DEVELOPMENT OF A LOCALISATION STRATEGY FOR THE SOUTH AFRICAN WIND ENERGY INDUSTRY

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

ABSTRACT

An investigation into the development of a wind energy industrial strategy for South Africa was undertaken by the Council for Scientific and Industrial Research (CSIR) and Risø-DTU of Denmark. This wind energy industrial strategy project aims to play a strategic role in paving the way for the gradual phasing in of wind energy in South Africa. The global and South African wind industries, energy markets and support mechanisms were critically reviewed where after a strategic analysis was undertaken to establish the economics of South African wind energy projects and scenarios for local manufacture were developed. It is beneficial to the South African economy that as much of the wind farm development costs are spent in South Africa as possible. Consequently, four scenarios for the localisation of wind-energy projects in South Africa have been proposed.

1. INTRODUCTION

The South African Wind Energy Programme aims to achieve two key strategic outputs that will guide South Africa on wind energy development. One of these outputs is the Wind Atlas for South Africa (WASA) that will play a significant role in providing information for potential investors for wind farms on areas that have opportunities. The other strategic output is the study of 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 CSIR and Risø-DTU of Denmark undertook this investigation into the development of a wind energy industrial strategy for South Africa and published a report, [1], that was delivered to the United Nations Development Programme.

The South African Department of Trade and Industry (the dti) has published a manual that describe the methodology for developing Customised Sector Programmes, [2], for South Africa. The standardised methodology and manual for the development of Customised Sector Programmes (CSP's) or sector strategies, is intended to generate the following institutional benefits:

- International best practice in the development of sector strategies
- Consistency and coherency of sector strategies
- Retention of institutional memory
- As a tool to aid institutional learning in the development and implementation of sector strategies
- Institutional cost savings and higher productivity, resulting from all of the above, both in human resource and budgetary terms
- Improved sector development as a result of well-formulated strategies

The investigation into the wind energy industrial strategy, [1], was executed to be aligned to the dti's Customised Sector Programme.

This report has been structured to have three parts to it as follows:

- Part 1: Global Wind-energy Market and Industry;
- Part 2: South African Wind-energy Market and Industry; and
- Part 3: Strategic analysis;

with the objective to research the opportunity to establish a local wind-turbine and component manufacturing and services industry in South Africa in support of the dti's Industrial Policy Action Plan, [3].

2. GLOBAL WIND-ENERGY OVERVIEW

The growth of the wind industry continued with an average growth in the last five years of 36%. This growth is expected to continue, with strong drivers being, among others, the increasing demand for new capacity in electricity generation, security of energy supply, environmental issues and the benefits to the local industry and economy. The strongest growth took place in China and secondly the USA, with China more than doubling its installed capacity in 2009 and coming in second place in cumulative installed capacity after the USA, [4], [5], [6].

The wind-turbine market still favours vertically integrated manufacturing for several reasons:

- in order to guarantee supply (due to component shortage); and
- to protect their know-how and secure product quality.

This can be achieved either by investing in sub-suppliers of key components or make long-term agreements with suppliers of key components, [7]. However, new component suppliers are entering the market, especially in Asia and the United States of America. The new large industrial conglomerates entering the market are gaining in market share and tend to outsource their activities, for example GE Wind and Chinese manufacturers, while traditional suppliers of wind turbines that in-source, for example Vestas and Enercon, are losing market share.

Guarantees of quality via the International Electrotechnical Commission certification and standards procedures are essential with the new suppliers. Furthermore, with the supply of components that are sourced externally, two types of sub-supplier groups are identified: Firstly, components where the focus is on the reduction of price rather than innovative design, in which case it is easier for new suppliers to enter the market and local manufacturing is preferred. Secondly, components in which experience and innovative design are required and where the turbine manufacturers prefer to keep the know-how in-house. Some new sub-suppliers enter the market with joint ventures.

Small wind turbines will never compete with large wind turbines in terms of efficiency, annual production or even specific cost, but there are significant markets or niches where they are or can become a viable means of satisfying local electricity consumption. A number of factors in the success of promoting the small wind-turbine industry are identified, for example government policy support, transparent and standardised performance assessment, [8], [9].

Due to poor quality, poor performance and weak maintenance organisations, small wind turbines have previously earned a bad reputation. Recently the American Wind Energy Association has launched a voluntary certification scheme that might serve as a model for other markets and contribute to restore the reputation of small wind turbines. [10].

3. SOUTH AFRICAN WIND ENERGY OVERVIEW

The uptake of wind energy in South Africa depends on whether robust policies and regulations have been put in place. The relevant policies of the dti related to the manufacturing and industrialisation have been discussed in the Introduction.

