REVIEW OF THE WIND ENERGY ACTIVITIES IN SOUTH AFRICA

Stefan Szewczuk
Council for Scientific and Industrial Research (CSIR)
Pretoria, Gauteng, South Africa

INTRODUCTION

South Africa, officially the Republic of South Africa, is a country located at the southern tip of Africa. It has 2,798 kilometers of coastline that stretches along the South Atlantic and Indian oceans. To the north lie the neighboring countries of Namibia, Botswana and Zimbabwe; to the east are Mozambique and Swaziland; within it lies Lesotho, an enclave surrounded by South African territory. South Africa is the 25th-largest country in the world by land area, and with close to 53 million people, is the world's 24th-most populous nation.

South Africa's electricity supply industry remains dominated by the state-owned and vertically integrated utility, Eskom, which ranks seventh in the world in terms of electricity sales. Eskom generates 96% of the country's electricity, which amounts to more than 70% of the electricity generated in Sub-Saharan Africa. Eskom was established in 1923 as the Electricity Supply Commission (ESCOM) by the government of South Africa in terms of the 1922 Electricity Act and renamed to ESKOM in 1986. Private generators contribute about 3% of national output (mostly for their own consumption) and municipalities contribute less that 1%.

Eskom's electricity infrastructure is heavily dependent on coal (92%) with nuclear, hydroelectricity, bagasse and emergency gas turbines accounting for the rest. Eskom owns and controls the national integrated high-voltage transmission grid and distributes about 60% of electricity directly to customers. The remaining electricity is undertaken by 185 local authorities that buy bulk supplies of electricity from Eskom. Eskom also imports power from Mozambique and to a lesser extent from the Democratic Republic of Congo and Zambia, It has sold electricity to neighbouring countries (Botswana, Lesotho, Mozambique, Namibia, Zambia and Zimbabwe). Imports and exports constitute about 5% of total electricity on the Eskom system. Eskom operates a number of notable coal fired power stations, including Koeberg nuclear power station in the Western Cape Province, the only nuclear plant in Africa.

The uptake wind energy in South Africa depends on whether robust policies and regulations have been put in place. The South African Department of Energy's energy White Paper on Energy [1] is the most crucial document from which the various supporting mechanisms are then derived. The White Paper sets out five policy objectives and then considers what they mean for demand sectors (energy users), supply sectors and crosscutting issues. The White Paper makes mention of the government's commitment to renewable-energy options for the country. However, it does not set out implementation plans and targets for renewable energies in the country's energy balance. This weakness prompted the government to develop a White Paper specifically for new and renewable energy [2].

To build on the Energy and Renewable Energy White Papers, the current iteration of the Integrated Resource Plan (IRP) for South Africa, [3], initiated by the Department of Energy after a first round of public participation in June 2010, led to the Revised Balanced Scenario (RBS) that was published in October 2010. It laid out the proposed new build electricity generation fleet for South Africa for the period 2010 to 2030. The IRP was derived based on the cost-optimal solution for new build options (considering the direct costs of new build power plants), which was then "balanced" in accordance with qualitative measures such as local job creation.

In addition to all existing and committed power plants, the RBS included a nuclear fleet of 9,6 GW; 6,3 GW of coal; 11,4 GW of renewables; and 11,0 GW of other generation sources. Additional cost-optimal scenarios were generated based on the changes. The Policy Adjusted Integrated Resource Plan has allocated 10,3% to wind in the overall generation capacity, in third place after coal, 45,9%, and nuclear, 12,7%.

SOUTH AFRICA'S WIND CLIMATE

South Africa's wind resources are influenced by the large scale weather patterns that have distinct characteristics between summer and winter.

Summer Winds

In summer, the "Westerlies" are situated well to the south of the continent (Figure 1). The south-eastern Trade Winds (A) influence the north-eastern part of the region. These winds can be strong, curving sometimes from the Limpopo Province (N) into the Free State Province (F), or moving over far northern areas, such as Zimbabwe and Zambia (Z). In the west, the South East Trade Wind (B) caused by ridging of South Atlantic High, are often strong and persistent. The strong "Westerlies" are only able to influence the western, southern and south-eastern coastal areas and adjacent interior.

