Supportive framework conditions for mini-grids employing renewable and hybrid generation in the SADC Region

Namibia Case Study

Gap analysis and National Action Plan

January 2014

RECP
Africa-EU Renewable Energy Cooperation Programme

This study has been elaborated on behalf of the Regional Electricity Regulators' Association of Southern Africa (RERA) to establish a framework for attracting increased investment in mini-grids employing renewable and hybrid generation in the countries of the Southern African Development Community (SADC). This project has been financed under the Africa-EU Renewable Energy Cooperation Programme (RECP, www.africa-eu-renewables.org), an integral part of the Africa-EU Energy Partnership (AEEP).

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Acronyms and abbreviations

CENORED	Central Region Electricity Distributors
CPV	Concentrating Photovoltaic
ECA	Economic Consulting Associates
Erongo RED	Erongo Regional Electricity Distributors
ESI	Electricity Supply Industry
EU	European Union
EUEI PDF	European Union Energy Initiative Partnership Dialogue Facility
kW	kilowatt
kWh	kilowatthour
LP	Large project
MME	Ministry of Mines and Energy
MW	Megawatt
MWT	Ministry of Works and Transport
NAMREP	Namibia Rural Electrification Master Plan
NIRP	National Integrated Resource Plan
NORED	Northern Region Electricity Distributors
NSI	National Statistics Institute
NTCRE	National Technical Committee on Renewable Energy
NWEC	North West Energy Company, Zambia
OGEMP	Off Grid Energisation Master Plan
OTRC	Otjozondjupa Regional Council
PAC	Practical Action Consulting
PMU	Project Management Committee
PSC	Project Steering Committee
RE	Renewable Energy
RET	Renewable Energy Technology
RED	Regional Electricity Distributors
REDMP	Regional Electricity Distribution Master Plan
REEEI	Renewable Energy and Energy Efficiency Institute
REFIT	Renewable Energy Feed In Tariff
RERA	Regional Electricity Regulators Association of Southern Africa
SADC	Southern Africa Development Community
SE4ALL	Sustainable Energy for All
SEIAN	Solar Energy Industries Association of Namibia
SHP	small hydro power
SPP	small power project
SPPA	Standardised Power Purchase Agreement
SSP	Small-scale Project

STM	Standardised Tariff methodology
UNDP	United Nations Development Programme
VSSP	Very small-scale Project

Executive Summary

The regional project initiated by the Regional Electricity Regulators Association of Southern Africa (RERA) to create a framework for the development of mini-grids included provisions for two country case studies. Following a request by the Government, Namibia was chosen as one of the countries by the Regional Electricity Regulators Association (RERA). The selection was based on the strong expression of interest and the country's current plans to introduce policies and regulations to promote investment in renewable energy generation. This interest is motivated by national power supply challenges, the high cost of conventional grid extension in a large but sparsely populated country and the recognition of the need to strengthen policy and regulatory environment for mini-grid development. With donor support, the country has successfully undertaken pilot mini-grids at Tsumkwe and Gobabeb Training and Research Centre (GTRC), among other centres.

The pilot projects have demonstrated the technical viability of using mini grids as an alternative and more competitive solution for rural electrification in Namibia compared to grid extension. Mini-grids can also be scaled according to the need. However the roll out of mini-grids beyond the pilot projects has remained low and a major constraint cited by the private sector has been the absence of a supportive and an enabling environment to allow them to play a more effective role.

The Government of the Republic of Namibia (GRN), working through the Ministry of Mines and Energy (MME), Ministry of Transport and Works (MTW), the Renewable Energy and Energy Efficiency Institute (REEEI), Electricity Control Board (ECB), the national utility NamPower and Regional Electricity Distributors (REDs) have participated in this study supported by the Desert Research Foundation of Namibia (DFRN) and the Solar Energy Industry Association of Namibia (SEIAN). Following a preliminary desk study based on documents submitted during the inception phase and others accessed through the internet, the in-country study commenced on 2nd of December 2013 and was completed with a National Stakeholder Workshop held in Windhoek on 12th of December 2013.

Gaps in the policy and regulatory environment subsisting in Namibia were identified and discussed at the National Stakeholder Workshop. The recommendations and key actions that will guide the country towards developing a national supportive policy and regulatory framework for mini-grids employing renewable energy and hybrid generation are summarized as follows:

Market Needs and Demand

Compared to other SADC countries, Namibia has a well-defined grid and off grid electrification master plan - the Regional Electricity Distribution Master Plan (REDMP) for electrification through grid extension and the Off Grid Energisation Master Plan (OGEMP) for electrification of areas not covered by REDMP. It has been able to identify areas that are off grid as well as those where the grid will not be expected in the next 20 years. In these areas government is providing standalone technologies and mini grids.

The REDMP and OGEMP were developed in 2005 and 2007 based on definitions of access and access targets that are now outdated. Prioritisation criteria were based on demand, cost, and types of institution served and excluded potential social and economic impacts and productive uses. The definition of access is also inconsistent with current thinking at regional and international level. Households and institutions located within 500m of a low voltage transformer were defined as having access. Namibia has now adopted the Sustainable Energy for All (SE4ALL) initiative whose definition of access and universal access target implies actual use rather than proximity of service.

It is recommended that:

- By December 2015, MME shall review the selection and prioritisation criteria for rural locations to include current and potential social and economic impacts including productive use.
- By December 2016 MME shall have reviewed the REDMP and OGEMP to align with the vision, objectives and access definitions of SE4ALL.

Technology Choice and Technical Regulation

Mini-grids using renewable energy and hybrid generation would be a viable strategy for increasing sustainable supply that is cost effective and environmentally friendly particularly in off grid areas. Use of indigenous renewable energy resources will help to reduce Namibia's electricity sector's high dependence on imports with the attendant vulnerability to security of supply, price and quality of power variations.

The country is blessed with an abundance of renewable energy resources (particularly wind, solar and biomass) that remain largely under-utilised. Pilot projects have demonstrated that technologies that are more suitable for mini-grids in Namibia are solar, biomass and solar/diesel hybrids. The lifetime of some solar PV panels is shortened by the harsh desert conditions in Namibia and therefore it is necessary to have equipment standards that take account of the country's climate.

The MME has recently concluded the national integrated resource plan (NIRP) whose goal is identifying the energy mix and resources that will meet long term consumer needs in an efficient and reliable manner at the lowest reasonable cost. The plan sets forth clear policy guidelines for procurement of renewable energy sources based primarily on amounts of renewable capacity and type of renewable technology; quotas or feed-in tariffs may be instituted to ensure a larger renewable share of supply. One key obstacle identified is underestimation of renewable energy resource potential due to the absence of a portal for accurate and updated renewable energy resource data.

A technical standards body is in place, the National Technical Committee for Renewable Energy (NTCRE). The role of the NTCRE is, among many other functions, to identify and promote adoption and development of Renewable Energy Technology (RET) quality standards in Namibia. It is currently using a Code of Practice and Components Register developed in 2006. More than six years have

passed without reviewing the code despite advances in technology and standards regarding Renewable Energy (RE).

All RE systems under OGEMP are financed by government and donors and implemented by the private sector. Once installed these systems are handed over to the Ministry of Transport and Works (MTW) for operation and maintenance. REEEI reports that a number of systems installed under the public institutions programme are failing due to lack of specialised skills in MTW. End user training and better use of capacity in the private sector can help to ensure technical sustainability of renewable energy systems.

It is recommended that:

- By December 2014, REEEI shall carry out a complete and accessible energy resource assessment and develop a digital portal for wind, solar and biomass resources in Namibia. By the same date REEEI, in consultation with NamPower and the private sector companies involved, shall carry out and publish a preliminary review of the concentrating photovoltaic (CPV) grid-connected generation.

- By June 2015, the NTCRE shall review the code of practice and update it where necessary.

- By December 2015, REEEI shall undertake capacity building for end users in the operation and maintenance of mini grids using renewable energy sources and hybrid generation relevant ministries. REEEI shall also promote the inclusion of technical training of renewable energy in the education curriculum at all levels. The Solar Energy Industries Association of Namibia shall develop a business model that responds to operation and maintenance needs of RE systems in the country.

Ownership, Funding and Economic Regulation

According to subsection 28 of the Regional Council Act of 1992, "*a regional council has the power to undertake planning of the development of the region for which it has been established with a view to the existing and the planned infrastructure, such as water, electricity…*" However, local authorities are unwilling to take ownership of mini grids citing lack of viability and regulatory uncertainties created by inconsistencies in the Electricity and Local Government laws which are known but have remained unresolved.

The RE systems installed in off grid areas on public institutions and remote villages have operation and maintenance costs met by the MTW. Users do not pay fees with the exception of Tsumkwe but there the tariffs are not cost reflective. As a result the systems are economically unviable and unsustainable.

Government through MME avails funding for off grid projects through the Solar Revolving Fund (SRF), rural electrification fund (allocated by treasury annually) as well as donor funding. Through the SRF, which is disbursed through two finance institutions, individuals can access concessionary loans to install their own solar systems. The SRF attracts an interest rate of 5% per annum against an average

inflation rate of 6%. Without additional re-capitalisation of the fund, the revolving fund will ultimately run dry. The fund is not adequate to meet the demand. It is reported that there is a backlog of customers who want to access the fund.

It is recommended that;

- ❑ By December 2015, MME shall provide capital subsidies to local authorities including REDs to help them to invest in mini grids.
- ❑ By June 2014 ECB shall help local authorities with tariff determination and where subsidies are required, to seek MME intervention.
- ❑ By December 2015, MME and the financial institutions need to consider re-capitalising the SRF and to review the interest rate policy in relation to inflation for sustainability of the fund.

Planning and Development process guidelines and role clarity

Namibia does not have a Rural and Renewable Energy Policy, Act and Agency to facilitate the coordination of the various rural and renewable energy players and projects. This creates a policy and institutional gap for coordinating rural and renewable energy projects and programs in Namibia. A rural and renewable energy agency could, among its functions, act as the mini-grid project coordinating agency.

Pending the long process expected in establishing new policies, laws and institutions the coordinating gap can be filled by increasing the capacity of the rural electrification unit in the ministry of energy as well as the REEEI. The additional capacity would serve as the nucleus of the proposed rural and renewable energy agency.

The off grid electrification projects and programs are continuously being implemented and there is no feedback regarding strategic achievements and impacts. A number of projects under the Off Grid Energisation Master Plan (OGEMP) are under implementation under the direction of the Ministry of Mines and Energy and government agencies under the Ministry. Other ministries and government agencies as well as NGOs are implementing their own solar electrification projects for public institutions (e.g. clinics, schools and government offices and houses) which are then handed over to the Ministry of Transport and Works for operation and maintenance. The challenge with these diverse projects and programmes is that they are not effectively coordinated to ensure fulfilment of national access targets and they are not being systematically monitored and evaluated.

It is recommended that:

- ❑ By December 2016, the MME shall have developed a rural and renewable energy policy, act and agency whose mandate will include the coordination of rural electrification projects.
- ❑ The rural electrification department in the MME and the REEEI shall be resourced adequately to coordinate the installation and maintenance of

mini-grids, off-grid solar and other renewable energy projects pending the establishment of the rural and renewable energy agency expected by December 2016.

- By June 2014 an effective monitoring and evaluation framework for electrification projects be established to measure the impact against national targets.

