# REVIEW OF WIND ENERGY ACTIVITIES AT THE CSIR

S Szewczuk
CSIR Built Environment, Pretoria, South Africa

**ABSTRACT**

**The Council for Scientific and Industrial Research (CSIR), the DoE and Eskom have jointly developed the South African Renewable Energy Resource Database. Since the wind resource database is not accurate enough the Global Environmental Facility and the Danish Government are funding a three year project to develop an accurate wind resource map for the coastal regions of South Africa.**

**Two wind/PV based pilot hybrid mini-grid energy systems have been implemented in the Wild Coast of the Eastern Cape Province. These two wind/PV mini-grids were implemented to provide the learning and experience for wind and other forms of renewable energy based systems to compliment the grid connected electrification programme. The CSIR, together with the then DME and the City of Cape Town investigated the feasibility of large wind turbines. This resulted in Eskom implementing its wind energy scheme at Klipheuwel near Cape Town. Even although the South African wind resource is not yet fully quantified it is recognised that the wind resource ranges from poor to moderate and the CSIR has designed and built wind turbines to operate in moderate wind conditions.**

**This paper will provide an overview of wind energy activities at the CSIR.**

## 1. INTRODUCTION

The CSIR's expertise in wind energy has evolved out of the capacity and expertise that was developed to support its work into research, development and demonstration of various technologies in the aerospace sector.

The Aeronautics Research Unit was established in 1968 out of the National Mechanical Engineering Research Institute's Aeronautics Division which was formed in 1960 [1]. At the time it was envisaged that the unit would fulfil a role as a research and development centre for an emerging South African aircraft manufacturing industry. As an initial aeronautical research project, embracing the unit's field of activity – aerodynamics, structures and propulsion – and offering research challenges in each, the concept of an autogyro as a short takeoff and landing machine (STOL) was adopted. An experimental prototype was successfully flown in 1973. One of the results of this project was the development of the design and manufacturing techniques for producing helicopter main and tail rotor blades in glass and carbon fibre reinforced composite material, offering significantly improved structural performance as well as lower cost by comparisons with imported metal blades.

Figure 1: CSIR's autogyro technology demonstrator.

## 2. CSIR'S LOW WIND SPEED TURBINE

The energy crisis of the 1970's stimulated interest in power generation by means of wind turbines. A programme for the research and development of wind turbines for generating electricity was launched by the CSIR [1].

The objective of this research programme was to develop small-scale wind energy conversion systems intended for operation in regions with low average wind speeds. This was to compliment the then existing machines that were designed to operate in much stronger winds.

The main objective of the programme was therefore to develop a wind turbine that could operate continuously in regions with low average wind speeds, such as in Pretoria that has an average annual wind speed of 1,8m/s.

Furthermore, the programme was also aimed at developing a wind turbine that was capable of producing a viable amount of power for the greatest number of days. In general, the development of a small-scale wind turbine producing a few kilowatts of power in regions where strong winds do not occur was considered to be a worthwhile research project.

The design, manufacturing and testing of a scale model followed by the full scale wind turbine is described by Esterhuyse, [2] in detail. In the development of this wind turbine only fixed pitch wind turbines were considered so as to keep the design as simple and as cheap as possible, and maintenance to a minimum. Another important consideration was to develop a wind turbine rotor which would start to rotate at very low wind speeds so as to xtract power from the wind for as many hours as possible per day.

A standard automotive alternator was modified to provide a suitable charging unit for a 36 volt bank of batteries. The torque required to overcome the static friction of the drive train was determined and a unique method of design was developed to match the available starting torque of a specific rotor with the required static torque of the drive train and charging unit. A rotor was designed according to the aerodynamics of axial flow wind turbines and a model was tested in the CSIR's 7 meter wind tunnel to establish the characteristics of its performance and starting torque.

The aerodynamic design of the full-scale rotor was executed according to these results and a prototype wind turbine was built. From the results of test done on the full scale wind turbine it was shown that a turbine rotor could be designed for effectively harnessing the wind energy in regions with very low average wind speeds.