The Department of Energy's Energy White Paper of South Africa, [11], is the most crucial document from which the various supporting mechanism 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. Studies have been carried out to assess the wind energy potential for South Africa but, to date; no resource assessment has been done using internationally accepted practices of developing resource maps based on high quality wind measurements at various heights using tall masts.

The South African Wind Energy Programme which is funded by the Global Environment Facility and the Danish Government has as one of its strategic outputs the development of a Wind Atlas for South Africa, [12]. Furthermore the data is available to the public on the following website: www.wasa.csir.co.za

The South African wind energy industry is still in its infancy. At present only about 0.05% of South Africa's installed generation capacity is derived from wind energy. This tiny amount can be divided into three categories:

- Large grid connected wind turbines (10.2MW)
- Small wind turbines (0.56MW)
- Borehole windmills (approximately 22 000 units - 12MW)

The large grid connected wind turbines are made up of:

- Eskom Klipheuwel (3.17MW)
- Darling (5.2MW)
- Coega (1.8MW)

South Africa currently has an active small turbine industry that not only supplies wind turbines to the local market but is achieving success through the export of small wind turbines. Small wind turbines are currently being manufactured by Kestrel Wind Turbines. Kestrel Wind Turbines range from 0.6kW to 3kW in size.

South Africa also has one wind-turbine company, PalmTree Power, which manufactures a medium-sized wind turbine of 300kW. This wind turbine is a direct-drive machine, i.e. this wind turbine has no gearbox between the wind-turbine blades and the generator. The variable speed, permanent-magnet multi-pole direct-drive generator is designed to operate the rotor blades at peak performance over the complete range of operating wind speeds. It has a stationary stator and permanent-magnet rotor.

Research and development is undertaken at various institutions and universities in South Africa. Notable research and development is being done at the University of Stellenbosch on permanent-magnet generators. The use of permanent-magnet generators eliminates the need for gearboxes.

4. STRATEGIC ANALYSIS

Internationally, energy policies are developed with an express intention that they lead to important industrial outcomes. Lund, [13], 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.

Research and technology development are more linked to the upstream side of the value chain, for example, components but vertical integration will most likely take place when global markets expand. Several exogenous factors, such as timing, target size, geography, amongst other factors, will influence both the industrial and policy positioning in practice.

Lund also suggests a possible industry evolution path and is illustrated in Figure 1 below. 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.

However, for such an evolutionary path to grow, a stable home market is required

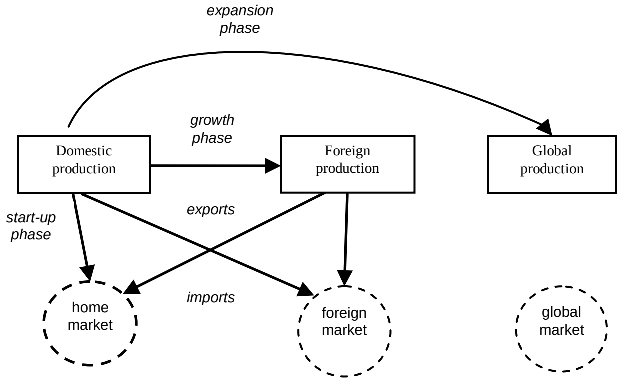

Figure 1: Typical production and market growth strategy (after Lund, [13])

The present global industry expansion in wind energy is associated with the growth in global markets. With increasing production volumes, companies also seek improved competitiveness through scale of economies types of growth strategies meaning larger manufacturing units, consolidations, etc. which may generate market thresholds for industrial laggards and would require more careful entry strategies and policy planning.

Lewis and Wiser, [14], 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. These different models for local manufacture are contrasted in Table 1.

The South African policy and regulatory environment and support mechanisms were analysed. These support mechanisms are in place as per international "best practise". Independent Power Producers (IPPs) are the organisations that will operate wind farms that will be developed in South Africa. Gratwick and Eberhard, [15], analysed 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.

Table 1: Policy measures to support wind power, country comparison (Lewis and Wiser, [14])

Direct policies	Primary countries where implemented
Local content requirements	Spain, China, Brazil, Canadian provinces
Financial and tax incentives	Canada, Australia, China, USA, Spain, China, Germany, Denmark
Favourable customs duties	Denmark, Germany, Australia, India, China
Export credit assistance	Denmark, Germany
Quality certification	Denmark, Germany, USA, Japan, India, China
Research and development	All countries to varying degrees; notable programs in Denmark, Germany, U.S., Netherlands

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 (PPA), and security arrangements where necessary, such as escrow accounts.
- 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, [16], 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 (O&M) 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, SCADA (Supervisory, Control and Data Acquisition) and monitoring systems (8% of total cost).

