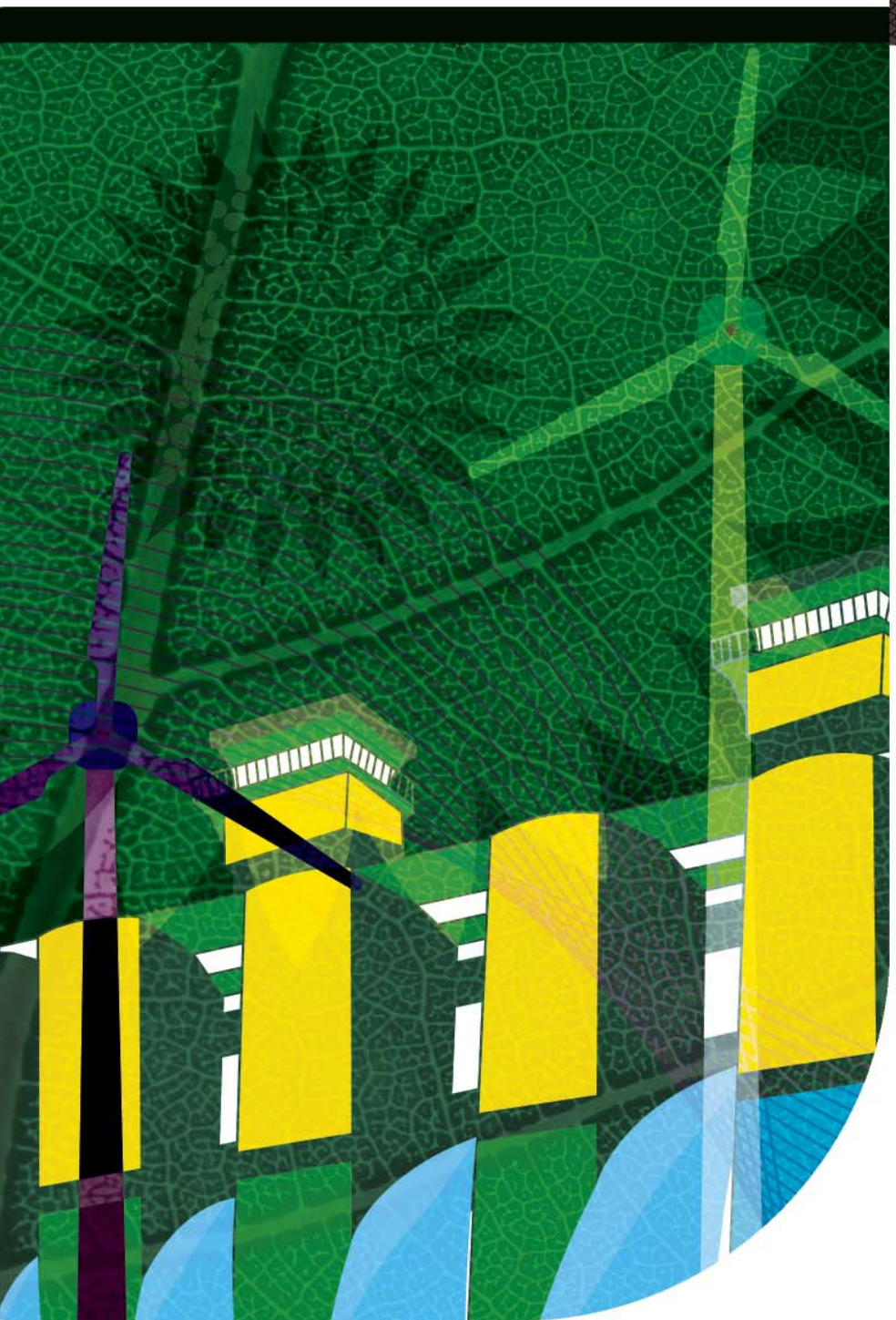
IRENA
International Renewable Energy Agency

ZAMBIA

RENEWABLES READINESS ASSESSMENT 2013



About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low carbon economic growth and prosperity.

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About RRA

A Renewables Readiness Assessment (RRA) is a holistic evaluation of a country's conditions and identifies the actions needed to overcome barriers to renewable energy deployment. This is a country-led process, with IRENA primarily providing technical support and expertise to facilitate consultations among different national stakeholders. While the RRA helps to shape appropriate policy and regulatory choices, each country determines which renewable energy sources and technologies are relevant and consistent with national priorities. The RRA is a dynamic process that can be adapted to each country's circumstances and needs. Experience in a growing range of countries and regions, meanwhile, has allowed IRENA to continue refining the basic RRA methodology. In June 2013, IRENA published a guide for countries seeking to conduct the process in order to accelerate their renewable energy deployment.

For more information visit www.irena.org/rra

Acknowledgements

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Disclaimer

ZAMBIA

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FOREWORD

Zambia joins the rest of the developing world, and in particular Africa, in taking advantage of the benefits that renewable energy can bring in contributing to sustainable economic growth. Zambia is also aware of how renewable energy can assist in achieving the Millennium Development Goals by ensuring access to modern energy services for the majority of the rural communities. In particular, small-scale renewable energy systems can provide affordable energy to the poor, help with creating employment by powering enterprises for increased production, and produce cleaner energy for cooking and heating.

The Government of the Republic of Zambia established the Rural Electrification Authority (REA) and the Rural Electrification Fund through the Rural Electrification Act (No. 20 of 2003), in order to give impetus to the rural electrification agenda. The Rural Electrification Authority strives to fulfil its vision, "Electricity for all rural areas by the Year 2030", by designing and offering smart subsidies for capital costs, to developers and operators that are selected on a competitive basis, for projects to supply energy for the development of rural areas.

The government has also formulated a Draft Renewable Energy Strategy, which outlines key strategic goals and objectives for each renewable energy source, along with the plans to be implemented to achieve these. The policy of greater utilisation of renewable energy will be realised by setting targets and strengthening Zambia's policy, legal and institutional framework.

Zambia is grateful to the International Renewable Energy Agency (IRENA) for being selected as a participating country for the Renewable Readiness Assessment (RRA) Process. The actions identified in the RRA process will help us to strengthen our investment framework, create a renewable-friendly institutional and regulatory framework, support techno-economic assessments of renewable energy systems, and develop a biofuels framework, all of which will go a long way in assisting us with the implementation of the Draft Renewable Energy Strategy for Zambia.

Zambia fully supports the mandate of IRENA to promote the deployment of renewable energy worldwide. We also fully endorse the RRA process, which creates a solid foundation for enhancing the contribution of renewable energy to social and economic development, not only for Zambia but for the rest of Africa as well.

Hon. Christopher B. Yaluma, MP
Minister of Mines, Energy
and Water Development,
Zambia

FOREWORD

The Africa High-level Consultative Forum held by the International Renewable Energy Agency (IRENA) in July 2011 highlighted the need for technical support for African countries and regions to identify their renewable-energy readiness. The Renewables Readiness Assessment (RRA) process stemming from this involves a holistic evaluation of a country's conditions and identifies the actions needed to overcome barriers to renewable energy deployment. This is a country-led process, with IRENA primarily providing technical support and expertise to facilitate consultations among different national stakeholders.

Since 2011, more than 14 countries in Africa, the Middle East, Latin America and the Caribbean, Asia and the Pacific Islands have undertaken the RRA process, which generates knowledge of good practices and supports international cooperation to enable accelerated deployment of renewable technologies. Zambia, in keeping with its strong and consistent support of IRENA's mission, is one of those ground-breaking countries.

RRA consultations have highlighted the opportunity for Zambia to develop sustainable biofuels for export; the need for an integrated resource plan for power generation; and the capacities that must be built up to expand rural off-grid electricity services.

IRENA would like to thank Minister Yaluma and his team for their patience and generosity in hosting this study. Their engagement and input have gone beyond what we could have asked for, and we are grateful for their contribution, which has enriched our insights for further RRAs in other countries in the 2014-2015 period. Additionally, this report will feed into other IRENA regional work, including the Africa Clean Energy Corridor initiative, which aims to fill the power-generation gap and expand energy access along the length of the continent with high shares of renewable energy.

We sincerely hope that the RRA process will help Zambia to achieve its ambition to scale up renewable energy. IRENA stands ready to provide continuing support to Zambia in implementing the actions identified.

Adnan Z. Amin
Director-General, IRENA

CONTENTS

ACRONYMS

CEEEZ	Centre for Energy, Environment and Engineering Zambia
CEC	Copperbelt Energy Corporation
ERB	Energy Regulation Board
GDP	Gross domestic product
GWh	Gigawatt-hour
IPP	Independent power producer
IRENA	International Renewable Energy Agency
km	Kilometre
kV	Kilovolt
KWh	Kilowat-hour
LHPC	Lunsemfwa Hydro Power Company
MEWD	Ministry of Energy and Water Development
MMEWD	Ministry of Mines, Energy and Water Development
MW	Megawatt
NDP	National Development Plan
NGO	Non-governmental organisation
OPPPI	Office for Promoting Private Power Investments
PJ	Petajoules
PPA	Power Purchase Agreement
PV	Photovoltaic
REA	Rural Electrification Authority
REMP	Rural Electrification Master Plan
RGC	Rural Growth Centres
RRA	Renewables readiness assessment
SADC	Southern African Development Community
SAPP	Southern African Power Pool
UNIDO	United Nations Industrial Development Organization
ZESCO	Zambia Electricity Supply Corporation Limited
ZDA	Zambia Development Agency

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Zambia is a Southern Africa Development Community (SADC) member state with a population of nearly 14 million people, an average growth rate of 2.9% and a current urbanisation rate of 3.2%. The population is 36% rural, with about 67% of the rural population living in extreme poverty. The estimated gross domestic product (GDP) in 2011 was USD 22.6 billion, translating to a per capita GDP of USD 1,600. The energy sector as a whole dominated by biomass, making up over 80% of supply and 70% of demand. Electricity is predominantly supplied from large hydropower, which provides 99% of the country's electricity, with the remainder coming from mini-hydro and diesel plants.

The country has significant renewable energy resources, including hydro, biomass, solar, wind and geothermal energy that can be exploited for both on-grid and off-grid systems. However, the national public utility, the Zambia Electricity Supply Corporation (ZESCO), dominates the electricity supply industry (accounting for 94%), with two other operators providing a small share (6%) of generation and 86% and 14% of transmission capacity, respectively. For hydro power, the current installed capacity is about 1,900 megawatts (MW), while the potential exceeds 6,000 MW, of which 3,000 MW could be harvested through planned projects. Zambia is currently battling an electricity supply deficit and has low electrification rates, 45% in urban and 3% in rural areas, while aiming to reach 90% and 51% access by 2030 in urban and rural areas, respectively. Considering its flexibility and ease of deployment, renewable energy is well poised to contribute to meeting this challenge. For this reason, undertaking a thorough renewable-energy resource assessment is essential. Zambia's untapped potential in the sector, once known, can contribute to meeting future electricity demand, especially given that the costs of renewable energy are coming down.

Zambia agreed to be part of the Renewable Readiness Assessment (RRA) roll-out project supported by the International Renewable Energy Agency (IRENA) to enhance deployment of renewable energy in Africa and globally. The RRA consultations have given Zambia the chance to more carefully consider how to exploit its extensive renewable energy resources. This will require technical, policy, regulatory and capacity readiness with specific regard to developing renewables. The country,

in its energy policy to date, has put more emphasis on grid-connected hydropower rather than other renewable energy technologies, although key government instruments, including Vision 2030, the Poverty Reduction Strategy Paper (PRSP) and National Development Plans (NDPs) allude to the importance of harnessing other renewable energy resources to meet the country's growing energy needs.

In regard to the legislative and regulatory framework, Zambia has put in place an energy regulator and developed a domestic Electricity Act and Energy Regulation Act, which provide some regulatory oversight of the electricity sector. It has developed a draft Zambia Grid Code that includes necessary provisions for the integration of variable power (large- and small-scale) in the grid network. In 1999, the Office for Promoting Private Power Investment (OPPPI) was established as part of regulatory reforms to support the development of the power sector. The OPPPI was set up to be a 'one window operation' to reduce the complexity of procedures, rules, regulations and red tape usually associated with obtaining the required approvals, permits and licences for investors in the electricity sector. In addition, independent power producers (IPPs) have some experience generating and/or transmitting electricity to the national grid, and IPPs such as the Lunsemfwa Hydropower Corporation (LHPC) and the Copperbelt Energy Corporation (CEC), along with, in recent years, foreign private investors, have expressed interest in the power-generation sector, although mainly for large hydropower projects. More effort is required to open the electricity market to greater participation by IPPs in non-hydro renewable-energy power projects. The development of new power projects is hampered by the low tariffs prevailing in the country. In 2009, the country decided to migrate towards cost-reflective tariffs by adopting a multi-year tariff framework in order to meet future power demand needs as well as to ensure quality of service. In 2010, ZESCO's average electricity tariff was increased to USD 0.065 per kWh, up 25.6% from 2009. To take the tariff efforts a step further, mining-sector tariffs were increased by 30% in 2011, though this was not carried forward to other sectors. ZESCO proposed a four-year tariff increase plan and submitted this to the Energy Regulation Board (ERB) for approval, with the intention of reaching an average tariff of USD 0.13 per kWh in 2015. However, this plan is still under discussion and has not been formally approved.

As part of its demand side management plan, ZESCO plans on deploying 350,000 solar water heaters in order to save the 40% of domestic electricity demand that is attributed to the use of electric water heaters – estimated to account for some 150 MW. This would help reduce morning and evening peak use, which were estimated at around 1,480 MW and 1,630 MW, respectively, in 2011. The project is designed in a way that the end-user would not contribute any of the installation costs of the systems, and instead, the utility would bear all initial costs. However, the project has not moved beyond its pilot phase.

The current low access to electricity in Zambia is expected to improve, in part because of the Rural Electrification Master Plan (REMP), which is being executed by the dedicated Rural Energy Agency (REA) formed in 2003. The REMP aims to improve rural access to electricity by 15% in 2015 and 51% in 2030, but this may be hindered by the considerable financial resources required, as outlined in the plan itself. The REA is in charge of the Rural Electrification

School children in Zambia
Courtesy: REA

Fund (REF), where financial resources are to be provided for the development of rural electrification projects. The fund is mainly drawn from a 3% levy on every unit of electricity consumed, as well as grants and loans from development partners, and is aimed at encouraging private-sector participation by providing finances for project preparation studies and smart-capital subsidies. As part of its mandate, the REA has developed an operational manual that states it will providea capital subsidy of up to 100% for public-led rural electrification projects and can support privately-driven rural electrification projects with up to 50% of their capital costs, with the remaining funds to be secured by the developer.

A large programme for the promotion of biofuels was initiated following the adoption of the National Energy Policy (NEP), which provides for the use of biofuels as a source of modern energy through their integration in the transport industry. To that end, statutory instruments legalising biofuels, standards and a regulatory framework on biodiesel, and pricing methodologies were developed, and a zoning exercise was completed, with the support of the Government of Brazil. To carry on from this initiative, the Biofuels Association of Zambia, the Civil Society Biofuels Association, and district and provincial biofuels farmers associations have all been formed. In order to enhance the sector the government is expected to declare biofuels a priority sector, so that investors can benefit from the appropriate incentives.

KEY RECOMMENDATIONS

Integrated resource planning is becoming an important tool that allows key stakeholders to participate in the identification

Solar photovoltaic power plant
Courtesy: REA

and optimisation of the appropriate mix of energy resources to meet near- and long-term electricity needs in a sustainable way. It can also enhance a country's security of supply by including all economically-viable and environmentally-friendly energy resources.

It appears to be beneficial for Zambia to initiate a dialogue that would include all relevant stakeholders in the development of an integrated resource plan (IRP) for power generation that will help guide the country in diversifying its electricity mix while meeting future demand. A prerequisite to such an activity is the undertaking of a thorough renewable energy resource assessment. A renewable energy resource assessment can trigger a remarkable change in the perceptions of decision makers, as well as in their knowledge base and awareness of the country's renewable potential and opportunities, thereby allowing them to make more informed decisions. Furthermore, a renewable energy resource assessment represents a fairly small investment that can attract significant interest from the private sector, eventually resulting in energy cost reductions.

Renewable energy targets that are set based on such a resource assessment would provide a realistic and achievable goal, consistent with the country's ambitions of adding other renewable energy types to the electricity mix.

Such moves would also provide a clear policy signal to attract private-sector investment in renewable energy, especially if the target included a mandatory clause for power generators and those who off-take power in bulk. Establishing a renewable energy target would be an ideal next step for Zambia after its renewable energy resource assessment and should be supported by a strong implementation and monitoring framework aimed at achieving specified target levels.

Grid integration of non-hydro renewable energy-based power requires a thorough assessment of grid capability, including for variable power, which entails the enhancement of the grid system through operational decision-making tools, long-term grid-planning studies, meeting the requirements for renewable power generators, and priority access to the grid for electric-

ity generated from renewable energy. The revision of the draft Zambia Grid Code to include these elements is essential before its formal adoption if the country is resolved to achieve large-scale deployment of non-hydro renewable energy-based power.

A programmatic approach for utility-scale renewable energy power projects should be developed with the requisite financial incentives. It should be backed by a standardised bankable PPA in order to attract scalable investment, limit elaborate and tedious negotiations and allow potential investors to form clear expectations about their investments.

Zambia aims to increase its rural population's access to electricity through a wide range of solutions in which renewable energy plays a critical role. Two of the solutions considered by all stakeholders in the sector include the dissemination of solar PV systems and the setting up of decentralised renewable energy mini-grids. However, much more needs to be done to scale up the deployment of these technologies. The relatively small size of the off-grid market and low income of end-users do not make it substantially attractive to foreign investors, which is why the sector has mainly involved local private operators with the support of donors and development partners. Local private operators face technical and financial constraints, including lack of technical expertise to develop bankable proposals, insufficient working capital due to difficult access to loans, high interest rates due to high risk perception, and lack of expertise from local financial institutions in appraising off-grid renewable energy proposals. Therefore, the capacity of local private operators and financial institutions alike must be built up, so that they can develop and appraise bankable renewable energy project proposals.

The country's objective of increasing rural access to electricity would be well served by creating a level playing field for local private sector involvement. On the one hand, the support provided by the OPPPI to power project developers (greater than 10 MW), which includes acquisition of water rights, licenses, permits facilitation and technical support in Environmental Impact Assessments (EIAs), should be extended to small-scale decentralised renewable energy mini-grids (less than 10 MW). On the other hand, the rural electrification approach should cater to commercially-oriented sustainable-electricity service delivery, by providing performance and matching grants as well as technical assistance to private sector-led project proposals.

