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

Inception Phase Report

March 2013

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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Zimbabwe-Mozambique border: views of a penstock for a private sector funded 2.2 MW mini-hydro scheme under construction (top picture – looking down towards powerhouse; bottom picture – looking up from the powerhouse). This is located in an ideal location for a mini-grid that can be run as a community or public private partnership for this remote and low income community. Productive agricultural uses would improve commercial viability of the scheme.

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Acronyms and abbreviations

BOT	Build Operate and Transfer
BPC Lesedi	National Utility of Botswana
CDM	Clean Development Mechanism
CEB	Central Electricity Board (Mauritius)
CFL	compact florescent lamp
CNELEC	National Electricity Advisory Council of Mozambique
CSP	Concentrated Solar Power
DBSA	Development Bank of Southern Africa
DME	Department of Minerals and Energy (South Africa)
DNO	Distribution Network Operator (Tanzania)
DOE	Department of Energy
DRC	Democratic Republic of the Congo
DRFN	Desert Research Foundation (Namibia)
ECA	Economic Consulting Associates
ECB	Electricity Control Board of Namibia
EDEL	Electricity Distribution Utility of Luanda
EDM	Electricidade de Moçambique – Mozambique electricity utility
EIA	Environmental Impact Assessment
ENE	National Electricity Utility of Angola
ERB	Energy Regulation Board of Zambia
ESCO	Electricity or Energy Services Company
ESCOM	Electricity Supply Commission of Malawi
ESKOM	National Electricity Utility of South Africa
EU	European Union
EUEI PDF	European Union Energy Initiative Partnership Dialogue Facility
EWURA	Energy & Water Utilities Regulatory Authority of Tanzania
FBE	Free Basic Electricity (South Africa)
GEF	Global Environment Facility
GVEP	Global Village Energy Partnership
GW	Gigawatt
GWh	Giga watt-hour
HCB	Hidroeléctrica de Cahora Bassa
INEP	Integrated National Electrification Programme (South Africa)

IPP	Independent Power Producer
IRP	Integrated Resource Plan
IRR	internal rate of return
IRSE	Institute for Electricity Sector Regulation of Angola
kVA	kilo volt-amperes
kWh	kilo watt-hour
LEA	Lesotho Electricity Authority
LEC	Lesotho Electricity Corporation
LED	light emitting diode
LPG	liquefied petroleum gas
LRMC	long run marginal cost
MDG	millennium development goal
MEM	Ministry of Energy and Minerals (Tanzania)
MEPD	Ministry of Energy and Power Development
MEPU	Ministry of Energy and Public Utilities (Mauritius)
MERA	Malawi Energy Regulatory Authority
MEWD	Ministry of Energy and Water Development (Zambia)
MHS	Micro- or mini- Hydro Scheme
MME	Ministry of Mines (Minerals) and Energy
MMEWR	Ministry of Minerals, Energy and Water Resources (Botswana)
MNREE	Ministry of Natural Resources, Energy and Environment (Malawi)
MW	Megawatt
N$	Namibian Dollar (on par with the Rand)
Nampower	Namibian electricity utility
NERSA	National Energy Regulator of South Africa
NTC	National Transmission Company (South Africa)
O&M	operations and maintenance
OGEMP	Off-Grid Energisation Master Plan (Namibia)
PA	Practical Action
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PV	photovoltaic
R	Rand (South African currency)
RE	renewable energy
RECP	Africa-EU Renewable Energy Cooperation Programme

RED	Regional Electricity Distributor (Namibia)
REEEI	Renewable Energy and Energy Efficiency Institute (Namibia)
RERA	Regional Electricity Regulators Association of Southern Africa
RREA	Rural and Renewable Energy Agency
SADC	Southern Africa Development Community
SAPP	Southern African Power Pool
SEA	Strategic Environmental Assessment
SEC	Swaziland Electricity Company
SEI	Swedish Environment Institute
SERA	Swaziland Energy Regulatory Authority
SHP	small hydro power
SHS	solar home system
SIRDC	Scientific, Industrial Research and Development Centre (Zimbabwe)
SME	small to medium scale enterprise
SNEL	National Electricity Utility of the DRC
SPP	small power project
SPPA	Standardised PPA (Tanzania)
SPV	special purpose vehicle
STM	Standardised Tariff Methodology (Tanzania)
Tanesco	Tanzania Electricity Supply Company Ltd
TaTEDO	Tanzania Traditional Energy Development and Environment Organisation
TSh	Tanzania Shilling
UNDP	United Nations Development Program
URA	Utility Regulatory Authority (Mauritius)
US$	United States dollar
USc	United States cents
ZERA	Zimbabwe Energy Regulatory Authority
ZESA	Zimbabwe Electricity Supply Authority (now ZESA Holdings)
ZESCO	ZESCO Limited

Executive Summary

The purpose of this report is to establish a more detailed understanding of the objectives, methodology and workplan for the Regional Electricity Regulators' Association of Southern Africa (RERA) project for developing tools for creating supportive framework conditions for mini-grids employing renewable and hybrid generation in the SADC region. The ultimate objective is to stimulate increased access to modern energy services and investment in distributed renewable generation capacity in fulfilment of regional and international goals for environmentally, economically and socially sustainable development.

The report summarises the output from activities undertaken so far which include the briefing meeting between the consultants and EUEI PDF in Eschborn, Germany, on 11th January 2013, responses to questionnaires on the current country situation sent out to SADC and RERA contact points on 24th January 2013 and received during the month of February, the project kick off meeting held in Windhoek, Namibia, on 21st February 2013 and desk research on regional and international best practice for grid and off-grid electrification of remote and low income communities in developing countries.

The project assumes that energy access is defined by connectivity and actual use rather than grid proximity. Mini-grids therefore include both off-grid and grid-connected small distribution networks that provide safe, secure and reliable supply to end users by using at least one or more embedded renewable energy generators backed up by other renewable or non-renewable energy generators.

The best practice tools to be developed for the planning and development of mini-grids will address four key focus areas:

- **Role Clarity**: establishing accountability for championing the development of the mini-grids, establishing consensus on the definition and role of mini-grids and eliminating or minimising conflict of interest among the different people who affect or are affected by the mini-grids. The key tool for achieving role clarity is proposed to be *Guidelines for planning and development of mini-grids* which will address these issues and provide a comprehensive checklist of requirements of the people and institutions involved.

- **Market needs and demand**: analysis of end user needs and the ability and willingness of the target beneficiaries to pay for the modern energy services required for fulfilling those needs; experience demonstrates the need for phased development and enhancing the ability of beneficiaries to pay through correctly targeted subsidies and promotion of productive end uses. The key tools will be *Criteria for selection and ranking of rural locations* (to guide grid masterplans and the complimentary off-grid masterplans) and *Guidelines for targeting of subsidies*.

- **Technology choice**: identification of the optimum technical option that fulfils market needs at least economic, financial, environmental and social cost on a life cycle basis; renewable energy resource assessments

and technology transfer are critical success factors. The tools for technology choice will include *Comprehensive Assessment of Technology Options*, *Guidelines for technical design and operation of mini-grids* and *Guidelines for main grid interconnection*.

- **Ownership and finance**: identification of sustainable business models to include community, public, private and hybrid options; optimum funding strategies will involve a combination of dedicated statutory funds, private equity, commercial loans, grants and risk mitigation instruments; *Standardised tariff methodologies*, *Standardised Power Purchase Agreements* and *Guidelines for Selection of Project Developers* and *Guidelines for use of energy funds for investment support* are some of the tools required.

The above is an indicative list that will be refined and finalised based on stakeholder feedback and discussion of the details at the Regional and Country Workshops as well as scheduled RERA subcommittee and annual meetings to be held in Lesotho, Zimbabwe and Mozambique. RERA will brief the SADC Energy Ministers and select the countries to be selected for the pilot phase of the project.

The assessment of current status established that the national energy policies and laws in the region support increased energy access and renewable energy development. Rural energy agencies and rural energy funds have been established to address the special challenge of electrifying remote and poor communities. With specific reference to mini-grids there are no legal barriers as the traditional utility monopoly no longer exists. This political commitment to increased energy access using renewable generation for rural areas is a major incentive for promoting the use of mini-grids.

The major barriers that need to be addressed to increase mini-grid development in the SADC region are:

- **Absence of access and renewable energy targets:** Most countries do not have explicit time bound targets for universal access or renewable energy. Many countries do not have explicit renewable energy policies. Without such targets and policies there are therefore no specific strategies and programs designed to achieve universal and environmentally sustainable energy access within the short to medium term.

- **Access definitions:** Countries that consider proximity to a distribution network to be access may not authorise mini-grid development within defined distances from the main grid when grid connected mini-grids could be very viable community or privately owned businesses.

- **Main grid bias:** off-grid options tend to be viewed at both policy and user levels as temporary pre-electrification solutions when they could be the only options for many years. Many subsidy and rural energy funds are focussed on main-grid extension.

- **De-facto transmission and distribution monopoly:** Although progress has been made in removing the legal monopoly of national utilities, in practice only the generation of electricity has really been liberalised and many national utilities are still the single buyer transmission and distribution grid operators. Their poor revenue collection reduces their creditworthiness for supporting IPP development and the flow of funds into rural energy funds.

- **Heavy-handed regulation for small scale generation:** several countries have very low thresholds for licensing and other formal regulatory compliance requirements which lead to very costly regulatory compliance costs relative to the size of small power projects such as mini-grids.

- **Few sustainable and replicable pilot projects:** Existing mini-grids are either government or utility owned isolated networks using diesel generation or donor-funded pilot mini-grids using renewable and hybrid generation. The pilot projects have been technology or donor driven rather than market driven and have therefore not been designed for replication as sustainable business models.

The technical assistance project is expected to be implemented over the twelve month period January to December 2013 in three phases: inception, formulation and pilot implementation and finalisation. To promote stakeholder buy-in, the opportunity will be taken to brief SADC Energy ministers and senior government officials, RERA subcommittees responsible for legal, economic and technical regulation and to involve the private sector in the regional and country workshops.

1 Background and context

This project is in response to a request submitted by the Regional Electricity Regulators Association of Southern Africa (RERA) with support from the SADC Secretariat for technical assistance from the Africa-EU Renewable Energy Cooperation Programme (RECP), managed by the European Union Energy Initiative Partnership Dialogue Facility (EUEI PDF).

At present, RERA member regulators and countries are from ten SADC member states:

- Institute for Electricity Sector Regulation of Angola (IRSE)
- Lesotho Electricity (and Water) Authority (LEA)
- Malawi Energy Regulatory Authority (MERA)
- National Electricity Advisory Council of Mozambique (CNELEC)
- Electricity Control Board of Namibia (ECB)
- National Energy Regulator of South Africa (NERSA)
- Energy and Water Utilities Regulatory Authority of Tanzania (EWURA)
- Energy Regulation Board of Zambia (ERB)
- Swaziland Energy Regulatory Authority (SERA)
- Zimbabwe Energy Regulatory Authority (ZERA)

The non-member countries (Botswana, Democratic Republic of the Congo, Mauritius, Madagascar and Seychelles) are expected to join as soon as they establish operational regulatory agencies or when their country circumstances allow them to. This study is therefore based on an assessment of the situation in both member and non-member countries.

1.1 Objectives of the technical assistance

The objectives of the technical assistance are as follows:

- ***Immediate objective (expected project output or deliverable)***: to provide the policy and regulatory tools for creating supportive framework conditions to foster the development of mini-grids in the SADC Region.
- ***Ultimate objective (expected project outcome)***: to stimulate increased access to modern energy and distributed renewable generation capacity.

The project is building upon a number of interrelated projects and programs at regional and continental level. Responding to the challenge of increasing energy access and renewable energy development the SADC Energy Ministers endorsed the ***SADC Regional Energy Access Strategy and Action Plan (REASAP)*** in 2010 and approved a project to develop the ***SADC Renewable Energy Strategy and Action Plan (RESAP).*** RESAP is expected to be endorsed by the Energy Ministers in 2013.

The RECP Strategy 2020[1] recognises that increased energy access through acceleration of renewable energy investment not only requires a ***supportive policy and regulatory framework*** but also three other support pillars:

- promotion of ***private sector involvement*** to stimulate investment and trade and facilitate effective technology transfer;
- preparation of ***bankable project proposals*** to facilitate adequate and appropriate financing;
- ***strengthening local capacity*** for renewable energy technology deployment through education, research and innovation in order to build the skills base that is necessary for sustainability.

These four pillars address the principal barriers to renewable energy development, namely:

- absence of an enabling environment for energy access and renewable energy development;
- inadequate financial resources due to limited private sector involvement and overstretched public sector budgets;
- inability to translate good project ideas into bankable project proposals; and
- limited local knowledge, skills and capacity for renewable energy research and development, project design and implementation, operation and maintenance.

It is important for policy makers and regulators to be aware of this big picture in evaluating the potential impact of the proposed policy and regulatory options on the expected outcomes. A supportive policy and regulatory framework is essential but not sufficient to ensure increased energy access and renewable energy investments.

It is also important to recognise that the regional guidelines can only be effective when ***adopted as national policies and regulations*** because they would then have the necessary legal force and stakeholder support. The terms of reference of this assignment have therefore included support for two countries to pilot the adoption

[1] *Africa-EU Renewable Energy Cooperation Programme Strategy 2020* published in April 2012.

of the guidelines. The objective of the project will however be fully achieved when all countries in the region have adopted the regional guidelines.

1.2 Activities so far

The project commenced with the ECA Team Leader and Project Director being briefed by the EUEI PDF Project Manager and her colleagues at the GIZ Head Office in Eschborn, Germany, on 11 January 2013. The project is one of the activities of the EUEI PDF's support program for development of national and regional energy policies and strategies and is part of the Renewable Energy Cooperation Programme (RECP) of the Africa-EU Energy Partnership (AEEP).

The Team Leader then visited the RERA Secretariat in Windhoek during the week of 21st – 26th January 2013 to establish contact with the key stakeholders. With the assistance of the RERA Executive Secretary a questionnaire was developed and dispatched to RERA and SADC contact points to begin the process of collecting information required to assess the current status of mini-grid policy and regulatory frameworks in the region. The request for information was reinforced with further communication from the SADC Secretariat urging the member states to respond timely in order to ensure that the project's tight timelines would be met.

While in Windhoek the team leader was also able to take the opportunity to have meetings with relevant staff from the Ministry of Mines and Energy and the Electricity Control Board of Namibia whose insights helped to define the expectations of policy and regulatory authorities.

The whole consultancy team was mobilised following a meeting in Harare between the ECA Team Leader, Project Director and Practical Action on 31st January 2013. A draft inception report was prepared and submitted to EUEI PDF Project management team and RERA Secretariat on 13th February 2013.

The draft inception report was used to facilitate discussions at a kick-off workshop held in Windhoek on 21st February 2013 where the RERA Executive Committee, EUEI PDF, relevant senior government, utility and regulatory officials and the consulting team were able to achieve consensus on the principal project objectives, workplan and methodology and to have a preliminary assessment of the existing situation regarding policy and regulatory issues affecting the planning and development of mini-grids in the region. A workshop report was produced which summarises the main issues and suggestions that have been taken into account in this report and will be considered in the subsequent phases of the project. The workshop report also summarises the agreed scope of work and the dates for the key deliverables which are reproduced in this report for convenience.

