REEE
-powering Namibia

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Conventions and Abbreviations

1.0	one
1 000	one thousand
1 000 000	one million
1 000 000 000	one billion
°C	degree Celsius
bn	billion
CEO	chief executive officer
CFL	compact fluorescent lamp
ECB	Electricity Control Board
EDI	electricity distribution industry
EE	energy efficiency
ESI	electricity supply industry
EWH	electric water heater
FY	financial year
GDP	gross domestic product
GWh	gigawatt-hour; equal to 1 000 MWh, unit of energy
GRN	Government of the Republic of Namibia
HDI	Human Development Index
HR	human resource
IPP	independent power producer
klh	kilolumen-hour, measure of the luminous intensity of light sources
kW	kilowatt; used as unit of electrical generation capacity, also denoted as kWe
kW_p	kilowatt peak; unit of peak electrical generation capacity, e.g. in solar PV
kWh	kilowatt-hour; sometimes also referred to as "unit of electricity", unit of energy
LA	local authority
LED	light emitting diode
LPG	liquid petroleum gas
LPU	large power user, such as a mine taking direct supplies from NamPower
MME	Ministry of Mines and Energy
MW	megawatt; used as unit of electrical generation capacity, also denoted as MWe
MWh	megawatt-hour; equal to 1 000 kWh, unit of energy
N$	Namibian dollar
N$/klh	Namibian dollar per kilolumen-hour
NamPower	Namibia Power Corporation (Pty) Ltd
NHIES	Namibia Household Income and Expenditure Survey
PPA	power purchase agreement
PV	solar photovoltaic technology that converts sunlight to electricity
RE	renewable energy
RED	Regional Electricity Distribution Company
SADC	Southern African Development Community
SME	small- and medium enterprise
SWH	solar water heater
TWh	terawatt-hour; equal to 1 000 GWh or one billion kWh, unit of energy
Wh	Watt-hour, a unit of energy

Foreword

Energy security and energy access are key challenges for Namibia's national agenda, and of course those of other countries in the southern African region too. A sufficient supply of energy is required to ensure that Namibia can embark on its ambitious development goals as spelt out in Vision 2030. However, the practical and regulatory challenges to ensure energy security are playing a key role in politics all around the world, and especially in countries such as Namibia.

Needless to say, the prosperity and economic growth of every country is based on how successful poverty and unemployment can be fought. All political efforts for a better education, healthcare-system or food- and water-security, and all visions and actions for a better future depend on a stable and abundant supply of energy.

As such, Namibia's energy future depends on how well the country can succeed in meeting the immediate short-term needs while building a sustainable base for the future. Today, Namibia still imports more than 60 percent of its electrical energy from South Africa. The dependency on foreign energy imports, in combination with insufficient local supplies of electricity, have a significant effect on the country's ability to eradicate poverty and grow the economy. The more the energy prices increase, the higher will the unemployment rate rise. That may well become reality in many countries in sub-Saharan Africa, but Namibia does not have to follow on this path.

In the context of a rapidly growing energy demand, will Namibia's development prospects be similar to the ones chosen in Europe or in Asia? The energy demand worldwide is expected to increase by 27% by 2030, with important changes to energy supply and trade flows. At the same time, the United Nations forecasts that the population in Africa will grow to around 2 billion people in 2050, which implies huge additional supply requirements. Today, only some 200 million of the more than 800 million people living in sub-Saharan Africa have secure and constant access to electricity.

How can the future be shaped if we do not find cost-effective means to give people access to energy? And which role will renewable energies play in Namibia, a country that is blessed with renewable energy resources, including some 350 days of sunshine per year? This book, which was written by Dr Detlof von Oertzen, who is one of Namibia's foremost experts on energy, gives a glimpse of how Namibia can embark on shaping its energy future. REEE-powering Namibia, as the author calls it, is seen by many as an indispensable pre-condition for the continued peace and stability of the country, and will pave a way into a better future for all.

I certainly hope that you, the reader, will enjoy this visionary text as much as I have. I also wish to invite you to engage in constructive deliberations on this critically important topic.

Dr Bernd Althusmann
Resident Representative of the Konrad-Adenauer-Stiftung
Namibia-Angola Country Office

Abstract

This study conceptually illustrates how the deliberate uptake and integration of renewable energy, energy storage and energy efficient technologies, i.e. *REEE-powering*, can drive Namibia's development and create local value.

There are several reasons why Namibia ought to embark on REEE-powering: the country's electricity supply is in a precarious state; Namibia continues to be extremely dependant on energy imports; and the billions of Namibian dollars leaving the economy every year to pay for energy in all its facets are a permanent drain on the economy. Money that leaves Namibia does not create local jobs, or local opportunities, or lift Namibians out of poverty, and is permanently lost to local development.

On the other hand, the use of renewable energies, integration of energy storage and the increased application of energy efficient technologies would create long-term local social, economic and environmental value. The choice for REEE-powering is therefore also a choice for local value creation, and against the perpetual export of opportunities. Today, Namibia's energy sector exports development opportunities, which limits local growth. But the country's energy sector can be transformed, and this is what REEE-powering is about.

In 2015, Namibia's electricity sector, as a key provider of energy to the country, is faced by many challenges, because of years of indecision in Namibia's power sector as well as unprecedented regional supply constraints. Yet, at the same time, a flood of increasingly affordable technologies becomes available and allows electricity users to produce some or all of their electricity requirements, store electrical energy and dramatically reduce their electricity demand.

Renewable energy technologies, and solar photovoltaics (PV) in particular, are game changers. Solar PV is a low-carbon emission energy generation technology with applications ranging from the supply for a simple light bulb to powering entire regions. In combination with modern energy storage and energy efficient technologies, these technologies begin to undermine today's centralised and highly protected utility business models, and will markedly influence their future operations and viability. REEE-powering has far-reaching consequences, including for NamPower and the country's electricity distributors. However, a utility view is only one part of the picture. Never before have so many affordable options existed to rapidly increase access to modern energy to the more than one-half of Namibia's population who remain largely

decoupled from the economy. At the same time, commerce and industry have begun to embrace the possibilities offered by REEE technologies, with many others to follow. The transformation has started but is just at its beginning.

This publication suggests how REEE-powering can transform Namibia to unlock economic growth, and with it create a foundation for sustained national development. Such a development has important *strategic considerations*, as REEE-powering is expected to enhance Namibia's energy security, reduce long-term currency outflows and our exposure to the whims of foreign exchange fluctuations, and enhance our resilience against climate change.

REEE-powering is expected to yield *social value*, particularly through local job creation, and the establishment of new income generation opportunities.

REEE-powering is also expected to create *economic value*, through new businesses, cost savings from local energy supplies, energy efficiency enhancements, stimulated local circulation of funds and reduced foreign exchange exposures.

In regard to *environmental value*, REEE-powering is expected to reduce local and regional greenhouse gas emissions, lessen the environmental footprint from the use of fossil fuels, and save water in the electricity sector.

Central to the concept of REEE-powering is that local value sources, such as Namibia's considerable renewable energy endowments, are converted into local economic value. This is mainly achieved by enabling energy sector participants to maximise the value of their own energy expenditures, and by the increased local recirculating of funds in the Namibian economy. In this way, the transformation of the country's energy industry is a democratisation process that establishes the foundation for sustained national development and local value creation.

The REEE-powering vision entails that more than one-half of all Namibians that do not have access to modern energy become actors in the economy by creating deliberate energy access pathways for all. Commercial and industrial entities can be weaned off their dependence on fossil fuels and imported electricity. Electricity distributors and the national electricity utility can more deliberately contribute to national development through the transformation of their business models to capture the innovative qualities offered by modern renewable energy, energy storage and energy efficient technologies.

REEE-powering Namibia includes the following main strategies:

- for domestic energy use, access to modern energy services must be strengthened to create the foundations on which national poverty alleviation efforts and the country's national development ambitions can be built;

- in commerce and industry, investments and uptake of REEE technologies must be further incentivised to create local jobs, foster innovation and the development of new local value chains, and promote local entrepreneurship in energy-related businesses;

- in the electricity distribution sector, business models must take cognisance of REEE technologies, broadening opportunities for an increased local sourcing of electricity, and extending energy-related service offerings to strengthen utilities' future revenue base;

- Independent power producers can significantly contribute to Namibia's energy security, the diversification of the energy mix, the creation of local jobs and fortifying the local economy, and must be attracted more readily through improved investor-friendly framework conditions;

- NamPower must be transformed into a national energy integrator that facilitates the provision of electricity to and between end-users, while leveraging its systems control capabilities to optimise value from national and its clients' generation assets.

REEE-powering Namibia's domestic, commercial, industrial and utility landscape enables each of these energy actors to become an active driver of the national development engine. In this way, Namibia would deliberately leverage its plentiful renewable energy endowments to energise national development in all its facets. And we do not have to wait for a decade or two, but can start today. *The time to act is now.*

1 Background

How can our energy requirements to ensure continued access to water, food, mobility and to power development be met without severely degrading the Earth's finite resource base? This is a key global challenge, and is also acutely relevant for Namibia.

Traditional energy planning views energy supply systems as configurations that satisfy our current and projected future demand for the various forms and types of energy that are part of the economy. We use the past to construct the future: we make assumptions about the growth of consumption, policies and policy direction, technologies, technology development, uptake rates, cost of fuels, maintenance and operating requirements, the economic development and others. While this process leads to a view of how our energy future may possibly look like, it more often than not fails to recognise and address how systemic changes would have to be made to transform the existing energy system in its totality. But this is exactly what is required today: we cannot realistically assume that our past energy consumption patterns can be perpetuated into the future.

In order to more sustainably power a nation and its development we need to address

1. whether specific national endowments, such as competitive or comparative strengths exist, that favour particular energy choices over others;
2. whether the social, environmental and economic changes introduced as a result of our particular energy supply choices are in fact desirable, or do at least not harm us; and
3. whether our energy choices enable the development of a society in which access to modern forms of energy is and remains secure, affordable and sustainable, without undermining the environment or negatively affecting the economy.

Previously, we attempted to answer the first question, suggesting that *Namibia is blessed with substantial solar, wind and biomass resources which constitute a comparative national advantage that the country can use to its long-term socio-economic benefit* [1]. However, we noted that despite the abundance of the natural blessings that Namibia is endowed with, their productive use and large-scale application remains limited. This is puzzling, as on closer inspection, few compelling reasons exist that would explain why the uptake and use of renewable energy (RE) and energy efficient (EE) technologies cannot be dramatically accelerated, and in this process, vigorously energise Namibia's development. This will therefore be the topic of this publication.

Based on the premise that numerous RE and EE opportunities exist, this study showcases specific examples that illustrate where such potentials exist, and how they can be developed. Our departure point is the realisation that various distinct energy user groups exist that have their own unique requirements: evidently, a small-scale end-user of electrical energy has different means, needs and abilities to take up RE and EE technologies than industrial or commercial users of energy have, and these in turn are different to the needs of an energy utility. This study therefore investigates the different energy user groups that exist in Namibia. It considers how small-scale energy users, commercial users including small and medium enterprises and large power users, local authorities and energy utilities stand to benefit from a more systematic adoption and use of RE and EE technologies, and energy storage. Throughout the text we use the phrase 'REEE-powering', which is to mean the systematic uptake and use of renewable energy and energy efficient technologies, as and when this is of benefit.

This concept paper presents various scenarios to illustrate typical end-user energy consumption requirements, and showcases the impacts that the adoption and use of RE and/or EE technologies would have, and the use of energy storage devices. The chapters below provide a first glimpse of the context in which various energy end-users operate, and presents approaches and measures to REEE-power their particular energy needs.

The study presents a synthesis of the choices that enhance access to modern energy across Namibia, and reflects on the energy security, affordability and sustainability that such energy choices create. While most of the study considers the financial and economic aspects of REEE-powering Namibia, the conclusions offer some thoughts on the wider social and environmental impacts that a deliberate transition towards clean energy sources would likely bring about, including the impacts on poverty, job creation and energy justice.

The case studies included in the text have been selected to illustrate the choices and wider changes resulting from the adoption and use of RE, EE and energy storage technologies. They are deliberately context-specific, and allow for a first assessment of whether an accelerated uptake of RE and EE is indeed desirable, and in which way such changes could be considered socially acceptable and economically justifiable.

As will be illustrated below, REEE-powering is about deliberately deciding for long-term benefits, for local value creation, and for environmentally benign energy use, and against the non-sustainable use of our natural resources and a perpetual import dependency.

The book ends with a philosophical view on our energy choices: we can strengthen Namibia's national energy supplies and long-term energy security by deliberately deciding in favour of a systematic large-scale uptake and use of renewable energy technologies, and the deliberate switching to energy efficient technologies. Namibia's renewable energy resources are abundant, readily accessible, available, safe and clean, and will remain so in future. In combination with modern energy efficient end-use equipment, ***REEE-powering Namibia is the key to energise the country's development. And it should start today.***

2 Introduction and Outline

Namibia is blessed with abundant local energy resources [1]. Yet, in mid-2015, the country's supply of electrical energy in particular is severely constrained, and remains uncertain [2]. It does not have to be that way. This concept paper illustrates how the country's energy future can be transformed, and in so doing, how enabling conditions can be created that drive national development.

Energy is a necessary pre-requisite for almost all aspects of our economic development. Other key ingredients for national development, such as the availability of adequate human capacity and resources, water, food, shelter and many others depend in one or another way or form on whether energy is available, accessible, and affordable.

Internationally, there is consensus about the importance of universal access to energy in general, and modern energy in particular, as a prerequisite and principal enabler of national and human development [3]. Individuals and nations can be lifted out of poverty by ensuring access to adequate energy. There is a considerable degree of positive correlation between energy use, economic growth and the level of national development. It shows that improved access to energy brings about a variety of personal and national development benefits, including the upliftment of livelihoods, improved health and education outcomes, increased income through productive uses of energy, and importantly, human dignity [4], [5].

In Namibia, where the national focus is now directed on poverty eradication, we realise that poverty reduction can take place by way of increasing household incomes, and importantly, by improving the health, education and productive capacities of individuals. It is therefore useful to take the immediate and direct impact that energy has on raising incomes into account, and factor in the many indirect impacts that an improved access to energy has on our education, health and other critical drivers of national development.

Being energy poor can imply not being able to cook adequate quantities of food, not having acceptable light to extend the natural hours of the day, forgoing educational, cultural and entertainment benefits, and possibly having to use polluting energy sources that have negative impacts on a person's health and therefore that of the wider community, while remaining caught in a life of hardship and unrealisable development opportunities [6]. Energy poverty is a trap that necessitates deliberate action. When energy poverty is addressed it unshackles individuals and enables them for development, and that of society at large.

Lifting people out of energy poverty creates personal and national development opportunities, and thereby transforms lives. It is the aim of this study to highlight some of the opportunities that Namibia can embrace to place national development on a road which can positively transform lives and lead to desirable and sustainable development outcomes.

This study once again highlights some of the low-hanging fruit on offer in Namibia's renewable energy (RE) and energy efficiency (EE) sectors and markets [1]. It illustrates how investments in RE and EE stimulate national development. How this strengthens the nation's social, economic and environmental fabric, for example through the upliftment of those in energy poverty, and the systematic uptake of RE and EE opportunities. And how REEE-powering creates local jobs, local value and energised national development.

In particular, this study assesses how private and public investments in both RE and EE technologies and practices can create local sustainable value. While this report is not attempting to provide advice on personal or public finance or investments, it showcases how a focus on RE and EE reduces poverty, creates individual and public wealth, and generates new business models and business opportunities. It shows how the deliberate adoption of RE and EE can strengthen Namibia's development prospects, driven by investments in decentralised energy and energy efficient technologies, though decision-making that focuses on creating local sustainable value through the multitude social, environmental and economic benefits that are created by REEE-powering Namibia.

The remainder of this book is structured as follows:

- **Chapter 3** provides a brief introduction and overview of Namibia's energy sector as a whole, and then highlights the prominent role of the country's electricity sector;

- **Chapter 4** highlights the important links between energy and the country's water, food, poverty alleviation and development imperatives;

- **Chapter 5** showcases how rural and urban Namibia can benefit through the systematic adoption of RE and EE technologies, and the requirements for systematically providing access to modern energy for all;

- **Chapter 6** reflects on the important role that commercial, industrial and large power users have for the economy of the country, and presents case studies that identify the costs and benefits when switching to RE and EE technologies;

- **Chapter 7** presents examples of how Namibia's electricity distribution utilities could benefit when embracing RE and EE technologies;

- **Chapter 8** reflects on the role that independent power producers have in REEE-powering Namibia;

- **Chapter 9** asks how the national electricity utility NamPower could advance Namibia's REEE-powering drive; and

- **Chapter 10** offers some concluding remarks and reflections on how today's energy decisions can positively shape Namibia's development and the country's future.

- **A reference section** provides links to some of the resources that were used, and presents additional details on select topics covered in the main body of the book.

3 Namibia's Energy Sector

This chapter provides a brief introduction and overview of Namibia's energy sector as a whole, and then highlights the prominent role of the country's electricity sector.

3.1 Introduction

Namibia's energy sector relies on the following primary energy sources (i.e. the energy contained in fuels and other energy carriers that has not yet been transformed) [7]:

- liquid fossil fuels, such as diesel, petrol, paraffin, liquid petroleum gas and related energy carriers;
- biomass, in the form of wood, processed wood products and charcoal; and
- to a lesser degree, coal.

The country's main secondary source of energy is electricity, which is both imported and generated domestically [7]. Of the locally produced electricity, the largest percentage contribution is from hydro-power [8], and a small but growing proportion is from solar energy.

The past decade's consumption of both primary and secondary energy sources, when expressed in GWh [9], is shown in Figure 1 [10].

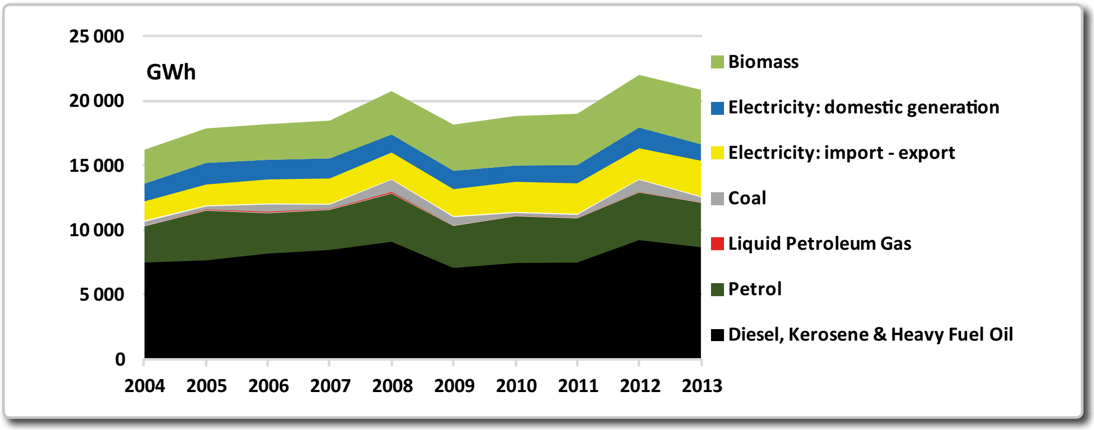


Figure 1:
Namibia's total primary and secondary energy use, in GWh [10]

In 2004, the country's total energy requirement amounted to some 16 TWh, and grew to almost 21 TWh in 2013 [10]. In this 10-year period, using a least-squares fit, the average growth in total energy use amounted to some 2.4% per year, while electricity consumption grew by an average of 3.1% per year throughout this period. Considerable year-to-year variations characterise the supply and use of energy in Namibia. Amongst others, this is due to local market responses to both global and local economic changes.

While the past decade's energy consumption increased at an average rate which was greater than the Namibian population growth rate in the same period [11], changes in the consumption of specific energy forms were mostly small, as is shown in Figure 2. It is noticed that Namibia continues to rely extensively on fossil fuels, including diesel, kerosene, heavy fuel oil, paraffin, petrol, coal, as well as imported electricity (which also mostly relies on the use of fossil fuels).

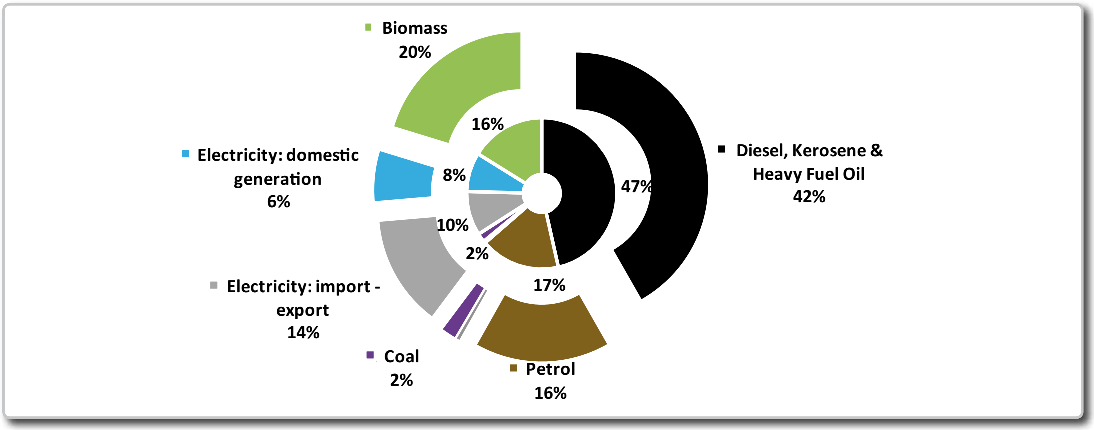


Figure 2: *Changes in the total energy mix between 2004 (inner ring) and 2013 (outer ring) [10]*

3.2 Namibia's Per Capita Energy Use

Figure 3 shows Namibia's total energy consumption, in TWh [18], and the country's total population [12], expressed in million, between 2004 and 2013.

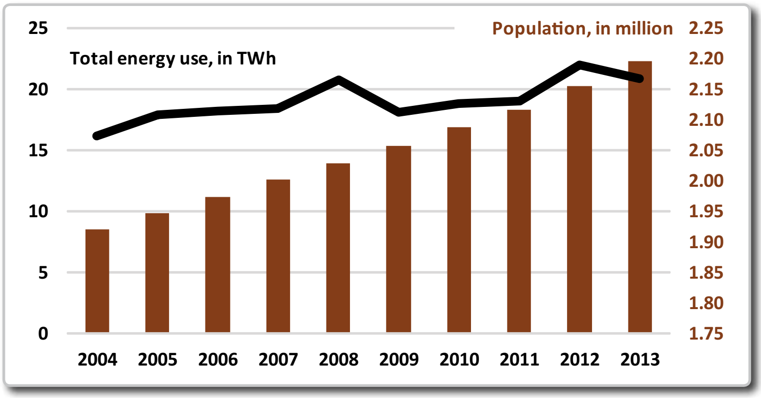


Figure 3: *Total energy use (in TWh) and population (in million) between 2004 and 2013 [10]*

Total energy use per capita increased from some 8 400 kWh/person/year in 2004, to almost 9 500 kWh/capita/year in 2013, as shown in Figure 4 [10].

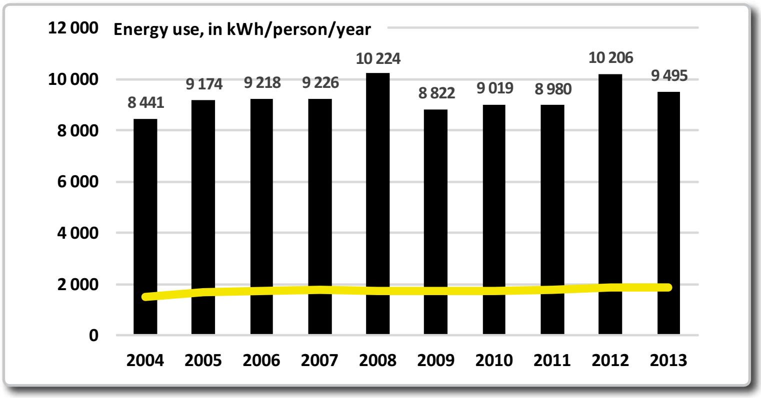


Figure 4:
Total annual energy and electricity use (yellow line) per person, in kWh/person/year [10]

In the same period, the electricity consumption increased from some 1 500 kWh/capita in 2004, to about 1 850 kWh/capita in 2013, as shown in Figure 4 and Figure 5 [10].

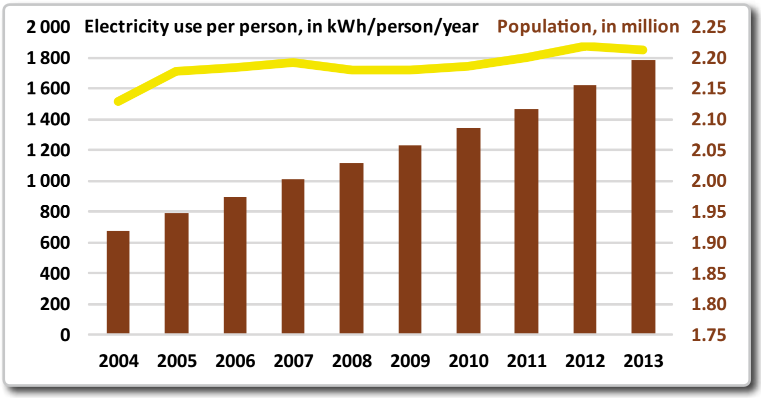


Figure 5:
Electricity use per person per year (in kWh/person/year) and population (in million) [10]

The average per capita electricity use as shown in Figure 5 can be misleading. It is the result of dividing the total electricity use in a specific year by the total number of people estimated to live in Namibia in that year. It is therefore an average consumption figure that says nothing about the actual electricity use per person. In order to establish a better understanding of the actual electricity consumption per person, or per household in Namibia, it is helpful to reflect on the number of households that are actually taking supplies from an electricity distributor in the country.

In a recent study undertaken for the Electricity Control Board, current household electricity consumption rates were assessed as part of the formulation of an electricity support mechanism for low-income electricity users [13]. In 2014, some 190 000 households take supply from one of the major distributions entities. An average of almost 4 200 kWh of electricity is drawn per connection per year. Assuming an average household occupancy of 4.2 therefore implies an actual average end-user electricity consumption of some 1 000 kWh/person/year.

Based on the research undertaken in the aforementioned assessment, the percentage of domestic customers as a function of their monthly electrical energy consumption can be ascertained. Figure 6 shows the result for the three operational Regional Electricity Distributors (REDs) and the City of Windhoek. Some 47% of all domestic customers served by CENORED have a monthly consumption of up to 100 kWh, while only 3% of domestic customers served by the City of Windhoek fall into this consumption bracket. The above indicates that – amongst those domestic end-users that are fortunate to have access to electricity – there is a considerable spread of the actual monthly electricity consumption.

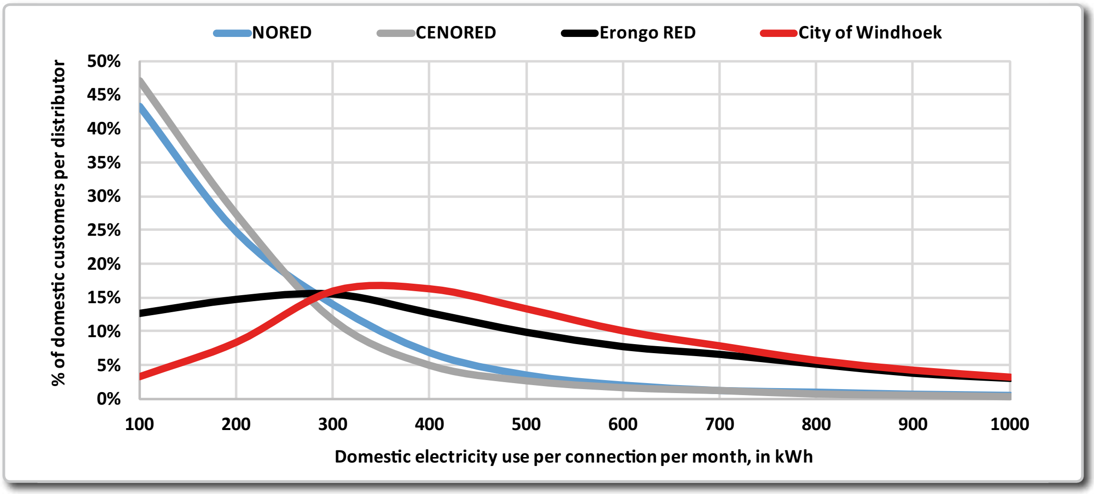


Figure 6:
Percentage domestic electricity clients and their monthly consumption, in kWh [14]

On the other hand, it is important to recognise that there are an estimated 74 000 households located in peri-urban areas in and around the urban centres of the country that have not yet been electrified [15]. In addition, an estimated 231 000 rural homesteads remain without access to electricity, despite considerable efforts and funds that have been applied for rural electrification efforts since 1990. Access to electricity therefore remains an important topic in Namibia today, and is therefore covered in more detail in chapter 5.

3.3 Energy Use and the Gross Domestic Product

A measure of a country's economic output is the gross domestic product (GDP) [16], [17]. Figure 7 shows the country's total use of energy in the decade between 2004 and 2013, in TWh per year (abbreviated TWh/a) [18], and the nominal GDP in billions of N$ per annum (which is abbreviated bn N$/a).

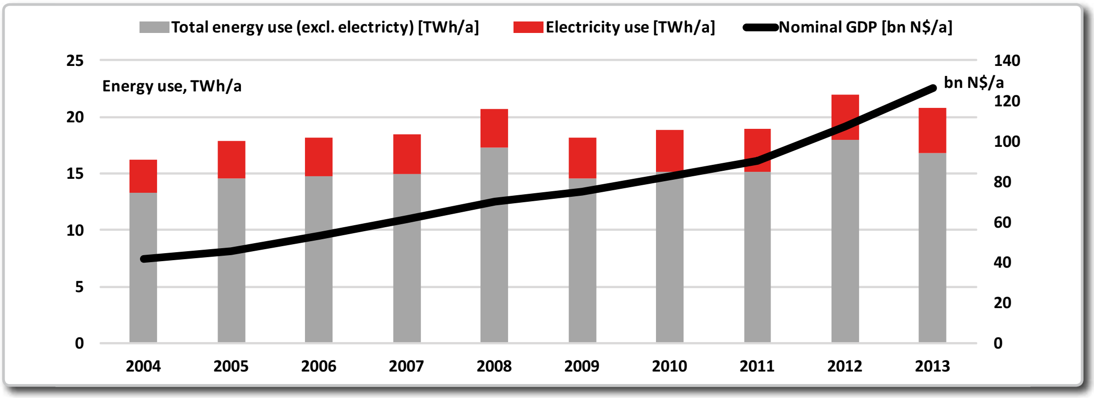


Figure 7:
Namibia's energy use and nominal gross domestic product [10]

Linking the nominal GDP with the total energy use, as depicted in Figure 8, shows that the economy has more than doubled its output as measured in nominal GDP per unit of input energy required [10].

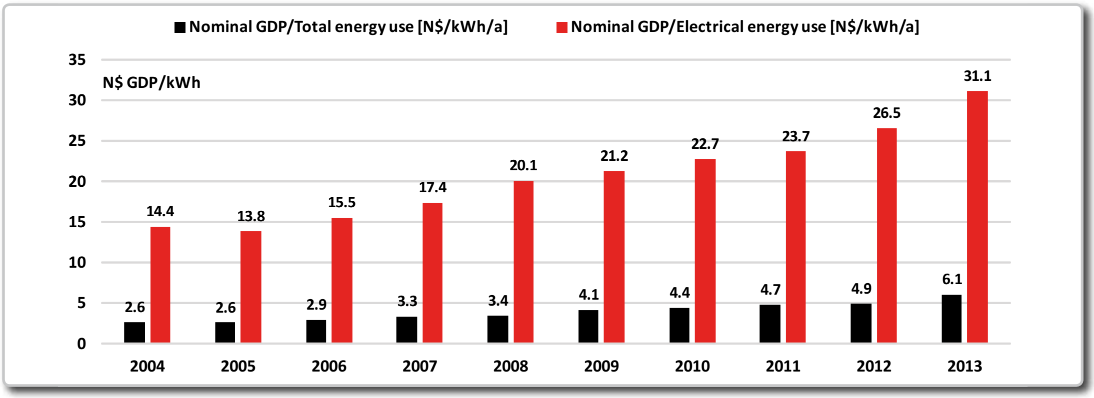


Figure 8:
Nominal GDP per unit of total energy used (black) and per unit electricity used (red) [10]

Namibia's economic growth is not linearly linked to energy consumption, as one would expect had the economy been mostly dependant on commercial and industrial activities that require additional energy to contribute to the GDP [16]. The tourism and service sectors are examples where the link between the input energy required and economic output produced is not as pronounced as it is in the extractive industries, such as in mining.

3.4 Energy Use and the Human Development Index

It is instructive to compare the average energy consumption per person from developing and developed countries, as it offers some insights into specific countries' state of development. Generally, it is accepted that a causal link exists between a given quantity of energy consumed, and the associated economic activity. Simply put, most activities necessitate some form of energy, and therefore, as the population grows and their overall activity levels rise, so does the average energy consumption per person.

An indicator that is often used to quantify the level of development of people living in a particular country is the Human Development Index (HDI) [19]. The HDI combines socio-economic aspects of a country's citizenry, such as their educational attainment, life expectancy, degree of poverty and income inequality, gross domestic product per capita and the environment into a combined indicator which ranges between 0 (lowest HDI) to 1 (highest HDI). In this way, countries can be classified according to their HDI attainment. Countries with a high HDI offer a generally high standard of living, while developing countries, and poor countries in particular, generally offer a much lower standard of life. Repeatedly, countries such as Norway score very high on the HDI, and attain levels close to 1, while countries such as Namibia, Botswana and South Africa are characterised by an HDI ranging between 0.6 and 0.65. Poor countries, such as Sierra Leone and Somalia, have an HDI of below 0.4.

Figure 9 shows the HDI of some 100 countries, as a function of the total energy use per capita. In 2014, Namibia's HDI was slightly above 0.6 [20]. The total average annual energy consumption per capita amounted to some 9 757 kWh/person in 2014 [21], as shown in Figure 4. Namibia's neighbours, including Botswana and South Africa, have HDI attainments similar to those of Namibia, but both have higher per capita energy consumption rates.

