

WIND ENERGY IN THE WESTERN CAPE:

Examining the role of carbon finance in the development of wind energy projects



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Date 28 Nov. 2006.

Rebecca White

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EXECUTIVE SUMMARY

*"The answer, my friend, is blowin' in the wind,
The answer is blowin' in the wind."
(Bob Dylan (1962), 'Blowin' in the Wind')*

The Western Cape is at an interesting juncture with regards to wind energy. There are several projects at implementation or planning stage – large scale, small scale and micro-wind projects. There are significant problems within the current electricity supply industry (ESI), which is reliant on coal-fired electricity generation in Mpumalanga and some power plants in the Western Cape. The ESI and electricity distribution industry (EDI) need reforming, and processes have been set in motion to establish six new Regional Electricity Distributors (REDs) – RED One is based in Cape Town. There is also growing energy demand and a continuing government commitment to electrification for all.

Wind energy projects could help to meet demand and ease problems of supply. The costs of wind energy project development are falling globally, but they remain high in comparison to conventional fossil-fuel powered generation, such as coal.

Furthermore, South Africa has high levels of carbon dioxide (CO₂) emissions per capita. CO₂ is one greenhouse gas (GHG) which contributes to global climate change. Wind energy projects could be used to mitigate the environmental costs of coal-fired electricity production, by replacing some conventional capacity. South Africa is a signatory to the Kyoto Protocol, which is an international agreement to reduce GHG emissions. Although South Africa, a Non-Annex I country, does not yet have a target to reduce GHG emissions, it can trade its emissions with capped (Annex I) countries. The Clean Development Mechanism (CDM) offers an opportunity to gain revenue from carbon emissions reductions (CERs) through such carbon trading. Internationally, wind power projects rank third out of twenty three in terms of the number of projects in the CDM pipeline.

The Western Cape is a case study that allows the relationship between wind power and the CDM to be explored. This research considers whether carbon trading can help the financial viability of wind energy projects. CER revenues are shown to make a positive difference to the financial viability of wind energy projects. The revenues can reduce required bulk electricity tariffs by 7-8c/kWh, which brings the cost of wind energy closer to that of coal-fired electricity generation.

Recommendations from the research include:

- CER revenues could make green electricity more attractive to consumers by reducing the premium paid for electricity from wind energy projects.
- If wind can compete with conventional supply during peak hours, through system management of variability, consumers are more likely to consider purchasing green electricity.

- Greater public awareness could raise demand for renewable energy, creating a willingness to pay a premium for green electricity.
- Experience with wind should reduce the perceived risks of wind energy projects. Hence there should be investment in demonstration projects.
- Advice and support for projects at a provincial and local scale is needed.
- Small scale wind energy projects can be bundled to ease the CDM process.
- Micro-wind should be considered. Payment can be offered for avoided use of grid electricity.
- Offshore wind resources and energy potential should be researched further.
- The REFSO capital subsidy could be used to help early wind energy projects cover CDM transaction costs.
- REFSO could establish a form of FIT that sets a price for renewable energy, enabling REDs and municipalities pay a premium for green electricity and distribute it at an affordable price (or at least a smaller premium) to customers. This would be effective now that there is a national medium term target in place. Given the current supply problems in South Africa, an FIT is likely to be a long term target.
- RED One should incorporate renewable energy into its portfolio, setting a target for its share of the energy mix. REDs can negotiate PPAs that allow wind energy projects to be profitable.
- There should be continued restructuring of the ESI to give IPPs easier access to the market.
- The EIA and other approval processes should be eased through the implementation of wind energy strategies and spatial planning in the Western Cape.
- New and accurate wind resource assessments are needed in order to plan for wind in the Western Cape and reduce costs for small scale projects.
- The avoided costs of coal must be reflected in the price charged for electricity to allow alternative forms of energy to compete. An *economic* evaluation of wind would be beneficial.
- Wind should be combined with other RETs to create portfolios of renewable energy that provide an effective energy mix specific to the Western Cape's natural energy resources.

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List of Abbreviations and Acronyms

CaBEERE	Capacity Building Project in Energy Efficiency and Renewable Energy
CCT	City of Cape Town
CDM	Clean Development Mechanism
CEF	Central Energy Fund
CERs	Certified emission reductions
CSIR	Council for Scientific and Industrial Research
CTMA	Cape Town Metropolitan Area
DBSA	Development Bank of Southern Africa
DME	Department of Minerals and Energy (South Africa)
DNA	Designated National Authority
DSM	Demand side management
EDI	Electricity distribution industry
EE	Energy efficiency
EIA	Environmental Impact Assessment
ERPA	Emissions Reduction Purchase Agreement
ESI	Electricity supply industry
EU	European Union
EU ETS	European Union Emissions Trading Scheme
FDI	Foreign direct investment
FITs	Feed-in tariffs
GEF	Global Environment Facility
GHG	Greenhouse gas
ICCTF	International Climate Change Taskforce
IDC	Industrial Development Corporation
IEA	International Energy Agency
IPP	Independent Power Producer
LRMC	Long Run Marginal Cost
NEP	National electrification programme
NER	National Energy Regulator
NFFO	Non fossil fuel obligation
NGO	Non-governmental organisation
NIRP	National Integrated Resource Plan
NPV	Net Present Value
ODA	Official development assistance
PPA	Power purchase agreement
RD&D	Research demonstration and development
RED	Regional Electricity Distributor
REFSO	Renewable Energy Finance and Subsidy Office
REPS	Renewable portfolio standards
RETs	Renewable energy technologies
RoD	Record of Decision
ROs	Renewable obligations
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SDIP	Sustainable Development Implementation Plan
SME	Small to Medium Enterprise

TRECs	Tradable renewable energy certificates
UK	United Kingdom
US	United States (of America)
UNFCCC	United Nations Framework Convention on Climate Change
VOM	Voluntary offset market
WAsP	Wind Atlas Analysis and Application Programme
WEPS	Wholesale Electricity Pricing Structure
WSSD	World Summit on Sustainable Development

1. INTRODUCTION

1.1 Why Wind?

For many centuries, wind was harnessed to pump water or mill grain, but it was only in the late 19th century that electrical use of wind energy became possible. Interest in wind energy was limited as it was expensive relative to conventional grid power. However, the historical precedent of energy emergencies such as World War II and the 1970s oil crisis provided enough impetus to develop wind technology, implement wind farms and use wind generated energy (IEA, 2003). Today, volatile oil and fossil fuel prices have prompted investment in wind energy and other renewable energy technologies (RETs).

RETs, including wind, are promoted as a clean form of energy. This results from mounting concern about climate change, and the link between global warming and burning fossil fuels. The United Nations Framework Convention on Climate Change (UNFCCC) aims to stabilise greenhouse gas (GHG) concentrations in the atmosphere at levels that prevent dangerous climate change, while ensuring ecosystems can adapt, there is food security and sustainable economic development (Article 2 of UNFCCC, 1992). Further, the Kyoto Protocol is now in force, creating targets for industrialised countries (UNFCCC, 1997b). However, the current average target of 5.2% below 1990 emission levels is not enough. 50-70% is needed immediately to make certain CO₂ is stabilised at its present levels (IPCC, 1995). Transforming how energy is produced and consumed will help to address climate change effectively (Winkler, 2005b). Part of achieving responsible climate policy requires governments' commitment to remove barriers to and increase investment in renewable energy and energy efficient technologies (ICCTF, 2005). This includes promoting and developing wind energy.

South Africa has put in place legislation for the expansion of renewable energy, including setting a medium term target. In the Western Cape, current wind atlases show wind resources to be 'good' (Diab, 1995 and CSIR, 2006a), and several wind energy projects are being developed. Rapid expansion, technological improvements and cost reductions in the global wind industry are promoting expansion of wind energy projects elsewhere, especially in Europe. This international experience means wind energy projects can be implemented with some degree of certainty about their outcomes (Banks and Schäffler, 2005).

These factors provide the premise for this research – namely, that wind is a renewable energy resource worth exploiting in the Western Cape.

1.2 Problem Statement

A major limiting factor to developing wind energy projects in South Africa is their cost relative to conventional energy sources – specifically coal. International figures for onshore wind energy suggest that typical costs are 24.7-37.1c/kWh¹ (REN21, 2005). This compares to the average cost of electricity generated by Eskom's power stations, which is just 9.3c/kWh (Eberhard, 2005). Eskom owns more than 95% of South Africa's generating capacity and 90% of its power stations are coal-fired (see **Appendix E**). However the long range marginal costs (LRMC) of coal are estimated to be 25-30c/kWh (Olver, 2005 and van den Berg, 2006), which suggests wind energy could compete against new coal-fired electricity generation in the future.

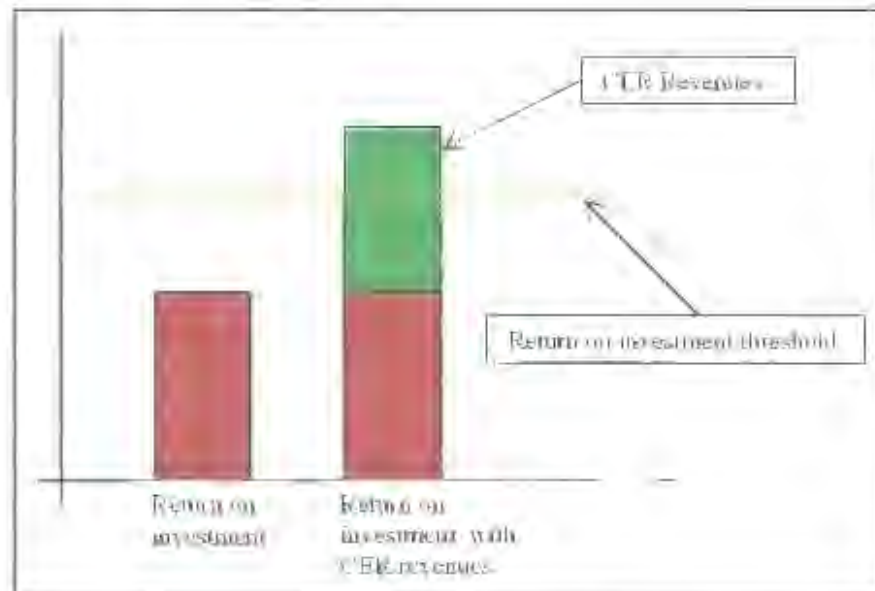
Sales of electricity are not enough to ensure the financial viability of wind energy projects – especially not in South Africa, where electricity tariffs charged for coal-fired electricity generation are very low. The average selling price of electricity, based on total Eskom sales, was 16.04c/kWh in 2005 (Eskom, 2005a). Eskom is not committed to investing in wind energy, although it has established a small pilot project in the Western Cape. Hence, it is the responsibility of private project developers to invest in developing wind farms in the Western Cape. Independent power producers (IPPs) have to negotiate power purchase agreements (PPAs) with buyers. The tariffs offered to IPPs at the moment are too low to make wind financially viable and meet project developers' required internal rates of return (IRRs). Project developers need to find other sources of finance, and the Clean Development Mechanism (CDM) offers one source.

The Clean Development Mechanism (CDM) established under the Kyoto Protocol and international climate change policy can provide an *additional* revenue stream to wind energy projects. Carbon finance describes financing that seeks to purchase greenhouse gas (carbon) emission reductions in order to offset emissions in Annex I countries (World Bank, 2004). In other words, carbon trading under the CDM can provide finance for a wind energy project by paying for the carbon emissions reductions (CERs) that it earns. Hence, the environmental value of the investment provides a second revenue stream (Ecosecurities, 2002).

This research explores the role of carbon finance in the development of wind energy projects in the Western Cape, South Africa. It considers whether CER revenues can make wind achieve its hurdle rates. The overarching research question is therefore ***“Can carbon trading under the CDM help the financial viability of wind energy projects in the Western Cape and what does this signify for future wind energy developments?”*** **Figure 1** is a simple model of how carbon revenues can help the financial viability of a project.

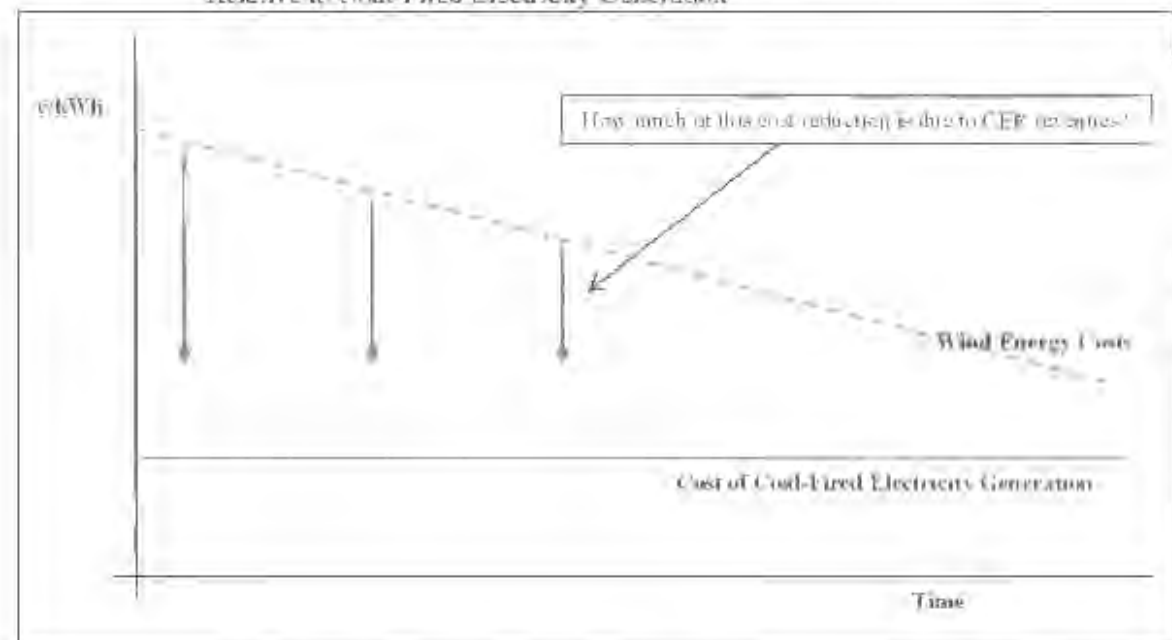
¹ All costs are quoted in ZAR cents per kilowatt hour unless otherwise stated.

Figure 1: How CER Revenues can help the Financial Viability of a Project (adapted from Marrens, 2005)



In a broader sense, this research considers whether CER revenues can reduce required bulk electricity tariffs for wind energy and make wind energy competitive with coal-fired electricity generation – see **Figure 2**.

Figure 2: The Effects of CER Revenues on Bulk Electricity Tariffs for Wind Energy Relative to Coal-Fired Electricity Generation



Section 2 explains how this problem statement is addressed and outlines the research methodology.

2. METHODOLOGY – THE RESEARCH

2.1 Approach

It is important that research questions and methods should 'match' as closely as possible – hence, the methods should follow logically from the questions (Punch, 1998). In this thesis, there is one overarching research question, which informs the entire methodology. Six research objectives structure the study. They are explored through appropriate methods of data collection and analysis. They help to provide answers to the research question.

The study's general research aim is to explore whether carbon finance under the Clean Development Mechanism (CDM) can help the development of wind energy projects in the Western Cape. At a broader level, the research area involves three topics:

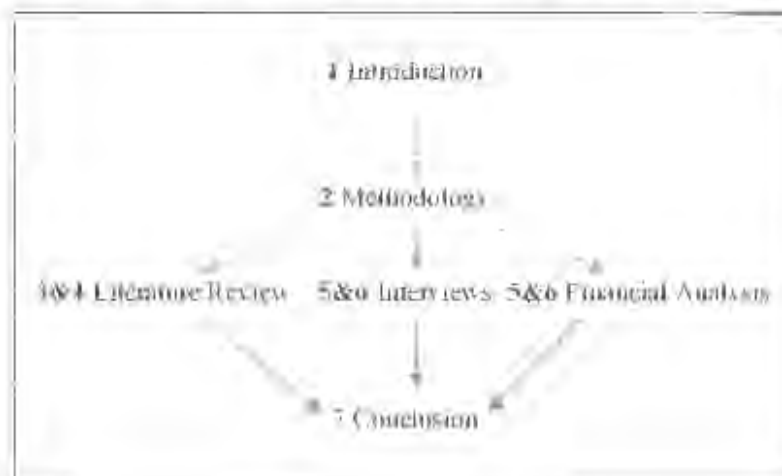
- The potential to harness wind energy
- The financial decisions of project developers
- The role of climate change

There are several wind energy projects in the Western Cape that are at the latter stages of pre-feasibility study. At this point carbon financing can be considered (Ringius et al. 2002). The province has therefore been chosen as a case study area.

The methodological approach is qualitative *and* quantitative. This approach was selected for three reasons (Punch, 1998). Firstly, the qualitative research (literature review and interviews) facilitates the quantitative research (financial analysis) by providing the context and background, and by helping in the formulation of research objectives. Secondly, the quantitative research provides specific data for the Western Cape, which adds to the more general findings from the qualitative research. Thirdly, qualitative research facilitates the interpretation of findings from the quantitative research.

The research model and outline of this report is illustrated in **Figure 3**.

Figure 3: Research Model and Associated Chapter Outline of the Report



2.1.1 Research Question

In order to ensure a good fit between the components of this research, an overarching research question is:

Can carbon trading under the CDM help the financial viability of wind energy projects in the Western Cape and what does this signify for future wind energy developments?

This question provides the framework for the research objectives in **Section 2.1.2**.

The first half of the research question is rooted in a concluding statement of a recent study of wind power projects and the CDM (Ringius et al, 2002). The authors state "...whether the CDM will accelerate the penetration of wind power in the developing world will depend upon how well the net balance of the wind energy costs and the GHG offsets price compares to the costs of electricity generation alternatives" (*ibid*, 2002). In South Africa, the National Integrated Resource Plan (NIRP) states that currently the costs of diversifying the electricity supply away from coal are expensive. The penalties for not diversifying, or the incentives to do so, or the opportunities for emissions trading, therefore need to be substantial in order to offset the economic benefits of continuing to use coal. Such penalties, incentives and opportunities need to be included in future analyses otherwise it is difficult to justify diversification on an economic basis (NER, 2004).

The second half of the question suggests that this research could add to the growing body of knowledge about wind energy and the CDM in the Western Cape, and in South Africa.

2.1.2 Research Objectives

The six research objectives to be examined are:

(1) To examine why wind energy is worth investing in

In order to establish the context for the research, the first objective is to answer: what is the significance of wind energy for the Western Cape?

Recent and future trends in the international wind energy industry and in South Africa are discussed. The energy situation in the Western Cape is outlined together with relevant energy policies and strategies. Since most wind energy projects under development in the Western Cape are grid-connected, the national energy situation and policies are important.

The significance of wind energy is discussed in **Section 3** of the report.

(2) To consider what mechanisms exist to support wind energy and what barriers limit investment

There are several mechanisms that support wind energy projects and renewable energy generally. Institutions providing finance are public and private, regional, national and international. Those relevant to this study are noted.

The introduction of a capital subsidy for renewable energy projects in South Africa is expanded on. In 2005 the Department of Minerals and Energy (DME) established a Renewable Energy Finance and Subsidy Office (REFSO) to manage renewable energy subsidies and advise to developers and stakeholders about renewable energy finance and subsidies (DME, 2005).

As the first subsidy for renewable energy in South Africa it is a positive step towards promoting renewable energy technologies (RETs), including wind. Its potential impacts are considered. These are compared with the carbon trading scenario.

There are also barriers to investment – financial, institutional and technical, as well as public opposition to the development of wind farms. Wind energy projects have high capital costs and barriers to investment are crucial to project developers' decisions whether to exploit wind resources.

Barriers and opportunities for wind energy are considered in **Section 4**.

(3) To identify the financial costs and benefits involved in wind energy projects in the Western Cape

In order to analyse the financial viability of wind energy projects with and without carbon finance, a finance model was developed. This tool is for use by potential wind energy CDM project developers. "Financial analysis is used [by project developers] to evaluate a project and to assist in deciding whether to make the investment" (Spalding-Fecher, 2000).

A cash flow was constructed for the finance model – to reflect the costs and benefits of the project (*ibid*, 2000). In this research two major project costs are considered:

- **Capital costs** – upfront costs of investing in wind
- **Operational and Maintenance (O&M) costs** – ongoing costs of managing a wind energy project

Using only capital costs and O&M costs is an oversimplification. There are several other important costs involved in wind energy projects, especially grid-connected projects. The complexities of integrating wind power into power systems are beyond the scope of this study. However, in the context of wind, three other costs, which form part of the price of electricity that is paid by most end-users, should be considered (Dale et al, 2004): **generating costs** (generation investment costs), which include the impact of wind on the need to establish and/or maintain other generation capacity (backing power); **extra balancing costs** (short run marginal energy production costs) to meet network losses and undertake system balancing, due to variations in demand, generation availability and

wind production; and **distribution and transmission system reinforcement costs**, which relate to network costs (both connection and infrastructure), reflecting the need for new assets and the maintenance or replacement of existing assets as patterns of production and consumption of electricity alter. Furthermore, the type of project ownership affects the project costs. Independent ownership is thought to be more expensive than utility-owned financing (Wiser, 1997).

The major benefits explored are:

- **Bulk electricity tariffs** – paid by the municipality or the Regional Electricity Distributor (RED) to independent power producers (IPP)
- **Renewable Energy Finance and Subsidy Office (REFSO) capital subsidy** – a once-off capital subsidy, R250/kW capacity for electricity projects
- **Certified emissions reduction (CER) prices** – carbon credits, traded through the CDM

Costs and benefits are placed in context, since they change over time. They are examined in **Section 4**.

The internal rate of return (IRR) of a project is a measure of financial viability. A project developer's required IRR (hurdle rate) was assumed – drawing from the literature and interviews – and used as a point of reference. Results from the financial analysis, in the form of IRRs, are compared against the hurdle rate.