Lessons from field studies

Existing solar/diesel mini grids demonstrate the technical feasibility of providing reliable 24 hour supply for off-grid communities in remote areas. Namibia has the largest solar/diesel hybrid mini grids in the region at Tsumkwe and Gobabeb. Technical success is a function of thorough assessment of market demand, comprehensive assessment of technology and energy management directed by a resident energy manager. Namibia experiences extreme climate conditions such as high temperatures and sandstorms which can shorten the life of solar panels and there is therefore the need to specify technologies that can withstand the extreme weather conditions.

Most of the mini grids installed in Namibia, though providing significant socio-economic benefits to the surrounding communities and improved service delivery, are heavily subsidised by government in their operation and maintenance. With the exception of Tsumkwe, the mini grids do not have cost recovery mechanisms. This is partly the reason why there are challenges with technical capacity for operation and maintenance on most off grid installations. There is an example of solar home systems installed in 70 households in Okongo and 50 households in Donkerhoek that are no longer functional.

Municipalities and regional electricity distributors are unwilling to take ownership of mini grids citing financial viability and regulatory issues. This demonstrates the need for a dedicated rural and renewable energy agency with appropriate funding, which could be based on a levy on existing electricity consumption.

1 Introduction

1.1 Background to the study

The Regional Electricity Regulators Association of Southern Africa (RERA), with support from the Africa-EU Renewable Energy Cooperation Program (RECP), managed by the EU Energy Initiative Partnership Dialog (EUEI-PDF) has developed guidelines to assist countries in the Southern African Development Community (SADC) to create a framework for attracting investment in mini-grids. Mini-grids employing renewable energy and hybrid generation will help to increase access to electricity for remote and low income communities and to increase investment in distributed renewable generation. Technological advances and cost reductions are making renewable energy technologies, which are environmentally friendly and sustainable, increasingly competitive compared to conventional fossil fuel generation.

Because projects are implemented at national level, the regional guidelines can only make an impact when countries use them to change their national policy and regulatory framework for mini-grids. Therefore two countries, Namibia and Zimbabwe, have been selected to pilot the application of the regional guidelines. Terms of reference for the country studies are outlined in Annex A2.

The two key deliverables of the country studies are a gap analysis and national action plan for creating the supportive framework for mini-grids. The gap analysis identifies areas where the existing policy and regulatory framework falls short of the proposed regional framework. The action plan is a series of recommendations for closing the gaps, with indicative timelines and sources of funding. This report presents the gap analysis and national action plan for Namibia.

The report is the outcome of a two month study that started with a desk study of documents on the Namibian energy situation submitted during the inception phase. Other documents were accessed through the internet. The in-country study formally started with an inception meeting on 2nd of December 2013 and ended with a National Stakeholder Workshop on 12th December 2013. The study was facilitated by the Ministry of Mines and Energy (MME) and supported by a Project Steering Committee (PSC) and Project Management Unit (PMU) comprising technical experts from the following organisations: the Renewable Energy and Energy Efficiency Institute (REEEI), Electricity Control Board (ECB), the national utility NamPower, Regional Electricity Distributors (REDs), Ministry of Transport and Works, Desert Research Foundation of Namibia (DFRN) and the Solar Energy Industry Association of Namibia (SEIAN).

The PSC and PMU were already in existence for the Procurement Mechanism of Renewable Energy. Subcommittees of the PSC and PMU would be appointed for mini-grids under the same chairpersons (namely MME Permanent Secretary and REEEI Director) which will include the REDS, Ministry of Finance, Ministry of Works and Regional Offices affected by the mini-grids. A recommendation on this was prepared for submission to the Minister.

The key milestones for the in-country study were as follows:

- 2nd December 2013 - Inception meeting chaired by MME Permanent Secretary (PS) and attended by PSC and PMU members. The REEEI Director, Dr. Zivayi Chiguvare, as PMU manager, was designated the study team leader for the mini-grids.

- 3rd December 2013 – The first PMU meeting was held to discuss study methodology and site visits. Representatives agreed on the proposed timetable of activities and confirmed the date of the National Workshop, including the list of organisations from which workshop participants were to be drawn. Members were allocated duties for desk studies on current policies and regulations relevant to mini-grids.

- 4th December 2013 – first field visit to Hardap Municipality accompanied by REEEI, MME and NamPower personnel. The visit was to a demonstration project, which is an experimental 26 kWp concentrating photovoltaic (CPV) system embedded into the grid.

- 7th – 8th December 2013 – second field visit to Tsumkwe mini grid project accompanied by NamPower. The project is a hybrid PV and diesel installation serving 100 households.

- 9th December 2013 – the second PMU meeting was held at ECB to update team members of progress of the study, findings and gaps and progress with the workshop preparations.

- 10th December 2013 – third field visit to Gobabeb Research and Training Centre (GRTC) was undertaken with REEEI. Gobabeb is the first solar powered mini grid established in 2004 in Namibia and it is backed up by a diesel power generator. It was also built to demonstrate solar technologies that are appropriate to the Namibian environment.

- 12th December 2013 - National Stakeholder Workshop discussed the Draft Final Gap Analysis report and Action Plan. The participants provided valuable feedback to both the Gap Analysis Report and the National Action Plan. In the Ministry's opening remarks the PMU was confirmed as the institution that would coordinate the implementation of the National Action Plan for mini-grids.

1.2 Outline of the Report and Study Limitations

This report starts by providing a brief description of the electricity policy, legal, regulatory and institutional framework. This is followed by a discussion of the current electrification situation in Namibia, including existing mini-grids and their potential for contributing to electricity access and renewable energy development. The information is derived from the site visits and desk studies as well as discussions with developers and beneficiaries of representative mini-grids.

A brief summary of the regional guidelines and how they were used for the gap analysis is then presented. The rest of the sections of the report discuss the gaps

identified and the recommendations specific to Namibia and lessons for the regional framework.

Study limitations

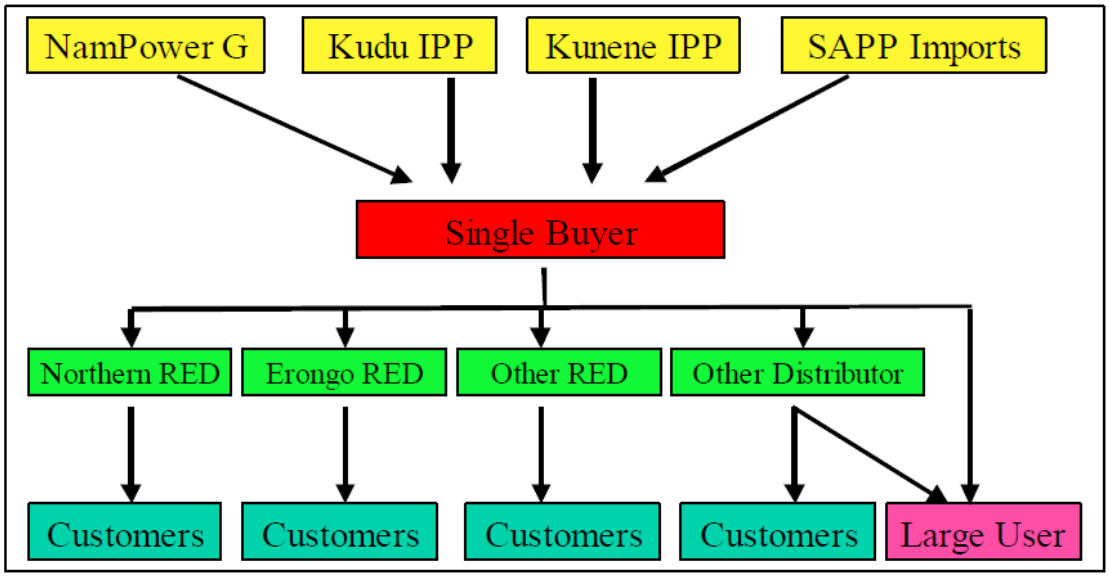
- Timing of the study was unfortunate to coincide with the onset of the Christmas season break. Thus most people provided apologies to the meetings as they had taken their annual leave.
- Namibia is a vast country and time and cost are barriers to field studies. The field studies had to be restricted to 3 sites.

1.3 Electricity Supply Industry policy, regulatory and institutional framework in Namibia

The Namibian electricity sector has undergone some profound changes over the past years since the adoption of the Electricity White Paper of 1998. This policy paper led to the Electricity Act of 2000, which created a regulatory body, the Electricity Control Board, and restructured the power sector. ***NamPower*** is the national utility responsible for three businesses of electricity generation, transmission and international trading.

Distribution is licenced to the Regional Electricity Distributors (REDs), in which NamPower is a minority shareholder. There are currently 5 REDs across the country: NORED, Erongo RED, CENORED, CENTRAL RED and Southern RED. The first three of the REDs are fully operational. In addition to the REDs there are municipalities like the Windhoek municipality involved in the distribution of power. Other bulk consumers like the mines are directly supplied by NamPower.

Figure 1: Single buyer model in Namibian electricity market



Source: Ministry of Mines and Energy, Namibia (www.mme.gov.na/energy/electricity/esi_public_presentation_document.htm)

The Electricity Act of 2007 provided for private sector participation and an Independent Power Producer (IPP) framework has been developed. A revised Electricity Bill seeks to modify the single buyer model by allowing large off-takers and distributors to participate directly in the wholesale market.

The structure of the market is summarised in the figure above.

Policy direction for the Namibian electricity industry is provided by the Ministry of Mines and Energy. The ministry published the White Paper on Energy Policy of 1998. The energy directorate of the Ministry of Mines and Energy is the responsible body for ensuring the compliance with the legal requirements specified in the country's energy legislation and regulations. The Directorate also carries out research into new sources of energy, especially renewable energy sources. Other responsibilities include the regulation of the petroleum industry: its exploitation, import and export activities, and the issuing of petroleum licenses.

There is no dedicated agency for rural electrification and the Ministry is responsible for rural electrification and the administration of a Solar Revolving Fund (SRF) which supports solar PV, solar water heaters and other solar technologies.

A summary of the relevant policies and laws are summarised in the table below.