Figure 9 allows for some broad observations: for example, given Namibia's per capita energy consumption, our HDI should be higher, as is for example achieved by Tunisia. In other words, we should have achieved a higher HDI given the amount of energy that is consumed on a per capita basis. Namibia's energy intensity is higher than is reflected in our HDI. Other countries 'achieve more development' with similar or less energy than is consumed by Namibia.

There are numerous country-specific aspects, such as Namibia's low population density and the presence of some energy-intensive activities such as mining that all have an impact on the quantity and demand of energy. At the same time, in 2015 there are still slightly more people living in rural Namibia than in urban areas, although rural-to-urban migration diminishes the difference between the two areas rather quickly. Energy access and the use of energy per person continues to be significantly skewed when comparing those living in urban areas and rural Namibia, as will be discussed in greater depth in chapter 4. This implies that while an indicator such as the average energy consumption per capita per year is interesting, it says nothing about access to energy, energy poverty and the potential upsides that the improvement of access to modern energy can have on the lives of individuals, and with it the development of the country.

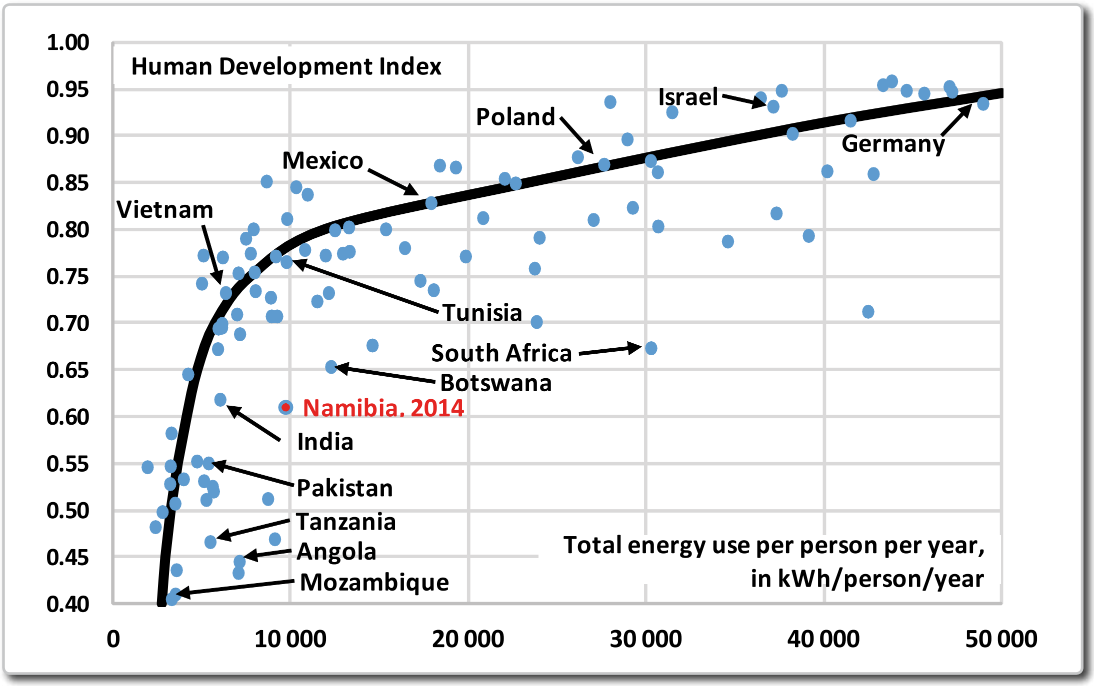


Figure 9:
HDI as a function of the energy consumption per capita, in kWh/capita/year [22]

Why is the correlation between Namibia's HDI and the average energy use per capita important? For one, energy is a critically important ingredient for development to happen. It is one of the essential prerequisites for most development efforts. It is not the mere fact that energy is indeed consumed, but that such energy consumption occurs as a result of powering the nation in its development. This implies that, although activities may be energy intensive, they may not be an effective contributor to national development, and may even hinder a country's ability to embark on a path of sustainable development. As an example, the extraction of minerals for export necessitates considerable resource use while potentially leaving a legacy of long-term liabilities.

From the perspective of an individual citizen, and despite a country's total per capita energy consumption being high, energy poverty may be part of the day-to-day reality. And with it, energy poverty limits people's ability to reach their own development aspirations, locks them into poverty, and effectively decouples them from economic activities and progress. As will be discussed in chapter 4, this is part of the face of Namibia, and little progress has been made in the past decades to effectively address this situation.

From an energy perspective, there are several critical aspects to consider:

1. Does Namibia have the requisite energy resources to power its development?
2. Is the energy that we currently consume used efficiently and effectively, and does it meaningfully contribute to enhance the country's development?
3. Can renewable energy sources and the rigorous use of energy efficient technologies contribute to national development?

Question 1 has been addressed in considerable detail, and we will not repeat what has been covered in a previous study [1]. However, we re-iterate that *Namibia is blessed with substantial solar, wind and biomass resources which constitute a comparative national advantage that the country can and should use to its long-term socio-economic benefit* [1]. However, we also noted that despite the abundance of these natural blessings, their productive use remains limited, and that there is no compelling reason why the purposeful use of the country's abundant renewable energy riches on the one hand, and the more deliberate uptake of energy efficient equipment and technologies on the other hand, cannot and should not be dramatically accelerated, to power Namibia's development.

Question 2 is addressed in more detail in chapters 4 and 5, and shows that the availability and accessibility of energy favours those living in urban Namibia who have the means to pay for it. There are many positive development-related aspects that the more deliberate uptake and use of renewable energy and energy efficient technologies could introduce, thereby enhancing people's lives while substantially contributing to national development efforts in a more environmentally benign, economically viable and socially just way. This is what REEE-powering Namibia is all about.

Question 3 is the topic of the remainder of this study. It is about REEE-powering Namibia, which is to mean the rapid and systematic uptake and use of both renewable energy technologies to power the country's needs, and the systematic focus on energy efficiency potentials by which the consumption and use of energy is optimised.

Specifically, this study reports on how the uptake of renewable energy technologies can make a positive impact on energy end-users, irrespective of whether such a person resides in urban or rural Namibia. In addition, we will consider how commercial, manufacturing and industrial entities can benefit when switching from conventional energy sources to renewables. And we offer suggestions and some reflections on how electricity utilities, including independent power producers as well as those responsible for generation, distribution and the supply of electrical energy, can benefit from the abundance of Namibia's renewable energy resources and the adoption of energy efficient technologies. This is what we call REEE-powering Namibia, and it is what the remainder of this concept paper is all about.

4 Energy Matters

This chapter discusses the links between energy and the country's water, food, poverty alleviation and development imperatives.

4.1 Introduction

The way in which energy is made available for domestic, industrial and commercial end-use shapes a country's economy. In the case of Namibia, the decisions and choices we make in regard to the energy system that powers the country's development has for some time been a central challenge for policy. At the same time however, the critical link between our energy choices and national development ambitions have seemingly not been recognised by the official custodians of the country's energy sector. Why not?

Today, the energy-related challenges faced by Namibia are complex, and have many aspects and characteristics that would not seem – at first sight – to be related to energy at all. However, poverty, challenges in the water sector, the scarcity of home-grown food supplies, our vulnerability to a changing climate, crime and a host of other symptoms relate in one or another way to how the country makes available energy for end use, to whom such energy is provided, and how much it costs in Namibia today.

As was shown in Figure 2, most of our established energy consumption patterns are slow to change. And such change necessitates deliberate action. One of the many reasons for resistance to change is the result of the multitude of personal interests that permeate our economy, and with it, our national energy supply systems. Web-like financial and other entanglements extend through the entities and organisations involved in the sector, as well as the structures and processes that underlie them. It takes strength to control the power kraken.

In Namibia, monopolistic structures and entities enjoying some protection by Government or its institutions have a self-interest in perpetuating a particular way of doing business. On the other hand, one also has to realise that most energy supply systems necessitate considerable investments, both in terms of human resources and in the form of capital, which individuals and organisations nurture and protect. By perpetuating their own approaches to business, the players that constitute the country's energy supply system have created a set of personal, organisational and societal arrangements that define the way in which the economy functions. And with it, these processes set the pace at which development ultimately takes place, including if and how the pace, scope and scale at which poverty and other societal ills and challenges are addressed. Granted, big words indeed.

Occasionally, prompted by the inability to plan and/or deliver supplies to cater for the energy required by the nation, or sudden changes in commodity prices or supplies, or demand bottlenecks, or innovations, a momentary instability occurs, sometimes even destabilising well-established actors. When this happens, end-users accustomed to a steady supply of life-giving energy become frustrated, and dissatisfied. Such situations necessitate decisions. And often, irrespective of whether the right decisions are made, or whether procrastination continues delaying them, such inflexion points can prompt the transformation of parts or an entire energy supply system, and with it, some or most of the social, economic and technical structures that have been built over decades.

In mid-2015, Namibia finds itself at one of these critical inflexion points in the country's energy sector. Planning has failed to ensure that entities tasked with the supply of energy have taken the necessary steps to implement energy supply systems that cater for the present and the future, further weakened by policy that has for years been oblivious to an impending energy crunch. For national development, and specifically for the alleviation of poverty, the apparent disconnect between the social, economic and environmental dimensions that are brought about by our choices and decisions about national energy security and an adequate provision of energy to power development is cause for concern, and does not bode well for Namibia's future.

Often, debates about energy fall into one of the following categories:

a. the legal focus, that considers how policies and laws guide investments, activities and processes within the energy sector;
b. the environmental focus, which views energy systems in terms of the requirements for services from the environment and emissions into it;
c. the techno-economic focus, that considers specific technologies, their price to supply a given quantity of energy, and the in- and outputs to make such supplies available; and sadly also
d. a self-centred focus, which is largely guided by the actual or potential shareholdings that can be enjoyed in current or new energy ventures.

Rarely does an energy debate consider the systemic and potentially significant positive implications that a well-planned and thoroughly implemented energy supply system can have on the country's economy, its societal development and the environmental imperatives. In this book we argue that short-term energy decisions – especially those that are taken when trying to quickly address an energy crunch – often stand in the way of the multiple potential benefits that can be reaped through longer-term strategic investments, and a focus on local sustainable energy supply systems. In fact, crisis management may bring about short- and long-term costs that harm or reduce the potential benefits that the energy industry could catalyse in the country. We therefore highlight select cases that illustrate how Namibia, through deliberate switching to local renewable energy sources, and by focusing on energy efficiency measures and technologies – i.e. REEE-powering Namibia – can initiate changes in the way we supply and consume energy. Such REEE-powering must aim to create long-term benefits for society and the environment while being economically prudent.

An energy supply system underpinned by renewable energy technologies – in contrast to an energy system based largely on fossil fuels – creates local re-enforcing feedback loops in which human and financial capital benefits through local use and re-investment. This creates local value through human capacity development, direct and collateral investments, job creation, generation of taxes and the strengthening of local supply chains. In contrast, high-input conventional energy supply systems operating on fossil fuels create value streams that permanently leave the investment locality, and therefore, in the case of Namibia, the country. As part of its design, such dependence on fossil fuels leads to permanent capital flight, thereby reducing the ability and the incentive to invest and build local structures.

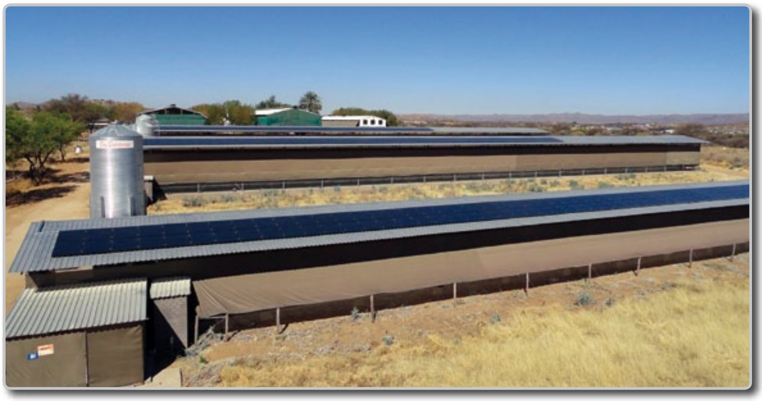
As a developing nation with a small local industry, but the ambition to become an industrialised country by 2030, Namibia needs to ensure that investments, for example in the energy sector, create local value chains in which value addition takes place through the creation of local re-enforcing value feedback loops. In this way, our energy supply system becomes the driver of a wider socio-technical system in which local economic value is created, which in turn strengthens the social and economic context in which it operates.

For example: an investment in imported solar water heaters brings about tangible and measurable local benefits, no doubt about that. However, had an investment in a local manufacturing plant in which new local jobs create new local economic benefits been made instead, the original investment for imports could have been multiplied several fold. Therefore, a policy decision about a target for the annual contribution that solar thermal devices are to make would consider and be centred around local economic value creation taking place as a result of such a policy target, rather than the mere technical specification of a national target. In this way, a small part of the overall Namibian energy use which is now accomplished by using solar water heaters, becomes an integral part of the larger transformation of the national energy system, which seeks to enable favourable societal developments, create economic growth and ensure positive environmental outcomes by targeted investments.

At the heart of the transformation of the national energy supply system is the question how such a transformation can be initiated and driven without necessitating numerous new laws and regulatory provisions, subsidies, get-rich-quick schemes and non-sustainable incentives. Here, the decision process that is to underpin such a transformation must be as close to the energy end-user as is reasonably possible, as it is the end-users' purchase decision that ultimately determines which services have to be supplied, and in what quantities. This implies that it is for policy to create a playing field that promotes the broad participation of as many energy stakeholders as possible, rather than promoting the enrichment of a select few at the cost of all other energy consumers. In this way, energy sector stakeholders benefit through improved collaboration rather than by exclusion. The guiding principle must be that we can ill afford to leave some in society without the benefits of access to modern energy services as this will essentially leave them decoupled from the economy, and therefore our national development in years to come.

The realisation is that it is to everyone's benefit if the economic base is sufficiently broad to accommodate every Namibian citizen. This also implies that universal access to modern energy – as will be defined further below – should become one of the central pillars of Namibia's vision of a future in which energy is available, accessible and affordable, and contributes to the social, economic and environmental development and growth.

Figure 10:
REEE-powering local chicken production, Waldschmidt Eggs near Windhoek [23]



4.2 Inputs and Outputs of Namibia's Energy Sector

A simplified systemic view of Namibia's energy sector is depicted in Figure 11. It shows that the sector – similar to many economic endeavours taking place on an industrial scale – relies on human capital (abbreviated HR, i.e. human resources), financial resources in the form of capital required for investments as well as ongoing operating and maintenance expenditure, and a variety of natural resources which mostly include water, land, and a variety of mineral, biological and other resources. Granted, the systemic view shown in Figure 11 is simplistic, as it is incomplete, but it shows those important in- and outputs that also play a key role in REEE-powerig Namibia.

The sector offers long-term career opportunities, and can therefore be a national job engine, both for direct jobs within the sector as well as a large variety of job-creating opportunities in and around the periphery of the sector. The sector's primary output is understood to be in the form of useful energy, expressed in TWh, for domestic, commercial and industrial use – i.e. the stuff that powers the nation. Critical in the delivery of energy for final consumption is whether it is available as and when needed, whether it is offered in the location and the form that end-users can have access to, and whether it is affordable.

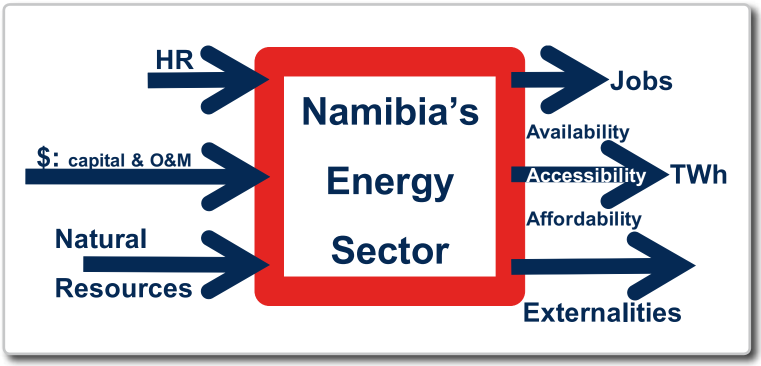


Figure 11:
Systemic view of Namibia's energy sector [22]

Arguably, the availability, accessibility and affordability of energy (the 3 A's) are not sector outputs per se, but are conditions that can be met when supplying energy. If such conditions are met, end-users can benefit from the supply of energy. The reason why the energy sector's 3 A's are depicted as outputs of the energy sector stems from the realisation that all other systemic outputs depend on meeting – at least partially – these critical conditions of supply. Whether and in how far Namibia's energy sector supplies energy to end-users and at the same time meets these conditions is expanded on in chapter 5.

Another critically important set of energy sector outputs includes the externalities, which are all those aspects that impact positively or negatively on society at large but which are not explicitly charged or paid for. Examples of positive impacts include human capacity development, and infrastructure that is built to deliver energy and turned into public commodities, as is the case for public roads. Examples of negative impacts include a variety of emissions, in the form of gases, particulates and liquids, as well as waste products. Decisions about a sensible energy future are challenging because the above in- and outputs depend on how one trades off today's costs and benefits with those arising in future. Such costs and benefits are neither easy to predict, nor is it always apparent why society values one outcome over another one.

4.3 The Interdependence of Energy, Water and Food

Namibia is a dry country. This makes the provision of potable water a priority that underpins all other endeavours. No development can take place without adequate supplies of water.

In Namibia, the provision of water depends most critically on the availability of energy. Most notably, electricity is used to drive pumps that extract water from boreholes and dams, to transport water along pipelines, for purification, for service delivery and most other aspects related to the extraction, preparation and delivery of this essential good. Indeed, most of NamWater's 4 210 km of pipelines, 823 boreholes, 377 reservoirs, 17 treatment plants and 19 dams depend on the availability of electricity [24].

The interdependence between energy and water is undeniable, and implies that the provision of reasonably priced electricity underpins all aspects related to the provision of water. This linkage is of strategic importance: Namibia's water sector and its development are undeniably and inextricably interwoven with our energy sector. A failing energy sector automatically leads to a more vulnerable water sector.

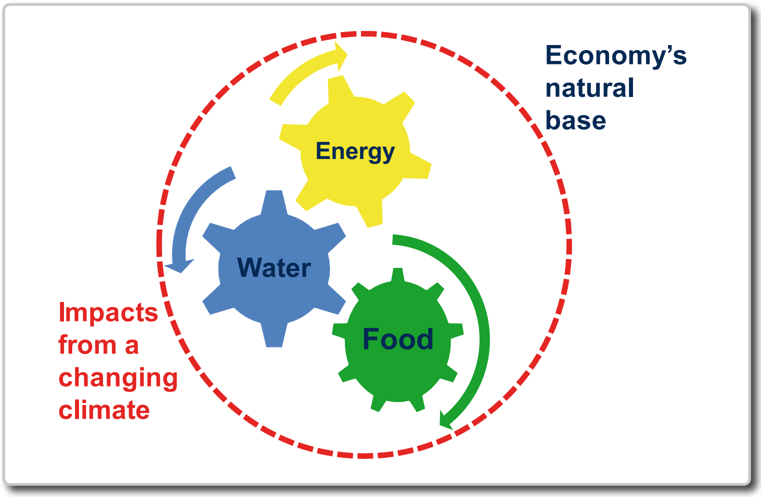


Figure 12:
The nexus between energy, water and food defines the economy's natural base [22]

Namibia remains a net importer of food. We do not produce what we consume. This makes us vulnerable. Supplying sufficient food is a key priority in any economy. The food we consume requires water, often in considerable quantities. And the requirement for water implies that energy provision is necessary. The interlinkage between energy, water and food is therefore deeply engrained in how the fundamental cogs of the nation turn, and illustrate the considerable interdependence and vulnerability of the country's natural economic base.

A particularly important consideration that emphasises the complex interdependency between energy, food and water is the realisation that all three are driving the changes in our climate. Specifically, our considerable dependence and consumption on fossil fuels and their associated greenhouse gas emissions are thought to accelerate human-induced climate change. As the water sector's key input, fossil fuel energy sources remain important even though we know that their consumption is directly linked to climate change. This dilemma is emphasised when one realises that the country's agricultural sector in general, and the food-producing part in particular is entirely dependent on water, and therefore energy. Also, agriculture is the sector that is responsible for large changes in the way that land is used, and is therefore directly and immediately driving greenhouse gases as a result of such changes. While Namibia is neither unique in this sense, nor does the country contribute any significant amounts of greenhouse gases from its energy and food-producing sectors, it is still expected to be particularly affected by the multiple impacts of climate change. The very way in which water, food and energy are linked through human activities such as organised agriculture is a key culprit responsible for causing increasing changes to the global weather system and with it, the ecosystems we depend on.

Climate change accentuates the interdependence of energy, water and food, and increases our vulnerability. As a country, measures to enhance the resilience of each of these sectors are important. Creating an understanding and awareness of how our adaptive capabilities can be increased are likely to be particularly effective in the agricultural and water sectors. As for the energy sector, creating and improving access to clean energy sources is important, particularly for the most vulnerable members of society. In this way, those that are most exposed to the impacts of climate change, and especially people in rural areas leading subsistence livelihoods, would benefit most if they had better access to modern energy supplies and services. This is an important topic for Namibia and is further discussed in chapter 5.

Concerns about the potential impacts of climate change warrant a serious revision of how the country's energy supply system can be restructured, particularly because Namibia is considered to be most vulnerable to the impacts of climate change. As for now, however, there is little evidence that energy planning is in any way seriously taking climate change into account. Later chapters will consider how electricity end-users, utilities and local authorities tasked with the distribution of electricity can invest in renewable energy technology and energy efficiency, principally to create positive feedback loops between economic, social and environmental benefits.

As Namibia contemplates a sustainable energy future, it remains largely unclear how such a transition could happen, who would need to do what to start it, and how to sustain it. It is important to note that a transformation of the country's energy supply system is not only about the types of energies or fuels that will be used in future. Rather, energy planning should focus on the social, economic and environmental requirements and implications that a new energy dispensation brings about. Specifically, one should ask how the social, legal and political arrangements that define the current energy supply sector hang together, so as to explicitly strengthen each of the three interdependent cogs – water, food and energy – which ultimately determine how resilient the base of the country's natural economy will be. In this quest, the application of renewable energy systems and the targeted use of energy efficient technologies are the natural choice that maximise social inclusiveness, maximise economic benefits and minimise adverse environmental repercussions, thus strengthening the energy sector and therefore enabling and securing the water sector to provide the principal feedstock to agriculture to feed the nation.

Ultimately, the pathways that we embark towards Namibia's energy future will determine how and to what level we stand to benefit tomorrow, and determine what we have to pay – both directly and indirectly – to have those benefits. These choices dictate our development prospects, who will be part of those that benefit from development, and who will remain decoupled from the economy. It is for this reason that this chapter is entitled *'Energy Matters'*, as our choices have and will continue to significantly affect what, how and how well we will all live.

Figure 13:
REEE-investment in local salt production, Salt Company, Swakopmund [25]

5 REEE-Powering Domestic Energy Use in Rural and Urban Areas

This chapter showcases how rural and urban Namibia can benefit through the systematic adoption of renewable energy (RE) and energy efficient (EE) technologies, and outlines the requirements to systematically provide access to modern energy services for all.

5.1 Context

In August 2011, the Namibia Statistics Agency undertook a population and housing census [11]. Amongst others, the census reports on the country's population size, growth rate and the population distribution across the country. For the development of sensible proposals on how the domestic energy use in both rural and urban Namibia can best benefit from being REEE-powered, we start with a brief overview of some of the pertinent insights gained from the census data.

5.1.1 Distribution of the Population and Households in Namibia

Figure 14 shows the distribution of the population and households per region, based on the data provided in the 2011 census [11].

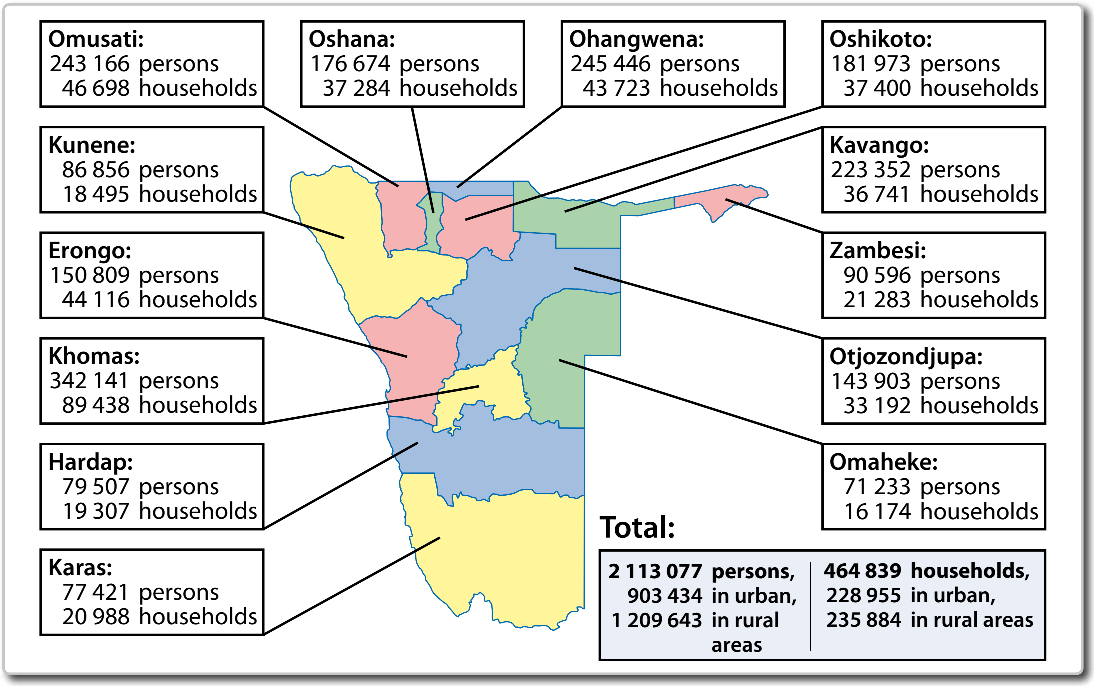


Figure 14: *Population and household distribution per region, as at August 2011 [22]*

Percentages of the population and households per region are shown in Figure 15.

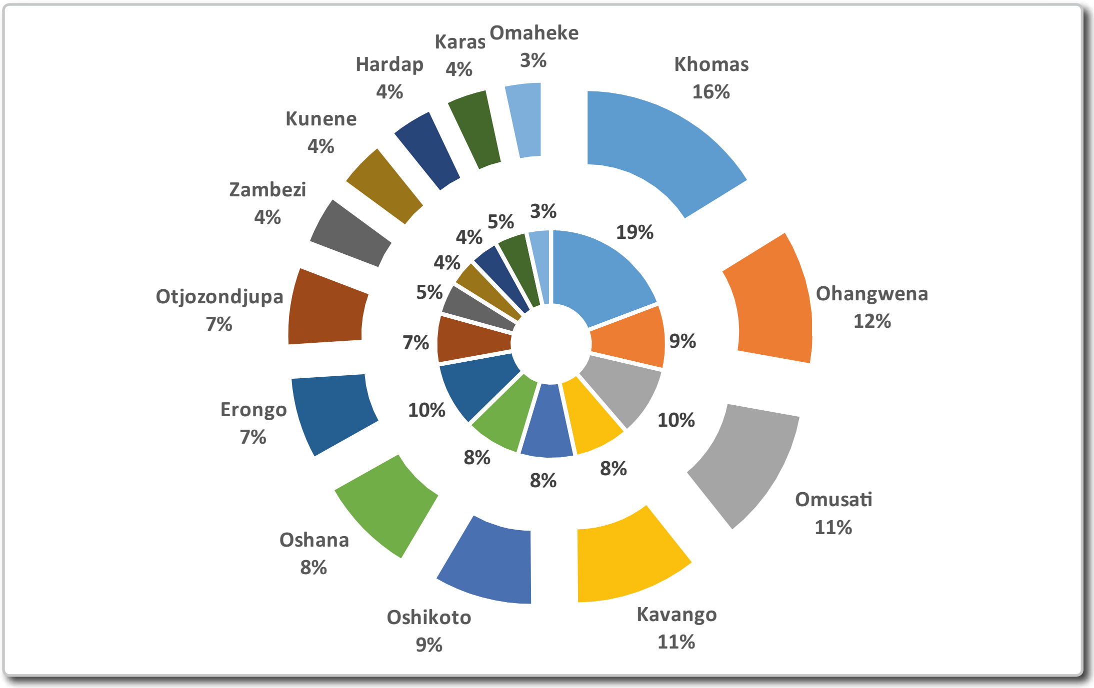


Figure 15:
Percentage population distribution (outer ring) and households (inner ring) [22]

The next sections focus on the domestic energy use in rural and urban Namibia, and reflects on what households are likely to pay to be able to meet such energy requirements.

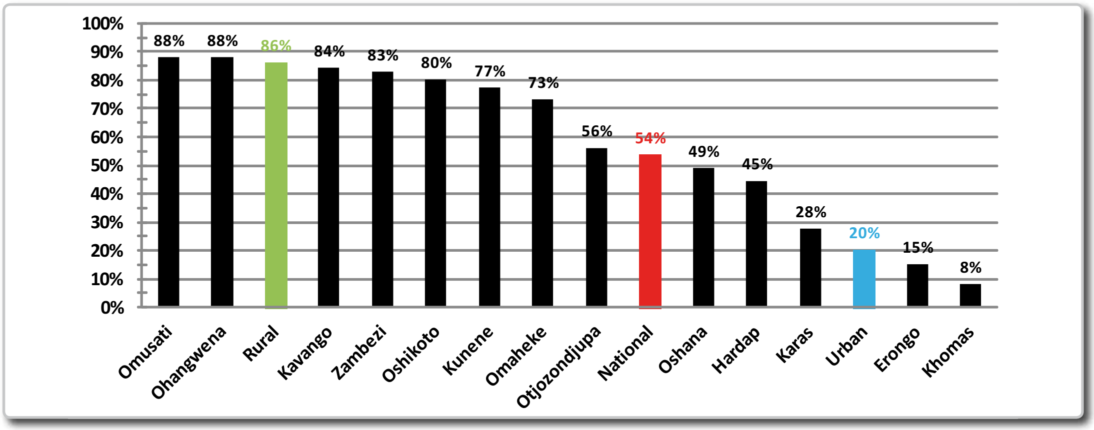
Figure 16:
The diesel-solar PV hybrid powering the off-grid community at Tsumkwe [26]

5.2 Domestic Energy Use in Rural and Urban Namibia

5.2.1 Energy for Cooking

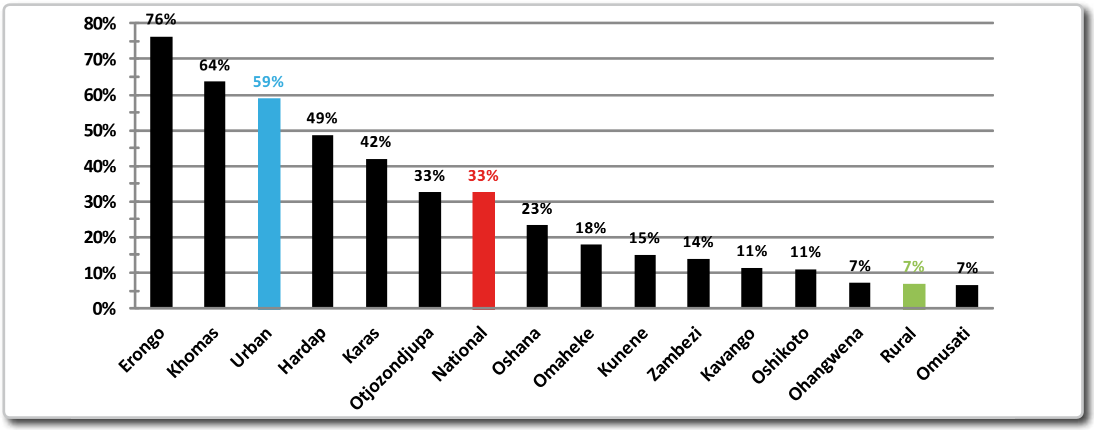
The 2011 Namibia Population and Housing Census identifies the main domestic energy use for cooking, lighting and heating [11]. Wood and wood products such as charcoal remain the most prevalent energy source used for cooking. Figure 17 shows that some 54% of all Namibian households continue to use wood/wood products for cooking. Some 86% of all rural households, and about 20% of all households in urban areas were still using wood/wood products for cooking.

Figure 17: *Percentage Namibian households using wood/wood products for cooking [22]*



The second-most used source of energy for cooking is electricity [11]. Nationally, almost 33% of all households reported using electricity for cooking. Some 59% of all urban households, and about 7% of all households in rural Namibia use electricity for cooking.

Figure 18: *Percentage Namibian households using electricity for cooking [22]*

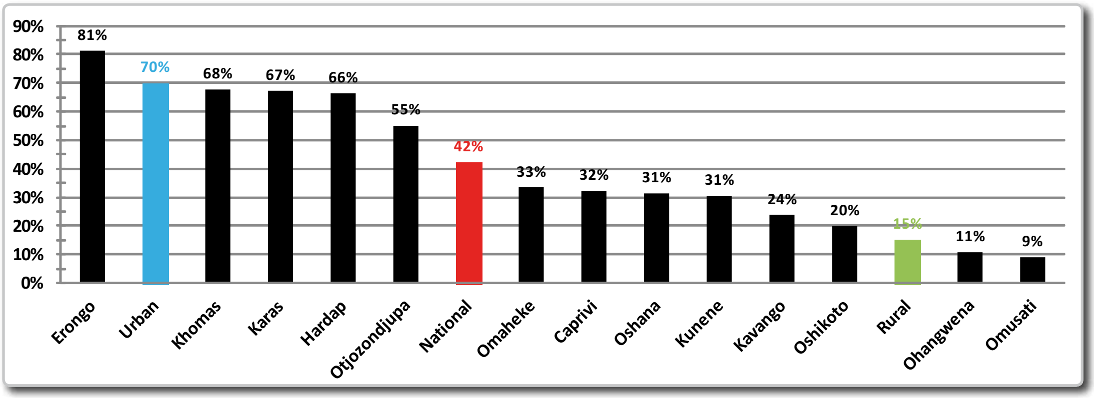


Only some 8% of all households reported using liquid petroleum gas (LPG) for cooking [11]. In urban areas, some 13% of end-users reported that LPG is the primary fuel used for cooking, in contrast to only some 3% of rural households.

