Foreword

by the Honourable Minister of Mines and Energy, Isak Katali, MP

In so many ways, having access to electricity creates and unlocks potential. It equips us to excel over and above accomplishing our day to day tasks as part of everyday living. It equips us to excel in terms of the business opportunities and subsequent economic growth it opens up for us, as individuals but also collectively as a proud nation. This is especially true for our people living in the more remote, rural areas of our vast country, where currently subsistence farming is the dominant economic activity – an electricity connection has the potential to uplift the whole community. Based on the studies conducted in this Master Plan, it is estimated that 63 percent of our population live in rural areas, and only 16 percent of these rural homesteads currently have access to electricity (status 2010). We as a Government, through the Ministry of Mines and Energy, recognize the urgent need for our active engagement in changing this situation for the better, and doing so in the most effective manner.

Government has formulated the National Development Plans (NDPs), components of Vision 2030, and the White Paper on the Energy Policy in Namibia, in its unwavering dedication to guide the sustainable development of the country's energy sector. Moreover, we have identified the need for further development of criteria, methodologies and prioritisation processes aimed specifically at complimenting Government's drive for decentralisation and improving the rural electrification of communities that have historically been neglected. This is to ensure that these communities receive and have access to at least adequate social services, which amongst others include health care and education.

It has been 12 years since the first *Rural Electricity Distribution Master Plan for Namibia* was conceptualised, developed and promulgated for implementation: an objective tool to form the backbone of and steer strategies for the future developments of the electricity supply industry. In 2005, the original master plan was again reviewed for relevance, and updated accordingly. The journey thus far has not been without challenges, and as we steadily progress toward meeting our set goals in an ever changing environment, we keep an open mind and continually look at ways to improve on the outcomes of previous master plans. This requires innovate thinking, and is seen most clearly in this 2010 master plan update. The Ministry of Mines and Energy directed the consulting team to take a proactive approach to not only develop an optimised, systematic plan of when and where rural areas will receive electricity infrastructure, but also investigate and propose solutions to practical implementation aspects, based on actual field experience, that are considered crucial to the successful execution of the electrification programme throughout the country. Central to this approach has been the prioritisation of all Government institutions, especially schools, for electrification in the short term horizon.

Most certainly, this will have to be an industry team effort, which again drives us to excel in terms of our local contractor's capabilities, involving not only the bigger players, but also new start-up businesses that will be given opportunities to establish themselves. We are confident that together, we can and will succeed in building a better future for our people living in rural areas. As an industry, we need to step up to the plate and be counted, meeting challenges head on. In our view, the Rural Electricity Distribution Master Plan has the potential to become a Namibian export product, showing the world that if we put our minds to it, we can make a positive and tangible difference, in spite of conditions that try to convince us otherwise.

We therefore encourage you to buy into and become part of our vision to empower the peoples of our great country, through the provision of something that many of us tend to take for granted – light to study at night, hot water, hot stove to cook our meals, charging cell phones, schools connected to the internet, sending a fax, availability of an x-ray machine at the local hospital, selling a cold soft drink – an electricity connection.

HON. ISAK KATALI, MP
MINISTER

Acknowledgements

In preparing this updated Master Plan, EMCON Consulting Group wish to express their gratitude to, and applaud the support from many sectors, i.e. government institutions, supply authorities, policy makers, companies and organisations, within the electricity distribution industry. Sincere appreciation to each and every contributor of information, services and other inputs. Your participation contributes to the success of the project. In particular, we would like to acknowledge with thanks the invaluable contributions of:

- Ministry of Mines and Energy as project champion, for their support and guidance throughout the project;
- Geo Business Solutions, for the Geographic Information System (GIS) support for database design, data capturing and cleaning, to ensure accurate, accessible and properly formatted spatial solutions; and
- Dr. Detlof von Oertzen of VO Consulting, for his guidance and contribution as peer reviewer, and insights in analyses of the financial and economic impacts associated with implementation of the proposed electrification projects.

A good understanding of local conditions is essential to properly address the electricity needs of the identified rural communities. Here we relied heavily on the participation of local government institutions as well as electricity distributors, to draw from their experience and expertise. We would therefore also like to thank the following stakeholders for their contribution:

- NORED
- CENORED
- Erongo RED
- NamPower
- OPE
- ECB
- NamWater
- Ministry of Lands and Resettlement – Directorate of Survey and Mapping
- National Planning Commission
- Ministry of Health and Social Services
- Ministry of Regional and Local Government and Housing and Rural Development
- Ministry of Home Affairs and Immigration
- Ministry of Works and Transport
- Ministry of Agriculture, Water and Forestry
- Ministry of Education, and

- Regional Councils of all 13 regions in Namibia.

Executive Summary

Master plan studies and the outcomes thereof provide the important planning base for the preparation and implementation of future strategic projects, while also taking into account the expected financial, economic and social impacts on the local communities and the country as a whole. The *Rural Electricity Distribution Master Plan (REDMP) for Namibia* was originally introduced in 2000, and was conceptualised and developed as part of the Government's policy agenda to guide the social upliftment of especially poor, rural communities and economic development of the nation. It is reviewed and updated every 5 years, due to the more conceptual nature of the medium to long term designs. The latest iteration of the master plan is the 2010 REDMP, which, as its predecessors, aims to:

- establish the status quo with regards to the planned versus achieved electrification of rural communities from 2005 up until 2010
- establish rural electrification targets and priorities for the next 20 years, and
- establish a structured methodology and approach to derive a rural electrification master plan for achieving the 20-year targets.

It is noted that the scope of this Master Plan is restricted to grid electrification only, thus complimenting the Off-grid Energisation Plan.

Review of the 2005 Rural Electricity Distribution Master Plan

Both the execution as well as expenditure in the period between 2005 and 2010 deviates quite significantly from the 2005 REDMP. Without analysing each and every Locality in detail, it is impossible to derive concrete conclusions as to why this occurred. One can however gain some insight into possible reasons for the deviation, which provides useful input into the planning and methodologies for the 2010 REDMP. Generally, it is not desirable to undertake ad hoc electrification activities which have neither been planned nor properly budgeted for, as such electrification efforts may well have taken place in areas which would not have qualified for the systematic electrification in the first place. These type of electrification activities were significantly prominent in the period 2005 to 2010, which points to a misalignment between national and regional electrification priorities and those envisioned in the 2005 REDMP.

National Priorities

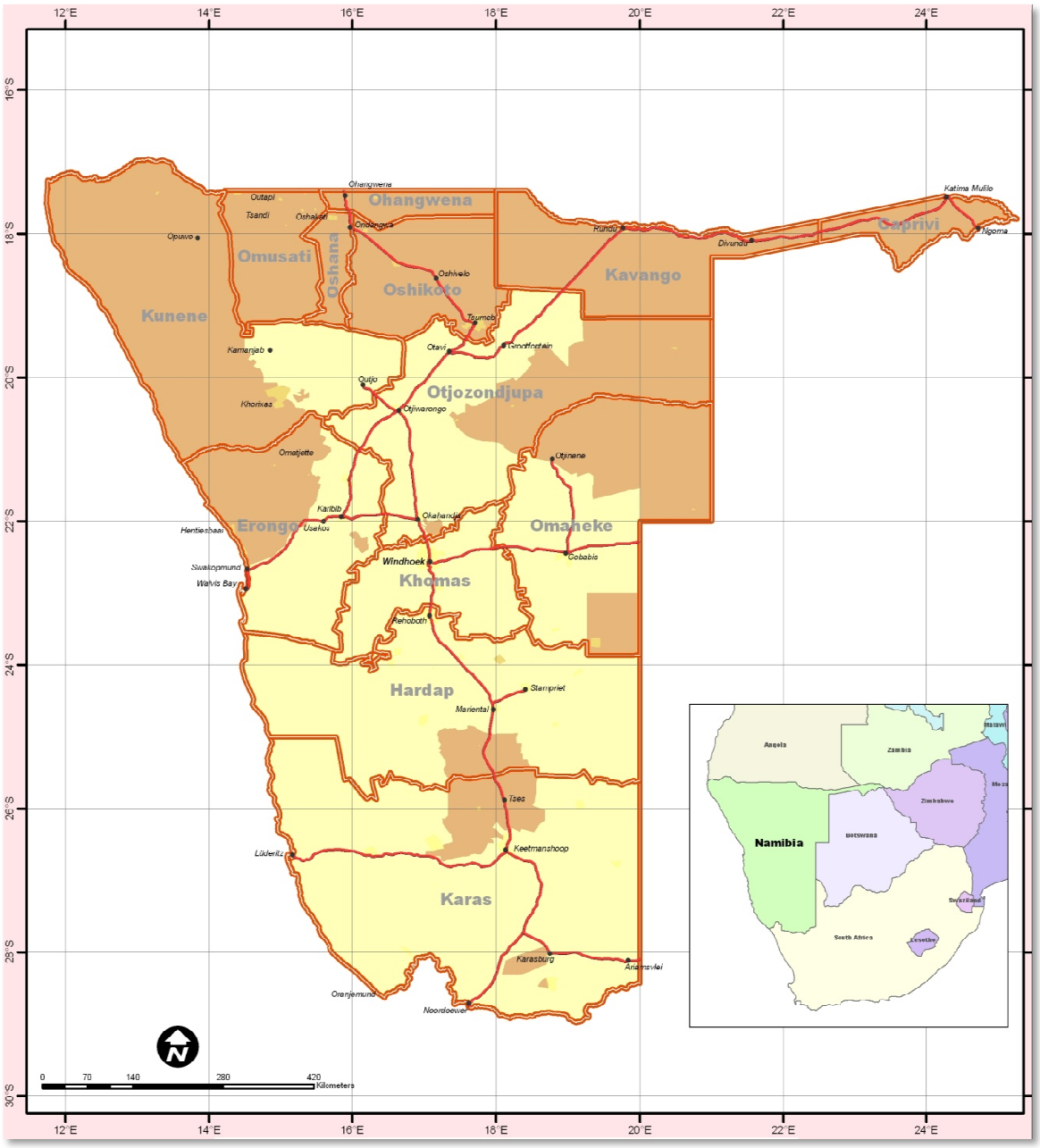
The 2010 REDMP update is first and foremost a master plan for the whole of rural Namibia – i.e. all rural communities should be taken into account and considered to benefit from the Government's initiative. In line with this overall objective, the rural electrification priorities are defined as:

- Government buildings, and especially schools, are to be prioritised within the REDMP
- existing Localities are to be prioritised, to ensure that as far as technically possible, at least one Locality per constituency is electrified per year for the next 20 years

- the rural electrification programme for a specific region is to conclude if all identified existing Localities within that region have been electrified, and
- Off-Grid Localities are to be identified and listed, but will not be electrified as part of the REDMP.

Key Definitions

For purposes of the present Study, *Rural Areas are defined as those communal areas that fall outside the proclaimed municipal areas and commercial farms*. Map A shows the areas that are included and excluded from the 2010 REDMP Study. It is important to note that, even though only the areas as defined above are considered for rural electrification, relevant data was collected and digitised for the entire country.



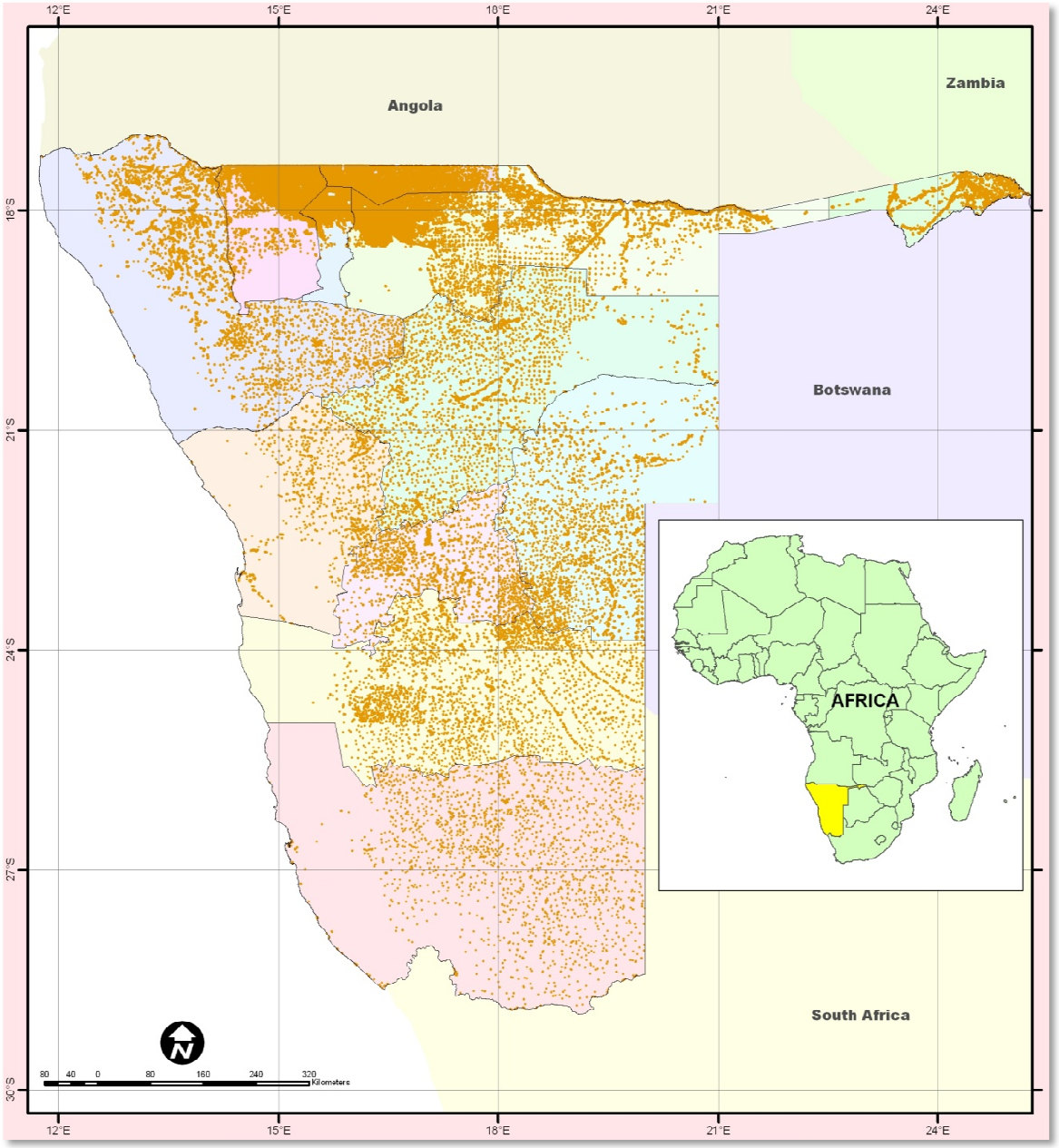
Map A: Areas included (brown) and excluded (yellow) from the 2010 REDMP Study