Table 1: Key energy-related policies, legislation and regulations

Policy/Law/Regulation	Year	Description
Regional Councils Act 1992 (Act 22 of 1992)	**1992**	The legislative framework for the institutionalising of the decentralised government. The official Decentralisation Policy of Namibia identifies functions to be decentralised and lays down the implementation guidelines, resource strategies and the choice of the form of decentralisation. Regional councils have power to supply electricity and gas.
Local Authority Councils Act (Act 23 of 1992)	**1992**	The legislative framework for the institutionalising of the decentralised government. The official Decentralisation Policy of Namibia identifies functions to be decentralised and lays down the implementation guidelines, resource strategies and the choice of the form of decentralisation. Local authorities have power to supply electricity and gas.
White Paper on Energy	1998	The energy policy is aimed at achieving security of supply, social development, effective governance, investment and growth, economic competitiveness, economic efficiency and sustainability.
Electricity Act	2000	Established an independent regulator for the industry, the Electricity Control Board (ECB). A single-buyer market was established with the national utility NamPower being the single buyer. On the distribution side, Regional Electricity Distributors (REDs) have been set up to take over the distribution function from local authorities
Rural Electricity Distribution Master Plan	2000	It is the guiding document for the rural electrification of the country through grid extension and gives time bound targets on how the electrification will be rolled

Policy/Law/Regulation	Year	Description
		out.
Petroleum Products and Energy Amendment Act, No. 16 of 2003	2003	Governs the Energy Fund and empowers the Minister responsible to impose a levy for the benefit of the fund on any energy source including electricity, nuclear and renewable energy
Vision 2030	2004	It envisages the transformation of Namibia into an industrialised nation with a viable natural resources based export sector.
Regional Electricity Distribution Master Plan (REDMP)	2005	This masterplan was an update of a 2000 plan and defined areas for grid electrification as well as classifying areas outside these areas as off-grid (grid extension not expected within 20 years), pre-grid (grid extension not expected within 5 to 10 years) and grey (unclear areas or timing such as informal settlements or un-electrified households
Off-Grid Energisation Master Plan (OGEMP)	2007	To support the roll-out of renewable energy systems and rural electrification. It assessed technologies appropriate for off-grid and mini-grid generation according to the following three factors: fuel and technologies which are already available in Namibia; fuels and technologies which address basic energy needs of households; technologies that require minimal operation and maintenance costs
Electricity Act	2007	It repealed the Electricity Act of 2000, by making provision for private participation in the sector. The Act describes the requirements, conditions and obligations for obtaining licences to generate, trade in, transmit, distribute, import and export electricity
Environmental Management Act	2007	It provides for the sustainable management of natural resources and protection of the environment in accordance with global commitments. Energy is a prescribed activity under the act. Thus it is mandatory for Environment Impact Assessment of all energy projects to be undertaken.
Fourth National Development Plan (NDP4) (2012 - 2017)	2012	The goals of the NDP4 are high and sustained economic growth, employment creation and increased income equality. It identifies basic enablers for economic development that include energy infrastructure. By 2017, Namibia expects to expand internal generation from 400 to 700 MW to support industrial development.
National Integrated Resources Plan (NIRP)	2012	NIRP is a 20 year electricity sector development plan. The NIRP focuses on electricity supply but also takes into account the possible impacts of other energy sources as well as potential demand side management programs.
Draft Net Metering Rules	2013	Provides for the exchange of power and energy between a customer's generation facility (of capacity below 500 kW) and a distribution licensee's network

The ***Electricity Control Board (ECB)*** was established by the Electricity Act of 2000. It oversees all segments in the supply chain of electricity, from generation to supply, as well as import and exports. The principal functions of ECB are defined by the Electricity Act (Act 4 of 2007) as follows:

- exercising control over and regulate the provision, use and consumption of electricity in Namibia;
- overseeing the efficient functioning and development of the electricity industry and security of electricity provision;
- ensuring the efficient provision of electricity;
- ensuring a competitive environment in the electricity industry in Namibia; and,
- promoting private sector investment in the electricity industry.

The ECB's main regulatory functions include tariff setting, standards setting, licensing, compliance monitoring and mediation.

The ***National Planning Commission*** is the body responsible for the implementation of the National Development Plans, the latest of which, the Fourth National Development plan (NDP4) was launched in July 2012 as part of *Vision 2030*. Energy Policies and plans are designed to facilitate the achievement of the goals of the NDP.

1.4 Current Electrification Status in Namibia

According to NamPower, the total installed electricity supply capacity as of 2012 was 1,108 MW (hydro – 341 MW; thermal – 167 MW), with the balance being a 600 MW interconnector with South Africa. NamPower generates electricity from the hydroelectric plant located at the Ruacana Falls on the Kunene River, the coal-fired Van Eck power plant close to the capital, Windhoek, and the Paratus and Anixas standby diesel-fuelled power plants at Walvis Bay. The design capacity and age of the power plants are given in the table 2. Energy generated, imported and sold is given in Table 3.

Hydro makes up 67% of the internal generation capacity with the remainder being contributed by the thermal power plants.

Table 2: Namibia's power supply capacity and approximate age

Power Supply Name	Technology	Design Capacity (MW)	Age
Ruacana (Kunene River)	Hydro	341	36 years
Van Eck (Windhoek)	Coal	120	42 - 34 years
Anixas (Walvis Bay)	Diesel	23	2 years
Paratus (Walvis Bay)	Diesel	24	About 40 years
Interconnector capacity		600	
TOTAL		**1,108**	

Source: NamPower.

Table 3: Total energy produced, imported and sold in Namibia.

	2012	2011	2010	2009	2008	2007	2006	2005
Units into System (GWh)	4,162	3,910	3,767	3,692	3,719	3,621	3,554	3,363
Internal Generation (GWh)	1,643	1,430	1,305	1,490	1,572	1,576	1,606	1,660
Imports (GWh)	2,519	2,480	2,462	2,202	2,125	1,930	1,866	1,695
Units sold (GWh)	3,431	3,543	3,431	3,246	3,392	3,259	3,199	2,976
% of Imports /Total Units into the system	61%	63%	65%	60%	57%	53%	53%	50%

Source: NamPower

Electricity demand in Namibia as of 2012 was 662 MW. Access to electricity as measured by connection is only 30% of rural households and 70% of urban households. ECB, as the regulator of the electricity market, publishes yearly statistical bulletins with data about the market, including the number of domestic customers for each RED, reporting growth rates in customer numbers as well. The total number of customers reported for 2012/2013 exceeded 200,000, which represent an increase of 34.3% since 2006/2007.[1] In addition, the statistical publication includes electricity consumption profiles.

The table below shows the trends in per capita electricity consumption.

Table 4: Trends of per capita electricity consumption in Namibia compared with other African countries

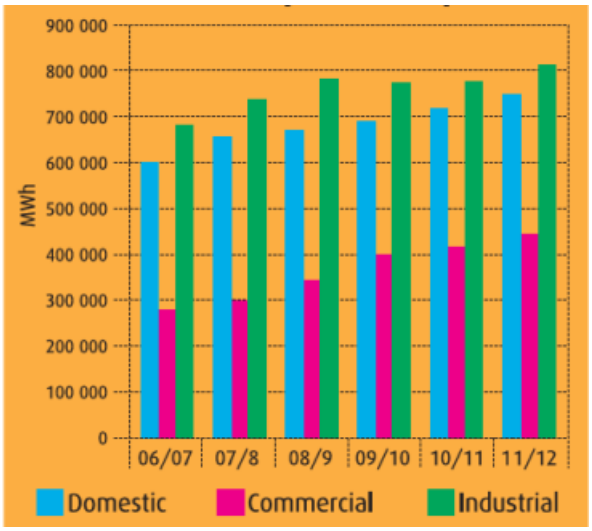
Country	2006	2007	2008	2009	Rank in Africa in 2009
Namibia	819	790	773	746	9
South Africa	4,658	4,886	4,935	5,019	1
Zimbabwe	760	714	701	668	11
Swaziland	367	383	399	416	14

Source: AfDB, Statistics Department, Africa Infrastructure Development Index, Economic Brief Volume 1, Issue 1, 25 April, 2011

The electricity energy demand per sector is shown in the diagram below and shows that both industrial and household energy demand is increasing.

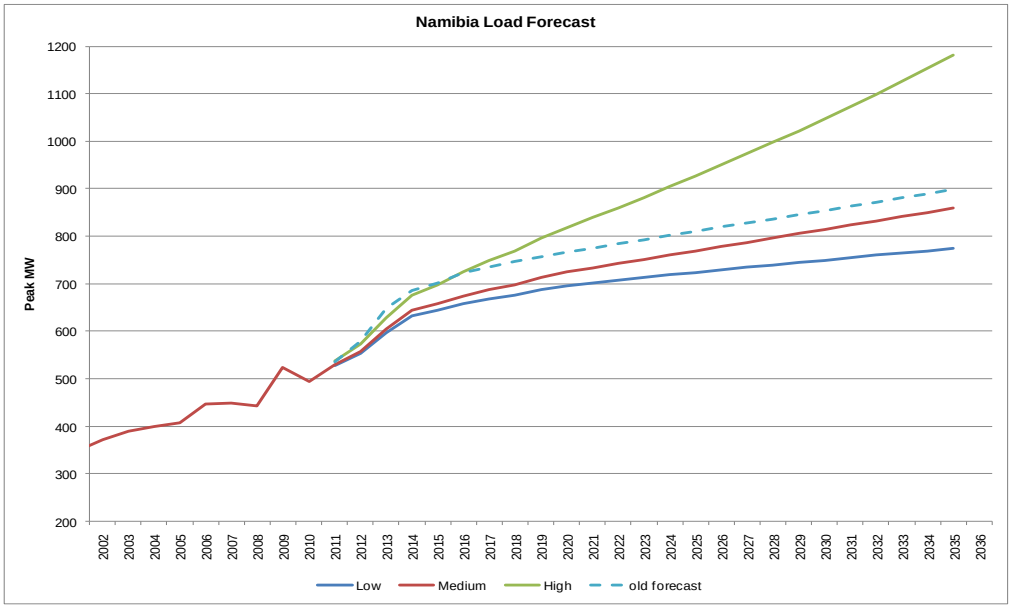
[1] ECB (2012) *Statistical Bulletin*

Figure 2: Namibia's electricity consumption by sector



Projections from various studies of the growth of electricity demand place it between 3 and 6% per annum. The country has just completed a National Integrated Resource Plan (NIRP). The NIRP is a 20 year electricity sector development plan. The NIRP focuses on electricity supply but also takes into account the possible impacts of other energy sources as well as potential demand side management programs. It provides an indication of Namibia's projected electricity demand, how this demand will be supplied and the cost of supply. The figure below gives the projected electricity demand for Namibia.

Figure 3: Namibia's load forecast



Source: World Bank & Electricity Control Board (2012), National Integrated Reource Plan

Given a business as usual scenario, the electricity demand forecast for Namibia projects a shortfall of 300 MW by 2015 without imports. Thus the country needs a base load power station to be commissioned by 2015/2016. Options that the government is seriously pursuing include the Baynes hydro power plant and the Kudu gas station.

Table 5: Future Energy/Power Projects (According to NDP4)

1. Baynes Hydro Power	660 MW
2. Kudu Gas to Power	800 MW
3. Concentrated Solar Power (CSP)	50 MW
4.Wind Power	44 MW (IPP project)
5. Solar PV (several projects grouped)	20 MW (IPP)
6. Solar PV (several projects grouped)	30 MW (through tender)

Source: Africa Energy Yearbook 2013.

The power supply situation will remain critical until the commissioning of Kudu Gas expected in 2018.

1.5 Potential role of Mini-grids

The challenges facing the power sector include the heavy reliance on imports (average 60%), unreliable and high cost of running the aged thermal plants (Van Eck and Paratus), low Kunene water flow which means that Ruacana cannot operate at full output, and the vast distances between sparsely populated rural centres. Currently Namibia is importing power from Zimbabwe, South Africa and Mozambique. Imports are sensitive to regional prices, the supply from Eskom is interruptible and there are doubts about Eskom's ability to extend the import agreement beyond 2015. The power purchase agreement with Zimbabwe will end in 2014 and there is no guarantee that it will be renewed due to power challenges facing that country. Internal generation of the thermal plants is dependent on imported diesel and coal. As a result, in recent years the price of electricity has been rising with a 32% increase being implemented during the year ended June 2011 with inflation adjustments in subsequent years.