5.2.2 Energy for Lighting

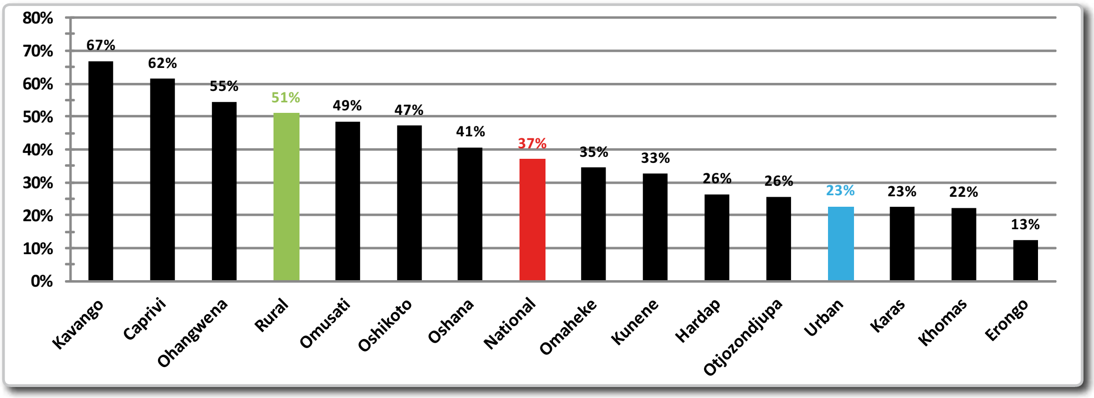
Nationally, electricity is the most common source of energy used for lighting, and some 42% of all households make use of it [11]. In urban areas, some 70% of all households report using electricity for lighting, in contrast to only some 15% in rural Namibia.

Figure 19:
Percentage of Namibian households using electricity for lighting [22]



Candles are the second-most prevalent energy source used for lighting, with some 37% of all households in the country using them [11]. In rural areas, some 51% of all households report using candles for lighting, in contrast to 23% in urban areas.

Figure 20:
Percentage of Namibian households using candles for lighting [22]

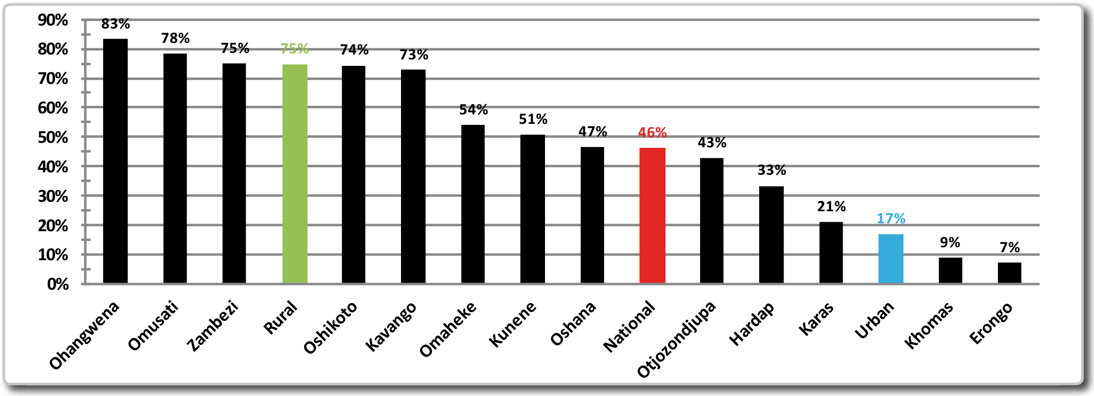


The third-most used energy source for lighting is paraffin, and some 10% of all Namibian households reported using it for this purpose [11]. In rural areas, some 16% of all households use paraffin as a fuel for their lighting devices, while approximately 4% of all urban households continue to use this energy source for lighting.

5.2.3 Energy for Space Heating

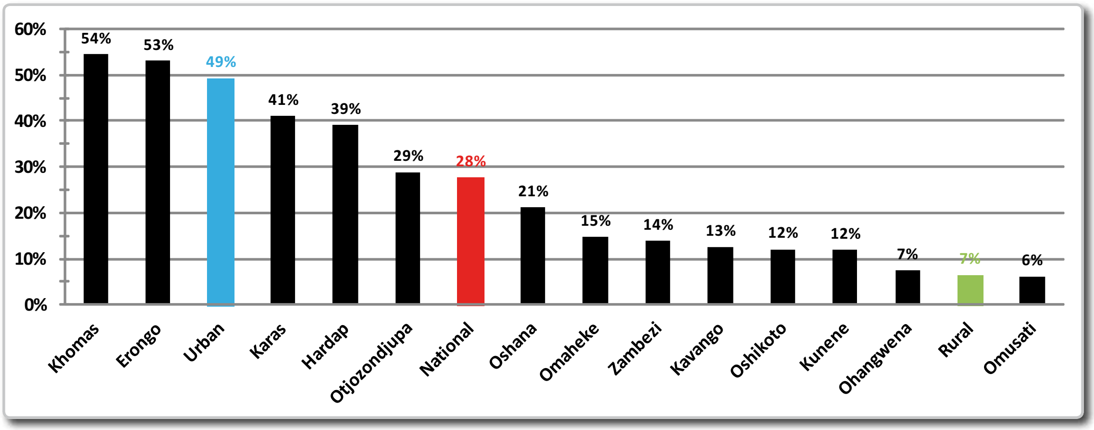
Figure 21 shows that some 46% of all Namibian households use wood or related wood products such as charcoal for heating [11]. Almost three-quarters of all rural households report using wood or wood products for space heating, in contrast to some 17% of all households in urban areas.

Figure 21: *Percentage of Namibian households using wood/wood products for heating [22]*



Electricity is the second-most prevalent form of energy used for domestic heating. Nationally, almost 28% of all households use electricity for space heating [11]. As expected, the urban penetration and use of electricity for heating is much higher than the corresponding use in rural areas. Some 49% of all urban households and less than 7% of households in rural Namibia use electricity for space heating. And interestingly, close to 22% of all households reported that they do not use any energy for space heating.

Figure 22: *Percentage of Namibian households using electricity for heating [22]*



5.3 Domestic Energy Expenditure

Information on actual domestic expenditure for the use of different energy sources is not readily available, and if so, is often locality-specific. However, as energy expenditure is often an important part of the overall cost of living, it is instructive to estimate how much domestic households are likely to spend to cover their most basic energy requirements. Critical in this assessment is an estimate of what it costs to prepare a warm meal per day, and what basic lighting services cost in Namibia today.

5.3.1 Energy Cost to Cook a Meal

As shown in section 5.2.1, wood and products derived from wood remain the most-used energy source used for cooking in Namibia today, followed by electricity, LPG and paraffin in second, third and fourth place respectively.

Figure 23 summarises the approximate cost to prepare a hot meal for one person in Namibia in 2015, taking the nominal full life-cycle costs of the various cooking technologies required to use such options into account [27].

Figure 23:
Cost for the energy required to prepare one typical hot meal, in N$ [22]

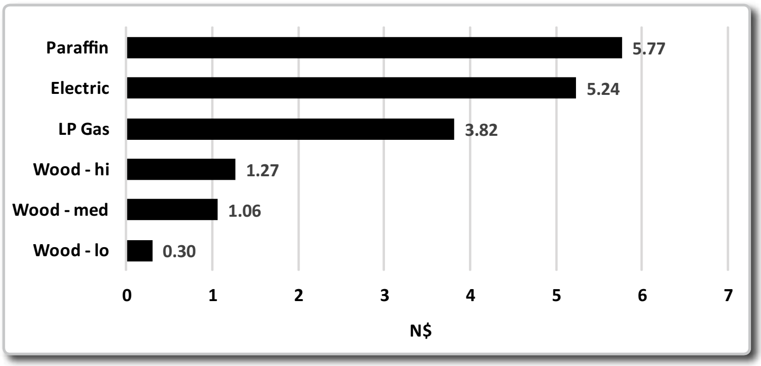


Figure 23 illustrates that wood fuel often remains the cheapest domestic energy source to prepare a hot meal in Namibia in 2015. Access to wood fuel varies across the country, which is reflected in the price of such fuel. Figure 23 assumes that three prices exist for wood fuel: for 'wood – lo', a price of N$ 0.2/kg is assumed, which is a broad average price for wood in rural Namibia where this fuel is often collected 'free of charge', or available at minimal cost. On the other hand, 'wood – med' assumes a price of wood of N$ 1/kg, and N$ 1.5/kg for the 'wood – hi' scenario. In addition, end-users are assumed to have an incentive to minimise the cost of wood fuel by using increasingly efficient wood stoves as the price of wood increases. Despite the generally low energy conversion efficiencies achieved by wood stoves (10% for wood-lo, 15% in the wood-med and 20% in the wood-hi scenario for a moderately fuel-efficient stove) wood fuel remains a cost-effective energy source to prepare a meal.

5.3.2 Energy Cost for Lighting

Section 5.2.2 has shown that electricity is the most-used form of energy used for lighting, followed by candles and paraffin in the second and third place respectively.

Figure 24 summarises the daily energy expenditure incurred as a result of using lighting services for four hours each day, per single lighting technology (e.g. using only candles). The three most commonly used electric lighting options used in Namibian households, namely incandescent lights, compact fluorescent lights (CFL) and light emitting diode (LED) lights are also included for comparison.

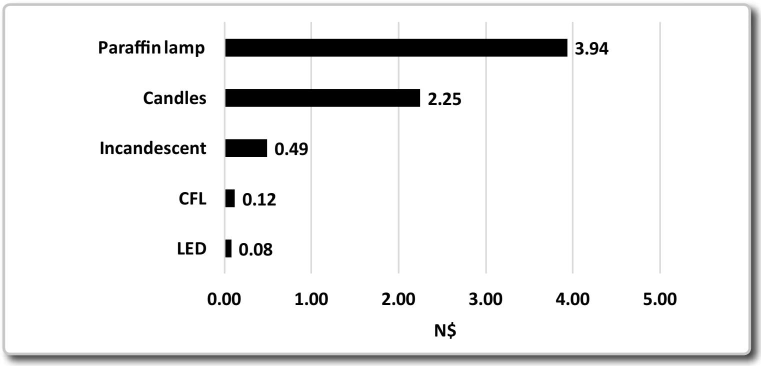


Figure 24: *Energy cost for 4 hours of lighting use per day, in N$ [22]*

Evidently, even the most inefficient electric light commonly used in Namibian households (incandescent) is far cheaper to operate than using candles or paraffin for the same purpose. Realising that some 58% of the Namibian population do not use electricity for lighting, end-users who do not have access to electricity or cannot afford it would either have to use expensive and polluting lighting alternatives, or simply have no light after dark. This is part of the stark reality in Namibia.

Figure 24 illustrates an important aspect of Namibian reality, namely that end-users who use lighting technologies powered by sources other than electricity face significantly higher costs for such use. Indeed, most end-users using candles or paraffin lamps are from amongst the poorer segments of society. Candles and paraffin lamps have much lower light intensities than those provided by modern lighting sources, and there are health risks in form of air pollution and the risk of fire when using fossil-fuelled lighting, as well as the risk of long-term damage to eyesight. As is evident, the poorest in society pay the highest price for a service that must be considered a pre-requisite of modern life – the availability of good lighting.

5.4 Access to Energy

One often hears that Namibians do not have adequate access to energy. Or it is stated that access to modern energy is a universal right. Before dwelling deeper on this topic it is therefore useful to clarify what is meant by *access to energy*, and what *universal access to modern energy* could possibly imply.

Here we put forward a basic definition for access to energy to guide our later discussions: *access to energy means that a person is able to use one or several forms of energy to meet some or all energy requirements for cooking, lighting and heating*. Energy for infotainment and mobility is deliberately excluded from this definition.

The above definition uses the phrase *'is able to use'* energy. In order to be able to use energy, it has to be available, and must be affordable. The above definition of *access to energy* therefore implies that energy that is accessed is both available and affordable, albeit possibly in most rudimentary quantities only. We recognise that availability and affordability are necessary pre-requisites for someone to have proper access to energy. Case Study 1 further elaborates on the above definition for access to energy.

Case Study 1: Access or no access to energy – that is the question [22]

I. Ananias is a casual labourer who lives at Vyf Rand Camp south of Okahandja, some 12 metres from a low-voltage electricity distribution line. He does not use electricity as his house is not connected to the local distribution grid. Instead, Ananias and his family use candles for lighting, which they buy at a local Cuca shop. They also use wood for cooking and heating, which they collect in the veld close-by the settlement. **Does Ananias have access to energy?** From the above, Ananias has the means to acquire and use both wood and candles, which are two distinct energy carriers. Therefore, based on the above definition, and although Ananias does not use electricity, he has access to energy.

II. Rosina is a new resident of the Democratic Resettlement Community (DRC) at Swakopmund, with an average monthly income of N$ 260. She rents a room in a house owned by a relative, for which she pays N$ 100 per month. Whenever possible, Rosina buys food from a local street vendor and occasionally has some kapana. Rosina does not prepare her own food, as she considers wood unaffordable, and carton boxes, plastic and other energy sources that are used for cooking at DRC are generally hard to come by. Rosina shares the paraffin lamp provided by her house-mate, but she does not own a source of light, and she has no means to heat her room either. **Does Rosina have access to energy?** Rosina is an example of a person who is classified as being food poor, and energy poor. Being food poor means that Rosina has less money available than she requires to meet her most basic average daily dietary requirements. Although a variety of energy sources are available in the DRC, they remain inaccessible for Rosina as she cannot realistically afford to pay the price to meet her basic daily needs. Rosina is therefore an example of a person who does not have access to energy.

5.5 Access to Modern Energy

Based on the definition for access to energy, we now ask what is meant by *access to modern energy*. Here we define *access to modern energy to mean that a person is able to use one or several forms of clean energy, such as electricity and/or other modern forms of energy, and/or high-efficiency end-use energy technology(ies) to meet the energy requirements for cooking, lighting, communication, infotainment and heating*. Again, the definition deliberately excludes all energy forms required for mobility, but includes the important aspect of being able to communicate and have basic information and entertainment (i.e. infotainment) services.

As before, the above definition makes no explicit reference to availability or affordability, as we once again argue that a person can only realistically *be able to use* energy if it is available and affordable. Availability and affordability are therefore pre-requisites for having access to modern energy. Case Study 2 provides examples that further illustrate the concept of access to modern energy as defined here.

Case Study 2: Access or no access to modern energy – that is the question [22]

I. Case Study 1 described how Ananias met his own and his family's energy needs. **Does Ananias have access to *modern* energy?** Using the above definition, Ananias does not have access to modern energy, despite living only a few metres from the electricity grid.

II. If Ananias, as described in Case Study 1, were to acquire a fuel-efficient wood stove, which would reduce the daily quantities of wood fuel and the particulate emissions from using an open flame, would he then have access to modern energy as per the above definition? Although using a high-efficiency end-use energy technology such as a fuel-efficient wood stove for cooking and some space heating is a start, Ananias would still not use one or several forms of clean energy to meet his lighting, communication and infotainment needs. Strictly speaking therefore, only when Ananias adopts other modern forms of energy to cater for lighting, communication and infotainment needs, such as a solar lantern, pico or micro solar home system, or grid electricity would he be considered to have access to modern energy.

III. If Ananias had the means to acquire a modern lighting device, for example a solar lantern, but he prefers not to spend his money on such technology, would he continue to remain without access to modern energy? The above is indicative that Ananias made a choice of how to spend his money, which does not include the acquisition of a solar lantern. Although possibly a more philosophical question it is nevertheless instructive to reflect on what the above definition for *access to modern energy* actually states. The key is the in-principle *ability to use one or several forms of clean energy*. Based on this, if Ananias has the means and can therefore in principle use modern forms of energy, then he has access to such energy provided that it is available. So, if modern lighting devices are available, and Ananias can afford them, then he has access to them, even if he decides not to use them.

5.6 Universal Access to Modern Energy

Now that both *access to energy* and *access to modern energy* has been defined, what does *universal access to modern energy* mean? Based on definition of access to modern energy, we define *universal access to modern energy as access to modern energy for all*.

Namibians would have *universal access to modern energy* if *all Namibians had the ability to use one or several forms of clean energy, such as electricity and/or other modern forms of energy, and/or high-efficiency end-use energy technology(ies) to meet the energy requirements for cooking, lighting, communication, infotainment and heating*. We note that, once again, the above definition deliberately excludes the energy requirements for mobility and transport.

As has already been shown in section 5.2, Namibians do definitely not have universal access to modern energy yet. Indeed, most Namibians do not have access to modern energy. But, and this is part of the energy ladder we will reflect on later, most Namibians have access to some forms of energy. By REEE-powering domestic energy use, merely having access to energy can be advanced to getting access to modern energy. And by being ambitious about national energisation for Namibia, universal access to modern energy can indeed be successively achieved. ***Not in 2030, but starting today.***

Figure 25:
REEE-powered domestic lighting, cooking and water heating [28]

5.7 Basic Household Energy Requirements

This section asks whether quantitative thresholds can be identified that describe the minimum amount of energy required to meet our basic energy needs. For the definition of such minimum thresholds we recognise that most Namibian energy end-users are likely to cover their energy requirements for cooking, lighting and heating using various forms of energy. Occasionally however, as is sometimes the case in urban areas in particular, an energy end-user will rely on the use of only one form of energy, for example electricity, to meet the daily energy needs (excluding for mobility). Here it is pointed out that it is yet to be defined what "basic needs" are, and that such a definition is both normative and depends on the locality and income group to which an energy end-user belongs.

Case Study 3 illustrates the energy requirements of a 5-person household using electricity for some basic lighting, refrigeration, the use of a radio and some mobile phone charging, and assumes that cooking and heating are done using fire wood.

Case Study 3: Basic monthly energy requirements of a 5-person household [22]

This case study estimates the basic energy requirements of a 5-person household, assuming that grid electricity is used to power four LED lights of 10 Watt rating each, a small refrigerator and some basic communication (two mobile phones are regularly recharged) and entertainment by way of a radio receiver.

Basic Electricity Consumption

Energy Use	Rating [W]	Use [h/d]	Energy [kWh/d]	
Refrigeration	95	5	0.48	
Lighting	40	4	0.16	
Radio	15	10	0.15	
Mobile phone chargin	10	3	0.03	
			24.9	**kWh per month**
			298	**kWh per household per year**
			60	**kWh per person per year**
			5	**kWh per person per month**

The table above includes the power rating of the different electric appliances, in Watt [W], the appliance use in hours per day [h/d], and the total electric energy drawn per day, in kWh per day [kWh/d]. It shows that basic electricity needs can be met with a per capita electricity consumption of some 5 kWh per month, which however excludes thermal energy use as is required for cooking and heating.

Assuming that elementary thermal energy needs, i.e. those for cooking, water heating and some space heating, are met using fire wood, between 0.5 and 1.5 kg (and sometimes more) of wood is required per person per day. The actual daily requirement for wood fuel depends on the availability, affordability and the efficiency of the stove or oven that is used. Assuming an average daily per capita consumption of 1 kg of fire wood therefore implies that the 5-person household considered in this case study has a consumption of slightly more than 150 kg of wood per month, or some 1 825 kg of wood per year.

As shown in Case Study 3, the electrical energy use in a 5-person household can be as low as 25 kWh per month, provided that cooking, water and space heating are carried out using another form of energy. In other words, having an average electrical energy use of some 5 kWh per person per month, additional energy sources are necessary to meet basic monthly energy needs, including those required for cooking.

Case Study 4 assesses the electrical energy requirements of the 5-person household introduced before, if all wood fuel was to be replaced by electricity. This implies that the preparation of meals, and some basic water heating would now have to be covered using electric appliances as available.

Case Study 4: Basic monthly electricity requirements of a 5-person household [22]

This case study estimates the basic electricity requirements of a 5-person household. It assumes that the household uses the following electric appliances: a small electric cook stove, a small refrigerator, four lights and a radio, and a wall charger to keep two mobile phones fuelled up.

Basic Electricity Consumption				
Energy Use	**Rating [W]**	**Use [h/d]**	**Energy [kWh/d]**	
Cooking & water heatin[g]	820	3	2.46	
Refrigeration	95	5	0.48	
Lighting	40	4	0.16	
Radio	15	10	0.15	
Mobile phone charging	10	3	0.03	
			99.9	**kWh per month**
			1 199	**kWh per household per year**
			240	**kWh per person per year**
			20	**kWh per person per month**

As in Case Study 3, the above table shows the power rating of the various electric appliances, the appliance use in hours per day and the total electric energy consumed per day. It shows that a basic electricity requirement, including some limited cooking and water heating, can be met by having some 100 kWh of electrical energy available per month, which implies an average per capita consumption of 20 kWh per month.

The 5-person household described in Case Study 3 uses a limited set of appliances. If cooking is to be done by using electricity, an additional appliance is necessary which draws additional electricity. Comparing the wood-plus-electricity household energy use as introduced in Case Study 3 with the fully electricity-dependant household introduced in Case Study 4 shows that the elementary preparation of food and hot water necessitates an additional 15 kWh of electrical energy per capita per month. It is emphasised that a household's actual electrical energy use and consumption of wood critically depends on the specific energy consumption patterns, type of appliances used, end-user behaviour and the climatic conditions throughout the year.

5.8 Energy Affordability

As highlighted before, the affordability of energy is a key determinant that decides whether and how much energy is potentially consumed in a household operating on a limited monthly disposable income.

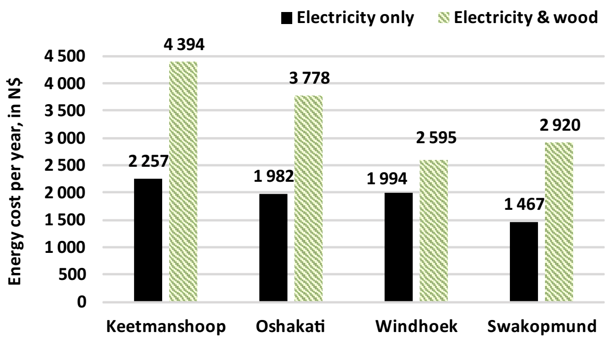
Case Study 5 investigates how much a typical 5-person household would spend on energy-related expenses, depending on whether only electricity, or a mix of electricity and wood fuel is used to meet the household's basic monthly energy needs.

Case Study 5: Energy expenses incurred by a 5-person household [22]

This case study calculates the basic monthly energy expenditure as incurred by a 5-person household, and presents these costs for different Namibian towns, including

I. Windhoek, Hakahana: a grid-connected household on a pre-paid tariff pays N$ 1.67/kWh and can procure wood at an average price of N$ 1.15/kg;
II. Oshakati: a grid-connected household on a pre-paid tariff pays N$ 1.66/kWh and buys wood at N$ 1.80/kg;
III. Swakopmund, Mondesa: a grid-connected household on a pre-paid tariff pays N$ 1.23/kWh and buys wood at N$ 1.40/kg;
IV. Keetmanshoop, Tsaiblaagte: a grid-connected household on a pre-paid tariff pays N$ 1.89/kWh and is able to source wood for N$ 2.10/kg.

Based on the electricity tariffs (using the official ECB-approved tariffs for 2014/15) and typical cost of wood (noting that costs vary substantially depending on when and where it is sourced), the total annual energy-related household expenditure is determined for a 5-person household using only electricity to meet its energy needs, and excluding transport, as well as a 5-person household where electricity is only used for lighting, infotainment, refrigeration and mobile phone charging, while basic thermal needs are met by using fuel wood which is purchased.



5.9 Energy and Poverty – A Namibian Perspective

This section applies the definition of poverty thresholds, as introduced in the Namibia Household Income and Expenditure Survey (NHIES) of 2009/2010 [29], to link energy-related household expenses to such thresholds. The NHIES derived adult-equivalent per capita expenditure from total monthly household expenditure, divided by the number of adult equivalent persons in the household. It used a 'cost of basic needs' approach to define three distinct poverty thresholds, i.e. a food poverty line, a severely poor poverty line, and a poor poverty line. This allows a first comparison of actual household incomes and relates specific household expenses such as those incurred for food, shelter, energy, transport and others to one another.

For 2009/2010, the NHIES determined that the monthly per capita food poverty threshold to be N$ 204.05. The per capita lower bound poverty threshold was estimated to be N$ 277.54 per month, while the per capita upper bound poverty threshold was estimated to amount to N$ 377.96 per month [29].

Here, the food poverty line identifies the threshold below which a person is considered 'food poor', meaning that their total consumptive expenditure is insufficient to meet their daily calorific requirements. On the other hand, the lower bound poverty threshold identifies the monthly per capita requirement of persons who are classified as being 'severely poor'. The upper bound poverty line identifies the threshold below which a person is considered 'poor' [30].

In 2015, the poverty thresholds of 2009/2010 are no longer correct, and need to be inflation-adjusted. In this way, equivalent poverty thresholds for 2015 can be inferred from those given for 2010, these are summarised in Table 1 [31].

Figure 26:
REEE-powering the off-grid community at Gam [32]

	Unit	2010	2015
Upper bound poverty threshold of a person considered poor	N$	377.96	505.80
Lower bound poverty threshold of a person considered severely poor	N$	277.54	371.41
Food poverty threshold	N$	204.05	273.06

Table 1:
Actual (2010) & inferred (2015) monthly per capita poverty thresholds [31]

The hypothetical 5-person household considered in Case Study 3 to Case Study 5 is assumed to comprise of two adults, two children between 6 and below 16 years of age, and one child below the age of 6 years. Based on the definitions in reference [33], this implies that the 5-person household considered here (which is used for illustrative purposes only) is equivalent to a 4-adult household. Based on the per capita thresholds for 2015, as listed in Table 1, equivalent monthly 5-person household income thresholds are derived, these are shown in Table 2.

	Unit	2015
Upper bound poverty threshold of a 4-adult household classified as poor	N$	2 023.18
Lower bound poverty threshold of a 4-adult household classified as severely poor	N$	1 485.64
4-adult household food poverty threshold	N$	1 092.26

Table 2:
Estimated monthly 5-person household poverty thresholds for 2015 [33]

The estimated annual basic household energy costs incurred when either using electricity only or a combination of electricity and wood, and excluding all transport-related energy costs, are summarised in Table 3.

Table 3:
Estimated total basic energy costs incurred by a 5-person household in 2015 [22]

	Electricity only [N$/year]	Electricity & wood [N$/year]
Keetmanshoop	2 257	4 394
Oshakati	1 982	3 778
Windhoek	1 994	2 595
Swakopmund	1 467	2 920

Table 2 and Table 3 are now used to compute the percentage annual income required to meet the energy needs of a 5-person household, depending on the poverty classification of a household.

A 5-person household using electricity for a select number of loads and meeting their thermal needs by using wood, the total energy-related expenditure expressed as a percentage of the total annual household income is shown in Table 4, depending on the income classification of the household.

	Poor	Severely poor	Food poor
Keetmanshoop	18%	25%	34%
Oshakati	16%	21%	29%
Windhoek	11%	15%	20%
Swakopmund	12%	16%	22%

Table 4:
Percentage household income required to meet basic energy needs with electricity and wood [22]

For households using only electricity to meet their annual basic energy needs, and excluding all costs to meet their mobility needs, the total energy-related expenditure when expressed as a percentage of the total disposable household income is shown in Table 5, as a function of the income classification of a household.

	Poor	Severely poor	Food poor
Keetmanshoop	9%	13%	17%
Oshakati	8%	11%	15%
Windhoek	8%	11%	15%
Swakopmund	6%	8%	11%

Table 5:
Percentage of household income to meet basic energy needs with electricity [22]

Table 4 and Table 5 give evidence of the desperate situation of households classified as poor, severely poor or even food poor, and show the very considerable proportion of household income required to cover basic energy needs.

The situation is particularly grave in towns where prices of both electricity and wood are high, such as in Keetmanshoop and Oshakati. On the other hand, as shown in Case Study 5, energy from the electricity grid can be a cost-competitive source of energy, if available, and can considerably reduce the overall cost requirements to meet basic household energy needs.

5.10 An Energy Ladder for REEE-powering Domestic Energy Use

The United Nations Secretary-General's Advisory Group on Energy and Climate Change has set a target of energy access, and recommends that access to energy is to be provided to all by 2030 [34]. Today it is widely accepted that access to energy can no longer be considered a luxury, but is an economic necessity, and a key enabler to lift people out of poverty and improve living conditions to satisfy basic human needs. Indeed, we consider access to energy as per the definition in section 5.4 a moral imperative. ***Access to energy is a pre-requisite to ensure that life's basic energy requirements can be met.***

While access to energy is undoubtedly a key enabler for development, the mere provision of energy is insufficient to eradicate poverty or bring about socio-economic upliftment. As such, energy is a necessary but insufficient condition for development. In other words, energy is a vital but not the only ingredient for advancement. And we recognise that poverty is more than not having access to energy. Eradicating or at least alleviating poverty therefore necessitates ingredients other than providing tangible access to energy.

Poverty is reduced by becoming increasingly able to afford the necessities of life. This implies that *the deliberate creation of opportunities for additional income generation are a key to address poverty*. By generating and improving earnings, people create more desirable livelihoods. And as livelihood conditions improve, people have more options in deciding what they consider to be their most important needs, and how these can best be met. We all need energy for survival, even if we do not consciously choose a specific form of energy: by using water and food, and in order to meet even elementary requirements for cooking, lighting, entertainment, information and heating, energy is required, always. And this is why access to energy and having a good understanding of how access is determined by its availability and affordability is such an important topic. Particularly for Namibia where poverty eradication is now recognised as one of Government's key objectives [35], [36].

Meeting our basic energy needs is often accomplished by using several forms of energy, i.e. an energy mix. For example, to meet our lighting needs, we may need an energy source that is different from the one we need to meet our cooking needs. Most end-users are interested in a particular energy service, or utility, rather than a specific energy form. Therefore, the energy ladder that we will put forward below focuses primarily on elementary energy services, and then matches clean energy forms to such services to best meet such requirements.

The energy ladder introduced here is built on the following *energy services*:

1. cooking, often incl. some heating
2. lighting
3. communication
4. entertainment and/or information
5. refrigeration
6. cooling
7. appliance use, depending on income level and needs, and
8. a variety of productive uses of energy.

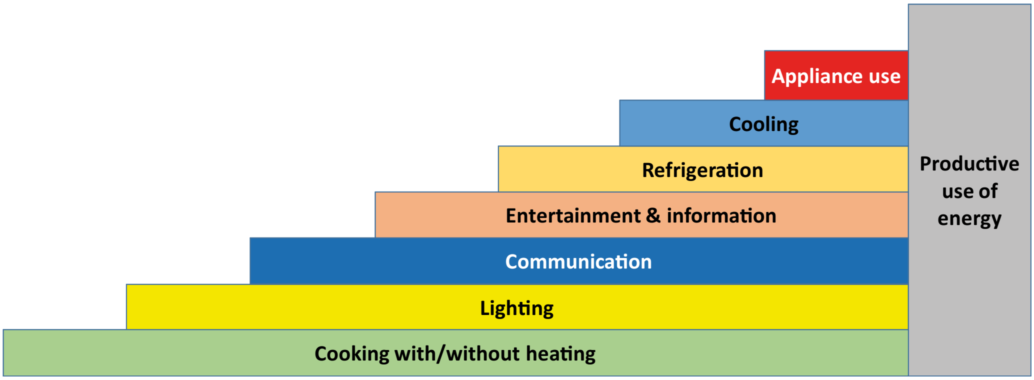


Figure 27:
Energy services, from the most basic to those addressing modern needs [22]

The energy ladder shown in Figure 27 enables some important insights that illustrate that basic access to modern energy does not automatically imply that access to grid electricity is always necessary. Indeed, as is also shown in Table 6, only the top rungs of the energy ladder make it advantageous to have access to electricity, and in many cases, the most viable and versatile choice of energy. However, such electricity does not necessarily have to be provided by the grid as there are an increasing number of alternatives to grid-supplied electricity, which can either augment or even fully replace grid services. However, the financial viability of grid augmentation or grid replacement is highly context-dependant and is best ascertained for each case.

For each of the rungs of the energy ladder, modern energy service technologies exist that enable end-users to meet their energy requirements, both with and without access to grid electricity. Often it is advantageous to use an energy mix to most cost-effectively meet the entire supply requirements. For example, if modern energy fuels, such as liquid petroleum gas (LPG), and/or fuel-efficient appliances, such as a fuel-efficient wood stove, are available, a combination of such energy sources often results in the most cost-effective overall energy solution.

Table 6 elaborates on the energy requirements of each step of the energy ladder, and provides examples of which energy sources can be used on each rung to enhance access to modern energy.

Rung #	Energy Services	Energy Requirement	Example of Energy Source(s)
Rung 1	Cooking (excl. deliberate and intentional space heating)	~ 0.1 kg LPG/person/day, or ~ 1 kg of wood/person/day, or ~ 0.5 kWh electricity/person/day	LPG stoves, fuel-efficient wood stoves, electric stoves
Rung 2	Lighting	a few 10's of Wh/person/day	solar lantern with a phone charger, or other source of electric energy
Rung 3	Communication	a few 10's of Wh/person/day	
Rung 4	Entertainment & information	a few 10's of Wh/person/day	pico or micro solar home system, or other source of electric energy
Rung 5	Refrigeration	~ 0.5 kWh/refrigerator/day (highly size- and quality dependant)	small solar home system, or other source of electric energy
Rung 6	Cooling	~ 100's + of Wh/device/day (dependant on type & usage)	solar home system, or other source of electric energy
Rung 7	Appliance use	highly dependant on the actual appliances that are used, and their length of use per day	possibly by way of a stand-alone solar system, or a connection to a mini-grid, or other source(s) of electric energy, such as grid electricity, if available
Rung 8	Productive uses of energy	highly dependant on the type and actual usage patterns	

Table 6:
The rungs of a ladder to improved access to modern energy [22]

In view of the above energy ladder and the minimum energy requirements per energy rung as illustrated in Table 6, what could *REEE-powering the domestic use of energy* mean?

