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**An Exploratory Study of the Sustenance of Rural Electrification
in the
Kingdom of Swaziland**



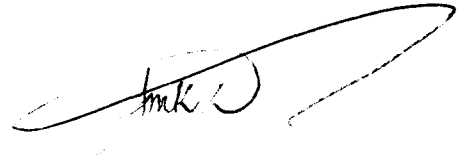
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**This is presented in partial fulfilment for the degree of
Master of Science in Energy and Development Studies
in the
Department of Mechanical Engineering
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Declaration:

I know the meaning of plagiarism and declare that all the work in the document, save for that which is properly acknowledged, is my own.

A handwritten signature in black ink, appearing to read 'Smk D', enclosed within a large, loopy oval stroke.

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My special regards are dedicated to my mother, Phetse Vilakati, for being the woman that never changed colours for me – as long as I lived. You maintained one identity to me Mphephetse: a dear mother. You let me taste the sweetness and bitterness, the love and grief of this world....

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ABSTRACT

The ‘Exploratory Study of the Sustenance of Rural Electrification in Swaziland’ aims to establish whether or not the government’s development objectives and current processes encourage sustainable development of the programme. The low access rate to modern energy services, especially in sub-Saharan Africa, as widely reported, led to the hypothesis that “*A sustainable rural electrification programme in Swaziland hinges on how the government development objectives are identified and implemented through sector reforms, governance, tariffs and processes.*” The hypothesis generated the key research question: “*What will make rural electrification sustainable in Swaziland?*” This question was complemented by five research questions.

A positivist research paradigm was pursued; the primary research methods included survey of empirical cases, informal interviews, field visits to rural electrification sites and programme beneficiaries in Swaziland. Information on Swaziland’s development objectives was gathered from government ministries and the Swaziland Electricity Board. The research established that four preconditions are required for successful electrification programmes:

- *Ring-fencing of rural electrification funds*
- *Legal and institutional frameworks (responsibility assignment)*
- *Technology innovations*
- *Tariff designs (affordability, cost causations).*

The guidelines were tested on a sample of international electrification programmes. It was discovered that most of the programmes that applied the guidelines were successful, which proved the hypothesis to be valid, within research grounds. The research concluded that Swaziland lacks a proper institutional framework and needs to formulate explicit policies – in line with the identified key aspects of international rural electrification policies.

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GLOSSARY OF TERMS

Anthracite coal	This is a type of coal with relatively high energy content compared to bituminous coal.
Bagasse	The chaff that remains after squeezing the juice from sugar-cane. It is mainly used by the sugar industries to supplement coal in their boilers during steam production.
Bituminous coal	A relatively soft dark-brown coal with a lower energy content than anthracite coal, It has higher volatility than anthracite coal.
Clean Development Mechanism	Cooperation by developing countries for mitigating the emission of greenhouse gases, by engaging in environmentally friendly practices.
Climate change	The change in the normal climatic conditions as a result of the accumulation of greenhouse gases from anthropogenic activities.
Cogeneration	It is the combined generation of process-steam and electricity.
Cost reflective tariff	It is a transparent tariff system that reveals all allocated cost, including cost of service delivery at different parts of the day.
Desertification	The degradation of land due to the depletion of natural vegetation.
Distribution	Refers to the transfer of current at low levels to consumers through electrical conductors. In Swaziland, the level is 11kV. Different distribution transformers are used to step the distribution voltages in accordance with the demand or load points.
Energisation	Provision or activation of energy undertaking.
Energy	The capacity of a system to perform work. There are different forms of energy thermal, mechanical, electrical, chemical, etc. In electricity the unit is a kilo-Watt-hour (kWh); other forms normally use the joule (J) as a standard unit.

Generation	The process of converting primary energy to produce steam or electricity. This could be the conversion of energy from coal through combustion, or, conversion of potential energy from a reservoir to electrical energy in the case of hydropower generation.
Governance	An institutional framework for the control of a sector, industry or market, etc.
Greenhouse gases	Gases that are transparent to short-wave radiation, but opaque to long-wave radiation reflected from the earth's surface to the atmosphere. These gases include carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O), hydro fluorocarbons (HFC), per fluorocarbons (PFC), sulphur hexafluoride (SF ₆). Accumulation of these gases in the atmosphere increases the global temperature and contributes to global warming. Global warming may contribute to climate change.
Grid	A grid is a network. In the case of electricity, it refers to electricity lines carrying electrical current from one point to another.
Molasses	It is a syrup that is obtained during sugar processing, from which ethanol is made through a fermentation process.
Phase wire	A phase wire refers to the electrical conductor that carries the current from the power station.
Processes	The practices and guidelines applied to achieve an end (in rural electrification)
Ready-boards	A ready board is a pack used as a socket for electricity, at the distribution box, normally before wiring. After wiring, the unit can be converted into an electricity distribution box.
Reform	A reorganisation in operation.
Regulation	The act or practice of controlling activities.
Rural electrification	The provision of infrastructure in economically disadvantaged areas such as rural and remote areas for the delivery of electrical services. This may include the extension of the electricity grid or provision of other alternative forms of energy systems, such solar, wind and stand-alone systems.

Single Wire Earth Return	It is a distribution system in electrification that uses the earth to complete its electrical circuit. It uses only one conductor. It works like a phantom loop in physics, which is an electrical network that uses natural environment to complete a circuit.
Solar energy	Solar energy is used in two common forms; photovoltaic and thermal energy. Solar photovoltaic (PV) uses sunlight to create a potential difference in semi-conducting material to cause a flow of charges, which constitutes current. Solar PV technology is normally used in stand-alone systems. On the other hand, solar thermal uses heat from the sun. The concept is used to manufacture solar water heaters.
Substation	It is an area with transformers and switches where the voltage is transformed or changed from one level to another.
Tariff	A charge associated with a common carrier or service .e.g electricity tariffs, water tariffs, telecommunications tariffs, etc.
Transmission	Refers to the transfer of current at high voltage levels through electrical conductors. In Swaziland, the levels are 400kV, 132kV and 66kV. Specifications differ for different countries.

ACRONYMS AND ABBREVIATIONS

A	Ampere or Amp. A unit of electrical current
AC	Alternating Current
AFUR	African Forum for Utility Regulation
ANER	Agence Nationale des Energies Renouvelables, which is translated to National Agency for Renewable Energy
BEE	Black Economic Empowerment
CIA	Central Intelligence Agency
CPI	Consumer Price Index
CNE	Comisi3n Nacional de Energ3a, translated to National Energy Commission
CO ₂	Carbon dioxide
DANCED	Danish Cooperation for Environment and Development
DC	Direct Current
DEOCSA	Distribuidora El3ctrica de Occidente
DEORSA	Distribuidora El3ctrica de Oriente
DME	Department of Minerals and Energy (of South Africa)
EdM	Electricidade de Mo3ambique
EDI	Electricity Distribution Industry
EDRC	Energy and Development Research Centre
ESB	Electricity Supply Board (of Ireland)
ESMAP	Energy Sector Management Assistance Programme
EU	Europe Union
FAO	Food and Agriculture Organisation (of the UN)
GDP	Gross Domestic Product
GHG	Green House Gas
GNESD	Global Network on Energy for Sustainable Development
GTZ	German Agency for Technical Cooperation
GWh	Giga-watt-hours (10 ⁹ watt-hours)
Hz	A unit of frequency
ICT	Information and Communication Technology

IEA	International Energy Agency (based in France)
IG	Ireland Government
INDE	Instituto Nacional de Electrificación
IPP	Independent Power producer
J	Joule. A unit of Energy
kV	kilovolt (10^3 volts)
kVA	kilo-volt-ampere. A measure of power capacity
kWh	kilowatt hour (10^3 watt-hours)
LPG	Liquefied Petroleum Gas
LV	Low voltage
MALT	Mise A La Terre
MDG	Millennium Development Goals
MDE	Ministry of Economic Development (in Tunisia)
MEPD	Ministry of Economic Planning and Development (Swaziland)
Met	Meteorology (e.g. Met Office)
MNRE	Ministry of Natural Resources and Energy
MoPWT	Ministry of Public Works and Transport
MV	Medium voltage
MW	MegaWatt (10^6 watts)
MWh	MegaWatt-hour
MTD	Million Tunisian Dinars
NDS	National Development Strategy
NEAC	National Electrification Advisory Committee
NEP	National Electrification Programme
NER	National Electricity Regulator
NERSA	National Energy Regulator of South Africa
NIEP	National Integrated Electrification Programme
NPDP	National Physical Development Plan
OECD	Organisation for Economic Cooperation and Development.
OEEC	Organisation for European Economic Co-operation
PCR	Price Cap Regulation
PER	Programa de Electrificación Rural

PV	Photovoltaic
PRSAP	Poverty Reduction Strategy and Action Plan
RAB	Regulatory asset base
RATPLAN	Rationalisation Plan
RCR	Revenue Cap Regulation
REA	Rural Electrification Administration (of USA)
RED	Regional Electricity Distributor
ROEA	Return on existing assets
ROI	Return on investment
RONA	Return on new assets
RORR	Rate of return regulation
RPDP	Regional Physical Development Plan
RPI	Retail Price Index
RSA	Republic of South Africa
SCORE	Select Committee on Rural Electrification (Swaziland)
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SEB	Swaziland Electricity Board
SEC	Swaziland Electricity Company
SG	Swaziland Government
SHS	Solar home system
SNEPP	Swaziland National Energy Policy Project
SNL	Swazi Nation Land
STEG	Société Tunisienne de l'Electricité et du Gaz
SWER	Single Wire Earth Return
SZL	Swaziland Lilangeni (Emalangeni for plural)
TD	Tunisian Dinar
TJ	Tera Joule (10^{12} Joules)
TVA	Tennessee Valley Authority
TWh	Tera Watt-hour (10^{12} watt-hours)
UN	United Nations
UNDP	United Nations Development Programme

V	Volt. A unit of electrical voltage
W	Watt. A unit of power
ZAR	South African Rand

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CHAPTER ONE

1 PROBLEM DEFINITION AND ITS SETTING

1.1 Introduction

Chapter one describes how the research was conducted. It highlights the general energy problems facing the developing world at large and Swaziland in particular, as a case-study country. It outlines the research objectives, the assumptions made and it justifies the need for this research, which leads to the formulation of the hypothesis, from which the key research question and complementary research questions were formulated. In addition, the limitations of this research are indicated, as well as how information from the outcomes or findings of the study will be disseminated to benefit society. Chapter one concludes with a summary of the context of the thesis.

1.1.1 General energy problems facing developing countries

Modern energy, in relation to poverty reduction and the Millennium Development Goals (MGD) instigated by the United Nations, is believed to improve the livelihoods of economically impaired people, most of whom are rural dwellers (UNDP, 2005); UN, 2006). Energy services such as electricity are envisaged to be a catalyst for the stimulation of social equity, socio-economic and economic growth; the development of agro-industries, micro-businesses, improved education and health-care facilities (GNESD, 2006a, 2006b). Robust national development strategies, policies and objectives are required to drive such developments.

World records indicate that about 1.6 billion of the world's population lack access to electricity; developing countries constitute ninety-nine percent (99%) of the total population without access to electricity. Eighty percent (80%) of the ninety-nine percent (99%) comes from rural areas. In the year 2000, Sub-Saharan Africa showed a relatively higher dependence on biomass for cooking and heating than such countries as Indonesia, India, China, East-Asia, Latin America and North Africa/Middle East (GNESD, 2004a).

Table 1.1 relates an estimate of electricity access rates for various regions in the year 2000.

Table 1.1: Regional access to electricity in 2000 (GNESD, 2004b)

Region	Population without electricity (millions)	Population with electricity (millions)	Electrification level (%)
Developing countries (total)	1634.2	2930.7	64.2
Africa	522.3	272.7	34.3
Developing Asia	1041.4	2147.3	67.3
Latin America	55.8	359.9	86.6
Middle East	14.7	150.7	91.1
Transition Economies	1.8	351.5	99.5
OECD	8.5	1108.3	99.2
World	1644.5	4390.4	72.8

Table 1.2: Electrification levels in 2000 (GNESD, 2004d)

	Rural (%)	Urban (%)	National (%)
Sub-Saharan Africa*	9.9	48.9	21.7
Africa	16.9	63.1	34.3
South Asia	30.1	68.2	40.8
Developing countries	51.1	85.6	64.2
Latin America	52.4	98.0	86.6
Middle East	76.6	98.5	91.1
East Asia/ China	81.0	98.5	86.9
World	56.9	91.2	72.8

*Statistics exclude South Africa.

It is evident from Tables 1.1 and 1.2 that relatively the continent of Africa has the lowest electricity access rates at less than thirty-five percent. More than eighty-three percent of rural Africa lacks electricity and the statistics rise to ninety-two percent (92%) for sub-

Saharan Africa. At the current electrification rate, it would take sub-Saharan Africa at least twice as long as East-Asia to become fully electrified (GNESD, 2004c).

Most low income people in developing countries rely on traditional fuels to meet their energy requirements, which produce hazardous emissions to human health. Both depletion of biomass and the world's finite resources pose a serious threat to the environment, including land degradation, desertification and climate change – thereby causing an imbalance in the ecosystem (GNESD, 2004a, Hadley Met Office, 1999). Energy analysts feel that the rate of access to electricity is too low. For instance, Foley *et al* (2004) stated that:

“The pace of rural electrification¹ over much of the developing world is painfully slow. In many African and South Asian countries, it is even lower than rural population growth.... The low population densities in rural areas result in high capital and operating costs for electricity companies.... Rural electrification programs can undoubtedly face major obstacles.”

In addition, rural people are deprived of lighting, heating, cooking and motive power services; lighting services can extend the workday, powering machines and thereby increasing production of goods and services. In addition, electric lighting enhances literacy for both children and adults by creating an enabling environment for reading and studying. It also increases the likelihood of the communities gaining access to better health-care facilities, media services and improved security through street lighting. In this respect therefore, the electrification and energisation of rural and remote areas are prerequisites for socio-economic development. It is the mandate of the state to define clear development objectives and to properly ring-fence funding for development activities.

¹ In the context of Swaziland, rural electrification refers to the extension of the national electricity grid to areas that are not covered by the electricity grid infrastructure - where extension of the grid is considered economically unviable on purely commercial terms (SG, 2003).

1.1.2 Energy problems facing rural Swaziland

Swaziland, as a developing country located in the south-eastern part of the African continent, is not immune to the economic stagnation facing some parts of Africa. The 1997 census indicated that 77% of the population live in rural areas and 23% live in urban and peri-urban areas (SG, 1997a). The vast majority of homesteads as well as a number of public facilities in the rural areas have limited access to modern energy and infrastructure services. In 1994, access to electricity in the rural areas was estimated at 4% (SEB, 2003b). This low access rate to electricity services is associated with the high cost of providing the infrastructure to the dispersed homesteads and communities in the rural areas (SG, 1997b).

Under-development in rural areas results in prevalent marginalisation of rural people. As such, rural areas are affected by high poverty rates, poor livelihoods, poor education, poor health-care facilities, very limited social equity and accelerated migration of dwellers from rural areas to urban areas in search of better living conditions. In essence, national resources are disproportionately distributed countrywide because of the settlement configurations of people in the urban areas.

On the other hand, competitive market forces dictate economically efficient and financially viable investments for service providers. Hence, the socio-economic development of rural and remote areas becomes an obligation of the government.

1.2 Research objectives

Despite extensive electrification of rural areas in Swaziland, the rate of electrification appears to be too slow to meet the government's development objectives. It is important, therefore, for the government to review whether its programmes are of benefit to the targeted social and economic groups.

In light of the highlighted predicament, the specific objectives of this research are to:

- Investigate the energy development policies of Swaziland to identify a cost-effective method of sustaining rural electrification in Swaziland, bringing optimal benefits to citizens.
- Review power sector reforms, the regulatory framework and energy governance in Swaziland, as they all have an impact on rural electrification programmes and tariff designs for affordable electricity services.
- Compare the implementation of rural electrification in Swaziland with successful programmes in other countries.

1.3 Assumptions

The assumption in this research is that the targeted people will make use of the delivered electricity and energy services, for various development activities, such as improving social equity and stimulating socio-economic growth.

1.4 Justification of research

Governments in developing countries have a tendency to formulate vague policies and incoherent development structures to foster changes in the livelihoods of economically impaired citizens. Some of the policies even hinder social and socio-economic growth, retard industrialisation and global exposure of developing countries. The current rural electrification programme in Swaziland seems to lack some key aspects of successful rural electrification, which, in turn, is hampering sustainable development and the fulfilment of Millennium Development Goals.

Current reports from public media services bear testimony to the public's dissatisfaction over the current rural electrification programme and access to electricity services. It is perceived that the rural electrification rate is slow, the cost of electricity is high and the quality of service is unsatisfactory – yet '*affordable electricity* for all citizens' is a prime issue in government's development policies (SG, 1999, 2003).

1.5 Hypothesis and Research Questions

Rural electrification has been a principal theme in international rural development initiatives. It is continuously advocated in forums as a subject of extensive research and

it has been an activity in numerous projects, ranging from small-scale pilot projects to mass electrification programmes. Varying degrees of failure or success have been observed in numerous projects in different countries. Observations, research into rural electrification, as well as experience from involvement in the implementation of various electrification programmes form the basis of the following hypothesis.

A sustainable rural electrification programme in Swaziland hinges on how the government development objectives are identified and implemented through sector reforms, governance, tariffs and processes.

Government's development objectives should guide both the funding mechanisms and how the programme will be sustained after implementation. Sector reforms include the regulatory frameworks and different forms of regulation pursuable for various tariff designs. The tariff designs determine cost-reflectivity, customer services and life-line tariffs. Social equity development programmes usually require cross-subsidisation of tariff and full funding for capital investment on infrastructure. Socio-economic development programmes may require funding for capital investment and then be able to run on their own. Economic development programmes are capable of financing all associated costs. Implementation processes detail technologies, strategies and associated procedures required for cost-effective rural electrification programmes.

The hypothesis leads to the following key research question:

What will make rural electrification sustainable in Swaziland?

Complementary research questions:

- *Under what conditions is rural electrification implemented in Swaziland?*
- *How is the energy sector governed and reformed in Swaziland?*
- *What are the development objectives of the energy sector in Swaziland?*
- *How is rural electrification implemented in Swaziland?*
- *What are the key aspects of rural electrification policies, and how are they applied in other countries?*

1.6 Limitations and scope of research

The research and analysis mainly concentrate on the supply of electricity, as opposed to general energisation, where other electrification technologies and options are considered in detail. The research is limited to a period of one year, as it is in partial fulfilment of a Master's degree. The research requires comprehensive case-study analyses and participation in rural electrification conferences, which is a budget intensive activity; this research is financially constrained therefore for other supplementary activities. The research was conducted in Swaziland, but supervised at the University of Cape Town, in South Africa. This increases limitations associated with the research sites, data and information sources, as access to some information, perceived to be privileged to some organisations, is difficult to acquire; these discrepancies hamper comprehensive and satisfactory research.

1.7 Context of thesis

Chapter one is the problem statement and its setting. It briefly outlines the energy problems facing developing countries and the need for expedient action to address the predicament, through effective programmes. Chapter two discusses the methodology pursued in this research. Chapter three provides background information on Swaziland's physical, socio-economic and economic profile and as well as an energy sector review in Swaziland. This information is crucial for situational analysis of new projects. It enables a project planner to make proper benchmarks and projections.

Chapter four forms the main part of the literature review in this dissertation. It addresses governance and reform issues relevant to the rural electrification programme in Swaziland. The chapter further surveys literature on rural electrification guidelines and key aspects in rural electrification policies. The guidelines are validated in chapter five by testing them against several rural electrification programmes in other countries. From the literature reviewed and cases analysed, the findings are discussed in chapter six. Chapter seven draws the conclusions of this study and makes the recommendations required for the sustenance of rural electrification in Swaziland.

CHAPTER TWO

2 RESEARCH METHODOLOGY

2.1 Introduction

The previous chapter detailed the problem definition and its setting. This chapter outlines the methodology used. It contains the research paradigm and its justification, the primary research methods, data collection and data interpretation techniques.

2.2 Research Paradigm

Research paradigms are normally categorised into positivist school and constructivist school (phenomenology). The paradigm to be pursued throughout the research is the positivist approach. Positivism follows quantitative research procedures and analysis.

2.2.1 Justification of research paradigm

According to Silverman (2000), positivist research is objective. This research paradigm follows the clear logic of established steps, guidelines and procedures. The procedures involve the formulation of a **hypothesis** and **research questions** about an existing problem. These, in turn, guide the literature review and other acquisitions in the research. In positivist research, a steady state with a single reality that is detached from or not influenced by the researcher's feelings, beliefs or perceptions is assumed; it seeks to establish relationships and deduce causes, success or failure in measured social, economic and scientific facts. (McMillan *et al*, 2006).

On the other hand, qualitative research develops the phenomenon through involvement, to some extent, with the research environment, the feelings of the participants and the lifestyles of the people. In phenomenological research, the decisions, conclusions and recommendations are subjective; they may be influenced by the researcher's political stance or personal opinions (Mason, 1996). The qualitative researcher is flexible about changing the strategies and procedures in the research and sometimes uses emergent designs of data collection techniques. Positivist or quantitative researchers use pre-

designed methods to establish relationships. Silverman (2000) further argues that most governments and agencies prefer positivist research if the outcome of the research is to be immediately applicable to a pending problem.

This research intends to establish sufficiently institutionalised systems and strategise implementation of rural electrification in Swaziland. It is therefore important to follow an objective approach to research, as opposed to a subjective approach. Validation of the hypothesis by answering the research questions is based on empirical facts gathered from an exploratory survey of successful programmes, practices and international guidelines for sustainable rural electrification.

The work comprises theoretical, practical and analytical aspects. Conclusions are drawn and recommendations are made based on empirical surveys from international existing systems. It should, however, be noted that both research paradigms have varying advantages and disadvantages; the choice of paradigm depends on the nature of the research and on a researcher's conviction.

2.3 Primary research methods

Information acquisition and data collection are gathered from the following sources.

Desk research:

- Literature review of electrification technologies, power sector reforms, regulation and tariff design
- Survey of public policy documents
- Project implementation processes: identification criteria, adjudication tendering, material procurement and monitoring
- Funding mechanisms
- Progress and completion reports
- A survey of case-studies in rural electrification.

Interviews:

- Government officials
- Implementing agents
- Communities.

It should be noted that conducting interviews does not form the prime part of this study. Interviews were only carried out to learn detailed information from the collected documentation. Hence, no structured or formal questionnaires have been used. Information acquired through the interviews was collected using an informal approach.