Affordability of electricity is a key issue in rural Zambia. This could be mitigated by providing options to facilitate end-user access to electricity service, including targeted subsidies and deferred payments schemes that could be pre-financed, either directly by service providers or through a micro-finance institution. A sound business model should be developed for both stand-alone systems and mini-grids in order to increase the viability and sustainability of decentralised renewable energy projects and improve access to electricity services in rural Zambia.

As ZESCO has clearly expressed a willingness to deploy solar water heaters (SWHs), a programme could be developed involving all relevant stakeholders, including the Ministry of Mines, Energy and Water Development, Zambia Business Survey, Zambia Development Agency and energy service companies. Such a programme would include capacity building for all stakeholders – namely policy makers, financial institutions, suppliers, installers

and others. These efforts would lead to the development and enactment of supportive policies and measures, including setting up mandatory quotas for different categories of end-users, the inclusion of SWHs in building codes, and financial and fiscal incentives. The programme would also bring about an effective communication strategy, including an awareness-raising campaign aimed at customers and financial institutions, and strong quality control comprising the setting up of SWH standards and a certification scheme for installers to ensure proper operation and maintenance.

The local market for biofuels is still to be established, and entering international markets has proven difficult. A review of Zambia's biofuel strategy and the development of sustainability criteria for biofuel production could help open the international market.

Research and development in the biofuels sector is paramount in order to ensure sound development of thebiofuel value chain. Funding should be made available for local research institutions, to conduct further assessments of economically feasible energy crops, to experiment with cost-effective ways to improve oil-yield ratios, and to disseminate lessons and best practises to out-growing contract farmers and large-scale plantation owners.

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I. INTRODUCTION

COUNTRY BACKGROUND

Zambia is located at the heart of the Southern African Development Community (SADC) and shares its borders with seven other countries, namely Angola, the Democratic Republic of Congo (DRC), Malawi, Mozambique, Zimbabwe, Botswana and Namibia. It spans an area of 752,681 square kilometre (km^2) and reaches an altitude of 2,300 metres (m) above sea level on the high plateau. Zambia is subdivided into ten provinces, with a total population of 13.8 million. The average population growth rate is 3.06% and the urbanisation rate projected for the years 2010-2015 is 3.2%.

Zambia has experienced strong economic growth in the past decade, averaging 6% gross domestic product (GDP) growth per annum, and is expected to reach 7.5% growth in 2013. The main contributor of GDP is the service sector, which accounts for 70%, followed by the agriculture sector with 20% and the mining and manufacturing sector with 10% (African Economic Outlook (AEO), 2013). More specifically, the strong growth can be attributed to a combination of improved macro-economic management, economic liberalisation and privatisation and a resource boom. Although the country's economic and governance landscape is improving, challenges remain. In the 2014 *Doing Business* report, the country ranked 83rd out of 185 countries, representing a seven-place improvement from the previous year (World Bank, 2013).

Despite strong economic growth, there has been slow progress in improving human development and social conditions. Indeed, the 2011 *Human Development Report* (UNDP, 2013) ranked Zambia 163 out of 187 listed countries with a Human Development Index (HDI) score of 0.45, against 0.48 for the Sub-Saharan Africa average, and with the exception of education, Zambia was expected to miss most Millennium Development Goals. In addition, inequalities in incomes, assets and social services are on the rise, along with unemployment (worsening from 22% in 2005 to 28% in 2010). This is due to the fact that 95% of employed labour is estimated to be in the category of temporary or vulnerable worker or is involved in the informal sector (AEO, 2013). This is further exacerbated by a labour force with low skill level that is concentrated around sectors such as mining, construction and services. In order to address some of these challenges, the government increased the budget share of its social protection programme to 2.8% in 2013 with the objective of pursuing various social safety net programmes such as public welfare assistance and social cash transfers.

ENERGY FOR DEVELOPMENT

The Government of Zambia highlights energy as being a driving force for the socio-economic development of the nation. This is evidenced through its Zambia Vision 2030, which represents the first long-term plan of the country's aspiration to become a prosperous middle-income nation. More specifically, the vision aims to provide "universal access to clean, reliable and affordable energy at the lowest total economic, financial, social and environmental cost, consistent with national development goals, by 2030". Consequently, the government has been undertaking a number of actions to improve access to reliable and affordable energy services, by developing five-year National Development Plans (NDPs) with a clear role for energy. The 6th NDP (2011 to 2015) focuses on securing reliable and affordable electricity supplies to spur the expansion of the country's growth sectors, namely mining, agriculture, tourism and manufacturing (Ministry of Finance and National Planning (MOFNP), 2011). With the national electrification rate standing at 22% (45% urban and 3% rural), a specific focus has been placed on enhancing national access to electricity to at least 40% nationally by 2015 (with 15% access rate for rural communities).

Mining is one of the most important sectors of the Zambian economy, contributing about 9% directly to GDP in 2010 (USD 590 million), with possible indirect contribution to the economy being as much as 50%. The direct contribution may reach USD 1.35 billion by 2015 (Zambia Extractive Industry Transparency Initiative, 2010). Moreover the sector is the major contributor of foreign exchange earnings, accounting for an estimated 70% of total earnings in 2010. Copper exports alone accounted for 78% of the Zambia's total exports in 2010 (Ibid), with a value of USD 5.8 billion. The sector is currently the major energy consumer and will need to be adequately supplied to maintain the key role it plays in the national economy.

Given Zambia's vast natural resources in terms of land, water and fertile soil, and with over 80% of the population relying on agriculture-related activities for their subsistence, transforming the agriculture sector is paramount to achieving the Vision 2030. However, the sector faces many challenges that result in low agriculture productivity, including the use of traditional agricultural practises and the lack of infrastructure and machinery to conserve and transform harvest into higher value agro-industrial products. Energy can play an important role in moving from subsistence-led agriculture to an agro-industry and export-oriented sector while ensuring greater food security.

Finally, traditional biomass is the country's main source of energy, accounting for more than 70% of energy consumption with 57% of urban populations using traditional biomass and 97% in rural areas (Central Statistical Office, 2012). Firewood is mostly used for cooking in rural areas while the main fuel used in urban areas is charcoal. The charcoal industry is thought to employ about 500,000 individuals in the country along its supply chain, including producers, distributers and marketers (Mwitwa and Makano, 2012).

THE RENEWABLES READINESS ASSESSMENT (RRA) PROCESS IN ZAMBIA

The Renewable Readiness Assessment (RRA) endeavour for Zambia was heavily reliant on a senior official of the Department of Energy (DoE) of the Ministry of Mines Energy and Water Development (MMEWD). As a first step, the Department of Energy official and the national consul-

Roof-mounted solar photovoltaic: rural electrification.
Courtesy: REA

tant were both made familiar with the RRA methodology. Next, national experts were identified from key institutions (including policy-making, regulatory and promotion agencies, non-governemntal organisations (NGOs), financial institutions, private sector and academia/research) to participate in the process. An initial consultation with the identified stakeholders led to the identification of three main areas of focus for the RRA in Zambia that are: on-grid electricity, off-grid electricity and biofuels. The stakeholders were divided into subgroups according to the three areas aforementioned and met to select and discuss the relevant service resource pairs for the country, capturing current status, issues/problems, capacity needs and proposed concrete actions.

The RRA Workshop was organised on 10-11 December 2012 and saw participation from the National Expert Team, the International Renewable Energy Agency (IRENA) and SADC, where they reviewed the templates, provided further inputs and built a consensus on the recommended actions. Bilateral meetings were also scheduled for IRENA and the SADC with high level stakeholders from the government, utility, private sector and financial institutions to balance and complement the process. Based on the outcomes of the RRA workshop and the findings from the bilateral meetings, the RRA report was drafted and submitted for peer-review.

This document presents the Zambia RRA Country Report. The report is structured into five substantive sections.

Section 1 presents the introduction, covering country background, the IRENA RRA methodology and process, and the RRA process in Zambia.

Section 2 presents both the energy and renewable energy context in the region, an overview of the energy sector in Zambia, challenges facing the energy sector, and an overview of renewable energy potential and use.

This section also provides a detailed discussion of the electricity sector. Section 3 explores Zambia's energy sector institutions, the policy and regulatory framework as well as the conditions for financing and investment in the country. Section 4 presents the emergent issues with respect to solar/wind electricity (on-grid), a range of decentralised (off-grid) applications, and the biomass sector. Opportunities and constraints that affect the scaling up of the deployment of these technologies will be discussed along with the findings from the RRA process. Section 5 presents the recommended actions necessary for scaling up renewable energy systems in Zambia. Finally, the detailed account of the recommended actions from the RRA can be found in the Annex.

Victoria Falls on the Zimbabwe-Zambia border
Courtesy: REA

II. ENERGY CONTEXT

REGIONAL CONTEXT

Zambia is a member state of the SADC that was formed in 1992 and is currently comprised of 15 countries[1]. The SADC population is about 280 million and its combined GDP in 2010 of USD 575.5 billion was growing at 5.14%. In 2008, the SADC primary energy supply was estimated around 9,552 petajoules (PJ) (International Energy Agency, 2011). Coal dominated the primary energy mix with a large share of 44%, followed by renewable energy (39%), oil (14%), gas (2%), and nuclear (1%). The 39% share for renewable energy is distributed among traditional biomass (36.66%), primarily used for cooking and heating, hydro (1.95%), and modern biomass (0.39%). Other renewable energy sources such as solar, geothermal, wind and biofuels were negligible (*Ibid*).

The SADC has drawn up many energy access goals. The strategic goal of energy access to adequate and reliable energy services for the entire SADC region was identified as playing a pivotal role in achieving a regional growth rate of 7% and reducing poverty on a sustainable basis. As a step toward this objective, the SADC established an operational goal to reduce the number of SADC inhabitants who do not have access to energy services by 50% by 2020, and halve the number of those remaining without access every five years until the strategic goal of full access is achieved. The 10-year goal to halve the number of people without energy access is indicative of the political will in the region to address energy access. Efforts to increase access to energy focus on the expansion of distribution networks, often implemented by the national utilities, and the use of small-scale distributed generation, often implemented through Rural Electrification Agencies (REAs) or funds.

Furthermore, the SADC is putting in place a Regional Renewable Energy and Energy Efficiency Agency (SACREEE) in response to the requirement identified by the SADC member countries' ministries of energy and other regional stakeholders during a consultation process. Upon its establishment, the SACREEE will concentrate on creating the enabling environment for the uptake of renewable energy and energy efficiency through energy planning and policies; business models and technical innovation;

1 SADC continental member countries are: Angola, Botswana, the DRC, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. The island member countries are; Madagascar, Mauritius and Seychelles.

finance and risk management; capacity building and knowledge management

In 1995, 12 continental SADC member countries signed an inter-governmental memorandum of understanding (MoU) that led to the creation of the Southern African Power Pool (SAPP) with the aim of creating a common market for electricity that would provide reliable and economical electricity to the consumers in each SAPP member country, optimise the use of available energy resources in the region, and support inter-country co-operation during emergencies. This initiative has been furthered by the 1996 signing of the Regional Energy Protocol, which recognises the need for a co-ordinated approach to energy strategy formulation and planning for the SADC.

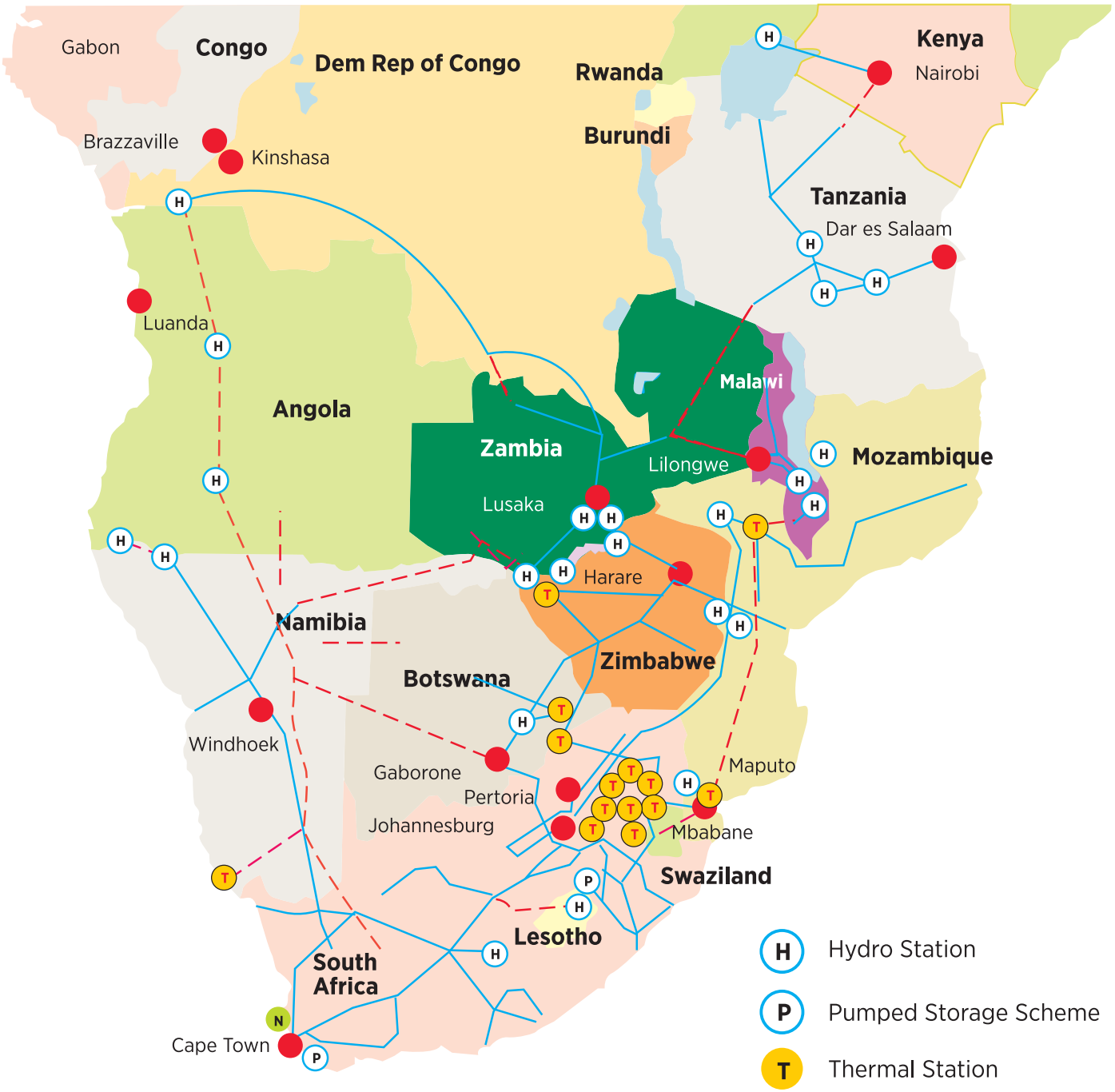
The SAPP electricity mix is dominated by coal with 74% of the total, followed by hydro 20% (largely from the Congo and Zambezi basins), nuclear 4% and diesel 2% (SADC, 2012). As of 2012, SAPP's total installed capacity was 57,182 Megawatts (MW) with an available capacity of 51,702 MW, against a peak demand of 53,833 MW (SAPP, 2013). The region is facing a critical power shortage due to escalating demand growth and capacity addition projects that are lagging behind targeted schedules. In 2009 the first SAPP master plan was commissioned based on member countries' national plans and envisaged an additional total capacity of 56 GW by 2025 composed of 23,883 MW of coal, 18,045 MW of hydro, 14,758 MW of gas and no non-hydro renewable energy. However, as countries are aspiring to a cleaner electricity mix, this has been reflected in their national plans and in the 2012 SAPP plans, with additional capacity of 55.5 GW comprising of 9,650 MW of coal, 14,646 MW of hydro, 9,600 MW of nuclear, 7,600 MW of gas and 14,000 MW of non-hydro renewable energy (wind and solar).

Electricity generation, transmission and distribution in the SAPP are mainly provided by publicly-owned, vertically integrated national utilities. Independent Power Producers (IPPs) and independent transmission companies (ITCs) have now been introduced by different SADC countries, albeit with varying degrees of success. Policies in most countries reflect an aspiration for greater private sector involvement in power generation, but efforts are hampered by risk perceptions from investors due to unfavourable legal and regulatory frameworks for private sector participation (namely, concerns over competition between public and private generation assets), and difficulties in developing well-structured bankable projects (Development Bank of Southern Africa, 2010).

The interconnected grid is operated through three control areas run by Eskom (for Botswana, Lesotho, Southern Mozambique, Namibia, Swaziland and South Africa), Zimbabwe Electricity Supply Authority (for Zimbabwe and Northern Mozambique) and ZESCO (for the DRC and Zambia). The three utilities, or the system operators, are responsible for balancing electricity supply and demand and power flows within their control areas. Besides being one of the control area operators, Zambia plays a critical role in the SAPP, both as a supplier of hydropower from the Zambezi River Basin, but also an interconnector to the Congo River Basin. Lunsemfwa Hydro Power Company and Copperbelt Energy Corporation are two successful IPPs in Zambia, with the later also being an ITC. Most of the SAPP power exchanges take place within the Eastern and Central area shown in more detail in Figure 1.

