatoes were not readily available and it was therefore decided to revert to using fertilizer data that is already being used by the BFAP model. However, it must be noted that the fertilizer data needed to be altered to incorporate the correct NPK usage by potato farmers. Data on this was made available by PSA for each region. This method by using the correct NPK usage with data on NPK costs resulted in accurate data on fertilizer costs during the period between 1997 and 2010.

Herbicides and pesticides data since 1997 were also not readily available. The researcher therefore made use of the oil price index to extrapolate the data on herbicides and pesticides from the base year 2010 to the year 1997. According to the FAO (2001), there is a strong relationship between the movement in the price of oil and the corresponding prices of herbicides and pesticides. An oil price index was calculated from data collected from Indexmundi (2010) on oil prices. This index was in turn used to extrapolate data from the 2010 year to 1997.

Diesel costs for potato farmers were extrapolated by making use of a calculated fuel price index. Data on diesel prices were collected from the DoE (2010) which were transformed into a diesel price index. This index in turn was used to calculate diesel costs for the period between 1997 and 2010 from the base year 2010.

Data on the interest on production credit of potato were also not available. To calculate data on this cost element, the researcher made use of an interest rate index calculated from data made available by the SARB (2012). Interest costs by potato farmers have a strong correlation to the interest rates for the specific year. If the interest rate for a specific year is high, farmers will have to pay more for credit and vice versa.

For the rest of the production costs elements, the general inflation index was used to calculate data on the specific cost element to the year 1997. These cost elements included contractor fees, seasonal labour, salaries, admin costs and provision for general expenses. The researcher was of the opinion that the general inflation rate served as a sound guideline to the above mentioned cost elements.

With the indices and method of extrapolating data from the base year 2010 explained, the tables below display the changes in the production cost elements since the year 1997 to the base year 2010 for all three regions.

Table 4.4: Production costs in the Sandveld region, 1997 to 2010

RAND TERMS	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Seed costs	R 4 282	R 4 508	R 4 777	R 5 041	R 6 057	R 8 090	R 8 937	R 8 904	R 9 544	R 9 500	R 10 602	R 12 592	R 14 500	R 14 500
Fertilizer costs	R 5 667	R 5 847	R 6 205	R 7 309	R 8 718	R 10 565	R 9 597	R 9 260	R 10 944	R 12 322	R 15 294	R 36 549	R 27 814	R 21 077
Herbicides	R 132	R 89	R 123	R 193	R 166	R 170	R 197	R 258	R 365	R 439	R 486	R 663	R 422	R 540
Pesticides	R 2 433	R 1 651	R 2 271	R 3 566	R 3 073	R 3 151	R 3 649	R 4 769	R 6 738	R 8 117	R 8 983	R 12 255	R 7 802	R 9 981
Contractor	R 957	R 1 022	R 1 076	R 1 134	R 1 199	R 1 308	R 1 387	R 1 406	R 1 454	R 1 521	R 1 629	R 1 817	R 1 946	R 2 030
Seasonal labour	R 963	R 1 029	R 1 083	R 1 142	R 1 207	R 1 317	R 1 396	R 1 415	R 1 463	R 1 531	R 1 639	R 1 828	R 1 959	R 2 043
Diesel costs	R 528	R 498	R 618	R 775	R 894	R 951	R 952	R 1 033	R 1 073	R 1 164	R 1 341	R 1 996	R 1 895	R 1 972
Repair	R 1 418	R 1 515	R 1 595	R 1 681	R 1 776	R 1 939	R 2 055	R 2 083	R 2 154	R 2 254	R 2 414	R 2 692	R 2 884	R 3 008
Irrigation	R 1 460	R 1 533	R 1 602	R 1 690	R 1 778	R 1 888	R 2 047	R 2 099	R 2 185	R 2 296	R 2 431	R 3 100	R 4 071	R 5 080
Salaries	R 1 612	R 1 723	R 1 814	R 1 911	R 2 020	R 2 204	R 2 336	R 2 368	R 2 449	R 2 563	R 2 744	R 3 060	R 3 279	R 3 420
Admin costs	R 1 291	R 1 380	R 1 452	R 1 530	R 1 618	R 1 765	R 1 871	R 1 897	R 1 961	R 2 052	R 2 198	R 2 451	R 2 626	R 2 739
Interests	R 4 488	R 5 283	R 4 357	R 3 381	R 3 128	R 3 614	R 3 124	R 2 565	R 2 448	R 2 740	R 3 148	R 3 556	R 2 821	R 2 215
Provisions	R 1 678	R 1 793	R 1 887	R 1 989	R 2 102	R 2 294	R 2 431	R 2 465	R 2 548	R 2 667	R 2 856	R 3 185	R 3 412	R 3 559
TOTAL COSTS	**R 26 910**	**R 27 870**	**R 28 861**	**R 31 340**	**R 33 735**	**R 39 257**	**R 39 979**	**R 40 522**	**R 45 325**	**R 49 165**	**R 55 764**	**R 85 743**	**R 75 431**	**R 72 164**

Source: Own data calculations[2]

[2] Please note that the data for the period 1997 to 2009 as presented above was extrapolated from the base year 2010 by using key economic indices as explained in the section 4.2.2.1

Table 4.5: Production costs in the South Western Free State region, 1997 to 2010

RAND TERMS	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Seed costs	R 4 818	R 5 072	R 5 375	R 5 672	R 6 815	R 9 103	R 10 056	R 10 019	R 10 739	R 10 689	R 11 929	R 14 168	R 16 315	R 16 315
Fertilizer costs	R 2 932	R 2 962	R 3 112	R 3 580	R 4 285	R 5 167	R 4 800	R 4 721	R 5 521	R 6 208	R 7 948	R 18 151	R 11 852	R 10 050
Herbicides	R 35	R 24	R 33	R 51	R 44	R 45	R 53	R 69	R 97	R 117	R 130	R 177	R 113	R 144
Pesticides	R 1 696	R 1 151	R 1 583	R 2 486	R 2 142	R 2 197	R 2 544	R 3 324	R 4 697	R 5 659	R 6 262	R 8 543	R 5 439	R 6 958
Contractor	R 276	R 295	R 310	R 327	R 345	R 377	R 400	R 405	R 419	R 438	R 469	R 524	R 561	R 585
Seasonal labour	R 1 930	R 2 062	R 2 170	R 2 287	R 2 417	R 2 638	R 2 796	R 2 835	R 2 931	R 3 067	R 3 284	R 3 663	R 3 924	R 4 093
Diesel costs	R 469	R 442	R 549	R 688	R 794	R 845	R 845	R 918	R 953	R 1 034	R 1 192	R 1 773	R 1 683	R 1 752
Repair	R 1 155	R 1 234	R 1 299	R 1 369	R 1 447	R 1 579	R 1 674	R 1 697	R 1 754	R 1 836	R 1 966	R 2 192	R 2 349	R 2 450
Irrigation	R 1 046	R 1 099	R 1 148	R 1 211	R 1 274	R 1 353	R 1 467	R 1 504	R 1 566	R 1 646	R 1 743	R 2 222	R 2 917	R 3 641
Salaries	R 948	R 1 012	R 1 066	R 1 123	R 1 187	R 1 295	R 1 373	R 1 392	R 1 439	R 1 506	R 1 613	R 1 799	R 1 927	R 2 010
Admin costs	R 1 264	R 1 351	R 1 422	R 1 499	R 1 584	R 1 729	R 1 832	R 1 857	R 1 920	R 2 010	R 2 152	R 2 400	R 2 571	R 2 682
Interests	R 3 769	R 4 436	R 3 659	R 2 839	R 2 627	R 3 035	R 2 624	R 2 154	R 2 056	R 2 301	R 2 643	R 2 986	R 2 369	R 1 860
Provisions	R 1 476	R 1 576	R 1 660	R 1 749	R 1 849	R 2 017	R 2 138	R 2 168	R 2 241	R 2 345	R 2 511	R 2 801	R 3 001	R 3 130
TOTAL COSTS	**R 21 814**	**R 22 716**	**R 23 387**	**R 24 880**	**R 26 811**	**R 31 380**	**R 32 601**	**R 33 062**	**R 36 334**	**R 38 856**	**R 43 842**	**R 61 398**	**R 55 021**	**R 55 670**

Source: Own data calculations[3]

[3] Please note that the data for the period 1997 to 2009 as presented above was extrapolated from the base year 2010 by using key economic indices as explained in the section 4.2.2.1