The consultancy team has been complementing information submitted by the contact points with information from various websites and relevant previous studies focussed on the region and beyond.

1.3 Outline of Inception Phase Report

The basic approach to the work is to adapt international best practice to SADC realities and this is done by offering cutting edge advice that is validated through key stakeholder consultations.

The inception phase report serves a dual purpose of clarifying the project deliverables, workplan and methodology as well as summarising the results of the assessment of the current country status. This highlights the major issues that can facilitate or hinder the development of mini-grids in the SADC region.

The report starts by providing definitions of key terms to enhance understanding of the objectives and focus of the project (section 1.4). This is followed by a description of the principles and elements that define best mini-grid practice (Section 2) before analysing the current status in the region (Section 3) using these benchmarks.

The methodology, workplan and expected deliverables, which are updated versions of those shown in our Technical Proposal, are presented in Section 4. These deliverables will be the principal agenda items for the Regional Workshop.

The Appendices summarise the information obtained from the questionnaire that was sent out to RERA and SADC contact points as well as that obtained from desk research and follow up discussions with relevant public and private sector officials. Appendix A1 is a list of the specific data requested. Appendices A2 to A8 present the data gathered that is relevant for developing the mini-grid policy and regulatory options. Appendix A9 lists the country specific and general references used and the websites of key institutions responsible for policy and planning, regulation and service delivery in the different countries.

1.4 Definitions

1.4.1 Policy and regulatory framework

The World Bank provides a useful definition for regulation that can be adapted for a policy and regulatory framework: ***"the combination of institutions, (documents), laws, and processes that, taken together, enable a government to exercise formal and informal control over the operating and investment decisions of enterprises that supply infrastructural services."***[2] This definition encompasses the concepts of regulatory governance (*how* decisions are made) and regulatory substance (*what* decisions are made). The scope of this technical assistance is predominantly focussed on the substance of the policies and regulations that affect the development of mini-grids.

[2] Adapted from Brown, Stern, Tenebaum and Gencer (2006) *Handbook for Evaluating Infrastructure Regulatory Systems*

1.4.2 Energy access

Energy access, according to the SADC Regional Energy Access Strategy and Action Plan***, is the actual use of the form of energy*** which implies its availability, affordability and acceptability**.** Many countries tend to define access in terms of availability only. The different definitions of access compromise the integrity of inter-country comparisons. A key role for a regional body such as RERA is to ensure that countries adopt the same definition for concepts such as this.

With respect to electrification the definition of access can affect the targeting of grid and off-grid solutions. When access is defined in terms of proximity to a grid network there is a tendency for off-grid policy guidelines to exclude households within a defined distance from an existing grid. The result is that many households and institutions can be next to power lines for decades without enjoying the benefits of using electricity. In this report and project references and recommendations on electricity access therefore refer to actual connections and use of electricity for different end user applications. Experience shows that countries which use this definition of access tend to have greater success in increasing their electrification rates.[3]

1.4.3 Distributed renewable and hybrid generation

Distributed renewable generation refers to small scale energy production units, which in many countries have an upper limit of 10 MW, using resources that can be naturally replenished in a relatively short period in comparison to fossil fuels. The small scale generators are classified further into micro-units below 100kW, mini-units between 100 and 1000 kW and small units above 1000 kW.

Hybrid generation for mini-grids is the combination of two or more small scale generating units to ensure security and reliability of supply. Hybrid generation can be the least-cost technically equivalent option to grid based electricity for remote and low income communities where distance from the main grid and limited consumption make it uneconomical to supply using main grid extension.

1.4.4 Mini-grid

In this study, which is focussed on mini-grids which have a renewable element, the following definition is adopted:

> ***Mini-grid definition*****:** A mini-grid employing renewable or hybrid generation is an isolated or grid-connected small-scale electricity distribution network supplied by at least one or more embedded renewable energy generators which may require back up from non-renewable energy generators in order to provide a safe, secure and reliable electricity supply to end use customers.

[3] Bhattacharyya S.C. (editor) (2013) *Rural Electrification through Decentralised Off-grid systems in Developing Countries* attributes Sri Lanka's success to this.

This is a qualitative definition which is however inadequate for policy and regulatory purposes. For the avoidance of doubt it is necessary to have a more quantitative definition that specifies the power supply, voltage and network size that is eligible for any incentive or other support framework.

Mini-grids can also be defined according to the ownership and financing arrangements of which the most common are either community, public, private or a combination of the three. In this study all types of ownership and financial arrangements are included as long as they have renewable or hybrid generation.

Mini-grids, also called mini-utilities or small power distribution systems, have been used in many countries in SADC and the world over as an effective way to reach areas unserved by the regional or national grids. There is therefore a tendency to assume that the term mini-grid only refers to an off-grid system when the most successful ones can in fact be grid-connected.

The following are some of the circumstances and reasons for grid-connected mini-grids:

- An automatic takeover of mini-grids by the national utility when they become grid-connected is the traditional option when national utilities had a legal monopoly on distribution. This unfortunately creates a major investment disincentive if grid encroachment occurs before there has been sufficient time to recover and earn a return on the mini-grid.

- Existing or proposed laws in almost every country are creating a more liberalised electricity supply industry where the monopoly of the national grid operator is removed and multiple suppliers are allowed. Therefore where it is advantageous for the end users, mini-grids can continue to be owned and managed independently from the national grid notwithstanding grid connection. Such mini-grids must be designed to operate either interconnected or islanded from the main grid. Net metering is used to record import and export transactions.

- Grid availability and household connectivity is not necessarily the same thing. A more enlightened definition of mini-grid allows communities and entrepreneurs to enter into a partnership with the main grid operator for development of a local distribution network that purchases power in bulk from the main grid.

- A mini-grid using renewable energy sources often faces problems of matching supply and demand over the course of a day or season. Interconnecting to a grid improves the load factor on the generators by allowing for energy purchasing or banking transactions with the main grid.

One of the major reasons and benefits for the merging of mini-grid and main-grid into one accounting entity when the mini-grid is interconnected is the benefit of cross-subsidisation through uniform national tariffs. That apparent benefit is

however usually made possible because of subsidy policies that favour grid-connected customers over off-grid customers.

1.4.5 Least-cost

The concept of least-cost refers to the optimum combination of technical, economic, financial, environmental and social costs over the life cycle of a project or program or course of action

1.4.6 Best practice

For the purpose of this study ***best practice is a combination of actions that contribute to sustainable, fast and efficient electrification of remote and low income communities using mini-grids*** in order to achieve universal access in the shortest possible time.

2 Elements of best practice

A study of international experiences shows that the factors that influence the successful development of mini-grids are not very different from the factors that need to be addressed by larger utilities or businesses in general in order to achieve and sustain operational efficiency and financial viability.

The Global Village Energy Partnership (GVEP) defines the following requirements for successful mini-grids:[4]

- ***Design based on detailed analysis of local context*** including natural resources, supply chains, energy demand and current and future energy policies;
- ***A favourable policy environment*** which does not discriminate in favour of main grid electrification
- In community schemes, ***investing sufficient time during project design to establish buy-in*** and clear governance structures as well as linkages to productive uses.
- ***Securing sustainable finance*** for upfront costs and tariffs that cover at least the operation and maintenance costs.

A more recent and comprehensive review, *Rural Electrification through Decentralised Off-grid Systems in Developing Countries,* edited by S.C. Bhattacharyya (2013), looked at lessons from electrification experiences in China, South and South-east Asia, Sub-Saharan Africa and Latin America and drew the following principal conclusions:

- ***Government commitment is essential*** and is expressed through appropriate policy and financial support and enforcement of technical and operational standards. However the subsidies and incentive schemes for rural electrification have tended to benefit the well-off citizens and not the poor.
- ***Grid-based supply is the preferred mode of supply at policy and user level*** and therefore grid encroachment can be the biggest threat to off-grid investments unless appropriate policies and regulations are put in place to address this.
- ***Capital subsidies for infrastructure development and cost recovery of operation and maintenance costs through tariffs*** appears to be the more practical and sustainable financial approach to the electrification of remote and low income communities.

[4] GVEP International (September 2011), *The history of mini-grid development in developing countries*

- ***Hybrid solutions are often necessary for small-scale generation projects supplying mini-grids*** because single renewable energy technologies are often not able to meet continuous demand in off-grid situations.

- China demonstrates a successful model for achieving universal electrification and ***escaping the subsidy trap*** by having a phased bottom up development approach, starting with local networks that are designed for integration into the main grid, and ***linking the electrification to rural development*** in order to generate the income to sustain the projects.

- ***Regulatory and governance of off-grid initiatives are not well defined in most countries***. There is need for clarity regarding grid and off-grid areas, tariff issues and quality of service. Regulatory capacity and information gaps need to be addressed.

These observations and conclusions are also supported by the experiences of developed countries such as the United States (US). According to the US National Rural Electric Cooperative Association (NRECA) "***Most rural electrification is the product of locally owned rural electric cooperatives that got their start by borrowing funds from REA (Rural Electrification Administration) to build lines and provide service on a not-for-profit basis.***"[5] The REA was created in 1935 and started lending in 1936. The results of this Government commitment and funding were dramatic. Whereas in the mid-1930's only 10% of rural homes in America had electricity by 1953 those not connected were less than 10%. Through US technical and financial assistance this model of development has been successfully used in many developing countries in Asia and Latin America.

These observed success factors can be classified into the following four focus areas: ***role clarity, knowledge of market needs and demand, choice of technology, ownership and financing***. The basis of classification is management research and experience.

Policies and regulations exist to influence the actions of people. Any successful project has a project champion who takes the lead role in coordinating the efforts of everyone else. Therefore the starting point is to identify the champion – an individual or institution – who can then identify the other people who need to collaborate in order to ensure a common understanding of what needs to be achieved and what role the different people will have to play to ensure a successful outcome.

Extensive management research has demonstrated that successful businesses are those that focus on customer needs. That is why the people promoting mini-grid projects must give precedence to market needs and demand. Strategies for fulfilling the needs become the logical next step. The final step is to ensure sustainability.

With specific reference to mini-grids, policies and regulations need to be formulated to pursue the following objectives for each of these factors:

[5] NRECA (2012) *History of Cooperatives* www.nreca.ccop/members/history

- **Role clarity:** the objective is to identify the individual and institutional accountability for championing the development of mini-grids, establishing consensus on the definition and role of the mini-grids and ensuring that there is minimum or no conflict of interest arising from overlapping jurisdiction and the differences in needs and expectations of the people that affect or are affected by the mini-grids.

- **Market needs and demand:** the objective is to achieve universal access to modern energy services and this implies paying particular attention to the needs of remote and low income segments of the population and their effective demand, which is their ability and willingness to pay. The access problem is essentially a rural and peri-urban problem because densely populated urban areas are much easier and more profitable areas to electrify.

- **Technology choice:** the objective is to ensure that the choice of technology is least-cost to fulfil market needs and demand in a given location.

- **Ownership and Finance:** the objective is to ensure accountability for adequate and optimal financing, design, construction, operation, and maintenance of the mini-grid projects.

2.1 Role clarity

Consensus on the definition and role of mini-grids employing renewable energy and hybrid generation should be built upon the following:

- **Shared desire to accelerate achievement of universal electricity access:** for remote and low income communities mini-grids can be the low cost alternative to main-grid extension.

- **Realisation that renewable energy options can be least-cost on a life cycle basis:** taking into account technical, economic, financial, social and environmental considerations.

- **Hybrid or grid interconnection:** may be necessary for safety, security and reliability of supply.

The planning and development of mini-grids involves several stakeholders with conflicting needs and expectations. The following are the most important stakeholders and the potential conflicts that can arise:

- **Central and local government agencies:** apart from the ministry responsible for energy policy and planning there are different government agencies that affect mini-grid development such as provincial and rural councils who determine land use; traditional leaders who are the custodians of social and cultural values; environmental, water and other resource management agencies; tax and

investment promotion bodies. Lack of coordination and overlapping jurisdiction among these authorities can delay or even prevent the exploitation of viable projects.

- **Electricity, energy or utility regulators as well as other regulatory bodies such as standards associations, competition commissions, environmental management agencies, etc:** are the equivalents of the judiciary that interpret energy policies in the form of rules and standards of conduct and resolve disputes among the market players. Potential conflicts arise where there are several agencies with overlapping regulatory jurisdiction that affect mini-grid development.

- **Market players:** investors, financiers, suppliers, consumers, customers, educators, etc, including the general public. Where the Government is involved as an investor, as has been the traditional experience in the energy and other infrastructural services, there is a tendency to abuse its authority to accord preferential treatment to its own investments thereby creating an entry barrier to other investors.

Conflicts of interest are eliminated or minimised by ensuring that decision making authority on any issue is not vested in more than one person or institution. If more than one person or institution has to deal with the same issue, one must have an advisory role and the other the decision making role. Ideally the separation of authority must follow the now tested and proven national governance model where the Legislature, Judiciary and Executive have distinct and separate areas of jurisdiction.

The principle of separation of powers or decision making authority is the basis upon which governments (policy and law makers) have been creating independent, professional energy regulatory agencies (policy interpretation and dispute resolution) as well as commercialising and privatising energy service provision (policy execution). When these institutional reforms are done correctly the conflict of interest inherent in vesting policy, regulatory and day to day management decisions in one person or institution is largely eliminated.

The Ministry responsible for energy must be the project champion that has the principal accountability for ensuring role clarity for mini-grids and stakeholders by developing and publishing a stakeholder coordinating tool in the form of guidelines that define mini-grids and their purpose and outline the roles of different players involved in the planning and development of mini-grids. In some countries the project champion role can be delegated to the Rural Electrification Agency.

The guidelines would assist developers to have a comprehensive checklist of requirements that need to be fulfilled and the assistance that is available. The development of these guidelines is a process that requires multi-sector stakeholder consultations and consensus. The guidelines can be published as a statutory instrument to give legal force for implementation effectiveness.

2.2 Market needs and demand

In the context of the objective of achieving universal access to energy, it is important to understand the distinction between the need and demand for modern energy services. Everyone needs to access energy services, whether traditional or modern, but not all are able and willing to pay the cost for modern energy services. In other words it is important to separate ***consumer needs*** from ***customer demand*** (ability and willingness to pay for a commercially provided service).

It is primarily the responsibility of the policy makers and planners and the service providers to establish the market needs and demand through the following steps:

- **Establishing a thorough understanding of the energy needs and how much it costs the individual and the nation to fulfil those needs:** this step is critical in determining the avoided costs and in the design of tariff structures and targeting of subsidies.

- **Establishing an indication of the initial number of people who are able and willing to pay:** the *ability to pay must be defined as a policy decision* while the willingness to pay is established from observation of existing consumers. The level of electricity consumption is often used as an indicator of ability to pay on the assumption that the lower the consumption levels the lower the ability to pay. A better indicator may be the proportion of income spent on energy needs.