Some people are reluctant to provide information once they realise that the information is going to be recorded. Others feel it is a form of investigation, where the research will be used to find scapegoats. It is typical behaviour for rural people and even some company staff members to avoid interviews. As a result, some interviewees may not reveal fundamental information in order to protect their identity. For this reason, it is helpful to conduct interviews informally because some of the information is revealed during informal conversations. A lot of information on the development plans of communities was able to be gathered during chieftaincy summons and assignments. This makes collection of data very difficult for non-citizens, because certain structures have to be followed during the acquisitions.

Field visits:

- rural electrification project sites
- Beneficiary communities.

2.4 Data collection techniques

Relevant data was collected from various sources by visiting the various institutions to acquire the appropriate documentation. Interviews were conducted by telephone, on physical site visits, by arranging short meetings with the responsible informant, as well as Information Communication Technologies (ICT) for sector-wide data. Government policies were physically collected from key ministries, including the Ministry of Economic Planning and Development (External Assistance Unit), the Ministry of Natural Resources and Energy, the Central Statistics Office, the Ministry of Education, and the Ministry of Public Works and Transport. The collected information was captured on

computer for further analysis. No interviews were recorded on audio media services for ethical reasons.

2.5 Data interpretation techniques

Most of the information collected does not need any special data interpretation tools for implementation. Microsoft Office tools were used in the analysis.

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CHAPTER THREE

3 COUNTRY PROFILE

3.1 Introduction

Many development projects fail partly because of the lack of situational analyses. Rural electrification is very culture sensitive and usually site specific. Analysing such pertinent issues improves the understanding of the implementation process, such as in acquiring rights of way for projects and acceptability. This chapter examines geographic and land-ownerships issues, the legislature, economic outlook and the energy sector review in Swaziland.

3.1 Swaziland's general profile

The kingdom of Swaziland shares borders with South Africa and Mozambique and stretches over 17 364km² of area; its population is estimated at 1.2 million (CIA, 2006).



Figure 3.1: Main towns and national flag of Swaziland (CIA, 2006)

Swaziland is an independent member of the Commonwealth; it is a former protectorate of the United Kingdom and it gained independence on 6th September 1968.

There are four administrative districts in Swaziland:

- **Hhohho district**, where Mbabane – the capital city of Swaziland, is located
- **Manzini** in the centre, with Manzini as the district capital
- **Shiselweni** in the south, with Nhlangano as the district capital
- **Lubombo district**, where Siteki is the regional headquarters or capital.

Lobamba is the royal and legislative town of Swaziland. The legal system is based on South African-Dutch law in statutory courts and Swazi traditional law and custom in traditional courts. There are two parliamentary houses; the House of Assembly has sixty-five (65) members, fifty-five (55) of whom are democratically elected by citizens from the fifty-five constituencies of Swaziland and the remaining ten (10) members are appointed by the monarchy. The second house is the House of Senate, which has thirty members; the monarchy appoints twenty members and the rest are elected by the House of Assembly. The king is the head of state and the prime minister is the head of government. The cabinet of ministers is recommended by the prime minister and approved by the king.

Swaziland has two land tenure systems; title deed land (TDL) and Swazi Nation Land (SNL). SNL covers 54% of the total land and the rest is TDL. Title deed land is privately owned and is used for most of the agricultural commercial activities and estate production; that is sugarcane, ranching, forestry, citrus fruits, etc. Swazi Nation Land is held in trust by the king, through designated chiefs, for the Swazi nation. The chiefs administer the land and allocate it to the people in their domains, in accordance with the Swazi traditional laws. This land mainly forms the rural areas and peri-urban areas of Swaziland (FAO, 2006).

Geographically, Swaziland is divided into four zones. The western-most zone, covering 29% of the country, is the High-veld. The climate is temperate and suitable for forestry;

the large wood and pulp industries are situated in this area. The subtropical, hilly Middleveld, lying at an altitude of 700 metres, covers 26% of the country. It is the most densely populated part of Swaziland. And the main commercial and industrial centre is found in this area. The relatively dry Low-veld covers 37% and lies at 200 metres above sea level. The country's coal deposits and large agro-industries, mainly sugarcane, are situated in this region and it is relatively sparsely populated. The land rises to 600 metres above sea level near the border with Mozambique. This region is identified as the Lubombo plateau, which covers the remaining 8% of the country. It is climatically similar to the Middleveld (SG, 1997b, 2003).

3.2 Economic outlook

The key to Swaziland's relative prosperity has been specialisation of the economy in areas where it has a comparative advantage (such as the agricultural and forest-based industries), political stability, homogeneity of the country and the openness of the economy; it provides a conducive climate for foreign investment.

The performance of the economy of Swaziland has been sluggish in recent years and this is a reflection of the vulnerability of primary production to climatic and external factors. The slowdown in economic activities in the late 1990s was mainly due to low agricultural production, low international commodity prices, weak demand and a generally depressed world economic environment.

Agriculture is principally based on subsistence farming, cash crops and livestock; its contribution to GDP is 10%. However, manufacturing of value-added products largely originates from the agro-based industries, such as sugar processing, wood pulp production and fruit canning. Most of the energy for these activities is provided through animate energy and machinery. The major role of the manufacturing sector in GDP is also reflected in the share of the total employment in the private sector compared to the public sector. The public sector accounts for 15% of GDP; however, growth has been negative since 1994. From an energy perspective, the agricultural and manufacturing sectors are not only interesting as sectors with large energy demands, but also because useful by-products are provided by these sectors and these by-products contribute to the

total energy supply for Swaziland. The sugar and pulp industries, in particular, produce vast amounts of biomass by-products that are used for process heat and electricity generation.

Swaziland's economy, like most others in the region, depends heavily on South Africa; it is inevitably influenced by the economic and financial developments in South Africa. The major forms of dependence include trade, investments and energy (electricity, refined petroleum products and bituminous coal). In 1998, the per capita income, which is the Gross Domestic Product (GDP) over the total population, amounted to 3 791 Emalangeni; this ranks Swaziland among the lower middle-income developing countries. The Lilangeni (SZL) is linked at par to the South African Rand (ZAR).

In 2003, the country's GDP was US\$1.8 billion; agriculture contributed 11.3%. Poor rainfall has made the figure fluctuate in the past decade. Maize is the staple crop for the Swazi people and it is mainly grown on Swazi Nation Land. However, there has been an increase in the number of farmers on SNL growing sugar cane, especially those with irrigation facilities. The major factor contributing to the shift is the increased income from sugar markets. The price of maize has always been regulated by government and so does not entirely reflect market conditions. As a result, a secondary market has emerged quoting substantially higher prices, especially in areas affected by drought. Swaziland has never been self-sufficient in maize production.

3.3 The Energy Sector Review in Swaziland

3.3.1 Energy supply

Energy supply entails the provision of such energy carriers as coal, petroleum products, electricity and renewable energy. Petroleum products are gasoline, diesel, kerosene, LPG (liquefied petroleum gas), jet fuel (including jet gasoline) and fuel oil. Figure 3.2 depicts the share of the various energy supply carriers used across the entire economy. The contribution of indigenous anthracitic coal was 12 950 TJ in 1999.

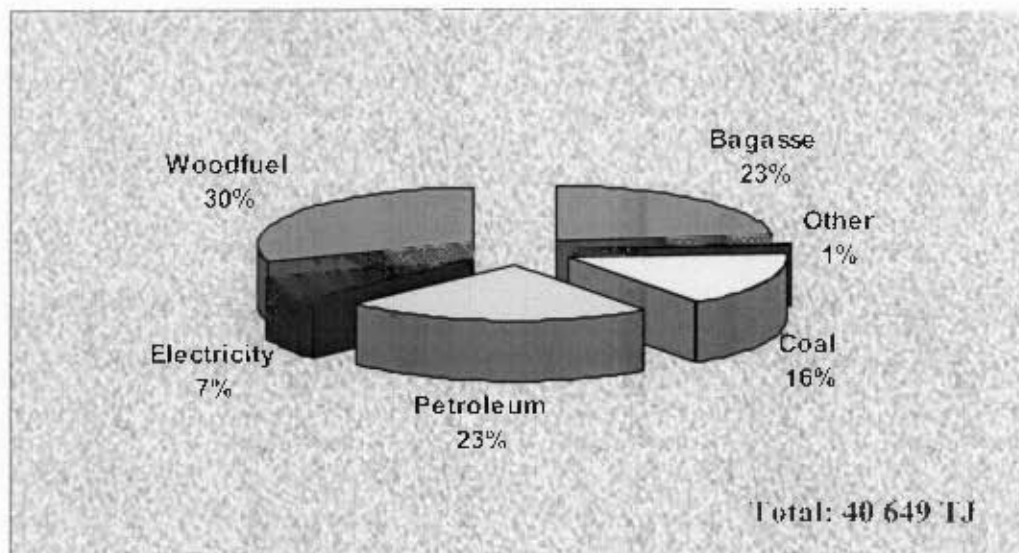


Figure 3.2: Energy supply by carriers in 1999 (SG, 2003)

In figure 3.2, 'other' comprises candles, agricultural and animal wastes. Wood-fuel includes firewood (for commercial and non-commercial purposes), industrial wood-waste, bark and black liquor (SG, 2003). The sugar industries produce a lot of bagasse and ethanol (from molasses); the bagasse is used to supplement coal in the cogeneration processes. Ethanol is still under consideration to be blended with petrol. The pulp industries produce wood-waste and black liquor that are used for process heat and electricity generation. Black liquor is a by-product of wood de-barking.

a) Coal

Swaziland has large anthracitic coal reserves that are presently under-utilised. Coal is the only naturally occurring fossil fuel in Swaziland. Defined as run-of-mines, the coal reserves are estimated at 207.6 million tonnes; the potential reserves are estimated at one billion tonnes. The reserves consist of semi-anthracite and anthracite coal. Almost all the coal reserves are located in the Low-veld, where some of the big sugar industries are located. Anthracite coal has higher energy content and is environmentally much cleaner than bituminous coal. Swaziland mines an annual average of 400 tonnes of anthracite coal through one colliery and the locally mined coal is all exported. An annual average of 243 tonnes of bituminous coal is imported by private companies for their own use. The

bituminous coal is imported because local industrial equipment is not designed for the indigenous anthracitic coal (SG, 2001).

Coal bed methane has not yet been explored, although it could be used as a potential source of energy. The prohibitively high exploration costs have so far been a major barrier. The Government has yet to embark on this process.

b) Petroleum and gas

Swaziland does not process any petroleum products, partly because there are no known oil reserves within the country. All refined petroleum products are currently sourced from the Republic of South Africa through five international oil companies: Shell, BP, Engen, Total and Caltex. Modes of transport for the importation of refined petroleum products are rail and road to distribution storages located in Matsapha (in the Manzini district) – the major industrial centre of Swaziland. LPG and lubricating oils are supplied by private companies.

The prices of petrol, diesel and illuminating paraffin are regulated by the government through a pricing committee. The number of petroleum service stations is controlled through a 'Service Station Rationalisation Plan' (RATPLAN). The government controls these processes mainly through the Energy Department. Petrol and diesel are the major fuels for the industrial and transport sectors. Prices of petroleum products such as lubricating oil, jet fuel, heavy fuel oil and LPG are controlled by the market. Illuminating paraffin is cross-subsidised because it is considered to be a fuel for low-income groups.

Future developments include the formulation of a Petroleum Act to maintain regulation, the setting of a time-frame for price controls to be removed and the phasing out of the Service Station Rationalisation Plan. The Act will also promote the involvement of indigenous citizens in the oil industry. Discussions are already at an advanced stage to source natural gas from the region, from for instance Mozambique. A pre-feasibility study for a strategic oil reserve was finalised and a feasibility study has already been commissioned to detail the analysis.

(c) Electricity

As depicted in figure 3.2, electricity from the national grid accounts for 7% of the total energy supply in Swaziland. Swaziland imports electricity from South Africa through three 132 kV transmission lines with a total capacity of 96 MW, and a 400 kV transmission line that adds 250MW to the existing capacity. The 400 kV line system imports power from South Africa to an aluminium smelter in Mozambique, via Swaziland.

The 400 kV line is still in the process of being integrated into the local transmission and distribution voltage levels, as part of the ongoing system strengthening initiative. Prior to the 400 kV line, transmission voltages in Swaziland were the 132 kV and 66 kV lines. Distribution is carried out at 11 kV. The 33 kV medium voltages are no-longer used. The integration of the 400 kV line into the national grid will improve the quality of supply to industry, and minimise outages and voltage instabilities. The improved power supply will benefit consumers throughout all spheres of the economy as power outages can result in huge losses of production. For example, small voltage fluctuations during the production of ethanol in the sugar industries can result in having to stop the fermentation process and start afresh. The incomplete fermentation process of molasses has to be thrown away as waste. As a result, the company generates its own electricity for the fermentation process in order to avoid inconveniences with power fluctuations from the national grid.

There are other self-producers of electricity, such as in the sugar belt, paper mills and pulp-producing industries, which contribute significantly to the total electricity supply in the country. Figure 3.3 depicts the various sources of the total electricity supply in the country.

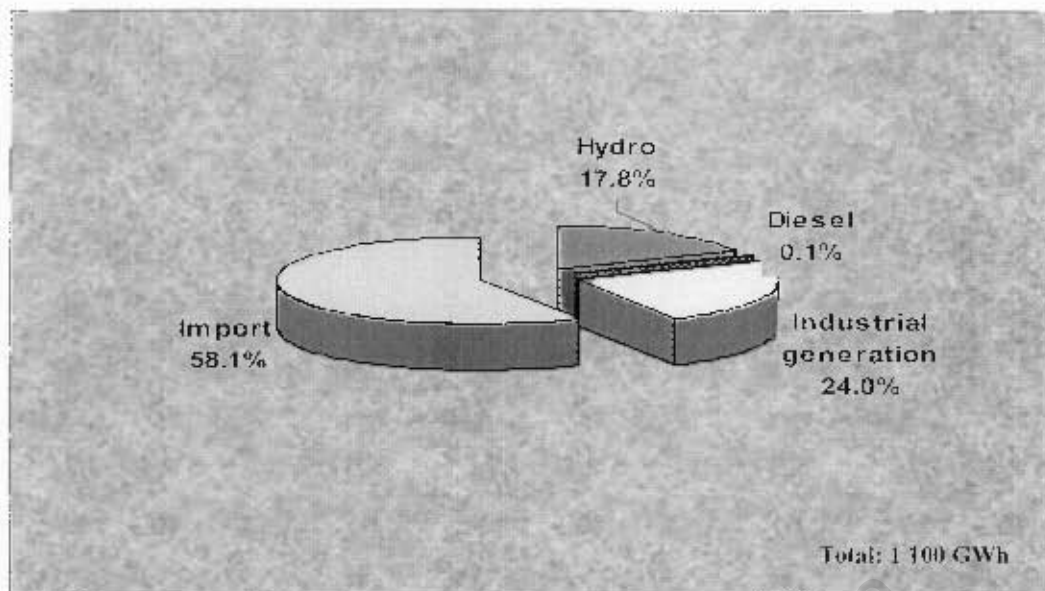


Figure 3.3: Total electricity supply in 1999 (SG, 2003)

Construction of a 19 MW (2 x 9.5 MW turbines) hydropower plant was completed in 2006. The plant will be used for peak lopping, bringing the total installed capacity to 60.1 MW of hydropower; there is also a 9.5 MW diesel generator. The total installed capacity for the national power grid is therefore 69.6 MW. The maximum system demand was 171.6 MW in 2003 (SEB, 2006b). All local power generation for the national grid by the Swaziland electricity Board is used for peaking purposes, which contributes less than 20% of the national electricity system demand. The rest of the power is imported from Eskom, Short Term Energy Market (STEM) through the Southern African Power Pool (SAPP) and EdM of Mozambique.

The SAPP was established in 1995 at the Southern African Development Community (SADC) Summit held in the Republic of South Africa. It comprises twelve SADC countries, excluding Mauritius, and it is represented by the electricity utilities in their respective SADC member states. SAPP's objectives are to increase electricity access in the SADC region and eventually to promote power accessibility in rural communities. There have been changes in the cooperative approach of SAPP towards more competitive markets in the electricity sector. This has resulted in the formation of the Short Term

Energy Market (STEM), where consumers can select supplies of energy in the SAPP region at any time of convenience (SAPP, 2002).

There are also discussions surrounding the establishment of a 100MW bagasse-fired cogeneration plant at Simunye Sugar Company. Natural gas could also be imported from Mozambique to be used in the plant. Other studies include the construction of a 1000 MW anthracitic coal thermal power plant. The major problem is the mining cost of the local coal, which is very high compared to the bituminous coal imported from South Africa, and this will mean that the power generated from this plant will be of a higher tariff compared to the current tariffs from the national power grid.

d) Renewable energy

The major renewable sources of energy in Swaziland are hydropower, commercial biomass and biofuels. Commercial biomass includes bagasse, agricultural waste and wood waste from pulp and wood processing firms. Biofuels comprise black liquor and ethanol and ethanol is obtained from the fermentation of molasses, especially at the sugar producing industries. Hydropower contributes close to 90% of locally generated energy for the national electricity grid (SEB, 2005a).

It is worth noting that the rural population of Swaziland depends largely on firewood. Access to modern energy is very limited. It is this fraction of the population that contributes to land degradation and environmental instability when toiling for basic energy needs, due to the over-harvesting of natural vegetation. As yet, supply statistics of traditional biomass have not been established; the demand is only evident from the extent of the land degradation and desertification taking place, similarly to other under-developed countries in the region.

3.5.2 Energy demand

A division of the final energy consumption for 1999 is shown in figure 3.4, and this is indicative of the national energy demand.

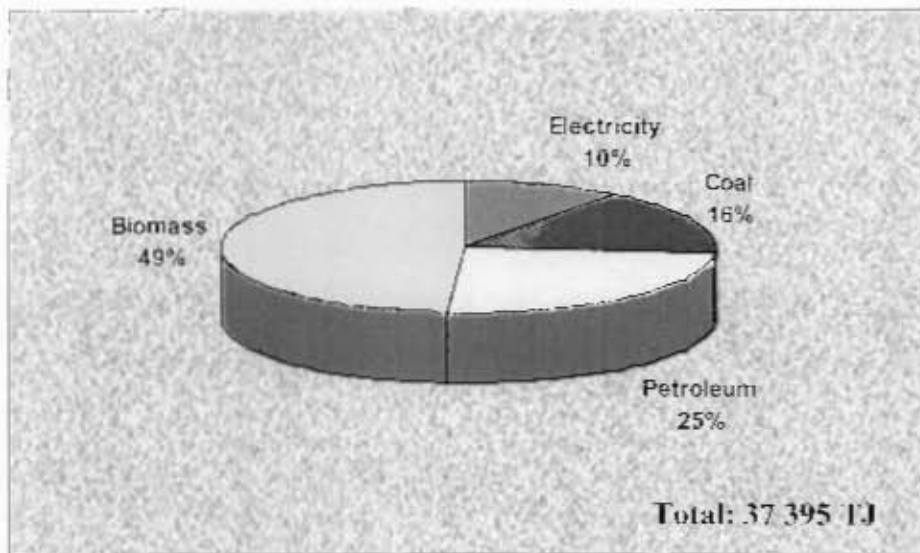


Figure 3.4: Total final energy consumption in 1999 (SG, 2003)

Figure 3.5, shows the distribution of energy demand according to the various sectors (SG, 2003).

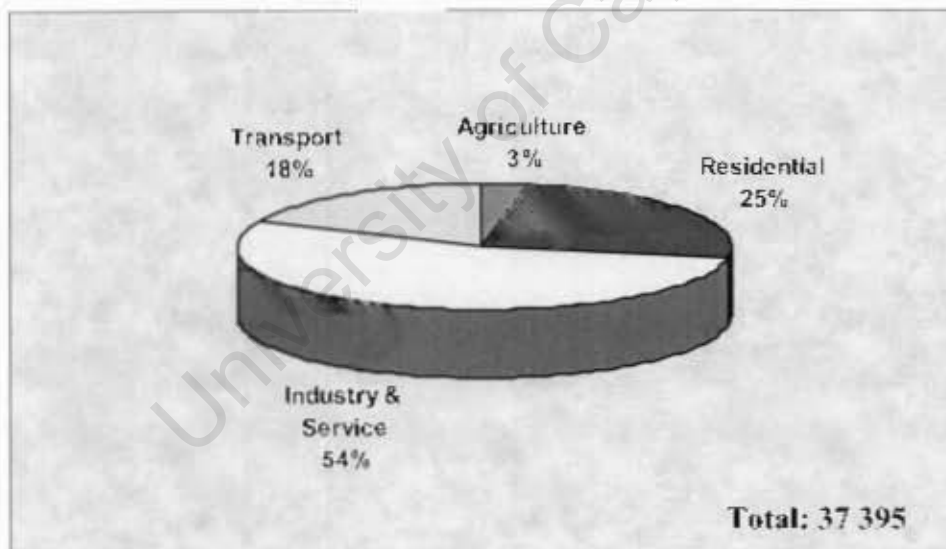


Figure 3.5: Energy demand by economic sectors in 1999 (SG, 2001).

Figure 3.5 indicates that rural electrification could further increase the demand for residential sector.

CHAPTER FOUR

4 LITERATURE SURVEY

4.1 Introduction

Chapter three discussed the conditions under which the rural electrification project takes place. Most of the information in chapter three can be considered background information essential for understanding the processes involved in the implementation of programmes. The development objectives of Swaziland and their prioritisation for implementation, the rural electrification programme and its governance, as well as guidelines for analysing case-studies from other countries form the main contents of this chapter. This chapter discusses the specific issues pertaining to rural electrification in Swaziland and key aspects of its implementation.

4.2 Energy governance and sector reforms in Swaziland

4.2.1 Institutional framework of the energy sector

In 1987, the World Bank conducted an Energy Sector Review for Swaziland; the mission concluded that no specific expertise existed in the area of national energy planning (SG, 1997a). The United Nations showed that comprehensive data is a prerequisite for sound energy planning (UN, 1984). A recommendation was made to bring all energy-related bodies under a single Ministry of Government and to establish an independent Energy Department. In 1989, technical assistance was offered to the Planning Unit of the Ministry of Natural Resources, already in existence since 1985, by the German Agency for Technical Cooperation (GTZ) to collect information on energy issues and to advise the Ministry on energy related matters.

In 1992, an office for energy issues was established in the Ministry of Natural Resources and Energy (MNRE) as an independent unit responsible for all energy related issues. Its *“mission is to ensure the sustainable supply and use of energy for all citizens of the country”* (SG, 1997a).