Renewable energy is one option available to Namibia to increase internal generation and reduce dependence on imports. Despite Namibia being blessed with abundant renewable energy resources in biomass, solar and wind, no single large scale renewable energy power plant has been developed so far. A number of IPPs have been licensed to provide power using the vast renewable energy resources. Progress has been stalled due to failure to resolve differences in pricing and security expectations of the public and private sector in the on-going Power Purchase Agreements.

However there is a vibrant private sector solar industry that has been making steady increases in installed capacity of small systems of up to 500 kWp (Table 6).

Table 6: Small power plants owned and operated by IPP's

Technology	2004	2005	2006	2007
Photovoltaic electricity (kW peak)	16.8	94.7	94.4	138.7
Solar water pumping (kW peak)	36.7	25	95.9	180.2
Solar thermal (kW peak)	356	641.6	2017.6	4312.8

Source: REEEI

Many of the solar power plants are grid connected and in urban areas. Solar/diesel hybrids have proven to be technically sound off-grid solutions for people in areas far away from the existing national grid. The Solar Energy Industry Association of Namibia (SEIAN) estimates installed PV capacity in Namibia to be close to 2 MW even in the absence of incentives such as REFIT. The situation is dynamic as one private sector solar installer estimated that in 2013 as much as 5 MW of solar PV was installed for supply to individual customers. With net metering regulations the investment level would increase substaintially.

There are a number of pilot mini-grids that are operational in Namibia. These are powered by either solar energy or diesel fuel, or a combination of the two (hybrid mini-grid).

- ***Tsumkwe village*** is supplied with 24 hours electricity through a hybrid mini-grid consisting of 200 kWp solar and 300 kW diesel plant. The mini-grid supplies power to the town's institutions and approximately 100 households. All the customers are connected to prepayment meters and pay a user fee. This was one of the mini-grids visited and more details are in Annex 3.

- ***Gam settlement*** is supplied with a few hours of electricity each day from one diesel generator. The users do not pay for the power.

- ***Gobabeb Desert Training and Research Station*** is supplied with 24 hours of electricity from solar energy, with diesel generators as back-up with a capacity of 26 kWp. The users do not pay for the power.

- ***Mangetti Duin*** is supplied by a 20kW diesel generator with supplies being limited to a few hours each day. The users do not pay for the power.

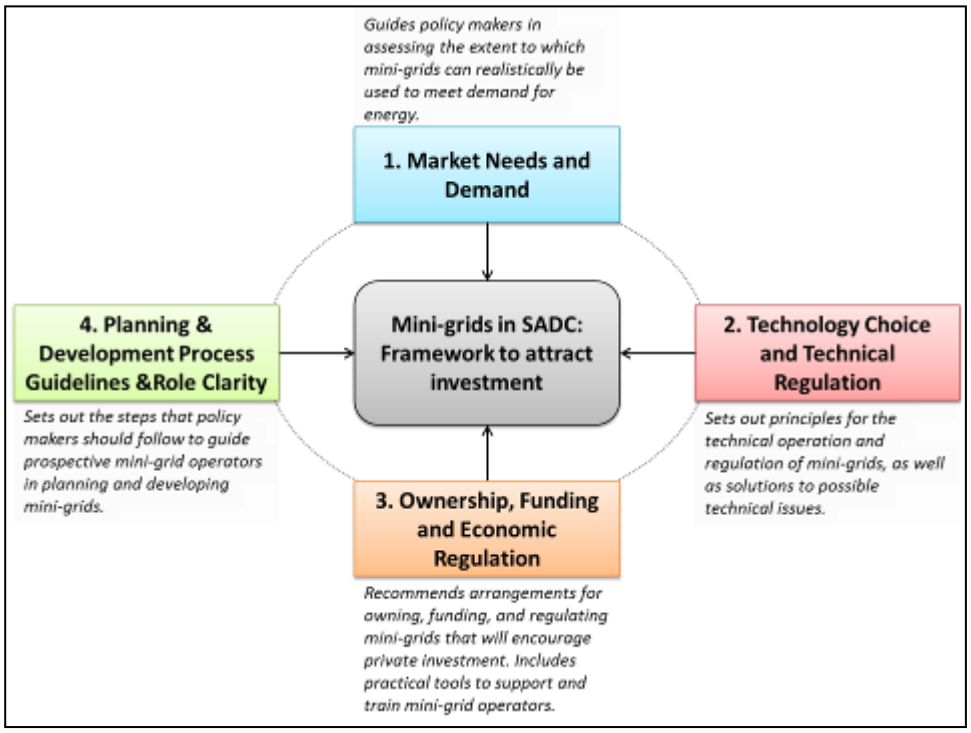
- ***Usib Primary School, Hardap:*** a demonstration concentrating solar photovoltaic (CPV) power plant of 26 kW is installed feeding into the main grid. The objective is to test the socio-economic and technical impacts of an embedded generator on the main grid.

Details of mini-grids visited during the study visits are summarised in Annex A3.

1.6 Application of SADC Regional Framework for Mini grids in Country Case Study

To attract increased investment in mini-grids using renewable energy and hybrid generation the SADC mini-grids project has established the guidelines for mini-grids with four focus areas illustrated in the figure below. The guidelines help policy makers and regulators to define and facilitate the implementation of the mission and vision for increased access and renewable energy development using mini-grids.

Figure 4: Support framework for mini-grids



The application of the guidelines can be summarised as follows:

a) **Undertake research to establish a thorough understanding of market needs and demand.** The ability and willingness to pay by the end users is the foundation for sustainable mini-grid businesses. The development of a national access strategy and masterplan helps to create stakeholder consensus on

- Definition of energy access and access targets, that is the time horizon for achieving universal access for different end uses.
- The role of the 3 basic energy supply options in fulfilling market needs and demand: standalone devices, main-grids and mini-grids. A comprehensive assessment of options ensures that only those

mini-grids that are the optimum solution for market needs are implemented.

- The selection and ranking of locations for use of the different options.

b) **Influence technology choice towards renewable energy.** This is an exercise in removal of barriers to renewable energy development through such measures as

- Renewable energy policy, targets and incentives
- Renewable energy resource assessments
- Development of safety and appropriate product and service quality standards to ensure value for money for mini-grid customers

c) **Provide for diverse ownership, funding and economic regulatory approaches.** Mini-grids can be developed by public sector, private sector and community organisation and by partnerships among these. A one-size fit all approach can be a barrier and therefore a classification system has been recommended.

- Mini-grid classification is by size, location relative to grid (off-grid or grid-connected) and ownership of mini-grid elements (vertically-integrated or non-vertically integrated).
- Some of the recommendations are that there should be no licence or tariff regulation for very small projects; there should be non-negotiable standardised project documents and tariffs or methodology for small projects; standardised but negotiable for large projects can help to reduce transaction costs and time.

d) **Have dedicated institutional responsibility for promotion of mini-grids.** This institution's main function is to reduce transaction costs and time by ensuring stakeholder role clarity and transparency of the planning and development process. Some of the key actions required are

- Documentation of planning and development process through stakeholder consultation process
- Documentation of technical planning guidelines and undertake audits and training for operators
- Facilitating the process by providing a one-stop service for developers

This framework helped to assess and identify gaps in current policy and regulations related to mini-grids which are reported in the rest of this report.

2 Assessment of Market needs and demand

2.1 Existing studies of market needs and demand

Namibia is one of the few countries with a grid and off-grid masterplan called the Regional Electricity Distribution Master Plan (REDMP) and Off-grid Energisation Master Plan (OGEMP) respectively developed in 2005 and 2007. The OGEMP was developed to complement the REDMP.

Namibia's long-term development strategies and objectives were also set out in 2004 in the *Vision 2030* strategy[2] drafted by the National Planning Commission. With respect to the electricity market, the strategy mentions the electricity distribution master plan, and how it aims to achieve almost full coverage of the country's population by 2030. This is aligned to the UN Sustainable Energy for All (SE4ALL) initiative which Namibia has now formally adopted. The SADC region as a whole has now decided to align the Regional Energy Access strategy and Action Plan (REASAP) with the SE4ALL vision.

The REDMP defines businesses, households or institutions that have access to energy as those located within 500 m of a low voltage (LV) transformer. The weakness of this definition is that it includes any establishment located within that range that either does not wish to be connected or that cannot afford. The adoption of the SE4ALL vision which defines access in terms of actual connection and usage means that Namibia will have to revise the REDMP.

The 2005 REDMP for Namibia identified 5,858 un-electrified rural settlements in the country, of which 1,543 were scheduled to be electrified by grid extension by 2025. The remaining, which comprise more than 106,000 households, are categorised as off-grid. The ***Off-Grid Energisation Master Plan for Namibia***[3] (OGEMP, 2007) was designed to complement the Regional Energy Distribution Master Plan by using alternative energy sources such as renewable energy. It adopts the REDMP definitions for off-grid, pre-grid and grey areas as follows:

- ***Off-grid areas:*** areas which are expected to lack access to grid electricity at least until 2027 (20 year horizon).
- ***Pre-grid areas***: locations which will lack access at least until 2013-2017 (5 to 10 year horizon).
- ***Grey areas:*** are those areas for which the 2005 REDMP does not clarify if they will have access to power. These may include informal settlements whose population does not have access to power or cannot afford it, and

[2] National Planning Commission (2004); *Namibia Vision 2030.*

[3] Ministry of Mines and Energy (2007) *Off-Grid Energisation Master Plan for Namibia*

commercial farm workers who lack access to power despite the farm owner having access to it.[4]

The Namibian Government has introduced, together with MME, NamPower, ECB, and REEEI, several demand management measures since 2006. These include programs for efficient lighting (CFL), domestic solar water heating (DSWH), maximum demand control, time of use tariffs, energy auditing and increased public and consumer awareness.

The Ministry of Mines and Energy gathers data about electricity demand through surveys and questionnaires. In addition, the ECB and the World Bank has recently (2012) commissioned a Load Forecast study[5] for grid power which was conducted by Hatch. The final report comprises a full assessment of the Namibian electricity sector as well as electricity imports. It was done as part of the development of the National Integrated Resource Plan (NIRP).

The ECB is also studying affordability of energy by the poor in order to guide policy and regulatory recommendations to promote access by the poor.

2.2 Gap analysis –market needs and demand

Namibia needs to be commended for investing a lot of effort and resources to establish the needs and demand for energy and has developed grid and off-grid masterplans. The gap that exists is the need for updating the plans to reflect the SE4ALL vision in terms of definition of access and target horizon for achieving universal access. Given that 6 years have elapsed since OGEMP was completed, and experience has been gained from the existing mini-grids, the time is opportune for a re-assessment of the scope for renewable or hybrid mini-grids. This should focus in particular on opportunities where productive use could be made of the electricity, creating jobs, raising incomes and making electricity affordable.

The selection criteria for rural locations therefore need to include current and potential social and economic impacts in addition to technology choice, population and type of institution to be served. In previous studies the density of population in the localities identified was unknown which would make the detailed planning of mini-grids impossible.

Other countries can learn from Namibia's experience of prioritisation of rural locations and developing complementary grid and off-grid masterplans for energy access.

[4] The latter case is not accounted for in OGEMP.

[5] The World Bank Group & ECB (2012) *National Integrated Resource Plan*. Load Forecast Final Report.