The Zambian power grid is interconnected to the DRC in the north and Zimbabwe in the south. On-going projects seek to inter-

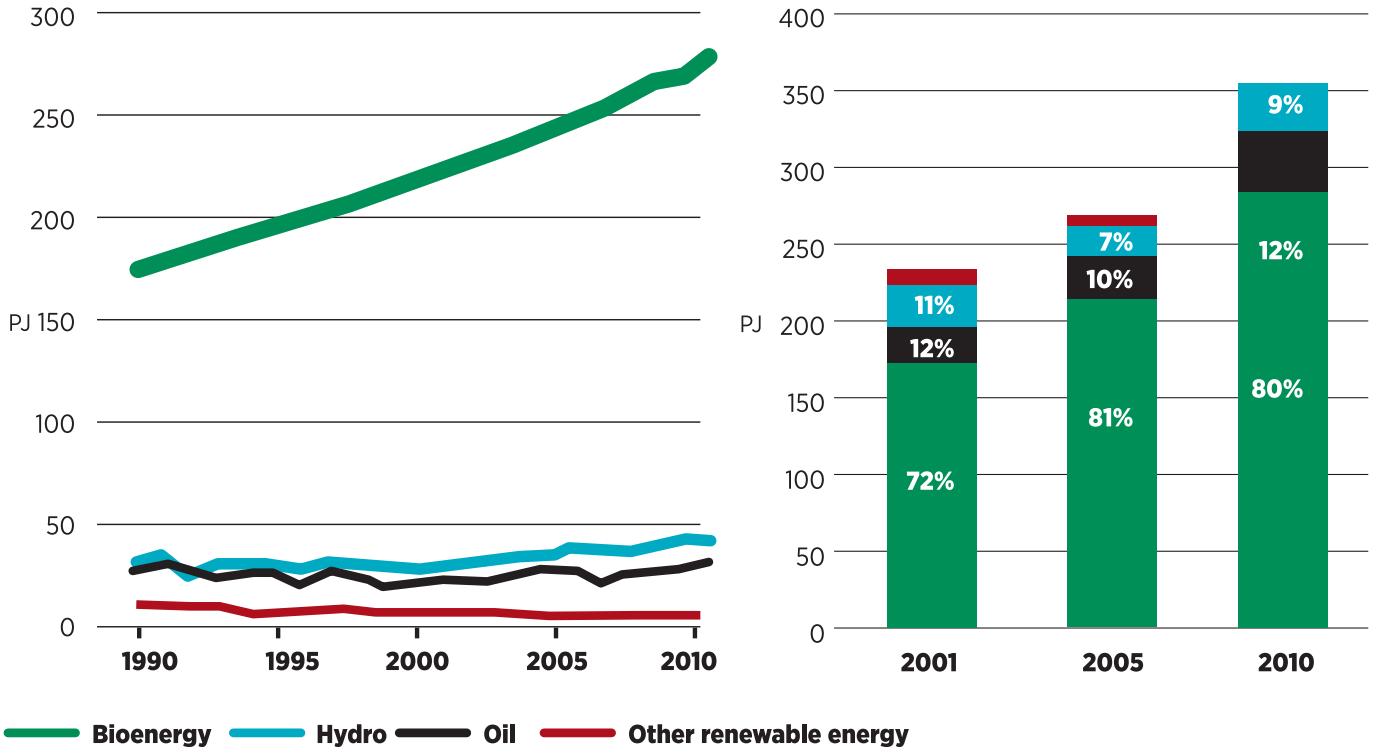
Figure 1
The Southern African Power Pool



Based on: SAPP (www.sapp.co.zw)

The term "country" as used in this material also refers, as appropriate, to territories or areas.

Figure 2
Total Primary Energy Supply by Fuel

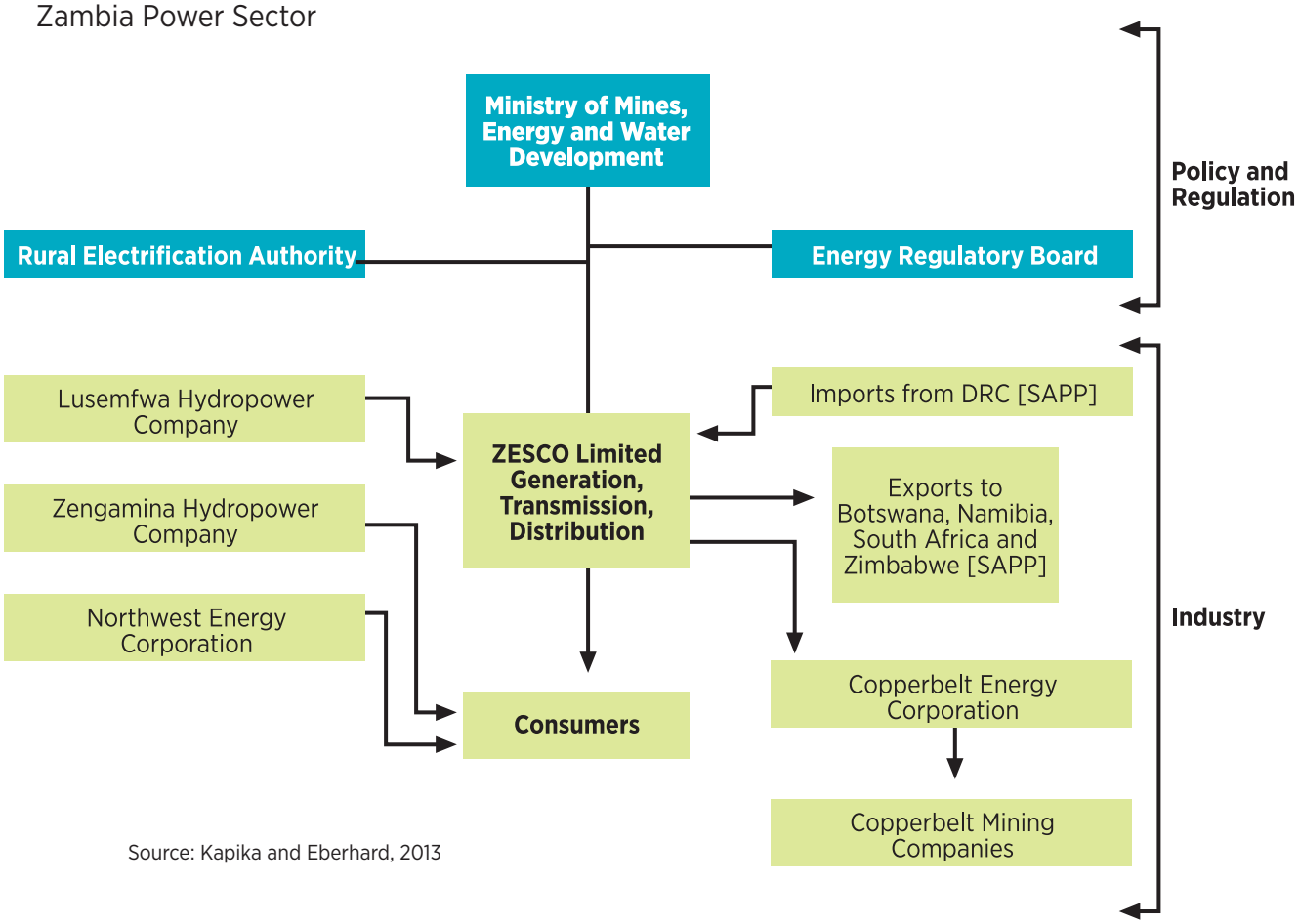


connect the country to Tanzania in the northeast, Malawi in the east and Namibia in the west through the Zimbabwe-Zambia-Botswana-Namibia interconnector. Zambia is also a participant in the SAPP Day Ahead Market (previously known as the Short Term Energy Market).

ENERGY SUPPLY AND DEMAND IN ZAMBIA

The total primary energy supply of Zambia is composed of four main sources: biomass, hydro, oil and coal (Figure 2). Biomass (firewood and charcoal) is very important, accounting for 80% of the country's energy needs by providing 284 PJ mainly for household cooking and heating purposes. In 2011, hydropower met 12% of the energy needs, providing 41 PJ mainly for electricity. Oil products accounted for 9% of the energy needs, used mostly for transport and electricity generation. As Zambia currently does not produce any crude oil, the country relies entirely on imports through a 1,500 km pipeline from Tanzania to a local refinery (with a capacity of 1 million tonnes) where it is refined into petrol, kerosene, diesel, aviation gas, and heavy fuel oil. Oil imports cost the country about USD 0.5 billion per annum (2.3% of GDP in 2011). Although there are proven recoverable reserves of coal estimated at around 30 million tonnes, and with copper mines utilising about 2,000 tonnes of coal annually, the contribution of coal in the current energy mix remains insignificant. However the country does plan on expanding its generation capacity by an additional 600 MW of coal by the end of 2014.

Figure 3
Zambia Power Sector



Source: Kapika and Eberhard, 2013

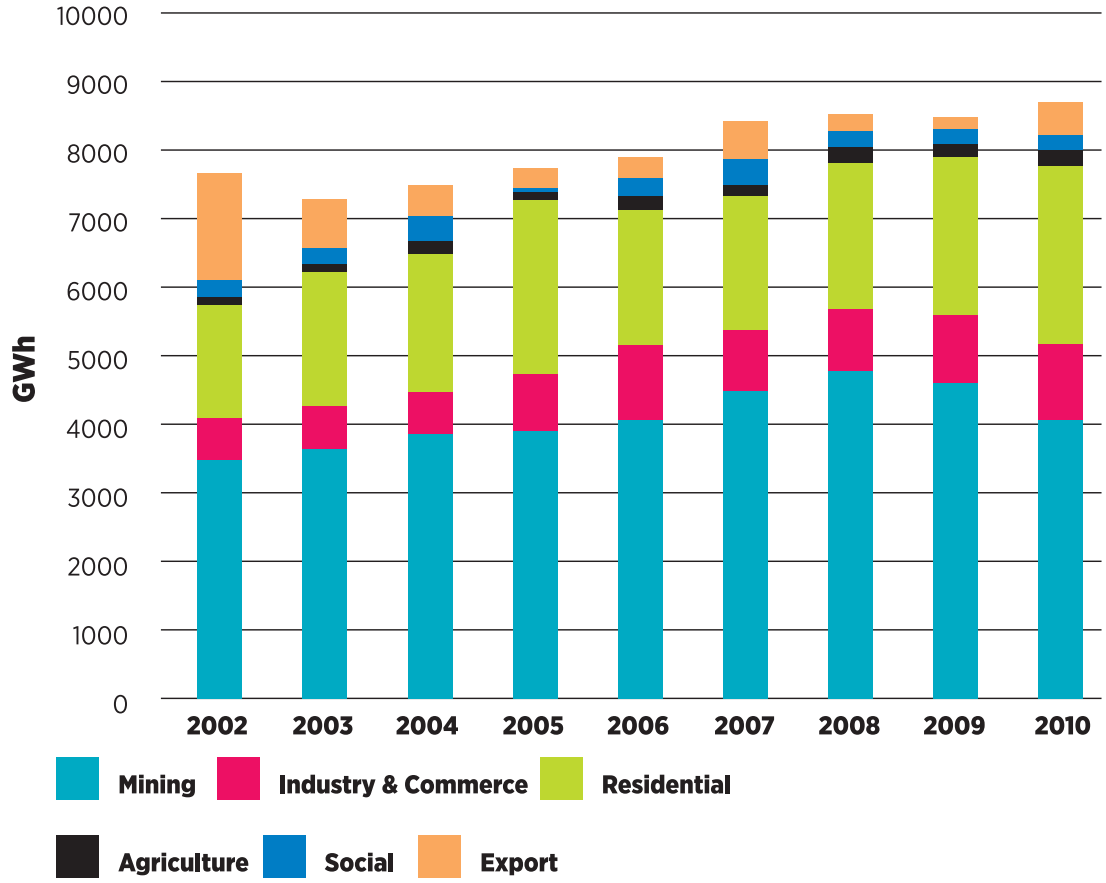
ELECTRICITY SYSTEM

The Zambia electricity sector is composed of a state-owned, vertically-integrated utility named ZESCO, a private company that generates power to the grid and manages off-grid small hydro systems called the Lunsemfwa Hydro Power Company (LHPC), and the Copperbelt Energy Company[2] (CEC); the latter provides electricity to the bulk of the mining sector from power purchased from ZESCO, and through its own gas-fired power plants. Finally the Zengamina Hydro Power Company (ZHPC) and the North West Energy Corporation (NWEC) distribute electricity to rural mining communities from off-grid mini hydro plants and the national grid, respectively (Figure 3). ZESCO, the CEC and the LHPC are currently the major power generators with shares of 94%, 4% and 2%, respectively. With regard to transmission activities, the respective shares are 69%, 29%, and 2%.

Electricity demand grew by an average rate of 3.5% between 2002 and 2010 with about 45% consumed by the mining industry, 30% by the residential sector, 15% by the commerce and industry sectors and

2 Since 2012, the CEC has been an independent power transmitter as part of the SAPP.

Figure 4
Historical Electricity Consumption of Zambia by Sector



Source: ZESCO, 2013a

the rest consumed by export, social and agricultural services (Figure 4).

Demand for electricity is projected to grow, with mining expected to consume 49%, industry/commerce 20%, residential 15%, agriculture 10%, social 5% and exports 2% of electricity produced according to the 2018 demand forecast. The current total installed capacity of 1,976 MW is only providing about 1,650 MW of power while peak demand is estimated at 1,800 MW and growing at 100 MW per year. Based on this it can be seen that electricity demand has clearly outstripped generation, with a power deficit during peak time of 250 MW, thus resulting in some challenges in the form of interruption in power supply (ZESCO, 2013b). This is corroborated by the load shedding timetable that ZESCO makes available for its customers. To address these issues Zambia has therefore developed the Zambia Power Rehabilitation Project (PRP), which is expected to fill in the electricity supply demand gap and include rehabilitation of existing power stations, upgrade transmission and distribution lines, as well as demand side management measures with a budget of more than USD 320 million supported by the World Bank, European Investment Bank (EIB) and ZESCO. Regarding demand side management, ZESCO plans on deploying energy efficient light bulbs, prepaid metres and solar water heaters to shave off-peak loads.

GENERATION CAPACITY

The PRP has allowed ZESCO to increase its installed capacity by an additional 210 MW by upgrading the Kafue Gorge Hydro Dam to 990 MW from 900 MW, the Kariba North Bank Dam to 720 MW from 600 MW and bringing the Victoria Falls Power Station to its full generating capacity of 108 MW. Additionally, a number of generation projects are to be developed in the short term (both hydro and coal) including the Kariba North Bank, Maamba Coal-Fired Thermal Power Station, Lunzua Mini-Hydro Power Plant, Itezhi-Tezhi Dam, EMCO Coal-Fired Thermal Power Station, Kabompo, Kalungwishi Hydroelectric Project and Kafue Gorge Lower (Table 1). If this project pipeline is commissioned as expected, the country's energy generation mix will shift from 99% hydro-based to just over 60% hydro-based by 2017.

In the medium- to long-term, the country intends to further tap into its hydropower potential, estimated at about 6,000 MW, to develop an additional 2,800 MW of new generation.

Rural areas that are not connected to the national grid are supplied by diesel power stations (with a total capacity of 7 MW) and decentralised micro hydro power stations (with a total capacity of less than 1 MW) (MEWD, 2009).

Qualitative resource potential for off-grid is reasonably known but there is a need for a comprehensive study to quantify these potentials.

GRID INFRASTRUCTURE

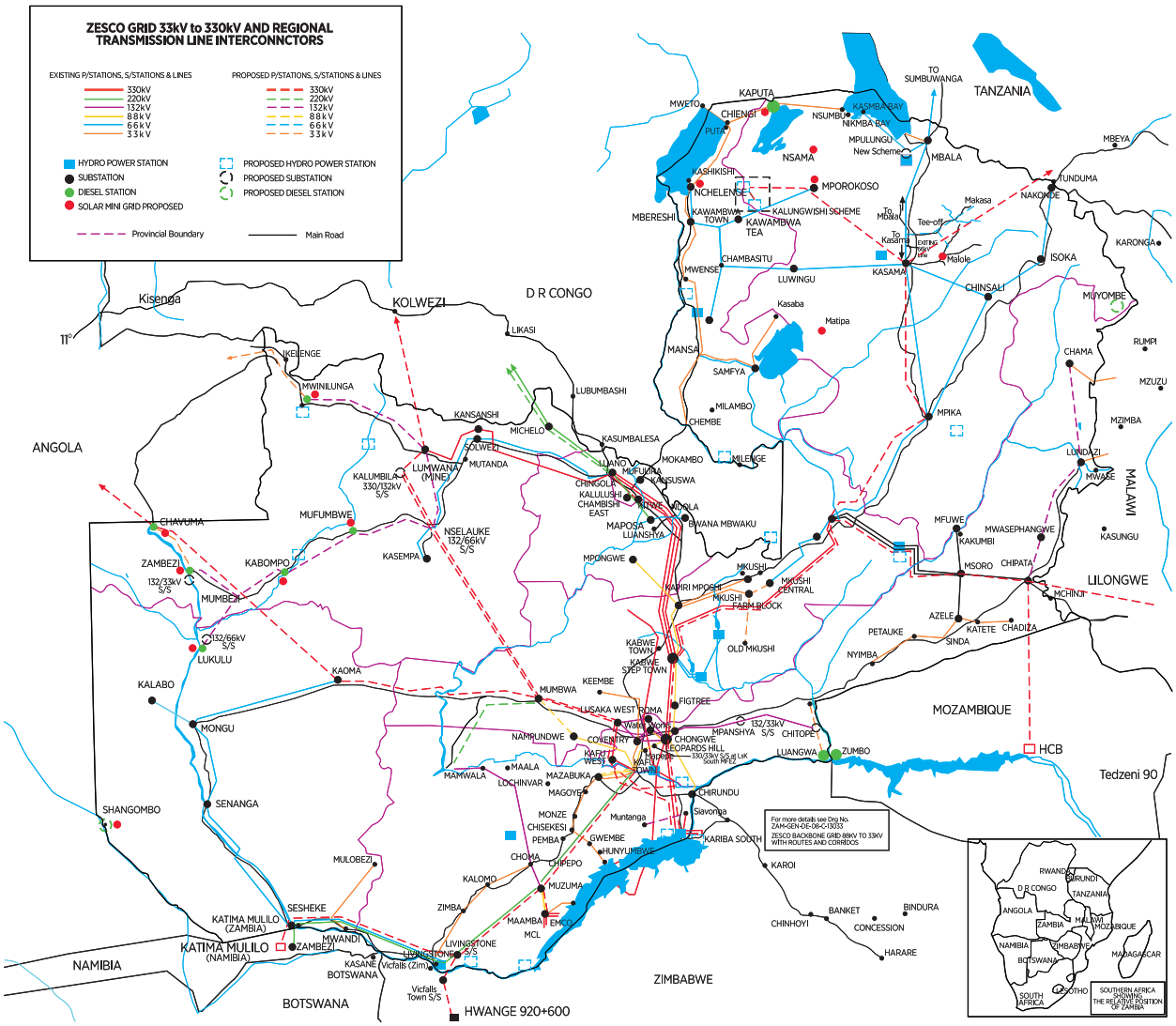
The Zambia National Grid is composed of the main 330 kilovolts (kV) trunk line that spans a total of 2,241 km across the country, from the south where the main hydropower generation stations are located (Kariba North and Kafue dams), to the north in the Copperbelt area where the main load centres are located due to mining activities. The rest of the transmission network is composed of 348 km of 220 kV lines serving as interconnectors with the neighbouring DRC, Namibia and Zimbabwe, 202 km of 132 kV lines and 754 km of 88 kV mainly in the Lusaka area, and 3,033 km of load

Table 1
Zambia Plans for Increased Generation Capacity

Project	Capacity (MW)	Implementers	ECD
Kariba North Bank	360	ZESCO	2013
Maamba Coal-Fired TPS*	300	NAVA BHARAT	2013
Lunzua Mini HPP**	15	ZESCO	2014
Itezhi-Tezhi Dam	120	ZESCO/TATA	2014
EMCO Coal-Fired TPS^	300	EMCO Energy Zambia	2014
Lusiwasi	86	ZESCO	2015
Kapombo	40	CEC	2015
Kalungwishi HP^^	163	Lunzua Power Authority	2015
Kafue Gorge Lower	750	ZESCO/SINOHYDRO/CAD Fund	2017

*Maamba Coal-Fired Thermal PowerStation **Lunzua Mini-Hydro Power Plant
^EMCO Coal-Fired Thermal Power Station ^^Kalungwishi Hydroelectric Project
ECD: Estimated Commencement Date
Based on: ZESCO, ERB, CEC

Figure 5
Zambia National Grid Network and Regional Interconnectors



Based on: ZESCO (2013b) Map, pg 12

transmission lines, and 66 kV in the north-eastern and western part of the country (Figure 5).