A Locality is defined as any rural location that has Government buildings. Any homesteads within a 500 meter radius of a prospective transformer point also forms part of such a Locality. It was recognized however that, if only the above definition is adopted, some parts of the country would no longer benefit from the roll-out of the REDMP, as most Government buildings would be electrified within the coming 10 year horizon. In order to ensure a fair and continuous benefit from the implementation of the REDMP across all regions, the definition was then further expanded to

accommodate locations where *at least 10 or more homesteads fall within a 500 meter radius of a prospective transformer point.*

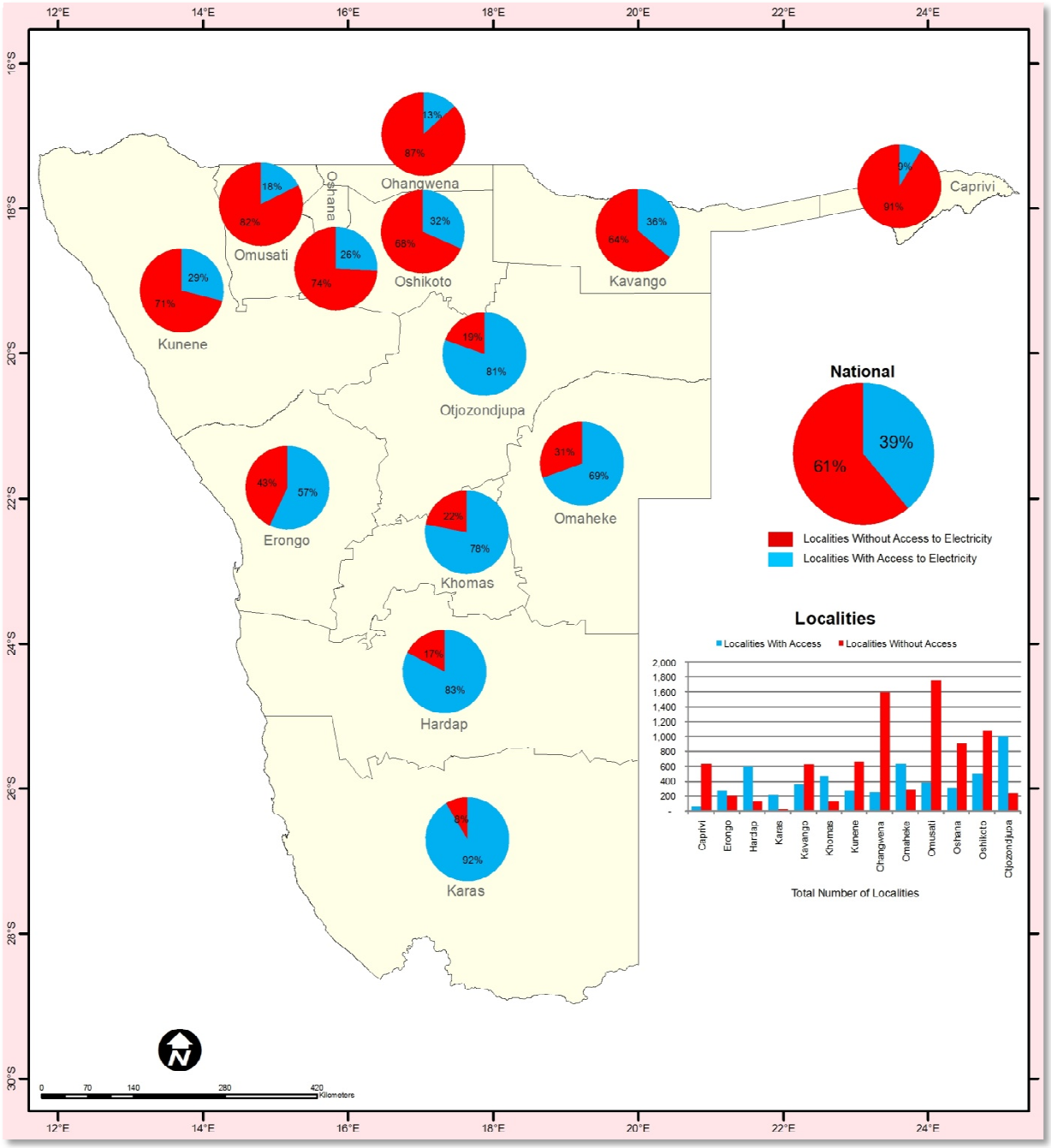
Approach and Methodology

GIS (Geographical Information System) was used as a platform to manage the multitude of datasets that were collected, but also as a planning tool because of the ability to geographically reference and display datasets for further manipulation and management of the network planning process. All identified rural homesteads and building structures were mapped as points, as is seen in Map B, to create representative Locality points based on their spatial location. Rural homesteads represent 63% of all identified homesteads (which includes urban homesteads otherwise excluded from the Study) in Namibia.



Map B: Mapped rural homestead points, REDMP 2010

Further GIS manipulation revealed that 16% of rural homesteads and 61% of Government buildings currently have access to electricity, with varying levels of access per region. Map C shows regional access to electricity for the representative Locality points. A rural homestead is classified as having *access to electricity* if it is either connected to the grid, or falls within 500 meters of a low voltage (LV) grid connection point, i.e. step-down transformer. In such cases, the homestead is considered to be able to be connected to the national grid through private funding as the cost of grid connection is deemed to be relatively low.



Map C: Localities with and without Access to Electricity in 2010, as defined by the Study area

Localities identified for grid electrification were prioritised based on a points score system, which considers the infrastructure within the Locality, thus ensuring that Localities with infrastructure deemed important depending on national priorities (schools, health centres and other Government buildings) rank high on the priority list. For this purpose, a fully automated priority model was developed which computes the most cost-effective electrification sequence to expand and develop networks to the identified Localities in order of their relative priorities.

An important aspect of master planning has been to ensure that industry standards in respect of existing load, future load forecasts and reliability requirements are achieved. Simulations were used to assess the ability of the existing and planned network infrastructure to meet these standards, and allow the planner to anticipate how much power must be delivered, as well as where and when it will be needed.

An optimised annual electrification programme and associated national budget and budget for each region constitutes the main output of the priority model, and includes information on:

- all names of Localities to be electrified
- associated electrification costs
- number of homesteads, schools and other infrastructure connected
- transformer capacity added
- distance in kilometres of electrical network added
- estimated cost per connection, and
- the energy consumption added.

The budget required for the annual electrification programmes is computed by the priority model. It is noted that the method applied in this REDMP differs from the algorithm used in previous studies, which provided a predetermined budget as input parameter.

Main Outputs and Findings

The 2010 REDMP update therefore envisions how and when rural areas will be electrified in the coming 20 years. It is a systematic and rational tool. If implemented as projected, the implementation of the master plan will ensure that national electrification targets can be met, while remaining within forthcoming annual electrification budgets. Fundamental to reaching the set targets is the assumption that electrification programmes can be followed and implemented properly, and done so in a timely manner. Although plans have been put in action to mitigate this, it will continue to be a challenge for the MME for at least the short term.

Based on a prioritised and most effective building sequence, this REDMP foresees the systematic electrification of 2,879 rural Localities. Within these is included 740 Government buildings, 642 of which are schools, and 59,774 rural homesteads. The total budget for the 20-year programme amounts to N$ 1,473,361,699, which translates to an annual budget of N$ 73,668,085[1].

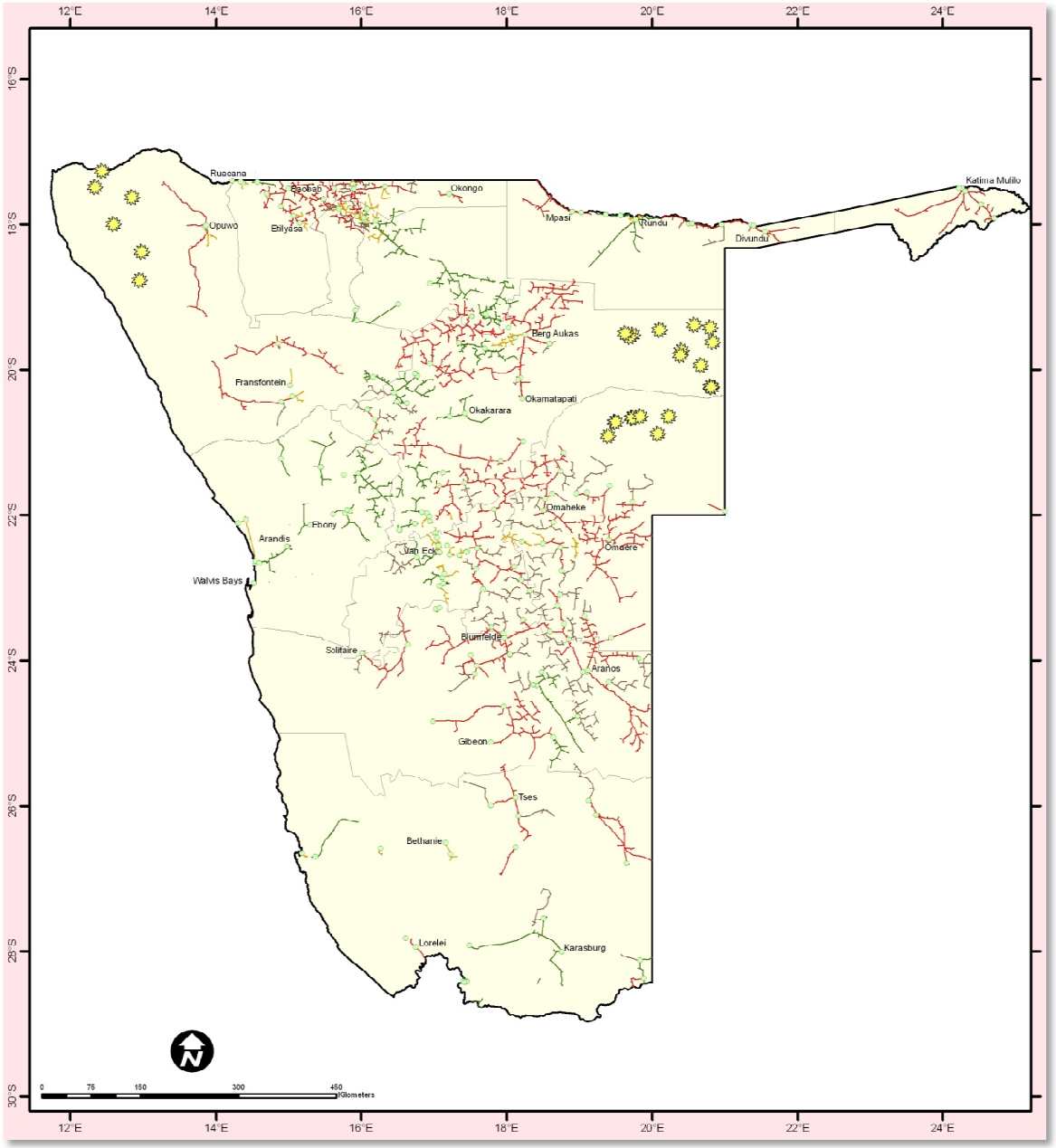
The MME set the target that all Government buildings, and especially schools, are to be electrified in the next 20 years. More specifically, the REDMP was developed to ensure that the MME is able to

[1] These values are as at 2011. The annual estimated budget is an average value. Regional reports show the actual budget required per region per year. Figures do not include escalation due to inflation.

electrify a total of 642 rural schools and 98 other Government buildings, representing 39% of the baseline number of Government buildings identified in 2010. The total of 59,774 rural homesteads to be connected in the 20-year period represents 21% of the total baseline number of rural homesteads identified in 2010. Should the plan be implemented in its entirety, the total number of rural homesteads with Access to Electricity will have increased to 104,362 by 2031.