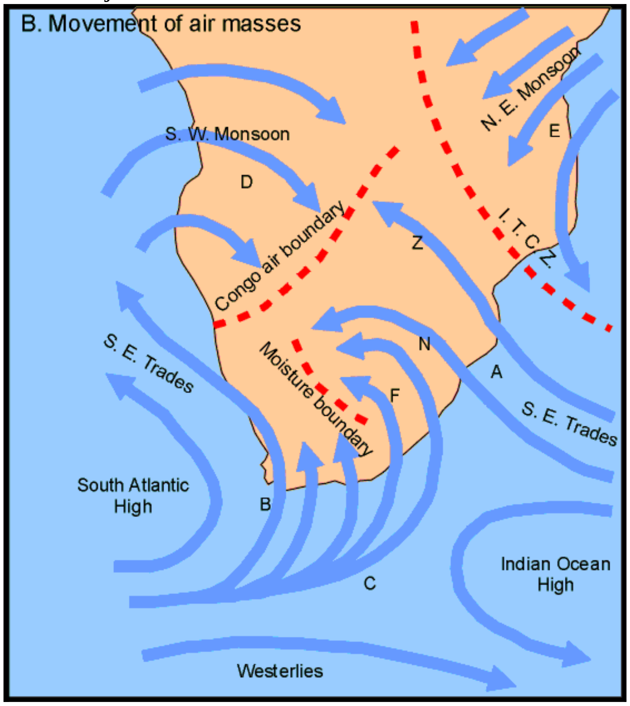

Figure 1: Summer winds over South Africa

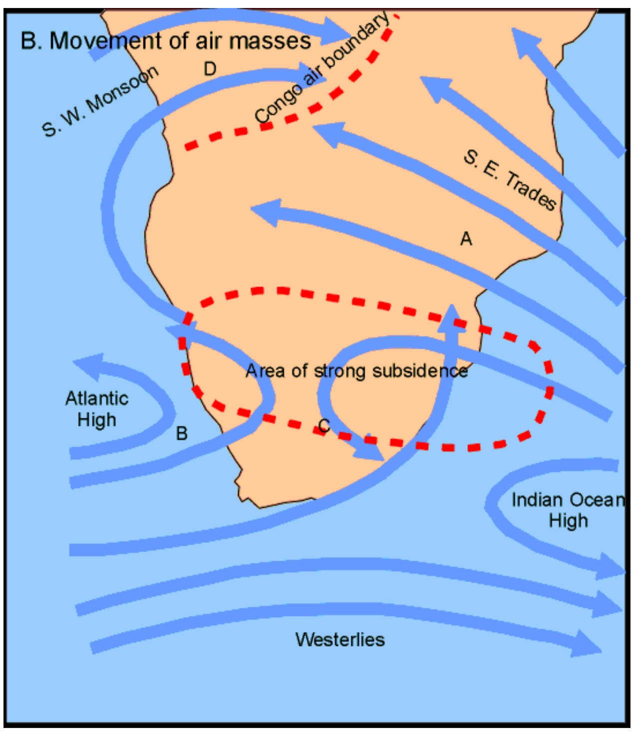

Figure 2: Winter winds over South Africa

Winter Winds

In winter all the circulation features (Figure 2) are situated more to the north than in summer. Strong winds and gusts during winter are usually caused by strong cold fronts, moving mostly over the southern half of South Africa, and also by the ridging of the high pressure systems behind the fronts. The "Westerlies" influence the weather of the southern and central parts of the subcontinent to a large degree. Cold fronts often move over these areas and may reach far to the north. The strong "Westerlies" are only able to influence the western, southern and south-eastern coastal areas and adjacent interior. When the Atlantic high pressure system moves more eastwards and stays strong, gale force winds can spread to the KwaZulu-Natal coast as far north as the Mozambique Channel.

SOUTH AFRICAN WIND ENERGY PROGRAME (SAWEP)

In 2001 the then Minister of Minerals and Energy requested international assistance to establish a South African wind energy industry. The South African Wind Energy Program (SAWEP) Phase 1 was formulated to undertake projects with funding from the Global Environmental Facility (GEF) and the Danish Government.

The goal of SAWEP Phase 1, [4], is to reduce greenhouse gas emissions generated by thermal power generation in the national inter-connected system. SAWEP's objective is to install and operate the 5.2 MW Darling wind farm and prepare the development of 45 MW combined wind farms. SAWEP is also intended to contribute to South Africa's national development objectives by diversifying power generation in South Africa's energy mix; setting up a wind energy industry that could generate employment and by promoting sustainable development and making use of South Africa's renewable and natural resources.

SAWEP Phase 1has been divided into six main outcomes to contribute to first lowering of identified barriers. Each component is associated with specific outputs and a set of activities.

(1) Increased public sector incremental cost funding, by assisting the Government of South Africa with detailing the most appropriate financial instruments that should be made available to stimulate commercial wind energy developments;

(2) Green power funding initialized, by assisting initiatives geared towards green power marketing and setting up and implementing Tradable Renewable Energy Certificates (TRECs) as well as implementing a green power guarantee scheme;

(3) Long-term policy and implementation framework for wind energy developed, by assisting the Government of South Africa;

(4) Wind resource assessment, by assisting interested public and private sectors entities with the generation of reliable wind energy data and other necessary information for wind energy development;

(5) Commercial wind energy development promoted, by assisting private sector developers with the (pre-) feasibility of a number of wind farms up to 45 MW installed capacity.
(6) Built capacity building and strengthened institutions, such as key government departments, public agencies, wind farm industry (e.g. South African Wind Energy Association) and independent private firms.

SAWEP Phase 1 also aims to achieve two key strategic outputs that will guide South Africa on wind energy development. The first strategic outputs is the Wind Atlas for South Africa (WASA) that is intended to play a significant role in providing information for potential investors for wind farms on areas that have opportunities.

The second key strategic output is the development of a Wind Industrial Strategy for South Africa. This will help determine the possibility of establishing a wind industry in South Africa. The Wind Industrial Strategy project aims to play a strategic role in paving the way for the gradual phasing in of wind energy in South Africa by informing the South African Department of Trade and Industry's plans for the local manufacture of wind turbines and the associated components.

WIND ATLAS FOR SOUTH AFRICA (SAWEP-WASA)

Several studies have been carried out to assess the wind energy potential of South Africa and the estimates range from a very low 500 MW to an extremely high estimate of 70,000 MW.