As part of the PRP, ZESCO plans on upgrading existing transmission infrastructures and developing new ones to evacuate additional power from rehabilitated and new power plants (Table 2). In addition to these projects, the country has planned on further expanding the national grid to the north-western province to new mining areas and developing new interconnectors with neighbouring countries to increase power trade.

The country had identified grid extension as being the main strategy to expand access to rural areas as highlighted in the 2009 Rural Electrification Master Plan (REMP). The REMP was developed with the following principles:

- Develop a logical, objective, numerical/quantitative, and convincing master plan.

Table 2
Zambia Transmission Infrastructure Projects under Implementation

Project	Capacity (MVA / kV)	ECD
KNBE- Kafue West	700 / 330	2013
Kalungwishi – Kasama	700 / 330	2013
Maamba – Muzuma	1400 / 330	2013
Kafue Gorge Lower – Lusaka South–Lusaka West (330kV)	1400 / 330	2013
Kafue West – Muzuma – Livingstone	700 / 330	2014
Itezhi-Tezhi – Mumbwa – Lusaka West	200/ 220 & 330	2015
Pensulo – Kasama	700 / 330	2016
Pensulo – Chipata	700 / 330	2016

ECD: Estimated Commencement Date

- Adopt a decentralised planning process[3] for selecting Rural Growth Centres (RGCs) and demand/ supply criteria[4] for their clustering into packages (180).

- Provide realistic a financial plan to be implemented.

The REMP identified that 80% of the country's RGCs will be electrified through grid extension. However in order to achieve the goals set in the REMP an annual amount of USD 50 million is required. Mobilising this amount has been so far a challenge, leading to slow progress in reaching annual targets of the REMP.

Finally, the country's distribution network consists of the main distribution network fed from the national grid and isolated networks served through stand-alone diesel generators and small hydro power plants. The total system losses in the Zambia grid network were estimated at 13.1%, with transmission losses averaging 4.6% and distribution losses averaging 13.8% in 2011 (ZESCO, 2011).

COSTS AND TARIFFS

Current production cost for large hydro plants, based on the available sizes feeding into the national grid, range between USD 0.02 to USD 0.03 per kilowatt-hour (kWh), while the production cost for small and mini-hydro plant range between USD 0.50 to USD 1 per kWh, and finally USD 0.35 per Wh for isolated diesel power plants (Electricity Regulation Board (ERB), 2008).

Prior to 2008, Zambia enjoyed the lowest electricity tariff in Southern Africa, with an average tariff of USD 0.027 per kWh, which given the generation costs, are clearly not cost reflective. This may have hampered new investment in the power sector and could partly explain why the last power

3 RGCs have been selected as electrification candidates based on information submitted by district planners who attended workshops held in all the nine provincial centres.

4 For the demand side potential, daily peak demands for the 1,217 un-electrified RGCs were forecasted by using the demographic data of these 1,217 RGCs and analysing the data collected from 19 electrified RGCs in the Socio-Economic Survey.

For supply side, the Unit Lifetime Cost (USD/kWh) of each electrification mode (grid extension, solar home systems, mini-hydro and diesel generator) was estimated, and electrification mode having the least Unit Lifetime Cost was selected as the optimal case.

Table 3
ZESCO's Proposed Tariff Path for 2012-2015

KNBE Avg. Price USD/KWh[5]	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016
Residential	0.07	0.07	0.09	0.12	0.16	0.18
% Change			32%	39%	34%	11%
Large Power	0.05	0.05	0.05	0.06	0.08	0.09
%Change			11%	22%	23%	11%
Small Power	0.05	0.04	0.06	0.07	0.09	0.11
% Change			24%	19%	40%	15%
Commercial	0.07	0.07	0.08	0.10	0.13	0.14
% Change			24%	21%	29%	12%
Services	0.05	0.05	0.06	0.08	0.10	0.12
% Change			18%	29%	37%	14%
Weighted Average[6]		0.05	0.07	0.09	0.12	0.13
% Change			26%	31%	34%	13%

generation project was commissioned more than 40 years ago. In 2009, the country decided to migrate towards cost-reflective tariffs by adopting a multi-year tariff framework in order to meet future power demand needs as well ensure quality of service. Therefore in 2010, ZESCO's average electricity tariff was increased to USD 0.065 per kWh (up 25.6% from 2009). In 2011, a further step was made to increase the tariffs of the mining sector by 30%, with no incidence on other sectors. ZESCO proposed a four year tariff increase plan and submitted it to the ERB for approval with the intention of reaching an average tariff of USD 0.13 per kWh in 2015 (Table 3).

The rationale behind this tariff application is underlined by the prevailing economic conditions, the changes in generation, transmission and distribution costs, the expansion of the system and thereby the customer base and the rising cost of electricity imports.

RENEWABLE ENERGY POTENTIAL

Zambia is well endowed with renewable energy resources, mainly hydropower in nature. These sources have great potential for electricity production and use in many sectors, but data on renewable energy resources is not readily available as shown in Table 4.

SMALL HYDRO

Zambia's hydro power potential is estimated at more than 6,000 MW with only 1,700 MW so far exploited. The Rural Energy Agency (REA) identified 29 small/mini hydro sites mainly in Northern and Luapula, (4 MW) and North-Western Province (13 MW). A number of feasibility studies have been undertaken in selected minihydro potential sites and the planned small hydro capacity (<30 MW) till 2019 is about 45 MW. For off-grid application, there are plans by the private sector to develop additional off-grid hydro power projects

5 Tariffs were changed in USD/kWh using exchange rate of 1 USD = 5 195 Zambian Kwacha.

6 Weighted Average Tariffs do not include mining and exports tariffs.

Table 4
Availability and Utilisation of Renewable Sources in Zambia

RENEWABLE ENERGY	OPPORTUNITIES/ USE	RESOURCE AVAILABILITY	POTENTIAL ENERGY OUTPUT
Solar	Thermal (water heating), electricity (water pumping, lighting, refrigeration)	6-8 sunshine hours	5.5 kWh/m^2/day (modest potential especially for limited irrigation)
Wind	Electricity, mechanical (water pumping)	Average 3 m/s at 10 m height	Modest potential, especially for irrigation
Mini-hydro	Small grids for electricity supply	Reasonably extensive	Requires elaboration and quantification
Biomass (combustion and gasification)	Electricity generation	Agro wastes, forest wastes, sawmill wastes	Requires elaboration and quantification
Biomass (biodigestion)	Electricity generation, heating and cooking	Animal waste, agro- and industrial waste, wastewater	Potential requires elaboration
Biomass (biofuels)	Ethanol and biodiesel for transport and stationary engines	Sugarcane, sweet sorghum, jatropha	150 km^2 of agricultural land to meet current demand
Biomass (household energy)	Improved charcoal production, improved cook stoves	Sawmill waste and indigenous trees from sustainable forest management.	Reasonably extensive
Geothermal	Electricity generation	Hot springs	Requires elaboration and quantification

Source: MEWD, 2008

to include Chavuma (15 MW), West Lunga (3 MW), and Chitokoloki Mission (0.15 MW) (MEWD, 2009). Furthermore, the REA is undertaking a feasibility study and detailed engineering design for a 3.5 MW off-grid hydropower generation plant at Chikata Falls and a 500 KW power generation plant at Kasanjiku Falls in Kabompo and Mwinilunga districts, respectively, in North-Western Province.

BIOMASS

Zambia has a total biomass resource and economic bioenergy potential of 2.15 million tonnes, and 498 MW, respectively (MEWD, 2008). The largest contribution is from agriculture waste, which registered 90% of total potential followed by forest waste with 9.3%.

ZESCO, in conjunction with United Nations Industrial Development Organisation (UNIDO), had planned to install a 1 MW biomass electricity generation plant to meet the electricity needs of Kaputa District. This facility was meant to replace 440 KW installed capacity of a diesel power generation system. ZESCO has since extended the national grid to Kaputa, resulting in the concept being taken over by the CEC, which will utilise feedstock from sawmills on the Copperbelt. Another on-going biomass-based electricity generation activity in Zambia is being implemented at Nakambala Sugar

Biomass power generation.
Courtesy: REA

factory. Presently, Nakambala Sugar uses 120,000 tonnes of bagasse from the sugar cane crushing component of the factory to generate 17 MW of electricity. A similar technology is used at Kafue Sugar, but with a smaller output of 3 MW.

SOLAR ENERGY

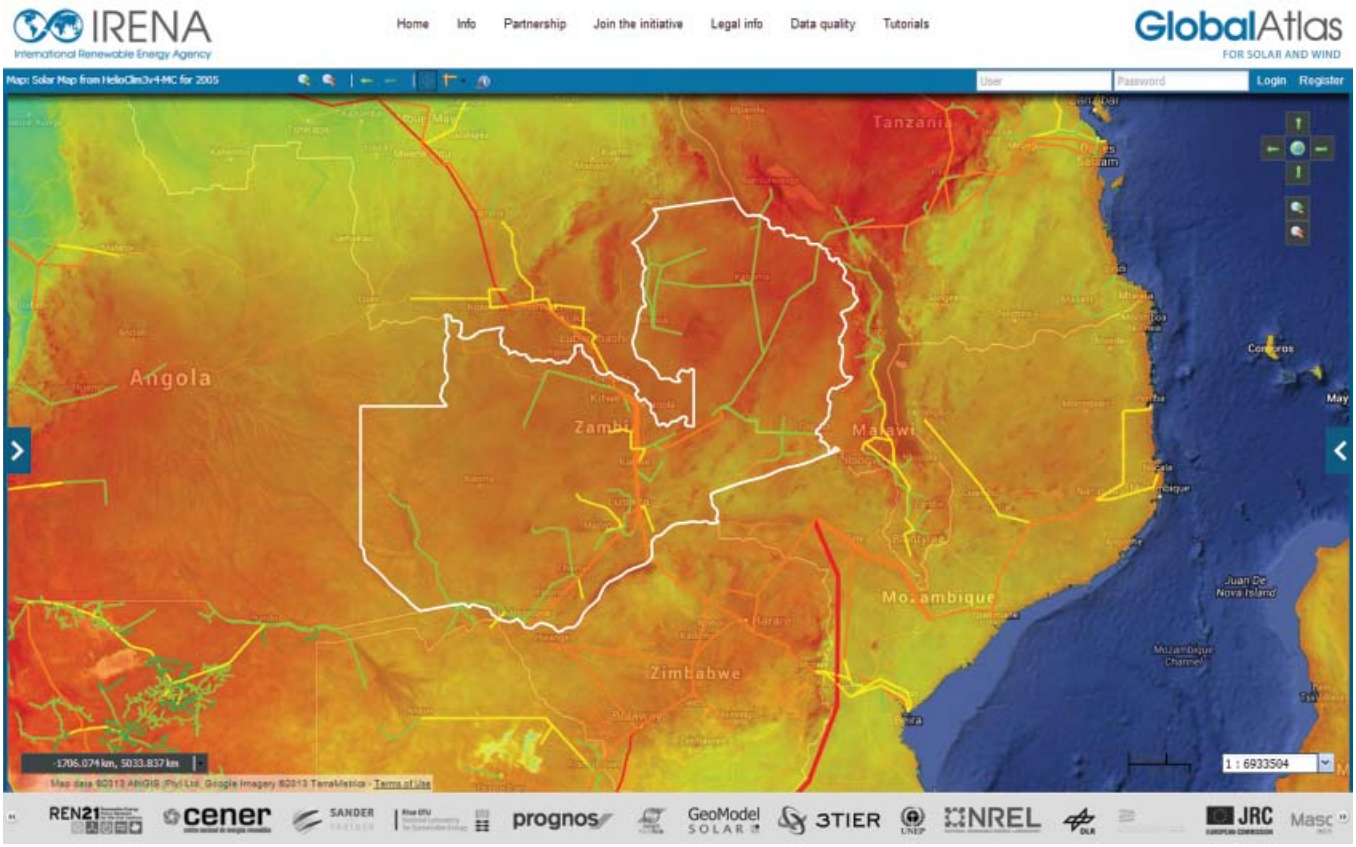
Zambia has an average solar insolation of 5.5 kWh/m^2/day, with approximately 3,000 sunshine hours annually, providing good potential for solar thermal and photovoltaic applications. A preliminary solar energy potential assessment for Zambia was undertaken using Geographic Information System data. Red regions have the highest solar irradiance values up to 2,750 kWh/m^2. Zambia's northern areas recorded the highest global solar irradiation of 2,300 kWh/m^2/year (Figure 6).

The REA has developed a solar mini-grid in Samfya District, Luapula Province. The solar mini-grid project is expected togenerate 60 KW of electricity, which will be supplied to a cluster of villages in the Mpata fishing community, which has an estimated total population of 6,000 people and 617 households. The project is being implemented under a loan facility agreement between the Development Bank of Zambia (DBZ) and the REA. The interest-free loan from the Development Bank of Zambia was facilitated by UNIDO, under the Global Environment Facility (GEF) agreement. The REA is providing part of the investment cost for the project. The government of Zambia has received tenders from various institutions to develop a total of 30 MW solar photovoltaic (PV), comprising 10 MW in the North-Western Province, 10 MW in Eastern Province, and 10 MW in Luapula on a build-own-operate (BOO) model. The bid process is still to be implemented and a policy is required to leverage tariffs currently being charged by ZESCO for on-grid customers.

GEOTHERMAL

Historic surveys have identified over 80 hot and mineralised springs in Zambia. Subsequently, a detailed study by an Italian-Zambian joint venture in the mid-1980s identified five prospective sites. Kalahari GeoEnergy Ltd., a self-funded private company, entered into an agreement with Government of Zambia in March 2011 under which the company would undertake geothermal research, exploration and development. The company has conducted field reconnaissance including hydrochemistry on all identified geother-

Figure 6
Global Solar Irradiation in Zambia



Source: IRENA Global Atlas (resolution: 3km)

mal targets, and geophysics on the more prospective targets. Having formulated a conceptual model, Kalahari GeoEnergy will conduct preliminary drilling at its first target, which is a low enthalpy system in a shallow sedimentary setting. It is anticipated that reservoir modelling and a test well will be completed during 2013 and a feasibility study will be completed in 2014. By targeting low-enthalpy geothermal systems, Kalahari GeoEnergy expects to be able to define a number of commercially viable geothermal sites across Zambia, which would provide both on-grid and off-grid power production capability, thus potentially benefiting both established users and the rural electrification and industrialisation programmes. Also, by using modular binary power plants, feasible targets can be brought into production more quickly at a lower capital cost than for large direct steam-fed turbines.

Aerial view of Kalahari Geo-Energy project
Source: www.kalaharigeoenergy.com

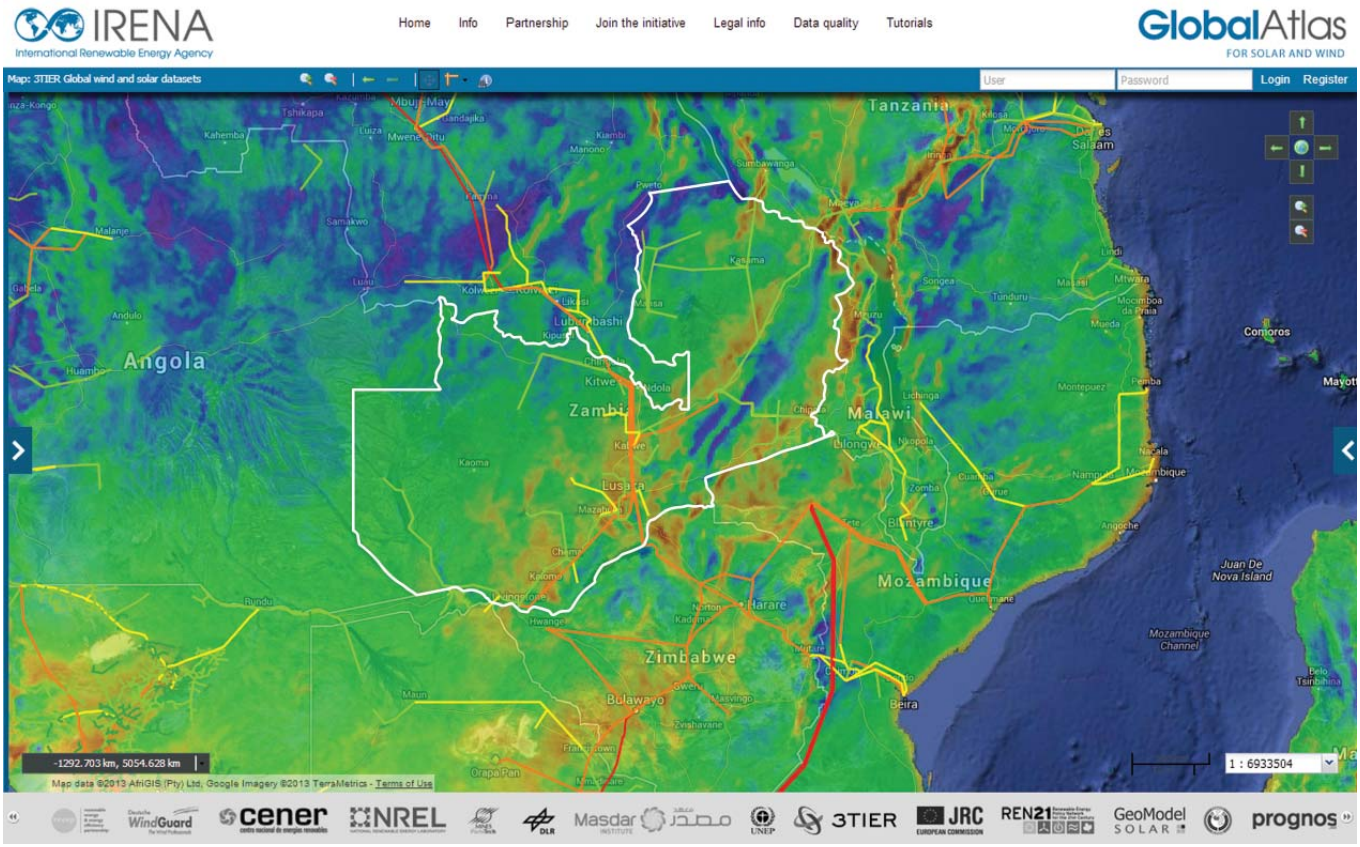
In spite of these efforts, more work is required on comprehensive resource assessments to guide policy formulation to support geothermal energy; including building capacity to design, build, operate and maintain geothermal plants in Zambia, along the lines that Kenya has developed in using this technology. South-South co-operation with regards to an exchange of resources, technology and knowledge with Kenya is commended, but should culminate in technology transfer in addition to building capacity and skills.

