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Benguela Community/UNAM Wind Power Demonstration Project—Experiences in Implementation

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Abstract: The government of Namibia has committed itself to promote the use of economically viable RE (renewable energy) technologies, as a complement to grid electrification, and to improve energy provision to rural areas. This paper presents the implementation of the Benguela Community-UNAM Wind-Power Demonstration Project, which is a community-run wind-power mini-generation pilot plant in Luderitz, Namibia. Luderitz 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 Luderitz and a first of its kind in Namibia. It demonstrates the application of small-scale wind energy systems in Namibia and contributes to the growing national awareness of RE and use of wind power in the country. 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 discusses lessons learned; envisaged future development plans; highlights technical, administrative and management activities; as well as potential for replication and barriers encountered during the project implementation including institutional constraints. The solution-methods developed are presented and discussed.

Key words: Renewable energy, community-run, micro-grid, wind-power, clean energy technologies, Namibia.

1. Introduction

The last century has demonstrated that every facet of human development is woven around a sound and stable energy supply regime [1]. In the last decade, there has been a growing emphasis on developing suitable and affordable technologies to meet the challenges of remote and rural settlements [2, 3], such as: hybrid renewable power generation and storage systems [4], and the micro-grid concept. 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, modular, low maintenance, easy to install 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 [5].

Namibia imports electricity from neighboring countries (Zambia, South Africa and Zimbabwe) to augment its local generation. Several rural and low-income communities are not served. In the south west region of Namibia, electricity supply for the local industry and housing is imported from South Africa via a central electricity grid. Namibia is projected to experience major power shortages in the near future due in part to the expiration of power purchase agreements and contracts with these suppliers [6].

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Concern for this dependency and increasing electricity prices that mainly affects poor and low income members of the community, are some of the reasons why this project was initiated.

According to the World Wind Energy Association, wind energy generated 1.5% of worldwide energy usage in 2008 and 2.5% in 2010 [7]. Given the rate of installed and projected growth, it is anticipated that wind power market penetration will be 3.35% in 2013 and 8% by 2018. There are an estimated 200,000 wind turbines operating throughout the world with a capacity approaching 300 GW [7]. Since the late 1990s, most wind turbine manufacturers have changed to variable speed wind turbines for power levels above 1.5 MW, mainly to enable a more flexible match with system requirements considering audible noise, power quality, and energy yield [8]. The gearless generator systems with direct-drive generators, was proposed from 1991 mainly to reduce failures in gearboxes and to lower maintenance problems [8]. Eq. (1) gives the amount of power captured from a wind turbine [9]:

$$P = \frac{1}{2}\rho A C_p V^3 A \qquad (1)$$

where, P = turbine power (Watts);

ρ = air density (kg/m^3);

A = swept turbine area (m^2);

C_p = coefficient of performance;

V = the wind speed (m/s).

The coefficient of performance of a wind turbine is influenced by the TSR (tip-speed to wind speed ratio), which is defined as the ratio of the speed of the rotor tip to the free stream wind speed given by Eq. (2) [8, 9]:

$$TSR = \frac{W_R}{V} \qquad (2)$$

where, W_R = rotor tip speed (m/s);

V = wind speed (m/s).

2. Project Aims and Objectives

2.1 Aims

The underlying 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 into the Namibian electric power grid.

2.2 Objectives

The long-term objective of the project is to s upply affordable renewable wind energy at cost recovery and on sustainable basis to the low income families engaged in local textile business; women-headed households and small businesses in the community. Excess energy will be sold to Luderitz Municipality.

Other objectives are to collect and disseminate information on wind energy; create awareness of RE (renewable energy); to install and maintain small wind energy systems as demonstration units; and to provide training to members of the community on installation, maintenance and servicing of wind energy systems (Fig. 1).

3. Methodology and Procedure

As this pioneer project seeks to demonstrate the use of small grid-connected wind systems in Namibia, to produce electricity, the low-income community of Benguela, a suburb of Luderitz was selected for the demonstration site. An evaluation of wind generator design systems was carried out for application in harsh environmental conditions of Luderitz.

Fig. 1 Training on installation of wind turbine equipment.

The types of wind generator designs considered for wind power application in Luderitz include:

- SCIG (squirrel cage induction generator);
- DFIG (doubly fed induction generator);
- EESG (electrical excited synchronous generator);
- PMSG (permanent magnet synchronous);
- MPIG (multi-phase induction generators).

DFIG-based wind turbines have reliability problems due to slip-rings, brushes and the gear-box [10-12]. The PMSG was selected as the most suitable based on overall superior performance in a harsh environment.