The effects of bulk electricity tariffs were analysed, since they impact the financial viability of a project. Avis (2006) suggests that there is only a 10% improvement for wind projects as a result of the CDM, because a project's viability has as much to do with the electricity tariffs as with CER revenues. Findings from the financial analysis of wind energy projects for a range of bulk electricity tariffs and CER prices, and with and without a REFSO capital subsidy, are reported in **Section 6**.

(4) To establish how much carbon revenue a wind energy project in the Western Cape receives

The CDM has established criteria for eligible projects. There is a generic project cycle and a number of accepted methodologies for establishing baselines. Before considering the role of carbon trading using financial analysis, it is essential to calculate the baseline for wind energy projects. Using this, the amount of CERs per kWh² to be earned by wind energy projects can be established.

² Carbon emissions are calculated per unit of electrical output – usually per kWh or per MWh. Hence CERs are given as CER per kWh or CER per MWh.

(5) To analyse whether carbon trading under the Clean Development Mechanism (CDM) can help the financial viability of wind energy projects in the Western Cape

South Africa is one of the world's major emitters of carbon dioxide (CO₂) per capita (DME, 2003). Although South Africa acceded to the Kyoto Protocol in 2002, it is a non-Annex I country (developing country). This means it has *no* quantified emission reduction targets during the first commitment period (2008-2012) (*ibid*, 2003).

However, Non-Annex I countries can provide low cost, CERs to Annex I countries, by trading them through the CDM. Thus Annex I countries can use these CERs to meet their own emission reduction commitments (DME, 2003 and Spalding-Fecher, 2002). South Africa is well-placed to benefit from the CDM as a non-Annex I country and as a country with high carbon emissions per unit of electrical output. Wind energy is one type of renewable energy project which could create CERs.

The role of carbon trading in wind energy projects is therefore important with regards to the financial viability of the project, and also with regards to reducing South Africa's part in climate change. This research addresses the first of these specifically.

Two variables have a significant influence on a project's financial viability by affecting the price of carbon emission reductions. These are (Ringius et al, 2002):

- **baseline chosen** (emission reductions per annum)
- **CER (offset) price** (revenues that can be realised per ton of CO₂)

Furthermore, **transaction costs** affect the financial viability of a project, by impacting on the upfront investment costs. Ranges of baseline values, CER prices and transaction costs (low, medium, high) were considered in the analysis of the role of carbon finance. The baseline and transaction costs change within a small range in a South African context, so the emphasis was placed on the CER price.

The impact of these variables on the financial viability of wind energy CDM projects is explored in **Section 6**. IRRs are used as a measure of financial viability.

(6) To make recommendations for future wind energy projects

In analysing the results and findings of this research, it is useful to make recommendations for the use of carbon finance in future wind energy projects.

2.2 Literature Review

A desk-based, comprehensive study of existing literature forms the basis of this research. The CDM and wind energy are relatively new concepts in the Western Cape, and most experience has been gained outside of South Africa. Access to this experience is through the literature.

Sources that were consulted for the literature review include: journal articles, books, published reports, government publications and grey literature (web documents and media articles).

A literature review was conducted (see **Section 3**) to examine why wind energy is worth investing in (**Research Objective (1)**). The literature review also informed **Research Objectives (2)-(6)**.

2.3 Semi-Structured Interviews with Experts

Interviews were conducted with experts in the industry. The purpose was to gain first hand knowledge of the wind industry in the Western Cape and experience with carbon finance under the CDM.

The findings inform **Research Objectives (2)-(6)**. The interviews were central to establishing the details of wind energy projects and carbon finance in the Western Cape. This was compared with information from the literature. The interviewees were also a source of financial data and a means to confirm present CDM rules and methodologies.

Several interviewees were identified. A full list is provided in **Appendix B**. The interviewees were grouped according to the information that they would provide. Aims were identified for each group, which informed the questions asked:

- **Wind Energy Project Developers**

Aim: to understand developers' financial decisions and to source data for financial analysis

- **Energy Strategists and Consultants**

Aim: to understand opportunities and challenges for wind energy project development in the Western Cape

- **CDM Strategists and Consultants**

Aim: to understand the role of carbon financing under the CDM

At least two from each group were contacted. Five CDM experts were consulted. This was because the CDM is a new and rapidly developing field, and there are wide-ranging opinions. Owing to time limitations and the commitments of experts, not all interviews could be conducted face-to-face or in depth.

The interviews were semi-structured, allowing for a flow of ideas. Detailed notes were taken and are included in **Appendix B** and **Appendix C**. The interviewees' answers are incorporated into the discussion and analysis.

2.4 Finance Model for Analysis of Wind Energy Projects

The financial analysis provides figures to help to explore if and how carbon trading under CDM can help the financial viability of wind energy projects in the Western Cape (**Research Objective (5)**).

2.4.1 The Finance Model Used

A simple finance model was developed in order to gain data for analysis. Several models were identified from the literature – notably EDRC, 2001 and Ringius et al, 2002. These were adapted into a cash flow model, which weighs up the costs and benefits of a wind energy project. An IRR was used as a measure of financial viability.

The premise was to establish what difference CER revenues make to the IRR of a project. IRR is often used to measure the performance of a project, not least because it helps to determine the profitability of an investment (Spalding-Fecher, 2000). The fundamental rule is that investment opportunities should only be accepted if they offer rates of return in excess of the opportunity costs of capital (Brealey and Myers, 2003).

2.4.2 Assumptions and Inputs

Scenarios were developed for comparison:

- without capital subsidy or CER revenues
- with capital subsidy
- with CER revenues
- with capital subsidy and CER revenues

Project data was taken from the **Darling National Demonstration Wind Farm**, which is due to be implemented in 2006 (Oelsner, 2006). Data was used to develop a reference case in order to explore the variables described above (**Research Objective (3)** and **(5)**) and their effects on the financial viability of a wind energy project.

Inputs to the finance model for the reference case are given in **Section 6 (Table 16)**. Findings are discussed in **Sections 6**. Full explanations, including assumptions and calculations, are given in the following sections:

- Wind project performance **Section 6**
- Financial costs **Section 4.1**
- Financial benefits **Section 4.2**
- CDM costs **Section 5.3**
- CDM benefits **Section 5.4**

Some simplified analysis was also done for the **Eskom Klipheuwel Wind Turbine Test Facility**, the proposed **Military Radio Station – Farm Langefontein** and five wind energy projects being developed by a private company (see **Section 6.3.6**). Langefontein is planned to have a capacity of 115MW, and would classify as a large scale CDM project. The effects of economies of scale are commented on, although in reality, large scale project finance is too complex for the simple financial model used in this study. Mini-grid, off grid systems and borehole windmills were not analysed in any depth, using

the finance model. However, their potential for use is commented on given the government's electrification programme, which focuses on providing electricity to all.

2.5 Limitations

Limited time and access to resources restricted the scope of this study. Other limitations included:

- Project costs were sourced from secondary data, which was as recent as possible.
- Not all interviewees were available for in-depth comment and some could not be contacted. Notably, Hermann Oelsner, of DarlIPP, was only available for a brief telephone conversation and did not have time to answer any questions.
- The financial analysis was simplified, and ought, in reality to be much more complex. Wind projects are mostly grid-connected, which means that costs such as generating, balancing, and distribution and transmission costs ought to be considered. The cost of finance should also be included for a full financial analysis, including the debt/equity ratio, terms of any loans and interest rates for repayments. Inflation also ought to be factored in to account for future changes in O&M costs. If it is likely that the wind farm will need to be refurbished, these costs and the timing of refurbishment should also be considered.
- The full socio-economic costs and benefits of wind would be interesting and useful to explore, but are beyond the scope of this study.
- A more detailed analysis of the environmental impacts of wind would also be interesting, but is again outside the scope of this study.
- The baseline was sourced and calculated from secondary studies as a result of a lack of access to appropriate data. This means that some of the calculated annual emissions reductions are based on figures from 2001.
- A further assessment of large scale wind energy projects and also micro wind would be beneficial in the Western Cape.

3. LITERATURE REVIEW

3.1 International Experience with Wind and Lessons Learned

Globally, modern wind energy is a "mature technology, which at windy sites is economic and competitive with conventional generation technologies, in particular when taking into account the environmental impact" (Painuly et al, 2005). Wind is an indirect form of solar energy (Banks and Schäffler, 2005). It is clean (non-polluting), safe, abundant and inexhaustible.

Internationally, five categories of wind power project have been identified (see Table 1).

Table 1: Categories of Wind Power Project (International) - including typical wind turbine sizes (taken from Painuly et al, 2005)

Installed Power	Categorisation	wind turbine size
< 1 kW	Radio systems	< 1kW
1-100kW	Wind home systems and hybrid systems	1-50kW
100kW-10MW	Isolated power systems and decentralised generation	100kW-1MW
> 10MW	Wind Power Plants – wind farms on-land	> 500kW
> 100MW	Wind Power Plants – wind farms offshore	> 2000kW

The wind industry has expanded and improved since the 1970s oil crisis. By 2001, wind energy was growing faster than any other power production technology in the world (Karotki et al, 2001). There is some discrepancy between figures, but a recent Global Wind Energy Council (GWEC)³ report stated that between 2000 and 2005 the cumulative installed capacity of wind energy grew from 13,932MW to 47,912MW – an average annual growth rate of 28% (Greenpeace and EWEA, 2005). The GWEC believes that by 2020 as much as 1,254,030MW could be installed – a capacity large enough to meet 12% of the world's electricity needs – and it sees no technical, economic or resource barriers to reaching this target (*ibid*, 2005).

Currently installed capacity of wind power concentrates in Europe – 72% of global capacity in 2004 (*ibid*, 2005). Growth rates for wind energy in Europe are high – the installed capacity there increased by a factor of 30 from 1993 to 2003 (IEA, 2003). Although fifty countries contribute to the global total, 66% of installed capacity is located in three countries – Germany, Spain and the United States (US) (Greenpeace and EWEA, 2005). However, other regions are emerging as significant markets – Australia, Japan and China in particular (*ibid*, 2005) and also India (IEA, 2003). As a continent, Africa contributes just 234MW to global cumulative installed capacity of wind power (Painuly, 2005).

³ The GWEC represents wind energy associations from America, Australia, Canada, China, Europe, India and Japan.

There are several international trends associated with the growth in wind power production. These include trends in:

- Technology design
- Cost
- System management of variability

a) Technology Design

Wind energy technology has improved recently, encouraging growth in the industry, especially in Europe. An International Energy Agency report noted how generating capacity is chiefly determined by the rotor-swept area and the local wind speed, not by the amount of installed power (IEA, 2003). Hence, installed power should match the wind speed and rotor-swept area in order to achieve optimum energy outputs and maximum economic efficiency (*ibid*, 2003).

The present design trend is towards even bigger wind turbines – more than 2,000kW – especially as offshore wind projects are developed (Painuly et al, 2005). Currently, onshore wind turbines generate 500-2,000kW. Other advances include: turbines that have reduced loads, through increased flexibility of design; or turbines that are lighter, due to fewer components, better materials and tools (IEA, 2003). Improved weather forecasting is still necessary so that accurate performance predictions can be provided.

b) Cost

The costs of wind power are coming down. This is linked to technological improvements. Three general factors affect the cost of wind, and other renewable energy technologies (RETs), and their market growth (IEA, 2006):

- Intensity and availability of the wind energy resource
- Maturity of the RET
- Market rules set by government

Technology changes, that have seen wind turbines increase in size from 50 kW to 4,500 kW since 1980, have led to a reduced cost per kWh produced (Painuly et al, 2005). Larger wind turbines are more cost effective because they have superior designs and can exploit economies of scale. They also have higher energy production per swept m² (*ibid*, 2005). The capital costs of wind energy projects are dependent on the price of wind technology since wind turbines form a large proportion of capital costs. These percentages vary according to the location of the wind energy project. EWEA (2006) research suggests that the cost of the turbine is more likely to be around 80% of the total costs. In this research capital costs were not broken down. **Table 2** gives the share of the costs for each component of a wind energy project.

Table 2: Share of Capital Costs for Components of Wind Energy Projects (BWEA, 2006a)

	Share of total cost (%)
Wind Turbines	64
Civil Works	13
Electrical Infrastructure	8
Grid Connection	6
Project Management	1
Installation	1
Insurance	1
Legal Costs	2
Bank Fees	1
Interest During Construction	2
Development Costs	1

Significantly, the costs of wind compare favourably with other RETs. Onshore wind is one of the cheapest forms of renewable energy production, costing less than solar power options, and slightly more than large hydro projects. The offshore market is still small as costs remain high, but these are predicted to decrease as the market matures and technology improves (REN21, 2005). Costs for small wind chargers vary. For generators between 200W and 2,500W the cost per kW installed is R20,000-30,000 for imported equipment and approximately R15,000 for locally made equipment. Mechanical water pumping windmills cost R33,000-42,000, depending on their application (DME, 2003a). **Table 3** compares energy costs for a range of power generating RETs.

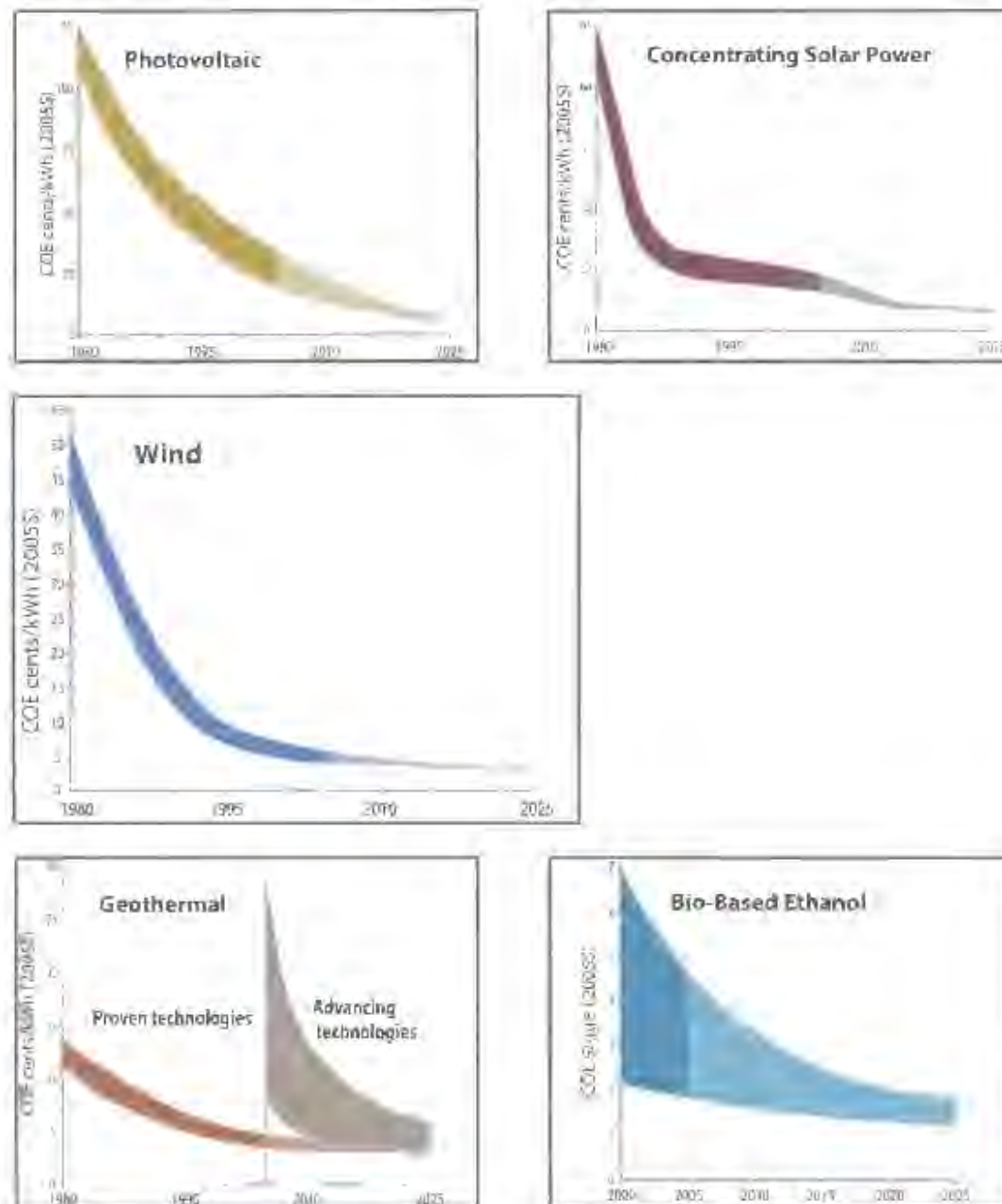
Table 3: International Status of Power Generating RETs including Costs and Trends (adapted from REN21, 2005)

Technology	Typical Characteristics	Typical Energy Costs (¢/kWh) ^a	Cost Trends
Large Hydro	Plant size: 10-18,000MW	18.5-24.7	Stable
Small Hydro	Plant size: 1-10MW	24.7-43.2	Stable
Onshore Wind	Turbine size: 1-3MW Blade diameter: 60-100m	24.7-37.1	Costs declining with technology improvements
Offshore Wind	Turbine size: 1.5-5MW	37.1-43.8	Currently small market, costs should decrease as markets expand and technology improves
Biomass Power	Plant size: 1-205MW	30.9-74.1	Stable
Geothermal Power	Plant size: 1-100MW Type: binary, single-flash, double-flash, natural steam	24.7-43.2	Costs have fallen since 1970s, could fall further with improved exploration and extraction techniques
Solar PV (modules)	Cell type and efficiency: Single-crystal: 17% Polycrystalline: 15% Thin film: 10-12%		Costs decreased by 20% with each doubling of capacity, for by 3% per year; costs rose in 2004 due to market factors
Rooftop Solar PV	Peak capacity: 2-5kW	123.5-247.0	Continuing cost reductions due to technology improvements
Solar Thermal Power (CSP)	Plant size: 1-100MW Type: tower, dish, trough	74.1-111.2	Costs fallen from 271.7¢/kWh in 1980s, future reductions as scale and technology improves

A comparison of cost reduction curves over time for various RETs shows how wind energy costs have fallen rapidly since 1980 - more rapidly than any other RET - and are expected to remain low until at least 2020 (see Figure 4). Costs today are half what they were in 1990 (REN21, 2005). Although the costs of solar are also reducing, they are currently much more than the costs of wind.

^a Unless otherwise stated, costs in this table are given in ZAR ¢/kWh.

Figure 4: International Cost Reduction Curves for a Range of RETs (NREL, 2005)



The costs of wind energy reduce as experience increases (Painuly et al. 2005). Experience curves show that deploying emerging technologies can force prices down, and results from wind energy projects demonstrate that power production costs decrease as technology develops (EWEA, 2006). Following this model a new competitive energy system could emerge to help stabilise carbon emissions (IEA, 2000).

A recent status report showed costs have fallen by 12-18% in line with each doubling of global wind energy capacity (REN21, 2005). They are predicted to continue decreasing

by around 10-15% with each doubling of installed capacity. Local manufacture of wind turbines could help cut costs (DME, 2004a). EWEA (2006) suggest a rule of thumb that implies manufacturers expect production costs of wind power to fall by 3-5% for each new generation of wind turbines added to the product portfolio. Furthermore, market growth looks set to continue with the scaling up of wind turbines, site optimisation, blade and generator design improvements, and developments in electronics.

Decision makers can influence when new technologies, such as wind, break even by altering the rates of deployment. The key questions are how much “deployment support” wind needs to become competitive, and how much of this support has to come from government budget (IEA, 2000). This research considers whether carbon finance could help by funding the costs of wind energy development in return for CERs. The process of technology learning needs long-term, stable energy policies, considerable investments (known as learning investments), and perhaps concerted action among governments (or regions) (*ibid*, 2000).

Renewable energy projects tend to be smaller than conventional, coal-fired electricity generation plants. Coal power stations in South Africa are some of the largest in the world – up to 3,600MW – while renewable energy plants are typically several MW (DME, 2004b). The disadvantage is that costs per unit of energy, throughout the project cycle, are much higher than for large scale generators. Some countries have begun to address this problem by developing diverse, integrated portfolios of renewable energy generators, which provide increased reliability and minimise any balancing or back up costs (DME, 2004b, see also Sinden, 2005a).

c) System Management of Variability

Power production from wind is reliant on the wind resources at a site. Wind is described as an *intermittent* energy resource⁵. More accurately wind power produces a variable pattern of electricity output (Sinden, 2005b). This variability refers to the lack of consistent wind resources, which means that wind speeds can be hard to predict and cannot provide a constant energy supply. The wind resource changes across all time scales (seconds, minutes, hours, days, months, years), creating challenges for its integration into electricity networks (Holtinnen and Hirvonen, 2005).

Yet energy demand levels are not constant either (Sinden, 2005a). Variations in demand *and* supply (or generation) require a balance to be maintained between consumption and production (Holtinnen and Hirvonen, 2005). Therefore, if wind energy is to be included in bulk electricity supply systems, efforts must be made to improve predictions of wind energy output in order to reduce risk. Although there are no technical limitations to integrating wind power into a power system, steps need to be taken to ensure that variations do not reduce the reliability of the power supply. In the short term this means balancing the power system. In the long term it means providing adequate power during peak load situations, and establishing energy storage methods – such as pumped storage schemes (*ibid*, 2005). The economic impact of wind on the operation of a power system

⁵ Intermittency implies an alternating presence or absence. In this report, variability will be used to describe the changing output characteristics of wind power (Sinden, 2005b).

will increase if wind power penetration is more than 10% (*ibid*, 2005). Significantly, since wind's capacity is not fixed, it cannot command a high price (DME, 2004b). Output is difficult to predict and wind energy supply generators are exposed to balancing market prices – which, in a regulated environment, translate into standby or backup charges for non-utility generators (*ibid*, 2004b).