The Energy Department of MNRE serves as the Government's focal point for policy formulation and operational activities pertaining to the energy sector in Swaziland. This portfolio was established through Legal Notice No.194 of 1996 (SG, 2006). The responsibilities of the department are, inter alia, distribution and marketing of petroleum products, other energy carriers, electricity supply and energy management. Energy is considered to be pivotal in alleviating poverty and stimulating economic growth in the country. The energy department must ensure that the overall development objectives of the government in the energy sector are effectively and efficiently implemented. A national energy policy process was completed in June 2002 (SG, 2003), in line with the objectives laid down in the National Development Strategy (SG, 1999a).

The department consists of five units: the renewable energy section, the electricity and coal section, the energy efficiency section, the data and economy section and the petroleum section.

- The Petroleum section deals with liquid fuel issues.
- The Data and Economy section is responsible for energy planning, energy data collection and analysis. This includes production and distribution of statistical information.
- The Renewable Energy section is in charge of new and renewable energy issues.
- The Electricity and Coal Unit focuses on the electricity supply industry, coal and gas utilisation, as well as rural electrification issues.
- The Energy Efficiency section concentrates on energy efficiency and demand side management issues in Swaziland (SG, 2002, 2004a).

In order to achieve its goal, the Energy Section initiated, monitored and evaluated various pilot projects and feasibility studies in the energy sector. The projects entail solar energy utilisation, rural electrification and molasses-based bio-fuel production, energy management and electricity supply options, which were carried out to obtain

the technical and economy information required to guide energy policy formulation. The Energy Section developed an energy database of energy demand, supply patterns, energy prices, energy reserves, energy technologies and the effects of energy activities on the environment. The collected information dates back to 1976 for most of the economic sectors of Swaziland (SG, 1997a).

Global and regional developments in the energy sector necessitated the formulation of appropriate energy policies to guide the developments of the energy sector in Swaziland. Its energy policies had to comply with regional and international initiatives in the energy sector aimed at encouraging globalisation and energy market reforms and its policies had to observe environment conservation, poverty eradication and stimulate economic growth. Swaziland is party to a number of international conventions and agreements (SG, 2003).

4.2.2 Energy policy formulation

In 1997, the Ministry of Natural Resources and Energy embarked on preparations for the formulation of a comprehensive national energy policy. The formulation of the energy policy was part of a response to the country's commitment to regional cooperation. The Southern African Development Community (SADC) Energy Protocol urges Member States to develop national energy policies that will enhance energy cooperation and integration in the context of the principles of the SADC Energy Regional Cooperation Strategy and Policy (SADC, 1996).

The policy formulation project came into effect in August 1999 and this signalled the start of the Swaziland National Energy Policy Project (SNEPP).

The Swazi Government's development goals and policy formulation were supported by the Government of Denmark, through the Danish Cooperation for Environment and Development (DANCED). The process was a consultative and participatory activity with a comprehensive involvement of stakeholders and decision-makers.

The Energy Department created an expert dialogue process with national, regional and international consultants to make informed decisions on the policy document. Contributions from national stakeholders comprised contributions from the different economic sectors of the country, including rural areas. Consultations with decision makers took place through workshops, interviews and questionnaires.

Collective contributions from stakeholders and the government's development aspirations resulted in the statement of the National Energy Policy vision (SG, 2003):

“Ensuring that the development goals of the country are met through the sustainable supply and use of energy for the benefit of all citizens of the country”

The policy is emphatic on affordable energy and efficient use of natural resources, whilst raising appropriate concerns for environment. The prime objectives of the National Energy Policy are to (SG, 2003):

- i. Ensure access to energy for all
- ii. Enhance employment creation
- iii. Ensure security of energy supply
- iv. Stimulate economic growth and development
- v. Ensure sustainable environment and health.

The identified objectives structure the policy document into demand sectors, supply sectors, rural electrification, cross-cutting issues and basis for implementation. Alongside the energy formulation process was the formulation of a rural electrification policy (SG, 2003).

4.2.3 Energy sector reforms in Swaziland

International trends and developments necessitated the restructuring of the electricity supply industry in Swaziland. The main activities were (SG, 2006a):

- Amendment of the Electricity Act of 1963
- Formulation of the Swaziland Electricity Company (SEC) Act

- Formulation of the Energy Regulatory Authority Act.

Liberalisation of the electricity supply industry aimed to allow new players into the sector, to stimulate competition and improve economic efficiency in the industry. The Swaziland Electricity Company Act (SG, 2006b) transforms the Swaziland Electricity Board from a parastatal into a company, wholly owned by the government and this removes the monopoly in the electricity supply industry. The regulatory authority Act (SG, 2006c) establishes a new body to regulate activities in the energy sector.

The three power sector reform legislations were enacted into Acts of Parliament in 2006. The Swaziland Electricity Company Act of 2006, assented by His Majesty King Mswati III, establishes the company under the Companies Act and Performance. The Swaziland Electricity Company (SEC) will assume all duties and powers conferred to Swaziland Electricity Board (SEB), as well as activities thereof; generation, transmission, distribution and supply of electricity and for matters associated therewith. The SEC Act will be effected once the SEC has been registered as a company. Currently, the government is processing the registration of the SEB as the SEC (SG, 2006b). The Electricity Act of 2006 (SG, 2006d), is an ‘Act to reform and consolidate the law regulating the generation, transmission, distribution and supply of electricity and to provide for matters incidental thereto.’ It amends the Electricity Act of 1963 (SG, 1963).

The Energy Regulatory Authority Act of 2006 established the Energy Regulatory Authority and provided for matters incidental to the authority. Currently, the Swaziland Electricity Board is responsible for handling licensing and electricity tariffs issues. This makes the SEB both a player and a regulator in the electricity supply industry. The regulatory authority is further tasked with enforcing compliance standards, approving tariffs, adjudicating concerns from consumers and promoting economic efficiency in the energy industry (SG, 2006c).

The institutionalisation of the energy regulatory authority is yet to be decided. One option is to have a multi-sector regulator that will accommodate water,

telecommunications, railway, media, energy, etc. The energy regulatory unit may comprise petroleum, electricity, gas (after the import of natural gas from Mozambique, etc). Alternatively, the regulated sectors may be established as independent single sector regulators. The route for the establishment of the regulatory regime in Swaziland is still to be devised in collaboration with the Public Enterprise Unit under the Ministry of Finance. Currently, refined petroleum products (petrol, diesel and paraffin) are regulated by government through the Energy Department of the Ministry of Natural Resources and Energy, in consultation with the oil industry.

4.3 Development objectives for Swaziland's energy sector

4.3.1 Macro-economic development objectives of government

Swaziland's macro-development policies and objectives are coordinated by the Ministry of Economic Planning and Development (MEPD), for all sectors of the economy. The different Ministries of the government systems can have their own micro-development policies, which have to be in line with the overall strategies coordinated by the MEPD, preferably with the respective development objectives of the other Ministries.

MEPD is coordinating a twenty-five (25) year National Development Strategy (NDS), spanning the years 1997 to 2022. The NDS (SG, 999a) seeks *"to uplift Swaziland to the top 10% of the medium development group of countries by the year 2022."* The strategy prioritises developments such as 'food security, human settlements and shelter, safe water and sanitation, health, social security and gender equity.' In addition, it encourages stimulation of economic growth through efficient utilisation of and equitable access to natural resources, the development of infrastructure, research and innovation. Poverty reduction takes the central focus of the NDS (SG, 999a).

Under Fuel and Energy, the objectives of the NDS are to (SG, 1999a):

- *"ensure improved access to a range of energy services for the whole population in urban, peri-urban and rural areas,*

- *make electricity available and affordable in rural areas so as to improve socio-economic development and welfare, and*
- *ensure sustainable wood fuel management.”*

The draft Poverty Reduction Strategy and Action Plan (PRSAP) is the overarching policy statement for alleviating poverty and other related challenges. Approximately 76% of the rural population lives below the poverty line²; one of the prime objectives of the strategy is to reduce the poverty statistics to less than 50% by the year 2015, and to eradicate poverty by the year 2022 (SG, 2005a).

The poverty reduction strategy identifies the following pillars for policy frameworks (SG, 2005b):

- *“macro-economic stability*
- *rapid acceleration of economic growth based on broad participation*
- *empower the poor to generate income and reduce inequalities*
- *fair distribution of the benefits of growth through fiscal policy*
- *improve the quality of life of the poor*
- *improve good governance and strengthen institutions.”*

The PRSAP document details the country’s macroeconomic, structural and social policies, programmes to promote growth and reduce poverty, as well as associated external financing needs. The fundamental reforms in development approach are required to achieve this goal. In light of the above motivation, rural electrification becomes a high priority issue in Swaziland.

4.3.2 Rural electrification objectives of the responsible ministry

The rural electrification objectives laid down in the White Paper are (SG, 2003) to:

- *“support the development of rural areas in the country in a sustainable manner;*

² The poverty line is 128 SZL/ZAR (7ZAR ≈ 1US\$)

- *promote the productive use of electricity in rural areas in order to facilitate socio-economic development;*
- *improve living conditions by satisfying the basic needs of electricity supply;*
- *promote electrification of public facilities in order to facilitate the delivery of services to rural areas;*
- *provide access to electricity to as many homesteads as possible in order to slow down the rate of wood fuel consumption;*
- *improve the social gap between rural and urban communities in order to limit migration; and*
- *contribute towards poverty alleviation.”*

The rural electrification objectives are part of other development strategies of the government system (SG, 1999a).

The Energy Policy dictates that the government must come up with a Rural Electrification Master Plan, which should detail the implementation framework. The objective of the Master Plan is to detail methods by which the vision of the government, in which it desires that every citizen must have access to modern energy by 2010 (SG, 2003) and access to electricity for all by 2022 (SG, 1999a). Consequently, a rural electrification agency will be established in order to implement and monitor rural electrification in Swaziland. It is the eventual policy of the government to establish a dedicated fund to support rural electrification.

4.3.3 Objectives of Swaziland Electricity Board

The Swaziland Electricity Board (SEB) implements funded rural electrification programmes and the normal rural electrification projects from either individual customers or group schemes. The non-funded projects pay the full capital costs; other projects are partially funded by various organisations.

It was discovered that capital funding for the community group schemes could speed up the uptake of electricity services – thereby improving the quality of rural life.

Communication with SEB indicated that there are currently no clear policies for the expansion of rural networks. The utility has yet to devise a mechanism and guidelines for prioritising rural projects. (SEB, 2007).

4.3.4 Objectives of other ministries

The Ministry of Housing and Urban Development is currently coordinating Regional Physical Development Plans (RPDP) for the four administrative districts of Swaziland: Hhohho, Manzini, Lubombo and Shiselweni. The integrated resource planning comprises the development of infrastructure for the delivery of essential services and the stimulation of socio-economic growth. The RPDP programme started with a background study detailing the situational analysis of the respective districts (SG, 2007a); the analyses were followed by a development plan (SG, 2007b) and a comprehensive implementation plan (SG, 2007c). The reports entrust the respective Ministries to facilitate the RPDP developments in its portfolio. The Energy Department of the Ministry of Natural Resources and Energy is responsible for energy development issues, which include rural electrification.

4.3.5 Prioritisation of the development objectives

To meet the aspirations of the government, policy objectives were prioritised into short term, medium term and long term objectives. The detailed policy statements are grouped according to the five objectives, reiterated below.

- i. Ensure access to energy for all
- ii. Enhance employment creation
- iii. Ensure security of energy supply
- iv. Stimulate economic growth and development
- v. Ensure sustainable environment and health.

The objectives are compliant with requirements of the National Development Strategy (SG, 1999a). The priorities are subject to regular reviews and may change from time to time, in accordance with the needs of the society. Short-term goals are considered to be within five years; medium-term goals are between five to ten years and government's long-term objectives are those that span over ten years

(SG, 1999a, 2003). The prioritisation structure of the objectives was extracted from the National Energy Policy document of 2003 (SG, 2003).

a) Short-term priorities

The short-term priorities of government follow below (SG, 2003).

i. Ensure access to energy for all:

- Develop a Rural Electrification Master Plan
- Provide electricity to all schools, clinics and essential public institutions in rural areas and facilitate the reticulation of services for domestic dwellings
- Develop a mechanism that will make prices affordable to rural areas
- Develop effective means of ensuring adequate access to energy services throughout the country, including financing systems
- Establish new electricity and regulatory legislation for liberalising the electricity supply industry
- Establish a detailed inventory for mini and micro hydro power sites and ranking of the sites with the highest potential
- Develop a conceptual framework on how to use sustainable energy to tackle poverty.

ii. Enhance employment creation:

- Facilitate the energisation of rural areas and create small–medium enterprises (SMEs) to assist locals gain entry to the energy industry.

iii. Ensure security of supply:

- Participate in the Southern African Power Pool (SAPP) to benefit from the increased electricity trade in the SADC region
- Maintain co-operation with regional and international bodies dealing with energy.

iv. Stimulate economic growth and development:

- Improve energy governance and institutional capacity framework to implement the Energy Policy
- Establish an Energy Regulatory Authority (ERA)
- Establish fully transparent and cost reflective electricity tariffs
- Liberalise the Electricity Supply Industry and investigate the various commercialisation opportunities for the utility
- Establish infrastructure in the country to encourage cooperation in the Clean Development Mechanism (CDM) developments and other similar arrangements
- Develop an annual energy policy statement targeted at stakeholders, politicians, investors and the general public, to be published by the Minister.

v. Ensure sustainable environment and health:

- Develop programmes promoting the utilisation of renewable energy resources
- Encourage a wider use of solar water heaters in residential and commercial buildings
- Formulate and implement programmes on awareness raising and information dissemination on energy savings.

b) Medium-to-long term priorities

The medium/long term priorities of the government are as follows.

i. Ensure access to energy for all:

- Ensure that there is adequate access to all appropriate forms of energy
- Develop sustainable financing mechanisms for the extension of the electricity grid throughout the country
- Facilitate and promote the adoption of sustainable energy options in an effort to assist low-income households
- Ensure that energy prices for low-income groups take into consideration affordability to ensure access to energy for all.

ii. Enhance employment creation

- Encourage the promotion of entrepreneurship in co-operation with players in the energy sector.

iii. Ensure security of supply:

- Establish a comprehensive study to evaluate the future energy supply options
- Develop and implement demand side management
- Promote and take full advantage of regional co-operation and ensure the development of legal, regulatory and institutional frameworks that comply with regional agreements.

iv. Stimulate economic growth and development:

- Introduce and encourage competition within energy markets
- Establish regulations for energy management programmes for Government institutions.

v. Ensure sustainable environment and health:

- Review and update the Renewable Energy Action Plan every five years
- Promote efficient and environmentally benign technologies for utilisation of indigenous resources for electricity production
- Monitor and assess the appropriateness of present legislation to ensure the health and safety of the population.

4.4 The rural electrification programme in Swaziland

4.4.1 Development of the rural electrification programme

In the mid-1990s, the Ministry of Natural Resources and Energy (MNRE) commissioned a rural electrification study. The study was divided into three phases:

- Phase 1 - Technical and financial analysis (SG, 1998)
- Phase 2 - Cost benefit analysis (Jansen *et al*, 1997)

- Phase 3 - Policy formulation (Davis *et al*, 1997).

Most of the data was collected during Phase 1 and analysed using a Land Information System in order to facilitate planning of the project. Phase 2 analysed the socio-economic implications of rural electrification in Swaziland. The third phase focused on the formulation of rural electrification policies and guidelines, in line with the findings of the studies in the previous phases.

Phase 1 was completed in September 1998. The phase 1 report made several recommendations for the MNRE on (SG, 1998): data collection, mapping for Swaziland, existing electricity network, electrification planning, load forecasting, master-planning, capital expenditures for rural electrification and financial models. A financial model to be followed by SEB was devised, during the study. The Ministry of Natural Resources and Energy needs to use the financial model to determine the appropriate funding mechanism for rural electrification, for example, grants, concessionary financing, government financing and commercial loans. The effectiveness of tariff levels and expenditure programmes should also be evaluated using the financial model.

Certain conditions have to be considered in rural electrification (SG, 1998):

- Rural electrification programmes must only be effected if subsidies will be used during the first ten years, so that the programme sustains itself thereafter.
- Capital funding should only be sourced from grants and concessionary funding. Free market financing is usually too expensive.
- The electrification monitoring committee must devise a way of minimising losses in the process; technical and financial losses.
- The rural electrification programme requires a cost effective operation and maintenance programme, as it has great effect on the financial viability of the system.
- The tariff structures at a national level must support rural electrification programmes.

- It is evident that the connection costs for rural electrification are relatively high; research and development are required to work on reducing the costs to appropriate levels for rural communities.
- Connection costs must also be reduced to encourage increased take-up in rural areas.

Most of the recommendations of the phase 2 report are included in the phase 1 and phase 3 reports of the rural electrification study. The phase 3 report had recommendations on:

- The 11 kV distribution line extension
- Reticulation programme
- Institutional issues
- Electrification planning
- Rural development initiatives
- Optimisation of rural electrification projects
- Off-grid electrification options.

The phase three report recommended that the distribution network for rural electrification should be implemented by the SEB and financed by the government through direct fiscal budgets, as capital projects and through cross-subsidies from non-domestic customers of SEB.

On reticulation, the study recommended that areas to be reticulated should be prioritised. Two tariff options would be applicable to the rural electrification programme. The first option is for the domestic customers to pay the full cost of reticulation upfront. The second option is to discount US\$ 300 from the cost of reticulation, and then add on a 30% surcharge to the energy tariff to recoup the initial discounted cost. In this case, the government must source the loans for the reticulation process to materialise. Government would thus bear the risk of repayment if the revenue from the 30% surcharges fails to recover the loan.

On the other hand, non-domestic users would pay the full cost of reticulation as an upfront payment, and would then be charged on standard tariff rates. The foreseeable cost would be increased operation and maintenance costs, which could be recovered by rebalancing tariffs.

On institutional issues, the planning and prioritisation of the rural electrification programme should be carried out through committees. A select committee on rural electrification (SCORE) would oversee the following functions in the electrification programme (Davis *et al*, 1997):

- Planning
- Information collection for line extension projects
- Monitoring of funds for line extension
- Evaluation of applications for grid extensions
- Monitoring of rural development initiatives with the aim of stimulating economic activities.

Rural development initiatives entail identifying rural services, such as rural health-care centres and schools. Physical infrastructure for services and rural water schemes also needs much attention for electrification to benefit the public. Some telecommunication repeater-stations need electricity, rather than solar panels currently used, which are less reliable during inclement weather conditions.

The rural electrification planning committee needs to liaise with the Ministry of Housing and Urban Development over the country's National Physical Development Plan (NPDP), which has developed a classification system for rural centres for future economic growth potential. The study underlines the need for involving businesses in marketing products that could be used by customers in electrified areas (SG, 1999b). Load management strategies have to be considered in order to control costs due to rural load factors.

The phase three report further outlined some off-grid technologies for areas remote from the electricity grid. These include solar systems and diesel generators. However, the off-grid electrification options bear very high capital investment and are not as reliable and preferred as grid electricity (Davis *et al*, 1997).

4.4.2 Implementation of rural electrification

The Energy Department of the Ministry of Natural resources and Energy started rural electrification through small-scale pilot projects, involving grid extensions and off-grid systems from the early 1990s. Grid electrification projects were carried out in co-operation with the Swaziland Electricity Board (SEB). The SEB is the only electricity parastatal in Swaziland (SG, 1963) and, as such, is the implementing agent for grid electrification. Prioritisation of appropriate target areas is done by a committee of stakeholders, known as the 'Select Committee on Rural Electrification' (SCORE). The committee comprises government officials, implementing agencies and other stakeholders in rural electrification (SCORE, 2003).

The rural electrification programme at the SEB is currently under the Executive Management Unit in the Managing Director's office. The rural electrification office comprises the rural electrification manager only. The rural electrification manager:

- participates in the SCORE meetings,
- estimates project costs,
- participates in tender evaluations, especially for line constructions,
- oversees the procurement of rural electrification material,
- compiles timeous progress and completion reports submitted to the Energy Department, which form part of the MNRE's reports to the line ministries, etc.

The rural electrification officer is sometimes assisted by the technicians from the SEB's regional offices; the technicians are not engaged on a full time basis to the rural electrification processes. The deficient staff in the rural electrification office sometimes affects the implementation process of the electrification programme (SEB, 2006f).

In line with the rural electrification policies, the electricity lines are routed through ‘densely populated, re-settled areas and areas with high potential for development’ on the way to the target areas; these include rural schools, health-care and rural development centres, etc. The proximity of the electricity line to the communities aims to reduce connection costs and thereby encourage optimal access and use of the electricity lines (SG, 2003; 2005c).

The Ministry of Education submits the list of schools for prioritisation to SCORE; the Ministry of Health and Social Welfare compiles the list of clinics and health-care centres; the Deputy Prime Minister’s Office submits the list of constituency (tinkhundla) and development centres for electrification. Other relevant stakeholders submit qualifying institutions for rural electrification through MNRE.

Rural electrification donor funds are controlled by the Ministry of Economic Planning and Development, as a liaising ministry with donors; these funds are managed by the Ministry of Finance. The Ministry of Natural Resources and Energy, through the Energy Department, applies for the disbursement of funds to the Swaziland Electricity Board for implementation of rural electrification programmes (SG, 1999a).

Mass electrification of rural areas started in the year 2000, when the Government of the Kingdom of Swaziland received grant funds from the Government of the Republic of China and Taiwan (SEB, 2002). The financial assistance is part of a bilateral agreement between the two governments (SG, 1997c):

“The overall objectives pursued under the Protocol are to enhance relations between the two countries, to achieve sustainable socio-economic development, to raise the standard of living and improve the quality of life and, in the long term, to promote peace and national stability in the Republic of China and the Kingdom of Swaziland.”

The rural electrification project was divided into several phases to allow control of the implementation process. Phase three of the grant-funded rural electrification

programme was completed in February 2006 (SEB, 2006a). According to the SEB's 2005/2006 annual report, phases one to three of the mass electrification project resulted in the electrification of 16 077 households, 250 schools and 25 clinics and rural development areas, as detailed in table 4.1.

As part of capacity building in the country, the SEB controls the network development of the project, material procurement, network designs, installations and constructions (SEB, 2004a, 2006c, 2006d, 2006e). According to the memorandum of understanding between the MNRE and the SEB, funds would be disbursed against invoices, which is the rule in the General Orders of Government for all payments due from the government. The MNRE negotiated with the other line Ministries for an upfront disbursement against quotations submitted by the SEB for projects in a phase (SEB, 2003a, 2003c).

Table 4.1 Mass rural electrification beneficiaries (SEB, 2006b).

Phase	Households	Schools	Other*
1	6,250	71	11
2.1	5,127	80	7
2.2	2,645	48	5
3	2,055	51	2
Total	16,077	250	25

* Clinics, rural development areas, etc.