The first attempt at estimating South Africa's wind energy potential was done in 1995 by Diab, [5], who reviewed and assessed meteorological data that was sourced from the South African Weather Services. Diab concluded that wind power potential is generally good along the entire coast with localized areas, such as the coastal promontories, where potential is very good, i.e., mean annual speeds are above 6m/s and power exceeds 200 W/m^2, that moderate wind power potential areas include the Eastern Highveld Plateau, Bushmanland, the Drakensberg foothills in the Eastern Cape and KwaZulu-Natal and areas with low wind power potential include the folded mountain belt (vast region of very complex and diverse terrain), the Western and Southern Highveld Plateau, the Bushveld basin, the Lowveld, the Northern Plateau, the Limpopo basin, Kalahari basin, the Cape Middleveld and the KwaZulu-Natal interior. The upper limit of wind energy available to be captured in South Africa was estimated by Diab to be at 3GW, [6], with an expectation that 198000 GWh could be supplied by wind in 2002.

As part of a larger scale project of the (then) Department of Minerals and Energy, ESKOM and the CSIR, compiled the South African Renewable Energy Resource Database (SARERED), [7]. This database provided the resource potential for solar, hydro, biomass and wind for South Africa. The wind component of this database was also known as the South African wind atlas. This wind atlas is based on the merging of two micro-scale analyses using DTU Wind Energy's WAsP model (Wind Atlas Analysis and Application Program). The input data for both analyses was meteorological data that was obtained from the South African Weather Services. This wind atlas, for the first time, provided more detail as to the possible locations of areas of good wind resources in South Africa but not of a quality that could be used for planning purposes.

This lack of quality provided part justification for the development of an accurate wind atlas for South Africa as part of the South African Wind Energy Program (SAWEP) that is discussed later in this paper.

Commissioned by the African Development Bank with the support of the Canadian International Development Agency, Helimax prepared a quantitative map of wind speeds for the African continent at a resolution of 50 km, [8]. The main purpose of the project was to identify target countries for investment in wind energy by the African Development Bank. In total eight countries were identified for priority investment by the Bank in wind energy projects: Tunisia, Morocco, South Africa, Mauritania, Madagascar, Cape Verde, Mauritius and Eritrea. No indication of possible wind energy production is given by the study

A meso-scale wind map of South Africa was produced by Hagemann, [9] in 2008 as part of his Doctorate research at the University of Cape Town. His thesis explores the utility of the MM5 regional climate model in producing detailed wind climatology for South Africa in the context of wind power applications. In terms of the resultant meso-scale 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. The study analysed wind speeds across South Africa for three scenarios to estimate for South African wind power penetration for wind farm development. This current published estimation of South Africa's potential wind resource. See Table1

All of the scenarios show that South Africa has a very high wind resource and that even under the low case substantial wind energy generation is feasible. Based on the work done by Hagmemann a meso-scale map of average annual wind speeds at 10m for South Africa is given in Figure 3

The main objective of the new Wind Atlas for South Africa (WASA) is to develop and employ numerical wind atlas methods and develop capacity to enable planning of large-scale exploitation of wind power in South Africa, including dedicated wind resource assessment and siting tools for planning purposes. The development of a WASA would therefore accelerate the investment in wind energy. This is in line with the

South African government's objectives of reducing greenhouse gases and diversifying energy supply and also developing human capacity to support the emerging renewable energy industry.

Table 1: Scenarios for wind development by Hagemann

Case	Assumptions	Result
Low case	All sites within 3 km of existing infrastructure (66+ kV grid, roads); 60 m hub height; minimum of 35% capacity factor	20 TWh of feasible annual electricity generation corresponding to approx. 6,000 MW of installed wind power capacity
Central Case	All sites within 4 km from existing infrastructure; 60 m hub heights; minimum of 30% capacity factor	80 TWh of feasible annual electricity generation, corresponding to approx. 26,000 MW of capacity
High Case	All sites within 5 km from infrastructure; 100 m hub height; minimum of 25% capacity factor	157 TWh of feasible annual electricity generation corresponding to approx. 56,000 MW of capacity

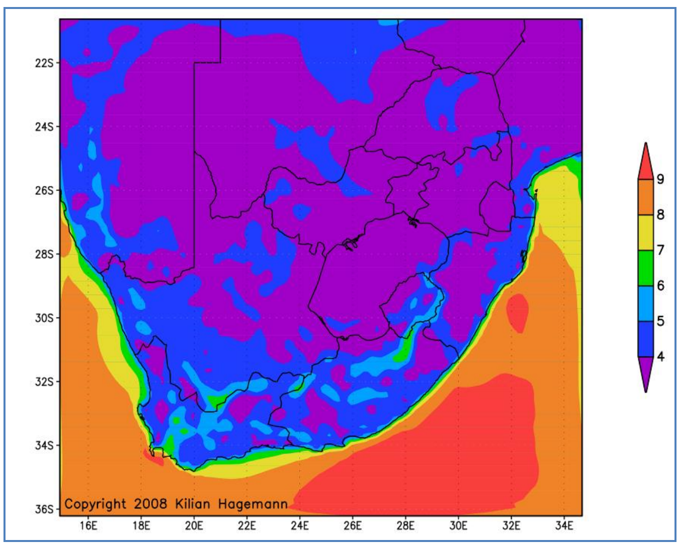

Figure 3: Average annual wind speeds at 10m above ground

The WASA project team consists of DTU Wind Energy of Denmark, CSIR, the University of Cape Town, (UCT) the South African Weather Services (SAWS) and the South African National Energy Development Institute, and (SANEDI). Phase 1 of this project is scheduled to be completed in April 2014.