This programme also proved that a wind turbine could be built from locally available parts to produce an attractive source of energy suitable for application in the underdeveloped regions of South Africa.

It was also recommended that three basic models of wind turbines, each having a rotor with a different diameter, should be developed for harnessing wind energy throughout the whole of the country. Figure 2 shows the full scale wind turbine that was mounted onto the roof of the CSIR's 7 meter wind tunnel building during its testing period.

Figure 2: CSIR's full scale low wind speed turbine

## 3. CSIR'S CURRENT AEROSPACE CAPABILITY

The technological importance of a national aerospace industry goes far beyond the development of air vehicles and the accruing of socio-economic benefits. The high technology benefits generate spillovers to other industries, create knowledge, increases competitiveness and stimulate innovation [3].

A CSIR and Denel flagship project was an aircraft known as Ovid that held the distinction of being the world's first all composite material trainer aircraft, being made from a carbon/glass honeycomb structure that was fully aerobatic with excellent flying qualities. Figure 3 shows a picture of the Ovid aircraft trainer and also represents the collaborative effort between aeronautics and materials research. The CSIR was a major contributor to the development of South Africa's first indigenous combat attack helicopter, the Rooivalk AH-2A (Figure 4).

Considerable CSIR resources were dedicated to helicopter technology through computational fluid dynamics, modelling and simulation, aero-elasticity advanced structures and wind tunnel testing to develop the Rooivalk. Much of this effort has been applied to the design and manufacture of the rotor of the helicopter.

Figure 3: Ovid all composite trainer aircraft

Consequently much of the know-how and expertise that was developed by the CSIR in the aerospace sector can be directly applied into the design and manufacture of advanced wind turbine rotor blades. It is this recent development in know-how and expertise in the aerospace sector that enabled the CSIR to reinvestigate opportunities in the wind energy sector.

Figure 4: Rooivalk AH-2A helicopter

## 4. RECENT CSIR ACTIVITIES IN THE FIELD OF LARGE GRID CONNECTED WIND TURBINES.

### 4.1 Wind Turbine Feasibility Study

In 1996 the CSIR, the Cape Town Electricity Department (CTED) and the then Department of Minerals and Energy Affaires (DMEA) undertook a project to investigate the feasibility for a wind energy scheme in the Cape Town area [4].

A review was undertaken of the wind energy climatology that was done for South Africa. Numerical models were used to analyse areas that were deemed to have excellent wind resources. This work was done primarily by Professor Roseanne Diab from the University of Natal and resulted in South Africa's first wind atlas.

A review was also done of other South African work done in the field of wind turbines at that time. The scarcity of published report was noted and by the mid 1990's there has been only one serious attempt to apply wind turbine generators in South Africa. A small 5kw wind turbine had been placed into off-grid operation at Mabibi on the Natal North Coast.

The Mabibi project was a joint undertaking between Eskom, the then National Energy Council (now Department of Energy), the University of Natal and Rotary and was located at a primary school at the remote rural settlement of Mabibi situated along the extreme northern coastal belt. The constraints of locally available equipment, the erecting and commissioning of a wind turbine in such a remote area had an impact on project lead times and ultimate system configuration.

In the CSIR, CTED and DMEA study a methodology for the selection and evaluation of wind turbine generators and sites was also discussed. This methodology was a generalised one based mainly on the then European experience of developing wind energy projects. Elements of this methodology were applied in the wind resource assessment and environmental impact assessment that were part of this overall study.

Meteorological wind data for 18 sites around the Cape Town area were evaluated. Applying criteria the wind data for the Cape Town area was assessed and the following areas were considered for further modelling studies:

1. The False Bay coast in the vicinity of Mitchells Plain
2. The west coast between Melkbosstrand and Koeberg and
3. An open site in the vicinity of Athlone power station due to it being a convenient site.

Modelling was done using WAsP (Wind Atlas Analysis and Application Programme) which is a PC based computer programme developed by Risø of Denmark.