The 2010 REDMP identifies a number of Localities for Off-Grid electrification[2]. Generally, such Localities are situated in remote parts of the country, are often disproportionally costly to electrify and face additional technical constraints. As such, Off-Grid Localities are unlikely to be provided with a conventional grid connection in the foreseeable future. A total of 27 Localities, having 17 schools, are earmarked for Off-Grid electrification, located in regions Kunene (6), Otjozondjupa (13) and Omaheke (8), as shown in Map D.

[2] Even though outside the scope of the 2010 REDMP, renewable energy sources and associated technologies are regarded as an integral part of Namibia's rural electrification strategy which aims to improve access to safe, affordable and energy to all.



Map D: Existing distribution networks and location of identified Off-Grid Localities (marked as yellow dots), REDMP 2010

The impact and relevance of the REDMP can best be determined by way of a continuous monitoring and evaluation programme which accompanies the electrification projects throughout the country, as and when they are implemented. A monitoring and evaluation programme would also provide a platform on which the plan can be updated and/or amended in a timely and relevant manner, long before the next review is undertaken. In this way, improvements and adjustments of the plan can be made, based on actual field experience during the roll-out of the plan, and in regular consultation and following the feedback from relevant stakeholders. Establishing a regular monitoring and evaluation

process is therefore an important part of improving rural electrification in Namibia, while it will also ensure that the gains made in the past years can continue to generate benefits for the country's ongoing development.

Financial and Economic Analysis

The Government's rural electrification programme commenced in 1992, to date representing 20 years of electrification. During the period 2005 to 2010 alone, a total of N$ 235,756,738 was invested in rural electrification from various funding sources. This translates to a significant infrastructure creation and expansion drive. A financial and economic analysis was therefore undertaken as part of the 2010 REDMP to identify and quantify the impacts of the infrastructure expansion on the Namibian Electricity Supply Industry.

The financial analysis shows that the impact of the REDMP is by far largest on NORED, thereafter on CENORED and the Central and Southern parts of Namibia. The impact on Erongo RED is relatively small. Assuming that the electricity distributors will be able to recover the cost of operating and maintaining the rural electrification assets from their entire customer base, it is estimated that for NORED all its customers will pay around 10% more than they would have done without the rural electrification assets and customers. The price premium at CENORED is estimated at 6%, with 3% for Central and South and around 0.5% for Erongo RED. Around 60,000 customers will be added to the distributors, of which over 50,000 will be in the NORED area.

The economic analysis indicates that the introduction of rural electrification (including the cost of rural electrification assets) has a value-reducing effect on all distribution entities. This is echoed by the financial indicator that the price of electricity to all consumers will have to be raised by up to 10% due to rural electrification. From a national perspective, it is estimated that each rural electricity connection needs to generate an economic benefit of around N$1,610 per annum (in 2011 terms) for the rural electrification programme to create more benefits than costs.

Way Forward

Namibia's 2010/2011 budget included significant expenditure for ongoing national development. Of significance to the country's electricity sector is that a considerable part of the Ministry of Mines and Energy's budget was allocated to the electricity sub-sector, and more specifically rural electrification and the hydro-electric power project at Baynes.

The initiatives by the Ministry will continue to shape the country's power sector in future. Other important developments will include the continued consolidation in the industry, to create sector-wide benefits by reducing fragmentation and leveraging economies of scale.

NamPower, as Namibia's generation, transmission and systems operator, faces significant uncertainties and risks which are related to the multitude of challenges faced by the electricity supply situation in Southern Africa. In addition, the country's electricity distribution sector has not yet reached maturity, and questions in regard to the structure of the future distribution industry remain.

The 2010 Rural Electricity Distribution Master Plan update is seen as an integral part and objective tool to form the backbone of and steer strategies for the future development of the electricity supply

industry, targeted specifically at reaching the Government's set goals for rural electrification in the coming 20 years.

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Abbreviations

AC	Alternating Current
ADMD	After Diversity Maximum Demand
CAD	Computer Aided Design
CBS	Central Bureau of Statistics
CENORED	Central-North Electricity Distribution Company
DC	Direct Current
ECB	Electricity Control Board of Namibia
Erongo RED	Erongo Regional Electricity Distribution Company
ESI	Electricity Supply Industry
GIS	Geographical Information System
GLF	Geographical Load Forecasting
GPS	Global Positioning System
GRN	Government of the Republic of Namibia
GWh	Gigawatt hour, a unit for energy
kV	Kilovolt
kVA	Kilovolt-ampere, a unit for apparent power
kW	Kilowatt, a unit for active power
LPU	Large Power User
LV	Low Voltage (220 V - 1,000 V)
MME	Ministry of Mines and Energy
MRLGH	Ministry of Regional and Local Government and Housing and Rural Development
MV	Medium Voltage (> 1,000 V - 33,000 V)

MW	Megawatt, a unit for active power
NENA	Namibia Electrical Network Asset Register
NIDS	Namibia Intercensal Demographic Survey
NORED	Northern Electricity Distribution Company
NPC	National Planning Commission
RE	Rural Electrification
RED	Regional Electricity Distributor
REDMP	Rural Electricity Distribution Master Plan
SG	Surveyor General
SWER	Single Wire Earth Return
V	Volt, SI derived unit for electric potential, electric potential difference, and electromotive force
Var	Volt-ampere reactive, a unit which is the imaginary counterpart of the watt

1 INTRODUCTION

1.1 Background

The Rural Electricity Distribution Master Plan (REDMP) for Namibia was originally introduced in the year 2000. The formulation of this initial plan and why it remains effective requires a clear understanding of the context in which the plan evolved, and in which the 2010 REDMP update is implemented.

Following the historic achievement of the country's independence in 1990, the Government of the Republic of Namibia set out to formulate a policy agenda to guide the social upliftment of the people and economic development of the nation. The establishment of the Namibian Development Plan was seen as a critical first step toward these goals. The initial energy programme represented an important element in the overall development direction of the nation.

Electrification projects initially commenced in the most densely populated northern regions of Namibia, and progressed clockwise around the country. Although the rural electrification programme had significantly extended electricity supplies to rural areas, only 9% of rural homesteads had an electricity connection in 1997. It was estimated that more than 75% of urban homesteads used electricity. Rural areas were defined[3] as those which fall outside the proclaimed municipal areas and include diverse settlement types ranging from commercial farms to communal areas. Although Namibia's urban areas were showing signs of rapid growth, 73% of the population lived in rural areas, where the dominant economic activity was subsistence farming.

In recognition of the need for further policy development of the initial energy programme, the Ministry of Mines and Energy (MME) set out to produce a comprehensive policy to guide the sustainable development of the country's energy sector. The White Paper on the Energy Policy of Namibia was promulgated in 1998, and embodied the commitment of the Government to ensure that the energy demand by the productive sectors of the economy would continue to be met through reliable competitively priced energy supplies, while giving special attention to those sectors of society that had historically been neglected, namely, poor urban and rural homesteads.

Policies proposed for these homesteads included those for increasing access to electricity (as well as other commercial fuels). They also sought to meet development challenges through improved access to renewable energy sources. Generally, not enough was known about the problems and needs in the energy sector, and so national studies were initiated as a basis for future policy development. A rural electrification fund was also established.

One of the main findings was that a large portion of homesteads in rural areas live in poverty, and are characterised by an inadequate provision of social services, which amongst others include health care

[3] As per the Local Authorities Act No 23 (1992).

and education. While the provision of electricity to community centres and villages in rural areas was a priority goal of the Government, increased rural access to electricity was hampered by a lack of financial and skilled human resources, a lack of clarity of the roles and responsibilities in the public sector and the electricity distribution industry, and limited knowledge about rural homestead income and energy use patterns. As a result, rural electrification was predominantly driven by socio-political factors.

Criteria, methodologies and prioritisation processes for rural electrification had to be improved, including the targeting of social institutions such as schools and clinics. Selection of priority areas, as well as the choice of the most appropriate means of electricity supply, had to be based on objective evaluation criteria, taking into account expected financial, economic and social impacts. Master plan studies and the outcomes thereof provide this important planning base for the preparation and implementation of future electrification projects.

In order to provide a tangible contribution towards improving the socio-economic situation in rural areas, it was the Government's intention to increase rural electricity connections from 9% (in 1997) to at least 25% by 2010. In 1998, EMCON Consulting Group was appointed by the MME to conceptualise and develop the first 20-year REDMP for Namibia, which provided a structured and objective approach to ensure cost-effective and well-defined planning guidelines to direct this national endeavour. Software-based planning tools included a prioritisation model to determine objective building sequences for electrification projects, based on electricity demand and costs. The REDMP provided the functionality to enable utilities and network planners to re-evaluate the electrification programmes as circumstances and priorities change.

Updates are required on a 5-yearly basis, due to the more conceptual nature of the 20-year REDMP designs. The original REDMP was reviewed and updated in 2005, to ensure that growth, new developments and changing priorities are taken into consideration and adequately provided for. The 2010 REDMP update again assesses the level of achievements and progress made in the last 5 years, and provides the planning framework of where and when electrical infrastructure needs to be created, to meet the future aspirations and goals of the Namibian Government in terms of rural electrification.

1.2 Aims and Objectives

The main aims of the 2010 REDMP are to:

- establish the status quo with regards to the planned versus achieved electrification of rural communities from 2005 up until 2010
- establish rural electrification targets and priorities for the next 20 years, and
- establish a structured methodology and approach to derive a rural electrification master plan for achieving the 20-year targets.

It is essential to have a good understanding of the extent to which electrification targets have been met in the past, as well as the factors that have influenced progress. In this regard, the important objectives are to:

- obtain a clear understanding of the existing conditions in the power supply and distribution sectors, and how this affects rural electrification in general
- review the 2005 REDMP, with special attention to the targets that were defined and whether these were achieved, and
- identify any shortcomings in previous studies and the way electrification projects in recent years were approached.

The 20-year electrification targets and main rural electrification priorities determine how the REDMP is formulated and what the main focus areas should be. In defining these, the main objectives of the 2010 REDMP are to:

- ensure that the 2010 REDMP update accurately captures and addresses the client's requirements
- encourage stakeholder involvement, to avoid misunderstandings and allow for informed decisions relating to priorities and targets
- meet both the present and future electricity demands of the rural communities identified in the plan
- have well-defined and measurable national electrification targets (which include regional points of view), and
- develop a realistic and practical prioritisation process.

The end goal of the 2010 REDMP review and update is the generation of an objective 20-year electrification programme through which rural Government institutions and villages will be electrified, by when these will be supplied with electricity, and what the associated costs will be. This is achieved through the process of:

- gathering the latest demographic and rural electrification information and data
- compiling a comprehensive and integrated database that can be manipulated and managed for further studies and analyses

- identifying all Government buildings, homesteads and other infrastructure in rural areas that require electricity supply
- developing proper methodologies, prioritisation and financial models, and the associated monitoring and review processes
- designing a robust overall electrification concept to ensure that planning is guided and remains cost effective
- presenting the results in a clear and logical manner so as to enable the client to effectively implement the required electrification projects
- clarifying the respective roles of all stakeholders and electricity distributors involved, and
- providing a software-based planning tool that allows the electrification programme to be updated as circumstances and priorities change in time.

Although the 2010 REDMP Study is seen as an update of previous REDMPs, the Consulting Team approached the Study within the context of present day circumstances and most probable future trends, and as such sought to improve existing criteria, methodologies and processes wherever possible.

1.3 REDMP Study Framework

The framework presented here describes the main tasks and activities that were carried out as part of the REDMP Study:

- An inception meeting with the client was held wherein the initial project scope was refined and finalised, and a detailed work programme presented;
- A stakeholder workshop[4] was held to present the project approach, obtain stakeholder buy-in and lobby support with regards to data required to complete the Study;
- Subsequent progress and technical clarification meetings were held when required;
- The 2005 REDMP was reviewed and assessed in terms of goals set and whether these were achieved to determine special focus areas for the update Study;
- All relevant data (which includes information on the existing customer base and electricity distribution infrastructure) was gathered through stakeholder consultation and field surveys;
- The collected data was digitised and captured into the GIS (Geographical Information System) platform for geographical reference, manipulation and management;

[4] A total of 51 stakeholders of 26 organisations and Government agencies attended the workshop.

- All un-electrified Government buildings and homesteads were identified from the GIS for electricity supply;
- Planning tools were developed, including the prioritisation and point score models, for generating a phased electrification programme;
- Scenarios were developed through demand forecasting and applying prioritisation and application of the off-grid criteria;
- Network extensions and upgrades were planned and modelled, which formed part of an iterative process. Costing was included;
- Following the network planning phase, the Study included development of a financial model and economic assessment. The financial and economic impacts of the proposed rural electrification plans were analysed; and
- The Study concludes with submission of the updated REDMP report made up of a national overview and 13 regional reports detailing the main outputs and findings of the study.

1.4 Outputs

The 2010 REDMP update consists of a National Overview Report as well as regional reports for each of Namibia's 13 regions.

The National Overview Report (this report) provides a summary of the 20-year electrification programmes for each of the 13 regions, and considers the financial and economic impacts of the proposed plans. It includes details on the approach and methodologies that were developed as well as the criteria and planning tools used in the Study. An important aspect of the National Overview Report is the discussion of the main findings and recommendations, as well as the implementation challenges.