A positive correlation between wind power generation and energy demand increases the value of wind to a system. However, variable sources can be available at the critical moment when other sources fail (Holttinen and Hirvonen, 2005). The relationship *between* various wind sites holds the key to smoothing the effects of variability – the difference between sites' wind characteristics can be exploited to reduce the overall variability by establishing a “diversified portfolio of wind-generating sites” (Sinden, 2005a). Another way to deal with wind's variability is to develop renewable energy portfolios, containing a mix of RETs that complement one another and react more efficiently to energy demand curves (Sinden, 2005a). In the UK the renewables obligation (ROs) scheme offers payment to users for the amount of grid electricity replaced by renewable sources such as wind. The value of avoided electricity is usually more than the value of exporting electricity to the grid (BWEA, 2006a).

The recent expansions and improvements in the international wind industry are significant, making wind an increasingly reliable and efficient source of energy. **Section 3.2** explores South Africa's potential to exploit wind energy and policies that support its development, in the light of the international experience discussed in this section.

3.2 Wind Energy and Energy Policy in South Africa

3.2.1 Wind Energy Resources in South Africa

In South Africa, wind has been used for:

- a. Providing electricity to the grid
- b. Rural mini-grids, unconnected to the grid
- c. Off-grid systems – independent electricity generation, usually with battery storage systems (DME, 2003a)
- d. Pumping water – at least 22,000 windmills (*ibid*, 2003a), most manufactured locally (Karottki et al, 2001)⁶

Power production from wind is reliant on the wind resources at a site. The most important factor for wind energy technology to reliably generate energy is wind speed in a given area. The amount of energy that can be tapped from the wind is proportional to the cube of the wind speed⁷ (AWEA, 2006, Painuly et al, 2005 and IEA, 2003). Hence, a slight increase in wind speed will produce a large increase in electricity generation. A second significant factor is turbine size. Wind turbines operate within a specific wind speed range – for example, a 2.5MW wind turbine⁸ will generate electricity from a wind speed of 4m/s and will be shut down at 25m/s due to safety concerns (Sinden, 2005b). Power output calculations for a 2.5MW turbine show that between 4m/s and 14m/s power output increases with wind speed. Between 14m/s and 25m/s the power output has reached its maximum (2.5MW) and remains constant (*ibid*, 2005b).

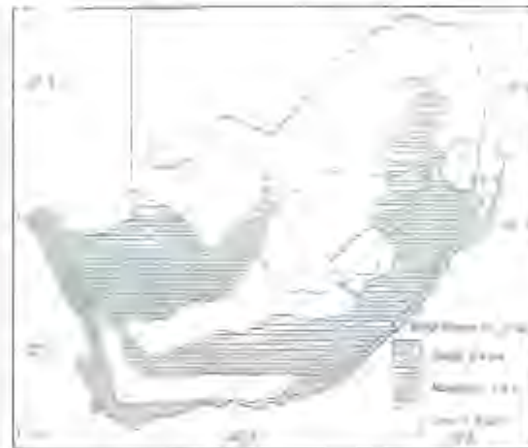
Accurate wind speed data is therefore essential to assessing the resource. There have been two wind resource assessments in South Africa. Both of these indicate wind speeds, but have been criticised for their lack of reliable data or data appropriate to wind turbine hub height (DME, 2003e).

The first comprehensive wind resource assessment was Diab's Wind Atlas of South Africa (1995). This shows that the best sites for wind energy generation lie along the coast and the Drakensberg escarpment, where there is a mean annual wind speed of more than 4m/s (see **Figure 5**). Wind power potential is particularly good in localised areas, such as coastal promontories, where mean annual wind speeds are more than 6m/s and power output exceeds 200W/m² (DME, 2003c). The data is limited because wind speeds were only recorded at 10m above ground level. Most wind measurements for wind energy projects need to be taken at heights of 30m to 50m (depending on the terrain) – near hub height (Painuly et al, 2005). Nevertheless, Diab's assessment is one of the best authorities to date on South Africa's wind resources.

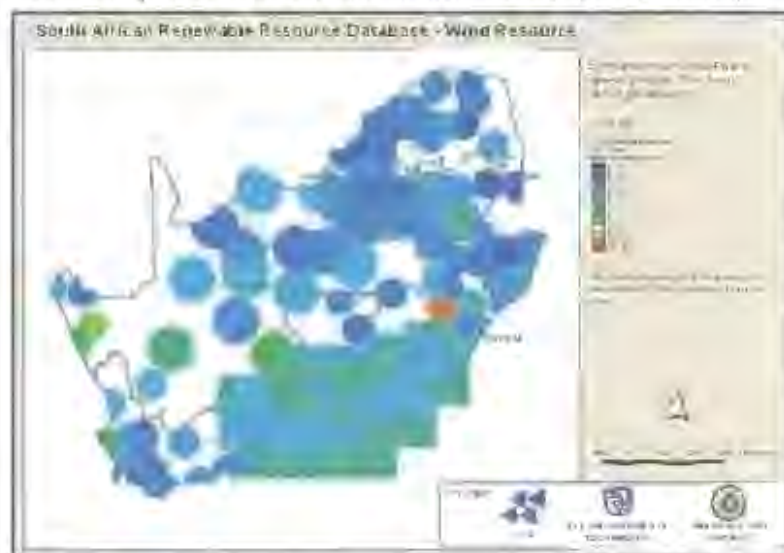
⁶ Karottki et al (2001) put this figure at >300,000.

⁷ Power output is proportional to wind speed raised to the third power. Hence if wind speed is doubled, the power of the wind increases by a factor of eight (Painuly et al, 2005).

⁸ These figures are based on the Nordex N80 model (Sinden, 2005b).

Figure 5: Wind Map showing Annual Average Wind Speeds in South Africa (Diab, 1995)

A more recent wind resource assessment was completed by the South African Renewable Resource Database project using a Wind Atlas Analysis and Application Programme (WAsP) model that estimates mean annual wind speeds at 10m above ground level (CSIR, 2006a) – see **Figure 6** (and **Appendix A** for associated statistics). Importantly, the data for this project shows the variations in estimated mean annual wind speeds at measurement sites. These can be considerable – at Simonstaad Kaappunt for instance, the minimum estimated mean annual wind speed is 2.30m/s while the maximum is 26.50m/s. However, this data is also limited because measurements were taken at 10m above ground.

Figure 6: Wind Map of Wind Resources in South Africa (CSIR, 2006b)

These resource assessments offer an overview of wind energy potential in South Africa. In reality, wind patterns are site specific and the resource must be accurately measured before a wind energy project can be approved as technically feasible. Specifically, data must be acquired for wind speeds at heights relative to turbine hubs and at exact locations

– to account for localised conditions, obstacles influencing wind flow, wind directions and so on (DMF, 2003e).

Karakezi (2002) believes wind energy development in southern Africa is hampered by inadequate or absent wind energy resource assessments, especially at the micro-level. Detailed, micro-siting analysis has been carried out for the Darling Wind Farm only (Hagemann, 2003). A recent DMF study describes current wind resource assessments as “very inaccurate”, and recommends that “present wind atlases ... should not be used to predict the energy output at potential sites” (*ibid*, 2003e). Project developers should carry out their own detailed wind study in order to assess the technical feasibility of a site. The lack of a useful wind atlas makes it difficult to plan for wind energy projects at provincial or national level, and each project is assessed individually. There is currently limited expertise in this area (Olivier, 2005). However, Hagemann at the University of Cape Town is researching a new wind atlas for South Africa (Hagemann, 2006).

The current contribution of wind energy in South Africa is small relative to other RECs – see **Table 4**. However, the potential for wind energy is significant. A recent DMF (2004a) report, under the Capacity Building Project in Energy Efficiency and Renewable Energy (CARURE), reported the technically feasible annual production output from wind energy as 231PJ (64,102GWh)⁹. The amount of this that is economically viable is 0.23PJ (63GWh)¹⁰ – the equivalent of the amount calculated for Class 1 wind only¹¹ or just 1% of the renewable energy contribution.

Table 4: Current Renewable Energy Contributions in South Africa (adapted from Banks and Schaffler, 2005)

	Existing mixed-Grid Production (for comparison)	Hydropower	Solar Water Heating	Solar Photovoltaic	Wind	Biomass
Capacity (MW)	39,485	641	242	12,1	29	Not applicable
Annual Energy Production (PJ)	7452	3.8	1.8	0.1	0.2	381.6

Estimates of the energy generation potential from the wind in South Africa are inconsistent – see **Table 5**. None of these estimations include figures for offshore wind – although offshore wind is currently being pursued in Europe and the United States (US) (Parnuly et al., 2005).

⁹ GWh to PJ is calculated at 3.6×10^3 (1000GWh = 3.6PJ).

¹⁰ Economic feasibility is 1/1000 of the technical feasibility (TPCC, 2001).

¹¹ Class 1 wind has an estimated mean annual wind speed of more than 3.5 m/s at 60m. Roughness Class 1 refers to open areas with few wind breaks.

Table 5: Comparison of Energy Generation Potential from Recent Wind Estimates for South Africa (excluding offshore wind)

Source	Energy Generation Potential from Wind (GWh)	Comment
Banks and Schäffler (2005)	106,000 per annum	From a resource potential of about 500GW, at 34-37% capacity factor, assuming 1% of land area in first five wind class zones can be used
DME (2004a)	64,002 per annum 0.7	Technically feasible production output
	19,800	Economically viable – Class I wind only (estimated mean annual wind speed at 60m: 8.5 m/s) Equivalent to 1% of South Africa's electricity requirements in 2002 (upper limit of wind energy taken as 3GW, 30% conversion efficiency, 25% capacity factor)
DME (2003d)	26,000 per annum	Theoretical potential for wind energy harvesting in South Africa
This Study	106	Economically viable

This thesis uses the most recent assessment of wind power potential, 106,000GWh – Banks and Schäffler, 2005 – and assumes that the *economically* viable potential of wind in South Africa is 106GWh (0.38PJ). This is almost double the 0.23PJ assumed in the DME (2004a) report.

In 2001, Karoteki et al noted that wind power could play an important role in adding to South Africa's generation capacity but that there was no suitable financial backing. This research explores the potential of carbon finance to bridge this gap and develop wind energy projects. This section has explored the estimated wind resources in South Africa. However, market rules provide the framework for developing the wind industry. Section 3.2.2 therefore explores energy policy in South Africa and its effects on wind energy.

3.2.2 Energy Policy in South Africa

South Africa is one of the cheapest electricity producers in the world (EMN, 2003). It is also one of the dirtiest – in terms of greenhouse gas emissions and local pollutants (such as DM, SO_x, NO_x and ash) – due to its reliance on coal and other fossil fuels. South Africa's carbon emissions per capita come close to those of industrialised countries – which represent the main threat to the global climate (EDRC, 2003). One of the main objectives of the White Paper on Energy Policy was to minimize the environmental impacts of energy production and use (DME, 1998).

On the other hand, one of South Africa's key challenges is to increase access to affordable energy services and there has been a focus on electrification for *all* (EDRC, 2003). A further aim of the Energy White Paper was to stimulate economic development (DME, 1998). The bulk electricity supply supports South Africa's energy-intensive industries, such as mining and minerals beneficiation (EDRC, 2003). As a result of this emphasis, South Africa has a very high energy usage per unit of economic output (*ibid*, 2003).

South Africa's energy policy needs to balance the development needs of its population with local and global environmental problems, such as those associated with climate change. This balance of objectives creates challenges as well as opportunities for RETs such as wind. Not least, while the upfront costs of wind remain high (more than those of conventional fossil-fuel based power), there are significant CO₂ savings to be made, which can be monetised through various international and national mechanisms (DME, 2003b) – for example, the CDM. Renewable energy in South Africa has been marginalised for use in off-grid electrification, making a negligible contribution to bulk supply (Winkler, 2005). Bulk renewable energy remains at research demonstration and development (RD&D) stage (EDRC, 2003).

Furthermore, the White Paper on the Renewable Energy of the Republic of South Africa predicted that South Africa will be short of electricity generation capacity by 2005-2007 (DME, 2003c). Recently, the media has reported power outages across the Western Cape, in particular. Warnings are being issued of more in the future, together with possible restrictions (see Bamford, 2006, Herman, 2006, Jasson da Costa and Ndenze, 2006, and Merten, 2005). This seems to confirm the DME's prediction and raise the profile of RETs, such as wind, to provide alternative energy solutions.

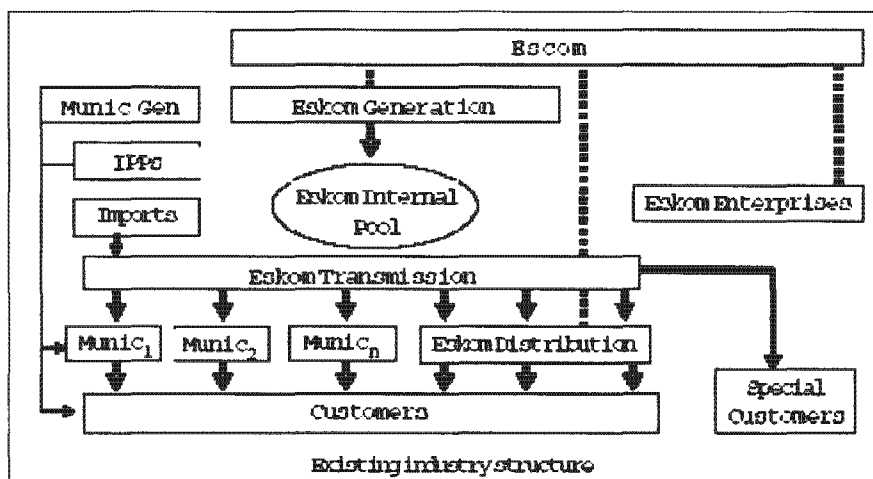
There are several national policy documents affecting the development of wind energy in South Africa. Before noting the details of these policies, it is important to highlight the government's desire to restructure the electricity supply industry (ESI) and the electricity distribution industry (EDI). The EDI Restructuring Bill and the Electricity Regulatory Bill provide the legislative framework for changes to the electricity industry (SoEnR, 2003).

Plans to restructure the EDI developed from financial problems of municipal electricity distributors and limited access to electricity (Eberhard, 2005). There will be six regional

electricity distributors (REDs) to replace Eskom and the municipalities as the only distributors of electricity. REDs are intended to standardise services and tariffs, ensuring the roll out of electrification (CCT, 2005) and improving the industry's financial viability (Winkler and Mavhungu, 2001a).

The Western Cape RED (RED One) was established in 2004, although only on paper (Eberhard, 2005). Despite this, RED One has first-mover advantages. It could manage capacity risks by diversifying supply, and one option is to increase supply from RETs. Furthermore, renewable energy should be integrated into RED One's portfolio, not least because this is the earliest opportunity to tap renewable resources at a broad scale (beyond municipal level) (Olver, 2005). In reality, there is uncertainty about the RED system. Local authorities are concerned REDs will limit their capacity to meet their constituencies' energy needs (SoEnR, 2003). Certainly, the REDs will prompt a constitutional amendment, limiting the role of local government in electricity distribution (Eberhard, 2005 and DME, 2004b). Recently, a media report suggested seven REDs may be created rather than six – one for each metropolitan area, with the remaining municipalities either joining a metropolitan RED or belonging to a seventh, national RED (Mabanga, 2005). REDs will be regulated at a macro-level by the National Electricity Regulator (NER) and at a micro-level by the municipalities (Winkler and Mavhungu, 2001a).

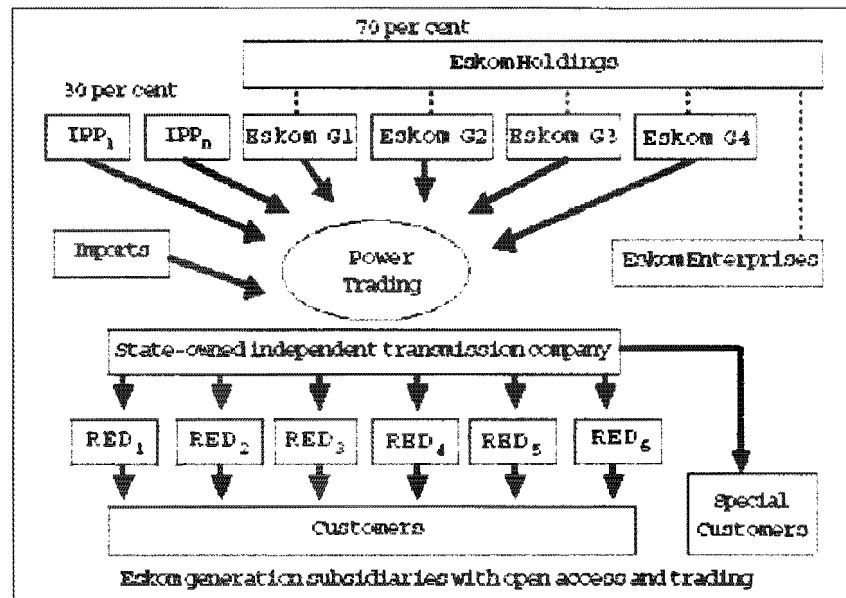
ESI restructuring was to involve changes in ownership, structure and regulation in order to encourage economic and technological efficiency in the industry (Winkler and Mavhungu, 2001a). However, international experience suggests that restructuring leads to higher prices and loss of public benefits (*ibid*, 2001a). Eskom has been able to charge low prices and fund electrification, due to cheap and plentiful coal supplies and its exemption (until recently) from taxation and dividends (Eberhard, 2005). Generating costs have been kept artificially low by writing off existing generating capacity and excluding the environmental impacts of generation (externalities) from the overheads (Brebol et al, 2003). Furthermore, Eskom has not had to invest in new generation since the 1980s. However, current supply problems mean Eskom needs to increase prices to fund new capacity (*ibid*, 2005). The current ESI structure is shown in **Figure 7**.

Figure 7: Structure of the ESI in South Africa (Eberhard, 2005)

Restructuring encourages wholesale competition, by promoting IPPs in the generation and supply components of the ESI (Treasury, 2001a). IPPs require access to the grid and the energy market (Winkler and Mahungu, 2001). Eskom's continuing dominance of the ESI may limit the ability of IPPs to sell energy and gain a foothold in the market (Brebol et al, 2003). IPPs depend on an enabling environment in order to balance their risks and investments, but they are also crucial to facilitating the reform process (EMN, 2003). The Energy White Paper (DME, 1998) therefore encouraged multiple players to enter the energy generation market (Winkler and Mavhungu, 2001).

However, government has been reluctant to implement proposed new market designs. The EDI is being restructured, but Eskom has not been unbundled nor generation plants sold off, and little competition has been created (Eberhard, 2005). The government is concerned about persistent poverty and is therefore emphasising state-led infrastructure investment and development. State utilities in energy and transport are key to this strategy (*ibid*, 2005).

Reform and regulation are continuing to help improve efficiencies and performance. Yet government is not implementing full competition or privatisation. Eskom is authorised to take on 70% of new investments and continues to dominate the ESI, leaving the remainder for the private sector. Thus a hybrid market is being established where the regulator continues to oversee the ESI and EDI reforms in order to consolidate and improve performance, but state-owned utilities carry on dominating the energy sector (*ibid*, 2005). One possible future model is shown in Figure 8.

Figure 8: A Possible Future ESI Model for South Africa (Eberhard, 2005)

Policies can effectively promote or hinder the development of RETs in South Africa. Government can regulate the quantity of electricity produced – setting targets for renewable energy – or it can fix prices by regulating tariffs (Winkler, 2005; see also Weitzman, 1974 and Menanteau et al, 2003). There is an international shift towards the use of market based instruments rather than regulatory mechanisms. The following are generic policy options, which have been adapted or could be used in South Africa (Winkler, 2005):

- **Feed-in tariffs (FITs)** – government sets the price for renewable energy (differs according to the technology); this has been applied successfully in Germany
- **Renewable portfolio standards (REPS)** – government sets a target for renewable energy, leaving electricity distributors flexible in how they meet that target; this is common in the US
- **Renewables obligations (ROs)** – government sets aside a quantity of electricity, which is put to tender; the UK has pursued this policy

National policy provides the scaffolding for building provincial strategies and implementation plans. Four national policies were considered:

- White Paper on Energy Policy
- National Integrated Resource Plan
- White Paper on Renewable Energy
- Integrated Energy Plan

This discussion of energy policy in South Africa sets the context for the examination of the energy situation in the Western Cape in Section 3.3.

a) White Paper on Energy Policy (1998)

The Energy White Paper has five chief objectives that can be met through investing in wind energy. Firstly, through mini-grids and off-grid systems, wind energy can **increase access to affordable energy services**. Secondly, most wind energy projects are developed by IPPs, thereby **improving energy governance**. Third, wind energy produces more jobs per unit of energy produced than other forms of energy production (DME, 2003c and AWEA, 2006b), therefore **stimulating economic development**. Fourth, wind is environmentally benign and helps to **manage and minimise energy-related environmental impacts**. Finally, wind helps to **secure supply by diversifying the energy portfolio**.

The Energy White Paper's stance on renewable energy is based on ensuring "an equitable level of national resources is invested in renewable technologies, given their potential and compared to investments in other energy supply options" (quoted in DME, 2003c).

b) National Integrated Resource Plan (NIRP) (2003/2004)

The NIRP is most significant to wind energy, which is used to produce electricity. It grew out of the Energy White Paper and plans to restructure the ESI. It aims: to determine **least cost energy supply options** for South Africa; to provide **information to market participants on opportunities for investment** in new power; and to **evaluate the security of supply** (NER, 2004).

The NIRP's conclusions relevant to development options such as wind include (NER, 2004):

- Options for diversification are insufficient to meet forecast electricity demands over the next 20 years. Hence, coal-fired options are still necessary to meet expansion targets.
- Diversified options refer to new technologies, including wind.
- It is difficult to justify diversification on an economic basis, unless the penalties for failing to diversify, or the incentives for doing so, are included in future analyses. The cost of diversification is becoming increasingly expensive, therefore these penalties and incentives, need to be substantial so as to offset the economic benefits of remaining with coal. One opportunity is presented by carbon emissions trading.