3.1 Project Site Location

Luderitz (26°38'S; 15°06'E), is situated in South-West Namibia along the Namib Desert. The town's economy mainly depends on mining, fisheries and tourism and is regarded as the industrial hub of the Karas Region. The area around Luderitz forms part of a narrow strip of land along the Namibian coastline in the cool desert climatic region. This region is swathed by strong south-westerly winds in summer and the occurrence of "Berg" winds during the winter months of the year. These seasonal winds contribute to the weather character of Luderitz making it one of the windiest places on earth. The prevailing winds range from an average of 2.8 m/sec during the winter to as high as 7.5 m/sec during the summer. This weather patterns makes the area suitable for the use of wind energy.

3.2 Technical Specifications

- Energy resource: wind.
- Technology: grid connected small wind systems.
- Application: lighting, electric appliances, battery charging, and manufacturing industry.
- Towers: 12 m monopole galvanized.
- Sector: SMEs (small and medium enterprises), low-income housing.
- Size of turbines: 2 × 800 W; E230i wind turbine, 12/24/48Vdc (Fig. 2).

3.3 Project Implementation

As a community-based project, skilled workers from the community engaged in the construction and installation of the wind turbine units.

Fig. 2 shows pre-installation earth works by a community member, while Fig. 3 shows the installation of the wind turbine on the 12 m monopole galvanized tower.

The primary equipment (wind turbine) is connected to the secondary system (located in-house), where power conditioning equipment consisting of inverters,

Fig. 2 Community member carrying out earth works for the wind turbine tower installation.

Fig. 3 Construction and assembling of wind turbine units.

charge controllers and deep cycle energy storage batteries are located.

Fig. 4 shows the installation of the interface equipment: battery system, inverter unit and metering units.

3.4 Project Development and Expansion

The implemented small-scale wind energy system project produces 250-500 W at a wind speed of 7 m/sec. It is designed to meet the energy need of an individual household, powering light bulbs, radio and/or television and other basic household appliances. The project has now entered its next stage of upgrading with an additional 10 kW grid connected system; the Benguela Community-UNAM (University of Namibia) Wind Power Demonstration Project, which will serve as a research and training facility, while serving the community.

In conjunction with UNAM, funding has been received from the Finnish Government. With expanded capacity, trial experiments in the use of off-grid wind energy systems that could be used to supply electricity to individual households, aquaculture farms, fish factories and businesses are in the horizon.

4. Results and Benefits

The successfully implemented pilot project is functional and operational since 2006 and fully community supported and managed. The electricity produced by the wind generators is used to power sewing machines and some of the income from the product sales is used to maintain the wind generators. This is to ensure sustainability of the project. This initiative enjoys the full support from the community, local businesses as well as the Regional/Local Authorities and a first of its kind in Namibia.

4.1 Project Sustainability

The project has developed from a pure wind energy experiment into an empowering scheme. Electricity from the project is used to power sewing machines

Fig. 4 Installation of interface equipment: battery system, inverter unit and metering units.

used by a group of women who are involved in the production of clothing and other household textiles.

Figs. 5 and 6 show local business of women sewing groups (Windy Creation). Figs. 7 and 8 show textile products from Wind Creations on display.

4.2 Environmental Benefits

Wind energy systems help reduce dependence on fossil fuels and are non-polluting. Thus they contribute to clean air and reduction in carbon emissions from conventional fossil derived energy sources.

4.3 Public Awareness

A major impact of this project has been the growing public awareness in Namibia to renewable energy. Figs. 9 and 10 show the RE information day creating public awareness on clean energy technologies and the wind-power project.

4.4 National Benefits

For Namibia, electricity generated from wind energy

Fig. 5 Women sewing groups (Windy Creations).

Fig. 8 Employment creation and empowerment of women.

Fig. 6 Women sewing groups: production, sales, and marketing.

Fig. 9 Information day on RE.

Fig. 7 Textile products on display by windy creations.

Fig. 10 Participant learns how RE is processed.

locally results in reduced dependency on foreign imports of electricity. It eliminates the high costs of installing high-voltage transmission lines. It offers the opportunity for a better control over demand and supply–a benefit to customers. This also contributes to the government's policy of decentralization as the responsibility for energy provision and control will be in the hands of the community and the local authorities.

4.5 Capacity Development and Skills Transfer

The Benguela-UNAM Wind-Power Demonstration Project is an initiative that is training community members to operate and maintain the energy systems and to supply electricity to local tailoring business. These previously unemployed women have also received training in tailoring, clothing design and marketing of textile products. Earnings from sale of textile products are used to support their families. Upgrading of the project is aimed at benefiting more families. Through its cooperation with UNAM, the project engages engineering students in research and development of locally manufactured RE technologies.

5. Conclusions

The project encountered institutional, technical and financial barriers in the setting up of wind energy systems in Namibia. Information and awareness campaigns conducted through the project have immensely contributed to awareness for RE in the area and the initiative enjoys the full support from the community, local businesses as well as the regional and local authorities. The project has received social acceptance and has contributed to the exposure of the community to a new technology and enhanced appreciation for a natural phenomenon in the form of wind.

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