Table 4.6: Production costs in the Limpopo region, 1997 to 2010

RAND TERMS	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Seed costs	R 7 073	R 7 446	R 7 891	R 8 326	R 10 004	R 13 363	R 14 762	R 14 708	R 15 764	R 15 692	R 17 512	R 20 798	R 23 950	R 23 950
Fertilizer costs	R 3 863	R 3 922	R 4 130	R 4 808	R 5 746	R 6 936	R 6 395	R 6 255	R 7 346	R 8 261	R 10 444	R 24 177	R 16 791	R 13 613
Herbicides	R 60	R 41	R 56	R 88	R 75	R 77	R 90	R 117	R 165	R 199	R 220	R 301	R 192	R 245
Pesticides	R 1 262	R 856	R 1 177	R 1 849	R 1 593	R 1 634	R 1 892	R 2 473	R 3 494	R 4 209	R 4 657	R 6 354	R 4 045	R 5 175
Contractor	R 896	R 957	R 1 008	R 1 062	R 1 122	R 1 225	R 1 298	R 1 316	R 1 360	R 1 424	R 1 524	R 1 700	R 1 822	R 1 900
Seasonal labour	R 2 206	R 2 357	R 2 482	R 2 615	R 2 764	R 3 016	R 3 197	R 3 241	R 3 351	R 3 507	R 3 755	R 4 188	R 4 487	R 4 680
Diesel costs	R 662	R 624	R 775	R 971	R 1 120	R 1 192	R 1 193	R 1 295	R 1 345	R 1 459	R 1 681	R 2 502	R 2 375	R 2 472
Repair	R 1 406	R 1 502	R 1 581	R 1 666	R 1 761	R 1 922	R 2 037	R 2 065	R 2 135	R 2 234	R 2 393	R 2 669	R 2 859	R 2 982
Irrigation	R 1 100	R 1 155	R 1 207	R 1 273	R 1 339	R 1 422	R 1 542	R 1 581	R 1 645	R 1 729	R 1 831	R 2 335	R 3 066	R 3 826
Salaries	R 2 643	R 2 824	R 2 973	R 3 132	R 3 311	R 3 613	R 3 830	R 3 882	R 4 014	R 4 201	R 4 498	R 5 017	R 5 375	R 5 606
Admin costs	R 1 429	R 1 527	R 1 608	R 1 694	R 1 791	R 1 954	R 2 071	R 2 100	R 2 171	R 2 272	R 2 433	R 2 713	R 2 907	R 3 032
Interests	R 4 730	R 5 566	R 4 591	R 3 563	R 3 296	R 3 808	R 3 292	R 2 703	R 2 580	R 2 887	R 3 317	R 3 747	R 2 973	R 2 334
Provisions	R 1 682	R 1 797	R 1 891	R 1 993	R 2 107	R 2 299	R 2 437	R 2 470	R 2 554	R 2 673	R 2 862	R 3 192	R 3 420	R 3 567
TOTAL COSTS	**R 29 011**	**R 30 574**	**R 31 369**	**R 33 038**	**R 36 030**	**R 42 461**	**R 44 035**	**R 44 205**	**R 47 925**	**R 50 746**	**R 57 128**	**R 79 692**	**R 74 261**	**R 73 382**

Source: Own data calculations[4]

[4] Please note that the data for the period 1997 to 2009 as presented above was extrapolated from the base year 2010 by using key economic indices as explained in the section 4.2.2.1

Table 4.4, Table 4.5 and Table 4.6 above depicts the production cost per year from 1997 to 2010 for the three regions under study. The tables display that production costs for potato farmers in the three regions have increased year on year. The Sandveld region experienced a total increase in production of 168.17 percent from 1997 to 2010 which equates to 7.3 percent per year increase in the total production cost. However, it is worth noting that this increase of 168.17 percent is not strictly comparable to the 141.8 percent increase in production costs as calculated and reported by the NAMC (2009) for the period 1997 to 2008. Possible reasons for this difference in production cost increases between the two studies include amongst other differences in the periods of comparison and differences in the components included and excluded in the production costs of the two studies.

The Limpopo region also experienced high increases in production costs with a total increase equal to 152.95 percent over the period. On a year to year basis production costs for this region increased by 6.85 percent. This same increase in production costs were seen in the South Western Free State region. This region experienced a total increase in production costs equivalent to 155 percent over the period which equates to 6.92 percent increase per year.

The major contributors to total production costs for all three regions were potato seed costs and fertilizer prices. During the period between 1997 and 2010, these two cost elements stayed in the range of between 20 and 30 percent of the total production costs

4.2.3 The improved potato supply function

One of the objectives of this study was to use the already existing supply response potato model and transform and/or improve it to enable the model to make electricity price adjustments. The crucial result of the study rests in the ability to incorporate electricity costs in the supply response model to enable the researcher to obtain the necessary results as to the impact of an increase in electricity tariffs. The supply response model was therefore altered to incorporate the production costs of potato farmers.

In section 4.2.1 comprehensive contextual information regarding the BFAP supply response model was provided. It was explained that the supply response model consists of three different blocks which are the supply block, the demand block and a price block. All three different blocks consist further of a series of interlinked equations which conclude in a closure equation (Mhlabane, 2011). Due to the nature of the study, the supply block was of particular interest as it consists of an area equation and a yield equation. Due to the reason that the main purpose of the study is to quantify the impact of an increase in electricity costs on hectares planted, the area equation of the supply response model should be altered to incorporate production costs.

Referring back to Equation 4.1 in section 4.2.1 it was denoted that the total area planted is a function of the previous period plantings, producer prices divided by the price of inputs which was denoted by fertilizer prices, the price of complements and or substitutes and the rainfall per annum. To do analysis on the impact of increased electricity prices, this equation was altered to incorporate not only fertiliser input prices but total production costs as depicted in Table 4.4, Table 4.5 and Table 4.6 of this chapter. The equation was therefore transformed as follows:

Equation 4.6: The improved potato area harvested equation

$$PAHR = f(PAHR_{t-1}, P_{p,t}/P_{pc,t}, P_s, Rain)$$

Where:

PAHR is the potato area harvested

$PAHR_{t-1}$ is the area harvested during the previous period

P_{pt} is the potato producer price (R/t)

P_{pct} is the price of total production costs[5] (R/ha)

P_s is the price of complements or substitutes (R/t)

Rain is the rainfall per annum

[5] Please note that the total production costs as used in Equation 4.6 include all the production cost elements that was mentioned in Table 4.4, Table 4.5 and Table 4.6

By incorporating total production costs to the model, the model now has the ability to take any production cost scenario and do calculations on what the impact on the area harvested will be in the potato industry. It must be noted that although total production costs are inserted in the equation, any production cost shock in the potato industry can be modelled. The model is structured with all the production costs elements that all add up to the total production costs which is then inserted in the area harvested equation.

The logic behind deconstructing the total production costs in to all of the cost elements is that the model now has the ability to do analysis on any increase in one specific production cost element. In this study, the price shock was done on electricity costs, meaning that of all the production cost elements, electricity costs increased at a more progressive rate than all other production cost elements. With an increased electricity cost, total production costs also increased which is then incorporated into the area harvested equation. The net result is that the producer price divided by total production cost element in the equation changed meaning that the model now has to be altered to bring all the equations back to equilibrium.

4.3 ESTIMATING SUPPLY RESPONSE

With the background of the potato supply response model explained in the preceding section, the manner in which this model was improved upon to incorporate production costs and a detailed analysis of production costs in the three areas under study concluded, the study can shift its focus to the results obtained from the analysis. This unit is divided into two sections. The first section will focus on the electricity price shocks that can be expected due to the increase in electricity tariffs while the second section is dedicated to quantifying the same price shock, however in the case of improved farm practices as explained in Chapter 3 of this study.

4.3.1 Modelling the effect of increased electricity tariffs on potato supply

The hypothesis of this study raised a two-fold question in terms of what the true impact would be on potato production should the electricity tariffs increase at the set NERSA rates over the short and medium term and secondly, whether this impact

would be of any significant value as was claimed by numerous industry leaders. To answer this two-fold hypothesis this section concentrates on the results obtained for the three regions as mentioned in the study.

4.3.1.1 Determining the supply elasticity in the supply response model

In any supply response model, it is important to determine the supply elasticity before analysis can be performed. It was therefore important that the supply elasticity of all three regions under study be identified as this places the impact of higher electricity prices into perspective. According to Meyer (2002) supply elasticity can be defined as "…the ratio of percentage change in quantity supplied relative to the percentage change in an independent variable…". Meyer (2002) further stated that own-price elasticity refers to the effect of a change in price on the quantity of a given product. Own-price elasticity, for example, in the case of this study refers to the change in quantity supplied as a result of a change in market prices. It must be noted that the own-price elasticity of supply should always be positive according to the neo-classical theory which explains the positive relationship between higher prices and quantity supplied (Meyer, 2002).

Mathematically, own-price elasticity can be written as follows (Meyer, 2002):

Equation 4.7: Own price elasticity

$$E = \frac{\Delta Q}{\Delta P}\frac{P}{Q} = \frac{\partial Q}{\partial P}\frac{P}{Q}$$

Equation 4.7 in layman's terms means that the own price elasticity can be calculated by multiplying the change in quantity supplied over the change in price by the average price over the average quantity supplied (Meyer, 2002).

Therefore, the own-price elasticities of the Sandveld, Limpopo and South Western Free State region were calculated to be 0.28, 0.13 and 0.04 respectively by the model. With these values close to zero, one can assume that supply is inelastic to

price. In the case of the Sandveld region, this can be interpreted as a 2.8 percent increase in the area planted in the case of a 10 percent increase in market prices. In much the same way one can interpret the elasticities of the Limpopo and South Western Free State.

With the elasticities of the regions under study identified, the true impact of an increase in electricity tariffs can be identified.

4.3.1.2 The impact of increased electricity tariffs on the Sandveld region

In terms of electricity usages and costs, the Sandveld region was identified to have the highest level of electricity usage of all three regions. Reasons for this high electricity usage ranged from a sandy soil texture to high windy conditions. The impact of increased electricity tariffs therefore can be assumed to be the highest in the Sandveld region. Figure 4.1 below demonstrates the change in area planted as a result of an increase in electricity tariffs in the Sandveld region.

