International Renewable Energy Symposium - Windhoek, Namibia (IRES - 2015)

Renewable Energy for Economic Prosperity

29 and 30 October 2015
Nampower Convention Centre

Book of Abstracts

ires
international renewable energy symposium Namibia 2015

Conveners

Welcome note by the Honourable Obeth Kandjoze, Minister of Mines and Energy

On behalf of the Government of the Republic of Namibia, let me take this opportunity to welcome you all to Namibia and to the African continent for those who are coming from overseas.

Today marks a very important day for Namibia as we host this International Renewable Energy Symposium, which aims to provide a platform for exchange of ideas towards 100% access to energy in Namibia and economic prosperity. It is indeed an honour for such a prestigious event on Renewable Energy to take place here in Namibia. This happens after 82 countries around the globe, adopted a declaration that calls for the up-scaling and increased deployment of renewable energy in order to improve global energy access and security and strive towards mitigating greenhouse gas emissions. Such a declaration was adopted at the closing of the South African International Renewable Energy Conference (SAIREC) on the 6 October 2015.

In addition, I would like to express Namibia's deep gratitude for being selected as the host country for the SADC Centre for Renewable Energy and Energy Efficiency (SACREEE) after a long drawn out, thorough and extremely competitive bidding process involving SADC Member States. In this process, no country should be considered as a winner or loser, and victor or vanquished. It is the SADC region that is the ultimate winner, and by extension, ALL the SADC Member States. The SADC region is the winner in a sense, because after all SADC Member States unequivocally expressed the urgent need to establish SACREE, the process then took us almost three (3) years.

I would submit that with the prevailing precarious and tight electricity supply, we do not have the luxury of time of unduly prolonging the establishment of SACREEE. The unfortunate situation in which the SADC region finds itself calls upon us to offer the necessary political leadership to ensure that measures are undertaken to enhance energy security by diversifying the energy supply options. SACREEE's mandate, if appropriately or effectively discharged, will greatly contribute to scaling up the development of renewable energy, a resource with great potential to contribute to the SADC regional energy security. SACREE is expected to guide the region towards 100 % access to energy while harnessing the abundant energy that flows from renewable energy sources every day. It will also facilitate and coordinate availability of sufficient, reliable least-cost energy services. Additionally

SACREEE will in principle enhance the efforts towards poverty eradication and environmental sustainability.

We also know that it is easier to save a unit of energy than building new capacity for it. Furthermore, improved energy efficiency can also help develop what the Southern African Power Pool (SAPP) calls a "Virtual Power Station". I am pleased to note that energy efficiency is part of SACREEE's mandate and we look forward to advances in this area to assist us in managing the energy supply challenges in the short to medium terms. The energy consumer should also be capacitated with knowledge on energy efficiency, and economically viable demand side management.

I would also like to take this opportunity to congratulate Professor Tjama Tjivikua, the Rector of the Polytechnic and his team for the successful transformation of the Polytechnic of Namibia into Namibia's University of Science and Technology. May this transformation impact the regional initiatives in the energy sector as well!

We welcome you all to Namibia and we invite you all to join us in this platform to create partnerships in scaling up renewable energy, and increase the benefit through investments, building skills and creating jobs to strengthen our economies. We hope that you will also take the opportunity to enjoy the beauty and richness of Namibia's landscape and hospitality of our people.

Welcome note by Professor Tjama Tjivikua, Rector of the Polytechnic of Namibia

On behalf of the Polytechnic of Namibia community, it is my honour and privilege to welcome you to Namibia, and to the First International Renewable Energy Symposium in Windhoek.

The success of our institution is based on the conviction that development, both national and international, relies on knowledge acquisition and knowledge management. Therefore, as a higher learning institution we cannot be up to date on the latest developments if we are isolated. We should therefore become part of the broader academic dialogue and community where we can learn from each other and teach others. As a result, the Polytechnic of Namibia's partnerships are vast and stretch to all corners of the globe and involve the academic, the industry and other development partners.

The seed of this symposium was sown by one of the projects funded by the European Union through the ACP-EU Cooperation programme in High Education (EDULINK II), whose overall objective is to ensure that the African partner Universities have advanced curricula in sustainable energy exploitation that comply with European quality standards for engineering education. This Southern Africa Sustainable Energy Initiative (SASEI) Project is coordinated by the Polytechnic of Namibia, and is implemented in partnership with the National University of Lesotho, University of Botswana, and the University of Darmstadt in Germany. We are partners to two other EDULINK projects namely, the Programme for Energy Efficiency in Southern Africa (PEESA), and the Participatory Integrated Assessment of Energy Systems (PARTICIPIA), also aimed at building capacity for renewable energy and energy efficiency. We are indeed deeply grateful for the support extended to us by the EU.

It is appropriately fitting that this symposium is held Namibia, a country blessed with abundant solar and wind power potential. As most of you might be aware, our institution, the Polytechnic of Namibia, is transforming to Namibia University of Science and Technology (NUST) and thus introduction of new programmes is one of the focus areas of the University will be to introduce new programmes in science and technology and several postgraduate programmes are being envisaged, including amongst others, a Masters' Programme in

Energy Systems. I am confident that the Polytechnic community and the country at large will benefit from your contributions in this Symposium.

The successful implementation of the development of Namibia, in particular, and of the SADC region in general, will depend on the availability of well-trained and skilled human capital to harness the abundantly available energy resources. The Namibia Energy Institute (NEI) together with the School of Engineering have the responsibility of developing and disseminating knowledge, skills and good practices towards a safer, more secure and sustainable energy system in Namibia.

The entire world has become a global village and knowledge cuts across all types of boundaries. I strongly believe that with the kind of cooperation and collaboration that the international renewable energy symposium seeks to establish between different regions, the country can only move in a positive direction and ultimately, everyone would have access to energy.

Please be open and feel free to share your views, so that at the end, we can come up with a way forward that will be adopted for the benefit of the people of this country and beyond. We all have an obligation to assist our communities and governments in framing policies and implementing projects that bring the much needed development in the region. The region relies on you as energy experts and stakeholders.

I wish you fruitful deliberations in the symposium.

Welcome note from the Symposium Chair

It is with great pleasure that we extend a warm welcome to all participants of the International Renewable Energy Symposium to Windhoek, Namibia. It is fitting that we meet in this beautiful city considering that Namibia has been selected to host the SADC Centre for Renewable Energy and Energy Efficiency (SACREEE).

Namibia over the years has become a striking example of what can be achieved through cooperation, innovation and investment, and the country is honoured to host a Centre which will promote renewable energy and energy efficiency technologies and the development of markets, through sharing of information and best practices, developing sound policy, regulatory, and legal frameworks, and building the capacity within SADC member states for widespread deployment of renewable energy and energy efficiency technologies.

The Symposium will provide a platform for exchange of ideas towards 100% access to energy in Sub-Saharan Africa, and particularly in Namibia. This reflects our intention to further strive for technological, economic, social improvements while making the benefits of renewable power available for all human beings.

During the course of the 2-day Symposium, delegates will be exposed to new areas of research and progress in renewable energy projects implementation in Namibia, the SADC region and the world over. The Scientific Committee has lined up a rich technical programme, which includes high level plenary discussions, key note addresses from renowned experts in the renewable energy sector, technical papers split between 3 parallel oral sessions each day, a field tour and numerous opportunities for informal networking.

I invite you all to use this Symposium to intensify the cooperative relationships between all renewable energy organisations worldwide, and work together for solving our energy problems, protecting the environment, mitigation of climate change, and creating a better world.

We want to thank each of you for attending the conference and bringing your energy and expertise to the gathering. You have the vision, the knowledge, the ability and the experience to help us pave our way into the future.

I wish to extend my appreciation to the Scientific Committee for putting together the technical programme and for their thorough and timely reviewing of the papers. I also wish to thank our various sponsors from government, private sector, CSOs and international Cooperating Partners alike. This event has been made possible because of your generous contributions. Lastly, I would like to recognise the Local Organizing Committee members who have all worked extremely hard for the details of important aspects of the conference programmes and social activities.

Throughout this Symposium, we ask you to stay engaged, and take time to enjoy the rich cultural diversity Windhoek has to offer.

Dr. Zivayi Chiguvare
Symposium Chair - International Renewable Energy Symposium 2015

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International Renewable Energy Symposium Program

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09h10 – 09h20	Welcoming remarks	**Prof. Tjama Tjivikua** Rector of the Polytechnic of Namibia
09h20 – 09h35	Background and Overview of the Namibia Energy Sector	**Mr. Simeon Negumbo** Permanent Secretary of the Ministry of Mines and Energy, and Chairperson of the NEI Advisory Board
09h35 – 09h50	Arts and Cultural Performance	**Amdhi Khoen**
09h50 – 10h05	Keynote Address	**Honourable Obeth Kandjoze** Minister of Mines and Energy
10h05 – 10h20	Vote of thanks	**Mrs Foibe Namene** Chief Executive Officer, Electricity Control Board
10h20 – 10h30	AU Anthem National Anthem	**All**
10h30 – 11h00	**Group photo and Tea Break**	

07h30 – 09h00	**Plenary Session** Ruacana 1 & 2	
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Facilitator: Zivayi Chiguvare **Rapporteur:** Susan Tise		
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12h00 – 12h20	Renewable Energy Penetration in the Namibian Electricity Grid: Possibilities and Realities	Margaret Mutschler
12h20 - 12h40	REEE-powering Namibia – Energising National Development	Detlof von Oertzen
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2. Renewable Energy Resource Availability, Technologies, and the Environment				
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16h10 – 16h25	Panelist 2	2.1.6	2.2.6	PEESA - Nam
16h25 – 16h40	Panelist 3	2.1.7	2.2.7	NEED
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16h55 – 17h15	Discussion	2.1.9	2.1.9	PARTICIPIA
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18h30 – 21h00	**Networking and Symposium Dinner** NamPower Convention Centre			

Facilitator: Ricardo Gaogoseb **Entertainment:** Elemotho		
Parallel Session 1 Ruacana 1		
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Facilitator: Conrad Roedern **Rapporteur:** Abraham Hangula		
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14h25 – 14h40	SASEI Botswana	Andrew Obok Opok
14h40 – 15h05	Sustainable Energy Curriculum Development under the SASEI project at the National University of Lesotho	L. Z. Thamae
15h05 – 15h20	Status of the Energy Sector in Namibia: A Review of challenges and priorities	Al-Mas Sendegeya
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16h10 – 16h25	Programme on Energy Efficiency in Southern Africa-Efforts towards Higher Education	Rajaram Swaminathan
16h25 – 16h40	Capacity Building in Renewable Energy Technologies in Namibia, Zambia and Botswana	Andrew Zulu
16h40 – 16h55	Solar Thermal Training and Demonstration Initiative	Helvi Ileka

16h55 – 17h15	Participatory Integrated Assessment of Energy Systems	Gideon Gope
17h15 – 17h30	Session resolutions	

IRES 2015 Symposium Dinner **Venue:** NamPower Convention Centre **Date:** 30 October 2015	
Director of Ceremonies: Mr. Ricardo Goagoseb	
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18h10	Welcome Remarks by the IRES 2015 Chairperson - **Dr. Zivayi Chiguvare**
18h20	**Dinner Served**
19h00	After-dinner Entertainment with **Elomotho Entertainment Group**
19h20	Recognition of Sponsors of IRES 2015 - **Mr. John Titus - Director Ministry of Mines and Energy and Dr Anna Matros Goreses**
19h40	Acknowledgement of the IRES 2015 Local Organising Committee, and Scientific Committee - **Mr. Simeon Negumbo – Permanent Secretary, Ministry of Mines and Energy**
20h00	Demonstration of Solar Lantern - **NORED**
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21h00	Closing

Day 2: 30 October 2015		
Plenary Session Ruacana 1 & 2		
08h30 – 09h00	Registration	
Report-back from parallel sessions (15 minute Presentations + 5 minute discussion)		
	Facilitator: Elijah Sichone **Rapporteur:**Virginia Roman	
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09h20 – 09h40	Renewable Energy Technologies for Thermal Applications	Werner Weiss
09h40 – 10h00	Training and Capacity building in Renewable Energy	Samuel John
10h00 - 10h30	**Tea Break**	
3. Energy Economics and Financing of Renewable Energy Technologies		
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15h00 – 15h20	Energy policy development	Miika Rämä
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5. Launch of South African Solar Energy Network		
Facilitator: Al Mas Sendegeya **Rapporteur:** Victoria Shipanga		
15h40 – 15h50	Introductory remarks	EU-ACP EDULINK
15h50 - 16h10	Rationale for Sustainable Energy Networks	Prof. Tjama Tjivikua
16h50 - 16h10	Southern Africa Sustainable Energy Network (SASEN)	Moeketsi Mpholo
16h10 – 16h20	Official Launch of SASEN	Rector; VC; DVC
16h20 - 16h25	Vote of Thanks	Andrew Obok Opok
16h25 – 16h35	Arts and Cultural Performance	Amdhi Khoen
Closing Ceremony **Director of Ceremonies:** Mr. Ricardo Goagoseb		
16h40 – 16h50	Symposium Resolutions	Margaret Mutschler
16h50 – 17h00	Vote of Thanks	Hon Minister of Mines and Energy
17h00	Closing	

ENERGY ACCESS FOR ALL THROUGH SUSTAINABLE ENERGY TECHNOLOGIES, ECONOMICS, & POLICIES

CHAPTER 1:

Options for Increasing Energy Access Worldwide

Energy Resources and Harmonisation of Their Exploitation in Sub-Saharan Africa with an Initial Focus on Southern Africa

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Abstract

In this paper, a previously developed SADC regional long range electricity planning model (the IRENA SPLAT model), is encapsulated in a grid computing (Amazon StarCluster) framework, enabling the combination to deliver advanced sensitivity analysis, monte-carlo simulation, as well as constrained and unconstrained least cost optimisations for Transmission and Generation expansion in the region as impacted by climate change influences. This solution was specifically established to investigate the impacts of climate change (e.g. long range changing water availabilities and changing temperatures) on the optimisation of different forms of energy sources of generation, per country, and for the region. The energy portfolio includes traditional fossil fuels, nuclear, hydro and renewables with capacity to add any other. The project is a work in progress, with this paper presenting an active, working demonstration model, where a GIS based graphical user interfaces has been established, and where inputs to the IRENA SPLAT models, in the grid computing architecture, are controlled via sliders and a graphical user interface, making for simple interaction, scenario and sensitivity analysis for power system planning, regulatory or renewable engineers and analysts. The outputs in turn may be sliced and diced in pivot mode in the graphical tool itself, or exported as detailed results into an Excel configuration. Utilizing the demonstration model thus far, the audience will be shown, live, how changes in water availability affect the deployment of all renewable energy resources, and the consequential impacts on total investment costs, operational/fuel costs and ultimately the affordability and sustainability of electricity in the region as a whole, or per country.

