Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Options for the Establishment of a South African Wind Energy Centre (SAWEC)

with Lessons Learnt from China and Germany

Final Report

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Based on an advisory mission carried out in Nov/Dec 2010

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Abbreviations

AfriWEA	African Wind Energy Association
BMZ	German Ministry for Economic Co-operation and Development
BZEE	Bildungszentrum fuer Erneuerbare Energien e.V. in Husum
CDM	Clean Development Mechanism
CIM-Jobs	Construction, installation and manufacturing jobs
CIM	Centre for International Migration (German international job agency supporting developing countries)
CEPRI	China Electric Power Research Institute
CPUT	Cape Peninsula University of Technology
CRSES	Centre for Renewable and Sustainable Energy Studies
CSIR	Council of Scientific and Industrial Research
CWPC	China Wind Power Center
CWPP	China Wind Power Programme – GIZ
DANIDA	Danish International Development
Darlipp	Darling Independent Power Producer
DEA	Department of Environmental Affairs
DEDT	Department of Economic Development
DEWI	Deutsches Wind Energie Institute
DME	Department of Minerals and Energy
DoE	Department of Energy
DP	Department of Development Planning
DST	Department of Science and Technology
DTI	Department of Trade and Industry
EIA	Energy Information Administration
EIA	Environmental Impact Assessment
ESETA	Energy Sector Education and Training Authority
FET	Further Education and Training
FRT	Fault Ride Through capability of modern wind turbines
GAHFA	**G**eschaeftsfeld, **A**rbeitsfelder, **H**andlungsfelder, **A**rbeitsaufgaben= (German Abreviation used internationally in skill development= Business Processes, Work Procs., Fields of Operation, Work Tasks
GDP	Gross Domestic Product

GEF	Global Environment Facility
GIZ	Gesellschaft für Internationale Zusammenarbeit GmbH (formerly GTZ)
IEA	International Energy Agency
IEC	International Electro-technical Commission (Standards body)
IMWatT	Internationalized Mechatronics for Wind Power Technology
IPP	Independent Power Producer
IRP	Integrated Resource Plan
LVRT	Low Voltage Ride Through capability of modern wind turbines
merSETA	Manufacturing, Engineering and Related Services Sector Education and Training Authority
MW	Megawatt
MWh	Megawatt-hour
NEEA	National Energy Efficiency Agency
NERSA	National Energy Regulator of South Africa
NQF	National Qualification Framework
NRF	National Research Foundation
NWIC	National Wind Power Integration Research and Test Center
O&M	Operation and Maintenance
PCC	Point of Common Coupling – between wind farm and public high voltage network
PGWC	Western Cape Provincial Government
PPA	Power Purchase Agreement
QCTO	Quality Council Trades and Occupations
REFIT	Renewable Energy Feed-In Tariff
Refit	renewable energy feed-in-tariff
SABS	South African Bureau of Standards
SANEDI	South African National Energy Development Institute
SANERI	South African National Energy Research Institute
SAQA	South African Qualification Authority
SAWEA	South African Wind Energy Association
SAWEC	South African Wind Energy Centre
SAWEP	South African Wind Energy Programme
SETA	Sector Education and Training Authority

SOE	State Owned Enterprise
TIA	Technology Innovation Agency
UCT	University of Cape Town
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
USD	United States Dollar
WAB	Wind Energy Agency Bremerhaven Bremen e.V
WAK	Wirtschafts Akademie
WC	Western Cape
WESGRO	Trade Promotion Agency of the Western Cape
WWEA	World Wind Energy Association

Executive Summary

South Africa is facing the challenge of securing electricity supply while at the same time reducing the comparatively high greenhouse gas emissions. The Government is committed to implement measures in order to meet the target of an ambitious reduction of emissions.

One of the measures to be taken will be the application of renewable energies, including wind energy. The wind resources especially in coastal areas would allow for large-scale installation of wind electricity facilities.

There are already a number of governmental commitments on the use of renewable energy. An institutional set-up to promote renewable energy and wind energy and a basic structures are in place. This includes government related entities or universities doing research in specific areas of wind energy. Professional associations in wind energy have been established. Local and international companies have offices or even production facilities in South Africa and are waiting for the take-off of wind energy in the country.

There are however a number of bottlenecks hampering the development of wind energy. This is due to a number of factors. The Mission identified the following two as the major bottlenecks:

- An unclear structure of responsibilities among the entities involved so far
- A clear decision of the Government to implement existing commitments

As soon as the impediments of the existing institutional framework have overcome, the other bottlenecks in the country can be tackled.

Other bottlenecks are e.g. a lack of reliable and detailed wind resource information, lack of skilled staff (not only in renewable energies), unprepared electricity transmission and distribution facilities (which is not surprising at this stage), outstanding implementation of regulations for IPPs, selection of proper sites for wind farms, etc. With a clear responsibility structure for developing renewable energies including wind energy and the implementation of respective measures, the private industry will foster the development.

Besides having clean renewable energy entering the energy supply system in South Africa of up to 15 per cent, this measure would have significant employment effects – creating new jobs of up to 200.000 in the following years.

Realising the needs but also positive socio-economic benefits of a large-scale deployment of wind energy, a consortium of Western Cape universities and colleges, in partnership with the provincial and national government, started an initiative to establish a national facility for the development of technological and human resource capacities in the wind energy sector – the so called South African Wind Energy Centre (SAWEC). The Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH was asked to assist in the development of different conceptual options, thereby drawing on the experience gained with support to a similar centre in China. In light of this, a delegation visit to South Africa comprised of German and Chinese experts was organized at the end of November, early December 2010.

During the mission it became clear that a Wind Energy Centre could play a major role in coordinating different activities already existing in the area of wind energy in the country. The concept of a South African Wind Energy Centre (SAWEC) was mostly welcomed by the entities and representatives met during the mission.

SAWEC could be a platform to support the coordination of activities in the wind energy sector, to facilitate concerted actions amongst relevant stakeholders by making use of existing activities and foster and increase them, to provide services and training and support the development of a local wind industry.

In 2010 the GIZ project "China Wind Power Programme" was concluded with outstanding achievements over the past five years in helping to build capacity in the Chinese wind sector. These achievements are based on innovative modes of know-how / technology transfer and training and testing facilities in China and have been well recognized by the sector. The results of the mission underpin the necessity for a similar institution in South Africa.

In this report we laid out the requirements for a successful wind power sector and calculated the required number of staff to be trained for the wind power sector of South Africa in each year, taking the IRP 2010 wind capacity development scenario (2011 – 2030) as a basis. Against this background, different options for areas of activities that may form part of a SAWEC were developed.

The resulting figures for training needs are on average per year as follows:

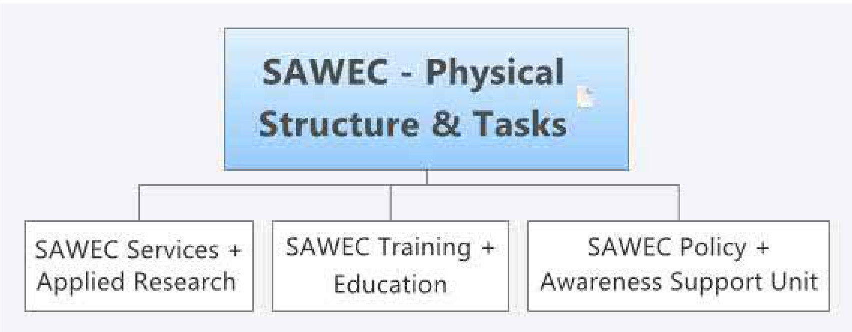
- 668 engineers
- 892 technicians
- 1,127 skilled workers
- 742 other staff (very diverse group)

We concluded that a SAWEC would be the right choice to develop wind power training materials, perform Train the Trainer courses and to implement parts of the training measures together with partners from the wind power sector. It shall serve as a training coordination centre between industry and training providers and relevant authorities (SETAs).

In order to cater for the developing wind power market and support wind developers as well as the local production of wind turbines, it is also recommended to setup a separate structure for SAWEC Services, which could be in charge of wind turbine (grid-) testing and certification, wind resource analysis and wind park design. Applied Research Projects could be initiated, which would result in services to be offered to the wind power sector by the Consulting Services Unit, closely linked to existing institutions in this area.

SAWEC could also be involved in Wind Power Policy support and Public Awareness building coordinated with other entities in the country, which are also (partly) involved in this matter. An appropriate location of this unit should be decided by the stakeholders.

Based on these recommendations SAWEC could have the following basic structure:



The implementation of a fully functional SAWEC would take up to 5 years. In order to facilitate this process it is recommended to learn from experiences gathered already in other countries. A trilateral cooperation involving German Wind Power Institutions and GIZ's partners in the China Wind Power Centre could be considered.

A. BACKGROUND OF THE MISSION

A.1. INTRODUCTION

South Africa has substantial wind resources, and due to the plan to diversify the electricity supply structure and to meet requirements of respective international agreements on reduction of CO2 emissions the Government of SA has decided to steadily integrate renewable energies into the energy supply portfolio of the country.

At the international climate change conference in Copenhagen (Dec 2009) South Africa's President Jacob Zuma confirmed the country's commitment regarding the reduction of emissions. The target committed will be a challenge for the country – 34 per cent below "business as usual" levels by 2020 and 42 per cent by 2025 is a strong commitment to "greening the economy".

Extension of electricity generation capacity by renewables is one important approach to meet this target. However, other policies and measures need to be taken and implemented – as there are: electricity price reforms and a substantial increase of efficient use of energy. Electricity prices in South Africa are among the lowest in the world, thus hampering the recovery of the most important "source of energy", which is energy saving. Energy efficiency is the cheapest way to balance supply and demand. The application of wind generating capacities can provide its contribution to a cleaner and sustainable environment in the future. Other renewables might also contribute, like solar or biomass.

Because of promising wind and solar resources and the Renewable Energy Feed-in Tariff (REFIT) it is expected that in particular wind energy will see a rapid uptake in South Africa.

The South African Government aims at harnessing the job creation potential of renewable energies, thereby addressing at the same time the national priority issues of security of energy supply and poverty alleviation. This aim was mentioned in speeches of high-ranking politicians at the Green Economy Summit as well as in various policy documents, as e.g. the White Paper on Renewable Energy (DoE), the Working for Energy Programme (DoE), the Industrial Policy Action Plan (DTI), the Ten Year Innovation Plan (DST) as well as the Wind Energy Industrial Strategy (DST) currently under development.

In order to realize the job creation potential, dedicated training institutions are needed to build-up the necessary local skills base. Against this background, Stellenbosch University in cooperation with the Cape Peninsula University of Technology, the University of Cape Town and the Northlink College consider setting up a South African Wind Energy Centre (SAWEC). The initiative is also supported by provincial and national government institutions and shall be a national platform for wind energy research, development and training open to interested stakeholders throughout the country.

The Centre for Renewable and Sustainable Energy Studies, Faculty of Engineering, of Stellenbosch University has initiated the idea of establishing a Wind Energy Centre in South Africa (SA) similar to the Centre, which has been successfully established in China some years ago. The China Wind Power Centre (CWPC) is a cooperation project between China and Germany. The German Counterpart of the CWPC is the Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH.

Stellenbosch University has approached the GIZ Office in Pretoria to support the establishment of a Wind Energy Centre fostering the development of wind energy in SA. GIZ SA agreed to consider respective support for the Centre and decided to arrange for an expert mission to South Africa with the following aim:

- Share experiences with similar centres in Germany and China
- Assess the need and suitable structures of a R&D and training centre for wind energy in South Africa by conducting interviews with important stakeholders
- Draft a concept for SAWEC (activities and institutional set-up)

The expert team (hereinafter: Mission) was composed of three experts from Germany and two experts from China. Among the German experts, the team leader (Dr. Kurt Wiesegart) has also been team leader for the mission sent to China in 2002, together with A. Dubois. Since 2005 Andreas Dubois is in charge as Director to implement the CWPC in China. A. Dubois has been engaged with wind energy since the early 1990s. The expert Dieter Sommer is running the Suzhou LongYuan Bailu Wind Power Vocational Training Centre. Before that he, amongst others, implemented and ran one of the important wind energy training centres in Germany (Bremen). One of the two Chinese experts, Prof. Wang Weisheng, Director of the Renewable Energy Department of the China Electric Power Research Institute (CEPRI), supports A. Dubois in managing the CWPC, and, in addition is head of the National Wind Power Integration Research and Test Centre (NWIC), which belongs to the China Electric Power Research Institute (CEPRI). The second Chinese expert Wang Yang is CTO/Head/Vice President of Repower North China Co.

The Mission was conducted from November 23 until December 8 2010. From Nov 23 the team expert for vocational training had meetings with several institutions/colleges dealing with vocational training. On the 29th November after the arrival of the other experts a kick-off-meeting was held in Cape Town with around 75 stakeholders interested in fostering wind energy developments in SA. From Nov 30 until Dec 7 the Mission held meetings with a number of entities working in wind energy on a regional (Western Cape) and on a national level. The meetings included governmental entities, departments of the national utility (Eskom), research institutes, universities, professional associations and representatives of the wind industry. The Mission visited two wind farms in Western Cape Province. .

Due to time restrictions the Mission concentrated on meetings at the national level and in one region (Western Cape) only. With more time available some other regions, e.g. Eastern Cape, would have been included in the Mission, since major wind energy developments are also taking place in these other regions. The focus on the Western Cape Province was due to the fact that the initiative for establishing a Wind Energy Centre was started in this region and because Western Cape will be one of the focus regions of wind energy deployment.

On Dec 8 a debriefing meeting was held at the Stellenbosch University together with Prof. Wikus van Niekerk the Head of the Centre for Renewable and Sustainable Energy Studies and Nigel Gwynne-Evans the Director of the Western Cape Dpt. of Economic Development & Tourism.

On Dec 9 the Team Leader presented the findings of the Mission at the GIZ Office (Pretoria) to S.K. Ohme, the Development Counsellor of the German Embassy, and representatives of other German Development Cooperation Organizations related to skills development in SA (GTZ, DED, IHK Nuernberg u Mittelfranken).

The very well prepared agenda for the mission arranged by the GIZ in Pretoria (D. Werner, supported by his intern, M. Reisinger) enabled the Mission to get a comprehensive overview of important stakeholder dealing with the wind energy sector in South Africa The Mission would like to thank The Centre for Renewable and Sustainable Energy Studies of Stellenbosch University for their contribution to this Report.

A.2. METHODOLOGY

The task of the Mission was to exclusively look into the possible establishment of a wind center for South Africa, as this has been established in China several years before. To decide on the inclusion of other renewable energy technologies in form of a SAREC (South Africa Renewable Energy Center) would have requested another approach of the Mission, which was not intended.

The objective of this Report is not to deliver another analysis of the wind energy sector of South Africa, since this has been done several times by various entities in the recent years. For that reason this report will only refer to those existing studies which deal with relevant issues for the SAWEC approach – the possible implementation of a wind energy centre in South Africa. In addition, this report will also refer to interviews held with various stakeholders during the Mission.

The need for support in the wind energy sector was assessed and analysed in a threefold approach:

- Review of a large number of documents and studies on the wind situation, policies, and institutions in charge of energy generation and supply and/or of renewable energies
- Presentation of the status quo of the wind energy sector and respective training and education institutions and facilities in Germany and in China to relevant stakeholders in South Africa. Possible applications of the approaches in Germany and China have been discussed
- Conduction of interviews with relevant stakeholders and representatives of relevant institutions in South Africa

The Report is structured as follows:

Chapter B.1 provides a summary of the analysis of the wind power situation in South Africa looking at wind resources and power system integration as well as energy policy and industry. The overview shortly describes the installed capacities, the basics of electricity transmission and distribution, and major actors like governmental institutions, the utilities and other relevant actors. It provides furthermore an overview of the status of renewables, especially regarding the application of and/or plans for using wind energy.

In chapter B.2 follows a review of the key success factors for wind power development in Germany and China and some lessons learned of value for the current developments in South Africa.

Chapter B.3 undertakes an analysis of the education and training sector with regard to the future wind power sector and develops a scenario on type and number of jobs to be created by government and industry.

In B.4 findings and recommendations for the realization of a “South African Wind Power Centre – SAWEC” are presented.

The vision of an “Operation Concept” for the SAWEC will be introduced in Chapter C.

The Annex lists a variety of important documents and included information on training curricula for vocational training and engineer training in the wind power sector, which could be realized with the support of GIZ and its project partners in China.

B. OVERALL ANALYSIS AND NEEDS ASSESSMENT FOR A SAWEC

B.1. WIND ENERGY IN SOUTH AFRICA

B.1.1. Wind Resources and Power System

B.1.1.1. Wind Power Potential and Utilization

South Africa has a fair wind resource that is currently being quantified through the South African Wind Map project coordinated by the South African Energy Research Institute (SANERI) in collaboration with the Riso Renewable Energy Laboratory in Denmark and the CSIR, South African Weather Services (SAWS) and University of Cape Town (UCT). In Figure 1.1 it can be seen that most of the wind energy resources are concentrated around west and south coasts, the Karoo inland area and the escarpment. There are currently a number of measurement masts in place, some as part of the national Wind Map project and some installed by private project developers. Early indications are that there are indeed sufficient wind energy resources in South Africa that can be exploited.

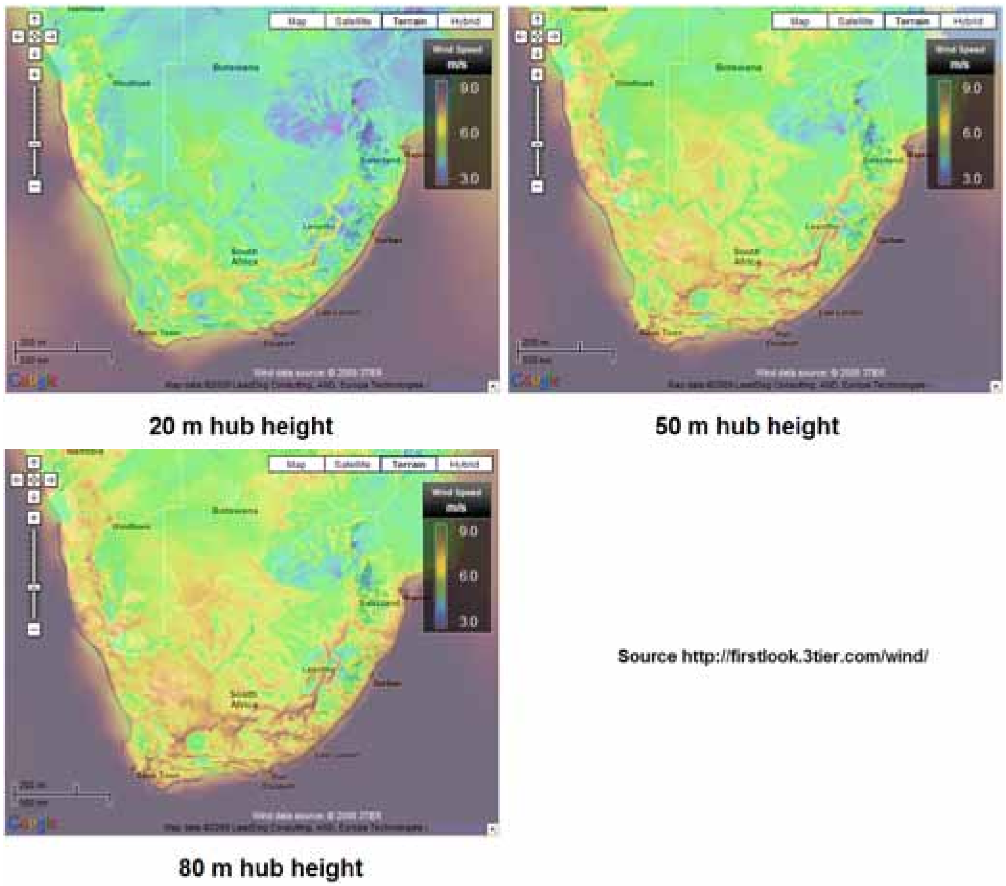


Figure B-1: Wind Map of South Africa

The current shortage of electricity and international pressures on reducing the carbon intensity of the electricity generation indicates that the prospects to implement wind farms in South Africa are favourable. The option of integrating wind energy into the national grid to alleviate the strain on the grid is especially attractive. According to a recent GIZ Grid Capacity Study it is possible to integrate at least 2.8 GW of wind energy capacity into the existing national grid in the Western Cape Province without setting up additional transmission lines and the threat of disrupting the stability of the grid.

It is estimated that currently there are several projects under development in various phases of completion of a combined capacity of up to 14.6 GW. These projects are geographically located in:

- The Western Cape Province
- The Eastern Cape Province
- The Northern Cape Province (Karoo and West Coast areas)
- The Escarpment area

The current large scale wind turbines in South Africa that are grid-connected are located at three facilities:

Klipheuwel, Eskom demonstration facility (3.17MW):

Wind turbines:

- Vesta V47 660kW
- Vestas V66 1 750kW
- Jeumont J48 750kW

This facility was installed in 2002 at a cost of R 30 million by the national utility to investigate wind energy. Unfortunately, the facility was not built in a proper area but in an area with a low wind resource and a capacity factor of less than 20%. Currently only the two Vestas turbines are operational.

Darling Wind Farm, Darlipp (5.2MW):

Wind turbines:

- Four 1.3MW Fuhrlaender wind turbines

The Darling wind farm was designated a national demonstration project partially funded by the Danish Government. In early 2008 the turbines were installed and the power plant was commissioned in May 2008. On the 23rd May 2008 the official "Switch-On" was undertaken, when the Minister of Minerals and Energy officially opened the wind farm. The capacity factor of this site was expected to be greater than 30%. Management and technical issues between the shareholders, the supplier and the operators limited the performance of this facility. No official production data are available.

Coega Industrial Zone (1.8MW) – Latest Development:

Wind turbine:

- One 1.8MW Vestas turbine

This turbine was installed in the Coega Industrial Development Zone (IDZ) over a very short period before the 2010 Soccer World Cup in South Africa.

Other wind turbines/pumps:

Wind energy has been used for centuries for practical purposes, for example to power windmills to mill wheat or to pump water. Only recently larger wind turbines have been designed to generate electricity. In South Africa, isolated and rural communities, that may otherwise rely on diesel generators, use wind turbines to displace diesel fuel consumption and augment solar PV systems. Individuals may purchase these systems to reduce or eliminate their dependence on grid electricity for economic or other reasons, or to reduce their carbon footprint. Wind turbines have been used for household electricity generation and agricultural purposes in conjunction with battery storage over many decades in South Africa, especially in the remote areas. Current uses of wind power in South Africa also include about 300,000 wind pumps to supply water for livestock and community water use.

B.1.1.2. Energy in South Africa

South Africa's primary energy supply is dominated by coal, due to rich coal resources. Coal provides 72% of the total energy consumption (in 2006), followed by oil (12%), renewable and waste (11%, which is primarily waste materials and biomass used in rural areas, not including hydro), gas (3%), nuclear (2%) and hydro (0.24%).

Currently South Africa is exporting approximately 28 % of its coal mined (2006). Regarding oil supply South Africa is depending on imports – with approx 70 % (2006). The remaining part is locally produced mainly by coal-and-gas-to-liquid plants, making South Africa a leading producer of synthetic fuel worldwide.

South Africa has the fifth largest coal reserves in the world. Given this fact, South Africa will continue to rely on coal also for electricity generation in the future.

B.1.1.3. Electricity Generation

The total installed electric generation capacity amounts to 43,601 MW (2008), out of which 39,413 MW (90.4%) are thermal power plants (coal, gas), 2.258 MW (5.2%) hydro, 1800 MW (4.13%) nuclear, 125 MW (0.3%) bagasse, and 5 MW[1] (0.02%) wind power.

94 % of the electricity is generated by the state owned Eskom. The remaining part is provided by municipalities (2.5%) and Independent Power Producers (IPPs with 3.4%). Providing 45% of all electricity generated in Africa, Eskom is by far the largest power company in Africa.

However, in 2008 the electricity supply in South Africa was faced with serious problems. A nationwide electricity shortages resulted in frequent blackouts led to significant economic losses. As a result, a massive expansion programme was launched by the Government aiming at the construction of additional capacity of 40.000 MW from coal, gas and nuclear power plants and additional transmission lines by 2026. In addition it was decided to open the market for more IPPs (up to a share of 30% of total installed capacity) instead of solely rely on the public owned utility. According to a White Paper for Renewable Energy which was published by the Department of Minerals and Energy in 2003, it was planned to generate 10.000 GWh from renewable energy sources by 2013 representing a share of 5% of the electricity mix. However, the development of renewable energies has been very slow, mainly due to low coal prices leading to very low electricity tariffs – belonging to the lowest in the world.

B.1.1.4. The Electricity Grid

Eskom, the national utility owns, operates and maintains the national transmission grid. Eskom's network amounts to 371.000 km of power lines, out of which 28.200 km constitute the national transmission grid. Electricity is transmitted in the range of 132 kV to 765 kV.

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[1] The figures about wind power are different in case the total capacity in the two wind farms Darling and Klipheuwel are accumulated 5.2 MW and 3.2 MW respectively. The 3 wind turbines of Klipheuwel, operated by Eskom since 2003, are however not considered in the statistics since targeted for management purposes only.

The distribution network of South Arica is partly decentralized. Eskom is the largest single distributor accounting for more than 50% of energy sales for final consumption, covering 47% of the total amount of customers. The remaining part is highly fragmented among several hundred companies responsible for the supply of electricity to end users.

With 1.2 million square kilometres being as large as France, Germany, Austria, Denmark, Benelux, Switzerland and Czech Republic_ together but with only 60% of Germany's population only about 80% of South Africa is electrified. Approx. 2.5 million households are not yet connected to the electrical grid. More than four million households do not cook with electricity and two million households rely on candles for lighting. Nevertheless, it is worthwhile to mention that South Africa has increased the rate of household electrification from 36 % in 1993 to 80 % in 2007. In 2008 the share of electrified households in rural areas was 73 %, non-electrified households are mainly in the provinces of KwaZulu-Natal and Eastern Cape.

B.1.2. Stakeholders in SA Wind Power Development

Below is a list of the major players of South Africa's energy sector which are relevant to the wind power sector.

B.1.2.1. Governmental Actors

Department of Energy (DoE)

The **DoE** is the ministry in charge of the energy sector. It was renamed in 2009, until then being the Department of Minerals and Energy (**DME**). DoE is responsible for the planning, development, implementation and monitoring of the energy policy and energy related programmes and, represented by the National Regulator also for regulating the energy market. This includes also renewable energy.

The DoE is responsible to set the policy that guides the energy sector and the electricity sector in particular. The DoE drafts green and white papers that develop, test and define policy and then compile the relevant legislation to implement the Government's energy policy. In addition, the DoE is responsible to draft the Integrated Resource Plan (IRP) for electricity generation as well as an overarching Energy Plan for the country. The DoE is also responsible to instigate and maintain projects to generate capacity in the country to ensure the optimum energy generation and mixture thereof. Some of the relevant outputs delivered by the DoE are:

- Renewable Energy White Paper in 2003
- IRP1 published in January 2010
- Draft IRP2010 published in October 2010

The final body approving the IRP and other energy policy is the cabinet comprising out of the President, Vice-President and all the ministers of the country.

National Energy Regulator of South Africa (NERSA)

NERSA is responsible for the electricity sector but also for oil and gas (according to the National Energy Regulator Act, 2004: for "..all piped and grid-linked energy sources…"). The major task is to issue licenses for electricity generation, transmission (for which Eskom has a monopoly) and distribution as well as for the fixing of electricity tariffs.

The Regulator is an independent body with regulators appointed by Government that controls the tariffs and permitting of energy providers. NERSA's powers include issuing licences for the operation of generation, distribution and transmission facilities, import, export and trading of electricity, and determining and approving electricity prices and tariffs as well as the conditions on which electricity may be sold. NERSA is also responsible for the standard Power Purchase Agreement (PPA) for renewable energy, which is still a draft document out for consultation.

NERSA announced the Renewable Energy Feed In Tariffs (REFITs) in 2009 and also mandated Eskom, as the Single Buyer Office (SBO), to distribute this additional cost to the entire customer base. Any wind farm that will be connected to the national grid will need a generation license from NERSA and a PPA signed by the SBO.

Department of Environmental Affairs (DEA)

DEA is responsible for the sustainable use of the natural resources, protection of the environment, nature and climate. In this regard, it is lead department for directing and formulating the national climate change policies, represents South Africa at the conferences of the international climate regime and has the responsibility of ensuring that South Africa's obligations in terms of the UNFCCC and the IPCC are fulfilled. Whereas the official mandate for renewable energy lies with the DoE, DEA can exerted influence in this area by means of spatial planning regulations (in particular Environmental Impact Assessment regulations and approvals), the setting of overall climate targets and strategies for the implementation of which it relies on other departments (mitigation: mostly DoE; adaptation: DoH, DAFF, DWA, etc.).

Department of Science and Technology (DST)

The **DST** is the line department for science and technology and oversees implementing agencies as e.g. TIA, NRF or CSIR. Strong emphasis is laid on energy, which is considered to be one of five "Grand Challenges". An energy R&D strategy has been developed and is currently undergoing internal approval processes. The DST is a strong promoter of RE and has its own division for that. It defines its mandate rather broad and is engaging also in the lower end of the innovation chain. The distribution of roles between the DST and DoE/SANERI aren't clearly cut and subject to possible conflicts of interest. The DST plans to set-up a Solar Centre of Competence (applied research with the aim of product commercialization, opposed to more fundamental research oriented Centres of Excellence) and also has plans to get active in the wind energy sector (although still not very clear).

The Technology Innovation Agency **(TIA)** is a newly established entity with the objective to stimulate and intensify technological innovation in order to enhance the country's capacity to translate a greater proportion of local research and development into commercial technology products and services. TIA tries to stimulate R&D and technology incubation within the private sector and will be the host of DST's Centres of Competence.

The objective of the National Research Foundation (**NRF)** is to support and promote (fundamental) research through funding, human capacity development and the provision of the necessary research facilities, in order to facilitate the creation of knowledge, innovation and development in all fields of the natural and social sciences, humanities and technology, including indigenous knowledge systems. The NRF establishes and funds Research Chairs and Centres of Excellence.

Whereas TIA focuses on technology and private sector development on the lower end of the innovation chain, the NRF focuses on fundamental research and capacity building (education) at the higher end of the innovation chain.

Department of Trade and Industry (DTI)

The **DTI** is the line ministry for industry (development) in South Africa. Due to the high unemployment rate, there is a strong focus on job creation and local production. The guiding policy document for industry development is the Industrial Policy Action Plan 2 (IPAP 2) which puts emphasis on a systematic promotion of green and energy-efficient goods and services.

Department of Public Enterprises (DPE)

The **DPE** is in charge of the state owned enterprises (SOE), including Eskom, the state owned utility.

The DPE controls all the companies owned by the South African Government, including Eskom and Transnet, the national railways. The DPE is responsible to appoint the Board of Directors of Eskom who then has to report to the SA Government as the sole shareholder. This could create some conflict between the DoE and DPE as they tend to have different objectives with the control of Eskom.

South African Bureau of Standards (SABS)

The South African Bureau of Standards (**SABS**) is responsible for maintaining national standards as well as some of the required certification testing. In the recent past, the SABS strategy has been to adopt international standards such as IEC and ISO standards as the local SANS standard. At this time, no test facilities for wind turbines exist in South Africa.

Western Cape Provincial Government Departments/Initiatives

The **Western Cape Province** is a forerunner in terms of sustainable energy and climate change in South Africa with ambitious sustainable energy and climate strategies..

In the Western Cape Provincial Government, **the WC Department of Environmental Affairs and Development Planning** took the lead, supported by various donors, inter alia GIZ carrying out the Western Cape Wind Energy Project in cooperation with DEA&DP and Eskom between 2008 and 2009. Since the beginning of 2010, the **WC Department of Economic Development** (DEDT), joined DEA & DP and actively promotes renewable energy and its associated socio-economic effects by setting up structures as e.g. the Green Cape.

The **GreenCape Initiative** embodies the strategic intent of the Provincial Government of the Western Cape to ensure that the Western Cape captures a significant share of the jobs created in the renewable and green economy, and is at the forefront of renewable energy and green technology.

Wesgro is the Western Cape investment and trade promotion agency and provides a range of services in order to attract investment in the Western Cape and facilitate exports.

Within the Western Cape, the **City of Cape Town** itself is strongly pushing for sustainable energy. It was the first city with a dedicated strategy and target (15% RE by 2015) and has made the Darling Wind Farm viable by entering into a PPA on a willing-buyer-willing-seller principle.

Council for Scientific and Industrial Research (CSIR)

CSIR is a state-owned and funded institution for scientific and technology research, development and implementation and is working on the SA Wind Atlas which is carried-out in course of the UNDP-funded South African Wind Energy Programme (SAWEP). The atlas is expected to be finalized by 2013. CSIR is furthermore active with advanced materials & manufacturing and small-scale wind turbines.

Central Energy Fund (CEF)

CEF was founded by the then Department of Minerals and Energy and is involved in supporting the Government finding appropriate solutions for the energy supply of the country, which includes all sources of energy as coal, oil, gas, electric power and renewables.

A department of the CEF, the Energy Development Corporation (EDC), established in 2004, is in charge of supporting investments in renewables. EDC focuses on solar energy, wind, hydro, biomass and biogas and on low-smoke fuels. It supports energy development through commercial, development and social projects.

South African National Energy Development Institute (SANEDI) /
South African National Energy Research Institute (SANERI)

SANERI is a subsidiary of the **CEF** and, as public institution, responsible for the coordination of energy research entities and undertaking own research activities, development and demonstration programmes in public interest, expected to bridge in particular the gap between R&D, demonstration and implementation of energy programmes. Among others SANERI focuses on clean energy solutions including RE, advanced fossil fuels and green transport.

SANERI is expected to arrange non-academic training in the RE sector, product research and development and via the establishment of a practice-oriented Renewable Energy Centre of Research and Development (**RECORD**).

According to the National Energy Act (2008) **SANEDI** was established on 1st April 2011 as an umbrella organization of SANERI and the National Energy Efficiency Agency (**NEEA**).

Based on the information available, the Mission got the impression that there are several entities at governmental level and/or among the subordinated entities, which have either not a clearly defined mandate, overlapping responsibilities or are in a process of restructuring.

B.1.2.2. Universities

There are a number of universities who started to provide academic curricula on RE and also wind energy related topics, as e.g. the Stellenbosch University, the Cape Peninsula University of Technology, the University of Cape Town, the North Western University and others. Below we provide some information about selected universities. The reader needs to take into account that these are only examples, but <u>not a complete overview</u> of universities active in the wind energy sector.

The **University of Stellenbosch** has been awarded to act as the national hub of the Postgraduate Programme in Renewable and Sustainable Energy Studies by the South African National Energy Research Institute (SANERI). In order to manage and implement that programme, the **Centre for Renewable and Sustainable Energy**

Studies has been founded, combining the different in-house research and capacity building programmes as well as liaising with other universities chosen to be the “spokes” for certain research areas. The focus in the field of renewable energies lies on technical research, where it has vast experience inter alia in solar thermal energy, wind energy, biomass, bio-energy, thermal energy storage and dry cooling. Policy research is provided by the School of Public Management and Planning but figures less prominent on the agenda. Recent innovations are on permanent magnet generators and the development of a small wind turbine for Antarctica (extreme conditions)

The **University of Cape Town (UCT)** is one of South Africa’s largest universities (25.000 students in 7 faculties). UCT has major activities in the energy field. In particular, it is the Wind Spoke affiliated to the DST/Stellenbosch Centre for Renewable and Sustainable Energy Studies (**CRSES**).

The **University of Cape Town** is active with meso-scale modelling of wind resources, wind turbine emulation system, control strategy for permanent magnet generators, power quality & network integration.

Since the end of apartheid the **Energy Research Centre** (**ERC**) at UCT has been one of the leading energy research centres of the country and was particularly in the nineties closely involved in policy-making processes.