The regional reports focus more on the implementation of the proposed electrification plans, and therefore only include a brief overview of the approach, methodologies and general technical evaluation undertaken. The 20-year electrification programme (including the estimate costing thereof) is presented in tabular form, and detailed sections on the key features, recommendations and an outlook on the regional level is provided.

National and regional maps are used extensively to display the electrification plans developed as part of the REDMP Study, and to illustrate the prioritisation process and other relevant information, making reference to the relevant geographical locations addressed in the plan. Detailed technical information is included in the form of annexes.

2 DEFINITIONS AND KEY CONCEPTS

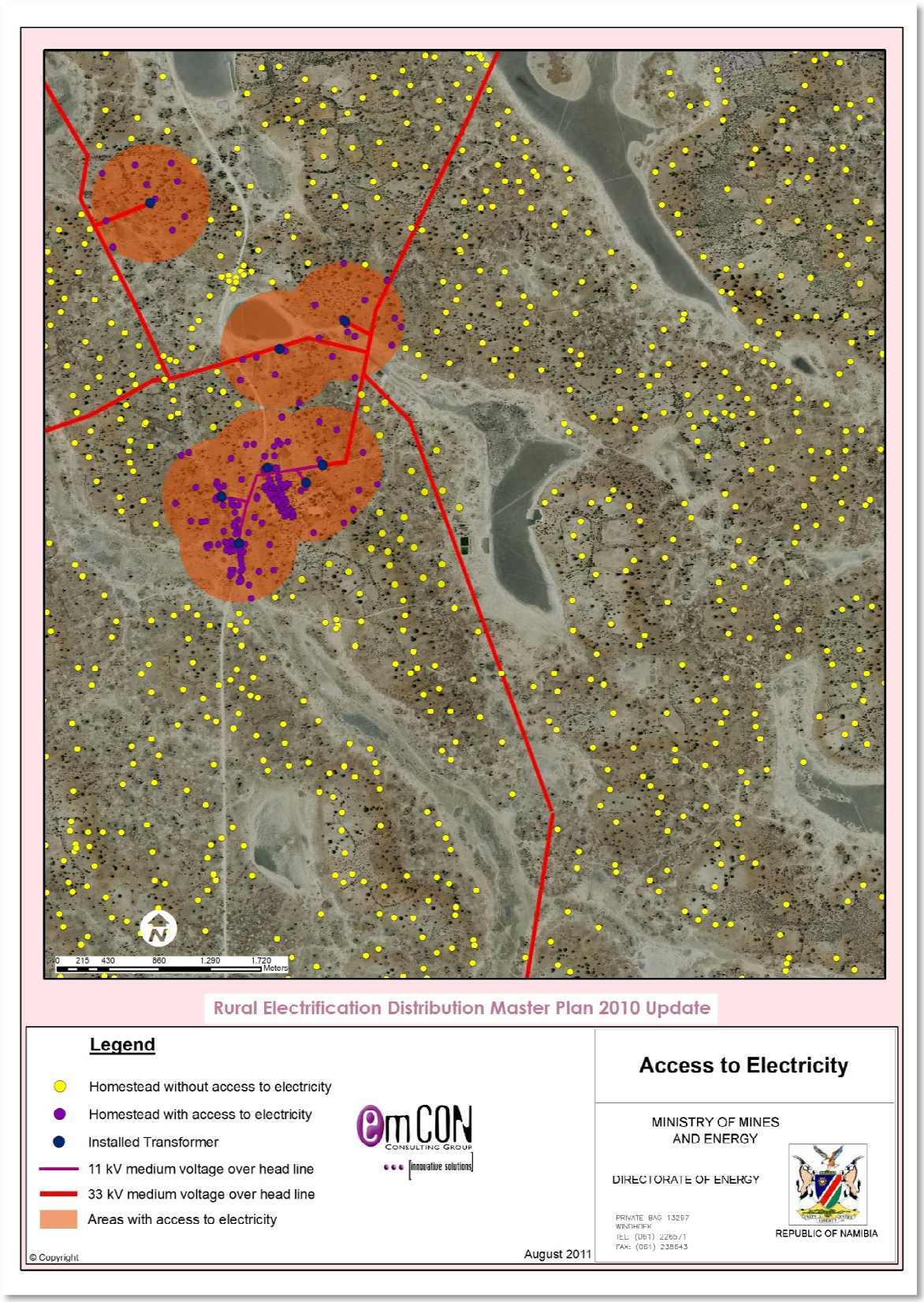
This section presents the key definitions, concepts and terminology that are used throughout the REDMP reports. These are defined and described to provide the reader with an unambiguous understanding of how they are used and interpreted in the REDMP.

For ease of reference, the terms are capitalised throughout the National Overview Report, and the regional reports.

2.1 Access to Electricity

A rural homestead is classified as having Access to Electricity if it is either connected to the grid, or falls within 500 meters of a low voltage (LV) grid connection point, i.e. step-down transformer. In such cases, the homestead is considered to be able to be connected to the National Grid through private funding, as the Cost of Grid Connection is deemed to be relatively low. Subsection 6.2.6.2 provides a breakdown of the Cost of Grid Connection.

Map 5 illustrates the definition of Access to Electricity, and how it is applied in the present REDMP.



Map 5: Rural homesteads classified as having Access to Electricity, REDMP 2010

2.2 ADMD

The After Diversity Maximum Demand (ADMD) is the average load per customer, which is determined by dividing the group maximum demand by the number of customers in the group. This provides a diversified per consumer demand result that can be used when undertaking network and growth planning.

The resulting ADMD figure per consumer is less than the individual consumer maximum demand, which is the result of different usage patterns. Not all consumers will reach their individual maximum demand consumption at the same time. The combined usage profile will have a maximum demand that is indicative of the group.

To illustrate, a typical example of the ADMD for rural electrification consumers is as follows: when 100 rural electrification type homesteads are considered, their maximum demand for a typical day and as measured on the feeder is 50 kVA. Therefore, the per consumer ADMD is the ratio of the feeder maximum demand divided by the number of homestead connections, i.e.

$$\begin{aligned} ADMD &= feeder\_md/number\_of\_connections \\ &= 50\ kVA/100 \\ &= 0.5\ kVA \end{aligned}$$

2.3 Cost of Grid Connection

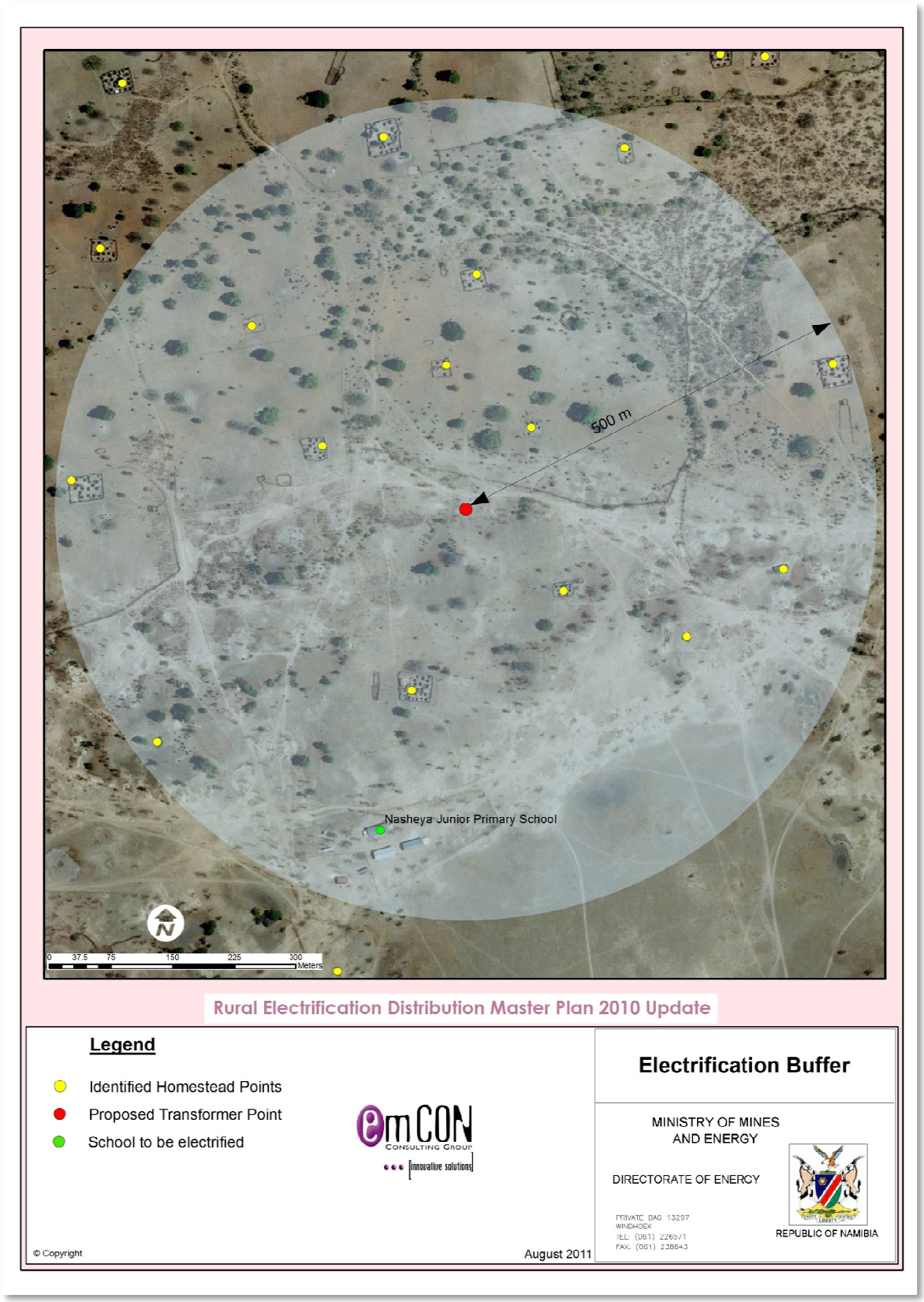
This subsection is included to provide some background on the costs of grid-based electrification in rural areas, and the factors that influence it.

One of the main constraints of rural grid based electrification is the issue of cost. The capital cost of the distribution system is usually high, and electrical demand in rural areas is often low. Homesteads can be widely dispersed, and often rural consumers will only want to use a few light bulbs and a radio in the evening. The cost-benefit relationship shows that there is little incentive for an electricity utility to extend the grid into remote rural areas. Often, rural Government buildings will be electrified, but the network will then stop there or bypass the more remote villages.

The Cost of Grid Connection is influenced by the supply voltage and proximity of the existing grid, and whether there is a step-down transformer already serving the area in question. Homesteads cannot be connected directly to high voltage transmission lines, and require a step-down transformer (which if not already installed, has significant cost implications) for the conversion to the end consumer voltage. Subsection 6.2.6.2 provides more information on the costs involved.

2.4 Locality

A Locality is defined as any rural location that has Government buildings. Any homesteads within a 500 meter radius of a prospective transformer point also forms part of such a Locality. It was recognised however that, if only the above definition is adopted, some parts of the country would no longer benefit from the roll-out of the REDMP, as most Government buildings would be electrified within the coming 10 year horizon. In order to ensure a fair and continuous benefit from the implementation of the REDMP across all regions, the definition was then further expanded to accommodate locations where *at least 10 or more homesteads fall within a 500 meter radius of a prospective transformer point.* Map 6 illustrates this definition.



Map 6: The 500 meter electrification buffer that defines a Locality, REDMP 2010

2.5 National Grid

A National Grid is an interconnected network of power lines which allows the transmission and distribution of electricity from the suppliers to the consumers. The National Grid can be connected to a single power source or electricity generating plant but is usually linked to other plants to provide a more flexible and reliable network.

After electricity has been generated, the voltage has to be stepped up (to a high voltage) for transmission, using a transformer, and then stepped down (to a lower voltage) for distribution and end use, which again requires a transformer.

Electricity is usually transmitted at very high voltage, typically several hundred thousand volts (depending on the power transmitted, national guidelines, etc.) as this reduces losses and means that smaller cables can be used, which in turn reduces the overall cost of the network.

Bulk electricity is transmitted in three-phase, alternating current (AC; 50 cycles per second) and depending on the end user requirements, is distributed as three-phase or single-phase power. Transmission by direct current (DC) is also used. Although losses associated with DC electricity are lower than for AC, additional costs are incurred as heavy duty rectification is needed to eventually supply AC electricity to the end consumer.

Typical consumer voltages are 400 V for three-phase, and 230 V for single-phase electricity supply. Three-phase electricity is used for higher power equipment (such as factory or workshop machinery), whereas domestic electricity supply is usually single-phase.