Cost savings from the previous phases of the project funds finance subsequent phases and stages in the project.

From 2004, the MNRE started financing the rural electrification programme as a capital project through its fiscal budget (SG, 2004b). An annual budget of three million Emalangeni (SZL) is disbursed to the SEB for rural electrification. The Deputy Prime Minister's Office is another source of funding for rural development. These funds primarily help rural community projects, including electricity group schemes.

There is another participatory programme funded by the European Union (EU) – Micro-projects, under the Ministry of Economic Planning and Development, where beneficiaries contribute 25% of the investment and the remainder is funded by the EU. The community contribution could be in the form of labour costs or other means. This programme is not limited to rural electrification; it is open to all forms of development projects in rural areas, such water schemes, dip tanks, etc.

In an effort to promote access to electricity for rural communities in areas in the vicinity of the grant-funded electrification programme, the SEB board of directors agreed on a connection charge of three thousand Emalangenzi (approximately US\$ 500). The connection charge is for communities within a radius of one kilometre from the electricity line that is funded through grants or government budgets, for single phase supplies; small commercial users are charged 25% of the capital investments (SEB, 2005b).

When the electrification of institutions in rural areas is almost complete, the SCORE may target rural electricity group schemes. These are communities that come together and apply for a collective quotation of electricity supply. The fees are then broken down per customer in the group scheme. Members of the group schemes must advance 40% of the total capital investment to the SEB, before applications from individual members of the group scheme can be considered. However, some members of the group schemes cannot afford to pay in time, and that delays the other members who want to use the service expediently. Discussions between the government and the SEB aimed at sourcing funds for group schemes are said to be at an advanced stage (SG, 2007).

An observation from this research and interaction with rural communities is that the decision taken by the Board of Directors of SEB is not currently being implemented by the technicians of the agency of the SEB. This is blamed largely on lack of communication amongst senior management, policy makers and technicians of the SEB. The project continues to target rural schools, health-care centres and rural development areas.

4.4.3 Electrification technologies

The common designs for the SEB's distribution network comprise the conventional 11 kV voltage, with either a three-phase or a single-phase system, depending on the electricity demand. The mink and gopher conductors are used in the distribution networks. The low voltage (LV) is reticulated at 400V and 230V for single phase supplies. This design is used throughout the country's economic sectors for residential use, as well as for urban, peri-urban and rural electrification.

The rural electrification programme finances the cost of providing the infrastructure, including the reticulation of low voltage at the beneficiaries' premises. However, the beneficiaries have to pay for the connection costs and the programme does not include electrical wiring of buildings. The slow take-up of electricity services caused due to unwired buildings is dealt with through the use of ready-boards. The ready-boards enable consumers to use the electricity while still carrying out electrical wiring of buildings. The wiring of public structures and other public residential quarters is not part of the rural electrification programme. Government buildings are owned by the Ministry of Public Works and Transport (MoPWT) and the electrical wiring of such buildings is monitored by the MoPWT.

4.4.4 Electricity tariffs

The SEB is responsible for setting electricity tariffs. Currently, the SEB imposes electricity tariffs without the interference of any other body. The tariffs are not fully transparent and cost reflective, and the SEB charges different tariffs for different economic sectors. Table 4.2 shows the 2004 electricity tariff structure.

Table 4.2: SEB's electricity tariffs in 2004 (SEB, 2004b)

	Type	Facility charge (E/Month)	Energy charge (E/kWh)	Demand charge (E/kVA)	Minimum charge (E/Month)
S1	Domestic	7.86	0.4147	-	31.12
S2	General purpose	7.86	0.5516	-	107.21
S3	Small commercial	7.86	0.5516	-	107.21
S4	Off-peak water heating	7.86	0.2943	-	54.02
K5	Commercial and industrial	7.86	0.2130	67.79	Cf: Interpretation
K6	Irrigation	7.86	0.2130	67.79	Cf: Interpretation

Interpretation of tariffs

The tabular (table 4.2) information on tariffs is interpreted in table 4.3 (SEB, 2004b). The tariffs are revised every year, to capture effects inflation, operation and maintenance costs. The Swaziland Electricity Board's financial year starts from April to March the following year. It is similar to the government's fiscal year. As long as the SEB is a parastatal or government company, it would be easy for it to align government-funded projects, such as rural electrification, with the budgeting period of the government.

Table 4.3: Interpretation of SEB's electricity tariffs (SEB, 2004b)

Type of tariff	Tariff interpretation
Domestic	Supply of electricity to residential areas, including electric machinery with a power rating up to 2 kVA.
General purpose	Supply of electricity to areas not falling under any defined tariff categories, such as community halls with a demand that is up to 20kVA. These areas are normally only occasionally used.
Small commercial and industrial	Provision of electricity to commercial areas, public areas, farms, etc, with a demand that does not exceed 20kVA at any time of the year.
Off-peak water heating	Charged to areas used for heating water where the demand for the installed capacity of the equipment is at least 9MW and where the supply is required for at least 1.5 hour per time of use. The heating periods may be twice a day.
Large commercial and industrial	Supply to customers with a demand of at least 20kVA at any time of the year. The demand charge is calculated per kVA recorded every respective month of the year. The energy tariff is the number of units the consumer uses per month measures in kWh.
Irrigation	Supply of electricity to agricultural or farming facilities with a demand of at least 20kVA. The demand charge is based on the maximum kVA recorded in six-month periods.

4.5 Key aspects in international rural electrification policies

4.5.1 Institutional frameworks and processes

Subsidies and cross-subsidies may diminish as a result of power sector reforms. Guidelines for effective rural electrification programmes have to be considered. The roles of government and proper institutionalisation, including legal issues, have to be well-defined for rural electrification programmes to be successful. (Haanyika, 2005; World Bank, 2004a).

The following guidelines have been found to be key aspects in international rural electrification policies, required for the success of programmes

(World Bank, 2004b; GNESD, 2004c):

- Ring-fencing of rural electrification funds
- Legal and institutional frameworks (responsibility assignment)
- Technology innovations
- Tariff designs (affordability, cost causations).

Institutions entail the establishment of a rural electrification agency/authority, a regulatory authority, rural electrification agencies and incentives for the implementation of programmes. The utilities must have access to electrification funds arranged by the government and be able to recover their investments from tariffs. For instance, in Chile, the implementation of the rural electrification programme was decentralised to local governments in the various administrative regions, where funds were disbursed by the central government upon presentation of appropriate rural development plans. Incentives were provided for the implementing companies. This resulted in accelerated access rates to modern energy in the rural areas (Jadresic, 2000).

Subsidies must not be used for consumption, such as life-line tariffs; subsidies should be used for expanding networks and stimulating income generation from the establishment of micro-businesses. The government can finance the programmes through fiscal budgets and attraction of investors to engage in micro-financing. The funds must be 'ring fenced' to avoid misappropriation to other commitments (ESMAP, 2005; Foley *et al*, 2004; GNESD, 2006b).

The government must encourage employment creation and capacity building by involving rural communities in the electrification programmes. If deemed feasible, local service companies can be engaged in the implementation of rural electrification, in a similar manner to the rural electric co-operatives in the Tennessee Valley Authority programme (Zomers, 2001). Care must be taken over compliance standards and the concerns of the system operator, in order to avoid conflicting interests.

4.5.2 Cost causalities

Consumers must be protected from unjust tariffs by proper regulatory authority. This involves the pass-through of costs from the power purchase agreement to captive customers or beneficiaries; these costs may be the result of power sector reforms. System operators are sometimes inefficient in procurement of services and could burden the consumers with irresponsible cost causalities. According to the World Bank (2004b), pass-through costs can be regulated using the following methods.

a) Full pass through:

This method is determined by the government and the regulator, in cases where the company has no control over volumes, prices, risk allocation or choice in power procurement.

b) The review of energy and power contracts:

This could be carried out before (*ex ante*) and after (*ex post*) the signing of a contract. The regulator determines the costs to be passed through. It may allow some or reject all of the costs to be passed onto the consumers. The *ex ante* is conducted to verify compliance with the electricity laws. The *ex post* is conducted in the event of there being a suspected element of malpractice or corruption.

c) The methodology of administratively set benchmarks:

This method involves setting benchmarks against which the performance in investment and the operating costs are gauged. Controversy may arise since the benchmark may be politically driven.

d) Multi-market benchmarks:

This is based on power trades between generation and distribution companies. The regulator sets a benchmark based on the traded price. If the company procures power at a lower cost than the benchmark, the difference is kept by the company as an incentive. If the cost is above the benchmark, the company is not allowed to recover the extra costs from tariffs. This promotes efficiency in procurement.

e) Mandated competitive procurement:

In this case, the cost is mandated for the distribution companies. Full pass-through to the beneficiaries is allowed by the regulatory authority.

The methodologies for controlling pass-through costs are not an exhaustive list. The regulatory authority must ensure cost-reflective tariffs or rebalancing of tariffs. Cost-reflective tariffs play a major role in energy efficiency and energy management for the domestic sectors, as well as other commercial sectors in relocating loads in the system – especially during peak hours. ‘Economists are disdainful of cross-subsidies because of inefficiencies and distortions in the process; it tends to complicate the system. Policy-makers must strategise their pro-poor policies for minimal inefficiencies and distortions’ (Sotkiewicz, 2005).

Estache (2004) argues that cross-subsidies can be handled with minimal distortions and are applicable to other development objectives, particularly rural electrification. This is true when cross-subsidies are used for subsidising infrastructure development. The rural electrification agents serve on behalf of the government in detailing such activities as planning projects, coordinating finances, managing programmes, liaising with stakeholders and the regulatory authority.

4.5.3 Utility regulation and tariff design

Regulation in power sector reforms is required to govern the conduct of players in the market, whilst ensuring a balance for social developments. Sector reforms involve structural changes and/ or privatisation of vertically integrated state-owned enterprises into small and manageable entities; sometimes small units may have to be grouped together to form a single entity. In the power sector, vertical unbundling or de-verticalisation entails separating the industry into generation, transmission and distribution units.

The World Bank (2004a) cautions against the unbundling of small utilities and advises that it could be more efficient to regulate the vertically integrated system, with minor adjustments in the operation of the entity. Full unbundling is recommended for medium

to large companies, in order to introduce better competition in both generation and distribution areas. It should strongly be emphasised that most developing countries reform their sectors in flagging economies, weak political and institutional frameworks, deficient human resource capacities and regulatory experience. As such, the reform process is likely to be inefficient and ineffective; the implementation of socio-economic programmes is prone to failure (Jamab, 2002).

The World Bank believes that without proper regulation policies, power sector reforms will not succeed (World Bank, 2004b). Social developments are services where the beneficiary does not normally pay for capital investment – such beneficiaries would include schools, clinics and other service centres for the public (Judge, 1980). Stakeholder representation needs to be considered during tariff adjustments in order to minimise political tensions (Clark, 1991).

Complications in the performance of state-owned enterprises and the need to develop infrastructure in a competitive way necessitated the introduction of regulation of essential industries and service providers.

Other drivers for reform in developing countries entail the following (Kidokoro, 1998; Martinot *et al*, 2000):

- Encouragement of economic efficiency in investment and operation of businesses
- Economic restructuring to define government roles in macro-economic activities
- Technology innovation for economies of scale and economies of scope
- Limiting of political influence
- International pressure from proponents of market reforms.

Competition in the industry may either encourage new investors to enter or force existing players to exit the market.

a) Methods of utility regulation

The regulatory body can pursue a number of regulatory methods, in accordance with the industry or regulatory environment; energy (electricity, petroleum, gas, etc), telecommunications, water, etc. Some of the common regulatory methods are:

- i. Rate of return regulation
- ii. Price cap regulation
- iii. Revenue cap regulation
- iv. Regulation by contract
- v. Benchmarking or yardstick regulation
- vi. Target performance based regulation
- vii. Sliding scale/ sharing regulation
- viii. Hybrid regulation.

Every model of regulation is considered to be an incentive.

i. Rate of return regulation:

In rate of return regulation (RORR), the regulator sets the tariff in such a way that the regulated company covers the operating costs plus a determined rate of return on investment. RORR is appropriate if the regulator wants to know the firm's assets, attract investors and maintain stable profits. However, there is a risk of inefficient over-investment and consumers bear most of the market risk (Nwaeze, 1997; Martinot *et al*, 2000). The RORR is sometimes termed 'cost of service' or 'cost-plus' regulation in the sense that it allows the utility to cover its solvency plus cost of service, based on a 'reasonable' return on capital investment. The expenses include certain taxes and depreciation.

ii. Price cap regulation:

Latin America provides some of the best references in terms of efficiency effects of ownership and regulatory reforms. It is approximated that one third of the countries in this region adopted price cap regulation (PCR), one third still use rate of return regulation and the rest use hybrid regulation (Estache *et al*, 2004). Treasury economist, Stephen Littlechild, in the United Kingdom, designed price cap regulation. This method has been

adopted by many countries, including Brazil and Argentina for their network companies. It contrasts with the RORR, in the sense that inflation, that is the Consumer Price Index (CPI), is used to estimate the price. CPI is synonymous with the RPI in the United Kingdom, the Retail Price Index. An efficiency factor X, termed the X-factor, is used during price estimates, so that the term becomes (CPI-X). In price cap regulation, prices are therefore not dependent on a target rate of return.

The next price adjustment (P_{t+1}) is calculated from the current price (P_t) using equation 4.1.

$$P_{t+1} = P_t + P_t (CPI_t - X) \quad \text{Equation 4.1.}$$

The term 'CPI_t' denotes the current inflation adjustment for some efficiency gain of X. Care must be taken when determining the X-factor. If the value of X is too small, the regulated firm will earn excessive profits; the regulator risks political support for the regulatory regime. On the other hand, if the value for X is too high, then the financial standing of the regulated company is jeopardised (Bernstein *et al*, 1999).

Since the prices are capped, it incentivises utilities to reduce costs and increase operational efficiency. The shareholders bear the market risk – thereby shifting market risk away from consumers, at least in the short- to medium-term. On the other hand, price cap regulation discourages investment, which may compromise service delivery and engagement in social services. If earnings are low, the company may be at risk of defaulting on bonds and servicing debts. However, it is appropriate for transmission and distribution networks, where price volatility is low. The infrequent price adjustments minimise regulatory costs. Price cap regulation requires accurate demand forecasts in order to realise reasonable rents (Alexander *et al*, 1997).

iii. Revenue cap regulation:

Revenue cap regulation (RCR) has similar characteristics to price cap regulation in terms of incentives for cost containment and rate review. Depending on the nature of the regulated firm, the regulator may choose either to determine a unit price or total revenue of the firm. If the costs hinge on increase in volume then the company may use

price cap, but if the firm's costs are extensively independent of the volume, then the regulator may decide to cap the revenue through RCR.

RCR is also appropriate for applications in transmission and distribution networks. For instance, the Nordic Pool applies revenue cap regulation in their electricity wire companies. The United Kingdom also introduced revenue cap regulation for their distribution industries. Various tariffs can be implemented under revenue cap regulation, such as charging fixed prices per customer. An instance of this is demand charges for electricity, which can be charged for individual customers. In this case, consumers bear the sales risk and the firm bears the remainder of the market risk because of the capped returns (Sotkiewicz, 2006).

iv. Regulation by contract:

The contract must explicitly define the involvement of the regulator in the market. Tariffs are set using a certain formula. In the event of public interest, the regulator may have difficulty intervening in the tariff-setting process under contract regulation. Another way of strengthening the regulatory governance and regulatory substance is to design incomplete contracts and additional regulatory mechanisms. There are numerous issues that may need stern regulatory intervention, such as pass-through of costs to consumers, service quality, efficiency targets, investment targets, pro-poor initiatives and other public interests. There is no contract that can be designed to address emergent issues in the sector. Hence, there is a need to frequently review the development policies of the country against the performance of investments in the various sectors (Sotkiewicz, 2006).

v. Benchmarking or yardstick regulation:

Benchmarking is normally used when information about a company is very difficult to organise; it is preferable in the case of information asymmetry between the regulated firm and the regulator. In this mode of regulation, a hypothetical firm or company – which is considered to be performing well, with efficient operations and investment, is used to set the benchmark for the regulated market. This can be designed for the entire company or part of the company.

There is no specific method for setting the benchmark or baseline analysis. This implies that different methods may result in different baselines – thereby increasing inconsistencies in the system. Another risk in analysis arises in the event of a limitation in the choice of companies against which a proper benchmark analysis can be made. This can lead to a poor benchmark, thereby exposing the regulated firm to market risk and incompetent performance (Sotkiewicz, 2006).

vi. Target performance based regulation:

In some cases, the regulated firm may be required to operate at a certain standard and offer certain delivery of services. The regulator agrees with the firm on the code of operation. The code must be both accurately designed and re-verifiable (for reproducibility of information). The issues need to reflect the strengths of the firm, the results from viable business goals and they should not be site-specific to allow the firm maximum flexibility in performance. It prevents the regulated firm from entirely focusing on the targeted performance, because that may compromise other essential services of the business. The regulator has to ensure that the company is not overstrained by the set targets. The targeted performance that the company may be required to improve could relate to the number of service interruptions and their duration, increased stable power supplies and reduced load shedding (Sotkiewicz, 2006).

vii. Sliding scale/ sharing regulation:

To avoid the exorbitant profit levels, some regulators suggest a profit-sharing mechanism that regularly revises prices to the benefit of consumers. Including this option in a regulator's objective function, a long-term equilibrium may arise with a state-contingent sharing rule that guarantees adequate profits. The sharing can be in the form of rents or cost deviation from the target. This option has been used in rate of return as a better approach for cost containment or for sharing earnings. In most cases, political influence determines the level of sharing for consumers (Sotkiewicz, 2006).

viii. Regulation hybrids:

Hybrid regulation uses a combination of regulation methods. The methods may include regulation by contract, benchmarking (yardstick), targeted performance-based regulation and sliding or sharing mechanisms, etc (Sotkiewicz, 2005, 2006).

b) Guidelines and principles in utility regulation

According to Berg (2001), there are ‘three factors that can determine the effectiveness of independent regulatory agencies, and these are the:

- Legal instrument that establishes the regulator. This determines the resource capacity and strength of the regulator.
- Legal mandate for the regulator to pursue appeals. Initial legislation may be inadequate for the effective performance of agency duties.
- During the formation of the agency some of the staff may not have reached the required maturity to competitively handle issues and priorities of the objectives of the agency. Resource development and strengthening are required in the establishment of an effective regulatory authority.

An Australian Competition Commission task force recommended nine principles of good regulation (Berg, 2001):

- **‘Communication** – information to stakeholders on a timely and accessible basis
- **Consultation** – participation of stakeholders in meetings
- **Consistency** – across market participants and over time
- Predictability – a reputation that facilitates planning by suppliers and beneficiaries
- **Flexibility** – by applying appropriate instruments in addressing changing conditions
- **Independence** – autonomy in decision making despite undue political influence
- **Effectiveness and efficiency** – cost effectiveness is emphasised in data collection and policies

- **Accountability** – clearly defined processes, rationales for decisions and associated appeals
- **Transparency** – openness of the process.’

Investments into the sector are attracted by the clear and predictable regulatory roles of the authority.

The African Forum for Utility Regulation (AFUR) recommends the following framework for utility regulation in Africa (Eberhard, 2006):

- *“Minimum regulation necessary to achieve policy and sector objectives*
- *Adherence to transparent decision-making and due process requirements*
- *Independent or autonomous regulation*
- *Accountability towards government, investors and end-users*
- *Non-discrimination when not in conflict with policy prerogatives of government*
- *Protection of investors against physical and regulatory expropriation*
- *Promotion of competition by limiting anti-competitive behaviour.”*

c) Tariff design

In the case of electricity, the price can be determined from the following equation 4.2 (Sotkiewicz, 2006).

$$P \times Q = B \times r + E + d + T \quad \text{Equation 4.2}$$

where

P is the price in kilowatt-hours (kWh) per unit of currency

Q is the quantity of units sold in kWh

B is the rate base or assets

r is the allowed rate of return on investment

E is the expenses

d is the depreciation of the assets

T is taxes paid by the utility.

The total revenue is given by equation 4.3,

$$\text{Revenue} = \text{Price} \times \text{Quantity} \quad \text{Equation 4.3}$$

The allowed revenue could thus be defined as (Alexander *et al*, 2005),

$$\text{Revenue} = \text{Cost} + \text{ROI} + \text{ROEA} + \text{RONA} \quad \text{Equation 4.4}$$

where,

Cost entails operation and maintenance costs

ROI is Return on investment

ROEA is Return on existing assets

RONA is Return on new assets.

Investors normally finance the investment from two main sources; equity³ and debt⁴. These form the capital structure of the company. There is often a problem in determining the initial rate of return for the company because of the scarcity of required data in countries without a mature capital market. The rate of return on investment is pivotal in all the reform stages of the industry; privatisation and regulation processes. The rate of return is normally calculated as the Weighted Average Cost of Capital (WACC). The WACC takes into account the relative weights of each component of the capital structure and presents the expected cost of new capital for a firm.

The standard approach to estimating the WACC is calculated from the following formula (Alexander *et al*, 1997).

$$\text{WACC} = [(1-g) \times r_e] + [g \times r_d] \quad \text{Equation 4.5}$$

where

r_d is the cost of debt finance

r_e is the cost of equity finance

g is the level of gearing or leverage in the company. It is the proportion of debt in the total capital structure (ie debt + equity).

³ In corporate finance, equity generally refers to the difference between a company's assets and liabilities – the value that accrues to the investor.

⁴ Debt entails bonds and notes the company holds with other financing or money lending institutions.

The cost of equity can be estimated from the Pricing Model, equation 4.6,

$$r_e = r_f + \beta_e(r_m - r_f) \quad \text{Equation 4.6}$$

where

r_e is the cost of equity finance

r_f is the risk free return

β_e is the equity beta

r_m is the level of market return

$(r_m - r_f)$ is the market risk premium

The risk-free rate (r_f) of return is a benchmark figure against which all investment in an economy should be measured. The equity beta (β_e) measures the relative risk of the company's equity compared to the whole market. The equity risk premium ($r_m - r_f$) is the second standard measure of the additional level of return that is required to persuade investors to hold equities in preference to a risk-free instrument.

To assess the specific risk level in the company's specific sector, an additional dimension is considered, which is termed the asset beta (β_a). The asset betas can be converted into equity betas by using equation 4.7.

$$\beta_e = \beta_a / (1 - g) \quad \text{Equation 4.7}$$

where,

'g' is still the fraction of gearing or leverage, which can be related to debt (D) and equity (E) by equation 4.8.

$$g = D / (D + E) \quad \text{Equation 4.8}$$

To update the rate base, the United Kingdom adopted the procedure in equation 4.9.

$$RAB_{t+1} = [RAB_t \times (1 + \Delta RPI_t)] + E_t \quad \text{Equation 4.9}$$

where

' E_t ' represents Equity, ' E_t ' = (Gross Investment_t – Depreciation_t)

RPI is the Retail Price Index or the Consumer Price Index (CPI),

The subscripts 't' denotes the current setting and 't+1' denotes the next rate base setting, so that:

RAB_t is the current regulatory rate base, and, RAB_{t+1} becomes the next regulatory rate base.