Including assessing the various wind atlases for South Africa site selection criteria was developed as to the sites where the 10 wind measurement masts were to be erected. Site visits were undertaken, interactions done with the various land owners and the relevant agreements to erect the masts were completed. The sites where the masts were erected are near Alexander Bay, Calvinia, Vredendal, Vredenburg, Napier, Sutherland, Prince Albert/Beaufort West, Humansdorp, Hartebeeshoek and Ntshe. These sites are representative of terrain types, suitable for meso- and micro-scale modelling and geographically spread out evenly over the project area.
The wind measurement stations were designed to meet International Electrotechnical Commission (IEC) standards and MEASNET guidelines. (MEASNET is a co-operation of companies who are engaged in the field of wind energy and want to ensure high quality measurements, uniform interpretation of standards and recommendations as well as interchangeability of results. See http://www.measnet.com) The sensors are proven of high quality and individually calibrated. The instrumentation was arranged on the masts to minimise errors and uncertainties caused by flow distortions. The 60 meter masts were designed, procured and manufactured in South Africa. The measurement equipment was designed and delivered from DTU Wind Energy in Denmark.

In accordance with South African Environmental Impact Assessment procedures, basic assessment procedures were negotiated and an application document submitted. After the environmental approvals were obtained, site preparations were initiated and the erection of the 10x60 meter masts completed. The entire wind measuring system and the transmission of wind data to the CSIR's Stellenbosch campus was commissioned during September 2010. The data that is collected can be monitored on www.wasa.csir.co.za

Monthly wind measurement data files are made available for download by anyone entering their registration information. Registration includes coordinates, affiliation and the intended use by the interested party. The data for each month will be made available after a quality check by the project team and is available on the following website:
http://wasadata.csir.co.za/wasa1/WASAData.

With the availability of one year's worth of wind measurements the first verified Numerical Wind Atlas was produced for the coastal region of the Northern Cape Province, the Western Cape Province and most of the Eastern Cape Province. This Numerical Wind Atlas is a generalised, climatological (30-year) annual mean wind speed [m/s] 100 m above ground level and is shown in Figure 4.

WIND ENERGY INDUSTRIAL STRATEGY (SAWEP)

The Council for Scientific and Industrial Research (CSIR) of South Africa and then Risø-DTU, now DTU Wind Energy, of Denmark undertook this investigation into the development of a wind energy industrial strategy for South Africa and published a report in 2010, (Szewczuk et al [10]) that was delivered to the United Nations Development Program. The objective of this investigation was to provide the necessary information for the South African Department of Trade and Industry to develop the official wind energy industrial strategy for South Africa.

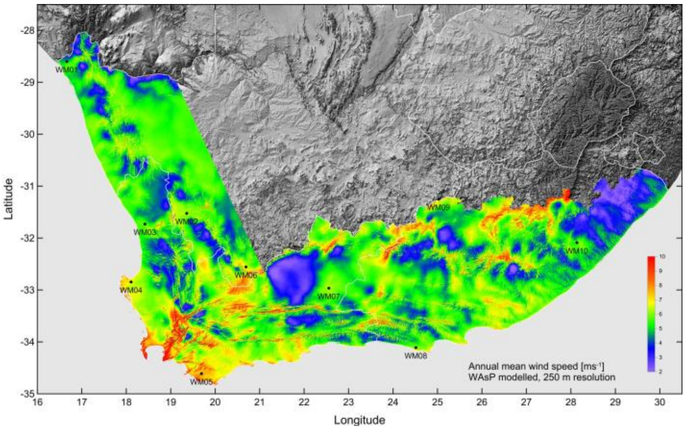

Figure 4: WASA wind resource at 100m wind speed

Internationally, energy policies are developed with an express intention that they lead to important industrial outcomes. Lund, [11], investigated the impacts of energy policies on industry growth in renewable energy. Lund showed that energy policies can significantly contribute to the expansion of domestic industrial activities in sustainable energy, including that for the wind energy industry. Market deployment measures that enhance home markets will in most cases lead to growing industrial activities in that country even when the related industrial base is relatively weak. However, irrespective of the domestic market situation, investment or research and development support to strong industries in related fields may be a powerful way to help diversification into the wind-energy field and to generate new export opportunities.

Considering the whole value/supply chain of the wind-energy production may be useful to position and identify industrial strengths but also to focus the energy policy measures optimally, in particular when industrial impacts are important to policy makers. Market deployment actions would basically influence the downstream part of the supply chain more, but would also cause upstream impacts. Lund also suggests a possible industry evolution path. A successful wind-energy industry expansion process leads to exports and foreign operations, and to a global industrial profile. This has been the case for many wind-energy companies and industry growth may happen through acquisitions, organic growth, mergers and other business processes.

Lewis and Wiser, [12], examined the importance of national and local policies in supporting the development of successful wind-turbine manufacturing companies by exploring the motivations behind establishing a local wind-power industry, and the paths that different countries have taken to develop indigenous large wind-turbine manufacturing industries within their borders. This is done through a cross-country comparison of the policy support mechanisms that have been employed to directly and indirectly promote wind technology manufacturing in 12 countries.