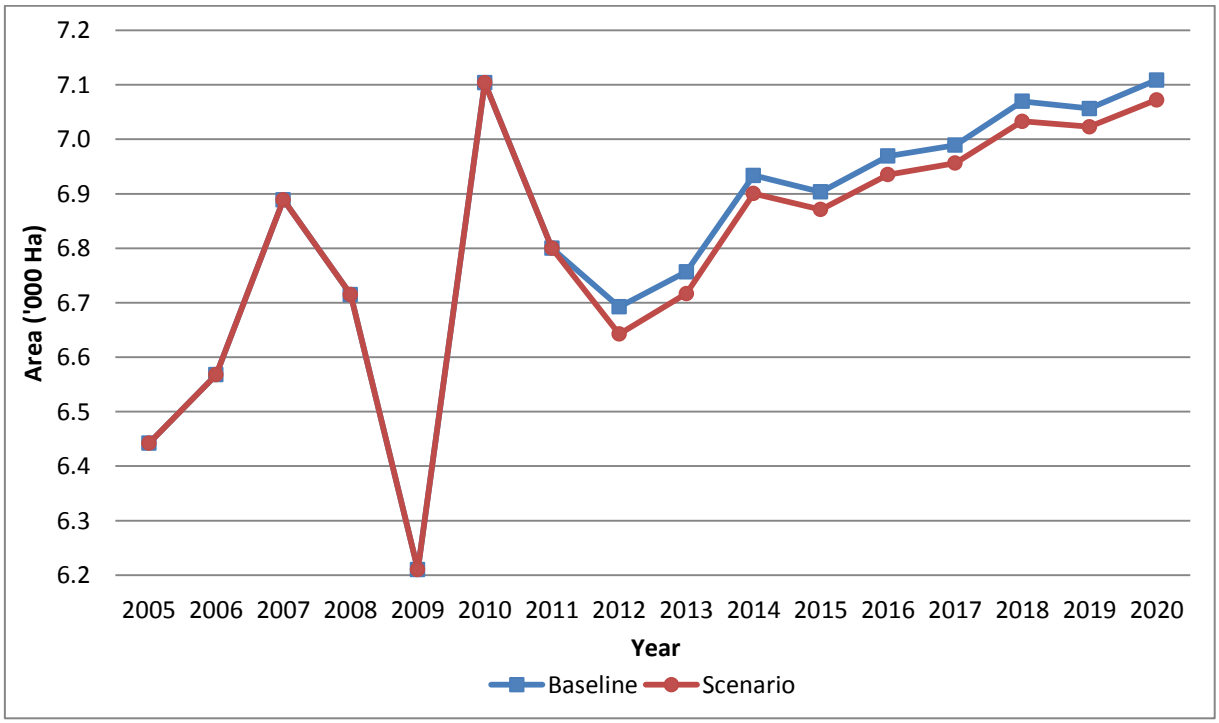


Figure 4.1: Sandveld Area planted: Baseline vs Scenario

Source: Own data estimates

The figure above shows that in the five years preceding the base year 2010, the area planted in the Sandveld region changed from one season to the next season on a regular basis. Some seasons saw a shift in hectares of between 400 to 900 hectares. It appears that any exogenous changes in potato production in the region have an effect on area planted. The electricity shock therefore would also have an effect on the area planted which is eminent from the figure above. There is a clear downward shift in area planted for the Sandveld region due to the increase in electricity tariffs. The shift in area planted occur in the 2011 production season, a year after the farmers became aware of increased electricity costs of the 2010 season. With another increase looming in 2011, total hectares again marginally decreased in 2012 as a result of an increased electricity cost for potato farmers. It must be noted that the deviation from the baseline in the figure widened in both of these two years. One must remember that the model is based on the Cobweb phenomenon whereby demand and supply are both affected by product price. The area that was planted therefore started to increase again from the 2012 production season as market prices (see Figure 4.2) increased at a steadier pace, enticing farmers again to increase their area under potato production. From the 2012 season onwards the area planted move back to increasing on a year to year base under the normal model assumptions. To understand the true effect of the electricity shock on area planted in the Sandveld region, the period after the final shock (2013 to 2020) is divided into three parts. An average area planted in hectares and percentages comparing the baseline to the scenario for the region is calculated and tabularised in Table 4.7 below.

Table 4.7: The impact of the electricity tariff shock on area planted in Sandveld: Baseline vs Scenario

Change	**2013 – 2015**	**2016 – 2018**	**2019 – 2020**
Hectare	-35.2 ha	-34.5 ha	-35 ha
Percentage	-0.51%	-0.49%	-0.49%

Source: Own data estimates

As can be seen from Figure 4.1 and Table 4.7 above, the effect of the electricity price shock on potato farmers in the Sandveld region is of a small nature. In percentage terms, the decrease in hectares planted due to the electricity price shock average at around 0.5 percent which is equal to a decrease of 35 hectares that can be expected.

This reduction in hectares also resulted in a lower level of production. As discussed, production equation is a function of hectares planted multiplied by the expected yield. Due to the nature of the study which has no effect on the yield of potato farmers, the yield as determined by the BFAP model was used to calculate the effect on production in the region. As with the table above, Table 4.8 below tabularises the change in production between the baseline and scenario.

Table 4.8: The impact of the electricity tariff shock on production in the Sandveld region: Baseline vs Scenario

Change	2013 – 2015	2016 – 2018	2019 – 2020
Tonnages	-1553.8 ton	-1571 ton	-1629.4 ton
Percentage	-0.51%	-0.49%	-0.49%

Source: Own data estimates

As the table above shows, it can be expected that the Sandveld potato production will decrease during the period between 2013 and 2020 by approximately 1 580 tons as a result of the electricity tariff hikes. The percentage decreases will stay the same as the decrease in the area planted due to the fact that the yield was used as determined by the BFAP model.

As previously mentioned, a reduction in the area planted and ultimately production will lead to changes in the market prices which will have an effect on the following year's area planted. It is therefore also important to quantify the effect that the electricity tariffs hikes will have on the overall market price during the period between 2011 and 2020.

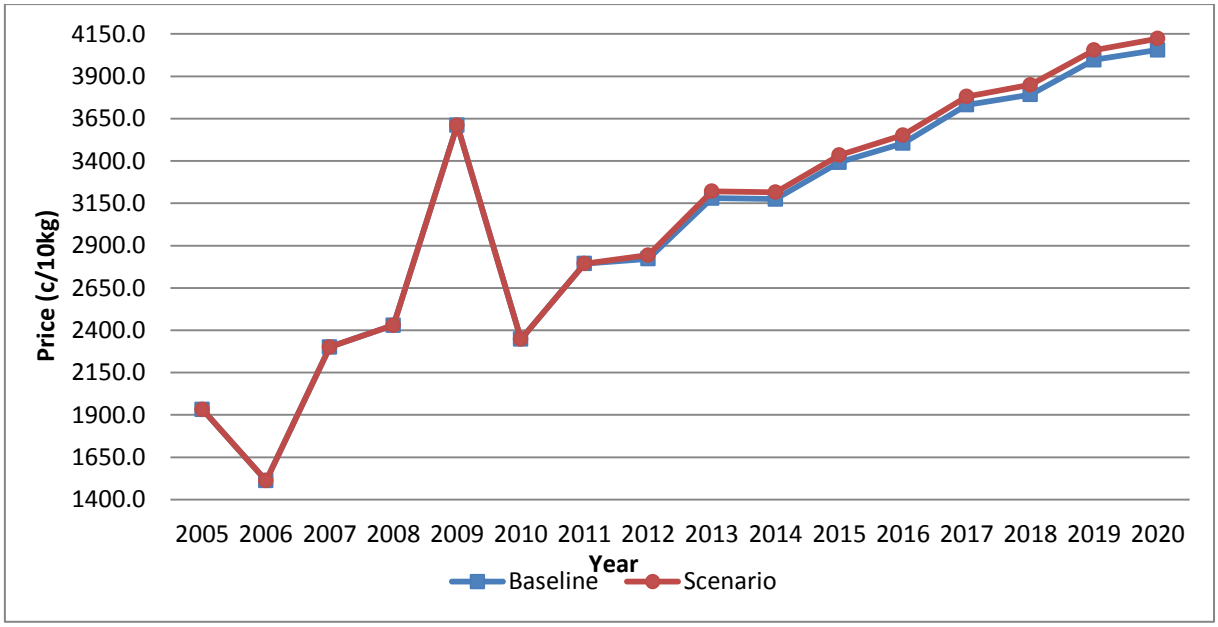


Figure 4.2: Sandveld Market Prices: Baseline vs Scenario

Source: Own data estimates

The figure above expresses the market prices for the Sandveld region during the period between 2005 and 2020. There exists a high correlation between the market prices and the area planted and or production. If market prices are high, it generally signifies that farmers will be enticed the following year to plant more hectares and vice versa. However, just as price has an effect on hectares; hectares have an impact on prices. Any exogenous shock in the market that reduces hectares planted will result in an increase in the overall market price. This is shown in the figure above where the electricity tariff hikes result in higher market prices. The effect of the electricity tariff hikes on market prices can best be summarised in Table 4.9.

Table 4.9: The impact of electricity tariff shock on Sandveld Market prices: Baseline vs Scenario

Change	**2013 – 2015**	**2016 – 2018**	**2019 – 2020**
c/10 Kg	41.26	52.18	62.57
Percentage	1.27%	1.42%	1.55%

Source: Own data estimates

In the first three years after the last electricity shock (2013 to 2015), the market prices on average will increase by approximately 41.26 c/10 kg which is roughly 1.27 percent higher than the baseline. It seems from the table above that the market price

difference between the baseline and scenario exponentially widens to the year 2020. The difference in the period between 2016 and 2018 is equal to an average of 52.18 c/10 kg or 1.42 percent. This increases to 62.57 c/10 kg or 1.55 percent in the 2019 to 2020 period.