Keywords: *Renewable energy resources, SADC, monte-carlo simulation, climate change, GIS, IRENA SPLAT models*

Renewable Energies – Key to Sustainable Development

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Abstract

Sustainable development is the organizing principle for sustaining finite resources necessary to provide for the needs of future generations of life on the planet. It is a process that envisions a desirable future state for human societies in which living conditions and resource-use continue to meet human needs without undermining the "integrity, stability and beauty" of natural biotic

systems. Spatial Organization is a key issue for sustainable development in general because transportation is a large contributor to greenhouse gas emissions. On a global average, more than one-third of all gasses produced are due to transportation processes. Integrated spatial planning of the built environment at all scales and in all dimensions (codes of law, construction…) can forward sustainable development in two ways:

- by reducing energy consumption; and
- by realizing the potential of renewable energy resources via integrating infrastructural planning with facility planning.

Renewable energy resources combined with now available grid technologies show a huge potential for development provided the possibilities for harvesting and in-grid-storage are integrated in intelligent ways. Concentrated energy harvesting can be combined with distributed feed-ins as well as local and temporally phased consumption; insular, off-grid and on-grid solutions can be integrated into an overall system with great advantages on the issues of future change and of storage. The most important prerequisite to launch a working roadmap for such a sustainable development is modeling the situation found in a defined model region (urban, semi-urban, and rural). Different strategic goals, different stakeholders' interests have to be incorporated to achieve a complex dynamic systems model that enables us to derive economically and technically feasible actions. I would like to show demonstration examples from our work for the GAM (Greater Amman Municipality)/Jordan and excerpts from the German national project "Showcase Electro mobility".

Keywords: *Sustainable development, spatial organization, greenhouse gas emissions, renewable energy, complex dynamic systems model*

Renewable Energy Resources and Technologies Availability in the SADC Region

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Abstract

Energy security was a key issue driving the formation of SADC in 1980, and it remains critical today. The region has enormous renewable energy resources that can serve as a strong basis for improved energy access, energy security and poverty alleviation within the region and across Africa as a whole. The resources are mainly small hydro, biomass, solar wind geothermal and tidal waves. In spite of the resources being abundant, their deployment in the region is still low; therefore there is a need to stimulate the uptake of RE technologies. Research and development are required for the adaptation of appropriate technologies to local conditions and also grow the

necessary human resources to support the industry. Research, development and demonstration contribute in creating the awareness and an enabling environment to grow the market.

As the renewable energy resources are unevenly distributed among the member countries, pooling and sharing resources is the only viable option. Energy security can be improved through increased electricity interconnections among SADC member states and/or by improving the reliability of existing power systems. But most RE projects, particularly those involving more than one country often take too long to be realized. This is mainly due to challenges with infrastructure, cross-border trade regulation and the fact that sometimes national interest prevail over regional energy needs. There is therefore a need to build regional institutions that will ensure that member countries harness the renewable resources for economic growth and sustainable development. Some of the strategic areas that can facilitate and catalyse the deployment are awareness raising on the benefits of renewable energy technologies, localization and development of country appropriate technologies and capacity building.

Keywords: *Renewable energy resources, energy security, SADC, RE technologies, research and development, pooling and sharing, infrastructure, regulations, deployment*

REEE-powering Namibia – Energising National Development

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Abstract

Namibia's energy sector is highly import dependent and remains extremely vulnerable: all liquid fuel requirements are imported, while more than 60% of the annual electricity needs are sourced abroad. This dependency constitutes a critical strategic risk, and necessitates currency outflows of billions of dollars every year. Payments leaving the country seldom create local jobs, or lift Namibians out of poverty, or bring about long-term local development. This state of affairs is clearly undesirable, and should not be perpetuated. And it does not have to, as alternatives have never before been as realistic and feasible as they are today: REEE-powering is the intentional large-scale adoption and use of renewable energy, energy storage and energy efficient technologies, which have become increasingly viable as a result of rapid technological advances made in the past years. REEE-powering is underpinned by local comparative advantages and strengths as offered by Namibia's abundant renewable resource endowments. By actively and deliberately REEE-powering Namibia's domestic, commercial, industrial and utility landscapes, the country's renewable energy blessings can be leveraged to energise national development, thereby creating local value that yields tangible long-term social, economic and environmental benefits. REEE-powering Namibia is therefore a choice for local value creation, and against the ongoing export of value and opportunities. Today, Namibia's energy sector continuously exports opportunities, which in turn limits local growth and

development opportunities. As is demonstrated in this paper, REEE-powering Namibia addresses several critical strategic aspects, such as strengthening the security of local energy supplies, reducing the foreign exchange dependency while lessening the impacts of foreign exchange fluctuations on the country's economy, while transforming Namibia's energy supply systems into development engines that power local sustainable value creation and national development.

Keywords: *Namibia's energy sector, vulnerable, renewable energy, storage and energy efficient technologies*

Renewable Energy Penetration in the Namibian Electricity Grid: Possibilities and Realities

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Abstract

Namibia is a vast country blessed with unparalleled solar resource, save for few other sunny places. Namibia's wind data confirmed substantial useful wind energy potential along the coast of Namibia. Solar photovoltaic (PV) plants can, literally, be erected on any surface under the sun. The opportunity for concentrated solar power (CSP) to be used as a heat source has not yet been quantified in Namibia. Hybridized with other energy resources, renewable energy can be a large contributor towards addressing the rural electrification dilemma. Renewable energy based generation can be load-sized and located close to load centers to match local demand, and therefore, save on substantial transmission losses. Transmission system engineers are enthusiastic about CSP solving some challenging network stability issues. The list of value additions on grid level, socio economic benefits and macro-economic benefits make renewable energy an attractive option for key decision makers in board rooms and parliament chambers. However, the positive energy and hype bubble deflates suddenly when the investors have to spend their money in Namibia building renewable power generation. There is a healthy debate on CSP meeting grid parity levels.

The GDP per capita in Namibia is USD 5666 [World Economic Database April 2014]. The GI coefficient is 59, one of the worst in the world. The unemployment in some areas of Namibia is quoted to be as high as 50% with an average of 2-3 out of 10 people in Namibia not benefiting from gainful employment. The affordability of electricity is considered to be a critical success factor for Namibia to eradicate poverty and reach its National Development objectives. Is renewable energy an affordable solution to Namibians?

The examination will not be complete without an honest hard look at supply alternatives. Namibia is importing a substantial amount of its consumption from its Southern African power

Pool (SAPP) partners. The same partners are also suffering from supply deficits and threatened with security of supply crises. Namibia is not blessed with large dams, big rivers and huge hydro storage. The one bankable gas source found has P90 recoverable resources for less than two decades. Its coal resources are still only entrepreneurial dreams and will be costly (in more than one way) to commercialize. Namibia has yet to find oil. Therefore all other resource estimations pale in comparison to the abundance of Namibia's solar resource. How vital is it to Namibia to exploit is abundant renewable energy resource?

The author will lead the reader down a thought provoking path to answer the question: Is renewable energy unaffordable for Namibians or is it vital to the development of Namibia? The paper will address demand, discuss the factors influencing demand, and briefly address price elasticity of both grid and off-grid consumers. The underlying tariffs and tariff paths are critical to answer the question of affordability and grid parity. The author will address transmission and grid related challenges and value, socio economic and local content value, macro-economic value and lastly the significance of reducing greenhouse gasses and carbon footprints. Strategies to reduce renewable energy cost, key cost drivers, and long term competiveness issues will be discussed and explored and weighed against the significant aspects that could constraint the success of renewable energy in Namibia. Lastly, the author will explore opportunities beyond Namibia's borders to supplement regional supply options by implementing renewable energy in Namibia contributing to the regional project volume and pipeline.

Keywords: *Renewable energy penetration, wind, solar, hybridized, unemployment, Southern African power pool, security of supply*

Capacity Building for Sustainable Energy Development: Role of the Academia

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Abstract

In all aspects of sustainable energy the following key issues are always mentioned: affordability, reliability, accessibility, clean (e.g. low Carbon, SOX, COX, NOX, toxicity etc.), renewable sources, energy efficiency and conservation, and consumer empowerment. All these concepts are more understandable among technocrats and academia than key stakeholders (policy makers, financers, developers, users etc.). It is important to preach these issues to the community in a clear context for sustainability of the energy sector. With the modern energy mix, renewable energy sources play a significant to contribute to positively to the realisation of other issues. Despite all the opportunities for economic and human development provided by renewable energy resources, and the promising growth in the technologies experienced so far the renewable energy sector still faces a number of obstacles. This means that there is still a need

for capacity building for the sector. The sector needs intellectual and material investment to reach a remarkable scale.

According to International Renewable Energy Agency (IRENA), there are various critical regulatory and infrastructure obstacles facing the development and large scale deployment of renewable energy worldwide. Furthermore, as adopted from IRENA report, the barriers to renewable energy deployment are classified as: 1) institutional and policy barriers, 2) market failures and economic barriers, 3) education and training barriers, 4) data, information and awareness barriers and 4) sociocultural barriers. The ability to break these barriers will depend on the capacity of the population. Studies indicate that education contributes to both short-term and long-term institutional building and human resource development must be supported by education and training (Keith M. Lewin, 1997). Both formal and informal education systems contribute significantly to the development and dissemination of any technology. To ensure long term sustainability and continuity of sectorial development, professional, technical training and research at tertiary level (technical and vocational institutions, colleges and universities) should be given high priority. Therefore to address all barriers to renewable energy, capacity building for the sector is needed. This paper proposes "Capacity Building for Sustainable Energy Development" as an approach to build abilities, relationships and values that will enable organizations, groups and individuals to improve the development, utilisation and performance of energy systems in an efficient and sustainable manner. Capacity building in this matter can easily be achieved through education and research especially at tertiary level. This will depend on the readiness, capacity to adapt and facilitation of the academia. It should be noted that the academia is still facing the challenge of providing updated and/or entirely new programmes to address the growing needs in the renewable energy sector. The designing and implementation of course modules or new programmes is a task which requires both time and funding. Therefore key stakeholders (e.g. governments and industries) should intervene to help in the development of up-to-date training programmes. However, the renewable energy sector is still new and comparatively immature thus, the availability of experienced professors, instructors, trainers and course materials is limited. This is still a serious challenge for most academic institutions to start renewable energy courses and programmes. Despite the challenges, this paper concludes that academic institutions at the centre of capacity building for sustainable energy development. Though academic institutions are seen at the centre of capacity building for the sector, the development of the sector will depend on the consorted and collaborative effort of all key stakeholders.

Keywords: *Sustainable energy, renewable energy, education, capacity building*

CHAPTER 2:

Renewable Energy Resource Availability, Technologies, and the Environment

Session 1: Renewable Energy Technologies for Electrical and Mechanical power

Photovoltaic Systems - State of the Art and Trend

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Abstract

Progress in PV technology over the past years is evident from the lower costs, the rising efficiency and the great improvements in system reliability and yield. Since 2000, the PV power capacity has been multiplied by a factor of 100 and in the year 2014, the global cumulative PV power installed has reached a level over 180 GWp. PV system price has declined of around 75% in less than 10 years and solar power is now broadly recognized as a cost competitive, reliable and sustainable energy source. In the field of PV modules, the wafer based crystalline silicon technologies have the role of workhorse of present PV power generation, representing nearly 90% of total module production. Further technology improvements have to be implemented without significantly increasing costs per unit, despite the necessarily more complex manufacturing processes involved. Trends towards minimising cost of produced electrical energy are discussed from the viewpoint of module cost, module efficiency and module service time. Factors limiting future development are also discussed taking into account also other parts of photovoltaic systems that influence the cost of electrical energy produced. Photovoltaic systems can be implemented in a range of applications, sizes and situations, meeting a wide range of power needs. The most of PV systems are grid connected using different inverter configurations. Increasing penetration levels the value of PV power will be more time-dependent. This requires higher controllability of PV systems and loads. New features for grid stabilization and optimization of self- consumption storage unit included in the PV system are also discussed.

Keywords: *PV system price, sustainable energy source, penetration levels*

Transition towards Sustainable Electricity Production in the Western Cape Province of South Africa: A System Dynamics Approach

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Abstract

Many of the energy challenges we face today are a result of actions that were taken in the past. The misallocation of capital over the past few decades has given rise to the current electricity crises within South Africa. A green economy transition is recognised as a key pathway to developing an electricity sector that is more sustainable and inclusive from an environmental,

social, and economic perspective. System Dynamics (SD) modelling is well suited to representing the economic, social, and environmental aspects of the development process. The SD modeling methodology has then been utilized to create the Western Cape Green Economy Model (WeCaGEM), with the purpose of investigating the complexity involved in response to a green economy transition in the Western Cape Province of South Africa. This paper discusses the development of the electricity sector within the WeCaGEM. Furthermore, the paper presents the positive effects from investments in renewable energy technologies, and which investment scenarios would be most advantageous. The results show that green economy investments (GEI) have a positive impact on reducing the gap between demand and supply, diversifying the share of electricity technologies, controlling air emissions, and creating employment within the electricity sector. The results also demonstrate the usefulness of gas power generation as a transition to a more sustainable electricity sector. However, the overall investment requirement from the Provincial Treasury to reach these outcomes is 1% of the GDP annually, which amounts to R3 billion in 2015 and increases to R8.5 billion in 2040.