- **Establishing a target for the number of people who are able and willing to pay:** subsidies and promotion of productive uses of energy are the most common strategies for increasing the ability and willingness to pay.

    - The *decision on level of affordability leads to the policy decision on the subsidies* required to increase the number of people who can afford. These decisions depend on the financial resources available or that can be raised and the pace required for achieving universal access. Tariff structure and methodology are also influenced by policies that are designed to ensure consumption by the poor.

    - The *promotion of productive uses of energy* is another policy tool to achieve the same objective of increasing the customer base, but more importantly to contribute directly to the universal goal of economic development and poverty reduction. Opportunities for productive use will generate the income needed to pay for household energy services. The SADC Regional Energy Access Strategy and Action Plan recommends a phased approach to increasing energy access by giving priority to energy applications or end-uses that generate income, which income is then used towards improved access to modern energy services by households and social institutions.

This preliminary policy related work is best done at a strategic level through comprehensive ***grid and off-grid energy masterplan studies***. Masterplans are the tools through which policy makers can define objective selection and ranking criteria for different locations and end users. An off-grid masterplan cannot effectively be developed in isolation: the primary planning has to be done in respect of grid extension, with those centres which are not going to be connected to the grid within a reasonable time horizon being the ones for which off-grid solutions need to be developed.

These documents must then be disseminated to market players for guidance in undertaking specific project feasibility studies and to regulators for guidance on licensing and the establishment of service standards. Regulatory authorities should ensure that market studies have been done to a satisfactory level as part of the due diligence required for project approval and licensing.

2.3 Technology choice

A mini-grid is essentially a technology choice that should be an outcome of a comprehensive options assessment that addresses supply and demand, grid and off-grid, short and long term and technical and non-technical alternatives[6]. The mini-grid option should satisfy the following minimum criteria as the basis for selection:

- ***Least cost*** - it must be the least-cost option to fulfil the identified market needs and demand. The concept of cost includes not only economic (accounting and opportunity cost), but also social acceptability and environmental friendliness.
- ***Sustainability*** - there must be effective technology transfer for sustainability. Technology transfer is effective when the expertise, experts and equipment are localised.
  - *Expertise* is the knowledge required to ensure least-cost design, construction, operation and maintenance of the *equipment* on a life cycle basis.
  - *Experts* are the skilled people with the expertise.

A mini-grid that satisfies these criteria will improve the financial viability of embedded renewable generators and can be able to provide superior customer service quality to that provided by remotely managed regional and national grids.

Energy resource assessments are the tools through which policy makers can assist communities and private sector developers to decide on the technology. Mini-grids can use hydro, wind, solar, biomass, biogas, geothermal, diesel and other renewable and non-renewable energy sources as well as supplies from the main grid.

[6] The World Commission on Dams (WCD) and the UNEP Dams and Development Compendium (DDP) address the topic of comprehensive options assessment in more depth (www.unep.org/dams/WCD/report and www.unep.org/dams/Publications).

Prioritisation of the different energy sources can be guided by policy targets set by Government following a stakeholder consultative process, especially where the targets will require direct or indirect subsidisation.

With respect to the network it is necessary to adopt ***appropriate and low cost design***s for the location and skills available for on-going operation and maintenance. For off-grid schemes there must be ***regulations to provide for the technical impact of transition to grid-connection***. It is generally cheaper on a life cycle basis for the off-grid mini-grid and main grid standards to be compatible to minimise the cost of transition. However this implies that the mini-grid may be overdesigned for the initial demand expected. The additional cost imposed on the mini-grid for preparedness for main grid connection should be a legitimate target for subsidy.

Figure 1: Mini-grid network may be overdesigned for initial load

Policies need to promote research and development, skills training and retention and local manufacturing. Facilitating private sector leadership and financing is essential for implementing such policies.

Regulations must define acceptable equipment and system quality standards and promote the use of low cost network designs without compromising safety, reliability and security. Accreditation of equipment and service providers is essential.

2.4 Ownership and finance

Ownership and finance are inter-related issues because funding is either from the owner's own resources or from loans and grants that depend on creditworthiness of the owner's business plan to lenders and donors. Mini-grids can be owned and financed by communities, private and public sector enterprises or a combination of these[7]:

- **Community** schemes that use a cooperative, trust or other legal structures. Most of the equity is likely to be in-kind contributions and externally sourced grants.
- **Public enterprises** such as state owned national utilities and rural electrification agencies which are funded by public funds (loans and grants) or commercial loans guaranteed by the state.
- **Private enterprises** that are funded by private equity funds and commercial loans. Private equity and debt inherently cost more than public funds because of market risk perceptions.
- **Public private partnerships** that are some combination of the above, for example, a private IPP selling to a public sector or community operated mini-grid. The motivation for such partnerships is to allocate risks according to ability to manage.

Guidelines are required on the procurement and approval procedures for the different ownership approaches preferably administered by a one stop mini-grid development coordination centre. If competitive bidding is used this must be a transparent and fair process. There is also a need for transparent rules for dealing with unsolicited proposals. What is important as a guiding principle is to ensure non-discrimination between the different approaches on matters that affect the quality and cost of service to the end-user or customer.

Eligibility for subsidies is a good example where discriminatory treatment is often practiced. For example, if there is a subsidy policy that allows a uniform national tariff for publicly owned mini-grids whether they are grid-connected or off-grid, the same uniform tariffs should not be forced on private sector mini-grids without similar subsidies. As highlighted before subsidies are best if non-discriminatory and used as a once-off grant and the project tariffs are set at a level that covers operation and maintenance including depreciation and investment returns.

Policy options for efficient subsidy delivery include the setting up of ***special funds*** (rural and renewable energy funds, carbon finance, funds to promote specific technologies, consumer finance, and micro-finance), ***tax credits*** and other investment incentives, ***guarantees*** and other ***risk mitigation instruments***.

[7]From GVEP International Policy Briefing on history of mini-grid development in developing countries, September 2011 (www.gvepinternational.org)

The RECP Strategy 2020 estimates that 20 billion Euros will be required for an additional 100 million people in Africa to have modern energy access by 2020. Public sector institutions are expected to raise less than 20% of the funding, demonstrating ***a need to significantly increase the involvement of the private sector***. Policies are required to enable the public funds to leverage private investment.

Regulatory options that facilitate financing include *tariff methodologies* and *standardised power purchase agreements* that allow cost-reflective and competitive pricing, *feed-in tariffs* that reflect an optimal balance between the supplier's costs and the purchaser's avoided costs and objective licensing procedures on the basis of *bankable project proposals*. For off-grid schemes there must be regulations to provide for the financial impact of *transition to grid-connection*. This could be in the form of a Build Own, Operate and Transfer (BOOT) arrangement, transition to a public private partnership or similar approaches.

2.5 Summary of policy, planning and regulatory requirements

From the foregoing discussion, it is evident that a 'best practice' environment to encourage investment and foster the growth of mini-grids has many different dimensions. From a practical perspective, the specific items which can be addressed are the sort of instruments which are summarised in Table 1.

Table 1 Instruments required for best practice mini-grid environment

Focus area	Level	Main institutional responsibility	Policy, planning and regulatory instruments
Role clarity	Primary	Ministry or Agency which decides Energy Policy and Plans	○ Guidelines for planning and development of mini-grids
Market needs and demands	Primary	Ministry or Agency which decides Energy Policy and Plans	○ Criteria for selecting and ranking rural locations for energy provision
		Rural and Renewable Energy Agency (RREA) and/or mini-grid developers	○ Template for assessing consumer needs and customer demand
	Secondary	Licensing Authority	○ Guidelines to appraise the demand analysis in feasibility study of project
		Rural and Renewable Energy Agency	○ Guidelines for use of rural funds for targeting of subsidies

Focus area	Level	Main institutional responsibility	Policy, planning and regulatory instruments
Choice of technology	Primary	Ministry or Agency which decides Energy Policy and Plans	○ Terms of reference template for renewable energy resource assessment
		Rural and Renewable Energy Agency and/or mini-grid developers	○ Comprehensive assessment of technology options
	Secondary	Regulatory Authority	○ Technical design and operational guidelines
		Rural and Renewable Energy Agency and/or mini-grid developers	○ Guidelines for grid interconnection ○ Guidelines for technology transfer
Ownership and financing	Primary	Ministry or Agency which decides Energy Policy and Plans	○ Mini-grid Procurement Guidelines (including feed-in tariffs, quotas, competitive bidding, first come first served, etc)
		Rural and Renewable Energy Agency	○ Guidelines for use of Energy Funds for investment (including capital subsidies, carbon credits, tax concessions, fiscal incentives, etc)
	Secondary	Regulatory Agency	○ Standardised tariff methodologies and power purchase agreements

3 Assessment of current status in the region

3.1 The regional paradox: energy poverty in the midst of resource wealth

At the kick off workshop the RERA Chairperson noted the paradoxical situation in SADC where there are energy supply shortages when the region is endowed with a diversity of renewable and non-renewable energy resources, the most important of which are biomass, coal, hydro, oil, natural gas and solar. Some countries have potential for wind, nuclear, geothermal and wave energy. Appendix A7 shows that off-grid hybrid systems in SADC are likely to be a combination of hydro, solar PV, small wind and diesel. This is confirmed by the few pilot projects highlighted in Appendix 8.

3.1.1 Electricity statistical highlights

Electricity statistics in almost every country tend to be restricted to those provided by the national utility (Appendix A6). There is an information gap on off-grid and self-generation. Access statistics may not be accurate or comparable for reasons of different access definitions but they do give a general indication that SADC countries are not only facing a challenge of access in rural areas but also in urban areas. The access levels are lower than 50% of the population with rural areas accounting for as little as 3 to 4%.

According to the SAPP annual report[8] for the period ending March 2012 the peak electricity demand was 43 339 MW on the interconnected regional grid and 45 436 MW for the whole pool. Out of installed capacity of 56 500 MW only 49 877 MW was available. This is less than the 50 200 MW required to meet the minimum 10.2% reserve margin for security and reliability. Several countries had to resort to planned load shedding to manage demand.

The small island nations such as Mauritius and Seychelles have been able to achieve near universal access using grid electricity but for the larger countries this is an option that is not feasible for the short to medium term. This is particularly the case for remote and low income communities which are in rural and peri-urban areas. Although South Africa's Integrated National Electrification Program (INEP) has managed to increase access to 82%, the bulk of the un-electrified 18% are in remote areas where grid extension is not economically and financially feasible in the short to medium term. The previous target of achieving universal access by 2012 has not been achieved because of this. However it is a positive demonstration of the Government's commitment to have such targets which are absent in many other countries in the region.

With respect to mini-grid development the conclusion that can be drawn from these statistical highlights are:

[8] SAPP Annual Report 2012 www.sapp.co.zw

- The desire for achieving universal access can be a major incentive to pursue cost-effective alternatives to main grid extension in order to reach isolated communities as early as possible. ***Unfortunately most countries do not have an explicit time bound target for achieving universal access.*** There are therefore no specific strategies and programs designed to achieve universal access within the short to medium term.

- The different definitions of access create a barrier for mini-grid development. ***Countries that consider proximity to a distribution network to be access may not authorise mini-grid development within the defined distance***. If access relates to actual household connections, communities and entrepreneurs could be encouraged to use the proximity of the grid to develop viable mini-grid businesses. This is one of the reasons this study includes the option of grid-connected mini-grids.

- There is need to close the information gap on off-grid and self-generation. Ministries of Energy and Regulators should either enforce existing legal reporting requirements or motivate the establishment of the necessary legal instruments.

3.1.2 Tariffs

Information on tariffs (Appendix A5) was surprisingly not as comprehensive as expected notwithstanding the fact that regulators now issue separate licenses for generation, transmission, distribution and retail. The questionnaire assumed that price and cost information would now be available according to these license categories. The few countries that provided a breakdown of cost at the different business levels show that tariffs are at breakeven level. The one country that shows a significant surplus, Zambia, was also shown to have one of the highest rate of return of 9% in the SAPP Annual report of 2012.

Except for South Africa and Lesotho, the other countries with positive rates of return had very poor revenue collection performance. This has negative implications for Rural Electrification Funds which are mostly derived from a levy on consumption. Tanzania's TANESCO is one of the utilities with a positive rate of return but also has one of the worst revenue collection records. As the utility is the single buyer for the small power program being vigorously promoted by the regulator EWURA, this poor collection performance adversely affects its creditworthiness. A single buyer which has poor creditworthiness is a major deterrent to private sector investment.

Some countries have done cost of service studies and developed feed-in tariffs for small scale renewable generation. Many of the feed in tariffs have just been completed and have not yet been tested and in the case of South Africa the feed in tariffs were abandoned in favour of competitive bidding. Tanzania has a feed in tariff policy that is being used (Appendix A8.6). TANESCO has to review its long run marginal costs every year as a requirement of the small power project promotion program which relies on the cost information to establish prices for grid and off-grid small power projects.

No country reported on the issue of avoided cost studies although Tanzania does assume that the long run marginal costs and diesel generation costs for off-grid are the avoided costs.

Although many countries have uniform tariff structures and levels, in theory prices for mini-grids could be different. Experiences elsewhere show that there is a tendency for political interference towards equalisation of tariffs but without the corresponding extension of subsidies.

The implications for mini-grid development are:

- RERA needs to have a database on tariffs for the different licensed activities which are the same in each country. This will provide policy makers with information to check whether the regionally adopted policy of cost reflective pricing is being implemented in practice. Investors are more interested in actual numbers rather than the policy rhetoric.
- Poor revenue collection adversely affects the Rural Electrification or Universal Access Funds that are based on levies on consumption. Mini-grid development can be adversely affected by the resultant limited funding.
- The absence of a systematic process of computing avoided costs presents difficulties in evaluating the competitiveness of renewable energy investments. Comparison of mini-grid to main-grid tariffs which may not be cost reflective or distorted by implicit subsidisation can result in viable projects failing to take off.
- Where there is a need to maintain uniform national tariffs for social and regional equity this must be accompanied by a policy to extend subsidies to both main and mini-grid projects.

3.1.3 Institutional framework and capacity

The information requested was designed to assess the status of institutional reforms taking place in the various countries as a result of policies and legislation which now require the unbundling and commercialisation of utilities, explicit funding of rural electrification and other subsidised services, and establishment of independent regulators, separating the regulatory function from policy and planning work of Ministries.

In line with international experience most countries have restructured their electricity sectors with the objective of improving operational and investment efficiency. Appendix A2 shows that most countries have now created separate regulatory and rural electrification agencies with mandates to promote access to remote and low income communities through renewable energy options and private sector and community involvement. There is also a progression towards multi-sector regulators, which should improve utilisation of scarce human resources and coordination of regulatory decisions. A few countries have dedicated statutory funds for rural energy services.

Many of the national electricity utilities have either been commercialised or are in the process. A significant number of countries now have operating Independent Power Producers (IPPs).

There are a number of institutions of higher learning and research with programs dedicated to renewable energy. They need coordination at regional levels so that their work can be complementary and used in harmonisation of technology for the mini-grids.