The **Climate System Analysis Group** at UCT is a multi-disciplinary research group with about 40 staff members and with a special focus on climate change. The key research areas include global and regional climate modelling, analysis of past and present climate variability, responses, trends and changes or development of research methods and tools for climate change analyses. It also offers climate services, which include operational seasonal forecasts, historical climate analyses, regional climate change products as e.g. multidecadal projections, supported by assessments of likelihood and uncertainty. CSAG is also involved in the wind atlas project (together with SAWEP and SANERI).

There are a number of other universities being involved in research and teaching on Renewable Energy related subjects and we list here the ones, which were referred to during the interviews of the mission.

The **University of the Witwatersrand** is doing research on wind turbines for low to medium speed conditions, power electronics and network integration. The **North West University**, Dept of Aero-Energy: is designing and manufacturing low and medium speed turbine blades. The **Vaal University of Technology** is concentrating on vertical axis wind turbine.

The **Cape Peninsula University of Technology (CPUT)** is currently conducting research into RE via several departments, which are uncoordinated. The Centre for Instrumentation Research is involved with the development of power electronics specifically applicable to wind turbine technology. Energy optimization concepts are being explored focused on energy efficiency and energy monitoring. The Mechanical Engineering Department is investigating alternative wind turbine designs, manufacturing techniques and optimization.

Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth currently develops a comprehensive Master Degree programme on renewable energy in cooperation with Germany via the University of Oldenburg’s RE-master programme. The Centre for Energy Research - CER is a leading institution on solar research and develops statistical models for wind energy prediction. The NMMU’s Department of Physics also forms the DST Solar Photovoltaic spoke with the Fort Hare Institute of Technology.

B.1.2.3. Public Actors – Eskom

Eskom (Eskom Holding Ltd.) is the state owned utility providing 94% of the generated electric power in South Africa. Eskom is – based on the installed generation capacity – the world's eleventh largest power utility. The main operation basis is South Africa, having offices in Uganda, Nigeria and Mali.

Eskom is an independent company wholly owned by the SA Government that is responsible for the generation, transmission and distribution of 94% of the electricity used in South Africa and approximately 45% of the electricity used in Africa. Eskom generates, transmits and distributes electricity to industrial, mining, commercial, agricultural and residential customers and redistributors. The majority of sales are in South Africa. Other Southern African countries account for a small percentage of Eskom's sales. Eskom is currently implementing the fifth largest utility capacity expansion programme internationally to expand the current total generation capacity of 41 GW.

Eskom is a vertically integrated utility. It owns the transmission grid and a significant share of the distribution grid. Eskom will host the Single Buyer Office (SBO) for RE electricity generated under the REFIT until an independent system operator has been established. The **Peaking Generation Division** is located in the Western Cape and has the responsibility for all of the generation other than coal and nuclear. This also includes wind energy and therefore the Klipheuwel Wind Farm, which has been moved from the Research Division to Peaking Generation Division. The division's support to SAWEC is crucial for a use of the wind farm.

B.1.2.4. Distributors, Associations, private companies

Distribution of electric power is already partly decentralized. Whereas 40% of the electric power is distributed directly by Eskom, 60% (by number of customers) of the electricity is distributed by 187 municipalities.

There are two Wind Energy Associations, the African Wind Energy Association (AfriWEA) and the South African Wind Energy Association (SAWEA). Due to personal interests of founders and members, there is limited coordination between them. They represent the interests of the member companies, which are developers, investors and manufacturers of wind power and wind power related products.

Private power generation companies – IPPs, Independent Power Producers – until now do not play a relevant role. The generation sector has not yet been unbundled. They provide 1% of the generated electric power. According to governmental plans, unbundling of the generation sector is considered, enabling IPPs to supply up to 30% of the generated power.

However, a number of private companies – manufacturers, developers, investors – are waiting for the take-off of South Africa's wind industry. During the Mission, a number of companies were interviewed in order to evaluate their expectations and purposes. Among others, the Mission met representatives of Vestas, Juwi,

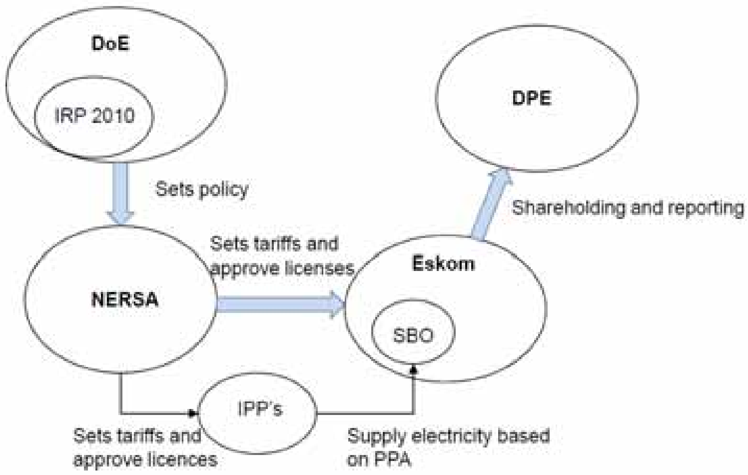

Figure B-2: Interaction of the various role-players in the electricity sector

Isuvungugu, Exxaro, Redcap, Windlab Systems, G7 Renewable Energy.

The relationship between the different role-players are illustrated in Figure B-2.

B.1.3. The Policy Framework for Renewable Energies

The legal framework of South Africa's energy sector is administered by the National Energy Act of 2008. The Act is to ensure the energy supply of the country in sustainable quantities and affordable prices supporting economic development, poverty alleviation et al. The Act also foresees contributions of renewables to the national energy supply. It stipulates that measures and incentives should be designed in order to promote the production, consumption, research and development and investments in the RE sector.

Against the background of different other laws and regulations the National Treasury (Ministry of Finance) has, introduced a carbon tax levy of 2 Rc/KWh imposed on electricity generated from non-renewable energy sources, in order to promote the development of renewables.[2]

Recently a number of policy documents were published that are stimulating a keen interest in the development and economic benefits of a renewable energy sector, including wind energy. The most notable of these are:

a) Renewable Energy Whitepaper, 2003 [3]

The South African Government's White Paper on Renewable Energy published in 2003 set a target of 10 000 GWh from renewable energy resources by 2013. It was based on an estimated 4 % of the total energy consumption in South Africa, electricity and liquid fuels, at that time. This energy was to be provided primarily from biomass, solar, wind and small-scale hydro. The RE whitepaper predicted a role for SMMEs (small, medium and micro enterprises), IPPs (independent power producers) and competition in the energy markets. It was envisaged that the roll-out of renewable energy projects would stimulate the economy and generate green jobs, increase energy security and reduce the carbon intensity of the electricity generation sector.

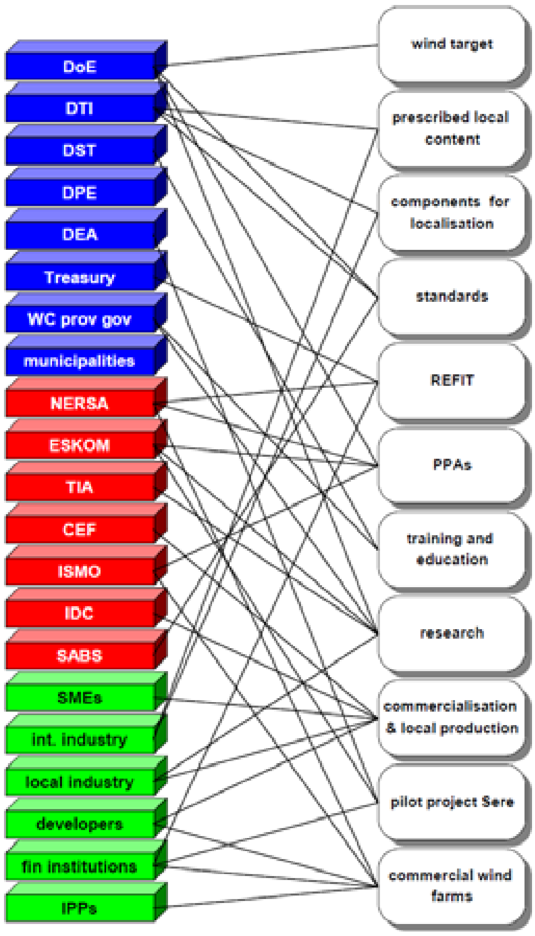

Figure B-3: Relationship between different role-players

The White Paper on Renewable Energy from 2003 had set the target to generate 10,000 GWh of electricity from renewable energy sources by 2013. This target was considered to be achievable with the help of subsidies and carbon financing.

[2] TERNA-Study GIZ

[3] White Paper on Renewable Energy, November 2003, Department of Minerals and Energy Republic of South Africa

b) Renewable Energy Feed-In Tariff, 2009

In March 2009 NERSA approved the Renewable Energy Feed-In Tariff (REFIT) guidelines as a regulatory instrument, being a fundamental pre-condition to initiate the interests of potential developers. The REFIT provides for Power Purchase Agreement (PPA), and considers among other issue also the establishment of a Renewable Energy Power Purchase Agency (REPA) housed in Eskom's single buyer office and the responsibility for cost covering of the grid connection et al. It included tariffs for wind, solar (CSP) with six hours storage, small-scale hydro and landfill gas. The second set of tariffs, which was announced in November 2009 included solid biomass, biogas, CSP (central receivers with six hours storage and troughs with no storage) and PV larger than 1 MW. There are still a number of steps required to facilitate the implementation of the REFIT and to date no power purchase agreements (PPAs) have been committed. According to the REFIT Guidelines the feed-in tariff of wind energy is set at ZAR 1.25/kWh. In course of a tariff review in March 2011, NERSA proposed to reduce the wind tariff to 0.938 ZAR/kWh; however, a public stakeholder consultation process is at the time of writing still underway with a decision on new tariffs announced for middle of June 2011.

c) Energy Act 2008

The Energy Act from 2008 refers to instruments to foster renewables energies in South Africa. Among others, the DME established the Renewable Energy Finance and Subsidy Office (REFSO) in charge of managing renewable energy subsidies and to offer advice to RE developers and other stakeholders on RE finance and subsidies. The objective of the subsidies is to increase the share of renewable energy in the country by offering incentives to developers and IPPs. REFSO stipulates in detail how to subsidize RE developers and specifies the respective conditions.[4]

d) Integrated Resource Plan, 2009 and 2010[5]

The Integrated Resource Plan (IRP) is the long-term electricity or capacity plan for the country. It should answer a number of questions: how much capacity is needed for South Africa in the long term, what mix of energy sources should be used and who should build the required capacity? The first Integrated Resource Plan (IRP1) set a target of 700MW of wind energy by 2013. Targets set by the IRP2010 will significantly impact on SA's wind energy deployment. The IRP2010 sets specific targets up to 2030.

The South African wind energy generation targets are spelled out in the IRP2010, published in March 2011. This plan makes provision for:

Phase 1 of the REFIT power purchase programme announced by NERSA which amounts to
1025 MW (made up from wind [700 MW], concentrated solar power (CSP), Photovoltaic, landfill and small hydro options).

A wind energy programme in addition to the REFIT1 wind capacity, commencing in 2014, with 8,4 GW of wind energy.

In addition to the proposed wind energy IPPs the national utility has been developing a project near Lutzville on the West Coast that will comprise up to 100 wind turbines of 2 MW for a total installed capacity of 200 MW. The first phase of 100 MW will be funded by the French Development Bank as well as the World Bank. This wind farm has

[4] TERNA Study by GIZ

[5] Integrated Resource Plan for Electricity, Final Version, 25th March 2011

received most of the regulatory approvals and is currently on tender for the third time. This power station is known as the Sere wind farm.

	Committed Build		New Build Options	
	Wind (IRP 1)	Sere (Eskom)	Wind (IRP 2010)	Total new build power stations (renewable plus conventional)
	MW	MW	MW	MW
2010	0	0	0	640
2011	0	0	0	809
2012	300	100	0	1103
2013	400	0	0	2 901
2014	0	0	400	3 021
2015	0	0	400	2 564
2016	0	0	400	1 432
2017	0	0	400	2 968
2018	0	0	400	1 523
2019	0	0	400	2 496
2020	0	0	400	2 010
2021	0	0	400	1 212
2022	0	0	400	1 365
2023	0	0	400	2 359
2024	0	0	800	2 424
2025	0	0	1 600	3 835
2026	0	0	400	3 500
2027	0	0	1 600	2 350
2028	0	0	0	1 414
2029	0	0	0	2 764
2030	0	0	0	2 948
Total	700	100	8400	45638
Overall		**Wind**	**9200**	

Table B-1: Final IRP (Policy Adjusted Revised Balance Scenario)

Source: Integrated Resource Plan 2010 Final Report (March 2011 Rev 2)

B.1.4. Wind power industry in South Africa and their needs

The South African Government is interested in developing an indigenous wind power industry. It has promulgated policies to support the wind industry development. It is too early to judge whether the policies are sufficient to foster the wind energy development in the country.

The example of China shows that it is possible to transform a wind power sector within 8 years from producing mainly small turbines for off-grid applications to a sector, which is in a position to manufacture large wind power generators of 3000 kW or larger. Especially the industry for producing components like blades and gear-boxes has been developed strongly. Nowadays, nearly 100% of all wind turbine components can be sourced locally.

South Africa is in the fortunate position that it has already a well developed manufacturing industry for mechanical and electrical components. The quality of the products is very good due to the requirements of and demands in the mining and automotive industry. Based on this it is possible to start a local production of components for wind turbines.

However, in order to better serving the wind industry in South Africa – though demand side analysis was not included during the mission – China's wind industry development status in 2003-2005 witnessed by GIZ provides a good reference for the study of South Africa's wind development needs.

Wind industry development in the initial stage has been a policy driven industry in all the countries, where wind industry is now in place. The type of policy deployed in different development stages will accordingly also substantially influence the development of the wind sector in South Africa.

Referring to the commitment to wind energy development stipulated in the IRP2010, the current situation of pending project selection criteria, and also the availability of mature wind technology which will possibly be introduced in South Africa, it is expected that the wind energy industry in South Africa is going to take off in the near future. Being in the early development stage, South Africa's wind industry needs can be summarized as follows:

Needs	Required services	Suggestions for the short term
Wind farm planning	Wind resources assessment & site suitability check; Grid planning & wind farm grid integration; Foundation design: Environmental impact; Feasibility study;	Existing capacity available from other countries could be utilized while at the same time, to build up the local expertise.
Wind farm O&M	O&M Troubleshooting	Qualified working staffs are the essential factors to run and maintain a wind farm well. This must be localized according to the requirements of the SA

		government. Troubleshooting could rely on know-how or know-why import from outside SA.
Wind farm project construction	Wind project management	This must be available in SA.
Local wind turbine component design & manufacturing	Wind turbine component design Wind turbine component manufacturing	Blade and tower shall be localized, as it is not economically viable to transport them to SA from outside. Though in the first several wind projects, these might still rely on importing, but the final goal is to have it locally made. The same applies to other components if localization is preferable.
Local wind turbine design & manufacturing	Wind turbine design Wind turbine assembly Wind turbine storage & transportation	To cater for the market requirement and the fact that developing a new wind turbine model takes time, the practical approach is <u>not to design a wind turbine right now</u>, but to learn the relevant engineering capacity via technology transfer deals and licensing. It is suggested that a minimum "local content ratio" or similar regulation is introduced as a requirement for selling wind turbines to "IRP-wind farms". This is not only good to build SA's wind sector, but also creating more local jobs.

As the wind sector in SA develops, more requests on local manufacturing capacity will be demanded by the market.

<u>View of the Government</u>

On 5 August 2009 the Minister of the then Department of Minerals and Energy (DME) announced the electricity regulations on new generation capacity. These regulations provide guidance on future investment in generation capacity by both Eskom and independent power producers (IPPs) in accordance with the integrated resource plan (IRP). IPPs have an important role to play in addressing the energy needs of the country since it is vital to diversify the source and nature of energy production, introducing new skills and capital in the industry and enabling the benchmarking of related pricing and performance. Eskom therefore, supports the introduction of IPPs and confirms that the Sere wind farm will be the only wind farm they will build and operate. All the other wind farms are expected to be IPPs. In order to ensure the successful implementation of these

regulations, it is imperative that resolution is reached on a number of critical issues such as the finalisation of the IRP 2010, a standard PPA and the designation of the independent system operator. [6]

Wind Farm Project Developers

The primary needs of the design, procurement and construction companies and operators are:

- Skilled professional staff including engineers, managers, etc.
- Skilled technical staff, from artisans, technicians to operators
- A developed localized manufacturing and service industry with respectively qualified employees able to supply the demand of an expanding market

There are currently only two wind turbine manufacturers in South Africa.: Kestrel, based in Port Elizabeth, manufacturing small wind turbines 600 W – 3 kW, and Palm Tree Power/Adventure Power, based in Gauteng, manufacturing a 300 kW wind turbine for rural deployment. There are other companies, such as Isivunguvungu, who indicated to be in the process of establishing a manufacturing base in South Africa, based on a partnership with an international technology provider.

Several of the well-known international, large-scale wind turbine manufacturers are currently represented in South Africa with offices, such as Vestas, Suzlon, Goldwind and Siemens.

The only local component manufacture for large wind turbines is John Thomas Boilers in Cape Town, who has delivered the tower for one of the Vestas turbines at Klipheuwel. Other companies, such as Dorbyl and Grinaker-LTA, are ready to produce towers and other parts, provided there is a demand.

B.1.4.1. Local production of Wind Power Equipment & Technology Transfer

There are in principal several ways of localizing production, which is basically

- technology transfer through licence manufacturing
- joint venture production with a foreign company
- establishment of wholly foreign owned companies

It is not intended here to discuss the pros and cons of the different options above. We just want to highlight a few aspects and point out some of the specifics as it was done in China: China's wind sector developed extremely fast; starting with less than 1 GW in 2005 to roughly 44 GW installed capacity by end of 2010. The speed of the development of the local supply side depends solely on the speed of the demand side.

Since the situation of the supply side in South Africa is far from being able to develop large-scale wind turbines indigenously, this option of "local product development", is not a feasible one, assuming that a take-off of wind power development should take place soon[7].

Technology transfer is the process of transferring skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities from a technology provider to a local manufacturer. This enables the local manufacturer apply the

[6] Eskom Integrated Report 2010, www.eskom.co.za

[7] Please refer also to Section B.2.3. of this Report

technology and – depending on the respective contract with the technology supplier - to further develop and exploit the technology into new products, processes, applications, materials or services. It is closely related to (and may arguably be considered a subset of) knowledge transfer[8].

However, technology transfer normally features the provision of complete design drawings, without a transfer of the Intellectual Property Rights (IPR). A royalty fee shall be applicable to the wind turbine licensee on an agreed percentage of the sale prices.

This method will be the fastest way to win a market share, but not really the know-how and know-why will be mastered through such deals.

It is suggested that local content ratio and certification requirements (at least design evaluation) shall be used to regulate the competition and healthy market development. Respective regulations initiate foreign suppliers to foreign direct investment in the country.

In China, the government set the goal of 70 to 80% local content for production in 2003. A minimum of 40% is required for the participation in programmes with state-support; the electrical equipment was required to be 100% of local production.

The five main components which have to be locally manufactured in the long run are:

- blades
- other composite parts like nacelle covers
- generator
- yaw
- gearbox
- (controller)

The Chinese local production only yielded sizeable results after joint ventures with international companies were set-up and some Chinese industry giants decided to buy licences for modern wind turbines in Europe or even gave design contracts to German wind turbine designers. Developing the supply industry without this help would have been impossible in such a short time.

There are various sub-component suppliers in the local industry, which could diversify into wind components:

Rotor Blades

Rotor blade manufacturing is a labour intensive product. Also the size and weight of the blade, which incur high transportation costs determine blades as a component which should localized in an early stage of the take-off phase.

There are quite a few shipyards in South Africa using composite material, which is also the main material of a blade. Accordingly, part of the know-how is already locally available.

Tower Manufacturing

Similar issues apply to the Tower Manufacturing. Even though, it is not a labour intensive product, its transportation cost will be high.

[8] *en.wikipedia.org/wiki/Technology_transfer*

It needs to be checked if the special high strength “T” or “L” shape tower flange steel is available in SA – if not it needs to be imported.

<u>Control Systems</u>

The control systems are suggested to be imported, while the services can be sourced locally. This counts also for the other products listed above. As large generators or gearboxes require a relatively comprehensive and mature manufacturing industry, it will take several years to produce these in SA..

B.2. FOREIGN EXPERIENCE IN WIND POWER - REQUIREMENTS FOR SUCCESS

In the following chapter, we highlight important aspects for the development of a thriving wind power sector in general and specifically explain the situation in Germany and China, based on the experience of the study-team in the respective countries, which should provide lessons learnt for the South African case.

B.2.1. Sustainable Long-term Policy Support

The single most important factor for the success of Renewable Energies is sustained and predictable government support. Although the cost of wind power has declined considerably in the past decade, its construction cost per installed MW is still higher than conventional power stations. The reasons for this cost-disadvantage originate in the wrong lifetime-cost-assessment of conventional fossil and nuclear power plants, which do not take into account the social cost of environmental damage due to CO_2, induced environmental damage and long-term cost due to nuclear radiation and waste disposal.

Therefore, a successful wind power development depends – beside other frame conditions - on preferential policies adopted in each country, such as Renewable-Quota in UK, Fixed feed-in-tariff in Germany, or a kind of mix, like in China.

B.2.2. Wind Power Education & Training

B.2.2.1. Introduction

For project developers and operators in the wind industry the economic success of wind power projects is heavily reliant on the qualification and skills of their employees. From personnel involved in wind resource assessment and micro-siting of turbines, via engineers overseeing construction and grid integration to management, maintenance and troubleshooting of the wind farm during operation, the profitability of the project is dangling on the string of staff qualifications.

The same applies to manufacturers in the wind industry; since the quality and reliability of wind turbines is a major factor, determining the energy output of wind farms and thereby their financial viability. In order to ensure a reasonable return on investment and reduce risks due to low wind turbine availability or turbine breakdowns, banks and insurance companies have become stricter with regard to standards and requirements. This is true for certification of materials and products, processing techniques and testing standards and affects enterprises at all stages along the value chain. Quality control and management are of crucial importance in every aspect of wind power equipment manufacturers' ventures, from initial research and design processes, via testing procedures to mass production. Off-shore wind power generators are exposed to even higher mechanical loads and adverse environmental conditions than turbines on land, therefore demanding even higher standards.

A wide range of qualified personnel with technical, legal as well as economic knowledge is needed in order to meet the high requirements of the wind industry at all stages of the value chain. Employees have to apply their knowledge in order to be able to innovate products and processes, to identify problems and solve them independently. Only companies with skilled personnel and qualification schemes in place to advance the knowledge base of their employees in order to keep up with technological innovation, will be able to survive in an ever more competitive industry. For that reason, qualification is of central importance to all companies in the wind power sector".[9]

The following table compares the likely outcome of employing properly trained wind power staff and those with inadequate training:

<table>
<tr><th>Player</th><th>Poorly trained</th><th>Well trained</th></tr>
<tr><td>Component Manufacturer</td><td rowspan="2">Improper use of tools;
poor workmanship during manufacturing;
Ignore quality control procedure;
Either injure human body or damage the tools or product</td><td rowspan="2">Careful and appropriate tools usage
quality procedures are observed;
Follow safety rules and use personal safety equipment correctly.</td></tr>
<tr><td>WTG Manufacturer</td></tr>
<tr><td>Logistic and Installation company</td><td>Quality issue during transportation and installation will arise, which will jeopardize both human body and the wind turbine.</td><td>Observe transportation requirements;
Use tools properly and ensure the requirements of the design to eliminate the risks in future operation;
Work safely.</td></tr>
<tr><td>O&M</td><td>Improper use of tools;
Missing system-knowledge and improper action on failure might cause big losses;
High risk of accidents and danger to health exist during work on site.</td><td>Use tools properly;
Mitigate the failure rate by observing set O&M procedures based on system-understanding.
Be safe and responsible.</td></tr>
</table>

Table B-2: Basic Analysis of merits of proper training

B.2.2.2. Situation in Germany

In the following, we present an introduction to education and training in Germany in the fields which are closely related to wind power.

A detailed overview is presented in the following GIZ report, which is also the major source for the information provided in this chapter:

"*Exemplary Research & Development Structures and most Relevant Elements of Training & Education in the Field of Wind Energy in Germany*", IWES report, 11/2010

The German situation for training and education is characterised by the usual two pillars of

[9] Project website of GIZ CWPC: http://www.cwpc.cn/cwpc/en/training

a.) Academic and

b.) Non-Academic Education.

The German rules are quite flexible and allow students to change between path a. and b. University graduates with a partial non-academic background have better chances in the job market, as German employers favour practical experience over pure academic merits. It is also often the case that non-academic master-craftsman will earn higher salaries then the usual engineer with a bachelor degree. The formal qualifications are kept to the latest technological level by attending short courses as part of life-long learning.

The general education structure is given below[10]:

Figure B-4: Education and Training in Germany

In the wind power field the current workforce will mostly have gained their knowledge through "*extra occupational further training*" as specialized wind power course are a recent new development.

B.2.2.2.1. Academic Training and Education

Currently more than 110 University courses containing aspects of wind energy, but only some of them are especially developed for the industrial working market. A complete list is provided in the IWES report[10].

Several universities and training centres offer certified study programmes and master programmes at academic level subsequent to bachelor degrees in mechanical or electrical engineering as well as economic engineering or in some extent architecture.

Master Programs

Master programmes in wind energy or with specialisation in wind energy are provided by the universities of Kassel, Oldenburg, Bremen, Magdeburg, Stuttgart, Hannover, and Bremerhaven. A short introduction of the university and the accordant education and training activities is given in the IWES report[10] together with information on the respective curricula.

[10] *Exemplary Research & Development Structures and most Relevant Elements of Training & Education in the Field of Wind Energy in Germany*", IWES report, 11/2010

A special programme is offered at the University of Oldenburg in form of a wind power online course, which includes several periods of classroom courses held over the weekend.[11] The lecturers / teachers are a wide selection of experienced consulting engineers, researchers, university professors and even wind turbine manufacturers.

B.2.2.2.2. Vocational Training

Basic Training

In Germany, basic vocational training after attending school for 10 years takes place in the commercial and technical area in a company as an apprenticeship. For education in the field of wind energy or renewable energy, in general there are various opportunities in the sector of mechanical and electrical crafts / industry. The apprenticeships usually take 2 to 3,5 years and they are organized in a dual system: that means the venue for training is the company where the apprentice learns the practical aspects mostly four days a week and theoretical aspects of the profession are taught at the vocational school one day a week. Other models of apprenticeship prefer theoretical education at vocational schools in a bloc of about three months a year besides learning and working at the company. A full list is provided in the IWES report[10].

The vocational and further training systems are controlled as far as possible by the "chambers" like the Chamber of Commerce (HK) and the Chamber of Industry and Commerce (IHK). Here instructional contents and test standards are specified and certified for the respective field of training through official regulations. The industry is recognizing these certified-degrees because it is involved in their development.
In recent years, training in the field of mechatronics has been recognized as providing an excellent starting point for a technical career in the wind power field. There are some IHK, which confer the degree "*craftsman mechatronics (wind power)*". However, the vast majority of staff are learning a "traditional craft" like mechanic or electrician and then undertake further training at an advanced level[12]

Further Training

Independent vocational training organizations are also developing their own training for a professional qualification (without recognition by the chambers) in a defined area of professional or business fields in cooperation with the industry. These are focused on the need for specialists specifically for the enterprises to cover different further qualifications for a wide range of wind-energy-related activities in Germany. These further educations have durations from 2 days to 9 months.

Since 2000, the question about an emerging lack of skilled workers in the wind sector in Germany was raised. To overcome this situation an association of manufacturers and service companies in Schleswig Holstein, the BZEE – Bildungszentrum für Erneuerbare Energien - was founded. It was their task to create a training strategy for the wind energy industry and to support the establishment of potential training companies in the wind power sector by development of courses with content specific to the required fields of operation in the wind industry – special

[11] www.windstudium.de

[12] Such approach may be applicable to South Africa as well: e.g. at FET colleges: finalizing the basic education and teaching the basic skills of mechanical / electrical subjects and then enabling the graduates to continue their studies at Universities of Technology in the wind power field.

emphasis was put on service and maintenance. For the first time the interests of the industry for continuing education were formulated.

The training approach of potential employees was partly in the hands of the BZEE but also shared with other participating educational institutions.

The advisory board set up by the member companies and institutions set the quality standards for qualifications. Furthermore, for special topics teams of experts from the industry were arranged. The compliance audit to the quality standards in the training courses is certified by BZEE certificates. In close cooperation with educational institutions, the training was implemented by trainers from the field.
At the sites in Husum, Bremen, Bremerhaven and Lauchhammer a half-year full-time course for service technicians for wind turbines was offered. The BZEE is responsible for ensuring quality in the educational institutions if they award certificates of BZEE. However, the certificates are not recognized as a formal level in Germany's education and crafts system, which led to some acceptance problems.

To overcome this situation the educational enterprise "bfw" took the initiative to establish a recognized certification and curriculum for this particular advanced training with the formal representatives of the Industry (Chamber of Industry and Commerce - IHK and Chamber of Commerce - HK) in Bremen in 2003.

bfw - Unternehmen für Bildung – set up Wind Power Training centres in Bremen und Bremerhaven[13]. and offers fully recognized courses as “Wind Power Service Technician” at German craft-master level. In addition, short courses and specific subjects are offered. The courses of bfw formed the core recource for the development of the curriculum for the GIZ supported wind power training centre at Suzhou, China.

Further education offers by bfw

- “Service technician for wind energy technology” (requirement: approx. three-year electrotechnical or mechanical professional experience / final electrotechnical or mechanical professional training and a relevant, approx. one year's professional experience) (course either IHK / HK certified) or (BZEE)
- Specialist for maintenance and repair of rotor blades (Carrier-internal certification)
- GRP components plastic practitioner (Carrier-internal certification) (IFAM)
- Manufacturing specialist (course for wind power career changers without or unrelated qualification as a Carrier-internal certification)
- skills training for employees
    - Electrical engineering
    - Hydraulic
    - Occupational safety (company's Certificate)
    - Safety for transporting (company's Certificate)
    - IT systems
    - Legal bases

[13] www.windzentrum.de

- First aid assistance at wind-power plants (company's Certificate)
- Offshore safety training (equivalent to BOSIET- (Basic Offshore Safety Induction and Emergency Training) according to STCW (Standards of Training, Certification and Watchkeeping) (company's Certificate)
- Rope climbing technique (Fisat e.V. company's Certificate)

A list of other institutions and courses in Germany is given in the IWES report[10].

B.2.2.3. Situation in China

B.2.2.3.1. Training & Education System Overview

The education system in China has three main categories:

- Compulsory education (Age 6 - 15),
- Secondary-level / vocational training (Age 15 - 18), as well as
- Higher education (Age 18 – 21/22).

This is illustrated in the Figure below:

Figure B-5: Overview of Chinese Education System

B.2.2.3.2. *Academic Training and Education*

For higher education on bachelor level, there are two categories:

- university and
- vocational college.

After graduation from University, the student will get a bachelor degree (with focus on academia / theory of a certain major), while students graduating from vocational college will get a junior bachelor degree, with focus on knowledge application. Further to the difference in learning content and direction between the bachelor & junior bachelor degree, is the rule that graduates with a bachelor degree can directly pursue his/her master degree, while the graduates with a junior bachelor degree cannot. The system is very rigid and a transfer after college to a regular University is almost impossible.

The following bachelor and junior bachelor with major in wind power are offered:

	Wind Power Bachelor (8 in total)
Wind Power and Power Engineering	1. Huabei Electric Power University (NCEPU) / North China Electric Power University[14] 2. Inner Mongolia University of Technology 3. Changsha University of Science and Technology 4. Hehai University (Nanjing) 5. Lanzhou University of Technology
Wind Power Technology	1. Hebei University of Technology
Wind Power Equipment & Automation Engineering	1. Hebei University of Science and Technology
Renewable Energy and its Application	1. Beijing Jiaotong University

Table B-3: Wind Power Bachelor in China

All wind power bachelor programs[15] listed above are 4-year based study. The 5 wind power junior bachelor programs - see Table below - are 3-year based study.

[14] First wind power bachelor degree program in China (On a strong recommendation from NDRC, the MOE allowed the NCEPU to establish the programme)

[15] Source: CWPC wind power training database at www.cwpc.cn; Li Yan, Paul Recknagel

	Wind Power Junior Bachelor (5 in total)
Wind Power & Automation Technology	1. Shenyang Technical College 2. Zilang vocational technical college 3. Tianjin Sino-German vocational technical college 4. Jiuquan vocational technical college
Wind turbine equipment manu-facturing & installation	1. Hunan Electronic vocational technical college

Table B-4: Wind power Junior Bachelor in China

Among the wind power bachelor programmes, North China Electric Power University has the first wind power bachelor degree program in China. The recruitment of this programme is increasing with a steady rate:

- 2006: 30 students for the 1st year
- 2007: 33 for the 2nd year
- 2008: 60 for the 3rd year
- 2009: 90 for the 4th year
- 2010: 120 for the 5th year

From the wind industry side there is considerable criticism towards the establishment of a full-time wind power degree as the graduates don't have enough depth of knowledge in the wind power specific subjects and the knowledge on the traditional engineering areas like electricity and mechanics is also less than standard engineering graduates (they know little about many things).

The industry recommended approach is a "standard engineering degree" followed by a master-degree in wind power with a special subject studied intensively as topic of an extended master-degree thesis.

The following master-degree programmes are in operation:

	Wind Power Master (4 in total)
Wind Power and Power Engineering	1. Lanzhou University of Technology 2. Xihua University 3. Shantou University
Wind Turbine Strength & Vibration	• Northwestern Polytechnical University

Table B-5: Wind power Master Degree in China

Except for bachelor, junior bachelor and master degrees with majors in wind power, there are also majors, which have renewable energy or wind power as a specialisation of the normal courses (Includes bachelor and master programs).

The wind power speciality is offered as part of the following studies:

- Electrical Engineering;
- Electronic engineering;
- Engineering Mechanics;
- Mechanical Manufacturing and Automation;
- Materials Science; electrical theory & new technology;
- High Voltage Insulation Technology; thermal energy & power engineering;
- Automation Science;
- Electrical Engineering & Automation Control System;
- Electronic Information;
- Materials, and Aerospace Engineering;
- Electrical Engineering & Power Electronics; Machinery & Automation; [16]

The special course in the above programmes may be called:

Renewable Energy technology, new energy (specialized on wind power), modern electrical technology, Wind Power Generation Technology, Dynamic Theory of Wind Turbine Structure, wind power generation, wind power project operation & management, Renewable energy analysis & prediction, renewable energy market;

There are also courses, which just contain basic knowledge for wind power, such as: *Power Electronics and Electric Drives, Detection and Automatic Equipment, Power Systems Automation, automation control, electrical system, Electronic engineering and so on.*

For the wind power University programmes at North China Electric Power University – NCEPU the curriculum / schedule is given in Annex 3.

[16] Source: CWPC wind power training database; CWPC presentations and reports by Liu Bangxiang, Paul Recknagel and Li Yan

B.2.2.3.3. Vocational Training

In China the professional training is usually defined and approved by the Ministry of Human Resource and Social Security whereas the implementation rests with the Ministry of Education. The specialization takes place in the vocational colleges sometimes in cooperation with companies. After a two-year phase of vocational education in the vocational school a one year training programme in the enterprise follows. Here however, only company specific skills are taught and students complain that they are just used as labourers.

The registered professions and courses are as follows:

Ministry of Education

- Wind Power Technology
- Wind Power Equipment & Automation
- Wind Power Equipment Manufacturing, Installation& Repairing

Ministry of Human Resource and Social Security:

- Wind Farm Operation & Maintenance (full registered profession)
- Small Wind Turbine Utilization

The following institutions are offering wind power related vocational courses:

	Vocational Schools
Wind Power O&M Technician Training	Inner Mongolia Electric Power School
Wind power technician training	Zhangjiakou Haitao Wind Power & New Energy School
Wind Farm O&M + WT Manufacturing	Yantai Wind Power School
O&M of Wind Power Equipment	Zhangjiakou Mingren (New Energy Middle) School
	Zhangjiakou Weilun Comprehensive School
RE Applied Science (wind power)	North China Baoding Electric Power Voc.&Tech. College

Figure 4: Secondary-level Vocational Training

After studying in listed vocational technician schools, graduates are issued the middle-level technician-license, or wind power technician license. The schools are authorized by Ministry of Human Resource and Social Security to grant such license.