Wind energy is a capital-intensive technology with capital costs being as much as 80% of the total cost of the project over its entire lifetime, with variations between models, markets and locations. The wind turbine constitutes the single largest cost component, followed by grid connection.

Discussions with South African wind industry stakeholders revealed that there was consensus that the cost distribution for European wind energy investments is similar to that for the average South African wind project. Hence, the capital cost breakdown as discussed above will be used for further analysis of an average South African wind-energy project.

5. ECONOMICS OF SOUTH AFRICAN 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, [17], 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, [17], 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.

Cost figures that have been sourced from a range of stakeholders in industry revealed the following range of costs/MW:

- US$2.5million/MW or ZAR19.5million/MW (average conversion rate in February 2012 of 7,8:1)
- €1.6million/MW or ZAR16.456million (average conversion rate in February 2012 of 10,28:1)

From these figures an average cost per MW is ZAR18million. Since this discussion relates to South African projects, further analysis will be in the South African currency, the Rand (ZAR). Until more accurate costs are established for a South African project the figure of ZAR18million/MW will be used in further analysis. Based on the weighting of the capital cost of a wind project from Blanco, [16], and Aubrey, [17], 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.

For every ZAR18million spent on developing 1MW of wind energy in South Africa, it will assist decision makers if it can be established how much of the ZAR16million could be spent in South Africa and under what scenarios such spending could happen. The financial structuring of a wind-energy project is a complex process and is not within the scope of work of this project. It can be said that the financial structure of a wind-energy project is likely to be made up of investments from various sources and ultimately forms one pool of funds. This pool of funds is what is spent in developing a wind-energy project and obviously it will be in South Africa's interests if as much of the funds from this pool is spent in South Africa. In terms of local spending it can be argued that the cost of grid connection, civil works and other capital costs is the minimum that could be spent in South Africa.

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

Item	% value	Cost (ZARmillion)/MW
Grid connection	12	2.16
Civil works	9	1.62
Other capital costs	8	1.44
Tower	18,7	3.366
Rotor blades	15,8	2.844
Rotor hub	1,0	0.18
Rotor bearings	0,86	0.155
Main shaft	1,36	0.245
Main frame	2,0	0.36
Gearbox	9,20	1.656
Generator	2,44	0.44
Yaw system	0,89	0.16
Pitch system	1,89	0.34
Power converter	3,56	0.641
Transformer	2,55	0.459
Brake system	0,93	0.167
Nacelle housing	0,96	0.162
Cables	0,68	0.122
Screws	0,74	0.133

6. SCENARIOS FOR LOCAL MANUFACTURE

In order to develop possible scenarios for a South African wind-turbine manufacturing industry a brief review will be given 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 soaring 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.

Manufacturers have sought to strike the most sustainable, competitive balance between a **vertical integration of component supply and full component outsourcing** to fit their turbine designs. These procurement trends have given rise to unique market structures for each component segment, underlining the complexity of wind-turbine design and manufacturing. The source of blades, gearboxes, generators and controllers for main wind-turbine manufactures is mainly in-house for at least half of the manufacturers, although they still source part of their supplies from external companies. From the components that are sourced externally, two types of sub-supplier groups are identified:

1. Components specified by the manufacturer for specific wind-turbine models. These components are usually the steel towers, the nacelle and spinner, and the cast and forged parts. For these components **it is easier for new suppliers to enter the market**, as the focus is reduction of price rather than innovative design. In these cases **local manufacturing is preferred**.
2. Standard components supplied by the component manufacturer, such as blades, control systems, gearboxes, generators and converters. For these components experience and innovative design is required. These are the components that manufacturers would rather produce in-house in order not to transfer the expertise and innovation.

Pullen *et al*, [18], 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. These segments have high entry barriers based on the size of investment and manufacturing ramp-up time. At the same time, controls, generators, castings and tower segments have lower entry barriers with a larger number of players.

It is evident that with such uneven market structures across the supply chain, turbine manufacturers will see an opportunity to vertically integrate in order to reduce risk. In addition, this supply-chain structure makes turbine shortages likely, as pinch points ripple through the market due to disparities in the availabilities of the different components. This means that in today's seller's market, turbine assembly volume is dictated by the number of units that slip through the tightest pinch point. Generally, according to Pullen *et al*, a proliferation in suppliers is anticipated throughout the supply chain, due to strong growth in the wind industry.