Wind is included in new supply-side options, alongside solar thermal and imported hydro options. The coastal regions are highlighted as having "good potential for wind power", although the lack of detailed data for specific sites is recognised (NER, 2004). A 20MW wind farm is proposed, providing peaking power. This is much less than the proposed 300MW from solar thermal and 1200MWe from imported hydro. All three are also being researched. However, the wind option is not included in the final reference capacity plan.

c) White Paper on the Renewable Energy of the Republic of South Africa (2003)

The White Paper on RE recognises that coal is, and is likely to remain attractive as an energy source as a result of its low cost and plentiful supplies (DME, 2003c). It also recognises South Africa's commitment to "the global effort to mitigate greenhouse

gases” (DME, 2003c). Furthermore, it reinforces the Energy White Paper’s intention to promote security of supply through diversification.

However it points to the need for financial incentives to encourage the development of RETs – from domestic and international sources. The government’s vision is (*ibid*, 2003c):

An energy economy in which modern renewable technology increases its share of energy consumed and provides affordable access to energy throughout South Africa, thus contributing to sustainable development and environmental conservation.

A starting point is the medium term goal, in the form of a 10 year target (*ibid*, 2003c):

10,000GWh (0.8Mtoe) renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar and small-scale hydro. The renewable energy is to be utilised for power generation and non-electric technologies such as solar water heating and bio-fuels. This is approximately 4% (1,667MW) of the projected electricity demand for 2013 (41,539MW).

Renewable energy would therefore replace the equivalent of two units of Eskom’s combined coal fired power stations – each unit has an installed capacity of 660MW (*ibid*, 2003c).

The medium term goal commits government to promoting RETs, including wind energy. Thus the policy aims “to create the conditions for the development and commercial implementation of renewable technologies” (*ibid*, 2003c). It will do this by addressing four strategic areas: financial instruments; legal instruments; technology development; and awareness raising, capacity building and education.

However, it is not clear whether the target is a cumulative figure or a figure to be reached *in* 2013, nor is it certain what share will be produced by biomass, wind, solar and small-scale hydro. However, a step in the direction of meeting the target has been the establishment of a Renewable Energy Finance and Subsidy Office (REFSO). Under the auspices of the DME, REFSO will manage renewable energy subsidies and advise developers and stakeholders about renewable energy finance and subsidies (DME, 2005) – see **Section 4.3.2**.

d) Integrated Energy Plan for the Republic of South Africa (2003)

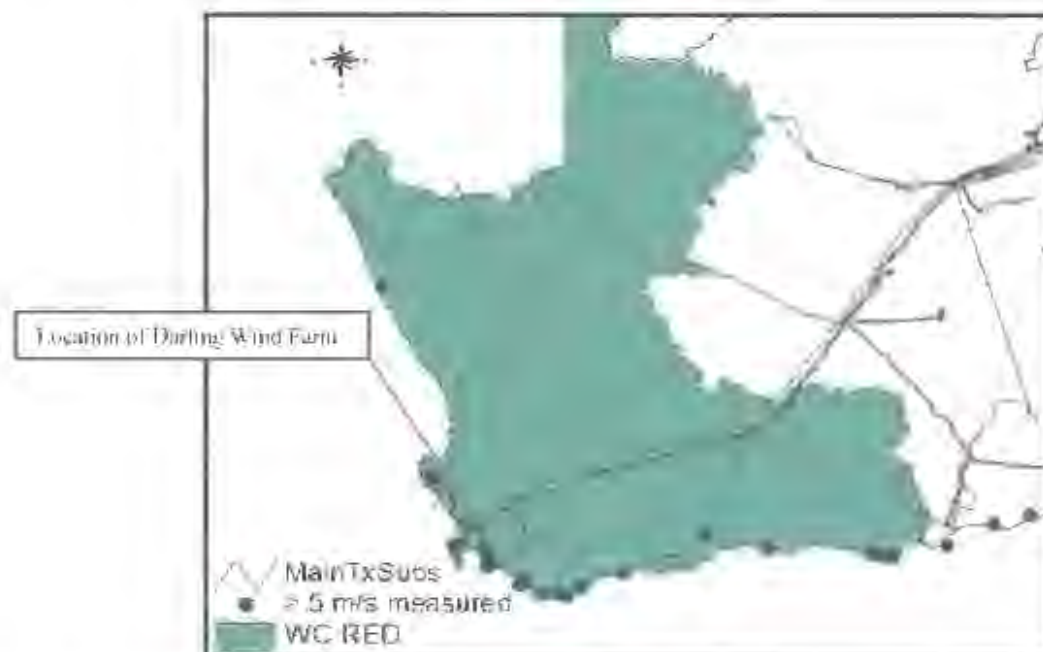
This plan aims to adopt an integrated resource planning approach to “large investment decisions by energy suppliers and service providers” (DME, 1998). Its purpose is to balance energy demand with supply, in line with environmental, health and safety issues. Three general goals are relevant to wind energy: ensuring environmental considerations are taken into account in energy supply, transformation and end-use; promoting universal access to *clean* and affordable energy; and introducing policy, legislation and regulation that promotes renewable energy and energy efficiency measures (DME, 2003b).

3.3 Wind Energy and Energy Policy in the Western Cape

3.3.1 The Wind Resource in the Western Cape

In the Western Cape the best conditions for wind energy exist on the Atlantic coastline especially at Langebaanweg-WO. Here, the data from the WASP model that was used to develop the Wind Map of Wind Resources in South Africa (see **Figure 6**) shows a range of estimated mean annual wind speeds between 4.90m/s and 11.30m/s (see **Appendix A**) (CSIR, 2006c). Langebaan is situated close to a major transmission line that runs along the Atlantic Coast, which eases connection to the grid (Oelsner, 2004 and Brehol et al. 2003). The first commercial wind farm to be built in South Africa, Darling Wind Farm, will be built in this area – see **Figure 9**. **Figure 9** also shows the boundary of RED One (see discussion in Section 3.2.2).

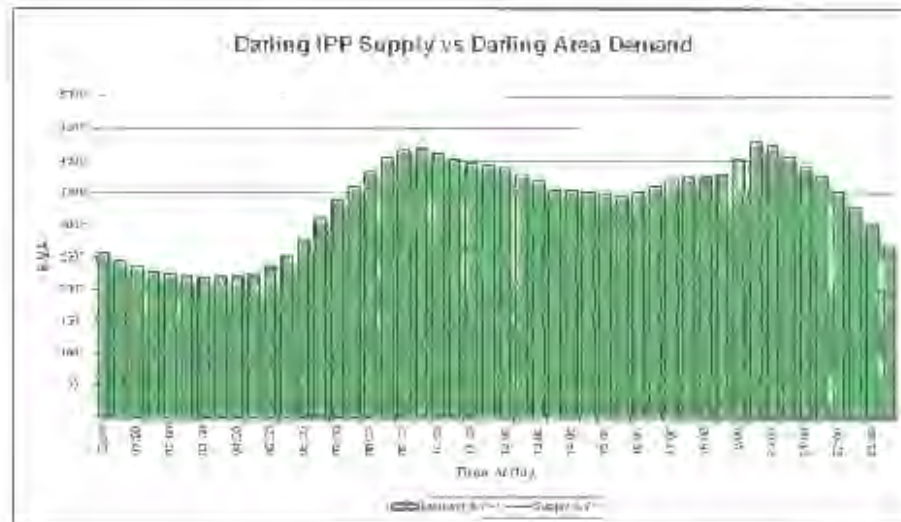
Figure 9: Correspondence between the Wind Resources and Transmission Lines in the Western Cape (Schäffler, 2001)¹²



There is little research on variability in the Western Cape, or South Africa. However, Brehol et al (2003) concluded “the biggest constraint for increased use of wind power in the Western Cape is that the production pattern is not in harmony with the demand for electricity on a daily and annual basis.” The relationship between supply and demand for the Darling Wind Farm can be seen in **Figure 10**. This kind of detailed assessment is necessary to establish the value of the wind resource at a particular site.

¹² WC RED refers to RED One.

Figure 10: Relationship between Darling Wind Farm Supply and Darling Area Demand (Oelsner, 2005)



The wind resources of the Western Cape are generally considered to be suitable for the development of wind energy projects, but currently available data is limited – see **Section 3.2.1**. More comprehensive wind resource assessments are needed in the Western Cape to enable more efficient exploitation of wind for electricity production. This is being addressed by research at UCT (Hagelmann, 2006).

3.3.2 Wind Energy Projects

In addition to the Darling Wind Farm, a number of other wind energy projects are being planned for in the Western Cape (see **Table 6**). Both Klipheuwel and Darling Wind Farm are pilot projects, with the emphasis being on RD&D (DMF, 2003a). Five further projects have also been initiated by a private company, Genesis Eco-Energy (approximate figures) (Chown, 2006):

- Beaufort West 50MW
- St. Helena 40MW
- Saldanha 45MW
- Lambert's Bay 45MW
- Southern Cape 30MW

Table 6: List of Wind Power Projects in the Western Cape (adapted from DME, 2003a)

Name ¹²	Owner	Location	Capacity (MW)	Annual Power Production (GWh)	Capacity Factor
Grid-Connected					
Burling Samuel Depositional Wind Farm	Private CEF, IDC ¹³	Western Cape	5.2	12	30%
Eskom Klipblommet Wind Turbine Test Facility	ESKOM	Western Cape	2.16	5	30%
Albany Baiter Station Farm Langebaan		Western Cape	1.15	400	30%
CSIR Steynbros Peka Wind Farm		Western Cape	1 (planned)	1 (planned)	25% (estimated)
Mini Grid					
Burling Wind Farm Ysterluis Coale		Western Cape	0.1	0.26	30%
Off-Grid Systems					
Wind Charger Kestrel 600kW		Western Cape	0.03	0.67	25%
World Power Whisper 1000W		Western Cape	0.12	0.26	25%
World Power Whisper 3000W		Western Cape	0.06	0.17	25%
Borehole Windmills¹⁴					
Various		Western Cape	45	100	25%

¹² Italics indicate projects that have planning or feasibility status.¹³ CEF – Central Energy Fund, IDC – Industrial Development Corporation.¹⁴ Approximate figures for the Western Cape were calculated using 2002 Census figures for gross farming income per province in South Africa (StatsSA, 2002).

3.3.3 Energy Supply and Demand in the Western Cape

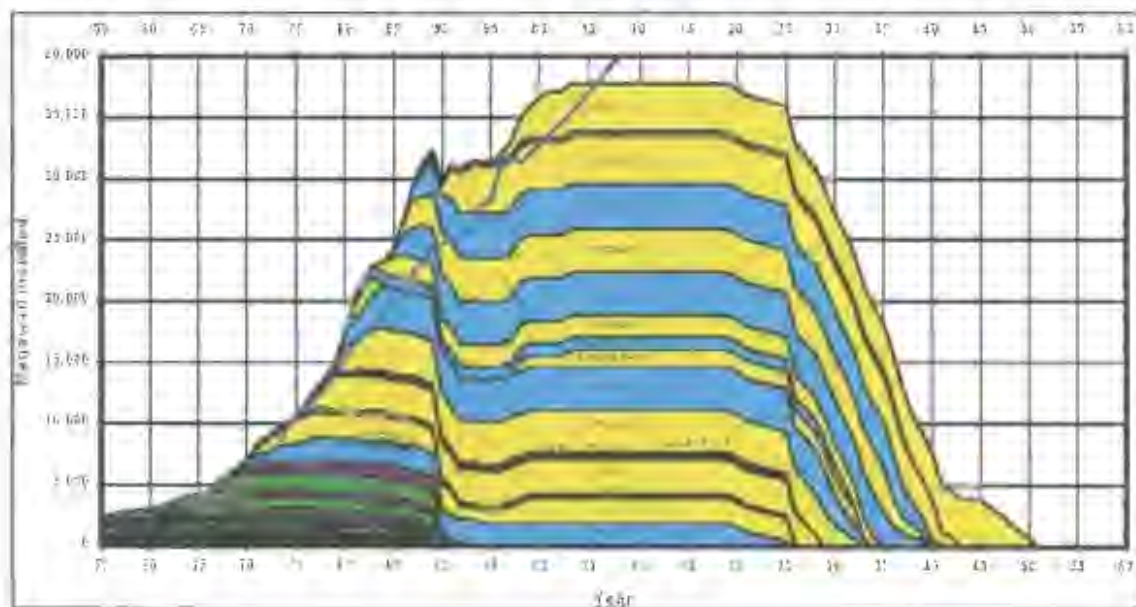
There are three major issues around energy supply and demand in the Western Cape:

- Capacity shortage
- Transmission constraints
- Increasing energy demand

a) Capacity Shortage

There is a capacity shortage, as predicted in the White Paper on Renewable Energy (DME, 2003c) – see Section 3.2.2. Figure 11 shows Eskom's *existing* generating capacity over time. Eskom controls 95.6% of electricity generation (LMN, 2003). It demonstrates how supply will decrease in the next two to three decades unless new capacity is added. The solid blue line indicates actual and projected demand, which exceeds supply from 2007.

Figure 11: Existing Eskom Generating Capacity over Time (DME, 2003b)



Media reports point to the lack of reserve margin, ongoing problems at Koeberg and the possible need for electricity rationing or controlled blackouts (see Merten, 2005; Herman, 2006; Bamford, 2006; Jasson da Costa and Ndenze, 2006). Eskom executives have suggested that electricity tariffs may need to be increased in order to support a capacity expansion programme.

b) Transmission Constraints

The Western Cape's reliance on coal results in transmission losses. The Western Cape, and South Africa as a whole, is almost totally reliant on coal for electricity – country wide approximately 90% of primary energy is generated by fossil fuels and coal provides 75% of this fossil fuel based energy supply (DME, 2003c). The coal fired power plants are situated in the northern provinces of South Africa (mostly in Mpumalanga), at a

distance from the Western Cape. At present there are two transmission lines to the Western Cape. Increased demand has put pressure on the network and total power losses from power plant to consumer are around 20% (Brehol et al, 2003). Eskom, which controls the high voltage transmission grid, has proposed graded transmission charges, increasing with distance from the coal-fired power plants (Eskom, 2005b). The necessary expansion of the transmission network is estimated to cost R16 billion (Brehol et al, 2003).

It may be more efficient to build new capacity within the Western Cape, near the source of demand. There are concerns about the decreased quality and reliability of supply from coal-fired power plants (Lieberhard, 2005). Since wind energy resources in the province are good, wind farms could provide new capacity in the province. **Figure 9** showed the correspondence between wind resources of >5m/s and major transmission lines. It shows the clustering of useful wind resource sites along the coastline, often at a distance from transmission lines. The costs of connecting to the grid are likely to be high, but are potentially less than the increasing transmission costs and losses.

Current Eskom power stations, which are situated within the Western Cape, and which provide electricity to the national grid, are listed in **Table 7**.

Table 7: Existing Eskom Power Stations in the Western Cape Providing Electricity to the Grid (adapted from Oelsner, 2004)

Plant	Capacity	Comment
Koeberg Nuclear Power Station	2 x 920MW	Baseload
Palmiet Pumped Storage Station	2 x 200MW	Mainly used in emergencies
Acacia Gas Turbines	2 x 57MW	Emergency use only
Total:	2,354MW	

c) Increasing Energy Demand

Thirdly, energy demand is increasing. 2004 estimates of electricity consumption in the Western Cape place demand at 22,000GWh per annum – of which 12,000GWh per annum is consumed by the Cape Town Metropolitan Area (CTMA) alone (Oelsner, 2004). Electricity consumed almost exclusively from the national grid and is growing by 3-4% per annum (*ibid.* 2004). Electricity consumption in the Western Cape is estimated to reach 25,000GWh in 2012 (Brehol et al, 2003). The NLR predicts *national* electricity demand at intervals to 2022. It shows annual growth in peak demand decreasing slightly (NLR, 2004). However, the forecast annual peak demand in 2022 is 53,256MW – 19,611MW more than the 2004 figure. Furthermore, the annual growth in system losses is expected to increase to more than 10% (*ibid.* 2004).

New generation capacity is therefore needed in the near future to support the proposed upgrade and enlargement of the transmission network, as well as to supply the predicted increase in electricity consumption (*ibid.* 2003). Building new generating capacity is likely to increase electricity prices for consumers. However, it does create opportunities to consider alternative sources of energy, such as wind.

3.3.4 Energy Strategy in the Western Cape

The White Paper on Renewable Energy made the first steps towards establishing an enabling environment for RETs in South Africa. National policies have been followed by strategies and implementation plans in the Western Cape, which aim to put national policy into practice at a provincial level. Those being developed in the Western Cape are:

- Sustainable Development Implementation Plan
- Integrated Energy Strategy and Programme for the Western Cape
- Strategic Initiative to introduce commercial land-based wind energy developments to the Cape West Coast
- Ikapa Ekhilumay

a) Sustainable Development Implementation Plan (SDIP)

The SDIP attempts to ensure the Provincial Growth and Development Strategy (PGDS) embraces the concept of sustainable development. It is intended to achieve sustainable development in all sectors. The finished plan will consider how to implement the following with regards to energy and climate change (SDIP, 2005):

- Ensure energy security
- Promote clean and safe energy for economic growth
- Introduce energy efficiency (EE) initiatives
- Promote alternative energy sources in order to decrease dependence on fossil fuels
- Provide affordable energy to all
- Promote renewable energy
- Diversify the energy mix
- Promote more efficient transport systems

Further aims include developing an Integrated Energy Strategy and Programme of Action; providing an enabling environment to stimulate investment in RETs and EE; to ensure full cost accounting of energy projects, throughout their life cycle; to support high profile energy and climate-related projects and incorporate renewable energy and EE initiatives into provincial events such as the 2010 Soccer World Cup (SDIP, 2005).

b) Integrated Energy Strategy and Programme for the Western Cape

This strategy is being researched by the Department of Environmental Affairs and Planning (DEADP). A draft status report highlights the need for an integrated approach to energy in order to meet future developmental challenges (DEADP, 2005). It is likely that the finished strategy will propose a renewable energy target for the province of 15% by 2020 (Chown, 2006).

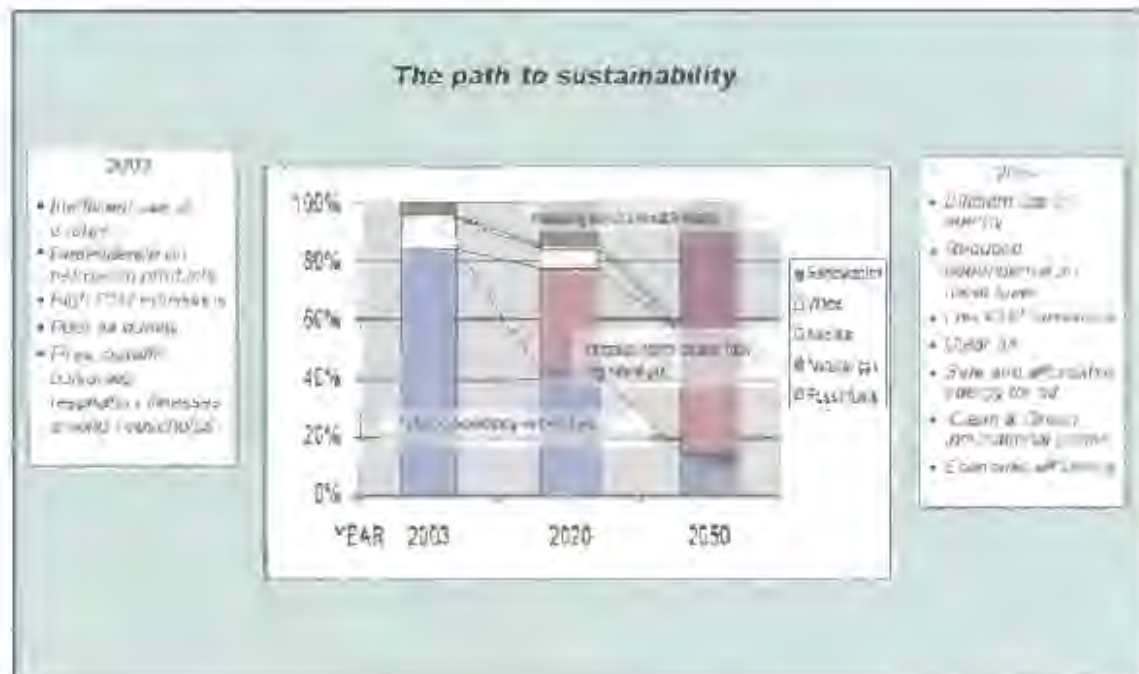
The Western Cape government recognises it can utilise “leap-frogging technologies and institutional opportunities” in order to attain sustainable development in the province (*ibid*, 2005). Two issues aim to establish a more sustainable energy mix that could include wind (*ibid*, 2005):

- Move to a renewable energy based supply – early projects will focus on ‘low hanging fruit’ (for example, solar water heaters)

- Diversify electricity generation to include wind, solar and biofuels

A combination of diversified supply-side options and demand side management should lead to a more affordable and better quality service than before. **Figure 12** shows the suggested 'path to sustainability', which is also included in the Cape Town Energy Strategy.

Figure 12: The Suggested Path to Energy Sustainability in the Western Cape (DEADP, 2005)



c) Strategic initiative to introduce commercial land-based wind energy developments to the Cape West Coast

This initiative is being researched by DEADP. It aims to establish regional criteria for identifying suitable areas for wind energy projects. There are concerns that these criteria will be too rigid. Already there are stringent guidelines for developments on mountains, hills and ridges in the Western Cape, limiting some of the best locations for wind energy projects (WCDECAS, 2002).

d) Ikapa Ekhlumay (Growing the Western Cape)

Three of the eight strategic pillars of Ikapa Ekhlumay inform energy planning in the Western Cape. Ikapa Ekhlumay falls under the PGDS, which strives for growth rates of 6-7% – taking its lead from a national drive towards growth rates of 6%. Firstly, the **Western Cape Provincial Spatial Development Framework** (CNDV, 2005) informs municipal strategies and their Integrated Development Plans (IDPs). 95% of the province is electrified – more than any other province. There is no off-grid electricity supply. Importantly, it is suggested renewable energy should contribute 25% to provincial energy supply by 2020 (SolER, 2004). Secondly, the **Sustainable Infrastructure Plan**

comments on electrical infrastructure in the province. It is negative about prospects for wind energy (Borchers, 2006). Thirdly, the Micro Economic Development Strategy includes a section on energy (Chown, 2006).