ΔRPI_t denotes the change in RPI.

The evaluation of the assets or regulatory asset base (RAB) can also follow different paths of evaluation, as indicated in figure 4.1.

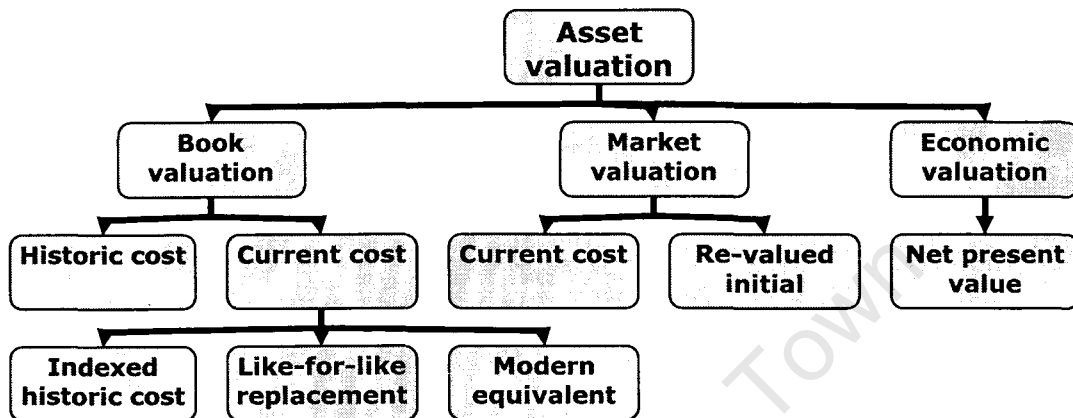


Figure 4.1: Asset valuation options (Alexander, 2006)

4.6 Summary of lessons

This chapter established the complexity of rural electrification – ranging from technical analysis to policy formulation with the objective of creating a fair environment for both the service providers and the beneficiaries of the services provided.

4.6.1 Swaziland

The institutional development of the Energy Department under the Ministry of Natural Resources and Energy (MNRE) was developed with the assistance, inter alia, of the World Bank and the German technical Cooperation (GTZ) – after a comprehensive analysis of the energy sector in Swaziland. The Energy Department is responsible for all energy governance issues in Swaziland. The department has five units: petroleum, data and economy, electricity and coal, renewable energy and energy efficiency.

In 2003, Swaziland adopted the country's National Energy Policy White Paper to guide developments in the energy sector. The Policy outlines how Swaziland intends to:

- ensure access to energy,
- enhance employment creation,
- ensure security of energy supply,
- stimulate economic growth and development, and
- ensure sustainable environment and health.

A rural electrification policy is incorporated in the National Energy Policy. The energy development objectives are categorised into short-term, medium-term and long-term priorities. The rural electrification programme in Swaziland commenced in the mid 1990s through studies and pilot programmes. Massive electrification of rural centres through grid extensions started in 2000, through donor funding. The programme targeted the electrification of rural schools, health-care facilities and development centres – routing the electricity lines through densely populated communities. The Swaziland Electricity Board (SEB) is the only implementing agent for the rural electrification programme. Cooperation between the MNRE and the SEB established the motion that the rural electrification unit at the SEB is deficiently staffed; it has only one full-time rural electrification officer.

Electricity tariffs in Swaziland are designed and set by the SEB. The SEB tariffs are categorised into six demand sectors; domestic, general purpose, small commercial and industrial, off-peak water heating, large commercial and industrial, irrigation. All the tariffs are not cost reflective. A flat tariff is implemented through-out the domestic sectors (urban, peri-urban and rural).

To address the changes and developments in the energy sector, Swaziland legislated three Acts in 2006; Electricity Act of 2006, Energy Regulatory Authority Act of 2006 and Swaziland Electricity Company Act of 2006. The government is currently in the process of effecting the Acts.

The government macro-development objectives are a mandate of the Ministry of Economic Planning and Development (MEPD). The MEPD currently implements a 25 year National Development Strategy (NDS) and a Poverty Alleviation and Reduction Plan. The two programmes intend to stimulate economic growth in the country and decrease poverty levels through socio-economic development. All development initiatives from the various economic sectors have to comply with the requirements stipulated in the macro-development plans.

4.6.2 Key aspects in international rural electrification policies

Literature indicates that the following guidelines are essential in developing effective rural electrification policies:

- Ring-fencing of rural electrification funds
- Legal and institutional frameworks (responsibility assignment)
- Technology innovations
- Tariff designs

It is important for customers/ beneficiaries of energy services to be protected from unjust costs emanating from inefficient operations of the service providers. It is the function of the regulatory body to determine the appropriateness of pass-through costs. Several regulatory methods can be pursued by the regulator.

The effectiveness of the regulatory agency is often affected, inter alia, by;

- Legal instrument of establishment,
- Legal mandate of appeals,
- Expertise and competitiveness of the staff in regulatory issues and techniques.

The regulator needs to understand the various components affecting tariff design in order to include social developments in the regulated companies. This involves economic and financial analyses; prices, quantities of units sold, investment, the company's rate base,

revenue, how to determine returns for the company. Several options can be pursued in determining the company's rate base, as outlined in figure 4.1.

The following chapter, chapter 5, analyses the implementation of rural electrification programmes in reference to the literature surveyed. The countries are chosen based on geographic location, electrification access rates and processes applied in their programmes. Major focus is made on the involvement of the government and its contribution to the success of the development programmes. Most often than not, the use of subsidies in subsidising consumption, as opposed to infrastructure development for energy services, is strongly condemned in this research. However, analyses of lifeline tariffs are included in the programme to pursue a holistic approach in the analyses. It does not necessarily imply that it is a good practice. A larger fraction of the sample countries is from Africa because Swaziland is an African country. Most of the regional developments and conditions prevalent in African countries are either similar or extensively affect developments in Swaziland.

CHAPTER FIVE

5 RURAL ELECTRIFICATION IN OTHER COUNTRIES

5.1 Introduction

The development of rural electrification in other countries reveals a diversity of processes and motives. This chapter discusses how the key aspects and processes of rural electrification were applied in ten selected programmes. The sample countries are: Ireland, United States of America, Norway, Chile, Guatemala, South Africa, Tunisia, Morocco, Mauritius and Kenya.

The following processes and key aspects, deduced from literature in chapter four, are used to test their applicability in the implementation of rural electrification programmes:

- Ring-fencing of rural electrification funds
- Legal and institutional frameworks (responsibility assignment)
- Technology innovations
- Tariff designs (affordability, cost causations).

The indicators for success will be determined by the rate of access to electricity. For each respective country, a brief summary of lessons will be extracted from the analyses of the programmes, to evaluate the extent to which the guidelines were applied.

The exploratory analyses commence with a detailed discussion of the energy sector review and associated activities in South Africa. Only key aspects of rural electrification will be considered for the other chosen countries. South Africa will be subjected to a detailed analysis of the energy scenario and the development activities pertaining to energy supply, governance and planning, as they have an extensive impact on Swaziland's sector developments. Swaziland imports more than 80% of electricity from South Africa.

The information gathered does not necessarily follow any structured pattern of analysis.

5.2 South Africa

5.2.1 Overview of the energy sector

Energy continues to be the key driver of the economy in many countries. South Africa is a major supplier and intensive user of energy in the Southern African region. South Africa (RSA), for instance, earns about 15% of its Gross Domestic Product (GDP) from the energy sector and the energy sector employs at least 250 000 people. The high energy intensity is attributed to the extraction of raw minerals and primary processing; the energy demand trend seems to be increasing. Coal provides above 70% of the total primary energy supply and over 90% of electricity in the country. RSA also uses coal as the feedstock for synthetic fuels and other petrochemical products and it is the biggest producer of synthetic fuels, which are RSA's third biggest foreign exchange earner after gold and platinum (SANEA, 2003).

The high reliance on fossil fuels makes South Africa one of the highest countries in greenhouse gas⁵ (GHG) emissions in Africa, and it ranks above the OECD⁶ average in energy sector emissions. In 2000, RSA was ranked the world's fourteenth highest country for carbon dioxide (CO₂) emissions and the nineteenth most carbon intensive economy (IEA, 2000a). RSA's per capita emissions are higher than those of many European countries, and at least three and a half times the average of developing countries. In terms of emission intensity, that is, the amount of emissions per economic output, South Africa ranks amongst the highest in the world – at more than triple the level of an average developing country (IEA, 2000b; Winkler, 2006).

⁵ Greenhouse gases, which are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydro fluorocarbons (HFC), per fluorocarbons (PFC) and sulphur hexafluoride (SF₆), trap the long-wave infrared radiation – thereby increasing the atmospheric temperature. The phenomenon of balancing the natural gases in the atmosphere is termed the greenhouse effect (Hadley Met Office, 1999).

⁶ OECD stands for Organisation for Economic Cooperation Development. Established in 1961 to replace the Organisation for European Economic Co-operation (OEEC), the OECD is an international organisation comprising the industrialised market economy countries, as well as some developing countries, by providing a forum in which to establish and coordinate policies.

5.2.2 Power sector reform in South Africa

Ninety-six percent of South Africa's electricity is generated by Eskom – the state owned, vertically integrated utility; the remaining 4% of generation is shared by municipalities country-wide and imports. South Africa's electricity generation accounts for more than 50% of the electricity supply on the entire African continent. Eskom exports power to some countries in the southern African region, including Botswana, Lesotho, Mozambique, Namibia, Swaziland, Zambia and Zimbabwe. Eskom imports hydropower from Mozambique, where it holds contractual rights to the output of the Cahora Bassa Hydropower Station on the Zambezi River.

By the end of 1999, South Africa had 49 power stations, producing about 43 142 MW of power (excluding reserve capacities). Eskom owns 24 power stations; there are 10 large coal-fired power stations that are located in the north-east of South Africa, where most of the coal fields are found. These power plants are built on the coal mines to reduce transport costs for the coal. Koeberg, the only nuclear power station in Africa, is located thirty kilometres north of Cape Town; it contributes to meeting the power demand in the Western Cape. Eskom runs two pump-storage hydropower schemes for peak lopping, as well as balancing and controlling the power system in the country. The municipalities run 22 small-scale power stations and gas turbines that contribute less than one percent of the national power supply. Independent power producers generate about three percent of the total output mainly for own consumption (Eberhard *et al*, 2005; Matibe *et al*, 2002).

It is reported that Eskom's energy tariffs are amongst the lowest in the world, for both industrial and residential sectors (Davidson *et al*, 2003; SANEA, 1998). This could be attributed to the possibility that Eskom has not been paying tax, dividends nor has it been subjected to investments to mitigate any environmental and social impacts of electricity generation. Such factors as clean coal technologies and the installation of de-sulphurisers, as well as increasing demand, could increase the electricity tariffs.

The state-owned electricity utility transformed from a statutory body in government to Eskom Holdings Limited on 1st July 2001 – through the enactment of the Eskom

Conversion Act of 2001. The transmission network is owned and operated by Eskom Holdings. The distribution is shared with 187 local authorities in the municipalities, which accounts for 60% of the consumer base and the remaining 40% is served by Eskom. The municipal distributors cover the customer base within their vicinity, whilst Eskom normally distributes electricity to geographically dispersed beneficiaries. The fragmentation is the reason behind the more than 2000 tariffs ranging from R0.19/kWh to R0.71/kWh in electricity distribution. The dispersed configurations deprive the country of investment in assets and economies of scale and scope, as well as the sharing of facilities, services and the development of the citizens of the country (Nzimande, 2006). Figure 5.1 is the organogram of the power industry in South Africa.

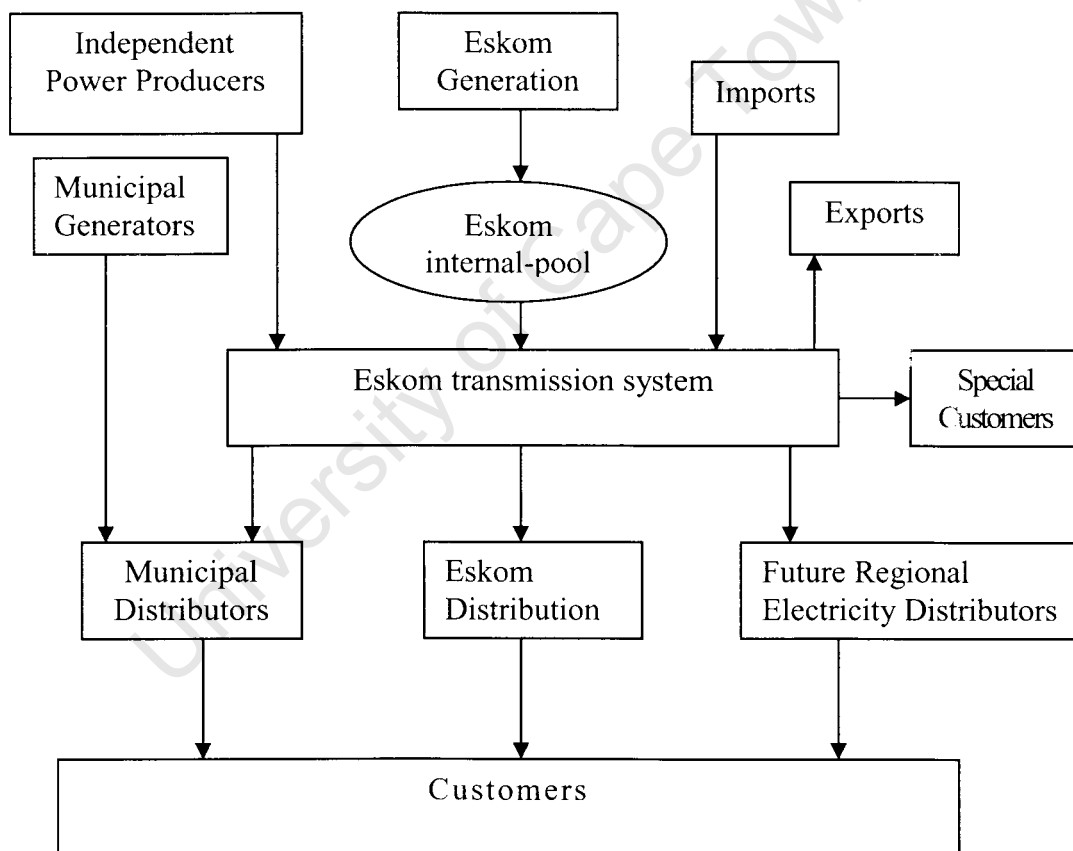


Figure 5.1: South African power sector (Eberhard *et al*, 2005).

The Department of Public Enterprises represents the government as the sole shareholder of Eskom. The Ministry of Mines and Energy sets the energy policy goals and obligations

for Eskom. The Treasury Regulations contained in the Public Finance Management Act of 1999 require Eskom Holdings to sign annual performance objectives and key performance indicators in the form of a compact. The indicators include revenue growths, social targets, electrification targets, equity targets, gender equity and black economic empowerment.

The Minister of Public Enterprises appoints the board of directors. Eskom has 15 directors, 13 of whom are non-executive; the two executive directors are the chairman and the director of finance. The board forms committees to execute some of the corporate duties, including executive management, remuneration, ethics, sustainability, risk management, tender, human resources, investment and finance, etc. Eskom's accounting conforms to international accounting standards. International accounting firms, such as KPMG Inc., Siswe-Ntsaluba VSP, Deloitte and Touche are involved in auditing Eskom's financial statements.

The government allows Eskom to engage in financial bonds without its involvement, except for some foreign bonds. Eskom's return on investment has been positive, although low in real terms, that is, including inflation adjustments. As a company, Eskom is subjected to payment of corporate tax and is expected to declare dividends to government. Hence, Eskom fulfils most of the regulations for corporate governance, which is a pivotal aspect in power sector reforms, regardless of reform direction – corporatisation or privatisation (Irwin *et al*, 2004).

Power sector reforms entailed several processes in South Africa; the establishment of an independent electricity regulator in 1995 – the National Electricity Regulator (NER), the corporatisation of Eskom, the rationalisation of the distribution business of local governments and Eskom Holdings into regional electricity distributors (REDs) and the involvement of independent power producers (IPPs) in the South African Electricity supply industry. The transition into REDs is managed by EDI Holdings (Pty) Ltd, which was established in 2003 and incorporated in the Department of Minerals and Energy (DME).

The objectives of restructuring the electricity distribution industry (EDI) are to:

- Consolidate the electricity distribution industry
- Rationalise the competitive tariffs
- Achieve access to electricity for everyone
- Improve the service delivery
- Achieve reliable and quality supply of electricity
- Enhance revenue for municipalities to encourage local economic growth.

These objectives follow the recommendations laid out in the Energy Policy White Paper of 1998 and the Blueprint on EDI restructuring of 2001 (DME, 1998, 2001b).

Implementation of EDI restructuring started with the establishment of RED One in the City of Cape Town, on 1st July 2005 (Nzimande, 2006).

5.2.3 Governance of the energy sector

The National Electricity Regulator (NER), now under the National Energy Regulator of South Africa (NERSA)⁷, regulates the electricity industry, licenses all electricity suppliers, ensures compliance standards, oversees adherence to obligations, approves electricity tariffs, monitors the electricity supply and resolves disputes in the electricity industry. The Minister responsible for energy affairs appoints the board of directors for the regulator. NER/NERSA uses rate-of-return regulation to regulate the electricity industry in South Africa. It is envisaged that the NER/NERSA will introduce incentive-based regulation (World Bank/UNDP, 2005; Eberhard *et al*, 2005).

According to the vision of the Energy Policy White Paper and developments in power sector reforms, development should involve:

- Affording consumers the right to electricity supplier
- Introducing competition into the industry, especially the generation sector
- Having an open transmission system
- Attracting private sector participation into the electricity supply industry.

⁷ NER ceased to exist when NERSA took over the responsibility for regulation in 2005.

The Cabinet of Ministers approved, in addition to the Energy White Paper, reforms in the electricity supply industry. It was recommended that Eskom should retain 70% of the generation capacity and privatise the remainder – where an initial 10% of the privatisation should be allocated to black economic empowerment (BEE). The de-verticalisation of Eskom into separate generation, transmission and distribution entities would be part of the reform process. A subsidiary transmission company of Eskom Holding would be formed. The distribution part would comply with the regional distribution plan of REDs. A high level of interdependence with the sector regulator should be developed in order to facilitate the participation of independent power producers (IPPs) and the diversification of primary energy supply.

However, with the diminishing power capacity in South Africa, policies veered towards ensuring security of power supply. As a result, the government felt that Eskom Holdings had to remain in state ownership; independent power producers would only compete for peaking power capacities. Baseload electricity supply would be managed by Eskom Holdings (Eberhard *et al*, 2005).

5.2.4 Development of rural electrification in South Africa

South Africa is a country that has suffered tremendous political upheavals, ranging from racial to economical discrimination. The majority of black and other disadvantaged races were resettled in under-developed areas where access to electricity was limited or non-existent. These areas entail rural areas, townships and informal settlements. In an effort to normalise the unrest, attention was drawn to the disparity in living conditions amongst the different racial groups in South Africa. Supplying electricity to disadvantaged communities was identified as an urgent need to uplift their livelihoods (Gaunt, 1998).

South Africa's settlements are somewhat differential in configuration. The rural areas are characterised by dispersed settlements; there is a heavy dependence on wood-fuel and biomass for cooking and space-heating. Kerosene and candles are used for lighting. In some cases, the kerosene is used in small stoves for cooking and heating. These areas are found in Kwa-Zulu Natal and the former rural Transkei, as well as some areas of rural South Africa. Such rural configurations are a normal trend in neighbouring countries and

most parts of rural Africa. Electrification of these areas is very costly because of the dispersed homesteads with very low electricity demands. This makes electrification non-viable in purely commercial terms.

Initially, South Africa's electrification process was driven by economics and financial viability. The electricity utilities implemented electrified areas using expensive technologies in network expansion, making connection less affordable for economically challenged citizens. The excess capacity in the system needed to be supplied to economically viable places. Socio-economic and social objectives were not popular on the electrification agenda. This focus slowed the electrification rate in South Africa. Studies and programmes were conducted with the intent to expand access in electricity services to meet the other needs of society such as good health, education and socio-economic development. Political influence and government intervention increased access to electricity from 36% to 67% in less than ten years – with some three million new connections being made (Borchers *et al*, 2001; NER, 1999).

There are numerous informal settlements in South Africa, some of which are located in townships and some peri-urban areas. These settlements are characterised by high densities and closely-packed residential structures. Most of the structures are built from temporary material that is very susceptible to fire outbreak. The major sources of fuel in these areas are coal and kerosene. It is reported that kerosene is the source of fuel for up to six million households in South Africa; however, kerosene is also the major cause of injury and mortality among South Africa's 0–4 year children. Children are often subjected to burns, and poisoning from ingestion of kerosene, as well as a high level of localised pollution in poorly ventilated shacks. Kerosene is the cause of most residential fires in South Africa. Coal also contributes to environmental pollution in residential areas, which exacerbates health conditions in the residential sector (Winkler, 2006).

The above-mentioned societal issues became the core drivers for rural electrification in South Africa. Electrification was perceived to improve the livelihoods of the society and protect the environment via a number of benefits.

- 'Mortality and morbidity from:

- localised air pollution (from kerosene, coal, biomass combustion, etc.)
- paraffin poisoning of young ages groups
- residential fires and burns (from kerosene and candles usage)
- Social cost of fending biomass for fuel
- Environmental degradation from deforestation

Despite the negative effects of electricity, it is believed that the substitution of other fuels in the residential sector can significantly improve the lives of the dwellers (Matibe *et al*, 2002).

Relief from political tension brought numerous development programmes in South Africa, including the ‘Access to Electricity for All’ initiative. This programme was funded by Eskom, as well as government and others. It turns out that Eskom achieved more connections than the government programme. Table 5.1 depicts the achievements made during the ‘Access to Electricity for All’ programme. The programme targeted previously disadvantaged communities, public clinics and schools (GNESD, 2004c).

Table 5.1: Access to Electricity for All programme (NER, 1995)

	1991	1992	1993	1994
Eskom	31 035	145 522	208 801	254 383
Government & Others	51 435	74 335	107 034	164 635
Total	82 470	219 857	315 835	418 918

After the establishment of the National Electricity Regulator (NER) in 1995, a National Electrification Programme (NEP) took over from the Access to Electricity-for-All initiative. Table 5.2 illustrates the development of electrification during the NEP.