2.6 Off-Grid Locality

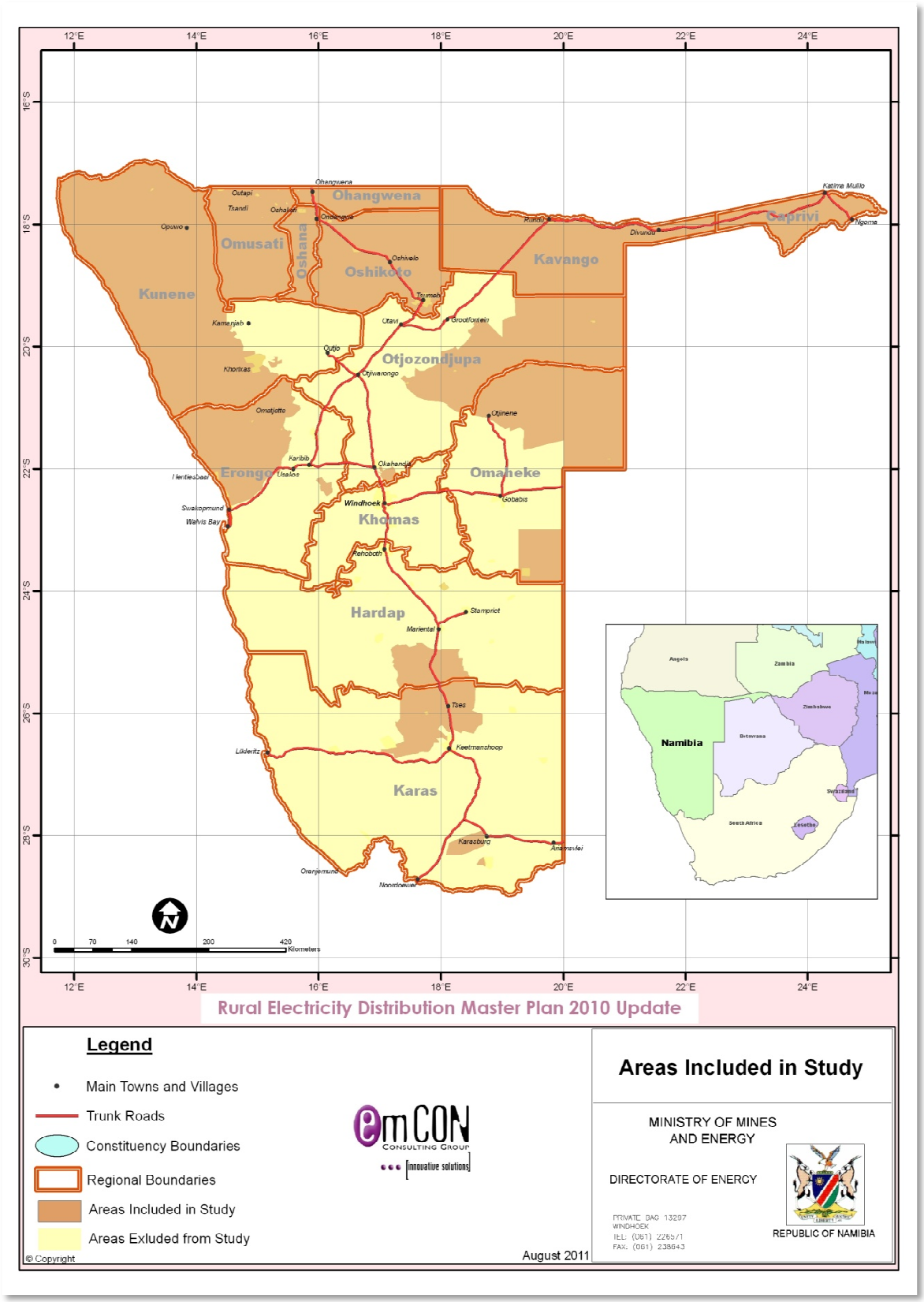
A locality is defined as an Off-Grid Locality if it will not be supplied with electricity from the National Grid. The REDMP allows the user to identify and decide on whether a locality is an Off-Grid Locality.

Generally, if a locality is located in a very remote part of Namibia (i.e. far from the existing National Grid) and is very isolated (as determined by the Locality density along the network route and the surrounding population density is very low) and is therefore unlikely to be provided with a conventional grid electricity supply within the next 20 years, it is defined as an Off-Grid Locality.

2.7 Rural Areas

For purposes of the 2010 REDMP Study, *Rural Areas are defined as those communal areas that fall outside the proclaimed municipal areas and commercial farms*. A map of the areas that are included and excluded from the REDMP is presented in Map 7.

It is important to note that, even though only the areas as defined above are considered for rural electrification, relevant data was collected and digitised for the entire country.



Map 7: Areas included and excluded from the 2010 REDMP Study

3 NATIONAL RURAL ELECTRIFICATION PRIORITIES

There are many factors that influence the timing and sequence of an electrification programme (i.e. which Localities are electrified first). These factors include, amongst others, the national development policies, the country's energy policies, priority areas, the availability of generating capacity, the question of how electrical supply and demand can be met, network development, technology options, load management, pricing and funding and others. It is therefore essential that the process of developing an REDMP is guided by clear and well defined priorities.

The 2010 REDMP update is first and foremost a master plan for the whole of rural Namibia – i.e. all rural communities should be taken into account. In line with this overall design objective, the national rural electrification priorities for the 2010 REDMP are defined as:

- Government buildings, and especially schools, are to be prioritised within the REDMP
- all rural Localities are to be considered for electrification within the next 20 years
- identified Localities are to be prioritised, to ensure that as far as technically possible, at least one Locality per constituency is electrified per year for the next 20 years
- the rural electrification programme for a specific region is to conclude if all identified Localities within that region have been electrified (even if this occurs within the next 20 years), and
- Off-Grid Localities are to be identified and listed, but will not be electrified as part of the REDMP.

Apart from the priorities related specifically to Government buildings and villages in rural areas, the 2010 REDMP update is to:

- take into account the recent developments in the Namibian Electricity Supply Industry (ESI), which might demand changes in the approach of implementing rural electrification projects, and
- propose network upgrades (i.e. the strengthening of the existing networks) and extensions that comply with contemporary planning methodologies, standards and policies used by the MME, NamPower, the REDs and the Ministry of Regional and Local Government and Housing and Rural Development.

The prioritisation approach and methodology, and associated outcomes, are further described in Section 6.

4 NATIONAL PROFILE

4.1 Geographic Setting

The Republic of Namibia is a vast, sparsely populated country situated along the south Atlantic coast of Africa, between 17 and 29 degrees south of the Equator.

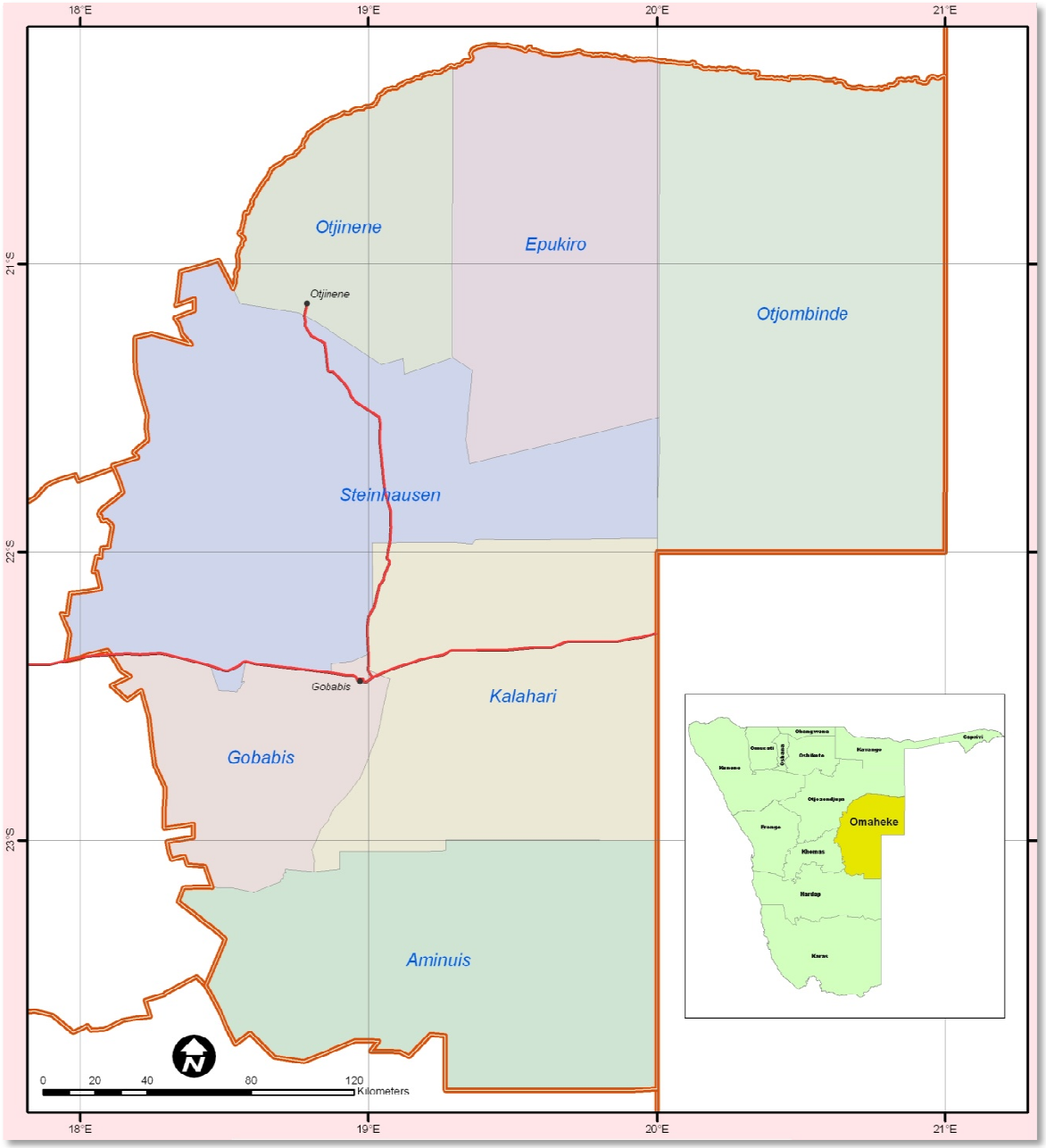
With its surface area of 825,235 km^2, Namibia is the 34^{th} largest country in the world. It stretches for about 1,300 km from south to north, and varies from 480 km to 930 km in width from west to east. Namibia is bordered by South Africa in the south, Angola and Zambia in the north and Botswana and Zimbabwe in the east. The oldest desert in the world, the Namib Desert, stretches along the entire west coast of the country, while the Kalahari Desert runs along its south-eastern border with Botswana and South Africa.

The country is demarcated into 13 regions, namely:

- the Caprivi, Kavango, Kunene, Omusati, Ohangwena, Oshana and Oshikoto regions in the north
- the Omaheke, Otjozondjupa, Erongo and Khomas regions in the central areas, and
- the Hardap and Karas regions in the south.

The country and its regional boundaries is shown in Map 8. The 13 regions are further subdivided into 107 constituencies. To illustrate, Map 9 shows the Omaheke region and its constituencies.

Map 8: Geographic setting of Namibia and its 13 regions



Map 9: Example of a typical region and its constituencies in Namibia

4.2 Population Demography

The 2011 Census results were unavailable at the time of the REDMP update. Therefore, the results that are presented here were obtained from the 2006 Namibia Intercensal Demographic Survey (NIDS), which was carried out in November 2006. The various estimates presented were derived from

a sample of the surveyed population. As in any survey, these estimates are subject to both sampling and non-sampling errors.

4.2.1 Population Size and Growth

The 2006 NIDS survey[5] estimated the Namibian homestead population to be 1,952,454, in 419,804 homesteads. The population growth rate between 2001 and 2006 was estimated to be 2 percent per annum, with urban regions growing faster than rural regions. The distribution of the population, and the estimated growth rate between 2001 Census and the 2006 NIDS by urban and rural areas, and by regions, is shown in Table 1.