We put forward an aspirational definition of what the deliberate *REEE-powering the Namibian domestic use of energy* should include:

> *REEE-powering the domestic use of energy in Namibia is the deliberate process, supported by relevant policies and regulatory provisions, by which modern energy and energy efficient technologies are available at prices that allow the country's citizens to meet their energy requirements in a socially acceptable and environmentally sound manner, while incentivising productive uses of energy that promote both personal and societal development.*

The above definit ion includes deliberate and specific references to economic, social and environmental aspects, as well as a perspective on the productive uses of energy as a catalyst for individual and societal development. ***We suggest that this definition for REEE-powering the domestic use of energy serves as a Namibian vision of how access to modern energy is to power national development in the years to come.***

What is the intended interpretation of the various elements used in the above definition for REEE-powering the domestic use of energy? And, could these be quantified to create some energy access benchmarks for Namibia?

Table 7 summarises some thoughts of how the above definition for *REEE-powering the Namibian domestic use of energy* could be framed, and provides some examples of how it might become actionable.

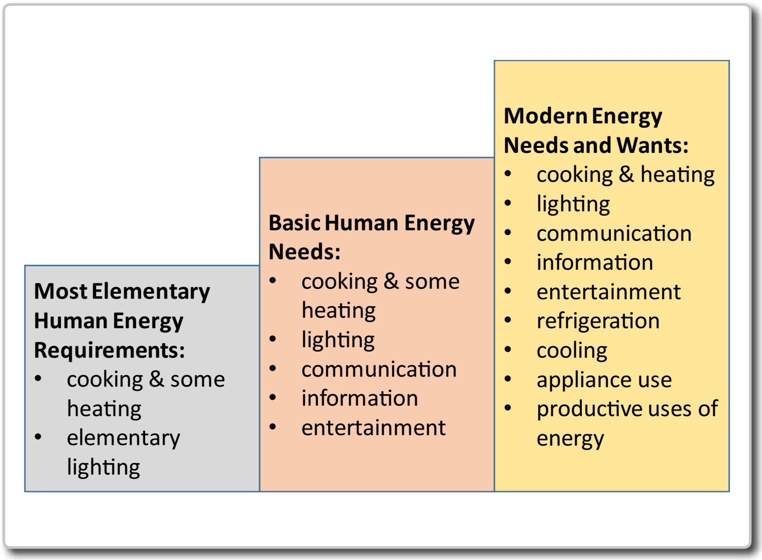


Figure 28:
Advancing energy needs, from elementary to modern needs & wants [22]

Aspect	What it means	Examples
…by which modern energy	energy technologies that are both environmentally benign and safe to use	RE-powered electricity, from a solar home system, or a mini grid, or grid-tied solar system, or grid electricity
and energy efficient technologies	technologies that optimise the benefit of their use by way of minimising consumption	high-efficiency light bulbs, such as LEDs, fuel-efficient stoves such as LPG stoves, improved wood stoves and appliances with a high EE rating
are available at prices	the market offers such products for sale when in demand, which may be created through dedicated Government programs and/or incentives	enable the uptake of at least the most basic of technologies, for example through specific Government support including taxes, implementation of programs and incentives
that allow the country's citizens	create the ability to be used by consumers of energy and users of energy technologies	as measured by quantifying uptake rates and appliance use, as is for example done in a census
to meet their energy requirements	the energy requirements for lighting, infotainment, cooking and heating	as measured by quantifying the use of specific energy-related behaviours and appliances , as is for example done in a census
in a socially acceptable	in a way that does not infringe the freedom of others	quantified by society-wide health and safety indicators
and environmentally sound manner	without causing harm to the ecosystem	quantified by emissions from the uptake and use
while incentivising productive uses of energy	encouraging behaviours	by creating Government programs that enhance the uptake and use
that promote both personal	support individual	measures of individual human development
and societal development.	enable progress for all Namibians.	measures of the societal human development achievements

Table 7:
Interpreting the definition of "REEE-powering the domestic use of energy" [37]

5.11 REEE-powering Domestic Energy Consumption

Section 5.2 illustrated how domestic Namibian households use energy for cooking, lighting and heating, while section 5.3 elaborated on the cost that households would likely incur when using different forms of energy to meet their basic energy needs.

This section asks whether and which domestic energy use can be switched to renewable energy sources, and where energy efficient technologies could possibly facilitate such a transition. As before, this section also illustrates the main insights by way of select case studies which are based on actual Namibian experiences.

5.11.1 REEE-powering Domestic Cooking

Section 5.2.1 has shown that more than 50% of all Namibian households use wood or wood products including charcoal for cooking. In fact, an estimated 86% of all rural users continue to rely on wood and wood products to prepare meals, while some 20% of urban users rely on wood for cooking.

When reflecting on the use of wood for cooking, the following aspects are important:

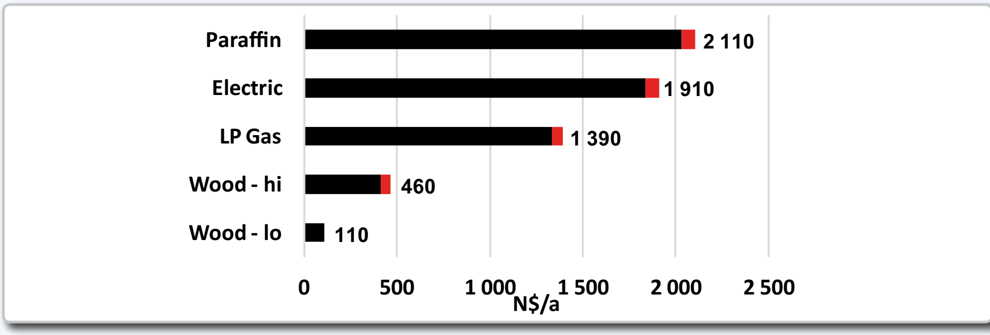
a. some areas in Namibia are abundantly endowed with wood resources, and the use of wood and wood products can therefore be desirable and effective provided that land and resource management principles are applied [1];
b. in rural Namibia in particular, wood is often available 'free of charge' (when ignoring the time taken to collect and transport it), or it is available at a much lower cost than that of comparable energy alternatives;
c. some Namibian areas are already severely deforested and do no longer offer adequate wood resources for ongoing utilisation; and
d. the use of open and inefficient wood fires is undesirable, as it leads to the inhalation of airborne particulates that are known to cause respiratory illnesses, and aggravate them.

This section reflects on the cost effectiveness of four of the most prevalent energy types used for cooking in Namibia. These energies include wood, electricity, liquid petroleum gas (LPG) and paraffin, as is further elaborated in Case Study 6. The case study illustrates the dilemma faced when wishing to convince end-users to switch to modern energy technologies: individuals having access to 'free fire wood' will not readily invest in a fuel-efficient wood stove, and free resources are often squandered or otherwise not used efficiently.

As the cost of fuel increases, as is the case when wood fuel becomes a traded and less freely available commodity, more fuel-efficient stoves become attractive. In Case Study 6, a price of wood of N$ 0.18/kg renders the annualised lifecycle costs of high- and low-efficiency wood stoves identical [37]. However, as is often the case in Namibia, prices per kg of wood often vary by a factor of 10 or more, especially when comparing rural and urban areas. Therefore it is unlikely that end-users will readily switch to more efficient technologies unless there is a tangible incentive to do so.

Case Study 6: Annualised cost to own (red) and operate (black) cooking technologies [37]

This case study compares the cost of preparing meals using five different cooking technologies: a low- and high-efficiency wood stove, as well as an electric, LPG and paraffin stove are included. It is assumed that these devices are exclusively used to prepare one cooked meal for one person per day, throughout the year. Under these conditions, which is the most cost-effective cooking technology to use, and what will it cost?



The figure above shows the annualised equipment cost in red (i.e. the cost for a stove when spread over 5 years), and the annual operating cost (for fuel or electricity) in black required to prepare one warm meal for one person per day throughout the year.

It is noted that the cost to operate a low-tech wood stove is only due to the cost of wood. If wood is collected for free, and there is no value attached to the time it takes to collect such fuel, then such wood use is 'free of charge'. Using a high-efficiency wood stove results in an annual cost for the stove, plus the cost of fuel.

The conversion efficiency of high-tech wood stoves is generally better than that of low-tech wood stoves. This case study assumes that a person using the former will pay N$ 1.5/kg of wood fuel, versus N$ 0.2/kg when a low-tech wood stove is used. This emphasises the important role of the cost of fuel when determining the annualised cost to own and operate a specific technology.

The above figure illustrates that the modern cooking technologies, such as LPG and electricity-powered stoves, are in the middle of the cost chart, while under the assumption used in this case study, paraffin stoves are the most expensive of the five options investigated here.

Case Study 6 also illustrates why those with access to modern energy for cooking are likely to ultimately switch from electricity to gas, provided that the prices are of the order as were assumed in this example: LPG is more effective and less expensive to use for cooking when compared to electricity as the instant heat of a gas fire leads to shorter periods of energy usage and therefore more rapid results in the kitchen.

5.11.2 REEE-powering Domestic Lighting

Section 5.2.2 has shown that some 70% of all urban households use electricity for lighting, compared to only some 15% of households in rural Namibia.

For domestic applications in areas that are connected to the electricity grid, or powered by a mini grid or solar home system, the three most common electric lighting types are incandescent lights, compact fluorescent lights (CFLs), and light emitting diode (LED) light bulbs, as shown in Figure 29.

Figure 29:
From left to right, an incandescent, compact fluorescent & LED light bulb [37]

But, which of the above is the most cost-effective way of lighting a household, and what are the costs of using one type of light source versus another one? Case Study 7 considers this question in more detail.

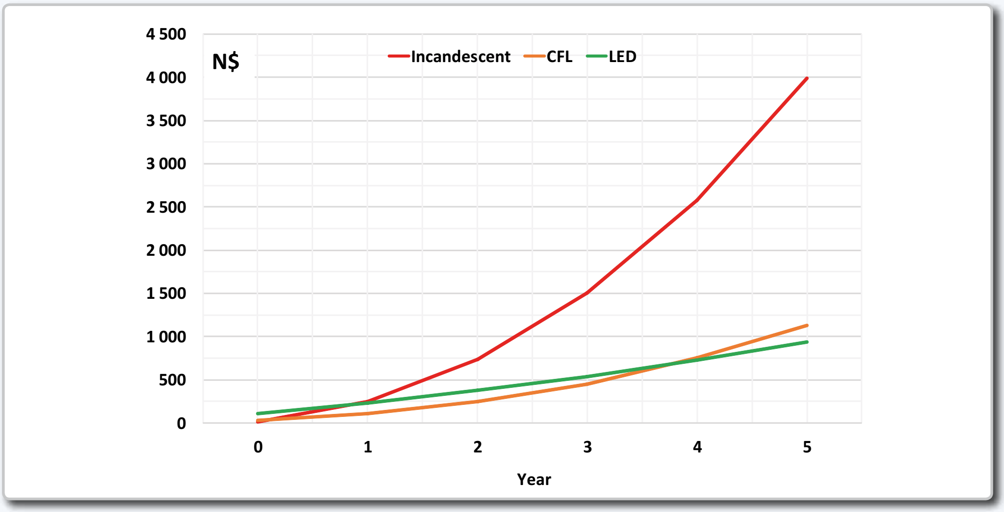
Lighting options that are often used in areas without access to grid electricity include candles, paraffin lamps, LPG lights, solar lanterns and solar home systems. Case Study 8 compares these technologies and identifies the most cost-effective lighting option.

As most end-users have experienced, the intensity of light from various lighting devices can vary significantly: a candle has a much lower light intensity than an incandescent bulb, or a hand-held torch with LEDs. Case Study 9 compares the cost per luminous intensity using different types of lighting sources, and presents their cost per kilolumen-hour (abbreviated N$/klh). In this way, different lights and their cost are comparable, and we can identify which light provides the most cost-effective output.

Case Study 7: Cumulative cost of using incandescent, CFL and LED lights over 5 years [37]

A household connected to the Windhoek electricity distribution grid uses a 60 W incandescent light, a 15 W CFL and a 10 W LED for 5 hours per day, throughout the year, over a period of 5 years. Pre-paid electricity costs N$ 1.665/kWh in 2014/15, and is assumed to increase by approximately 10% per year in the next years.

Which is the most cost-effective of the above lighting options?



Shown in red is the cost to own and operate incandescent light bulbs. These are often cheap to acquire (assuming N$ 15.50/bulb in year 0, escalating at 6% per year thereafter, with a lifetime of 1 000 hours), but their high operating cost and frequent replacement requirements imply that incandescent lights are the most costly of the three lighting options considered in this case study.

The cost to own and operate CFL light bulbs (assuming N$ 32/bulb in year 0, escalating at 6% per year thereafter, with a lifetime of 7 000 hours) is shown in orange. Their total cost of ownership is higher than that of using an LED light (assuming N$ 109/bulb in year 0, with a lifetime of 30 000 hours) after the first CFL bulb replacement is made in year 4 of operations.

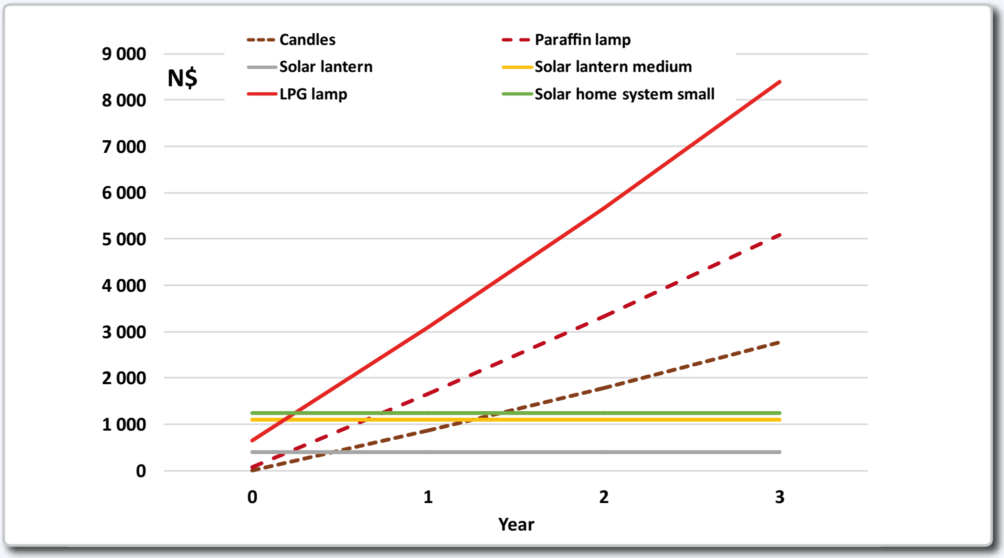
The example shows that LED lights are the most cost-effective of the three lighting options introduced in this example, even though they have the highest upfront cost.

Of note are the favourable environmental attributes of LEDs when compared to CFLs. Therefore, the way to REEE-power our lighting choices is simple: where possible, replace incandescent and CFL light bulbs with LED lights!

Case Study 8: Comparison of cumulative cost of grid-independent lighting options [37]

A household on the outskirts of Windhoek is not connected to the city's electricity distribution grid, and therefore uses one of the following to meet its lighting needs to provide for lighting for 5 hours each day, throughout the year: candles, a paraffin lamp, a LPG light, two types of solar lanterns or a small solar home system

Which of the grid-independent lighting options is the most cost-effective to use?



Shown in red is the LPG light, which is the most expensive of the six lighting options considered in this case study. On the other hand, the small solar lantern is the most inexpensive of the options compared above.

Lighting options that require ongoing fuel purchases, i.e. the LPG lamp, the paraffin lamp and candles, are the more expensive lighting options when considered over a period of 1.5 years or longer. Fuel cost just add up, year after year.

The solar lighting options on the other hand have an upfront cost only, and are not expected to require any further operating or maintenance (O&M) cost during their useful lifecycle. Clearly, whether or not O&M costs are eventually required depends on the quality of the technology used, and the technology specifications.

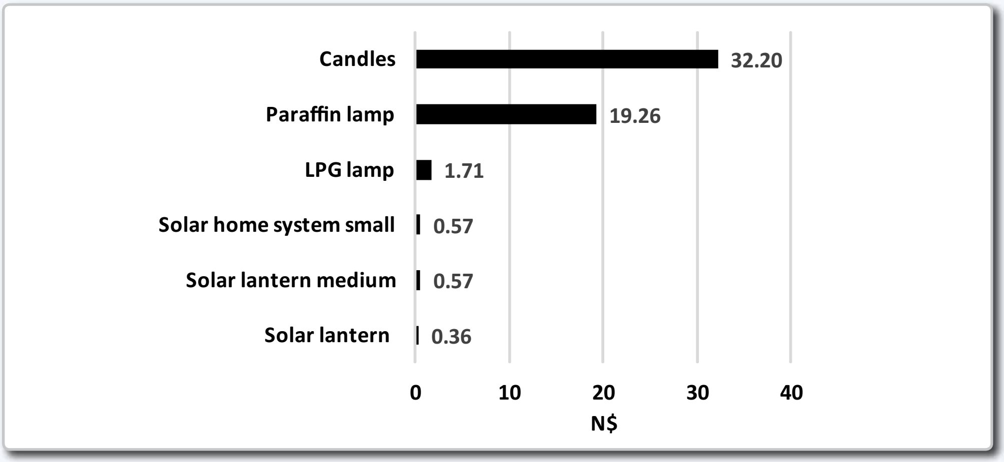
This example illustrates that the small solar lighting option considered here is the most cost-effective of the six lighting technologies investigated in this example. However, the present assessment does not answer the question whether the less expensive lighting options also provide the most effective lighting services. This is an important consideration, and will therefore be further investigated in Case Study 9.

Case Study 9: Cost comparison of various lighting options, in N$/klh [37]

One particular type of light is seldom exactly as bright as another type of light. Therefore, in order to compare different lighting options, one compares their luminous intensity. This physical characteristic is measured in lumen: the luminous intensity is an objective measure of the brightness of a particular a light.

A light that provides 1 000 lumens in one hour provides a lighting service of one thousand lumen-hours, i.e. one kilolumen-hours (abbreviated klh).

Which of the six lighting technologies considered in Case Study 8 is the least expensive in providing a given standard lighting service of 1 klh?



The figure above shows that candles provide the most expensive lighting service, in N$/klh, while a small solar lantern is the least expensive of the six grid-independent lighting services considered in this example.

The reason that solar lighting services are less expensive than lighting provided by LPG, paraffin and candles is mostly due to the high-efficiency high-intensity LED light bulbs which are an integral part of most contemporary solar lighting systems today. In fact, LEDs are the most efficient high luminous intensity light bulbs available for small electric systems.

The above also illustrates another important feature of grid-independent lighting systems: all of the technologies considered in this case study are much more expensive per luminous intensity than the contemporary lighting options such as incandescent light bulbs, CFLs and LEDs powered with grid electricity. To illustrate, the cost per klh of a 60 W incandescent light bulb is of the order of 14 cents, i.e. almost 3 times less expensive than that of the small solar lantern considered in this example, while this service from a grid-connected CFL using Windhoek tariffs costs only some 8 cents per klh, and 3 cents/klh for LEDs.

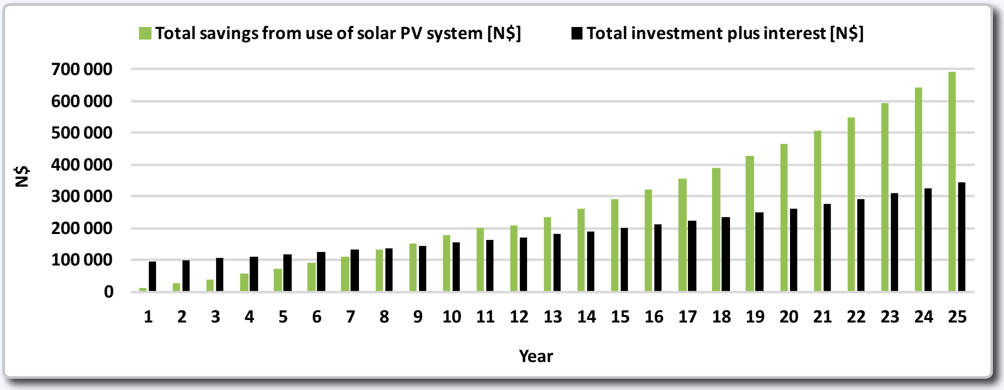
Case Study 10: What interest is generated by PV when viewed as an investment? [37]

Obeth resides in Windhoek and has decided to invest in a grid-connected solar photovoltaic (PV) system of 4 kW_p. The system costs N$ 90 000, supplying some 7 800 kWh of electricity in year 1. It carries a 25-year warranty, requires little maintenance, and its output is to decrease by 0.5% per year. The inverter will need to be exchanged in year 12.

The solar PV system displaces grid electricity. This implies that grid electricity will not be required whenever sufficient energy is generated by the PV system, which reduces the total annual electricity costs for 25 years. In year 1, the pre-paid tariff is N$ 1.665/kWh. Tariffs are expected to escalate at some 10%/year for the next 4 years, and at some 6%/ year thereafter, which is assumed to be the same as the inflation rate in the years to come.

When Obeth's solar PV system is installed, his neighbour invests N$ 90 000 through a brokerage firm. Over a period of 25 years, what is the annual interest rate that the cash investment has to offer so that it plus the accumulated interest is the same as the total savings generated when displacing grid electricity by the solar PV system?

The graph shows the cumulative savings from the solar PV system, and the investment plus interest on the investment, assuming an interest rate of 5.5%/year.



For an interest rate of 5.5%/year, the cumulative savings from the use of the PV system exceeds the total value of the investment from year 9 onwards. In year 25, total savings amount to N$ 693 000; by then the investment is worth N$ 343 000. An interest rate of 8.5%/year ensures that the investment plus the interest generated over 25 years is equal to the total savings generated from the use of the solar PV system.

The above calculation does not take any tax benefits into account, such as for example depreciation charges on the PV system, or value added tax benefits that may apply. It also does not include the 10% deduction on interest earned on cash investments, as applies in Namibia. If such factors are taken into account they further enhance the value of savings from PV, and necessitating a nominal interest rate on the investment exceeding 8.5%/year.

5.12 The Role of Electrical Energy Storage

Inexpensive electrical energy storage is expected to be the major game changer in the energy industry in the next years. Indeed, it is considered likely that both conventional and to-be-developed storage solutions will revolutionise the way in which renewable energy generation is used in both on- and off-grid applications [38].

Electrical storage systems are based on the principle that electricity is converted into a form of energy in which it can best be stored and dispatched. The energy forms used in modern electrical storage systems include chemical energy as used in lead-acid or lithium-ion batteries, potential energy as used in pumped storage hydro-electric power stations and compressed air systems, thermal energy as used in heat stores, rotational energy as used in flywheels or electric (e.g. in super-capacitors) or magnetic energy (e.g. in superconducting magnetic storage systems) [38].

Traditionally, energy storage systems were expensive and therefore often limited to high-value or remote applications, such as for backup and stand-alone power systems. Lead-acid batteries have been extensively used for backup applications, such as in the telecommunications sector, remote area power systems, and for applications in localities without grid power, or those with an unreliable grid. They continue to be the standard electrical backup solution for small- to medium-scale applications, but their short lifetime and limited efficiency render them less useful for large-scale applications. While electrical energy storage systems are ubiquitous and readily available today, their uptake and use to power domestic, commercial, industrial and utility users remains limited, especially when compared to the uptake rates of renewable energy generation technologies. This is likely to change in the years to come, and the large-scale use of electrical storage systems for domestic users, as well as communal and even national level applications is likely.

Today, there is a most significant effort underway to improve energy storage systems. This is, in parts, fuelled by developments in the automotive sector that focuses on commercial electric vehicles. It is considered likely that the large-scale production, as is commonplace in the automotive and electronic industries, will result in battery systems with far lower production cost than has been the case in the past, and these are likely to integrate easily into stand-alone and grid-tied systems. Potential areas where inexpensive energy storage systems are likely to increasingly find applications include the domestic sphere, as uninterruptable power supply solutions in the business, commercial and industrial sectors, and even for utility applications, such as for managing the dynamic capacity markets of the future [38]. Besides backup power, modern storage systems are also required to smooth out the electrical output due to sporadic or cyclic generation, for shifting demand, preventing power outages, managing overloads on power lines, and many other applications.

However, the cost of electrical storage systems is and remains a key barrier that continues to inhibit the large-scale deployment of such systems. As advances in the electronic consumer goods and electric vehicle sectors are made, and large-scale manufacturing capacity is established, costs are likely to decline more rapidly than has been the case in the past. Recent announcements by car manufacturers such as Tesla [39], Mercedes Benz [40], Honda [41] and others show that key manufacturers have entered the battle ground. These begin to offer electric storage solutions for small- and large-scale applications at a cost that is close to being competitive.

This begs the question: what characteristics do electric storage systems need to have to be considered competitive? There are a number of answers, depending on the context in which such storage systems are to be used. Generally, electrical storage cost is expressed as a cost per usable unit of electrical energy that can be retrieved from the system, i.e. the cost for storing and releasing a unit of electrical energy over and above the cost to produce that energy. In addition, both the power rating (expressed in watts, kilowatts or megawatts) and the storage capacity (expressed in Wh, kWh or MWh) are important indicators characterising electrical storage systems. Table 8 summarises some typical technical and economic characteristics of battery systems as applicable in the contemporary domestic power market.

Table 8:
Characteristics of five electrical energy storage systems [37]

Characteristics	Unit	Lead Acid 1	Lithium Ion 1	Tesla PowerWall	LiFePO4 1	Tesla PowerPack
Capacity rating	kWh	14.4	8.0	7.0	7.0	100
Power rating	kW	5	5	3.3	3.5	23
Depth of discharge	%	50%	100%	100%	50%	100%
Number of cycles	#	2 800	6 000	4 000	3 650	4 000
Price	N$	122 375	259 875	54 688	57 170	390 625
N$ per rated kWh	N$/kWh	8 498	32 484	7 813	8 167	3 906
N$ per rated kW	N$/kW	24 475	51 975	16 572	16 334	16 984
N$ per useable kWh per cycle	N$/kWh/cycle	6.07	5.41	1.95	4.48	0.98

Assumptions:	
N$ to Euro exchange rate	13.75
N$ to US$ exchange rate	12.50
Dealer markup for Tesla	25%
Discount rate	10%

The range of costs per useable unit of energy per cycle shown in Table 8 is between N$ 1/kWh/cycle and more than N$ 6/kWh/cycle, which is a considerable spread [42]. Favourable characteristics are offered by two products that have only recently been announced by Tesla, i.e. the PowerWall for domestic applications, and the PowerPack for commercial applications [39]. Based on the assumptions underlying the calculations in Table 8, some storage systems have energy costs that are at or even below current Namibian retail prices for electricity, while others remain considerably above current grid energy prices [41]. This is a significant result, and illustrates that contemporary battery storage systems are at or (in some cases) close to grid parity, excluding the cost of generation. Grid parity in this context refers to the threshold at which electrical energy that is retrieved from a storage system is at or below the cost of electricity supplied by the grid [43].

Figure 30:
Namibia's largest off-grid solar PV plant at Gam [44]

Figure 31:
The battery storage system (left) and inverter assembly (right) at Gam [45]

Table 8 also illustrates that electrical storage cost depend on system-specific characteristics, such as depth of discharge and the number of charge/discharge cycles.

Do contemporary battery storage systems make sense for a domestic grid-connected consumer? This is a question that is explored in further detail in Case Study 11.

Given the current cost of battery storage systems, when is likely to be the best time for investing in such a system? This question is further investigated in Case Study 12.

And how does a solar photovoltaic system and battery storage system interact with one another? This question is discussed in Case Study 13, which shows some graphs to illustrate the interplay between a solar PV system, a consumer's electricity use throughout the day, and the feed-in and draw-off from a battery system.

Case Study 11: Electricity costs with and without storage [37]

A 5 kW_p grid-tied domestic solar photovoltaic installation in Windhoek delivers some 9 750 kWh of electrical energy in the year of installation (i.e. 1 950 $kWh/kW_p/a$), and costs a total of N$ 112 500 (i.e. N$ 22 500/kW_p). The solar panels have a production guarantee of 25 years, but their output will degrade by some 0.5% per year.

In view of the possible electricity supply shortages in the coming years, the owner is now considering to upgrade the system by adding an electrical energy storage system. The owner's principal consideration is to become as independent from the supply of grid electricity as possible, maintaining an average consumption of some 9 kWh per day throughout the year.

Two separate offers for electrical storage systems only have been received:

1. a lead acid battery system with a nominal capacity of 7 kWh, with 2 000 cycles at 50% depth of discharge, for N$ 60 000, and
2. a lithium-ion battery system with a nominal capacity of 7 kWh, with 4 500 cycles at 100% depth of discharge, for N$ 145 000.

In its 25-year life, the solar system will produce some 229.67 MWh of electrical energy. The owner suggests that her investment therefore implies that she will now only pay some N$ 112 500 / 229 670 kWh ≈ N$ 0.49/kWh for the next 25 years. A friend, who holds a day-job as a financial analyst, however suggests that such a calculation does not include the time value of money. Arguing that the owner's cost of capital is 10%, he suggests that the actual average cost of electricity from the solar PV plant is the levelised cost of energy (LCOE), which is N$ 1.32/kWh, not taking an inverter replacement or other maintenance costs into account. He does however point out that such additional expenses will most likely be required within the lifetime of the power system, and would therefore add some cost in future.

When including the lead acid battery system mentioned above, the LCOE for the full system is N$ 3.91/kWh, while the use of the lithium ion batteries implies a LCOE of some N$ 4.17/kWh. In the case of the lead acid system, the LCOE includes 4 battery replacements, while a lithium ion system would most likely need to be replaced in year 13. It is assumed that the price of the replacement products will increase at an annual inflation rate of 6%.

It is evident that the battery prices assumed in this example may change in future. It is considered likely that certain battery types will become substantially more affordable than they currently are as technological learning is expected to drive down costs.

However, this case illustrates that the addition of a battery system remains non-viable for most domestic applications unless there are appliances to be powered that cannot be allowed to go without a permanent power supply, even in case of short grid power interruptions.

Case Study 12: When is the right time to invest in a battery storage system? [37]

Based on the analysis presented in Case Study 11, at what price does it become viable to invest in a battery storage system?

For a domestic solar PV plant with storage, as introduced in Case Study 11, the electric storage system is financially viable once the solar production cost plus the cost of the battery storage are less than the residential tariff at which electricity is drawn from the grid (not taking grid feed-in into account).

The above system viability considerations illustrate why conventional electricity storage, such as contemporary lead acid or lithium ion battery systems, are not readily integrated into grid-tied solar power systems. However, as shown in Table 8, the cost of some storage options, such as the Tesla PowerWall, may in time become attractive for ordinary domestic solar PV grid-connected systems.

The following hypothetical case illustrates the viability considerations in further detail: driven by the potential market size for electrical storage systems for electric vehicles and their many large- and small-scale applications, it is postulated that prices of battery systems will decline in real terms by some 5% per annum, starting in 2015. Under this assumption, a storage system similar to the Tesla PowerWall, that costs N$ 1.95/kWh in 2015 (refer to Table 8), will decline to N$ 1.53/kWh by 2020, and to N$ 1.20/kWh by 2025.

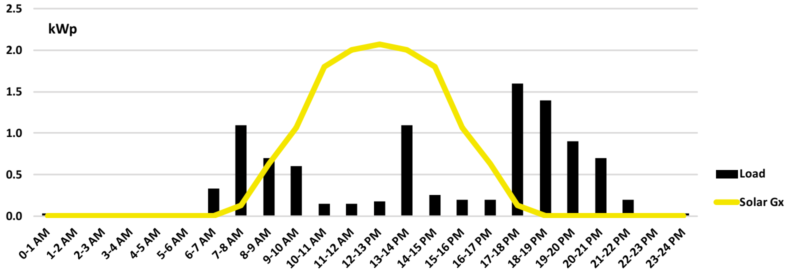
Considering that the domestic electricity price is expected to increase at or close to 10% per annum for the next few years (assuming until 2019), and at 6% per annum thereafter, the cross-over point where the cost of solar generation (at today's prices) plus storage is less expensive that grid power is expected in about 7 years, assuming that today solar PV price will not reduce any further in real terms, which is considered to be a too conservative view. What does this mean?

For most domestic applications, and unless load shedding events become more regular, an investment in a battery storage system that complements a grid-tied solar PV supply is not yet considered financially viable, except for applications where an uninterrupted power supply function is required for essential loads. Other specialist applications do exist too where the above reasoning does not apply.

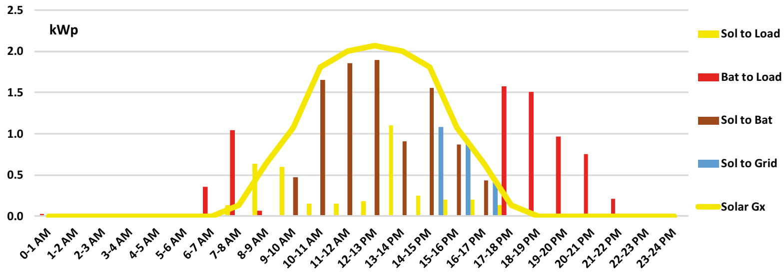
In view of the very considerable international investments in battery manufacturing infrastructure it would not surprise if prices of high-quality electrical storage systems will decrease at real rates of 5% per annum or more. In addition, at the current pace of innovations, and given the enormous market share that a first mover battery manufacturer will have, it does not seem unrealistic to expect innovations that could introduce battery storage technologies at a scale and price that would be considered unrealistic today. ***The run is definitely on.***

Case Study 13: A day in the typical life of a solar-plus-battery system [37]

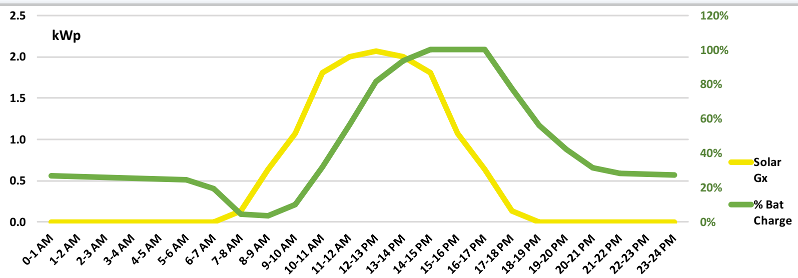
A grid-connected domestic Windhoek prosumer has an average electricity consumption of 10 kWh/day. She operates a 2.5 kW_p solar photovoltaic plant, coupled to a lithium ion battery pack with a 7 kWh capacity. The typical daily load curve (energy consumption) and solar generation profile (abbreviated solar Gx) are shown below.