Investigation of wind speeds of these three areas revealed that two were suitable candidates for a wind turbine demonstration project. These two sites were the Strandfontein area south of Mitchell's plain and the Koeberg inland area where the hilly topography enhanced the wind speeds. At Strandfontein the average wind speed at a height of 10 meters is 5, 6 m/s. At the Koeberg inland areas north of Durbanville the wind speeds ranged from 4,0m/s at the base of the hills to 7,0m/s at the tops of the hills.

A preliminary environmental impact assessment concluded that the majority of people would be likely to support the proposal for a wind energy scheme to be established in the greater Cape Metropolitan Area, provided that all concerns raised are adequately addressed.

This feasibility study recommended a proposal to establish a wind turbine demonstration project with an engineering emphasis. It was further proposed that an operating company be established as an Independent Power Producer and supply power to the Cape Town Electricity Department who had indicated a willingness to purchase the output of the turbines.

### 4.2 CSIR's Darling Wind Monitoring Programme

To develop capacity and know-how in wind measurements for wind farm development, the CSIR undertook a wind monitoring programme on the Slangkop Farm near Darling from June 1997to February 1998 and is described by Struthers and Watt [5]. Simultaneous wind measurements were done at two heights, at 6 m and 12 m. A 12 m mast structure was erected as shown in Figure 4 to undertake the wind measurement programme.

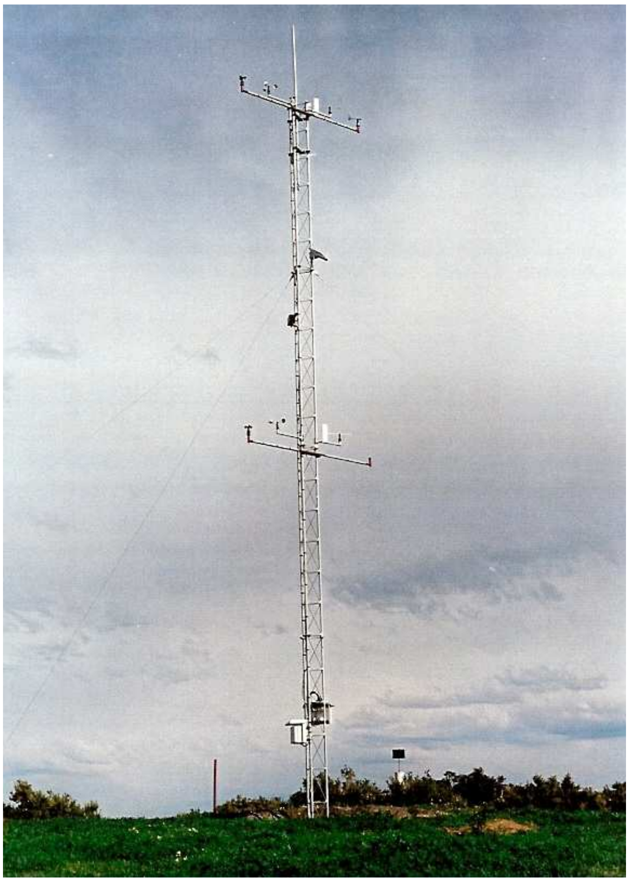

Figure 4: 12 meter mast at Darling

Two wind monitoring systems were used to capture wind data, a Mike Cotton System (MCS) and an Ammonit system from Germany. The Mike Cotton System was chosen since several years of experience had already been gained with this system and sophisticated software was developed at the CSIR Stellenbosch to process the data further. The two systems were evaluated against each other over the full recording period interval and each system consistently produced data of high quality.

The wind monitoring programme had the following objectives:

a) The routine collection, processing, analysis and presentation of wind data collected at the Slangkop Farm site
b) The historic wind data available from the Namakwa Sands Saldanha Bay Weather Station, the Eskom Koeberg Weather Station and the Cape Town International Airport were to be used as a comparison with wind data recorded at Slangkop Farm
c) To describe the characteristics of the wind conditions from the three sites with an emphasis on the Darling site.
d) To draw conclusions as to what the wind speeds and directions could be over a period of one year at Slangkop Farm and the expected average wind aped at Slangkop Farm over a longer period than one year.
e) To evaluate the Slangkop data recorded over the nine-month period against the longer term Namakwa Sands Saldanha Bay, Eskom Koeberg and Cape Town International Airport data. This process would reveal whether the actual data recording at Slangkop represents a below average year, an average year or an above average year in terms of wind power potential.