3.3.5 Energy Strategy in Cape Town

The Cape Town Metropolitan Area (CTMA) dominates the Western Cape in terms of population, government and energy needs. The CTMA also anchors the first RED. Two documents are significant:

- Cape Town's Energy Strategy
- Integrated Development Plan

a) Cape Town Energy Strategy (CES)

This aims to increase the renewable energy contribution to the supply mix to 10% (571MW capacity) by 2020 (CCT and SEA, 2003). They will begin by integrating the most financially viable and environmentally sound options. The city has established a PPA with Darling Wind Farm.

b) Integrated Development Plan (IDP)

The IDP for the city incorporates energy, outlining Cape Town's commitment to ensuring a safe and reliable supply of electricity to all (CCT, 2005). It also highlights Cape Town's role as the anchor for RED One, which serves the Western and Northern Capes. However, recent talks could result in RED One being limited to the CTMA only, leaving smaller municipalities with the option to join RED One (Chown, 2006).

3.4 Barriers to Investment in Wind Energy

A decision about whether to implement wind energy needs to consider the national policies and provincial strategies discussed in Sections 3.2 and 3.3, since these provide the framework for other opportunities and stumbling blocks. Several barriers were identified in the Western Cape, which limit the uptake of wind energy in the province:

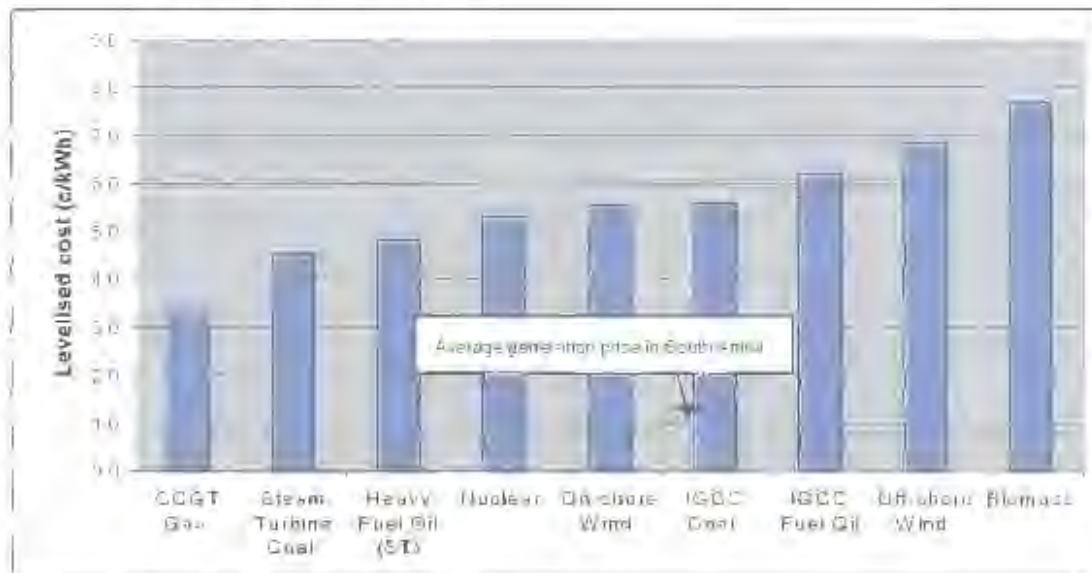
- Financial barriers
- Institutional issues
- Environmental impacts of wind

3.4.1 Financial Barriers

A wind energy project needs to be profitable in order to be viable – its return on investment must be higher than the opportunity cost of capital. Typically, wind energy projects have high capital costs and low operation & maintenance (O&M) costs, relative to conventional supply options (Sonntag-O'Brien and Usher, 2004). There is therefore a need for financing that is repaid during the project's lifetime. Furthermore, RET projects are seen as high risk because they are quite new. Developers may be under-financed or have no track record, which makes lenders reluctant to provide finance (*ibid*, 2004). This means they need to provide accurate financial analysis to demonstrate their potential internal rates of return (IRRs).

From a financing perspective, the project should be the "least-cost alternative for attaining the required output" (Khatib, 1997). Despite falling technology costs internationally, wind energy and RETs in South Africa are *not* yet competitive with conventional supply. The discrepancy is particularly notable in South Africa because coal prices are among the lowest in the world (EMN, 2003). **Figure 13** compares international supply costs for several power producers. It shows the marked difference in price between the average generation price in South Africa, which is linked to coal-fired electricity generation, and the levelised cost of onshore wind – almost 5c/kWh. Note too how the levelised cost of onshore wind is close to that of nuclear, which forms a significant part of supply in the Western Cape.

Figure 13: Comparison between International Supply Costs for Several Types of Power Producer (DME, 2004b)¹⁶



The low cost of coal-fired electricity generation is the primary limitation to the uptake of wind and other RETs. Eskom controls 95.6% of this generation (EMN, 2003). Until recently, Eskom benefited from a lack of dividends and taxes (Schäffler, 2001). There was considerable over-investment in coal-based generation in the 1980s so most of Eskom's investment has been paid off. The corporation also has easy access to public funding. Hence, the average cost of electricity generated by Eskom is 9.3c/kWh.

Furthermore, the externalities of coal-fired electricity generation have not been internalised (*ibid*, 2001). Even if they were to be internalised, wind energy would still be more expensive to produce – previous analysis showed Darling Wind Farm requires an electricity tariff of 38c/kWh in order to be financially viable (EEU, 2002). In contrast the long range marginal costs (LRMC) of coal-based generation, including desulphurisation and decreased NO_x emissions are estimated to be 25-30c/kWh (Olver, 2005 and van den Berg, 2006).

An *economic* rather than a financial evaluation would include all costs and benefits that can be evaluated – including environmental, social and health impacts. The last of these is most significant with regards to coal (Thorne, 2006). Coal-fired electricity supply includes many avoided costs, or externalities, which are not reflected in the coal price because they are not priced by the market. An externality refers to a cost that is borne by a party outside of the activity in question (Schäffler, 2001). It can be positive or negative.

Van Horen (1996) suggests that failing to reflect the environmental, social and health costs of electricity generation in the price of coal amounts to an actual subsidy. In other words society is subsidising Eskom's commitment to producing the cheapest electricity

¹⁶ Prices are from 2000

in the world (*ibid.* 1996). By partially or wholly ignoring the health and environmental implications of conventional energy sources, governments and markets create a hidden subsidy that is "typically much larger than direct subsidies to [conventional] energy sources" (AWEA, 2006a).

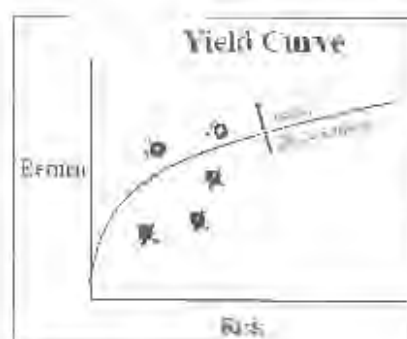
There are several potentially significant environmental impacts of the coal fuel cycle in South Africa (Van Horen, 1996):

- Occupational health effects in coal mining
- Air and water pollution from coal mining
- Water consumption in power generation
- Air pollution from power generation: health impacts
- Air pollution from power generation: impacts of acidic deposition
- Air pollution from power generation: visibility impacts
- Water quality impacts from power generation
- Greenhouse gas emissions from power generation

In general and internationally, there is limited accounting of environmental externalities, with regard to the costs of wind energy *and* the costs of conventional power generation such as coal (Kennedy, 2005). Yet wind energy and other RETs can make considerable savings. Some kind of CO₂ credit for wind power production could help make wind competitive with conventional power (*ibid.*, 2005). However, Schäffler (2001) wrote "the inclusion of externalities would currently not account for the discrepancy between wind and coal-based generation costs, even with inclusion of CO₂ abatement costs". EWEA (2006) disputes this, stating if environmental costs were levied on electricity according to impact, wind would not need any support.

While the costs of wind energy are central to investment decisions so too is an assessment of project risk. If the risks are greater than the returns for an investor then the decision will be *not* to invest – see Figure 14. Risks include credit risks related to the project sponsor and the country, and commercial risks such as the wind resources, the level and reliability of the technology, the need for maintenance, the environmental impacts and the ability of consumers to pay for electricity produced. Returns relate to the project costs, revenue streams and means of finance (Sonntag-O'Brien and Usher, 2004).

Figure 14: Non-specific Yield Curve for a Wind Energy Project: Risks versus Returns from an Investor's Perspective (Sonntag-O'Brien and Usher, 2004)



This research investigates the financial costs and benefits of wind energy projects from a project developer's perspective. However, it is worth considering that for wind energy projects to attract carbon finance, the risks and returns for an investor must also be weighed up – and the risks minimised wherever possible (Cartwright, 2006). The following sections explore the institutional issues and environmental impacts of wind, which create barriers to investment in wind energy projects in South Africa. Technical limitations have already been discussed, and include the lack of resource assessments, small size of wind energy projects and variability.

3.4.2 Institutional Issues

Not only is coal cheap, but most wind energy projects in the Western Cape are being developed by IPPs, who face considerable barriers to selling electricity into the grid or directly to customers. Klipheuwel is an exception since it is a pilot project developed by Eskom. Barriers to IPPs include:

- Significant grid-extension costs – the best wind sites can be located far from transmission lines (see **Figure 9**) (Schäffler, 2001)
- A lack of legislation to guide IPPs' activities (*ibid*, 2001) – some research and guidelines have been developed (DME, 2000 and DME, 2003d)
- Eskom's dominance of the ESI limits IPPs' ability to sell energy (Brebol et al, 2003)
- The NER prefers short term PPAs because of uncertainties around restructuring – IPPs need long term contracts to secure funding and cover high capital costs (*ibid*, 2003)
- IPPs have to find their own customers to enter into PPAs and they must sell 'green' electricity separately on the grid (see **Section 3.5.2**) (*ibid*, 2003)

Renewable energy generators are typically small scale compared to conventional supply. This means that they have a weak voice within market governance systems. As such, they are unlikely to obtain rule changes that support RETs (DME, 2004b). Public sector bodies could help by promoting RETs as part of environmental policy, as could international pressure for South Africa to respond to the threat of climate change. However, as in other developing countries, local concerns such as poverty alleviation tend to be prioritised over environmental or international fears (Schäffler, 2001).

One problem may be access to suitable land. Good wind sites may be in remote places, protected areas or on private land, which will mean strict approval processes (DME, 2004b). Gaining planning permission and purchasing or leasing land may become a lengthy, expensive process. A DME resource assessment (2004a) used very conservative figures for land availability. They assumed only 1,174km² of the 410,000km² exposed to wind speeds of more than 6.5m/s was available for wind farm development (Banks and Schäffler, 2005). Banks and Schäffler (2005) assumed 1% of suitable land was available – 4,100km².

Environmental and planning approvals can be costly and time-consuming. The National Environmental Management Act Regulations (DEAT, 2005) defines all electricity generation projects of 10MW or more capacity, or covering more than 1 hectare of land as Category II projects (section 23), which require an Environmental Impact Assessment

(EIA). Wind farms that are not covered under this definition are required to carry out the screening phase of an EIA, because they classify as Category I projects. See **Section 3.4.3** for a discussion of the environmental impacts of wind. Financing from international institutions, such as the World Bank, could impose further safeguard policies and approval processes, which are costly to small scale renewable energy projects (DME, 2004b).

There is a lack of legislation regarding energy projects (including RETs), and few clear statutory mechanisms to accommodate RETs or facilitate their introduction. The regulatory environment is currently uncertain, which deters investors. There are changes being made to the licensing regime through an updated Electricity Regulation Act, but stakeholders are unsure this will address RETs (DME, 2004b). One significant legal barrier is the need for clarity on the different roles and responsibilities of state authorities – at national, provincial and local levels (*ibid*, 2004b). National government is committed to providing electricity to all, the Department of Minerals and Energy (DME) has overall responsibility for renewable energy policy and the National Energy Regulator (NER) controls market access through licensing and regulates prices (DME, 2003c). Province's responsibilities are unclear. However, until now, local authorities have had jurisdiction over electricity distribution and there is some confusion as the Constitution implies municipalities can also set tariffs (SoEnR, 2003). The establishment of REDs at a provincial level may therefore lead to conflict (DME, 2004b). However, the problems the new REDs may bring should be short lived. In the long term they should simplify the EDI and standardise electricity tariffs. Furthermore, the targets that are in place for renewable energy are tentative. Such uncertain measures cannot overcome the doubts of investors, particularly international investors (Chown, 2005).

3.4.3 Environmental Impacts of Wind Energy

Wind energy is a benign energy technology – meaning that it does not directly produce any pollutants. However, it does have some potentially negative environmental impacts. Common issues that are raised about the environmental impacts of wind during EIA public participation processes include (EEU, 2002 and CSIR, 2001):

- Impacts on flora and fauna – especially bird fatalities due to interference with their flight paths
- Visual impacts – often linked to a not-in-my-backyard attitude
- The effects of noise on humans and livestock
- Electromagnetic interference
- Land use restrictions
- Associated infrastructure – for example, access roads

Most of these issues, on detailed study, are found to be of low significance and can be mitigated against. For the Darling Wind Farm, it was recommended an environmental management programme be implemented to mitigate the potential impacts, and an environmental control officer be appointed to ensure the programme is carried out (EEU, 2002).

Many environmental impacts are beneficial. Wind energy can improve reliability of supply, add to rural electrification programmes and encourage environmental preservation (Khatib, 1997). Rural electrification programmes, such as the one pursued in South Africa, usually lead to a financial loss. However, they have *economic* benefits in the form of access to electricity (*ibid*, 1997).

One important benefit in a South African context is employment creation – wind energy creates more jobs per unit of energy production than other forms of energy (AWEA, 2006b and DME, 2003c). European figures suggest that on average, 6 people per year are employed for each MW of new turbines. Between 100 and 450 people are employed for operation and maintenance per year per million MWh of electricity production (EEU, 2002). Employment figures for the Darling Wind Farm suggested about 40 jobs will be created during the six month construction period, with another 2 to 4 personnel needed to operate and maintain the wind turbines. Job creation will also involve skills and technology transfer (*ibid*, 2002).

Elsewhere, wind energy has decreased dependence on fossil fuels, which can be subject to price fluctuations and have environmental implications (AWEA, 2006a). Furthermore, if land is leased, this can provide a steady income for landowners – often good wind sites are located in remote regions that are difficult to farm profitably (*ibid*, 2006a). In the Western Cape, some wind farms are being developed by communities that have recently made successful land claims. The development of a wind farm provides part of their required business plan and a source of income for communities (Chown, 2006).

Compared with conventional energy generation, wind is a relatively benign source of energy, creating few pollutants. For the Darling Wind Farm, it was calculated that during its 25 year life span, approximately 350,000 tons of coal and 870 million litres of water would be saved (*ibid*, 2002). Darling Wind Farm's avoided release of CO₂ was calculated at 653,000 tons over 25 years. This compared to Eskom's coal-fired electricity generation, which produces 161 million tons per annum CO₂. Similar avoided releases were calculated for sulphur dioxide (SO₂) (5,300 tons), nitric oxide (NO_x) (2,700 tons), particulates (322 tons) and slag and fly ash (40,000 tons) (*ibid*, 2002).

The EIA for Darling Wind Farm took more than 8 years to complete, which demonstrates the controversy around establishing wind farms. There were many reasons for this lengthy process – including a sensitive political situation and tensions between stakeholders (Bodenstein, 2006) – but central to the delay was a lack of criteria for developing wind farms. Further, there was no reference case, strategic or spatial planning level environmental assessment against which a wind farm could be considered (*ibid*, 2006). The final EIA report recommended a Strategic Environmental Assessment (SEA) be carried out as part of a broader plan to assess the viability of wind energy in South Africa. Klipheuwel's EIA was much simpler and three pilot wind turbines were established (CSIR, 2001 and Bodenstein, 2006).

3.5 Domestic and International Financing of Wind Energy

Financial solutions for renewable energy projects of all kinds need to be appropriate to the given market and regulatory environment. To be fully effective, it is essential to create “financial incentives for investors to change the pattern of investment away from carbon-emitting conventional technologies in favour of large-scale investment in renewable/non-carbon emitting technologies” (Sonntag-O’Brien and Usher, 2004). Two types of financial incentives were identified:

- Domestic and international sources of finance
- Green energy market in South Africa

3.5.1 Domestic and International Sources of Finance

The structure of finance is central to the success or failure of a project (Chown, 2006). However, financiers are cautious about new investments, and “the differences between [renewable energy] and conventional energy systems and the risk perceptions they imply can become the most significant barriers to investment, even for [RETs] that are cost-competitive with conventional energy-supply options” (Sonntag-O’Brien and Usher, 2004). There are several types of finance for wind energy and other RET projects, including (*ibid*, 2004):

- **Private finance**
- **Risk capital** – equity investment; one of the few options for new businesses
- **Mezzanine finance** – variety of structures between high risk/high upside equity and lower risk/fixed returns debt
- **Corporate finance** – provided by banks
- **Project finance** – debt provided by banks to companies who have a PPA (and therefore a certain cash flow with which to pay back the loan)
- **Participation finance** – lending by a group of investors (for example, a wind fund)
- **Export credits, insurance and other risk management instruments** – can transfer specific risks from project sponsors/lenders to insurers/other parties
- **Third-party finance** – independent party finances many individual energy systems
- **Consumer finance** – may be necessary for rural clients to help make modern energy services affordable

Several recent DME reports have outlined the domestic and international funding possibilities for renewable energy projects in South Africa. **Appendix D** provides a comprehensive list of current sources of finance available to such projects. The size of funds available for each organisation is not known. However, it demonstrates that there is a considerable number of finance organisations that could help RET developers in South Africa. **Appendix E** shows two possible finance continuums for grid-connected and off-grid wind energy projects.

3.5.2 Green Energy Market

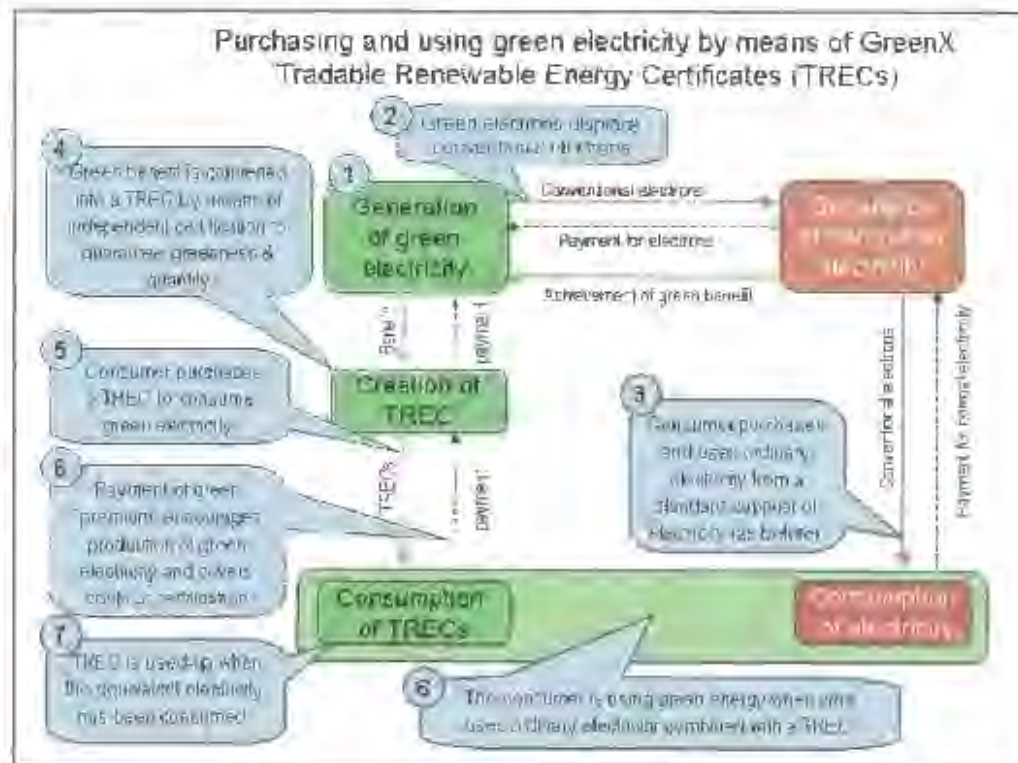
There is a small, but emerging green energy market in South Africa. Green electricity (or energy) is that which is “generated in a sustainable manner from renewable energy resources such as wind” (Morris, 2001). It can be MW class power stations, or smaller, distributed generation capacity. Schäffler (2001) concluded that while the market was

likely to be small, it was needed. Morris (2001) believes the green electricity generation capacity exists in South Africa, but that some changes must occur for green electricity to mature – including greater customer awareness and more commercially available green electricity.

Concerns regarding the regulatory structure are being addressed by the change in regulatory structure. These include a requirement that the electricity generation sector is open to competition, that the transmission system is accessible to all suppliers, that there is retail competition to enable customers to choose a service provider and that electricity should be certified to ensure retailers are providing a product that reflects their product descriptions (*ibid*, 2001). The PPA that has been agreed between the CCT and Darling¹⁷ is a case in point. The CCT is willing to pay a premium for clean energy produced by a wind farm – a premium of around 20c/kWh¹⁷. The premium alone is twice the current rates paid by Eskom to IPPs (10-11c/kWh).

In addition, the beginning of a market in tradable renewable energy certificates (TRECs) has been established in South Africa. Two companies, Amatola Green Power and Green X Energy are helping to create this market. Figure 15 shows the process of purchasing green electricity via TRECs.