To conclude, the impact of the increased electricity tariff on the Sandveld region is quantifiable to an extent but of a small nature. The analysis proves that some hectares will be lost due to the increased electricity tariff but it will not be more than any other factor contributing to seasonal changes in hectares planted. It does however seem that market prices will be negatively affected by the tariff increases and that market prices will follow an exponential increase over the studied period.

With the estimated effect of electricity tariff increases on potato production in the Sandveld region quantified and explained, focus can shift to quantifying the same effects on the potato farmers in the Limpopo region.

Figure 4.3 below shows the area planted under potato production for the Limpopo region during the period from 2005 to the projected 2020. Note again the deviation from one season to another in terms of the area planted. For example, the area under potato production from the 2006 to 2007 season increased by 1 100 hectares and decreased again from the 2007 to 2008 season by a 1 000 hectares. This indicates that potato farmers in this region shift area under production according to the market conditions that prevail at a specific time period.

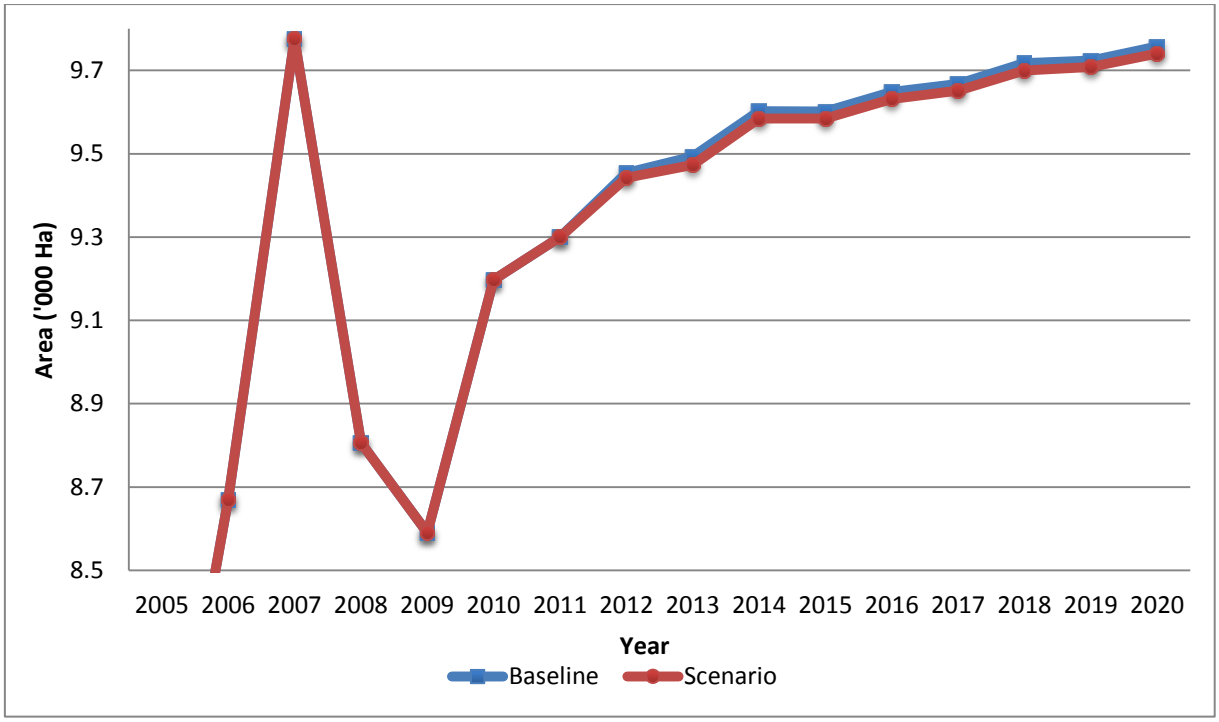


Figure 4.3: Limpopo Area planted: Baseline vs Scenario

Source: Own data estimates

As with the Sandveld region, the change in the area planted only occured in the 2011 season once farmers identified the higher electricity prices and the effect thereof on their overall production budget. The figure above showed a small downward shift in hectares planted once the model is altered by the higher electricity tariffs. This downward shift is however of a smaller nature compared to the shift that was seen in the Sandveld region. A possible reason for this is that the Limpopo farmers' electricity costs as a share of their total production costs is much lower than the Sandveld farmers. They are not as exposed to windy conditions and sandy soil textures as the Sandveld farmers which leave them less exposed to electricity costs. Another reason is that their overall on-farm profitability is also much higher than their Sandveld counterparts which make them more inelastic in terms of shifting hectares from one season to another. Nevertheless, although of a relatively small nature, a downward shift in hectares can be identified from the 2011 season. Table 4.10 below tabularises the absolute and percentage change that can be expected in the Limpopo region due to the higher electricity tariffs.

Table 4.10: The impact of electricity tariff shock on area planted in Limpopo: Baseline vs Scenario

Change	2013 – 2015	2016 – 2018	2019 – 2020
Hectare	-18 ha	-17.1 ha	-16.3 ha
Percentage	-0.19%	-0.18%	-0.17%

Source: Own data estimates

The table above displays that in absolute terms one can expect a decrease in the first three years after the electricity increase of 18 hectares in the Limpopo region. As the higher electricity prices are absorbed by farmers, some hectares will be restored and reverted back to the production of potatoes during the period between 2016 and 2020. At the end of the projected period, it can be expected that roughly 16 hectares will be lost due to the increased electricity tariff prices. The impact therefore is small on potato production in the Limpopo region. There exist much greater threats to the reduction of hectares in this region than the increased electricity tariffs.

Due to the small extent to which farmers will reduce hectares under potato production, the effect on the level of output in this region can also be expected to be of a small nature. To quantify the effect on the change in the level of production, Table 4.11 below gives a summary.

Table 4.11: Electicity shock on production in Limpopo: Baseline vs Scenario

Change	2013 – 2015	2016 – 2018	2019 – 2020
Tonnages	-865.25 ton	-867.06 ton	-863.28 ton
Percentage	-0.19%	-0.18%	-0.17%

Source: Own data estimates

Total production for the Limpopo region was calculated for the 2010 season at 398 060 ton (PSA, 2010d). This total production will decrease by a mere 865 ton on average for the period between 2013 and 2015 , which will result in a total production at the end of 2015 of 397 195 ton as a result of higher electricity tariffs. This is equal to a decrease of 0.19 percent over the specified period. This emphasises the small impact that the increased electricity tariffs will have on potato production in the Limpopo region. Although the impact on the area planted and the level of production

is small in nature, the effect of increased electricity tariffs on the Limpopo market prices is slightly more identifiable.

Figure 4.4 below show the change in market prices that can be expected for the Limpopo region due to the higher electricity tariffs that result in a lower level of production.

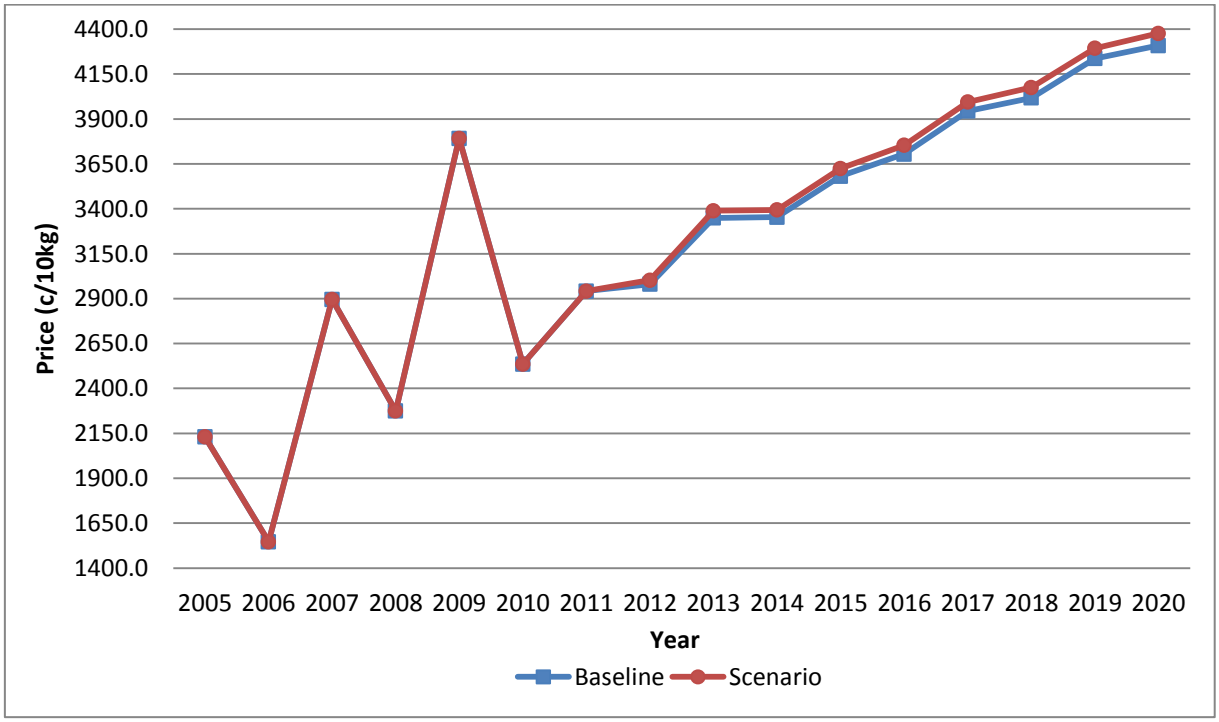


Figure 4.4: Limpopo Market Prices: Baseline vs Scenario

Source: Own data estimates

Limpopo farmers are exposed to a high level of volatility in terms of market prices as Figure 4.4 above shows. Prior to the base year 2010, farmers were exposed to changes in market price of between 6052 c/10kg and 1517 c/10kg. Market forces therefore have a high impact on market prices. With this in mind, one can also expect that the increased electricity tariffs which result in a slightly lower level of production will to some extent impact the market prices. This can be seen in the figure above as a deviation between the baseline and scenario can be witnessed. As was the case in the Sandveld region, it seems that this deviation over the projected period increases year on year.