The Darling Wind Station on Slangkop Farm produced excellent data with data coverage for both systems being 100% since the commissioning date. Comparison of the wind roses for the MCS system revealed that with the exception of the month of July, the predominant wind direction for each month at the 6 m and 12 m levels were the same. The predominant wind direction during the month of July at the 6 m level was east-north-east and south-south-east at the 12 m level. This changed to northerly for June at both levels. For the remaining seven months (August 1997 to February 1998) the predominant wind direction was southerly.

When comparing the more predominant wind directions for each month at each level, in all cases, except the month of July, these directions were either the same or only slightly different. Referring to the Namakwa Sands Saldanha Bay wind data for March 1997 to May 1997 it would appear that the expected wind direction at Slangkop Farm was southerly to south-westerly and to a lesser extent north-north-westerly.

Referring to the wind roses for Slangkop Farm and Namakwa Sands Saldanha Bay the following is revealed:
1) The two MCS wind direction sensors indicate practically identical wind directions.
2) The Saldanha Bay wind direction data is very similar, particularly with the strong southerly winds from September to February.
3) Allowing for the approximate $20^{o}$ negative offset of the Ammonit wind direction sensor, it tracks the two MCS wind direction sensors very closely.

When comparing the wind speed data recorded at Slangkop Farm against that of Saldanha Bay, Eskom Koeberg and Cape Town International Airport, the following was observed:
1) The stronger wind conditions start during September and continue through to March.
2) The average monthly wind speeds recorded, considering the different levels above ground of the anemometers, are remarkably similar when referring to the Saldanha Bay wind station.
3) The average monthly wind speeds of the MCS and the Ammonit system showed very close grouping. This reflected the accuracy of the MCS and Ammonit systems.
4) The Slangkop wind data recorded between July 1997 and February 1998 showed that the average wind speeds recorded at the 6 m and 12 m levels tended to track the average wind speeds recorded at the Cape Town International Airport rather closely. This would indicate that the 10-year average of the airport would give a good idea of the longer term wind power potential of the Slangkop site at Darling.
5) Examination of the wind data revealed that the earlier part of 1997 indicated average wind speeds at Eskom

Koeberg and Saldanha Bay to be somewhat lower than their longer term average values.

When comparing the average monthly wind speeds recorded at the three stations during 1997 to the 10-year averages the following was revealed:
1) The data for the Cape International Airport indicate that 1997 was an above average year in terms of average wind speed.
2) The data for the Eskom Koeberg 10 m level indicate that 1997 was a below average year for average wind speed.
3) The Saldanha Bay data revealed that the earlier part of 1997 was slightly above the three-year average for Saldanha Bay, July to September below this average and October to December similar to the three-year average. The nett result is that the 1997 12-month average of 4,2 m/s is approximately 98% of the Namakwa Sands Saldanha Bay three-year annual data average.
4) The above would tend to indicate that the average monthly wind speeds recorded at Slangkop Farm during July 1997 to February 1998 should be regarded as close to the longer term average.
5) Analysing the wind data it is seen that the ratio of the average wind speeds recorded at Saldanha Bay and Slangkop Farm track very closely, even although the actual recorded wind speed range was closer to that of the Cape Town International Airport data.

Referring to the MCS system data and the Ammonit system data it is seen that the diurnal wind pattern is strongly developed in the early afternoon through to 22:00 hours from November to February.