Table 5.2: National Electrification Programme from 1994 (Gaunt, 2004)

	1994	1995	1996	1997	1998	1999	Total
Eskom	250 000	300 000	300 000	300 000	300 000	300 000	1 750 000
Other*	100 000	100 000	150 000	150 000	150 000	150 000	800 000
Target	350 000	400 000	450 000	450 000	450 000	450 000	2 550 000
Achieved	418 918	478 767	453 995	499 391	427 426	443 290	2 669 345

*Other includes government funding and sponsored projects

According to a World Bank/UNDP (2005:106) report, “*up until 2000, all of the electrification programme was funded by Eskom, either through direct investment in Eskom’s own electrification projects or through transfers to an electrification fund that the NER allocated to municipalities. This funding was primarily sourced through cross-subsidies from other customer categories... In 2001, the government took over funding of electrification through a separate National Electrification Fund (NEF) in the Department of Minerals and Energy (DME) funded by the National Treasury.*” Government funding comprised both grid and off-grid electrifications.

In 1999, the government launched an off-grid initiative to increase access to modern energy services in disadvantaged areas. Concessions were granted to six private concessionaires to carry out photovoltaic (PV) electrification in various areas in the country. The target was to install 350,000 solar home systems (SHS) in the country, including schools and clinics. Reports indicate that the off-grid electrification option does not seem to fulfil the objectives of developing the society, as it results in very high connection costs.

The off-grid concessionary areas are reported to be 73 to 93% more expensive than the areas electrified by the national electricity grid. The beneficiaries express their dissatisfaction over the limitations in energy services, as they can only use the solar home systems for lighting and some media services. On the other hand, the grid connected areas can use the energy services for cooking, heating requirements and lighting – at a cheaper access cost (DME, 2001a; Banks *et al*, 2000).

It transpires that the original installation targets were not met through the off-grid systems. This is partially attributed to policies, legal uncertainties and misunderstandings in concessionary agreements, timeframes, access to funds and conflicting interests between concessionaires and Eskom's rural electrification planning. The implementation of off-grid electrification seems to counter-fulfil the visions of the 1998 National Energy Policy White Paper of "*Giving customers the right to choose their electricity supplier*" (DME, 1998).

Studies indicate that access and consumption of electricity are a function of income. This implies that those with better incomes can easily access electricity and have a higher demand for electricity because they can afford to use various electrical appliances of their choices. To afford everyone in society the right to basic service of electricity, South Africa introduced a direct subsidy in the form of a "poverty tariff" in 2002 – for very low income groups. Under this subsidy, beneficiaries are offered 20–50 kWh of free electricity every month. There seems to be increasing usage of appliances in the low-income groups, which somehow reduces the dependence on hazardous fuels.

While there is a positive 33% increase in the use of electrical appliances, some sectors of the low-income groups still do not benefit from the subsidies. There is currently no known substitute benefit for the communities that are not connected to the electricity grid. As the number of connections increases, the subsidy will cost the government a fortune to maintain; the long-term sustainability of such programme remains a mystery to the general public. Socio-political influence played a major role in the electrification of South Africa. When the economic power and political arena change, it is still not known what will happen to the millions of disadvantaged South African whose basic services hinge on free electricity.

The delayed formation of the regional electricity distributors (REDs) poses another challenge in the implementation plan for rural electrification in South Africa. Identifying non-viable areas and allocating funds to such areas, can only be done through a comprehensive analysis of all the six REDs in South Africa.

Series of studies have been carried out to address the probable predicament of REDs and the implementation of rural electrification in South Africa. The studies entailed a financial and economic analysis of two electrification projects, the financial impacts of rural electrification and the sustainable financing of electrification in South Africa. The latter study concentrated more on the viability of rural electrification under the REDs restructuring (Davis, 1996, 1997; Thompson et al, 1998).

In a summary of studies compiled by the Energy and Development Research Centre (EDRC, 1998), it was indicated that the financial situation of the REDs poses difficult policy challenges. The study pointed out that technology innovation is important for reducing the cost of electrification. This involves the use of current limiters, at low consumption levels, instead of designing the network with the standard technologies, which result in higher connection costs. The use of prepayment meters is optimal over much greater consumptions. The analysis quantified the extent of subsidies and the capital financing mechanisms required for rural electrification.

Some of the financing mechanisms with respect to the regional distributors entail the following policy options (EDRC, 1998; van Sleight *et al*, 2003):

- ‘The government could provide the capital grants required to sustain the viability of REDs. This would be required in the first ten years, and then they would sustain on their own thereafter.
- Relocation of funds from viable REDs through proper cross subsidisation.
- Imposition of a levy in the electricity sales and the relocating the funds to a central fund for the REDs.
- Re-adjusting the zone for the REDs in way that enables the REDs to be financially viable; subsidies would be sourced from the electricity consumers.’

While the list of benefits for rural electrification is evident from such socio-economic benefits as improved health, better education facilities and stimulation of economic growth, it still needs cushioning for proper development. In the inception stages, the government needs to play a pivotal role in its development. The level of subsidies should

be accompanied by a proper zoning or prioritisation exercise for optimum and appropriate direction of central RED funds.

The following set of criteria for approval of projects in the RED's rural electrification programme was suggested by EDRC reports (Banks, 1998; Banks *et al*, 1998):

- Clear established demand for the service
- Well-identified cost / benefit analysis of projects
- Stakeholder and community involvement in the project planning, implementation and operation stages
- Respect for environmentally and culturally sensitive sites
- Compliance with design specifications for electrification of system operator
- Meeting of quality assurance and technical standards
- Ensuring of long-term sustainability
- Compliance with the long-term plans of the national electricity grid.

In its goal of universal access, the government's target is 300 000 new connections annually. Since Eskom was corporatised in 2001, electrification has been the prime initiative of the government. Rural electrification is funded through a rural electrification fund from the government's fiscal budget in the National Treasury as a capital project under the Department of Minerals and Energy (DME). Another possible funding that DME suggested in their 1998 annual report was the introduction of a levy. All the funding mechanisms would be managed by the regulator under the directive of the DME (DME, 1998).

To carry out macro-economic planning for electrification, a team was seconded from Eskom and programme resources were committed every year. The electrification programme is still in progress and has only been slowed down by the formation of the regional electrification distributors (REDs).

5.2.5 Summary of lessons

The success of South Africa's rural electrification programme is seen from the increase from 36% to 67% during the 'Access to Electricity for All' and the National Electricity

Programmes (NEP), run from 1991–1994 and 1994–1999, respectively. This great increase almost doubled access to electricity in ten years (Gaunt, 2004).

(a) Funding:

Rural electrification was initially financed by Eskom from its own budget. The government started getting more involved in financing the rural electrification programmes. The strong socio-political will contributed to the increased rural electrification programmes. After converting Eskom to a public company, the government included rural electrification in its fiscal budgets, to sustain the ongoing programme.

(b) Responsibilities

The government took control of the implementation process and the setting of rural electrification targets. The Department of Minerals and Energy (DME) is the overall custodian of the programme, but it has delegated some of the responsibilities to the National Energy Regulator of South Africa (NERSA). The DME has lobbied for funds from the government's fiscal budget in the National Treasury department to create a rural electrification fund, which is monitored by NERSA. The planning and socio-economic analyses of the programme are carried out by a select team from Eskom (NIEP Business Planning Unit), which directly involves the major electricity supplier in the development of the project.

(c) Tariffs

The government currently finances the development of infrastructure. The introduction of the poverty tariff of up to 50kWh of free electricity reduces the tariffs for low-income groups. But, the tariff only benefits those with access to electricity. Estache (2004) argues that rural electrification funds must be used for developing the infrastructure, instead of financing lifeline tariffs. The funds have to be ring-fenced and not diverted to other activities (GNESD, 2006c).

(d) Technology and planning

From the information accessed, it was established that Eskom was using the ordinary convention technologies for distribution with no special technologies, such as the SWER⁸, to reduce costs. The confusion with the solar photovoltaic electrification somehow delayed the programme and also cheated people of reliable power sources, as well as the benefits from the poverty tariff introduced in 2002. The limited energy supply from solar sources hinders socio-economic development, which should be the main driver for rural electrification. The cost of solar electrification was prohibitively high. A wide spectrum of electrification would have been covered with same cost, if the government had pursued grid electrification. The REDs programme is a barrier to rural electrification; the failure of RED1⁹ created more confusion in the REDs system.

5.3 Ireland

5.3.1 Introduction

The island of the Republic of Ireland is situated on the west fringe of Europe. Its economy is dominated by the industry, which accounts for about 46% of the total Gross Domestic Product, approximately 80% of exports and it employs some 29% of the labour force. Agriculture, which has slowed down in recent years, played a major role in driving socio-economic rural electrification – a process termed ‘the Quiet Revolution’ by its proponents. The rural electrification programme took thirty years in Ireland, from 1946 to 1976, and it resulted in some 420 000 rural connections to electricity, which accounted for ninety-eight percent (98%) of access to electricity in rural Ireland (ESB, 2007; IG, 2007; Shiel, 1984).

5.3.2 Rural electrification development

The Electricity Supply Board (ESB) is a vertically integrated enterprise, almost entirely state-owned, which is responsible for supplying electricity in Ireland. It was established through an Act of Parliament enacted in 1927, after great success with a hydropower scheme at Ardnacrusha, under the Shannon Scheme (IG, 1927). Existing electricity

⁸ SWER stands for Single Wire Earth Return. As opposed to the conventional single phase, which uses two conductors, this system uses only the live wire and it does not have the neutral wire.

⁹ RED1 was the first one to go on trial out of the six REDs to be implemented.

undertakings at that time were taken over by the ESB. The rural electrification initiative began in 1939, when the government approached the ESB to discuss the feasibility of rural electrification implementation. The process was delayed by the Second World War, until 1946, when the rural electrification programme was finally established.

After comprehensive discussions with the ESB, it was agreed that the rural electrification programme should be implemented by the ESB rather than be outsourced to other organisations or implementing agencies. The government had, inter alia, the reasons listed below, for keeping the development of the programme within the state obligations (Zomers, 2001).

- Required capital investment was prohibitively high for private sector
- Low returns on investment in rural areas
- Socio-economic development did not tally with commercially driven investment by the private sector
- Government wanted to control infrastructure development in Ireland and limit foreign influence on assets, as well as avoid the rural electrification programme from being hindered by municipal boundaries and way-leaves country-wide.

The construction of Huntstown (North Dublin) and Dublin Bay Power (Ringsend, Dublin) in 2002 and 2003 brought the total installed capacity to 4 651 MW, which currently serves a customer base of close to two million (ESB, 2006). There are also independent power producers of wind power, which generate about 590 MW, feeding into the national electricity grid (Foley, 1990).

The implementation process was decentralised into regions of local governments in order to increase control of the activities in the programme (Foley, 1990). The increase in demand for electricity forced the ESB to invest in power generation. Table 5.3 shows the investment process in generation capacity from 1927 to 2005.

Table 5.3: Electricity Supply Board's generation plants (ESB, 2006)

Station	Capacity (Megawatt)	Type of fuel
Shannon bridge	125	Peat
Lanesboro	85	Peat
Bellacorick	40	Peat
Turlough Hill	292	Hydro (Pump-storage)
Liffey	38	Hydro
Ardnacrusha	86	Hydro
Erne	65	Hydro
Clady	4	hydro
Lee	27	Hydro
Moneypoint	915	Coal
Tarbert	620	Oil
Great Island	240	Oil
Aghada	525	Gas
Poolbeg	1,020	Oil and Gas
North Wall	266	Oil and Gas
Marina	115	Gas

5.3.3 Responsibilities and tariff adjustments

The government of Ireland realised that the electrification programme was a socio-economic development and that capital investment in infrastructure, subsidised tariffs and the use of power driven farm equipment were necessary for socio-economic development. Meanwhile, the Electricity Supply Board realised the need for proper institutionalisation of the rural electrification programme. To ensure coherence in government policies and implementation strategies, the government never imposed conditions on the utility – rather, a collaborative approach was used.

The rural electrification agency in government sourced and managed funds for the programme. The government funded fifty percent (50%) of the capital outlay. It allowed the ESB to operate very close to break-even point with 5–12 % returns on investment, in order to keep supply tariffs as low as possible. The ESB was not liable for equity to other shareholders, since it was 100% owned by the state, hence, no shareholders pressurised the utility for high profits. This was merely a strategic involvement of government to undertake non-economic development, at least in the short-term.

The rural to urban customer ratio of approximately 8:5 made cross-subsidisation unacceptable. Therefore, the tariffs had to be split to make them cost reflective. However, in the end the government and the ESB resolved to settle for a uniform tariff countrywide, after introducing smart subsidies. Meanwhile farmer equipment manufacturers were strongly advised to invest in automated tools to increase production of farm workers and consequently electricity demand – thereby stimulating socio-economic development. A reassessment of tariffs in 1968/1969 revealed that rural tariffs were below the required level by 29%, whereas urban tariffs were higher by 9% than the set calculations, without the smart subsidies designed for the rural electrification programme (Shiel, 1988).

The Electricity Supply Board formed a Rural Electrification Office to monitor, guide and coordinate the decentralised processes associated with rural electrification in Ireland. A monthly newspaper was issued by the office to update the satellite offices of shuffles and reshuffles in staffing, progress in respective regional projects and projected plans for subsequent activities in the project. The paper kept everyone at the ESB, government and the rest of Ireland abreast with the progress in the rural electrification programme. As the programme became economically viable, the government and the ESB readjusted the tariffs to follow corporate governance. Priority areas were based on willingness to accept the service and ability to pay for it. Women were involved because of their use of domestic appliances (Matly, 2005; Shiel, 1984).

5.3.4 Electrification technologies and standards

The rural electrification was designed by the Electricity Supply Board and it followed most of the European standards, especially those of the United Kingdom and Germany. The urban loads were linked by a 110 kV transmission system and supplemented by a sub-transmission system at 38 kV. Most of the rural electrification distribution networks were designed at 10 kV, with three-phase and single-phase (phase-phase designs) electricity lines. The three-phase system uses three conductors. The rural loads were served with 2.5 kVA and 3 kVA transformers.

Increasing demand from farm machinery required upgrading of the system and the change of single-phase supplies to three-phase supplies. Operation and maintenance was carried out by the regional technicians under the administration of the satellite offices of the Rural Electrification Office. Local participation by beneficiaries made the implementation of the programme affordable. In many cases, the frequency of replacements of single-phase transformers made maintenance costs higher than when using three-phase supplies to the farms, which seemed to be more reliable.

For the residential sector in Ireland, the normal fuse system for the mains supply is 63A. This system gives a limitation on the use of power and sometimes gives problems for multiple heating systems in the same residential settlement. This implies that consumers use few appliances –thereby limiting the consumption of energy which would have otherwise been higher, resulting in higher revenue for the utility. The consumer has to be cautious not to invest in much household equipment because of the limited current flow. The UK uses 80A or 100A mains fuse supplies, which allows more current to be drawn than the 63A system (Zomers, 2001).

5.3.5 Summary of lessons

Analysis of the implementation of rural electrification in Ireland shows that the government of Ireland understood the socio-economic nature of the programme and the consequences thereof. Despite the utility's capability to fund the programme, the government was aware of its obligation to develop social equity, and it set up framework for implementation by establishing an agency. The government also understood the

importance of collaborating with the electricity utility, involving the beneficiaries and developing effective governance for the success of the rural electrification programme. Meanwhile, the Electricity Supply Board did not let the programme side-track it from its business obligation of supplying reliable and adequate power to urban areas and industrial sites.

The government prepared proper legislation, such as way-leaves and rights-of-way, to create an enabling environment for the implementing agent. It was realised that the capacities would be affected by new demands for electricity and the ESB continuously invested in generation plants, from 1927 to 2005. However, the use of Single Wire Earth Return (SWER) technology could have reduced the construction costs of the infrastructure. The use of 63A supply mains resulted in cheap conductors and construction material for low-income groups, but reduced the revenue for the utility in areas of high income.

The need for affordable electricity in socio-economic development was evident from the implementation of uniform tariffs and the introduction of smart subsidies. The government reduced the return on investment and permitted operations of the ESB to be close to break-even margins to keep the tariffs low and make electricity affordable. To ensure the recovery of investment over time, the government encouraged the use of automated machinery for farming in order to increase both production and demand for electricity – thereby ensuring the socio-economic viability of the programme.

The lessons from the development of rural electrification in Ireland indicate that proper processes and governance play a crucial role in addressing electrification motives. The key factors in rural electrification programmes were adhered to.

The cost for the supply of electricity to domestic dwellings in rural Swaziland is more expensive than supplying a similar service in the urban domestic sectors. In essence, the tariffs should differ. But a smart subsidy would make electricity affordable in the rural areas. Affordable electricity could encourage the use of mechanisation, which would lead

to more production of rural products; sewing, wood carving, welding, small holding agriculture and other activities that could boost the tourism industry.

5.4 United States of America

5.4.1 Introduction

Initial development initiatives in the United States of America (USA) followed a somewhat capitalist approach. Most of the investments were driven by private investors based on economic viability. Electricity was supplied by private utilities to urban areas and other viable load centres. As a result, rural areas lacked access to electricity services for a long time because private investors were reluctant to undertake investment in the rural farms, owing to the lack of economic viability. Only two percent (2%) of rural farms had access to electricity by 1910 (Nye, 1990). A European visitor to the USA in the 1930s expressed the pathetic nature of rural farm life, saying he “...*discovered that a very large percentage of them had kitchens with wood-burning ovens,...they were lit by dim, smoking, smelly oil lamps,...washing of clothes was done by hand in antiquated tubs....*”(Keun, 1937:29-31).

5.4.2 Development of Rural Electrification in USA

The development of rural areas in the USA was characterised by the socio-political will, the intervention of government and its regulatory reforms, as well as the participation of rural communities through the formation of rural electric cooperatives.

On 18th May 1933, President Franklin Delano Roosevelt and his administration enacted the Tennessee Valley Authority Act (TVA). Roosevelt started supporting rural electrification in 1931, before he became president. By then, he was the governor of New York. Disparity in lifestyle and obsolete technologies used by the rural farmers stimulated the petition for connection to electricity services. The TVA Act allowed for the development of agricultural activities, hydropower schemes, re-forestation of land, navigation and the establishment of economic activities in the TVA region. Tennessee Valley was constantly troubled by floods, which destroyed a lot of vegetation and settlements. The hydropower schemes were to be used for rural electrification, for food

production on farms and socio-economic activity areas. In addition, the TVA Act established the TVA as a federal corporation (Matly, 2005).

In 1935, the Rural Electrification Administration (REA) was established, primarily as a financing agency for the development of rural electrification projects. The Rural Electrification Act of 1936 institutionalised the implementation of rural electrification in the USA. The REA lent the funds as soft loans to rural electrification cooperatives, repayable over twenty-five years. The rural electrification cooperatives were granted concessions to distribute and operate electricity networks in the rural areas and develop socio-economic activities that would encourage electricity consumption (Davis, 1986).

In addition, the Rural Electrification Administration provided electrification standards and technical guidelines to the cooperatives. The rural cooperatives also extended their businesses by supplying electrical appliances in rural areas. The beneficiaries of the rural electrification programme owned the cooperatives and maintained membership through paying annual membership fees (Moore, 1967; Conkin *et al*, 1983).

The cooperatives purchased some sixty-percent of their electricity for distribution from federal electricity generators, such as TVA power generation schemes. TVA is one of the largest state-owned power producers in USA, contributing some 32 000 MW to electricity supply in the country. The federal corporations transmit power the municipal distributors and rural electricity cooperatives (Creese, 1990).

The Roosevelt administration believed that if private companies regarded rural electrification as a chafe to their companies, then it was the responsibility of the government to implement it. The Roosevelt administration established a rural electrification administration (REA) within the government of the United States. The REA faced a lot of opposition from the private sector. The private investors did not want the government to be involved in the development of rural areas, articulating that it was unfairly competing with individual investors. The private investors were required to obtain licences for electricity undertakings from the Rural Electrification Administration, but they would often bypass the process and supply electricity to economically preferred

areas. Sometimes, they would zigzag the lines to potential loads without consent from the federal states (Chandler, 1984).

The private sector did not offer any subsidies to the beneficiaries. According to Morris Cooke, one of the early presidents of the REA and a strong proponent of the programme, commented that in addition to the energy charged, the farmer was expected to pay in advance the construction and connection costs to the private company. That made access to electricity prohibitively expensive for most rural dwellers. By 1939, 417 rural cooperatives had been established, serving some 288 000 households. The rural electrification programme led to electrification of most of rural farms by 1950 in TVA.

The social, socio-economic and economic benefits of the rural electrification programme in the United States of America were evident from public press and media service. The rural farmers could use the electricity to increase production from farms. It is worth pointing out that some of the resistance by the private sector was the fear of losing competition and the fear of corruption associated with some politicians, and their taking advantage of the programme. The private sector felt that keeping investment in the private sector would limit influence from politicians. These are some of the reasons that drive sector reforms and privatisation of state-owned enterprises (Matly, 2005; Zomers, 2001).

5.4.3 Electrification technologies

The private sector was well-advanced in electrification and general engineering designs compared to the federal corporations. The federal state agencies did not interfere much with standards and designs, except that the REA had to ensure that cooperatives were compliant and well-trained in energy management issues. Morris L. Cooke, a mechanical engineer and former president of the REA, exerted considerable influence in the electricity power business and the development of electrification codes and standards. The training reduced the tension between private investors and the cooperatives. In 1910, the generation frequency was kept at 60Hz and domestic appliances were designed for 120V, which was the acceptable voltage.

Currently, distribution voltages used in rural electrification are 14.4 kV and 24.9 kV. The distribution lines are sometimes affected by lightning strikes and corrosion from highly corrosive environments. The common systems used to protect anomalies in voltage or current fluctuations are:

- over-current and differential relays
- re-closers, fuses and surge arrestors.

Some of the poles have to be dressed with lightning protectors in areas prone to serious electric storms.

High loads, such as in urban areas and industrial sites, are serviced with a three-phase, three-wire system; an extensive use of phase-to-phase single transformers is applicable to appropriate areas. The rural areas are normally served with single-phase systems, which are multi-grounded. The REA uses special conductors to reduce the construction costs (Zomers, 2001; Gaunt *et al*, 2007).

5.4.4 Power sector reforms and regulation

The nature of the development in the electricity sector forced the United States of America (USA) to regulate the industry as early as 1906, in order to protect the public and entrants into the business (Matly, 2005). Regulation of the industry by REA resulted in extensive social and socio-economic benefits. This setting gave a fair treatment to the society and the proponents of the system.