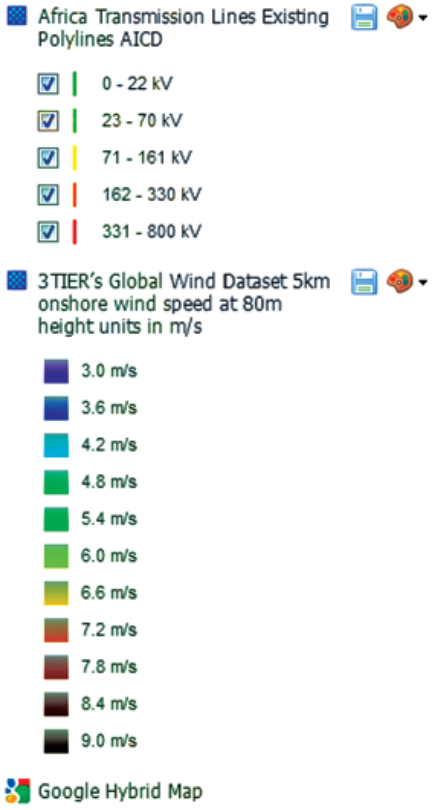
WIND ENERGY

Wind speeds in Zambia average 3 metres per second (m/s) at 10 m above the ground, a speed which is mainly suitable for mechanical applications. Some meteorological data on wind speeds at 10 m above ground is available, but is not adequate to guide investment for power generation. At that height, wind energy is only useful for mechanical energy, such as water pumping. Indications that higher wind speeds may exist at higher heights, *e.g.*, 70 m to 100 m, needs to be explored to direct any strategy to develop wind in Zambia.

Encouraging wind hotspots at a higher altitude were identified from a recent SADC study (2012), the Renewable Energy Strategy and Action Plan, around Chongwe area east of Lusaka (Location: 28° 47′ 40″ East, 15° 30′ 45″ South), and along the Muchinga escarpment centred on Chipembele (Location: 31° 28′ 57″ East, 12° 1′ 53″ South), which are shown in Figure 7.

Figure 7
Wind Hotspots in Zambia





Mini-hydro dam on the Nanshya River, Zambia
Courtesy: REA

Kasanjiku Falls, where micro-hydro has been developed
Courtesy: REA

III. ENABLING ENVIRONMENT FOR RENEWABLE ENERGY

KEY ENERGY STAKEHOLDERS

The main players in the Zambian energy sector and their roles are presented below:

MINISTRY OF MINES, ENERGY AND WATER DEVELOPMENT (MMEWD)

The Ministry of Mines, Energy and Water Development is responsible for policy framework and guidance through the Department of Energy.

OFFICE FOR PROMOTING PRIVATE POWER INVESTMENTS (OPPPI)

This is a unit (or cell) within the Ministry of Energy that was set up in 1999 to attract private sector funds for generation (including mini-hydro) and transmission projects.

ENERGY SECTOR ADVISORY GROUP

The Energy Sector Advisory Group is a committee formed under the MMEWD, including representatives from government ministries and authorities, development agencies and commercial enterprises. Its purpose is to encourage harmony between all sectors of the economy in terms of energy policy, and provide an informed opinion on energy matters to policy makers.

ENERGY REGULATION BOARD (ERB)

This is an independent energy sector regulator responsible for electricity, petroleum and other forms of energy including renewable. The ERB is responsible for ensuring a reasonable return on investment for operators/utilities, quality service at affordable prices to the consumer, licensing of operators/utilities, setting tariffs, and monitoring competition in the market

RURAL ELECTRIFICATION AUTHORITY (REA)

Established by the Rural Electrification Act of 2003, the Rural Electrification Authority's main mandate is to implement rural electrification developing mechanisms for the operation of a grid extension network for rural electrification, as well as applying a subsidy for capital costs on projects designed to supply energy in rural areas. The rural electrification programme also encourages the use of solar technology that has been applied only in pilot projects, with encouraging results.

ZAMBEZI RIVER AUTHORITY (ZRA)

The Zambezi River Authority is the authority responsible for the operation and maintenance of the Kariba Dam Complex, and investigating and developing new dam sites on the Zambezi River. It also analyses and disseminates hydrological and environmental information pertaining to the Zambezi River and Lake Kariba.

ZAMBIA ELECTRICITY SUPPLY CORPORATION LIMITED (ZESCO)

The Zambia Electricity Supply Corporation Limited is a state-owned public utility that operates Kafue Gorge Power Station, Kariba North Bank Power Station, Victoria Falls Power Station and the majority of Zambia's transmission and distribution networks. ZESCO also operates small hydro-power stations and a number of diesel powered generators scattered across the country in areas not connected to the main grid. Total installed capacity is about 1,900 MW.

COPPERBELT ENERGY CORPORATION (CEC)

A privately owned utility, the Copperbelt Energy Corporation purchases bulk power mainly from ZESCO and distributes it to the various mines in the Copperbelt. It also operates standby gas turbines.

LUNSEMFWA HYDRO POWER COMPANY (LHPC)

The Lunsemfwa Hydro Power Company owns and operates hydropower plants in Zambia (Lunsemfwa and Mulungushi hydro) and sells power to ZESCO Ltd.

ZAMBIA DEVELOPMENT AGENCY (ZDA)

The Zambia Development Agency is responsible for fostering the country's economic growth and development by promoting trade and investment, innovations that promote high skills and productive investment. The ZDA is a one-stop-shop for all investors including those in the energy sector.

ZAMBIA BUREAU OF STANDARDS (ZABS)

The Zambia Bureau of Standards' mandate is to develop and enforce Zambian standards, provide facilities for the examination and testing of commodities, materials and equipment and provide quality assurance schemes including training and consultancy in standardisation, quality management and assurance.

ZAMBIA GENDER AND ENERGY NETWORK (ZGEN)

The Zambia Gender and Energy Network is an organisation under the Department of Energy, engaged in the promotion of gender concerns in energy policy consideration. A 2011-2013 strategy has been developed to facilitate the mainstreaming of gender issues into energy policy.

BIOFUELS ASSOCIATION OF ZAMBIA (BAZ)

The Biofuels Association of Zambia (BAZ) is an association of firms, companies and individuals who are producers or service providers in the biofuels industry in Zambia. It is a lead industry association in the promotion of the production and use of biofuels in Zambia, in accordance with quality and social standards, and economically-sound production principles.

ENERGY AND ENVIRONMENT RESEARCH GROUP (EERG)

The Energy and Environment Research Group (EERG) is a research and consultancy group within the Department of Physics of the School of Natural Sciences at the University of Zambia. It focuses on energy and environment related to high quality and targeted consultancy, capacity-building and useful research in energy and the environment.

CENTRE FOR ENERGY, ENVIRONMENT AND ENGINEERING ZAMBIA (CEEEZ)

The Centre for Energy, Environment and Engineering Zambia (CEEEZ) is a non-governmental research organisation whose activities involve investigating, analysing and making useful conclusions, policy recommendations and providing training in energy and areas that are environmental concerns.

PETROLEUM SUB-SECTOR FACILITIES

Key institutions in the petroleum sub-sector are the INDENI Refinery and the TAZAMA Pipeline, linking Ndola in Zambia to the port of Dar-es-Salaam in Tanzania.

Grid transmission lines in Zambia
Source: REA

ENERGY POLICIES AND REGULATORY FRAMEWORK

POLICIES AND STRATEGIES

In 1994, Zambia formulated a National Energy Policy (NEP94) aimed at promoting optimal supply and utilisation of energy, especially indigenous energy forms, for socio-economic development in a safe and healthy environment.

In 2002, the country formulated a Poverty Reduction Strategy Paper (PRSP) that acknowledged the importance of harnessing renewable energy resources, mainly hydropower, to meet the country's energy needs, but did not stipulate the strategy for doing so.

Furthermore several five-year National Development Plans (NDPs), namely the Transitional National Development Plan (TNDP) (2002-2005), the Fifth National Development Plan (FNDP) (2006-2010), and the Sixth National Development Plan (SNDP) (2011-2015), provided additional perspective with respect to the development of renewable energy in the country.

The SNDP has capacity addition targets of 1,000 MW above the 2010 capacity level and aims to increase electricity access to 15% in rural areas and 40% in urban areas by 2015. In addition, it also provides for the introduction of a cost-reflective electricity tariff regime, establishing an open and non-discriminatory transmission access regime in the electricity sector, and introducing an appropriate cost-effective renewable energy feed-in tariff (FiT). Finally the SNDP laid out the framework for developing a Biomass Energy Strategy to improve the sustainability and effectiveness of biomass supply, as well as how to upscale biogas technologies for cooking, lighting and electricity generation, while targeting a 10% biofuel blending mix with petroleum.

The implementation of the PRSP and the NDPs has raised new insight and awareness among decision makers on the cross-cutting role of energy in socio-economic development. This prompted a review of the NEP94 in order to take into account recent changes not only in the energy sector and domestic economy, but also at the regional and international level. The review of the NEP was conducted in 2008 through an extensive consultative process that encompassed a wide range of individuals and institutions in the country.

The new National Energy Policy formed in 2008 (MEWD, 2008) set out the government's intentions to ensure that the energy sector's potential to drive economic growth and reduce poverty is harnessed. Some of the key issues that have emerged from the policy review include the need to recognise the cross cutting nature of energy. Critical social and economic services like health and education cannot be efficiently and effectively provided in the absence of reliable and affordable energy services. The new energy policy further takes account of important issues, such as the high incidence of poverty, the HIV/AIDS epidemic, gender, environment, household energy, rural electrification and the role renewable energy can play in Zambia's future energy mix. More specifically, on renewable energy, the objective of the NEP is to address barriers to the wide deployment of renewable energy technologies (RETs).

In 2010, a draft Renewable Energy Strategy was developed in order to translate the objectives of the NEP into a practical implementation plan. The key objectives of this strategy, in line with the goals of the NEP, FNDP 2006-2010 and the Vision 2030 are:

- Access to modern energy services for all
- Meeting growing energy demand in a sustainable way

The renewable energy strategy includes long-term renewable energy targets for specific applications. In terms of electricity, the targets are to generate 100 MW from solar, 200 MW from small hydro and 100 MW from biomass by 2030. In addition, it envisages the dissemination of 500,000 solar home systems and installation of 350,000 solar water heaters in order to reduce the demand load by 150 MW. The strategy was developed in two phases. The first phase consisted of collecting data and conducting situation analysis of the resources in solar, biomass, small hydro, wind and geothermal energy. In the second phase, a strategy was developed based on the situation analysis. The strategy, however, has not been adopted as of now.

In the same year the Rural Electrification Master Plan (REMP) was developed with the support of the Japanese International Cooperation Agency (JICA) through a high-level consultative process (MEWD, 2009). The REMP is the blueprint for rural electrification for the period 2008-2030 and is to be implemented by the Rural Electrification Agency (REA). The REMP has identified 1,217 rural growth centres (RGC) throughout the country to be electrified during that timeframe. These rural growth centres will be electrified using three main methods:

i) extension of the national grid;

ii) construction of mini-hydro power stations where potential exists; and

iii) installation of solar home systems.

Adequate implementation of the REMP would increase the rural electrification rate of 3% in 2008 to 51% by 2030 at an estimated cost of about USD 1.1 billion, translating into an annual expenditure of USD 50 million.

LEGAL AND REGULATORY FRAMEWORK

The following instruments have been so far adopted/initiated by the Government of Zambia for the promotion of the energy sector:

Electricity Act of 1995 (amended 2003): The act was formulated to regulate the generation, transmission and distribu-

tion of electricity in Zambia. It liberalised the electricity sector by opening all three segments to private operators and led the government to set up two key new institutions. The Energy Regulation Board was tasked with regulating the operations and pricing of the electricity sector while the OPPPI was meant to attract new players to the electricity market.

Energy Regulation Act of 1995 (amended in 2003): The act established the Energy Regulation Board and defined its functions and powers as regulating the energy sector in a fair, transparent, effective and efficient way to safeguard the interest of all stakeholders. The ERB is responsible for establishing fuel prices (including electricity tariffs), establishing and monitoring the application of the Zambia Grid Code, and designing standards with regards to the quality, safety and reliability of supply of energy in conjunction with the Zambia Bureau of Standards.

Rural Electrification Act of 2003: The act established the Rural Electrification Authority and equipped it with a Rural Electrification Fund. The REA is responsible for implementing the REMP by facilitating the creation and monitoring the operation of rural electrification organisations or companies. These organisation and companies (including entrepreneurs, community-based organisation and others), shall fulfil their obligations and perform in accordance with standards and appropriate tariff structures (jointly set up with the ERB), keeping a balance between the need for affordability with sustainability of electricity delivery systems. The Rural Electrification Fund is to be sourced by monies approved by the parliament, as well as electricity levies, loans, grants and donations from any sources in Zambia. Funding from sources outside the country must be approved by the minister.

The Zambia Grid Code of 2006: The Zambia Grid Code was drafted in 2006 with the objective of facilitating open and non-discriminatory access to the transmission system in order to ensure that the goals of liberalisation of the electricity sector, primarily enhanced efficiency and more rapid electrification, are achieved. Although the document has been drafted and reviewed, it is still being considered for adoption.

FINANCING AND INVESTMENT

The energy sector in Zambia has traditionally been funded and implemented by the government through ZESCO and by IPPs and IPTs (namely the CEC, Lunsemfwa Hydropower Company and Northwestern Energy Corporation). However, in recent years, the sector has attracted investment from private foreign investors as well as development partners and institutions. These include, the China-Africa Development Fund (CAD Fund), EXIM Bank of India, the World Bank, the African Development Bank, the European Investment Bank, the French Agency for Development and the Development Bank of Southern Africa.Although most of these investments have been for the most part geared toward the development of large hydropower dams and transmission infrastructures, this renewed interest of financiers in the sector is mainly due to the favourable investment framework that includes fiscal and non-fiscal incentives as well as investment subsidies.

The ZDA was established in 2006 by an Act of Parliament in the frame of private sector support programmes to make the country more conducive to business. In line with the economic reforms, the ZDA is encouraging private investment in all priority productive sectors including agriculture, mining, manufacturing, tourism and

The Chitokoloki Hospital has 24-hour power generated by several banks of solar batteries, a large battery storage area and an inverter. The new system is able to handle almost all the hospital demands
Source: www.chitokoloki.com

energy. In that regards, the development of power plants to generate electricity from various energy resources, including renewable energy, qualify for tax exemptions under the ZDA Act's priority sector incentives. The tax concessions for various types of investment are outlined as follows:

GENERAL INCENTIVES

INCOME TAX:

- Income earned by companies in the first year of listing on the Lusaka Stock Exchange qualifies for a 2% discount on the applicable company tax rate in the particular sector.

  However, companies with more than one-third of their shareholding in the hands of Zambians qualify for a 7% discount.

- Initial allowance of 10% on capital expenditure incurred on the construction or improvement of an industrial building is deductible.

- Foreign exchange losses of a capital nature incurred on borrowings for the building and construction of an industrial or commercial building are tax deductible.

- Carry forward of losses up to five years.

VALUE ADDED TAX (VAT):

- Relief for VAT-registered enterprises on imports of eligible capital goods.

- Zero rate on export of taxable products.

- Relief of VAT on transfer of business as a going concern.

- Equal treatment of services for VAT-reverse VAT.

- VAT relief on input tax paid for purchases made by registered suppliers.

- Input tax claim for three months prior to VAT registration for businesses that have already commenced trading.

PRIORITY SECTOR INCENTIVES (ENERGY-SECTOR INCLUSIVE):

- Zero percent tax rate on dividends for five years from year of first declaration of dividends.

- Zero percent tax on profits for five years from the first year profits are made. For years six to eight, only 50% of profits are taxable and for years none and ten, only 75% of profits are taxable.

- Zero percent import duty rate on raw materials, capital goods, machinery including trucks and specialised motor vehicles for five years.

- Deferment of VAT on machinery and equipment including trucks and specialised motor vehicles.

MICRO AND SMALL ENTERPRISES

In addition to general incentives, the following incentives are provided under this category

- For an enterprise in an urban area the income shall be exempt from tax for the first three years.

- For an enterprise in a rural area, the income shall be exempt from tax for the first five years.

Furthermore, the country has initiated several regulatory reforms for supporting the development of the power sector leading to the establishment in 1999 of the Office for Promoting Private Power Investment (OPPPI). The OPPPI was set up to be a 'one window operation' to reduce the complexity of procedures, rules and regulations and red tape usually associated with obtaining the required approvals, permits and licences for investors in the electricity sector. The mandate of the OPPPI is to:

i) attract private investment in generation (for projects no less than 10 MW) and transmission projects;

ii) assist the private sector in working through bureaucracy by acting as one-stop-shop;

iii) negotiate implementation agreements and transmission service agreements between the government and the project developer; and

iv) conduct pre-feasibility and feasibility studies on most potential hydroelectric sites in Zambia.

Through the OPPPI, the government offers non-fiscal incentives which involve risk-sharing/allocation between the developer and government. Under the implementation agreement between the OPPPI and the developer, the former promises to share the cost of risk related to droughts and geological effect and to support in the acquisition of water rights and environmental impact assessments.

The Development Bank of Zambia is a development finance institution established in the early 1970s as a joint venture between the Government of Zambia, public sector financial institutions, local and private sector and foreign bilateral and multilateral institutions. The bank's mandate is to provide medium- and long-term development finance and has been involved in the sectors of agriculture, mining, forestry, fishery and manufacturing. The bank was recently involved in supporting a 1 MW isolated small hydro mini-grid in Shiwang'andu (Chisali District) that was co-financed by GEF and UNIDO. The bank co-founded the project by signing a Trust

Decentralised rural electrification grid
Courtesy: REA

Fund Agreement of USD 3.55 million with ZESCO for the construction of the power plant, which was commissioned in 2012.

Through the REA, the Zambia government has set up a Rural Electrification Fund aimed at increasing access to electricity in rural areas through grid extension and decentralised power systems. The fund is mainly drawn from a 3% levy on every unit of electricity consumed as well as grants and loans from development partners. It is aimed at encouraging private sector participation by financing project preparation studies and providing smart-capital subsidies with the intent of lowering the end-user tariffs or cost to access electricity. The REA, as part of its mandate, developed an operational manual[7] that highlights the capital subsidy of up to 100% it offers for publicly-led rural electrification projects and can support privately-driven rural electrification projects for up to 50% of the capital costs, with remaining funds to be secured by the developer with a minimum level of 20% of equity, and a minimum internal rate of return of 10% before grants. In addition, the project proposal must contain enough indication allowing the REA to make a good assessment in terms of technology and expected benefits, meaning that the proposal should be backed by a complete business plan and financial studies.