Keywords: *Electricity production, Western Cape Province, system dynamics, WeCaGEM, and technologies.*

Strategic Solar PV Project Development in Namibia

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Abstract

The Namibian power sector is currently facing a severe crisis. Consumption will most likely outstrip supply which could result in load shedding's, blackouts and in increased price levels. This is due to the countries reliance on a redeveloped hydroelectric power system and imports from at South African Power Pool. Solar photovoltaic implementations with their ease of implementation and minimal negative environmental and social impacts are seen as part of the potential long-term solution for this problem. Namibia has one of the best solar regimes in the world with an average high direct insolation of 2,200 kWh/m² per year. Appropriate regulation of the Solar PV power generation investments will prove decisive for the pace and extent of their expansion both for public and a private initiatives. This paper starts with a brief analysis of current operational and regulatory frameworks in Namibia, assessing their relevance for Solar/PV technologies, e.g., resources, capacity of systems, grid status, applicable grid-code, renewable energy policies, institutional framework conditions and roles of public institutions in solar energy policy implementations in the mentioned countries. As a result of this qualitative assessment, recommendations for an ideal business plan and competitive strategies to overcome the already existing barriers for implementation of solar PV systems in the country are

pointed out, comparisons with example implementations from various solar energy policies and market incentives worldwide are presented. The research is based on desktop and on site research and workshops performed with key stakeholders from governments, international donors and private investors in Africa; applications in Namibia are analyzed as sample business cases. Opinions are discussed regarding the financial perspectives of photovoltaic investments from the perspective of private investors: project bankability and economical feasibilities are examined using sample discounted cash flow analysis and levelized cost of electricity case studies where technology specific data is combined with the resulting energy production data in order to calculate several economic indicators such as payback periods, project IRR and NPVs. IFC`s Sustainability Framework and the eight Performance Standards which are directed to investors and provide guidance on how to identify risks and impacts, and to support avoid, mitigate, and manage environmental and social risks and impacts for development projects are introduced, and their applicability to Solar PV projects are discussed.

Criteria for the selection of the most suitable sites and red flags will be highlighted to minimize the potential social and environmental impacts and mitigation strategies will be included. Another key technical concept, the integration of photovoltaic energy into the grid will be evaluated considering the grid extension costs and costs for grid connection of photovoltaic power plants via analysis of grid protocols and regulations on their suitability of solar power integration. Land acquisition and securing construction and operations permits had been an issue in Solar PV project development pipeline in its examples in the US and EU; therefore the role of different government entities in land allocation are investigated, different practices of land allocation and best-practice examples on the different options with their pros and cons are provided. Finally with examples of access to funding and availability of funds for Solar PV power generation in the mentioned countries and introducing different financing options available; such as the Get Fit Program an innovative future road map for Solar PV applications in Namibia from green field stage to operation will be presented, where solutions are provided from a diverse pool of competencies.

Keywords: Solar PV, solar regimes, private investors, energy policy, financial perspectives, integration, funding

Uniqueness of Molecular Precursor Method (MPM)-Route Toward a New Type of Solar Cell

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Abstract

Metallic Ag-nanoparticles titania (Ag-NP/TiO2) composite thin films with various silver molar concentrations (Ag mol%) to titania were prepared at 600°C using the molecular precursor method, in order to study their photo-electrochemical properties. Respective precursor solutions for Ag nanoparticles and titania were prepared from Ag salt and a titanium complex. X-ray diffraction (XRD) patterns, X-ray photoelectron spectroscope (XPS) spectra and transmission electron microscopy (TEM) images indicated that the Ag-NP/TiO2 composite thin films consist of rutile, anatase and metallic Ag nanoparticles homogeneously distributed in the titania matrix. The photo-electrochemical property of the Ag/TiO2 composite thin films with the dispersed Ag-nanoparticles (Ag-NP) of different concentrations in the range of 10–80 mol% was examined. Anodic photocurrent densities were recorded for pure TiO2 thin films under UV-light irradiation as expected due to the band gap width of 3.2 eV. Whereas, cathodic photocurrent densities could be observed under UV- and Vis- light irradiation enhanced by increased Ag concentration in TiO2 matrix as well as by the conductivity of the thin film. Optical spectroscopy reveals that Ag level has a marked effect on the absorption properties of TiO2. Their excellent Vis-light response, the major factors affecting their photo-response and photocurrent polarity are discussed, from the viewpoints of a localized surface plasmon resonance (LSPR) band of Ag-NP in the titania matrix on the basis of photoinduced electron transfer from Ag-NP to the conduction band of TiO2. A plasmonic photo-electrochemical mechanism was therefore proposed.

Keywords: Metallic Ag-nanoparticles titania, absorption properties, photo induced electron transfer

Demand Side Generation Solar Farm at Moshoeshoe International Airport

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Abstract

The solar photovoltaic farm is comprised of 1196 polycrystalline modules capable of peak generation of 281,060 WP. The annual production of the farm in the 2014/15 financial year (April 2014 to March 2015) was 461 MWh, enough to power 220 households in Lesotho. Over 130 MWh of this energy was fed into the grid free of charge, generating over ZAR 130,000 ($1≈ ZAR 12) for the utility company by supplying it to the neighbouring households. Using net metering, the airport stands a chance to reduce its electricity bill by 47%, almost half. Normalised values are utilised for the performance parameters so that it would be easy to compare with other farms. The average monthly array, inverter and system efficiencies are 12%, 89% and 10%, respectively. These are ideal for grid-connected photovoltaic systems. The annual final yield is 1640 kWh/kWp, which is higher than a lot of solar power generating leading countries. The average performance ratio is 0.72, which is slightly below the global optimal value of 0.74. Lesotho uses over ZAR200 million/annum to import 40% of its energy consumption. With the optimal technical parameters observed at the farm this money would be well spent on local independent power producers and demand side generating plants. These plants shift the financial risk of development, financing, ownership and operation away from the utility company. ZAR 200m would secure over 250 GWh of solar PV electricity locally, which is about as much as is imported from South Africa and around 80% of the total imports.

Keywords: *Demand side generation (DSG), solar PV, Lesotho*

Comparison and Verification of Lidar and Cup Anemometer Wind Speed Data

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Abstract

Traditional wind speed and direction measurement utilizes latticed or tubular towers with boom-mounted sensors attached to it. A telecommunication tower that is not built according to International Electro-technical Commission (IEC 1264100-12-1) standard was utilized at Amper-bo, Namibia for wind data measurement. The boom mounted sensors were installed at different heights below the tower top which exposes the sensors to tower shadow effect. This arrangement is necessary to ascertain the wind shear and associated project risks. For comparison and verification, a ground based wind profile; QinetiQ Ltd (UK) ZelphIR (Z300) Lidar (Light Detection and Ranging) was installed 5.4 m away from the foot of the tower. This equipment can take spot-check of wind data at different hub heights which could reduce uncertainty associated with hub heights extrapolation. This paper compares and verifies the wind data collected from both techniques to ascertain their suitability for wind resource assessment. Results obtained at 64 m height indicate a strong correlation between LIDAR measured data and the tower data in respect to the wind speed and direction. The Lidar records higher average wind speed at all compared heights and the mean wind speed distribution of the Lidar shows a strong agreement with the tower data. Lidar predicts slightly higher turbulence intensity compared to tower data and both measurements gives almost the roughness of the Amper-bo site that is considered a flat terrain. Lidar is not influenced by tower shadow effect; therefore, it is used to generate a correction factor for tower shadow effect for the two collocated anemometers at 16 m height and 120 degrees apart. This aspect of the work is not fully reported until further investigation and comparison with other algorithms are completed.

Keywords: *Lidar, communication tower, wind resource assessment, tower shadow, correction factor*

Benguela Community - UNAM Wind Power Demonstration Project - Experiences in Implementation

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Abstract

The last century has demonstrated that every facet of human development is woven around a sound and stable energy supply regime. In the last decade, there has been a growing emphasis

on developing suitable and affordable technologies to meet the challenges of remote/rural settlements, such as: the micro-grid concept, hybrid renewable power generation and storage systems. These viable solution alternatives can provide an effective method of electric power generation to alleviate the energy scarcity experienced by isolated and low-income communities. The systems are robust, easy to install, modular, low maintenance and cost effective for power generation. This is most relevant to Namibia, where the demography shows that the majority of the population is located in remote and isolated settlements, with no access to the electric grid and often lack basic infrastructure. The government of Namibia has committed itself to promote the use of economically viable renewable energy technologies, as a complement to grid electrification, and to improve energy provision to rural areas. This paper provides an overview of the Benguela Community-UNAM Wind-Power Demonstration Project, which is a community-run wind-power mini-generation pilot plant in Lüderitz, Namibia. The town of Lüderitz is located in south-western Namibia along the Namib Desert. The region experiences abundant south-westerly winds and the coastal weather conditions make it a suitable location for wind energy. This project is an initiative from the community of Lüderitz and a first of its kind in Namibia. It demonstrates the application of small-scale wind energy systems; it contributes to the growing national awareness of renewable energy and use of wind power in Namibia. Through its activities, the project has created a dialogue between the local authorities, business community, schools and the greater community. The balance of the paper provides an account of lessons learned, discusses envisaged plans for future developments; highlights technical, administrative and management activities; as well as potential for replication and barriers encountered during the project implementation including institutional constraints. Solution-methods developed are presented and discussed. The long-term objective of the project is to supply affordable renewable wind energy at cost recovery and on sustainable basis to the low income women engaged in local textile business; women-headed households and small businesses in the community, with excess energy being sold to Lüderitz Municipality. The aim of this project is to achieve energy sustainability for an embedded community-run wind power mini-generation scheme, which can be expanded, upgraded and integrated in the Namibian electric power grid.

Keywords: *Renewable energy, community-run, wind-power, clean energy technologies, micro-grid, Namibia*

Assessment of Electrical Energy use in Backpackers: Case Study Sites in Cape Town (South Africa) and Windhoek (Namibia)

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Abstract

Namibia and South Africa are amongst the Southern African countries that face serious shortages in electricity if immediate and long term efforts are not initiated in order to curb the excessive and unsparing use of electricity by public and private institutions in these countries. It is against this background that we revolved to assess the efficient use of electricity by backpackers situated in Cape Town and Windhoek, with the aim of comparing the extent of electricity consuming activities or operations carried out by backpackers in Cape Town and Windhoek in South Africa and Namibia. The objective of the study was to compare energy efficiency measures in place at accommodation sites in Cape Town and Windhoek. For data collection, questionnaires containing questions key questions on electricity usage and conservation were used to collect data either through allowing participants to kindly fill in the information onto the questionnaire themselves. Data was collected from two backpackers in Long Street (Cape Town, South Africa) and two others in Windhoek (Namibia). The results yielded that the shower time length at all backpackers from both Cape Town and Windhoek was more than 10 minutes, and officials at these accommodation sites revealed that their residents switch off all unneeded lights regularly. Although the awareness on efficient use of electricity in both cities was notably good, there still seemed to be a lack of knowledge that short shower length can help conserve electricity, hence tenants at all back packers did not seem to make any effort to cut on their the length of their shower time.

Keywords: *Renewable energy, community-run, wind-power, clean energy technologies, micro-grid, Namibia*

Renewable Energy for Mining Operations

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Abstract

Mining operations require secured energy source to maintain their operation and many around the world typically have to resort to expensive diesel generated power, with fuel operating costs alone varying from $300/MWh in West Africa to over $800/MWh in the Canadian Arctic. Renewable energy solutions such as small hydro, wind and solar offer significant cost saving opportunities for these mines, and in addition help the miners attain their “Social License” to

operate. If these mines have a shorter operating life (i.e. 10-15 years), the renewable energy infrastructure can provide a "Legacy Asset" for the local community and/or a longer-term revenue stream for the mine that typically needs to monitor the decommissioned mine and waste management facilities for decades after production has ceased. This presentation will cover the following:

- Power potential in Africa
- Typical mine power requirements
- Economics of renewable energy for mining operations
- Legacy Assets
- Presentation of five case Histories:
  - MW Hydro for Gold Mine in the DRC
  - 16 MW Hydro for Gold Mine in Sierra Leone
  - 247 MW Hydro for Lunzua Power Authority in Zambia (IPP)
  - Run off River Hydro Projects in the DRC
  - Copper and Gold Project – Concentrated Solar Thermal Power Plant in Southern USA

Keywords: *Small hydro, renewable energy infrastructure*

CHAPTER 2:

Renewable Energy Resource Availability, Technologies, and the Environment

Session 2: Renewable Energy Technologies for Thermal Applications (CSP, space, and water heating); Geo-thermal energy resources

Energetic and Economic Potential of Solar Thermal Energy in Sub-Saharan Africa

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Abstract

Sub Saharan Africa is facing a crisis evidenced by rolling electricity blackouts. These shortcomings in the power sector threaten Africa's long-term economic growth and competitiveness. A significant contribution to reducing the stress on the electricity supply could be made by large-scale utilization of solar thermal systems for domestic hot water, heating and cooling demand for hospitals, hotels but also for industrial process heat.

Keywords: *Blackouts, solar thermal systems, domestic hot water*

Technologies and Perspectives for Solar Water Heating and Solar Process Heat in Sub-Saharan Africa

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Abstract

In sub-Saharan Africa, domestic solar water heaters are widely used. Accelerated growth of this market is currently hindered by technical problems like calcification and thermal degradation of system components on the one hand, but also by discontinuous support schemes. Compared to solar domestic hot water, solar process heating is still a niche market. Recently, this segment has been growing dynamically, with a number of large-scale ST systems between 100 and several 10,000 m2 of collector area newly installed. But optimal integration of solar heat into industrial or agricultural processes can be complex and requires know how on large-scale solar thermal systems, process engineering, and energy efficiency. This paper provides a review of solar thermal collector- and system concepts, which are technically and economically suitable for sub-Saharan Africa. Realized projects from all over the world are shown and their success factors are discussed. As examples, a large-scale domestic system from South Africa, a brewery in Austria, a mining project in Chile, and a fruit drying project in Guatemala are discussed. The South African Solar Thermal Technology Roadmap, which has recently been finalized, is summarized. The paper concludes that the perspectives for solar thermal systems in Sub-Saharan Africa are good against the background of very high solar irradiance levels and with the potential to generate

high local value. Key aspects for further market deployment are quality assurance and training, but also political support of the technology.