The capacity of the various institutions in terms of staff strength relative to establishment was also requested. Of the few countries that addressed this, only the South African regulator, NERSA, appears to be well-staffed. The Zimbabwe Energy Regulatory Authority which is less than two years old, appears to be well staffed according to the figures given (25 out of 28 posts are filled) but the relative in-experience of the organisation and its incumbents adversely affects capacity.

These institutional reforms have the following impact on mini-grid development:

- In theory the establishment of independent regulators should lead to cost reflective tariffs in practice as well. The independence has not yet had time to be tested which could result in a wait and see attitude by potential investors. Recently Eskom of South Africa had requested a five-year tariff increase of 16% per annum which was reduced by the regulator to 8%. It is not certain whether this major difference is a result of computational error by Eskom or political pressure on the regulator NERSA.

- The establishment of dedicated institutions and funds for rural electrification is a positive development provided the funds are not wrongly targeted at subsidisation of the well-to-do at the expense of the poor. The challenge is to ensure optimum use of the funds through correct targeting and leveraging private sector funding through risk mitigation instruments.

- Research institutions need to be coordinated at a regional level so that they compliment and build upon each other's achievements. A closer link with industry is necessary for technology transfer.

3.1.4 Policies, strategies and plans

Since the late 1990's and 2000 most countries have adopted national energy policies and developed grid and off-grid electricity or energy masterplans which emphasise the role of renewable energy and private sector investment for increased rural energy services. Few countries have gone beyond general energy policy to developing specific policies and targets for renewable energy. Some countries have done studies on identification and removal of barriers to renewable energy development.

However as Appendix A3 shows very few countries have progressed from policy intentions to implementing specific programs and actions towards these objectives.

Only South Africa has a target for universal access and an Integrated Resource Plan for Electricity which has a clear target of increasing the share of renewable energy from almost 0% in 2010 to 9% in 2030. Although the feed in tariffs are not being used there is a competitive bidding process that has been adopted as an alternative strategy for attracting private sector investment in renewable energy.

Subsidy policies for rural and renewable energy vary but are generally focussed on grid extension. South Africa has a Free Basic Electricity policy that is designed to allow the poorest to use electricity for lighting and media access.

As observed in other regions, policy makers and users have a bias towards main-grid extension and tend to view off-grid solutions as temporary or pre-electrification strategies.

The implications for mini-grids:

- Generally national energy policies and strategies are supportive of mini-grids for off-grid but in practice there are mostly donor funded pilot projects.
- It is necessary to have explicit policies and law as well as targets for renewable energy in general and universal access in particular. The resultant strategies will have to include mini-grids in order to accelerate the electrification rates. South Africa, within the region, and Uganda in East Africa, has renewable energy policies that could serve as models.
- Off-grid solutions should not be viewed as temporary solutions because many of these are likely to be the only options for many years. Investors also need certainly in terms of the period required to recover investments and make a rate of return that reflects the risks taken.

3.1.5 Laws and regulations

Laws and regulations should generally be developed as policy implementation strategies. Most countries have followed up the development of national energy policies by enacting laws that establish and govern the new institutional frameworks (refer to Appendix A4). The laws generally remove the generation monopoly hitherto held by national utilities but there is a tendency to retain government ownership for transmission and distribution. This has been interpreted to mean that the government owned entities become the single buyers for all power generated by IPPs.

Grid codes have been developed that regulate the connection and operation of embedded renewable energy generators.

There is a wide variation in the laws in defining the threshold for licensing generation plants but the exemption generally applies to self-generation. These exemptions range from as low as 25 kW or less in Botswana and Malawi to as high as 1 MW in Tanzania. Most countries specify license fees in terms of a percentage of turnover but some have standard fees. Swaziland has explicit provisions that allow

for the exemption of off-grid and mini-grids from licensing. Zambia is considering an off-grid promotion policy that will give a composite license for mini-grid rather than separate ones for generation, distribution and retail.

Only Tanzania has an operational standard tariff methodology and standardised Power Purchase Agreement focussed on small power projects. Light handed regulation is also being planned in other countries.

The implication of current laws on mini-grid development is:

- Mini-grids require light handed regulation and the idea of a composite mini-grid license is one that should be considered seriously and given legal force.
- Generally laws and regulations favour renewable energy in general and provide for development of mini-grids for off-grid communities. Grid connected mini-grids for sale to third parties are not explicitly provided for.
- Although in theory there is no legal monopoly on all segments of the electricity supply industry, in practice it is generation that has been opened up. The de facto monopoly of main grid utilities on transmission and distribution is a barrier to mini-grid development. The utility monopoly *generally means that isolated grids become state owned when grid connected*. This is certainly the case in Tanzania which has attractive feed-in tariffs for off-grid small power plants but which are expected to revert to lower tariffs when grid connected.
- Regulations that permit embedded generation to feed into the main-grid encourage small power project investment which can continue to operate even when there is interconnection to the main grid.
- There is merit in defining a threshold for either exemption of licensing or charging nominal fees. Regulatory compliance costs should be reasonable in relation to project size. It is also better to charge fees as a percentage rather than in steps which can result in very different charges for very similar sized plants.

3.1.6 Case studies

The most common mini-grids in SADC have been government or privately owned networks using diesel generators to provide limited number of hours a day of electricity to remote administrative centres, institutions or business operations. The initial priority of many rural electrification schemes have been targeted at interconnecting these mini-grids to the national grid which are then taken over by the national utility.

Appendix A8 presents several case studies of mini-grids using renewables which are mostly government or donor funded pilot schemes that have not been designed for replication. With the exception of a few most of the pilots were poorly designed

and are not sustainable as stand alone businesses. The case of the EU funded micro-hydro powered mini-grids appears to be replicable and deserves closer scrutiny in the next phases of this project.

Observations and lessons from these case studies, some of which were discussed at the kick-off workshop, which have a bearing on mini-grids are:

- Pilot projects are necessary for learning but to provide useful lessons they must be designed for sustainable replication. Instead of being market driven most of the existing pilots have been donor and technology driven.
- Costs for micro-hydro are highly site specific which does present challenges to support schemes such as feed-in tariffs.
- There is a tendency for a mismatch between policy in theory and policy in practice. All players need a common understanding for policy consistency.
- Awareness of the different options to the main-grid is lacking at policy and user level as well as for critical stakeholders such as banks. Rural Electrification Agencies could address this gap by providing technical support and financial guarantees for community, private sector and partnership projects.
- Ownership models that work are site and country specific. This emphasises the importance of investing time and money into understanding market needs and expectations. In one case study more than a third of the project cost was invested for such soft issues.
- Case studies confirmed the importance of taking time to ensure role clarity, to study market needs and demand, to select the appropriate technologies and to ensure accountability for on-going financing and operational sustainability of the investments.

When assessed against the elements of best practice it is evident that some countries are much more advanced than others in some areas but none have a policy and regulatory framework that matches best practice. Therefore all countries should be able to benefit from the tools to be developed in the next phases of the project. The following sections highlight some of the current practices that can be replicated or demonstrate issues that have to be dealt on a site and country specific basis.

3.2 Guidelines for role clarity

The guidelines for role clarity should be able to address the following questions:

- Are mini-grids explicitly mentioned in the energy policies and regulations?

- ❑ If so how are mini-grids defined?
- ❑ Are there policy and regulatory guidelines that outline the role and requirements of the different stakeholders involved in the planning and development of mini-grids? Is there an organisation or office that is the mini-grid champion?

Tanzania and South Africa are the two countries which have guidelines that can assist mini-grid developers in this respect. Tanzania's energy regulator, EWURA, has ***Guidelines for Development of Small Power Projects, March 2011*** that outline the steps for Small Power Project (SPP) development in Tanzania. The guidelines are intended to assist SPP developers to understand:

- ❑ The SPP legal framework and process;
- ❑ EWURA's licensing requirements and procedures;
- ❑ How to obtain authorisations from other government institutions;
- ❑ Other technical, commercial and regulatory requirements necessary to bring an SPP into operation.

South Africa has ***Electricity Regulations on New Generation Capacity, May 2011*** and ***Non-grid Household Electrification Guidelines, March 2012*** which respectively define the procurement process for new generation capacity by organs of the state and the provision of basic electrical services to off-grid households.

The procurement process for new generation capacity by organs of the state in South Africa can be summarised as follows:

- ❑ The Minister of Energy, after consulting the Regulator and System Operator (the National Transmission Company (NTC)), develops an integrated resource plan (IRP) which identifies the size and resource mix for new generation capacity. The latest IRP for 2010-2030 published in 2011 defines the requirements over the planning horizon as 9.6 GW for nuclear, 17.8 GW for non-hydro renewable energy (8.4 GW solar PV, 8.4 GW wind, 1 GW Concentrated Solar Power (CSP), 6.3 GW for coal and 8.9 GW for large hydropower imports and other resources.
- ❑ The Minister or buyer, as the case may be, identifies a specific project or option for detailed feasibility studies to determine the estimated costs and benefits, proposed risk allocation between the buyer and generator, and the development model (public; public/private; IPP, etc).
- ❑ The Minister decides the development model. If the IPP route is taken, the IPP procurement programme determined by the Minister is followed.

The non-grid household electrification policy guidelines assume that grid electricity is the preferred mode and therefore focuses on small solar home systems (SHS) as a

temporary pre-grid solution. The following is a summary of the key points in the guidelines:

- A clear definition of the off-grid household system and what it is to be used for is provided (refer to the details of the SHS in Appendix A8.5.2),
- A clear definition of grid and non-grid areas is provided. A licensed distributor has to certify that a target area is at least 2 km away from the existing grid and that there are no plans to extend the grid within the next 3 years.
- When the grid encroaches, homes within 2 km of the grid are expected to be connected and the solar home systems dismantled for re-use if possible.
- Private concessionaires, selected through a competitive bidding process, or municipalities are contracted by the Department of Energy for the exclusive right to provide a service within a defined geographic location for a period of 5 years, but with an obligation to provide support services for 20 years.
- Municipalities apply to the DOE to provide off-grid service within their licensed areas.
- The DOE signs service contracts and service level agreements with the service providers who are in turn expected to sign service level agreements with the municipalities where they operate.
- Service providers finance the capital, operation and maintenance costs of providing the service and recover the cost and allowed rate of return in connection fees and monthly service charges.
- Customers are required to apply for service, pay the connection fee and monthly service fee.
- The DOE provides an 80% subsidy for capital costs and 80% subsidy for the monthly service fees in order to make the service affordable to the target households.

Although mini-grids are not explicitly the focus of the regulations cited above, they provide a model for the proposed ***Guidelines for Planning and Development of Mini-grids*** (refer to Table 1, Section 2.5)

3.3 Understanding market needs and demand

Some of the questions that need to be answered by the guidelines proposed for assessment of market needs and demand include the following:

- ❑ Does the country have adequate information on current and potential market needs and demand?
- ❑ Are productive uses of energy for enhanced economic productivity given priority?
- ❑ Is there a grid and complimentary off-grid energy masterplan with clear selection and prioritisation criteria?
- ❑ Is affordability, that is ability to pay, explicitly and correctly defined as a guide for correct targeting of subsidies? Is subsidy policy non-discriminatory?

The Hluleka and Lucingweni pilot schemes in South Africa are an example of the negative consequences of inadequate up front research to understand the needs and expectations of the market (see Appendix 6 for the details).

A good example of analysis of market needs and demand was that done for the Gobabeb Research hybrid mini-grid in Namibia. Proceedings of a symposium held at Gobabeb in 2007 provide interesting information that is worth summarising here. Gobabeb was first electrified by the Ministry of Works in 1972 using 2x50 kVA diesel generators that provided free power to the residents from 0600 to 2200 every day. However as the costs of maintaining the ageing generators continued to increase this became unsustainable and a review of the energy supply system was undertaken in 2000.

It was noted that there were both supply side and demand side inefficiencies that needed to be addressed. The diesel generators were operating inefficiently due to low capacity factors. On the demand side users were unaware of their consumption patterns as there was no metering and they did not pay for the power. It was noted that daily consumption could be reduced from 230 kWh to 135 kWh by undertaking the following measures:

- ❑ Using more efficient appliances – CFLs instead of incandescent lights, efficient refrigerators, etc
- ❑ Revenue metering and charging for the service
- ❑ User education to achieve behavioural changes – switching off lights and computers when not in use, coordinating heavy power uses through prior notice to system operator, replacing worn out refrigerator seals, etc
- ❑ Using LPG for cooking and heating.

The following table provides the summary of the energy usage before and after these demand side measures.

Table 2 Energy usage, Gobabeb Research hybrid mini-grid in Namibia

Section	Diesel only period (16 hour service)	PV/diesel Hybrid (24 hour service)
	kWh/day	kWh/day
Main station	69.0	31.7
Bungalow and old home	16.5	2.9
Staff houses	47.0	40.5
Slums	16.0	8.0
Pool, water and sewerage	8.0	8.0
Workers' houses	24.0	12.0
Training centre	3.3	2.8
Library	3.0	2.6
Offices	6.0	5.1
Reserve capacity	39.0	22.0
TOTAL	**230**	**135**

Source: Desert Research Foundation of Namibia, 2007

The hybrid system that was installed for the new demand scenario comprised 26 kWp solar PV for day operation, 200 kWh battery bank for night operation, and the 2x50 kVA diesel generators for back-up battery charging, standby and heavy duty applications. The hybrid system cost Namibian dollars, N$2 901 351 in 2007.

An analysis done in 2007 indicated that the actual daily consumption averaged 112.3 plus or minus 22.8 kWh with a peak of 228.4 kWh and a low of 72.8 kWh. The estimated costs per kWh for low, medium and high usage levels were N$5.34/kWh, N$4.72/kWh and N$4.22/kWh respectively.

With this type of needs and demand assessment it becomes easy to decide the policy interventions such as the level of subsidies that should be extended to achieve usage by all.

3.4 Guidelines for selection of technology

The instruments that address technology choice should be able to address some of these questions:

- Does the country have a comprehensive options assessment process to guide the selection of the least-cost approaches to fulfilling market needs and demand?

- ❑ Was the choice of existing mini-grids an outcome of a comprehensive options assessment?
- ❑ Has the country undertaken renewable energy resource assessments?
- ❑ Is there a renewable energy target for the energy mix?
- ❑ Are there technology transfer, research and development programs on mini-grid technologies?
- ❑ Are there equipment and system quality standards for mini-grids?
- ❑ Are there guidelines for interconnection of mini-grids to the main grid?

Successful mini-grids should be the least cost options to meet the needs of a proposed location. Traditionally mini-grids in the region have used diesel generators with network standards being the same as those used by the national utility. Many of the pilot schemes in the region using renewables have been based on technologies that were pre-defined by donors. With the exception of the Gobabeb hybrid there are no other cases that demonstrate a comprehensive options assessment process.

It is instructive to provide more details here on the options assessment done for Gobabeb.

The solar PV/diesel hybrid for Gobabeb was selected because it was the least cost option compared to grid extension, diesel only or solar PV only. All options had to provide 24 hour service over a 20 year period. For the diesel option it was assumed that there would be an annual 5% escalation in the price of diesel and a 5% salvage value for the machines at the end of this period. All options were going to use LPG for cooking, escalating in price at 2% per year. Other assumptions used in the analysis were an inflation rate of 10% and real loan and discount rates of 5%.