Figure 15: Process of Purchasing Green Electricity via Tradable Renewable Energy Certificates (TRECs) (Steyn, 2005)



¹⁷ Average estimated retail rate from RFD One are around 18c/kWh (Schäffler, 2001). CCT will pay 37.5c/kWh for electricity produced by Darling Wind Farm (Climate Group, 2006).

TRECs are the unbundled, beneficial attributes of electricity generated by renewable sources. They are then sold or traded separately from the actual electricity (Bird, 2005). There is some concern that TRECs may lead to double crediting if CERs are also claimed for a project. However, many believe a project can benefit from both mechanisms (Thorne, 2006 and Chown, 2006). A TREC system was used in South Africa in 2002, in order to obtain 845MW of green electricity to supply the venues of the World Summit on Sustainable Development (WSSD) in Johannesburg (Morris, 2004). Since then, there has been some interest in using TRECs as a mechanism to implement renewable energy in South Africa and the Southern African Development Community (SADC).

Although there is great potential, TRECs and the green energy market are not currently significant enough to be considered in the financial analysis in **Section 6**. Furthermore, there is little public knowledge about the size of the market.

3.6 Summary of Findings from the Literature Review

Internationally the costs of wind are coming down per kWh and this pattern looks set to continue for several decades (Painuly et al, 2005 and Banks and Schäffler, 2005). Furthermore, the technology and expertise exists globally to enable wind power plants to be installed fairly quickly – renewable energy plants have an estimated three year lead time compared with conventional coal-fired plants that have a lead time of five years (DME, 2003c). Technology and system management improvements have encouraged the development of the wind industry internationally, and make it an efficient and cost-effective form of renewable energy. Consequently, **wind could help to provide new generation capacity to the Western Cape.**

Brebol et al (2003) investigated wind, solar and landfill gas as the three most feasible RETs in the Western Cape – with regards to availability of resources, the current energy planning and the stage of technological development. Eskom's focus is on solar thermal. Despite this competition, **wind energy could go some way to reducing energy supply problems and meeting increasing demand in the Western Cape.** Wind can increase the diversity of power supply options, thereby adding to security of supply. Grid-connected wind energy projects could help to provide base load capacity. Wind could also be used to support pumped storage schemes, which would help supply electricity during peak demand or emergencies. Since wind farms can be located *within* the Western Cape, there will be fewer transmission losses in the transfer of energy from producers to consumers. Although Klipheuwel is an Eskom pilot project, all other wind farms in the Western Cape are being pursued by IPPs and Eskom only considers solar thermal to be financially viable at present (CNdV, 2005). The presence of IPPs adds to the restructuring of the ESI.

Wind could help meet the Western Cape and CCT targets for renewable energy. Current wind atlases suggest that wind resources are good in the province (Diab, 1995 and CSIR, 2006b), although more accurate analysis is needed. Some sites that are identified as good, especially on the south coast, will need to be connected in order to feed electricity into the grid. However, connection costs are likely to be less than the estimated R16 billion needed to upgrade the transmission network and increase the efficiency of supply from coal-fired power plants in Mpumalanga.

The need for an EIA and other approval processes slow up the implementation of wind energy. However, **the low cost of coal remains the largest stumbling block to investment in wind energy**, although, prices for electricity from conventional sources are likely to increase from 2007 as supply shortages create upward pressure (Olver, 2005). **Access to domestic and international sources of finance and a growing green energy market could help make wind competitive.**

Since costs are central to whether wind energy can be competitive with other forms of energy and will be implemented in the Western Cape, the following sections therefore focus on a financial analysis of wind energy projects in the province.

4. THE FINANCIAL COSTS AND BENEFITS OF WIND ENERGY

4.1 Financial Costs of Wind Energy Projects

In this research, two major project costs are considered:

- **Capital Costs** – the upfront costs of investing in wind energy
- **Operational and Maintenance (O&M) Costs** – the ongoing costs of managing a wind energy project

International cost estimates¹⁸ for commercial onshore wind energy projects are given in Table 8.

Table 8: International Capital and Operation and Maintenance Cost Estimates for Wind Energy Projects

Source	Capital Cost Estimate (per kW installed)	Capital Cost Estimate (per kW installed)	O&M Cost Estimate (% of capital cost)
BWEA (2006a)	£700	R7,500	2%
AWEA (2006a)	\$1,000	R6,000	1.5%
EWEA (2006)	€900-1,100	R5,500-8,500	
This Study		7,000	2%

Cost estimates for onshore wind energy projects in South Africa are summarised in Table 9.

Table 9: Capital and Operation and Maintenance Cost Estimates for Wind Energy Projects in South Africa

Source	Capital Costs (ZAR/kW installed)	O&M Costs (ZAR/kW installed/annum)
Banks & Schöffel (2005)	6,000-8,000	
NER (2004)	7,714	16.7
Schöffel (2001) ¹⁹	7,227	
This Study	7,000	140²⁰

Estimated costs of current wind energy projects in the Western Cape are taken from Kluhnenwiel and Darling Wind Farm data, and are summarised in Table 10.

¹⁸ Where prices were in another currency, the ZAR were calculated according to exchange rates on 1st March 2006:

+ Euros to ZAR — 7.52310

+ US\$ to ZAR — 6.17390

+ UK Pounds Sterling to ZAR — 10.8388

Current exchange rates can be calculated at <http://www.x-rates.com>

¹⁹ Figures are calculated for Darling Wind Farm and are for 2000.

²⁰ Calculated as 2% of the capital cost.

Table 10: Cost estimates for Wind Energy Projects in the Western Cape (Klipheuwel and Darling Wind Farm) (adapted from Brebol et al, 2003)

Project	Capital Costs (ZAR)	O&M Costs (ZAR)	Preparation Costs (ZAR)	Connection Costs (ZAR)
Eskom Klipheuwel	38 million (approx.)		2.3 million	1.9 million (approx. 4% of capital costs)
Darling Wind Farm	47 million	10c/kWh (financial discount factor of 6%) or 1.3 million per annum (for a predicted output of 17.2GWh)		0.94 million (approx. 2% of capital costs)

4.1.1 Capital Costs

The capital costs of MW class, grid-connected wind turbines are often estimated as US\$1,000/kW installed (DMF, 2003a). However, these costs vary depending on the number of turbines, the exchange rate, the financing costs, the location of the wind farm relative to the grid, and transport and rigging requirements. Darling Wind Farm's costs were considerable due to the high cost of barrier removal prior to implementation (*ibid*, 2003a). The costs for the Klipheuwel project are not representative of other wind farms since it is a RD&D project, led by Eskom. By using three different wind turbines its developers have prevented cost optimisation (*ibid*, 2003a). When the Langefontein project is implemented, its size (around 115MW) is likely to create cost savings, through economies of scale. However, actual costs will only be available once the feasibility study is completed (DMF, 2003a).

Capital costs contribute 75-90% of the total costs for onshore wind (BWEA, 2006). For the financial analysis in this study, a capital cost of R7,000 per kW installed is used. This is close to the average of figures quoted in Tables 8 and 9. Given the current downward trend in capital costs of wind energy projects, the figure chosen is likely to fall over the next few years.

4.1.2 Operation and Maintenance Costs

O&M costs are the principal ongoing cost element for a wind energy project. They are likely to include (EWEA, 2006): regular maintenance; repairs; insurance; spare parts; and administration. Data for O&M costs is limited since wind energy is a relatively young technology, and data is only available for approximately 20 years. However, O&M costs appear to be decreasing. New turbine designs require fewer service visits and therefore less downtime (*ibid*, 2006).

O&M costs consist of fixed and variable costs. There is a range of estimates for these costs. AWEA (2006a) suggest that fixed costs for a 100MW plant are in the region of R93/kW installed per annum, with no variable costs. Meanwhile, the NRP in South

Africa – in summarising the cost and performance data of new supply-side options – gives a figure of R167/kW installed per annum for fixed costs of a 20MW wind energy project, and again no variable costs.

Further estimates recommend that O&M costs are a certain percentage of capital costs, as is shown in **Table 8** above. For this study, an O&M cost equivalent to 2% of capital costs is used. Again, this is an average figure taken from the quoted BWEA and AWEA figures in **Table 8**. O&M costs are usually given per annum. For comparative purposes, a figure was calculated in ZAR/kW installed using the reference case data. This figure, R140/kW installed is shown in **Table 9**.

4.1.3 Cost of Financing

The cost of financing refers to how the capital cost is repaid. Wind energy is capital intensive. Hence the cost of financing is an important variable in financial and economic evaluations of wind energy projects (AWEA, 2006a).

The feasibility of the project is affected by how fast investors want their loans repaid and what rate of return is required. Currently, the cost of financing is decreasing, as wind technology develops, reducing risk factors for investors and giving them increased confidence to invest (BWEA, 2006a). However, relative to conventional supply, wind energy is still seen as new and risky, and lenders offer less favourable financing terms, demanding a higher return on investment (AWEA, 2006a).

The wind energy project to be analysed is relatively small scale (5.2MW), therefore only the actual cash costs and benefits through the project's life cycle are looked at (Khatib, 1997). This means that debt, equity and other financial instruments have not been included in the financial analysis. However, a previous analysis of the Darling Wind Farm (EDRC, 2001) gave the debt/equity ratio as 2:1. The cost of debt was taken as what the Development Bank of South Africa offered to the project – 16.5% nominal (8.4% real, assuming 7.5% projected inflation) (*ibid*, 2001).

However, the cost of capital is reflected in the discount (interest) rate (EWEA, 2006). An assumed discount rate (-10%) was included in the Excel spreadsheet IRR formula used in the financial analysis.

4.2 Benefits of Wind Energy Projects

Three financial benefits are considered in this research:

- **Electricity Sales**
- **Renewable Energy Finance and Subsidy Office (REFSO) Capital Subsidy**
- **Certified Emission Reduction Revenues (CER) under the Clean Development Mechanism (CDM)**

The first two are domestic benefits, although some electricity could be sold into the Southern African Power Pool and therefore exported. The last is an international mechanism.

4.2.1 Revenue from Electricity Sales

The sale of electricity is the major benefit of a commercial wind energy project and the primary source of income (Schäffler, 2001). It is calculated by multiplying the amount of production with the estimated base price (Khatib, 1997). Wind energy prices vary from country-to-country. If customers are prepared to pay a premium for green electricity from wind energy projects, the amount above market price is determined by reflecting the environmental benefits of wind technology (EWEA, 2006).

Revenues are dependent on the nature of electricity tariffs (Spalding-Fecher, 2000). Currently, it is difficult to predict trends in electricity tariffs. There are currently many electricity tariffs, charged by different municipalities. The adoption of the RED system should simplify the complicated tariff structure, which includes cross-subsidies and exemptions, and a range of prices for the same service (Treasury, 2003). The NER is currently looking at ways to make tariffs easier (Chown, 2006). In the future, customers will be able to choose their service provider and buy energy direct from power plants – which could mean buying from wind energy IPPs. The new Wholesale Electricity Pricing System (WEPS), developed by Eskom and the NER, is available to direct, large customers who consume more than 100MW in any consecutive 12 month period (Eskom, 2005). It is interesting to compare the WEPS energy charges with what income is needed by wind energy projects.

IPPs must negotiate a PPA with a willing buyer, which means that the price paid per kWh of electricity generated by a wind energy project is project specific (Chown, 2006). The Beaufort West municipality pays IPPs approximately 18c/kWh (Chown, 2006) and Darling municipality's average wholesale price is around 19c/kWh (Schäffler, 2001). Commercial wind energy projects are not yet established in the Western Cape. It is likely that they will receive revenue in the form of a wholesale price paid by RED One. Schäffler (2001) estimated that this price would be 18.7c/kWh. Bulk pricing strategies are difficult to source, since they are not disclosed by Eskom. However, currently Eskom is thought to pay IPPs 10-11c/kWh for electricity onto the grid (Olver, 2005).

In order to simplify the range of energy charges, the estimated average wholesale price to be paid by RED One to IPPs is used – 18.7c/kWh, rounded to 19c/kWh. Since revenues from the sale of electricity are central to the financial viability of a wind energy project, a range of revenues is explored, to establish at what price the reference case will break

even. The range looked at is 10-60c/kWh. It is assumed that revenues from the sale of electricity will be taxed at the normal corporate tax rate of 29%²¹.

4.2.2 Renewable Energy Finance and Subsidy Office (REFSO) Capital Subsidy

In 2005 the DME established a Renewable Energy Finance and Subsidy Office (REFSO). This office aims to provide advice to developers and other stakeholders regarding renewable energy finance and subsidies, as well as other funding sources.

Under the auspices of REFSO, a capital subsidy has been established. REFSO offers a once-off capital subsidy per project of R250/kW capacity for electricity. It cannot be more than 20% of the total capital cost of the project and the minimum project size is 1MW – implying a minimum subsidy amount of R250,000 (*ibid*, 2005). This will help wind energy projects that meet REFSO's criteria to cover their upfront investment cost. If capital costs are taken to be R7,000/kW installed the capital subsidy amounts to 3.6% of these costs.

The REFSO funds are limited and project developers are encouraged to apply for other sources of funding – for example, the CDM. The total budget allocated to the capital subsidy is approximately R14 million over three years. Hence, the effects of the capital subsidy on the development of RETs are small (van den Berg, 2006 and Chown, 2006). At R250/kW, R14 million can support 56MW of RET capacity across South Africa²² – or the equivalent of just more than ten 5.2MW wind farms. Where subsidy funds are unavailable for all eligible applicants, projects will be judged according to: capital cost per unit of installed capacity, planned average production levels per year, and the number of direct jobs that will be created (DME, 2005a). REFSO also advises on alternative financing mechanisms.

Applications will only be considered once a project reaches 'maturity', which implies that the project has met the following criteria (DME, 2005a):

- Project must produce renewable energy
- Project must be located within South Africa
- Black Economic Empowerment (BEE) ownership
- Feasibility study showing: capital cost per unit of installed capacity; capital costs of project <R100 million; number of direct jobs created; planned average production levels per annum
- Positive RoD for EIA
- Project must have reached financial closure
- Off-take agreements with customers must be in place
- All permits/licenses must have been granted
- Project will commence shortly after signing contract
- Project must comply with section 38 (1) (j) of Public Finance Management Act
- Availability of subsidy funds

²¹ The South African corporate tax rate is 29% as from 2006. More details of tax rates can be found at www.ftomasek.com/rates.html.

²² R14 million / R250/kWh = 56,000kW = 56MW.

- DME approval

These criteria are quite stringent and may prevent some project developers from applying.

Nevertheless, a REFSO capital subsidy would be an additional benefit and would help reduce capital costs of wind energy projects. Its effects on the reference case are therefore analysed.

4.2.3 Certified Emission Reductions under the Clean Development Mechanism

The Clean Development Mechanism (CDM) creates the possibility for an *additional* revenue stream for wind energy projects. This revenue relates to the environmental value of the investment, and is monetised through sales of carbon emission reductions (CERs) (Ecosecurities, 2002). These can be traded under the CDM and used to meet targets for carbon emission reductions in Annex I countries, set by the Kyoto Protocol (Article 3 in UNFCCC, 1997b).

Now that the Kyoto Protocol is in force, and carbon trading has begun formally, it is interesting to ask whether carbon (CER) revenues can be seen as a driver of investment. If CER revenues have the positive effect of pushing a project's return on investment (IRR) past the stipulated threshold (hurdle rate), then carbon revenues can be seen as a driver.

Section 5 discusses the details of the CDM and the potential for revenue from CERs.

5. THE CLEAN DEVELOPMENT MECHANISM AND WIND ENERGY

5.1 Background to the Clean Development Mechanism

5.1.1 Climate Change – South Africa’s Role and Responsibilities

South Africa ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 (UNFCCC, 1997a). By ratifying the Convention, it confirmed its commitment to stabilising concentrations of greenhouse gases (GHG) in the atmosphere at a level that limits dangerous human interference with the global climate. Under the UNFCCC, the Kyoto Protocol was also established in 1997 (UNFCCC, 1997b). Annex I countries (industrialised countries) pledged that they would reduce their GHG emissions by at least 5% less than 1990 levels in the commitment period 2008-2012 (Article 3 in UNFCCC, 1997b). The six main GHGs identified under the Kyoto Protocol are: carbon dioxide (CO₂); methane (CH₄); nitrous oxide (N₂O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF₆) (Painuly et al, 2005).

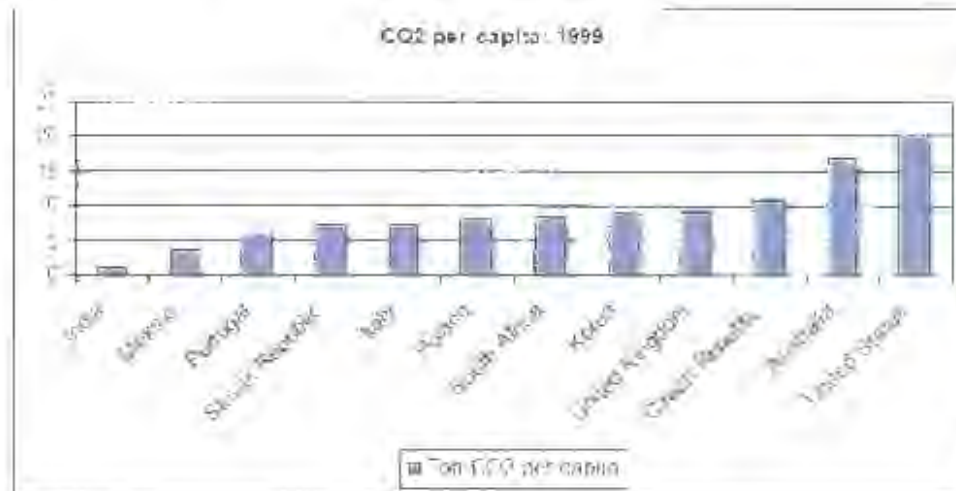
Although South Africa acceded to the Kyoto Protocol in 2002, as a non-Annex I country (developing country) it is not committed to any quantified emission reduction targets in the first commitment period (2008-2012) (DME, 2003c). The White Paper on Renewable Energy recognises that South Africa may be required to take on a commitment to reduce GHG emissions after 2012 since “power plants last 40 years or more – long after South Africa may be required to take on commitments related to GHG emissions” (*ibid*, 2003c).

Non-Annex I countries can provide low cost, certified emission reductions (CERs) to Annex I countries, by trading them through the Clean Development Mechanism (CDM) – Annex I countries can use these CERs to meet their emission reduction commitments (*ibid*, 2003c and Spalding-Fecher, 2002). One of the major aims of the CDM is to promote sustainable development in developing countries. At the same time, it encourages technology transfer from industrialised to developing nations (Ellis et al, 2004). Painuly et al (2005) put this basic principle in clear terms:

... Developed countries can invest in low-cost abatement opportunities in developing countries and receive credit for the resulting emissions reductions, thus reducing the cut backs needed within their borders. While the CDM lowers the cost of compliance with the Protocol for developed countries, developing countries will benefit as well, not just from the increased investment flows, but also from the requirement that these investments advance sustainable development goals.

As a non-Annex I country, South Africa is well placed to benefit from this mechanism. South Africa creates around 2% of international GHG emissions, and yet its population represents only 0.7% of the world’s people and its GDP stands at 0.9% of the global figure (CAIT, 2006). This makes it one of the world’s highest per capita emitters of CO₂ – see **Figure 16**. Given this data it is anticipated that there will be international pressure put on South Africa to commit to emission reduction targets sooner rather than later (Winkler, 2005b).

Figure 16: CO₂ Emissions per Capita for Selected Countries (IEA, 2001, quoted in DME, 2003c)



South Africa's global commitment to climate change mitigation and its high CO₂ emissions, combined with the commitments of industrialised nations, present opportunities for the financing and development of wind energy projects.

5.1.2 The CDM and Wind Energy Projects

Wind energy has become a popular project choice under the CDM (Ollis and Levina, 2005). The number of small renewable electricity projects demonstrates a willingness to develop projects even if they do not generate large emissions reductions. Figures 17 and 18 compare the number of projects by type, and the percentage of annual carbon credits awarded by project type. These clearly show that although the majority of projects are renewable energy projects, this is not reflected in their share of annual credits – the nine fossil gas projects make up 23% of the annual credits and renewable energy has the second highest percentage of annual credits (20%).