3 Technology choice and technical regulation

3.1 Existing technology assessment studies

The OGEMP of 2007 assessed the technologies appropriate for off-grid and mini-grid generation according to the following three factors:

- Fuel and technologies which are already available in Namibia
- Fuels and technologies which combined can address basic energy needs of households
- Technologies that require minimal operation and maintenance costs

Accordingly, the complying technologies were identified as solar photovoltaic energy for basic electricity supply and liquefied petroleum gas technologies for thermal energy. Attached to the OGEMP as an appendix, the presentation given to the Ministry of Mines and Energy by the responsible consulting firm makes reference to the fact that developing mini-grids in Namibia is not well-suited due to the dispersed nature of households classified as off-grid.

The main concept developed in the OGEMP for off-grid supply of electricity is the use of Energy Shops. Such shops are expected to be located at a reasonable distance from the communities. The Energy Shops would be set up in existing shops or petrol stations, and will sell energy products and appliances. The REEEI has so far facilitated the setting up of 13 energy shops in 12 regions. Typical products are dry cell batteries, 12V car batteries, LPG and energy efficient light bulbs and fuel-efficient wood stoves. A credit facility was established to provide revolving loans to customers.

In addition to outlining the creation and implementation of Energy Shops, the 2007 OGEMP considered the possibility of setting up hybrid mini-grids. The Solar Revolving Fund (SRF) established in 1996 is also part of the implementation strategies for the OGEMP which helps to fund the stocking of energy shops. However the SRF charges interest rate of 5% that is below inflation estimated at 6% which implies a need for regular review of charges or re-capitalisation.

The ***Renewable Energy Feed-in Tariff (REFiT) for Namibia*** of 2013 designed by Nexant assessed the renewable energy generation technologies that are most suitable for the introduction of feed-in-tariffs. The report concluded that solar PV is the most suitable technology for REFiT. Hydro power was excluded because the country does not have resources of the necessary size to justify small scale grid-connected generation, while wind power was left out due to the fact that viable wind power resources are in unpopulated areas where the feasible option is to develop generators that will be feeding into the national grid.

3.2 Renewable energy policy, standards and resource assessment

Although the country does not yet have a formal renewable energy policy the White Paper of 1998 states the government's intention to use renewable energy technologies as on-grid and off-grid solutions to power facilities that provide basic services to the population, such as hospitals, schools and post offices. Specifically:

> *"Government will promote the use of economically viable renewable technologies, as a complement to grid electrification, to improve energy provision to rural areas.*
>
> *Government will ensure that funds made available for rural electrification will be allocated between grid and off-grid energy supply options, on the basis of their relative social and economic costs and benefits."*

In 2006 the Government established the Renewable Energy and Energy Efficiency Institute (REEEI) within the Polytechnic of Namibia. It is disseminating research and information about renewable energy as well as providing technical assistance to the MME in the implementation of renewable energy projects and programs including addressing barriers to renewable energy development. The REEEI's current projects include the establishment of Energy Shops as provided for in the OGEMP, the Namibia Renewable Energy Program (NAMREP), preparation and administration of regulations for procurement renewable energy projects, feasibility study for a 50 MW concentrating solar power (CSP) project, energy efficiency program for buildings, renewable resource assessments and active participation in the development of the National Integrated Resource Plan (NIRP) and net metering regulations. REEEI requires capacity building to update renewable energy resource data and ensure that the information is sufficiently detailed to help developers in preparing bankable project proposals.

Norms, standards and codes of practice for performance, manufacturing, installation and maintenance of renewable energy technologies titled 'Code of Practice and Register of Products' were developed in 2006. The code of practice and standards are developed by a national committee, the National Technical Committee on Renewable Energy (NTCRE) headed by the National Standards Institute (NSI) and comprising of RE stakeholders. Any project, policy or regulatory document that is to address and regulate mini-grids should incorporate minimum technical standards in accordance with the code of practice.

3.3 Gap analysis – technology choice and technical regulation

The establishment of REEEI demonstrates the Government of Namibia's commitment to the promotion of renewable energy technologies which are expected to play a major role in helping the country to achieve the goal of universal energy access by providing a more cost effective alternative to main grid extension for rural areas. The institute provides the technical assistance that the Ministry's rural

electrification department requires. However the REEEI requires the technical skills and resources to use modern methods such as satellites to create and present renewable energy resource maps. Private developers would gain from building the technical capacity of REEEI. Carrying out detailed resource assessments would be an important step in the promotion of renewables in Namibia, including the development of renewable-based mini-grids.

Existing mini-grids and end user standalone systems require technical capacity for operation and maintenance. The Ministry of Transport and Works does not have the technical capacity to maintain the systems that it develops in addition to those handed over by other ministries and NGOs. The situation can be alleviated more through end user training and more efficient of private sector capacity.

Technical standards and codes of practice require more regular review and updating than current practice. Since 2006, the standards and code of practice have not been reviewed and updated despite rapid developments in RE technology.

4 Ownership, funding and economic regulation

4.1 Ownership and funding

Experience to date of RE powered mini-grids in Namibia is limited to government and donor initiated pilot projects. The Desert Research Foundation of Namibia (DRFN) has played a key role in developing two of the existing mini-grids. Concessionary finance has been important in getting the projects started. The subsidy includes operation and maintenance as users do not pay fees with the exception of Tsumkwe, but even there the tariffs, which are not related to main grid tariffs, are not cost reflective. The systems are technically sound but economically unviable and unsustainable. The regional electricity distributors are unwilling to take ownership of mini-grids citing lack of viability. The Tsumkwe mini-grid is currently under the operation and control of the local authority while the DRFN operates and controls the Gobabeb mini-grid.

4.2 Economic regulation

Tariffs for mini-grids are not regulated. The only regulated tariffs published by ECB are tariffs for the supply of power from the grid. These vary depending on the RED that supplies the electricity. A particular feature in the Namibian market is that Local Authorities and Regional Councils (LAs and RCs) are allowed by ECB to charge their customer a surcharge for the grid electricity they consume. These revenues are intended to cover the costs of supplying power and are used to cross-subsidise other municipal activities.

Since the Electricity Act of 2007, the Government of Namibia has been trying to get private power producers on board to meet the power needs of the country. An ***IPP and Investment Market Framework*** was drafted in 2008 which allows any private power producer to apply for a licence and ECB will determine what tariff may be charged by each producer separately. NamPower is the exclusive single buyer. Although several IPPs have been granted provisional licenses none except a 250 kW biomass project have been able to take off due to unresolved power purchase agreement problems relating mainly to tariffs and risk sharing. This demonstrates the need for the government and regulatory authority to consider introduction of a standardised tariff methodology and standardised power purchase agreements.

The other regulatory instruments that are likely to have a positive impact on mini-grid development in Namibia are the proposed net metering and renewable energy feed in tariffs (REFiT) structured as follows:

- ❑ All RE systems less than 500 kW, will be regulated by the net metering rules.
- ❑ All RE systems less than 5 MW, but greater than 500 kW, will be regulated by the renewable feed in tariff (REFiT).

- For systems greater than 5MW, government will issue tenders. But normal licensing provided for by the IPP framework also applies.

The ***Draft Net Metering Rules***[6] were designed in June 2013 and are awaiting government approval. Only Erongo RED is implementing net metering rules in the Erongo region.

4.3 Gap analysis – ownership, funding and economic regulation

There is a clear need for clarity on the ownership and financing mechanisms for mini-grids, particularly in respect of ways to leverage private sector financing. One of the Regional Electricity Regulators, CENORED, refused ownership of a vertically-integrated mini-grid because it does not hold a generation licence. The mandate for generation is with Regional Councils. This regulatory gap could be addressed by having a mini-grid license that authorises both generation and distribution.

On grid regulations are being clarified but off-grid regulations are still a grey area. For small projects, which in Namibia are defined as those with energy source less than 500 kW, the regional guidelines recommend minimal regulation for safety and other technical issues but no tariff regulation. The existing de facto policy on this should be continued. However the regulator can assist the off-grid project developers by providing training in setting cost reflective tariffs, for example using the retail tariff tool. Namibia also has tariff tools which have been developed for IPPs and they can be adapted for mini-grid developers. User fees need to be introduced on all off grid systems to avoid developing a culture of 'free' service.

Thought needs to be given to the economic arrangements when the mini-grid becomes connected to the main grid – in this event, which party will pay for the interconnection and will a grid connected mini-grid continue to be operated by the existing project sponsor or manager or will it be taken over by the utility?

To address the high capital cost barrier for investing in RE technologies, MME introduced a Solar Revolving Fund. The fund is administered by financial institutes who charge an interest of 5% per annum and with a repayment period of 5 years. To date, due to limitations of funds, the fund has not been able to meet the demand and there is a large backlog. The interest rate charged is below the average yearly inflation currently 6%, thus the revolving fund without external financial injections will not be sustainable. Other countries in the region have also been able to create sustainable funds for rural electrification through levies charged on electricity consumption.

[6] ECB (2013) *Draft Net Metering Rules*.

5 Planning and development process guidelines and role clarity

5.1 Role clarity and coordination

As has been highlighted there is clarity on the responsibility and regulations for on grid electrification but there are grey areas for off-grid electrification. Not only are there the known uncertainties with respect to ownership and regulatory jurisdiction created by provisions of the Electricity and Local Government laws but there are many players with overlapping responsibilities for off-grid electrification who are not very well coordinated. The off grid electrification projects and programmes are continuously being implemented by many different players and there is no feedback regarding strategic achievements and impacts. The projects and programmes are not being systematically monitored and evaluated.

International best practice addresses this by having a clear rural and renewable energy policy and law which includes the creation of an institution such as a rural and renewable energy agency. In the absence of such an agency there has evolved a situation where many uncoordinated initiatives for solar electrification are made by various government and non-governmental institutions and then operational and maintenance responsibility is given to the Ministry of Works and Transport. That ministry has limited technical and financial resources for operating and maintaining these systems.

The project for the creating a rural and renewable energy policy, act and agency can be organised as a special project of the Ministry of Energy with technical assistance from the following organisations some of whose functions would become those of the new agency:

- The ***Renewable Energy and Energy Efficiency Institute (REEEI)***
- The ***Desert Research Foundation of Namibia (DRFN)*** is a non-governmental organisation working towards achieving a greater degree of sustainable development, implementing projects in the areas of energy, land and water. DRFN developed and carried out the largest hybrid mini-grid project of its kind in Africa, the *Tsumkwe Solar/Diesel Hybrid project*.
- ***Solar Energy Industries Association of Namibia (SEIAN)*** is the association of private sector players supplying solar products and services.
- ***National Technical Committee on Renewable Energy (NTCRE):*** NTCRE was created to register RE product/service suppliers and installers. It is headed by the National Standards Institute and the committee is made up of the stakeholders from the energy supply industry. It has a database of approved equipment for application in government tender projects.

5.2 Gap analysis - Role clarity, planning and development

There is a policy and institutional gap for coordinating rural and renewable energy projects and programs in Namibia. A rural and renewable energy agency would, among its functions, act as the mini-grid project coordinating agency. The agency would become the sole renewable energy coordinator in charge of rural electrification, and as such, manage any programmes and funds related to this objective. The levy on electricity consumption would be adequate to fund such an agency and its coordinating functions. The regional framework for mini-grids is designed to attract the bulk of funding for projects and programs from communities, beneficiaries and the private sector.

Pending the long process expected in establishing new policies, laws and institutions the coordinating gap can be filled by increasing the capacity of the rural electrification unit in the ministry of energy as well as the REEEI. The additional capacity would serve as the nucleus of the proposed rural and renewable energy agency.