The wind power vocational technician schools have similar curriculum and courses. As an example the Zhangjiakou Weilun Comprehensive School offers wind power equipment O&M courses, which include:

Professional Basics:

Mechanical basis, mechanical knowledge maps and computer graphics, mechanical manufacturing technology based on the basis of Electronic and Electrical

Professional knowledge:

Electrical and Electronic Technology, Electrical Machinery, electrical equipment, power networks and power systems, wind power generation principle and the principle of wind power generation equipment, relay protection and automatic equipment, the wind power plant operation and maintenance, electrical systems integration and automation.

Practical Skills (internship):

Fitting, welding, machining, electrician, electronic internship, internship turbine assembly.

Most of these kinds of training are only of interest for manufacturers of turbines.

Operators of wind-power plants depend on other training models - the standard being training in a company-training centre.

Take “wind farm operation & maintenance” as an example, among the 14 organizations, which are authorized to issue vocational qualification exams, there, are:

- 4 Training centre’s of power companies
- 3 Local electricity companies
- 2 Grid company’s training centres
- 2 Vocational schools
- 2 Vocational colleges

As there is no independent, supervision and no involvement from a powerful quality-setting organisation, the results of this approach are unsuitable for the wind power sector. A transfer of these qualifications from one company to another or from one province to another is also not possible.

Thus with support of the GIZ a special training centre for wind energy was established at the “*Long Yuan Bailu Wind Power Vocational Training Centre*” in Suzhou in 2007 – even today it is the only one of this kind in China.

That centre is majority-owned and operated by GIZ’s CWPP-project partner “China Long Yuan Electric Power Group Corporation – CLYPG” This training centre follows the German model of the advanced training – as pioneered by the “bfw”. The already-trained workers will be upgraded in their knowledge according to the needs of the wind farm operator – the focus is here on operating & maintaining wind turbines.

The training centre trained more than 3000 students in the past 3 years on a variety of subjects. The curriculum of the basic course in Suzhou is included in Annex 5. It is now running at full capacity and cannot cope with the demand. Another shortcoming is the fact that it belongs to one wind farm operator and that the access for the competitors is not fully ensured. The training market in China is still evolving and approaches to spread this concept country-wide with state-level partners are in the planning-phase.

In chapter C the training concept will be explained in more detail.

B.2.2.4. European Unified Approach – Windskill & IMWatT

As mentioned in the chapter on the German experience in wind power vocational training there were and still are several competing systems of qualification:

- Formal 3 years training in wind power mechatronics (small number)
- Further training by special training providers (not transferable and certified)
- Further advanced training in wind power (state and industry recognized)

At the same time when Germany established these trainings, other "wind power countries" in Europe were developing their own type of courses. About 5 years ago the need was felt to unify these endeavours and create a unified standard.

Two EU supported projects were executed:

- **Windskill** Initiative 2006 - 2009
- International Wind Power Mechatronics Technician **- IMWatT** 2006 - 2008

B.2.2.4.1. Windskill Initiative
A Systematic Approach to Wind Energy Qualifications

Windskill was led by the German Wind Energy Association - BWE and the BZEE. Execution took place in a project joint venture of training providers, universities, associations, etc from 7 European countries.

The emphasis was put on the development of major "job descriptions" and "skill-modules" - making this especially suitable for <u>short specialized courses</u>. The previous work of BZEE was the starting point and has been adapted and expanded for a European windskill-base, which is available to the industry. European certification is still under way.

"Windskill is an EU Intelligent Europe sponsored project, which aims at overcoming the lack of sufficiently skilled and internationally qualified wind energy technicians. One of the major problems is the currently unaligned national and regional qualification requirements. These unaligned requirements, cause artificial delays increase costs and reduce cooperation potential.

The Windskill initiative targets are enrolling authorities and sector stakeholders in the development of a European Qualification Profile, develop an appropriate modularized curriculum and set up pilot training courses to meet these requirements.

Windskill is driven by three key objectives:

・Set up an industry-based skills network for the wind energy sector

・Deliver a European industry qualification standard for operational skills in the wind

energy sector (on-shore and off-shore)

・Boost the skills capital of the wind energy sector"[17]

The following Figure shows the aims of Windskill with the important wind power process chains, which were agreed among the Windskill project partners:

[17] Training Future Professionals, Dr. Ir. Jan van der Tempel, Dr. Gerard van Bussel, Delft Uni

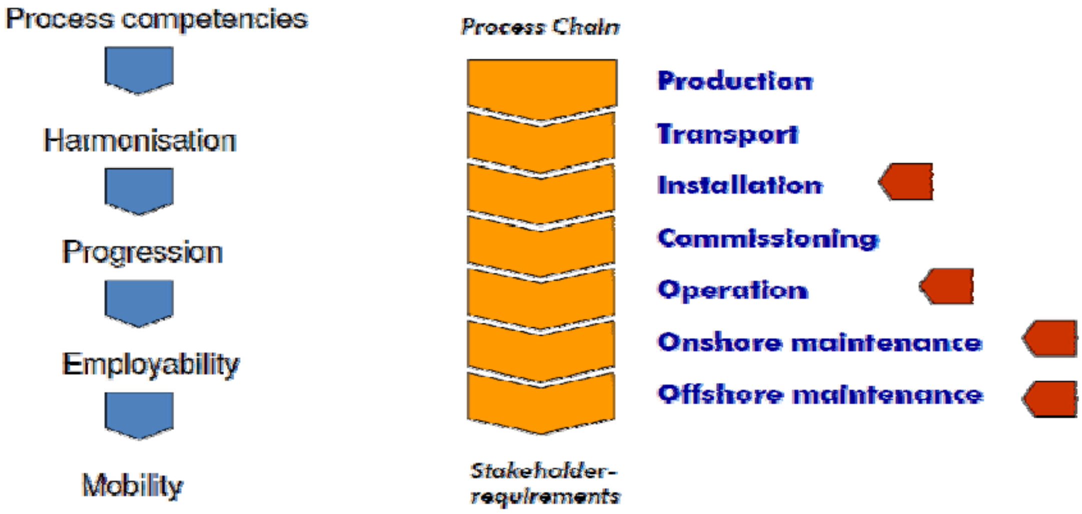

Figure B-6: Windskill – Wind Power Industry Project Chain

For the process steps marked in RED, full job profiles and training modules were defined. The status of Windskill is given in the Figure below:

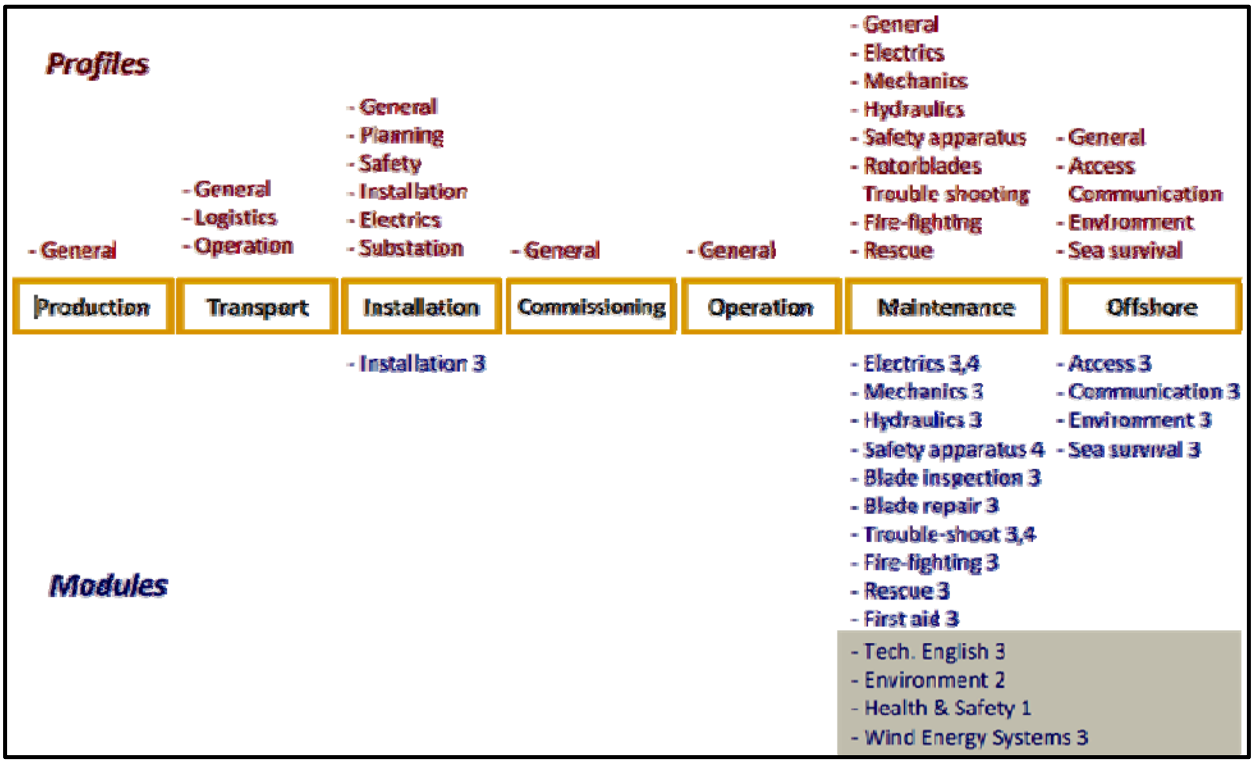

Figure B-7: Windskill Status of available Job Profiles and Training Modules 2009

The focus was put on the area of "Service and Maintenance" as these jobs are the most important for the long-term success of a project and require the most detailed training.

➔ GIZ China is utilising the Windskill results in their second phase "China Wind Power Programme" and adaptation to South Africa is certainly possible.

As an example for the developed Windskill Modules, the following training module content is presented:

Trouble shooting and repair

Description:

This training programme aims to train technicians in applying systematic trouble shooting- and repair techniques in a safely manner.

Learning Outputs:

1. Knowledge of systematic fault finding techniques.
2. Knowledge of authorized repair techniques.
3. Knowledge of WTG component and their function.
4. Knowledge of sensors and their function.
5. Communication on WTG sites.
6. Knowledge of PPE equipment, its functions and maintenance.
7. Knowledge of possible sources of risk or danger and possible environmental influence factors on site, knowledge of weather conditions and symptoms.
8. Knowledge of existing law and regulations.

Indicative content:

1. **General requirements for execution of the job assignments**
   - **A.** Hydraulic- and electrical tools
   - **B.** Bolt torque
   - **C.** Electrical joints
   - **D.** Measuring instruments and techniques
   - **E.** Calibration of equipment
   - **F.** Inspection and maintenance of Personal Protective Equipment (PPE)
   - **G.** Risk assessment techniques

2. **Secure the installation**
   - **A.** Lock-out and tag-out procedure

3. **Electrical circuits**
   - **A.** System, function and components
   - **B.** Sensors and their functions
   - **C.** Read and understand a wiring diagram
   - **D.** Fault finding techniques
   - **E.** Tools and instruments
   - **F.** Authorized repair techniques
   - **G.** Risk assessment
   - **H.** PPE, its functions and maintenance

4. **Hydraulic circuit**
   - **A.** System, function and components
   - **B.** Read and understand a hydraulic diagram
   - **C.** Fault finding techniques
   - **D.** Tools and instruments
   - **E.** Authorized repair techniques
   - **F.** Risk assessment
   - **G.** PPE, its functions and maintenance

5. **Gearbox, cooling system and lubrication**
   - **A.** Gearbox
   - **B.** Cooling system
   - **C.** Lubrication
   - **D.** Fault finding techniques
   - **E.** Tools and instruments
   - **F.** Authorized repair techniques

G. Risk assessment
H. PPE, its functions and maintenance

6. **Generator**
   - **A.** Function
   - **B.** Delta- and star connection
   - **C.** Fault finding techniques
   - **D.** Tools and instruments
   - **E.** Authorized repair techniques
   - **F.** Risk assessment
   - **G.** PPE, its functions and maintenance

7. **Sources of risk or danger on WTG sites**
   - **A.** Environmental influence factors
   - **B.** Weather conditions and symptoms
   - **C.** Communication equipment – mobile phones, radio
   - **D.** Sign language
   - **E.** Communication structure

8. **Existing law and regulations**
   - **A.** Working with electricity
   - **B.** Working with hydraulics
   - **C.** Working at heights
   - **D.** Working on rotating parts
   - **E.** Material safety data sheets

Relevant work process parameters:

- Assess work environment
- Site communication
- Site organization
- Planning and execution of the job assignments
- Work in team of at least two

Teaching-learning Methods:

- Class room training with dialog
- Practical training in classroom on WTG simulators or similar
- Theoretical and practical assessment

Tools and equipment required:

- An electrical circuit with analogue- and digital sensors, relays and a controller
- A hydraulic circuit with sensors, valves, accumulators, actuators and a controller
- A generator and gearbox with cooling systems
- WTG components
- Class room training facilities and tools
- Projector and laptop
- PPE

Learning assignments:

- Find and correct a fault in the hydraulic- and electrical system in a safely manner. The most common fault should be simulated in:
  - A hydraulic system
  - A cooling system
  - A generator
  - An electrical system
- Lock-out and tag-out an electrical- and hydraulic circuit.

Evaluation criteria:

- Demonstrate the ability to use a systematic trouble shooting strategy to find the root cause of a problem simulated in:
  - A hydraulic system
  - A cooling system
  - A generator
  - An electrical system
- Show the ability to risk-assess work assignments and inspection of personal safety equipment
- Demonstrate how to Lock-out and tag-out an electrical- and hydraulic circuit
- Show the ability to select technically appropriate and authorized repair technique
- Demonstrate ability to communicate repercussions of identified damage

Pre-requirements (participants):

- Electrical and mechanical backgrounds: technical knowledge coming from professional institute or from job's experience.
- Fitness certificate
- Health certificate
- General and technical English

Demands on trainers/instructors:

- Electrician, marine engineer, electrical engineer, or similar

or

- WTG experience as a service technician, technical supporter or similar.
- Alternatively some weeks of intensive supervised field training. In this case the candidates should be guided through a service training programme in the field, with the aid of a supervisor.
- Good English qualifications are mandatory
- Experienced user of Microsoft Office
- Vocational skills
- Presentation skills

B.2.2.4.2. IMWatT - Wind Power Mechatronics Project

IMWAatT was a project, which ran between 2006 and 2008 within the INTERREG IIIA programme to enhance cooperation over European borders.

This wind power education initiative took place between the north German State of Schleswig Holstein and the Danish region south Denmark. Under the project-leadership of the Wirtschaftsakademie Schleswig-Holstein in Husum the project set-out to define new curricula for education and training in wind power. The latest didactical concepts were incorporated in various "business fields, action fields and tasks".

IMWatT[18] started out with an evaluation of the existing BZEE courses and the certified IHK courses of "bfw". Questionnaires were sent to wind power manufacturers, service providers and operators in north Germany to evaluate their real needs. The following results were achieved:

- a new <u>curriculum for education at technical colleges</u> in the field of **wind-power-mechatronics**

[18] http://www.imwatt.eu

- an updated curriculum for wind power further training

A field trial was implemented in cooperation with two vocational colleges.

IMWatT developed in contrast to Windskill **no** specialized **courses** or **modules**, but a set of ***learning and action fields*** in which both the theory and practice in technology and work in wind turbines can be taught. This includes also more technical topics and issues such as Environmental Protection or Work Organization. This is done to create better and more ***work-oriented learning outcomes*** to achieve ***occupational competence*** rather than merely remembering by heart a list of steps to be performed, without being able to comprehend the overall system.

The underlying **didactical approach** and Wind Power Work Processes are (partially) presented in the diagrams[19] in chapter B.3.4.1.

A new project-component of Phase 2 of the GIZ CWPP (2010 – 2014) will utilize the results of IMWatT and Windskill.
However, the Chinese "*culture of learning*" is vastly different from the German or European approach, so that this will need to be modified to fit the local situation.

➔ In contrast to this we feel that a combination and adaptation of the Windskill results together with the didactical approach of IMWatT would be appropriate to the South African situation.

The updated curriculum fur further training is included as a German original in Annex 7

[19] IMWatT „Internationalisierte Mechatronik für Windkraft-Technologie", final report 2009; http://www.imwatt.eu/content/Imwatt_Bericht_final_17_12_2008.pdf

B.2.3. Research & Development (R&D)

Research & development (R&D) in wind energy has many definitions and will vary from country to country, and also the focus will shift during its development. The concept of R&D will be the leading force of advanced wind technology, and be an essential criterion of the wind industry in South Africa.

In general, one can distinguish the organizing of research in the wind power field in the following four model types:

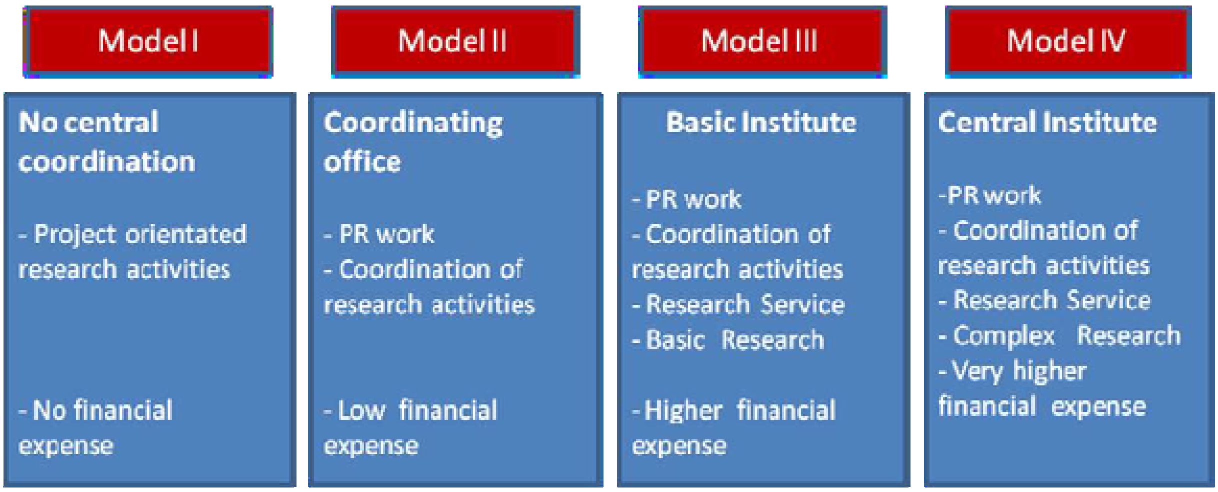

Figure B-8: Wind Power Research Structure[20] by IWR

The world famous institutes Risoe/DTU (Denmark), ECN (Holland), CENER (Spain) and NREL (USA) belong to the Model IV structure "Central Institute".

Germany

In contrast to this structure, the research landscape in Germany is characterised by the Model I approach. There is no central research institute and no overall coordinating entity. The wind power research is embedded in the general research structure of Universities and e.g. Fraunhofer Institutes. In addition, there are some institutes partly funded by local provinces e.g. DEWI. The financing of the research activities is mainly based on competitive bidding for projects based on their own ideas or for research programmes with a certain research budget setup by the federal government or European Union e.g. off-shore grid planning, environmental impact mitigation etc. This structure has led to a much diversified R&D sector with public and private players, which can react quickly to the needs of the industry.

China

The Chinese wind power expansion has to a very large extend not taken place based on indigenous research and development, but is based on licensing of foreign technology and especially the Chinese-paid development of turbine designs by foreign R&D companies; the intellectual property rights are then being owned by the Chinese manufacturer. In

[20] *Exemplary Research & Development Structures and most Relevant Elements of Training & Education in the Field of Wind Energy in Germany*", IWES report, 11/2010, page 4;

2010 a survey by the GIZ-CWPP project came to the conclusion that more than 70% of all turbines produced in China are in one or the other way based on German know-how.

Due to this situation little local know-how has been developed. The Shenyang University of Technology being an exception as it has developed 1 MW, 1.5 MW and 2 MW turbines by itself and has licensed it to some manufacturers. Basically China is following a Model I approach but with the National Energy Administration NEA taking over partly a coordinating / directing activity similar to Model II. There are a number of new "National Research Institutes or Key Laboratories" for specific wind power areas (Simulation, Operation, Maintenance, etc). However, in most cases these are not institutes in the western understanding, but rather existing units or daughter companies of large state own enterprises having just received this title for a good product or specific achievement. The only institute with structures and research activities at par with international institutes is the State Grid owned "National Wind Power Integration Research and Testing Center - NWIC", which is operated by GIZ's CWPP-project partner China Electric Power Research Institute - CEPRI.

B.2.4. Wind Power Services

A key success factor for the quick development of wind power has been the availability of a multitude of "Wind Power Services", which support the design, development and operation of wind turbines.

The reason for the importance of these service-providers are mostly related to them offering special solutions to overcome problems, as it is one thing to build a wind farm, but quite another to produce electricity for the power grid in a sustainable way.

In this field, there are large differences between Germany and China. In Germany, these services are offered by many small consulting companies as well as some research institutes. However, in China, there are almost no independent consulting companies and the usual realization of such services is via a research institute, department or daughter company of the wind farm operator, turbine manufacturer etc – which is then only working for the mother company.

Whether the Chinese system can cope with the expected demands of the wind sector will only be seen in the next 5 to 8 years. The German approach is regarded as very successful and flexible. 20 years ago, many wind power services were developed by state-supported research institutes and with growing demand, many experienced researchers and engineers left these institutes and set up their own consulting companies.

Wind Power Services are covering a wide range of activities and can basically be divided in the three services groups as listed below.

The first group includes developer and operators.

GROUP A

- Wind farm feasibility
- Wind farm realization
- Wind farm operation
- Wind farm / turbine maintenance

In addition there are those services which are focused on the wind turbine itself, which are in

GROUP B

- Wind turbine testing according IEC61400-xx
- Wind farm grid compatibility assessment (verification of the turbine simulation model-application by operator on the specific wind farm layout according to grid operator requirements) (!)
- Wind turbine electrical compatibility certification (!)
- Wind turbine type approval and certification
- Independent wind turbine safety inspection (!)

These 2 groups are characterized by the fact the first group is mainly related to activities by or for the wind farm operator and the second group include services, which are provided because of existing regulation and (safety) standards. The latter group of services is often performed by state-affiliated entities or private consulting companies holding state recognized accreditations

A further important Group C of specialized services are add-on services directly relating to some of the required sub-activities in Group A and B.

GROUP C

- Wind data measurement services (!)
- Wind resource simulation services (long-term)
- Wind farm planning and optimization services (!)
- Wind power prediction services (short-term for power dispatch) (!)
- Wind turbine vibration detection services (gear-box and bearings)
- Wind turbine rotor balancing services (static weight and aero-dynamic)
- Wind turbine blade inspection and cleaning (visual and ultra-sonic)
- Wind turbine blade repair
- Wind gear-box refurbishment services
- Wind turbine remote condition monitoring / detection service (gearbox, bearing and oil-condition)
- Wind farm technical management (intelligent SCADA and CMS data analysis with maintenance management)
- Others

For priorities in the development of a wind services we see those with (!) as the most urgent. For some important services we have given further explanations in the following chapters; others will be explained in Chapter C.2.3 as part of the SAWEC concept and activities.

B.2.4.1. Testing according to IEC 61400

The main contents of wind turbine testing are

- Power Performance IEC 61400-12
- Power Quality IEC 61400-21
- Acoustic Noise IEC 61400-11

As wind power develops, the quality of the wind turbine product quality becomes more and more important. Without a high quality of products, wind power industry cannot develop well. The wind power industry in South Africa is just currently in its infancy stage, but it is important to pay attention to product quality right from the start so that this whole industry-sector develops in the correct direction. It is however recommended, that quality issues are given high priority from the very beginning.

Wind turbine testing according to international standards is the very important means to ensure product quality in the wind power industry. By means of various kinds of wind turbine testing and analysis of testing results, the knowledge of real characteristics of the wind turbine can be shown – this is essential for the wind farm investor and financing banks.

If South Africa embarks on the path of developing its own wind turbine manufacturing industry it will certainly start first with a subset of the main components like towers and rotor blades.

At a later stage, maybe also large generators, gearboxes, convertors and main shafts may be localized.

Independent testing will put pressure on the manufactures to ensure the safety of wind turbines and a stable operation as well as promote the development of new technology.

B.2.4.2. Turbine Type Certification

Certification is the confirmation of compliance of a product or a service with defined requirements (e.g. guidelines, codes and standards). In the field of wind power the focus lies on complete wind turbines or components such as rotor blades, gearboxes or towers. The scope consists of the examination of structural integrity, safety and compliance with these requirements.

IEC 61400-22 Conformity testing and certification, which comprises Design Evaluation, Manufacturing Evaluation, Type Testing, Foundation Design Evaluation (optional) and Type Characteristics Measurement (optional). By means of certification, the wind turbine and component's safety system, blades, machinery, support structure, electric, etc. will be evaluated and testing data will be considered.

The re-testing of wind turbines becomes a requirement at the point where a main component is replaced by a different locally produced component, which was originally not assessed for the Type Certification of the turbine. The type certificate will not be valid anymore.
In Europe no bank would finance a project, which intends to install uncertified turbines.

For this reason, the complete turbine may have to undergo a new load testing or power performance retest. In addition, a different converter would require a new power quality and LVRT grid compatibility test.

Such tests can only be done by laboratories, which are accredited according IEC17025 and the testing itself has to follow the IEC61400 specific test-rules, which an accredited test-institute needs to undertake.

The certification of complete wind turbines is done by organizations with decades of experience, as there are German-Lloyd GL, DNV, DEWI, TUV etc.

Even with a local production of complete turbines, it is very unlikely that a new organization in South Africa could successfully compete with the established players in the market. It is expected that more and more developing wind market main certifiers will setup local offices to offer their services.

However, the certification of certain components and industrial processes may well be done locally as part of the above certification process.

B.2.4.3. Project Certification

The certification of complete projects – usually for the financing bank – is an important activity in the chain of services for wind farm realization.

The relationship between Type Certification and Project Certification as performed by German Lloyd is given below:

The availability of these kinds of certifications makes the risks for developers and investors quantifiable and enables the marketing of wind farms with verifiable guarantees. It's an important aspect of developing sustainable wind power projects.

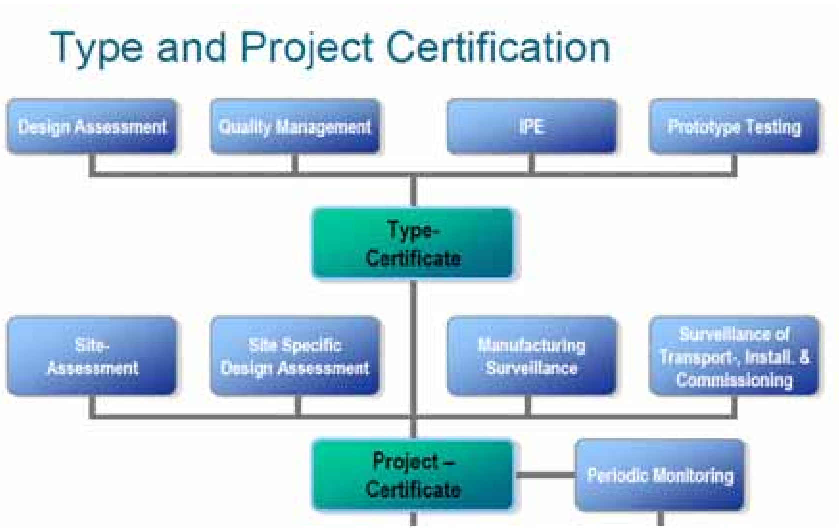

Figure B-9: Project Certification by German Lloyd

B.2.4.4. Retesting of Power Performance

In the sales contract for wind turbines, the supplier usually guarantees the performance of his wind turbine. This is most often expressed in form of a guaranteed power curve – included as a table and graph – which has to be met after a deduction of an allowed deviation of 3 – 5 %.

The verification of this power curve may be included in the contract or may be allowed to be performed by the wind farm owner. Such verification has to be performed by an independent test institute according IEC 61400-12.

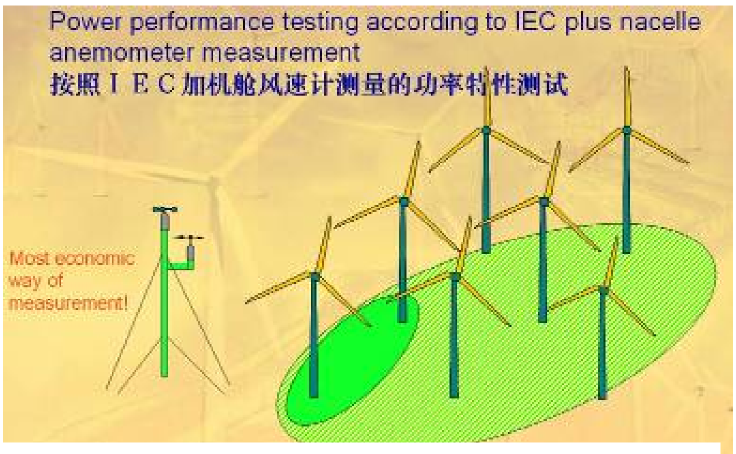

Figure B-10: Power Performance Retesting

This retesting is often required as the electricity generated by the wind farm may deviate from the expectations of the investor. One possible reason may be a different power curve of the wind turbines due to rotor blade problems, wrong pitch operation or systematic yaw error. Test institutes are often offering these kinds of service.

B.3. TRAINING & EDUCATION FOR WIND POWER – STATUS AND FUTURE REQUIREMENTS

B.3.1. Educational System in South Africa

The layout of the educational system of South Africa can be seen in Figure B-11. The first general phase at primary and high school is compulsory. It is education from grade 1 up to grade 7 (primary school), and then grades 8 and 9 on high school level. (NQF level 1/ General Education Band) High school education is from grade 8 up to grade 12 (matric). Grade 10, 11 and 12 fall under the NQF levels 2, 3 and 4, the FET Further Education and Training Band. After successful completion of high school a national senior certificate is obtained. Dependent on the marks achieved, a person may gain access to a university.

To be able to apply for higher education on university level, a person needs to have a matric certificate (NSC). Admission to FET Colleges and National Certificate Vocational (NCV) requires education up to the level of grade 9. The so called Vocational Education falls under the Further Education and Training Band, NQF level 2, 3 and 4, parallel to the matric stream in the schooling sector. The successful completion of the vocational stream does not automatically qualify for University entrance.

SETA - *Sector Education and Training Authority*, Department of Higher Education and the Department of Basic Education are the role players in the support of training. The SETA's are responsible to develop Unit Standards (learning units) and qualifications, SETA's are also responsible for the quality assurance of training and assessment in the occupational stream of the NQF. – in future also for wind power, but in particular for the training of Operation and Maintenance (O&M) staff.

Figure B-11: Educational System of South Africa (based on the 8-level NQF)

Excursus: Job Creation by fostering the use of Renewables

According to different reports, South Africa's economic development is heavily hampered by the lack of skills in many sectors. This is especially true for green skills and for greening of existing skills[21]. According to the study carried out by the ILO in 2010 the country is short of approx 12.600 industrial and mechanical engineers and technologists, 5000 electricians, 7000 specialist managers, and about 24.000 qualified experts for other sectors. The shortage of training facilities and qualified trainers is considered as one of the most serious bottlenecks.

After roughly thirty years of green energy promotion it is nearly common sense in an increasing number of countries that the integration of renewable energies into the energy supply system not only fosters a clean and sustainable energy supply but also substantially contributes to job creation and employment.

The wind power industry currently employs approximately 400,000 workers worldwide, as estimated by the Global Wind Energy Council[22]. The job employment has positive effects on rural and regional development, implies direct and indirect employment effects.

In Europe in 2007 there were nearly 109,000 people directly employed in the wind energy sector, headed by Germany (38,000), Denmark (24,000) and Spain (21,000). Another roughly 150.000 people were indirectly employed. For 2030 it is expected that around 360,000 people will be directly employed, onshore and offshore[23].

The number of jobs created is directly related to the installed capacity of wind power generation. The Global Wind Energy Council estimated that 0.33 jobs per MW are to be created, this mainly for operation and maintenance of a plant. Around 15 job-years per MW of new capacity will be created when looking at the whole cycle – starting from commissioning, to manufacturing, installation, operation and also the indirect employment[24].

Based on the ILO Study[25] which refers to the government's Renewable Energy White Paper (2003), that sets the target of 10.000 GWH as the renewable energy contribution in the final energy consumption structure (in 2013), substantial employments effects would result.

In case South Africa's target alternative energies to provide 15 per cent of electricity generation capacity in 2013 would be met, the direct job creation effect for the renewable energy sector would sum up to 36,400 new jobs. Estimated 110,000 more jobs would indirectly be generated[26]. Among the 36,400 direct jobs created within the renewable energy sector, 22,400 would be within the wind energy sector.

The Mission will provide some own estimations on possible job creations, which are based on experience gathered in Germany and China. Please refer to Chapter B.3.5 below.

[21] Please refer to the ILO Study "Skills for green jobs in South Africa", 2010

[22] Please refer to IDC: The Potential for Developing a Wind Power Industry in South Africa", 2010

[23] Global Wind Energy Council 2008.

[24] ICD: The Potential for Developing a Wind Power Industry in South Africa", 2010

[25] ebd.

[26] Ebd.

B.3.2. Vocational Training System

Compared to either the German or Chinese system the South African system of vocational training has a different structure.

The system of vocational training in South Africa is subordinate to the section „Higher Education & Training "[27]. The National Qualifications Framework Act assigned the following tasks to the *South African Qualification Authority* - SAQA[28] .

SAQA is the guardian of the National Qualification Framework and has to register and quality assure flexible education and training systems for life-long learning. It supervises and certifies the standards and qualifications amongst others also for vocational education and occupational training. Accredited qualifications and „unit standards"(Learning units) are publicly accessible on the Internet.

The objectives of the NQF as outlined in the NQF Act No 67 of 2008 are as follows[29]:

- To create an integrated national framework for learning achievements;
- Facilitate access to, and mobility and progression within education, training and career paths;
- Enhance the quality of education and training;
- Accelerate the redress of past unfair discrimination in education, training and employment opportunities;

The new SAQA National Qualification Framework – NQF (based now on 10 NQF levels) is presented as follows:

NQF LEVEL	Qualification Type	BAND
10	Doctorates and Post doctoral research Degrees	HIGHER EDUCATION AND TRAINING
9	Masters Degrees	
8	Honors Degrees	
7	3 Year Degree (First Degree and Professional Qualifications)	
6	2 Year Diploma	
5	1 Year Certificate	
4	Grade 12	FURTHER EDUCATION AND TRAINING
3	Grade 11	
2	Grade 10	
1	Grade 9 (ABET level 4)	GENERAL EDUCATION AND TRAINING

Table B-6: SAQA National Qualification Framework - NQF

27 http://www.education.gov.za

28 South African Qualifications Authority

29 http://www.saqa.org.za/show.asp?include=about/nqfobjectives.htm

The diverse „unit standards" and qualifications are managed by the so-called *Sector Education and Training Authority* – SETAs. There are different SETAs for different sectors of the industry.

They are responsible for the development of the curriculum framework and its coordination with the sector industry and educational institutions[30]. If new *Unit Standards* are presented in accordance with national rules, they will be submitted for certification and publication to the SAQA. A *unit standard* is legally binding with the day of the publication by SAQA.