When considering the wind power potential at Slangkop Farm, the following points needed to be considered:
1) The average wind speed recorded over the almost nine-month period was 6,2 m/s at the 6 m level and 6,9 m/s at the 12 m level.
2) Using the Cape Town International Airport historic data to estimate the average monthly wind speeds for March 1997 to May 1997, for the Slangkop site, the estimated annual average wind speed was 6,5 m/s at the 12 m level.
3) Using the Namakwa Sands Saldanha Bay historic data to estimate the average monthly wind speeds for March 1997 to May 1997, the estimated annual average wind speed was 6,5 m/s at the 12 m level for the Slangkop site.
4) Projecting these values to a 50 m level above ground produced an estimated annual average wind speed of 9,8 m/s and 9,75 m/s in 2) and 3) above.
5) Based on these two figures, the expected average wind speed figure is taken as 9,8 m/s for the 50 m level at Slangkop Farm for 1997.
6) This estimated figure should be verified in future wind monitoring at the Slangkop site with a greater degree of accuracy, using more complex wind measuring instruments.

### 4.3. Site selection study for Eskom SABRE-GEN

The aim of the site selection study, [6], for Eskom was to identify a number of suitable sites for their proposed wind power demonstration facility, assess them according to defined technical and environmental site selection criteria, and then recommend two or three preferred sites for assessment in the Environmental Impact Assessment (EIA). The site selection criteria that were provided by Eskom were intended to guide the evaluation of potential sites in an objective manner, and to inform the choice of two to three 'preferred' sites, for investigation in the EIA. The technical and environmental criteria identified as being important in determining the location and performance of the wind demonstration facility are listed in Table 1.

Table 1: Criteria identified for use in the site selection

| | |
|---|---|
| **Technical criteria** | Wind energy and climate |
| | Speed |
| | Direction |
| | Turbulence and obstruction |
| | Existing data sources |
| | Accessibility |
| | High profile |
| | Land ownership |
| | Planning and zoning |
| | Grid integration |
| **Environmental criteria** | Proximity to socially sensitive sites |
| | Proximity to ecologically sensitive sites |
| **Other criteria** | Electromagnetic interference |
| | Potential for supporting local alliances |

Included in the wind turbine techno-economic feasibility study were limited areas that were modelled using WasP [4]. These areas included the Strandfontein coast, parts of the hills north of Durbanville and the area around Athlone Power Station. The results of this analysis were used to provide inputs into the assessment of some of the sites that have been selected. Where sites fall out of the area that was modelled an expert opinion was given.

The assessment of each criterion for the various sites is summarised in Table 2. A comparative assessment of each site with reference to the site selection criteria indicated that the Klipheuwel Telkom Site was the most technically and environmentally feasible site at that stage of investigation, due to its unobstructed position, large land area, accessibility, potentially high profile and relatively easy integration with the Eskom grid. The Oliphantskop Farm and Philadelphia sites were very closely matched in terms of their fulfilment of the site selection criteria used in this study, but were slightly less favourable than the Klipheuwel Telkom Site.

It should be stressed that this analysis was based on expert judgements, particularly in the case of the wind energy and climate, for which there was no measured data for any of the sites during the time of investigation.

| Table 2: Synthesis of detailed site assessments | | | | | |
|---|---|---|---|---|---|
| **Criteria** | **Klipheuwel** | **Oliphantskop** | **Philadelphia** | **Strandfontein** | **Wingfield** |
| Wind Speed | 5 $m.s^{-1}$ (modelled) | 5 $m.s^{-1}$ (modelled) | 5 $m.s^{-1}$ (modelled) | 6 $m.s^{-1}$ (modelled) | 5 $m.s^{-1}$ (measured) |
| Turbulence & Obstruction | Medium | Medium | Medium | Low | Medium |
| Grid Integration | Favourable | Medium | Unfavourable | Unfavourable | Favourable |
| Land ownership | Negotiation required | No negotiation required | Negotiation required | No negotiation required | Negotiation required |
| Accessibility | High | Medium | Medium | Medium | High |
| Profile | High | High | High | Medium | High |
| Social Sensitivity | Residential: near site | None identified | Residential: near site | Residential: near site | Residential: near site |
| Ecological Sensitivity | None identified | Possibility of bird strikes | None identified | Possibility of bird strike | Possibility of bird strike |
| E'magnetic Interference | To be assessed | To be assessed | To be assessed | To be assessed | To be assessed |
| **Ranking** | **1** | **2** | **3** | **4** | **5** |

The Strandfontein and Wingfield Aerodrome were the least favourable of the remaining five sites, being close to the Cape Town City and with potentially serious land ownership / land use issues to be resolved; both sites were also close to socially and ecologically sensitive sites and would have had widespread aesthetic impacts.