The off grid electrification projects and programmes are continuously being implemented and there is no feedback regarding strategic achievements and impacts. The ***Baseline Study: Barrier Removal to Namibian Renewable Energy Programme***[7] (NAMREP) conducted by Consulting Service Africa for MME, reviewed in 2005 the state of solar power in the country by conducting visits to 12 regions and carrying out surveys. What is needed is to have such surveys on an on-going basis for all renewable energy technologies and not as an occasional exercise.

[7] Ministry of Mines and Energy (2005) *Baseline Study: Barrier Removal to Namibian Renewable Energy Programme (NAMREP).*

6 National Action Plan

From the gap analysis results presented above and the workshop inputs, the following plan of action was developed.

Table 7: Summary of the Namibia Gap Analysis and National Plan of Action

Identified Gap	Objective / Deliverable	Description of Activities	Responsibility	Resources	Due date
Market Needs and Demand					
1. The selection criteria for off grid locations do not include current and potential social and economic impacts including productive use.	**Revised grid and off grid selection criteria.**	Engagement of expert advice to undertake the revision in consultations with all stakeholders	MME	Ministry Funds	December 2015
2. The Regional Electricity and Off- Grid Energisation Master Plans are not aligned with the SE4ALL objectives.	**Revised REDMP and OGEMP aligned with the SE4ALL objectives**	Engagement of expert advice to review and update master plans while developing in-house expertise for replication of the studies	MME	Ministry and Donor Resources	December 2016
Technology choice and Technical Regulation					
3. There is no portal for accurate and updated renewable energy resource data and competitiveness for Namibia	**Renewable Energy Resource Assessment**	Build the capacity of REEEI to develop RE resource maps using modern methods such as satellites, coordinating the work with other institutions such as the Meteorological Dept. Undertake preliminary review of study by NamPower on its embedded generation project in Rehoboth	REEEI With NamPower & Soitec	Donor funds Soitec and NamPower Funds	December 2014
4. Inadequate technical capacity for	**Training programme on RE established.**	Undertake capacity building for end users for operation and maintenance of	REEEI/SEIAN	End user and Donor Funds	December 2015

Identified Gap	Objective / Deliverable	Description of Activities	Responsibility	Resources	Due date
operation and maintenance of off grid systems in the country.	**Better utilisation of private sector capacity**	renewable energy systems in mini-grids. Include technical training of renewable energy in the education curriculum at all levels. The Solar Energy Industries Association of Namibia (SEIAN) to develop a business model that responds to operation and maintenance needs of RE systems in the country.			
5. Norms, standards and codes of practice for performance, manufacturing, installation and maintenance of mini grids need more regular reviewing.	**Review and update Code of Practice** **Technical guidelines for energy project proposal appraisal developed**	The mandate of the National Technical Committee on Renewable Energy (NTCRE) needs to be expanded to include development of technical guidelines for appraising all RE projects including mini-grids that are being implemented nationally. The NTCRE should update its Code of Practice and also database of RE components.	NTCRE	REEEI/NTCRE funds	June 2014
Ownership, Funding and Economic Regulation					
6. The regional electricity distributors are unwilling to take ownership of mini grids citing lack of viability and regulatory uncertainty.	**REDs promoting mini grids in areas of their jurisdiction**	Once off capital subsidies, which could be funded by levies on electricity sales, should be considered to help REDs and other developers to invest in mini grids.	MME/REDs	Donor Funds/MME/levies	December 2015
7. The off grid systems on public institutions and remote villages are not financially sustainable	**Financially viable and sustainable mini grids.**	Local authorities and other project developers need help with tariff determination to establish tariffs that cover operation and maintenance costs including system	ECB	Donor Funds/MME	June 2014

Identified Gap	Objective / Deliverable	Description of Activities	Responsibility	Resources	Due date
		replacement.			
8. Solar Revolving Fund is unsustainable and has a backlog of customers.	**A sustainable SRF that adequately meets user needs**	There is need to consider the re-capitalisation of the SRF and to review the interest rate policy in relation to inflation to ensure sustainability	MME	MME funds	Dec 2015
Planning & Development Process and Role Clarity					
9. Namibia does not have a Rural and Renewable Energy (RRE) Policy, Act and Agency	**RRE policy and RRE Act and agency established**	Development of rural and renewable energy policy and act that to establish a Rural and Renewable Energy Agency	MME	MME and Donor Funds	December 2016
10. There is ineffective coordination among players and the implementation of projects	**Effective coordination of stakeholders and projects**	Capacity building for existing agencies pending new agency for coordinating rural and renewable energy. New agency to develop and publish mini-grid planning and development process and technical planning guidelines	MME	MME budget	December 2016
11. The off grid electrification projects and programmes are not being systematically monitored and evaluated.	**Develop a sustainable monitoring and evaluation framework for electrification projects**	MME to implement an impact assessment and M&E framework for electrification projects	MME/REEEI	MME budget	June 2014

7 Conclusion and Lessons for Regional Guidelines

The following specific objectives were achieved and lessons for other countries were noted from this case study:

- **The development of a Gap Analysis Report**: The SADC regional framework for mini-grids that has been developed provides an easy basis for reviewing the policy and regulatory framework of a country and to identify the gaps and develop a report that can provide productive discussions at a stakeholder workshop. Field visits helped to highlight the practical realities of operating and maintaining solar systems under the extreme weather conditions of high temperatures and sand storms that can adversely affect performance and longevity of solar panels. Specification of equipment to meet these conditions is necessary. The need for user training for operation and maintenance should be obvious but is often neglected resulting in systems not fulfilling end user needs and sustainability.

- **Stakeholder feedback on gap analysis and recommended action plan:** The workshop was attended by 24 delegates drawn from MME, ECB, REEEI, NamPower, MWT, SEIAN, private sector, media and NGO involved in energy and rural development. The morning was devoted to presentations to bring everyone to the same understanding so that they could engage effectively in the analysis of the recommendations. The afternoon had been planned for separate group discussions based on the professional and business interests of delegates but as only 15 delegates attended the session it was decided to have one group. Effective feedback was still provided with this approach. Other countries which may not be able to have large numbers for their stakeholder workshops can follow the same approach.

- **A coordinating agency is necessary:** Although Namibia has an impressive set of masterplans, standards and code of practice for renewable energy, the absence of a coordinating agency is still felt because of the overlapping projects and programs of various government, non-government and private sector entities. Municipalities and regional electricity distributors are unwilling to take ownership of mini grids citing financial viability issues. Thus it is important for government to have a dedicated institution backed up by appropriate financing, which could be a levy on electricity consumption, to facilitate rural and renewable energy development using mini-grids. The agency would facilitate financing through subsidies and guarantees to support project developers and to help the local authorities in fulfilling their legal mandate for provision of electricity within their areas of juridiction.

- **Existing solar/diesel hybrid mini grids demonstrate the technical feasibility of providing 24 hour reliable power if there is the technical capacity for operation and maintenance:** Namibia has the largest solar/diesel hybrid mini-grids in the region at Tsumkwe and Gobabeb.

Their technical success is due to thorough assessment of needs and demand, comprehensive assessment of technology options and efficient energy management under the direction of resident operators. This is partly the reason why there are challenges with technical capacity for operation and maintenance on most off grid installations. As an example there are solar home systems installed in 70 households in Okongo and 50 households in Donkerhoek that are no longer functional.

- **It is necessary to have pilot projects that are focussed on financially viability:** Most existing mini-grids are pilot projects designed to test technology and hence there are no cost recovery programs for the beneficiaries except at Tsumkwe where there is partial cost recovery through a prepayment system.

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A2 Terms of Reference for Country Case Studies

1. Country/ Region

Namibia & Zimbabwe

2. Background

Regional guidelines for mini-grids have been developed for RERA; including instruments to develop role clarity, assessment of market needs and demands and technical and economic regulation. The objective of these instruments is to assist RERA members (i.e. individual countries) in the development of supportive framework conditions for mini-grids. The instruments provide guidance, but do need adaptation to the specific circumstances and needs of the member countries.

Following the regional workshop and the analytic work done during earlier phases, two SADC member states have been selected where further investigations are to be carried out regarding mini-grid opportunities and constraints. The criteria for selection of the two countries included: 1) demonstrated interest from the relevant institutions (REAs, ministries); 2) the need for policy and regulatory support; 3) the potential for renewable energies. The two country studies will be sufficiently detailed and include a review of policy and regulatory issues around mini-grids in the subject countries and result in a set of recommendations and action plan for implementation of mini-grids.

3. Purpose and Objective

3.1 Objective

The main objective is to review the policy and regulatory framework around mini-grids within two selected SADC countries in order to develop country specific action plans to improve this framework.
A secondary objective of this trial of the Regional Guidelines is to generate feedback and further improve those guidelines.

3.2 Activities

The main objective shall be achieved by the following activities:

- **Gap Analysis**: Study of the country's existing policy and regulatory framework to assess readiness against recommended framework. This will entail the review of the energy and related policies and legislation such as Regulatory law, Electricity law, Investment law, Licensing Procedures, licenses, concession agreements and other relevant permits issued to existing mini grids.

- **Development of a national action plan**: Based on the gaps or constraints identified a report will be produced with a set of recommendations for application of the regional recommendations for the country. The recommendations will include, but not be limited to an outline of the specific policy and legal actions required, mini-grid planning and development process guidelines, standardised templates for mini-grid registration or licensing, templates for power purchase and concession agreements, and templates demonstrating application of tariff tools. The actual development of a tariff structure is not part of this assignment.

- **Stakeholder consultation through a national workshop**: in each country, the outcomes shall be presented during a workshop that is expected to have about 30 delegates drawn from organisations involved with or affected by mini-grid development such as electricity utilities, rural electrification agencies, regulatory agencies, energy and economic development ministries, local authorities, private sector, financing agencies, community and NGOs involved in energy and rural development including productive use of electricity. The list of participants shall be drawn up and agreed with the country counterpart at a kick off meeting for the study.

- **Production of Workshop and final Country Reports**: workshop proceedings shall be summarised in a report and the final country national action plan report shall incorporate stakeholder consensus and input from the national workshop.

3.2 Expected Outcomes

The outcomes of the national focused case studies will be country specific range of suitable policy options responsive to their situations and action plans that will assist in developing or improving mini-grids frameworks that are consistent with the recommended Regional Policy and Regulatory Framework on Mini Grids for Southern Africa.

A secondary outcome is the adaptation of the regional guidelines, if the outcomes of the country studies have shown a need for adaptation.

4. Scope of Work

The work will involve a combination of a desk study and field trips for data gathering. Working with the counterpart team the consultant will undertake the following:

1. **Information and Data collection**: the Consultant will specify the information and data required and the country contact person will expedite the provision of the information by the counterpart team, preferably before or at the start of the country visit. Any additional information will be provided during the first week of the country visit. It will be desirable for the counterpart team to work on a day-to-day basis with the consultants so that capacity development can take place.

2. **Market mapping for Policy and Regulatory Gap Analysis**: The approach is to apply a market mapping methodology that looks at mini grid development as a market system to analyse procedures and obstacles for investors. Investors are expected to be from the private and public sectors. The process will carry out a mapping of market actors in the sector and their interrelationships. Additionally, an audit trail will be taken; a journey through the system of an existing investor who has made investments in mini grids within the country. We will follow through the investment process and identify constraints and bottlenecks. This historical perspective from existing mini grid will provide valuable and localised lessons to input into the policy and regulatory framework. In addition we will look at potential obstacles that future investors may face.