A multitude of local financial services institutions are involved in providing technical assistance to project developers in structuring bankable proposals for small-scale renewable energy and Clean Development Mechanisms (CDMs). A study titled "Financial Sector Survey on Clean

7 The REF Operational Manual is aimed at developinga transparent and effective capital subsidy scheme, project selection criteria based on economic and financial principles, eligibility criteria and principles for capital subsidy, appraisal of project proposals, etc.

Development Mechanism Awareness and Predisposition in Zambia" revealed that most of the local financial institutions do not provide medium- to long-term loans. They require feasibility studies to be conducted at the applicant's expense, since bank officials have limited knowledge in assessing renewable energy projects. In addition, banks require land titles as collateral, portfolios of project sponsors and managers, data on past and current operations, approximate value of existing investment, valuation reports, raw material procurement plans, and marketing strategies for the finished product. As renewable energy projects are relatively a new investments field, it is often difficult for the developer to provide the required information and track history. Another issue linked to the local finance of renewable energy projects is related to the interest rates. Indeed, a check with 12 local banks indicated that the interest rate for loans on investment projects ranged between 10% to 12% for foreign currency, while being subjected to rates between 19% to 20% for local currency (Zambian Kwacha). However, experts in the field indicated that interest rates actually ranged between 20% to 35% per annum, after considering hidden costs (CEEEZ, 2011).

To remove such investment barriers at the local level, local financial institutions' capacities should be built to assess renewable energy projects to remove the high risk perception of the sector. In addition, insurance and risk mitigation mechanisms should be developed to reduce the risk profile of renewable energy projects.

IV. EMERGING ISSUES IN THE DEPLOYMENT OF RENEWABLE ENERGY

ON-GRID ELECTRICITY

Power development in Zambia's southern areas, near the Victoria Falls and in the Copperbelt areas, started when decentralised thermal generation was established to supply electricity to the burgeoning lead and zinc mining projects. To meet the increasing demand of the mining sector, which became a pillar of the country's economy, interconnectors were built with the neighbouring DRC, while dams were developed along the Zambezi River (Kariba North, Kafue Gorge, and Victoria Falls) to supply hydroelectricity to the mines on the Copperbelt. This led to the development of the transmission backbone linking the dams in the south to the Copperbelt area in the northwest, while supplying nearby towns along its path.

The electricity demand in Zambia is expected to reach 3,544 MW by 2030 in low case[8] scenarios and 5,406 MW in high case[9] scenarios. However 2,390 MW of the OPPPI pipeline of projects is expected to be part of the SAPP to meet regional power demand, leaving the country with a potential power deficit of 1,000 MW in the high case scenario if the country is to meet this growing demand on a self-sufficiency basis (MEWD, 2010).

The strong reliance of the country on hydro (representing over 90% of the electricity mix) exposes the power system to seasonal climate variation known to include droughts and floods, which can greatly hamper hydropower generation. Although the country's power system can sustain a decrease of power from the hydro schemes by up to 16% during dry year/season (MEWD, 2010), a higher deficit was experienced during the 1991-1992 drought with a deficit of 30% (from around 9,000 gigawatt-hour (GWh) to 6,200 GWh) (Kapika and Eberhard, 2013). The supply gap for that year was only met thanks to imports from the regional power pool. Subsequently the power system has

8 Economy will grow at 5% from 2013, electrification ratio growth of 3.5% per annum.

9 Economy will grow at 7% from 2011, electrification ratio growth of 6% per annum.

been affected with intermittent droughts over the past ten years. Furthermore, a study on climate variability implications on hydroelectricity generation in the Zambezi River Basin[10] has shown that hydroelectric power potential has a tendency towards a gradual reduction for both existing and proposed hydroelectric power schemes (Yamba *et al*., 2011). The study has revealed that seasonal climate variability will affect hydropower generation by reducing water run-off and reservoir storage capacity in dry years, and water overflow, which can affect hydropower infrastructure during wet years. To mitigate such risks, integration of renewable energy sources other than hydro in the power generation plans is critical to sustain future demand. For that to happen, the country should engage in a thorough renewable energy resource assessment process that will allow for the identification of sound technical and economic potential, which may lead to the development of an integrated resource plan that will include a high share of non-hydro renewable energy. Furthermore, as the country already plays a critical role in interconnecting SAPP countries that have higher electricity tariffs than Zambia, integrating other renewable energy in the power grid will allow the country to reinforce its position within the SAPP.

TARGET SETTING

As mentioned earlier, the renewable energy strategy has defined targets for the deployment of renewable energy power generation. However, the targets have been set without any thorough investigation of the economic potential of each renewable energy resource considered (solar, small hydro, geothermal and biomass). Moreover, cost implication of each renewable energy technology as well as socio-economic opportunities, should be considered when developing targets, as there is no clarity on the expected share of renewable power to be supplied to the grid, and the implication on the latter to accommodate variable power.

There is therefore a need for the Ministry of Mines, Energy and Water Development and relevant stakeholders to undertake a thorough study on the renewable energy potential (including both the technical and economic). This may lead to the review of the current targets for more realistic ones.

ENABLING ENVIRONMENT

Major power sector reform in Zambia occurred in 1995 with the establishment of the ERB, abolishing the statutory monopoly of ZESCO and allowing the participation of other private operators in the sector. Despite that reform, however, the CEC and the LHPC remain the only private players in the market. The LHPC supplies power to ZESCO while the CEC transmits ZESCO's power to the mines though a bulk supply agreement (BSA). Furthermore, since the Kariba North Dam commissioned in 1977, no greenfield investment has been done in the sector. This is due to the fact that the country enjoyed surplus capacity from the 1980s till early 2000, when electricity demand began to escalate due to the recovery of copper mining and the extension of ZESCO's customer base. In recent years, foreign investors have expressed their interest in the power sector and have engaged with ZESCO and CEC to expand the country's generation capacity. However the pipeline of projects so far only includes hydro and coal-based power plants due to their economical generation

10 The study has analysed the effects of various factors on hydroelectric power generation potential to include climate change/variability, water demand, and installation of proposed hydroelectric power schemes in the Zambezi River Basin.

cost that continue to reflect the country's low national electricity tariffs, which are recognised as being among the lowest in the SADC region.

Tariffs in Zambia are not only unattractive for private sector participation, but have also partly hampered ZESCO's plan to further expand and rehabilitate the electricity grid. In January 2011, the energy regulator ERB approved a 30% electricity tariff increase for the mining sector, although contracts signed under these new tariffs are still not cost-reflective, as they only cover about half of the cost of new generation capacity (hydro-based). Through ZESCO's 2012 business plan, it intends to spend USD 5.3 billion between 2013 and 2018, raised mainly through external debt, to expand the electricity infrastructure and address the power deficit. In that regard, the company submitted a tariff increase proposal to the ERB with the objective of an average tariff increase of 26% across all customers. The rationale behind this tariff increase includes rising costs of generating, transmitting and distributing electricity (56% increase in operation costs and 59% increase in cost of sales between 2009 and 2011), system and customer base expansion, and rising costs of electricity imports (ERB, 2012).

A grid code is a critical element in the management and operation of a power system. As renewable energy power requires flexible conditions for their adequate integration, it is important for the grid code to consider options that would allow renewable power integration without affecting the grid safety and stability. The Zambian draft grid code, although allowing open access to the grid for IPPs, does not provide any guidelines or standards for accommodating renewable energy-based electricity. For instance, the current power forecast time is set a day ahead, which is not favourable for renewable energy, in particular wind and solar, due to their variability. Best practises show that forecasts are more accurate the closer they are to real time and sub-hourly scheduling is recommended. The Grid Code should additionally provide priority to renewable power in the dispatch schedule. The draft Grid Code, before its formal adoption, should integrate these necessary conditions to allow more renewable energy-based power into the grid. The use of forecasts requires operational changes, thus grid operators need to be made capable of integrating forecast data in daily operations, as well as the provision of the necessary tools such as sophisticated information and communication infrastructure for better system-wide decision-making.

Another constraint in the financing of grid connected renewable energy power projects is the negotiation of power purchase agreements (PPAs). In Zambia, PPAs are drawn up on a case by case basis and have only been concluded for hydro- and fossil fuel-based generation. Attracting investment in variable renewable energy-based power in the grid could be enabled by considering important factors to strengthen the bankability of a PPA. These could comprise mitigating dispatch risks by including clauses that calculate the tariff based on the energy delivered by embedding a fixed charge not dependent on dispatch or a capacity charge along with charges for the energy actually delivered. This would make the PPA bankable by providing enhanced predictability of revenue stream for the plant. The country should therefore engage in a consultative process to develop a standardised PPA to increase the bankability of renewable energy power projects

Zambia relies heavily on hydro-based generation to meet current electricity

demand and plans on developing new hydro and coal capacity to meet future demand. However, the country should tap its tremendous renewable energy potential to diversify its electricity mix as non-hydro renewables are increasingly becoming cost-competitive, provided that a conducive framework is built to allow their rapid deployment for power generation.

RECOMMENDATIONS

Integrated resource planning is becoming an important tool that allows key stakeholders to participate in the identification and optimisation of the appropriate mix of energy resources to meet near- and long-term electricity needs in a sustainable way. This also enhances the security of energy supply by including all economically viable and environmentally friendly energy resources.

It would be beneficial for Zambia to initiate a dialogue that would include all relevant stakeholders in the development of an integrated resource plan for power generation that will help guide the country in diversifying its electricity mix while meeting future demand. A premise to such an activity is the undertaking of a thorough renewable energy resource assessment.

A renewable energy resource assessment can trigger a remarkable change in the perception of decision makers in their knowledge base and awareness of the country's renewable potential and opportunities, thereby allowing them to make more informed decisions. Furthermore, renewable energy resource assessment is a fairly small investment that can leverage significant interest for private sector involvement and lead to cost reduction.

Setting renewable energy targets, based on the resource assessment, would provide a realistic and achievable goal for the country's efforts to increase renewable energy in its electricity mix. This would provide a clear policy signal to attract private sector investment in renewable energy, especially if targets have a mandatory clause for power generators and those who off-take bulk power. It would be worthy for Zambia to partake in this activity upon completion of the renewable energy resource assessment and develop a strong implementation and monitoring framework to achieve these targets.

Grid integration of non-hydro renewable energy-based power requires a thorough assessment of the grid's ability to include variable power. Improving a grid's ability to include variable power entails the enhancement of the grid system operation through operational decision-making tools, long-term grid planning studies, meeting the requirements for renewable power generators and priority access to the grid for electricity generated from renewable energy.

The revision of the Zambia draft Grid Code to include these elements is essential before its formal adoption if the country is resolved to achieve large-scale deployment of non-hydro renewable energy-based power.

A programmatic approach for utility scale renewable energy power projects should be developed with the requisite financial incentives and be backed by a standardised bankable PPA in order to attract scalable investment, limit elaborate and tedious negotiations and give potential investors clear expectations on their investment.

OFF-GRID RENEWABLE ENERGY OPTIONS

In Zambia rural electrification has been achieved mainly through grid extension by ZESCO until 2006, when the REA was established and put in charge of rural electrification. The first approach of the REA to provide rural access was through grid extension (53 grid extension projects completed by 2008). In addition to grid extension, the REMP outlined that 20% of the RGCs would be electrified through solar home systems and mini-hydro power plants[11]. However, achieving the required mobilisation for the grid extension component has proven to be a challenge, evidenced by slow progress in reaching annual targets of the REMP. This is supported by a 2011 review of donor support programmes in rural electrification, which pointed out that the clustering concept of RGCs requires considerable technical and financial resources above the means of the REA (Dastgeer, *et al.*, 2011). In fact, JICA, which supported the development of the REMP later recognised the need to repackage these concessions in smaller and more manageable ones that could attract local private sector involvement (Ibid).

This slow progress in grid extension encouraged the REA to rethink its rural electrification approach by expanding the solar home systems and mini-hydro power systems while also exploring other renewable energy-based mini-grids (solar and biomass).

SOLAR PHOTOVOLTAIC SYSTEMS

In 2008 a solar photovoltaic (PV) system component was developed under the World Bank *Increased Access to Electricity Services* (IAES) with a financial allocation of USD 9 million. The project aimed to aggregately install solar PV systems in social infrastructures such as schools, health centers and palaces, as well as in rural enterprises and households, to achieve commercial viability through economies of scale. As of February 2013, 199 households and 264 social infrastructures were provided electricity through solar PV systems. The target for this programme was to install 10,000 solar home systems and 450 solar PV panels for institutions by the end of 2013.

Other development partners such as the Swedish Development Agency (SIDA) and the Dutch International Cooperation Agency (DGIS) also provided financial assistance for similar activities. However, this approach in Zambia has evidently had a poor implementation track record, as the sector relies on donor-driven distribution of free or highly subsidised solar PV systems. Although solar PV systems are a practical option for meeting part of the electricity needs of populations in remote areas, they often face major maintenance issues throughout their lifecycle due to the lack of local skills and ownership from the beneficiaries. For a more sustainable and successful solar PV programme, the REA should aim for a long-term delivery approach on a commercial basis by involving the private sector, especially entrepreneurs, throughout the supply chain, as well as micro-finance institutions, to provide end-user finance for the uptake of these systems. Price discovery by REA through a mechanism of aggregating the demand, coupled with strong technical evaluation of the equipment and capacity of the vendors, could facilitate this process by reducing costs of the systems and allow for the commercial viability of standalone PV systems.

11 Although many potential mini-hydro sites exist in Zambia, only three sites (Mujila Falls Lower, Upper Zambezi, and West Lunga in North-Western Province) were financially feasible.

RENEWABLE ENERGY MINI-GRIDS

Zambia has a wealth of experience with the development of isolated mini-grids running on different energy resources and ownership structures. ZESCO is operating eight diesel mini-grids of various sizes totalling an installed capacity of 8 MW. These diesel mini-grids cost the utility between USD 0.35 to USD 0.40 per unit of power generated and with current tariffs set at USD 0.065 per kWh, they are running deficits. Given the fact that some of these isolated mini-grids are located along perennial rivers or in areas with favourable solar radiation, ZESCO is planning in the medium- to long-term to either hybridise or replace these mini-grids with hydro or solar plants as well as develop Greenfield hydro and solar mini-grids. In order to demonstrate the technical and economic viability of renewable energy based mini-grids, the utility recently completed a 1 MW small hydro mini-grid in Shiwang'andu (Northern Province) financed through a GEF/UNIDO grant and a trust fund agreement with the Development Bank of Zambia for a total amount of USD 4.5 million[12]. Through the same GEF/UNIDO project the REA was able to develop the first solar PV mini-grid in the country with an installed capacity of 60 kW in Samfya District (Luapula Province) through a loan facility agreement signed with the Development Bank of Zambia.

Furthermore, several hydro mini-grids have been established in the country by a range of stakeholders including Zengamina Power Limited, which owns and operates

Table 5
Least-cost Analysis*

	Hydro		Grid Extension		Diesel	
Investment Capital		6,900,000		26,000,000		500,000
Investment Lifespan		15		15		10
Production (kWh)		7,400,000		7,400,000		7,400,000
Price/unit		0.10		0.10		0.10
Revenue		740,000		740,000		740,000
Variable cost/unit		0.01		0.01		0.01
Cost of energy/unit		0		0.00		0.40
Total fixed costs		30,000		30,000		30,000
Amortisation/unit:	0.06	460,000	0.23	1,733,333	0.01	50,000
Direct costs per unit:	0.07	499,960	0.24	1,773,293	0.41	3,049,960
Gross Margin/unit	0.03		-0.14		-0.31	
Fixed costs/unit	0.00		0.00		0.00	
Total costs	0.07	529,960	0.24	1,803,293	0.42	3,079,960
Net Margin	0.03	210,040	-0.14	-1,063,293	-0.32	-2,339,960
ROI	3%	-4%	-468%			
Payback period years	10.30	38.80	-0.22			

*The least-cost analysis has been carried out in the absence of any subsidies.

Source: (REA, 2008).

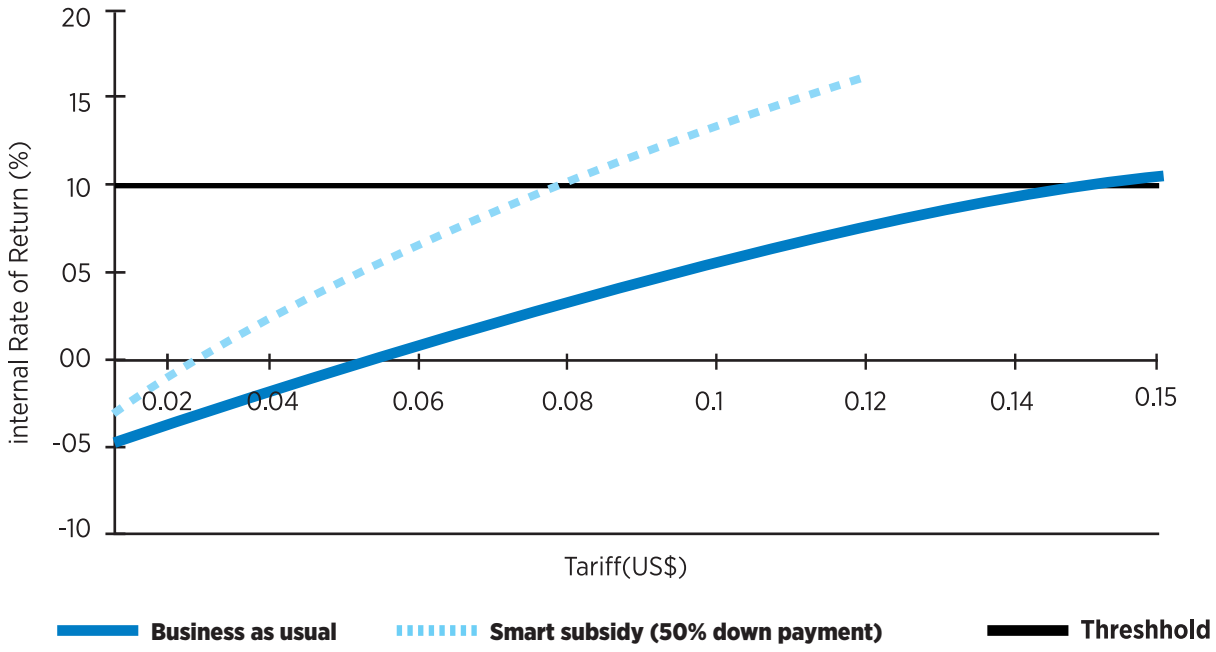
12 No details on the business model and the tariff structure of the project were made available.

a 750 kW run-of-the-river hydro scheme with a grid covering 35 km in the North-Western Province, in addition to many mini-hydro plants (of less than 100 kW capacity) owned and operated by communities including resident cooperatives and missionaries.