In a regulated environment, the government controls most of the activities in the different sectors of the economy. Reports indicated that the USA strongly considered deregulating most of its utilities in the 1970s. This created a complex trading system in the electricity sector. There were mixed feelings about this initiative. For instance, Joskow (2003) commented that the United States of America started on the wrong footing in their restructuring process of the electricity sector in many parts of the country. It was argued that many of the policy advisors underestimated the requirements for institutional set-up and sustainable introduction of competitive wholesale, as well as retail markets. There was an oversight of the process involved in the operations of deregulation, vis-à-vis market architecture, economic efficiency and trading efficiency (Tishler *et al*, 2006).

Proponents of the reform process thought that transition was appropriate, until the California debacle in the year 2000, where there were power black-outs and prices rocketed by more than 100% within an hour stretch. Reports show that in some hours prices increased from \$30 per MWh to \$150 per MWh, rising up to \$750 per MWh in some instances (Rose, 2004). This led to a revitalisation of the deregulation process. It is argued that since the year 2000, no state in the USA has issued a law on deregulation. The need for government backing became evident (Hurlbut, 2004). Deregulation may still negatively affect electrification of rural areas that are still not connected to the grid, in terms of investment prejudice.

5.4.5 Summary of lessons

The implementation of rural electrification in the USA is a clear indication that capitalism is not appropriate for socio-economic development. The rural farms of the USA would not have had access to electricity services if the Roosevelt administration had not taken control of the rural electrification programme. The formation of a rural electrification administration made significant changes in the lives of the USA citizenry. The migration of the people from the rural areas to urban areas in search for better living conditions may have been discouraged by the improved living standards associated with electricity; clean water pumped from the sources, modern domestic appliances and farm equipment.

The formation of rural electric cooperatives provided good ownership of the projects and stimulated socio-economic development. The training offered by the REA to the cooperatives empowered rural people with better skills, processes and practices in the electricity sector. It also offered coherence in electrification technologies and standards, which helped to standardise the electricity supply industry. The government showed support for private sector investment by letting them lead the design process of the electricity networks. The involvement of the REA president in establishing design standards for power stations, transmission and distribution systems had a lot of impact on the players in the market, regardless of economic status.

The rural cooperatives were empowered with business skills such that they started other businesses linked to the electrification projects, such as supplying electrical equipment and other enterprises. It is evident that there was extensive stakeholder involvement in the implementation process. People knew about the project and were involved in strategising for their own development.

Regulation is another important element in making electricity affordable for the low-income groups. The conflict of interest between private investors and the cooperatives emphasises the need for a mediator in society. The interests of the private sector are commercially driven and they believe in the creation of wealth, as opposed to socio-economic development, which develops over time and hinges more on belief and hope than on economic and financial viability within defined timeframes.

The California electricity crisis is clear evidence of the need for federal involvement in a large share of essential service investments in the country, instead of entirely entrusting the economy to private investors. The involvement of the state in the development of rural farm in the USA underscores the need for reliance on capitalism to drive development in the country. Federal involvement helps to cushion some of the exorbitant escalations in the supply of essential services.

It seems appropriate for the federal states to own a significant amount of infrastructure, before other entrants are allowed a share of investment in any markets. This gives a better control of the assets in the country. In addition, this case is relevant to developing countries, such as those in sub-Saharan Africa, where the governments have difficulty regulating the oil industries, because most of the infrastructure belongs to foreign companies. Similarly, the Tennessee Valley Authority initiative sets a better example of the USA's control of assets and development of its own people. As a result, tens of millions of rural customers are currently supplied by the cooperative companies, for the development of agricultural activities and other entrepreneurships in USA (Nye, 1990; Zomers, 2001).

5.5 Norway

5.5.1 Introduction

The development of electrification in the Scandinavian (Denmark, Norway and Sweden) countries was somewhat similar. The development of the electricity market, the funding mechanisms and the regulatory frameworks drove rural electrification in Scandinavia. In this case, Norway is chosen for analysis because of the varied energy sources and activities characteristic of the other Scandinavian countries. In 2002, statistics indicated that the access rate was already 100% (IEA, 2002).

5.5.2 Energy profile

Norway is well renowned for its water resources and fossil fuels, especially oil and natural gas. The petroleum sector contributed 25% of Norway's Gross Domestic Product (GDP) in 2006. These petroleum resources are part of the country's wealth, and account for 50% of Norwegian exports. Norway is currently the tenth largest producer and fifth largest exporter of oil in the world. In 2006, Norway produced 2.8 million barrels of oil per day. Statoil was established as a totally state-owned enterprise in 1972 to undertake most of the petroleum activities in Norway; it was partially privatised in 2001.

Natural gas is another common energy source in Norway. Norway is the seventh largest producer and the third largest exporter of natural gas in the world. It supplies about 15% of the European Union, and it is the second largest producer of natural gas in Europe. Norway plans to establish a reliable gas market and a well-regulated transmission system for natural gas. The gas industry is presently a natural monopoly.

The electricity demand in Norway is entirely catered for by hydropower. Norway is the world sixth largest producer of hydropower and the highest producer in Europe. The annual hydropower production is estimated at 120 TWh, which covers 100% of the electricity demand in the country. Hydropower is currently the biggest business on-shore business in Norway. Norway's hydropower is integrated into the Nordic electricity pool, which comprises Norway, Denmark, Sweden and Finland. The government wants to

establish appropriate cooperation amongst the Nordic Pool operators of the transmission system, the regulators and involved authorities in the electricity market.

The Norwegian government works on promoting the use of other renewable energy sources, such as wind and gas generated electricity. Reports show that Norway currently generates about 1 TWh of electricity from wind power stations, and the target is to generate about 3 TWh from wind by 2010 (Enoksen, 2007)

5.5.3 Electrification processes in Norway

Abundant water resources in Norway made the supply of electricity to rural areas be driven by hydropower. Small hydro-electric schemes were developed country-wide to stimulate economic activities such as farming. Independent power producers (IPPs) would have a certain number of customers to serve with electricity. The generation frequency was standardised at 50Hz; the generators would supply both direct current (DC) and alternating current (AC) power to the customers at that time. Nowadays, most systems and appliances require AC power, generated at 50Hz and specific voltages pertaining to the respective country standards. The electricity tariffs were not based on the amount of energy used; rather, a fixed cost, based on the capacity supplied, was charged. Some power stations were owned by families and the state did not interfere much at that time.

As the generation capacity increased, a need for a centralised transmission system arose. Distribution companies had to buy from the transmission companies and serve customers. Similar developments took place in the other neighbouring countries including Sweden, Denmark and Finland. Developments in the electricity sector gave insight to electricity pooling or wholesale. As a result, the Nord Pool was established. The Nord Pool is an electricity exchange spot market, which came into effect in the 1990s. Distribution companies can purchase electricity at wholesale price for resale to individual customers.

Nowadays, there is a new development in the electricity supply industry noted with distribution companies in Scandinavia. The companies have interests in small-scale

hydropower schemes, which can supply them directly. The following reasons could be associated with their interest in such investment:

- The cost of supplying to places far away from the load centres
- Environmental requirements
- Reduction of dependence on power from the pool or wholesale supply
- New ventures into more hydropower generation to maximise incomes.

The latter desire was realised in 1996–1997, when a 2 x 4.75 MW run-of-river hydropower station was commissioned to supply Sør Aurdal area, where a concession was offered to Oppland Energiverk. The annual energy produced at the station is approximately 53 GWh (Zomers, 2001).

Small hydropower generation seems appropriate for the electrification of rural and remote areas in Norway. Investors, however, still have some fears about their investments (Zomers, 2001); their fears are linked to:

- Future business risks in revenues
- Funding and access to selling power to the grid
- Regulatory frameworks and stakeholder involvements
- Required technical expertise and competence.

In Norway, the government facilitated the supply of affordable electricity to the low income groups and financing mechanisms for the farmers in the rural areas, to increase access to electricity. The farmers and cooperatives were supported by the national electricity utilities, but they financed their own investments. The State Electricity Board exercised fixed tariffs for all customers, to make the electricity affordable to the farmers and rural areas.

5.5.4 Summary of lessons

Norway is a rich country for both large scale and small scale hydropower resources. There is a great potential for increasing renewable energy generation through small-scale hydropower schemes; these power schemes could be the best strategy to address power demand in remote areas, although it could result in differential tariffs and would need state intervention. It is evident in any energy setting, where socio-economic development

is involved, that there is a need for cost-effective technologies, effective energy governance and an understanding of rural electrification motives.

The Norwegian government played a major role in ensuring that the tariffs were not dependent on investment cost. Generation and transmission costs often affect the distribution costs and hence connection cost for the beneficiaries. By absorbing some of the investment costs by the government, it would enable some of the very remote customers to afford the energy services. This is similar to the Irish case where the development of rural electrification was realised as a service provision rather than a business driven by excessive returns.

5.6 Chile

5.6.1 Introduction

In Chile, the electricity supply industry comprises thirty-one (31) generation companies, five (5) transmission companies and thirty-six (36) distribution companies – to meet an approximate annual demand of 25 GWh of electricity. Chile privatised the state-owned electricity companies and liberalised the energy market in the 1980s. The National Energy Commission (Comisión Nacional de Energía, CNE), established through a decree in 1978, is the principal energy agency. It carries out most of the normative and regulatory roles for the energy sector. It formulates policies and strategies, and it controls tariffs and establishes service standards in the energy sector (Alexander *et al*, 2005).

5.6.2 Rural electrification programme

Prior to the reformation of the energy sector, rural electrification in Chile was implemented by the state-owned utilities through subsidies from the government. Tariffs were adjusted through cross-subsidisation between urban and rural areas. Urban areas were overcharged in order to offset the high tariffs associated with supply of electricity to rural areas. The access to electricity in the rural areas was less than 50% and close to 97% in the urban areas (Jadresic, 2000).

In 1994, the Chilean government launched a national programme of rural electrification, which was driven by the private sector. It was based on competition and decentralised decision-making. Electricity distribution was divided into four major zones, which shared the total electricity demand in the country. The main idea was to make rural electrification a business opportunity for the distribution companies.

The state provided subsidies for capital investment in the infrastructure and the distributing company would then maintain the infrastructure. Beneficiaries would finance the in-house wiring, electricity meters and coupling to the electricity grid. However, these costs, which were in the margin of 10% of the total project, were initially financed by the distributing company and recovered from the beneficiaries, over agreed times. That enabled the consumers expedient use of the services. The CNE managed all funds, subsidies from the state and donor funds.

The rural electrification programme was decentralised to local governments. Communities would submit a request to the zonal distributing company, which in turn compiled a detailed implementation plan – accompanied by a cost-benefit analysis. The plan was then submitted to the local government, which, upon approval, would request the subsidies from CNE through the central government. The central government allocated the funds according to the progress made and the need for further electrification in that area. The commission would only disburse the funds to the implementing company upon presentation of proper plans. To avoid sub-standard designs, the government would allow the distributing company to operate and maintain the system, whilst recovering its return on investment. The rate of return on investment was fixed at 10%, over a thirty-year period.

5.6.3 Rural electrification technologies

For grid extensions, a single-phase or three-phase distribution system was adopted. The system frequency was 50 Hz, with a supply voltage of 220 volts. Where extending the national grid was not cost effective, the following alternatives were applicable:

- Photovoltaic systems

- Hybrid systems that discouraged dependence on fossil fuels and reduced operating and maintenance costs
- Small hydropower schemes, combined with other energy sources
- Pilot projects based on wind power and biomass technologies.

Project life cycles were submitted during proposals, and revised as per requirement.

5.6.4 Programme success

The state budget estimate for the rural electrification programme amounted to US\$150 million for the connection of 110,000 rural dwellings. The target was to reach 75% of rural coverage after six years, and cover the remaining 25% in a period of four more years. The rural electrification programme was planned to run from 1994 to 2004. In 1992, the access to electricity was estimated at 53% in rural areas. The mass electrification programme commenced in 1994 and raised access to 76% in the rural areas by 1999, which had already exceeded the projection. According to statistics from the International Energy Agency, the access was estimated at 99% in 2002 (IEA, 2002).

The state invested US\$112 million between 1995 and 1999, whilst private sector investment reached US\$60 million in the same period. The implementation extensively involved regional authorities, which resulted in great political support (Jadresic, 2000).

5.6.5 Summary of lessons

The implementation of the rural electrification programme indicates that the government invested 65% in subsidies, whilst private investment covered 35% of the capital expenditure. The National Energy Commission (CNE) played a major role in planning, managing funds, ensuring compliance to standards, providing technical assistance (appropriate technologies, etc.) and coordinating the rural electrification programme.

The private sector was encouraged to participate in the development of the country with support from CNE and the offer of a fair return on investment (10%) plus an autonomous period of thirty years to recover the cost of investment. The only fear was that rural electrification is a riskier business than urban electrification because of low demand

compared to urban areas, and high operation and maintenance costs. Beneficiaries' reliable power supplies were protected by allowing the investor to operate and maintain the system, whilst recovering the costs through energy tariffs.

5.7 Guatemala

5.7.1 Introduction

The government of Guatemala privatised the two distribution companies undertaking rural electrification in 1998. The two major distribution companies by then were the Empresa Electrica de Guatemala S.A. and the Instituto Nacional de Electrificación (INDE). The INDE was bought by Union Fenosa International S.A., and it was split into two distribution companies – Distribuidora Eléctrica de Occidente (DEOCSA) and Distribuidora Eléctrica de Oriente (DEORSA).

The government of Guatemala developed a five-year rural electrification programme, termed Programa de Electrificación Rural (PER). The PER was included in a fifty year concession agreement to operate the distribution assets granted to DEOCSA and DEORSA during privatisation. Union Fenosa International S.A. was obliged to implement the rural electrification programme (PER). The PER aimed to increase access to electricity in rural areas from 60% to 90% between 1999 and 2004. By 2000, access had reached 66.6% (IEA, 2002).

5.7.2 Rural electrification programme

The government of Guatemala decided to follow an output-based approach (OBA) to implement the rural electrification programme (PER), whereby the private sector was used to develop the infrastructure. The output-based model was initiated by the World Bank Group's Private Sector Development Strategy to extend basic infrastructure and social services to economically disadvantaged groups in society (World Bank, 2002). Under the OBA, the government would pay the implementing company US\$650 for every new connection made. To qualify for the subsidy, the company needed to connect a residential area located at least 200 metres away from the national electricity grid. The more connections made, the better income the company would make.

The Guatemalan government set aside a capital budget of US\$333 million to finance the expansion of transmission and distribution networks to rural areas. The budgeted US\$151 million for transmission networks was to finance line extensions and substations. The remaining budget (US\$182 million) would be used to connect some 280 000 rural beneficiaries in 2 600 communities by the end of the five year implementation plan in 2004. The supply voltage in-house was 120V from a system frequency of 60Hz.

5.7.3 Regulation of the energy sector and tariff structure

The Comisión Nacional de Energía Eléctrica is the electricity sector regulator in Guatemala. It regulates tariffs proposed by the distribution companies, DEOCSA and DEORSA. Residential tariffs below 300 kWh are subsidised through a social tariff; the social tariff has a fixed charge and a variable energy tariff. The distribution companies were not satisfied with the fixed charge because they were having difficulty recovering operation and maintenance costs, which meant that the social tariff was not appropriately designed. The companies were penalised for poor service to the beneficiaries, but they were not required to refund the capital subsidy obtained from the government.

5.7.4 Ring-fencing of funds

A technical committee comprising the Ministry of Energy and Mines, INDE and two companies was established to manage the rural electrification fund. Annual work plans and an up-front payment of 20% for the projects were approved by the committee. To verify the eligibility of claims by the implementing companies, the committee hired independent supervisors. The supervisors would visit the project sites and beneficiary communities to verify the claims of subsidies from the companies.

The trust fund established for the rural electrification programme (PER) was administered by a local bank, Banco Agrícola Mercantil de Guatemala. The Bank of New York kept the money and would only disburse it upon request by the Guatemalan bank. The government raised US\$100 million from the privatisation process of DEOCSA and DEORSA, as well as US\$50 million from bonds. The balance of US\$180 million was acquired from different sources, in order to make the US\$330 million for the PER programme. The plan was that the remainder of the 90% of rural connections would either be covered through reduced costs due to proximity to connected neighbours, or,

financed differently. The 10% left out were mostly very remote communities where off-grid and stand-alone energy systems would be an option (Foster *et al*, 2001).

5.7.5 Summary of lessons

In any social development, there is a need for government intervention in financing and guiding the development of the investment. The private sector may need to be incentivised in order to effect output-based programmes in expanding infrastructure for risky investments. The service provider must be involved in ensuring quality service after developing the infrastructure. This protects the beneficiaries from unreliable service and sub-standard investments. The government must have a way of protecting infrastructure in the country by fast tracking the contractors or implementing companies. This should also be applicable to other such services as roads, telephony and water.

During the planning stage, the government needs to consider the delays in projects associated with obtaining right-of-way for the projects. The government must clearly define the conditions of development to the public, so that people do not see development projects as opportunities for acquiring money from interference with private property. In most developing countries, rural dwellers live in communal lands, which are held in trust for the state. Acquiring right-of-way therefore should result in minimal claims for interference with property.

In planning rural electrification programmes, financiers must budget for the effect of the programmes on the transmission systems and generation capacities. The government of Guatemala catered for the transmission component in its rural electrification programme. Voltage boosters are often overlooked in small scale recurrent electrification programmes.

5.8 Tunisia

5.8.1 Introduction

Tunisia is the smallest northernmost country on the African continent. It is bordered by Algeria, Libya and the Mediterranean Sea. In 1902, electricity generation started in Tunisia through the involvement of French companies. After its independence in 1958,

the government of Tunisia embarked on the nationalisation of major economic activities, such as rail, roads, gas, banks and electricity as a way of controlling investment and infrastructure development in the country.

On 3rd April 1962, a utility enterprise called STEG (Société Tunisienne de l'Electricité et du Gaz), translated as the Tunisian Electricity and Gas Company, was formed. The company was responsible for the supply of electricity and natural gas in Tunisia as Tunisia holds reasonable reserves of natural gas in Africa. At that time, only 26% of the residential sector had access to electricity. Investments in electricity supply and gas development were driven by demand, that is, by economic development. There was a demand for energy supplies to steel-works and textile industries (ESMAP, 2005).

5.8.2 Development of rural electrification in Tunisia

Rural development in Tunisia was triggered by the migration of rural people to urban areas in search of better infrastructure and social services. With assistance from Hydro-Quebec, a Canadian company, STEG conducted a feasibility study for the supply of energy services to rural Tunisia. The study was aware of the low levels of energy consumptions in rural areas, and the associated high investment intensity of the programme. At the time, the government was engaged in an integrated rural development plan.

Table 5.4: Electrification of Tunisia from 1972 to 2001(ESMAP, 2005)

Plans	4 th (1972–6)	5 th (1977–81)	6 th (1982–6)	7 th (1987–91)	8 th (1992–6)	9 th (1997–2001)
Cost (MTD*)		29	52	105	130	134
New connections ('000)	30	70	80	114	180	135
Cumulative connections('000)		100	180	294	474	608
Rural electrified (%)	6	16	28	48	76	88
Total electrified (%)	37	56	69	81	90	95
Solar PV installations					919	3 838

*MTD – million Tunisian Dinar. The Dinar fluctuated between 0.36 and 1.4 from 1975 to 2001 against the USA dollar (US\$).

Table 5.4 shows the development of rural electrification in Tunisia in five year plans from 1972 to 2001. The rural development plan of the five-year period state plans was implemented as fourth plan (1972–1976). It was driven by the following motives:

- Basic education
- Improved health services
- Socio-economic development.

5.8.3 Technological innovations

Initially, the Rural Electrification Master Plan for distribution voltages was designed based on a single/three phase with 30 kV medium voltage (MV) distribution systems, termed MALT (Mise A La Terre), which was adopted from a North American design. The MALT system seemed very economical at the time and it would result in savings ranging from 18 to 24%. The electricity network designs were consistently improved to lower the connection costs (ESMAP, 2005).

Savings from each respective programme were used to electrify more areas. The difference in the Tunisian approach was that households in the vicinity of an electrified area were all connected to the service, either with assistance from neighbours or through other sources. That increased the rural electrification from 28% in 1986 to 88% in 2000 and 94.6% in 2002 (IEA, 2002). The target was to reach 100% rural electrification rate by 2010.

To control the cost of rural electrification through techno-economic strategies, STEG later adopted the use of the Single Wire Earth Return (SWER) system. The SWER added 26–30% of savings to the programme. Customers were allowed to choose a technology of their preference, because of the environmental risk associated with the return current in SWER systems. Other cost-reduction measures included changing (ESMAP, 2005):

- conductors, from copper to aluminium alloys, when the global price of copper spiked
- suspension chains to pin insulators
- pre-stressed armoured concrete to round-steel poles

- circuit breakers at MV/LV (medium voltage/low voltage) substations to fuses
- the use of cement in pole fastenings
- expensive poles for cheaper ones
- spark gaps for lightning arresters to protect pole-mounted MV/LV substation transformers. This further reduced breakdown occurrences of transformers.

Capacitor banks were installed at MV branch lines and in big substations for customers to increase the power factor, reduce voltage drops and the level of technical losses in the system. Large customers were encouraged to install the capacitor banks instead of risking paying power factor costs for drops below a 0.8 value. In dispersed villages, the MALT 4.16 kV single-phase system was adopted to significantly reduce the costs. In fact, areas with low load points were served with single-phase systems.

The programme also involved solar PV electrification, as shown in table 5.4. The solar PV programme was implemented by the National Agency for Renewable Energy, called the Agence Nationale des Energies Renouvelables (ANER). This programme is mainly used for very remote areas (ESMAP, 2005).

5.8.4 Financing the rural electrification programme

The government of Tunisia drove the funding of the rural electrification programme from internal sources. External assistance was sought for the implementation of the seventh rural development plan. Finance was sourced from foreign banks and organisations. STEG and the beneficiaries were also involved in the financing programme by contributing a certain amount to the capital cost before being connected to the system. STEG initially contributed 100 Tunisian Dinars (TD) per customer and the beneficiaries would pay 200 TD for connection. The contributions from STEG varied with the economic development, that is, the contribution was different for agricultural and residential connections. The state paid the balance of the fees. Table 5.4 relates the periodic investment to the rural electrification programme. A block tariff design was set to benefit low-income groups, whilst protecting the interests of large power users. For instance, consumers less than 50 kWh benefited from a lifeline tariff.