This site selection study that identified Klipheuwel as the most favoured site was followed by a comprehensive Environmental Impact Assessment ahead of Eskom developing and constructing its wind energy scheme at Klipheuwel.

## 5. RECENT CSIR ACTIVITIES IN THE FIELD OF SMALL WIND TURBINES.

### 5.1 Wind Resource Map for Eastern Cape Province

A three-year investigative project entitled *"Renewable energy sources for rural electrification in South Africa"* was undertaken [7]. The aim of this project was to obtain firsthand understanding of the complexity of sustainable socio-economic development as well as identify any projects that could be implemented. Due to its impoverished state, particular attention was given to the Eastern Cape province of South Africa in this project.

The primary objective of this project was to identify the commercially viable opportunities for rural electrification in the Eastern Cape Province (ECP) of South Africa using wind, hydro and biomass powered Remote Area Power Supply (RAPS) systems. The long term wind resource at 60 m and 25 m above ground level (possible hub heights of large and small wind turbines respectively) has been estimated to 1 $km^2$ spatial resolution throughout the Eastern Cape using a combination of wind flow modelling techniques. Figure 5 shows the results at a height of 60m.

The above wind resource assessment for the Eastern Cape Province was combined with a wind resource assessment that was done by Eskom into the current wind atlas for South Africa and is shown in Figure 6 below.

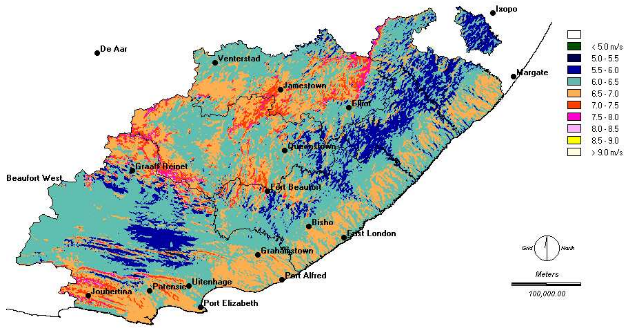


Figure 5: Mean wind speeds at 60m

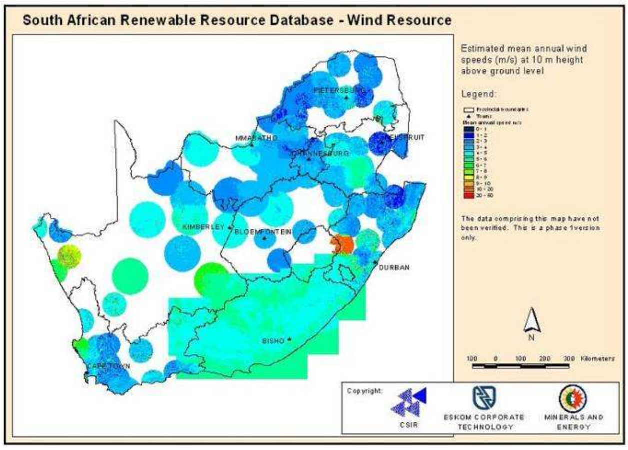


Figure 6: Current wind atlas for South Africa

### 5.2 Pilot Hybrid Mini-Grid Energy Systems

During the course of the above described project an opportunity was identified for a renewable energy based project at the Hluleka Nature Reserve in the Transkei region of the Eastern Cape Province. This energy project formed the basis of South Africa's pilot hybrid mini-grid project, [8].

A hybrid mini-grid energy system can be defined as an independent, or grid inter-tied community energisation service employing a combination of conventional and/or renewable energy technologies. Such energy systems allows for the provision of a comprehensive electricity service, where 220V AC 50Hz can be supplied as per grid. This then allows for standard 220V appliances can to be used.