Before the solar generator produces a tangible output in the morning, the battery feeds the load, as shown in 'Bat to Load' in the graph below. The same happens at sunset and thereafter. Once the sun is up and the plant produces an output, it feeds the load ('Sol to Load') and charges the battery ('Sol to Bat'). Any excess energy, over and above that required to serve the load and charge the batteries is fed into the grid ('Sol to grid').



After being re-charged, the battery system reaches a fully-charged state in-between 14:00 and 17:00, and is then steadily being discharged as it feeds the load. In the morning, before the solar plant starts to charge it again the battery discharge further.



5.13 Conclusions

Every human being requires energy to live. While the actual amount of energy that is consumed per person ranges in-between that of those who are considered energy poor and the most affluent members of society, energy use is a necessary part of life, even if it is a life endured in abject poverty.

While energy use is universal, access to energy is most certainly neither universal, nor part of the basic services available to each citizen. In today's Namibia, there are those who suggest that the country should provide universal access to modern energy, or pronounce that access to energy is a human right. But what is the meaning of such statements? This study provides basic some pointers and reflections to indicate how statements or policy intentions in regard to access to energy can be concretised. It shows what it would mean if we were to adopt a particular policy in regard to access to energy in Namibia.

This chapter has shown that a person who has access to a few tens of watt-hours of electrical energy per day can meet the bare minimum needs for lighting and some basic infotainment. On the other hand, a grid-connected person who consumes some 5 kWh of electrical energy per month can have elementary lighting, infotainment and refrigeration services. If such amounts of electrical energy are complemented by a thermal fuel, for example LPG (at least some 3 kg/person/month) or wood (at least some 30 kg/person/month), a person's most basic energy needs can be met.

In case a person has some 20 kWh of electrical energy available per month, and provided that the consumer can afford the associated costs, the minimum of what is considered necessary for an elementary life in *energy dignity* begins to be possible, even without having to use additional thermal energy sources. Such an amount of electrical energy begins to cover the energy minimum required for life's basic essentials, and is the threshold above which a person can no longer be considered energy poor. It is important to note that the use of such quantities of electrical energy assumes that a person is grid-connected and has access to electrical appliances, all of which cost money and may prevent the use of such services.

But, what is *access to energy*? We defined access to energy to mean that a person is able to use one or several forms of energy to meet some or all energy requirements for cooking, lighting and heating. This definition implies that energy is both *available* and *affordable*. In this context, availability refers to one or several energy forms being offered for use. Affordable energy on the other hand refers to an end-user being able to meet the cost of a given energy source or energy service, even if only for a minimum quantity of energy to ensure that basic human needs can be satisfied without incurring unacceptable difficulties in another aspect of the consumer's life.

For a typical 5-person household in Namibia, having access to energy implies that some 25 kWh of electricity is available per month when connected to the grid, to meet the most basic lighting, communication and entertainment needs, plus some 150 kg of fire wood or 15 kg of LPG per month, to enable the householders to do some basic cooking and heat some water. These quantities therefore constitute a minimum of what is considered essential to lift people out of *energy poverty*. In the absence of a grid connection, as is often the case in rural Namibia, electrical energy needs can still be met using a variety of modern off-grid electricity technologies, ranging from solar lanterns, to pico and micro solar systems, or solar-powered mini grids, of other stand-alone power sources.

The use of energy does not automatically lift people out of poverty. While energy use is essential in order to meet life's energy-related requirements, having access to funding or being able to generate an income can lift people out of poverty. Energy however, either directly or indirectly, is a pre-requisite for most income-generating activities. This implies that, if a minimum energy consumption threshold is to include income generation and the productive use of energy, then an additional energy budget must be available and the minimum energy budget indicated above is not sufficient. Here it is noted that it is only through income generation that growth and development can take place. It is therefore a necessity that adequate amounts of energy are available over and above those required to meet basic consumptive needs, and such energy requirements will be for productive uses.

We have emphasised that Namibia needs a vision in regard to access to energy that can underpin the country's national development. To this end we have put forward an aspirational definition that focuses on *the domestic use of energy in Namibia:*

> *REEE-powering the domestic use of energy in Namibia is the deliberate process, supported by relevant policies and regulatory provisions, by which modern energy and energy efficient technologies are available at prices that allow the country's citizens to meet their energy requirements in a socially acceptable and environmentally sound manner, while incentivising productive uses of energy that promote both personal and societal development.*

We conclude with a summary of the most important insights from this chapter:

1. Energy poverty exists when a person is unable to meet the minimum energy requirements necessary for basic cooking, lighting and heating. Lifting people out of energy poverty enables them to more meaningfully participate in development.

2. Being materially poor also often implies living in energy poverty. Energy poverty is particularly pronounced when most or all energy sources must be purchased, which then further accentuates the degree of poverty.

3. In 2015, access to energy in Namibia remains significantly skewed. The most affluent in society have an actual or potential access to energy that is many orders of magnitude larger than that which is accessible by the poor or the poorest in society.

4. Unless access to energy is deliberately strengthened, the very foundations of national poverty alleviation efforts will remain insecure, and national development efforts will remain stifled.

5. The minimum thermal energy required per person per month is 3 kg of LPG or 30 kg of wood fuel, which is required for basic cooking and water heating. Such thermal energy needs must be complemented by at least 5 kWh of electrical energy per person per month when such a person is connected to the electricity grid, to meet basic lighting, communication, information and refrigeration needs. If not connected to the electricity grid, a variety of modern off-grid electricity technologies, ranging from solar lanterns, to pico and micro solar systems, or solar-powered mini grids of other stand-alone power sources exist which can provide minimum electrical energy services, but usually not those required for thermal applications.

6. More than 50% of all Namibians continue to rely on fuel wood to satisfy their thermal energy needs. In many urban and peri-urban areas, wood has become a tradable commodity, and can no longer be gathered ‘free of charge’. This has a significant impact on the availability of energy of poor households in particular as such expenses represent an additional drain on household incomes.

7. If a person has access to grid electricity for lighting, cooking, heating, entertainment and communication needs, some 20 kWh of electrical energy per person per month is the threshold that begins to meet modern minimum energy requirements.

8. In many cases, a household that uses electricity sparingly can have the benefit of grid services at a lower total annual cost than a comparable household that depends on purchases of fuel wood. However, significant variations in the price of fuel wood exist, especially in peri-urban areas around Namibia.

9. For socio-economic development to take place, the energy availability to domestic end-users must include a provision for productive uses.

10. REEE-powering the domestic use of energy should follow an energy access ladder that first enables end-users to meet their most basic energy needs, then incentivises the rapid uptake of energy efficient technologies, and the switching to clean energy sources. Such a deliberate effort will assist poverty alleviation initiatives by creating conducive living conditions that are a pre-condition for any meaningful participation in the country's economic development.

6 REEE-Powering Commerce and Industry

6.1 Introduction

Large- and small-scale commerce and industry actors provide a multitude of services in Namibia, including those which involve the conversion of raw materials into goods and products. In this way, commerce and industry create jobs and supply the lubricant to the country's economy. It has become evident that neither Government nor the traditional providers of jobs, such as the agricultural sector, can create as many new job opportunities as are potentially locked in commerce and industry, including at the scale of small and medium enterprises. If long-term jobs are to be created in Namibia, these are likely to be in commerce and industry.

The conversion of resources into inputs for commerce and industry requires primary energy in the form of fossil fuels, coal and possibly biomass, as well as secondary energy sources such as electricity. In view of Namibia's small manufacturing sector and the limited number of products that are locally manufactured, the energy requirements (for example when expressed in kWh per gross domestic product generated) in commerce and industry are lower than those in industrialised countries.

Figure 32: *REEE-powering the Gwashamba Mall in Ondangwa [46]*

Some two-thirds of the total energy used in industrial processes worldwide is consumed in developing countries and economies in transition, with China accounting for almost 30% of the global energy demand in manufacturing [47]. Between 2015 and 2030, total global industrial energy use is projected to grow by almost 50%, unless large-scale energy efficiency improvements are put in place [48]. Such increases in energy demand are difficult to meet, and necessitate considerable process improvements, by for example focusing on process efficiencies in general, and the application of energy efficient technologies and practices in particular, as well as self-generation. On the other hand, generating power for own consumption does not decrease the total energy use, but is likely to significantly change the traditional grid dependency and draw patterns, such as the timing and quantity of electricity demanded from the national and local distribution grids.

Namibia's Vision 2030 envisages the creation of an industrialised country [49]. There is little specificity in how the most fundamental input commodities, such as water and energy, are to be provided to enable the intended development. This study will only focus on some of the high-level energy-related issues that will have to be addressed and operationalised to ensure that at least some of the energy requirements of a partially industrialised country can be met in future. Consequently, we will mainly focus on how individual commercial and industrial actors may opt to address their energy needs in the years to come.

Developing commercial and industrial sectors require several energy-related inputs, such as fossil fuels and their derivatives, electricity and possibly biomass and biofuels. It depends on the type and scale of an industrialisation effort that determines the variety of energy feedstock that has to be available. While electricity demand can be significantly managed through the introduction of energy efficient processes and the rigorous application of energy efficient practices, the total energy requirement can generally not be eliminated through the application of energy efficiency improvements. This emphasises the importance of having access to a secure and cost-effective energy mix. Modern energy requirements are changing, and the deliberate switching of fuels is a common practice in industry. It can result in the significant reduction of import dependencies and uncontrollable future costs.

Namibia, as a developing country, is not alone in grappling with ways to secure its future energy requirements. The country has choices in how the energy needs of the future will be provided, and the role and dependency on fossil fuels. While the country does not have carbon dioxide emissions targets yet, it is important to realise that the continued dependence and increased use of fossil fuels will further contribute to the production of greenhouse gases and their associated negative environmental impacts, and will require a continuous outflow of hard currencies from the country.

As environmental taxes become a reality in Namibia, commerce and industry is well-advised to embrace clean energy production, energy efficiency and reduce greenhouse gas emissions. In this context the next sections will focus on efforts to REEE-power Namibia's commerce, manufacturing and industry sectors, focusing on the role of renewable energy and energy efficient technologies in decreasing the sectors' dependence on fossil fuels on the one hand, while improving efficiencies and becoming more sustainable on the other.

6.2 What, Where and How

This chapter asks how commerce and industry can bring about efficiency increases and wean itself off fossil fuels. The central theme of this book, i.e. how the country and the sectors in the economy can be REEE-powered, is the main focus. To this end, we ask how the use of electricity and heat could benefit from higher penetrations of renewable energy sources as well as the systematic use of energy efficient technologies.

It is noted that the use of fossil fuels, specifically for transport and mobility purposes, is and remains a painfully obvious omission from the present discussion, and will require further assessment focusing on greenhouse-friendly fuels, fuel efficiency standards, electric vehicles and others. These topics, although important, will not be further developed here.

The approach used in this chapter assumes that current technologies used to enhance the energy efficiency of buildings, plant and equipment will become increasingly more attractive as a result of rapidly increasing energy costs. This assumption seems sensible, as the current regional electricity supply bottleneck will not be readily alleviated. A flood of inexpensive new electricity supplies arriving any time soon is therefore considered unlikely. At the same time, considerable technological learning takes place across the globe, lowering the price and enhancing the performance of many renewable energy supply options and energy efficiency measures.

While not yet recognised by policy, it would seem realistic that Namibia will – in time – take measures to limit the scale of national carbon dioxide emissions. This may be realised, for example, by putting a price on carbon emissions, which is expected to stimulate technology and fuel switching, away from fossil fuels to low-carbon or carbon neutral renewable energy and energy efficient technologies, where available.

As to possible pathways in which REEE-powering can be achieved in commerce and industry, the following list highlights specific tangible actions, as will also be illustrated in the case studies elaborated below:

1. replacing lighting, air conditioning, electric motors and related equipment and machinery with their modern energy efficient equivalents;

2. shifting of specific electric loads away from peak demand into off-peak periods, and using local generation to reduce the reliance on the grid;

3. using solar thermal systems in favour of electric and fossil fuel-powered heating systems, especially for water and process heat as used in commerce and industry;

4. using biomass and biomass-related products, to displace liquid and solid fossil fuels used in heaters, ovens, kilns and similar devices;

5. using electrical instead of fossil-fuelled engines, which allows for the introduction of high-efficiency electric appliances on the one hand, and the use of renewable energy generation technologies on the other;

6. diversifying the energy supply mix for energy-intensive plant and equipment, to reduce the dependency on fossil fuels while tapping into the array of modern renewable technologies, including biomass and solar;

7. applying energy-efficient processes to reduce operating costs and the dependency from fossil fuels and grid supplies;

8. enhancing interactions between commerce and industry and local electricity distribution entities, through smart-grid technologies and distributed generation capacities, thus enhancing the scale and scope of demand response participation and increasing the use of RE generation options;

9. creating national incentives to invest in energy efficient and distributed generation technologies used in commercial and industrial plant, to reduce peak demand, deliberately enhance the sectors' efficiencies and ensure the dedicated application of carbon taxes for environmental enhancements; and

10. emphasising EE and RE technologies in the promotion and marketing of Namibian goods and services, to capitalise on the clean and sustainable manner in which these were produced, and how such use is supported by Namibia's rich natural endowments in renewable energy sources.

Figure 33:
Commercial grid-connected solar photovoltaic plant powering Woermann Group Supermarket, Windhoek [50]

6.3 The Role of Small- and Medium Enterprises

If small- and medium enterprises (SMEs) are to play an increasingly important role in Namibia's economy, as envisaged by Government, it will be of interest to highlight how such enterprises could benefit from REEE-powering their operations. There is no uniform way in which SMEs operate in the country, and their variety is considerable. This implies that some specific assumptions will have to be made to highlight some of the energy-related aspects that characterise SMEs.

Figure 34:
Walking the talk – REEE-powering of Solar Age Namibia in Windhoek [51]

The cost of energy is a common operational expense for most SMEs. Typically, and highly dependent on the type of operation under consideration, energy expenditure ranges between 5% and 20% of total monthly expenditure, not including liquid fuels such as petrol and diesel, as are required for transport. Energy costs form a part of the total production costs, albeit often not the largest part. However, in the absence of a continuous supply of energy, for example when load shedding happens, vital input energy is unavailable, and may result in the partial or complete stand-still of the business. This implies that, although energy expenditure may not be the most important cost driver, the availability of energy remains a mission-critical requirement.

Typically, an SME operator would ask a) how to reduce ongoing costs as a result of operations, and b) how to ensure the continued supply of energy to the enterprise. Both questions can – at last partially – be addressed by deliberately REEE-powering a business, as is further illustrated in Case Study 14 and Case Study 15.

Case Study 14 illustrates how an investment in energy efficient equipment and the use in locally produced wood fuel can reduce the operating expenses incurred by a pizza restaurant. Case Study 15 compares the costs associated with a diesel generator and a solar generating plant used for a small-scale grain mill in rural Namibia. Both cases illustrate that investments in energy efficient technologies, or those powered by Namibia's abundant natural resources, can bring about savings that make investments in such plant more viable than those offered by older equipment or those powered by fossil fuels, despite the fact that such changes require initial capital outlays.

The case studies highlight that a considerable number of opportunities exist for either fuel switching, or technology exchanges, or both, which arise when replacing older and/or inefficient equipment. In addition, the case studies demonstrate that the replacement of inefficient equipment and/or investment in renewable energy generation capacity may lead to considerable savings for the owners of such equipment, even if such savings are not evident when only considering the upfront capital investment costs required to effect such changes.

What is also illustrated is that a commercial entity can increase its operational flexibility and decrease its dependence on fossil fuels and grid electricity when opting for energy efficient technologies. While there are few tangible incentives driving Namibian businesses to reduce their greenhouse gas emissions, it is expected that an increasing number of clients will recognise and be willing to reward those businesses that take voluntary steps to reduce their overall environmental footprint, by for example lowering their carbon dioxide emissions through the uptake and use of energy efficient equipment and choosing sustainable energy options to power their businesses.

Figure 35:
A REEE-powered Meike's Guesthouse in Swakopmund [52]

Commerce and industry are important demand drivers, and can, through their purchasing decisions, initiate the development of local value chains. In Namibia, where plentiful biomass resources exist, the creation of a supply chain to harvest, process and deliver such energy sources to the market is expected to be incentivised through increased end-user demand. Here, enterprises from the commercial, manufacturing and industrial sectors can play an important role in creating the demand to warrant the establishment of value chains or specific value chain elements that have previously not existed, including those required for biomass harvesting, the processing of biomass into useful fuels, and the logistics and transport requirements to cost-effectively deliver such energy carriers to end-users.

Figure 36:
NamWater headquarters on the road to becoming REEE-powered [53]

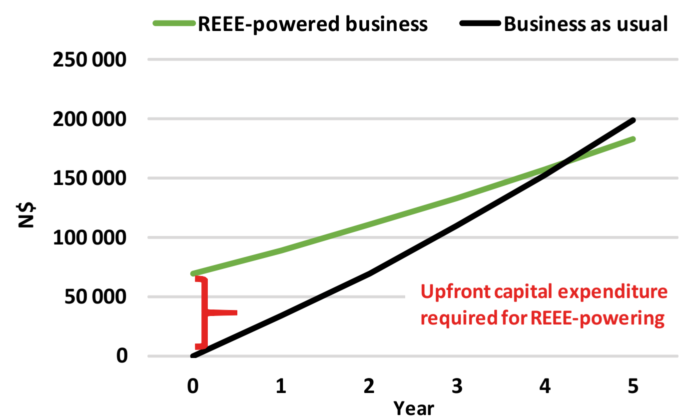
It is also noted that commerce and industry as well as SMEs can exert a market pull, and in this way incentivise the development and technology deployment along a given supply chain. Replicating positive experiences becomes easier as additional end-users decide to use specific

Case Study 14: REEE-powering a pizza restaurant [37]

An example of a typical SME is a pizza restaurant. This case study illustrates the typical costs and benefits when such an establishment decides to REEE-power its operations. For the business under consideration, some 20% of the monthly overhead costs are the result of electricity costs, arising from the use of an electric pizza oven, two fridge-freezers, an air conditioning system, an electric water heater and various lights, including an illuminated external billboard.

The owner of the restaurant has just recently invested in moderately energy efficient fridge-freezer systems and a new air conditioning system, and is of the opinion that these components cannot be further optimised in terms of their efficiency. An energy audit identified the pizza oven, water heater and lighting system as the prime candidates for further optimisation, with an electrical energy consumption of some 14 000 kWh/a, 4 000 kWh/a and 2 000 kWh/a respectively. In 2014, the restaurant paid N$ 1.665/kWh. It is assumed that municipal electricity prices will escalate at 9% per annum for the next 5 years.

The salvage value of the electric pizza oven is estimated at N$ 8 000, and the electric water heater is still worth some N$ 2 000, while a wood-fired pizza oven costs N$ 31 000, and consumes some 50 kg of wood per day for 300 operating days per year, at a cost of N$ 1.25/kg in the first year. A solar water heater with an electric backup element is quoted to cost N$ 30 000, including installation cost. The complete refurbishment of inefficient lighting is expected to cost N$ 18 000, and to reduce the associated electricity consumption by 80%.



The analysis shows that the REEE-powered option breaks even in year 5, not considering any tax advantages, such as depreciation charges. Considering that wood fuel from Namibian invader bush is a plentiful local resource, while electricity is not, and in view of the authentic flair that a wood-fired pizza oven lends to a restaurant, this case study illustrates that REEE-powering can be considered as the way to go as it increases profitability while creating local value by using a plentiful resource, i.e. biomass, while optimising the use of electricity.

technologies. In this way, both commerce and industry play a pivotal role in preparing, trialling, showcasing and marketing their experiences when choosing to embark on a journey of energy efficiency and the deliberate use of renewable energy technologies, and thereby encourage others to replicate their REEE-powering journey.

Access to cost-effective energy technologies is and will remain essential for all businesses. A traditional barrier to more readily ensure that access to technologies is optimised has been the field of financing. While established electricity distribution entities operate under regulatory protection in Namibia, companies deciding to invest in energy efficiency and/or augment their energy supply by investing in own generation sources do not have such regulatory protection. Here, the finance sector plays a pivotal role. As such, it is often the perception and experience of local financing institutions that decides whether a particular technology transition is considered realistic, or remains largely blocked.

In Namibia, the more traditional providers of funding to commercial and industrial entities are not particularly known for their technological nous, nor have they exhibited significant forward thinking or courage to go beyond "green-washing" their marketing efforts, and in some cases, their company logos. However, technological progress hinges on having access to financial services and products that enable the uptake of plant and equipment that bring about efficiency improvements and cost reductions, similar to what energy efficient technologies and select renewable energy generation options readily offer. In this regard, most providers of commercial loans would benefit from updating their in-house understanding of REEE technologies, and to get up to speed with the multitude of advances that are radically reshaping the energy efficiency and renewable energy sectors in recent times.

Figure 37: *REEE-powered beer brewing at the Namibia Brewery Limited [54]*

6.4 Biomass use for Commerce and Industry

Namibia offers considerable biomass resources which are locked in bush-invested rangelands in the central and northern parts of the country [55]. This resource offers considerable potentials for local sustainable use, including for the country's power sector and for process heat in commerce, manufacturing and industry, and other applications. Presently, with the exception of the Ohorongo cement plant and a few small-scale applications, the country's biomass resources have not yet been recognised as a versatile and sustainable local source of energy. This needs to urgently change.

Biomass, and its prolific manifestation in the form of bush encroachment in Namibia, is a plentiful resource, estimated to have an energy equivalent exceeding 1 000 TWh in 2015 [55]. This amount is equivalent to about 50 times the total energy used in Namibia per annum, which is of the order of 20 TWh/a, including all fossil fuels and electricity. The bush resource grows at a rate of up to 5% per annum, depending on the rainfall intensity and length of the rainy season. In Namibia, biomass from invader bush is the central connector between productivity in commercial agriculture, the country's groundwater resources, and local meat production. As a renewable resource, biomass from invader bush is therefore at the nexus of water, food and energy, and could become a prominent driver of rural development.

Figure 38:
The 250 kW bush-to-electricity power plant at farm Pierre, south of Outjo [56]

For Namibian commerce and industry, the country's biomass resource remains almost completely unused. This is despite its huge potentials for energy, power and heat, as a locally produced bio-based polymer for building materials and bio-degradable filler materials, as an agricultural feedstock, and for numerous other applications. As a renewable product, biomass offers many opportunities for the creation of new or adapted products that seek to benefit from its versatility. As a resource that does not have to be cultivated at great expense, in contrast to many other agro-forestry products, Namibian biomass could become a commodity where local value addition and use creates new commercial ventures, creates permanent jobs and invigorates rural development.

While the consumption of biomass for heat and power represents a once-through use of the resource, opportunities in which biomass is used several times prior to its final use to generate heat and/or power are certainly possible. Such a cascading resource use could, for example, start with an application as a feedstock for bio-based polymers, which offers opportunities for re-use and re-cycling, up to the point where such feedstock is eventually incinerated at the end of its useful life. Such multi-use creates multiple opportunities for job and income generation, through value chain creation, trade, local value addition, and end-use. In Namibia, recycling remains largely limited to metals and some plastics, and commercial biomass recycling would have to be initiated from scratch. However, informal biomass recycling and multiple end-uses are already taking place at most waste disposal sites throughout the country, and are part of the daily chore of informal traders making a living from products that are disposed here.

For commercial and industrial activities requiring high-temperature process heat, such as in the case of the Ohorongo cement plant or in the mining industry, biomass is a tangible renewable energy option that can provide such high-temperature heat on demand. Off-the-shelf combustion systems are available, for use with local biomass. Such applications however necessitate readily available biomass feedstock, which is not yet fully available, and remains limited to a few off-takers who have succeeded in establishing a system in which such feedstock is supplied almost continuously. But, locally grown and harvested biomass can be a cost-effective replacement for imported fossil fuels, provided that a proper harvesting, preparation and logistics infrastructure is established, and transport is minimised [1].

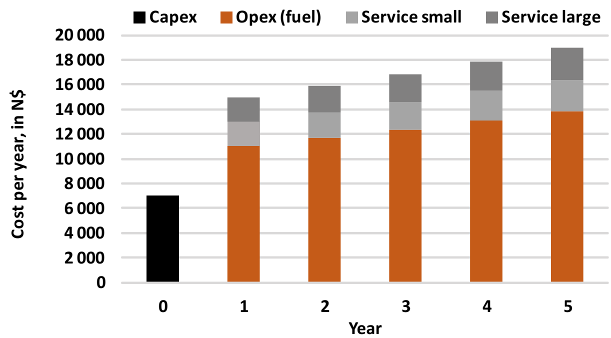
Case Study 15: REEE-powering a grain mill [37]

This case study considers a small enterprise operating a grain mill in rural Namibia. The mill's business involves the collection and grinding of grain for rural farmers.

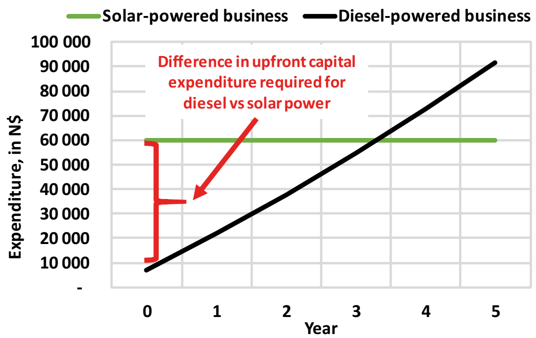
Presently, the mill is powered by a diesel generator. However, the generator is old and unreliable and requires frequent maintenance for which expensive spare parts have to be purchased, which are not always readily available. As a result, the mill's owner is investigating the options to either invest in a new diesel-powered generator, or a solar-powered generator. The following quotations were received:

a. Diesel-powered generator with a rating of 2.5 kVA, at a cost of N$ 7 000, and using some 1.8 litres of diesel per hour which costs N$11/litre in 2015, and a service interval of 250 hours for the small service costing N$ 300, and 1 000 hours for the major service, costing N$ 1 200.
b. Solar photovoltaic generator, rated at 3 kW_p, at a cost of N$ 60 000, including a direct-to-alternating current inverter with a peak supply of 2.5 kVA, and installation and mounting on the mill's roof.

The capital and annual operating costs (abbreviated capex and opex respectively) for the diesel-powered generator are shown below.



A comparison of the cumulative capital plus operating cost of the two power generating options shows that the solar plant is less expensive after some 3 years, which is the result of ongoing diesel and maintenance costs, which are assumed to escalate at 6% per year.



6.5 Solar Thermal Technologies in Commerce and Industry

Solar thermal systems are ideally suited to provide low- and medium-temperature heat for commercial, manufacturing and industry applications. Presently, most operators requiring such heating systems still utilise electric boilers, installed at a time when electricity tariffs were cheap and load shedding and insufficient electricity supplies were largely unknown.

In 2015, the playing field has changed, and grid-supplied electricity prices are set to continue rising each year, while at the same time, technology costs for solar thermal applications are competitive, and in some cases, are declining. While upfront capital costs and siting requirements are sometimes cited as barriers, commercial interest rates remain below the annual electricity price escalations. There is no doubt that an era of greater penetration and use of solar thermal technologies has arrived, and that these offer numerous opportunities for commercial entities requiring plentiful low- and medium-temperature hot water and/or heat, as illustrated in Case Study 16.

As yet, solar thermal systems are not produced in Namibia, and contractors rely on imported systems. While this section focuses on commercial and industrial applications, it suffices to emphasise that policy has ignored the potentially significant contribution that the large-scale roll-out of locally manufactured solar thermal systems can have. Only recently has the Namibian Energy Institute embarked on the development of a solar thermal vision for the country, which is hopefully going to lead to a changed mind-set and perception of the value of solar thermal technologies in the country.

Commerce and industry has fortunately not waited for Government, and is beginning to embrace solar thermal systems and their applications, albeit not yet at a scale that begins to turn heads. Local manufacturing opportunities could be unlocked if there would be a concerted program to deliberately roll out such systems. Opportunities, such as NamPower's envisaged 20 000 electric to solar water heater replacement program have seemingly not triggered an entrepreneurial appetite to create local production facilities, despite an evident local demand for such systems.

Of note is the Government's mass housing programme, which would offer long-term opportunities for local low-cost solar water heater manufacturing. Unfortunately, such a development seems to have been missed in the programme's overall approach to planning, and it remains uncertain if and how the programme's building stock will be pro-

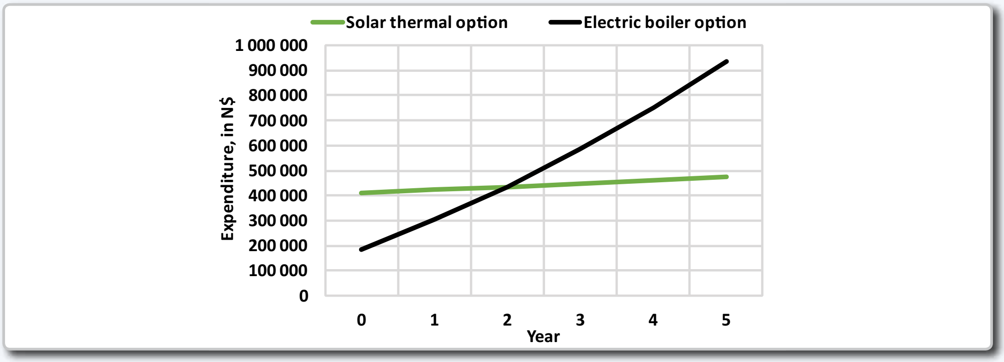
Case Study 16: REEE-powering a guest house [37]

This case study introduces a guest house requiring some 3 500 litres of hot water at 55°C every day, which is supplied by two separate electric boilers. Each boiler is close to the end of its useful life. The manager is uncertain whether to replace the boilers, or invest in a solar thermal plant, and has received the following all-inclusive quotations for these two options:

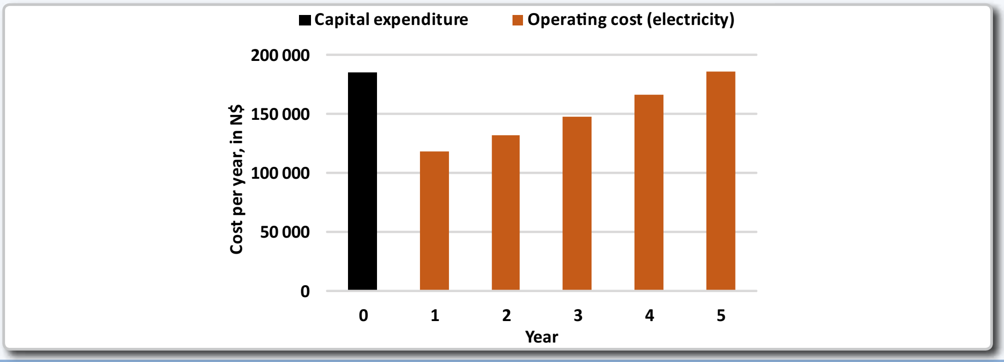
a. Two industrial boilers, each of 2 000 litre capacity, equipped with electric elements rated at 15 kW each, at an all-inclusive price of N$ 185 000;
b. A solar thermal plant with two storage tanks, each of 2 000 litre capacity, with a solar field that has been dimensioned to ensure that 3 500 litres of water can be provided each day, costing N$ 412 500, and requiring maintenance equivalent to some 2.5% of the total capital cost each year.

The establishment is located in Keetmanshoop, and has a 60 Ampere three phase connection, with a flat-rate electricity tariff of N$ 1.83/kWh and a service charge of N$ 1 310, both excluding value added tax. Tariff escalations of 12% per year are expected in the coming five years, while maintenance and service charges will likely escalate at 6% per year.

The total cumulative costs of the two options are shown below, including capital, operating and maintenance costs. Total costs are the same in year 2, where after the solar thermal option is less costly than the comparable electric boiler option.



Operating costs incurred by the electric boiler system escalate at 12% per year. In year 5, operational expenses are the same as the original capital cost.



vided with hot water facilities. Without the deliberate inclusion of solar thermal systems, the beneficiaries of the programme will likely rely on grid electricity for water heating. Such additional use has not been factored into Namibia's electricity demand projections in any meaningful way. Here, low-cost locally manufactured solar water heaters can be a solution.

In Namibia, a multi-pronged deployment strategy for solar thermal systems for low-income domestic end-users, those for medium-to-high income domestic users as well as commercial and industrial applications seems most sensible, and could result in products that meet the low- and medium-temperature requirements of specific end-user groups. Such endeavours would necessitate niche-specific financing: a low-income mass housing client may benefit most if a solar thermal product is an integral part of the overall monthly repayment fee paid for the dwelling. Commercial and industrial users on the other hand may have less specific finance requirements, for example targeting only solar thermal technologies. These could be readily folded into existing finance arrangements offered through local commercial banks.

The SME group of commercial and industrial operators may offer a market to solar thermal suppliers, which in many ways resembles the medium-income domestic market. While this particular group of end-users may still use the services of electric water heaters, their barriers to change are low, especially when offered a technology-plus-finance package that results in immediate financial savings. Many SME operators who rely on electric systems for the production of hot water and/or heat will find that existing technologies, when combined with over-the-counter financial loan packages offered by most commercial banks, result in immediate cost savings, which translate into reduced operating costs, as illustrated in Case Study 17.