Once again, it should be noted 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, with the rest of the components having different weightings to make up a complete turbine.

Consider the tower: it is a high value item with low barriers to entry in terms of local manufacture and, if manufactured locally, has a large impact on local content. Consider the blade: it is also high value item but due to its high intellectual property value this would require huge investments to be made locally. However, it should be noted that the South African industry has a high propensity to innovate[19]. 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.

Manufacturing blades locally would further increase the local content of a wind-turbine system. Similar discussions and motivations can be put forward for most of the components in a wind-turbine system. Finally, since South African industry has the propensity to innovate, this places South African industry in a strong position to leapfrog in wind-energy technology advances.

For a typical South African wind-energy project the total cost is ZAR16million/MW. Weightings have been allocated to the various costs that make up a wind-energy project, with the primary weightings being allocated to grid connection, civil works, other capital costs, tower, blades, gearboxes, generator, nacelle and the other components that make up a wind turbine.

It is beneficial to the South African economy that as much of this ZAR16million/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

Scenario 1: Low-industrial content consists of the costs associated with grid connection, civil works, other capital costs and the wind turbine being fully imported, since this is the minimum that can be spent on a local wind-energy project. This scenario gives a local content spend of 29%, with a local spend ZAR4.64million/MW. Within the context of generation targets it is suggested that the target date be 2015.

Scenario 2: Medium-low industrial content consists of the costs associated with grid connection, civil works, other capital costs and the tower being made locally with the rest of the turbine being imported. This scenario is essentially Scenario 1 with the tower being made locally. The high value of the tower increases the local content to 47% with a suggested target date of 2015.

Scenario 3: Medium-high industrial content consists of the costs associated with grid connection, civil works and other capital costs with the tower and blades being made locally with the rest of the turbine being imported. This scenario is essentially Scenario 2 but with the blades being made locally. Since the blade is a high value this increases local content to 66% with a suggested target date of 2020.

Ideally Scenario 4: High industrial content could be one where the entire wind turbine is made in South Africa. However, based on the information that has been gathered from engagement with stakeholders it will be more prudent to suggest that certain specialised and critical items such as gearboxes and rotor bearings be imported. Consequently, for Scenario 4 the following is suggested:

Scenario 4: High industrial content consists of the costs associated with grid connection, civil works, other capital costs, most of turbine made locally, except for specialised items such as gearbox, rotor bearings. In this scenario the local content value is 87% with a suggested target date of 2020.

Table 3 summarises the four scenarios for the localisation 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	ZAR5.22 million
2. Medium-low industrial content	Grid connection, civil works, other capital costs, tower locally made, rest of turbine imported	47	ZAR8.46 million
3. Medium-high industrial content	Grid connection, civil work, other capital costs, tower, blades, generator and nacelle made locally, rest imported	66	ZAR11.88 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	ZAR15.66 million

7. DISCUSSION

Buys, [19], undertook a survey on innovation and found that 52% of South African firms in the manufacturing sector had technological innovations. This figure is surprisingly high – it is the same as the European average and higher than that of developed countries such as Italy, Norway and France. Furthermore, 31% of South African innovators reported that their relative market position had improved substantially due to their innovative activities and that 30% of their total sales in 2000 could be attributed to innovative products and services.

Consequently South African Industry has a propensity to innovate that is in the same league as their counterparts in Europe. To state this differently, South African Industry has a can-do attitude and mindset, i.e. the ability to “make a plan”.

South African Industry has experience in manufacturing components to exacting specifications, integrating complex systems and this being done with efficient use of resources and is very much aware of the need to be globally competitive by reducing costs and maintaining, if not increasing, on quality.

Discussions with industry stakeholders revealed there are small manufacturing concerns that are proactive and explore manufacturing opportunities in the South Africa and global wind-turbine market. Some success in manufacturing components for wind-turbine companies is achieved as well as exploring related opportunities such as the provision of condition monitoring and SCADA equipment for wind turbines.

In response to international and South African market demands small, low-medium speed wind turbines are being manufactured. This broadens the opportunity for wind-turbine manufacturers, in particular the small wind-turbine manufacturer as these concerns do not only need to rely on markets that have high wind speeds.

Significantly small wind turbines are being exported from South Africa and South Africa is a recognised global player in the manufacturing of small wind turbines.

A key challenge facing current and potential South African wind-turbine manufacturers is that of certification and testing of their systems to be able to export their products. Nevertheless, the South African Bureau of Standards (SABS) and the South African National Accreditation System (SANAS) are responding by developing or adopting the appropriate certification and testing standards.