Lewis and Wiser first examined strategies for local industry development, including models for wind turbine manufacturing, technology acquisition and incentives for technology transfers. The potential benefits of a domestic wind-power technology manufacturing industry were described, as well as barriers to entering this business. The experiences of some of the major existing or emerging national wind markets around the world were analysed, focusing on 12 countries: Denmark, Germany, Spain, the United States, the Netherlands, the United Kingdom, Australia, Canada, Japan, India, Brazil and China.

All of these countries have either fostered, or are attempting to foster, the development of a domestic wind-technology manufacturing industry, though to varying degrees. The importance of sizable and stable home markets in supporting emerging local wind-power technology manufacturers were discussed, and the policy mechanisms used by these countries to directly or indirectly support localisation of wind-power technology manufacturing were highlighted.

In many instances there is a clear relationship between a manufacturer's success in its home country market and its eventual success in the global wind-power market. Whether new wind-turbine manufacturing entrants are able to succeed will likely depend in part on the utilisation of their turbines in their own domestic market, which in turn will be influenced by the annual size and stability of that market. Consequently, policies that support a sizable, stable market for wind power, in conjunction with policies that specifically provide incentives for wind-power technology to be manufactured locally, are most likely to result in the establishment of an internationally competitive wind industry. Lewis and Wiser further describe the extent to which a local wind industry may aspire to manufacture complete wind-turbine systems, to manufacture certain components and import others, or just to serve as an assembly base for wind-turbine components imported from abroad.

The South African policy and regulatory environment and support mechanisms were analysed. These support mechanisms are in place as per international "best practice". Independent Power Producers are the organizations that will operate wind farms that will be developed in South Africa. Gratwick and Eberhard, [13], analysed Independent Power Producers (IPPs) in Africa at country-level and at project-level to obtain insights into what mechanisms would be needed to make IPPs' success more likely.

Country-level mechanisms that the South African government would need to provide to make an IPP's success more likely include:

- Favourable investment climate in terms of stable macroeconomic policies and good repayment records in a legal system allowing for contracts to be enforced and laws to be upheld.

- A clear policy framework embodied in legislation that specifies a market structure, roles, and terms for private and public sector investments.
- Lucid, consistent and fair regulatory supervision improving general performance of private and public sector assets.
- Coherent power sector planning with energy security standards in place and clarified planning roles and functions, as well as built-in contingencies to avoid emergency power plants or blackouts.
- Competitive bidding practices with a transparent procurement process to potentially drive down prices.

Project-level mechanisms that are likely to contribute to the success of IPP investments are:

- Favourable equity partners with preferably local investment as well as experience in developing country project risk, and expectations of a reasonable and fair ROE.
- Favourable debt arrangements including low-cost financing where the share of local capital softens the impact of foreign exchange differences, and flexibility in terms and conditions.
- Secure and adequate revenue streams through commercially sound metering, billing and collections by the utility, a robust Power Purchase Agreement, and security arrangements where necessary
- Credit enhancements and other risk management and mitigating measures including sovereign guarantees, political risk insurance, partial risk guarantees and international arbitration.
- Positive technical performance in terms of availability and capacity factors as well as sponsors that anticipate potential conflicts, like operations and maintenance or budgeting issues.
- Strategic management and relationship building where sponsors create a good image through political relationships, development funds, effective communications and well-managed contracts.

The economics of wind projects were investigated, including the costs of the components of a wind turbine. According to Blanco, (14), the key parameters that govern wind-power costs are:

- Capital costs, including wind turbines, foundations, road construction and grid connection
- Variable costs, the most significant being the operation and maintenance of wind turbines
- The electricity produced
- The discount rate and economic lifetime of the investment.
- The discount rate and economic lifetime of the investment reflect the perceived risk of the project, the regulatory and investment climate in each country and the profitability of alternative investments.

The capital costs of wind projects can be divided into several categories:

- the cost of the turbine itself (ex-works) which comprises the production, blades, transformer, transportation to the site and installation (71% of total cost);
- the cost of grid connection, including cables, sub-station, connection and power evacuation systems when they are specifically related to and purpose-built for the wind farm (12% of total cost);
- the cost of the civil work, including the foundations, road construction and buildings (9% of total cost); and
- other capital costs, including development and engineering costs, licensing procedures, consultancy and permits, and monitoring systems (8% of total cost).

ECONOMICS OF SOUTH ARICAN WIND PROJECTS

One of the key factors affecting the development of a wind-energy scheme is that of supply chains associated with the integration of a complete wind-energy scheme where it is seen that a turbine ex-work comprises 71% of total project value. Aubrey, [15], discussed the supply-chain challenges associated with the procurement of the components of wind turbine itself and presented a diagram that illustrates the components that make up a large 5MW wind turbine and their share of total wind turbine cost. Further discussions with South African wind industry stakeholders revealed that there was consensus that the cost distribution as presented by Aubrey is similar to that for a South African wind project.