Today, most mid-sized solar thermal devices are mature technologies, requiring no or very little additional local adaptation before they can be deployed and put to use. This places the onus for a greater uptake of solar thermal technologies on four core areas, namely policy, technology, funding and local market demand. In Namibia, policy is yet to recognise solar thermal applications and their potential value to the economy. On the other hand, additional technology suppliers have entered the local market, albeit with all-imported equipment. Maybe these players can infuse some competitiveness and thereby help the sector mature.

Had policy been in place, the solar thermal value potential could have been unlocked before. The banking fraternity too has been slow

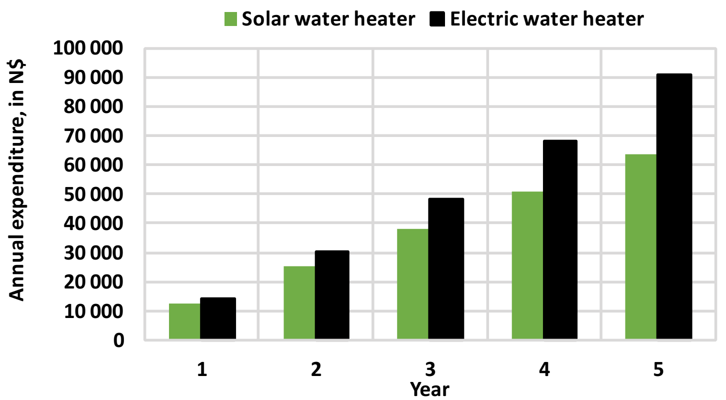
Case Study 17: REEE-powering a T-shirt print shop [37]

A T-shirt print shop in Swakopmund uses some 400 litres of hot water on 220 days per year to wash the daily print-run of shirts and trousers prior to preparing these for sale. Currently, an electric water heater is used to supply hot water, and uses some 21 kWh of electricity when in full production, and some 3 kWh on all other days. The SME takes electricity supply from Erongo RED, and is on a pre-paid business tariff, paying an all-inclusive price of N$ 2.47/kWh in 2014/15.

Although the hot water system is still considered new, and is expected to provide services for at least another three years, the SME owner considers replacing it with a solar water heater, which would cost N$ 51 000 and is guaranteed for 10 years.

A commercial bank operating in the town has suggested that the owner includes the upfront cost in an existing bank loan, which attracts an interest rate of 9% per year, which is repayable monthly over 5 years. Because the print-shop relies on seasonal sales to tourists, the owner is only willing to invest in technology if it results in an immediate improvement of her operational cash-flow position.

Based on the above information, the owner currently pays some N$ 14 269 per year for electricity used by the electric water heater. When the electric water system is replaced by a solar water heater, and based on 12 monthly repayments, the SME operator would save some N$ 1 565 per year, as a result of the total annual expenditure of N$ 12 704, including interest and capital.



The above implies that the solar water heater option incurs annual expenses which are below those required to operate the electric water heater, despite the considerable capital investment that is required to switch technologies.

This case study illustrates that REEE-powering significantly depends on suitable financial arrangements. In the present case, a loan that is re-paid over 60 months ensures that the average monthly expenditure incurred by the SME owner is less than the operating expenditure incurred by using an electric water heater, while allowing the owner to switch to a product with a 10-year guarantee.

to recognise the value of technologies that lead to electricity demand reductions and therefore immediate cost savings for end-users. On a more positive note however, local market demand has significantly recognised the beneficial characteristics of solar thermal applications – which is not that difficult to understand considering that solar energy is one of Namibia's prime commodities! All in all, very significant scope exists for the increased uptake, use and adoption of solar thermal systems exist in Namibia, not only in the domestic sector, but specifically too in the commercial, manufacturing and industrial sectors, wherever reliable and competitively-priced heat and hot water services are required.

6.6 Solar PV in Commerce and Industry

Electricity is a high-value form of energy, and drives many of the core processes in commerce and industry. Indeed, modern life without the benefits of readily accessible electrical energy is hard to imagine.

There is no doubt that the demand for electrical energy, including in Namibia's commercial, manufacturing and industrial sectors, will increase further in future. At the same time, efficiency improvements of electrical motors render them increasingly more cost competitive when compared to machinery that is powered by fossil fuels. As such, the continued electrification of production processes is a fact, and happens both in areas which have enjoyed access to electricity as well as in rural areas where such access cannot yet be taken for granted.

Figure 39:
REEE-powering trade at the Mega Centre, Windhoek [57]

Switching from fossil fuels to electricity has mainly taken place as a result of better access and availability to electrical energy, even if in the form of a mobile generating unit, and the steadily decreasing capital and operational costs of electrically-powered machinery. Today, as a

Case Study 18: Comparing grid feed-in versus self-consumption [37]

This case study compares the benefits of grid in-feeding versus self-consumption, both in Windhoek, and in Omaruru, comparing two solar PV plants which are assumed to provide the exact same amount of electrical energy per year. It is assumed that 6 000 kWh/year is fed into the grid, which is again drawn from the grid when the PV plant does not generate electricity, i.e. in the early morning hours and throughout the night.

The City of Windhoek does not yet follow the net metering rules put forward by the Electricity Control Board. Electricity at Omaruru is distributed and supplied by Erongo RED, who have a grid feed-in tariff.

For a Windhoek business using a conventional credit meter that is capable of turning both forward and backwards, the 6 000 kWh that are fed into the grid are fully 'credited' and remain available free of charge for consumption at and when required. Using such an electricity meter, the consumer ends up only paying the monthly connection fee as is charged by the municipality.

For a credit-metered Windhoek business where only net draws from the grid are recorded, the 6 000 kWh grid in-feed are not registered and therefore not credited. Such an end-user pays for a net annual draw of 6 000 kWh from the grid, plus the monthly connection fee.

A business at Omaruru pays 1.58/kWh for electricity drawn from the grid, and receives N$ 1.08/kWh for electrical energy fed into the grid. For feeding 6 000 kWh of electrical energy into the grid, the utility pays 6 000 kWh * 1.08 N$/kWh = N$ 6 480. For the draw of 6 000 kWh from the grid, the consumer pays the utility 6 000 kWh * 1.58 N$/kWh = N$ 9 540. So, although 600 kWh of surplus energy was credited to the consumer, and 600 kWh of electrical energy was drawn from the grid, the consumer ends up paying the utility N$ 9 540 minus the electricity fed into the grid, i.e. N$ 6 480, plus the monthly connection fees.

Which business is best off, and which one is worst off?

The Windhoek business that uses the grid as a free electricity storage unit, i.e. having electricity metered by way of a forward and backwards turning credit meter, is best off, as the total electricity draw from the grid can be off-set by what is generated using the solar PV installation. In this context it is important to note that the use of the grid as a 'free battery' is considered undesirable. This is because the use of the grid implies that adequate grid infrastructure has to be in place, which has to be paid for. Such payments are necessary, and most equitable when shared by all who make use of the grid, in proportion to their individual use.

On second place is the Omaruru business that benefits from a feed-in tariff, even if it does not fully cover the expenses incurred for electricity drawn from the grid.

Worst off is the Windhoek business that receives no credit nor remuneration for any electrical energy that is fed into the grid.

result of a greater focus on the environmental repercussions of using fossil fuels, and the associated focus on climate- and health-related matters, the increasing use of electricity as the energy form of choice in both commerce and industry seems to be a trend that is unlikely to be reversed any time soon. Indeed, the international electricity demand from industry alone is projected to grow from some 24 EJ in 2015 to at least 26 EJ by 2030 [48].

In view of the expected increase of the electricity demand of commercial and industrial operations, how can this benefit from solar photovoltaics? And, what are the benefits of using solar photovoltaic generation technologies?

Switching from grid-based electricity to solar photovoltaic generation brings about several important benefits:

1. Commercial operators increasingly recognise the financial benefits of locking in the price of electricity for the coming 25 years. This creates operational certainty which is important in a part of the world where electricity prices have escalated dramatically in the past decade, and where tariffs increases at above-inflation growth rates are considered likely for years to come.

2. Possibly the most important aspect in Namibia's near future is the question of the security of energy supply. As the local and regional electricity capacity is insufficient to ensure that the Namibian economy can be adequately provided with electrical energy, supply interruptions as they nowadays occur with great regularity in South Africa may become more frequent in Namibia too. Such power interruptions are extremely costly, and commerce and industry is becoming increasingly aware of the benefits of owning some generation plant, even if it does not cover the entire demand. Here, decentralised renewable energy generation plant, and specifically solar photovoltaic generation, is a prime candidate that can cost-effectively contribute to the energy requirements of commerce and industry. Given the Electricity Control Board's net metering proposal, the decision to invest in one's own generation plant may become even easier, although it is noted that the economics are already stacked in favour of optimising one's self-consumption of electricity generated on site, as is further illustrated in Case Study 18.

3. Commerce and industry is sensitive to consumer demands, such as may include whether goods and services are produced in a way that minimises negative environmental impacts. Indeed, while Namibian enterprises may not yet feel consumer demand for low-

carbon goods and services, service provision benefitting from clean energy use is certainly becoming a part of the arsenal that marketers use, apparently with success.

4. And while many lament the fact that electricity tariffs continue to increase year after year, the cost of unserved electricity is often a factor ten or more higher than grid electricity costs. This is an important consideration, and often justifies investments in backup power systems, or stand-alone solar PV systems. As the cost of electric storage technologies decreases, solar PV systems coupled to local battery systems are bound to become more commonplace in commerce and industry, even if such systems are not yet financially viable when compared to being able to use grid electricity.

6.7 REEE-powering Mining

Namibia's mining sector is a significant contributor to the country's economy, with direct contributions of some 13% to the country's gross domestic product in 2014, and 12.6% in 2013 [58]. In addition, the mining sector creates both direct and indirect jobs, and the Chamber of Mines reports that its members *'directly employed 7 903 permanent employees, 947 temporary employees and 8 920 contractors'* at the end of 2014, and paying almost N$3.5 billion in wages and salaries in that year [58].

The mining sector is a significant user of energy, water and other resources, and accounts for close to one-third of the national electricity load alone [59]. As additional multi-billion dollar investments are made in local mining, the sector's consumptive requirements are set to continue to increase, thereby significantly contributing to the constraints faced by the country's electricity and water sectors [60].

Traditionally, mining has been the most energy-intensive actor in Namibia's commercial and industrial landscape. In the absence of major industrialisation efforts, this will remain the case for the foreseeable future. As such, energy is a critical operational requirement in mining, and implies that the sector is exposed to additional risks if regional and local electricity constraints are not effectively addressed. In an operating requirement that is substantially characterised by the volatility of international commodity prices, rapidly increasing energy prices in general and electricity prices in particular have a negative effect on operating margins.

In Namibia, the fact that our finite energy supplies have to be shared in one or another way by end-users has up to now received little attention. Energy planning in particular has not considered how the productive use of energy can contribute to economic growth. This is surprising, as the contribution of a unit of energy consumed in the mining sector makes a substantially greater contribution to the economy than energy used for mere consumptive purposes. And, while a domestic electricity end-user may dislike having to endure a load shedding episode, such instances create immediate and long-term losses if they are suffered in the productive sector of the country, including in the mining sector.

Today, while miners in particular consider investing in their own electricity generating plant to be able to continue operations in case of load shedding taking a toll on production, there is a marked shift in thinking about the type of capacity that is best to be employed. Indeed, as the costs for renewable energy generating technologies continue to decrease, the investment rationale for such technologies have never been better, especially when compared fossil-fuelled systems. When a specific renewable energy systems makes economic sense, they also almost always reduce the operational footprint of a mine, which is a desirable outcome when measured in terms of economic, social and environmental outcomes.

The deliberate REEE-powering of mining operations can have a multitude of benefits:

1. Of primary importance to continuous operations is the question of the security of supply. Investments in own generating capacity reduce the dependence of grid supplies, which is therefore an important consideration in a supply-constrained context.

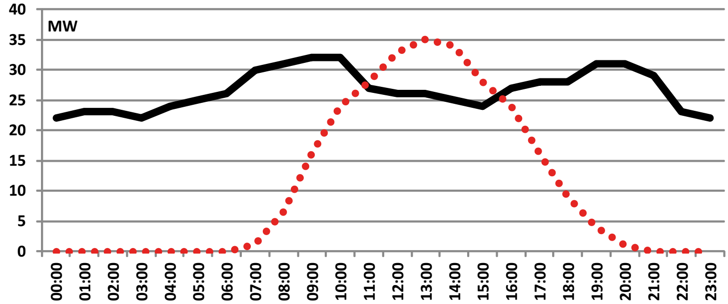
2. When year-to-year production costs can be capped through an investment in a RE supply, the price volatility inherent in traditional energy supplies is removed. It is most advantageous to lock in electricity prices for the long haul.

3. As product stewardship considerations become more important to consumers, investments that actively reduce the environmental impacts of an operation begin to be monetised, and add to a miner's sustainability and social license credentials.

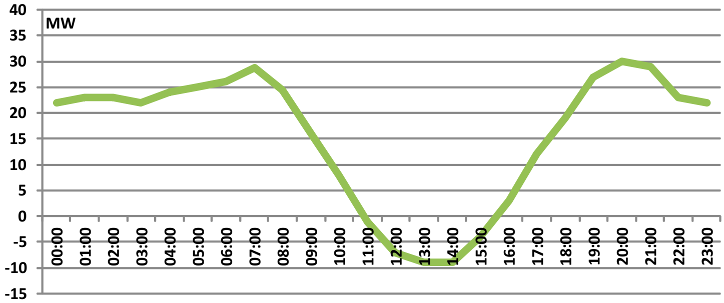
It is important to note that REEE-powering a mining operation does not automatically address all energy-related challenges of such an operation. Typically, mining load curves are relatively flat throughout the day, as a result of near-continuous operational requirements. The use of variable renewable energy generators therefore requires the introduction of additional control measures, to avoid creating new peak de-

Case Study 19: Solar photovoltaic generation in mining operations [64]

This case study describes a mining operation with an average daily demand of some 26.5 MW, peaking at 32 MW, and with a minimum load of 22 MW. Currently, the electrical engineering department investigates the costs and benefits of adding a grid-connected solar photovoltaic plant of 37 MW_p. The graph below shows the mine's load curve, as a black line, while the envisaged solar PV generation profile is shown as the dotted curve, in red.



The addition of a solar PV generator would reduce the demand from the national grid and result in a new average daily load curve, as is shown below.



The costs associated with such an investment include the capital costs for the generating plant and associated network integration and switchgear, the costs associated with the preparation of the land area on which the plant will be located, and the construction, erection and commissioning costs. Some ongoing operating costs will be required too, including for equipment services and panel cleaning.

Like most large power users the mine is on a time-of-use tariff, which implies that the cost per unit of electricity from the grid is time-dependant, and distinguishes between peak, standard and off-peak tariffs, in addition to a maximum demand charge. It is also noted that the mine would become a net supplier of electrical energy, in the period between 11:00 and 16:00, which necessitates a power purchase agreement with feed-in tariffs. The viability of the above investment depends on how the costs are to be financed, the development of future electricity tariffs, and tax considerations, and require a detailed analysis.

mand periods which are expensive to meet and may not be provided for by either the grid or the new RE generators. On the other hand, as is conceptually illustrated in Case Study 19, there may be considerable case-specific advantages when having available a local generating source that removes a sizeable chunk of a typical day's demand from the network.

Today, as an increasing number of actual field cases demonstrates, renewable energy technologies, with and without storage, make inroads in large commercial enterprises, including in the mining sector. Dismissive attitudes, citing yesteryear's arguments against the role of RE and EE in mining, are making way for innovative finance and technology solutions that contribute to power the sector [61], [62], [63].

Of particular importance is the development of large-scale energy storage systems, for better integration and management of intermittent generating sources, such as solar and wind systems, into standard mining operations. While considerable technological advances are made in the field of advanced storage technologies, grid-connected renewable energy system can already make sizeable contributions to reduce energy costs. In addition, investments in energy efficiency and energy management technologies play an increasingly important role in reducing operating costs, while lowering the demand throughout a typical operational cycle. Of note are the many opportunities for remote area operations, as introduced in Case Study 20.

6.8 Conclusions

This chapter provided arguments and case studies to illustrate the significant potentials to REEE-power Namibian commerce and industry. This includes examples showcasing the sector's potentials, ranging from energy efficiency opportunities, to load shifting, to self-generation and fuel switching from fossil to cleaner fuels.

The chapter highlighted some of the very many cases where contemporary energy efficient equipment, and/or renewable energy generation technologies, can readily displace yesteryear's technologies, and in this way contribute to reduce the environmental impacts that are brought about by using fossil fuels. And save costs.

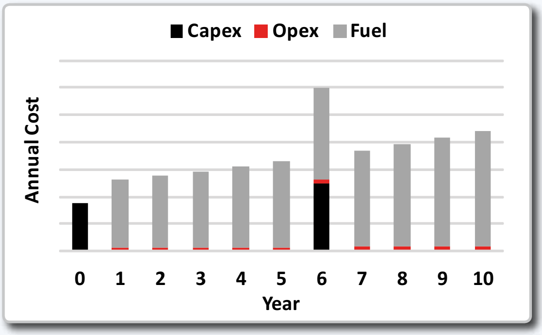
It was argued that the deliberate inclusion of energy efficiency and renewable energy targets can contribute to the marketing of Namibian goods and services, over and above the actual social, economic and environmental benefits associated with the use of energy efficient technologies and contemporary renewable energy plant. No doubt, Na-

Case Study 20: Select REEE-powering options for an off-grid mine [64]

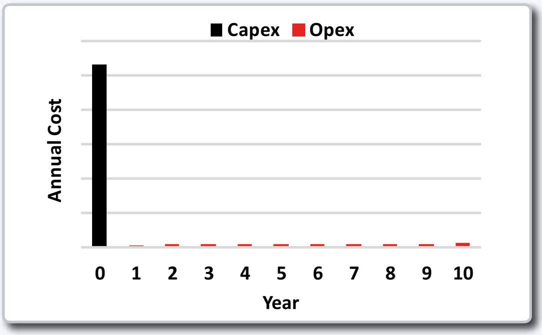
This case study describes a mine that will be operating in a remote location in which grid access is and remains unavailable in the coming decade. Three supply options are considered:

- Option 1: acquiring and operating diesel-powered generators;
- Option 2: acquiring and operating a solar photovoltaic plant with storage;
- Option 3: having the electrical energy requirements provided by a third-party supplier who builds, owns and operates (BOO) a solar PV-plus-storage plant.

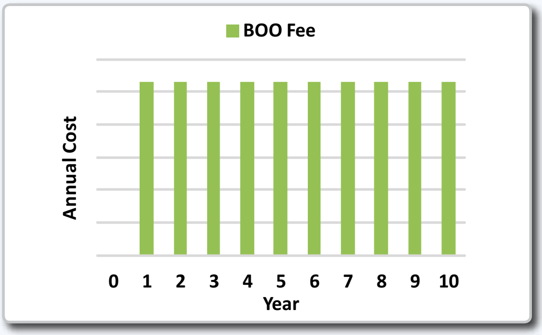
Option 1 includes capital cost (capex), operating cost (opex) and fuel costs:



Option 2 necessitates significant upfront costs to cover the capital required for the solar PV-plus-storage system, with minor operating expenses and no fuel costs:



Option 3 implies a constant BOO fee throughout the service period, or an inflation-linked annual fee. Predictable annual energy costs are most advantageous. However, outsourcing the electricity supply may be considered too risky, and may not offer the tax advantages of other investments in equipment. Such issues therefore necessitate further investigation.



mibia's commercial and industrial standing would improve if goods and services are deliberately produced using clean and sustainable energy sources, which optimise the country's many natural endowments, and create local sustainable jobs.

This chapter ends by focusing attention on a handful of actions that may accelerate the transition towards the REEE-powering of the commercial and industrial sector:

1. While most Namibian REEE-powering activities have taken place despite the support of specific policies, a fully-fledged uptake of RE and EE necessitates dedicated policies. Namibia's current policy environment does not recognise the systemic benefits arising from a REEE-powered Namibia, and offers few tangible incentives for those wishing to embark on such investments. Policy is about intent, and it is the Government's intent in regard to RE and EE that needs to be spelt out in greater detail.

2. Liquid fuels as used for logistics and transport constitute the single most important use of energy in the Namibian commerce and industry sectors. The country remains fully dependant on liquid fuel imports, and its economy therefore continue to witness an almost continuous outflow of funds to pay for such fuels. There is no indication that policy intends to address this perpetual dependency, which also implies that valuable hard currencies will continue to be spent on these commodities for a long time to come.

3. Rapidly increasing electricity tariffs are the primary driver that leads commerce and industry to invest in more energy efficient processes and technologies. In view of the continued escalation of electricity prices throughout southern Africa, the use of energy efficient appliances will become part of most processes, by necessity.

4. Most renewable energy technologies have dramatically improved their cost competitiveness in the past years. In Namibia, this is readily witnessed in the case of solar PV and wind technologies, and to a lesser degree in biomass generation, which have all benefitted from the rapidly increasing scale of international manufacturing and their brisk uptake throughout the world.

5. In Namibia, the use of local biomass resources in commerce and industry is less than what it could be. This is likely to change, as biomass fuel offers excellent benefits when used to generate process heat, to power electricity plant, and as feedstock for materials production. However, the commercial availability of local biomass

feedstock remains limited, and necessitates the development of a proper local supply network.

6. There is a significant potential for the introduction and use of solar thermal equipment and related technologies, including heat pumps. Their cost-competitiveness as sources of low-temperature heat has been firmly established in Namibia, and most such technology is considered mature.

7. On the way towards industrialisation, Namibia seems to overlook the opportunities offered by our excellent local resource endowments. In particular, in creating a manufacturing base, products that have a local and regional use, such as for example solar water heaters, ought to be supported as these are low-technology entry opportunities where local manufacturing capacity can be honed, and jobs be created.

8. Accessible and affordable funding is the lifeblood of investments in commerce and industry. While commercial banks offer a range of traditional loan services, and while a variety of specialist commercial lenders make available tailored financial products, the local finance sector has not yet fully grasped the potential scale and scope of investments that are required to REEE-power commerce and industry. This is viewed as an impediment that is anchored largely in yesteryear's notions and prejudices about what renewable energy and energy efficiency costs, and what their benefits are.

Here, awareness is the key, and can in time change perceptions of risks and investment opportunities. It will probably remain the responsibility of those that seek funding to change the mind-set of local lenders. This can be supported by deliberately showcasing the value that REEE-powering has on the bottom line of businesses, including in Namibia's commercial and industrial sectors.

7 REEE-Powering Namibia's Electricity Distributors

7.1 Introduction

The future of Namibian electricity distributors is uncertain. The viability of current distribution businesses rests on regulatory provisions and protection, and is underpinned by an increasingly outdated approach to service provision. While a considerable number of potential end-users exist that are not served by the grid, those that are connected to the grid have more choices to reduce their demand and meet their own energy requirements than ever before. This exposes the electricity distribution business to innovative and affordable end-user technologies that are bound to change the way in which they are operating. For now, it remains uncertain where the journey will ultimately go to.

Potential pathways into the future include the following:

a. *The road of steady decline*, whereby distributors become overwhelmed by having to provide services to a rapidly increasing group of customers with low or very low consumption patterns while at the same time seeing high-value clients reduce their demand, or in some cases, defect from the grid.

b. *A business-as-usual road*, whereby distribution entities continue to supply electrical energy to end-users, if and when available, but do not take pro-active steps to meet the challenges of the future. Such challenges include the rising cost of grid-supplied electricity and questions in regard to the security of grid supplies. At the same time, rapid rural-to-urban migration leads to an increasing number of unserved end-users in urban areas, as can be seen across Namibia today. Rapid urbanisation requires investments in additional infrastructure, while the expansion of services necessitate greater maintenance and more rapid grid modernisation. All this incurs additional costs. Increased expenses for grid infrastructure however lead to increasing tariffs, which are already escalating at or near double-digit rates every year, which prices electricity out of reach of low-income off-takers, and incentivises high-end customers to take action.

c. *The road of enhanced value-added service provision*, which would see distributors change their approach of being mere suppliers of electricity, to become energy-related service providers and facilitators. Such future services may include generating electricity, or taking supplies from local generators. Other energy-related services may focus on providing energy efficient technologies to end-users.

New services are likely to lead to a shift in the focus of distributors, from supplying electrical energy which is sourced centrally, to supplying grid connectivity services that optimise local generation, include utility-scale storage and facilitate trading opportunities between grid customers, while offering cost-competitive electricity to consumers.

7.2 Positioning Distributors for the Future

Which of the above scenarios is likely to best describe the future of Namibia's electricity distribution industry? We do not know. However, in order to reflect on the possible future that Namibian distribution entities face it is useful to identify those forces and reactions that will most likely shape the future of the sector as a whole.

Systemic sector-wide forces of change are likely to include

1. escalating end-user electricity prices;
2. an increasing number of choices that high-end consumers have in regard to when and how much electricity they will likely require at any particular moment in time;
3. ever-increasing opportunities to reduce the consumption of grid-supplied electricity, or even defect from the grid;
4. a significant increase of the number of small-scale grid users, who may only occasionally make use of grid services, while at the same time necessitating considerable grid extensions and therefore costly infrastructure investments; and
5. a steady decline of the consumption patterns of high-end grid users in particular, as a result of measures taken to complement or augment their grid-supplied electricity requirements.

Figure 40:
REEE-powering Spar Supermarket's retail space in Swakopmund [65]

In view of the forces and factors that Namibian distribution entities are likely to face in future we ask how these entities can best position themselves to meet such challenges. The next sections focus on the current utility business model, and how this could be reshaped to better meet the challenges of the future.

7.3 The Business Model of Today's Electricity Distributor

Today, as a result of the regulation of the Namibian electricity distribution sector, entities responsible for the distribution and supply of electricity to end-users are able to recover the costs associated with such services, while earning a regulated return on the assets they apply to distribute electricity. Distributors have one function, and that is to supply electricity using the distribution grid. They provide grid services.

Figure 41 depicts the traditional business relationship between a distributor and its end-users. It shows a simple two-way relationship, in which the distributor provides the infrastructure to enable the supply of electrical energy to end-users, while end-users pay for the electricity consumed and the use of distributor's assets. This business relationship implies that the commodity "electrical energy" is exchanged for regular payments, either in form of a monthly post-use invoice, or as a pre-payment for a certain amount of electrical energy that will be consumed in future.

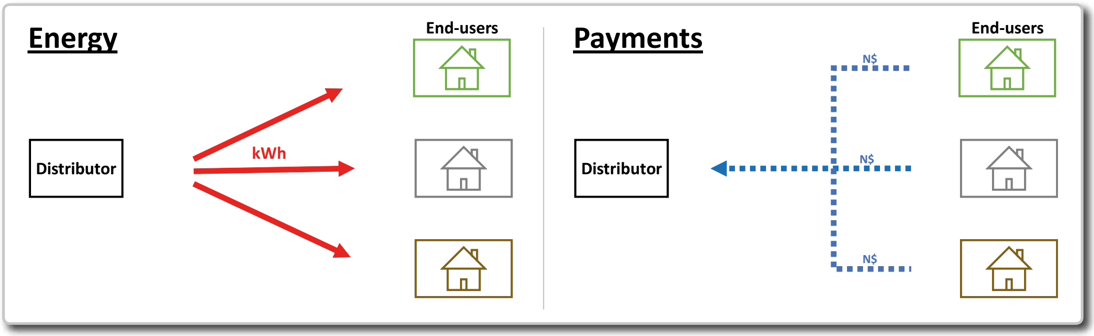


Figure 41: *Traditional relationship between a distributor and its end-users [64]*

In an environment of little technical advancement, and with a steadily growing number of consumers and consumption, this model of a distributor's business seems robust and self-preserving, and would likely be long-lived. However, in reality, neither the context nor the business environment in which distributors operate today will remain unchanged. Indeed, technology advancements will have a profound impact on how, when and how much future electricity consumers will use grid services.

In Namibia, more than one-half of the country's population remain without access to electricity. At the same time, the pace of rural-to-urban migration and urbanisation increases. This exerts pressure on electricity distributors, and requires them to increase the rate at which new end-users are electrified. The increasing number of end-users wishing to benefit from grid electricity stand in contrast to the decline of consumption of high-value clients. Such end-users have begun to invest in their own electricity generating capacity and contemporary energy efficient technologies, to cap their exposure to the steadily rising cost of electricity supplies. This development can potentially develop into a vicious circle for distribution entities, i.e. the so-called utility spiral of death. Namibia's electricity distributors and the business models that underlie their operations are not considered sufficiently robust to cope with these challenges as the above developments undermine the viability of distributor operations to the core.

In the past years, the cost of electrical energy as procured from NamPower has risen dramatically. End-users faced by increasing retail prices have a number of options of how they can best minimise their exposure to tariff escalations: they can, for example, invest in more energy efficient devices and technologies. This is a particularly attractive option for businesses and well-heeled end-users wishing to modernise, while taking advantage of new technologies and the tax advantages associated with such acquisitions. In addition, end-users can invest in their own electricity generation and storage technologies, for example a roof-mounted solar photovoltaic plant, either with or without battery storage. Such options are of particular interest to those that have access to finance and reduce their exposure to possible load shedding events, and/or capitalise on tax advantages, while at the same time reduce their operating costs.

The number and scale at which end-users actively decide for efficiency improvements and a reduction of operating costs associated with their electricity consumption is expected to increase. This phenomenon is driven by an increasing availability of energy efficient technologies and the rapid growth of grid-connected distributed generation facilities.

There is also an increasing general awareness about the environmental impacts of our resource consumption habits. In addition, there is a greater focus on reducing greenhouse gas emissions. And, individuals and businesses become aware that the collective environmental footprint on the resources of the world have to be managed, and are best kept small. Today, the market provides numerous options to address these concerns while offering ways to personalise the way in which we generate and consume electricity. This trend is likely to continue in future, and will further change our individual and collective electricity consumption behaviours.

Already, Namibian distributors begin to experience the impacts that the greater adoption of distributed energy technologies and uptake of energy efficient technologies has on their revenues. It is not clear whether distribution entities have grasped the potentially significant threat that technology advances have on the way that they conduct their day-to-day business. Of particular importance will be the impact of solar photovoltaic generation technologies, coupled with increasingly affordable electrical storage that allow customers to become considerably or completely independent of grid electricity. In addition, the impact that the large-scale uptake of energy efficient technologies and demand side management measures will have on the distribution sector is also considered to be significant. The playing field changes, whether distributors like it, or can cope with it, or not. It is therefore important to ask how the business models of Namibian electricity distributors could be transformed to prepare them for the future, which is covered in the next section.

7.4 Reshaping Business Models

In view of the above factors one could be tempted to assume that distributors will have little choice and can only embark on the *road of steady decline*, as was identified as one of three distinct pathways to the future. While this may well be the fate of some distributors, it does not have to be that way. In fact, it is considered probable that distributors that are pro-actively re-shaping their business models to explicitly take the impacts of new distributed generation and energy efficiency into account will emerge as successful electricity service providers of the future. Such future services are expected to be closely linked to the presence of the distribution grid, and the services that can be provided through and by way of the grid.

Figure 42: *REEE-powering tertiary education at UNAM's Ongwediva campus [66]*

Today, distributors supply electrical energy through the distribution grid. While this aspect may not change very much, it seems likely that distributors of the future will increasingly include other energy-related services in their service bouquets, and in this way, REEE-power their operations.

The following will likely form part of the business models of future distributors:

1. sourcing electrical energy from prosumers and from local generators who feed directly into the distributor's network, for re-distribution, in addition to sourcing electricity from NamPower as is currently done;
2. facilitating services through the distribution grid, such as the transfer of electrical energy between local generators and prosumers;
3. providing support services to end-users, thereby enabling consumers to use the grid to feed in and draw electrical energy while remaining a grid customer;
4. facilitating energy-related services that are demanded by its clients, for example through local service provision partners. Depending on the demand for such services and the specific business cases underpinning such additional services, these may include
   i. providing certified clean energy generated by renewable energy technologies in its area of responsibility;
   ii. offering specific energy efficient technologies, such as energy efficient air conditioners, fridges, pumps and associated control equipment such as power factor correcting equipment, either on a fee-for-service basis or as a direct sale, debited by way of the distributor's monthly invoice;
   iii. providing grid-connected rooftop solar photovoltaic plant;
   iv. offering energy-related services through one-stop shops that offer energy efficient equipment and accessories, as could be operated in partnership with local suppliers, installers and businesses;
   v. facilitating finances to enable clients to purchase select energy-related equipment; and
   vi. offering cost and/or service benefits in exchange for direct access to select loads which are owned and operated by clients, to enable the distributor to remotely manage the client's demand in peak demand periods.

Most services that a REEE-powered distributor of the future will offer will be new, and will quite likely differ substantially from those that are currently offered. Such future service offerings necessitate much closer relationships with clients, which in turn require more sophisticated communications and interactions with clients.

Assuming that distributors see value in embarking on a road of broadened service delivery, the following question is important: how can a distributor extend its service offerings without at the same time undermining its core business, i.e. the supply of electricity?

While it is beyond the scope of the present study to develop individual business cases for each of the above services, a few pointers to how the business models of Namibian distributors could be re-aligned will suffice. In this context it is noted that business practices of most contemporary distributors do not include a personalised focus on how customers can optimally benefit from current services. Symptoms of a lack of service orientation include the generally lacklustre service offerings of distributors that do not seriously take the customer's needs and wants into account. In marketing speak, this is the well-known product view, i.e. a take-it-or-leave-it approach, possibly the result of the protected monopolistic business environment in which distributors operate. The business sphere is characterised by the absence of competition, and a lack of choice. Customers have no option other than to accept the tariffs and service offerings made available by the particular distributor that is operating in a given geographic area.

Figure 43: *REEE-powering retail at WB Supermarket, Independence Avenue [67]*

The REEE-powered future is likely to be very different from the present. From the point of view of distributors, embarking on a *road of enhanced value-added service provision* implies having to supply electricity, as is currently done, in addition to facilitating and/or offering energy-related services, either directly or in close collaboration with service partners. Depending on their individual viability, new services may include buying of electrical energy from its clients, and re-distributing such energy to other clients, providing energy-related technologies, financing and maintenance services. Such service offerings may seem absurd, as they include new and potentially risky activities for which most of the country's distribution utilities are not geared. However, as stated before, the traditional business model of Namibian distribution entities is under threat, and will undergo dramatic changes in the years to come. Yesteryear's revenue models will be undermined and disappear. This calls for new perspectives on how the future can be created.