The following table summarises the life cycle cost calculations for the different options.

Table 3 Life cycle costs, Gobabeb Research hybrid mini-grid in Namibia

Item		Diesel	Grid	Solar PV	PV/Diesel Hybrid
		N$'000	N$'000	N$'000	N$'000
Initial costs	**System**	86	1925	2375	1200
	Upgrade	-	-	50	50
	Conversions	-	-	14	14
	TOTAL	**86**	**1925**	**2439**	**1264**
On-going costs	**O&M**	2773	1655	190	1189
	LPG	224	224	581	581

Item	Diesel	Grid	Solar PV	PV/Diesel Hybrid
	N$'000	N$'000	N$'000	N$'000
TOTAL	**3083**	**3804**	**3210**	**3034**
Annual life cycle cost	**247**	**305**	**258**	**243**

Source: Desert Research Foundation of Namibia, 2007

The link between the assessment of market needs and demand and technology selection is very well demonstrated by this case.

At a national level the needs and demand analysis involves policy decisions on the criteria for selecting and ranking remote and low income communities in terms of order of development, and using these to guide the development of grid and off-grid energy masterplans. Mini-grid developers then use these studies to select target areas of interest where they undertake detailed assessment of needs, assess ability and willingness to pay levels, decide technology options to establish supply costs which can then be used to determine project viability.

3.5 Ownership and financing models

Guidelines aim to ensure adequate and optimal financing which necessarily mean being able to answer the following questions:

- Does the law permit community, public, private or hybrid ownership of mini-grids?
- If so, are there existing mini-grids?
- Who owns them?
- Are they operationally efficient and financially viable?
- What are the procurement, approval and licensing procedures for mini-grid investors? Is there a competitive bidding process? What about unsolicited proposals?
- What are the licensing costs?
- What financing facilities support infrastructure services in general and mini-grids in particular? Are there clear guidelines on how to access the funds?
- Is there a mandatory uniform national tariff? Can mini-grids charge different tariffs or access subsidies needed to sustain national tariffs?
- Are there feed-in tariffs? If so are they based on cost of supply or purchaser's avoided costs?

- ❑ Are there standardised tariff methodologies or power purchase agreements?

Traditionally mini-grids have been owned and funded by governments or national utilities. They have therefore benefited from the cross subsidisation implicit in national tariffs.

The major weaknesses for many of the case studies presented in Appendix A8 were either an unsustainable business model or the absence of clear ownership beyond post pilot phase. Subsidies, where they were applied, were not correctly targeted. South Africa has a free basic energy (FBE) subsidy that is biased towards grid connected people when the greater need for subsidies is by the off-grid schemes.

The EU micro-grid pilot projects in Malawi, Mozambique and Zimbabwe provide good models for potentially sustainable ownership and financing models.

4 Proposed methodology and workplan

The project is being implemented over the 12 month period January to December 2013 in three phases:

- **Inception phase** which is focussed on establishing a clear understanding of the deliverables and compiling information on current policy and regulation as it affects existing or proposed mini-grids in the region;
- **Formulation phase** which will use international best practice to build upon regional best practice to produce the first draft of the Policy and Regulatory Options for SADC mini-grids. This draft will be validated through a Regional Workshop;
- **Pilot implementation phase** where two countries will be selected for developing action plans for application of the regional guidelines to improve national policies and regulations. The action plans will be produced and validated through country stakeholder workshops.

These three phases will inform the final draft of the policy and regulatory options.

4.1 Inputs

The principal inputs into the work will be as follows:

- Consultant expertise and experiences
- Desk research and field visits to operating mini-grids
- Key stakeholder consultations
- International renewables and mini-grid experience
- Feedback on draft deliverables.

The proposed work schedule is summarised in the table below.

Table 4 RERA Mini-Grid Summary Project Schedule

No	Activities	Timeline	Location	Responsibility
1	Debriefing meeting with ECA on project start (Completed)	11.01	Eschborn, Germany	EUEI PDF
2	Request for information from RERA and SADC Contact points (Completed)	24.01		RERA
3	Draft inception report	13.02		Consultants

No	Activities	Timeline	Location	Responsibility
	(Completed)			
4	Project kick-off meeting (Completed)	21.02	Windhoek, Namibia	RERA
5	Final inception report – including proposed changes to the scope of work	08.03		Consultants
6	Presentation of inception report to RERA Committees	04.04	Maseru, Lesotho	Consultants
7	Draft list of policy and regulatory options	30.04		Consultants
8	Criteria for country case studies	30.04		RERA
9	Pre-workshop feedback from stakeholders on policy and regulatory options	10.05		RERA
10	Project brief to SADC Energy Ministers	14-16.05[9]	Maseru, Lesotho	RERA
11	Regional Workshop to validate proposed policy and regulatory options	17.05	Maseru, Lesotho	Consultants
12	Regional workshop report	31.05		Consultants
13	Selection of countries for case studies	07.06		RERA
14	TOR for national case studies (2 selected countries)	28.06		Consultants
15	Country workshops to validate proposed action plans for national supportive frameworks for mini-grid development	(TBA)[10]	Selected countries to advise	Consultants
16	Brief to RERA Committees on country case studies	09.09	Victoria Falls, Zimbabwe	Consultants

[9] Meetings of the SADC Energy Ministers will be held in Lesotho from 14-16th May 2013 which shifts the Regional Workshop venue from Windhoek to Maseru for convenience of the delegates who will be attending both meetings.

[10] Scheduling of the country workshop in **August** or **September** will be done in consultation with the selected countries

No	Activities	Timeline	Location	Responsibility
17	Country Workshop Reports (2)	31.10		Consultants
18	Country case study reports (2)	31.10		Consultants
19	Presentation to RERA Annual Conference	05.11	Maputo, Mozambique	Consultants
20	Final Reports (Project summary and final list of policy and regulatory options)	10.12		Consultants
21	Final project debriefing	31.12		EUEI PDF
22	Submission to SADC Energy Ministers	(TBA) [11]		RERA
23	Launch event (after Ministerial approval)	(TBA)		RERA

4.2 Deliverables

The deliverables for this project are as follows:

- **Inception Phase Report** which (1) highlights the key aspects of the workplan and methodology whose details are in the technical proposal and, (2) provides a summary of the information on current country status. (This report is a combination of what was, at the proposal stage, envisaged to be two separate reports - the 'Inception Report' and the 'Summary Report')

- **First Draft of Policy and Regulatory Options:** the following is a long list for discussion about relevance and applicability and prioritisation. The list was provisionally accepted at the kick off workshop but the final list of deliverables will be subject to a review after presentation of the detailed recommendations. The options will address the four focus areas as follows:

  - **Role Clarity:** - ***Guidelines for planning and development of mini-grids*** – definition and role of mini-grids and checklist of requirements by the different people and institutions involved

  - **Market needs and demand:** - ***Template for assessment of consumer needs and customer demand*** – focussing on remote and low income communities; ***Guidelines for effective use of rural***

[11] The SADC Secretariat will be consulted on the scheduling of the meeting of the SADC Energy Ministers in **2014**

energy funds for targeting of subsidies - to create demand by remote and low income communities (to include harmonisation of grid and off-grid subsidies etc); ***Criteria for selecting and ranking rural locations for energy provision*** –to include terms of reference template for rural and renewable grid and off-grid masterplans; ***Guidelines for appraisal of demand analysis in feasibility studies*** - submitted in support of licence applications

- **Technology choice:** – ***Comprehensive assessment of technology options*** - focusing on remote and low income communities ; ***Terms of reference template for renewable energy resource assessments*** – to incorporate strategic environmental assessments (SEA); ***Technical design and operational guidelines for mini-grids*** – to address equipment and system standards and low cost designs; ***Guidelines for interconnection of isolated mini-grids to the main grid*** – to include ownership and financial issues; ***Guidelines for sustainable technology transfer for mini-grids***

- **Ownership and Finance:** - ***Procurement and licensing procedures for mini-grids*** - to include competitive bidding, feed-in tariffs, quota obligations, net metering, fiscal incentives, etc; ***Guidelines for use of energy funds for mini-grid investment support*** - to include carbon credits, capital subsidies, tax concessions, guarantees, etc; ***Standardised tariff methodologies and power purchase agreements*** – to include procedures for developing feed-in tariffs, calculating avoided costs,

- **Regional Workshop Presentations and Report:** the objective of the meeting is to provide an opportunity for the consultants to present their recommendations to government, utility, regulatory and private sector stakeholders. The discussion and feedback on the draft policy and regulatory options will be incorporated into the workshop report.

- **Terms of Reference for National Activities:** these will be designed to pilot the application of the regional guidelines to the specific situation of the selected countries. The selection of the two countries will be made by RERA with advice from the consultants and EUEI PDF.

- **Two Country Studies and Action Plans:** the detailed programs of activities will be agreed with the relevant country authorities. The countries selected must be able to serve as role models for other countries.

- **Two Country Workshop Presentations and Reports:** these will be attended by similar stakeholders to those expected at the regional workshop and the purpose of the workshops will similarly be to provide feedback to be incorporated into the final reports.

- **Presentations to RERA meetings:** the purpose of the presentations is to promote buy-in by the managerial, professional and technical officials

expected to play a leading role in the application of the tools being developed.

- **Final Draft of Policy and Regulatory Options:** this will provide the reference document for roll out of the implementation of the guidelines by all countries.

A1 Questionnaire on Current Country Status

The following list of information was requested from RERA and SADC Contact points:

1. **Institutional framework and capacity of energy sector**

   - ❑ Institutions responsible for Policy and Planning (including managerial and professional staff establishment and current strength)
   - ❑ Institutions responsible for Energy Regulation (including managerial and professional staff establishment and current strength)
   - ❑ Public and major (relative to the country) private sector companies and organisations in grid energy
   - ❑ Public and major (relative to the country) private sector companies and organisations in off-grid and renewable energy
   - ❑ Financial institutions and infrastructure finance facilities provided (typical loan amount and tenure)
   - ❑ Higher education and research institutions with renewable energy programs (including managerial and professional staff establishment and current strength)

2. **National Energy Policy and Plans**

   - ❑ General energy policy document
   - ❑ White papers or other support schemes for energy and electricity sector investment
   - ❑ White papers or other support schemes for renewable energy investment including targets for share of renewable energy for electricity production
   - ❑ Renewable resource assessment studies
   - ❑ Grid and off-grid electrification masterplans

3. **Energy Laws**

   - ❑ General energy management law
   - ❑ Electricity law
   - ❑ Renewable energy law
   - ❑ Investment law
   - ❑ Other relevant laws

4. Regulations

- ❑ Electricity market structure (integrated or unbundled)
- ❑ Procurement and Licensing procedures for large-scale and small-scale electricity production, transmission, distribution and supply
- ❑ Grid code, distribution code, tariff code
- ❑ Mandatory performance reporting requirements for electricity sector licensees including latest reports where applicable
- ❑ Other relevant regulations

5. Tariffs

- ❑ Average revenue per unit (USc/kWh)
- ❑ Average generation cost per unit (USc/kWh)
- ❑ Average transmission cost per unit (USc/kWh)
- ❑ Average distribution and supply (retail) cost per unit (USc/kWh)
- ❑ Cost of service studies
- ❑ Long run marginal cost studies
- ❑ Avoided cost and feed-in tariff studies

6. Statistical Highlights

- ❑ Current total (utility and non-utility) annual electricity power and energy demand
- ❑ % off-grid (self-generation; mini-grid)
- ❑ % private sector share
- ❑ % renewable energy share (split into hydro and non-hydro)
- ❑ % household, agriculture, mining, manufacturing, commercial, transport, other
- ❑ Electrification access (% households connected – urban and rural)

7. Other relevant information

- ❑ Number, size (installed generation capacity and network voltage and length) and ownership (public/private/community) and location of existing mini-grids. For this study a mini-grid is an off-grid or grid

connected network with embedded renewable energy generation which may be backed up by a fossil fuel generator.

- ❑ Any case studies of existing mini-grids (highlighting operational and financial performance including a comparison of mini-grid and national tariff levels)

- ❑ Previous regional and country studies or policy and regulatory framework for renewable energy development and the status of implementation of the recommendations of such studies.

A2 Institutional Framework and capacity of energy sector

On the basis of documents and information submitted, the institutions responsible for final decisions regarding the following functions of relevance to establishment of mini-grids are summarised in the following table.

Table 5 Summary of institutions responsible for establishment of mini-grids

Country	Policy & Planning	Regulation	Service Delivery	Finance	Renewable Energy Education and Information
Angola	Ministry of Energy and Water -National Department of Rural Electrification (head of department plus 6 junior engineers who need training)	Institute of Energy Sector Regulation (IRSE) (advisory role for tariffs) Ministry of Finance (tariff approvals)	National Electricity Enterprise (ENE), Electricity Distribution Enterprise of Luanda (EDEL) Proposal for rural electrification agency	No information	None
Botswana	Ministry of Minerals, Energy and Water Resources (MMEWR) – Department of Energy Affairs	MMEWR – Department of Energy Affairs	BPC Lesedi Solar Industries Association Of Botswana	National Electrification Fund	Botswana International University of Science and Technology; University of Botswana; Botswana Institute of Technology, Research and Innovation
DRC	Ministry of Mines and Energy (MME) – National Energy Commission Ministry of Hydrocarbons	MME	National Electricity Utility (SNEL)	No response to questionnaire	No response to questionnaire

Country	Policy & Planning	Regulation	Service Delivery	Finance	Renewable Energy Education and Information
Lesotho	Ministry of Energy, Meteorology and Water Affairs – Department of Energy	Lesotho Electricity Authority (LEA	Lesotho Electricity Company (LEC); Department of Energy (Rural Electrification Unit)	Universal Access fund; local banks	University of Lesotho
Madagascar	Ministry of Energy and Mines	Office of Electricity Regulation (grid); Agency for Rural Electrification (off-grid)	National electricity utility (Jiro sy Rano Malagasy (JIRAMA)) Agency for Rural Electrification	No response to questionnaire	No response to questionnaire
Malawi	Ministry of Natural Resources, Energy and Environment (MNREE) – Department of Energy Affairs	Malawi Energy Regulatory Authority (MERA)	Electricity Supply Corporation of Malawi (ESCOM)	Rural Electrification Fund	Mzuzu University – Test & Training Centre in Renewable Energy Technologies Renewable Energy Industries Association
Mauritius	Ministry of Energy and Public Utilities	Utility Regulatory Authority (not yet operational)	Central Electricity Board (CEB); IPPs	Ministry of finance loans	University of Mauritius; Mauritius Research Council (MRC)
Mozambique	Ministry of Energy – National Directorates for Electrical Energy and New & Renewable Energy	National Electricity Advisory Council (CNELEC)	Electricity Company of Mozambique (EDM); Cahora Bassa Hydroelectric Company (HCB)	Energy Fund (FUNAE)	No response to questionnaire