A Credit Point system was setup by SAQA, which established rules according which the achievement of a certain level / result in a „*unit standard* " assessment leads to the assignment of „Credits ". The basis for the „credit point" is "national hours of learning". A credit corresponds to approximately 10 hours. A full unit standards based qualification on the NQF requires a minimum of 120 credits. Qualifications can however have higher credit requirements. For advancing from one level of the NQF to the next learners have to obtain the credit value given for the qualifications they wish to master. Each qualification contains a list of Unit Standards, which form the qualification. For achieving the qualification, learners not only have to have mastered all Unit Standards prescribed but also have to be found competent in an exit level assessment also prescribed by the qualification.

The development of Unit Standards and qualifications for a new occupation in Renewable Energies needs to be driven by a Standard Developing Body (SGB) under the auspices of the relevant SETA. This standard generating body is also responsible for the assignment of credits to the individual new Unit Standards and for the determination of the Credit value of the full qualification.

A detailed explanation on South Africa's education & training system is provided in the report: "*An introduction to the Education System in South Africa for linking future SAWEC training programmes" by Martin Reisinger,11/2010 GIZ South Africa*

B.3.3. Existing Human Wind Power Resources in South Africa

South Africa has a very heterogenic structure of the workforce. It is characterised by a large number of un- or undereducated workers lacking proper basic education and a smaller number of very well educated professionals - the situation being a result of the grave injustice during the Apartheid years.

It is impossible for the mission team to analyse the quality and quantity of existing staff potentially being interested to be employed in the wind power sector. It is however possible to calculate the number of new job opportunities arising out of the planned wind power development. This is done in chapter B.3.5.4 below.

From the history of man-power training in Europe and China one can certainly assume that also South Africa will have experienced technicians and engineers from other industries in the start-up phase, who want to continue their career in wind power.

➔ For this reason there will be a high demand for specialized further training courses

A few general remarks on the existing situation and future demands are given below:

Engineering Level

- Several universities are at the international top-level

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[30] A comprehensive description of the SETAs is found in "Skills Development Act (No. 97 of 1998) chapter 3"

- Wind power research is already undertaken and researchers will be able to react to the challenges of the planned expansion of wind power (assuming funding is made available)
- Engineering education in general will have no problems to incorporate the subjects important for the specifics of wind power into their teachings
- In order to develop the right skills for project design and verification, engineers with a "*wind power specific*" education are best suited – the establishment of Master Degree programmes is the logical choice
- It would be advantageous to enlarge cooperation with "*wind-power universities*" abroad and make the international experience available to the young generation

Technician Level

- South Africa's University's of Technology – former Technikons, may offer the right balance of theory and practical elements to educate future staff being involved in Operation and Technical Management of wind farms
- The education levels of BTech and Technologist seem to be well suited to these demands - they would also be in charge of supervising and ensuring work quality of tasks executed by "skilled workers"

Skilled Worker Level

- The staff being responsible for servicing and maintaining wind turbines will be those with a solid practical training involving specialized tool-use and being able to work according to manufacturers handbooks and following safety rules taught during their education or training courses
- From the mission's discussions and observations we have come to the conclusion that colleges for "Further Education and Training - FET's" will have a major role in training staff, which would be suitable for working in wind farms

B.3.4. Job Definitions and Required Training Levels and Skills

B.3.4.1. Identification of required Skills and Job Profiles

On the following page, we present the IMWatT suggestions (see also chapter B.2.2.4.2) on defining a didactical approach to wind-power-business-fields and work-processes in the wind power sector.

It allows a complete definition of e.g. all Tasks in Wind Power Service + Maintenance and forms the basis for:

- Identification of work processes
- Job requirements
- Job specifications

From this, a calculation of required man-power with their respective qualifications has to be done together with industry partners. The questionnaires and framework for this is available from the IMWatT und WindSkill projects and could be adapted for the South African context.

Wide ranges of applications in the wind energy sector require employees with higher education levels like university and college degree. This is valid for most of the services in planning and design of wind energy projects (e.g. wind and energy yield assessment, wind farm design and calculation, construction etc.), as well as design and adaptation of wind turbines and technical operation of wind farms. Most of these subjects have to be specifically trained in schools or universities or are trained on the job by means of further training courses held on a part time basis. A good education is required to realize a high quality in performing wind energy projects. For the trainees or graduates from wind energy training in these fields generally an engineering or related degree (meteorologist, physicist etc.) will be required.

However, the largest number of staff employed will be those with a medium education level. In most of the special wind-power work-fields at the wind farm, skilled workers and technicians are required. Generally, a secondary level I with a FET college education could be the base for wind power skilled workers. But there are also job requiring the skills taught in Technologists or BTech courses.

Part of the basic work in wind resource assessment (installation of meteorological towers, sensors and measurement equipment) could be left to these workers, if they are specially trained for the required jobs. The operation, maintenance and repair of wind farms is a very broad field where skilled technicians will be needed. These workers also have to be specifically trained for the different areas (maintenance and repair) and have to obtain additional training by wind turbine manufacturers for technical operation or maintenance companies.

With the realization of wind power projects the need for skilled personnel in the beginning will be in project development and construction as well as other related areas. Training in these areas is essential to guarantee a high quality of realised projects. With growing numbers of wind energy installations, the need for trained staff will also rise in the area of wind farm operation, maintenance and repair. The latter area is mainly manned with permanent jobs and would require more staff in a developed wind market than in a wind market under development, where staff is moving from one project to the next one.

By far the largest number of jobs would be generated through localizing wind turbine and component manufacturing.

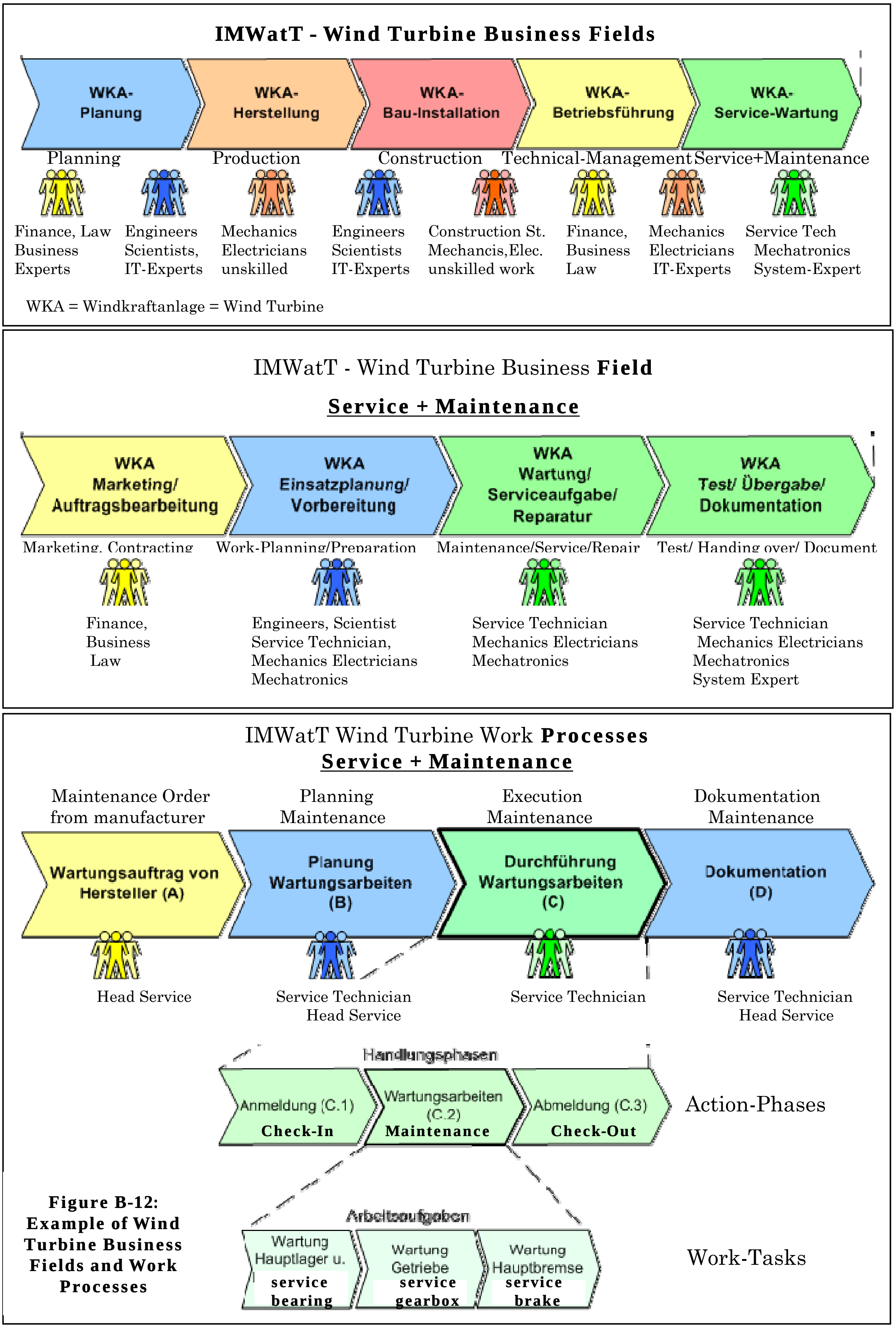

Figure B-12: Example of Wind Turbine Business Fields and Work Processes

B.3.4.2. Wind Power Jobs – Types and Categories

The following generic list of jobs are either directly wind power related operations or partly involved in wind power. The education and training requirements for these jobs are quite divers. For example, there is no need to give special wind power training to the electrical engineer who is in charge of the wind farm internal network. The same applies to construction workers or even the factory workers assembling the wind turbine. However, most other jobs need special and detailed wind power knowledge. For a systematic development of this employment sector a project team including the relevant SETA's, like Construction (CETA) and Metal (merSETA), would need to undertake the wind power work-process-analysis and combine this with the following list of wind related jobs. Based on the results the required training measures will be specified.

The list below also reflects the complexity of skills required for a successful development of wind power. The lines below the skills required indicate the "supply source" of the skills.

Manufacturing (permanent jobs – provided the market demand allows for)

1. wind turbine designer
   a) working at design departments in wind turbine manufacturing companies and
   b) independent design consulting companies
2. wind turbine manufacturing worker
   a) assembling turbine from components at WT manufacturer
   b) producing components at component manufacturer
3. wind turbine rotor blade manufacturing worker
   a) producing components at component manufacturer
4. wind turbine manufacturing supervisor
   a) working at WT manufacturer
   b) working at component manufacturer
5. wind turbine installation supervisor
   a) working at WT manufacturer
   b) working at independent installation service provider
6. wind turbine commissioning engineer
   a) working at WT manufacturer

Wind Farm Construction & Installation (permanent jobs – provided the market demand allows for; otherwise: casewise with staff having respective knowledge and experience))

7. wind turbine logistics planner
   a) working at independent logistics company
   b) working at WT manufacturer
   c) working at component manufacturer
8. civil engineer – construction, foundation, roads

a) construction company
b) unit of wind developer - owner
c) wind farm operator

9. wind farm construction supervisor
    a) construction company
    b) unit of wind developer - owner
    c) wind farm operator
10. wind farm construction workers
    a) construction company
    b) electrical installation company
11. wind turbine installation worker
    a) working at WT manufacturer
    b) working at independent installation service provider
12. electrical engineer - medium voltage / integration
    a) construction company
    b) electrical installation company
    c) unit of wind developer - owner
    d) wind farm operator

Academic, Training and Research Jobs

13. wind power researchers (engineers and scientists)
    a) research centres
    b) universities
14. wind power lecturers, teachers and trainers
    a) universities
    b) vocational schools
    c) vocational training centres
    d) secondary school science teachers

Wind Power Services in Operation & Maintenance (permanent jobs over lifetime of turbines)

15. wind measurement installation technician
    a) measurement tower manufacturer (OEM)
    b) wind research centre
    c) independent wind consultant
16. wind measurement operation + data collection technician
    a) wind research centre
    b) independent wind consultant

17. wind measurement data quality supervisor
    a) wind research centre
    b) independent wind consultant
    c) unit of wind developer
18. wind resource assessment expert
    a) wind research centre
    b) unit of wind developer
    c) independent wind consultant
19. wind farm design expert
    a) wind research centre
    b) independent wind consultant
    c) unit of wind developer - owner
    d) (regional planning department)
    e) (environmental impact assessment agency)
20. wind project feasibility experts
    a) unit of wind developer - owner
    b) independent wind consultant
    c) wind research centre
    d) financing institution
    e) insurance company
    f) regional planning department
    g) environmental impact assessment agency
21. wind farm maintenance technician
    a) unit of wind turbine manufacturer
    b) independent service provider
    c) unit of wind developer - owner
    d) wind farm operator
22. wind farm technical management engineer
    a) independent service provider
    b) wind farm operator
23. wind turbine rotor blade inspection & repair technician
    a) independent service provider
24. wind turbine technical safety inspection engineer
    a) independent service provider (accredited)
    b) government agency
25. wind power prediction specialists
    a) wind power research center

b) independent service provider

c) grid operator

d) wind farm operator (if required by grid operator)

B.3.5. Future Demand for Wind Power Staff

As mentioned already above: the exploitation of renewable energy is more labour intensive than conventional power generation.

Job opportunities are provided during the planning phase, the erection phase and for the operation period. Due to the fact that wind farms are normally erected in remote areas where no other or very limited other job opportunities are available, we assume that direct and indirect employment effects are initiated – the direct effects during erection and operation and indirect jobs as a result of up-coming social infrastructure for the employees at the wind farm.

Direct employment effects for local people during construction phase are given for the construction of the foundations of the wind turbine, road building, grid works etc. Based on European cost of labour, the share of labour-costs of wind farms is approximately 25 % of total project investment costs.

The expected future demand for staff will depend on the projected (a) increase in installed capacity and (b) on the volume of locally produced turbines. Based on this we have calculated the demand for staff with the IRP 2010 as the development scenario. The results are presented in the following pages.

There is no study available, which analyses the job needs in the wind sector according to the detailed job definitions mentioned in the last chapter. The results have rather been grouped by sub-sectors of the wind power sector.

The JEDI model[31] was developed in 2002 for NREL to demonstrate the state and local economic development impacts associated with developing wind power plants in the United States.

Although the structure of industry with its high and mature level of local production as well as labour and union regulations are very different between the US and South Africa, the JEDI provides certain information which are helpful to estimate possible impacts on job creation in South Africa.

The model evaluates three separate impacts for each expenditure: direct, indirect, and induced.

Direct impacts are the on-site or immediate effects created by spending money for a new wind project. In the JEDI model, the construction phase includes the on-site jobs of the contractors and crews hired to construct the plant as well as their managers and staffs. Direct impacts also include jobs at the manufacturing plants that build the turbines as well as the jobs at the factories that produce the towers and blades.

Indirect impacts refer to the increase in economic activity that occurs, for example, when a contractor, vendor, or manufacturer receives payment for goods or services and in turn is able to pay others who support their business. This includes the banker who finances the contractor and the accountant who keeps the contractor's books, as well as the steel mills, electrical part manufacturers, and suppliers of other necessary materials and services.

[31] JEDI can be downloaded at www.windpoweringamerica.gov

Induced impacts are the changes in wealth that result from spending by people directly and indirectly employed by the project. For example, when plant workers and other local workers receive income from expenditures related to the plant, they in turn purchase food, clothing, and other goods and services from local business"[32].

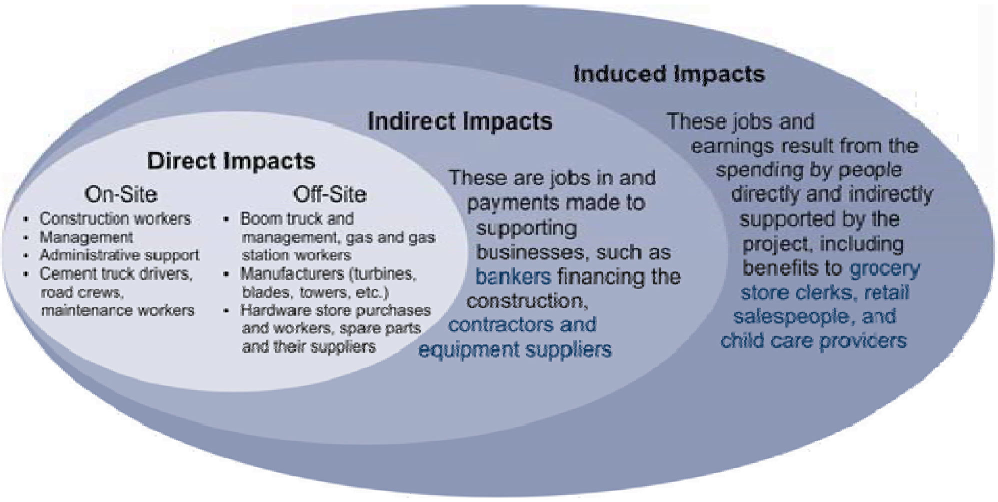

Figure B-13: The Wind Power Ripple Effect[33]

A study, which was conducted by the European Wind Energy Association[34], came up with a distribution as presented in the Figure below:

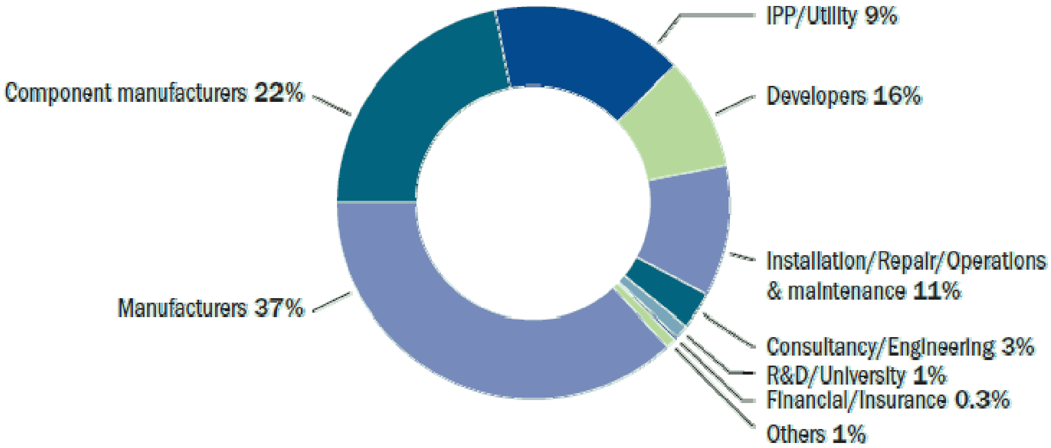

Figure B-14: Job creation in different wind sub-sectors in the EU 2008

Unfortunately, the authors grouped in this diagram the areas "installation, repair, operation" into one number. As this was regarded as not useful, EWEA also combined the results of this study with other references and came up with the following figures.

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[32] 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply, July 2008

[33] U.S. Department of Energy: "20% Wind Energy by 2030 Report" http://www.20percentwind.org/20p.aspx?page=Report

[34] "Wind at Work – Wind energy and job creation in the EU", EWEA, 2009/01

Employment/MW (2007)	Jobs	Variable Jobs due to **new** MW Jobs/ Annual MW	Permanent Jobs due to **exist** MW Jobs/ Cumulative MW	Basis
WT Manufacturing – Direct	64,074	7.5		Annual
WT Manufacturing – Indirect	42,716	5		Annual
Installation	10,665	1.2		Annual
Operations and maintenance	18,657		*0.33*	Cumulative
Other direct employment*	15,204	1.3	*0.07*	75% annual/ 25% cumulative
Total employment	**151,316**	**15.0**	***0.4***	

* IPP/utilities, consultants, research institutions, universities, financial services etc

Table B-7: Job Creation per MW in Wind Power Sector of EU 2008

This study[34] has analyzed the mature wind power market in the EU and the results are only partly applicable to the South African situation. The percentage distribution just for the South African market would look very different because there is only negligible local manufacturing now.

The important numbers from this study are the **0.33 Jobs / MW** of operating wind turbines for Operation & Maintenance and **0.07 Jobs / MW** in the services industry. The manufacturing part is still speculation but has a future in South Africa.

The importance of these "maintenance jobs" can also be seen from a study by the GWEC[35], which states "*…missing specialized human resources for maintenance of the turbines are regarded a limiting factor for the construction of wind energy projects…*"

In order to calculate the employment effects of wind power manufacturing as expressed by the figures under "Variable Jobs" in Table B-7 one needs to assume that the government will introduce *local content requirements* for wind turbines to be installed - these will increase over time.

A starting value of 30% represents the share of investment for foundations, road infrastructure and electrical connection, which could already come from local sources in the first few years of wind farm development.

The subject of job creation in wind power has been investigated in detail by a recent study of CSIR and Risoe DTU[36], as part of a wind-power industry strategy.

In this study, a strategy for wind power industrial development is laid out. It includes a comparison of all available international studies on the employment effect of Wind Power. Their conclusions are mainly based on a study[37] by *Wei et al*.

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[35] "Global Wind Energy Outlook 2010", GWEC (Global Wind Energy Council

[36] "Investigation into the Development of a Wind Energy Industrial Strategy for South Africa", Study by CSIR and Risoe DTU, 2010-10

[37] Putting renewable and energy efficiency to work: How many jobs can the clean energy industry generate in the US?, Wei M, Patadia S. and Kammen D, 2010, Energy Policy, 38, (2010), 919 - 931

The results are presented according two job function groups:

1. Construction, installation and manufacturing - CIM; and
2. Operation and maintenance – O&M

	EWEA	Wei et al converted		Wei et al original	
Jobs/	MWp	min MWp	max MWp	min MWa	max MWa
CIM Jobs - direct	10	7.25	31.25	0.29	1.25
O&M	0.4	0.175	0.399	0.5	1.14

Table B-8: Comparison of job creation figures in EWEA study and CSIR/DTU

MWa = average jobs/MW over 25 years at 100% capacity factor

MWp = jobs based on "installed in 1 year" or "operating" MW peak capacity (nameplate)

This study[38] assumes an arbitrary capacity factor of 35% on the installed wind power capacity and expresses the generated jobs in the units MWa. The reason for the adjustment is the difference in capacity factor between PV-Solar, Solar-CSP, Nuclear and other energy sources and tries to normalize the job figures to 1000 MWa with 100% capacity factor. The capacity factor of 35% is rather high and will certainly not be achieved for the majority of wind farms.

- To compare the results with the widely published results of the EWEA study one needs to multiply them by 0.35 ➔ *Wei et al converted* in Table B-8: Comparison of job creation figures in EWEA study and CSIR/DTU.

Another methodological difference is the purely theoretical conversion of the variable CIM-jobs - which only exist if new capacity is produced and installed – to average jobs over wind farm lifetime. In our view, this is not helpful for policy formulation at all as during the years of manufacturing many more jobs – in fact 25 x – than the given numbers are created or need to be trained. These jobs would just disappear if the target value for wind power is reached before 25 years are over.

- To compare these figures with the EWEA study one needs to multiply them by 25

Comparing the figures in Table B-8 shows that the EWEA value for CIM jobs is within the max-min range of the CSIR/DTU study. The EWEA value of 0.4 jobs/MW for O&M jobs is just above the CSIR/DTU max-value of 0.399 jobs/MW.

The CSIR/DTU study mentions large differences in the way jobs or job-years and study methodologies are varying (Wei et al is based on five other studies). The large differences (min-max) may originate from these inconsistencies. It should be mentioned that the EWEA study "borrows" results from other studies too and combines them with their own data. However, their findings have been validated by various methods [39]

- For this reason, we have based our calculations of generated jobs on the EWEA figures.

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[38] page 45 "Wind at Work – Wind energy and job creation in the EU", EWEA, 2009/01

[39] P.45 "Wind at Work – Wind energy and job creation in the EU", EWEA, 2009/01

Another reason for not using the figures from the CSIR/DTU study is the mixture of construction, installation and manufacturing (CIM) into one figure. However, this is - as mentioned above - not properly reflecting the situation of an up-coming localization process. With increasing local content more and more of the manufacturing jobs will be located in South Africa. For our purpose of estimating, the jobs created in the sector one needs to have access to the number of manufacturing employees in order to apply the local content share.

B.3.5.1. Scenario for the Increase of the Installed Wind Power Capacity

Based on the information made available during the meetings and the documents provided, we calculated the required numbers of staff in the wind power sector, which would work and require training during the period 2011 to 2030.

Scenario – IRP 1 & IRP 2010 + Sere 2012

This scenario is based on the IRP's plan up to year 2030.

Originally, we intended to include a scenario assuming that 25 GW of wind power might be reached by 2025. According to local perception, this is unrealistic and will hence not be included as a scenario (Remark: In China, the expansion from less than 1000 MW wind to 25.000 MW happened in just four years).

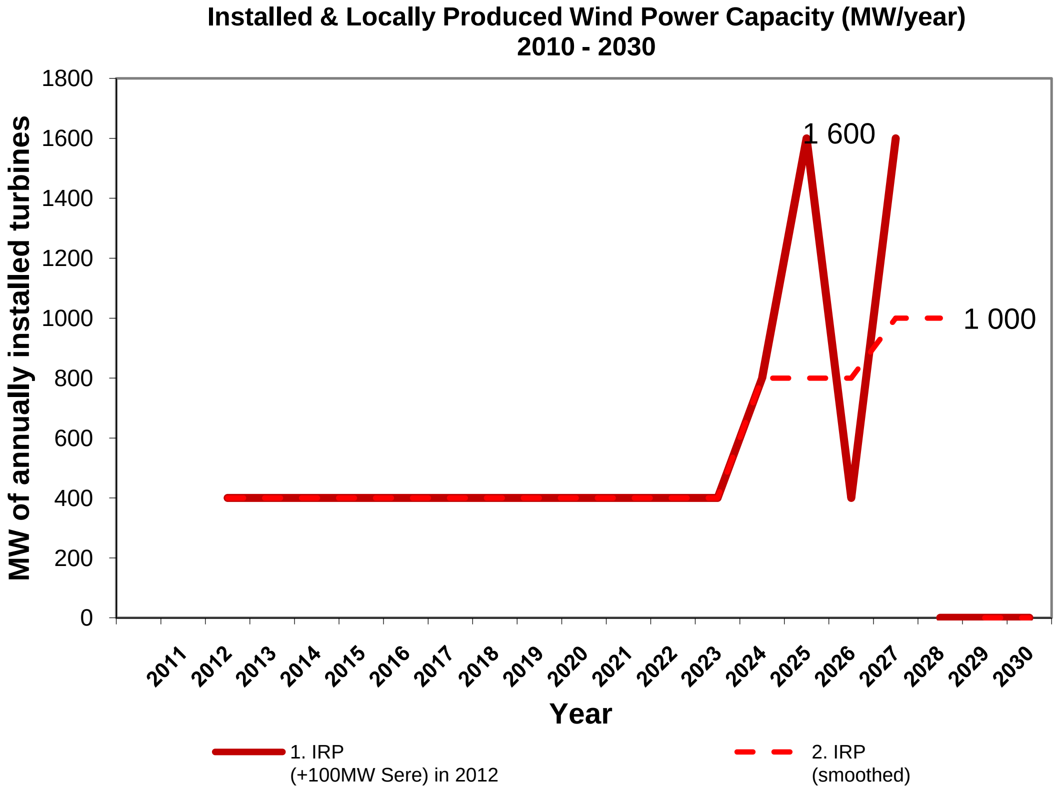

Figure B-15: Scenarios of wind power development in South Africa

The 2nd curve above – labelled smoothed – is identical to the IRP 2010 installation figures except for 2025 – 2028 where we have adjusted the annual installation in such a way that the installation figures are gradually increasing and not jumping up and down by more than 100%. No business would be able to operate according to those theoretical numbers. The total installed capacity for these four years is of course unchanged!

B.3.5.2. Parameters used in Job calculations

In order to calculate the employment effects of the IRP-induced wind power development we have taken the following assumptions as presented in Figure B-16.

1. Local manufacturing content:

It is assumed that the government introduces a favourable policy, to enable the development of a local wind turbine manufacturing industry. As mentioned in previous chapters the requirements for a certain percentage of locally produced components has been very effective in China. We have taken the simplified assumption that the number of jobs required to produce turbine components is the same for every percentage share of a wind turbine. This is inaccurate but only leads to an underestimation of the job numbers, as those parts being locally produced first (e.g. foundations, towers, blades, etc) are actually the most labour intensive ones.

Local manufacturing content starts out from 30% to reach 50% after ~7 years and 75% after 15 years. It is assumed that certain parts like e.g. controllers and special generators can be produced more economically abroad.

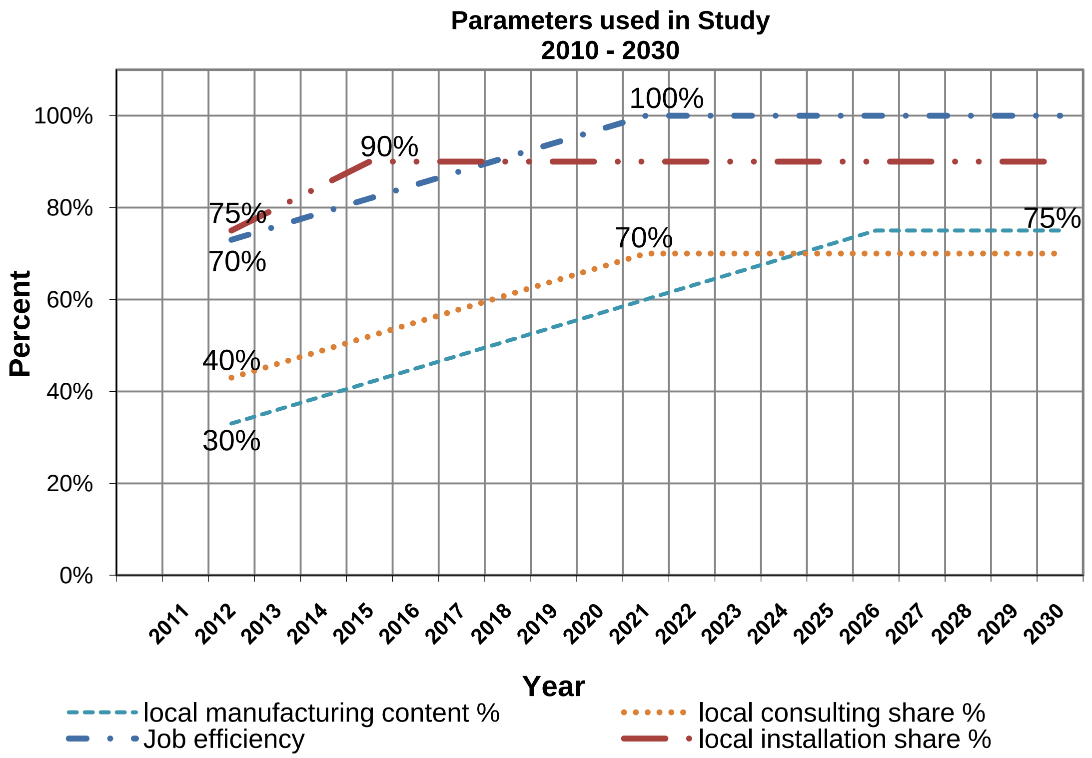

Figure B-16: Calculation Parameters for Calculation of Wind Power Jobs

Analogous to the local manufacturing content we introduced Local Consulting Share and Local Installation Share. They are defined as follows:

2. Local Consulting Share

The local consulting share is the share of consulting services being implemented by local consultants.

We expect that in the first years mainly foreign consultants will be in charge of these services. Hence, we assume a local share of 40%, which will rise to 70% in the next 10 years. Afterwards we expect it to remain at this level, as foreign manufacturers will continue to use their own staff and certain services may not be available in SA.

3. Local Installation Share

The installation of turbines and construction of foundations will very quickly be dominated by local labour and we expect that these jobs will already at the start be performed to 70% locally and after about 5 years, a share of 90 % may be reached. The remaining 10% may be filled by supervision and quality control experts from abroad.

Finally, we introduced a Learning Curve, expressed as Job Efficiency:

4. Job Efficiency

It is assumed that every worker needs to accumulate experience and be trained on the job; so his job efficiency in performing completely new tasks will be low first. We assumed that all wind power staff would start with 70% efficiency and reach 100% after a period of 10 years experience. This is included in above figure as Job efficiency.

Remark:

Indirect jobs at component manufacturers are not included in the number estimated for wind turbine production, as they are very difficult to estimate and the figures for Europe are likely very different compared to South Africa. One can however state, that the total number of indirect Jobs generated in the whole industrial sector will be considerable and may amount to 50% of the direct employment for manufacturing.

B.3.5.3. Scenarios for the Development of Qualified Wind Power Staff

Based on the wind power capacity-scenarios in chapter B.3.5.1 an estimation of the required jobs in the wind energy sector in South Africa has been undertaken. The calculation results are given on the following pages. However, it has to be stressed that the local job demand will gradually be phased in, with skilled workforce (e.g. O&M, consulting services) or components (manufacturing) being imported to a greater extent in the first years than reflected in the average values underlying the calculations in this report. This means the employment effects may be overestimated for the first years.

The basic assumptions are the figures of **employees per installed MW** as they are expressed in the EWEA study, which we already presented in chapter B.3.5 .

Below table lists the values used here:

Employment / MW (2007)	New capacity non permanent Jobs / Annual MW	Permanent Jobs per MW operating
WT Manufacturing – Direct	7.5	
Wt manufacturing – Indirect	5	
Installation / Construction	1.2	
Operations and maintenance		*0.33*
planning & construction consulting	1.3	
R&D, education, consulting		*0.07*
Total employment	**15**	***0.4***

Table B-9: calculation values used for job creation

The calculations are done to estimate the needs for staff training in these new employment fields. Below we present the results in the form of charts and Tables.

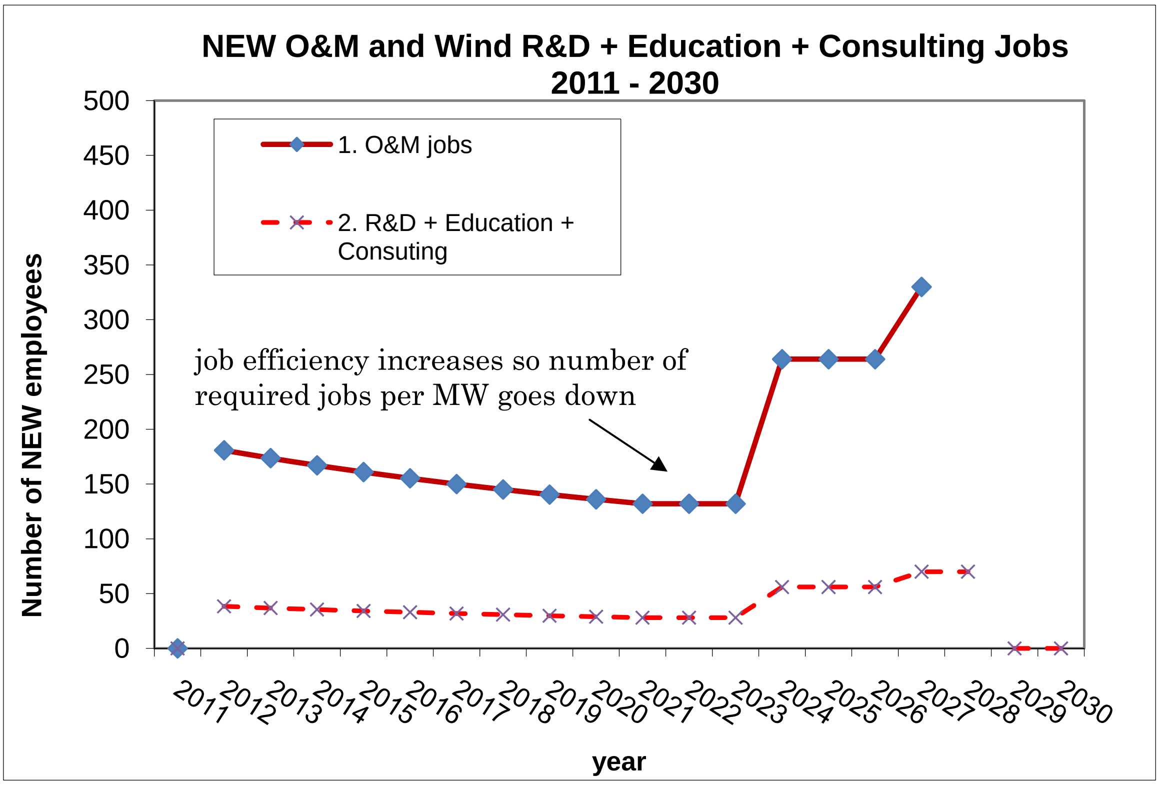

Figure B-17: Jobs in O&M, R&D and education

As the above job figures are permanent (20 years) it is interesting to have a look at the job development over time. The conversion factors are 0.33 and 0.07 jobs per MW.