Hence, the capital cost breakdown as described by Aubrey will be used for further analysis of a typical ex-works wind turbine for a typical South African wind-energy project. However, it should be noted from Aubrey's breakdown of a wind turbine that three components the tower (26%), the rotor blades (22%) and the gearbox (13%) make up approximately 60% of the value of a wind turbine To assist in analysis of the economics of a South African wind- energy project, it is important to establish costs under South African conditions. In this context of developing a full wind- energy project it is useful to establish the average cost/MW of a project in South African currency, the South African Rand (ZAR). Cost figures were sourced industry stakeholders revealed the following range of costs/MW:

- US$2.5million/MW or ZAR25million/MW (average conversion rate in August/September 2013 of ZAR10:US$1)
- €1.6million/MW or ZAR21.6million (average conversion rate in August/September 2013 of ZAR13.5: €1)

From these figures an average cost per MW is ZAR23.3million. Since this discussion relates to South African projects, further analysis will be in the South African currency, ZAR. Based on the weighting of the capital cost of a wind project from Blanco, [14], and Aubrey, [15], the weighting of the components that make up a turbine ex-works, the cost breakdown per MW for a South African wind project is presented in Table 2.

Table 2: Cost breakdown of components/MW of a wind-turbine project

Item	% value	Cost (Rmillion)/MW
Grid connection	12	2.80
Civil works	9	2.10
Other capital costs	8	0.18
Tower	18,7	1.86
Rotor blades	15,8	3.68
Rotor hub	1,0	0.23
Rotor bearings	0,86	0.20
Main shaft	1,36	0.32
Main frame	2,0	0.47
Gearbox	9,20	2.14
Generator	2,44	0.57
Yaw system	0,89	0.21
Pitch system	1,89	0.44
Power converter	3,56	0.83
Transformer	2,55	0.59
Brake system	0,93	0.22
Nacelle housing	0,96	0.22
Cables	0,68	0.16
Screws	0,74	0.17

For every ZAR23.3million spent on developing 1MW of wind energy in South Africa, it will assist decision makers if it can be established how much of the ZAR23.3million could be spent in South Africa and under what scenarios such spending could happen.

SCENARIOS FOR LOCAL MANUFACTURE

Developing possible scenarios for a South African wind-turbine manufacturing industry an understanding is needed of the supply chain associated with the global wind-turbine industry. Supply chain management is essential to wind-turbine supply.

The relationships between manufacturers and their component suppliers have become increasingly crucial, and have come under increasing stress in the past few years as global demand has required faster ramp-up times, larger investments and greater agility to capture value in a rapidly growing sector. Supply chain issues have dictated delivery capabilities, product strategies and pricing for every turbine supplier. Pullen *et al*, [16], provides an overview of the turbine component supply chain and illustrates the fact that the market is highly concentrated for multiple segments, including blades, bearings and gearboxes.

It should be noted that the South African industry has a high propensity to innovate, [17]. Building on an existing aerospace industry where experience has been built over the years on manufacturing aircraft components out of composite materials, the same basic materials used in wind-turbine blades, South African industry has the know-how and ability to manufacture wind-turbine blades, for instance.

It is beneficial to the South African economy that as much of this ZAR23.3million/MW is spent in South Africa as possible Based on the above; four scenarios for the localisation of wind- energy projects have been proposed and are:

- Scenario 1: Low-industrial content
- Scenario 2: Medium-low industrial content
- Scenario 3: Medium-high industrial content
- Scenario 4: High industrial content

Table 3 presents the four scenarios for the localization of a wind-energy project for South Africa and the value of local spend/MW and the associated % weighting of local content.

Table 3: Scenarios for the localisation of wind-energy project spend

Scenario	Assumptions	% value	Local spend/MW
1. Low-industrial content	Grid connection, civil works, other capital costs, fully imported wind turbines	29	R6.58 million
2. Medium-low industrial content	Grid connection, civil works, other capital costs, tower locally made, rest of turbine imported	47	R10.95 million
3. Medium-high industrial content	Grid connection, civil work, other capital costs, tower, blades, generator and nacelle made locally, rest imported	66	R15.4 million
4. High industrial content	Grid connection, civil works, other capital costs, most of turbine made locally, except for specialised items such as gearbox, rotor bearings	87	R20,27 million

RENEWABLE ENERGY INDEPENDENT POWER PROCUREMENT PROGRAM (REIPPP)

South Africa has a high level of Renewable Energy potential and presently has in place a target of 10 000 GWh of Renewable Energy. The Minister of Energy has determined that 3 725 megawatts (MW) to be generated from Renewable Energy sources is required to ensure the continued uninterrupted supply of electricity. This 3 725 MW is in

accordance with the capacity allocated to Renewable Energy generation in IRP 2010-2030. This REIPPP has been designed so as to also contribute towards socio-economic and environmentally sustainable growth, and to start and stimulate the renewable industry in South Africa. Details of the REIPP can be found on the following website:
http://www.ipprenewables.co.za/

The allocation of the 3 735 MW per generation technologies is presented in Table 4 with onshore wind being allocated 1 850MW

Table 4 Allocation per generation technologies

Technology	MW
Onshore wind	1 850
Concentrating solar thermal	200
Solar photovoltaic	1 450
Biomass	12,5
Biogas	12,5
Landfill gas	25
Small hydro	75
Small projects	100