Table 4.12 below shows the absolute and percentage increase in market prices that can be expected for the Limpopo region during the projected period between 2013 and 2020.

Table 4.12: The impact of electricity tariff shock on Limpopo Market prices: Baseline vs Scenario

Change	2013 – 2015	2016 – 2018	2019 – 2020
c/10 Kg	41.26	52.18	62.57
Percentage	1.20%	1.34%	1.46%

Source: Own data estimates

From the table above it is expected that the market price of potatoes during the period between 2013 and 2015 will increase by approximately 41.26 c/10kg from the baseline. As mentioned, market prices seem to exponentially increase over the projected period. In the 2016 to 2018 period, market prices can be expected to increase on average by 52.18 c/10 kg which will widen even further to 62.57 c/10kg during the period between 2019 and 2020. In percentage terms this is equal to a 1.20, 1.34 and 1.46 percent increase respectively for all three periods. Taking the high level of volatility of market prices before the base year 2010 in consideration and the fact that farmers are exposed to high seasonal swifts in market prices, the change in market prices as summarised above will not have any adverse effects on market forces. These changes will be absorbed by farmers and market participants over the projected period.

The South Western Free State region, the smallest of the three regions studied, the results obtained showed the smallest reduction in area planted. Figure 4.5 below shows this almost non-existent change in area planted for the South Western Free State region.

Again, as with the previous two areas, the area under potato production changes from one season to another depending on the prevailing market forces and conditions at a specific time period. The area under production decreased from 1 900 hectares in 2006 to 1 000 hectares in 2009, after which it rebounded again to 1 300 hectares in 2010. Focusing on the period after the base year 2010, no real changes in area planted can be seen once the model is shocked by the increased electricity

tariffs. The baseline and scenario lines in the figure below are virtually coincided indicating that no real change in area under production can be expected due to the higher electricity tariffs.

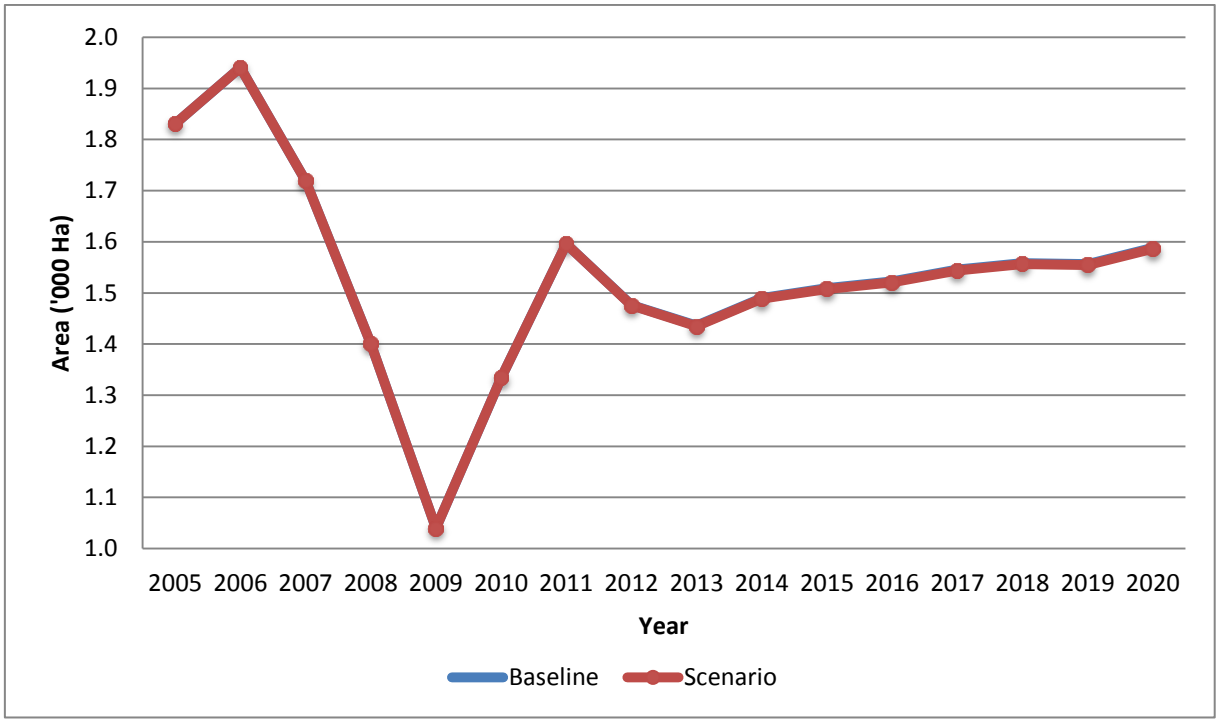


Figure 4.5: South Western Free State Area planted: Baseline vs Scenario

Source: Own data estimates

Although almost non-existent in the figure above, there is a slight deviation from the baseline and scenario which is summarised in the Table 4.13 below.

Table 4.13: The impact of electricity tariff shock on area planted in South Western Free State: Baseline vs Scenario

Change	2013 – 2015	2016 – 2018	2019 – 2020
Hectare	-1.61 ha	-1.72 ha	-1.66 ha
Percentage	-0.11%	-0.11%	-0.11%

Source: Own data estimates

Of all three areas, the South Western Free State region is least effected by the increase in electricity tariffs in terms of area under production. The region in the base year 2010 had an area under production of 1 334 hectares. Over the projected period this area is set to decrease by only 1.6 hectares which is equal to a decrease of 0.11 percent. This change is negligible in absolute and percentage terms as the calculated

change will be absorbed by market participants and farmers. One can therefore conclude that the impact of higher electricity prices will have no effect on the level of area planted in the South Western Free State.

Due to the limited changes in area planted, production in the South Western Free State region will also not change due to higher electricity tariffs. The absolute and percentage change in production for the South Western Free State region is summarised in Table 4.14 below.

Table 4.14: The impact of electricity tariff shock on production in South Western Free State region: Baseline vs Scenario

Change	2013 – 2015	2016 – 2018	2019 – 2020
Tonnages	-75.9 ton	-84.3 ton	-84.1 ton
Percentage	-0.11%	-0.11%	-0.11%

Source: Own data estimates

In the base year 2010, the South Western Free State region produced a total of 57 611 tons. Due to higher electricity tariffs this is set to decrease to 57 535 tons over the period 2013 to 2015. This will decrease a further eight tons over the remaining projected period to 57 527 tons. With such a small change in production expected, one can again conclude that the change in production will be absorbed by market participants and farmers with no real negative effects impacting the region.

Market forces depict that reduced production should lead to higher market prices and this is also the case for the South Western Free State Region. Although of a small nature, the change in area planted and ultimately production does seem to have an impact on market prices. Figure 4.6 below shows the change in market prices that can be expected due to higher electricity tariffs.

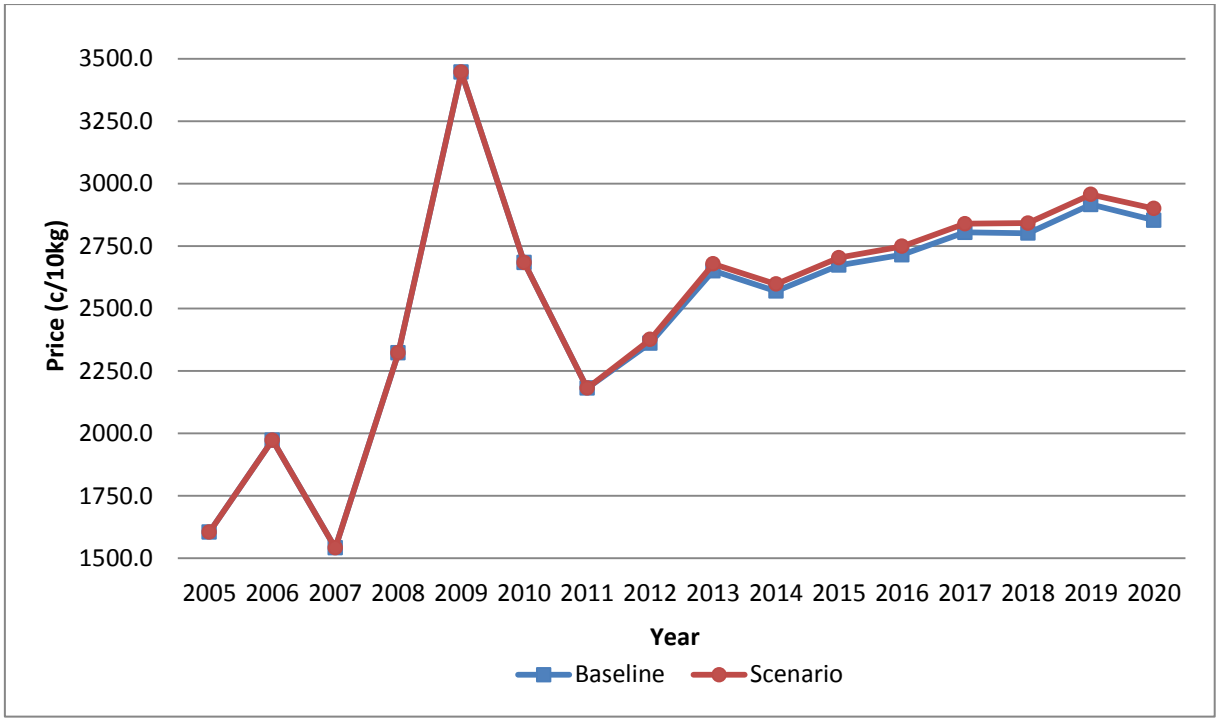


Figure 4.6: South Western Free State Market prices: Baseline vs Scenario

Source: Own data estimates

Market prices had a high level of volatility prior to the 2010 base year. Prices increased from the 2007 season from 1 542 c/10kg to 3446 c/10kg in 2009 after it dipped back to 2 684 c/10kg in 2010. There seemed to be a change in market prices due to higher electricity tariffs with the scenario line sliding slightly further away from the baseline line in the figure above. It again, as was the case with the previous two regions, seems to exponentially widen over the projected period. To summarise the impact of higher tariffs on market prices, Table 4.15 below is shown.