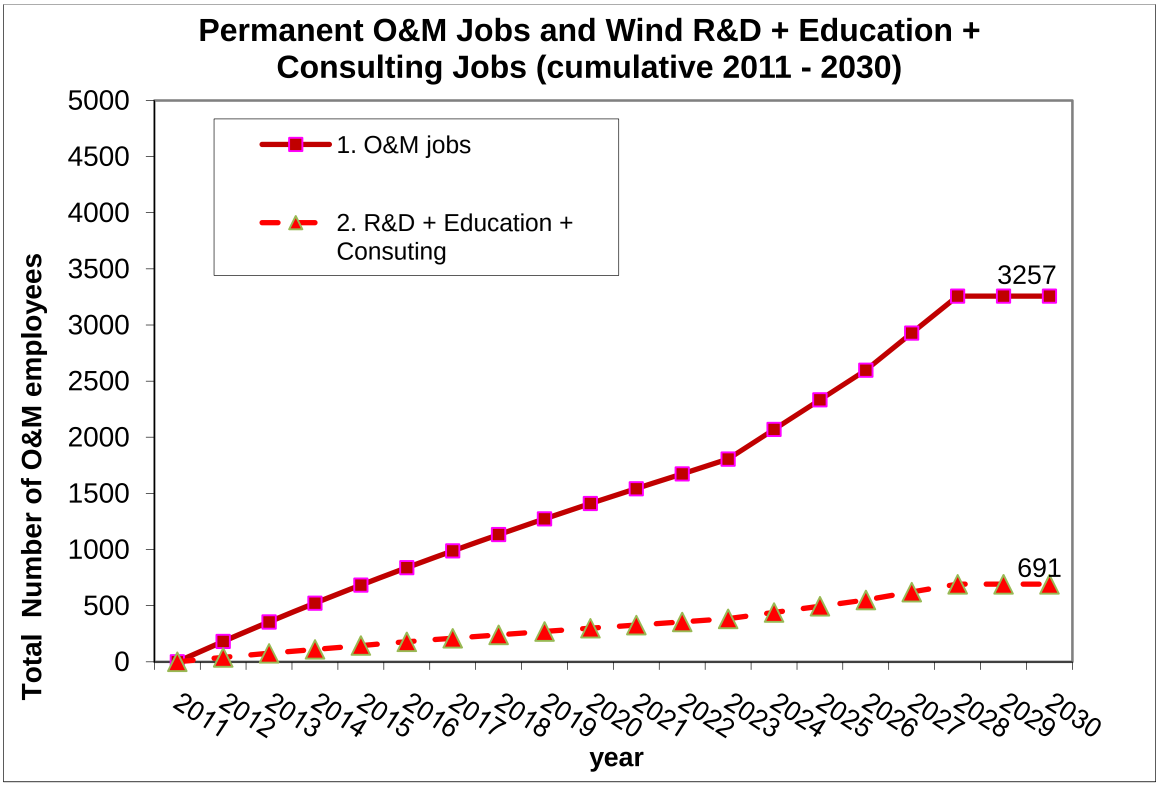

Figure B-18: cumulative job numbers for O&M and R&D + Education

In contrast to the job-types shown in the diagrams on the following pages, these O&M jobs above are "permanent jobs" for the "20 years lifetime" of a wind farm. So new wind turbines add new jobs to the already existing jobs for O&M. The jobs (working opportunities) involved in construction, production and related consulting are a direct result of NEW wind turbines being produced and wind farms being constructed (no NEW wind turbines = no jobs in these sectors, which is the case after 2028).

The jobs directly connected with the installation work of a new wind farm are given in the following figure. The staff working in this field does not have a high job-security as job availability depends directly on new wind farms being constructed[40] (1.2 jobs / MW).

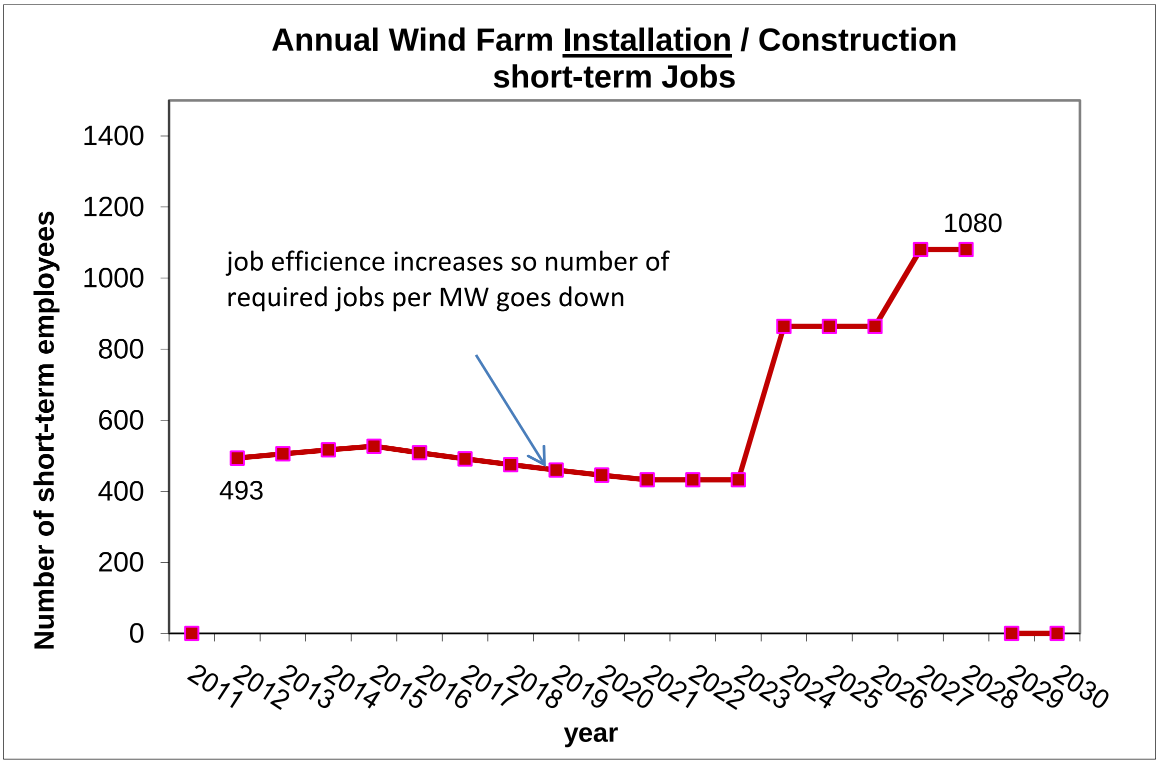

Figure B-19: Jobs in wind farm construction

The manufacturing industry depends on an existing market for selling wind turbines, so the jobs created here are on an annual basis. In order to calculate the employment effects of local production the following formula applies:

Annual jobs in manufacturing = annual capacity increase in MW x 7.5 Jobs / MW x local content share / job efficiency

We assume that these consulting and service jobs are directly connected to new wind turbines and hence the above calculation has to be done with a factor of x 1.3 Jobs / MW The results are given in the figure below

[40] **Remark**: Wind Farm construction includes the activities: building of roads and foundations, power grid connections and cable laying as well as the turbine erection and installation – all these activities together are in the literature sometimes called construction or installation. In reality installation is a subset of construction. – We are referring to construction according to the above definition, but have included the term installation with the same meaning, as this is the way it has been used in our main reference – the EWEA report "*Wind at Work*."

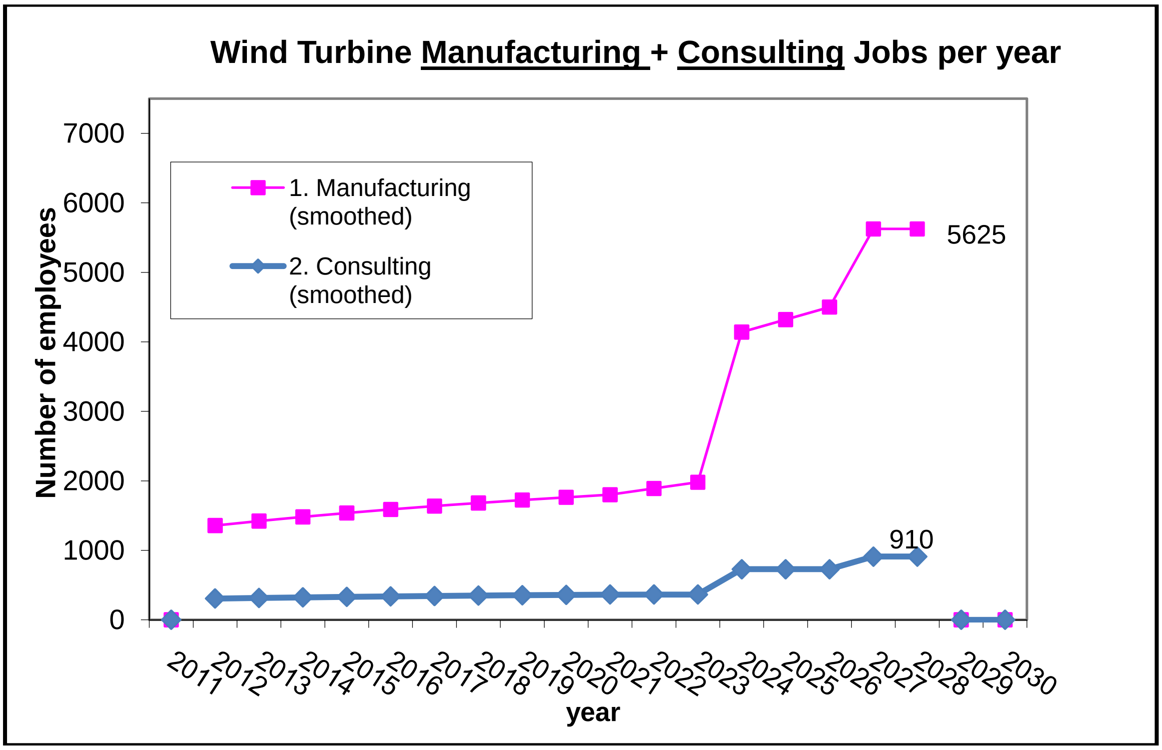

Figure B-20: Jobs in Manufacturing and consulting

The above diagram is based on the IRP 2010 installation figures except for 2026 – 2028 where we have adjusted the annual installation in the way explained in chapter B.3.5.1

B.3.5.4. Estimation of Staff to be Trained

The following table shows the amount of labour in any year newly added to the wind-job market according to the categories introduced above (see also chapter B.3.5.3. explanation below Figure B-18).[41]

Year	IRP MW / year	*O & M*	*R&D + Educ. + Consulting*	Instal-lation	Manu-facturing	Consulting
2011	0	-	-	-	-	-
2012	400	*181*	*38*	493	1,356	306
2013	400	*174*	*37*	505	1,421	315
2014	400	*167*	*35*	516	1,481	323
2015	400	*161*	*34*	527	1,537	330
2016	400	*155*	*33*	508	1,588	336
2017	400	*150*	*32*	491	1,636	343
2018	400	*145*	*31*	475	1,681	349
2019	400	*140*	*30*	460	1,723	354
2020	400	*136*	*29*	445	1,763	359
2021	400	*132*	*28*	432	1,800	364
2022	400	*132*	*28*	432	1,890	364
2023	400	*132*	*28*	432	1,980	364
2024	800	*264*	*56*	864	4,140	728
2025	1600	*264*	*56*	864	4,320	728
2026	400	*264*	*56*	864	4,500	728
2027	1600	*330*	*70*	1,080	5,625	910
2028	0	*330*	*70*	1,080	5,625	910
2029	0	-	-	-	-	-
2030	0	-	-	-	-	-
Total	**9200 MW**	***3,257***	***691***	**1,080**	**5,625**	**910**

Table B-10: Annual NEW Wind Power Staff

The overall employment in the wind power sector in the period 2011 - 2030 is presented in the following diagram:

[41] In line with the explanation of B.3.5.3 that for each MW added new permanent O&M as well as R&D / Education jobs are being created over the lifetime of the wind turbine, the total amount of jobs in these categories is the sum of new jobs created in the individual years. Since in contrast installation. construction and consulting jobs are non-permanent, i.e. are only being created during the construction of the wind farm and not over its entire lifetime, the total amount of jobs in these categories are those created in the year with the highest deployment rate, which in this case is the 2028.

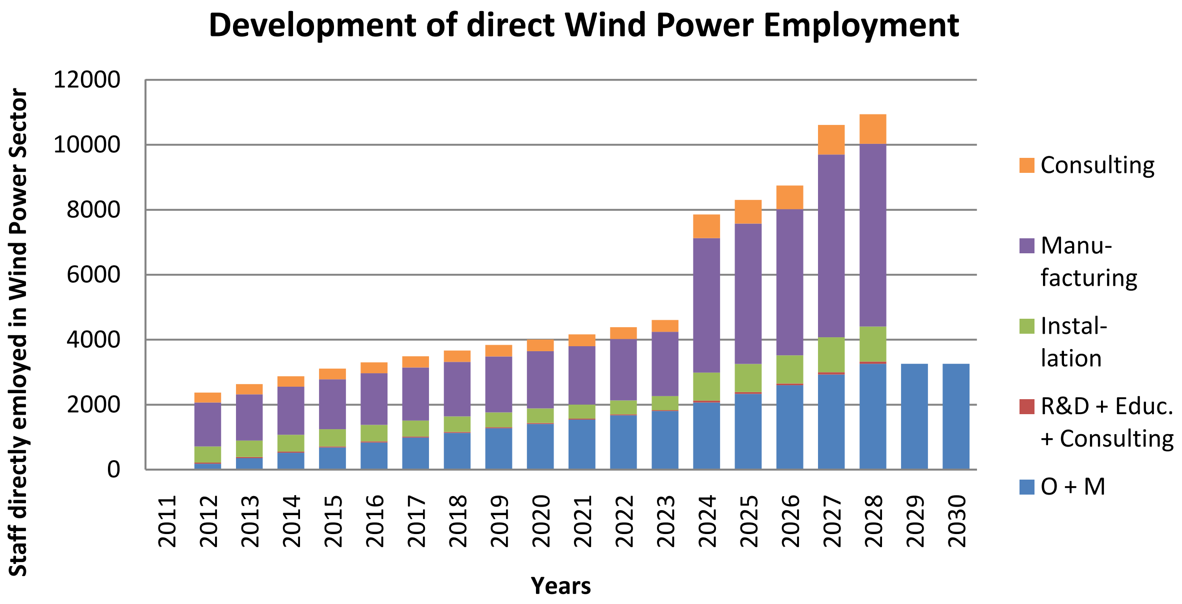

Figure B-21: Employment in the Wind Power Sector 2011 - 2030

As there are currently no plans for further wind power installations after 2028, the production-related jobs (8306) would disappear thereafter. This is however purely theoretical, as e.g. the first batch of wind turbines will have reached its end of life and would need replacement.

In the following paragraphs, the employment figures are being broken down further according to the individual categories:

O&M

Maintenance

- The largest proportion of staff will be technicians who are supervised by a service engineer or an experienced master-technician. Each group consists of 2 technicians and 1 skilled worker. The ratio is estimated as 1 service engineer for 3 maintenance groups.
- At the beginning of a newly created industry service engineers will mainly be experienced engineers from power stations or mining operations.

Operation

- We define Operation here as the staff working in the control room of a wind farm or group of wind farms. Also part of the engineers at power company dispatch centres are in this group

		Maintenance			Operation
Year	**O&M**	Technicians	Service Engineers	Skilled Worker	Engineer
	100%	52%	10%	33%	5%
2011	-	-	-	-	-
2012	181	94	18	60	9
2013	174	90	17	57	9
2014	167	87	17	55	8
2015	161	84	16	53	8

2016	155	81	16	51	8
2017	150	78	15	50	8
2018	145	75	15	48	7
2019	140	73	14	46	7
2020	136	71	14	45	7
2021	132	69	13	44	7
2022	132	69	13	44	7
2023	132	69	13	44	7
2024	264	137	26	87	13
2025	264	137	26	87	13
2026	264	137	26	87	13
2027	330	172	33	109	17
2028	330	172	33	109	17
2029	-	-	-	-	-
2030	-	-	-	-	-
Total	**3,257**	**1,694**	**326**	**1,075**	**163**

Table B-11: Distribution of Qualification Groups in O&M

Distribution of job qualifications based on interviews among wind power consultant and manufacturers' service staff.

R&D + Education + Consulting

This group of staff consists of

- Engineers and scientists undertaking research projects
- Test engineers for turbine testing
- Lecturers and researchers at university
- Trainers at vocational colleges
- Trainers at turbine manufacturers
- In addition those consultants offering operation related services e.g. wind farm remote technical management, wind power prediction services are in this group
- The SAWEC staff would belong to this group.

Year	**R&D + Education + Consulting**	Engineers / Scientists	Lecturer	Teacher/ Trainer	Consultants Technical Manage-ment
	100%	40%	10%	35%	15%
2011	-	-	-	-	-
2012	38	15	4	13	6
2013	37	15	4	13	6
2014	35	14	4	12	5
2015	34	14	3	12	5
2016	33	13	3	12	5
2017	32	13	3	11	5
2018	31	12	3	11	5
2019	30	12	3	10	4
2020	29	12	3	10	4
2021	28	11	3	10	4
2022	28	11	3	10	4
2023	28	11	3	10	4
2024	56	22	6	20	8
2025	56	22	6	20	8
2026	56	22	6	20	8
2027	70	28	7	25	11
2028	70	28	7	25	11
2029	-	-	-	-	-
2030	-	-	-	-	-
Total	**691**	**276**	**69**	**242**	**104**

Table B-12: Distribution of Qualifications in R&D + Education + Consulting

Distribution of jobs qualifications is based on discussions among wind power consultants. The qualifications in this group are all based on persons having at least a bachelor degree or experience equivalent to a university type of education. The majority will be at MSc level.

Installation

The term installation includes all the work required to construct a wind farm e.g.

- Civil construction of roads, cable trenches and foundations
- Transport of rotor blades and nacelle
- Erection by crane
- Installation of towers
- Low voltage and medium voltage cabling and installation of transformer
- Test-run and commissioning of turbine

Year	**Installation**	Engineers	Technicians	Skilled Worker	Unskilled workers
	100%	10%	20%	30%	40%
2011	-	-	-	-	-
2012	493	49	99	148	197
2013	505	51	101	152	202
2014	516	52	103	155	207
2015	527	53	105	158	211
2016	508	51	102	152	203
2017	491	49	98	147	196
2018	475	47	95	142	190
2019	460	46	92	138	184
2020	445	45	89	134	178
2021	432	43	86	130	173
2022	432	43	86	130	173
2023	432	43	86	130	173
2024	864	86	173	259	346
2025	864	86	173	259	346
2026	864	86	173	259	346
2027	1,080	108	216	324	432
2028	1,080	108	216	324	432
2029	-	-	-	-	-
2030	-	-	-	-	-
Total	**1,080**				

Table B-13: Distribution of Qualifications among Installation Staff

Manufacturing

This category has the least reliable data as there are many assumptions about the market share, the share of local content in the components and work efficiency. However, it is very likely that South Africa will put a big emphasis on this area.

The manpower in the manufacturing group depends mainly on standard engineering skills of the workforce. Wind power specific knowledge is only required for the engineers and those technicians involved in repair and service.

Year	**Manufacturing**	Engineers	Technicians	Skilled Workers	Management
	100%	15%	25%	40%	20%
2011	-	-	-	-	-
2012	1,356	203	339	542	271
2013	1,421	213	355	568	284
2014	1,481	222	370	592	296
2015	1,537	230	384	615	307
2016	1,588	238	397	635	318
2017	1,636	245	409	655	327
2018	1,681	252	420	673	336
2019	1,723	259	431	689	345
2020	1,763	264	441	705	353
2021	1,800	270	450	720	360
2022	1,890	284	473	756	378
2023	1,980	297	495	792	396
2024	4,140	621	1,035	1,656	828
2025	4,320	648	1,080	1,728	864
2026	4,500	675	1,125	1,800	900
2027	5,625	844	1,406	2,250	1,125
2028	5,625	844	1,406	2,250	1,125
2029	-	-	-	-	-
2030	-	-	-	-	-
Total	**5,625**				

Table B-14: Distribution of Qualifications in Manufacturing of Turbines

Consulting

The term consulting encompasses here all services directly connected with the turbines – this includes:

- Wind measurement and resource assessment
- Wind park planning and optimization
- Grid connection planning
- Wind turbine vibration analysis
- Power curve re-testing
- Feasibility Study support
- Damage assessment
- Financial consulting services
- etc

Year	**Consulting**	Engineers	Technicians	other
	100%	55%	30%	15%
2011	-	-	-	-
2012	306	168	92	46
2013	315	173	94	47
2014	323	177	97	48
2015	330	181	99	49
2016	336	185	101	50
2017	343	189	103	51
2018	349	192	105	52
2019	354	195	106	53
2020	359	198	108	54
2021	364	200	109	55
2022	364	200	109	55
2023	364	200	109	55
2024	728	400	218	109
2025	728	400	218	109
2026	728	400	218	109
2027	910	500	273	137
2028	910	500	273	137
2029	-	-	-	-
2030	-	-	-	-
Total	**910**			

Table B-15: Distribution of Qualifications in Consulting Group

In the following table we have calculated the training needs of those staff entering the wind power sector in each year, but we do not differentiate the required learning content within each group.

Numbers of Staff to be Trained according to Qualification

Year	IRP Wind MW	Engineers	Technicians	Skilled Worker	other
2011	0	-	-	-	-
2012	400	464	624	750	520
2013	400	478	641	777	539
2014	400	490	657	802	556
2015	400	502	672	826	573
2016	400	511	680	839	576
2017	400	518	688	851	580
2018	400	525	695	863	583
2019	400	532	702	874	586
2020	400	538	708	884	589
2021	400	544	714	893	592
2022	400	558	737	929	610
2023	400	571	759	965	628
2024	800	1,170	1,563	2,002	1,291
2025	1,600	1,197	1,608	2,074	1,327
2026	400	1,224	1,653	2,146	1,363
2027	1,600	1,530	2,067	2,683	1,704
2028	0	1,530	2,067	2,683	1,704
2029	0	-	-	-	-
2030	0	-	-	-	-
Average per year ===>		**668**	**892**	**1,127**	**742**

Table B-16: Number of Staff in need of Training

In order to calculate the number of possible participants for each training course one would need to categorise the different "*qualification groups*" from the tables on the previous pages and then decide which content and duration of course is required for which job function / work process.

Such a task is required and will be made easier by the materials already available from the IMWatT and WindSkill projects. However, it is not part of this study but should be the first step in realizing a wind power training system for South Africa.

For a possible GIZ support one would apply a simplified approach based on the experience of other GIZ projects to come up with a project design matching the needs of the current situation – one should however realize that changes to the wind and renewable sector are happening quickly (Fukushima), making changes to planning an annual necessity. In the following some points to consider in the planning:

- In the near future the demand for trained staff will mainly lie in project development and related areas (wind resource and energy yield assessment, wind farm design etc.).
- With growing wind energy installations the need for trained staff will increase in the area of wind farm operation, maintenance and repair also.

- Finally, with a strongly developed wind energy installation capacity, the requirement for skilled staff will rise higher for the wind farm operation area than for the area of wind energy development.
- In case of a growing wind turbine manufacturing the need for trained employees will rise here, too. The share of technicians and skilled workers will be predominate. Education and training in this area will aim largely at a smaller group of design and production engineers.
- In the area of wind farm implementation a larger portion of jobs will lie in the engineering field; jobs in project development like wind resource and energy yield assessment, wind farm design, feasibility studies, wind farm construction and project management but also Testing and certification will require mainly higher educated staff. In this section, a large target group for education and training will exist for the wind energy centre, coupled to the growing number of wind farm projects.
- For maintenance and repair the need for technicians and skilled workers will be large. Skilled workers are required in all occupations such as “erection of wind turbines” or “specialist for rotor blade repair” and so on. This group does not require intensive technical knowledge of the whole wind turbine system but special knowledge on the limited area of their later activities.
- For these target-groups, a wind energy centre would support “Train the Trainer” courses for external trainers to enable them to provide training of technicians in basic wind energy knowledge and the special skills for the skilled workers.
- Management staff will be target for education in all relevant employment areas.

B.4. SUMMARY OF MISSION AND RESULTS

B.4.1. Agenda and Meetings

B.4.1.1. Kick-off-Workshop

The Agenda of the Mission has been well prepared by Stellenbosch University and the GIZ Office, Pretoria.

During the first view days, after the arrival of the expert for vocational training, several institutions carrying out vocational training have been visited and interviewed. After the arrival of the other Mission members a Kick-off Meeting was conducted in Cape Town with about 80 participants, consisting of representatives of Stellenbosch and other universities, and representatives of the private industries.

During the Kick-off-Meeting the Mission presented the rather complex situation of training and education of wind energy experts in Germany, which has started to develop already in the 80ies. This presentation was followed by an introduction of the vocational training as carried out in Suzhou City by the Mission expert Mr. Sommer, who is delegated by the CIM organization to support wind power training in China. Then the wind energy centre project of GIZ in China was presented, which is somehow considered as a kind of an archetype project for SA. This presentation was completed by presentations on the general wind energy development in China and the role of the State Grid CEPRI.

The representative of the Stellenbosch University who is also head of the Centre for Renewable and Sustainable Energy Studies (CRSES) presented the centre and its proposal for the set-up of a wind centre in South Africa.

B.4.1.2. Meetings during the Mission

The Mission met a representative selection of entities related to renewable energies. A list of the meetings, agenda and background information of the different entities is attached in Annex 1

Due to time restrictions, the meetings were limited to the Western Cape and to Pretoria. The Western Cape was selected for the Mission, because it is one of the regions with the best wind resources in SA and because the Western Cape is very active in following up the use of renewable energies, including wind energy. Pretoria as the capital of SA, is the location with the relevant ministries and departments.

Below we shortly summarize the messages of our meetings and the lessons learned. We would like to point out that the messages below are not to be considered as official statements but only as the opinion of the person(s) consulted during the meeting, as the Mission perceived it. Since, as mentioned before, the meeting and discussion are considered from both sides as a start to discuss the option of a coordinated approach for a SAWEC concept.

ESETA at SAQA/QCTO

Every FET college or private provider who has the facilities and teachers to teach this course could contribute to specific training programmes. Great interest was indicated to cooperate with SAWEC in Skills Development. Skills programme can be taught on every level and is flexible to fit the demand for skilled people. It was mentioned that currently there is basically no (close) cooperation with different FET colleges. An approach as considered with SAWEC might also initiate a closer cooperation between the colleges.

Northlink College

The NL College co-operates at present with other colleges, as MerSETA, CETA and the ESETA. Interest was indicated to participate in the SAWEC project. More discussions need to be held in order to specify possible contributions and to prepare respective curricula and training courses, which might fit with the set-up of the Colleges, which is focusing on.

False Bay College

False Bay Colleges indicate interest to face the challenges for the wind industry and to support with its fields of training, as there is Electrical Infrastructure, Mechatronics, Welding, Fabrication, Fitting.

Since the False Bay College also offers courses on boat building, and has full equipment for the range of glass Fibre technology, this workshop could be immediately usable for the vocational and further training in the range of rotor blade repairing of wind converters

West Coast College

A strong interest was indicated to establish an extra a range for the wind power training in case SAWEC should be implemented. It was mentioned that West Coast College was already considering to expand its educational training also to wind power related issues.

Summarizing the visits and meetings at the Colleges: All colleges are equipped with the basic technical conditions needed for training program for „the Service technician for wind energy technology", as there are the fields of mechanical engineering, electrical technologies, mechatronics and/or construction. However, the specific skills for wind energy oriented technicians will request an enlargement of the courses. Interest in expanding the training courses to wind related subjects was indicated. However, it was also indicated that more information about the SAWEC approach needs to be provided before final decisions will be made and actions taken.

Cape Peninsula University of Technology (CPUT)

The CPUT, which prepares students for work in the industry, indicated interest to consider respective training programmes for wind experts, provided that there will be a market for the students after examinations. In other words: It needs to be proven that the students educated in wind skills will find job opportunities in this field. CPUT has a close link with the Northlink FET college, which allows a close coordination of training programmes on different levels – which would also be interesting in case of setting up curricula for wind technicians and engineers. Furthermore, CPUT provides modern training facilities (workshops, laboratories) suitable for infrastructure requirements of a SAWEC.

Stellenbosch University

Stellenbosch University is hosting the Centre for Renewable & Sustainable Energy Studies (government-funded national Renewable Energy Hub). It is one of the initiators for the SAWEC approach. The Centre is already doing research to produce a cost competitive small wind turbine (4-15KW) with a permanent magnet synchronous motor without a gearbox. It furthermore has designed the generator for a 300 kW wind turbine for Palmtree Power, South Africa's only medium-scale turbine manufacturer.

Stellenbosch wants to be a flagship in the RE development in South Africa.

University of Cape Town (UCT)

UCT trains mechanical engineering students. UCT is hosting an Energy Research Centre and a Mathematic Modelling Centre. It furthermore is the wind spoke in the RE Hub hosted by Stellenbosch University. UCT is keen on cooperating in the establishment of SAWEC.

Western Cape Prov. Gvmt (PGWC), GreenCape, Wesgro, City of Cape Town

PGWC indicated strong interest in realising a skills program with local FET colleges. The problem is to provide respective expertise. An option was already discussed in more detail that SAWEC could host the main training facility with a training turbine and the FET colleges could pay a rent when using it as a facility for training and education. Vice versa, also the FETs could provide their facilities for training purposes of other stakeholders as coordinated through SAWEC.

It was suggested during the meeting that PGWC should develop a time frame for training implementation. PGWC is prepared to play a coordinative and supporting role to get the SAWEC training off the ground since this is one of the priorities within the Green Cape initiative.

Eskom Headquarter and Peaking Generation

For its already established wind power facilities Eskom currently is relying nearly 100% on the service of the turbine supplier (Vestas). The in-house technicians were trained five days only, which is not enough to adopt the requested skills for maintaining the facilities.

A wind centre like a SAWEC design is needed for South Africa in order to push *the development of wind power.*

From Eskom's point of view, a SAWEC, could provide different services, as there are training for staff of wind power facilities, setting standards in cooperation with Eskom and international experts for the upcoming Wind IPPs, or provide support for wind mapping and wind power prediction.

A close coordination of SAWEC with the Government is needed in case SAWEC should also be in charge of Certification of wind technologies. In this case independency (from manufacturers) is a must.

Eskom would be willing to act as participant in the wind centre . It needs to be specified in a later stage, what kind of contribution could be provided. For example, Eskom would investigate means of making the Klipheuwel Wind Farm available for training purposes of SAWEC. Also other facilities could be made available, e.g. workshops of Eskom. A final decision how to participate will be made after a draft concept for SAWEC will be in place.

Department of Energy (DoE)

The DoE was supportive of the SAWEC initiative, especially since it could fill the capacity gaps in the wind energy sector and thereby contribute to the establishment of a wind energy industry.

"A lot is happening" in the wind sector in South Africa but unfortunately it is not coordinated. A coordination of the activities might contribute to an acceleration of the wind development in South Africa. SAWEC could play an important role in this regard.

Department of Science and Technology (DST)

DST is willing to support and to push in the initial phase a concept like SAWEC since initiatives are necessary to get things in the field of RE moving. This is referring to wind research issues, which are currently still on a relatively low level, but also to training of wind technicians and engineers. It would be necessary to check available sources in the country and to combine and coordinate them.

In any case, SAWEC needs to be an activity on a national level. Entities of all relevant provinces should whenever possible be integrated. The Energy Office in Durban was especially mentioned as a potentially interesting partner for SAWEC.

DST is not in the position to directly support SAWEC in the medium and long-term because SAWEC doesn't fall under DST's mandate. But DST could be one of the stakeholders in the center and support coordination.

Department of Trade and Industry (DTI)

The DTI is willing to support SAWEC, since SAWEC could contribute to the development of local manufacturing of wind energy facilities which would create green jobs. The DTI pointed out that job creation needs to be enforced also by measures like tax reliefs and local contents.

The DTI is willing to work together with SAWEC to set up and revise localisation strategies for the respective industries. Until now there is a lack of standards for wind energy manufacturers. This gap needs to be filled, possibly also with the help of SAWEC.

SANERI / SANEDI

SANERI is very interested to support the wind industry development. Vocational training for all levels – technicians and academic training - would be mostly welcome. A coordination between different levels of education is strongly needed, since there are no close connections between the different levels of education and training. In case this is successfully implemented for the wind sector, this could facilitate closer coordination also for other sectors of the industry. The development of the wind sector could also contribute to create jobs and reduce the high rate of unemployment.

SANERI considers awareness building of the public as an important task for SAWEC, since not much has been done until now in this field.

A number of entities are concerned with aspects of wind-research, which makes coordination an important topic.

SANERI is currently undergoing a restructuring process. It will be merged with the National Energy Efficiency Agency into the South African National Energy Development Institute (SANEDI) and then have more resources (financial and personnel). Research activities in the field of energy will be expanded. In this regard, SANERI can imagine to act as the official host for SAWEC with SAWEC being a sub-centre under the Renewable Centre of Research and Development (RECORD).

B.4.2. Outcome and Results

B.4.2.1. General Aspects

Summarizing the experience gathered from the above listed entities and the measures taken so far in order to implement renewable energies in the energy mix of the country: responsible entities are in place, major laws and regulations, procedures and agreements have been designed. A number of entities are about to foster the development of wind energy in the country.

Nevertheless, the development of renewables in SA is still very slow – if not, as far as implementation is concerned, zero during the recent seven years. After the establishment of the wind converters in Darling and the demonstration converters at Klipheuwel only one wind turbine has been installed.

Based on analysis of the respective literature and also on the information gathered during the Mission there seem to be several reasons hampering the implementation of the policy regarding the development of renewables, including wind power.

An unclear system of responsibility for the development and overlapping responsibilities between the Department of Energy, the Department of Public Enterprises, the Department of Environmental Affairs and NERSA and a lack of coordination between these entities are hampering progress.

There is (according to the knowledge of the Mission), for example, also no full formal process mapped by NERSA and/or Eskom stipulating the conditions for renewable energy grid connection.

The research on wind resources for power generation is neither far developed nor coordinated. This is not surprising, since the initiative of the Government remained in the stage of announcement without taking measures entering the implementation stage. Respective research institutes, like CSIR, more or less refrain from initially doing research intended to foster wind power development.

All entities met

…showed interest in establishing a wind centre as presented by the Mission

…are convinced that South Africa will develop wind energy sources for generating electricity: "There is a future for it but no one could tell us when the future will begin"

… are concerned that the Government was not pushing wind energy development strong enough in the past.

… claimed that there is no real coordination regarding wind power activities in South Africa

…claimed that due to unclear and overlapping responsibilities of entities involved the respective entities are partly blocking each other thus hampering the process of developing wind energy resources

…are interested in participating coordinated activities to foster the use of wind energy in SA

…want to actively support the establishment of a wind energy centre, respectively by their character – either by administrative measures, as member of an institutional set-up, by providing training facilities, or by providing financial sources (last of which indicated for example by the representative of the Western Cape Department of Economic Development & Tourism during the debriefing meeting).