The Minister of Minerals and Energy extended the mandate of the National Electricity Regulator to facilitate the implementation of pilot hybrid mini-grid energy systems with a view to use these pilots projects to gain experience and understanding of such energy systems so that a national roll-out plan can be developed. CSIR was contracted to co-ordinate the development of an implementation plan with Shell Solar Southern Africa being the implementation company.

To reduce risks and increase the probability of success emphasis was placed on proving the technical concept first, hence the decision to implement South Africa's first mini-grid in a nature reserve, namely the Hluleka Nature Reserve Thereafter, with the technical dimension of the mini-grid being proven the social dimension of implementing the pilot mini-grid was addressed.

The electricity generation system for the nature reserve is provided by two small wind turbines, each being a Proven 2.5 kW machine, and a photovoltaic array consisting of 48 X 100W solar panels. (Figure 7) Included in the electrical generation system is a control system, batteries for electricity storage and a diesel generator as a backup. This system provided the electricity for the electrical appliances for the nature reserve, namely lighting, office equipment etc.

Figure 7. Wind, PV array at Hluleka Nature Reserve

To demonstrate the suitability of hybrid mini-grid energy systems in communities several villages and settlements in the Hluleka area were surveyed and the communities consulted. This process, undertaken by Shell Solar South Africa, resulted in the identification Lucingweni village, 10kms from the Hluleka Nature Reserve, as a site for a hybrid mini-grid system. Lucingweni village has 220 households. The mini grid consists of: Power Generation, Reticulation, and Premises Equipment components. Figure 8 shows a picture of the mini-grid at Lucingweni village.

Power Generation is achieved through the use of a combination of solar photovoltaic panels and wind generators and their associated control, accumulation and distribution equipment providing a nominal electricity generation capacity of 86kW. In brief this consists of the erection of 6 X 6Kw mast mounted wind generators (6m tall) and an array of 560 X 100W solar photovoltaic panels mounted on steel structures and a building to house the control system and a bank of batteries for storage.

Figure 8: Lucingweni 86 kW hybrid mini-grid

## 6. WIND ATLAS FOR SOUTH AFRICA

The development of an accurate Wind Atlas for South Africa is intended to accelerate the investment in wind energy in South Africa. This is in line with government's objectives of reducing green house gases and diversifying our energy supply and also developing human capacity to support the emerging industry. The Wind Atlas can find applications is at least two areas, namely to assist in the development of large grid connected wind farms and to provide more accurate wind resource data to identify potential off-grid electrification opportunities.

The DoE, Eskom and CSIR are jointly funding the development of an off-grid electrification planning tool based on harnessing renewable energy resources. However, this off-grid electrification planning tool is dependent on good quality resource data and inputs. The current South African wind energy resource database is inadequate and a more accurate and reliable wind energy resource database will enhance the value of the off-grid electrification planning tool.

The Global Environmental Facility (GEF) and the Danish Government are funding a three year project to develop an accurate wind resource map for the coastal regions of South Africa. Figure 9 shows the area in blue that is currently planned to be assessed. The project team consists of Risø-DTU of Denmark, CSIR, University of Cape Town, the South African Weather Services and the South African National Energy Research Institute.

The primary activities are: wind measurements, meso-scale wind modelling, micro-scale wind modelling, extreme winds investigations.

Objectives are to also develop capacity and to develop the CSIR into national competence centres for high quality wind measurements and micro-scale modelling.


Figure 9: Area to be modelled for new wind atlas.

### 6.1 Mesoscale Wind Atlas for South Africa

The mesoscale modelling is being done by the University of Cape Town as part of the overall wind atlas project. It may be appropriate to provide the reader with a sense of what the current, and growing, understanding of South Africa's wind resource is.

Hagemann, [9], explored the use of a regional climate model to produce a detailed wind climatology for South Africa in the context of wind power applications. In terms of the resultant mesoscale wind atlas of South Africa a significant inland wind resource was discovered over the three Cape Provinces which was previously unknown. Hagemann puts forward the case that South Africa's wind resource is higher than some previous studies have suggested and is comparable to some of the windiest markets in the world.