Keywords: *Solar water heater, calcification, solar thermal systems*

Solar Cooker Performance Evaluation - A Case-study of the Döbra Parabolic Solar Cooker

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Abstract

The rising wood consumption in Namibia for purpose of cooking and heating coupled with the growth in population in the rural areas have resulted in the deforestation of large areas, creating severe ecological, economic and social problems. One of the top three primary energy sources in Namibia includes biomass in the form of wood or processed wood products. Unfortunately Namibia is not the only nation utilizing wood as a source of energy. In some Sub Saharan countries, up to 90 % of energy use is from firewood. Fortunately non-profit organizations like the Döbra Solar Development Project (DSDP) are doing their part in educating Namibians about the benefits of using solar energy through the development and education of solar cookers. One of their flagship products, a parabolic solar cooker was tested and analysed at the Polytechnic of Namibia's School of Engineering. The results and observations are briefly discussed in this extended abstract. Evaluation and measurements were conducted strictly using the guidelines of the ASAE S580 JAN03 – Testing and Reporting Solar Cooker Performance standard which was established by the American Society of Agricultural Engineers in 2003. The research concludes by determining the extent to which the efficiency of the Döbra parabolic solar cooker could be improved. One option to be explored is by equipping it with a proportional controller, to automatically track the sun. The result of the measurements is a relationship between the standardized cooking power and the temperature difference (Td) between the water in the pot and the ambient temperature. Furthermore the standardized cooking power at Td = 50K is calculated with a linear regression of all measurement points and stated in the report. The cooking power is standardized to an insolation of 700 W/m².

Keywords: *Parabolic solar cooker, ASAE S580 JAN03*

Feasibility Study of Biofuels Energy Exploitation for Southern Africa's Prosperity- Case Study Zimbabwe

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Abstract

The Southern Africa's Economy is slowly re-emerging from a protracted period of economic decline (in particular Zimbabwe) due to the raise in exploitation of biofuels energy resources. The energy challenge is especially acute in the transport sector, as most vehicles will continue to rely on liquid fuels for the decennia to come. Diesel and petrol (gasoline), obtained from fossil oil, will gradually be replaced by renewable liquid fuels, which are called biofuels. Most of the Southern Africa Member States can grow most of energy crops. The ecology of the region can accommodate most crops. In some of the Member States land is still abundant e.g. in Angola, DRC, Mozambique, Tanzania, Zambia and Zimbabwe such that production of energy crops will not disturb food production. Agricultural research and the seed industry have untapped capacity to improve yields and productivity for all energy crops. The purpose of this desk study was to assess the feasibility for the production of biofuels in the Southern Africa Region. The study reveals that the current petroleum consumption in Southern Africa is about 0.7 million barrels a day. After refinery this produces roughly 12 million tons of diesel a year. If all of this were biodiesel region needs it could be met from 400 factories with a capacity of 30,000 tons a year each. The cost of such a plant is 40 to 50 million Euros. The biofuels exploitation in the Southern Africa can completely change the living standard of the people. At macro-economic level, the production of biofuel could employ millions of rural labourers, thereby boosting economic growth. Moreover, most Member States can make huge savings on foreign exchange. The region's energy sector will be less dependent on external vagaries, and exchange rates, and will produce clean energy, which in turn will yield Kyoto-bonuses.

Keywords: *Biofuels, Jatropha curcas, Southern Africa, prosperity*

Solarus Concentrated Photovoltaic and Thermal collector

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Abstract

The energy sector is currently in a state of change as conventional energy sources are questioned by the need of new clean and sustainable energy sources to satisfy the global energy

demand in the long term. Renewable energies respond to this increasing demand and solar energy is an advanced example of them. Photovoltaic modules are experiencing a steady reduction in their production costs. It is needed that this trend continues and, along with it, their propagation and expansion in the market continues. One way of reducing production costs is by using inexpensive light concentrators to increase the output of the costly photovoltaic cell. In this respect, the Solarus AB hybrid PV/T collector has been designed based on this principle. This collector is a CPC (Compound Parabolic Collector) and belongs to the (Maximum Reflector Collector) MaReCo family.

The studied collector is a Photovoltaic thermal (PVT) collector, which means it can produce both heat and electricity from the same area. The main advantages of this collector design are the reduction of material cost due to concentration and the increase cell efficiency by reducing its working temperature through active cooling. The third advantage is that when the cooling has taken place inside the collector there will be heat produced that can be used for different applications such as showers and low-grade heat in industry. A fourth benefit is that the collector is designed so that it can be produced anywhere in the world. This offers local job creation and up to 85% of the material can be sourced from local industry. This further brings down the cost of production and stimulates the local economy. In this research the performance of the collector is being tested and an investigation on how the technology can benefit developing countries is continuously being carried out.

Keywords: *Photovoltaic modules, Solarus AB hybrid PV/T, MaReCo, material cost, cost of production*

Feasible Usage of the Chinyunyu Hot Spring in Zambia

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Abstract

Zambia has more than eighty (80) hot springs spread out in different parts of the country. If these renewable energy resources are utilized using the current technologies, especially for electricity production, they present a unique opportunity of providing solutions to the lack of or limited access to electricity being experienced in rural areas. The development of geothermal power generating plants in areas with hot springs, which are in most cases remote areas, would ensure that the local communities access off-grid electricity.

To date, only the Kapisya Hot Spring, in the rift valley part of Zambia, has been developed to commercial scale, while studies on the Chinyunyu Hot Spring have not been concluded. The Chinyunyu Hot Spring was, therefore, selected as case study with the view of exploring possible utilization of the heat energy from the hot water spring. The Chinyunyu hot spring is located on the Great East Road (T4) about 90km east of Lusaka the capital city of Zambia. The Chinyunyu Hot Spring is a hot water geothermal reservoir. The main spring is situated on the eastern slope of the Chinyunyu Valley, about 100 m on the northern side of the Great East Road (T4). The water is too hot for comfortable bathing; it is mixed downstream with surface water to reduce the temperature and used for bathing and Balneological purposes. The overall purpose of this study was to evaluate the economic benefits of the current use of the geothermal energy from the Chinyunyu Hot Spring, and also explore economically viable future use of the geothermal energy.

Based on the baseline studies, previously conducted with regard to the physical and chemical properties of the geothermal fluid, mathematical computations of the spring was done.

The major finding among other is that the temperature of hot-water reservoirs varies from 60 to 100 °C and they occur at depths ranging from 1500 to 3000 m. Therefore, the Chinyunyu Hot Spring can be used for industrial economic activities by installing a binary geothermal power station.

Keywords: *Chinyunyu hot spring, hot water, geothermal reservoir, binary geothermal power*

An assessment of Waste - to - Energy Applications for the Namibian Waste and Energy Sectors

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Abstract

Southern Africa has been plagued by energy shortages since the 2007-2008 energy supply deficit in South Africa. Most countries in the Southern African Development Community (SADC) are part of the Southern African Power Pool (SAPP). As a result of this, all neighbours of South Africa experience the effects of this deficit. Namibia is one of the largest importers of South African electricity, with the SAPP supplying 60% of its consumption [1]. Namibia has also long been ranked as one of the cleanest countries in Africa, with Windhoek regularly being awarded as the cleanest city in Africa [2]. The same unfortunately cannot be said for the country as a whole, with municipal solid waste (MSW) still littering the Namibian countryside. The quantities MSW in Namibia are only said to increase with continuous urbanization and immigration [3]. In conjunction with the increase in population comes the never ceasing problem of unemployment,

which for Namibia already stands at a high rate of 28.1%. [4] If not already a serious enough problem, MSW will only lead to more environmental, health and subsequent economic pathologies in this country. With increasing numbers of citizens in its cities, towns and lesser settlements, these administrations and the country as a whole, furthermore, have to urgently reassess their MSW management plans. As a small-scale, short-term solution to the above socio-economic issues, various Waste-to-Energy (WtE) technologies exist. These can alleviate the constant increase in MSW and simultaneously address the energy deficit and the scourge of unemployment. This solution however, need not only be short term, nor small-scale, as the possibility exists to create a thriving MSW industry. There are, among others, even possibilities for MSW imports from Namibia's neighbours to power its WtE plants in the future. There are many different WtE technologies available, which are in use in countries around the world [5]. These technologies can vary in the amount of waste required to generate power, the type of waste required, the cost thereof (capital and operational expenditures), ease of implementation, operation and maintenance at different scales, their by-products and the job creation potential associated with each. Most importantly in this regard, are sustainability considerations, inclusive lifecycle costs, and the imperative to reform the Namibian economy from a linear use-and-abandon pattern to a circular use – deconstruct – recycle – and - redesign philosophy. With solar and wind power systems receiving the most attention in recent years, as their maturity advances, WtE implementation appears to be left out of consideration across the sub-continent. This is in spite of a rapid pace of technological progress on this front. Timely implementation of WtE programs in Namibia would be a key step forward in rendering this country more sustainable. This will not only stem from a vastly better waste management strategy and increased energy production, but also from a higher GDP thanks to higher employment and factors such as improved tourism due to a cleaner environment. This study aims to serve as preliminary assessment of WtE applications for the Namibian energy and waste sectors. It will compare the different technologies available within the context of the Namibian waste and energy landscape. These comparisons will respectively attend to the relevance (immediacy of need), appropriateness (fitness for purpose) and functionality (efficiency) of each technology seen within the Namibian socio-economic and natural ecosystem. Based on these criteria, proposals are to be made as to which of these technologies should be considered viable candidates for more detailed simulations and studies. The particular environmental and renewable energy policies that will aid in the integration of WtE into the national MSW management plan will also be considered. Ultimately this study intends to serve as a prelude to a holistic business model involving local governments, the private sector and rural communities with the aim of constructing a closed loop waste-cycle. This cycle must benefit the nation as whole and ensure its natural beauty, its talents and its resources for future generations.

Keywords: *Waste – to – Energy, Windhoek, urbanization and immigration, municipal solid waste, lifecycle costs, renewable energy policies*

Renewable Energy and the Smart Grid: Vehicle for Promoting the Deployment of Renewable Energy Sources in SADC Countries

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Abstract

The smart grid is an upgraded electricity grid network enabling two-way information and power exchange between suppliers and consumers, due to the pervasive incorporation of intelligent communication monitoring and management systems. Through the smart grid, the electric industry is poised to make the transformation from a centralized, producer-controlled network to one that is less centralized and more consumer-interactive. The move to a smarter grid promises to change the industry's entire business model and its relationship with all stakeholders, involving and affecting utilities, regulators, energy service providers, technology and automation vendors and all consumers of electric power.

The integration of renewable energy, which is generally intermittent by nature, into energy systems, while maintaining the reliability and affordability of energy supplies is a major challenge at integration levels above 20-50%. The paper describes and analyses the existing potential of renewable energy sources within the SADC countries and how smart grid can be used to enhance deployment of renewable energy sources in the region. Cases of development and promotion of smart grid in SADC member states are cited. The paper demonstrates the potential benefits of using smart grids to overcome problems and challenges associated with increasing the deployment of renewable energy within the region.

Drawing from the above insights, the paper proposes strategies and policies on adoption of smart grid technology as a vehicle for enhancing greater deployment of renewable energy among SADC member countries. The paper concludes that to achieve effective and efficient integration of renewable through smart grid in the region requires a fertile interaction of tripartite solutions: sound regulation, robust smart grid technology and sustainable finance.

Keywords: *Smart grid, power exchange, integration levels*

Namibia's Uranium Industry – Paradox and Promise

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The nuclear industry and uranium mining are inextricably linked as the demand for uranium depends primarily on the nuclear-power industry. In Japan, a major customer of Namibia, the 3/11 Fukushima disaster drastically changed attitudes towards nuclear energy and nuclear

plants were either closed, or their operation suspended for safety inspections. Namibia was not spared and some projects were put on hold while others delayed their expansion and exploration plans.

Industrialized and emerging nations such as China, India and others need large quantities of clean, reliable and affordable electricity and see the nuclear option as a means to achieve their energy goals and reduce their enormous air pollution problems caused by coal-fired power generation. Although heavily disputed by the anti-nuclear lobby, the mining of uranium and its use in power generation is, in reality, one of the safest means of producing cleaner energy. Far more people will die worldwide as a result of air pollution from fossil fuelled power plants than will have had their lives shortened by the very rare nuclear power plant disasters and nuclear technology and safety is evolving as lessons are learned from those which have occurred.

The World Nuclear Association reports that there are 437 nuclear reactors operable in 30 countries as of April 21, 2015. Based on these most recent statistics from the World Nuclear Association, there are a total of 230 reactors that are either under construction, or planned around the world. Primary mine production supplies approximately 85% of current utility requirements. The balance is supplied from secondary sources such as commercial inventories, reprocessing of spent fuel, sales by uranium enrichers and inventories held by governments securing supplies purchased at the lower prices. Low grade operations, like the Namibian uranium mines, provide the bulk of the world's supply at present but they are rapidly becoming uneconomic, as long term contracts run out and need to be renegotiated at lower levels. In terms of new projects, grade is therefor going to be key.

Although the challenge of managing the nuclear future remains, Namibia is well positioned to satisfy the most stringent requirements of present and future customers. Through the implementation of a comprehensive regulatory framework and a Strategic Environmental Management Plan (SEMP) by the Namibian government, the cumulative impacts and performance of the uranium industry are jointly monitored and managed to enhance opportunities and mitigate adverse impacts by government and industry. In this article the fundamentals which drives Namibia's optimism about uranium mining is discussed.

Key words: *Uranium, nuclear energy, economic drivers, legal framework, best practices*

CHAPTER 2:

Renewable Energy Resource Availability, Technologies, and the Environment

Session 3: Training and Capacity Building for Renewable Energy (SASEI, NEED; PEESA; PARTICIPIA)

Developing Sustainable Capacity in the Energy Sector

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Abstract

The most important problems the energy sector faces are scarce domestic resources and unfavorable energy mix, high electricity prices, a high degree of inefficiency in energy production and use, as well as insufficient institutional and human capacities. Renewable energy technologies can significantly contribute to address short term electricity supply gaps, while offering outstanding opportunities for the country's long-term development and also create opportunities for job creation and skills development to address energy needs. There is a significant need to increase graduate outputs of artisans and engineers to meet the envisaged expansion in electricity demand.