In terms of the REIPPP Bidders will be required to bid on tariff and the identified socio-economic development objectives. The tariff will be payable by the Buyer pursuant to the PPA to be entered into between the Buyer and the Project Company of a Preferred Bidder. The first two rounds of the bidding process have reached financial closure and the successful bidders are currently constructing their REIPPP facilities. The 15 successful wind farms from Bids 1 and 2 and the locations of these wind farms can be seen in Figure 5. Details of which are in Table 4

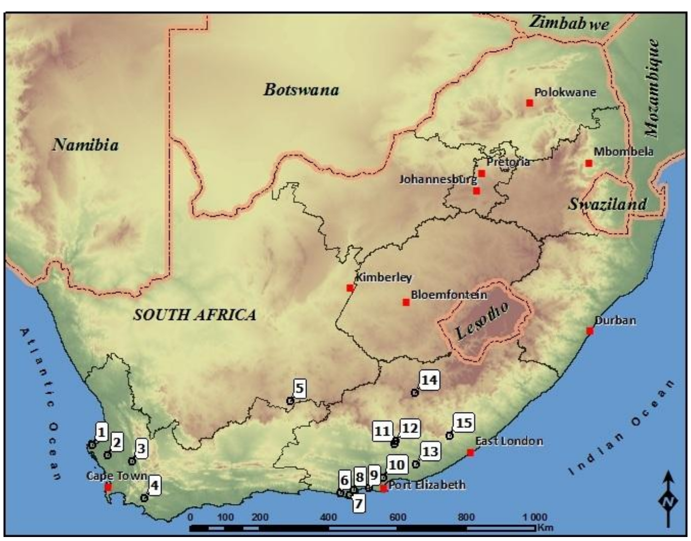

Figure 5: Location of bids 1 and 2 wind farms

Table 4: Details of bids 1 and 2 wind farms

No.	Name of wind farm	Capacity MW	Location Nearest town
1	West Coast 1	90.8	Vredenburg
2	Hopefield Wind Farm	65.4	Hopefield
3	Gouda Wind Farm	135.2	Gouda
4	Dassiesklip Wind Farm	26.2	Caledon
5	Noblesfontein Wind Farm	72.8	Noblesfontein
6	Tsitsikamma Community Wind Farm	94.8	Tsitsikamma
7	Red Cap Kouga Wind Farm	77.6	Port Elizabeth
8	Jeffreys Bay Wind Farm	133.9	Jeffreys Bay
9	MetroWind Van Stadens Wind Farm	26.2	Port Elizabeth
10	Grassridge Wind Farm	59.8	Port Elizabeth
11	Cookhouse Wind Farm	135	Cookhouse
12	Amakhala Emoyeni (Phase 1)	137.9	Bedford
13	Waainek Wind Farm	23.4	Grahamstown
14	Dorper Wind Farm	97	Molteno/ Sterkstoom
15	Chaba Wind Farm	20.6	Komga

On 29 October 2013, the South African Department of Energy sent letters of appointment as Preferred Bidders to seven Bidders who submitted Bid Responses for onshore wind on the Third Bid Submission Date. The total wind generation capacity allocated to the third bid is 787MW. Financial close for these bidders is scheduled for 2014, where after construction of the successful wind farm bids can commence

DISCUSSION

Based on the policy and regulatory documents that various South Africa Government Departments have put in place to support a renewable energy industry a model has been developed that relates the different stakeholders with their respective roles as well as to indicate the collaboration and partnerships between the various stakeholders from country-level to project-level, Szewczuk *et al*,[10]. In Figure 6, the different groupings of stakeholders are represented in different colours:

- Government departments – Blue
- Government Implementation Agencies – Red
- Private sector stakeholders - Green.

This model illustrates the stakeholder and function relationships from a country-level down to a project-level. Each organisation, as depicted on the left, operates within its specific mandate and due to the complex nature of developing wind farms collaboration between the various government departments and partnerships with industry stakeholders is needed to meet project objectives.

The objective of this model is to highlight the list of role-players in the development of wind energy projects and since more than one role-player is linked to any process item on the left careful coordination by role-players is needed to reduce bureaucracy. A large number of links to a process item on the left is an indication of where bottlenecks are likely to occur i.e. a large number of stakeholders active around that role, with a potential for coordination problems and misalignment.

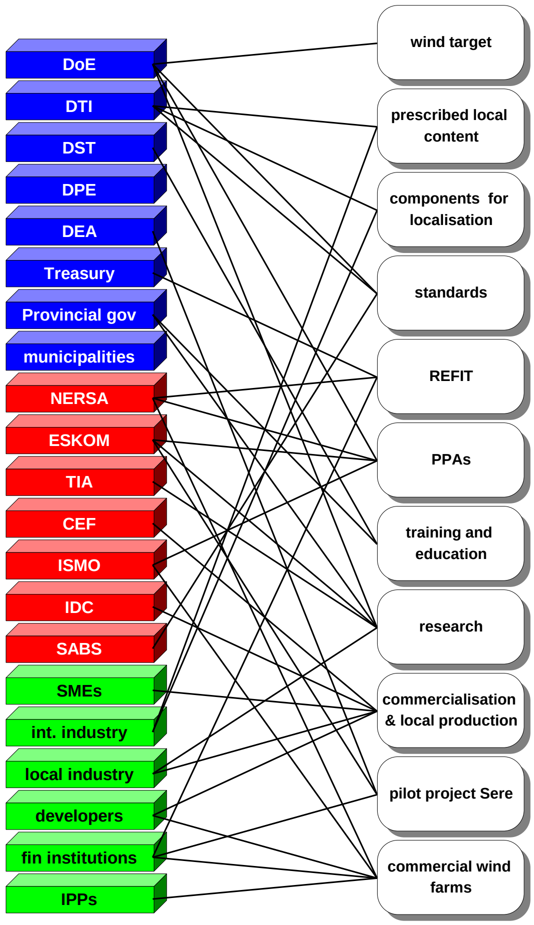

Figure 6: Stakeholder and function relationships from country-level to project-level