Figure 17: Number of CDM Projects by Type (Ellis and Levina, 2005)

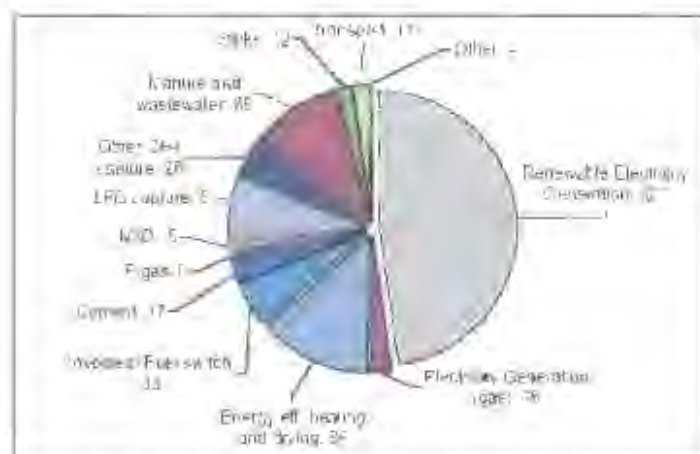
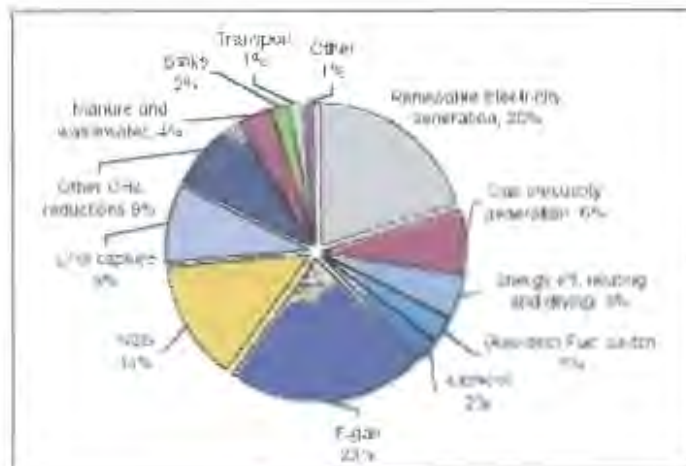


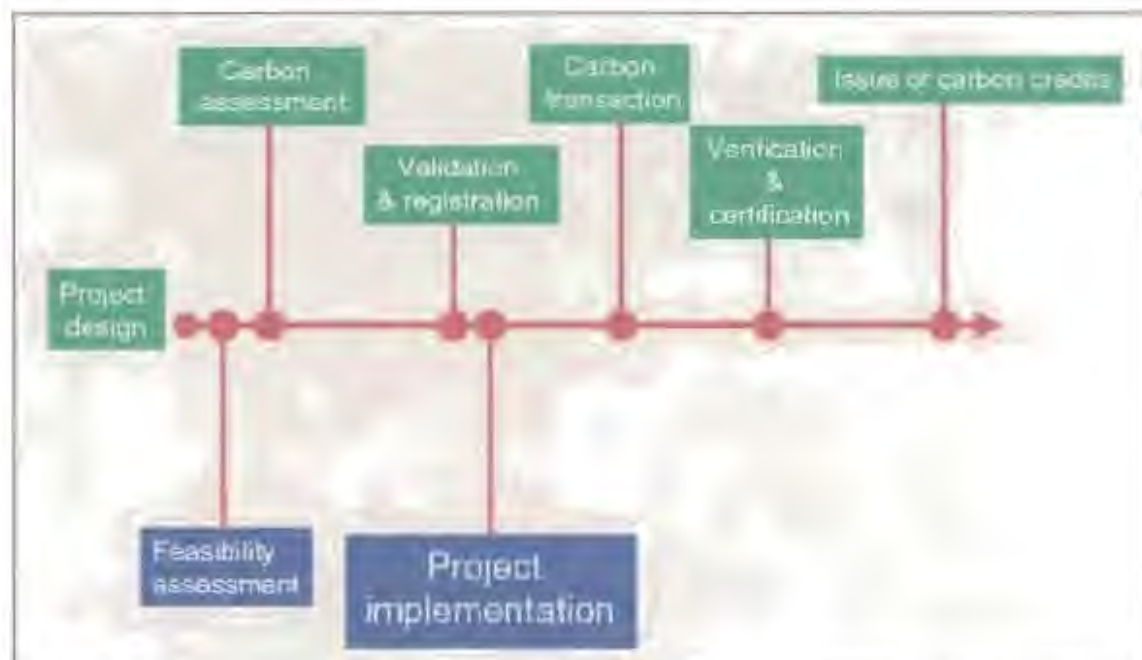
Figure 18: Percentage of Annual Carbon Credits by CDM Project Type (Ellis and Levine, 2005)



Wind energy projects are significant, constituting 12% of the CDM project pipeline – 84 projects out of a total 693. This is the third highest percentage after biomass and hydro (Fenham, 2006).

The CDM process can be shown graphically – see **Figure 19**. The lower boxes represent elements of a standard project cycle.

Figure 19: Carbon Crediting Project Cycle (Ecosecurity, 2002)



There are a number of principles that underpin the CDM and set the boundaries for projects. These include (adapted from FES and ERI, 2002):

- The host country must confirm that a CDM project is helping to achieve sustainable development
- CDM projects *can* be unilateral
- All technologies except for nuclear power are eligible for CDM
- Fast-track procedures have been developed for small-scale projects
- The CDM aims for CDM projects to be equally distributed geographically
- Investment in CDM projects must be additional to existing aid from developed countries
- Technology and knowledge transfer as a result of the CDM should be “sound and environmentally safe”
- The Executive Board of the CDM will maintain the ‘registries’ of CERs generated

In the context of this research into carbon finance, it is important to remember that a project is *not* eligible if public funding from Annex I parties has diverted ODA. Public funding for CDM projects must be kept separated from the financial obligations of these parties (FES and ERI, 2002). Hence a project developer must weigh up the pros and cons of carbon finance versus other sources of finance shown in **Appendix D**.

It is essential to note the distinction between small scale and large scale projects. Wind energy projects fall into the category of renewable energy projects. According to the Marrakesh Accords, which established a fast track for small scale projects, small scale can be defined as (UNFCCC, 2001):

Renewable energy project activities with a maximum output capacity equivalent of up to 15MW (or an appropriate equivalent)

Of the wind projects in the Western Cape, Darling Wind Farm is small scale – for both Phase I (5.2MW) and Phase II (13MW) – as is Klipheuwel (3.16MW). If the Langefontein project goes ahead, it will be large scale (115MW). All Genesis Eco-Energy projects are large scale (30-50MW).

The CDM is thought to make approximately 10% positive difference to the viability of wind energy projects (Avis, 2006). This comment was based on experience gained by Ecosecurities²³ on three large scale wind projects in Morocco (Essaouira), Jamaica (Wigton Wind Farm) and China. Thus far there have been no wind energy CDM projects in sub-Saharan Africa – among a total of 13 CDM projects in the region (Fenhann, 2006).

Large scale wind farms – with a capacity of >15MW – are thought to be more effective as a result of economies of scale. However, projects only need to pass a 5MW threshold in order to be attractive and begin to recoup their costs (*ibid*, 2006). Nevertheless, investors are still concerned about the financial costs and competitiveness of alternative

²³ Ecosecurities provides carbon finance solutions to projects reducing GHG emissions. It is based in the UK, but has offices, personnel and projects around the world.

electricity generation technologies. These costs will “strongly shape investments in renewable energy technologies in developing countries over the coming decades” (Ringius et al, 2002).

The details of designing and implementing wind energy CDM projects, as well as the costs and benefits involved, are discussed in the following sections.

5.2 Establishing a CDM Project

5.2.1 Additionality and Baselines

To be considered a CDM project, a project must be shown to be additional. In other words, it must produce credible emissions reductions – by reducing emissions per unit of output (tCO₂/MWh) to *below* the baseline in that country (paragraph 43, UNFCCC, 2001). The baseline is the level of carbon emissions, which would have existed without the CDM project, and the project emissions must also not be equal to this. To establish what would have existed without the CDM project, an accurate baseline must therefore be calculated. For a project to be *fully* additional, it ought not to occur ‘anyway’, as part of business-as-usual, but should be planned as a specific CDM project.

Baselines can be project specific or standardised (multi-project). The former will increase transaction costs, since it is time consuming. The latter, by establishing a generic baseline for an activity, sector or region, could lead to emission reductions that are not real (Winkler et al, 2001b). There are three possible scenarios that could be employed for a wind energy project. These are all for multi-project baselines since wind energy projects, such as Darling Wind Farm, will be grid-connected (Winkler et al, 2001b):

- average emissions from all grid electricity generation (Eskom’s power stations) = 0.85kgCO₂/kWh
- carbon emissions for most recent power plant additions = 1.08kgCO₂/kWh
- emissions from the next few capacity additions (1997-2005) = 0.84kgCO₂/kWh

A more recent figure for grid emissions, using Eskom’s power stations’ emissions, is 0.963kgCO₂/kWh (Eskom, 2005a).

The second of these would produce the most emission reductions. An alternative, and more recent baseline analysis, gave two options (DME, 2002b):

- coal based plant only = 1.08kgCO₂/kWh
- coal, gas and hydropower = 0.88kgCO₂/kWh

Analysis of multi-project baselines for the electricity generation sector in South Africa showed that in 2001 a *near future* scenario was most appropriate (Winkler et al, 2001b). This means estimating what power plants are *likely* to be built, and allows for a consideration of new, more efficient technologies (*ibid*, 2001b). In 2001, near future plants included two mothballed power stations, new gas and an imported hydro scheme. The NIRP (NER, 2004) gave details of the non-Eskom capacity as well as new supply-side options for South Africa. These are summarised in **Tables 11 and 12**.

Table 11: Existing Non-Eskom Generating Capacity (NER, 2004)

Plant	Capacity (MW)
Mosses 1 – coal-fired capacity	720
Mosses 2 – coal-fired capacity	630
Sasol – coal-fired capacity	720
Steenbras (pumped storage plant)	180
Mini hydro	65
Mini OCGT	300
Total	2615

Table 12: New Supply-Side Options (NER, 2004)

Plant	Capacity (MW)
New Coal-Fired Plants	
CF Dry + FGD	3,850
Pumped Storage	
Pumped Storage (Hazardous public data)	1,350
Pumped Storage (general)	998
Gas Turbines	
CCGT (without Trans benefits) pipe	1,935
CCGT (with Trans benefits) pipe	1,935
CCGT (without Trans benefits) LNG	1,935
CCGT (with Trans benefits) LNG	1,935
GT-Open Cycle (Liquefied)	240
GT-Open Cycle (LNG)	240
GT-Open Cycle (Local syngas)	240
GT-Open Cycle (LPG)	240
New FBC	
Greenfield FBC	400
Imports	
Imported hydro	1,300
Renewables	
Solar Thermal	500
Wind	20
Nuclear	
PBMR (1.1 MM excl. trans benefits)	1,320
PBMR (1.1 MM excl. trans benefits)	1,320
PBMR (Series MM excl. trans benefits)	1,364
DWR (incl. trans benefits)	1,747
DWR (excl. trans benefits)	1,747
Total	24,362

However, as a result of recent power outages in the Western Cape, near future scenarios are currently uncertain. Furthermore, there have been very few recent additions to electricity generation in South Africa. In 2001, recent plants were taken to be the two units at Majuba (Winkler et al. 2001b). However, these only represent one form of electricity generation – namely coal. Renewable energy in South Africa should be compared to a sector wide baseline that represents more than coal-fired production (Ibid.

2001b). The latest NERP capacity outlook for the next twenty years does not consider commissioning wind energy (NER, 2004).

For the purposes of this research, the most recent carbon intensity calculated for the entire grid will be used as the baseline – this is taken as the carbon intensity of all *existing* Eskom power plants, since Eskom generates more than 95% of electricity in South Africa. A full list of all Eskom power plants is included in **Appendix F**. The carbon emissions intensity used to calculate the baseline in this study was therefore $0.963\text{kgCO}_2/\text{kWh}$ (Eskom, 2005a). Two other baselines were considered for comparison: recent plants (Majuba), $1.08\text{kgCO}_2/\text{kWh}$ (Winkler et al. 2001b), and near future plants, $0.7113\text{kgCO}_2/\text{kWh}$ (adapted from *ibid.*, 2001b).

Due to current uncertainties regarding the PSI, a dynamic baseline is used. This can be updated at the end of each 7 year crediting period – with a maximum of two renewal periods (*ibid.*, 2001b). Hence, a 21 year crediting period is used in the financial analysis. The lifetime of most wind projects is 15-25 years (BWEA, 2006a and Hagemann, 2006).

5.2.2 Emissions Reductions from Wind Energy Projects

Annual carbon credits from a CDM project are calculated as follows (Spalding-Fecher, 2000):

$$\text{Carbon credits (tCO}_2\text{/annum)} = \text{baseline emissions} - \text{actual emissions}$$

Actual emissions for a wind energy project are taken to be $0\text{kgCO}_2/\text{kWh}$. When other GHGs are involved in a project, carbon is taken to mean CO_2 -equivalents (CO_2e). Carbon revenue for a given year is therefore calculated as (*ibid.*, 2000):

$$\text{Carbon revenue (R/annum)} = \text{carbon credits (tCO}_2\text{e/annum)} \times \text{carbon price (R/tonne)}$$

Carbon prices are quoted in Euros (€) and converted to ZAR Rands (ZAR). In order to simplify calculations, a carbon emissions intensity figure will be used for baseline scenarios – measured in kgCO_2/kWh . The annual emissions reductions from a given wind energy project will therefore be calculated as:

$$\begin{aligned} \text{Emissions reductions (tCO}_2\text{/annum)} &= \text{annual generation of wind project (MWh)} \times \\ &\quad (\text{baseline emissions intensity} - \text{actual emissions intensity}) (\text{kgCO}_2/\text{kWh}) \end{aligned}$$

The emissions reductions figure is used in the financial analysis to calculate how much CRR revenue is possible from the given wind energy project. It is assumed that wind energy has zero emissions intensity ($0\text{kgCO}_2/\text{kWh}$). For the reference case the calculation is as follows:

$$\begin{aligned} \text{Emissions reductions (tCO}_2\text{/annum)} &= 15,943\text{MWh} \times (0.963\text{kgCO}_2/\text{kWh} - 0\text{kgCO}_2/\text{kWh}) \\ &= 15,353\text{tCO}_2\text{/annum} \end{aligned}$$

This annual avoided emissions figure was then used to establish the avoided emissions over the project life (21 years), which amounted to **322,419tCO₂**. It was also used to calculate the revenue from CERs (see **Section 6.3.1**).

5.3 The Costs of a CDM Project

There are two major costs associated with setting up a CDM project, aside from the necessary US \$5,000 registration fee per project:

- Transaction costs
- Monitoring and Verification costs

5.3.1 Transaction Costs

Transaction costs relate to a project's development and approval by the CDM. The feasibility study requires a baseline analysis and a proposed monitoring and verification plan (Spalding-Fecher, 2000). These costs can be significant, particularly for small scale projects. A recent article suggested that even at premium CER prices, a small scale CDM project that produces a low volume of credits – such as a wind farm – is unlikely to be financially viable as a result of the design and registration costs (Tyler, 2006a). These costs can be overcome through bundling smaller projects, or spreading the costs over more emission reductions (Spalding-Fecher, 2000). However, the major problem is not necessarily the actual cost involved – especially not if this is seen in the context of future income – but the need to pay that cost upfront. For small scale project developers, this can be difficult (Cartwright, 2006 and Chown, 2006). A range of transaction costs were given by the CDM experts interviewed – see Table 13.

Table 13: Estimated Transaction Costs for CDM Projects

Source	Organisation	Transaction Costs (ZAR)	Project Type
Cartwright (2006)	Promoting Access to Carbon Equity (PACE)	225,000 (approx.)	Small-scale
Tyler (2006)	SouthSouthNorth	600,000 (approx.)	Large-scale
Van den Berg (2006)	CDM Africa	300,000-600,000	All projects

Transaction costs can be brought down by implementing projects that already have approved methodologies, under the Executive Board of the CDM. Furthermore, several wind energy projects have already been approved or are awaiting validation, and the experience of these can be used to develop new projects. Two generic methodologies are frequently used for wind energy projects (Ellis and Levina, 2005):

- **Simplified methodology for small-scale renewable energy projects (AMS-I.D.)**
- **Consolidated methodology for renewable electricity generation (ACM0002)**

For this research, transaction costs were assumed to be R300,000 per small scale project. The transaction costs for a large scale project are taken as R600,000.

5.3.2 Monitoring and Verification Costs

A CDM project must be both monitored and verified. A Designated Operational Entity (DOE) will carry out the verification. For wind projects verification is made easier by the simple methodologies (Spalding-Fecher, 2002) and it is likely that verification costs will be in the region of R20,000-R50,000 per year. The only output that has to be monitored

is the electricity output. Since this would be carried out regardless of the project's CDM status, monitoring costs are assumed to be zero (*ibid*, 2006).

For this research, the verification costs are assumed to be R35,000 per year.

5.4 The Benefits of a CDM Project

5.4.1 What is a Certified Emission Reduction (CER)?

A CER is one type of carbon credit, which can be sold and traded nationally and internationally in the compliance market. It is equivalent to 1tCO₂e. As yet, CERs are not available beyond the first commitment period (2008-2012), although it is likely that carbon credits will continue to exist – perhaps in an alternative form (Avis, 2006). They are fungible, and can be transferred for use in the European Union Emissions Trading Scheme (EU ETS).

Although CER sales provide a source of income, it is “unlikely” that this income will be taxed in the near future (Tyler, 2006a) and no tax was included in the financial analysis.

5.4.2 CER Revenues

CER prices are hard to predict since they are negotiated at the time of sale, between the seller and the buyer. Nevertheless, certain trends can be observed. CER prices are dependent on two factors: risk and the conditions of the emissions reduction purchase agreement (ERPA).

If a project is low-risk, with a guaranteed number of credits that are close to being tangible, CERs can sell to the market at close to the EU Allowance price of around €20-30/tCO₂ (Avis, 2006). Van den Berg (2006), CDM Africa, suggests that it would be useful to discover what the forward price²⁴ needs to be in order to make a project viable, since a forward price is fixed and can therefore be used in project budgets. It is also vital for smaller project developers to fix a price upfront, since this helps them to bank their projects. Smaller projects cannot carry the risks of waiting to sell at a later price in the hope of negotiating a better price (Chown, 2006). Big national power producers are able to take that risk (Avis, 2006).

Current price estimates for CERs, from CDM specialists in the Western Cape, are summarised in Table 14. These are for CERs from registered projects, being sold into the compliance market. The Carbon Positive estimates are quoted for comparison with an international estimate.

Table 14: CER Price Estimates quoted by CDM Experts

Source	CER Price (€)
Cartwright (2006)	9-11
Chown (2006)	5-11
Tyler (2006a)	11-14
Carbon Positive (2006)	8-11
This Study	9

²⁴ There are two types of forward price, which is broadly a price set now for the future delivery of CERs. A *future* price is an ‘over-the-counter’ price established privately between two parties for delivery in the future, whereas a price that is *not quite a future* is an exchange traded price for delivery in the future (van den Berg, 2006).

If the project developer or seller of CERs is prepared to carry the risks of the project, the price can be as high as €20/tCO₂ (Carbon Positive, 2006). These risks can be at a project level, meta level or national level (Cartwright, 2006). Risks relate to external factors that create uncertainties for investors. These could include government taxation, sales quotas, limited access to new technologies, political and economic instability, subsidies from developed countries to their own local industries, and local currency fluctuations (Kossoy, 2006). National level risk underpins all other risks. **Table 15** shows the CER prices that the Climate Protection Programme (CaPP) assumes for different levels of risk, reducing as risks decrease.

Table 15: CER Price Estimates with Associated Levels of Risk (CaPP, 2006)

Level of Risk	CER Price (€)
Medium-risk forwards	4-6
Low-risk forwards	8 (approx.)
Registered projects	11-14 (approx.)
Gold Standard registered projects	15 (approx.)
Issued CERs	15-17

It is therefore essential to try to minimise the risk for buyers through best practice, in order to negotiate a better price for CERs at the time of sale (Kossoy, 2006). The question is whether a project developer takes on the risks of the project, and holds on for a better price. Or whether projects utilise upfront project finance, offering future CERs as part of the debt or equity repayments (Avis, 2006 and DME, 2002b).

Market predictions of future CER prices are optimistic. Recent reports suggest that EU Allowance prices could reach up to €35-40/tCO₂ in the next year or so (DrKW, 2006 and JPMorgan, 2006), and there is no reason to suggest that CERs will not follow the same pattern. However, if Russia and Ukraine decide to sell their 'hot air', this could have a detrimental effect on the price of CERs – potentially reducing their value to €0/tCO₂ (Avis, 2006).

For this research, a range of CER prices were considered, between €5-€40/tCO₂. Where other variables were explored, an assumed CER price of €9/tCO₂ was used.

6. FINANCIAL ANALYSIS OF WIND ENERGY PROJECTS IN THE WESTERN CAPE

6.1 Financial Model

6.1.1 Cash Flow and Internal Rate of Return

In order to establish the worth of a project, it is necessary to carry out financial profitability projections. Project developers' concerns are with their cash flow and return on equity. Commonly used methods include (Khatib, 1997):

- Internal Rate of Return (IRR)
- Evaluating the Net Present Value (NPV) of the project
- Calculating a cost/benefit ratio
- Other criteria – for example, the payback period, profit/investment ratio, commercial return on equity capital

Project developers focus on the net benefits of a project, and the net present value (NPV) of these in relation to the value of their investment (equity) (*ibid*, 1997). A project is viable if the NPV is more than 0 – when the sum of the discounted benefits is more than the sum of the discounted costs. Financiers will further consider the return on the total investment and its profitability, hence integrating the views of loan providers and equity investors (*ibid*, 1997).

IRR is a popular and widely understood method of financial analysis. IRR is the discount rate that equates the cost and benefit streams of the projects *or* the rate of return that makes the project's NPV equal to zero. It is calculated by a process of trial and error, according to the formula (*ibid*, 1997):

$$\Sigma[C_n/(1+r)^n] = \Sigma[B_n/(1+r)^n]$$

C_n is the stream of costs, B_n is the stream of benefits and r is the rate of return. By iterating values of r , it is possible to calculate at what point the sum of the discounted costs is equal to the sum of the discounted benefits. For this research, the finance model was developed as an Excel spreadsheet – see **Table 16**. Hence, the Excel formula for calculating IRR was used. An approximate discount rate (r) of -10% was used.

A project is deemed worthwhile “if IRR is equal to or above the opportunity cost for a private project, or the social discount rate (as set by the government) in public projects” (*ibid*, 1997). Put simply, if the IRR is more than the hurdle rate then the project is attractive to an investor or project developer (Spalding-Fecher, 2000).

6.1.2 Inputs and Assumptions

For this study a reference case was developed, which was used to test the two variables under investigations:

- **Renewable Energy Finance Office (REFSO) Capital Subsidy**
- **Certified Emission Reduction (CER) Revenues**

These variables were investigated through consideration of the following scenarios:

- **without capital subsidy or CER revenues**
- **with capital subsidy**
- **with CER revenues**
- **with capital subsidy and CER revenues**

Inputs to the finance model for the reference case are shown in **Table 16**. Costs and benefits have been discussed in **Sections 4** and **5**. This section considers the project performance data inputs and describes the model used.