Enabling sustainable energy development requires the adoption of a comprehensive energy strategy built upon sustainability principles, intensified utilization of the natural gas, economic prices of electricity, structural changes in industry, promotion of energy efficiency and renewable energy technologies, enforcement of environmental standards and meeting the environmental requirements, as well as institutional and human capacity building.

Hence the opportune financial support from the ACP-EU Cooperation Programme in Higher Education (EDULINK) through the Southern African Sustainable Energy Initiative which aims to enhance the institutional, human and systems development capacity of the Consortium of Regional (Botswana, Lesotho, Namibia and Germany) Universities in the area renewable energy and energy efficiency (sustainable energy).

Keywords: *Sustainable energy, renewable energy and energy efficiency, capacity development*

Capacity Development for Renewable Energy- The Case of Botswana

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Abstract

Renewable energy resources cover bio-energy, solar, wind, small- and mini- hydro, geothermal, and tidal waves and in Southern Africa context these exist in abundance in the region. For the region, capacity development in these fields have predominantly had limited attention because of policy direction; institutional arrangements; financing mechanisms, educational planning and coordination. The problem been compounded by the rapid growth of renewable energy uptake

as a result of advancements in technology and related decline in their costs. Consequently a gap has been created in capacity development to cope with the regional growth in renewable energy application and deployment. The paper presents the landscape of renewable energy in Botswana in relation to policy, financing and technology. This is then followed by training needs analysis using quantitative and qualitative study based on questionnaires, interviews and workshop processes to determine the state of capacity development in renewable energy-leading to gap analysis. Subsequent to that, a verification assessment was undertaken to establish the extent of training needs in renewable energy. The outcome of the study showed that there are skills capacity shortages at various levels of tertiary education in renewable energy programs for Botswana. Such gaps were of medium to long-term nature. In the short term, gaps in capacity development identified were related to short course programs that attract immediate demand from stakeholders. Drawing from the study, the article proposes strategic programs, for short, medium and long-term programs to address the capacity development problems in renewable energy for Botswana.

Keywords: *Renewable energy sources, capacity development, needs analysis*

Sustainable Energy Curriculum Development under the SASEI project at the National University of Lesotho

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Abstract

The National University of Lesotho (NUL) in collaboration with the University of Botswana and Polytechnic of Namibia carried out the Energy Sector Needs Assessment of their respective countries under the ACP-EU Edulink II – SASEI (SOUTHERN AFRICAN SUSTAINABLE ENERGY INITIATIVE) Project. The objective was to identify national priorities, challenges and tentative solutions. As academic institutions, we mainly aimed to help in identifying and implementing solutions that have to do with human capital, research and knowledge dissemination. The first stage we have undertaken in order to assess the energy situation in Lesotho was to analyze the published literature related to energy in Lesotho and SADC region over the last 20 years, including a diverse number of documents, a total of 49, which were representative of the energy sector in Lesotho in terms of priorities, projects, challenges and solutions. It was identified that Lesotho's energy challenges include lack of institutional co-ordination, human capacity, research and development, relevant policies, credible technical data to support existing policies, clean energy for the majority of rural population and sufficient grid electricity. In an effort to help address Lesotho's apparent low level expertise (education and skills) in energy sector as identified in the needs assessment, various stakeholders (government departments, regulator, utility, non-governmental organizations and private companies) were requested to present their

training needs. Based on the stakeholders' inputs, NUL has proposed Sustainable Energy modules that can be integrated as electives into the existing undergraduate programs or be offered as short part-time courses to working professionals. They cover topics as diverse as Renewable Energy & Energy Efficiency, Solar Energy Technologies, Wind Energy, Hydropower, Bio-Energy, Electrical Power Systems, Energy & Environment, Energy Policy & Regulation, Energy Economics and Finance, Energy Project Management and Engineering Design for Rural Villages. Efforts to establish Energy Research Centre at NUL are also underway.

Keywords: *Sustainable energy initiative, needs analysis*

Status of the Energy Sector in Namibia: A Review of challenges and priorities

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Abstract

The linkage between economic development and modern energy usage has been hypothetically proven by various researchers and scholars. It might be taken as a dogma that access to reliable energy services is a requirement for survival of communities, but the provision of modern energy services especially in a sustainable manner is crucial for the accelerated development of modern societies. This paper presents a holistic review and analysis of challenges and priorities in the energy sector in Namibia. The research was accomplished through desk work reading various documents in the country and through stakeholders' consultations. In the effort to increase energy access to the population of Namibia, the government is committed to increase energy generation, implementing and planning various energy projects. Promotion of generation from renewable energy resources for interconnection to the grid is given high priority. The challenges of the energy sector identified (though may not exhaustive) include: increased demand which exceeds supply, limited awareness, luck of clear database, limited skilled human resource and training programme. The need for increased generation, training and public awareness are identified as the crucial and urgent priorities in the energy sector. In terms of education and training the paper proposes a strategy to address the issue of sustainable energy development through development of relevant education programme in Namibia. Research confirms that there are opportunities to introduce energy education programmes at under graduate and postgraduate levels to upgrade to Energy studies in tertiary institutions. In case of long term and sustainable planning, energy education programs in tertiary institutions should be strengthened focusing more on postgraduate programmes. Innovative and competitive research must also be emphasised in academic and research institutions. Research and development should be a concerted effort by all key stakeholders, institutions, industry and government.

Keywords: *Sustainable development, sustainable energy, priorities, challenges*

The PEESA Project: Addressing Human Capital Needs Relating to Energy Access and Energy Efficiency in Southern Africa

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Abstract

Improving energy access in Africa has become a major socio-political priority. Excluding South Africa, more than half the population in Sub-Saharan Africa does not have access to electricity. Even in South Africa, where over 80% of the population has access to electricity, about 90% of the power comes from coal fired power making South Africa by far the largest emitter of greenhouse gases on the continent. South Africa is currently experiencing rolling blackouts as it does not have sufficient generating capacity to meet the growing demand. Any solution to these problems will involve inter-alia a major transition to renewable energy and more efficient use of existing technologies. A major concern however is that the sector is constrained by severe shortages of skills to address these energy related challenges. The primary purpose of the PEESA project is to develop high level skills for the Energy Sector. The project involves a consortium of universities from Southern Africa and Europe that sets out to develop a Master's programme in Energy Efficiency at each of the Southern African Universities that meets both national and European standards. The main outcomes of the PEESA project along with the new Master's programmes are Guidelines on Engineering Programme Design and an on-line Engineering Faculty Training Programme to be implemented in the South African and Namibian context.

Keywords: *Access to electricity, blackouts, sustainable energy, engineering programme design*

Programme on Energy Efficiency in Southern Africa-Efforts towards Higher Education

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Abstract

In Africa, the transition towards a knowledge economy provides significant opportunities for higher education. This calls for developing an interdisciplinary approach and strengthening capacity with the ability to combine theory and practice. The EDULINK Programme on Energy Efficiency in Southern Africa (PEESA) facilitates this process of strengthening capacity. The PEESA project focuses on the opportunity of using existing energy resources as efficiently as possible by developing new processes and technologies, which will have a positive impact on the socio-economic conditions in Africa. Three of the six existing universities of technology in South Africa

including the Polytechnic of Namibia are partners of the PEESA project. The major aim of PEESA is to deliver a high-level postgraduate programme in engineering that meets the needs of the respective African regions, and thereby contribute towards building academic capacity. As a project partner, the Polytechnic of Namibia has developed the curriculum for a Post Graduate Programme in Renewable Energy Systems. A course based Masters programme with a Research component has been developed. The programme envisages 12 modules with 240 credits. The purpose of this programme is to help meet the demand for graduates who are expected to take up leadership positions in the energy sector and work effectively in the framework of national development and international cooperation. The programme is fully aligned with European and National standards. The project has also a component for developing the course materials for the Train-the Trainer programme. The target year for rolling out the programme by the Polytechnic of Namibia (transforming to Namibia University of Technology) is 2017.

Keywords: *PEESA, renewable energy, education*

Capacity Building in Renewable Energy Technologies in Namibia, Zambia and Botswana

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Abstract

This paper presents the current situation for capacity building in renewable energy technologies (RETs) in three countries in the Southern Africa region – Namibia, Zambia, and Botswana. Institutions and universities in these countries offer various training programmes and qualifications in RETs, mainly solar and wind energy. This is because RETs have gained momentum in the recent past due to power load shedding in Botswana and Zambia (with Namibia importing more than half its power from neighbouring countries). Concurrently, regulatory bodies have introduced policies to ensure sustainability in capacity building in RET. It is observed that despite the efforts made by countries, the region still lacks skilled personnel in RETs and much remains to be done to increase the skills capacity. This paper looks at the various efforts made by these countries in skill development in RET. It also analyses some relevant policies and curricula at various levels from vocational training to master's degree to identify the common trend. In conclusion, the paper proposes a curriculum framework that would be ideal for the three countries and with the potential for it to be replicated to other African Countries.

Keywords: *Capacity building, renewable energy, policies and curricula*

Solar Thermal Training and Demonstration Initiative

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Abstract

The overall goal of this southern African regional project is to contribute to the switch from a fossil fuel based energy supply to a sustainable energy supply system based on renewable energies. This should be achieved by building up training capacities in the participating countries in the field of solar thermal technology and the improvement of the quality, performance and lifetime of solar thermal systems. Furthermore it is the aim of the project to create new jobs at small and medium enterprises and to initiate and/or to strengthen political support mechanisms for solar thermal systems. To achieve objectives of the project has entered into a co-operation agreement with National Housing Enterprises regarding the use of solar water heaters on a pilot project of 62 houses to strengthen the relationship of Ministry of Mines and Energy and National Housing Enterprise in the implementation of Cabinet directive on Solar Water Heaters. Another major activity implemented by NEI is a sustainable institutional structure and focal points for solar thermal information, training, and support for industry and policy as well as for applied research at Vocational Training Centres as Centres of Competence and at the Polytechnic of Namibia. Furthermore “Solar Thermal Technology Platforms” (STTP) and Vision of Solar Thermal were established.

The SOLTRAIN project is financed by the Austrian Development Agency (ADA) and it is implemented by AEE - Institute for Sustainable Technologies from Austria in cooperation with project partners from South Africa (Sustainable Energy Society of Southern Africa and Stellenbosch University), Namibia (Polytechnic of Namibia), Mozambique (Eduardo Mondlane University and N&M Logotech Lda.), Zimbabwe (Domestic Solar Heating) and Lesotho.

Keywords: *Solar thermal use, solar water heaters*

Participatory Integrated Assessment of Energy Systems

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Abstract

Energy supply problem is inherently considered as part of a more general economic development problem. At macro, national and regional scales, energy may be considered as a pre-condition for economic development. However, at micro and local community scales, the provision of requisite energy supply must also be addressed together with the sustainable

supply of water and food. Sustainable energy, water and food form an interrelated and very complex nexus, which requires the development of the requisite competencies through capacity building initiatives that will deliver a new breed of energy planners, consultants and decision makers so as to adequately inform the policy formulation and implementation thereof. New methodologies, together with novel application of new and existing tools is required in order to address these multi-faceted societal problems, through application of complexity and both multi-criteria and multi-scale planning techniques.

Keywords: *Participatory integrated assessment, energy water and food nexus*

CHAPTER 3:

Energy Economics and Financing of Renewable Energy Technologies

Refit – Renewable Energy Feed in Tariff (A Tariff – Based Mechanism)

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Abstract

A REFiT Policy is effectively an energy Policy for a low carbon, climate-resilient and resource - efficient green economy. The REFiT mechanism is an instrument that can contribute to expansion and diversification of the renewable energy sector, as REFiT opens up the renewable energy sector for a wide range of stakeholders, including the private sector and local communities. The REFiT Policy for a Country is often presented against the need to expand and diversify the Country's energy sector; a dedicated REFiT policy for expanding and diversifying renewable energy uptake and private sector involvement, with a clear institutional framework and an appropriate and effective financial regime, will aid the development of a diversified renewable energy sector. The REFiT Policy shall contribute to a sustainable inclusion of a diverse range of renewable energy technologies and private sector involvement, and a more diverse energy generation mix within the existing constrained financial and social framework. At the core, REFiT is based and depends on external private sector financing and must attract national and or international investors. This means that the tariff must be high enough to cover the generation cost of a given technology, including a sufficient rate of return and supplements for technology and country risks. The Government however needs to balance need to keep energy prices low (in cognisance of existing poverty levels) while offering profitable tariff rates to attract private investment. Alternatives exist to passing on costs to end consumers; these include: Levies on fossil fuels; Funding through international Climate change funds; and Subsidies for low-income households.

Keywords: *REFiT Policy, diversification, institutional framework, and financial regime*

Determining the feasibility of different types of consumer loads for the installation of Solar PV systems

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Abstract

The rapid increase in electricity prices and the reduced cost of Solar PV systems has made the installation of this technology in order to reduce the costs of energy for electricity users in Namibia a feasible option. Solar PV systems are, however, not equally feasible for all different types of consumer loads. This paper will explore the feasibility of different types of consumer loads for the installation of Solar PV systems. Over the last five years Africa Power & Light Company (Pty) Ltd has conducted measurements on several different consumer loads including

schools, lodges, office buildings, restaurants and various industrial facilities. The paper will give examples of these measurements and will show how different types of consumer loads are more or less feasible when it comes to the installation of Solar PV systems in order to reduce the energy consumption at these different types of consumers. An innovative solution will also be proposed in order to increase the installation of Solar PV systems across Namibia.