The South Africa Department of Trade and Industry (the dti), has an obligation in terms of the Industrial Policy Action Plan (IPAP), [18], to support the development of the South African wind energy industry. The IPAP has prioritised Green Industries as one of the emerging sectors with a high potential for employment creation. The roll-out of the REIPPP provides an opportunity to develop a local wind energy manufacturing industry.

Within the context of the REIPPP, it is crucial to have a clear understanding of the optimum level of localization that can be achieved in South Africa and under what conditions. During the first half of 2014 the dti will be undertaking a study on the development of the wind energy industry localization roadmap, in order to explore the localisation potential of the wind energy. This study seeks to build on the outcomes of the study undertaken by Szewczuk *et al*, [10] by providing an update on the status quo from 2010 to date, and developing a detailed strategy on how localisation imperatives will be rolled out.

The author has been invited by the dti to be a member of the Project Steering Committee for the development of the South African wind energy localization roadmap.

As a final comment, the South African government has established the necessary and robust framework for the establishment of a wind energy industry in South Africa. The effectiveness of the various policies, regulations and strategies will be visible in the short to medium term when the wind farms that are currently under construction are commissioned

ACKNOWLEDGMENTS

The author led the investigation into the development of the SAWEP wind energy industrial strategy and wishes to thank the funders of this project: the United Nations Development Program and the Royal Danish Embassy of South Africa. Acknowledgement is also given to Niels-Erik Clausen, Helen Markou, Tom Cronin and Jørgen Kjærgaard Lemming, all from DTU Wind Energy of Denmark who also worked on the project. The author is also the CSIR project manager on the Wind Atlas for South Africa and wishes to thank the funders of this project: the United Nations Development Program (UNDP) and the Danish Government. In this project acknowledgement is given to Eric Prinsloo and Eugene Mabille (CSIR Stellenbosch), Jens Carsten Hansen, Niels Gylling Mortensen, Andrea Hahmann (DTU Wind Energy), Chris Lennard (University of Cape Town) and Andries Kruger (South African Weather Services).

REFERENCES

[1]. DME 1998: White Paper on the Energy Policy of the Republic of South Africa, Department of Minerals and Energy, Pretoria.
[2]. DME 2003: White Paper on Renewable Energy, Department of Minerals and Energy, Pretoria.
[3]. DoE 2011: “Integrated Resource Plan for Electricity 2010-2030, Revision 2, Final Report, Department of Energy.
[4]. UNDP Project Document, Government of South Africa, UnitedNationsDevelopment Program, Global Environment Facility Technical Assistance to the South Africa Wind Energy Program (SAWEP), PIMS 163
[5]. Diab, R. 1995, “Wind atlas of South Africa”, Department of Minerals and Energy, Pretoria.
[6]. Diab, R. 1988, "The wind energy resource in South Africa"in Renewable Energy Resources and Technology Development in Southern Africa, eds. A. Eberhard & A. Williams, Elan Press, Cape Town, pp. 157.
[7]. DME/Eskom/CSIR, South African Renewable Energy

Resource Database (SARERD), database available from CSIR.
[8]. Hélimax Énergie inc., 2004, “Strategic Study of Wind Energy Deployment in Africa*”,* prepared for the African Development Bank, March 2004
[9]. Hagemann K., 2008, “Mesoscale Wind Atlas of South Africa”, Thesis presented for the degree of Doctor of Philosophy, University of Cape Town.
[10]. Szewczuk, S.; Markou H.; Cronin T.; Lemming, J.K.; Clausen, NE.; 2010, “Investigation into the Development of a Wind Energy Industrial Strategy for South Africa*”*, Prepared for the UNDP
[11]. Lund P.D., 2009, “Effects of energy policies on industry expansion in renewable energy”, Renewable Energy, 34, 53-64
[12]. Lewis, J.I.; Wiser R.H., 2007, “Fostering a renewable energy technology industry: An international comparison of wind industry policy support mechanisms”. Energy Policy,35, pp.1844-1957
[13]. Gratwick, K.N.; Eberhard, A., 2008, “An Analysis of Independent Power Projects in Africa: Understanding Development and Investment Outcomes”. Development Policy Review, 26, pp. 309-338.
[14]. Blanco, M.I., 2009, “The economics of wind energy” Renewable and Sustainable Energy Reviews, 13, pp.1372-1382.
[15]. Aubrey, C., “Supply chain: the race to meet demand”, W Wind Directions, January/February 2007, pp. 27-34
[16]. Pullen, A.; Hays, K.; Knolle, G Wind Energy: The Facts, Industry and Markets.
[17]. Buys, A., 2007, “Measuring Innovation”. Essays in innovation, No2, pp. 52-54
[18]. The dti, 2010/11 - 2012/13 Industrial Policy Action Plan February 2010