During the meetings it turned out that the development of wind energy is about to take off. The initiative definitely needs to come from the Government. But, due to

- a lack of pressure groups strong enough to push the Government and
- a strong monopolistic power generating company relying on cheap coal resources being at the same time the major utility and not really interested to support the development of future competitors (IPPs) jeopardizing the monopolistic position and – at the same time – having a strong position when advising the Government on energy supply strategies

Not many measures - besides REFIT - have been taken (until end of 2010) towards implementation of the targets for a modified energy mix as formulated already years ago. In particular, the outstanding implementation of the REFIT is one of the biggest hurdles for renewable energy deployment.

A number of private entities, as there are local and foreign potential developers, investors or manufactures are already preparing and investing in the future of the wind market in South Africa.

Several of the entities, especially the private companies, are concerned about the fact, that, when the wind power development will start, there will be no trained human resources available to ensure a smoothly take-off and respective sources for establishing and maintaining wind power facilities, and hence human resources would have to come from outside the country.

The importance of an employment effect initiated by establishing wind energy facilities was explicitly mentioned by some entities. Employment opportunities could especially be generated in rural regions where wind resources are concentrated, thus helping to prevent migration to cities and there enlarging unemployment resulting to social problems.

The Mission came to the conclusion, that the framework is prepared but it still needs a substantial push to get things running. It is most likely that this push might be more effective if coming from the outside. The involved national entities are blocking each other, and a certain attempt for coordination could contribute to overcome internal barriers.

B.4.2.2. Remarks on Policy Advisory Services by a SAWEC

It is essential to have a clear and achievable target, which is set forth by the central government. On one hand the target will be considered as the commitment to the world, and on the other hand, related policy might be developed and promulgated to fulfil the target.

The IRP 2010 of South Africa appropriately defines the development of large scale wind energy. The target is associated with economic growth in South Africa and, technically, the yearly target shall be achievable which is subject to geographical distribution across South Africa of planned wind farm projects, and its allowable grid connection points in the ESKOM power network.

Preferential policy with sustainability

Policies, strategies and instruments in South Africa have outlined and formed the law environment for the wind energy development, such as feed-in-tariff instrument, etc, however, a proper “project selection” criteria and the electricity trade mechanism with Eskom will be very essential to pave the way for wind energy development in South Africa, which might finally take up the shape of the wind industry.

Overall policy will ensure the achievement of the set target, and more particular, policy of building up or enhancing local manufacturing capacity is also essential if the central government has made certain that South Africa shall have local manufacturing capabilities, regardless of localizing the production from the prospective of bring down the cost.

In order to make the foreign experience in this field easily available to South Africa and to develop renewable energy policy support strategies for the government it is recommended that a SAWEC will have a role in policy advice, with a dedicated Renewable Energy Policy Support Unit. Its tasks would also include the raising of public awareness for wind power.

B.4.2.3. Remarks on Research and Development

Although wind turbine technology and wind industry has become mature in the past decades, the wind industry in South Africa is young, and the wind turbine and its application in this country might face different challenges, such as, different environmental condition (such as: higher sun radiation), different grid connection situation, different operation mode, different manpower skill, etc. Therefore, certain research and development capability will help to face these challenges.

- R&D capability might include the adaptation of wind generators, which are appropriate for local climate and off-grid operation. Optimized component design and wind farm planning tools taking into account local environmental planning rules, etc.
- This R&D capability might best be concentrated in a national level wind power R&D centre which will build up capacity and gain reputation along with the wind energy development.
- Taking into account the current status of wind industry development in South Africa, which is in its very early stage, the following goals of a R&D Centre are important:
- In the near term: technically facilitate the wind energy development, necessarily understand the required wind and wind turbine technology, be supportive in wind activities and build up capability & publicity.
- In the short and midterm: improve wind farm planning capability, reduce cost of wind farm investment and operation, and ensure operation reliability.
- In the long term: develop adequate measures for large scale wind farm grid integration.

The setting up of a national level competence centre for wind energy (hereinafter referred to "SAWEC" or "Centre") will be suggested in this report.

We agree with the content of the table[42] entitled "SAWEC R&D Primary activities", by Theo Fischer, CSIR, which summarizes the primary R&D activities as discussed at the stakeholder workshop at the beginning of the Mission. The timing of research and certain specific aspects would need further discussions, but in general the R&D map looks right – we included several of these activity in the plan for SAWEC in chapter C.

[42] "SAWEC R&D Primary activities", by Theo Fischer, CSIR

Wind energy development zones – GIS strategic assessment of wind resource and constraints
Wind/ renewable modelling energy Atlas/ mapping
Wind/ renewable energy inter-annual variability
Wind/ renewable development areas (potential excluding constraints)
Wind/ renewable area infrastructure plan (stepwise largest volume of wind energy with minimal capital outlay)
Policy and economics
Targets, rates of implementation and barriers to entry
Dependency of local industry on local and foreign factors
Grid infrastructure development and integration
Best practises guideline and grid code (e.g. British practises guideline)
Transient and grid stability studies
Wind/ renewable modelling
Wind/ renewable energy forecasting
Penetration potential and priorities
Matching IRP and grid development
Design and manufacturing of blades
Materials research
Testing and certification
Aerodynamics, materials and local content
Maintenance
Leveraging current blade and wing expertise and manufacturing (Denel etc)
Testing and certification
Suite of wind turbine and ancillary infrastructure components
Testing agencies

Table B-17: R&D Primary activities (by Theo Fischer)

B.4.2.4. Remarks on Standardization, Testing & Certification

We explained in chapter B.2.4 in detail the importance of standardization, quality and related testing and certification.

Certification is necessary, as Project Financing will be most likely the preferred method to finance the wind farm projects in South Africa. Accordingly, investors and banks will request certified units.

Therefore, demand for testing will also develop and part of these services could be provided by South African institutions. Cooperation with e.g. GL and FGH in Germany may be an appropriate solution.

B.4.2.5. Remarks on Klipheuwel Wind Energy Demonstration Facility (KWEDF)

It was the task of the mission to assess the suitability of the existing KWEDF for the following tasks:

1. Wind power demonstration facility
2. Location for a wind power training facility using “live wind turbines”
3. Wind turbine test site for IEC turbine tests
4. Use of onsite turbines to generate income as an IPP

B.4.2.5.1. Public Demonstration and Publicity Site

The KWEDF has been specifically built to raise awareness for renewable energy and wind power in particular. It can very well serve this purpose, also in future.

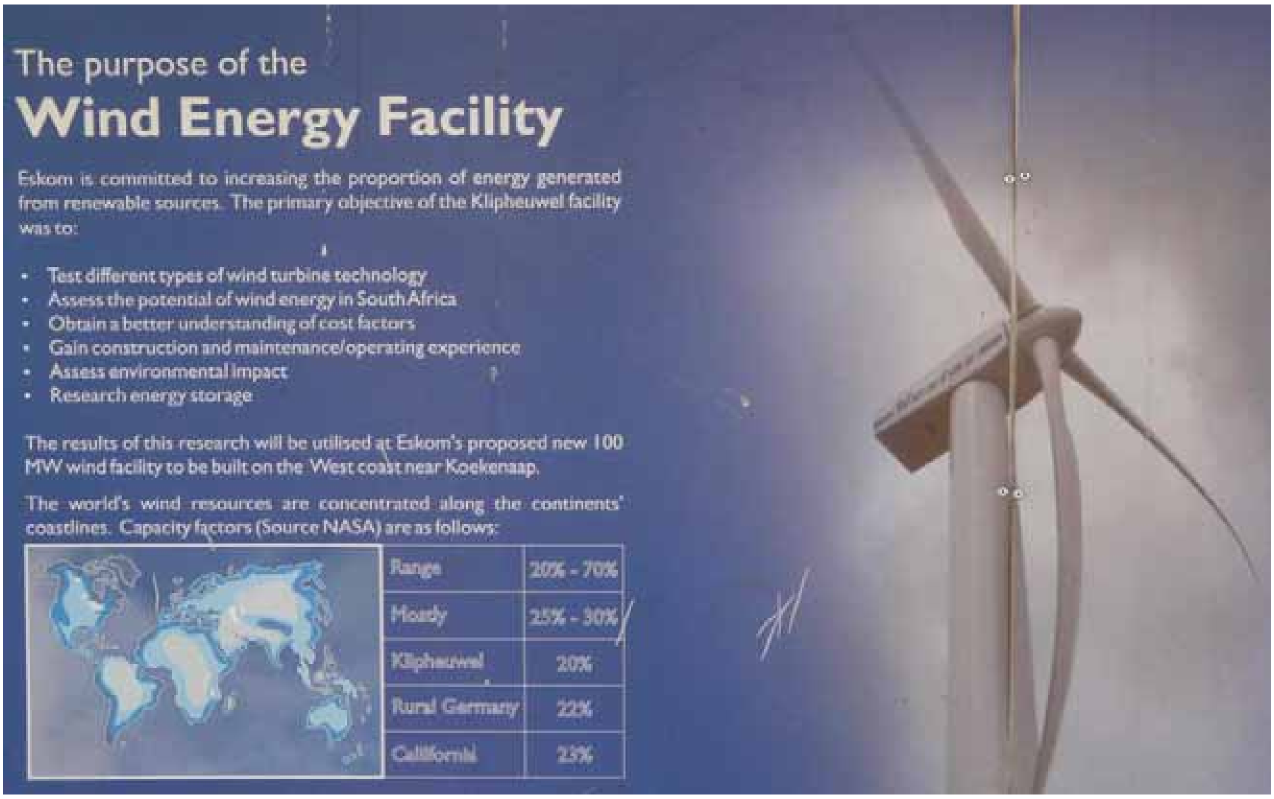

Photo 1: Klipheuwel Information Board

B.4.2.5.2. Test Site Requirements – Klipheuwel Suitability

Test engineers prefer to have their (field) office close to the wind turbines they are testing. Also from a technical point of view, it is desirable to be able to have short distances as there are frequently checks on the system, trouble shooting or improvements required.

However, test sites need to be located in areas with good wind resources to allow short measurement periods. In most countries, the leading test institutes have their own test-sites but are also installing their measurement equipment in remote wind turbines of the customer – then being connected via the internet to the central testing office.

In general, the following major factors need to be considered when selecting a central test site or remote test site:

1. Good wind resources
2. Wind direction
3. Obstacles and roughness within standards requirements
4. Terrain steepness within standards requirements
5. Turbulence within standards requirements
6. Grid configuration
7. Grid connection voltage
8. Grid short circuit capacity
9. Elevation
10. Climatic condition
11. Accessibility for staff / remoteness
12. Internet connection

A major factor is of course the wind resource distribution, which needs to allow measurement in all wind speed classes as required by the relevant IEC 61400-X standard, within an acceptable timeframe.

For the measurement of the turbines power curve according IEC 61400-12 there are stringent requirements on obstacles and steepness of the terrain surrounding the measured turbine, in order to exclude any terrain-induced turbulence.

For the testing of grid compatibility of a turbine (FRT capability) certain minimum grid conditions need to be ensured at the point of the medium voltage-connection.

The mission team was asked to review the possibility to utilize the existing ESKOM demonstration wind farm at Klipheuwel as a combined training and test-site. The following chapters show the results of this analysis.

Photo 2: LVRT Test-Container by FGH

B.4.2.5.3. Testing of Grid Compatibility

The most important test for the grid operator is the compatibility of the turbine / wind farm with the conditions laid out in the grid code. Such testing required that the electrical grid near the wind turbine is being tested by means of a test-container fulfil certain minimum conditions.

Based on data provided by ESKOM we have calculated the situation for the 10 kV grid at Klipheuwel. The resulting voltage deviation due to the LVRT test would amount to about 2%, which is fully acceptable. The full calculation[43] is provided in Annex 9

[43] Preliminary Feasibility Statement on LVRT Measurement of Wind Turbines in Klipheuwel Wind Farm; State Grid – CEPRI, 02/2011

➔ By calculation and analysis, it was concluded that the Klipheuwel wind farm is suitable for LVRT measurement by properly choosing the impedances of the LVRT test containers.

B.4.2.5.4. Suitability according IEC 61400-12 – Power Performance

The requirements for a test site are based on the specific test items, e.g. power performance, power quality, acoustic measurement, load-measurement und LVRT.

The terrain requirement of a test site is most important for the power performance test.

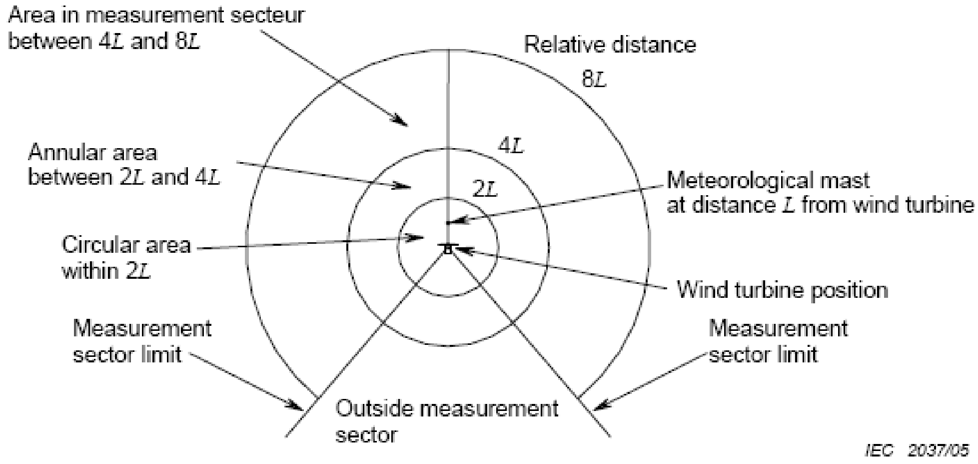

Figure B-22: Arrangement of Turbine and Measurement Tower – IEC 61400-12

The terrain at the test site may only show minor variations from a plane, which passes both through the base of the tower of the wind turbine, and the terrain within the sectors.

If the terrain complies with the requirements of Table B-18, then no site calibration is required. If the terrain characteristics are within an additional 50 % of the limits of the maximum slopes shown in Table B-18, then a flow model can be used to determine if a site calibration measurement can be avoided. The flow model shall be validated for the type of terrain. If the flow model shows a difference in wind speed between the anemometer position and the turbine's hub less than 1 % at 10 m/s for the measurement sectors, then no site calibration measurement is required.

Distance	Sector	Maximum slope %	Maximum terrain variation from plane
<2L	360°	<3*	<0.04（H+D）
≥2L and <4L	Measurement	<5*	<0.08（H+D）
≥2L and <4L	Outside measurement sector	<10**	Not applicable
≥4L and <8L	Measurement	<10*	<0.13（H+D）
* The maximum slope of the plane, which provides the best fit to the sectoral terrain and passes through the tower base ** The line of steepest slope that connects the tower base to individual terrain points within the sector			

Table B-18: Terrain requirements according to IEC 61400-12

H: Hub Height;

D: Rotor Diameter;

L: Distance between Met mast and test wind turbine, L = (2 - 4) * D

In order to assess the suitability of the Klipheuwel Site for testing purposes we downloaded the high-resolution ASTER-Digital-Elevation Data and imported it together with appropriate Google-Maps into the WindPro software, which allows an assessment of the terrain's steepness and slope.

Photo 3: Klipheuwel Wind Farm

The results show that the nearby terrain of the VESTAS V47 and JEUMONT turbines are suitable according to the IEC standard. However, the terrain near the VESTAS V66 is not suitable; nevertheless, there is sufficient suitable space towards the south of these turbines (the terrain is similar to the Zhangbei test centre in China).

We assumed that this site will be utilized for further testing of turbines and that in the future another <u>seven test turbine-sites are required</u>. The turbine sizes are 3 x 1.5 MW (each one rotor diameter class 3 class 2 and class 1), 2 x 2 MW (each one class 3 and class 2) and 2 x 2.5 MW (each one class 3 and class 2).

We identified 7 suitable places for the extra test wind turbines. The main wind direction from the wind data WM04 is southwest. We calculated 2 situations: main wind direction is southwest; main wind direction is northwest. Both of the two situations have <u>enough</u>

useful sectors for the power performance and load measurement test and conform to IEC standard.

The coordinates are the following:

No.	Capacity	East	North
#1	1.5MW	18°45′36.85″	-33°41′15.32″
#2	1.5MW	18°44′29.03″	-33°41′26.74″
#3	2MW	18°44′19.10″	-33°41′42.90″
#4	2MW	18°43′24.00″	-33°41′56.70″
#5	1.5MW	18°42′46.01″	-33°42′03.75″
#6	2.5MW	18°45′19.91″	-33°42′23.66″
#7	2.5MW	18°44′33.91″	-33°42′29.16″

These wind turbine sites only consider the terrain requirement, but are not optimized for energy production, do not considerate the length of transmission lines and the position of transformer substation on the spot.

B.4.2.5.5. Wind Resources for Wind Turbine Testing

A test site needs sufficient wind resources to be able to provide the complete data set required for the IEC 61400 tests in a reasonable time (e.g. 6 months to maximum 1 year) and the wind speed distribution needs to cover all required wind speed ranges. We did not have access to onsite data from Eskom but a sufficiently accurate estimate of the wind speed distribution may be done based on the data provided by the "*Wind Atlas of South Africa*[44]".

Figure B-23: The location of the Wind Farm and the two Wind Towers

The wind resource analysis was based on the met-tower Fisantekraal. One reason to select Fisantekraal is the distance of 10 km between Klipheuwel wind farm and the met-tower Fisantekraal, which is much nearer than the met-tower Philadelphia, which is 15km from the wind farm. Another reason is the leading wind-direction of the area, which is from south - so we selected this southern station (see Figure B-25).

Based on this data we plotted the Weibull Distribution of wind speed and the Frequency Distribution of every direction. The height of the data is for 10m only.

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[44] Wind Atlas of South Africa, Roseanne Diab, DMEA Pretoria 1995

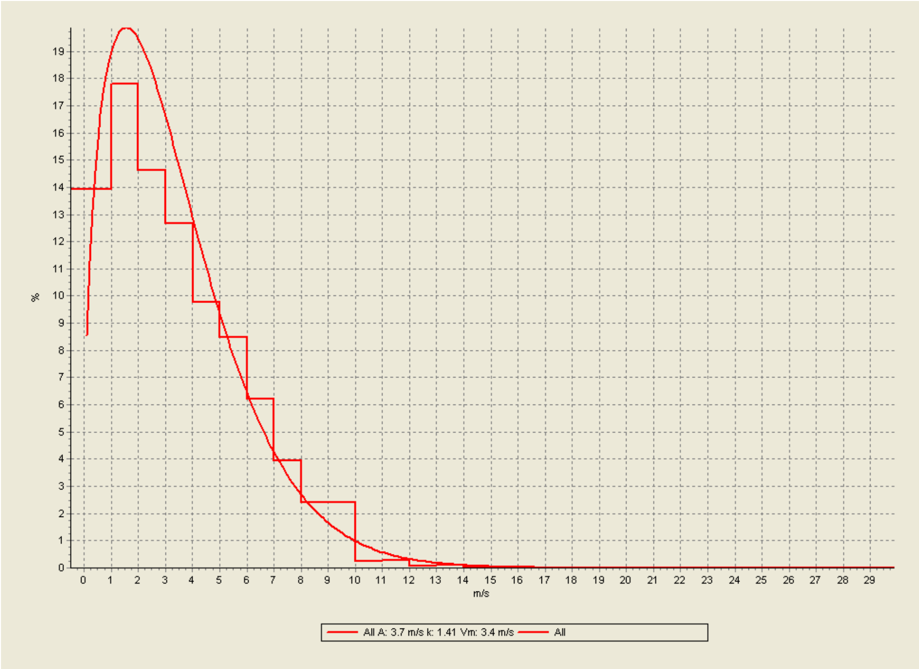

Figure B-24: Fisantekraal Weibull Distribution of Wind Speed at 10m Height

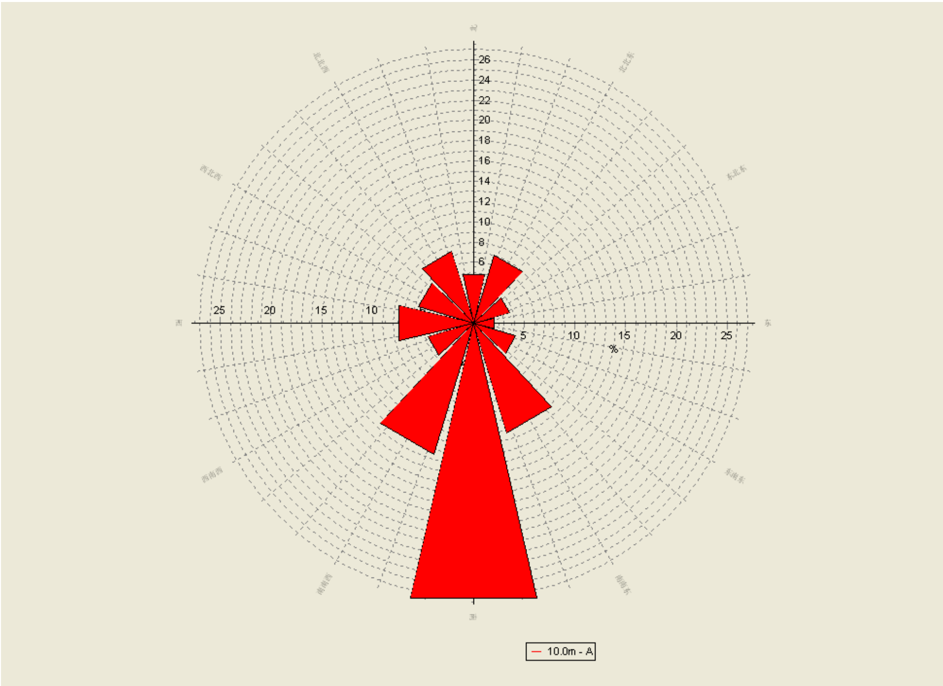

Figure B-25: Wind-Speed Frequency Direction Distribution at 10m Height

The next step would have been to generate a WAsP Lib-file and to transfer this data by means of WAsP/WindPRO to the Klipheuwel site. However, this is quite a large effort and the above wind speed resource – even if one converts it to a height of 60 m – indicates poor wind resources.

Therefore, we did a plausibility check on the Philadelphia data, which confirmed the above wind speed distribution. In addition, we found references[45] to the observed capacity factors at Klipheuwel, which are in the range of 16% only, which is consistent with the above wind distribution. For this reason, we did not undertake a WAsP analysis.

Based on the above data and observed capacity factors one can clearly say that this site is unsuitable as a test site. It could take more than one year to accumulate enough measurement data in all required wind speed ranges and the higher wind speeds may never be reached.

➔ We recommend that Klipheuwel will not be selected as a test site for the SAWEC. Turbine testing needs to be predictable for the customer and the wind speed resource at the site do not allow for a planning of such tests. Also for research, it is not useful to invest money at a site, which only experiences full load conditions for a small fraction of the year.

➔ It is strongly recommended to select a different site with good wind resources. Maybe it is possible to come to an agreement with ESKOM, so that a test-site close to the planned 100 MW wind farm can be built, so that it can profit from the infrastructure developed by ESKOM anyway.

B.4.2.5.6. Use of Klipheuvel as a Training Facility

Usually a training centre must be equipped with a functional turbine in a workshop. An available wind turbine on a test field is a nice addition but not or seldom required. For safety reasons and lack of space a “live teaching unit” cannot substitute for a turbine in a workshop.

In case the site could be obtained at no cost and only the building facilities for the training centre need to be built, it would be useful to disassemble one of the three turbines to be used in the teaching workshop. However, the Jeumont turbine is not suitable as it is technology wise too different from today’s turbines; it is also not in a working condition and needs repairing. Although the V47 turbine is much smaller than today’s 1.5 to 2.5 MW units, it would be the only logical choice to use it in the workshop, as the large V80 turbine is able to generate much more power and provide more income for the training centre if it is kept in operation. It could be run as an IPP- independent power producer. Based on information from ESCOM the income from power sales would certainly be sufficient to pay for maintenance of the turbine(s)[45].

B.4.2.5.7. Conclusions

Based on the available data we come to the following conclusion concerning the Klipheuvel site:

1. Wind power demonstration facility
   - It is well suited as a demonstration site
2. Location for a wind power training facility using “live wind turbines”
   - The site location, available infrastructure and availability of three wind turbines are an advantage when selecting a wind farm as a training centre location.

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[45] Wind Energy Research and Operations Experiences at Klipheuwel, R Smit, I Smit, D Westhuyzen, L Heerden, 2004

- However, the benefits of having a wind farm as a training site are outweighed by the fact that proper training will need a real wind turbine in a "training-workshop" in any case
- Construction of such a training workshop with classrooms at Klipheuvel would require a large investment. A cost-benefit analysis would need to also compare the additional transport-costs for teachers and students from cape town to the site with a setting where most of the teaching / training takes place in a FET or University of Technology in Cape Town itself.
- In addition, safety training may be fully performed on a turbine tower of just 25 m height located in a residential or school area instead of a real wind turbine in a remote wind farm.
- It is therefore suggested that a possible SAWEC should seriously consider a training-centre-setup where
    - The V47 wind turbine at Klipheuvel is disassembled and converted to a test-bench training wind turbine located in a permanent training-workshop at a FET or University of Technology
    - Safety training is performed at this school location utilizing a small tower (or part of the old tower of the V47 turbine) and several indoor training-ladder systems[46]
    - Klipheuvel is made accessible so that it may be used for day-trainings of small groups of up to 5 senior-students (a few container-offices may be sufficient on site in this case)

3. Wind turbine test site for IEC turbine tests
    - We concluded based on calculations with the provided grid data that Klipheuvel may be used for grid compatibility testing
    - Based on the performed site assessment and calculations it was concluded that the topography of the Klipheuvel site is within the requirements to perform IEC 61400 tests on site and that there would be an extension potential for further 7 turbines.
    - However, based on the available wind data information and wind turbine production data we concluded that due to the low wind power resources and specific wind speed distribution, this site is not suitable to be used in an economic way for testing and research activities. The duration of power performance and grid tests is difficult to estimate as even during a whole year not enough data points may be accumulated in all IEC-required wind speed bins.
    - It is therefore recommended to find a site with better wind resources to be used for wind turbine testing. Alternatively a SAWEC may chose (in the beginning) to only perform testing in existing wind farms and not to develop its own test site. Depending on market and manufacturing development, this may be changed later.

[46] These are ladders attached to the wall of the workshop, which allow several students simultaneously being trained on the proper use of PSE – Personal Safety Equipment (belts, helmet, etc)

4. Use of onsite turbines to generate income as an IPP
    - The viability of income generation for a training centre through the utilization of the Klipheuvel turbines is seriously diminished by the low wind resources
    - In case the turbines may be obtained at no-cost, the sale of electricity from the V80 turbine will complement the income of a SAWEC – an analysis should be done as part of the overall financial concept for a SAWEC.

<u>Overall, the recommendation is summarised as:</u>

1. Dismantle the V47 turbine for use in a cape town training workshop and use Klipheuvel for day-trainings
2. Do not use Klipheuvel for IEC turbine testing and research but find a different site or start testing on customer's premises

B.4.2.6. Remarks on Local Production of Wind Turbines

Based on discussions in South Africa and with manufacturers in Germany, Denmark and China we see that South Africa may be facing the following problems in connection with local production:

- Government support policy for manufacturing industry development not (yet) fully clear
- Market volume may be <u>too small</u> for economic production
- Quality of sub-components may sometimes not be according to international standards
- "Playing field" may not be level – some manufacturers may have certain advantages
- Local and international banks may not take the risk to finance wind farms with local turbines due to lack of knowledge and risk of unproven wind turbines

However, with the right policy and support mechanisms these problems may be solved.

Based on technological constraints and experience in other countries one can expect the following sequence of development of a local wind industry:

1. Initial activities – 2011
    - Wind power consultancy for wind measurement (already happening with CSIR)
    - Electrical network planning based on likely wind farm regions (under way)
    - Training of engineers (now) and technicians (soon) need to start
2. Construction Phase of first wind farms starting – low threshold standard business will develop – 2012 - 2014
    - Foundation construction as pretty basic civil engineering work
    - Demand for very large cranes will increase (important constraint in construction)
    - Tower production can be ramped up quite quickly but needs quality advise
    - Electrical switch-gear, transformers and cables may be procured locally (not really special equipment)

3. After the construction of a larger number of wind farms is approved, specialized industries can develop, but may need some time to ramp up production. They will also depend on state-support via e.g. a mandatory local content requirement in wind turbines. – 2015 - 2018
    - Demand for special steel for tower flanges will develop (only interesting for local production if material already available – for wind turbines alone there would not be enough demand to start special steel production)
    - Rotor-blades in cooperation with foreign manufacturers
    - DFIG-Generators for wind turbines (special adaptations of locally produced generators / motors)
    - Turbine assembly with partly locally manufactured components
4. Wind turbine testing and certification requirements – 2015 -
    - The need for testing of those locally assembled turbines will arise once locally built rotor-blades are used
    - The testing of turbine grid-compatibility will likely develop shortly thereafter

B.4.2.7. Remarks on Education & Training

The Wind energy sector is a sector which could create "green" jobs for the country, thus, adequate training for the working staffs in a wind turbine manufacturer or in a wind farm operator is a must to ensure premium quality product and safe wind turbine (or wind farm) operation. Large amount of the engineers and workers are required in the wind industry and the quantity is proportional to the development of wind industry, high skill level working staff will be beneficial to the wind industry by delivering products and services.

Wind power education and training are an important foundation for the wind industry. The people required to be trained; will do their daily work at a blade lamination workshop, a wind turbine assembly workshop, or on a wind farm under construction or in operation. Poorly trained staff will not do their job well and may jeopardize the product quality, or even may injure themselves.

In order to achieve a well-trained workforce a system of five grades: junior, intermediate, senior, technician, senior technician could be adopted with methodology of incorporating socialized vocational skills assessment, evaluation of skilled and talented people for enterprises, vocational qualification certification by colleges and universities and test on special vocational capacity.

This needs to consider:

- Carrying out cooperation in terms of mechanisms, models and methodologies for school-enterprise cooperation, comprehensive training courses for vocational skills and development of equipment for practical skills training.
- Setting up a cooperation in terms of improving skilled workers, vocational skills training system and life-time vocational training system for the workers.
- Developing an enterprise-school cooperation system to train highly skilled and talented people to expedite training of talented people in urgent need by enterprises.

- Enabling the role of enterprises as a key player to strengthen pre-employment training and job skills training. On one hand, establishing a modern training system for staff workers of enterprises, and on the other hand, promoting the system for experienced technicians to train apprentices

Photo 4: Darling Wind Farm

Based on the provided documents and the discussions with the stakeholders during the Mission it became clear, that at present the qualification of employees or, respectively, the quality of the performed work is insufficient. In various discussions it was emphasized, that the existing wind farms do not perform as calculated in the planning phase, meaning that also the economic performance of these projects is below the project targets. Examples of these problems were observed during the visit to Klippheuwel and Darling wind farms.

The energy yield - the performance in energy generation of a wind farm - strongly depends on the technical reliability and availability of the wind turbines. A high availability is the result of a good and reliable technical operation and a fast and reliable maintenance and repair. To achieve this high technical performance well trained workers, engineers and technicians, are required. Insufficient training and education of potentially available staff will be a major bottleneck in the economic successful development of wind energy in South Africa. .

This already starts with basic education on vocational level. Transparent and clear structures will be necessary in focusing on wind energy related subjects in the area of vocational education. The wind turbine manufacturing enterprises, which will be developed in South Africa in the first five to ten years after take-off, will focus mainly on the characteristic that their work consists mostly of assembling of parts delivered from sub-component suppliers. This definitely will create jobs, which however are mostly not specific to wind energy. Required performance and, accordingly, training subjects, will remain on the general level of factory skills for mechanics or electrical installation. The specific skills for the turbine assembly can be taught “on the job” in the factory, in the start-up phase supported by the equipment supplier.

The situation is different in the area of wind turbine service, repair and maintenance, where a thorough understanding of the wind turbine system is required. Due to the nature of the job, with scheduled tasks and an outside working environment on top of the turbine, the operational requirements for a professional, comprehensive training, such as automation engineers (mechatronic) with wind energy specialisation, are not yet covered in existing qualifications on the NQF in South Africa. They are also not likely to be developed by an industry, which is not really in existence in the first years. This calls for government supported independent training.

In Germany and (to a lesser extend) also in China external vocational training strategies have been developed, which allow the teaching of appropriate wind power curricula in a combination of workshop, class-room, wind farm and maybe online-courses.

SAWEC could take over the function as a link between the industry, the FETs, the SETAs, the Universities, foreign institutions as partners, the SAQA and the government agencies regionally and country-wide in order to balance current and future demand of skills and its supply on different skill level. There is a need to

- find providers for education and training, which could be FETs, private training providers and partners in the (manufacturing) industries.
- approach the relevant SETAs for the various sectors involved. It seems advisable to form a SETA-cluster with a leading SETA as counterpart.
- assign and adapt existing "unit standards" to the requirements of the wind power materials proposed in the training framework of the German and Chinese institutions
- develop new „unit standards" for the occupational and further training based on the adapted materials; change them according to the system of "Credits" assignment in the NQF; train wind power as part of the existing vocational training programs in the category skills programmes / learnership programmes
- establish entry requirements for participants of vocational programs; accreditation process with SAQA; minimum equipment standards setting for participating educational institution of an audit committee for a standardised test procedure

FETs need to play an important role in wind power education by providing vocational training for mechanical and electrical skills. Respective partners need to be identified. During the Mission, it turned out that FETs are interested to participate in wind power related training programmes. However, more discussions will be necessary to co-operatively develop respective vocational curricula. From our point of view, different SETAs need to work closely together to come to the issues of wind energy work in a meaningful way. e.g. in the area of "Maintenance and Repair" there are electrical and mechanical topics interlinked and they cannot be separated. In case a specialized "Wind-SETA" is setup - which would allow to focus more specifically on the required needs of the wind sector - it would be advisable to integrate it into the system from the beginning.

Respective adjustment of resources of the FETs (Hardware and Software) and the development of curricula in cooperation with the responsible SETA to the requirements from the NQF will be necessary.

It is recommended to establish a coordination centre in the beginning of the development process. The experience in Germany has shown that such a unit - as it is incorporated with the BZEE - was helpful in the initial phase of training development. Co-operation links of the education enterprises with universities and the industry are also established by the WAB (wind energy agency Bremerhaven Bremen E.V) in the northwest region of Germany. WAB has 270 member enterprises from industry as well as education and research institutes. Funding is ensured partly by member fees and conveyances of the federal state government. The WAB approach could provide a model unit when fostering the wind development in South Africa, which could be initiated and organized by SAWEC.

Another model to learn from and potentially to (partly) adopt is the training centre in Suzhou, China. The Suzhou model is starting to play more and more a coordinating role for the standardization of training and education to meet the requirements of the wind industry. In the South African case it needs to be ensured, that a respective facility is open to all the interested industries and not only to one large wind farm developer, as it is the case in Suzhou .

B.4.2.8. Suggested Action on Wind Farm Planning

The IRP2010 defines the targeted yearly wind energy installation-capacity from 2011 to 2030, and it will be of huge value if a “wind energy implementation plan” will be prepared to guide the activities in the coming 10 years.

In details, we suggest the following work to be carried out to achieve a feasible and harmonious wind farm planning: All of the activities listed hereinafter could be either coordinated or supported by a SAWEC.

(1) Wind resource assessment and wind mapping

Each country has its specific geographical locations, landscape exposure and its wind resource. Wind resources shall be assessed and evaluated properly in the form of wind mapping, which will guide wind farm planning.

Wind resources can be found everywhere, but not all of them could be utilized by a wind turbine. Only wind speed levels between the set cut-in wind speed (normally it’s about 3.5m/s to 4m/s) and the set cut-out wind speed (normally it’s about 20m/s to 25m/s) could drive a grid connected wind turbine. General wind farm planning could be estimated geographically, based on the landscape and area of the available land.

To ensure scalability effect, it is suggested that a minimum size of an individual wind farm might be 20 MW to facilitate the power grid connection-design and wind farm operation and management.