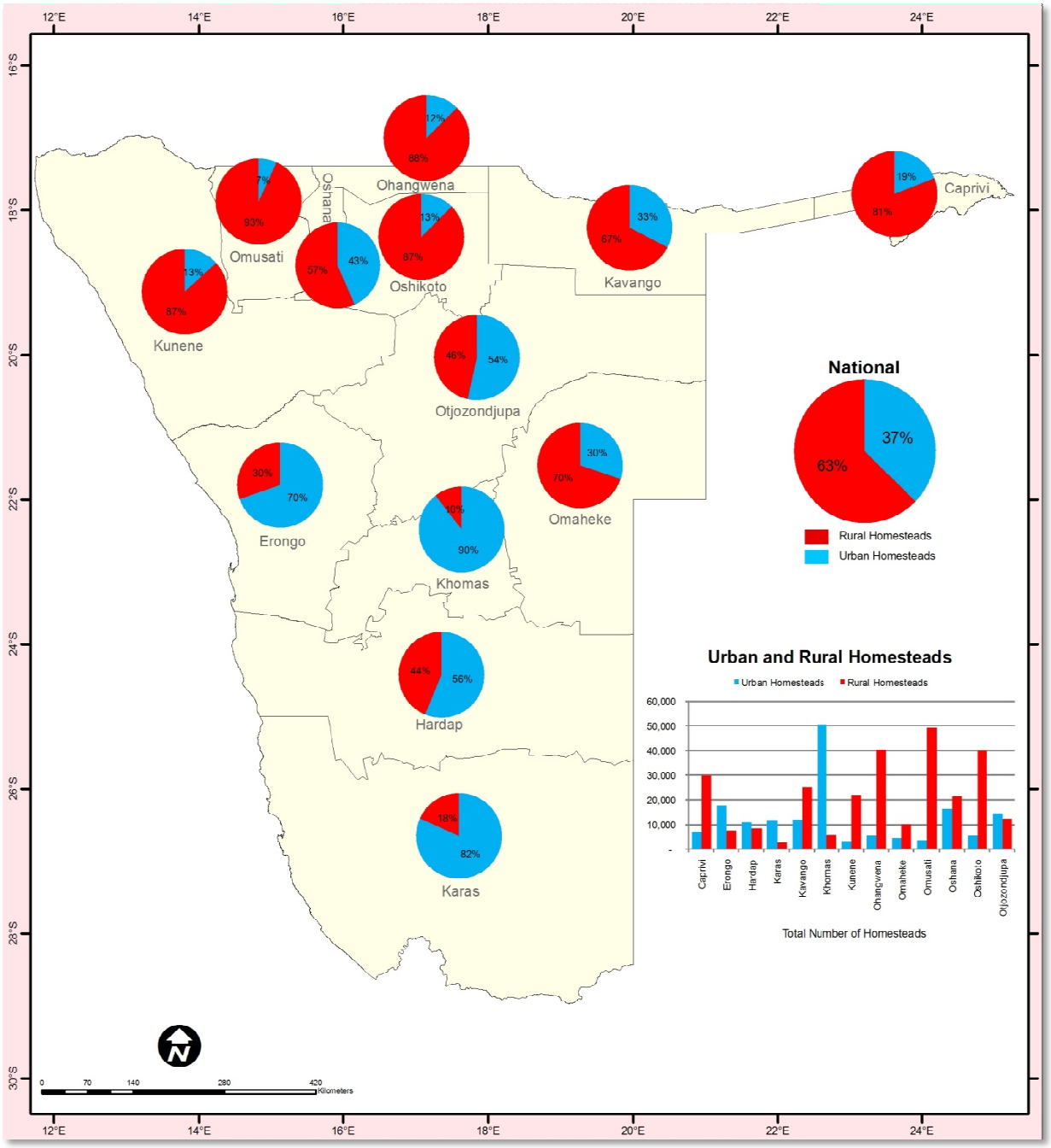
[5] 2006 Namibia Intercensal Demographic Survey (NIDS), as on 19 November 2006.

Table 1: Population distribution, urban vs. rural homesteads, and percentage population growth rate by area from 2001 to 2006, Namibia

Area	*Homestead Population 2001 [persons]*	*Homestead Population 2006 [persons]*	*Average Annual Growth Rate [%]*
Namibia	1,773,235	1,952,454	2.0
Urban	578,812	695,268	3.7
Rural	1,194,423	1,257,186	1.0
Caprivi	78,785	85,224	1.6
Erongo	103,180	134,966	5.4
Hardap	66,028	74,495	2.4
Karas	64,039	64,872	0.3
Kavango	198,963	237,657	3.6
Khomas	243,585	301,050	4.2
Kunene	66,385	76,329	2.8
Ohangwena	226,416	247,103	1.7
Omaheke	66,779	60,773	-1.9
Omusati	226,337	224,256	-0.2
Oshana	158,181	159,827	0.2
Oshikoto	158,352	161,102	0.3
Otjozondjupa	116,205	124,800	1.4

From Table 1 above it is evident that more than half (64.4%) of Namibia's population live in rural areas. Urban areas have a higher growth rate (3.7%) when compared to rural areas (1%). There is a distinct migration of people from rural- to urban areas. At a regional level, the Erongo and Khomas regions recorded the highest annual growth rates of 5.4 and 4.2 percent respectively, while Omaheke and Omusati recorded a negative growth rate during the same period.

The rural and urban distribution of homesteads, as derived from the 2010 REDMP Study, is shown in Map 10.



Map 10: Rural and urban distribution of homesteads, REDMP 2010

4.2.2 Homestead Size

Based on the 2006 NIDS, the average homestead size in Namibia is estimated to be 5 persons. In urban areas, the average homestead size is 4 persons, whereas in rural areas more than 5 persons inhabit a homestead.

It is further observed that most regions in Namibia's north and north-eastern have larger homesteads than those in the south. The average homestead size in both the Kavango and Ohangwena regions is above 6 persons. Erongo, Karas, Khomas and Omaheke are the only regions with an average homestead size below 4 persons.

Table 2 shows the estimated homesteads and population used to calculate the average homestead size for Namibia, the urban- and rural- as well as regional homesteads.

Table 2: Average homestead size by region in 2006, 2006 NIDS

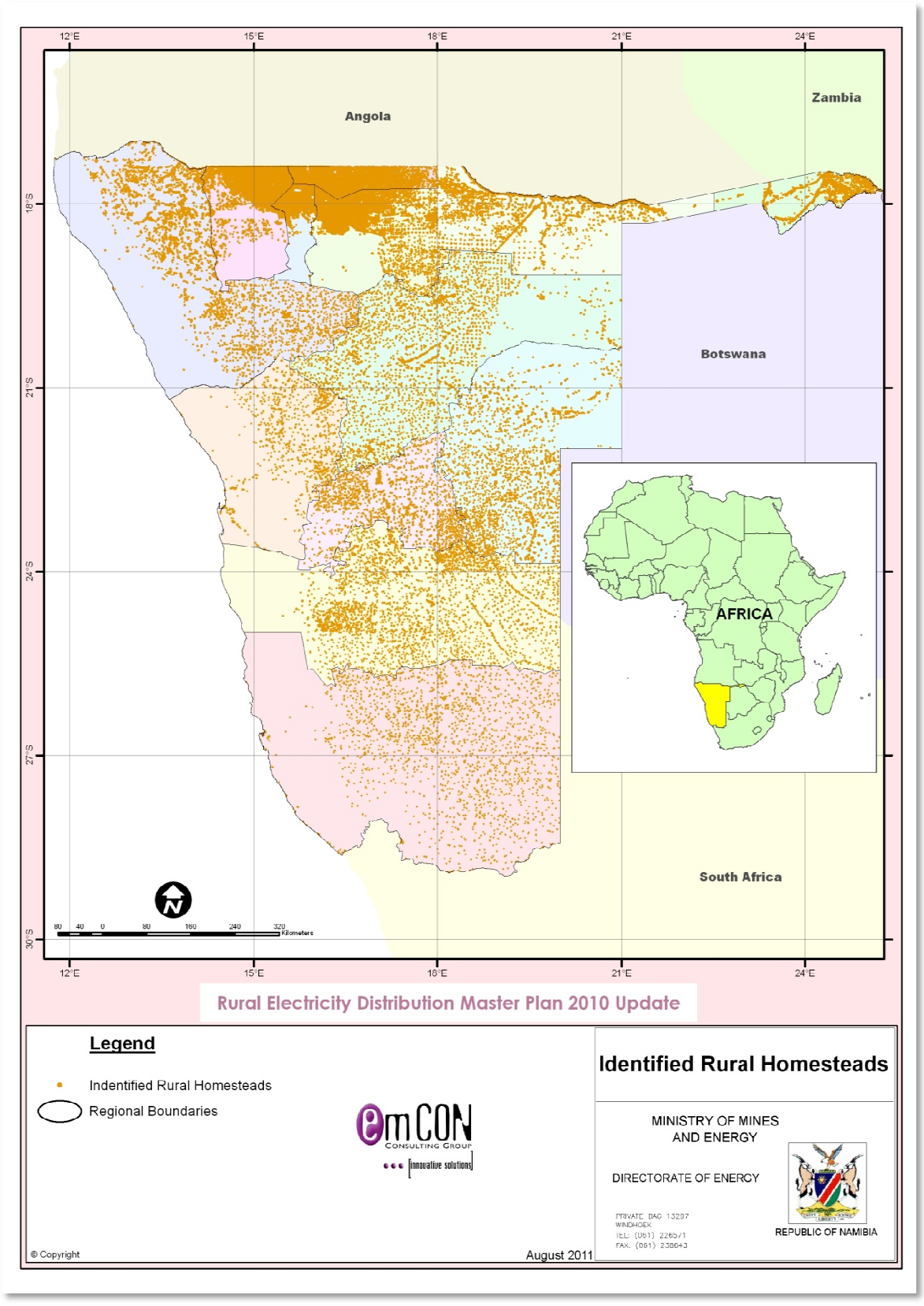
Area	*Homesteads*	*Population*	*Average Homestead size*
Namibia	419,804	1,952,454	4.7
Urban	179,603	695,268	3.9
Rural	240,202	1,257,186	5.2
Caprivi	19,270	85,224	4.4
Erongo	42,801	134,966	3.2
Hardap	17,832	74,495	4.2
Karas	16,788	64,872	3.9
Kavango	34,111	237,657	7.0
Khomas	77,604	301,050	3.9
Kunene	16,236	76,329	4.7
Ohangwena	40,174	247,103	6.2
Omaheke	15,885	60,773	3.8
Omusati	42,044	224,256	5.3
Oshana	34,366	159,827	4.7
Oshikoto	31,626	161,102	5.1
Otjozondjupa	31,069	124,800	4.0

4.2.3 Population Distribution and Density

Table 3 presents the distribution and density of the population by region. The REDMP identified a total of 275,859 rural homesteads, their regional distribution is shown in Map 11.

Table 3: Population and population density by region in 2006, Namibia

Area	*Area [km^2]*	*Homestead Population [persons]*	*Population Density [persons/km^2]*
Namibia	825,235	1,952,454	2.37
Caprivi	14,668	85,224	5.81
Erongo	63,639	134,966	2.12
Hardap	109,712	74,495	0.68
Karas	161,395	64,872	0.40
Kavango	48,580	237,657	4.89
Khomas	36,949	301,050	8.15
Kunene	115,616	76,329	0.66
Ohangwena	10,705	247,103	23.08
Omaheke	84,742	60,773	0.72
Omusati	26,605	224,256	8.43
Oshana	8,656	159,827	18.46
Oshikoto	38,673	161,102	4.17
Otjozondjupa	105,295	124,800	1.19



Map 11: Distribution of the rural homesteads identified as part of the 2010 REDMP Study

4.3 Electricity Sector

4.3.1 Overview

Although liquid fuels, mainly in the form of petrol and diesel, dominate the Namibian energy sector, the electricity sector is the next largest sector in Namibia's energy economy. It accounts for an important component of commercial energy consumption and GDP formation in Namibia. Most of the electricity is currently being imported.

Namibia does not have exploitable coal reserves, which therefore has to be imported. Although the country is yet to witness a commercial oil discovery, largely undeveloped energy resources in the form of hydro-power and natural gas exist, in addition to the country's excellent solar and wind resources. Namibia's gas and hydro-power resources well exceed the country's own requirements, and may in future offer significant opportunities for exploitation and export-oriented industries.

The generation, transmission and bulk supply of electricity is currently the sole responsibility of NamPower, which is a para-statal enterprise. NamPower also supplies electricity directly to large mining and industrial customers. Vision 2030 tasks NamPower to supply 75% of the country's electricity needs[6], and in that way contribute towards the goal of enhancing self-sufficiency and to support the Namibian national development.

Electricity distribution is decentralised. Within the context of the Government's National Development Plans, the White Paper on Energy Policy (1998) and Electricity Act (2000) provide for, amongst others, the re-organization of the electricity distribution industry through the formation of electricity distributors, such as the Regional Electricity Distributors (REDs). This also forms part of the role of the Ministry of Regional and Local Government and Housing and Rural Development, that coordinates the national decentralisation process. REDs are legal entities that are tasked with the supply and distribution of electricity in a dedicated area, as a means of improving service delivery and efficiency in the electricity sector as a whole. NamPower is however still responsible for electricity distribution.

Under the Electricity Act of 2000, the Electricity Control Board (ECB) was established. Its mandate is to exercise control over the Electricity Supply Industry, and regulate the generation, transmission, distribution, supply, import and export of electricity through the issuance of licenses.

Prior to the establishment of the ECB, electricity prices – particularly for large mining and industrial users – were low by international and southern African standards. The financial viability of the distribution industry was not clear, as rural area distribution was largely not financially viable (low levels of consumption, high operating costs and inadequate management capacity). This had negative implications for the sector's efficiency and economic resource allocation. A unified regulatory framework for electricity pricing, and the country's first tariff study, was undertaken in 2001.

[6] In 2010, NamPower supplied some 35% of Namibia's required electricity from local generation.

4.3.2 Generation and Supply

In 2010, Namibia consumed 3,648 GWh of electricity (6% increase from 2009), and had a peak load of 564 MW. The net imports of electricity from South Africa, Zimbabwe, Zambia and other trading partners accounted for 65% of the total requirement in 2010. The remainder was supplied mainly by the Ruacana hydro-electric plant (249 MW capacity, but highly dependent on the flow in the Kunene River). Electricity is also generated at the coal-fired Van Eck power station in Windhoek (120 MW), and diesel driven Paratus power station at Walvis Bay (24 MW), but utilisation of these plants is low.

The total supply capacity in the NamPower system amounts to 993 MW, of which 600 MW is from the double-circuit 220 kV and 400 kV interconnection with South Africa. The key statistics of the electricity system are summarised in Table 4.