3. **Analysis**: the analytic work will focus on defining the interrelationships between various actors doing business involving mini-grids, evaluation of the financial and economic performance of the existing service delivery system, identification of capacity gaps to support policy and technical capability for local manufacture and back service, evaluation of the technical and financial performance of existing mini grids, assessment of funding sources and opportunities for alternative funding sources. It will include an assessment of the renewable energy framework in the countries as well as the extent of mainstreaming of gender.

4. **Workshop organisation**: the consultant will organise the workshops and prepare power point presentations to stimulate active and focused discussion and feedback on the national action plan report. The workshop will also in addition seek to identify other important issues that the country will have to follow up on after the study. Because of the limited time available for the country studies the workshops will be restricted to a single day and the focus will be on achieving consensus on an action plan to increase mini-grid investments. Thirty participants are expected to attend the workshop with costs for the workshop, excluding participants' travel, being met by the consultant.

5. Deliverables

The key deliverables from the assignment will be

- Gap analysis report
- National action plan

In addition, the consultant will be responsible for providing the meeting/workshop reports to EUEI-PDF, RERA and the country counterpart.

Furthermore, adaptations made to the Regional Guidelines should be indicated.

Note: *This assignment is a part of an existing project and ends with the development of the National Action Plan. Please note that the implementation of the National Action Plan is not envisaged as part of this assignment. However, separate specific needs for further EUEI PDF assistance in the implementation of the National Action Plan may be requested and obtained by the country under certain circumstances and beyond the scope of this project*[8].

6. Coordination and Reporting

The country studies will be undertaken within the respective countries under the direction of a Project Steering Committee (PSC) supported by counterpart team of 1 to 2 people to be established by the country and advised to the Consultant and RERA Secretariat before the start of the project. The membership of the PSC could comprise a representative each from ministry responsible for energy, regulator, power utility and rural electrification agency, as the case maybe. The PSC Chairperson is expected to have sufficient authority to make or obtain the necessary approvals required to facilitate the conduct of the country study.

[8] See www.euei-pdf.org for more information

The Consultant will meet with the full PSC at the beginning of the cooperation and liaise with the PSC Chairperson to establish the actual dates and logistics for the project activities which are expected to be completed within three calendar weeks from the start date for each country. The Country Workshops are expected to be scheduled during the last five days of the country visit. The two country studies and reports are expected to be completed by the end of October 2013.

ANNEX 1: Background Note on National Consultation and Finalisation

(*Task 4: National Focused Consultation - Extract from the RERA Project Terms of Reference*)

Following the regional workshop and the analytic work done during earlier phases, the consultant (in consultation with RERA) will select two motivated SADC member states where there will be further investigations regarding mini-grid opportunities and constraints. The criteria to select the countries should at least include: 1) demonstrated interest from the relevant institutions (REAs, ministries); 2) the need for policy and regulatory support; 3) the potential for renewable energies.

The consultant will develop, before the start of the two national activities, brief terms of reference to address regulatory and policy issues in these countries. These ToRs must be approved by EUEI-PDF and RERA, as well as be requested by the appropriate ministries of the countries targeted.

The two national consultancies will include a review of policy and regulatory issues around mini-grids in the subject countries, and will result in a set of recommendations for implementation of mini-grids, including specific legal actions required, templates for contracts, and a proposed structure for a tariff regime. The national consultancies will each result in a country study and a proposed country action plan including potential funding sources. The study and action plan will be presented to relevant stakeholders in the country (at least including relevant ministries, agencies and REA) during a national workshop. All costs related to the workshops should be included in the offer.

This work of the national consultancies will be sufficiently detailed to enable generation of specific recommendations for authorities in the subject countries, assisting them in developing their own policy and regulatory approach to mini-grids, whilst ensuring that the resulting work is closely aligned to, and contributes to, the policy options for the region. The expected length of the consultancy will be ca. 3 weeks per country, excluding write-up time. As this activity will require strong cooperation with national bodies, the consultant is expected to carry out the activity in the respective countries.

A3 Mini-grid Case Studies

A3.1 Usib Primary School: Solar Power Demonstration Project

Location: Rehoboth Hardap Municipality

Date: June 2013

Implementer & Financier: Soitec

Cost: Not disclosed.

Technical Partners: NamPower

Generating Capacity: 25 kWp

Introduction

Soitec and NamPower entered into a cooperative agreement in which Soitec constructed and operates the Concentrating Photovoltaic (CPV) plant and will transfer the knowledge gained as well as operations and maintenance duties to NamPower. CPV technology differs from the conventional PV by concentrating sunlight on solar cells in order to increase efficiency and reduce the amount of PV material required for a given output. It is suited to areas with plenty of direct sunlight such as Namibia but would not be very efficient in areas with indirect sunlight.

Usib is an isolated rural community with a school providing education to more than 100 children from the surrounding area. Additionally Soitec's subcontractor Alensy has installed a solar water pump at the community garden to ensure there is sufficient water to irrigate up to one acre of crops without increasing the electricity bill. Production from a small vegetable garden supplements the diet of the school's boarders. Funds from the sale of electricity generated by the power plant and injected into the grid will be credited to the school's electricity bill. The power plant will be in operation for at least 20 years.

Market needs and demand

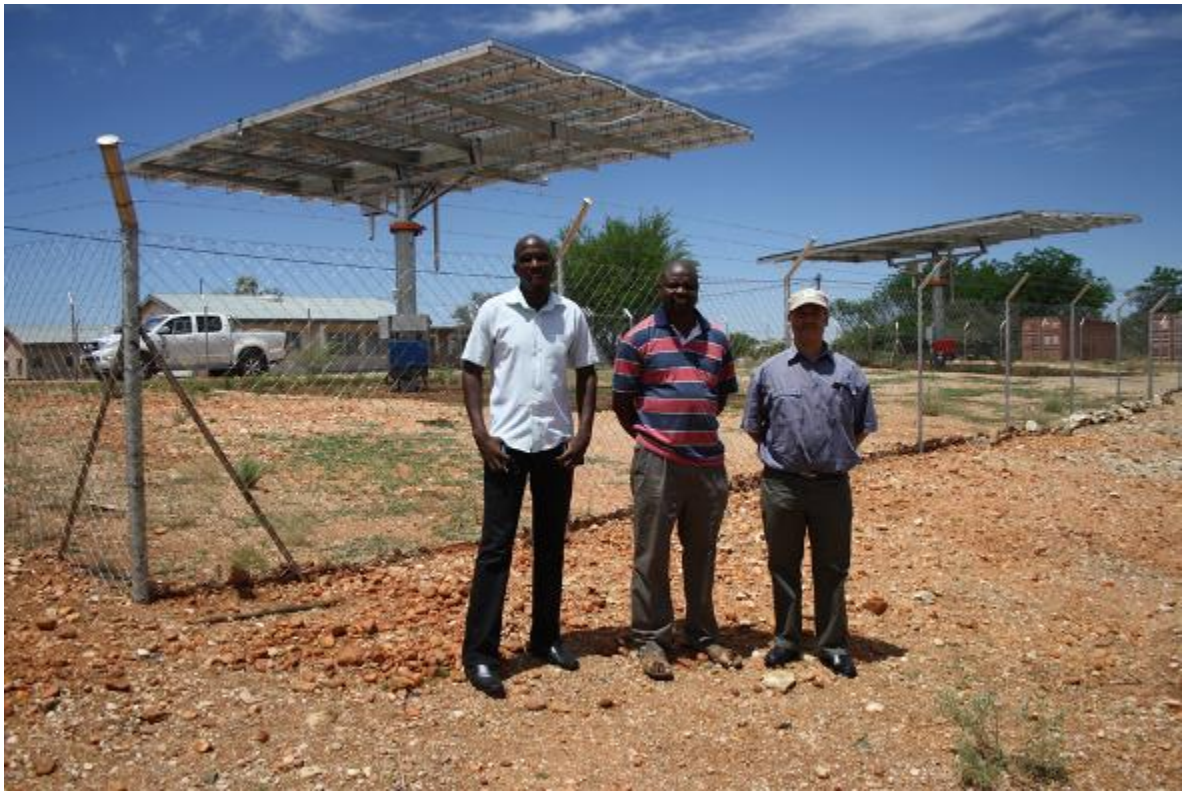
The demonstration project's overall objective is to establish market needs and demand for embedded power generation. In this particular case Usib primary school has been paying electricity bills to Hardap municipality. The project is expected to reduce electricity demand from the national grid with the benefit accruing to the primary school.

Technology choice and technical regulation

The project is demonstrating the application of CPV technology in hot and arid

conditions. All technical data related to operation and maintenance of the system is electronically logged and sent via satellite to Soitec head office in France.

Figure 5: Soitec installed 25 kWp Concentrating Photovoltaic System at Usib Primary School, Rehoboth



Ownership, Funding and Economic regulation

The power plant was wholly funded by Soitec. So far NamPower oversees the operation and management of the plant while the ownership of the system is still with Soitec under a cooperation agreement of 18 months after which it will be handed to NamPower. It is not yet clear what NamPower will do with the system after being officially handed over. The direct financial benefit will accrue to the school through reduced imports from the main grid. Surplus electricity generated by the power plant will be injected into the grid and will be credited to the school's electricity bill. For safety the utility requires grid connected solar systems to have anti-islanding protection that disconnects the system in case of grid supply interruption. This eliminates the danger of energising the power line while it is being repaired. It should also be noted that the cost of island operation for a solar system would be very high because of the storage required. An analysis of the financial benefit is still to be done.

Recommendation

From the perspective of high energy consumers such as REDs who are charged on peak demand and energy consumption by NamPower, this example provides an interesting case for the REDs. It is a potential energy saving and demand

management strategy that REDs can implement to avoid the heavy penalties from NamPower. It is important for REEEI as the mandated Renewable Energy (RE) research institute to monitor the results of the demonstration plant in order to assess the technology for potential up-scaling and roll-out.

A3.2 Tsumkwe - Solar PV/Diesel Hybrid Mini Grid

Location: Tsumkwe, Otjozondjupa Regional Council.

Date: June 2013

Financier: European Union 75%, NamPower, Ministry of Mines and Energy and Desert Research Foundation of Namibia

Cost: US$ 2,8 million.

Technical Partners: NamPower, DRFN

Owners: Otjozondjupa Regional Council

Generating Capacity: 202 kWp Solar PV/ 350kVA Diesel

Introduction

Tsumkwe is a settlement in north eastern Namibia which is home to about 1000 permanent residents and a service centre for a San community of about 3000. The Tsumkwe PV/diesel mini-grid project was implemented over a 4 year period by the Desert Research Foundation of Namibia (DRFN), NamPower and the Otjozondjupa Regional Council of Namibia (OTRC).

The project cost was 28 million Namibian dollars (N$), of which N$18 million was for the equipment and N$10 million was for soft issues such as studies and community meetings for awareness and buy-in. The Africa Caribbean and Pacific (ACP) European Union (EU) Energy Facility provided 75% of the funding, NamPower, 15% and the Ministry of Mines and Energy and the Regional Council provided the balance.

The mini-grid comprises 202 kWp Solar PV, a battery bank and a 350 kVA diesel plant that consumes 110 litres per hour at full output and 35 litres per hour on average load. The supply system can accommodate other supply sources that may become available in future.