(2) Regional economic growth

Forecasting economic growth in the area with wind resources will facilitate grid planning. In case future electricity from the planned wind farm could be absorbed locally, thus no power transformed to high voltage level and no power transmitted over a long distance is required. Wind generated electricity, which is distributed in the local grid system will help stabilizing the grid and reduce power losses. In case (large) wind resources should not be congruent with the economic development of respective areas, connections to power transmission grids need to be planned.

(3) Restrictions in building up wind farms

Wind farm planning has to consider existing or forthcoming political and environmental restrictions, as there are military areas, natural reserve areas, acoustic sensitive areas, etc.

(4) Geological conditions

The geology has a direct influence on installation costs, as there are foundation construction, access road construction, etc. For instance, in areas with low bearing capacity of the soil, pile foundations (or other type) are required instead of flat foundations, which incurs higher cost and influence the financial returns.

(5) Power grid planning and possible grid connection points (PCC – Point of Common Coupling)

Whenever possible: a wind farm should be established close to the existing power grid or a forthcoming power grid. This is not only for economic reasons, but also to ensure power system stability.

Wind power is a fluctuating and intermittent source making it rather complicated to handle and to feed into the grid. Safety and smooth integration of the wind farm into the grid is - especially in those countries with already a substantial share of wind in the energy mix - a major problem.

Within the framework of the above listed items a number of services need to be developed in order to meet the challenges of integrating wind power into the electricity supply mix, such as

a) Wind resource assessment

b) Wind power integration simulation and analysis, and

c) Wind power prediction.

(a) Wind resource assessment is required to optimize the utilization of wind energy. Feasibility studies need to be undertaken. The assessment focuses among others on

- Wind speed measurement
- Wind farm macro-siting
- Wind turbine micro-siting et al

(b) The wind power grid integration simulation and analysis mainly focuses on

- Modelling and simulation of wind turbine/wind farm
- Planning, operation and control technology of wind farm grid connection
- Capability analysis of regional power grid to accommodate wind power, and
- Reliability analysis of wind energy generation, to obtain the necessary information about technical and operational measures for risk mitigation and safe operation of the power grid.

(c) Wind power prediction mainly focuses on

- Short-term and very short-term wind power prediction, to maintain the active power balance of the power grid. Production and consumption must balance minute by minute. Otherwise, the power grid may break down. Since the average electricity consumption is predictable, a key task is to find out whether the wind power is actually near the number predicted.
- Short-term prediction normally provides the wind power 24 hours ahead, while the very short-term prediction provides the wind power 4 hours ahead.

C. SAWEC – OPERATION CONCEPT

C.1. OBJECTIVES OF SAWEC

The experience of the reference countries, Germany and China has shown that for the establishment of centres for research and development and further education for the wind energy industry a coordination centre is important

The objective of SAWEC is to provide as a national facility state-of-the-art training, education as well as research and development services in the wind energy sector to meet the expected future needs of the industry. This can be achieved by providing own services, by offering a platform that can be used by independent service providers and/or by coordinating different stakeholders and initiatives in this area.

It should be in the interest of all political and economic organizations to establish a hub for the wind industry, providing comprehensive training, and, in addition, other services required in order to support the development of the wind industry. The specific tasks would finally result from the development of the wind industry and its requirements for research, development and education in the coming years.

The SAWEC could be established as a confidence-building organisation, satisfying the needs of all participants by their activities. The exchange between the manufacturing companies and the service companies will benefit the development of the wind industry in South Africa. The coordination between industry and occupational education plus the universities should be defined as a target.

The following examples of tasks would fit the Objective:

- Bringing together players in the wind industry in one organization
- provider of education and training in coordination and cooperation with industry and actors of the education system
- provide a platform for R&D activities; coordinate and/or implement R&D activities
- support the establishment of a wind service industry
- mediator between politics and business
- public relations for the wind industry
- organization of national and international conferences/workshops

As a possible organizer of workshops and conferences, the SAWEC could use all resources from all sectors of the wind industry, which are to cooperate and to benefit from a facility like SAWEC.

The tasks will certainly expand and or differentiate over time. The WAB in Germany shows that such a centre can be operated with a lean staff.

SAWEC could take over the function as a link between the industry, the FETs, the SETAs, the Universities, foreign institutions as partners, the SAQA and the government agencies regionally and country-wide in order to balance current and future demand of skills and its supply on different skill level.

Hereinafter, we distinguish between Stakeholders and Target Groups of SAWEC. The stakeholders are considered as entities, which are directly supporting SAWEC – either as member of the Board of Directors or as member of the Advisory Committee and are being dealt with at a later stage (see C.5.2). The target groups are specified in the following paragraph.

C.1.1. Target Groups

The below listed potential target groups are divided in two major groups:

- those participants who would take part in information seminars and conferences.
- the 'direct target group' which will participate in medium (and long) term programmes for training, research and services. Target group will be found in wind farms, utilities and manufacturers.

Activity	Direct beneficiaries	With which effects
Training	Wind farm operators Developers Teachers Researchers	Improved efficiency Competition on service market Research, teaching international standards Planning period will be shortened
Policy consulting	State authorities Regulator	Improved basis for decision making Awareness Lobbying for wind power
Applied research	Developers Wind farm operators Manufacturers Consultants Researchers Students	Optimizing production Improved availability of wind power Improved management Increased efficiency of wind power Improved development Higher level of qualification
Technical consulting	Developers Wind farm operators Manufacturers State authorities Regulator Financial institutes Insurance companies	Faster planning process Improved planning quality Improved risk assessment
Certification Support & Testing	Certification institutes Developers Manufacturers Wind farm operators Investors Insurance companies	Fair competition for wind farm manufacturer Quality Assurance Improved Cooperation with international institutions Improved precondition for insurance cover

Table C-1: Direct beneficiaries of SAWEC activities and the effects concerned

C.2. SAWEC TASKS AND ACTIVITIES

C.2.1. Vocational Training and Education

C.2.1.1. Implementation of a vocational training and further education system

South Africa's power industry did not have the chance to continuously evolve with the wind power technology. With the starting development in the country, wind energy plants of the megawatt class will be installed. These plants require technical personnel with a competent understanding of the system and its maintenance. Vocational training and education is a top priority in South Africa. In addition, the development of low-threshold qualifications in the adjacent sectors such as building of towers (welder qualifications) and rotor blade manufacturing/rotor blade service-enterprises (Fibre reinforce plastic (FRP) components qualifications) must be included in the strategic skills development deliberations.

Experiences in Germany and China suggest that industry participation in the development of qualifications could be assumed to take place in SA as well. Considering the implementation of education and training models, it is necessary to integrate those within the industry.

The concept with a leading institution (SAWEC) offers also the advantage that with a future extension of the wind power education system beyond the Western Cape region the quality of training can be immediately supervised and be built on existing contacts with the wind industry – this is to the benefit of all partners.

Special attention must be paid (mentioned already above) to the integration into the existing system. The targeted education and training will be incorporated fully into the NQF system. Related to this is assignment of sufficient credits to ensure the progression to the various levels of training. A possible independent education and training institution under the Chinese model in Suzhou seems not to be suitable for the South Africa vocational training system as it is solely based on the needs of one wind power developer.

In the following paragraph, the development process will be discussed briefly:

There is a necessity for special training programmes for qualifications in an industrial sector. The SETA is the responsible entity. Regarding the integration of developing wind skills within the SETA it will be necessary that

- the process will be based on the demand by industry,
- skills need analysis are conducted,
- classification into the NQF system according to agreed standards is ensured,
- in the end of the process the registration of the qualifications by SAQA, and publication on the SAQA webpage is performed.

The developed program could be offered – after proper design - by FET colleges, which have already or will meet the respective requirements for accreditation by the relevant SETA's.

An expert of SAWEC – or designated by SAWEC - could advise with technical know how about planning and implementing training phases and necessary training infrastructure.

C.2.1.2. Wind Turbine Technicians and Artisans Training

C.2.1.2.1. Training Concept

The development of the wind industry is dependent on various education- and training models.

It may be sufficient for the manufacturing branch of the wind industry to work with existing professional profiles and to teach the specific activities „on the job“.

However, the training requirements for staff in the wind-service industry are higher than in most other industries. In addition to basic training (mechanical or electrical engineering) for service and maintenance personnel, a comprehensive understanding of the integrated system is required.

This requires a concept of further-education and should follow the model of practice-oriented teaching.

The specialized knowledge available in enterprises and institutions should continuously flow into the education and training. It belongs to a modern industrial training, that the training institute (e.g., FETs or other for example Cape Peninsula University of Technology) has a good network into the industry, service companies and universities.

In the above-mentioned training centres in Germany and in China, teaching is done and practiced on real wind turbine components. It has been shown that it is important not only to teach under laboratory conditions. In laboratories, the foundations are laid for the understanding of issues. The real experience, which is important for working in the field, can only be achieved with real components.

An effective approach to teaching is the dual structured instruction by the coach or teacher. This means that the theory is prepared in small steps in the classroom and then applied in the workshop area on the real components with the appropriate special tools.

Another feature of further education in the training centres in Germany and China is the method of independent learning. After receiving the theoretical background learners are given a task of service or maintenance, which then has to be solved practically including the preparation of written work schedule. Besides the correct approach, which should be in accordance with the manufacturers' manuals, the work organization is learned.

Fully functional components in the workshop will put the students on the way of understanding the system. Through built-in faults troubleshooting and the proper repair, “faults and their effects” have to be trained”.

C.2.1.2.2. Training Materials for Instruction Planning

Along with the Curricula, training material needs to be developed for the specific need of the South African situation. The cooperation with institutions from Germany and with an expert on Vocational Education could ensure good and fast results. The main topics of a framework curriculum for the “service technician for wind energy technology“ according to the German model are:

- Introduction to Wind Energy Plants
- Mechanical Engineering I: Mechanics
- Mechanical Engineering II: Hydraulics
- Electro technology
- Electronic Data Processing and Data Transfer

- Control Techniques
- Fibre Composite Materials / Rotor Repair
- Hooking and Strapping Techniques
- Legal Framework
- Environmental Protection
- Work Safety, Accident Prevention and Health Protection
- Business Organisational Framework
- Technical and Organisational Communication
- Specialized Technical English

A complete curriculum of bfw (Berufsfortbildungswerk Bremen Windzentrum) is attached as Annex 6 and adjusted core curricula of the training centre Suzhou are attached as Annex 5.

The training by bfw in Germany includes approx. 780 hours of instructions and is supplemented by an 8-week internship in the wind power industry. After passing, the State-approved training course in Germany, a certificate of the IHK (Chamber of Industry and Commerce) is provided to the trainees.

In Suzhou, the framework curriculum could be shortened to 3 months duration only because participants are mainly from wind farm enterprises and thus having already a certain skill level. Other models in Suzhou have emerged from the aforementioned training in cooperation with industry; e.g., there will also be short-term trainings for new staffs from the wind industry on offer. The contents of the training follow the main curriculum of the Training Centre but it will be adapted in consultation with the client to a further reduced-size version. However, the education provider is still the organizer and responsible for the training.

In contrast to this, trainings for “employed staff” are also offered. They are conducted with special tailor-made content as requested by the client-companies. This qualification, which must be regarded as external further education, contains topics of general wind energy themes but adapted to the turbine-type used by the client. These trainings are usually not open to the public. They are not part of the vocational training / qualification system and do not qualify for promotions. It is an internal qualification by the client company and is partly carried out by their own training-staff. The courses are usually decoupled from the core curriculum.

For South Africa, it is expected that these demands will come mainly from industry. If "unit standards" are created and accredited such courses can be developed very easily and brought to implementation in the NQF system. The need for new course designs will arise in a later stage of the wind sector development e.g. for the erection of wind turbines and in the rotor blade industry (manufacturing and service). For example: These topics are taught in Germany by different institutions on different skill levels. Courses have duration between 4 weeks for skilled staff and 12 weeks for untrained workers or for workers, which require retraining in case they come from another line of business than the usual electrical or mechanical engineering. (Refer to list in Annex 6).

C.2.1.2.3. Required Training Facilities and Hardware for Training Centre

To meet the requirements of industry for a professional qualification, the institutions for *further education* must meet equipment standards. The requirements extend over the fields of mechanical engineering, electro-technology and electronics, the FRP components technology, communications technology and the safety engineering in and at wind-power plants. It is also essential to have components of real wind turbines on display and use them for the practical training of technical skills and the use of special tools. Training centres in Germany, which want to offer wind power training, have to fulfil the standards for equipment and buildings around the respective qualification.

The following facilities are necessary for regular training measures:

- Lecture rooms with multimedia equipment for theoretical instruction
- Workshop laboratory with components and equipment of the wind energy technology
- Laboratories for practical training on hydraulics/pneumatics, electrical engineering and electronics must be available to ensure the basic training.
- Areas for assembling and disassembly of wind turbine components (gearboxes, generators, large bearings, clutches, brakes, etc.) by teams with group sizes of ideally no more than 4 person per component.
- Crane to handle the wind turbine components
- Computer laboratory for training in PC use and report writing.
- Laboratory of composite material technology FRP (production and use of laminates and resin systems).
- Opportunities to practice the use of fire extinguishers.
- In or outside of a building a ladder systems to have the possibility for safety and rescue training.
- Wind turbine tower (>25 m) or other adequate possibility to practice the emergency exit from a wind turbine. A turbine in a field can be used also.
- Full size training test-bench wind turbine > 250 kW (as explained below)

Since parts of the premises or workshops are rather costly, a SAWEC could then take the coordinating role in case parts of the premises are available in one of the stakeholder units only. This kind of strategic partnership is also carried out between educational entities in Germany.

C.2.1.2.4. Wind Turbine as Training Test Bench

The experience has shown that a training centre must be equipped in any case with a functional turbine of a size not below 250 kW. A criterion in the selection should be that the dimensions are close to those wind turbines used in the region of the training centre. It is necessary to train on heavy and large dimensioned components. Training courses for system-understanding and debugging can only be held this way, as an operating wind turbine in the wind park cannot be setup to generate fault conditions due to safety concerns.

An available wind turbine on a test field can only to a certain extend be a complementary training facility in addition to the qualifications or trainings held at a test-bench in the training centre. For safety reasons and lack of space a teaching unit is of limited use and cannot substitute for a turbine in a workshop, since assembling and disassembling is usually not possible.

A wind turbine, which is accommodated within a workshop, would offer all possibilities for training for all participants at the same time. In Suzhou, an 850 kW turbine was converted into a motor driven turbine, which allows holding training under "real conditions" within the workshop.

Necessary equipment within a workshop are:

- Nacelle of wind turbine not smaller than 250 kW – grid-connected and motor-driven
- Components from wind-power plants
- Tools of the general mechanical engineering and electro-technology
- Common special tools of the wind energy technology (Self-acquisition or co-operation with manufacturing firms)
- Illustrative material and working models from all subjects' area (Old parts, models or original parts placed by the manufacturer)
- Industrial safety equipment for the training, the laboratories and workshops
- Safety equipment against fall for the work on wind-power plants

C.2.1.2.5. Requirements for Teachers and Trainers

Teachers and trainers must have experience in the subjects they are teaching. In Germany, this is achieved by having vocational school teachers and engineers doing the trainings together. In addition, also a way must be found to engage temporary lecturers with wind energy related knowledge on special topics to supplement the full-time teachers. During the discussions at the visited colleges, it became clear that at present no background knowledge on wind energy exists. Therefore, further trainings for the future wind-power trainers have to be held (possibly abroad), which include theory and practice. Based on GIZ's experience competent partners for this can be found in Germany and China.

In China and Germany training courses for the staff is done regularly - by arranging internships in wind farms or at manufacturers to be able to follow the technical development of wind turbine technology and experiencing *real-life wind farm problems*.

In Germany and China, it has been shown that training-class sizes with more than 20 people are not conducive for the desired education or training. Particularly in the practical training at turbines or with full-size components, large groups of more than 20 people cannot be handled by the training staff. This has implications on the number of trainers and size of the training centre. The training centre in Suzhou is currently working with 6 full-time trainers and approx. 20 temporary trainers. Also safety and quality aspects are to be considered when deciding about the number of trainers required.

C.2.2. Specialized Training for Engineers

A solid foundation for the success of a wind power centre and the wind power sector as a whole are well-trained engineers and scientists.

In chapter B.3.5.4 we calculated the number of staff with engineering background, which would need to be trained in various fields. The average number per year is 668 engineers.

An important activity for the SAWEC will be to organize and teach special courses as further-education for engineers.

The proposed concept for a SAWEC is based on the assumption that a large proportion of the "Engineer Training Staff" is not directly employed by an *engineer-training unit,* but is sharing their work-time between *Services, Research and Training.* This setup has been successful in many wind power centres abroad and it allows the trainers to be involved in real projects, which use the latest techniques and technologies. This way, their experience will be made available to the participants of the training courses.

Below we have listed those courses, which were taught at DEWI and Deutsche WindGuard in Germany and also formed the planning foundation for the China Wind Power Centre. It is suggested to base the SAWEC training on these course topics:

Fundamentals of Wind Energy Technology

- Historical development of wind energy use,
- Global overview of the potentials, in comparison with other energy sources,
- Physical and aerodynamic principles of wind energy use,
- Technology and prospects of wind energy use,
- difficulties and obstacles to implementation,
- scenarios and their evaluation.

Technology of wind turbines

- Classification of the technical concepts of wind turbines,
- Function and behaviour of system components,
- rotor blade calculation and construction,
- Loads and Dynamics,
- types of rotor and rotor design,
- work on the wind turbines for power regulation,
- Mechanical drive train,
- Sensors.

Power supply / operational characteristics

- Generator systems,
- power conditioning and grid connection,
- inverter, rectifier,
- Electromagnetic Compatibility,

- Protective measures
- Network effects (harmonics, flicker, Short-circuit power),,
- lightning protection and grounding
- Resonance phenomena in the power system during normal operation,
- filter, power control.

Planning of wind energy systems and site selection

- Procurement planning basics
- Assessment of sites (criteria for site assessment),
- Preparation of specifications for a wind project
- Evaluation of grid connection scheme,
- Planning of wind measurement campaigns, selection of data loggers,
- Selection and evaluation of meteorological data,
- Wind data analysis, yield estimation, correlation with long-term data,
- Conduct a site assessment and other engineering services,
- competitive tendering procedures, evaluation procedures, development of a procurement proposal,

Assessment of the manufacturer (power curves, experience, etc.).

Training on Wind farm design

- The participants have been introduced to various measures to improve the integration of wind energy in the power system.
- Design of sales and service contracts, permit applications and working with local authorities, public relations,
- Three-day software training on the application of integrated planning software.
- Time behavior of the WT-total power output, ramp-rate,
- Wind farms as integral parts of an electrical supply network,
- Influencing the conventional power generation by large grid connected wind power, necessary reserve power
- Wind power forecasting.
- Optimization of farm efficiency,

Advanced Courses / Research Support on Wind Farm Effects on the overall Power-System Integration

1. The participants will be able - based on given figures of wind power penetration – to assess the impact of high wind power feed-in to the conventional power generation.
2. The participants will understand the basics of the interdependence of spatial distribution of wind power and the related time-constants on the total wind power fed into the grid and the impact this will have on the dispatch and operation of conventional power plants.

Financial Feasibility of Wind Energy Systems

- Cost structure of investment, energy production and energy costs, amortization,
- Maintenance costs, maintenance contracts, insurance, leasing, remote monitoring and other costs,
- Income, allowances, typical tariff structures for electricity purchases and feeding,
- Methods of economic analysis (NPV, / annuity), cash flow analysis of wind farm projects
- Economic factors, external costs,
- Regional impact on the economy,
- Job creation
- Financing and operating models
- Economic aspects of renewable energy,

Installation and commissioning

- Transport of equipment, site preparation,
- Access roads,
- Foundations,
- Assembly, organization, logistics and hoists,
- Systems for network connectivity,
- Wind power plant construction and grid connection,
- Safety rules
- The safety of installations in operation, signage,
- Transfer of responsibility, rights, warrantees and guarantees,
- Public information
- Routine independent bi-annual technical inspections of turbines

Operation and maintenance of wind turbines and wind farms

- Personnel and infrastructure requirements for the technical operation of wind farms,
- Personnel and infrastructure requirements for maintenance and repair,
- Technical equipment for the management and operation of wind turbines and wind farms,
- Communication and data transfer,
- Introduction to experience gained from the "Scientific Wind Turbine Measurement and Evaluation Programme" of the German Ministry of research and technology
- Real practical examples of technical audits of wind turbines,
- Evaluating information for report publication
- Dealing with project partners: communication, assignment and control.

C.2.3. SAWEC Services and Applied Research

C.2.3.1. Introduction

The SAWEC Services and Applied Research could be one of the 3 pillars of SAWEC. It should aim to achieve the international level of academic recognition of Wind Power Research Institutes like Risoe-DTU, DEWI, ECN, NREL.

It would need to develop its own unique expertise as a wind service provider for South Africa and southern Africa as a whole, by providing renewable energy solutions, which are technologically sound and cost effective and at the same time provide more jobs than solutions developed for the northern hemisphere..

➔ The foundation for this are well trained engineers and other wind power staff with practical experience.

In the following, options will be described that could be included in the SAWEC portfolio; however, the concrete selection amongst the options still needs further analysis and stakeholder engagement. Furthermore, we do not want to distinguish at this point between the activities and even staff / hardware for applied research and services, as the wind power industry is very dynamic and new services are mostly generated out of previous applied research projects. Both fields of work are hence interdependent and will be developed together.

As we mentioned in the previous chapter a SAWEC needs to develop *applied-research, wind-services* and *wind-training* in a cooperative way. None of the three areas can succeed in the long-run in isolation and hence need to be setup in an environment, which enables synergies to be utilized.

C.2.3.2. Possible customers and market chances

The following chapters list the possible scope of activities, sample projects and products that could be developed and offered by the SAWEC Services Department. Services would be developed gradually and could evolve with increasing wind energy deployment.

Looking at the landscape of the players involved in the wind power sector one can identify the following customers or target groups for products, services and research results of SAWEC:

- Wind farm developers, planning authorities, planning consultants
- Investors (institutional / private), project appraiser, financing banks, risk analyst, insurers
- ESKOM in general, ESKOM dispatch centre,
- Turbine Manufacturers, component manufacturers, foreign certification bodys
- Research and academic projects
- International donors
- Wind farm owners (institutional or private)
- Technicians / engineers in general
- RE advisors in government (e.g. SANERI)
- Regulating Bodies, Electricity regulator, Standards institutes
- Associations e.g. power equipment manufacturers etc

• Universities, Engineering & Research Associations / Institutions, e.g. CSIR

The appropriate number of research and service staff would depend on the chosen realization approach and specific service demands from the wind sector. Most likely a SAWEC would balance its activities between own service development and training of external participants from the wider wind power sector. This way it would provide *training-services* for the whole SA wind sector so that a wide range of consulting services can also develop outside of SAWEC, which could then also compete with offerings by SAWEC.

In the following chapters, we give our recommendations on the most important engineering services that could be developed at SAWEC. The decision on whether or when to develop a service, needs to be taken at a time when the real market demands are known or can be estimated. The wind measurement related services will certainly be the first ones to be realized.

C.2.3.3. Wind Measurement Services

Customer:

Wind farm developers, turbine / component manufacturers, international donors,

Priorities: **High**

This kind of service will be required before the actual wind farm development is started and should be developed first.

Description:

Wind measurement is one of the most basic work to use wind energy, for all the wind farm planning, services and testing using the wind measurement data as the basic data is required.

Wind observations are taken at a fixed location using two parameters: wind speed and wind direction. Wind speed and wind direction can be measured with a variety of tools. The most common, included with complete weather stations, is the anemometer, which is fixed in the wind measurement mast. The wind measurement mast[47] will have a number of anemometers in different heights and is equipped with temperature, (humidity) and pressure sensors. The data is usually transferred daily automatically via GSM or satellite networks.

Photo 5: Measurement Tower 120 m

The use of a LIDAR [48] for wind measurements is anther useful (and costly) tool, which is used to measure wind speed and define wind height profiles. It has the advantage of being in service within 2 h of

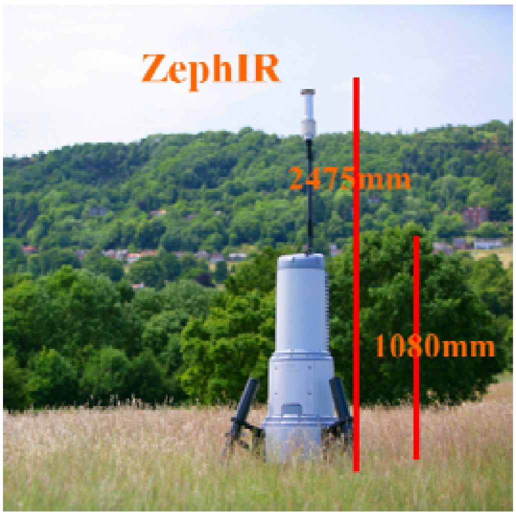
[47] Photo Deutsche WindGuard

[48] LIDAR - Light Detection And Ranging **-** optical remote sensing technology using laser

reaching a new site. The wind industry community agrees that the best practice wind measurement is the use of a LIDAR in combination with a fixed mast. It offers a reduction of several uncertainties according to the following promising practice: one fixed mast (60 – 80 m for the whole wind resource assessment period of 1 to 2 years, and in parallel one moving LIDAR for shorter periods but for a number of locations.

In order to be able to offer high quality wind services, the acquisition of a LIDAR is recommended, although the cost is very high. Another aspect is that every respectable wind research centre in the world is currently undertaking research on LIDAR based wind measurements and this technology needs to be known in SA. It is also expected that LIDARs will in future also be use for power curve measurements – an IEC standard is under preparation[49].

➔ Already from the start, SAWEC should have at least 2 measurement masts for services and possibly one for research. As far as finances permit, it is recommended to procure a LIDAR system.



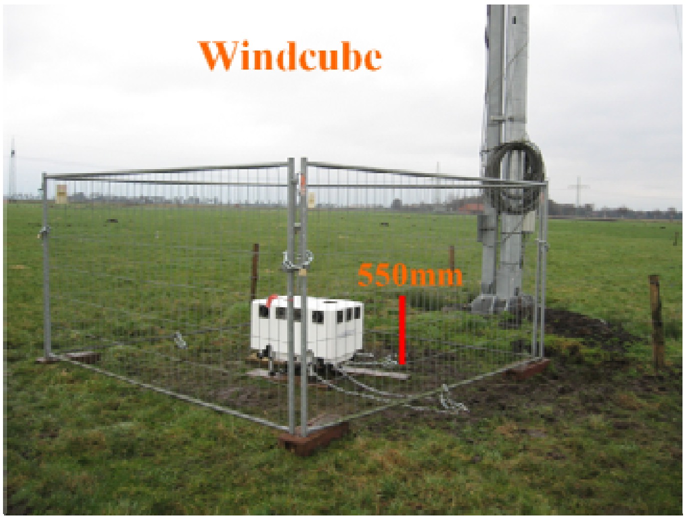


Photo 6: LIDARs for wind measurement – cost ~130.000 Euro

C.2.3.4. Wind Resource Assessment, Wind Farm Planning & Optimisation

Customer:

Wind farm developers, financing bank, international donors,

Priorities: **High**

This kind of service will be required at the onset of wind farm development and should be developed first.

Description:

How much wind energy is available at potential wind farm sites must be estimated before construction, and the accuracy of this estimation will greatly influence the economics of the wind farm development. The main input parameter for this task is wind measurement data of high quality.

The Wind Farm Planning Unit is in charge of the wind resource assessment, the wind farm macro-siting, wind turbine micro-siting and environmental impact assessment. The

[49] Photo 6: Deutsche WindGuard + WindCube Lidar of GIZ CWPC project

common software for wind farm planning and design are WindPRO, WAsP, WindSim and WindFarmer.

➔ Experienced experts for these tasks are required and need to be trained.

Normally, large-scale wind resource mapping will be of help to guide wind farm development activities, and the high-resolution wind maps will be good even for wind farm planning and layout.

As CSIR in South Africa is currently undertaking wind measurements and is involved in the development of wind maps, its validation and fine-tuning will benefit wind industry greatly. This can be achieved by using new computing tools and new meteorological data sets leading to compound maps with higher horizontal resolution and allowing for more accurate depiction of the overall wind resource. SA should develop this technology as it will aid in the identification of new wind development areas where the wind resource was previously considered unsuitable.

➔ In order to avoid duplication of efforts it is required that there is an agreement on the participation and/or cooperation of CSIR in the SAWEC Research and/or Services Unit.

The focus is to provide the wind industry, policy makers, and other stakeholders with applied wind resource data, information products (e.g., maps), and technical assistance with increasing emphasis on increased heights to effectively evaluate and develop the wind potential. Whoever will be mandated with this task shall work with all available data sources to validate the nation's wind resources and support advances in wind forecasting techniques and dissemination. In addition, validating new high-resolution wind resource maps will give people interested in developing wind energy projects greater confidence as to the level of wind resource for a particular site.

C.2.3.5. Environmental Impact Analysis

Customer:

Wind farm developers, financing bank, planning authorities,

Priorities: **High**

This kind of service will be required at the onset of wind farm development and should be developed quickly.

Description:

The SAWEC Research & Service Centre could help to identify and resolve environmental issues that may hinder acceptance of wind energy technologies by collaborating with developers, government authorities and other concerned organizations. The activities will combine activities that address the potential effects of wind development on the environment (wildlife, birds, water reserve, etc.) and identify corresponding mitigation strategies.

Tasks would also include the assessment of wind farm noise according to South African limits defined in applicable standards, to give guidance to planners in the process of planning permissions for wind farms. The relevant measurements would need to be performed by a test centre (see chapter C.2.4) and the wind farm noise calculation would be performed by a wind farm planning unit by means of WindPRO or other software.

➔ With the large areas of natural beauty under protection the provision of services in this field are very important and should be developed quickly.

C.2.3.6. Grid study and grid impact analysis

Customer:

ESKOM, wind farm developer,

Priorities: **Medium** (operational within ~3 years)

This kind of service will be required soon but in the beginning an informal approach might be used; it is however necessary to start training and applied research on this quite quickly as the training is very intensive and a lot of experience needs to be accumulated before a grid unit can perform this service effectively

Description:

South Africa is having a similar problem as China: “Where there is wind, there is no load”, which is why detailed grid planning and integration studies need to be performed before the wind industry in the country really takes off.

Though, within ESKOM, the grid planning engineers have already done a lot of work on how to connect wind regions to the grid and how to absorb the electricity generated from the wind farms, it is certainly required to undertake further grid integration studies to evaluate whether the individual wind farm connection-proposals are technically feasible. Here would be a market for expertise to be developed by SAWEC Services.

The SAWEC Research & Service Centre might be able to support wind farm developers in their internal wind farm grid planning and may be accredited by ESKOM to undertake the calculation of the wind farm behaviour based on the wind turbine models provided by the manufacturers.
It could even be useful to develop SAWEC Services as an independent wind turbine and wind farm certification centre for the grid behaviour. Wind turbine Manufacturers would have to submit their models for validation – together with the results of a FRT test (see chapter C.2.4) - and wind farm developers would need to use those models to prove to ESKOM that the grid code parameters at the PCC can be met. The German Certification Centre of FGH Mannheim could partly be an example for this.

➔ ESKOM’s role and mode of participation in the SAWEC needs to be defined urgently

As this work depends on data and inputs from ESKOM a transparent collaboration with ESKOM is required. In case an independent solution is not required / possible, ESKOM could also be a direct partner here. In China, the CEPRI as a daughter company of State Grid is in charge of the above-mentioned tasks. This means that State Grids dominating role is similar to ESKOM’s and the important question of independence due to market competition is not such a big concern. However, part of these services could also be provided by independent engineering-firms who might feel disadvantaged by a powerful SAWEC with ESKOM as a partner. This is a decision to be taken by the government or regulator.

C.2.3.7. Short term wind forecasting

Customer:

ESKOM dispatch centre, Wind farm developers (if required by grid code)

Priorities: **Medium to Low** (operational in ~4 - 5 years**)**

This kind of service will be required when the wind power penetration in the grid in a region reaches a certain percentage of total generation. The timing of such a service would need to be estimated together with ESKOM. Depending on the grid topology and power station-mix in a regional network the need for wind power forecasting may arise already at capacity-levels of 5 - 8 % wind.

Description:

Although wind is an intermittent energy resource, it is not unpredictable and forecasts up to a maximum of 36 hours ahead of time are possible in Europe. This technology will enable effective "control" of wind farm operation. It may also provide additional potential economic benefits for the wind farm owner as he may then be able to guarantee with acceptable risk a certain "firm power."(This of course requires a relevant tariff policy to be in place, such as in UK and Germany.) The short term forecasting will also improve the economic operation of the grid system (energy saving in spinning capacity). The seamless integration of wind plant output forecasting—into both power market operations and utility control-room operations—is a critical next step in accommodating large penetrations of wind energy in power systems.

To predict wind power, numerical weather prediction (NWP) data is required. The calculation is based on mathematical models of the atmosphere and oceans to predict the weather based on current weather conditions. The numerical weather prediction is usually provided by national weather service or meteorological forecast companies.

The next step is to build relationship between the wind and the power. There are two main types of models, the physical model and the statistical model. The physical model for short-term prediction does not require historical data to operate, as it explicitly models the wind flow based on the NWP results and then calculates the wind farm power forecasts based on this "digital wind" and the type of wind turbines in the wind farm.

Statistical models, on the other hand, use the correlation between historic NWP and power data to establish a power curve. If they use online data, which most models do, then they can adjust the first few hours of the forecast to the actual measurements, thus being able to outperform any model without online data for the first hours of the forecast. The disadvantage of statistical models is that they need historic power and weather data to train an "artificial neural network - such data is not available in the case of new wind farms.

C.2.3.8. Hybrid System and Remote Area Applications

Customer:

System integrators, Turbine Manufacturers, ESKOM, international donors, foreign states,

Priorities: **Medium – continuous capacity development**

Description:

South Africa is in need of power supply solutions, which can provide power at affordable prices in remote off-grid regions. The latest wind power technologies making use of full-converter solutions and dump loads / heat storage cookers, are able to operate in stand-alone mode even without a diesel or backup system. However, system reliability is improved by utilizing hybrid Solar and battery systems, but at higher cost.

This field has a large potential for unique product development for southern Africa. The current state of intermediate technologies would benefit from the inflow of foreign high-tech ideas, which could be made useable by South African engineers for the specific conditions found here. A possible application of remote full-converter wind turbines to raise the available power in rural electrification schemes utilizing Single Wire Earth Return – SWER may be a possible area of research.

➔ It is recommended to develop from the start the field of remote wind power + hybrid applications. This field has a large potential to develop local intellectual property, which may find a market in many African countries. As certainly a number of other research entities are active in this field a coordination is required from the government side.

C.2.3.9. Other Areas

Design review and analysis

Customer:

Turbine Manufacturers or foreign certification bodies

Priorities: **Low**

Description:

Provide industry players with design reviews, analyses and technical assistance. Design review and analysis ensures that product is in compliance with the applicable international standards. It also helps to reduce the risks of wind farm development and ensure market acceptance for wind turbine technologies. Available software programmes will be of help to enable this, such as: ADAMS, GH Bladed, FLEX, etc. It may also provide technical services to solve specific technical problems known as troubleshooting.

These type of services will only find a market if there is a sizeable wind industry of its own and will in the next 5 – 8 years not be demanded by local industry. However, the development and maintenance of the expertise including the use of these softwares should also be known to engineers in SA.

➔ It is hence a political / strategic decision to develop these services at an academic or research level. Alternatively, cooperation with a foreign partner may be interesting.

Wind Flow & Wind Turbine / Farm Modelling.

Customer:

Turbine Manufacturers, developers

Priorities: **Medium**

Description:

Provide and support the wind industry with state-of-the-art analysis capability by using advanced design tools. For the wind turbine design or design verification, appropriate application of realistic models that simulate the behaviour of a wind turbine in complex environments (such as, gusty winds, extreme wind condition, etc) have to be used.

They model the effects of turbulent inflow (or in complex terrain), unsteady aerodynamic forces, structural dynamics, drive train response, etc. and will be of great help in the design or wind farm planning. Usually a combination of CFD-Models like WINDSIM and the softwares mentioned in the previous chapter are required.