It is expected that tomorrow's distributor will be energy service provider. It supplies electricity, which is mostly sourced from local generators and its own clients. It also facilitates new service offering to clients, including for access to finance, technology and maintenance. Such new services are likely to be offered by external service providers, who have partnered with the distributor for the delivery of specific services. This is a synergetic business arrangement in which the distributor leverages its key competitive advantage, i.e. a grid that serves an established client base, while service partners provide new energy-related services in their field of expertise and reach.

In contrast to the traditional relationship between a distributor and its end-users, refer to Figure 41, the future will likely see the establishment of a multi-layered set of relationships between the distributor, its clients and various service partners, as shown in Figure 44.

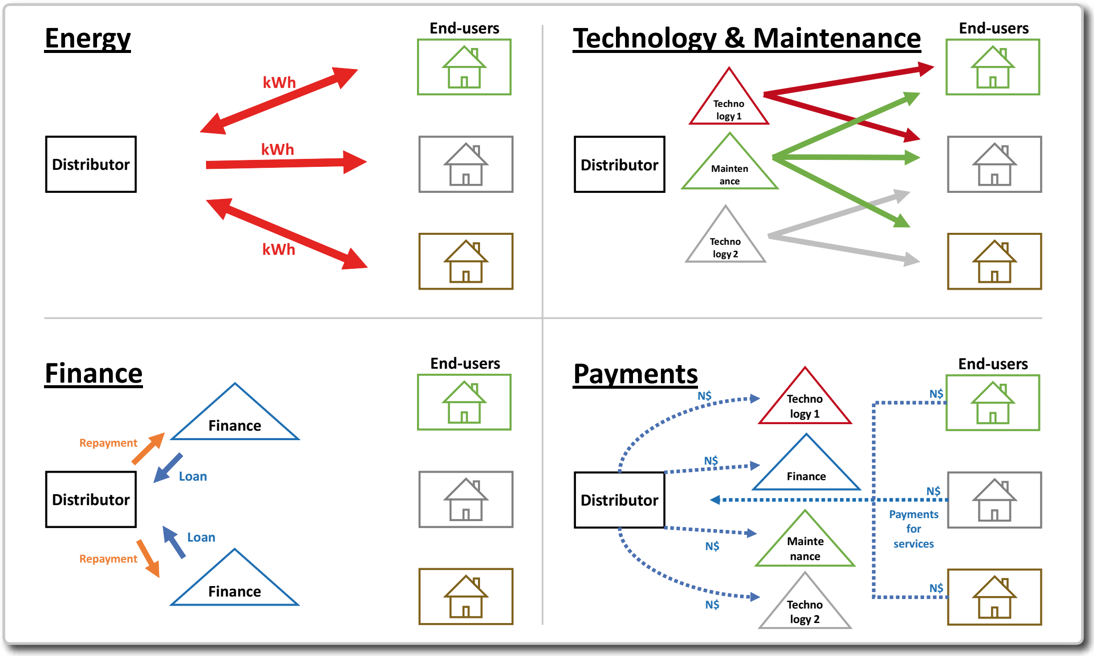


Figure 44:
REEE-powered relationships between distributor, service providers and end-users [64]

The conceptual model depicted in Figure 44 shows the REEE-powered distributor of the future: here, the utility no longer merely provides energy in the form of kWh to its end-users, but also receives such energy for further distribution from those clients who operate distributed generation plant at their premises. The distributor also takes supply from local generators, such as Independent Power Producers. In addition, various service partners are drawn in to become active participants within the same business space that has originally only included the distributor and its clients. Such service partners provide energy-related services, facilitated through the distributor. This allows the REEE-powered distributor to leverage the established business relationships with its clients, while ensuring that value-added energy-related products and services become more readily accessible to its clients.

The REEE-powering message for distributors is simple: maximise grid opportunities and develop service offerings that dis-incentivise clients to defect from the grid. In this way, the REEE-powered business model includes a much broader service offering than was traditionally available, and now includes an intentionally broadened range of energy-related services. These are made available in partnership with suppliers, when viable, and offer energy-related services meeting its clients' changing needs.

Case Study 21: Costs and benefits of a specific energy service bundle [64]

This case study reflects on the typical costs and benefits of a bundle of energy efficiency services that may be offered by a REEE-powered distributor and its service partners.

This case study assumes that the distributor offers a so-called energy efficiency bundle. Energy-related services including energy efficiency bundles are delivered by external service provision partners, and usually commence with a high-level energy audit at the client's premises. The audit identifies the client's current energy use patterns, the energy-related service needs and wants, and the savings potentials when opting for specific energy efficient appliances.

The specific end-user considered in this case is a prepaid metered client who incurs average monthly electricity expenses of N$ 738 as a result of the consumption of 450 kWh. The energy audit identifies three main electrical loads that could be reduced if new technologies were to be used, including an electric water heater, electric lights and a fridge, which account for 158 kWh, 90 kWh and 45 kWh of electricity use per month respectively.

The audit recommends that the loads identified above are replaced with modern energy efficient solutions, which would result in savings of some 241 kWh per month. Such savings would be achieved by replacing the electric water heater with a solar water heater (SWH), replacing inefficient lights with modern light emitting diode (LED) lamps, and replacing the inefficient fridge with a modern energy efficient fridge.

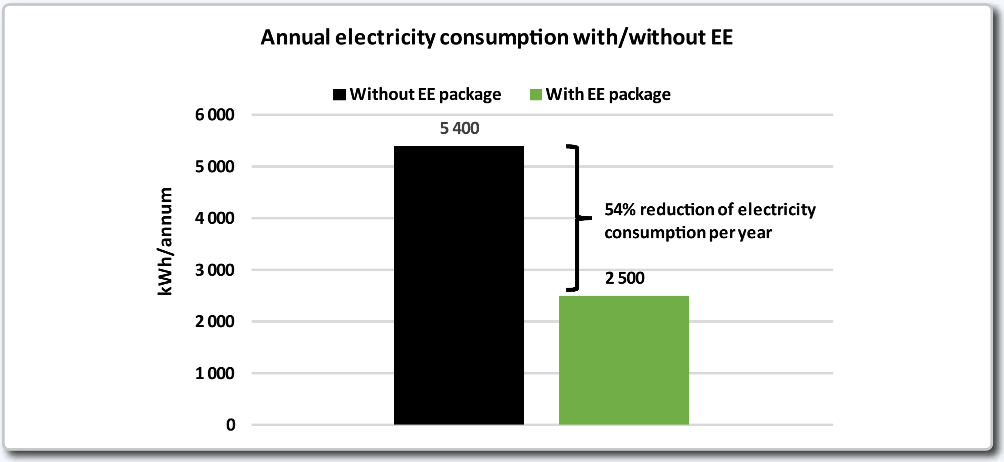
The distributor, through its service partners, offer the following package: an energy efficiency service bundle including a modern SWH, LEDs and fridge, valued at N$ 17 000, N$ 1 200 and N$ 7 000 respectively. The offer is financed in a way that leads to client savings of more than N$ 20 000 over a period of 8 years, which is the re-payment period that is offered. The offer would also imply that the total electricity bill in year 1 stays the same, irrespective of whether or not the client decides in favour of acquiring the EE bundle or continues as is.

For the end-user, the offer implies that future electricity expenses are capped while having access to new energy efficient appliances plus a net financial gain.

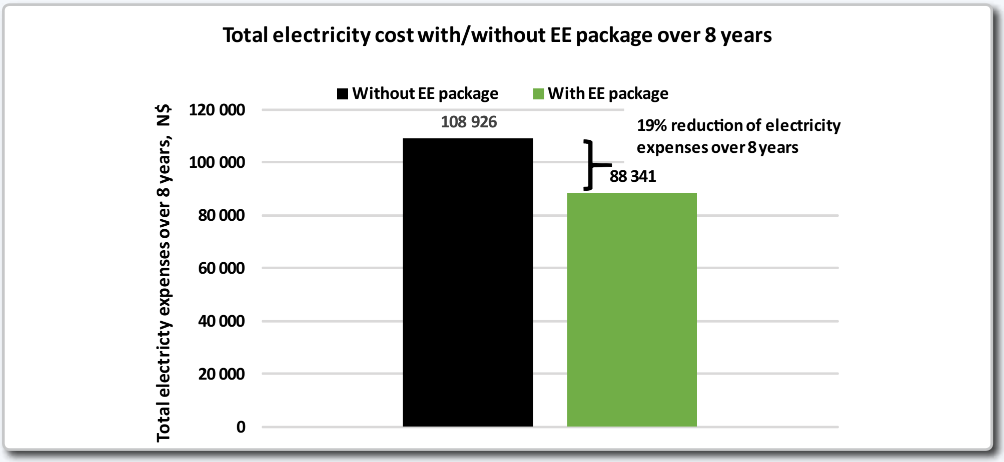
From the perspective of the distributor, offering the energy efficiency bundle implies that the client is likely to reduce electricity consumption by some 23 150 kWh over 8 years, leading to direct revenue losses exceeding N$ 58 000 over 8 years. Such losses however, can be minimised, by a) serving new clients that have previously not used electricity, b) being able to provide more electricity for productive purposes to commercial and industrial clients, at more profitable rates than is the case for domestic clients, and c), by offering a service bundle that locks EE bundle clients into a service agreement for the period in which additional services are provided. This will be further elaborated in Case Study 22, Case Study 23 and Case Study 24: Impact of the uptake of EE service bundles on a distributor .

Case Study 22: Energy efficiency services from the perspective of the end-user [64]

This case study highlights the most important impacts on an end-user who decides to take advantage of the energy efficiency service bundle introduced in the previous case study. These impacts include the significant reduction of electrical energy required as a result of switching to energy efficient appliances, specifically by replacing the electric water heater with a SWH, replacing inefficient lights with modern LEDs, and replacing an inefficient fridge with an energy efficient fridge.



As a direct result of the switch to energy efficient appliances, the end-user will benefit from the reduction of total electricity expenses, as well as the benefit of using modern energy efficient appliances. Other benefits, such as a reduced environmental footprint, are also part of REEE-powering end-users, even if these may not result in immediate benefits that can be monetised by the recipient.



Case Study 23: Energy efficiency services from the perspective of the distributor [64]

This case study considers the perspective of the distributor that offer energy efficiency bundles and similar energy-related services to end-users. As shown in Case Study 21, a distributor that offers the particular EE bundle introduced before experiences revenue losses of some N$ 58 000 over 8 years as a result of the client reducing the electricity consumption by some 23 150 kWh in the same period.

However, the loss of electricity sales to one particular client does not automatically imply a net loss to the distributor. This is because sales reductions in one client segment do not automatically translate into sales reductions in other client segments. In fact, even within the domestic client segment, most Namibian distributors have very substantial numbers of un- and underserved clients.

In addition, as the Namibian economy grows, it is considered likely that new small- and medium enterprises and commercial and industrial clients establish themselves in the distributor's area of responsibility, all of which require electricity supplies. There is as yet no evidence that would indicate that such new clients would opt for being completely self-reliant in regard to their electricity supplies. These consumer groups are therefore a new and additional source of revenues for distributors.

There will also likely be established clients, both small and large, who will increase their grid electricity consumption. Here, an increased use of electricity for productive purposes is considered the most realistic area from which such growth is likely to originate. As Namibia's economy grows, and as the country embarks on greater industrialisation efforts, its electricity use is very likely to continue to increase. And, as long as grid services are provided cost effectively and reliably, the risk of a full-scale grid defection may not be too significant for now. A further source of new revenues for distributors who embark on the provision of energy-related services will be generated through service fees from services provided by the distributor's service partners. Such fees would likely have several components: depending on the specific business model that is applied, such fees could include a percentage of the loan amount that a client signs up for, and/or a percentage of the interest generated through such loans, and/or a percentage of the supplier's mark-up on the appliances included in the bundle, or a combination of the service fees paid by the end-user. Such income would likely allow the distributor to recoup some of the revenue losses associated with the uptake of EE bundles, even though it is considered most unlikely that the total revenue loss from the uptake of EE will be recouped in this way, as is shown in Case Study 24.

Therefore, while pessimists would possibly argue that the reduction of sales to individual clients spells doom for Namibian distributors, this case study argues that the long-term service relationship between distributors and their clients is likely to benefit from additional service offerings offered by utilities, while creating opportunities for new and additional sales as long as these are offered reliably and remain cost-effective when compared to competitor products and services.

Case Study 24: Impact of the uptake of EE service bundles on a distributor [64]

This case study introduces a simple quantitative model to project the impact on distributor revenues when introducing an energy efficiency service bundle as introduced in Case Study 21. The high-level model compares revenue projections derived from sales to domestic customers, assuming a) a business as usual (BAU) future, and b), a future in which EE bundles are offered. The BAU projection assumes that the distributor's customer base grows at 0.5%/a, energy consumption grows at 1.5%/a, and tariffs increase at 10%/a. It is assumed that each EE bundle reduces energy sales by 2 900 kWh/a, and that 1% of all domestic customers take up the bundle every year. The distributor receives 20% of the total upfront value of the bundle in the year of its installation, and bundle prices increase by 6%/a.

The BAU case is illustrated for NORED, which serves ~51 000 domestic customers, contributing some N$ 272 million in 2014/15 [81]:

NORED	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Number of domestic customers [#]	51 000	51 255	51 511	51 769	52 028	52 288	52 549	52 812	53 076
BAU domestic consumption [kWh/a]	169 119 000	171 655 785	174 230 622	176 844 081	179 496 742	182 189 193	184 922 031	187 695 862	190 511 300
BAU revenues [million N$]	272	304	339	379	423	472	527	588	657

Following the introduction of the EE bundle, the projection changes as follows:

NORED	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Energy/Customer/year [kWh/customer/a]	3 349	3 382	3 416	3 450	3 484	3 519	3 554	3 589
Rev/Customer [N$/customer]	5 925	6 582	7 313	8 124	9 025	10 027	11 139	12 375
Number of EE uptakes [#/a]	513	510	507	505	503	500	498	495
Energy reduction - EE bundles [kWh/a]	1 486 395	2 965 358	4 437 001	5 901 433	7 358 765	8 809 106	10 252 563	11 689 243
Total domestic electricity demand [kWh/a]	170 169 390	171 265 264	172 407 081	173 595 309	174 830 428	176 112 925	177 443 299	178 822 057
Revenues from elec sales [million N$]	301.1	333.3	369.1	408.8	452.9	501.8	556.1	616.5
Revenue gain (loss) [million N$]	-2.6	-5.8	-9.5	-13.9	-19.1	-25.1	-32.1	-40.3
Additional income from EE [million N$]	2.7	2.9	3.0	3.2	3.4	3.6	3.8	4.0

As shown, gross revenue losses from electricity sales increase from N$ 2.6 million in 2015/16 to more than N$ 40 million in 2022/23. The sale of EE bundles generates additional income, but revenue losses exceed such additional income. This implies that 1) "doing nothing" erodes a distributor's revenues as technology and finance providers will seize opportunities to offer such products, and 2) additional revenue compensation measures are required.

There are several ways in which additional revenues may be generated: a) sourcing lower-cost electricity, e.g. from those operating their own generating plant and local IPPs, b) increasing tariffs, c) increasing customers, d) increasing sales to other consumer segments, such as the commercial and industrial sectors, and others. For example, by securing access to lower cost generators reduces the distributor's expenses. Revenue loss from the uptake of EE bundles (same assumptions) requires a tariff increase of 0.8%/a to ensure revenue neutrality. The domestic energy reduction as a result of the use of EE bundles requires 440 new "average" domestic consumers each year, which may be difficult as many clients joining the grid may have a below-average energy consumption. New customers in the commercial and large power user segments, and an increase of the energy consumption in these client groups may offer additional revenue options. This implies that a multi-pronged approach is needed whereby the above and other revenue-increasing measures are applied to ensure the continued viability of the business.

7.5 Conclusions

Today, the business environment in which most Namibian electricity distributors operate is strained. This is just the beginning. Increasingly, new electricity end-users with minimal consumption requirements will join the grid. Such clients necessitate additional capital expenses that cannot readily be recovered without increasing electricity prices. These render tariffs even less affordable than they are today.

In addition, in a country that is blessed with solar energy resources, it is considered very likely that well-off electricity users decide to invest in their own power plant, either with or without storage. Some may even decide to leave the grid. At the same time, electricity consumption is reduced by adopting energy efficient appliances and processes. Such developments plus a reduction of the electricity consumption of those end-users who previously constituted the backbone of the distributor's client base herald challenging times for distributors.

However, by deliberately reshaping the business models that underpin Namibia's electricity distribution entities new value propositions can be created for electricity end-users, while shielding utilities from the inevitable changes that new RE, storage and EE technologies create.

The analysis presented in this chapter is conceptual in nature, and requires further in-depth customisation before it is fully applicable to specific distribution entities. It does however indicate that distributors can effectively lower their input costs, by purchasing electricity from competitively priced local generators, including from the distributor's own clients and IPPs. And, by offering innovative energy-related services that provide access to finance and modern energy efficient technologies, distributors shield end-users from rapid tariff increases, while converting savings into benefits from high-efficiency technologies. This is particularly relevant in Namibia where electricity prices have escalated with double-digit growth rates for several years, and have steadily eroded the affordability of electricity for the vast majority of grid-connected electricity consumers.

From the perspective of Namibian electricity distributors, broadening the electricity sourcing options while extending service offerings may be one of the very few strategies to strengthen the revenue base in future. These are likely to come under increasing pressure as highly efficient appliances become affordable, while the rapid uptake of grid-connected solar PV substantially reduce the electricity requirements of select end-users. And while it seems unlikely that substantial numbers of end-users decide to completely defect from the grid, technical progress and the rapid reduction of energy storage prices make such scenarios more likely than at any time in the past. While new service offerings must be carefully crafted to ensure their viability, the very concept of such new service offerings emphasises the central role of the grid and the distributor's advantages in regard to having and maintaining direct access to all grid-connected clients in its area of responsibility.

A cardinal question is how the distributors' income base can be strengthened. Two distinct strategies are discussed: a) sourcing lower-cost electricity, e.g. from clients operating their own generating plant and local IPPs, and b) providing energy-related services in partnership with service partners. When substantiated by a solid business case, these strategies are likely to enhance future revenues, even when the average energy consumption per customer decreases. Central to this realisation is that distributors' have direct access to all electricity users in their areas, which constitutes a strategic advantage that other technology-plus-finance providers do not have.

By leveraging the access to end-users, distributors can re-shape their service offerings, from the traditional sale of electricity, to become providers of energy-related services. Such a transition is not trivial, and necessitates that distributors become market savvy, and operationally efficient. These are not traits that the natural monopoly position in which Namibian electricity distributors find themselves have honed. But they are essential to develop competitive future energy service offerings that stand a chance of securing the longer-term viability of distributors. And it could be the only real chance that distributors have if the energy consumers' appetite for innovation and the pace of technological advancement in the electricity sphere is anything to go by.

Figure 45:
Mr Appolus (CEO, CENORED) and Dr Hopperdietzel (HopSol) following the signing of Namibia's first RE-powered supply contract to a RED, 2 July 2015 [68]

8 REEE-powering Namibia by Independent Power Producers

8.1 Introduction

Namibia's White Paper on Energy Policy of 1998 states that *'... it is the aim of government that 100% of the peak demand and at least 75% of the electric energy demand will be supplied from internal sources by 2010'* [69]. In mid-2015, this aim has still not been achieved. Since the launch of the White Paper in 1998, several ministers have been at the helm of the Ministry of Mines and Energy. They came, and they went, without having the necessary decisions taken to turn policy intent into reality. Some say this shows a lack of leadership, others blame it on procrastination, or the all-pervasive influences of Cabinet. Whichever factors have contributed to Namibia not making headway in securing its energy future, yesteryear's state of play can no longer be perpetuated without there being serious repercussions for the country's future.

In 2010, Namibia's first local power purchase agreement was drawn up and agreed to by NamPower and a newly established independent power producer (IPP). It made all the necessary provisions to feed electricity into NamPower's transmission grid. On 22 September 2010, the 250 kW biomass-powered pilot plant was inaugurated on farm Pierre in north-western Namibia [70]. At the time, common opinion suggested that NamPower would not allow grid in-feeding, and would permanently delay the entry of IPPs. Such opinions were clearly unfounded, as the author and his team experienced a most accommodating national utility team who was willing to negotiate and agree on favourable terms for access and in-feeding to the grid.

Figure 46:
Namibia's first IPP, a biomass-powered pilot plant of 250 kW, farm Pierre [71]

Namibia's first commercial independent power producer – a 4.5 MW_p solar photovoltaic plant – was inaugurated on 13 May 2015, and is owned and operated by the Franco-Namibian company InnoSun Energy Holdings. At the inauguration, NamPower's managing director suggested that *'the 4.5 MW solar power plant is a clear testimony of the fact that IPPs can work in Namibia and NamPower is more than willing to support and enter into power purchase agreements with IPPs'* [72]. The present chapter seeks to describe the most important conditions for creating further opportunities for IPPs, and their role in REEE-powering Namibia and our national development.

Figure 47:
Preparations for InnoSun's Omburu solar power station close to Omaruru [73]

Figure 48:
InnoSun's 4.5 MW_p solar power station at Omburu, Omaruru [74]

8.2 Policy Considerations

The Government of Namibia's energy sector policy is codified in the White Paper on Energy Policy of 1998 [69]. In mid-2015, and although still considered most relevant to developments in the country's energy sector, the White Paper can no longer be considered contemporary, and is in urgent need of revision and an update.

Importantly though, the White Paper explicitly mentions IPPs, by stating that *'for competition in electricity generation and supply, particularly by encouraging independent power producers to enter the market. This will create an enabling environment for both public and private involvement in the electricity supply industry'* [75]. With such specific articulation by policy, why is it that so little progress has been made in attracting additional IPPs, especially considering that Namibia's electricity supply shortfall has been known and spoken about for more than a decade now?

Evidently, the Government's policy of encouraging investment in the country's electricity sector has not been successful. Considering that Namibia's Vision 2030 envisages the country to be *'largely self-sufficient with reliable and competitively priced energy, meeting industry demands, plus some export of energy'* by 2030 [76], much remains to be done.

While the rhetoric on IPPs seems inviting, in practice there is little evidence that Government has any appetite to tangibly incentivise the establishment of IPPs. In particular, there seems to be no attempt to provide specific financial incentives to would-be IPPs, as could for example be achieved by offering equity contributions, or shareholding, or energy tax incentives, or tax breaks, or creating IPP-specific national implementation goals, or IPP generation targets or other such instruments.

8.3 Structural Considerations

NamPower is the country's national utility, and is wholly owned by the Government of Namibia. The utility is the sole owner and operator of the Ruacana, van Eck, Paratus and Anixas power stations that have a combined name-plate generating capacity of some 500 MW (see for example [1]).

As a vertically integrated utility, NamPower is a generation and transmission monopoly, transmitting power to regional electricity distributors (REDs), local authorities (LAs) and other electricity distribution entities as well as large power users such as mines and select industrial clients. Where other distributing and supply entities do not operate, NamPower also provides power to select small-scale consumers and power users.

Increasingly, the Namibian electricity supply industry is moving towards a modified single buyer structure, under which NamPower continues to be the sole buyer of imported electrical energy as well as exporter [77]. It supplies large power users and distributors, while domestic IPPs can sell electricity directly to distributors and the so-called contestable customers, provided that such supply arrangements have been approved by the Electricity Control Board (ECB) [77]. While the modified single buyer industry structure has not been formally adopted, and remains to be fully implemented, NamPower would most likely retain the control over the country's electricity transmission assets under such an arrangement, and also continue to exercise its role as the country's systems operator [78].

The current structural constellation in Namibia's power sector remains tilted towards protecting NamPower. This has had many advantages for Namibia and its electricity end-users, including that the utility has established and maintained an international credit rating that allowed for favourable terms on loan agreements. The entry of IPPs into the country's power sector is not likely to undermine NamPower's credit ratings as long as the utility continues to be protected by Government. The slow pace of entry of IPPs is therefore not a structural impediment, but mostly the result of Government's uncertain intent and lack of specificity in regard to additional actors in the country's power sector.

8.4 Regulatory Considerations

The Electricity Act of 2007 mandates the Electricity Control Board (ECB) as the regulator of the country's electricity sector [79]. The Act implies that the generation, transmission, trading, distribution and supply, as well as all import and export of electricity is allowed once the Minister of the Ministry of Mines and Energy, on recommendation of the ECB, has issued a license for it.

The ECB's main role is to regulate and control the electricity supply industry (ESI) and the country's electricity distribution industry (EDI). This is achieved through licensing and oversight of generation, transmission, distribution and supply activities, as well as electricity imports and exports. The ECB also approves electricity tariffs, and is responsible for the screening, preparation and ultimately the recommendation of ESI and EDI licenses for approval by the Minister of Mines and Energy.

In regard to IPPs, the ECB is tasked with ensuring that the Government's electricity sector policies are implemented. This is supposed to be achieved by, by amongst others, the liaison and promotion of private sector investments in the country's electricity sector.

For the formation of an IPP, a key consideration is the tariff structure at which it is able to sell electricity to an off-taker. In Namibia, electricity tariffs necessitate the approval by the ECB. The regulator has developed a renewable energy feed-in tariff methodology and approach which is to guide the in-feeding of generators that have an electric generation capacity of less than 5 MW, once officially accepted and promulgated. For IPPs with an installed capacity exceeding 5 MW, a feed-in tariff and associated power purchase agreement has to be agreed to with the off-taker, irrespective of whether it is NamPower or a distribution entity. Such a tariff must comply with the ECB's tariff methodology for generation entities, and must be reviewed and approved by the ECB before it becomes operational.

Figure 49:
Mrs Kawana and Dr Hopperdietzel at HopSol's 5 MW_p Otjiwarongo site [80]

Since he country's first electricity tariff methodology was developed in 2001, the aim has been to create a tariff structure that ensures that electricity prices become cost reflective over time. Such cost reflective tariffs include all reasonable costs that arise as a result of the supply of electricity. In 2015, most electricity distributors have succeeded in being at or close to applying cost reflective end-user tariffs. For IPPs, the cost reflective tariff approach would seem to create commercial opportunities. Reality though has shown that tariffs alone are not sufficient to attract IPPs.

The ECB approves tariffs, including any increases which may result from changing operating conditions. As such, IPPs have no formal guarantee that future feed-in tariffs will reasonably meet their changing investment expectations. For international investors who aspire to shield their investments from adverse foreign exchange developments, this regulatory approach may likely not suffice to create investment comfort. When operating in a region that has historically been adversely affected by foreign exchange developments, other securities may well be required. However, it should also be noted that the ECB considers tariff adjustments on an annual basis, which implies that actual operating cost increases are likely to be acceptable as long as they can be considered justifiable.

For IPPs and their ongoing viability is also important to understand how and to what extent Government continues to directly intervene in electricity prices in future. In the past, Government has effectively changed NamPower's electricity bulk tariffs by direct subsidisation payments to the utility. Such financial interventions have likely assisted end-users as they imply that the utility's bulk tariffs can be lowered. Subsidies do however distort the cost reflectivity of tariffs. Direct Government payments to NamPower therefore affect the playing field in which IPPs operate, by for example eroding the incentives that cost reflective tariffs offer to potential third-party power sector participants. In this way, Government subsidies increase the commercial risks that IPPs are facing. In mid-2015 it remains unclear how Government intends to ensure that a proper regulatory control of the electricity sector can be maintained while it undermines existing regulatory provisions through the direct subsidisation of the national utility NamPower.

Of importance for future IPPs is the country's Electricity Bill, which envisages an electricity sector in which commercial power generators can sell to NamPower, or directly to REDs, LAs and large power users [78]. At the time of writing it remains unknown if or when the Bill will be finalised and enacted, and what the final version may eventually in- and exclude.

8.5 Risks and Risk Mitigation by IPPs

In the past, prospective IPP operators lamented that the Government of Namibia did not offer explicit guarantees vis-à-vis changes in the legal, policy, fiscal and regulatory environment. Indeed, a recent analysis pointedly states that *'the most significant risk allocation issue for Namibian IPPs that has yet to be resolved is the allocation of government risks, such as expropriation, nationalisation, war, civil disturbances, sanctions, the imposition of fiscal controls, changes in law,* *delays in consents, etc.'* [82]. It also seems unlikely that NamPower will accept any actual or perceived risks which may result from actions or omissions by the Government, even if the utility continues to be the country's single buyer of electrical energy.

One of the main concerns of prospective IPPs is that political changes would possibly expose investments to the risk of loss, for example through an act of expropriation. However, the Namibian Constitution requires that the state may only expropriate property in the public interest subject to payment of just compensation [83]. It would therefore seem that IPP investors have some constitutional protection. Past experience however has shown that foreign lenders, despite such assurances, have sought additional contractual protection from Government, for example in form of an implementation agreement for their investments. This has been a long-standing stumbling block in liberating foreign investments in Namibia's electricity sector.

The current approach to address IPP risks could be improved by Government introducing specific measures, such as national IPP targets, tariffs, tax breaks and/or tax incentives, and an explicit protection regime that spells out in greater detail how policy, legal and regulatory changes will be dealt with. Such measures would most likely address many of the concerns that seem to limit the current appetite of prospective IPPs to do business in the country.

On the other hand, it is considered unnecessary that additional protective fiscal and profit repatriation measures are spelt out in greater detail than is already the case. Under Namibia's Foreign Investment Act of 1990, foreign investments including reinvestments of profits from investments for which a Certificate of Status Investment has been issued, are protected by law [84], [85]. Such protection includes the right to convertible currency required for the repayment of principal and interest, subject to the approval of the Bank of Namibia, and for the repatriation of profits from an investment, including those resulting from the sale of a local investment. Also, the Act grants protection from expropriation of the business or any interests in or rights over property without payment of compensation in convertible currency.

REEE-powering Namibia is likely to be advanced by additional IPPs. Small- and medium-sized IPPs could be funded from local or regional sources. This caps the scale of each such project, and makes them attractive to the local market. Locally funded projects minimise the burden on consumers, as they do not require foreign currency hedges, and do not have to satisfy rate of return expectations in currencies other than the local one.

8.6 Conclusions

IPPs can make a profound contribution to REEE-power Namibia. In this way, IPPs can contribute to energy security, the diversification of the energy mix, and very importantly, the creation of local jobs and the strengthening of the local economy.

IPPs are not limited to renewable energy generation only. However, Namibia's current energy sector structure would seem to offer greater opportunities for small-and medium-sized IPPs, which could benefit from Namibia's considerable renewable energy endowments, including those locked in the country's abundant solar, wind and biomass sectors.

It is considered likely that the creation of more investor-friendly framework conditions offering specific IPP targets, tariffs and tax incentives and offering greater transparency in regard to how IPPs are protected against changes in the country's policy, legal and regulatory environment will enhance Namibia's ability to attract new actors to the energy sector. Here it is noted that almost all countries in southern Africa seek investments in their energy sectors. This implies that countries offering the best investment conditions are going to be more successful in attracting such investors than those where conditions remain uncertain or unattractive.

A case in point is the South African approach to attract power sector investments, as implemented by the National Energy Regulator of South Africa. This model, while clearly not applicable in its totality to the much smaller Namibian energy sector, still offers valuable lessons, in particular in regard to how the process is benefitting from a competitive system of price bidding. For Namibia it would seem appropriate to take cognisance of some of the regional lessons to place private investments in the energy sector on a more secure and results-oriented footing. In particular, a transparent system of project procurement will be necessary, and should create entry points for both solicited and unsolicited projects, provided they have merit. This is not currently the case in Namibia, and calls for much greater controls, to safe-guard the common public good and minimise corrupt practices by well-connected individuals.

In order to address some of the uncertainties expressed by IPPs wishing to do business in Namibia, Government should codify guidelines that address the state's intentions in regard to IPPs. Spelling out energy targets, tariffs, tax breaks and other incentives, as well as the protection regime in case of policy, legal or regulatory changes would go a long way in clarifying the realities of investing in Namibia.

As for specific financial framework conditions, it seems advantageous to incentivise the establishment of a number of smaller IPPs rather than a few larger ones. Such an approach will better spread the risks and benefits of such investments, and create additional local investment opportunities. Funding for IPPs that originates locally does not require foreign exchange hedging, creates local opportunities and allows for local value creation through the active recirculation of funds generated in Namibia.

9 REEE-Powering NamPower

9.1 Introduction

NamPower is Namibia's national electricity utility, and is a 100% state-owned enterprise [86]. Recently, the local media has become more interested in the fate of the country's electricity industry and has published various accounts of how the utility purportedly operates [87], [88]. Rather than dwelling on such media stories, this chapter considers some strategic considerations that are expected to shape the utility's future operating environment. It then addresses the question whether a deliberate REEE-powering of the utility is possible, and whether this would add value.

Figure 50:
Soot from the coal-fired van Eck power station clogging up Windhoek [89]

9.2 Context

In mid-2015, the installed electricity generation capacity that is owned and operated by NamPower is barely able to supply the country's base load requirements [90]. What is not be supplied from local sources is imported. In the past years, imports have consistently shown year-to-year increases, and now exceed 60% of the total annual electrical energy requirement as previously illustrated in reference (see for example [1] and references therein).

Southern African countries have been slow to invest in new power generation capacities, and even slower to complete projects that have been in the pipeline for a long time. Today, the sub-region suffers from a severe power shortage, with wide-spread negative impacts across the sub-continent's economies. While regional energy ministers meet regularly, and utilities spend a fortune on planning for expansions, most countries in southern Africa cannot show that tangible progress is made in expanding and modernising their fleet of power generating capabilities as fast as is necessary [91].

At the same time, and in parts as a direct result of load shedding becoming a daily disruptive reality for millions of consumers across southern Africa, a significant yet largely silent development becomes evident that will shape the business environment of tomorrow's electricity companies, including that of NamPower.

The following forces of change will critically affect NamPower's future:

1. Electricity end-users, irrespective of whether they are a large power users or modest domestic electricity consumers, have an ever-increasing array of affordable technologies at their disposal that dramatically change the way that electricity is generated and consumed. In particular, distributed renewable energy generation capacities, energy storage and highly energy efficient end-use technologies re-shape the very way in which consumer needs are met, and how they will rely on grid electricity in future.