Country	Policy & Planning	Regulation	Service Delivery	Finance	Renewable Energy Education and Information
Namibia	Ministry of Mines and Energy; National Planning Commission	Electricity Control Board (ECB) – to be transformed into energy regulator	Nampower; 3 Regional Electricity Distributors (CENORED, ERONGO RED, NORED); Selco; Local Authorities; NGOs	National Energy Fund; Solar Revolving Fund; KongaLend; Commercial banks	Polytechnic of Namibia - Renewable Energy and Energy Efficiency Institute (REEEI); Habitat Research Centre
Seychelles	Ministry of National Development – Energy Steering Committee; Ministry of Environment, Natural Resources and Transport – Seychelles Energy Commission	Public Utilities Corporation	Public Utilities Corporation Solar Energy Company	No response to questionnaire	No response to questionnaire
South Africa	Ministry of Energy – Department of Energy	National Energy Regulator of South Africa (NERSA) Staff establishment (177); strength (161)	ESKOM; municipal electricity distribution departments; Proposal for Regional Electricity Distributors	State Electrification Capital Fund Industrial Development Cooperation Development Bank of Southern Africa (DBSA)	South African National Energy Development Institute (SANEDI) Universities: Fort Hare, Nelson Mandela Metropolitan; Stellenbosch (Centre for Renewable and Sustainable Energy Studies).
Swaziland	Ministry of Natural Resources and Energy	Swaziland Energy Regulatory Authority (SERA)	Swaziland Electricity Company (SEC); Sugar companies	Public Service Pension Fund; European Investment Bank (EIB) DBSA	None

Country	Policy & Planning	Regulation	Service Delivery	Finance	Renewable Energy Education and Information
Tanzania	Ministry of Energy and Minerals (MEM)	Energy and Water Utilities Regulatory Authority (EWURA)	National Electricity Utility (TANESCO); IPPs Rural Energy Agency	Tanzania Investment Bank Rural Energy Fund	Tanzania Traditional Energy Development Organisation
Zambia	Ministry of Energy and Water Development (MEWD); Rural Electrification Authority	Energy Regulation Board (ERB)	National Electricity Utility (ZESCO); Rural Electrification Authority; Copperbelt Energy Corporation (CEC); IPPs	Rural Electrification Fund	No response to questionnaire
Zimbabwe	Ministry of Energy and Power Development (Staff establishment 152, Strength 89)	Zimbabwe Energy Regulatory Authority (ZERA); (Staff establishment 28, Strength 25)	National Electricity Utility (ZESA); Rural Electrification Agency IPPs	Rural Electrification Fund; Infrastructure Development Bank of Zimbabwe (5-10 year loans)	Scientific and Industrial Research and Development Centre (SIRDC) – Energy Institute. (Staff establishment 15, Strength 10) University of Zimbabwe-Renewable Energy Department; (Staff establishment 10, Strength 8) Chinhoyi University of Technology – Dept of Fuels and Energy Engineering (Staff establishment 20, Strength 14)

Sources: Responses to questionnaire and www.reegle.info/countries

A3 National Energy Policies, Strategies and Plans

Table 6 Summary of national energy policies, strategies and plans

Country	Latest General Energy and/or Electricity Policy, Strategy and Planning Documents	Renewable Energy Targets (% of energy mix)	Significant provisions with impact on Renewable and Hybrid Mini-grids
Angola	The National Energy Security Strategy and Policy, 2011	No Clear target	o Proposed Electricity Supply Industry ESI unbundling o Long term plan to use renewables (hydro, wind and solar in that order of preference) and small thermals as options for isolated grids. o Feed-in tariffs proposed for small power projects (up to 10 MW) but only in isolated areas; grid interconnection subject to public utility approval o Proposal for uniform national end-user tariffs and cost-reflective tariffs o Proposed subsidies for lifeline or social tariffs
Botswana	Draft National Energy Policy of 2012 PV Masterplan 2003 Renewable Energy Technology Barrier Removal Study 2005	No clear target	o Strong Government and private sector interest in promoting renewable energy, especially solar energy o Government supports subsidisation of renewable energy and energy access to low income communities. Low interest loans for rural households to buy PV systems o Government is still to decide on best option for restructuring of the electricity supply industry
DRC	DRC Energy Sector Policy Letter (2009).	No response to questionnaire	o National utility has monopoly for transmission and distribution o Hydropower is preferred resource for grid and off-grid electrification o Many solar systems for off-grid institutions
Lesotho	National Electrification Masterplan 2007	No clear target	o Renewable energy resource assessment on-going o Lesotho Renewable Energy Based Rural electrification project supported by GEF/UNDP

Country	Latest General Energy and/or Electricity Policy, Strategy and Planning Documents	Renewable Energy Targets (% of energy mix)	Significant provisions with impact on Renewable and Hybrid Mini-grids
Madagascar	Madagascar Action Plan (2007-2012),	No response to questionnaire	○ Promotion of Rural Electrification through Renewable Energies (2008-2014, with support from GIZ).
Malawi	Malawi Energy Policy (2003) Malawi Electricity Investment Plan (2010)	No response to questionnaire	○ Proposed 13 feasibility studies for hydro power projects on 6 rivers; coal fired generation and wind mapping to prepare for competitive bidding for private sector investment
Mauritius	Integrated Electricity Plan, 2013-2022 Long Term Electricity strategy (2009-2025) Renewable Energy Development Strategy (work in progress) Geothermal, wind and solar resource assessments (work in progress)	No Clear target	○ Island already covered by national grid and has near universal household connectivity
Mozambique	Energy Strategic Plan 2009-2013	No Clear target	○ Commissioning of studies to determine the mini-hydro power potential and establish a wind power map for the whole country ○ Development of low cost rural networks and training rural communities to manage them ○ Prioritisation of rural locations electrification at district government level ○ Program of grid interconnection of isolated networks serving district capitals ○ Proposal for tax exemptions for rural electrification equipment ○ Proposal to simplify planning and development procedures for small hydropower below 15 MW including exempting them from water payments

Country	Latest General Energy and/or Electricity Policy, Strategy and Planning Documents	Renewable Energy Targets (% of energy mix)	Significant provisions with impact on Renewable and Hybrid Mini-grids
Namibia	Draft National Integrated Resource Plan Reports White Paper on Energy Policy 1998; Rural Electrification Distribution Masterplan (REDMP) Off-grid Energisation Masterplan (OGEMP) 2007 Development of Procurement Mechanisms for Renewable Energy Resources 2011	No Clear target	○ Off-grid masterplan provides clear prioritisation criteria for rural locations and focuses on total energy needs using energy shops ○ Strong and tangible Government support for renewable energy initiatives e.g. establishment of a Solar Revolving Fund ○ Pilot mini-grid projects using PV/diesel
Seychelles	Second National Energy Policy	No response to questionnaire	○ Potential for solar and wind energy to reduce current dependence on diesel generation

Country	Latest General Energy and/or Electricity Policy, Strategy and Planning Documents	Renewable Energy Targets (% of energy mix)	Significant provisions with impact on Renewable and Hybrid Mini-grids
South Africa	Integrated Resource Plan for Electricity, (2010-2030), 2011 Electricity Pricing Policy, 2008 Electricity Basic Services Support Tariff (EBSST) Policy (Free Basic Electricity (FBE)), 2003 Renewable Energy Resource Database (RRDB) (DME, Eskom, CSIR, 2001) Renewable Energy White Paper, November 2003 National Climate Change Response Green Paper, Nov 2010 Non-grid electrification guidelines, March 2012 White Paper on Energy Policy, 1998	4% by 2013 (10000 GWh, 1667 MW); 9%by 2030	○ 17.8 GW Renewable energy generation planned (8.4 GW solar PV, 8.4 GW Wind; 1.0 CSP) ○ Affordability defined by level of consumption for grid connected consumers – 350 kWh/month current limited to 20 A. ○ Competitive bidding for new renewable energy IPPs with REFITS as upper limit ○ DOE to develop renewable energy guideline ○ Energy Policy objectives include environmental sustainability, enhanced energy efficiency; increased private sector participation; social equity by addressing low income needs ○ First 50kWh given free to low income (free basic electricity) connected to the grid. Off-grid consumers discriminated as they have a lower FBE level of R48/month (2002 Rands) ○ Proposal for more research into off-grid generation for incorporation into IRP reviews ○ Provision for price premiums for renewable if needed to meet target ○ Renewable energy projects can access CDM support with government help ○ Special tax exemptions for renewables ○ Uniform national tariff structures but different tariff levels to reflect local conditions
Swaziland	Energy Policy 2003 Renewable Energy Strategy and Action Plan 2003	No clear target	○ Minister can grant exemption from licensing for off-grid and mini-grids

Country	Latest General Energy and/or Electricity Policy, Strategy and Planning Documents	Renewable Energy Targets (% of energy mix)	Significant provisions with impact on Renewable and Hybrid Mini-grids
Tanzania	National Energy Policy 2003 Power System Masterplan 2009 (under review) Guidelines for Small Power Producers Draft Guidelines for Large Power procurement	No clear target	○ Country has very clear framework for promotion of small power projects with generous tariffs for off-grid ○ TANESCO is the single buyer
Zambia	National Energy policy 2008 Rural Electrification Masterplan 2008-2030 (2009) Power System Development Masterplan 2010	No clear target	○ Targets to increase rural electrification access from 3% to 51% between 2009 and 2030 ○ Plan to use grid extension or renewable energy sources (mainly micro-hydro and solar PV home systems) for isolated mini-grids currently using diesel generation ○ Prioritised list of rural locations for electrification by grid and off-grid options
Zimbabwe	National Energy Policy 2012	No Clear target	○ Proposal to transform Rural Electrification Agency into a Rural and Renewable Energy Agency ○ Restructuring from single buyer to hybrid of captive retail market and competitive wholesale market ○ Plan to develop grid and off grid rural energy masterplan in 2013/14

Sources: Responses to questionnaire and www.reegle.info/countries

A4 Energy Laws and Regulations relevant to mini-grids

Table 7 Summary of national laws and regulations relevant to mini-grids

Country	Laws	Regulations	Key provisions relevant to mini-grids
Angola	General Electricity Law, 1996 Draft National Electrification Institute Act	Laws and regulations under review to align with the National Energy Strategy.	o Vertically integrated ESI market o Ministry of Finance approves tariffs
Botswana	Electricity Supply Act Amendment of 2007	Control of Prices, Goods and Other Charges Act	o Single buyer model o Minimum self-generation capacity for licensing – 25 kW
DRC	Electricity Law	No response to questionnaire	o National utility has monopoly
Lesotho	Lesotho Electricity Authority Act of 2002	Application for license rules 2012 License fees and regulations 2009 Electricity price review and structure regulations 2009 Quality of service supply standards for grid and off-grid systems	o Integrated utility; single buyer model o Revenue requirements tariff methodology
Madagascar	No response to questionnaire	No response to questionnaire	o Tax exemptions for Renewable energy investments o Agency for rural electrification regulates off-grid operations

Country	Laws	Regulations	Key provisions relevant to mini-grids
Malawi	Energy Regulation Act (2004) Electricity Act (2004) Rural Electrification Act (2004)	No response to questionnaire	o Laws provide for private sector investment in energy sector using IPPs, PPPs, o Vertically integrated national power utility o Revenue requirements tariff methodology
Mauritius	Electricity Act CEB Act URA Act	Grid code allows connection of small solar and wind power producers to connect to grid	o Vertically integrated ESI industry o Single buyer
Mozambique	Electricity Law 1997 Electricity Act	No response to questionnaire	o Integrated national power utility
Namibia	Electricity Act, 2007	Licensing procedure Tariff methodology Connection Policy guidelines	o Integrated generation and transmission utility; unbundled distribution o Regulator recommends and Minister approves issue of licenses o Revenue requirements tariff methodology
Seychelles	No response to questionnaire	No response to questionnaire	No response to questionnaire

Country	Laws	Regulations	Key provisions relevant to mini-grids
South Africa	National Energy Act 2008 National Energy Regulation Act 2004 Electricity Regulation Act, 2006 Eskom Conversion Act, 2001 Local Government Municipal Systems Act, 2000	Electricity Regulation on New Generation Capacity, May 2011 RSA Grid Code version 8.0 Renewable Energy power Plants Grid Connection Code	o Integrated generation and transmission and unbundled distribution and supply o Competitive bidding for IPPs, off-grid concessions o Revenue requirements tariff methodology
Swaziland	Electricity Act 2007 Energy Regulatory Authority Act 2007	Licensing by-laws	o Vertically integrated national utility o Revenue requirements tariff methodology
Tanzania	Rural Energy Act, 2005 Energy and Water Utilities Regulatory Authority Act 2006 Electricity Act 2008 Public Private Partnership Act	Draft Electricity (Tariff Setting) Rules, 2012 Draft Electricity (Regulation of Power Projects) Rules, 2012 Guidelines for Development of Small Power Projects 2011 Standardised Power Purchase Agreement (SPPA) and Standardised Tariff Methodology (STM)	o Vertically integrated ESI industry o Single buyer o Minimum generation capacity for licensing – 1000 kW
Zambia	Electricity Act 1995 amended 2003 Energy Regulation Act 1995 Rural Electrification Act 2003	Off-grid regulatory framework being developed	o Smart subsidies offered on a competitive basis for capital costs of developers targeting rural customers o Minimum self-generation capacity for regulation – 100 kW o Revenue requirements tariff methodology

Country	Laws	Regulations	Key provisions relevant to mini-grids
Zimbabwe	Electricity Act, 2002 & 2003/2007 amendments Energy Regulatory Act 2011 Rural Electrification Fund Act	Electricity licensing regulations (2008) Electricity pricing methodology 2005	o Tariff to cover cost plus allowed rate of return o Small hydro model power purchase agreement o Minimum self-generation capacity for licensing – 100 kW o Revenue requirements tariff methodology

Sources: Responses to questionnaire and www.reegle.info/countries

A5 Tariffs

Table 8 Summary of electricity tariffs

Country	Average Revenue (USc/kWh)	Average Generation cost (USc/kWh)	Average transmission costs (USc/kWh)	Average distribution cost (USc/kWh)	Feed-in tariffs (USc/kWh)
Angola	12.5 (2008)[12]	No response to questionnaire			Study proposed
Botswana	9	No response to questionnaire; no information on referenced websites			Study completed in March 2011
DRC	No response to questionnaire or SAPP documents				
Lesotho	7.5 (2012)	1.3 (local) 3.0 (import)	Not available		Study proposed
Madagascar	No response to questionnaire				
Malawi	6.1(2011)	No response to questionnaire			o Wind (12) o Biomass/Biogas (8-10) o Hydro (8-15) o Solar (10-15) o Geothermal (10.5)
Mauritius	19	17	2.8		Nil
Mozambique	No response to questionnaire; no information on referenced websites				
Namibia	17.1 (N$1.55)	6.7	3.3	7.1	Work in progress
Seychelles	3.2 (2008)	No response to questionnaire			
South Africa	6.1 (2011)[13]	No response to questionnaire; no information on referenced websites			Calculated but not in use
Swaziland	12	No response to questionnaire			
Tanzania	12.4	No response to questionnaire; no information on referenced websites			10 (Main grid) (2012) 32 (Isolated Mini-grid) (2012)
Zambia	5.4	1.5	0.72	0.97	Work in progress
Zimbabwe	9.9	5.1	4.8		Study proposed