For the full scope of these services the same assessment as in the previous chapter is true: so there will be little demand in the next 5 – 8 years.
However, the terrain assessment by means of CFD software and comparison with design assumptions may have some realistic market potential once more complex wind sites will be used. In addition is a CFD calculation often part of a site calibration for Power Performance measurement and this should also be known to engineers in SA.

➔ It is hence recommended to develop at SAWEC the capacity for the analysis of wind fields in complex terrains and the general use of CFD software within the next 4 years.

Energy storage application

Customer:

Research projects

Priorities: **Low**

Description:

Short term forecasting could mitigate the negative effect due to wind natural variation brought to the grid operator. Though when wind farm grid penetration is very high, other measures will need to be used to help to ensure the system stability and safety, energy storage projects combing with wind farm projects would be a good approach. But what type of storage to be implemented is subject to further investigation. Hydro plant which is widely used for regulating the power stability is limited only in hilly area where there are water resource; battery application is either expensive or with low recharge cycle, CAES (Compressed Air Energy Storage) is subject to big sealed cavity under the ground (normal approach), etc. The Research Centre would collaborate with *Peaking Generation* of ESKOM on finding proper solutions and try to support an accelerated realization.

Study on novel and state-of-art technology

Customer:

Research and academic projects

Priorities: **Low**

Description:

The SAWEC Research Department shall keep tracking the innovation in wind technology and stay in front curve of the industry, such as novel blade design (new material application, assembled blade, etc), novel tower and foundation design, reliable gearbox design, new drive train design, and new grid friendly features. All these might be capability reserve of serving the future industry, and collaboration with other organization might be required to share equipment and know-how, such as wind-tunnel test for the blade aerofoil, etc.

The responsibilities in this field would include the transfer of the above state of the art technology and latest research to the universities so that the young generation of engineers has a chance to quickly close the gap to international levels of expertise.

➔ SAWEC Research Department should have a role in teaching at university. It is recommended that the SAWC functions are taken up part-time by Professors of related universities and that thesis and dissertations can be done at SAWEC.

C.2.4. SAWEC Test and Certification Unit

C.2.4.1. Introduction

The testing of wind turbines is a service which would in the institutional-setup of the centre be located in the Services and Applied Research Department. However, it needs to have its own administrative unit, as the accreditation as a measurement laboratory according to IEC 17025 has certain requirements, which do not need, or cannot be met by the whole organization. This also relates to the personnel in charge of testing, which regularly needs to demonstrate their competence for performing testing services.

Relating to the certification of wind turbines we suggest that a SAWEC should at an appropriate time - after consultation with ESKOM and SABS - only develop certification services for "*electrical grid compliance*" of wind turbines and specifically wind farms. The general *type certification* of turbines should most likely be left to the experienced international certifiers e.g. GL, DNV, DEWI, TUV etc. as the small market size in South Africa compared to the efforts to become an internationally recognized certifier does not justify such a development. Cooperation with these organizations could be a useful compromise.

a) Staff

A wind turbine test centre needs administration staff, engineers and technicians. The latter two groups would most likely share their work time with projects in the general services unit of the centre. The required background of people is quite wide, including mechanics, electrical, physics and acoustics, etc.

b) Facility

The test centre needs (expensive) measurement equipment. A wind tunnel is useful for research and calibration of anemometers, but could be used part-time at universities. Drive train test-bench, blade-test facility are also options but as mentioned above will most likely not be developed locally due to limited market demands.

c) Test site

Most test centres in the world have their own test site. Manufactures can install their wind turbines in the test site for testing and R&D work. However, off-site testing is getting more and more popular in recent years. We elaborated on this already in Chapter *B.4.2.5 Remarks on Klipheuwel Wind Energy Demonstration Facility (KWEDF).*

C.2.4.2. Tasks and Activities

The main task of a test centre in SA would be to provide measurement services to wind turbine manufactures and ESKOM to technically characterise wind turbines (with non-standard components). The appropriate measurement contents are shown below.

Here are some examples of important aspects:

The main contents of wind turbine testing are

- Power Quality IEC 61400-21
- Grid Compatibility – local grid code
- Power Performance IEC 61400-12
- Acoustic Noise IEC 61400-11
- Mechanical Load IEC 61400-13

Power Quality testing will test the wind turbine output current and terminal voltage, then calculate the flicker coefficient, flicker step factor, voltage change factor, current harmonics, inter-harmonics and higher frequency components, etc. These are very important when the wind turbines connect to the grid and provide power to consumers. The local grid operator will set the locally permitted values and the test-institute performs the test according to the internationally recognized standard IEC61400-21

Grid Compatibility testing provides the grid operator with the information to assess whether a wind turbine or rather the wind farm will comply with the local grid code. It becomes very important especially once a rapid growth of capacity of wind power has to be integrated into the grid. Wind turbines will need to stay connected during grid voltage disturbances as a sudden disconnection of several hundred MW of generating wind turbines would be very problematic for the grid stability. Hence modern wind turbines need to undergo *Fault Ride Through* testing for Low- and High-Voltage conditions (LVRT and HVRT testing). If the wind turbine does not have this FRT capability, the wind turbines will cut out when grid transient fault occurs. FRT testing will ensure that turbine manufacturers are only installing wind turbine and components with up-to-date technology to meet the grid code requirements.

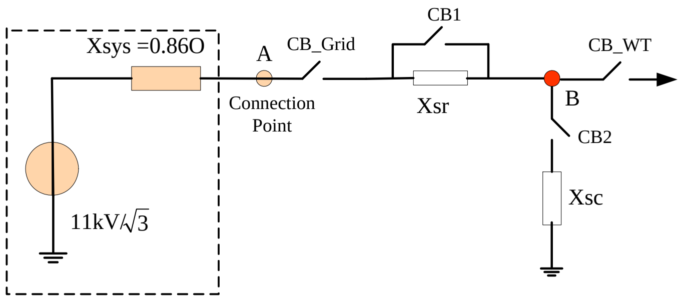


Figure C-1: Equivalent Circuit of LVRT Test Unit

As it is technically not possible to test the FRT-behaviour of the full wind farm, it is required that each new type of a wind turbine has to undergo a FRT test according to the limits set by the grid operator. The behaviour of the full wind farm at the point of common coupling PCC is then calculated by means of a *wind-turbine-model*, which has been validated by means of the FRT Test (the independent verification of wind-turbine-models is an important service for the grid operator; see below).

Grid Compliance Certification for a turbine is provided by a test-institute based on the verification of the above explained *grid compatibility* test-results and *wind-turbine-model* in relation to the grid-code / standards defined by ESKOM / SABS. A turbine certification certificate is a prerequisite for the grid-connection-application of the developer, as this application needs to be accompanied by the calculation results on the compliance of the whole wind farm with the grid-code.

Power Performance testing will give the results of a wind turbine power curve, power coefficient and annual energy production. These values can evaluate the output power of the wind turbine and are essential for investors and banks. It is recommended to develop a power curve retesting services (see chapter B.2.4.4 right from the beginning.

Acoustic Noise testing will test the noise from wind turbines, get the apparent sound power level, 1/3 octave band levels, tonality of the wind turbines. These values are provided for environmental noise influence evaluation from wind plant.

Mechanical Load testing provides frequency spectra, load spectra and equivalent load of wind turbine. This testing is necessary to measure the loads, which enter the safety and lifetime calculation in the type certification process. There are also additional loads to be taken into account because of the wind turbine FRT-requirements.

d) Possible customers and market chances

The demand for tests will develop gradually with the introduction of locally produced components – most likely rotor-blades first and once turbines are assembled locally.

The possible customers of a test centre are wind turbine manufacturers, grid operator, wind farm operators, financing institutions (power-curve re-test) and maybe component suppliers.

- In planning for a test centre in SA, many tasks need to be completed and it might be advisable to decide on a step-by-step approach instead of a full wind power test centre right from the beginning.
- The decision on the right test-site is very important for the financial viability of the test centre as it is in the interest of manufacturers to get their results quickly and for the centre to receive payment for their test services in a short time. A site with low wind resources might be unpredictable ever experiencing the wind conditions to verify the design according to the relevant IEC standards.

C.2.5. Policy Support &Public Awareness

Since SAWEC is considered to play a coordination role with the stakeholders involved in RE, it makes sense for SAWEC also to focus on policy support and awareness building.

When closely coordinating with the relevant stakeholders SAWEC will become a certain information hub for wind energy in South Africa, bringing together relevant information or, at least, having access to information and knowledge and information carriers.

As knowledge & information hub consultancies could be provided to decision makers of the government – either on a regularly basis or case to case – be it by using in-house expertise or by hiring short term experts for specific purposes and topics.

Policy advice could cover the whole range of issues related to wind energy – be a clean energy resource, its impacts on the economy, potential job creation, etc.

Furthermore, SAWEC could take a role in public awareness building. Countries where renewable energies have taken already a substantial share in the energy mix of the country (e.g. Germany, Denmark), the development towards green energy – including energy saving – was strongly driven by an increasing awareness of the public about the necessity of using clean and renewable energy sources. This public opinion fostered the development of the legal framework and facilitated the acceptance of higher prices for "green electricity".

The necessity of publicity for renewable energy is also given by the fact that wind energy integrated in the electricity grid might possibly lead to an increase of the electricity tariffs, provided the utility is in the position to save costs otherwise thus balancing higher wind electricity costs. Awareness campaigns might help to generate the acceptances of the public.

The envisaged SAWEC department for this task could start at the beginning with one qualified (local or international) expert, who carries out mainly a coordinating role of purchasing short term experts to work on specific requested topics. Depending on the necessity and acceptance of SAWEC as RE energy consulting entity expansion of staff could be considered in a later stage.

C.3. STRUCTURE OF SAWEC

The organisational structure is mainly determined by the tasks, which shall be performed by SAWEC and which have been outlined above.

For those tasks, which are connected to testing and certification and require an independent assessment in order to receive international certification according to IEC 17025, it is highly recommended to establish an organization with a status independent of the SAWEC training activities. The reason being, that training will be done in cooperation with the wind power industry and the certification rules require that a test-institute is independent from influence by companies being involved in manufacturing of items being tested at the institute.

Also from a business perspective and partner constellation a separation into two legal entities may be advantageous.

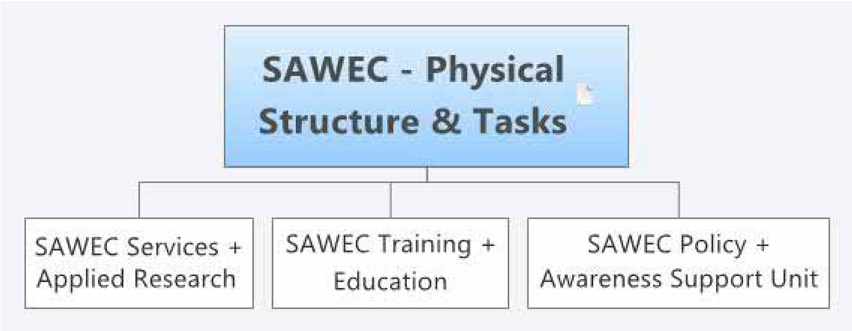


Figure C-2: Basic structure of SAWEC

C.3.1. <u>SAWEC Services + Applied Research</u>

In our experience it is advantageous to setup working units for activities which have specific working requirements or as in the case of the wind turbine test laboratory are governed by state regulations concerning accreditation and quality management.

This department should have Units for:

- Wind turbine testing
- Certification of wind turbine grid compatibility
- Applied research
- Consulting services

It would closely cooperate and participate in the engineer training activities of a SAWEC.

Testing Lab IEC 17025 for IEC 61400 measurements

The composition of the different testing tasks requires a wide span of technical expertise. For a gradual setup of this business unit, the following order of development is suggested:

1. Power Quality + LVRT (in case different from European Standards)
2. Power Performance (required with local rotor blades)
3. Noise (may be required with local rotor blades)

The following test-services could be developed later

4. Load
5. Test-site (off-site-testing starting early together with task 1.)

Certification

Basically we recommend to develop the certification of grid compatibility.

Even this task should only be started once it is clear that the ESKOM Grid-Code / SABC standards for wind farm connection is considerably different from other European Codes and would require a retesting of a turbine, which has already been tested in Europe. For locally produced turbines, or those with major local components, it could be necessary anyway (different converter, generator, may be rotor blades – a design verification by the certifier for the type-certificate would decide about this).

Project Certification[50] is today more frequently required by project financing banks (see page 42, Chapter B.2.4.3 Project Certification). However, this service will require many years of experience and we expect that this may only be done in cooperation with an experienced certification body - e.g. German Lloyd - as a partner.

Turbine Type certification is not realistic for the same reasons, but again cooperation opportunities may arise.

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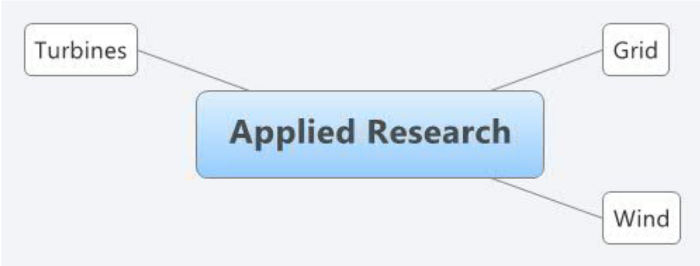
[50] See: http://www.gl-group.com/en/certification/renewables/CertificationGuidelines.php http://www.gl-group.com/pdf/Type_and_Project_Certification_GL_Woebbeking_2009.pdf

Applied Research

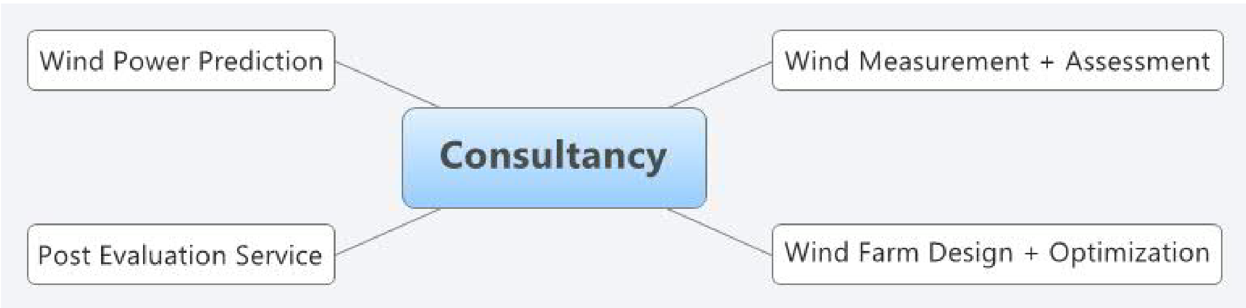


The applied research will have a wide scope and we expect that it will often be done in cooperation with institutes / companies not directly involved in SAWEC.

The main research areas may first be related to specific South African subjects like wind power in remote regions or hybrid system application. We do not see any need to replicate basic research already under way abroad or at other establishments in South Africa. The Applied Research subjects should be tightly coordinated with the CSIR.

The development of numerical weather prediction models for southern Africa may be a task, which will generate income in the future, as it is the basis for the “wind power prediction services” – without this data it would need to be bought from foreign providers.

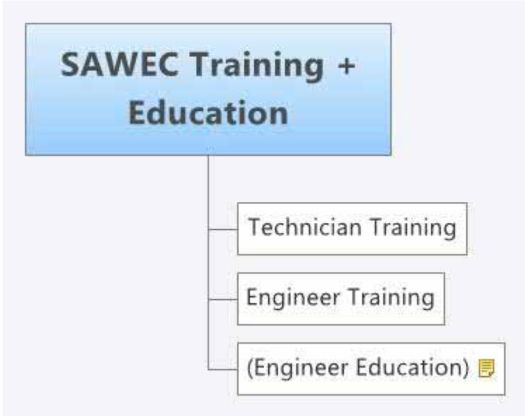
Consultancy



The following main units in the consultancy department would be required according to the tasks we defined in the last chapter.

- Wind Measurement + Assessment
- Wind Farm Design + Optimization
- Wind Power Prediction
- Post Evaluation Service

C.3.2. SAWEC Training + Education



The working tasks of this Department or independent entity is the

- Technician Training and
- Engineer Training

Engineer Education is usually best left directly to Universities. However, as there will be some sharing of staff some interaction in the form of student research projects or dissertations are important for SAWEC.

With the envisaged role of SAWEC as a national coordination centre for all matters concerning wind power training and education as well as being a contact point for any information concerning wind power in South Africa, it is very important to give SAWEC a formal role on these matters.

Technician Training

This unit will offer training courses according to curricula and training materials specifically adapted for the South African situation.

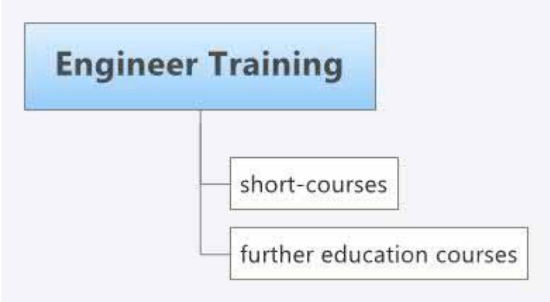
Turbine Training (as part of the technician training)

The training with real wind turbines is very important for the acquisition of practical experience. As already explained in chapter C.2.1.2.4 we put the preference on training measures implemented at a turbine in the workshop – usually referred to as test-bench. Additional specific courses may be held in a real wind farm e.g. Klipheuwel.

Special facilities for safety training with ladders, ropes and safety belts need to be established. A tower > 25m is required to train the rescue of injured workers from wind turbines.

Engineer Training

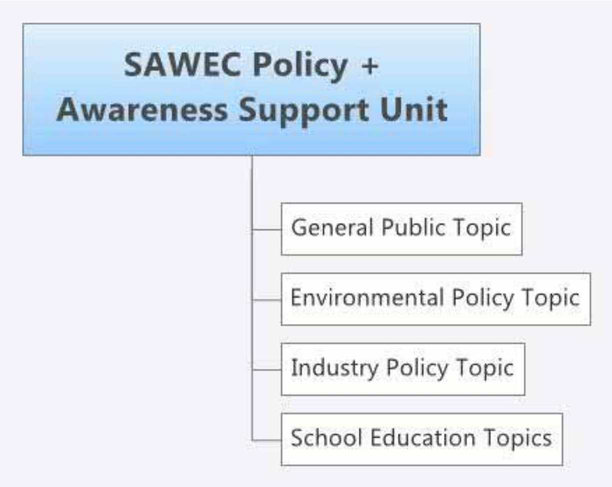
The training of engineers could be a major task of a SAWEC, where the staff involved in testing, services and applied-research as well as external trainers from university and industry would offer trainings to interested parties, e.g. up-skilling of professionals in specific areas (for instance the areas described un C.2.3 and C.2.4 via expert short-courses).



(Engineer Education)

Engineer Education in contrast to Engineer Training is the formal process of educating young persons at University level. This is in our opinion best done directly by the universities. However, in order to enhance the practical experience of students, a SAWEC could offer short training courses, which are open to students (to anybody), offer internships, safety courses at wind farms and courses on specific subjects, which could count towards the required credits for a degree at the university. This entails offering a site for practical training, demonstration and real world data gathering and analysis.

C.3.3. SAWEC Policy + Awareness Support Unit



We see the possible function of SAWEC as arranging and launching public awareness campaigns - an activity which is primarily done upon request of the government. As mentioned before: Integrating renewable energies will - among others - lead to changes in the electricity tariffs. The consumers will need to be prepared for price increases, which will require not only a short-term oriented awareness campaign. Since the very low tariffs in S-Africa will have to be adapted in several steps, several or continuous campaigns will be necessary to meet acceptance of the electricity consumers (and to avoid political unrests). A long-term oriented awareness campaign strategy will be advisable to care for awareness of a “green future”. All parts of the society should be addressed - starting from campaigns in schools.

Public awareness is nothing, which arises out of nowhere. Actions need to be taken by the politicians, implementation could be done by SAWEC.

Coordination will be necessary with other stakeholders, like SAWEA. It is however understood by the Mission that SAWEA is a strongly industry oriented association, and, accordingly, might have a different approach in this matter.

The following figure shows the complete structure of the SAWEC.

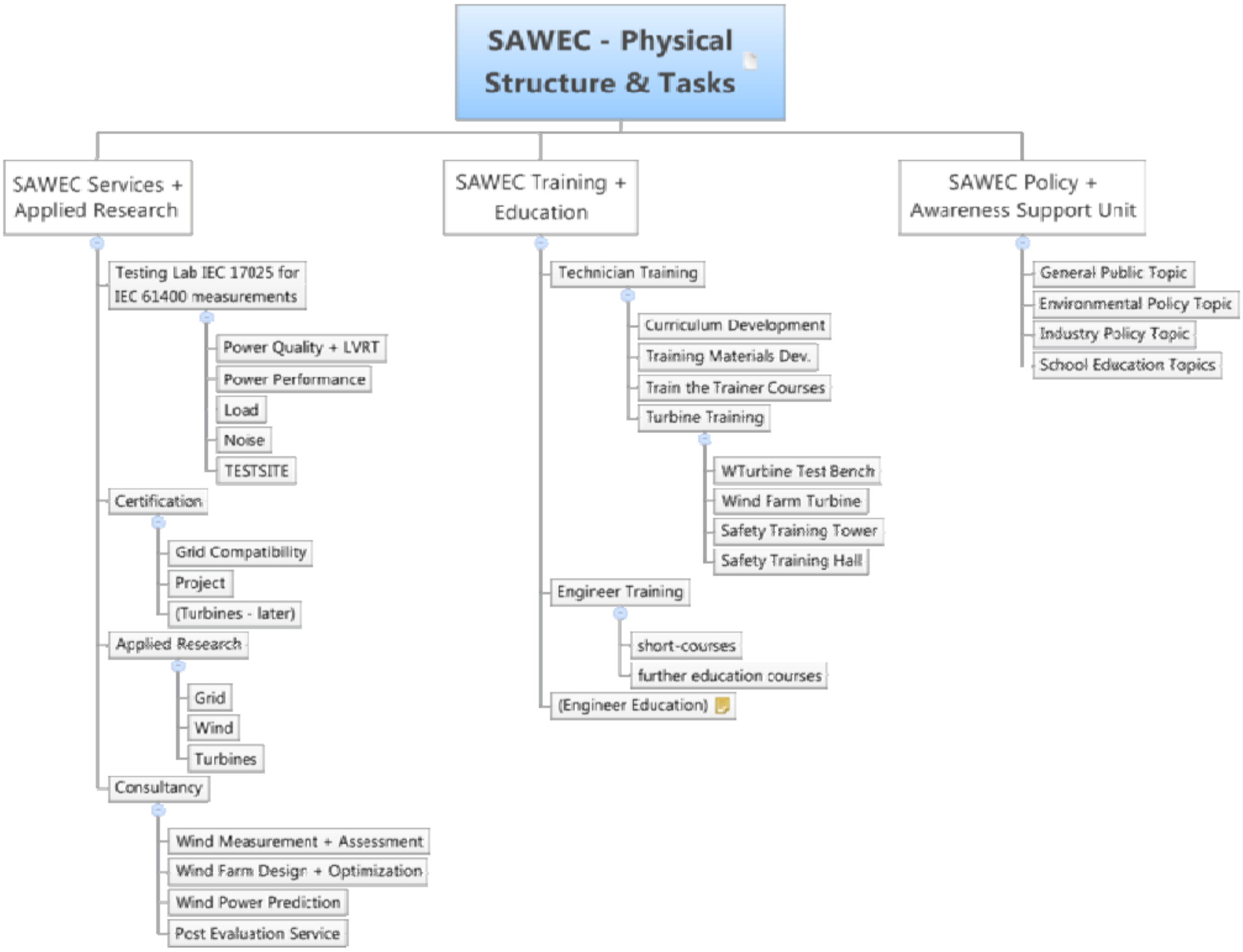


Figure C-3: Complete Structure of SAWEC

C.4. STAFF OF SAWEC

In the following we present estimates on the requirements for the type and quantity of staff required to setup a SAWEC.

These estimates are based on the following assumptions:

1. SAWEC will not undertake training of technicians with its own staff, but will coordinate and sub-contract with external training entities - most likely FETs and CPUT
2. SAWEC will develop training materials for technicians and engineers based on “best-practice” from Europe.
3. SAWEC will offer engineer training on its own account
4. Teachers / lecturers for training are part-time active in the SAWEC Services and Applied-Research Unit
5. Testing is only developed for Power Performance and Power Quality / LVRT
6. Wind Measurement services are a major activity
7. Power curve verification services will be developed
8. Wind resource assessment and wind park planning services are offered
9. Applied Research is developed gradually and includes wind power prediction
10. Power Prediction will be offered as consultancy service
11. The SAWEC Policy + Wind Power Awareness department is implemented and run by an external partner with government baseline funding – therefore only limited staff inside SAWEC are required

The estimates on the following pages are based on historic planning data of DEWI Deutsches Windenergie Institut (German Wind Energy Institute) and were adapted in 2004 to the specific planning conditions for the China Wind Power Centre.

We are aware of the fact that the local conditions in South Africa are different and that the staff requirements can only be estimated based on discussions with the involved stakeholders, after the operation concept has been decided.

Initial Staff Requirements for a SAWEC part 1 (Draft)

	Unit	Jobtype	Qualification						
			Prof	**PhD**	**Admin**	**MSc**	**BSc**	**Techn**	
SAWEC	**Management**	President	0.5						
	Secretariat				1				
	IT						0.5		
	Finance				2				
	PR					1	1		
	other						1		
	Total		**0.5**	**0**	**3**	**1**	**2.5**	**0**	**7**
Services + Applied Research									
	Management	Director	0.5						
	Secretariat				0.5				
	Finance				0.5				
	IT					1	2		
	Testing Lab	Head		0.5	0.5				
		PQ expert				0.25		0.5	
		PP Expert				0.5		2	
		Quality Expert IEC				0.5		1	
	Certification	Head		0.25		0.25			
		Grid Engineer				1			
		Quality Management				0.25			
	Applied Research	Head	0.5		0.5				
		Physicist		1		1		1	
		Meteorologist				0.25			
		ET-Engineer				0.5	0.5	2	
		Energy Economy		0.25					
	Consultancy	Head		1	0.5				
		Geographer				0.75	1		
		GIS				0.75			
		ET-Engineer					1	3	
		wind measurement				2	1	4	
		Environmental Expert				0.5		1	
	Total		**1**	**3**	**2.5**	**9.5**	**5.5**	**14.5**	**36**

Table C-2: Initial SAWEC Staff Requirements part 1

Initial Staff Requirements for a SAWEC part 2 (Draft)

Unit	Jobtype	Qualification						
		Prof	**PhD**	**Admin**	**MSc**	**BSc**	**Techn**	
SAWEC Training + Education								
Management	Director				1			
Secretariat				1				
Finance				0.5				
IT						0.5		
Course Coordination	Didactics Training Expert					1		
Technician Training								
	Curriculum expert				1			
	Training Material Expert				1	1		
	Course Designer				0.5	1		
	Safety Course Expert					1	3	
Engineer Training								
	wind farm grid planning					0.5		
	wind resource assessm.				0.25	0.5		
	wind farm planning				0.25	0.5		
	EIA				0.5			
	Wind Measurement					0.5		
General Training								
	Policy		0.5					
	other					0.5		
Total		**0**	**0.5**	**1.5**	**4.5**	**7**	**3**	**17**
SAWEC Policy + Awareness								
Management	Director	0.25						
Secretariat				0.5				
Finance				1.125				
	Government Relation				0.5			
	Energy Economist		0.25					
	Sociologist / Policy Exp.		0.75					
Total		**0.25**	**1**	**1.625**	**0.5**	**0**	**0**	**3**
							TOTAL	**63**

Table C-3: Initial SAWEC Staff Requirements part 2

C.5. LEGAL STATUS

C.5.1. Organizational Options

The Mission discussed several options of a possible legal status of the SAWEC centre. The basic options considered are to have SAWEC as

1. a private limited liability company
2. an entity which is organized as a so called Section 21 company

or

3. as an entity/ a department which is integrated into one of the governmental entities already concerned with RE issues

All the three options considered have pros and cons.

Figure C-4: Possible SAWEC Institutional Links

In case SAWEC should be organized as a private entity (1), it could offer and sell its services on a very independent basis to all stakeholders – public entities, private entities, as there are developers, manufacturers, service companies. Hampering this approach are currently several issues. The major issue is that the commitment of the government to develop wind energy was not yet followed by systematic implementation measures - beside IRP, REFIT. Accordingly, potential investors will be reluctant to invest in SAWEC. Furthermore, it might take some time for a newly established company to be accepted by the market in case of not having a strong back-up by stakeholders which are before and currently already working on wind energy issues.

Similar problems might occur also for the Section 21 option (2). However, it might be considered as an option, provided relevant stakeholders will be prepared to join as a member and to bring in expertise, management and willingness to closely cooperate. A respective statute needed to be prepared by lawyers based on the law of South Africa.

Based on the information gathered during the Mission we prefer option (3) – having a governmental entity hosting the SAWEC, closely coordinated with other stakeholders in the RE area.

The advantage of this option would be that the entity is already recognized as an important stakeholder in RE in South Africa. Furthermore – a clear commitment of the Government provided – it will have direct access to the ministry/ministries thus having a stronger influence on governmental decision making than a small private consulting company or a Section 21.

The risk of this option would be a limited willingness of other stakeholders to accept the designed hosting entity. However, giving the commitment of the government, measures can be taken to strengthen the position of a SAWEC, which is attached to a governmental entity. This entity may be provided with a dedicated responsibility for the development of wind power, by channelling study / research projects through SAWEC (which is forwarding these studies to the other stakeholders having already respective knowledge and expertise) or allocating the tasks to launch specific awareness campaigns.

A Board of Directors and an Advisory Committee consisting of different stakeholders will have a guiding role and controlling function. Responsibilities need to be clarified and fixed.

Based on the meetings held in course of the mission, we consider SANERI / SANEDI as a promising candidate for hosting SAWEC. During the meeting it has been indicated that due to the foundation of SANEDI the role and resources of SANERI will increase. SANERI/SANEDI has – via the Energy Act – the legal mandate to promote, coordinate and carry-out applied research, training and product commercialization in the renewable energy sector. Furthermore, SANEDI is linked to the Department of Energy thus having direct access to decision makers in the energy field and from there close linkages to other relevant ministries (trade, industry, science, etc.). GreenCape could be a suitable institution to drive the establishment of SAWEC at a provincial and day-to-day basis in cooperation with relevant education institutions (universities and FET colleges) and initiatives in other provinces (e.g. the Eastern Cape). These are only indicative suggestions; the institutional set-up should be decided on by South African stakeholders as a function of commitment, mandate and resources of the relevant institution(s).

It has to be noted that also the wind energy centre in China, when established with the support of GIZ, was linked to a semi governmental entity. This was at that time the China Electric Power Research Institute (CEPRI), belonging to the China Electricity Corporation, which was until 1997 the Ministry of Electricity (then renamed and reorganized as a state owned corporation). This ensured that the newly established wind power centre in China was directly linked to a high central entity having comprehensive decision-making power or at least access to decision makers on a ministerial level.

The Chinese government decided to establish the Centre besides with CEPRI also with a strong player in the field of electricity, Longyuan Corporation. This is also a state owned company and was expected to ensure that the industry takes over an important role within the wind centre thus ensuring that the Chinese wind centre follows not only a research oriented but a practical oriented approach by meeting the demand of the industry. The bottleneck of this concept however is, that Longyuan Corporation became the major player in wind energy in China. As partner of the wind centre it controls access of other players to services and trainings and hence limits the outreach of the facilities of the wind centre to outsiders. A similar development should be avoided when establishing the SAWEC.

C.5.2. Partners, Board of Directors, Advisory Committee

During the Mission we identified a number of stakeholders already somehow active in the wind sector in South Africa – governmental entities or subordinated institutions, universities and industries. As indicated already above, also the governmental entities seem to be not coordinated, mandates seem to be not very clear. This is, again, the impression of the Mission, gathered through the meetings. We do not exclude that this impression might not be correct.

As elaborated in the minutes of the different meetings (see above) interest to cooperate and/or to support was indicated by all the entities. As far as the universities are concerned, there are universities in other cities of South Africa, which are having some activities in the wind sector as well. These entities also need to be contacted in order to find out their willingness to support.

Those entities that are finally willing to directly contribute to SAWEC would have the role as a partner of SAWEC. Contributions could be for example to make workshops or laboratories available for training issues. The tasks, responsibility and rights of the partner would be determined in bilateral agreements with the respective partner.

Compensation of contributions, balancing of cost relevant issues, etc., will need to be clarified in the agreement.

These partners who finally confirm willingness to strongly and continuously support SAWEC, could be organized in a **Board (of Directors) of SAWEC**. Board meetings could be held twice a year in order to have a balanced approach of the management of SAWEC. During the start-up phase more meetings might be reasonable.

In addition, an **Advisory Committee,** which includes also stakeholders from the industry (manufacturers, consulting companies or other related services) could act as an representative of a larger scale of stakeholders contributing to SAWEC's overall focus of work, also by advising about new curricula and/or service facilities to be developed by SAWEC. The Advisory Committee should meet at least once a year or upon request of the Board.

The Board of SAWEC is – based on our current knowledge of the situation in South Africa - suggested to consist of members of SANEDI / SANERI, DST, DoE, provincial Governments (like Green Cape), CSIR, Stellenbosch University and possible other universities with a relevant current or future stake in wind issues as well as those FETs, which are direct partners of SAWEC.

A statute with the tasks, responsibilities and rights of the Board and its members needs to be developed. The Board will be responsible to decide for a platform for the Advisory Committee.

As indicated before, this is only a recommendation based on the information gathered during the mission that needs to be discussed among the potential stakeholders. The common interests need to be clarified and then next measures for implementation to be taken.

C.6. COST FOR CENTRE HARDWARE

We already mentioned many hardware items that would be required to establish a fully functioning SAWEC with its training and technical departments and units.

In the following, we present the full list of main items that should be procured for test and research facilities.

Equipment	Sector	
	training	research & service
Measurement and Analysis of Wind Resources	16,000 €	52,000 €
Planning and Design Technology of Wind farms	24,200 €	22,400 €
Wind turbine Performance Test Technology	22,500 €	62,500 €
Grid integration - simulation - LVRT	595,000 €	595,000 €
Establishing a National Data Base for Wind Farms	5,000 €	5,000 €
Wind turbines Load + Design-Test	50,000 €	325,000 €
Operation simulators + SCADA	25,000 €	1,000 €
Practical training	55,000 €	8,750 €
Office requirements	87,250 €	89,500 €
Laboratory requirements	202,500 €	155,000 €
Sub-total	**1,082,450 €**	**1,316,150 €**
	Total	**2,398,600 €**

Figure C-5: Summary Table for Cost of Hardware for Engineer Training + Services & Research

A detailed item list has been prepared for GIZ.

Statement on Equipment Costs for Vocational Training

The Chinese model of a "stand alone training centre" run by a company in the sector gives an approximate view of the expected costs. The investments for the “LongYuan Bailu wind power vocational training Centre” amount without the building to approximately:

Hydraulics laboratory (10 didactics stands by Festo) for 20 persons	4,000,000	ZAR
Pneumatics laboratory (10 didactics stands by Festo) for 20 persons	2.000.000	ZAR
Electrical engineering laboratory for 20 persons	300.000	ZAR
Tools	100.000	ZAR
Equipment (components etc.)	1.500.000	ZAR
850 KW wind turbine converted	10.000.000	ZAR
Other costs	10.000.000	ZAR

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D. ANNEX

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Annex 7: IMWatT Curriculum Wind Power further Training (German)

Annex 8: WindSkill Example Job Description

Annex 9: Draft Feasibility Statement on LVRT Measurement of Wind Turbines in Klipheuwel Wind Farm

Annex 10: Potential Corporate Forms for the Establishment of The South African Wind Energy Centre (SAWEC)