Table 4: Key Power Sector Statistics, NamPower 2010 Annual Report

	2010	*2009*
System Maximum (hourly demand) [MW]		
- Excluding Skorpion	477	443
- Including Skorpion	564	517
Units into System [GWh]	3,767	3,692
- NamPower	1,305	1,490
- ZESCO (Zambia)	47	29
- Eskom (South Africa)	1,429	1,501
- ZESA (Zimbabwe)	891	648
- EDM (Mozambique)	95	24
- STEM	-	-
Units sold [GWh]	3,648	3,434
- Customers in Namibia	2,681	2,651
- Skorpion Zinc mine	673	639
- Exports	294	144
Installed Capacity [MW]	993	993
- Ruacana	249	249
- Van Eck	120	120
- Interconnector (from South Africa)	600	600
- Walvis Bay	24	24

Although the Ruacana hydro power station is currently responsible for 96% of local generation, its utilisation is severely constrained by lack of regulation of water flow in the Kunene River, especially during the winter months. The operation of Van Eck power station is costly due to the high cost of coal. The plant therefore mainly serves as emergency standby power station and operates for short

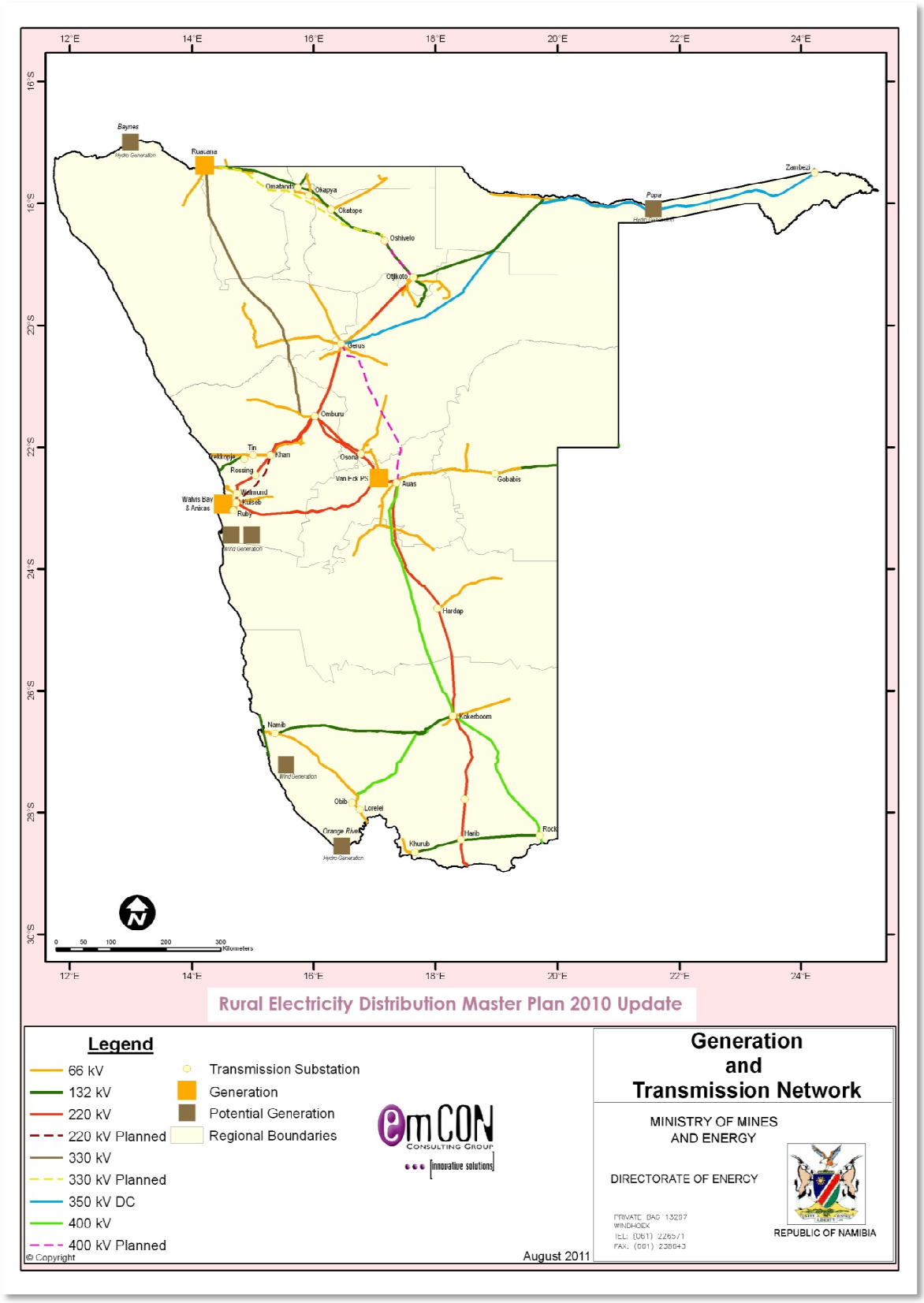
periods only. Due to critical power supply shortages since 2006, NamPower has been operating this power station for longer periods and sometimes on a continuous basis.

One of the key projects undertaken in 2010 included the installation of the fourth 92 MW generator and hydro turbine at Ruacana. The expected completion date for bringing the additional power from this plant on stream is set for March 2012.

In addition, the 22 MW Anixas diesel generator power station at Walvis Bay has been inaugurated in 2011. It is to provide emergency standby generation, and is to assist in power supply to the national grid during peak power consumption periods.

Other potential future generation projects (both local and international) include the rehabilitation of the Hwange coal-fired power station in Zimbabwe (the 1st phase was completed and ZESA is delivering the contracted 150 MW until 2013), a Walvis Bay coal-fired power station of between 200 and 400 MW, one or several Orange River hydro power station adding between 80 and 120 MW, the Kudu gas power plant (800 MW) and the Baynes hydro power plant (approx. 400 MW) in the Kunene River.

Namibia has abundant renewable energy resources. In addition to the hydro-power potentials, solar radiation is amongst the highest in the world (up to 3,100 kWh/m^2 per year in certain areas), as well as favourable wind conditions along the coast, with wind spreads of up to 10 meters per second. Solar and wind resources remain largely underutilised in Namibia.



Map 12: Generation and transmission system in Namibia, REDMP 2010

4.3.3 Namibia's Electricity Transmission and Distribution System

The three existing power stations in Namibia (status 2010) are located far apart; Ruacana in the extreme north of the country, Van Eck in the central region and Paratus on the west coast. This makes the transmission and distribution systems a critical component in delivering power to the entire country, especially considering that the supply from local stations is substantially supplemented by imports from neighbouring countries, via transmission lines which dissecting the country from north to south.

The delivery of power to customer centres is accomplished through a network of transmission lines connecting transmission substations located at strategic access points countrywide. Some of the main substations include Kokerboom in the south; Auas, Omburu and Gerus in the central regions; and Ruacana and Okatope in the north. Transmission voltages of 400 kV, 330 kV and 220 kV are typically converted to 66 kV, and more recently to 132 kV, for further transmission. Distribution substations again convert these voltages to 33 kV and below. Through an extensive network of distribution lines, low voltage power eventually feeds consumer connections (400 V; 230 V). Maps 12 and 13 show the transmission and distribution networks respectively. The maps include the existing as well as potential future generation power plants, and substations. Table 5 provides a summary of the total line length used for the different high voltage reticulations in the country.

Table 5: Transmission and Distribution Lines, NamPower 2010 Annual Report

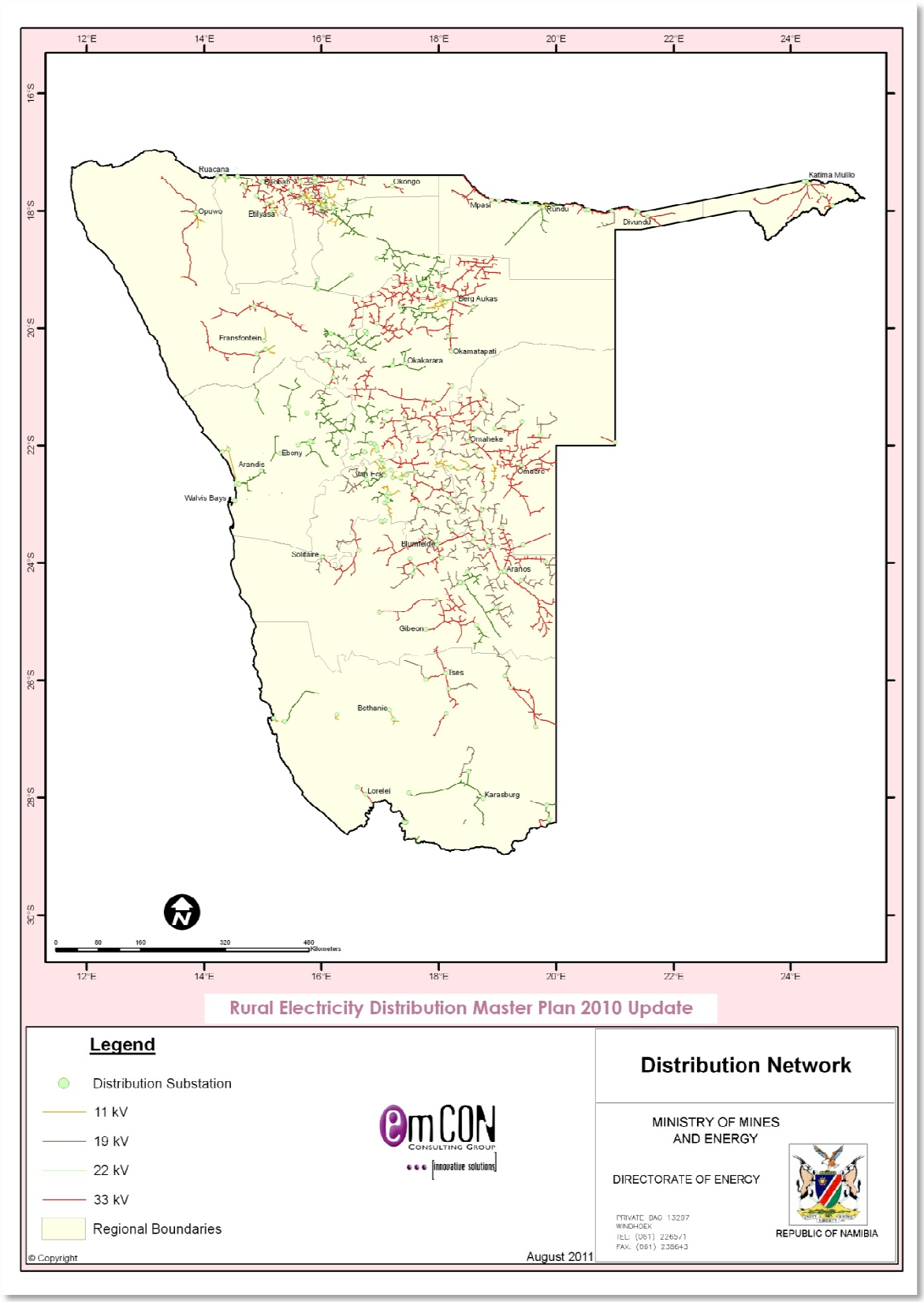
	2010	*2009*
Transmission Lines [km]		
- 400kV	988	988
- 330kV	521	521
- 220kV	2,800	2,746
- 132kV	2,102	2,102
- 66kV	3,708	3,673
Distribution Lines [km]		
- 33kV	11,305	10,866
- 22kV	4,724	4,610
- 19kV (SWER)	4,258	4,188
- 11kV	1,099	1,099

The Caprivi Link Interconnector was commissioned in May 2010. Some 951 km of 350 kV HVDC lines and converter stations link the far north-east with central Namibia, to reinforce and stabilise national supplies. The Caprivi Link provides a north-south interconnector within the Southern African Power Pool (SAPP), which will add to the energy trading potential and improve the dynamic stability of the region's transmission network.