Hageman estimated that wind power may realistically provide 81TWh or 35% of South Africa's 2007 electricity demand.

## 7. DISCUSSION

The CSIR's aerospace related expertise in aerodynamics, materials analysis, advanced structural analysis, computational fluid dynamics, modelling and simulation and aero-elasticity can quite readily be transferred into the wind energy domain. The CSIR's expertise in computational fluid dynamics and modelling can also be readily transferred into modelling of wind resources using WAsP.

CSIR used WAsP numerical analysis techniques in trying to establish the wind resource for regions in and around the Cape Metropolitan area. Using the results of this numerical analysis and well as expert inputs into the wind resource of the area around the Cape Metropolitan area provide insight into those areas where a wind energy scheme could be established. With this information as well as other criteria Eskom developed its wind energy scheme at Klipheiwel as a basis to develop a firsthand understanding of grid connected large wind energy schemes.

The CSIR invested in developing expertise and capability in wind resource measurement and this was pllied in the preliminary stages of the development of the Darling wind farm. This investment has resulted in the CSIR being included in the project to develop South Africa's comprehensive and accurate wind atlas.

Once this wind atlas is in place not only can large grid connected wind energy schemes be facilitated but also those off grid electrification projects where wind is a renewable energy to be considered.

Towards developing the new wind atlas for South Africa the current mesoscale wind atlas suggests that South Africa's wind resource is higher than estimated by previous studies.

Since the wind atlas will cover those areas where the wind speeds may be low to moderate, wind turbines that operate in low to moderate wind speeds can be implemented. Such wind speeds can be found in off-grid areas that are densely populated.

Consequently the CSIR has the know-how to design and build low to moderate wind speed wind turbines to contribute to the Government's objective of universal access to electricity for all of the citizens of South Africa.

## 8. REFERENCES

[1] Kingwill D.G., "The CSIR, the first 40 years" Published by the CSIR, 1990, ISBN 0-7988-4939-8

[2] Esterhuyse J.C., "Harnessing the wind using axial flow wind turbine", *CSIR Research Report 619, Pretoria, South Africa.*, October 1986, ISBN 0-7988-3775-6

[3] Gerryts B.A, Naidoo K. and Barker D.,"CSIR aeronautical research contribution to the RSA aerospace industry", *2nd CSIR Biennial Conference,* November 2008, ISBN 978-0-7988-5573-0.

[4] Szewczuk S, "Wind turbine techno-economic feasibility study", CSIR Report Number AERO 96/100, March 1996. Accession Number 96109.

[5] Struthers M.J and Watt L., "Slangkop Farm Darling: Wind Monitoring Programme, Data Summary Report and Wind Data Comparison", CSIR Report ENV/S – C 98027, March 1988

[6] Davies S., "Site selection study: SABRE-Gen wind demonstration facility, Western Cape, South Africa", CSIR Contract Report ENV-S-C 2000-128, November 2000.

[7] Szewczuk, S., Fellows, A. and van der Linden, N.: "Renewable energy for rural electrification in South Africa", European Commission FP5 Joule-Thermie Programme, 2000.

[8] Szewczuk S., "Hybrid mini-grid systems: distributed generation systems for communities based on renewable energy resources", *International Conference on Industrial and Commercial Use of Energy*, Somerset West, South Africa, 10-12 June 2009.

[9] Hagemann K., "Mesoscale Wind Atlas of South Africa", Thesis presented for the degree of Doctor of Philosophy, University of Cape Town, November 2008.

**Author:**

Stefan Szewczuk holds an MSc degree in Mechanical Engineering the University of the Witwatersrand and an MBA from the Herriot-Watt University in Scotland. At present he is the Research Group Leader for the Rural Energy & Economic Development group in the Built Environment at the CSIR. Stefan's primary interests are in wind energy, distributed generation and conversion of organic waste to biogas.

.