Table 4.15: The impact of electricity tariff shock on Market prices in the South Western Free State region: Baseline vs Scenario

Change	2013 – 2015	2016 – 2018	2019 – 2020
c/10 Kg	28.60	36.31	43.37
Percentage	1.09%	1.31%	1.50%

Source: Own data estimates

Table 4.15 above emphasises this exponential increase in market prices as a result of higher electricity tariffs. During the period between 2013 and 2015, the market price of potatoes is set to increase by 28.6 c/10kg. This will increase further to 36.31

and 43.37 c/10kg for the periods 2016 to 2018 and 2019 to 2020 respectively. In percentage terms this is equal to 1.09, 1.31 and 1.50 percent respectively.

4.3.2 Price and supply response with improved farm practices

With a comprehensive analysis of higher electricity tariffs on the overall level of production and market prices presented above, one last question still remains: Are there any farm practises that farmers can use to reduce the effect of higher electricity tariffs on the overall level of production and market prices in a specific region even further? In Chapter 3 of this study special mention was made of the cost saving techniques available to farmers by making use of the Ruraflex electricity tariff structure. It was mentioned that the Ruraflex tariff structure entices farmers to consume electricity during specific periods of the day that will result in lower costs per kilowatt usage. Farmers therefore can control their electricity cost to some extent by irrigating their land during these specific periods that would save them electricity costs.

Although analysis of electricity consumption in the Ruraflex tariff structure was performed in all three regions, the Sandveld region was best represented by farmers using the Ruraflex tariff strucuture instead of the Landrate tariff structure. A detailed analysis was performed on farmers in the Sandveld region and the overall effectiveness of farmers in using the Ruraflex tariff structure. Seven of the 13 interviewed farmers in the Sandveld region consumed electricity under the Ruraflex tariff structure. It was concluded that all seven farmers were inefficient in terms of consuming electricity during the off peak and standard periods. Their respective overall electricity costs for the peak period were the same and higher than that of their off peak and standard period consumption. This section will therefore only focus on the Sandveld region in answering the question; could more efficient consumption of electricity during the off peak and standard period reduce the effect of higher electricity tariffs on the overall level of production and market prices in that specific region?

In Chapter 3 of this study it was mentioned that should these seven farmers reduce their electricity consumption in the peak periods and consume more in the off peak

and standard periods, the average electricity cost per hectare for the region would decrease from R5 080 to R4 866. If one extrapolates this to all 15 interviewed farmers in the study and assumes that all 15 farmers consume electricity efficiently within the Ruraflex framework, this weighted average for the region can be assumed to reduce to approximately R4 720. The average electricity cost per farmer therefore decreases by approximately R360 per hectare or eight percent as a result of more efficient electricity consumption.

As already has been mentioned, the supply response model makes use of all regions in the model when doing analysis. One therefore also needs to alter the other regions with this cost saving technique before an accurate analysis can be done. With the Sandveld region serving as a guideline, the other regions in the model were altered by the same magnitude as was calculated with the Sandveld region farmers. The assumption was that the other regions' farmers will have the same irrigation schedule as the farmers in the Sandveld region as the majority of farmers irrigate their land early in the morning and late at night (peak periods). Their profile will therefore be much the same, with a high concentration of electricity consumption taking place during the peak periods. This was also found by the study, in that over the three regions under study, all the farmers that consumed electricity under the Ruraflex tariff structure had average electricity consumption in the peak periods of between 28 and 43 percent. This indicates that farmers are unaware of the cost saving benefits available to them and secondly that the majority of farmers in the Ruraflex tariff structure consume roughly the same amount in the peak periods, strengthening the assumption made earlier.

With this in mind, the average electricity cost of all three regions under study were altered by this cost saving technique and re-analysed in the supply response model. The baseline in the model in this analysis is the actual electricity cost as analysed in section 4.3.1., with the scenario indicating the lower electricity costs as a result of the cost saving technique available to farmers. The results of this analysis on the Sandveld region can be summarised as follows: In terms of the area planted, due to the slightly lower electricity costs, the overall production costs of farmers in the Sandveld region decreased slightly, resulting in higher profitability on farm level.

Figure 4.7 below compares the effect of the cost saving technique on area planted between the baseline and scenario.

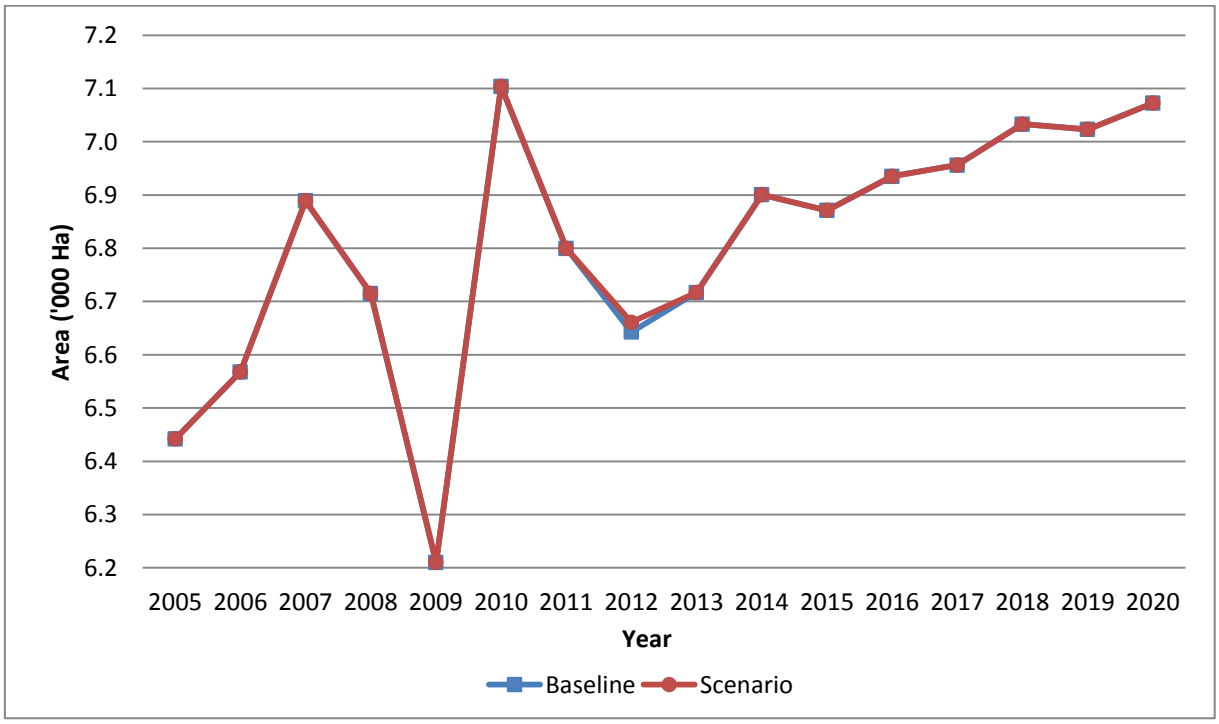


Figure 4.7: Cost saving analysis on area planted in the Sandveld region: Baseline vs Scenario

Source: Own data estimates

The area planted showed a slight increase as a result of farmers consuming electricity efficiently according to the Ruraflex tariff structure. However, this increase will only be affected in the 2012 season after which the area planted reverts back to the baseline. In absolute terms, 2012 will increase by a mere 19 hectares which is of no significant value. Much the same trend can be observed with production which increased in the 2012 season by 80.68 tonnes after reverting back to the baseline from 2013 onwards. The analysis also indicated that the market prices showed no change between the baseline and scenario analysis.

Although the cost saving techniques available to farmers show no real impact on the level of production and market prices in the Sandveld region, farmers should not underestimate the cost saving abilities as explained in Chapter 3 of this study. It still has the potential to save farmers from unnecessary electricity costs. This technique will increase in importance over the coming years as farmers will be exploited to

higher electricity tariffs. One reason for this low impact on the level of production and market prices could be a result of the small absolute change in the level of production and market prices as a result of the higher electricity tariffs as explained in section 4.3.1.

4.4 SUMMARY

The impact of higher electricity tariffs on potato production and market prices was analysed in Chapter 4 by altering the BFAP potato supply response model by incorporating a detailed production cost breakdown into the model. This altered model was shocked by higher electricity tariffs equal to the rate as set out by NERSA. The findings of the study in terms of the impact of higher electricity tariffs on potato production and market prices are tabularised in Table 4.16 below.