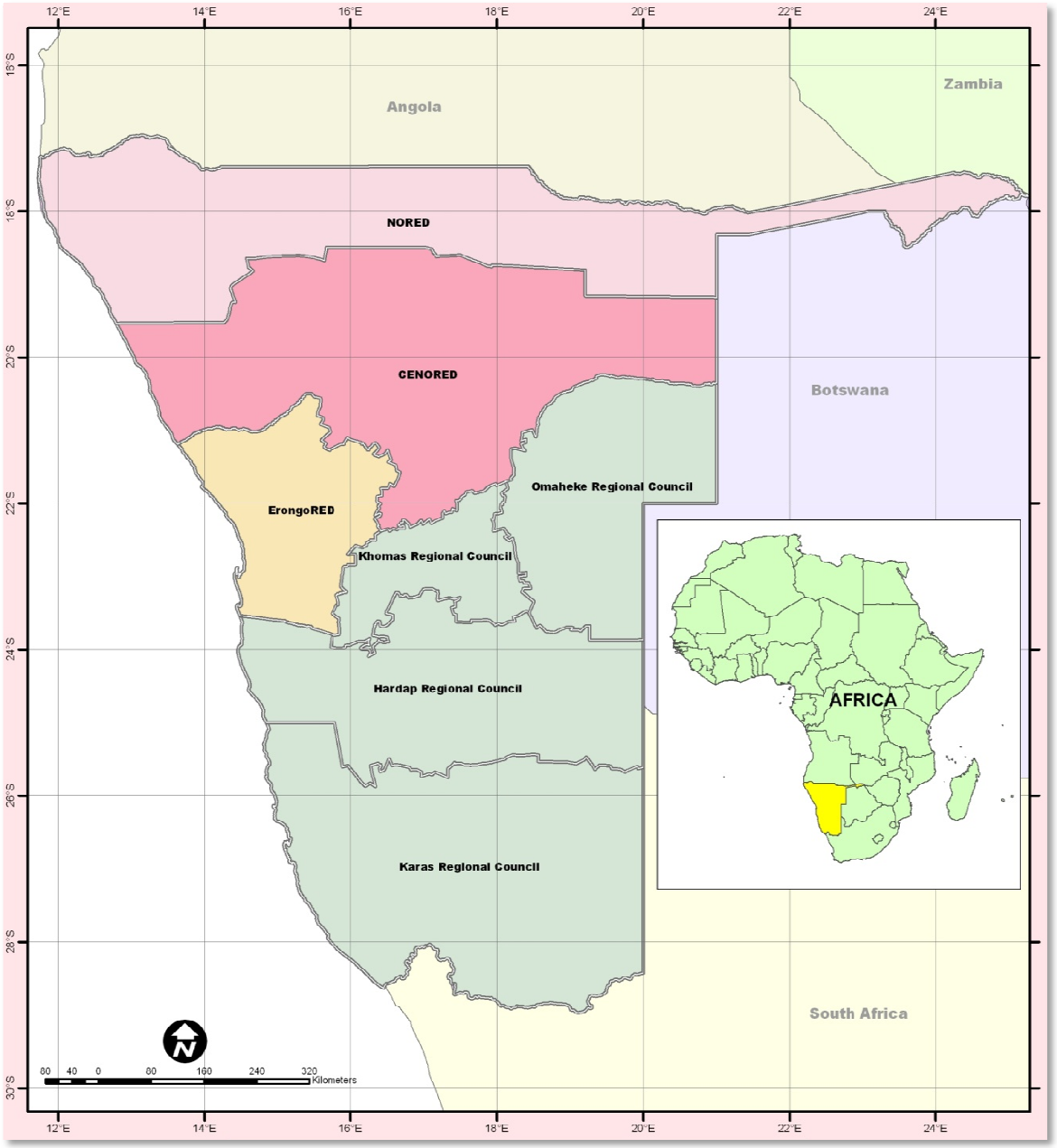
Various transmission projects are currently undertaken by NamPower: the West Coast development is to ensure the availability of sufficient energy for new and upcoming mines, mostly in the Erongo

Region. The uranium rush along Namibia's central west-coast regions necessitates extensive transmission infrastructure development, and the existing 220 kV transmission backbone is reinforced by a second line, as well as a dedicated 220 kV line which is to supply the Trekkopje Uranium Mine. In addition, the upgrade of the distribution transformers at the main Otjikoto distribution station and the new 80 km 132 kV transmission line to reinforce the supply to the central-southern area around Rehoboth have been undertaken. Various projects have been initiated to accommodate the general growth in electricity demand in the northern regions of Namibia, particularly to strengthen the transmission backbone supplying the distribution substations.

The REDs are responsible for the distribution and supply of electricity to end consumers within their respective areas. Three of the five envisaged REDs have been established (shown in Map 14) and are operational: NORED was established in 2002, while CENORED (Central-Northern RED) and Erongo RED started operating in 2005. Within the proposed Southern RED and Central RED areas the local and regional authorities as well as NamPower remain responsible for the distribution of electricity.



Map 13: Namibian electricity distribution network including substations, REDMP 2010



Map 14: REDs and other electricity supply licensees, Namibia 2010

4.3.4 Infrastructure

The main national infrastructure considered as part of the Study include educational and health facilities, water supply points, post offices and telecommunication infrastructure, transport, agricultural development facilities, police stations, as well as administration and pension payout points.

All Government buildings identified to be without electricity supply were included as Localities to be prioritised as part of the rural electrification programme. Maps 15 and 16 show the health and educational facilities identified.

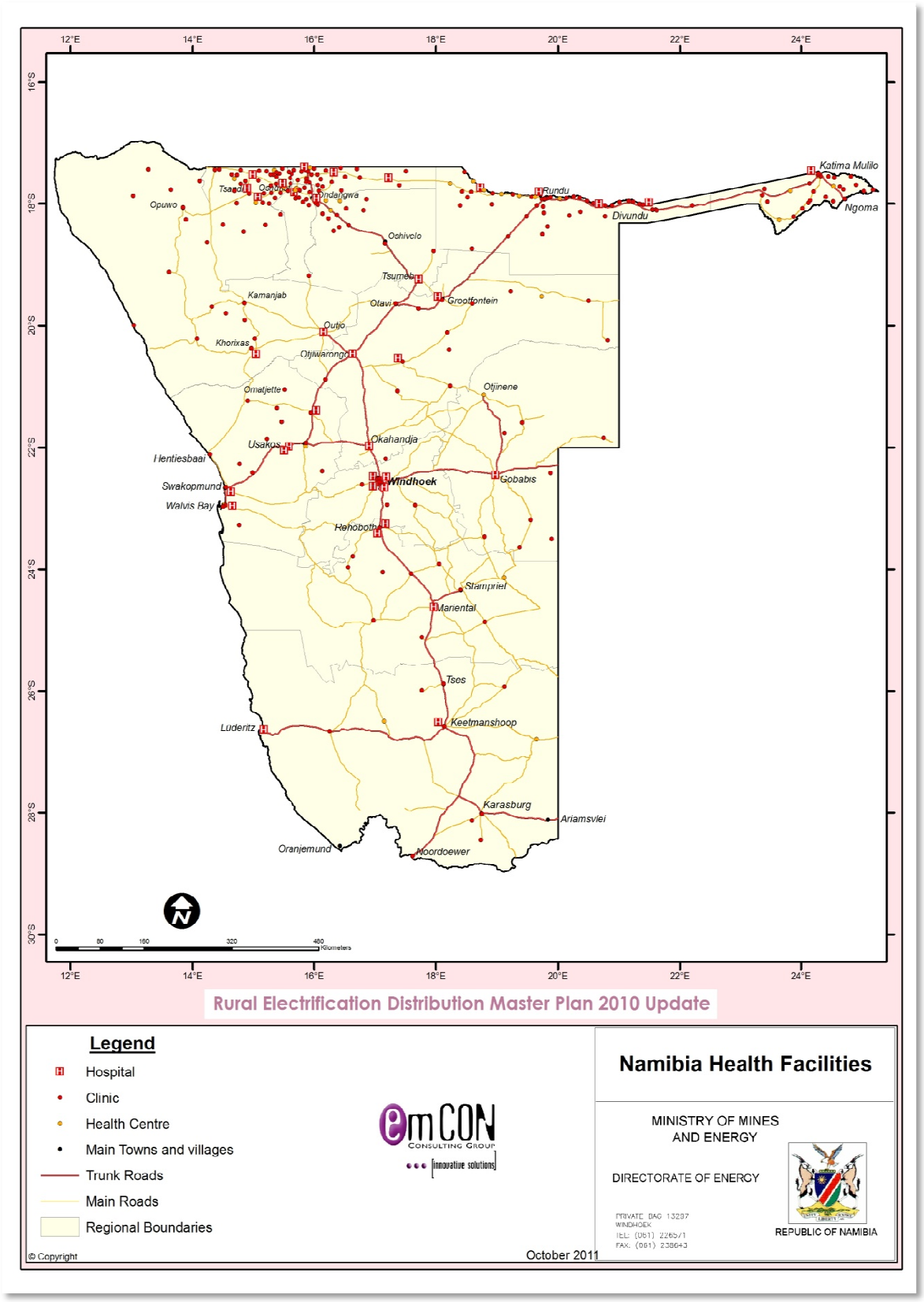
4.3.5 Way Forward for the Electricity Sector

Namibia's 2010/2011 budget included significant expenditure for ongoing national development. Of significance to the country's electricity sector is that a considerable part of the Ministry of Mines and Energy's budget was allocated to the electricity sub-sector, and more specifically rural electrification and the hydro-electric power project at Baynes.

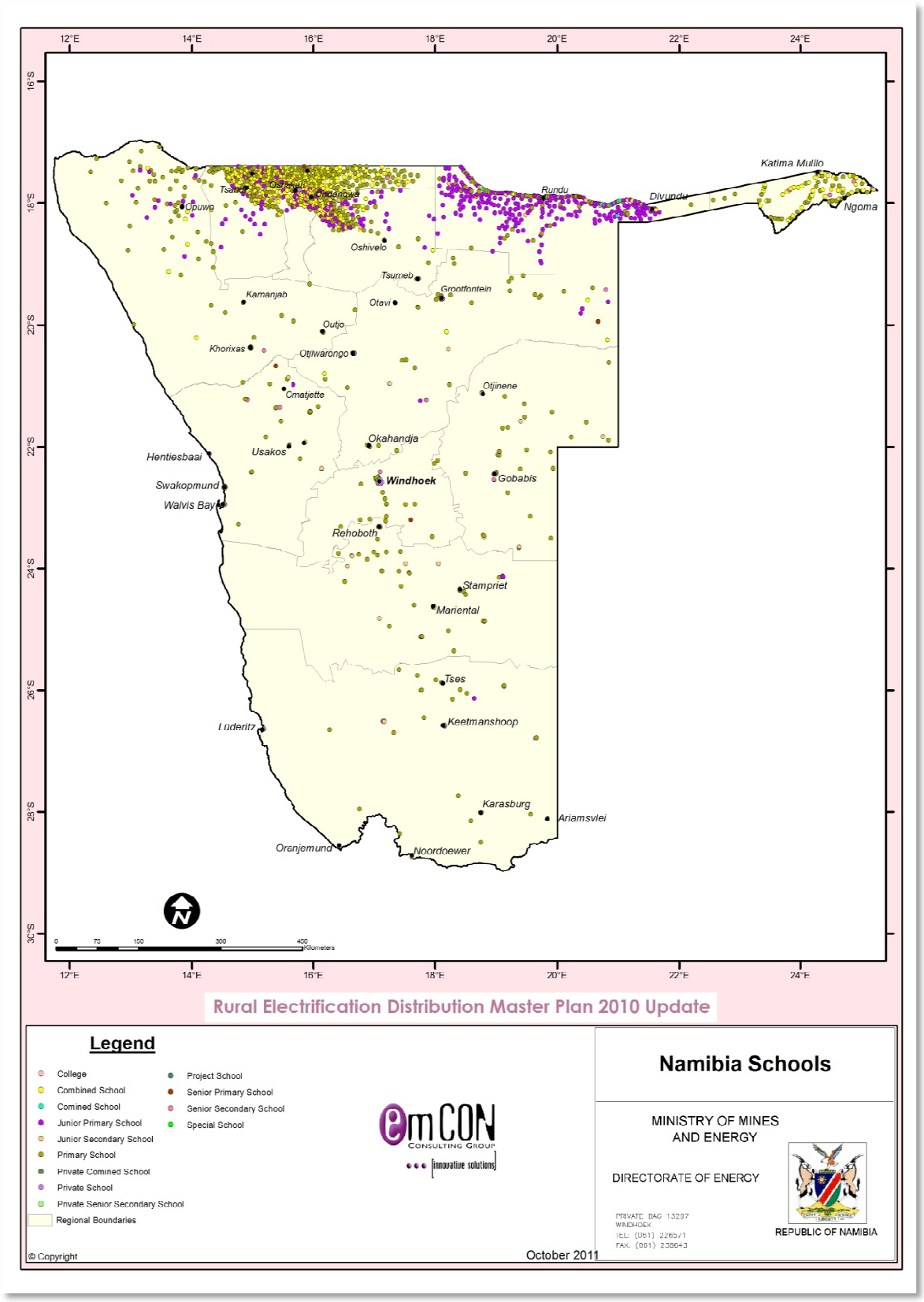
The initiatives by the Ministry will continue to shape the country's power sector in future. Other important developments will include the continued consolidation in the industry, to create sector-wide benefits by reducing fragmentation and leveraging economies of scale.

NamPower, as Namibia's generation, transmission and systems operator, faces significant uncertainties and risks which are related to the multitude of challenges faced by the electricity supply situation in Southern Africa. In addition, the country's electricity distribution sector has not yet reached maturity, and questions in regard to the structure of the future distribution industry remain.

Uncertainty in the country's distribution sector continues to affect ongoing rural electrification programmes, and remains to be resolved.



Map 15: Hospitals, clinics and health centres in Namibia, REDMP 2010



Map 16: Distribution of schools in Namibia, REDMP 2010

4.4 Social Aspects

The social impact of introducing electricity to a region is enormous. It is considered a specialist subject. This section therefore provides only an outline of some of these aspects.

There are the obvious benefits of improved social services; lighting at health centers, hospitals and schools; refrigeration of vaccines, and many others. Social gains as a result of improved electrification also include street lighting, television, community services such as milling of grain, sawmills or battery charging (often an alternative to grid connections).

A community's status rises in the eyes of rural inhabitants when electricity is introduced. This helps to stem the flow of rural to urban migration, as many young people are keen to head for the 'lights' of the big cities as soon as they are old enough. Introducing electricity may reduce a rural exodus, which in some developing countries has already created huge problems. The introduction of electricity often helps to create productive employment in rural areas, which in turn results in a positive impact on economic as well as social development.