[12] In the absence of submissions from the countries statistics for 2008 taken from RERA Publication of 2009 on electricity tariffs

[13] Malawi and South Africa are estimated from SAPP statistics on revenue and consumption

A6 Electricity Statistical Highlights

Table 9 Summary of electricity statistical highlights

Country	Annual Power Demand (MW)	Annual Energy Demand (GWh)	% off grid	% Access (National)	% Access (Urban)	% Access (Rural)
Angola	870	3427	No reliable off-grid statistics available	30%	~30	<5
Botswana	542	3118		67	80	40
DRC	1050	6723		Not available	Not available	Not available
Lesotho	142	651		28	75	4
Madagascar	Not available	Not available		Not available	Not available	Not available
Malawi	277	1476		17	70	4
Mauritius	429 (2012)	2495 (2012)		~100	~100	~100
Mozambique	616	2380		18	20	3
Namibia	611	3648		40	70	18
Seychelles	40	232		~99	~99	~99
South Africa	36543	224446		82	90	65
Swaziland	200	1019		45	70	25
Tanzania	890	3770		14	50	2
Zambia	1562	10688		16	50	3
Zimbabwe	2029	7367		37	83	13

Sources: (1)Except for Lesotho and Mauritius, figures for annual maximum power and energy demand are from the 2011/2012 SAPP Annual Report; (2) Access figures are from a combination of questionnaire responses and statistics quoted in previous studies e.g. RERA Publication on Electricity Tariffs and Selected Performance Indicators; SADC Regional Energy Access Strategy and Action Plan (2010)

A7 Mapping of off-grid electrification options in SADC

Table 10 Mapping of off-grid electrification options

Country	Diesel	Mini and micro-hydro	Solar PV and Solar Home Systems	Solar thermal	Small Wind	Biomass	Biogas	Geothermal
Angola	✓	✓	✓		✓			
Botswana	✓		✓	✓	✓		✓	
DRC	✓	✓	✓		✓	✓		
Lesotho	✓	✓	✓		✓			
Madagascar	✓	✓	✓		✓	✓		✓
Malawi	✓	✓	✓		✓		✓	✓
Mauritius		✓	✓		✓			
Mozambique	✓	✓	✓		✓			
Namibia	✓		✓	✓	✓	✓		
Seychelles	✓		✓		✓			
South Africa	✓	✓	✓	✓	✓			
Swaziland	✓		✓		✓	✓		
Tanzania	✓	✓	✓		✓			✓
Zambia	✓	✓	✓		✓	✓	✓	✓
Zimbabwe	✓	✓	✓		✓		✓	✓

Sources: Responses to questionnaire and www.reegle.info/countries

A8 Mini-grid Case Studies

A8.1 EU Mini-grid micro-hydro pilot projects in Malawi, Mozambique and Zimbabwe

A8.1.1 Programme description

The report on the above programme gives regional examples of practical solutions to rural electrification using mini-grids. It documents critical experience, including lessons learnt to inform the proposed development of a regulatory system for the SADC region. Regulation agencies, their processes and systems are relatively new in the region and as such the report also draws experiences from other case studies outside of the region that will help to inform the SADC regional framework.

The lessons from this case study are derived from a 5 year programme funded by the ACP – EU Energy Facility. It was developed and implemented by Practical Action in partnership with Malawi (Mulanje Mountain Conservation Trust), Mozambique (Kwayedza Simukai Manica) and Zimbabwe (individual communities) from 2007 until end of 2012. The main objective of the programme was to improve access to modern energy services and increase uptake of renewable energy technologies in the energy mix in poor rural areas of Malawi, Mozambique and Zimbabwe.

The specific objectives of the programme were:

- Adapting and promoting at least 2 viable and innovative mini-hydro scheme (MHS) delivery models
- Enhancing capacity for all relevant stakeholders in planning, designing and implementing decentralised community MHS
- Addressing the policy barriers to promotion of decentralised community MHS
- Strengthening local industry, government and finance institutions to support growth of MHS.

The schemes were pre-selected from sites identified through Practical Action's regional experience working in the energy sector in three countries. These sites were then subjected to detailed technical feasibility studies. The choice of the sites was based on river potential, number of intended beneficiaries and distance away from the grid. Whilst technical designs were provided by Practical Action, the partners were responsible for community mobilisation and site supervision.

Two models of ownership were tested:

- ***Community owned*** in Malawi and Zimbabwe;

- ***Individual ownership*** in Mozambique. Historically micro-hydro schemes in Mozambique have been privately owned and energy service delivery models are quite old dating to as far as the 1970's.

The community based approach model was selected to leverage community resource input into the schemes to bring down the cost of building and operating the schemes. Practical Action trained local communities in the construction, operation and management of the schemes and facilitated the building of local capacity for production and supply of equipment and spares.

By the end of 2012, the project had demonstrated the technical and economic viability of community based schemes and the in-built sustainability aspects of sound business management models that include tariff setting, revenue collection and operation and maintenance. These models can sustainably provide modern energy services required at village level.

Ten demonstration mini hydro grids with a total generation capacity of 320kW were installed in Zimbabwe, Mozambique and Malawi. The schemes, their costs and locations and the ownership model used is summarised in the following table.

Table 11 Summary of demonstration mini-hydros in Zimbabwe, Mozambique, and Malawi

Scheme Name (Location)	District	Owner	Generation (kW)	Estimated Cost US$	Cost per Capacity US$/kW
Bondo (Malawi)	Mulanje	Community Cooperative	88	395,176	4,490
Nyafaru (Zimbabwe)	Nyanga	School Development Committee	20	41,138	2,057
Chipendeke (Zimbabwe)	Mutare Rural	Community Cooperative	25	195,013	7,800
Dazi (Zimbabwe)	Nyanga	Community Trust Fund	20	123,232	6,162
Ndiriri (Mozambique)	Manica	Private	27	46,437	1,720
Nyamwanga (Zimbabwe)	Mutasa	Community Cooperative	30	130,768	4,359
Nerufundo (Mozambique)	Manica	Private	24	16,000	667
Chitunga (Mozambique)	Manica	Private	33	109,745	3,326

Hlabiso (Zimbabwe)	Chimanimani	Community Cooperative	30	120,000	4,000
Ngarura (Zimbabwe)	Mutasa	Community Cooperative	25	75,000	3,000

The schemes provide power for schools, rural clinics, houses and small businesses that include grain mills and supermarkets. The investment costs included grant financing, community own contribution in the form of 'sweat equity' and local material. Technical operation and maintenance is provided by the local population.

The price of energy service is based on a cost recovery formula including minimum margin that also takes into consideration the ability to pay by the local communities. A prepayment platform was installed that improved payment collection and avoided conflicts in communities where people are closely related.

A8.1.2 Observations and Lessons

Emerging issues from the project include:

Technical Issues

- **The capacity of regulatory and rural energy agencies with ability to understand the technical and socio-economic benefits of off-grid systems has been limited**. The programme developed training toolkits for local operators to enable them to operate and maintain the pilot energy schemes. The manuals include the setting up and constitution of local management teams and systems. The manuals are being used in the training as well reference material for local operators.

- **There is need to engage and encourage private public partnership to enhance capacity and skills development.** For example Practical Action worked with a private energy company CONLOG Electrical of South Africa which resulted in the latter contributing skills and knowledge and applied its prepayment energy meters to one of the communities in Chipendeke in Zimbabwe. The prepayment metering system has become one of the greatest innovations to come with the hydro project as the challenges in collection of service fees has been reduced and also the need to switch off a customer is now automatic.

Policy and regulatory Issues

- **With the exception of Mozambique, energy planning remains highly centralised** with no grassroots representation unlike other sectors such as agriculture, health and education. Grassroots participation in policy formulation and decision making is insignificant. This has meant that the needs of the rural population have remained generalised and on the other hand policies and strategies are produced for them and rarely filter to them.

- **Incentives for the promotion of renewable energy systems such as the removal of value added tax and customs duty are provided for by policy but not implemented consistently on the ground**. Malawi is developing a separate strategy document on renewable energy. The policies and strategies are however not supported by action plans to realise the set targets and ambitions.

- **There is a disconnect between general development planning and energy planning:** the interplay of the different planning and socio-economic levels has not been fully explored and developed in all the countries leaving the few pilot projects and programmes as isolated interventions that have failed to grow beyond the project direct targets. Energy still remains a very abstract concept to explain and plan for at the lower levels such as the village, ward and the district. Often communities and support agencies plan for the end use such as grinding mill and not the enabling energy service (say solar power).

- **Over-regulation:** In all the 3 countries the installation of a micro-hydro system requires compliance with more than one regulator, a case that was not only costly but also added delays in the installation of the systems. There is the water regulator, the environment regulator and in some instances the electrical regulator (Malawi).

- **Standards Compliance**: The system design was required to comply with at least two regulations. These are costly considering the size of the system and the investment cost. For example in Zimbabwe compliance with Environment Management Act would require the developer to identify a consultant to undertake the environmental impact assessment. In all the assessments undertaken the cost was not less than US$10,000 per study. In this case the community would require the technical assistance of engineers in preparing the terms of reference and meeting the cost of the impact assessment.

  A water permit is required for water use in a micro hydro system. The type of permit in the Zimbabwean context is the non-consumptive use permit. By the time the project was under implementation there were no gazetted fees for non-consumptive uses. Even where the permit was issued, it was difficult to enforce as other users would also abstract water from the same stream without permits thus rendering the need for a permit unnecessary.

- **Licensing**: Whilst electricity regulation in Zimbabwe and Mozambique in terms of licensing is not mandatory for small systems below 100kVA, in Malawi there is a separate license for generation, transmission and distribution. The licensing fees for registration of off-grid RE systems in rural areas attract high registration fees in excess of US$10,000 which is barrier to donor and private sector investment.

- **Incentives**: In all the 3 countries there are incentives in place for renewable energy (RE) equipment. However there is often conflict with

people in the Revenue Collection Authorities as they cannot tell the difference between a battery for solar and that for automotive use. In Malawi, the energy policy states that all renewable energy equipment can be imported duty free, in practice not all RE equipment such as batteries is included. In addition surtax is paid on all renewable energy equipment defeating the idea of increasing affordability of the technology.

- **Tariff Setting**: The simple principle is that all tariffs have to be cost reflective. However in Zimbabwe, since mini grids are exempt from licensing, they tend to set their own tariffs commensurate with affordability and ability of people to pay. In Mozambique, the private operators of the micro hydro are not supposed to charge more than what the national utility EdM charges. Fees for grinding mills coupled to hydro turbine should not charge more than the gazetted price set by the local government at district level. Similarly the same applies to Malawi.

A8.1.3 Conclusion and Way Forward

The emerging lessons from the project have provided critical questions in how delivery of energy access for the poor could potentially be achieved. Some key questions that need to be answered are highlighted in the following paragraphs.

- ***Does having productive end uses for energy help to make energy services more financially sustainable?***

  There is evidence among the poor communities (micro-hydro project areas) that providing energy without productive end use of the service compromises the system's financial viability. Naturally there are operation and maintenance (O&M) costs and often in the absence of payment for those services the system will naturally die. Rural communities' livelihood options are not diverse, making it difficult to get extra income to pay for energy services. Conversely, when productive end uses are made possible by electricity, people are able to afford to pay the O&M costs and have a string incentive for doing so, because if the electricity system fails their incomes will decline.

- ***Are subsidies what is needed to reach the poorest energy users, in micro hydro projects?***

  The underlying economics of rural energy supply are fragile. Although subsidies tend to encourage dependency syndrome among the communities and limit their financial management and fundraising capacity, they are required to establish the market for example, capital subsidies of small hydro power through grants. Even if individual households are too poor to be connected, the capital subsidies benefit them through provision of improved quality of services from schools, clinics and business centres, or irrigation facilities. For example, at Chipendeke micro-hydro scheme, Zimbabwe, the local clinic which was a beneficiary of a grant facility, has now been able to extend its reach to the population beyond its former boundaries and vaccines are now readily

available as people no longer have to travel long distances to towns 100 km away in search of treatment.

- ***What models sustainably deliver electricity to rural communities?***

  The projects demonstrated that there is no one-size-fits-all model of community ownership - local factors and perceptions have to be taken into account.

  - In *Mozambique* individual owned schemes were preferred because communities believe communally owned development projects are not sustainable.

  - In *Zimbabwe*, all schemes were community owned but with the composition and structure of management differing. At Chipendeke scheme, community shareholder model was demonstrated in which the ownership was acquired by labour contribution and an elected committee manages the scheme. At Nyafaru and Dazi the school development committees by default took over the ownership and management of the schemes since the major beneficiaries were the schools.

  - Financial sustainability was ensured through payment for service. To enhance revenue collection, at Chipendeke a pre-payment system was installed and this was more viable and sustainable as the consumer paid for the energy in advance whereas in earlier systems they used a use fee based on number of light bulbs.

- ***What are critical policy issues that have been realised during the project implementation?***

  - **The institutional framework for scaling up off-grid electricity exists in all the three countries**. This has been enabled through the statutory set up of the Rural Energy Funds and the Rural Energy Agencies that administer the funds. *However these agencies have tended to be biased towards extending the existing grid* even though there are shortages of generation capacity and the reality that in some areas it will be practically unfeasible for the grid to reach them.

  - **Legislation is in place that allows for the participation of independent power producers (IPP's)**. *However the playing field has not been level due to state subsidies enjoyed by national utilities allowing them to charge below cost energy tariffs.* This has crowded out potential IPP's and to enable them to participate, fair market conditions need to be put in place. Thus incentives such as taxes (removal of import duties and corporate income taxes), waiver of license fees for schemes, feed in tariffs, environment credits are some examples that can be enacted for the benefit of IPP's. The

energy regulatory authorities in existence in all the countries must play an increasing role in driving this.

A8.2 Botswana

A8.2.1 Sekhutlane Village

This is under construction and consists of 1X9kW solar PV and 20kW biogas.

A8.3 Lesotho

There is a 180 kW mini-hydro backed up by a 120 kW diesel generator supplying a mini-grid operating at 11 kV. Mini-grid tariffs are the same as the national tariffs.

A8.4 Namibia

A8.4.1 Tsumukwe Solar PV/Diesel Hybrid

Tsumukwe is the largest off-grid settlement in the country. It has a 200 kW PV/Diesel Hybrid mini-grid owned by Otjozondjupa Regional Council. It operates 6 hours on solar PVs, 6 to 8 hours on Batteries and the remaining hours on diesel. Tariffs are N$1/kWh (11USc/kWh) for residential and N$2.50 (27.5USc/kWh) for business. National grid tariffs average N$1.50/kWh (16.5USc/kWh).

A8.4.2 Gobabeb Solar PV/Diesel Hybrid (46 kW)

This comprises 26 kWp solar PV plus 30 kVA inverter, 200 kWh battery bank, 2x50 kVA diesel generators providing 24 hour service to 30 to 70 residents at a desert research station. The hybrid solution was arrived at after undertaking an options assessment that showed that this was the least cost on a life cycle basis. In 2000 Namibian dollars the diesel hybrid option had a life-cycle cost of N$243000 compared to N$305000 for grid connection, N$258000 for solar PV only option and N$247000 for diesel only option.