Table 4.16: The true impact of higher electricity tariffs on potato production and market prices in the regions of Sandveld, Limpopo and South Western Free State

Region	Sandveld	Limpopo	South Western Free State
Absolute change in Area planted	-35 hectares	-17.1 hectares	-1.66 hectares
Percentage change in Area planted	-0.5 percent	-0.18 percent	-0.11 percent
Absolute change in Market prices	+52 c/10kg	+52 c/10kg	+36 c/10kg
Percentage change in Market prices	+1.41 percent	+1.33 percent	+1.3 percent

Table 4.16 above summarises the finding of the study and it can be concluded that the impact of higher electricity tariff prices are of a small nature. Between all three regions, the Sandveld region will be the most effected with a total decrease in hectares of 35 which is roughly 0.5 percent of the total hectare planted. Market prices in this region will be slightly higher averaging around 52 c/10kg higher than what it would have been without the electricity tariff hikes. The South Western Free State region will be least effected with a mere decrease in hectares of 1.66 hectares which is roughly 0.11 percent of total hectares planted. The market prices in this region will also see a higher market price of around 36 c/10kg.

A technique that is at the disposal of potato farmers in these three regions is to counter higher electricity tariffs by consuming electricity efficiently during the set

times as directed by Eskom, farmers could potentially counter the higher electricity tariffs. The analysis showed that should farmers consume electricity efficiently, some of the impact of higher electricity tariffs could be absorbed. However, due to the fact that the impact of higher electricity tariffs had only a small impact on the production of farmers, this technique could not be accurately quantified. The researcher is of the opinion that this technique could result in lower on-farm electricity costs which increases the on-farm profitability.

To conclude, the changes in production and market prices are of a small nature, which can and will most likely be absorbed by potato farmers. This erases the fears that the set increases in electricity tariffs will drastically reduce potato production which will result in higher market prices, ultimately impacting food security negatively.

CHAPTER 5

SUMMARY AND CONCLUSION

5.1 CONCLUSION

At the start of 2010, NERSA announced that electricity tariffs would increase at an average rate of 25 percent per year over a three year period (Njobeni, 2010). This raised fears within the economy and specifically within the agricultural sector that these increases would negatively impact the agricultural sector. Various stakeholders within the agricultural sector also raised opinions about what the estimated impact would be on agricultural production and market prices. This study's main objective was to quantify the estimated impact of higher electricity tariffs on production and market prices within the potato industry. The potato industry represents 13.4 percent of South African horticulture (DAFF, 2012) and R13.802 billion of private consumption expenditure was spent on potatoes in 2010 (DAFF, 2012). With the majority of potato production taking place under irrigation scheduling, the impact of higher electricity tariffs on the potato industry could be negative.

The study focused on the potato producing regions of the Sandveld, Limpopo and South Western Free State. These three regions collectively represent 51 percent of the total potato production in South Africa (PSA, 2010b). In total 13 farmers in the Sandveld region, seven farmers in the Limpopo region and eight farmers in the South Western Free State region were interviewed to collect electricity consumption data and the associated costs thereof on potato production. The study found that electricity consumption and costs varied from one region to another which was influenced by the fact that farmers have different irrigation scheduling techniques, that the soil moisture and textures from farms differ and that some farming regions received more precipitation over the growing season of potato farming than the other regions. The findings of the study in terms electricity consumption and cost are summarised in Table 5.1 below.

Table 5.1: A summary of electricity consumption and costs in the three regions under study

Region	Average electricity cost per hectare	Average electricity consumption per hectare
Sandveld	R5 080.00	6862 kWh
Limpopo	R3 826.00	3809 kWh
South Western Free State	R3 641.00	3865 kWh

The study found that the Sandveld region consumed on average the most electricity out of all three regions which is supported by the fact that these farmers are exposed to sandy soil textures which result in low soil moisture levels. They are further also exposed to windier conditions which make the application of irrigation more difficult. On average, the Sandveld region consumes 6 862 kWh per hectares which is equal to an electricity cost per hectare of R5 080 in the production season of 2010. The Limpopo region was found to consume the least amount of electricity, with the South Western Free State region close behind as can be seen in the table above.

The collected electricity consumption and cost per hectares for the three regions was a vital ingredient to the overall success of the study as it was used in the supply response model to analyse the absolute change in production and market prices brought about by the increased electricity tariffs. A supply response model developed by BFAP was used to do the necessary analysis required by the study. However, it was required that this BFAP supply response model be altered in a manner that would equip the researcher to perform analysis on increases in electricity tariffs. The BFAP model consisted of a supply, demand and price linkage block with each block consisting of behavioural equations and identities (Meyer, 2002). The supply block was of particular interest to this study as it consisted of area harvested equations. It was this area harvested equation that required some alterations before analysis could be performed. One of the components of the area harvest equation in the original model was a producer price divided by input prices with the input prices denoted by fertilizer prices.

This producer price over fertilizer price component changed in the altered model to a producer price over production cost component, with the collected electricity cost per hectare included in this production costs component. However, this required that

time-series data, from the year 1997 to 2010, on production costs also be collected. Due to the unavailability of production costs over this period, the researcher used the production costs of the 2010 production season as made available by PSA (2010c), as a base year and extrapolated this data back to 1997 using key economic indicators. This provided the researcher with data on producer prices as well as production costs which could be inserted in the supply response model.

With the supply response model altered to incorporate production costs, which in turn included the collected electricity costs, analysis on the impact of higher electricity tariffs on production and market prices in the three regions could be performed. In conducting the analysis, electricity prices were increased by an average of 25 percent per year over a three year period with all other production costs assumed to increase over the same period by an average inflation rate. Table 5.2 below summarises the impact of higher electricity tariffs on production and market prices of the three regions under study.

Table 5.2: A summary of the impact of higher electricity tariffs on production and market prices of the three regions under study

Region	Sandveld	Limpopo	South Western Free State
Absolute change in Area planted	-35 hectares	-17.1 hectares	-1.66 hectares
Percentage change in Area planted	-0.5 percent	-0.18 percent	-0.11 percent
Absolute change in Market prices	+52 c/10kg	+52 c/10kg	+36 c/10kg
Percentage change in Market prices	+1.41 percent	+1.33 percent	+1.3 percent

The study found the impact of higher electricity tariffs on potato production and market prices to be of a small scale. The Sandveld region had the highest impact as it was calculated that on average, during the period between 2013 and 2020, a total of 35 hectares of potato production will be lost due to this higher electricity tariffs. One can further expect that the market price in the Sandveld region would increase by a mere 52 c/10kg over the same period. The South Western Free State region was least effected by the higher electricity tariffs as a mere 1.6 hectares of potato production land could be lost due to the higher electricity tariffs which will lead to an increase of around 36 c/10kg in market prices during the period between 2013 and 2020.

A last objective of the study was to identify possible techniques that farmers can use to counter this increased electricity tariff. The study found that a possible technique at the disposal of farmers rests in the choice of electricity tariff structure used by farmers. Many farmers' electricity tariffs still fall within the Landrate tariff structure which has limited benefits for farmers. It was found that farmers using the Ruraflex tariff structure have a greater degree of flexibility in terms of saving electricity costs without reducing electricity consumption.

The Ruraflex tariff structure is designed to entice consumption of electricity out of peak periods of the day. Eskom therefore acknowledged different periods of the day and classified them as peak, off peak and standard. Farmers consuming electricity during the off peak periods pay a lower c/kWh than farmers consuming electricity during the peak periods. Some of the farmers interviewed were already utilising the Ruraflex tariff structure but were unaware of the benefits of this structure. The study did a comprehensive analysis of electricity consumption of farmers under the Ruraflex tariff structure and found that they were inefficient in terms of consuming electricity within the off peak and standard periods of the Ruraflex tariff structure. To calculate the benefits of the Ruraflex tariff structure, an assumption was made by which farmers halve their consumption during the peak periods of the day and transfer the same amount equally in the off peak and standard periods of the day. The study found that should farmers apply this technique; the weighted average costs per hectare per farmer will decrease between R190 and R455 in the Sandveld region.

5.2 RECOMMENDATIONS

A recommendation from this study therefore is that farmers switch their electricity accounts to the Ruraflex tariffs structure and that farmers consume electricity during the off peak periods with minimal consumption that should take place during the peak periods. This will lead to lower electricity costs without reducing electricity consumption.

To analyse the effect of this reduced electricity cost technique, the study focused on the Ruraflex tariff farmers in the Sandveld region. With improved efficiency in

consumption of electricity during the off peak and standard periods, the research question was raised about whether this technique would counter the higher electricity tariffs. The study found that the area planted show a slight recovery as a result of farmers consuming electricity more efficiently. However, this increase will only be realised in the 2012 season after which the area planted reverts back to the baseline. In absolute terms, 2012 hectares planted will increase by a mere 19 hectares. However, it must be noted that before this technique was applied, total area planted in the Sandveld region will decrease by 35 hectares as a result of the increased tariffs. In other words, of this reduction of 35 hectares, 19 hectares will be recovered by farmers by applying this cost saving technique. Much the same trend can be observed with production which increased in the 2012 season by 80.68 tonnes after reverting back to the baseline from 2013 onwards.

With these results, the study concludes that the impact of higher electricity tariffs on potato production and market prices in the Sandveld, Limpopo and South Western Free State regions are of a small nature which will most likely be absorbed by the farmers. The claims by various industry participants that the potato industry would be adversely negatively impacted were unfounded in this study. However, if electricity tariffs continue to increase after the year 2012 at the same rate of 25 percent or more, the degree of impact will exponentially increase in the future. Nevertheless, in the event that electricity tariffs continue to increase in the future, farmers have at their disposal a cost saving technique that will aid them in countering a portion of the negative effects. Having said this, continued increases in electricity tariffs in the near future will negatively impact potato production which policy makers should understand.