Keywords: *Solar PV systems, consumer loads*

Biomass Briquette Market Analysis in Uganda

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Abstract

This article analyses the briquette market and points out the associated challenges that constrains the briquettes demand and supply chain in the Ugandan markets. Biomass briquettes are forms of solid fuel that can be used for cooking/heating energy and have the potential to address the sustainability of the Ugandan biomass fuel market to improve the energy security and efficient utilization of agricultural waste materials. Briquettes could be an alternative cleaner fuel to replace charcoal and firewood for cooking and space heating which will not only reduce the over dependence on virgin biomass (which is quickly diminishing) as a major source of energy but also minimise environmental degradation and health impact due to indoor air pollution. This article therefore studies the briquette market and points out the related challenges. The approach to community-based research as regards briquettes has been mainly guided by one-to-one interviews and use of questionnaires randomly targeting the Ugandan society. Findings reveal that access to finance, technical expertise, and access to technology, legislation, and consumer awareness as setbacks to briquette market penetration. Centre for Energy and Water Research-Ndejje University developed a bio-energy research and production plant to be a doorway to sustainable efficient biomass utilization as well as inventing and/or improving the appropriate biomass utilization techniques like energy efficient stoves for different briquette sizes. Steps and possible interventions that could lead to their (briquettes) full production and consumption are identified and characterised. Briquette market analysis was therefore conducted to gain a better understanding of the businesses operating in the biomass briquette sector, the main challenges holding market expansion and interventions required for briquette market-dominance.

Keywords: *Biomass briquettes, municipal solid waste, greenhouse gas emissions, indoor air pollution, market assessment, sector mapping, relative road map*

Dimensioning of Hybrid Solar-Battery-Grid Micro-Energy Power Systems to Alleviate Domestic Power Outages in Urban Zimbabwe: A Reliability-Cost Approach

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Abstract

Power outages are rampant in most of Southern African countries due to inadequate electricity generation capacity by the utilities in these countries. This situation results in direct and indirect costs to both the consumers of electricity- those that are lucky to be connected to the electricity grid- and to the utilities themselves. In a region endowed with abundant solar resource, hybrid solar-battery-grid micro-power systems are an attractive option to alleviate the power outage problems, resulting in improved electricity supply reliability at reasonable cost energy. In this study, an approach to the dimensioning of these hybrid power systems, for domestic consumers in Zimbabwe is presented. For a given hourly load profile, and for a desired level of electricity supply reliability, a combination of solar photovoltaic (PV) array and storage battery can be specified in a fairly general way (i.e. independent of size of daily load) by use of dimensionless component size parameters, A/Ao and Bcap/Lday, respectively and defined in the study. A "home-made" Excel program is utilized for performing the necessary simulation of the systems. A plot of the dimensionless battery size parameter, Bcap/Lday, versus the PV array size parameter, A/Ao, maps the locus of points of system-component combinations resulting in a desired level of electricity supply reliability. Least levelized cost of energy (LCOE) is then used as the objective function to select among systems delivering the same level of reliability. Properly dimensioned hybrid solar-battery-grid micro-energy systems are found to be much cheaper than the commonly used approach to alleviating power outages by use of an auxiliary petroleum fuel generator.

Keywords: *Solar-battery-grid systems, power outages, reliability, levelized cost, dimensionless size*

Lessons from South Africa's Embedded Generation Market, What Becomes Possible

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Abstract

As national electricity prices continue to increase, end users are beginning to explore alternative supply options in a bid to mitigate rising costs and decreasing security of supply. The municipality, the traditional on-seller of electricity, sits in a precarious situation in between Eskom calls for consumption reduction, increasing self-generation by consumers and the need to remain financially sustainable. At the same time the country seeks to grow the green economy – of which renewable energy is a part. The challenge to growth in the embedded generation market is that it mostly sits within the municipal grid (majority of end users are municipal customers), where embedded generation tariffs, rules and regulations are not fully established. Hesitance, on the part of the municipality, to embrace the advent of embedded generation poses a serious threat to the utility's revenue stream as end-users install their own systems, which are becoming increasingly attractive price-wise. Furthermore, this regulatory uncertainty inhibits the potential growth of renewable energy, a significant contributor to the green economy and sustainable energy supply. South Africa's national energy regulator (NERSA) is set to publish guidelines on embedded generation, to support a responsible uptake. This will enable municipalities to set the right rules and regulations without exposing themselves to the worse-case-scenario of "rogue" installations and financial impacts that are infeasible to mitigate. A case study of the City of Cape Town's embedded generation regulations and tariffs will be presented – highlighting the application process, connection regulations, equipment specifications, tariff structure implemented. This demonstrates how some large metros have taken the initiative to develop interim embedded generation tariffs for their end users. The discussion then ventures into what becomes possible, touching on notions such as the future utility and how municipalities, as utilities, need to adapt to the changing energy landscape.

Keywords: *Embedded generation, electricity prices, Eskom, NERSA, rules and regulations, some large metros*

The Impact of Renewable Energy and Energy Efficiency on the National Economy of Namibia

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Abstract

Namibia cannot continue to be electrified by conventional means. A population of 2,16 million, spread over 824 000 square kilometres cannot come up with the financial means to put each of the estimated 465 000 households on a centrally supplied grid. Even if all these houses could technically be connected to a national grid, the majority of the Namibian population cannot afford rising prices for electricity, which would be unavoidable to finance the connection and centralised generation plants. According to the Namibia 2011 Population and Household Census, 59% (135 084) of urban and 7% (16 512) of rural households are connected to grid electricity, and are thus exposed to the centralised distribution system with all its weaknesses and exorbitantly rising costs and tariffs. To try and finance further investment in the outdated technical concept of centralised, fossil-based electricity supply from tax-payers' money will put further constraint on the national budget and disappoint many of the people who voted for the new Namibian government in big numbers, because many long-awaited investments will not be possible since the money needs to be used to service expensive international loans. Government thus has two choices: either to bring electricity to where the people are, in order to make life more attractive in the countryside to persuade people to stay there, or to wait until people come to where the electricity is. Namibia is in the historical situation to be able to decentralise Power generation not only technically, but also with regard to the value-streams attached. Estimations say that 20 000 to 50 000 – some say even more – direct and secondary jobs of a permanent, sustainable nature can be created mainly in rural areas if the opportunities that are related to decentralised, renewable energy (RE) generation in conjunction with energy efficiency (EE) are put to use. Prices for renewable energy can easily be kept at a consistent level, because the source of power generation is free and eternal, while prices for all fossil fuels and nuclear energy are subject to international developments beyond the control of any Namibian.

Keywords: *Centralised generation plants, renewable energy generation*

CHAPTER 4:

Policy Environment for Improved Sustainable Energy Access

Renewable Energy Zones - Multi-Criteria Analysis for Planning Renewable Energy in Southern and Eastern Africa

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Abstract

Inadequate geospatial and economic information regarding renewable energy resources is a significant barrier to policymakers and project developers in promoting socially equitable, low environmental impact, and cost-effective development of wind and solar generation technologies in Africa. About half the countries in Eastern Africa Power Pool (EAPP) and Southern African Power Pool (SAPP) lack even basic renewable energy resource assessments. The ability to identify priority, low-regret renewable energy development options that satisfy multiple stakeholder concerns is crucial for African countries with limited financial and institutional resources for energy planning and development. An approach that combines geospatial, statistical, energy engineering, and economic methods to comprehensively identify and value high-quality wind, solar PV, and solar CSP resources for grid integration based on techno-economic criteria, generation profiles (for wind), and socio-environmental impacts, the Multi-criteria Analysis for Planning Renewable Energy (MapRE) is presented. MapRE, developed as part of IRENA's African Clean Energy Corridor initiative, is applied in 21 countries in EAPP and SAPP to identify large areas of potential, or zones and estimating various criteria relevant to prioritizing and valuing potential renewable energy projects. Main findings and conclusions from the study are that: although abundant wind, solar PV, and solar CSP resources exist within the EAPP and SAPP, the uneven geographic distribution of high quality resources demonstrates that regional collaboration and grid interconnection will be necessary to promote the supply of low-cost clean wind and solar energy to all countries; Almost all countries with sufficient renewable energy potential can develop zones that are cost-effective and have low environmental impact; renewable energy planning using a multi-criteria approach promotes more socially and environmentally equitable, cost-effective, and reliable generation development; and Modeling and analysis can only be expeditiously and accurately conducted if government agencies and utilities collect, maintain, and share data.

Keywords: *Multi-Criteria Analysis, geospatial and economic, wind, solar generation technologies, energy engineering, and economic methods, MapRE, EAPP and SAPP, grid interconnection, socially and environmentally equitable*

Solar Strategy Options for Namibia: from a Power Importing to a Power Exporting Country

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Abstract

Namibia's fundamentals for the deployment of solar technologies are first class. The solar irradiation values for technologies such as Photovoltaics (PV) as well as those for Concentrating Solar Power (CSP) are at top-of-the-world levels. Today, the country is highly dependent on neighboring countries such as South Africa for its power supply; however these countries are increasingly worried about their own supply and will be reluctant to provide power to Namibia. Hence, Namibia needs to care for self-sufficiency. Harnessing the immense solar resource has many benefits: quick development and deployment, much faster than conventional power plants, modular roll out, both central and decentralized supply, tailored to load center profiles, reducing transmission and distribution cost, price competitive with other conventional power sources, hedge against world market fuel price volatility and future electricity price increases, highly complementary to large-scale hydropower in the resource availability, positive employment and qualification impact to the country, strategic perspective for Namibia to become leading power supplier in the SAPP. Evaluating the most recent developments in the solar sector, Namibia could choose among smart and cost competitive options: large-scale solar parks, both with PV and CSP or a combination of both that could provide competitive cost, dispatchable power, financing schemes such as Public Private Partnership Schemes (PPP) to significantly reduce cost and mobilize large amounts of capital, auctions schemes to enable highly competitive prices and quick deployment of solar power plants, a visionary perspective to supply SAPP countries with competitive solar power, turning Namibia from a power importing to a power exporting country, effectively using the largest energy resource of the country to export high value electricity, with a high impact to the country's trade balance.

Keywords: *Solar resource, dispatchable power, autonomy*

The CSIR Proposed NETFIT Concept

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Abstract

Due to drastically reduced prices for Photovoltaic (PV) systems and significantly increased electricity tariffs in the last five years, small scale embedded generators (particularly PV units) are now attractive for many electricity customers in South Africa as a supplement to their main

electricity supply. Rooftop solar PV installations are already increasing in South Africa today as seen in the following media article: http://www.fin24.com/BizNews/Power-to-the-people-Parkhurst-residents-getting-off-the-grid-20150706. A large market uptake of Solar PV without any countermeasures will put the financial stability of electricity distributors (municipalities and Eskom) at risk because self-consumed PV energy reduces sales. The reduced sales therefore also reduce the gross-margins of distributors which they need to cover their fixed cost of building, operating and maintaining the distribution grid, as well as cost of metering and billing. Apart from this primary adverse effect on the finances of distributors, there are other potentially serious implications of having a growing "under the radar" market of small-scale embedded generators including:

- Compromised safety within the distribution grid network due to non-compliant connections
- Difficulty with grid operations due to "hidden" generators and less predictable demand
- Weakened ability to regulate a market that is neither monitored nor quantified

Conceptual solution

The CSIR Energy Centre therefore developed a Net Feed-in Tariff (NETFIT) concept in which electricity distributors are made financially indifferent to embedded PV, and in which the business case for the PV owner is de-risked at the same time. The most important features of the proposed NETFIT scheme are the compensation to the municipality for their financial gross margin loss as well as the secure revenue stream to the PV owner for the excess electricity that is fed into the grid. The amount of compensation is determined by a Central Power Purchasing Authority (CPPA) which measures and aggregates all power fed into the grid.

Keywords: *NETFIT concept, photovoltaic, electricity tariffs, small-scale embedded generators, financial gross margin loss, secure revenue stream, Central Power Purchasing Authority*

Supporting Energy Efficiency in West Africa – Experiences from the Development of the ECOWAS Regional Energy Efficiency Initiatives and Further Action

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Abstract

With the establishment and operationalization of the ECOWAS Centre for Renewable Energy and Energy Efficiency, the West African region has embarked on a pathway towards ensuring access to affordable, reliable, sustainable and modern energy for all, which has recently been defined as SDG 7. Energy efficiency is a key element to expand and improve access to energy,

guaranteeing the effective use of financial resources, augmenting the energy services provided by existing and planned energy supply sources, and providing final users with the opportunity to save costs. The adoption of the ECOWAS Energy Efficiency Policy (EEEP) by the Heads of State and Government in July 2013, which included targets and regional initiatives contained in an action plan, marked the first step towards enhancing energy efficiency in the region. Setting the agenda, raising awareness of high-level political actors, launching ECOWAS flagship initiatives for implementing energy efficiency, and initiating the process to develop National Energy Efficiency Action Plans (NEEAPs) all contributed to the creation of a functioning policy framework for energy efficiency in the region. The presented SEEA-WA project supported and facilitated a substantive dialogue on energy efficiency priority areas resulting in concrete policies, as well as the harmonisation of standards, policies and plans across ECOWAS Member States, which helped them to pursue common approaches in a concerted, structured manner. Next to the flagship energy efficiency initiatives on lighting, standards and labeling, cooking, electricity distribution, and buildings, mainstreaming gender aspects in energy access has both been considered as a cross-cutting issue in the flagship initiatives, and has been defined as an ECOWAS Programme on its own. The Austrian Energy Agency, together with other partners, supported ECREEE and ECOWAS Member States in the development of regional and national policies, initiatives and action plans within this project and beyond.

Keywords: *ECREEE, energy efficiency, ECOWAS*

Energy Policy Development

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Abstract

Energy policy is one of the most important tools for any government in supporting the development of the energy sector. A good energy policy requires long term vision, clearly set objectives and best information possible on options for a specific country, taking advantage of resources available. Uncertainties involved make this task far from trivial, but at the same time a good policy aims to create a predictable environment in order to support investment and activities on all levels of a society. The balancing between uncertainties and need for stability is one of the key issues in policy development. Energy sector does not develop in a void but interacts with industry and society in general. These interactions should also be taken into account in policy development. Global trends on emerging and maturing technologies as well as global energy market situation should influence decision making as well. Necessities and other key ingredients of energy policy development are discussed in the presentation. A model of the process is proposed. Policy development in Finland as part of European Union is considered as a case example, focusing on the role of renewable energy policy in the existing policy. Policy

development as a process and lessons learned are discussed from Namibian point of view. This is done by taking into account the current status of Namibian energy policy and sector. Opportunities and prospects for renewable energy are argued.