The rural electrification was a synergic development of the rural development programme. It was funded from the regional fiscal budget of the government. To address the socio-political will, the president established other funding mechanisms for projects that did not readily qualify for regional development funds. The funds were a special presidential fund and a national solidarity fund. The presidential fund was used to finance projects identified by the president after visiting different regions in the country. The national solidarity fund was sourced from different sectors of society in Tunisia (ESMAP, 2005).

5.8.5 Synergic development and success indicators

The national development plan initiated by the Ministry of Economic Development (MDE) resulted in clean drinking water, improved transport and communication infrastructure, improved health facilities, education and socio-economic development. According to a UNDP/ World Bank analysis (ESMAP 2005: 12,13.), development indicators showed a parallel between rural electrification (1976–2001) and poverty reduction, from 40% in 1956 to 7% in 1995. Increased enrolment in Primary School Education, with a graduation rate of 60–70% in the Tunisian education system was reported in recent government statistics.

The real Gross National Product per capita increased from US\$770 to US\$1 060, from 1975 to 1999. An increase to 33% of women in the labour force was reported in recent surveys. Approximately 35% of Tunisia's total population lives in the rural areas. The rural development programmes bridged the gap, since rural dwellers have unlimited access to media and information services, they can realise better economic savings from the use of refrigeration and other equipment. Life in rural areas is not as costly as it is in the urban areas. The availability of modern energy and other services makes life comfortable in the rural areas. They have enhanced safety from security lighting and students can enjoy better light for studying in the evenings (ESMAP, 2005).

5.8.6 Summary of lessons

If development projects receive the proper implementation process, planning and funding, they can benefit the citizens of the country. A strong socio-political will is required to drive development in the country. The state committed at least four hundred

and fifty million Tunisian Dinars (450 MTD) to develop rural electrification in Tunisia; about two hundred million Dinars was sourced from foreign debts for rural development.

Tunisia had the key aspects of rural electrification in place before the implementation of the programme:

- Ring-fencing of rural electrification fund.
- Legal and institutional frameworks (responsibility assignment)
- Technology innovations
- Tariff designs (affordability, cost causations).

The success of the programme resulted in numerous socio-economic activities; it slowed rural-to-urban migrations and improved the quality of life. The synergic development significantly reduced poverty levels, which should be the ultimate objective of rural electrification.

5.9 Morocco, Mauritius and Kenya

5.9.1 Introduction

The emphasis in the following three cases is on the need for protecting rural electrification funds. Table 5.5 depicts the successes and failures of some rural electrification projects, despite having been established a long time.

Table 5.5: Other rural electrification programmes (GNESD, 2006c)

Country	Morocco	Mauritius	Kenya
Duration (years)	27	32	31
Initial rate (%) of rural electrification			Less than 1
Estimated investment (US\$)	4.05 billion	22 million	103 million
Estimated No. of connections('000)	5 375	737	93
Recent rural electrification rates (%) [#]	71.1	100	7.9

[#]Access statistics were extracted from IEA (2002).

5.9.2 Conclusion

Morocco and Mauritius succeeded because they had strong ring-fencing of rural electrification funds. Kenya did have a funding mechanism, but most of the funds (80%) were diverted to addressing the operations and system losses of the utility. Only 20% of the total budget was used for the implementation of rural electrification (GNESD, 2006c).

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CHAPTER SIX

6 RESEARCH FINDINGS AND DISCUSSIONS

6.1 Introduction

The previous chapters have broadly analysed the processes involved in the implementation of rural electrification. The research led to deducing key aspects for rural electrification policies for sustainability of the programmes. The key guidelines were applied in ten international case-studies to test their validity. This chapter discusses the findings of the research by summarising answers to the research questions guiding information pertaining to this study. In addition, a brief answer to the key research question concludes chapter six.

6.2 Contextual analysis for Swaziland

6.2.1 Situational analysis for rural electrification

Swaziland is governed by a highly bureaucratic system. Regarding land ownership, 54% is held in the king's trust by appointed chiefs, and the majority of the rural population lives on this land, where the rural electrification programme must take place. Hindrances to the implementation of the rural electrification programme may involve way-leaves and compensations. The geography of Swaziland shows that 29% of the land is in the highveld, which is very prone to lightning but the geography of the remaining land is less susceptible to lightning strikes. This implies that a variation in designing distribution networks needs to be considered. This may increase the rural electrification budget for other regions.

The economic outlook indicates that agriculture contributes significantly to the country's gross domestic product (GDP). Commercial agricultural activities used to be carried out mainly on Title Deed Land, which is privately owned. Recently, there has been a paradigm shift; most subsistence farmers grow commercial crops such as sugar-cane and vegetables, and they engage in poultry-farming, piggeries and other rural micro-

industries. These industries require electricity and can be drivers for socio-economic rural electrification in Swaziland.

6.2.2 Energy governance and sector reforms in Swaziland

The Energy Department under the Ministry of Natural Resources and Energy (MNRE) serves as a focal point for all energy policy formulation issues and operational activities of the energy sector. Energy issues are managed through five units; the electricity and coal section, the energy efficiency section, the data and economy section and the petroleum section. The electricity office is, inter alia, responsible for rural electrification in Swaziland. Electricity and refined petroleum products are the main commercial forms of energy. Bituminous coal is imported by private companies for own power generation. Petrol, diesel and paraffin are regulated by the Energy Department in consultation with the oil industry.

Swaziland imports more than 80% of its electricity for the national grid, mainly from South Africa, through the Swaziland Electricity Board (SEB). A significant supply of electricity in the country comes from self-generators, which does not contribute to electricity for the national grid (see figure 3.3). Most of local electricity generation for the national grid comes from peaking hydropower plants, owned and operated by the SEB. The SEB was established through the Electricity Act of 1963, to monitor all electricity undertakings in Swaziland, and thus the Act effectively monopolised the electricity supply industry. In 2006, the government enacted three Acts: the Electricity Act of 2006, the Swaziland Electricity Company Act of 2006 and the Energy Regulatory Authority Act of 2006, all aimed at reforming the energy sector. These reforms amended the 1963 Act, transforming the SEB into a company and establishing an energy regulatory authority. An explicit institutional framework is still not in place, except the structure annexed in the National Energy Policy of 2003 (SG, 2003:104).

6.2.3 Development objectives of the energy sector

The Swaziland National Energy Policy envisions that:

‘...the development goals of Swaziland must be met through the sustainable supply and use of energy...’

The national policy's objectives include:

'...increasing access to energy, enhancing employment creation, ensuring security of energy supply, stimulating economic growth and development...'

The development objectives pertaining to the energy sector, as outlined in the public policies, are coherent throughout the spectrum of government ministries. However, the policies are not explicit on how the objectives will be achieved. A rigorous implementation plan still needs to be formulated. The research did not find clear objectives for rural electrification from the implementing agency, the Swaziland Electricity Board. The short-term priority objectives show that a rural electrification master plan is required for the implementation of rural electrification in Swaziland.

6.2.4 Implementation of rural electrification in Swaziland

Rural electrification, through the extension of the electricity grid, is implemented by the SEB. The SEB subcontracts some of its work to contractors run by former employees of the SEB. The government allows the SEB to design the network according to their own engineering standards and the SEB autonomously sets the electricity tariffs. It applies a flat tariff structure throughout the residential sectors.

The capital investment for the rural electrification programme is financed by the government through donor funds and fiscal budget, as capital projects under MNRE. Donor funds are controlled by the Ministry of Economic Planning and Development (MEPD), and are disbursed to the SEB upon request by the MNRE. Disbursement terms are negotiated between the MEPD and the MNRE to speed up rural electrification projects. Other sources of funds are the Deputy Prime Minister's Office and the European Union (under MEPD), but they have different conditions. Currently, the programme targets rural schools, health-care centres and public development centres. A select committee on rural electrification, comprising a wide representation of stakeholders, prioritises the rural electrification projects.

6.3 Key aspects in rural electrification policies

This research established that the following key aspects are necessary in rural electrification policies:

- Ring-fencing of rural electrification funds
- Legal and institutional frameworks (responsibility assignment)
- Technology innovations
- Tariff designs (affordability, cost causations).

6.3.1 Applications of key aspects in international case-studies

In order to compare the implementation of rural electrification programmes in other countries, a ranking system of processes practised is given in table 6.1. A scoring system of 1–5, for each component of the guidelines used in analysing the programmes has been devised. Five points denotes the highest score and one point means the lowest score. A score of five implies that the guidelines were satisfactorily considered during the implementation of the rural electrification programme. The scores are based on the information gathered in the case-studies discussed in chapter five.

The key aspects tested in the case studies are as follows, where one point is allocated for each sub-component.

1. Ring-fencing of rural electrification funds:

- Sources of funds from the government
- Established funds for programme
- Involvement of the implementing agent in funding
- Contribution from beneficiaries
- How the funds are monitored

2. Legal and institutional frameworks (responsibility assignment):

- Understanding of drivers and art of project selling
- Government agencies for programme
- Government's objectives and policies, including way-leaves, etc.
- Implementing agency's organogram and strategies for the programme
- Collaboration and synergy

3. Technology innovations

- Distribution system (1-phase, 3-phase, etc)

- Transformer sizes
- Single wire earth return (SWER) system
- System integrity
- Other off-grid systems

4. Tariff designs (affordability, cost causations):

- Cost allocation
- Affordability
- Sustainability
- Social tariffs
- Cost recovery of investment

Information from the case-studies indicated that ring-fencing of funds and responsibility were the most important parameters in developing the energy infrastructure. These two parameters happen to be the first indicators of understanding the drivers for the programme, whether it is a social, socio-political or socio-economic development. The comparative case of Kenya, Mauritius and Morocco was included to show the importance of the two parameters.

Tariffs were crucial in making the electricity services affordable in the rural areas and in enabling the implementing agency to recover capital investment, as well as being able to meet operation and maintenance costs. The research shows that technology innovation was not the main feature in planning rural electrification programmes; however, it was realised during the process that it was necessary. Some of the electricity system developers were reluctant to explore new technologies, such as the SWER system, which could have significantly reduced the construction cost of the infrastructure.

Table 6.1: Ranking of rural electrification programmes

Country	Access (%)	Period (years)	Ring-fenced Funds	Responsibility	Technology	Tariffs	Totals (20)
Ireland	100	30	4	5	4	5	18
USA	100	-	5	4	3	4	16
Norway	100	-	4	4	4	4	16
Mauritius	100	32	5	-	-	-	-
Chile	99	10	5	5	4	4	18
Tunisia	94.6	30	5	5	5	3	18
Morocco	71.1	27	5	-	-	-	-
RSA	67	10	5	3	3	5	16
Guatemala	66.6	5	4	4	3	3	14
Kenya	7.9	31	1	1	-	-	-
Swaziland	4 [#]	9	3	2	1	1	7

[#]Access rate before 1999.

The statistics in table 6.1 show that countries that developed their programmes in line with the key aspects of rural electrification policies had significant success in implementation. Figure 6.1 relates the total points to the access rate for the sample countries. The total scores have been converted to percentages. The graphs in figure 6.1 show that there is a relationship between access rate and the total score – the higher the score, the higher the access rate. This implies that countries that applied the key aspects in their programmes succeeded in significantly increasing access to electricity. For instance, Ireland, USA, Norway, Mauritius, Chile and Tunisia have access rates ranging from 94% to 100%.

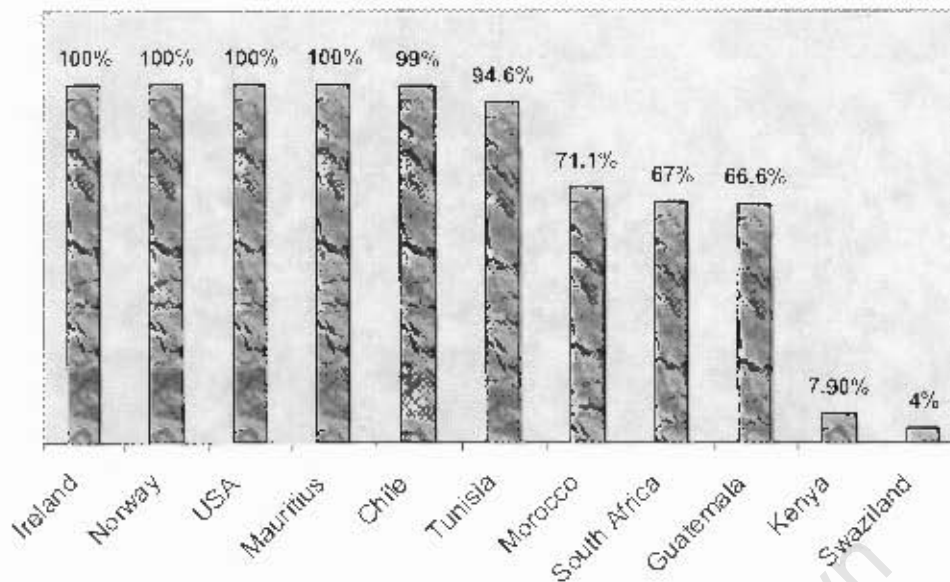


Figure 6.1: Access rate and accumulated points of sampled countries

The relevant governments understood the implications of socio-economic developments. The Irish government, for instance, was involved in promoting the use of machinery to increase the demand for electricity and increased production of farm produce. The government of Ireland introduced a flat tariff applicable to both rural and urban areas; otherwise, the rural tariffs would have been higher.

South Africa showed an understanding of the socio-economic and socio-political drivers for the rural electrification programme; the access rate almost doubled in a ten-year period, but it was hindered by the unclear direction of the Regional Electricity Distributors (REDs) programme and the photovoltaic (PV) electrification programme. Energy services from the PV concessionary areas were perceived to be more expensive than grid-electrified areas. The introduction of the social tariff in 2002 created mixed feelings in low-income groups because it only benefits those connected to the electricity grid.

Swaziland comes at the bottom of the list both in its access rate and its scores achieved in the ranking system. It appears to be the least electrified country of the sample countries.

6.4 The sustenance of rural electrification in Swaziland

Swaziland started rural electrification in the early 1990s, yet its access rate is still very low. The lack of a proper institutional framework, governance and processes has retarded the development of rural electrification in the country. To sustain the programme, Swaziland must reformulate its current indistinct development policies into a more rigorous approach, by incorporating the preconditions suggested in international rural electrification policies. For instance, some of the short-term objectives have not been implemented, yet the period for their implementation is already over. The following chapter draws its conclusions about this subject and makes several recommendations required for the sustenance of rural electrification in Swaziland.

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CHAPTER SEVEN

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

The research has produced enough information to validate the hypothesis made in the beginning of the study. The validity of the hypothesis will be evaluated in relation to the prevalent conditions in Swaziland. Conclusions are drawn on the basis of the information ranked in table 6.1 and interpreted in figure 6.1.

7.2 Validity of hypothesis

The initial development of rural electrification in Swaziland depended on foreign advice from donors and such international agencies as the World Bank, GTZ and others. Meanwhile, there was pressure from foreign agencies to reform and liberalise the electricity supply industry in Swaziland.

Local initiatives to develop the rural areas became manifest when the government issued a National Development Strategy in 1999. By then, activities on rural electrification in the energy sector were at advanced stages. Processes of formulating a National Energy Policy, reforming the power sector and institutional governance of the energy sector were already being addressed by MNRE. Studies conducted by foreign agencies on rural electrification at that time recommended that the government must fund rural development.

On the other hand, the implementing agency, the SEB, had developed an understanding that rural electrification would not bring any significant returns to the utility. Subsequent analyses that required the SEB to contribute to the capital investment in rural networks for socio-economic development were barely entertained. As a result the SEB did not realise the need to change its approach to rural network designs in order to optimise available resources. The SEB implemented the rural electrification programme with the

old conventional approach, which made connection costs prohibitively expensive in the rural areas.

The government has been funding the entire capital investment of the programme through various sources. The SEB also implements group scheme programmes, which are supposed to be blanket electrification. But no specific approach in terms of optimal technology designs is applied in the group schemes. Some of the decisions taken by the SEB's Board of Directors to reduce connection costs are not timely implemented by the utility's technicians. This shows adverse lack of understanding of the objectives and proper planning for the development.

In this study, several case-studies on rural electrification have been analysed to indicate the need for advanced cooperation and the problems associated with the lack of certain preconditions in socio-economic development programmes. The analyses included institutional, financial and technical aspects as preconditions for the success of development programmes. Table 6.1 and figure 6.1 show that programmes that lacked the key aspects in rural electrification policies performed poorly and those that regarded the key issues were successful in increasing their energy access rates.

The comparative analysis of the case-studies indicated that Swaziland has a low access rate because of the lack of proper guidelines, which include an institutional framework, and comprehensive development objectives and processes. Based on the grounds researched and the resultant findings, it can thus be concluded that *“a sustainable rural electrification programme in Swaziland hinges on how the government development objectives are identified and implemented through sector reforms, governance, tariffs and processes.”*

It proves the inference made at the beginning of this study and the hypothesis as valid.

7.3 Conclusions

7.3.1 General observation from international programmes

Most of the case-studies considered during this research show that they would not have succeeded without strong government intervention. The efficiency or effectiveness of some rural electrification programmes could be attributed to the lack of key preconditions in their processes. Some countries prematurely introduced power sector reforms in a bid to liberalise the electricity supply industry. Others introduced autonomous electrification agencies that tended to compete with the main utilities or limited the operation of the utilities, which created a negative attitude towards rural development programmes, which sees rural electrification as a burden to the utility.

Resistance to technology innovation by some utilities has kept the electrification of low load areas prohibitively expensive; it is regarded unviable on pure commercial approach, because of the excessively low return on investment. It becomes inevitable that a more proactive approach, with full understanding of the socio-economic objectives, needs to be adopted.

7.3.2 Swaziland

Swaziland has an immature electricity infrastructure. It is a net importer of electricity (and most of the commercial energy) from neighbouring countries in the SADC region. Local generation for the electricity grid accounts for only 20% of the system demand. This situation poses a major challenge to socio-economic development programmes. Introducing competition in such an immature industry could create a conflict of interest between the socio-economic development goals driven by the government and the corporate performance expected from the implementing utilities. Developing the electricity infrastructure requires optimal designs to deliver the services at the least feasible cost.

The government needs to be mindful of village governance issues, especially in rural areas controlled by the chiefs, which may delay the implementation processes. This affects the acquiring of way-leaves and construction.

The analysis of the rural electrification programme shows lack of proper institutional framework and understanding of the motives behind rural development. The cost overruns and delayed completion reports from previous projects are an indication of insufficient implementation capacity. The current proposed restructuring process of the power sector requires the establishment of an energy regulatory authority and an electrification agency. The regulatory authority requires the SEB to adhere to efficient corporate ethics, as opposed to service delivery to socio-economic activities.

The establishment of an autonomous electrification agency may set up competition between the SEB, as a system operator, and the rural electrification agency. Institutionalising the regulatory authority and the rural electrification agency may have a direct cost bearing on the government, which may affect focus on the rural electrification programme. The new organisations (regulator authority and agency) may affect the human resource base from the relevant government ministries and the SEB; staff members may migrate to the new institutions, in pursuit of autonomous environment.

The use of ordinary government officials and the staff of the SEB has caused some of the delays in the implementation of the rural electrification projects, due either to multiple commitments or conflicting interests.

The SEB does not have fully transparent and cost reflective tariffs, which makes it difficult to see cost allocation and required responsibilities, as well as subsidies.

7.4 Recommendations

7.4.1 Recommendations of the study

Swaziland started the rural electrification programme as a joint implementation undertaking between the Energy Department and the SEB. The government discouraged the use of open bidding systems to the electrification programme. The sole reason was to encourage capacity building within the SEB in handling big projects. It is thus recommended that the government maintains the initiated development cooperation. The

current legislations converting the SEB to a state-owned company imply that the SEB must adopt transparency in all its operations.

The general ethics of organisational behaviour¹⁰ require companies to act rationally and minimise uncertainty; companies should exhibit responsibility and proper control:

- Institutional framework
- Management competence
- Technical capacity.

The government must thus facilitate the strengthening of the SEB and the Energy Department to implement rural electrification. An appropriate example is the Irish rural electrification programme. The government used the utility (ESB) to drive the programme; the government of Ireland ensured that all legal issues (way-leaves, etc) were addressed by the government, not the ESB.

To speed up the rural electrification programme the rural electrification office at the SEB must be upgraded to a fully-fledged department, with strong technical and managerial expertise. The current rural electrification office at the SEB is understaffed and is thus unable to implement the rural electrification projects in a timely manner, which makes fiscal budgeting for capital projects very challenging to government.

The new rural electrification department at the SEB must be able to perform the following duties:

- a) Advise the government on socio-economic viability of rural electrification projects, in order to assist the government in estimating fiscal budgets for capital projects in rural development programmes
- b) Present the annual implementation plan to the select committee on rural electrification (SCORE)
- c) Submit the annual list of projects to the government to be included in fiscal budgets.

¹⁰ Refer to Clark (2000: 43-46, 49-51, 56-59) for comprehensive analysis on organisation behaviour.

- d) Implement the projects in time (procurement of material, tendering, construction processes)
- e) Account for the rural electrification programme
- f) Optimise resources in terms of appropriate technology innovation (cost effectiveness, reliability and service-delivery) for the various rural areas.
- g) Report back to the government in time to facilitate disbursement of rural electrification funds
- h) Carry out proper energy planning for the rural electrification programme and its impact on the electricity system, in order to advise the generation department on power procurement.

The SEB must remain the network developer and system operator of the national electricity grid, in order to maintain the integrity of the system. The government must set annual electrification targets for the SEB. The performance of the department must be assessed according to their meeting of the annual electrification targets set by the government.

Another factor in sustainable rural electrification involves the establishment of reliable funding mechanism. The rural electrification fund for the development of infrastructure must be coordinated by the government. However, the capital investment can be shared by SEB, the government and the beneficiaries. The conditions of contributions can be worked out by the government and the SEB. The tariffs must be designed to attract the use of the delivered service. A strong cooperation must be maintained between the government and the SEB in designing the tariffs, so that the programme does not become a burden to the SEB. The tariff design must encourage cost recovery of investment over a set period of time.

Rural electrification is not a panacea to rural social stress. But, it can be a catalyst for integrated rural development, such as agriculture, tourism, water schemes and micro-business initiatives. This implies that further studies need to be conducted in rural electrification.

7.4.2 Recommended further studies

At the beginning of this study an assumption “*that the targeted people will make use of the delivered electricity and energy services, for various development activities*”, was made. Hence it would be prudent to:

- Conduct an impact assessment of rural electrification in Swaziland, preferably every five years.
- Investigate how rural electrification can be a synergy project in the ongoing integrated resource plans for the development of the four administrative regions in Swaziland.

These further studies will be aimed at improving the implementation process, encouraging socio-economic development and increasing electricity demand in the rural areas – thereby sustaining the rural electrification programme in Swaziland.

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