A8.4.3 Others

Kanab (26 kW PV); Betta (8 kW/6 kW Wind) Hybrid; Okongo District Mini grid (20 kW PV) (was used mostly for water pumping but no longer operational due to theft).

A8.4.4 Observations and Lessons

Namibia is sparsely populated and ideally suited for electrification using mini-grids employing renewables of which solar and wind are the most abundant resources. The Gobabeb hybrid has the following positive lessons:

- **Comprehensive market needs analysis**: the expected demand was arrived at after assessing the end uses and understanding consumer expectations. Previously consumers did not pay for the service t but they were now going to be paying. A strategy to manage expectations was therefore incorporated in the project.

- **Comprehensive options analysis:** the hybrid solution selected was the least cost solution, after assessing both supply side and demand side options.

A8.5 South Africa

A8.5.1 Hluleka and Lucingweni Hybrid mini-grids

In order to test the viability of hybrid minigrids for off-grid electrification the Department of Energy installed two systems in the Eastern Cape:

- **Hluleka** (2x2.5 kW wind; 3 PV arrays of 56x100 W solar PV panels and 5 kVA diesel) and a 75 kVA standby diesel generator;
- **Lucingweni** (6x6 kW wind; 560 x 100 W solar PV and 10140 Ah battery bank).

A8.5.2 Concessions

In 2001 the Department of Energy launched a non-grid electrification program as a complement to the grid program in order to reach remote and poor communities. The followings six concessionaires were selected after a competitive bidding process:

Table 12 Non-grid concessions, South Africa

Concessionaire	Province
KwaZulu Energy Services (KES)	KwaZulu Natal (KZN) and Eastern Cape (EC)
Nuon RAPS Utility (Pty) Ltd	KZN
Solar Vision (Pty) Ltd	Limpopo
Ilitha Cooperative	EC
Summer Sun Trading (Pty) Ltd	EC
Shine the Way cc	EC

According to the Non-grid Electrification Policy guideline (March 2012) the concessionaires are located in areas where the grid is uneconomical in the medium to long term and the focus is on provision of basic household energy services for a monthly fee to these remote and low income communities. For affordability 80% of the capital costs are subsidised by Government and consumers also receive an 80% subsidy of the monthly service fee. The concessionaire therefore co-owns the equipment with the Government and the Government is a co-customer for the service.

The concession provides exclusive rights for 5 years to provide electricity services within a defined geographical location. However the service contract obligations are for 20 years.

The technology chosen for basic electricity supply for lighting, media access and cell-phone charging is a 50 Wp solar PV home system (SHS) with a 105 Ah battery. This SHS can provide, per day, 250 Wh adequate for 4 hours of black and white TV, 4 hours of lighting using 4 compact fluorescent lights (CFLs) and 10 hours of radio. The concessionaires were encouraged to supplement this by providing Integrated Energy Centres which would address the thermal energy needs though paraffin and LPG.

A8.5.3 Observations and Lessons

A Department of Energy review of the pilot Hluleka and Lucingweni hybrids which was published in August 2008 sought to assess the viability and replication potential. The conclusion was that these mini-grids were not viable or replicable in their pilot form for the following reasons:

- **Market Needs and Demand were not adequately assessed:** the communities expected that they would receive a service similar to that provided by the national grid and purchased appliances in anticipation. Unfortunately the project developers had designed the systems for basic lighting and small power applications and this led to system overload and frequent power outages. Subsequent socioeconomic studies showed that lighting and media access were not the primary energy needs desired by the community but cooking and water pumping.

- **Lack of Clarity on Ownership and Sustainable financing models:** the pilot projects did not establish at the outset that there would be a need to have ownership clarity in order to sustain revenue collection and operation and maintenance.

- **Bias towards grid electrification:** Government subsidies for grid connected customers, for example the 50 kWh free basic electricity scheme, are more generous than the monthly service fee contributions for off-grid customers. Even the Non-grid Electrification Policy Guidelines of March 2012 express this bias for grid electrification by defining solar home systems as temporary solution.

- **Low incomes of target communities:** several reviews have concluded that the primary focus of mini-grids should be on social services and productive applications.

A8.6 Tanzania

While all countries have national energy policies that express commitment to promotion of renewable energy projects and mini-grids, Tanzania has proceeded to develop a very comprehensive small power project scheme that has interesting lessons for the region and is therefore explained in some detail below.

In 2008, as a consequence of the National Energy Policy adopted in 2003, the Government of Tanzania launched the small power project (SPP) support scheme by developing a standardised power purchase agreement (SPPA) and standardised tariff methodology (STM) for connection to the main grid or isolated mini-grids. The small power projects in Tanzania are defined as renewable energy projects of 1MW to 10 MW.

In August 2010 the Energy and Water Utilities Regulatory Authority (EWURA) issued guidelines which outline the steps for SPP development in Tanzania and summarises the SPPA's major features as follows:

- **It is a "must-take" contract**: all energy produced by an SPP Developer will be purchased by the Distribution Network Operator (DNO) subject only to such necessary directions and protocols as may be issued by the DNO for the protection of its electric system;
- The Standardized Power Purchase Tariff, SPPT, announced each year, is **based on the avoided costs of the DNO**;
- The **floor tariff** over the term is 100% of the tariff in the year in which the SPPA is signed;
- The **tariff is capped** at 150% (Tanzanian CPI-adjusted) of the tariff in the year in which the SPPA is signed;
- All small power projects, independent of technology, are paid the price calculated in the year subject to the applicable floor and ceiling; and
- The SPPA has a term of 15 years, starting from commencement date of operation.

The SPPA also includes duties and obligations that bind both the DNO and an SPP Developer, including:

- The grid interconnection requirements (specifying power quality standards, relay and other technical requirements for safe interconnection with the DNO grid);
- Metering arrangements; Billing and payment;
- Force majeure; Limitation of liability; and
- Dispute resolution.

Through the Working Group on Small Power Development (WGSPD) the regulator calculates the tariff in September for application in the subsequent year starting January 1st.

The tariffs are currently based on the avoided costs of the national power utility, TANESCO, with a provision for takeover of the utility's obligations by the successor companies envisaged when the utility is unbundled under proposed

reforms. The rationale for this tariff methodology is to ensure that the buyer does not pay more than its best alternative options.

The Standardised Tariff Methodology (STM) can be summarised as follows:

a) **SPPs connected to the main grid**: the avoided cost is defined as the financial long run marginal cost (LRMC) at the medium voltage level adjusted to reflect short term market conditions and the avoided network losses. The tariff is derived as follows:

- ❑ The LRMC is theoretically the cost of meeting an indefinite increase in demand but is practically estimated on the basis of the marginal cost of the buyer's least-cost 20 year generation expansion plan.
- ❑ The economic LRMC obtained from this is converted to a financial LRMC by adding taxes that are paid by the buyer and not recoverable.
- ❑ The short term market condition is the cost of the existing generation system for the following year.
- ❑ The average of the two costs is the avoided generation cost which is then adjusted upward by a factor reflecting the network losses at medium voltage level.
- ❑ The main grid tariff is adjusted by a factor of 120% for the dry season (August to November) and 90% for the low season (December to July) to reflect the seasonal differences in the value of the energy to the grid.

b) **SPPs connected to isolated mini-grids**: the avoided cost is defined as the financial long run marginal cost at the medium voltage level adjusted to reflect the avoided incremental cost of diesel generation.

- ❑ The adjustment to the LRMC is done by taking the average of the LRMC of the main grid and the incremental cost of supplying the mini-grid using a diesel generator. This results in a much higher avoided cost and therefore tariff than for grid-connected SPPs.
- ❑ The SPPA for isolated mini-grids provides for conversion to the grid-connected contract if and when the isolated mini-grid is interconnected to the main grid.

c) **Tariff review**: Tariffs are reviewed using a five year moving average of the Tanzania consumer price index.

Table 13 Tanzania electricity tariffs

	2009				2012			
	Main grid		Mini-grid		Main grid		Mini-grid	
Currency per kWh	**TZS**	**USD**	**TZS**	**USD**	**TZS**	**USD**	**TZS**	**USD**
SPP Tariff for the year	96.11	0.08	334.8	0.28	152.54	0.10	480.5	0.32
Dry Season (Aug - Nov)	115.33	0.10			183.05	0.12		
Wet Season (Dec – Jul)	86.5	0.07			137.29	0.09		
Exchange rate (TZS/USD)	1194				1518			
CPI (5-yr moving average)	6.4%				9.68			

Source: Calculations using information from EWURA documents - www.ewura.go.tz

The above table shows the movement of tariffs in Tanzania Shillings (TZS) and United States Dollar (USD) equivalent between the first tariff announcement for 2009 and the latest for 2012:

A measure of how successful the scheme has been is given in the 2010 annual report of the Energy and Water Utilities Regulatory Authority, which indicates that by that year five developers with a total of generating capacity of 24.4 MW had signed the SPPAs with TANESCO. Three developers with a total of 10.8 MW were in negotiation with the power utility while another 40 were at various stages of project appraisal. The energy sources included hydro, bagasse and other biomass.

The major advantages and weaknesses of the scheme are:

- **Role clarity**: there are guidelines that clarify the requirements for SPP development and the roles of different institutions;
- **Understanding of Market**: because the tariff methodology is unrelated to SPP costs the sharing of costs and benefits between the purchaser and seller can be inequitable. While the methodology ensures that the buyer does not pay more than its alternative cost the buyer can pay much more than is necessary and the seller can earn windfall profits.
- **Choice of technology**: the scheme leaves the market to choose the technology whose costs are competitive relative to the purchaser's avoided costs.
- **Ownership and Financing**: the scheme encourages private sector participation but financial viability can be compromised by over-dependency on a single off-taker purchasing in a depreciating local currency.

A8.7 Zambia

A8.7.1 Summary of a Paper on Current Status of Mini-grids

The following is a summary of a paper submitted in response to the questionnaire which provides some interesting observations and lessons. Additional information on the projects was obtained from the Rural Electrification Masterplan of 2009.

Definition: Mini-grid in this paper is defined as an off-grid or grid connected network with embedded renewable energy generation which may be backed by a fossil fuel generator. This definition excludes the majority of mini-grids in Zambia at isolated District Administrative Centres which use diesel generators and are mostly owned by ZESCO and the Government.

The table below shows the mini-grids in Zambia as at December, 2012.

Table 14 Summary of Zambia mini-grids

Mini-grid name	Ownership	Installed capacity	Network voltage	Location	Length
Shiwan'gandu	ZESCO	1MW	33 kV	Muchinga Province	68Km
Zengamina	NWDT[14]	0.75MW	11kV/33kV	North western province	35km
Lunzua	ZESCO	0.75MW	11kV/66kV	Northern	26km
PV Energy Service Companies (ESCO)	Private			Eastern	

Source: Rural Electrification Authority (REA), ZESCO Ltd

In addition to these mini grids, the Rural Electrification Authority is in the process of developing a solar mini-grid in Samfya, Luapula of installed capacity 60kW. Studies are also being carried by the Copperbelt Energy Corporation on the development of a 1 MW biomass gasification plant in Kitwe, Copperbelt province.

Brief Description of the schemes

Shiwang'andu is a 1 MW mini-hydro power station, and **Lunzua** is a 750 kW mini-hydro and both are projects under the Renewable Energy Based Electricity Generation for Isolated Mini Grids in Zambia which have been successfully implemented and are now fully operational.

Zengamina Hydro Power Station is a 750kW power station which is managed by Zengamina Power Limited and owned by the North West Zambia Development Trust. It is located in the Ikelenge area of North-Western Zambia and with electricity

[14] NWDT North Western Development Trust

covering approximately 35km. It has provided a renewable and reliable source of electricity since July 2007 to families, businesses and organisations in this remote area, with a vision to promoting development and an improvement in people's standard of living. Over the last 3 years, the company has continued to steadily grow its customer base that increased from 250 customers in 2009/2010 to a current customer base of 315.

Photovoltaic Energy Service Companies in Zambia: the country has solar radiation of about 5kW h/m2/day which is suitable for generation of power with solar photo voltaic (PV) panels. In 1998, the Government through the Department of Energy, with funding from the Swedish International Development Agency (SIDA) embarked on a pilot project by establishing three (3) Energy Service Companies (ESCOs) in the Eastern Province of the country:

- Nyimba Energy Services Company (NESCO);
- Chipata Energy Services Company (CHESCO);
- Lundazi Energy Services Company (LESCO).

The companies were provided with 50 Wp solar photo voltaic (PV) systems and these were installed in domestic dwellings in the three respective areas. The clients paid a fee to the ESCOs for the service but the equipment remained the property of government. In total four hundred (400) by 50 Wp units were installed with NESCO having 100 and both CHESCO and LESCO having 150 units each.

Observations and Lessons Learnt

Even though the Shiwang'angu and Lunzua projects were technically successful, they faced the following challenges:

- Some issues such as power purchase agreements and ownership, that should have been concluded before construction commenced, were only addressed afterwards.
- Statutory requirements like EIA approvals, licences and water rights were not concluded in good time.

The Zengamina hydro-electric scheme has produced a wide range of benefits that are immediate and long term in nature. These include:

- Removal of diesel generated power with its attendant high costs, unreliability and associated air and noise pollution.
- 24 hour access to electricity to critical establishments such as Kalene mission hospital and Ikelenge Hospital, and the local schools, thereby improving quality of medical and education services.
- There has been a marked increase in attractiveness of local professional jobs (especially in attracting qualified Zambian staff to Kalene Hospital and local schools).

- Power delivery to over 1000 rural poor in Nyakaseya Village and School, Kalene schools and Ikelenge town who have never had electricity.
- Employment for local Zambians (both in construction and maintenance of the scheme).

The company is faced with a number of challenges that include the following;

- The limited scope for increasing the customer base and tariffs given the low income levels in the district
- Inability to raise capital from commercial sources. Local commercial banks are reluctant to give loans to small rural companies.
- Difficulties in attracting qualified personnel to run its operations.

The ESCOs were not replicated after the project ended in 2000 because of sustainability challenges. Funding using commercial loans was not feasible as the costs would become too high for recovery from customers. In a study of one of the ESCOs, NESCO, it was found that the energy costs of the ESCO clients were higher than grid-connected households or the households that did not have the service. Although the clients appreciated the service because of increased light hours which provided opportunities for reading by school children and entertainment through television and radio, the subsidies provided to grid-connected low income customers resulted in them paying less than half the monthly service fees charged by ESCOs.

A9 References

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Lesotho	○ Lesotho Electricity Authority www.lea.org ○ Lesotho Electricity Corporation www.lec.co.ls
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Zimbabwe	○ Chinhoyi University of Technology: Department of Fuels and Energy Engineering: www.cut.ac.zw ○ Ministry of Energy and Power Development www.energy.gov.zw ○ Scientific and Industrial Research and Development Centre: www.sirdc.ac.zw ○ University of Zimbabwe, Renewable Energy Department; www.uz.ac.zw ○ ZESA www.zesa.co.zw

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