Keywords: *Energy policy, global energy market*

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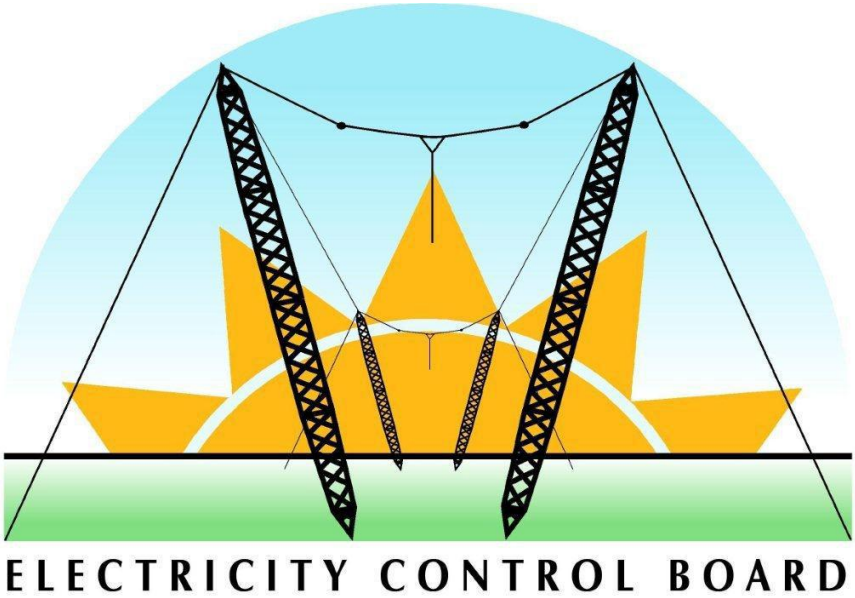

Friedrich – Ebert – Stiftung

Friedrich-Ebert-Stiftung was founded in 1925 as a political legacy of Germanys first democratically elected President, Friedrich-Ebert, who was a social democrat from a humble crafts background and had risen to the highest political office in his country.

Friedrich-Ebert-Stiftung is a private cultural non-profit institution, committed to the ideas and basic values of social democracy.

The Friedrich-Ebert-Stiftung consists of 120 offices worldwide. The office in Namibia was opened in 1989 just after Namibia Independence.

In response to his own painful experience in political confrontation, he had proposed the establishment of a foundation to the serve the following aims;

- Furthering the political and social education of individuals from all walks of life in the spirit of democracy and pluralism
- Contributing to international understanding and co-operation
- As a private cultural non-profit institution it is committed to the ideas and basic values of social democracy

Through the Friedrich-Ebert-Stiftung activities, the Namibia Office aims at;

- Civic education
- Labour relations
- Economic and social dialogue
- Gender mainstreaming
- Promotion of social protection; the Regional Media Project has been located at FES Namibia since 2002

Get Green Energy Corp. Ltd

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GGE

National Energy Fund-Ministry of Mines and Energy

The Ministry of Mines and Energy (MME) is the State's lead agency in attracting private investment in resources exploration and development through the provision of geoscientific information on minerals and energy resources, and management of an equitable and secure titles systems for the mining, petroleum and geothermal industries.

It also carries prime responsibility for regulating these extractive industries in the country, including the collection of royalties, and ensuring that safety; health and environmental standards are consistent with the relevant State and Commonwealth legislation, regulations and policies.

The Ministry offers service to geoscience organisations, universities, research centres, mining and petroleum industries and the public under the following directorates.

1. Directorate of Diamond Affairs
2. Directorate of Mines
3. Directorate of Energy
4. The Geological Survey of Namibia
5. Directorate of Petroleum Affairs

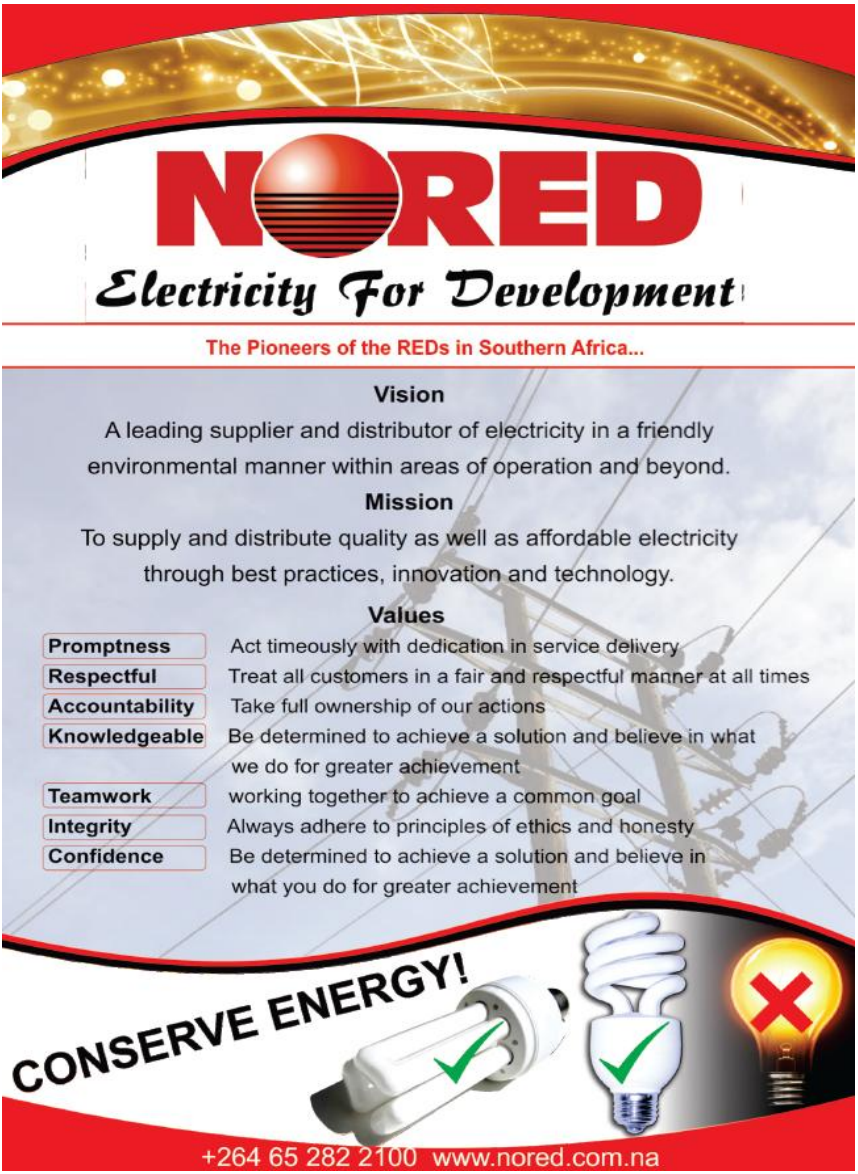
National Energy Fund (NEF): Directorate of Energy

NEF is a Statutory Fund established by the Petroleum Products and Energy Act, of 1990 amended in 2003. The main objectives of the Fund are to receive all moneys collected in respect of levies imposed on energy sources and to subsidies the energy prices.

The NEF provides loans to electricity undertakings for financing capital projects, subsidize electricity prices and provide guarantees to the Regional Electricity Distributors. The Fund also manages and administers the fuel Road delivery subsidy to the rural or far outlying areas of Namibia.

The National Energy Fund plays a significant role in the national development in terms of equalising the national pump price when the international price becomes unaffordable to the consumer, thus reducing inflation rate in the economy.

Nored


NORED
Electricity For Development
The Pioneers of the REDs in Southern Africa...
Vision
A leading supplier and distributor of electricity in a friendly environmental manner within areas of operation and beyond.
Mission
To supply and distribute quality as well as affordable electricity through best practices, innovation and technology.
Values
Promptness
Act timeously with dedication in service delivery
Respectful
Treat all customers in a fair and respectful manner at all times
Accountability
Take full ownership of our actions
Knowledgeable
Be determined to achieve a solution and believe in what we do for greater achievement
Teamwork
working together to achieve a common goal
Integrity
Always adhere to principles of ethics and honesty
Confidence
Be determined to achieve a solution and believe in what you do for greater achievement
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Southern African Sustainability Energy Initiative Project

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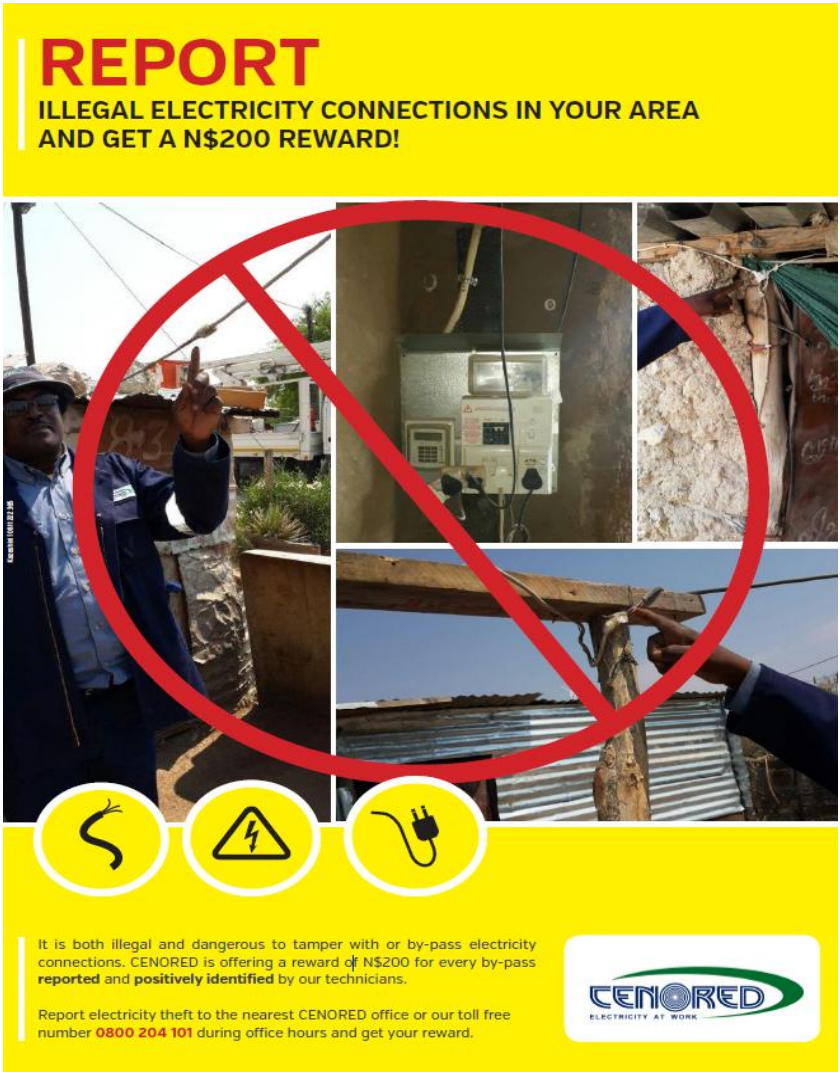

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City of Windhoek

City of Windhoek

City of many faces

Erongored

Envisaged as a dynamic and efficient commercialised electricity distributor for the Erongo Region, the Erongo Regional Electricity Distributor Company (Pty) Ltd, commonly known as Erongo RED, started trading on 1 July 2005 within the context of the Namibian Government's National Development Plan.

Erongo RED was formed by merging the service of electricity distribution from various municipalities and town councils in Erongo region namely the Municipality of Walvis Bay, Swakopmund, Henties Bay and Omaruru; the Town Council of Karibib, Usakos and Arandis; Erongo Regional Council; and NamPower. All these individual institutions are shareholders of Erongo RED. The initiative to create RED's was part of the Electricity Supply Industry (ESI) and Electricity Distribution Industry (EDI) restructuring Policy to distribute and supply electricity through economies of scale, pooling of human and operational capital resources to ultimately stabilize electricity prices and ensure reasonable, affordable and cost reflective tariffs to electricity consumers.

The company purchases electricity from NamPower for both urban and rural customers. The electricity is transmitted and distributed to different customers segments ranging from residential, business and industrial customers. Erongo RED uses about 15% of the total electricity requirement of Namibia. Electricity industry in Namibia is regulated by Electricity Control Board of Namibia, thus Erongo RED operates under the set regulations.

The core business of the Erongo RED is to distribute and supply electricity within the mighty region of Erongo. Erongo RED received a distribution and supply licences which are valid until 2030. The company also received a generation licence in 2006 for embedded power generation for a 220 kW wind generator near Walvis Bay, the first known network-connected wind generator in Namibia.

GIZ- Support to De-Bushing Project

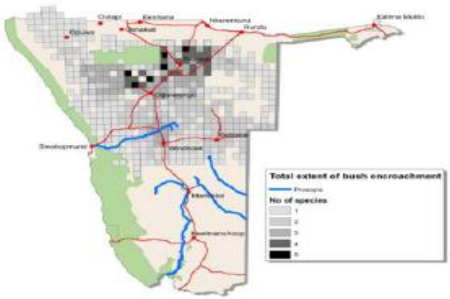
Support to De-bushing Project

Beyond Bush

Bush Encroachment & Biomass Energy

Namibia is affected by bush encroachment on a massive scale. The phenomenon currently affects some 26 to 30 million hectares of farmland in 9 of the country's 14 regions. That amounts to roughly 30 per cent of Namibia's land area. Bush encroachment has lowered the livestock capacity of rangeland by up to two thirds. It further results in severely reduced biodiversity and limits the recharge of groundwater.

Total Extent of Bush Encroachment



Encroacher Bush is growing into a huge biomass resource. The amount of 200 to 300 million tones on Namibian farmland meets an increasing national and international demand. 50% of the annual re-growth would cover Namibias national power demand. Biomass energy is a CO2 neutral and renewable fuel. The wood fuel is a local resource and supports domestic economic development, supports a variety of value chains and creates sustainable employment.