   Such a transformation is only accelerated if utilities cannot meet their traditional responsibilities, and end-users decide to take matters into their own hands. And because such end-user decisions are becoming more accessible and financially viable, yesteryear's client base on which a utility shaped its service offerings may have reduced its grid dependence, or may disappeared completely by the time that utilities have finally addressed the core supply problems. REEE-powering, in all its facets, is a game-changer that electricity utilities cannot afford to ignore.

2. A wealth of demand-changing technologies, ranging from distributed generation technologies, to smart appliances and control technologies, is entering the consumptive space. This happens at a pace and scale that has not been witnessed before, and enables direct interactions between utilities and its customers. Through such means, instantaneous electricity demand patterns, hourly and daily load profiles can be changed at a flick of a button to more optimally benefit from distributed generation sources, customer-specific demand response capabilities, and the available energy mix.

Today's demand response capabilities completely re-shape the way in which utilities can interact with its clients. Yesteryear's top-down you-consume-what-we-supply relationship is changed in favour of a state of play where electricity end-users are both consumers and producers, they become prosumers. Such clients consume electricity, and produce it, and interact with their utility as clients as well as other off-takers and suppliers.

In addition, by granting access to some or all of their loads, to facilitate the dynamic matching of demand and supply, clients help their utility to ensure the security of supply, hour by hour, can be assured. Such mutual interactions are of benefit to all participants, as they allow the utility to optimally and cost-effectively use all available generation assets, irrespective of whether these are utility- or client-owned, and at the same time, interactively shape the load profile by actively managing all available generation assets as well as the loads connected to the network. More and more, the relationship between a modern-day electricity utility and its clients is characterised by the synergies between them, and their mutual dependency, to the benefit of both.

3. Depending on deliberate steps taken by the electricity regulator in opening the electricity distribution and supply markets, a multitude of mostly small- and medium-scale supply opportunities are created in which end-users and entrepreneurs can and should become engaged. The playing field can be democratised, to the benefit of everyone.

   For example, while current net metering arrangements, as are to become operational in Namibia, create opportunities for individuals wishing to off-set some of their electricity use from own generation sources, other more interactive market arrangements may be created too. To illustrate, manufacturers wishing to procure carbon-neutral electricity produced by a local generator could engage in direct trade with one or several suppliers of clean electricity. Such interactions necessitate supply and wheeling arrangements, all of which need regulatory provisions and controls.

   The upside of allowing third-party interactions within the electricity supply industry, even if these were to be capped to generation scales below 5 MW capacity per generator, is the creation of new investment and trade opportunities in a market that has largely remained locked out to private sector investments and engagement.

   While such market expansion may seem novel today, the deliberate opening of the electricity supply industry holds many advantages, including the creation of small- and medium sized electricity sector actors, and with it, new business models and trade that has not been available in the past. By opening the market for direct participation, NamPower and the country's distribution industry operators who have previously been locked into a space devoid of competition begin to meet their peers, and compete for clients. In this way, REEE-powering Namibia creates a new supply environment in which the end-user have greater choices, and can actively participate, when and with whom they believe they can make it happen. Such an opening of the electricity arena unfreezes investments and shakes up encrusted structures that have mostly survived because of the grace of regulatory protection. Whether such protection has been to the common good remains unanswered.

9.3 NamPower's Tools of the Trade – Yesterday and Tomorrow

In the past, NamPower's tools of the trade consisted largely of the following:

- **Imported power:** for a national utility such as NamPower, provided that it has sufficient transmission capacity to import power, and that foreign power plants are willing and able to supply such power, meeting some of the country's demand through imports can be beneficial. However, as is evident from the last statement, in case too many conditionalities exist, i.e. if capacity exists, if the price is acceptable, if the timing of supply coincides with local demand, if sufficient transmission capacity is accessible and others, the reliability of imports becomes prone to risks, and cannot be guaranteed. Namibia's current power supply bottleneck is, amongst other factors, the result of insufficient local capacity as well as regional supply shortages, which have implications for the accessibility, availability and cost of such power. Now, and in future.

- **Base load power stations:** the hydro-electric Ruacana power station, although constrained by the availability of water in the Kunene River, and the coal-fired van Eck power station outside Windhoek, were part of NamPower's baseload arsenal for many years. Today, the van Eck power station does no longer offer its nameplate capacity of 120 MW for base load purposes, and the plant has become expensive to maintain and operate. Generally, base load power plants do not readily change their power output throughout a given day, as they are mostly slow to start, or stop, or modify their output. The envisaged Kudu gas-to-power plant is intended as a base load plant, to meet the most permanent part of the country's electricity demand.

- **Mid-merit power plants:** in terms of the generating capacity, mid-merit power plants are mostly of smaller capacity than their base load equivalents, and can change their output significantly more rapidly than base load power stations can. In practice, as a run-of-river plant with four separate turbines, Ruacana can be used as a mid-merit power station, provided that sufficient volume of water are available from the Kunene River.

Figure 51:
Solarification of NamPower and the Ministry of Environment and Tourism [92]

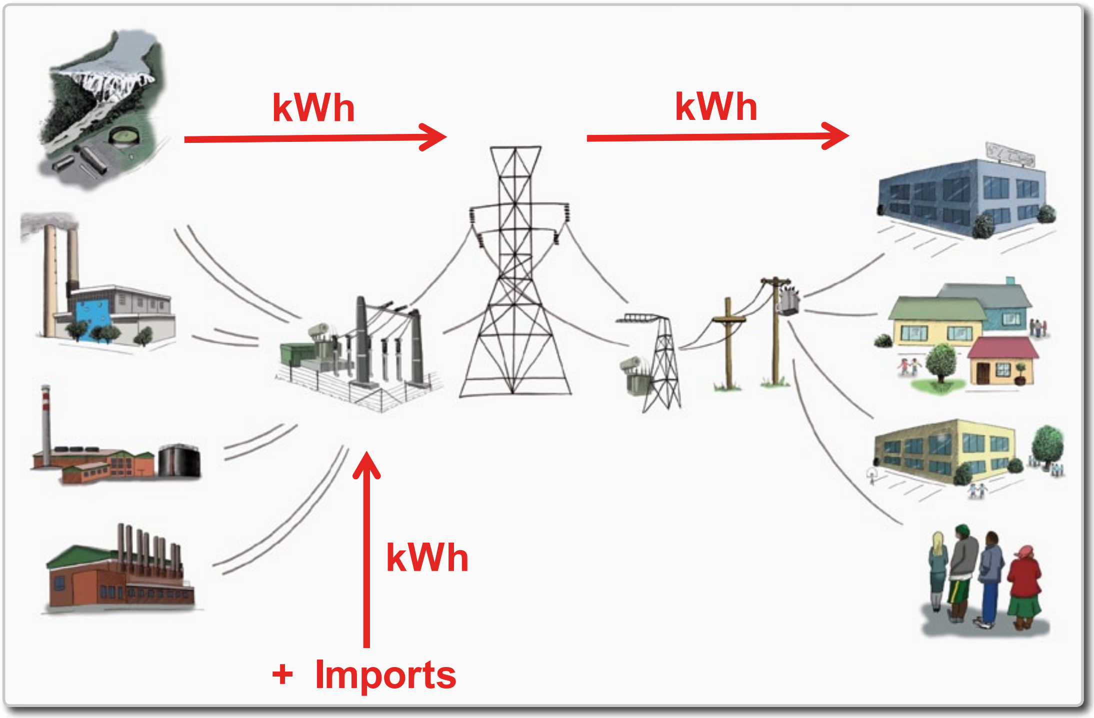
- Many utilities throughout the world operate **peaking power plants**, which are important when the mid-merit capacity is close to operating at full capacity, to assist in supplying electricity in short-term peak demand periods. Often, peaking power plants are pumped storage hydro-powered or gas-powered generators. The intention of both the Anixas and Paratus power stations at Walvis Bay was to serve as peaking plants.

- **Transmission infrastructure:** high-voltage power lines that connect in- and external generating plant with electrical sub-stations;

- **Systems control:** as the supply from different electricity generators has to meet the momentary demand for electrical energy, an overall systems control is required. The function of such a control is to actively match the demand and supply and ensure that this is done in the most cost-effective manner.

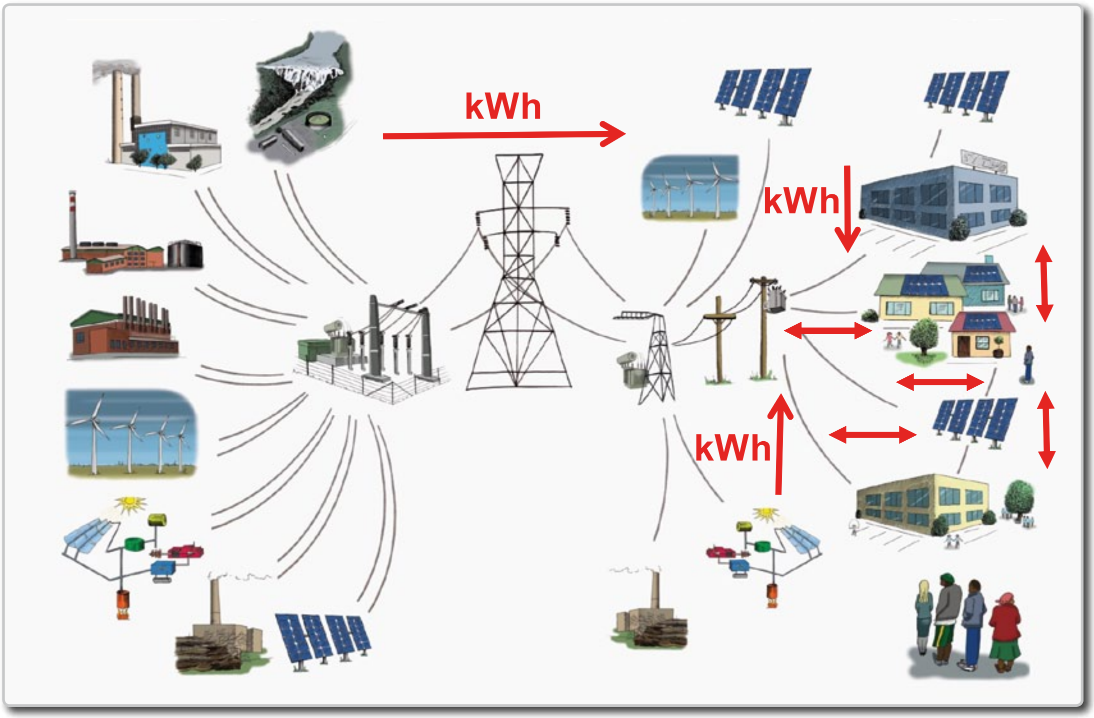
Yesteryear's medium- and low-voltage electricity distribution grid, which supplies electrical energy from select sub-stations and electrical transformers to electricity consumers, will undergo massive changes too. One-way energy transfers, as depicted in Figure 52, from the direct of the utility generation assets to end-users, are no longer the only possible way in which grid infrastructure is used. As more and more distributed generation capacity joins the grid, and local grid feed-in increasingly feeds lower power consumption, a multitude of REEE opportunities are created. Feed-in changes the architecture of the grid, and the way it needs to be managed. It implies that tomorrow's electricity distribution grid has to be designed and geared for multiple in- and outflows of electrical energy, and managed to more optimally satisfy the changing requirements of generators, prosumers and consumers, all wishing to interacting with the grid. For this to become an effective and safe process, utilities need to adapt and accommodate the successive REEE-powering of its client base, and the participation of new actors, such as local generators and IPPs, joining the grid.

Figure 52: *One-way electrical energy flows in Namibia's electricity sector in 2015 [93]*



With the changes described above, NamPower's traditional role is likely to change. This necessitates forward-looking decision-making. The utility's new roles and responsibilities are a direct result of changing consumer requirements, and the increasing array of interactive technologies that become available. It is anticipated that sophisticated control systems will enable utilities to directly interact with customers, and manage their generation capacity and optimise the load by way of direct customer demand response and load control. In this way, the utility of the future has closer mutually beneficial ties with its customers, and ensures that the instantaneous demand is met with the available electrical supplies. Such utility interactions with end-users are radically different from the past or those characterising today: as consumers become prosumers, utility management includes the traditional control of generation sources and the grid, in addition to remotely managing loads and generating capacities made available by its clients. This is the face of an interactive future in the electricity sector, as illustrated in Figure 53.

Figure 53:
Energy exchanges in Namibia's REEE-powered electricity future [93]



For NamPower, whose current core mandate is the generation and transmission of electricity, there is no way in which the economics of future investments in large-scale generation capacity can be guaranteed. This is particularly true because of the immense costs associated with evacuating power from the furthest corner of the land, and its transmission to where consumers live and work.

Namibia has some excellent natural resource endowments, not only in the solar, biomass and wind sectors, but also in form of the hydro-potential in the Kunene and Orange Rivers, the natural gas resource of the Kudu gas field. However, neither the envisaged Kudu gas-to-power plant nor the Baynes hydro-electric power plant in the Kunene River are located in areas where any significant electricity consumption takes place. Therefore, most of what is generated will have to be transmitted, thus necessitating substantial additional investments in high-voltage power transmission infrastructure, which add to the overall costs as well as to line losses. And the addition of one large power plant, such as the envisaged Kudu plant, increases the overall riskiness of the country's electricity supply. This is because a country's energy mix is most resilient to external shocks and changes if several of its generation assets can be taken out of service without affecting its security of supply. This is not possible if there are either too few generation assets in the mix, as in the case of Namibia, or if these are too large to be taken out of the mix. Large plant in small countries therefore often constitute an added security of supply risk.

In contrast, small- and medium-sized generation assets located at or close to where the consumption takes place saves on investments in transmission infrastructure. At the same time, such plant reduce line losses, and strengthen the diversity of supply. Even if a few small- or medium-sized plant are out of action, there will still be other generation assets in the mix which will continue to provide service. This reduces the overall supply risk. These factors will increasingly tip the viability scale in favour of small-scale distributed generation capacity, as will characterise Namibia's REEE-powered future.

9.4 Variability, Base Load, Energy Mix and Security of Supply

At any given time, the supply of electricity must be matched to the existing demand. An electricity supply system must therefore be designed to offer sufficient flexibility to enable the systems operator to mix and match different sources of supply with the prevailing demand. Some renewable energy generation options, most notably those powered by solar and wind resources, may not be available at times when there is a demand for electricity. Alternatively, and depending on the total installed generation capacity, they may generate more than is required at a given time. For this reason it is occasionally suggested that the natural variability of renewable energy generation render such power options unsuitable to meet base load power requirements. Before delving deeper on this topic it is instructive to reflect on the reasons why an electricity system has base load requirements in the first place.

Whenever electric machinery is used in a commercial or industrial setting, or when domestic appliances such as lights, air conditioners, ovens or electronic gadgets are used, electricity is drawn from the grid. In Namibia, far fewer than half of the population benefit from grid electricity. Some end-users have considerable electricity requirements, e.g. those in the mining sector. Others have minimal electricity requirements, e.g. an end-user using a single light bulb. No-one knows when any one client decides to use a particular load. However, when considering all electricity end-users, there are always some users who draw electricity at any given time, even when there is very little overall demand for electricity. This minimum demand for electricity is what needs to be matched by base load power. Therefore, base load is the result of the *consumption of electricity and is a demand-side characteristic*. In most cases, base load is not a supply side requirement unless the generation mix only consists of inflexible generation assets.

With the above in mind, one needs to ask the following: does the variability of renewable energy generation plant, such as solar PV or wind, imply that such plant cannot contribute to base load power? The answer is: no. The variability of such plant is not an issue, provided that the national power system has the ability to meet the entire range of load conditions, all the way between base load to peak demand. As stated before, the systems operator needs flexibility to optimally match supply and demand. Such flexibility is what characterises a good energy mix. And such a balanced energy mix should therefore include a combination of generation options that can be used to match all reasonably expected load requirements arising throughout any given day.

The flexibility of an energy mix is usually the result of more generation assets being in the mix than will ever be called upon at any given time. As the diversity and flexibility of generation assets in a supply mix increase, the security of the supply system increases too. A power supply system that is deliberately designed for flexibility can more readily absorb variable generation capacity, as is offered by solar and wind resources. As stated before, base load requirements are principally the result of the demand for electricity. It is neither more cost effective nor does it reduce the risk of supply when having only one or a few generation plants contributing to such base load. Instead, the supply risk is lowered when depending on several generation assets, and having spare capacity available in case specific generation capacities become temporarily unavailable. Such spare capacity however is expensive as it locks capital in non-productive assets.

A well-balanced energy mix therefore implies that one follows a strategy of not 'putting all eggs into one basket'. Rather, a resilient power system is designed using multiple generation sources that complement each other in a cost-effective and reliable manner. This is what the deliberate REEE-powering of a power supply system can achieve, and has no actual bearing on the question whether all supply options are dispatchable on demand at all times.

A REEE-powered utility future therefore necessitates much higher system flexibility than were available in the past, so as to allow the systems operator to achieve an optimal match. Power systems which are heavily dominated by traditional base load power sources are generally less flexible, and are therefore likely to prevent the gradual uptake of newer generation options.

In this context it is important to point out that a single large base load power station, such as the envisaged Kudu gas-to-power plant, will decrease the overall flexibility of the Namibian power system, and hence increase the overall risk of the system. It also implies that Namibia's power system will become considerably dependant on a single source of electrical energy, which delays delays the road towards REEE-powering Namibia.

9.5 NamPower and the Supply of Electricity in Future

This section highlights some of the factors that are likely to lead to, contribute to or change the way in which the national utility NamPower will operate in future. It is not comprehensive, but focuses only on factors that are of immediate relevance for REEE-powering Namibia.

Evidently, many of the changes in Namibia's electricity sector depend on how pro-active and effective the regulatory provisions are that shape the utility's operating environment. On the one extreme, regulations could demand that the utility rapidly embarks on a road to REEE-power operations. This is a rather naïve view, and is in stark contrast to how NamPower and its operations have changed in response to past regulatory provisions.

Continuing the business-as-usual approach to how the utility operates would imply that regulations are little else than formal afterthoughts, and do not actively shape the strategic planning and structure of the utility's future. It will not be productive to speculate which path will eventually be embarked upon. Therefore, the remainder of this section attempts to answer which factors beyond those that are directly or indirectly affected by regulatory provisions are likely to have an impact on the utility and its future.

As introduced in section 9.2, across the world, electricity generation and consumption alternatives arise that are expected to dramatically alter the way in which vertically integrated monopoly providers such as NamPower will operate in future. Three aspects are considered to be of particular importance:

1. *uptake of end-user electricity generation and energy efficient appliances;*

2. *availability of increasingly cost-effective electrical storage, as the critical link between variable output renewable energy generation and electricity use; and*

3. *integrating energy management control capabilities into utility operations.*

The mainstreaming of renewable energy generation, storage and energy efficient technologies are considered critical drivers of change. They are game changers, and expected to radically reshape NamPower's traditional business model. What is a requirement for the future is that ongoing innovations are embraced, and operations actively re-shaped to meet the changing needs of the utility's business environment. This however, is neither automatically the case, nor can it be assumed to happen without deliberately unpacking and realising future opportunities.

For NamPower, the cardinal role will be how it can best leverage its capacities as systems operator, and strengthen these to become an effective electricity integrator. This role requires further investments in own generation capacity, at scales and in locations that maximally benefit from Namibia's competitive advantages in the field of solar, wind and biomass energy resources, while aggressively building energy, demand management and demand response capabilities. In this way, a picture of a responsive and service-oriented electricity utility emerges that embraces REEE technologies to provide modern, clean and cost-effective REEE-powered services to its clients.

Realising the vision of a REEE-powered NamPower, as spelt out in the paragraph above, may not be as remote and unrealistic as it may seem at first sight. As the utility of last resort, NamPower is already engaged in the distribution and supply of electricity to end-users. It has both systems and processes to provide the so-called 'last-mile' services, even if these are not fancied by management. In addition, NamPower ensures the dynamic matching of demand and supply, minute by minute, throughout the year. A key to the future of a REEE-powered electricity utility lies in its integrative capabilities. In this regard, NamPower has and increasingly builds such experiences, for example with end-user demand management programs initiated in the past years, and demand response activities with some large power users. It is in this way that the utility can pave the way to transition to a REEE-powered utility, even if many may not readily recognise it as such.

The key to expand on NamPower's integrative capabilities will most likely lie in improving the co-ordination and co-operation between the utility and its key clients, principally the country's REDs, local authorities and large power users. Improved integration also means becoming more pro-active in the management of supply and demand, in close collaboration with its clients. It is important that the utility embarks on the delivery of client-focused services, in order to respond to client needs and wants.

NamPower will also have to ensure that the requirements of the country's distributors can be met. This implies a deeper operational involvement between and amongst NamPower and the distributors, so as to ensure their continued mutual viability. As such, disengagement from the challenges of the electricity distribution industry cannot be an option for NamPower, as the multiple challenges faced by the last-mile suppliers of electricity have a profound impact on the viability of the utility and therefore its future.

Clearly, a lot still needs to happen. However, when faced with reduced revenues per customer as a result of customers' embracing REEE, and increasingly sophisticated end-users who have more sophisticated needs, traditional business approaches must be overhauled. A key to change the current mind-set is the realisation that customers will get REEE-powered, and there is little that the utility can do about it. Applying the same old business recipe will therefore not address the changes that shape the operating environment. What can assist in driving change is a reflection about customer needs and their changing requirements, and recognising that customers are the reason that the company exists. This boils down the choices to either waiting for external changes to happen, and then reacting to such changes, or proactively developing new business interaction models that create new value in a rapidly reshaping electricity supply environment.

In order to embark on a REEE-powered road to the future, NamPower's value proposition to end-users must be re-considered. Yesteryear it was sufficient to provide electricity, tomorrow it is the service-oriented utility that survives because it offers end-user services despite most customers wishing to reduce their energy-related expenses and reliance on the utility by active REEE-powering. A new service orientation necessitates a client-specific engagement that delivers a suite of products and services that a REEE-powered client needs. For example, through an energy supply contract, NamPower could on-sell electricity while at the same time benefit from investments in generation technology made by the client, plus access to the client's loads. In this way, a synergistic relationship between the utility and its clients can see rewards for participating end-users, by driving down their electricity costs, while allowing the utility to generate income through the re-sale of electricity that is generated in off-balance sheet generation assets, plus the active demand control of some or all of its clients' critical loads. This is of benefit to the utility, and it is of benefit to its clients. And it leads to new business ventures as the utility and its clients see a value addition in continuing their mutual dependency.

The bottom line of the transformation towards a REEE-powered NamPower is the realisation that the utility's clients will continue to expect to benefit from services, which will have to be delivered both reliably and affordably. The business relationship must survive in an environment where clients have unprecedented access to affordable technologies that reduce the dependence and reliance on utility services. In the REEE-powered future, the key value proposition of a utility lies in convincing its clients that there continues to be value in utility services. The provision of reliable low-cost grid-tied services is a key value considerations that determines whether a utility such as NamPower can survive in a REEE-powered future. In addition, the future-oriented utility business model must also enable clients to benefit from their investments in REEE technologies, while at the same time continuing to use grid services. Such a service and value orientation is not a given, and necessitate active preparation by NamPower. REEE-powering Namibia changes the playing field. For everyone.

9.6 Conclusions

This chapter highlighted some strategic considerations that are expected to shape NamPower's future operating environment. It also addressed the question whether a deliberate REEE-powering of the utility is possible, and what the benefits would be. It is suggested that a multitude of strategic risks are arising as a result of electricity end-users having access to increasingly affordable technology options to partially or even completely reduce their dependence on the utility. At the same time, innovative energy management control options become available to more readily enable tomorrow's utility to manage diverse generation options and end-user loads, which can have tremendous value, both for the utility and end-users.

The chapter puts forward an approach whereby NamPower transforms to become an energy integrator, providing electricity to end-users and at the same time leveraging its systems control capabilities to optimise customer generation assets and loads. In this way, the utility establishes mutually beneficial relationships with its client base, which is a fundamentally different way of viewing and interacting with end-users. The utility's future is tied to how effective it is in serving its clients' evolving needs.

A REEE-powered NamPower, as conceptualised in this chapter, is an agile utility that connects multiple generators, both big and small, owned and operated by itself as well as its clients, to provide reliable and affordable electrical energy, while optimising the country's load to maximise local value creation. Such future operations necessitate investments in multiple renewable energy plant, as well as upskilling in modern energy management, demand management and demand response technologies and processes. In this way, NamPower would leverage its considerable technical expertise as Namibia's systems operator, while benefitting from its own, IPP-owned and its clients' generation resources, as well as recent experiences in the roll-out demand response activities.

Embarking on a road to REEE-power its operations implies that the utility's customers can reap the benefits of investments in their own electricity generation technologies while remaining a utility client, and having the advantage of being supplied by the provider of last resort if and when required. In exchange for competitive tariffs from the utility, future prosumers would likely also allow the utility to access its key loads. These will form part of an arsenal of utility tools by which electricity demand is managed, for example through load shifting as well as the optimal integration of generation capacities that the utility's clients and future IPPs have connected to the grid. This creates a synergistic utility-client model that drives investment into REEE technologies, while enhancing the fleet of utility- and client-owned generation assets in the country. Such future partnerships reduce the risk that top revenue generating clients decide to go it alone and defect from the grid, while offering fair and plannable compensation for investments in decentralised generation assets made by the utility's clients and other electricity supply industry actors. In this way, active REEE-powering replaces yesteryear's top-down utility-centred business model, in which client interactions were limited to receiving monthly bills for capacity and energy demanded, reshaped into an interactive relationship which avails assets, energy and capacity to the market. Through this approach, the utility business model is expanded from owning and operating assets to becoming an active energy and capacity integrator and broker, optimising total economic value created rather than focusing on preserving utility revenues. This is a change in the mind-set: NamPower must first and foremost provide the services required to power Namibia's development. As the national utility it must seek to optimise the national value of electricity supplies, which must include the value contributed by all grid-connected customers.

Throughout the past decades, NamPower has benefitted from the unprecedented protection by its owner, i.e. the Government of Namibia. In many ways, this has created benefits for all electricity end-users, e.g. when Government funded the utility to lower bulk tariffs. However, such subsidies distort electricity tariffs, and dis-incentivise the entry of new players into the country's electricity supply industry. It also remains doubtful whether the subsidisation of NamPower creates optimal value for the economy. While it could be argued that the utility is too important to fail, and will therefore likely continue to benefit from direct Government allocations, a more prudent approach to the utility's future lies in the creation of new value for its clients. In the past, the value proposition consisted in the provision of electricity. Today, such a limited notion of what constitutes the value of a national utility does no longer suffice. Indeed, it is argued in this chapter that unprecedented advances in decentralised energy generation technologies, electricity storage systems and energy efficient technologies create an entirely new playing field which makes it necessary that the utility becomes both value-focused and customer-oriented.

NamPower is in a unique position to embrace and apply many contemporary technology advances, including in the field of RE, EE, storage and demand response management. In this way, the utility can create new business propositions and value for its clients that these may not be able to realise themselves. As such, REEE-powering NamPower offers a long-term pathway to safe-guard the country's investments in its generation, transmission and distribution infrastructure. The utility's future will, to a large degree, be determined by how it achieves to integrate its services with the needs of its clients. Amongst others, this necessitates closer integration and deeper operational involvement in the affairs of the country's electricity distributors, to ensure that the multiple challenges faced by these last-mile suppliers can be managed in a way that places Namibia's formal electricity supply and distribution sectors on a firm future-oriented footing. REEE-powering implies the deliberate creation of pathways to leverage Namibia's considerable natural renewable energy endowments, and to match these with modern end-user aspirations, to ensure energy security while offering a clean and affordable electricity future for all. And this is the national value contribution that NamPower must make.

10 Concluding Remarks

This final chapter offers some concluding remarks on how the energy decisions we take today can positively shape Namibia's development and the country's future.

The present study describes conceptual approaches that illustrate how the deliberate uptake and integration of renewable energy, energy storage and energy efficient technologies can be brought about in Namibia. The text makes frequent use of the phrase REEE-powering. For example, REEE-powering domestic energy use. And REEE-powering commercial and industrial users, or electricity distributors. And REEE-powering IPPs. And REEE-powering NamPower.

However, **the phrase *'REEE-powering'*** cannot be found in a thesaurus, and Google does not offer any entries either. So what does REEE-powering mean? This study introduces the concept of **REEE-powering as the deliberate switching to electricity supplies based on renewable energy technologies and the uptake of energy storage and energy efficient technologies.**

Why would REEE-powering be desirable? REEE-powering is, first and foremost, a decision in favour of clean, sustainable and locally abundant renewable energy resource use, as well as the application of energy storage and energy efficient technologies, to reduce electricity consumption. Large-scale REEE-powering can be readily achieved today, and in many cases, the cost associated with such a transition is quickly recovered through savings. The more than 20 case studies included in this study illustrate both qualitatively and quantitatively how and under what conditions REEE-powering can be achieved in Namibia.

There are many good reasons why Namibia ought to embark on a road of greater sustainability, of which REEE-powering is a part. For one, the country's energy sector is highly import-dependent, and therefore remains extremely vulnerable. Indeed, Namibia imports all liquid fuels, while more than 60% of the country's electricity is imported. This dependency is a permanent drain on the economy as it necessitates currency outflows amounting to many billions of Namibian dollars every year. None of the funds leaving Namibia create local jobs, or lift Namibians out of poverty, or power local development. This is a clearly undesirable state of affairs.

In contrast, **the use of renewable energies and the uptake of energy storage and energy efficiency opportunities create local value, including in the social, economic and environmental spheres.**

The choice for or against REEE-powering is therefore also a choice for local value creation, and against the continued export of value and opportunities. Namibia's energy sector, in its current form, exports opportunities, on a daily basis, and thereby limits local growth and development. **The design of the country's energy sector can be changed, and this is what REEE-powering is all about. Creating local value.**

REEE-powering creates value, locally.

For example, **social value** is enhanced when local jobs create local income opportunities and new local capacities. And it strengthens the country's social fabric.

REEE-powering creates **economic value**, through cost savings from locally generated electricity, per unit of energy saved through efficiency enhancements, improved local circulation of funds through local investments and local income generation, as well as taxes from local jobs and new business activities that bring about local value addition, and reduced currency outflows and foreign exchange exposure.

REEE-powering creates **environmental value**, amongst others, through the reduction of greenhouse gas emissions, water savings in the electricity sector, and reducing the environmental footprint from the use of fossil fuels.

REEE-powering also addresses important **strategic considerations**, such as the enhancement of the security of supply of energy, reducing the country's vulnerability to foreign exchange dependency and the whims of foreign exchange fluctuations, and enhancing the country's resilience against the impacts of climate change by strengthening the local economy.

Namibia's present-day energy supply system is an apparatus delivering a variety of energy products to the market, including various liquid fuels, electricity, coal and others. However, the energy sector can be much more than a mere set of supply arrangements. Indeed, ***the energy sector can become a development engine, the locomotive for local value creation.*** But the machinery to realise such a vision must first be created. It requires new perspectives on: how the more than half of all Namibians that remain without access to modern energy can effectively be included in the country's economy; how commercial and industrial actors can be weaned off their dependence on fossil fuels and imported electricity; and how electricity distributors, independent power producers and the national electricity utility can more deliberately benefit from recent REEE technology developments and begin to actively drive national development efforts. Clearly, these are ambitious goals. And they cannot all be achieved in an instant. But a step-by-step approach will bring progress.

The chapter on REEE-powering domestic energy use argues that Namibia needs to provide specific and realistic entry points to create access to modern energy for those that still remain without it. This will significantly assist in the upliftment of individuals and communities, out of poverty, and towards a more meaningful participation in the economy. **Without access to modern energy, transitioning people's lives into the 21st century can just not be accomplished. And unless access to modern energy is deliberately strengthened, the very foundations of national poverty alleviation efforts will remain shaky, and continue to shackle Namibia's national development ambitions.**

The chapter on REEE-powering commerce and industry points out that most activities in which renewable energy and energy efficient technologies have been adopted in the productive sectors of the economy have taken place despite an absence of specific policies. As the engine of the economy, commerce and industry is particularly well-suited to capitalise from the systemic benefits that arise from REEE-powering, including the creation of local jobs through established and new local value chains, as well as the generation of taxes, entrepreneurship and innovation, to name but a few.

As discussed in the chapter dealing with **REEE-powering the country's electricity distribution sector**, the deliberate reshaping of the business models that underpin Namibia's distribution entities can create new value propositions. These will be of benefit to electricity end-users, while shielding the utilities from the inevitable changes that rapid technology changes in the field of distributed generation, energy storage and the energy efficiency space bring about. It is suggested that the broadening of the local sourcing and supply of electricity, and extending service offerings to end-users are strategies that benefit from the modern energy consumers' appetite for inexpensive and secure supplies while creating new opportunities to strengthen the revenue base of Namibia's electricity distributors.

The chapter on REEE-powering independent power producers emphasises the significant role that IPPs can have in firming Namibia's energy future, enhancing the country's energy security, diversifying the energy mix, creating local jobs and thereby fortifying the local economy. Such a development will become more tangible through investor-friendly framework conditions. These may include specific IPP targets and tariffs, as well as tax incentives, and spell out how IPPs are to be protected against changes in the policy, legal and regulatory environments, both today, and in future.

The chapter dealing with REEE-powering of NamPower envisages the transformation of the utility into a national energy integrator that provides electricity to end-users while leveraging its systems control capabilities to optimise value from the national and its clients' generation assets. This view of the future includes the creation of new business value for the utility by leveraging Namibia's considerable renewable energy endowments, and matching these with modern end-user aspirations to ensure energy security while offering a clean and affordable electricity future for all.

We end this book with reflections on how to embark on the way forward. The main thrust underpinning the conceptual description of a REEE-powered Namibia rests on the premise that national development is significantly enhanced when local strengths, such as our national renewable resource endowments, are put to deliberate use. As such, REEE-powering Namibia's domestic, commercial, industrial and utility landscape would allow each of these energy sector actors to become an active driver of the national development engine. And in this way, Namibia would leverage its renewable energy blessings to energise national development in all its facets. **Not in a decade or two, but starting today.**

The time to act is now.

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Errors, omissions and/or misrepresentations are entirely the responsibility of the author, who welcomes feedback and suggestions.

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