Market needs and demand

Tsumkwe was identified by the national energy master plans as an off grid village. Thus according to the OGEMP, it qualified for standalone systems or a mini grid. The decision for mini grid was made on the basis of a relatively high population density and service delivery needs already obtaining in the area.

Energy needs and demand were already demonstrated because Tsumkwe was using a diesel generator which was only providing power for a limited period of the day. Energy needs and demand were further clarified by an in-depth assessment of the needs of the users. The survey established the essential energy demand and separated it from the non-essential energy demand. Essential loads included such service providing centres that include the police, hospital, telecommunications and schools. These will have to be provided 24/7.

Technology choice and technical regulation

Tsumkwe is located 500 km away from the nearest main grid. Thus naturally the option for grid extension though technically feasible was economically unviable. Solar was the other option considered including the existing diesel generator sets. Thus an optimal design that took consideration of existing diesel generators hybridised with solar was selected.

In addition the designs noted that in the old system inefficient loads were widely used. Among the loads included incandescent light bulbs, electric hot plates and electric water heaters. Cognisant of the need for thermal energy and optimising on the system operation efficiency, the design integrated energy efficiency measures and use of alternative thermal energy sources (LPG and solar water heaters). An energy awareness programme was implemented but energy saving culture is still not as effective as it should be. This is demonstrated by the long periods that the diesel generator remains switched on and the wide spread use of incandescent light bulbs.

Due to the sensitivity of the solar system to weather conditions and the diesel generator to availability of diesel, two parallel distribution lines were installed as per code of practice of Namibia to for ease of separation of the essential and non – essential loads. Thus the cost of the distribution line was twice the anticipated cost due to this requirement. Because the national code of practice was applied, the mini-grid network, which operates at medium voltage, could be interconnected into the main-grid in future.

Useful lessons from a technical perspective which have been learnt include the necessity for a resident operator or energy manager to operate and maintain the system; the advantage of using well proven hybrid system technology that is easy to maintain and replicate.

Ownership, Funding and Economic regulation

Ownership of Tsumkwe took long to resolve. The local authority has been reluctant to take over ownership of the new system citing viability issues. At the same time NamPower could not viably run Tsumkwe from a distance of 500 km. Another factor in the protracted wrangle over ownership was a result of the existing conflict between the Electricity Act (which governs the operations of NamPower, the local distribution board and the Electricity Control Board) and the Local Government Act (which governs the Regional Council and grants it the right to set the current tariffs). Both Acts create overlapping jurisdiction and there is a task force that has been set up to recommend to the Minister of Energy how to resolve the conflicts created by

this situation. The task force comprises the Ministry of Mines and Energy, NamPower, the local distribution board and the Regional Council.

In the past using diesel only, the supply was available for only 12 to 14 hours a day and was heavily subsidised by the Regional Council at N$1/kWh for residential and N$1.90 for businesses against a cost of N$6/kWh. The hybrid system provides a 24 hour service. Pre-payment meters from the same supplier that supplies NamPower were selected. The Regional Council has kept the residential tariff at the same level but the business tariff is now N$2.5/kWh. The prepaid meters for the consumers ensure that people pay in advance for their electricity and also helps in management efficiency.

Figure 6: The 202 kWp Tsumkwe Solar Power Plant

Conclusion

Tsumkwe is the largest solar/diesel hybrid project in the region and serves as a good example of off grid electrification where grid extension is economically unviable. It also demonstrates the role of renewable energy in providing sustainable development. With 24 hour electricity supply the economic growth at Tsumkwe is unprecedented with new infrastructure and services never anticipated emerging. The lessons learnt from Tsumkwe will benefit other communities in Namibia when developing off-grid energy systems.

It demonstrates clearly technical sustainability through a high level of technical input and planning as well as community engagement. The provision of metered supply is essential. Management systems of off grid systems are different from grids due to

low energy production and the low economies of scale. Energy production and use needs to be maximised on the solar side and minimised on diesel utilisation. Thus encouraging demand side management and energy efficiency as is happening in Tsumkwe is critical for its sustainability.

The cost of setting up the infrastructure is high. Thus public support in form of subsidies is essential to meet part of the capital costs. Cost reflective tariffs that cover operation and maintenance costs including depreciation to ensure sustainability are essential. Installation of prepaid meters for the consumers is good initiative for system sustainability but it should be accompanied by viable tariffs.

Recommendation

- Network costs could be lowered by relaxing some of the main grid standards adopted and using cheaper ways to manage essential and non-essential loads.
- Reliability is essential for mini-grids, otherwise the mini-grid becomes a liability.
- Response to an application for a tariff approval by the regulator has been pending for a long time due to the need to resolve the conflicts created by the legislation.
- The costs of soft issues can be very high compared to the cost of the project and hence adequate funding for soft issues is critical.

A3.3 Gobabeb - Solar PV with Diesel Backup Mini Grid

Location: Gobabeb, Namib Desert

Date: November 2004

Owners: Desert Research Foundation of Namibia /Gobabeb Research and Training Centre

Generating Capacity: The solar PV array consists of 370 modules, 26 kWpeak, consisting of 7 kWpeak mono-crystalline, 7 kWpeak copper indium disellenide (CIS), 10.5 kWpeak polycrystalline and 1.5 kWpeak used mono-crystalline photovoltaic modules. The various types of the solar panels used were also meant for demonstration purposes. There are 2 Deutz diesel generators each of 50 kVA, installed in 1972. The battery storage is 420 kWh, tubular deep cycle batteries.

Introduction

The Gobabeb Training and Research Centre (GTRC) is located in the middle of the Namib Desert of Namibia. It is 120 kilometres away from the nearest town, Walvis Bay, and is about sixty kilometres from the Namibian coast. The Centre focuses primarily on field research with basic equipment rather than state-of-the-art high power technologies. The GRTC houses about twenty residents, as well as visitors for conferences and workshops.

The solar PV/Diesel hybrid system at Gobabeb Research and Training Centre was inaugurated in December 2004. It was the first solar-diesel hybrid energy system in Namibia and has been serving as a role model for the development of similar systems throughout the country. Tsumkwe learnt from the Gobabeb system. It incorporates photovoltaic (PV) solar modules as the renewable energy resource as well as fossil fuel sources through the use of two diesel generators.

The diesel generators are used for monthly battery recharge cycles and backup energy. A backup supply of energy is needed during prolonged overcast periods and times of high electricity demand. The hybrid system generates standard 230VAC/400VAC power for the mini-grid.

Market needs and demand

GTRC was developed before the Off Grid Energy Master Plan was in place. It had traditionally used diesel generators installed in 1972.

GRTC has twenty-two permanent buildings, including offices, a library, laboratories, kitchens, conference facilities and housing. All of these buildings are in the main compound with the exception of the maintenance staff living quarters. An in-depth assessment of the needs of the users was carried out. Before 2000, the energy consumption was about 230 kWh per day.

Technology choice and technical regulation

The Namib Desert receives about ten to eleven hours of day light each day,making solar the most preferred source of energy. Other sources of energy that could be used for energy generation include coal, natural gas, and oil. In this part of the world they are not economically justifiable. Gobabis is about 50 km from the coast and wind power was not technically feasible. Grid extension was too costly as the nearest appropriate connection was more than 100 km away. However the mini-grid network, which operates at medium voltage, was designed for easy main-grid interconnection in future. The choice of the various solar modules was deliberate to demonstrate how they would perform in the long term.

Figure 7: The 26 kWp Gobabeb Solar Power Plant

Ownership, Funding and Economic regulation

The system was installed by the GTRC using their own resources with additional funds coming from various donors. The system is wholly owned by the training centre and provides power to its staff quarters, offices and visitors' quarters.

The GRTC lacks a cost recovery system for the maintenance and operation of their energy system. This does not provide incentives for energy conservation.

Observations and Lessons

The system has a local energy manager. Energy use needs constant monitoring and

regulation because of the energy limitations of the GRTC's current solar-diesel hybrid system. Decreasing energy consumption will reduce the need for diesel to run the generator, thus decreasing the use of expensive fuel with its significant additional costs for transportation and harmful environmental effects. However the energy manager has other tasks to carry out and energy efficiency remains a challenge due to constant coming in of external people who in their short time at the centre might not understand the need for energy management and the way the system operates.

The metering system at the Centre has not been well-maintained making it difficult to monitor each resident's energy consumption and also to charge occupants for personal energy use.

The PV systems are supposed to have a life expectancy of up to twenty-five years but after only 8 years many of the panels had degraded or are degrading, showing that it is important to have specifications that take account of the extreme temperatures and sandy conditions of the desert.

Conclusion

GRTC continues to serve as a best case model for solar-diesel hybrid energy systems in Namibia. It demonstrates clearly technical sustainability through a high level of technical input, through planning and development community engagement. Management systems of off grid systems are different from grids due to low energy production and the low economies of scale. Energy production and use needs to be maximised on the solar side and minimised on diesel utilisation. Thus encouraging demand side management and energy efficiency as is happening in GTRC is critical for its sustainability.

Recommendation

There is lack of adequate operation and maintenance funds for the system. To make it more sustainable and financially stable the research centre need to be put in place energy management systems. It is recommended to create a fund for the maintenance, eventual repair, and/or replacement of the energy system. Historical records of plant operation and maintenance are lacking and proper record keeping on plant performance is critical for operation and maintenance.

As a demonstration facility, the outcomes of the demonstration are not being systematically captured, documented and shared. It is recommended to encourage research into the system at GTRC to look at various aspects of the solar technology and meteorology.

Figure 8: The effect of extreme weather at GTRC and how it is affecting the solar modules

A4 Main contributors to the study

The PSC for the Namibia Case Study consisted of representatives from the following institutions: MME, NamPower, REEEI, REDs and ECB. The table below gives the names and institutions of the representatives of the PMU.

Table 8: The names of the representatives of the PMU and their organisation

Name of Representative	Institution
Dr. Zivayi Chiguvare	REEEI (Chairperson)
Abraham Hangula	REEEI
Helvi Ileka	REEEI
David Jarrett	NamPower
Ben Hanghome	NamPower
Francois Robinson	ECB
Dr.Maxwell Muyambo	ECB
Nico Snyders	Ministry of Mines and Energy
Daniel Zaire	Ministry of Mines and Energy
Andreas Shikongeni	Nored
John Nambahu	Nored
Fessor Mbango	Erongo Red
Vermaas Bisset	Erongo Red
Manfred Uvanga	Cenored

The organising team for the workshop composed of staff members from Practical Action Consulting (PAC) and REEEI. The speakers and presenters included the Guest of honour, the Permanent Secretary in the Ministry of Mines and Energy, whose speech was read on his behalf by the Deputy Director of Energy, Mr. Daniel Zaire. The welcome remarks were given by the Chief Executive Officer of ECB, Mr. Siseho Simasiku who was represented by Ms Charity Nsofu, a senior engineer at ECB. Other presenters, besides the consulting team, were Mr. David Jarett of NamPower who were the technical partners for the Tsumkwe mini grid, and Mrs. Helvi Ileka of the REEEI who are implementing the energy shops project.

The workshop participants included representatives from MME, ECB, Ministry of Transport and Works, NamPower, REEEI, Solar Energy Industries Association of Namibia, Gobabeb Training and Research Centre and media. The workshop was successfully facilitated by Dr. Zivayi Chiguvare of REEEI.

EUEI PDF is an instrument of the