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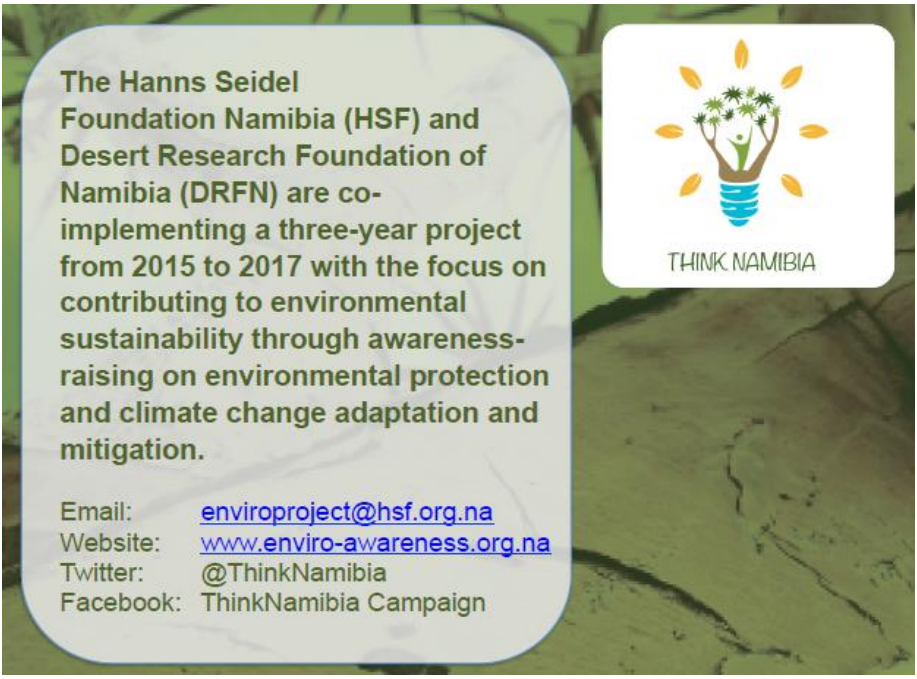
german cooperation

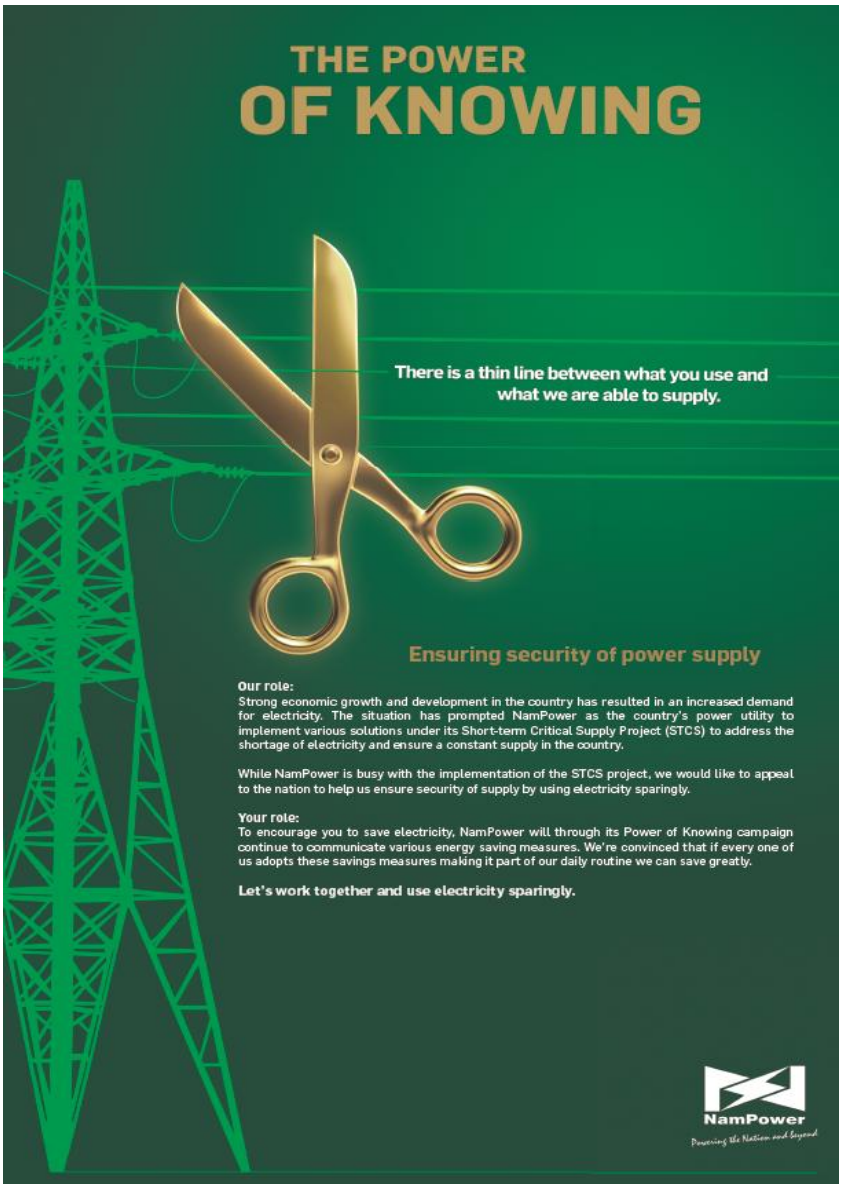
Implemented by giz

Hanns Seidel Foundation



Hanns Seidel Foundation

Nampower


THE POWER
OF KNOWING
There is a thin line between what you use and what we are able to supply.
Ensuring security of power supply
Our role:
Strong economic growth and development in the country has resulted in an increased demand for electricity. The situation has prompted NamPower as the country's power utility to implement various solutions under its Short-term Critical Supply Project (STCS) to address the shortage of electricity and ensure a constant supply in the country.
While NamPower is busy with the implementation of the STCS project, we would like to appeal to the nation to help us ensure security of supply by using electricity sparingly.
Your role:
To encourage you to save electricity, NamPower will through its Power of Knowing campaign continue to communicate various energy saving measures. We're convinced that if every one of us adopts these savings measures making it part of our daily routine we can save greatly.
Let's work together and use electricity sparingly.
NamPower
Powering the Nation and Beyond

Old Mutual Life Assurance Company (Namibia) Limited

KEY NOTE SPEAKER BIOGRAPHIES

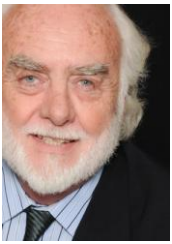
Key Note Speaker Biographies

Al-Mas Sendegeya

Al-Mas Sendegeya holds a PhD in Power Systems specialising in modelling rural electricity from Makerere University (Uganda), Technical Licentiate in Power Systems from Royal Institute of Technology (KTH, Sweden), MSc. Renewable Energy from Oldenburg University (Germany), BSc. Electrical Engineering from Makerere University (Uganda), Advanced Certificates in Solar Engineering India) and Advanced Certificate in Small Hydropower Engineering Development (Japan). Currently he is the Head of Department of Electrical and Computer Engineering in the School of Engineering, Polytechnic of Namibia. Dr Sendegeya has provided various consultancy services in the field of Sustainable Energy e.g. Energy Audit, Solar Energy training and rural energy development with GIZ Uganda. He is an active member on the management and board of an NGO (East African Energy Technology Development Network-Uganda) promoting Renewable Energy and Appropriate technologies in Uganda.

Clement S. Shonhiwa

Clement. S. Shonhiwa holds a MSc Degree in Renewable Energy and a MSc. Degree in Chemical Engineering from the University of Zimbabwe and University of Las Villas Santa Clara Cuba respectively. He is a registered professional engineer with the Zimbabwe Institute of Engineers. He is also in his final year of Doctor of Philosophy in Science at University of Zimbabwe. He has over 21 years experience in engineering design and manufacturing and over 12 years experience teaching Renewable Energy, Process Engineering, Thermodynamics, Power Plants, and Engineering Mathematics at University of Zimbabwe. He is currently the Renewable Energy Coordinator at University of Zimbabwe. He is also the founder of the BSc. Honours Degree Programme in Fuels and Energy at Chinhoyi University of Technology. He pioneered the Zimbabwe National Biodiesel Programme and patented The Jatropha Biodiesel Processing Plant. For the past two years he has been working on the resuscitation of MSc Degree in Renewable at University of Zimbabwe.



Dr Wotan Swiegers MBChB FCFP MFOM DTM&H DOM PhD is the current and inaugural Director of the Namibian Uranium Institute and Chairperson of the Atomic Energy Board of Namibia and an Advisory Board Member of the Namibian Energy Institute (NEI). He is a previous Manager of Health, Environment and Water Management of Rössing Uranium and previous Director of the MRC (RSA) Research Institute for Environmental Diseases (REID). He spearheads the Namibia Uranium Stewardship programme and is an Adjunct Professor at the School of Health and Applied Sciences at the Namibian University of Science and Technology (NUST).

Cornelia Schenk

Cornelia Schenk is an expert with extensive experience in European and international projects, energy economics and infrastructure, as well as energy and climate policy. He holds a Master of Science in Environmental Technology and International Affairs from the Technical University of Vienna/Diplomatic Academy and a Master of Legal studies from the University of Vienna.

Margaret Mutschler

Margaret Mutschler holds a degree in Electrical Engineering from the University of Stellenbosch and a Masters degree in Finance and Financial Law. She has served as a factory engineer at an export and EU approved red meat abattoir and has extensive consultancy experience in project development, management and continuous improvement initiatives. She was employed by the Polytechnic of Namibia in 1998 to establish and lead the electrical engineering department. In July 2003 she was recruited as the Head of Generation to NamPower's executive management. Her responsibilities included that of Kudu gas to power project leader from 2004 to 2009. Since 2007 she is part of the NamPower business unit responsible for the implementation of capital projects where she is heading the division implementing new power station projects, conventional and renewable, as well as NamPower's national Demand Side Management Project. She is serving on a number of multi disciplinary steering committees in the Namibian electricity supply industry, giving guidance to development and representing NamPower.

Harald Schütt is actively involved with the Namibian cause since 1983. He founded the Organisation "Practical Solidarity International" 1985 in Bremen, Germany, which is still contributing in various ways to National development in Namibia. In 1997 he was seconded by German Development Service (DED=GIZ) to Valombola Vocational Training Centre in Ongwediva; in 2000 promoted to be Programme Coordinator for DED. Since 2002 he is running Amusha Consultancy Services, working mainly with issues around sustainable management and Renewable Energy as well as Energy Efficiency. In 2006 he was appointed coordinator for Renewable Energy and Energy Efficiency Institute (REEEI) at Polytechnic of Namibia, while leading the programme "Renewable Energy and Energy Efficiency Capacity Building" (REEECAP). Currently, he is an independent consultant coordinating the Climate Change programme for Konrad Adenauer Stiftung as well as the activities of Renewable Energy Industry Association of Namibia (REIAoN). He is also partnering with a German Company in a programme to measure the intensity of sunshine at three strategic points in Namibia.

Kudakwashe Ndhlukula

Kudakwashe (Kuda) Ndhlukula is presently a consultant/energy infrastructure expert for a number of organisations including, AfDB, IRENA and UNDP. Previously he was Programme Officer – Capacity Building for the IRENA in Abu Dhabi since November 2012. In this position, he managed various projects including the Africa Clean Energy Corridor, Photovoltaics Promotion in West Africa and Capacity Building in Small Hydropower Development. Before joining IRENA, Kuda was the Director/Coordinator of the Renewable Energy and Energy Efficiency Institute (REEEI) in Namibia where he formulated and executed various projects on concentrated solar power, wind mapping, renewable energy and energy policy and regulatory frameworks, Green Building Council Namibia, training of installers and energy experts, amongst many others. Kuda is a Certified Energy Manager and Certified Energy Auditor. He possess an MSc in Renewable Energy Engineering and an MBA, amongst other qualifications.

Miika Rämä

Miika Rämä (MSc.) works as research scientist in VTT Technical Research Centre of Finland and has over 10 years of professional experience in both domestic and international research projects. Rämä's main competences include considerable know-how on general energy technologies, applied thermodynamics, energy systems modelling and analysis. He also has special expertise in district heating and cooling as a technology and on its role in an energy system. During the recent years Rämä has been involved in research work concerning the development of the Namibian energy sector. In cooperation project with Ministry of Mines and Energy, VTT and a team led by Rämä was tasked to support the effort to update the energy policy of Namibia. As one of the main results of the project, national energy statistics for Namibia was founded. Currently, Rämä is working with the Namibian fishing industry to evaluate available renewable energy options and to identify energy efficiency improvement opportunities.

Thembakazi Mali

Thembakazi Mali holds a Ph. D in Chemistry and a Graduate Diploma in Engineering in Environmental Engineering from the University of the Witwatersrand. Her career spans over a decade in the chemical and petrochemical fields. Presently, she is the Senior Manager: Clean Energy Solutions (Renewable Energy and Alternative Energy) at the South African National Energy Development Institute (SANEDI), which is a state-funded energy research organisation that focuses on public interest energy R&D that seeks to assist government in meeting the national goals of economic development and the improvement of quality of life of all citizens. She serves as the South African representative and executive committee member to the International Energy Agency's (IEA) Implementing Agreements on Ocean Energy Systems, Bioenergy and Solar Cooling and Heating. She is the director of the Southern African Regional Secretariat for the Renewable Energy and Energy Efficiency Partnership (REEEP) which is hosted by SANEDI.

Werner Weiss

Werner WEISS is a mechanical engineer and director of AEE – Institute for Sustainable Technologies (AEE INTEC) in Austria. He was chairman of the Solar Heating and Cooling Programme of the International Energy Agency (IEA) from June 2010 to May 2014. Furthermore he is a board member of the European Technology Platform on Renewable Heating and Cooling. He has been project coordinator of more than 50 national, European and international solar thermal energy projects. His main research activities are on solar combi-systems and solar heat for industrial processes. Since 2007 he is lecturer at Vienna University of Technology and faculty member of the continuing education centre. Werner Weiss also has 20 years of experience with a number of training and capacity building projects in Africa, South and Central America and other developing countries.

THE SCIENTIFIC COMMITTEE

The Scientific Committee

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Dr	Anna Matros-Goreses	Project Services Unit-Polytechnic of Namibia
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Mr	Conrad Roedern	Renewable Energy Industry Association of Namibia

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The Local Organising Committee

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Mr	Ndakema Hamunghete	Namibia Energy Institute-Polytechnic of Namibia
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