However, if large-scale production of both small to large wind turbines is successful, this will need to be supported by skilled workers. The curriculum for such skilled workers, to a large extent, still has to be developed.

International wind-farm developers, wind-turbine suppliers, Engineering, Procurement and Construction (EPC) companies and financing institutions are establishing a presence in South Africa to take advantage of a new emerging market for wind energy in South Africa

8. RECOMMENDATIONS

Based on the data and information presented above the following recommendations are suggested:

- The South African government continue on the path of developing and implementing policies that support a sizable and stable market for wind power, in conjunction with policies that specifically provide support mechanisms for wind turbines and components to be manufactured locally so as to result in a competitive wind industry
- Current public funding programmes for innovation in South Africa must be intensified and better publicised.
- To develop a globally competitive wind industry a coherent national certification and testing facility be investigated.

9. ACKNOWLEDGEMENT

The author wishes to thank the funders of this project: the United Nations Development Programme (UNDP) and the Royal Danish Embassy (RDE) of South Africa. Also the Project Steering Committee comprising of representatives of the South African Departments of Energy, Trade and Industry, Science and Technology, Environmental Affairs, the UNDP and the RDE who provided guidance during course of the project. I also wish to acknowledge Niels-Erik Clausen, Helen Markou, Tom Cronin and Jørgen Kjærgaard Lemming all from Risø-DTU of Denmark who worked with me on the project as being contributing authors..

10. REFERENCES

[1] Szewczuk, S.; Markou H.; Cronin T.; Lemming, J.K.; Clausen, NE.; “Investigation into the Development of a Wind Energy Industrial Strategy for South Africa”, October 2010.

[2] The Department of Trade and Industry South Africa; Manual – DTI/TISA *Customised Sector Programme* Development Methodology V.19

[3] The Department of Trade and Industry South Africa: 2010/11 – 2012/13 Industrial Policy Action Plan, Economic Sectors and Employment Cluster, February 2010.

[4] International Wind Energy Development – World Market Update, BTM-Consul, March 2010

[5] Global Wind 2009 Report, Global Wind Energy Council.

[6] “Pure Power, Wind Energy Targets for 2020 and 2030”, EWEA, 2009 update

[7] BTM-Consul, “International Wind Energy Development – Supply Chain Assessment 2010-2013”, January 2010

[8] U.S. Small Wind Turbine Industry. U.S. Small Wind Turbine Industry Roadmap. American Wind Turbine Association. June 2002.

[9] Kühn, P.; “Big Experiences with Small Wind Turbines – 235 Small Wind Turbines and 15 Years of operational Results”. EWEC 2007. Institut für Solare Energieversorgungstechnik e.V. (ISET).

[10] American Wind Energy Association. AWEA “Small Wind Turbine Global Market Study. Year ending 2009”.

[11] DME 1998: “White Paper on the Energy Policy of the Republic of South Africa”, Department of Minerals and Energy, Pretoria. 1998.

[12] Szewczuk, S; Prinsloo, E.; “Wind Atlas for South Africa (WASA): Project overview and current status”, EN16-PA-F, CSIR Science real and relevant conference 2010

[13] Lund P.D.; “Effects of energy policies on industry expansion in renewable energy”, *Renewable Energy*, 2009, 34, 53-64

[14] Lewis, J.I.; Wiser R.H. “Fostering a renewable energy technology industry: An international comparison of wind industry policy support mechanisms”. *Energy Policy.* 2007, 35, 1844-1957

[15] Gratwick, K.N.; Eberhard, A. “An Analysis of Independent Power Projects in Africa: Understanding Development and Investment Outcomes”. *Development Policy Review*, 2008, 26, 309-338

[16] Blanco, M.I. “The economics of wind energy”. *Renewable and Sustainable Energy Reviews*, 2009, 13, 1372-1382

[17] Aubrey, C. “Supply chain: the race to meet demand”, *Wind Directions*, January/February 2007, pages 27-34

[18] Pullen, A.; Hays, K.; Knolle, G. “Wind Energy – The Facts, Industry and Markets”

[19] Buys, A. “Measuring Innovation”. *Essays in innovation.* 2007,No2, 52-54

11. AUTHOR

Principal 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. He is a Senior Researcher at the CSIR and has worked on a wide range of projects around the world on behalf of the World Bank, UNDP, GEF and the EU. Stefan’s primary interests are in wind energy, distributed generation and strategy development.

Presenter: The paper is presented by Stefan Szewczuk