The researcher recommends that future studies on electricity tariff increases be done on a broader economic sense, which includes linkages to other sectors of the economy that are directly and or indirectly linked to the potato industry. A study of this magnitude will add to the existing body of knowledge in that policy makers will, apart from changes in production and market prices, understand the impact on a broader economic sense that include changes in economic output and employment creation.

LIST OF REFERENCES

Aye, G.C. 2012. *The Long and Short Run Impacts of Food and Energy Price Shocks: Evidence from Nigeria.* [Online] Available from: www.ageconsearch.umn.edu/bitstream/125048/2/AARES2012Aye.pdf [Accessed: 2012-08-31]

Almirall, C., Auffhammer, M. and Berck, P. 2012. *Farm Acreage Shocks and Food Prices: An SVAR Approach to Understanding the Impacts of Biofuels.* [Online] Available from: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1605507 [Accessed: 2012-08-31]

Bureau for Food and Agricultural Policy (BFAP). 2009. *The South African agricultural baseline*. [Online] Available from: http://www.bfap.co.za/reports/BFAP%20baseline%202009.pdf [Accessed: 2010-04-06].

Bureau for Food and Agricultural Policy (BFAP). 2010. *The Effect of Electricity Costs on Irrigation Farming.* [Online] Available from: http://www.namc.co.za/dnn/LinkClick.aspx?fileticket=CN2FbG3Vu6s%3D&tabid=77&mid=551 [Accessed: 2012-08-30]

Department of Agriculture, Forestry and Fisheries. 2012. *Abstract of Agricultural Statistics 2012*. [Online] Available from: http://www.nda.agric.za/docs/statsinfo/Ab2012.pdf [Accessed: 2012-11-10]

Department of Energy. 2010. *Comparison of prices 2010 – Petrol, diesel and illuminating paraffin (IP).* [Online] Available from: http://www.energy.gov.za/files/esources/petroleum/historyprice2010.html [Accessed: 2012-08-30]

Eggerman, C.R. McMahon, S.A. Richardson, J.W. and Outlaw, J.L. 2006. *Impact of Fuel Price Increases on Texas Crops.* A selected paper prepared for the Southern Agricultural Economics Association Annual Meeting. [Online] Available from: http://ageconsearch.umn.edu/bitstream/35303/1/sp06eg01.pdf [Accessed: 2012-06-24]

Eskom. 2009. *Tariffs & Charges 2009/10.* [Online] Available from: http://www.eskom .co.za/content/Website%20PDF.pdf [Accessed: 2010-08-23]

Eskom. 2010. *Eskom's average price adjustments.* [Online] Available from: http://www.eskom.co.za/live/content.php?Item_ID=937 [Accessed: 2010-10-05].

Food and Agriculture Organization. 2001. *The Economics of Conservation Agriculture.* [Online] Available from: http://www.fao.org/DOCREP/004/Y2781E /Y2781E00.HTM [Accessed: 2012-08-31]

Food and Agricultural Policy Research Institute. 2009. *The Effect of Higher Energy Prices from H.R. 2454 on Missouri Crop Production Costs.* [Online] Available from: http://www.fapri.missouri.edu/outreach/publications/2009/FAPRI_MU_Report_05_09. pdf [Accessed: 2012-08-31]

Food and Agricultural Policy Research Institute. 2011. *FAPRI U.S. and World Agricultural Outlook.* [Online] Available from: http://www.fapri.iastate.edu/outlook/ [Accessed: 2012-08-31]

Hanson, K., Robinson, S. and Schluter, G. 1993. *Sectoral Effects of a World Oil Price Shock: Economywide Linkages to the Agricultural Sector.* [Online] Available from: http://ageconsearch.umn.edu/bitstream/30818/1/18010096.pdf [Accessed: 2012-08-30].

Jordaan, A.J. and Van Schalkwyk, H.D. 2002. *Impact of the potato industry on the South African economy*. Unpublished report. Department of Agricultural Economics, University of the Free State, Bloemfontein.

Kilian, L. 2007. *The Economic Effects of Energy Price Shocks.* [Online] Available from: www-personal.umich.edu/~lkilian/jel052407.pdf [Accessed: 2012-08-31]
Indexmundi. 2010.

Kotze, T. 2010. *Theme 9: Writing the "Research design and methods" section of a research proposal*. Lecture notes to the EBW 801 course. University of Pretoria.

Lambert and Gong. 2010. *Dynamic Adjustment of U.S. Agriculture to Energy Price Changes.* [Online] Available from: http://ageconsearch.umn.edu/handle/90666 [Accessed: 2012-08-31]

Meyer, F. 2002. *Modelling the market outlook and policy alternatives for the wheat sector in South Africa*. Unpublished MSc. University of Pretoria. [online] Available from UPeTD: http://upetd.up.ac.za/thesis/available/etd-09222005-122509/ unrestricted/00dissertation.pdf [Accessed: 2010-07-19].

Mhlabane, T.C. 2011. *Developing a simulation model for the South African potato industry: A regional approach.* Unpublished MSc. University of Pretoria. [online] Available from UPeTD: http://upetd.up.ac.za/thesis/available/etd-07232012-172854/unrestricted/dissertation.pdf [Accessed: 2012-08-29].

Miranowski, J.A. 2005. *Energy Consumption in U.S. Agriculture.* [Online] Available from: http://www.farmfoundation.org/projects/03-35AgEnergyCommissionedPapers .htm [Accessed: 2012-08-31]

Mouton, J. 2001. *How to succeed in your Master's and Doctoral studies: a South Africa guide and resource book*. Pretoria: Van Schaik Publisher.

National Agricultural Marketing Council (NAMC). 2009. *Input cost monitor: the story of potatoes.* [Online] Available from: http://www.namc.co.za/ASSETS/NewPdf140409 /Input%20cost%20trends%20report%20-%20Story%20of%20Potatoes%20- %20March%202009.pdf [Accessed: 2010-04-06].

National Agricultural Marketing Council (NAMC). 2007. *A diagnostic study of the potato subsector: Unlocking the potential for contribution towards ASGI-SA*. [Online] Available from: http://www.namc.co.za/dnn/LinkClick.aspx? fileticket=RCxpz7Le-Hw%3d&tabid=72&mid=542 [Accessed: 2010-04-06].

National Planning Commission. 2012. *The Presidency – annual report 2011/12.* [Online] Available from: http://www.thepresidency.gov.za/MediaLib/Downloads/Home/Publications/AnnualReports/The%20Presidency%20Annual%20Report%202011-2012.pdf

Niemi and Lethonen. 2008. *Modelling the Dynamics of Production Adjustments to Short-Term Market Shocks.* [Online] Available from: http://ageconsearch.umn.edu/bitstream/6401/2/sp08ni20.pdf

Njobeni, S. 2010. *Nersa hike deals blow to Eskom funding*. *Business day*, 25 February. [Online] Available from: http://www.businessday.co.za/articles/Content.aspx?id=94691 [Accessed: 2010-02-25].

Potatoes South Africa (PSA). 2010a. *SA potato industry – Dryland versus Irrigation.* [Online] Available from: http://www.potatoes.co.za/SiteResources/documents/National%20Annual%20Information%20-%20SA%20Potato%20industry%20-%20Dryland%20versus%20Irrigation.pdf [Accessed: 2010-04-07]

Potatoes South Africa (PSA). 2010b. Regional Services. [Online] Available from: http://www.potatoes.co.za/regional-services.aspx [Accessed: 2010-05-07]

Potatoes South Africa (PSA). 2010c. *Produksiekostebegroting: Aartappels.* Unpublished report. South Africa: Pretoria [28-07-2010].

Potatoes South Africa (PSA). 2010d. *Regional Services.* [Online] Available from: http://www.potatoes.co.za/regional-services/regional-map/limpopo.aspx [Accessed: 2012-01-14]

Reinders, F. 2009. *Moenie dat jou spilpunt 'n skuldpunt word nie!*. [Online] Available from: http://www.grainsa.co.za/documents/SAGraan%20Des09_Spilpunt.pdf [Accessed: 2010-07-28]

Sands, R. and Westcott, P. *Impacts of Higher Energy Prices on Agriculture and Rural Economies.* [Online] Available from: http://www.ers.usda.gov/media/118256 /err123_1_.pdf [Acessed: 2012-08-31]

Saunders, M., Lewis, P. and Thornhill, A. 2009. *Research methods for business students*. England: Pearson Education limited.

Shock, C.C., Pereira, A.B. and Eldredge, E.P. 2007. Irrigation best management practises for potato*. American Journal of Potato research*, 84:29-37. [Online] Available from: http://www.springerlink.com/content/n025752p22m758r5/ [Accessed: 2010-07-02].

South African Reserve Bank. 2012. *Selected historical exchange rates and other interest rates.* [Online] Available from: http://www.resbank.co.za/Research/Rates /Pages/Rates-Home.aspx [Accessed: 2012-08-31]

Van Tongeren, van Meijl and Surry. 2000. *Global models applied to agricultural and trade policies: a review and assessment.* [Online] Available from: http://www.sciencedirect.com/science/article/pii/S0169515000001092 [Accessed: 2011-01-14]

Wang, S.L., McPhail, L.L. 2012. *Impacts of Energy Shocks on US Agricultural Productivity Growht and Food Prices.* [Online] Available from: http://ageconsearch.umn.edu/bitstream/124892/2/Wang.pdf [Accessed: 2012-08-30]