A feasibility study commissioned by the REA was performed for a 1 MW hydro scheme in Chilinga (Eastern Province) that provided some interesting insights regarding the economics of small hydro mini-grids and could be further investigated for other available renewable energy sources such as solar and biomass. The Chilinga study compared three electrification scenarios including grid extension and decentralised generation using either diesel or small hydro[13]. The least cost financial analysis of the study showed that although grid extension is generally perceived as being the least costly option for rural electrification in Zambia, the distance of the site to be electrified from the closest sub-station made it financially unattractive. Similarly, when comparing the economics of a diesel-based generation plant to a small hydro plant, the study showed that the high operating cost of the diesel scheme due to high fuel prices was also not financially attractive (Table 5).

Furthermore, a financial/sensitivity analysis was performed using the UNIDO COMFAR model[14] with prices ranging between from

Figure 8
Internal Rate of Return against Tariffs



Source: (REA, 2008)

13 Assumptions used for the financial analysis are: capital cost for grid extension (132 kV line) USD 100,000 per kilometre; capital cost for diesel is USD 500 per kW; diesel price is USD 1.2 per litre (now USD 1.65 after removal of subsidies) and tariff assumed at USD 0.10 per kWh

14 The UNIDO COMFAR is an internationally recognised computer model for feasibility analysis and reporting that provides comprehensive data on working capital requirements, income statements, cash flow and balance sheet. In addition it calculates internal rate of return, NPV and payback period.

USD 0.02 to USD0.16 per kWh of electricity produced. As it was assumed that the loan portion of the capital costs of the projects will be obtained from international markets, an interest rate of 8% and discount rate of 12% with a debt/equity ratio of 20% equity and 80% debt was applied. In the Business As Usual scenario, implying that all capital expenditure will be borne by the private entity, the project would pay back in eight years for cost reflective tariffs between USD 0.15 to USD 0.16 per kWh. As mentioned earlier, the REA could contribute to private sector led rural electrification projects by providing up to 50% capital subsidy to the project developer and when applied the project would pay back in six years with tariffs between USD 0.08 to USD 0.10 per kWh (Figure 8).

Another feasibility study was commissioned by the REA for a small-sized biomass power generation plant of about 4 MW around the Lamba National Forest and the Emerald Mining Areas. It is estimated that the number of people in the area was around 10,000 with a possible initial connection of between 900-1,000 households, schools, clinics and commercial and industrial facilities. The power generation is envisaged to meet the total electric demand in the project area, with surplus sales to ZESCO. The investment cost for the plant was estimated at USD 10.928 million with operation and maintenance (O&M) costs of USD 96,000 per annum. Without capital subsidy the financial analysis indicated a cost reflective tariff of USD 0.073 per kWh with an internal rate of return of 12.5%. This tariff is favourable and compares well with current on-grid electricity tariffs of USD 0.065 by ZESCO. This project would become even more economically sound for investors and make electricity tariffs affordable for rural populations when considering the fact that the REA could provide a capital subsidy of up to 50%.

Moreover another analysis completed for a typical remote rural village with about 2,000 inhabitants, showed that similar sites throughout the country could be best electrified in an economically viable way by considering various renewable based mini-grids. The study demonstrated that each technology becomes economically viable as grid extension reaches a certain threshold, known as the Economical

Table 6
Economical Distance Limit per Technology (Compared to Grid Extension)[15]

Technology	Capital Cost (USD)	O&M Cost per year (USD)	Total Net Present Cost (USD)	Levelised cost of energy (USD)	*EDL for grid extension (km)
Mini-hydro	1,600,000	20,000	1,855,667	0.198	41.6
Biomass gasification	180,000	187,381	2,575,355	0.274	74.2
Wind turbine	1,721,956	78,228	2,481,729	0.382	82.0
Solar PV	2,343,956	41,181	2,983,905	0.786	92.7

Source: Chitalu (2013).

***EDL**: Economical Distance Limit

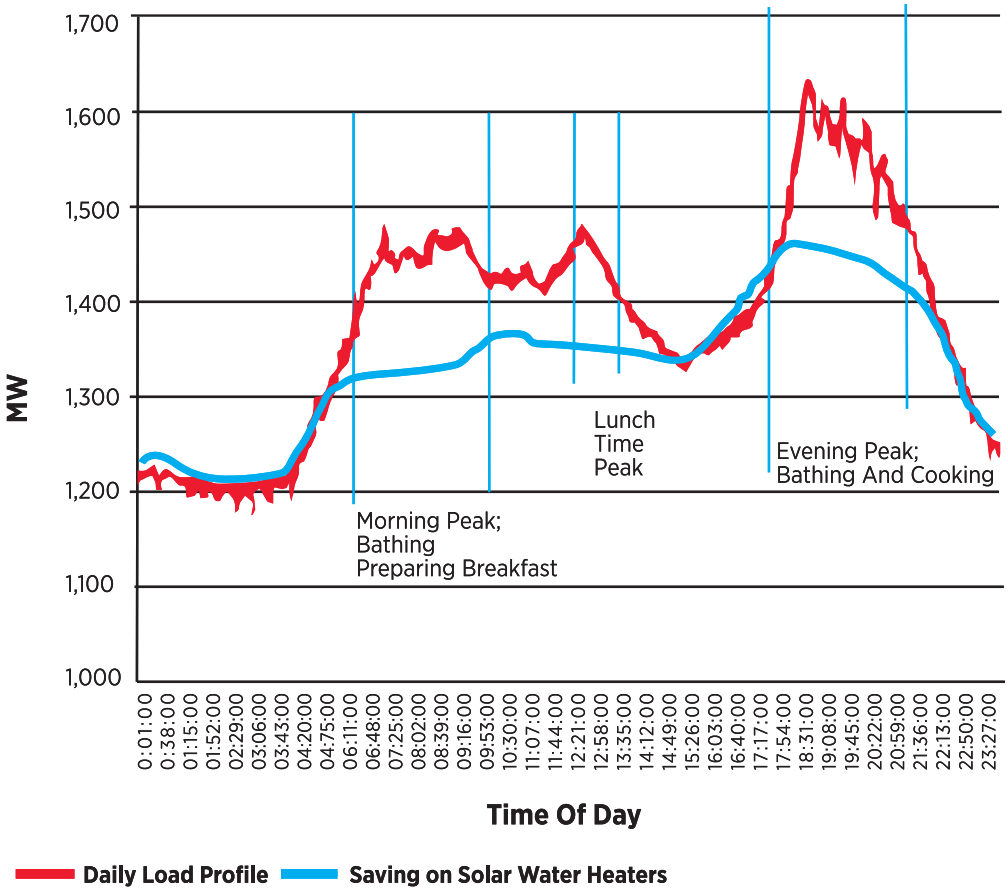
15 The Economic Distance Limit is defined as the break-event point at which grid extension become less economically viable than decentralised alternatives

Distance Limit (EDL). For example, small hydro mini-grids become economically attractive when grid extension is done over a distance greater than 41.6 km, while for biomass gasification mini-grids the EDL is 74.2 km (Table 6).

SOLAR WATER HEATING

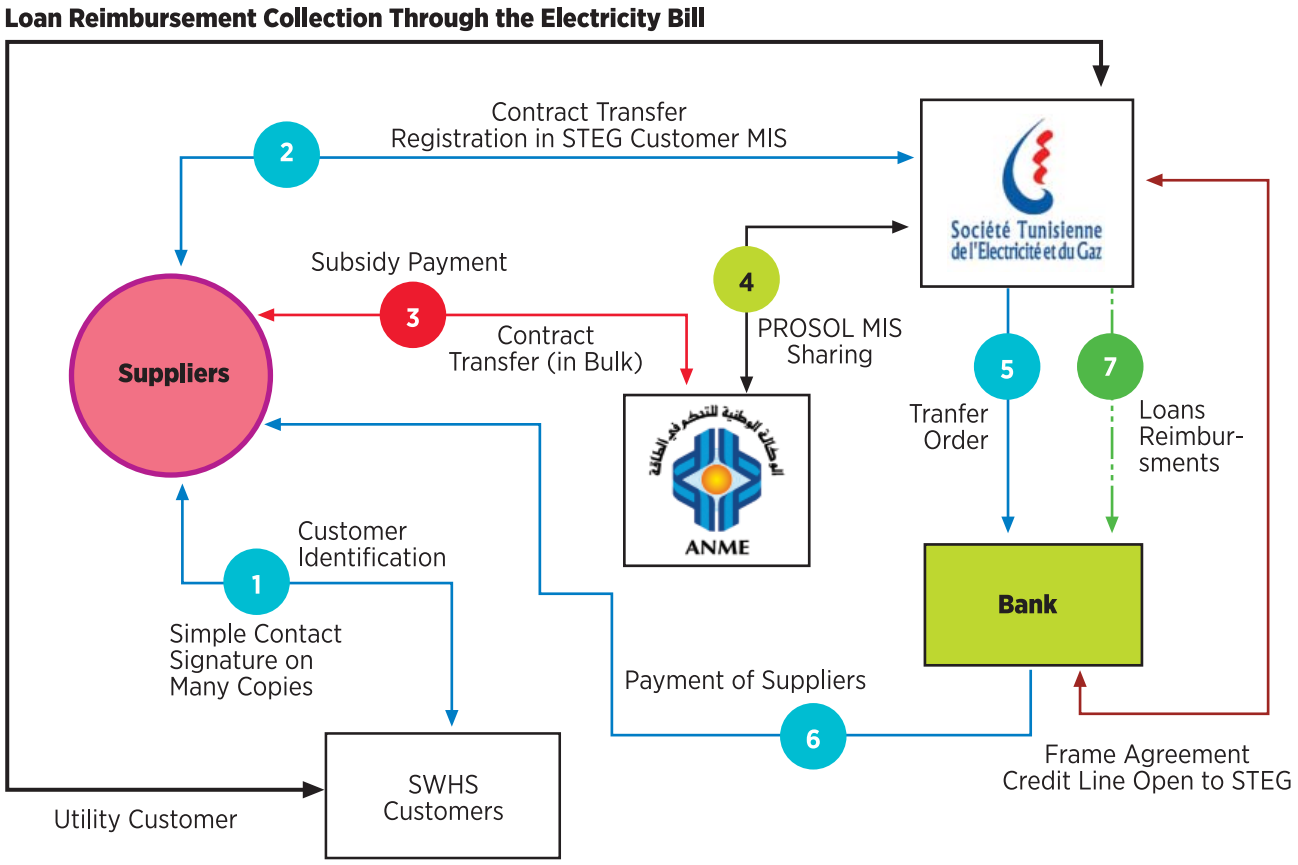
As part of its demand side management plan, ZESCO intends on pursuing projects that include free energy audits and advice for power factor correction (PFC) and time of use tariff (ToU) to maximum demand customers in industry and commerce, as well as distribute compact fluorescent lamps (CFLs), and install prepayment meters in residential and commercial customers, power alert systems and ripple control system of electric water heaters. In addition, ZESCO plans on deploying 350,000 solar water heaters in order to save 40% of domestic electricity demand corresponding to 150 MW that is attributed to the use of electric water heaters. This would help by shaving the morning and evening electricity demand peak estimated around 1,480 MW and 1,630 MW in 2011 (Figure 9). The proper implementation of this initiative would reduce load shedding, which currently costs the utility around USD 6.1 million per year, and will reduce electricity import from SAPP to meet peak hour demand. The first phase of the project seeks to install 100,000 solar water heaters with an initial investment of USD 40 million and is expected to save ZESCO about USD 180 million over the lifespan of the

Figure 9
Reduced Electricity Demand from the Installation of Solar Water Heaters



Source: (REA, 2008)

Figure 10
Tunisian PROSOL Business Model



Source: (REA, 2008)

solar water heaters, which is estimated at 15 years with a payback period of 3 years (ZESCO, 2011). The project is designed in a way that the end-user would not contribute to any of the installation costs of the systems, as the utility plans on bearing all initial costs.

However, as of today, except for the initial solar water heaters disseminated as pilots in the Lusaka area (less than 100 systems), the project has been stagnant with no further roll out of these systems.

Despite the slow progress in the implementation of the solar water heater project, ZESCO is to be commended for taking such an initiative. However, the current business model of the project will make it extremely difficult for the utility to deploy the intended number of solar water heaters and realise the expected electricity savings. Therefore fundamental measures need to be taken to create strong a programme with a sound business model that will lead to the large uptake of solar water heaters in the country. One of the most successful solar water heater dissemination programmes in Africa is the Tunisian PROSOL, started in 2005 by the Ministry for Industry, Energy and Small and Medium Enterprises and the National Agency for Energy Conservation (ANME) with the support from the United Nations Environment Programme (UNEP).

The objective of PROSOL was to stimulate uptake of solar water heaters to replace Liquified Petroleum Gas (LPG)-fired boilers and electric water heaters, thereby reducing the country's reliance on LPG imports. The success of PROSOL was due in part to its innovative business model and the active participation of all of relevant actors in the sector, especially local financial institutions. The main local actors involved in the design and implementation of the programme were the national utility STEG (Tunisian Company of Electricity and Gas), the ANME, local commercial bank Attijari Bank, local suppliers (importers and manufacturers) and installers, as well as the renewable energy association. The business model was designed in a way that solar water heater suppliers accredited by the ANME (which developed a series of technical requirements and performance standards of solar water heaters), would act as indirect lenders to the utility customers who enter an agreement with both the suppliers and the utility, committing themselves to pay back the loan over a five-year period through their electricity bill after an initial 10% down payment. Finally the bank dealt directly with both the suppliers and the utility by opening a credit line for the utility and paying the suppliers in full upon satisfactory installation of the SWHs. This arrangement allowed for a risk mitigation scheme as the customers could see their electricity suspended in case of non-payment of their bill while the utility acted as a guarantor to the customer's loan. The model is presented in Figure 10.

It is important to note that prior to the PROSOL there were seldom any incentives that would favor the uptake of solar water heaters in Tunisia, especially with the presence of 50% subsidy in the LPG sector. Moreover the dissemination of solar water heaters was conducted with no involvement of the private sector and no robust quality control system. PROSOL allows for the establishment of a self-sustaining market for solar water heaters and the setting up of accompanying policy and regulatory instruments to create an enabling environment as well as reducing the commercial lending rate for solar water heaters by half.

RECOMMENDATIONS

Zambia aims at to increase access to electricity for its rural population through a wide range of solutions where renewable energy plays a critical role. Two of the solutions considered by all stakeholders in the sector include the dissemination of solar PV systems and the setting up of decentralised renewable energy mini-grids. However, much more needs to be done to scale up the deployment of these technologies. The relatively small size of the off-grid market and poor affordability for end-users does not make it substantially attractive to foreign investors, which is why the sector has mainly involved local private operators with the support of donors and development partners. Local private operators face technical and financial constraints that include lack of technical expertise to develop bankable proposals, insufficient working capital due to difficult access to loans, high interest rates due to high risk perception and lack of expertise from local financial institutions in appraising off-grid renewable energy proposals. Therefore local private operators and financial institutions' capacity to develop and appraise bankable renewable energy project proposals should be built.

The country's objective of increasing rural access to electricity would be facilitated by creating a level playing field for local private sector involvement. On the one hand, the support provided by the OPPPI to power project developers (with projects

greater than 10 MW), which includes acquisition of water rights, licenses and permits, facilitation and technical support in environmental impact assessments (EIAs), should be extended to small-scale decentralised renewable energy mini-grids (of a size less than 10 MW). On the other hand, the rural electrification approach should cater to commercially oriented sustainable electricity service delivery by providing performance and matching grants, in additon to technical assistance for private sector led project proposals.

As affordability of electricity is a key issue in rural Zambia, options to facilitate end user access to electricity services should include targeted subsidies and deferred payments schemes that could be pre-financed directly by the service providers or through a micro-finance institution. A sound business model should be developed for both stand-alone systems and mini-grids to increase viability and sustainability of decentralised renewable energy projects and access to electricity services in rural Zambia.

As ZESCO has clearly expressed willingness to deploy solar water heaters, a programme could be developed involving all relevant stakeholders (MMEWD, ZBS, ZDA and energy service companies). Such a programme would include capacity-building for all stakeholders (policy makers, financial institutions, suppliers, installers and others) and would lead to the development and enactment of supportive policies and measures (including setting up mandatory quotas for different categories of end users, inclusion of solar water heaters in the building codes, financial and fiscal incentives). It would also bring about an effective communication strategy including an awareness raising campaign aimed at customers and financial institutions, and strong quality control comprising the setting up of solar water heater standards and a certification scheme for installers to ensure proper operation and maintenance.

BIOFUELS

Zambia imports all of the petroleum it requires in the form of spiked crude oil, transported through the TAZAMA Pipeline and refined at the Indeni Petroleum Refinery in Ndola in the Copperbelt Province. Petroleum contributes to about 9% of the national total energy requirement as it plays a crucial role in the country's key economic activities that includes mining, agriculture and transport (ZDA, 2013). Due to economic growth, the country's petroleum consumption increased rapidly in recent years, reaching an average monthly consumption of about 52 million litres in 2009 and is projected to grow at around 40% per annum (Ibid). The country's reliance on imported fuel, subjected to price volatility, to sustain its economic activities has prompted consideration of alternative solutions. The country's suitable climate, vast arable land and abundance of fresh water resources has stimulated the promotion of the cultivation energy crops for biofuel production with the dual vision of reaching the agricultural reform targets and reducing the dependency on imported oil.

A large programme for the promotion of biofuels was initiated following the adoption of the NEP, which provides for the use of biofuels as a source of modern energy through its integration in the transport industry. In that regard, statutory instruments legalising biofuels, standards and regulatory framework on biodiesel and pricing methodologies were developed. Institutionally, the Biofuels Association of Zambia, the Civil Society Biofuels Association and District and provin-

Biofuel crops in rural Zambia
Courtesy: REA

cial biofuels farmers associations have all been formed. In order to enhance the biofuels sector the government is intending to declare it a priority sector so that investors can benefit from the appropriate incentives.

Furthermore, blending ratios for bio-ethanol and bio-diesel have been set at 10% (E10) and 5% (B5) for ethanol and biodiesel respectively. A land zoning exercise was completed with support from the Government of Brazil under a MoU signed between the two governments. The study looked at appropriate zones for the development of energy feedstocks, including: cotton, peanut, rice, sugarcane, elephant grass, eucalyptus, bean crop, sunflower, jatropha, caster beans, manioc, corn, African oil palm and soy. The study concluded that sugarcane for ethanol production may be the only viable solution for biofuel production, with a potential ethanol production of 127 million litres per year for 72,000 tonnes of sugar per year for a total cultivated area of 200 km^2 and would require a capital investment of USD 471.5 million with an internal rate of return of 22%. (FGV PROJETOS, 2013). Currently, there are two major sugar plants, namely Nakambala Sugar and Kafue Sugar, producing an estimated 400,000 tonnes and 20,000 tonnes of sugar, respectively.

Their combined molasses waste can produce an estimated 40 million litres per annum. If implemented, this figure can contribute to Zambia's ethanol demand at the recommended 10% blending.

Despite the initial enthusiasm for biofuels, the sector has performed poorly due to many factors including, but not limited to the following:

- lack of systematic research on feedstocks oil yield, especially in the case of jatropha

- lack of coordination on the supply side (farmers are dispersed and operate individually)
- land issues and impacts on surrounding communities
- high cost of doing business due to difficult access to concessionary funds
- lack of appropriate delivery infrastructure at the national level including storage infrastructure, blending infrastructure at pump stations
- lack of interest to invest in blending facilities by the local oil marketing companies (OMCs)
- lack of adequate infrastructure to deliver the product to market, combined with the difficult access to the foreign markets (namely European Union markets) due to trade restrictions

RECOMMENDATIONS

As the local market for biofuels is still to be established and accessing international markets has proven to be difficult, there can be some benefit from a review of the biofuel strategy and the development of sustainability criteria for biofuel productionto open the international market.

Research and development in the biofuels sector is paramount to ensuring sound development of its value chain. Funding should be made available for local research institutions to conduct further assessment of economically feasible energy crops, experimentation on cost effective ways to improve the oil yield ratios and disseminate lessons learnt and establish best practises for contracting out grower farmers and large-scale plantation owners.

OPPORTUNITIES AND CONSTRAINTS FOR SCALING UP RENEWABLE ENERGY DEPLOYMENT

OPPORTUNITIES

Zambia is a credible democratic country and hence is an attractive destination for investment. The country is putting in place some conducive policies, strategies, laws and regulatory and institutional frameworks to promote RE, although strengthening is required to achieve the desired results. The energy sector is liberalised to some extent with participation of the private sector, albeit small. The government is moving towards a study on RE feed in tariffs and determination of long run marginal costs, both of which can assist in determining cost-reflective tariffs for electricity. The movement to rationalise PPAs and approve of an open grid system will also be attractive to potential private investors and energy off-takers. The ambitious targets set for access to modern energy, particularly electricity, are a strong sign of the government's support for the energy sector, which is expected to have a positive response from the investor community.

At the regional level there is a strong movement to embrace non-hydro renewable energy, as countries in the SAPP have started to determine their grid capacity to accommodate renewable energy and policies to import renewable energy-based electricity, as can be seen in South Africa. The regional grid continues to be strengthened to enable sharing of electricity in the region. Given Zambia's ample solar, wind and geothermal resources and its central position in the SAPP, the country could play a leading role in expanding non-hydro renewable energy in both the SAPP and Eastern African Power Pool (EAPP) (through Tanzania).

The country would therefore greatly benefit from the African Clean Energy Corridor Initiative being developed by IRENA that aims to harness the renewable energy potential of countries in the SAPP and EAPP by engaging stakeholders in the planning and zoning, creating the enabling environment to upscale the deployment of renewable energy in cross-border electricity trade. The country could further benefit from the Mini-Grid Policy Toolkit currently being developed by the European Union Energy Initiative Partnership Dialogue Facility/ Renewable Energy Co-operation Programme (RECP),

in partnership with the Renewable Energy Network for the 21st Century (REN21) and the Alliance for Rural Electrification (ARE). This toolkit is aimed at building awareness of the potential and applicability of renewable energy mini-grids to policy and decision makers in order to improve the policy and regulatory framework to upscale mini-grid deployment.

CONSTRAINTS

The major constraint remains as investment, which is negatively affected by the non-cost reflective tariffs and limited

incentives to invest in renewable energy. The high costs of capital also limit local investors who could venture into renewable energy investment.

New potential investors also lack the capacity to develop bankable projects that can attract funding. Innovative financing mechanisms to buy down cost of capital and risks are thus needed to enable the growth of renewable energy in Zambia.

Poverty is also still rampant in Zambia, limiting the majority of its population from access to clean renewable energy, due to lack of affordability.

The off-grid market that can benefit the majority is driven by non-mainstream investors and is often supported by short term donor support, which means that projects rarely survive after donor support ends.

Reaching Zambia's widespread communities in an effort to reach energy access targets will require substantial investment in distribution networks,

in addition to generation and transmission capacity. Zambia used to benefit from support for 'least developed countries' (LDCs) but has now moved away from the LDC group and hence does not qualify for some sources of funding that very poor nations can avail,such as debt relief.

V. SUMMARY OF RECOMMENDED ACTIONS

Based on the inputs from the RRA process and validation workshop, Zambia has been advised to pursue cross-cutting actions for on-grid energy, off-grid energy and biofuels:

ACTION	STEPS
Develop integrated resource planning that considers all renewable energy sources	• Secure funding for renewable energy resource assessment, including measurement campaigns • Seek technical partners and expertise to assess the economic potential of renewable energy and grid capacity to accommodate variable power • Initiate a consultative process to develop the integrated resource plan
Revise renewable energy policy and adopt strategy to set renewable energy targets	• Organise stakeholder consultations on required revisions of the renewable energy policy and strategy • Elaborate realistic and achievable targets based on renewable energy's economic potential • Develop a strong implementation and monitoring frame work to achieve the targets
Revise and adopt the draft Grid Code, including provisions and conditions for renewable power	• Revise the draft Grid Code to ensure it includes all aspects such as guidelines and standards for connecting and managing variable power sources, like solar and wind • Fast track the approval process of the revised Grid Code and its formal adoption

Develop the policies and regulatory framework to facilitate private-sector involvement in decentralised renewable energy technologies	• Extend the support provided by the OPPPI to large-scale power projects to small-scale decentralised renewable energy projects • Provide technical and financial assistance to private sector-led decentralised renewable energy projects
Develop a programmatic approach for utility-scale renewable energy power projects with the requisite financial incentives that is backed by a standardised bankable Power Purchase Agreements	• Initiate a programme with all relevant stakeholders to develop a large-scale renewable energy power portfolio of projects subsequent to the resource assessment and amendment of the existing Power Purchase Agreements to be standardised and bankable
Establish tailored business models for private-sector involvement in off-grid renewable energy systems	• Revise the rural electrification strategy to provide technical and financial assistance to private operators • Provide performance-based and matching grants to private operators • Develop a deferred payment scheme and/or targeted subsidies to increase affordability of renewable energy systems to end-users
Build capacity for renewable energy deployment	• Build capacity of local private operators in the development of bankable off-grid project proposals • Build capacity of local financial institutions in appraising renewable energy power projects, especially decentralised ones • Build capacity of relevant institutions to support the development of renewable energy standards and certification schemes for installers

Develop the framework and sustainability criteria for feedstock optimisation and biofuel production	• Revise the biofuels strategy to demonstrate sustainability criteria to attract investment and open access to international markets • Secure financing for a feasibility study to address all aspects of the biofuels value chain • Support research on best yielding feedstocks, particularly for biodiesel to disseminate to outgrowers

The actions identified can play an important role in increasing Zambia's readiness to scale up renewable energy. The actions (elaborated in the Annex) are designed to be implementable in the short to medium term, largely by the Government of the Republic of Zambia.

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Photovoltaic panels
Courtesy: REA

ANNEX: DETAILED DESCRIPTION OF RECOMMENDED ACTIONS

The RRA process identified and recommended the actions below. These are not given in any order of priority, and the list of action points from a rapid assessment is unlikely to be exhaustive. But these actions could improve Zambia's readiness to scale up its renewables deployment. They are designed to be taken in the short- to medium-term, largely through decisions made by the Government of Zambia.

Action 1: Develop integrated resource planning for all renewable sources

Action	Development of integrated resource planning that considers all renewable energy sources
Resource-service pair(s)	On-grid electricity involving all renewable energy (biomass, geothermal, hydro, solar and wind)
Description	Zambia's electricity supply mix is overwhelmingly hydro-based, at 99.9%, making the country vulnerable to any climate hazard, such as droughts, floods, etc. Further, electricity demand in Zambia is projected to increase at 4% per annum. This will lead to exhaustion of electricity potential, estimated at 6,000 MW in the year 2030. Integrated resource planning is becoming an important tool that allows key stakeholders to participate in the identification and optimisation of the appropriate mix of energy resources to meet near- and long-term electricity needs in a sustainable way. This also enhances the security of energy supply by including all economically viable and environmentally friendly energy resources. It is important for Zambia to initiate a dialogue that would include all relevant stakeholders in the development of an integrated resource plan for power generation that will help guide the country in diversifying its electricity mix while meeting future demand. A premise to such an activity is the undertaking of a thorough renewable energy resource assessment. A renewable energy resource assessment can trigger a remarkable change in decision makers' perceptions, knowl-

	edge base and awareness of the country's renewable potential and opportunities, thereby allowing them to make more informed decisions.
Stakeholders	Ministry of Mines Energy and Water Development; Ministry of Agriculture and Livestock; Ministry of Finance; Energy Regulation Board; Zambia Electricity Supply Corporation (ZESCO); other relevant stakeholders
Timing	18 months
Keys for success	Leadership of the Ministry of Mines Energy and Water Development and broad consultations with all relevant stakeholders

Action 2: Revise approach to setting renewable energy targets

Action	Revision of renewable energy policy and the strategy employed to set renewable energy targets
Resource-service pair(s)	All applications
Description	Zambia's renewable energy strategy stipulates defined targets for the deployment of renewable energy power generation. However, these targets have been set without any thorough investigation of the economic potential of each renewable energy resource considered (solar, small hydro, geothermal and biomass). Moreover, cost implications of each renewable energy technology, as well as socio-economic opportunities, were not considered when developing targets. Moreover, there is no clarity on the expected share of renewable power to be supplied to the grid, nor on how the grid will be adapted to accommodate variable power. There is therefore a need for the Ministry of Mines, Energy and Water Development and relevant stakeholders to undertake a thorough study of renewable energy potential (including both technical and economic). This may lead to the review of the current targets for more realistic and achievable ones. This would provide a clear policy signal to attract private-sector investment in renewable energy, especially if the targets include a mandatory clause for power generators and those who off-take bulk power. It would be worthwhile for Zambia to undertake target revision upon completion of the renewable energy resource assessment, and to develop a strong implementation and monitoring framework to achieve the revised targets.

Stakeholders	Ministry of Mines, Energy and Water Development; Ministry of Finance; Energy Regulation Board; ZESCO; Rural Electrification Authority; other relevant stakeholders
Timing	18 months
Keys for success	Leadership from the Ministry of Mines, Energy and Water Development and broader consultations with all relevant stakeholders.

Action 3: Revise and adopt the draft Grid Code, including renewable power provisions

Action	Revision and adoption of the draft Zambia Grid Code, including its provisions and conditions for renewable energy-based power
Resource-service pair(s)	For on grid-electricity generation
Description	A grid code is a critical element in the management and operation of a power system. As renewable-energy power requires flexible conditions for its adequate integration, the grid code must incorporate options that would allow renewable power integration without affecting grid safety and stability. The draft Zambian Grid Code, although allowing open access to the grid for Independent Power Producers, does not provide any guidelines or standards for accommodating renewable energy-based electricity. For instance, the current power forecast time is set a day ahead, which is not favourable for renewable energy types, particularly wind and solar, due to their variability. Best practises show that forecasts are more accurate the closer they are to real time, and sub-hourly scheduling is recommended. The Grid Code should additionally provide priority to renewable power in the dispatch schedule. The draft Grid Code, before its formal adoption, should integrate these necessary conditions to allow more renewable energy-based power on the grid. The use of forecasts requires operational changes, with grid operators being enabled to integrate forecast data in daily operations and equipped with the necessary tools, such as sophisticated information and communication infrastructure, for better system-wide decision-making.

Stakeholders	Ministry of Mines, Energy and Water Development; Energy Regulation Board; ZESCO; Independent Power Producers; Office for Promoting Private Power Investment; others
Timing	Up to 12 months
Keys for success	The Ministry of Mines, Energy and Water development should lead the revision and fast track the formal adoption of the Zambian Grid Code in consultation with relevant stakeholders

Action 4: Develop policies and regulations for private-sector involvement in decentralised renewable technologies

Action	Development of lighter-handed policies and a regulatory framework to facilitate private-sector involvement in decentralised renewable energy technologies
Resource-service pair(s)	Off-grid electricity
Description	The rural electrification rate in Zambia is relatively low, estimated at 4%. Current efforts to increase rural electricity access focus on grid extension. The country's objective of increasing rural access to electricity would be facilitated by creating a level playing field for local private-sector involvement. Furthermore, the support provided by the OPPPI to power project developers (with projects greater than 10 MW), which includes acquisition of water rights, licenses and permits, facilitation and technical support in environmental impact assessments (EIAs), should be extended to small-scale decentralised renewable energy mini-grids (of a size less than 10 MW).
Stakeholders	Rural Electrification Authority; Energy Regulation Board; Ministry of Mines, Energy and Water Development; Ministry of Finance; Ministry of Local Government and Housing
Timing	18 months
Keys for success	Involvement of all stakeholders

Action 5: Develop utility-scale renewable power projects with a bankable purchase agreement

Action	Development of a programmatic approach for utility-scale renewable-energy power projects with the requisite financial incentives that is backed by a standardised, bankable power-purchase agreement.
Resource-service pair(s)	On-grid electricity
Description	In Zambia, power-purchase agreements are drawn up on a case by case basis and have only been concluded for hydro- and fossil fuel-based generation. Attracting investment in variable renewable energy-based power for the grid could be enabled by considering important factors to strengthen the bankability of a power-purchase agreement. These could include mitigating dispatch risks, through clauses for calculating the tariff based on the energy delivered, by embedding either a fixed charge not dependent on dispatch, or a capacity charge along with charges for the energy actually delivered. This would make the power-purchase agreement bankable by providing enhanced predictability of revenue streams for each power plant. A programmatic approach for utility-scale renewable-energy power projects would have to include the requisite financial incentives and be backed by a standardised, bankable power-purchase agreement, in order to attract scalable investment, limit elaborate and tedious negotiations, and give potential investors clear expectations on their investment.
Stakeholders	Ministry of Mines, Energy and Water Development; ZESCO; Energy Regulation Board; other relevant stakeholders
Timing	Up to 18 months
Keys for success	Engagement of the Ministry of Mines, Energy and Water Development with all relevant stakeholders in a consultative process to develop a standardised power-purchase agreement to increase the bankability of renewable-energy power projects

Action 6: Establish business models for private-sector off-grid renewable energy

Action	Establishment of tailored business models for greater involvement of the private sector in promoting off-grid renewable energy systems
Resource-service pair(s)	Off-grid all applications
Description	The country's objective of increasing rural access to electricity would be facilitated by creating a level playing field for local private-sector involvement. On the one hand, the support provided by the Office for Promoting Private Power Investments to power project developers (with projects greater than 10 MW), which includes acquisition of water rights, licenses and permits, facilitation and technical support in environmental impact assessments (EIAs), should be extended to small-scale decentralised renewable energy mini-grids (of a size less than 10 MW). On the other hand, the rural electrification approach should cater to commercially oriented sustainable electricity service delivery, by providing performance and matching grants as well as technical assistance to private sector-led project proposals. As affordability of electricity is a key issue in rural Zambia, options to facilitate end-user access to electricity services should include targeted subsidies and deferred payments schemes that could be pre-financed directly by the service providers or through a micro-finance institution. A sound business model should be developed for both stand-alone systems and mini-grids to increase the viability and sustainability of decentralised renewable energy projects and access to electricity services in rural Zambia.
Stakeholders	Ministry of Mines, Energy and Water Development; Rural Electrification Authority; others
Timing	Up to 18 months
Keys for success	Engagement of all stakeholders, in particular the Rural Electrification Authority

Action 7: Build capacity for renewable energy deployment

Action	Capacity-building initiatives to support renewable energy deployment
Resource-service pair(s)	All applications
Description	The relatively small size of the off-grid market and poor affordability for end-users does not make it substantially attractive to foreign investors, which is why the sector has largely only attracted local private operators, with the support of donors and development partners. Local private operators face technical and financial constraints that include lack of technical expertise to develop bankable proposals, insufficient working capital due to difficult access to loans, high interest rates due to high risk perception, and lack of expertise from local financial institutions in appraising off-grid renewable energy proposals. Therefore,the capacity of local private operators and financial institutions to develop and appraise bankable renewable energy project proposals should be built. Capacity building for all stakeholders (policy makers, financial institutions, suppliers, installers and others) has to be accompanied by the development and enactment of supportive policies and measures (including setting up mandatory quotas for different categories of end users, inclusion of solar water heaters in the building codes, financial and fiscal incentives). Such initiatives must also involve an effective communication strategy, including an awareness-raising campaign aimed at customers and financial institutions, and strong quality control, including setting up solar water heater standards and a certification scheme for installers to ensure proper operation and maintenance.
Stakeholders	Ministry of Finance; Ministry of Mines Energy and Water Development; Office for Promoting Private Power Investment; Rural Electrification Authority; Zambia Development Agency; financial institutions
Timing	Up to 18 months
Keys for success	Engagement of all stakeholders and goodwill from financial institutions

Action 8: Develop the framework and sustainability criteria for feedstock optimisation and biofuel production

Action	Development of a comprehensive framework, including sustainability criteria, and encourage research and development for feedstock optimisation and biofuel production
Resources-service pair(s)	Biofuels
Description	Zambia, due to its suitable climatic and soil conditions, has a wide variety of crops suitable for bioenergy production. With large areas of currently unutilised arable land, Zambia is strategically positioned as a country with enormous potential for biofuel production. Of great importance is the need to address sustainability and cost-effectiveness issues. Sustainability of feedstock production requires assessment of land availability and suitability, which takes account of land requirements for food production and biodiversity. Another important requirement is the development of standards and regulations for the biofuels industry. In the last few years, good progress has been made in the promotion of the biofuels industry in the country. The biofuels industry has been added to a list of priority industries to benefit from incentives through the Zambia Development Agency. At the regulatory level, trade in biofuels has been permitted, while ethanol and biodiesel standards are now available. However, some issues still need attention, including financing, cost-effectiveness, sustainability, transportation, storage and pricing. To address these issues, a study is being conducted on the development of a comprehensive framework, taking account of production and marketing arrangement modalities, including a dedicated fund to support feedstock and biofuel production, land availability and suitability assessments, development of sustainability criteria, and research and development for feedstock optimisation.
Stakeholders	Ministry of Mines, Energy and Water Development; Ministry of Agriculture and Livestock; Energy Regulation Board; Zambia Environmental Management Agency; Biofuels Association of Zambia
Timing	Up to 18 months
Keys for success	Engagement of all stakeholders, in particular the Ministry of Agriculture and Livestock

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