Project performance data was taken from available figures for Darling Wind Farm (Oelsner, 2005), which will be the first commercial wind farm in the Western Cape. Phase I will be 5.2MW and Phase II, 13MW (Oelsner, 2005). For the financial analysis in this section, a 5.2MW project equivalent to Phase I of the Darling Wind Farm is considered. Previous analysis of the Darling Wind Farm calculated that in order to break even, the project needs an income of 38c/kWh (Spalding-Fecher, 2000). The EIA for the Darling Wind Farm suggested that doubling the capacity to 10MW could reduce the break even point to 33c/kWh. To bring that price down further, to the equivalent of what Eskom charges municipalities for bulk electricity (on average 20c/kWh) would require grant funding of R20 million – in order to reduce the capital cost of the project (EEU, 2002). A PPA between DarlIPP and the CCT will help the project, since the agreed price is 37.5c/kWh (Climate Group, 2006). This price has been underwritten by a loan from the Global Environment Facility (GEF) (van den Berg, 2006).

Capacity factors for onshore sites are estimated to be 20-40% (1,800-3,500h/yr). Offshore or very good sites can have capacity factors of 45-60% (Holtinnen and Hirvonen, 2005), closer to those of other RETs – hydro, biomass, landfill and newer technologies, such as wave power, have capacity factors of above 50% (Banks and Schäffler, 2005). A capacity factor (or load factor) is a measure of the amount of electricity generated by wind turbines compared to the theoretical maximum output of those turbines under ideal wind conditions (Sinden, 2005b). It refers to the average power production at a site, expressed as a percentage of the nominal capacity (Banks and Schäffler, 2005). In South Africa, it is estimated that capacity factors for wind will be 30% until 2007, and 35% from 2008 onwards (*ibid*, 2005). In this research a capacity factor of 35% was used. The number of full load hours was calculated using this assumed capacity factor multiplied by 8,760h/yr²⁵. To gain a figure for annual generation, the number of full load hours (3,066h/yr) was multiplied by the capacity (5.2MW).

²⁵ The full number of hours per year, and the theoretical maximum number of full load hours, is 8,760h/yr.

Previous financial analyses of the Darling Wind Farm used the modest IRR of 8% (Spalding-Fecher, 2002, EEU, 2002 and Schäffler, 2001). This is lower than is usual for an emerging market. IPPs generally use a hurdle rate of 15% (Schäffler, 2001 and Hagemann, 2006). Early investment in projects with low IRRs, is usually by “conscientious investors” (Schäffler, 2001), who hope their investments will stimulate growth in the sector and create more profitable investment opportunities for the future. For this research an IRR of 15% is used as the hurdle rate. However, since DarlIPP has used an IRR of 8%, results are also compared to this lower hurdle rate.

Table 16: Inputs to Finance Model for Reference Case, Darling Wind Farm (Phase I)
(author's calculations)

REFERENCE CASE: Darling Wind Farm (Phase I)

Financial Evaluation of a CDM Project

Yellow fields require manual input

INPUT	UNIT	VALUE
Wind Project Performance		
Capacity	MW	5.2
Capacity Factor	%	35%
Generation (Full Load) Hours	Hours per annum	3,066
Annual Generation (Power Output)	MWh per annum	15,943
Project Lifetime	Years	21
Costs		
Capital Costs (turbines, installation, land purchase, etc)	ZAR per kW installed	- 36,400,000
Transaction Costs (CDM Set Up Costs)	ZAR per project	- 300,000
Total Upfront Investment Costs	ZAR (year 0)	- 36,400,000
Operation and Maintenance Costs (O&M)	ZAR per annum	- 728,000
Monitoring and Verification Costs	ZAR per annum (from year 1)	- 35,000
Total O&M Costs	ZAR/yr (from year 1)	- 728,000
Tax Rate	% of income	29%
Benefits		
Bulk Electricity Tariff - paid by municipalities or RED to IPP	ZAR per kWh	0.19
PPA price (CCT with DarIPP)	ZAR per kWh	0.38
REFSO Capital Subsidy	ZAR per kW capacity	250
Total REFSO Capital Subsidy	ZAR (in year 0)	1,300,000
Annual Revenue	ZAR	2,981,378
Annual Revenue (less 29% corporate tax on income)	ZAR	2,057,151
GHG Emissions from Wind Energy Project	tCO ₂	-
Annual Avoided Emissions (Baseline: Grid Emissions, Eskom)	tCO ₂ per annum	15,353
Annual Avoided Emissions (Baseline: Recent Plants)	tCO ₂ per annum	17,219
Annual Avoided Emissions (Baseline: Future Plants)	tCO ₂ per annum	11,340
Avoided Emissions over Project Life	tCO ₂	322,419
Today's Price of CERs (€)	€ per tCO ₂	9
Price of CERs (ZAR)	ZAR per tCO ₂	68
Annual Revenue from CERs	ZAR per annum	1,039,816
Total Revenue from CERs over Project Lifetime	ZAR	21,836,140
Output Values		
Internal Rate of Return (no Capital Subsidy, no CER Revenues)	%	-2%
Internal Rate of Return with Capital Subsidy (no CER Revenues)	%	-2%
Internal Rate of Return with CER Revenues (no Capital Subsidy)	%	3%
Internal Rate of Return with Capital Subsidy and CER Revenues	%	3%

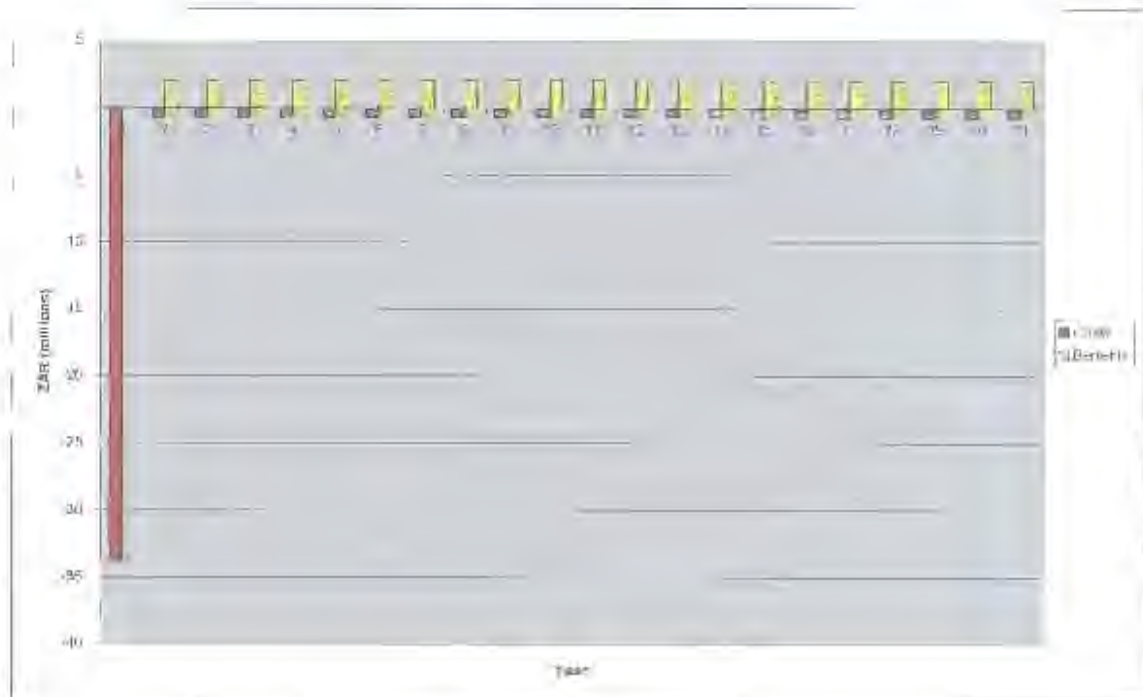
All costs were treated as negative and all benefits as positive. Initially, for example during the construction phase, costs are likely to outweigh benefits. Later, discounted net benefits must be positive or the project will not go ahead (Khatib, 1997). Figure 20 shows a typical project cash flow, using figures from the reference case given in Table 17. The figures given are for the 'without capital subsidy or CER revenue' scenario.

Table 17: Costs and Benefits for the Reference Case Wind Energy Project (without capital subsidy or CER revenues) (author's calculations)

Year	Costs (ZAR)	Benefits (ZAR)
0	-33,800,000	
1	-676,000	2,057,151
2	-676,000	2,057,151
3	-676,000	2,057,151
4	-676,000	2,057,151
5	-676,000	2,057,151
6	-676,000	2,057,151
7	-676,000	2,057,151
8	-676,000	2,057,151
9	-676,000	2,057,151
10	-676,000	2,057,151
11	-676,000	2,057,151
12	-676,000	2,057,151
13	-676,000	2,057,151
14	-676,000	2,057,151
15	-676,000	2,057,151
16	-676,000	2,057,151
17	-676,000	2,057,151
18	-676,000	2,057,151
19	-676,000	2,057,151
20	-676,000	2,057,151
21	-676,000	2,057,151

Costs in year 0 are capital costs. Costs from year 1 are O&M costs. Benefits are from the sale of electricity at bulk electricity tariff.

Figure 20: Cash Flow for the Reference Case Wind Energy Project (without Capital Subsidy or CER Revenues) (author's calculations)



6.2 Financial Analysis of a Wind Energy Project

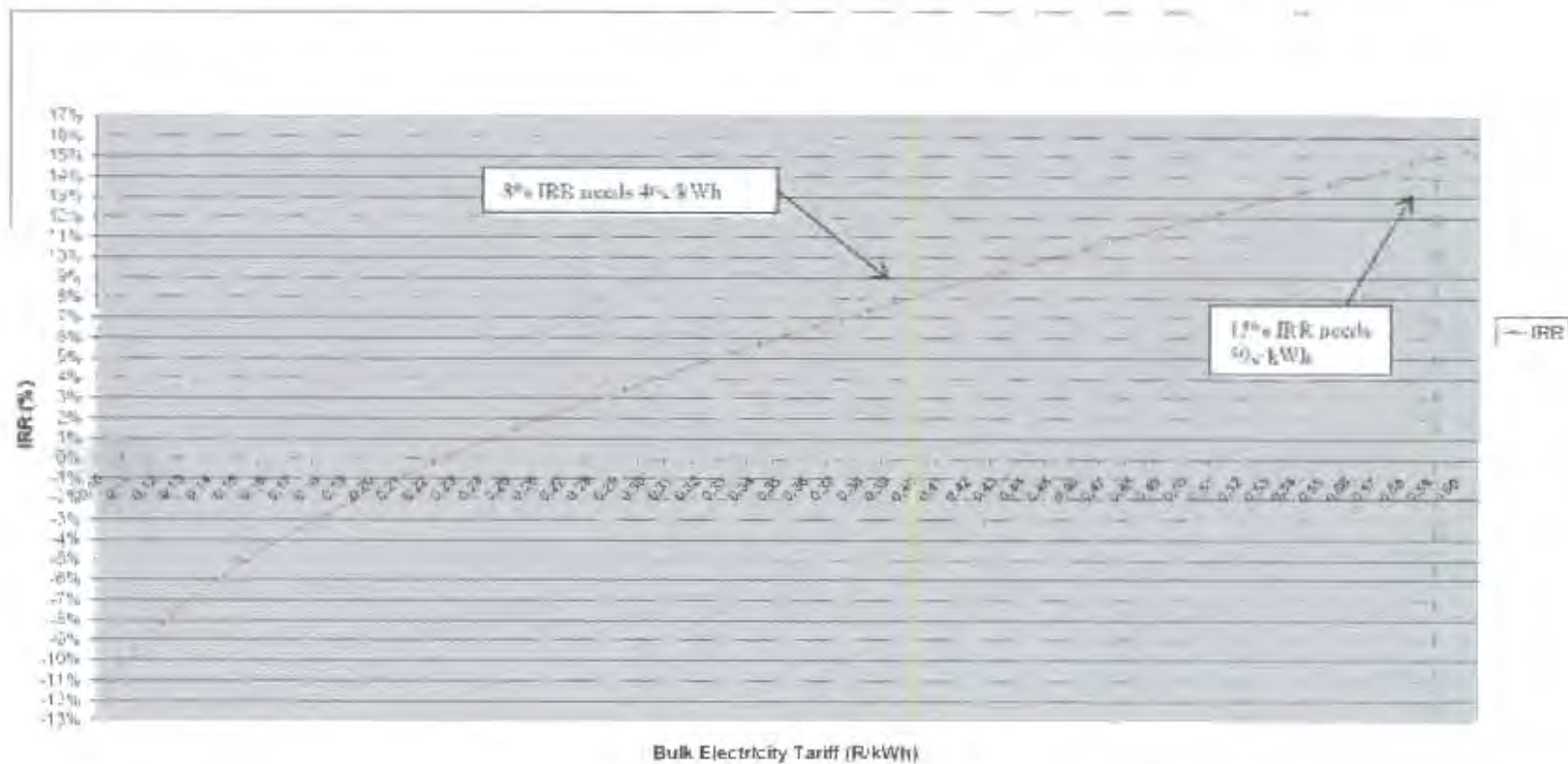
6.2.1 Sensitivity to Bulk Electricity Tariffs

The analysis considered a range of bulk electricity tariffs, and their effects. Importantly, the results show that without any additional financial mechanisms – namely the REFSO capital subsidy and CER revenues – wind energy projects are not financially viable. **Figure 21** shows the bulk electricity tariffs required to achieve IRRs of 8% and 15%.

In order to achieve 8%, a bulk electricity tariff of R40c/kWh is needed. This is close to the 37.5c/kWh that is being offered by the CCT for electricity from Darling Wind Farm. However, it is four times the current bulk electricity tariffs charged by Eskom (10-11c/kWh) and 10-15c/kWh more than the LRMC of coal-fired electricity generation (25-30c/kWh).

To achieve the more realistic 15% that most investors or project developers require, a bulk electricity tariff of 59c/kWh is required. This is slightly more than the WEPS charged to direct or embedded Eskom customers for peak electricity in high demand season. It is almost six times Eskom's bulk electricity tariffs and double the LRMC of coal.

At current bulk electricity tariffs charged by Eskom to IPPs, IRRs for a 5.2MW project are negative. At 10c/kWh, the IRR is -11%, and at 11c/kWh it is -10%. These figures are well below what is needed to make a project financially viable. If RED One pays IPPs the estimated 18.7c/kWh for their electricity, IRRs for a 5.2MW wind energy project will be -2%. Although this is a significantly greater return than IPPs are receiving using the Eskom tariff, it remains negative, and well below the IRR required to make a wind energy project financially viable.

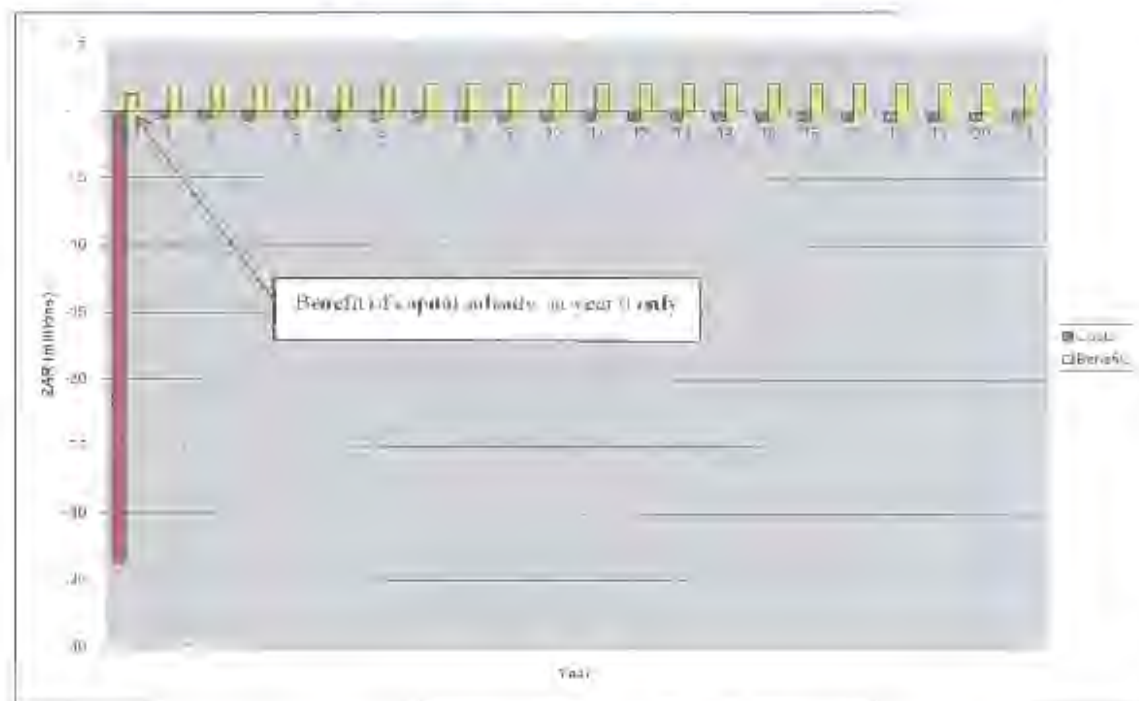
Figure 21: Bulk Electricity Tariffs Required to achieve IRRs of 8% and 15% for the Reference Case Wind Energy Project

6.2.2 Financial Analysis with REFSO Capital Subsidy

The government's REFSO capital subsidy makes a slight difference to these figures: in the order of 2-3¢/kWh – see **Figure 23**. For an 8% IRR with a capital subsidy, a bulk electricity tariff of 38¢/kWh is needed, and for 15% IRR, 56¢/kWh is required. However, at IRRs of 8%, the required bulk electricity tariff is much closer to the tariff offered by the CCT for electricity from Darling Wind Farm (37.5¢/kWh). Hence, if a project was very marginal, the addition of a REFSO capital subsidy could make it profitable by helping to cover upfront investment costs.

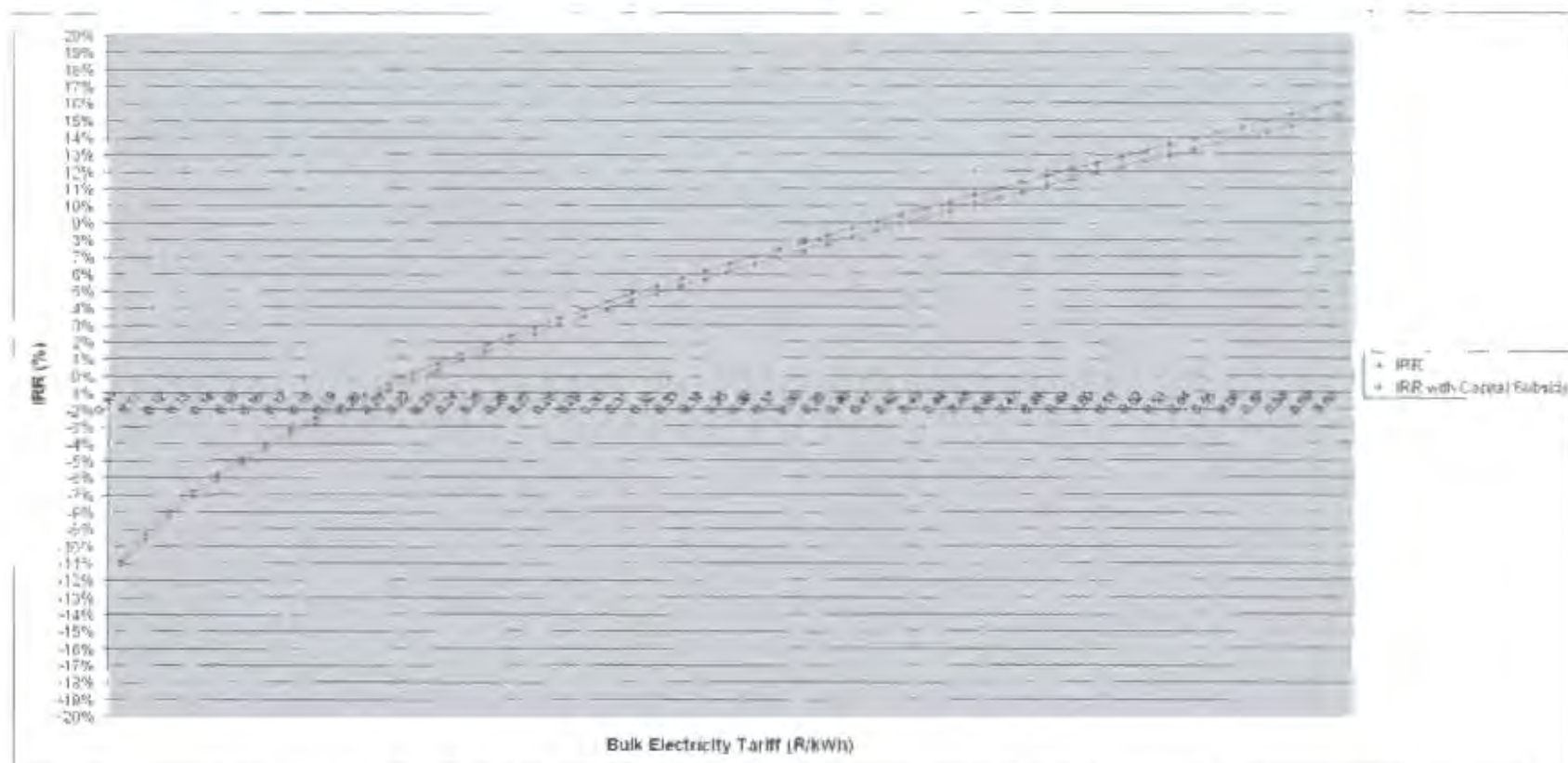
Figure 22 demonstrates the effects of the REFSO capital subsidy on the cash flow of the reference case wind energy project.

Figure 22: Cash Flow for the Reference Case Wind Energy Project with Capital Subsidy (author's calculations)



Wind energy is clearly not financially viable without the REFSO capital subsidy, and requires high bulk electricity tariffs to be viable with the subsidy. **Section 6.3.4** considers whether CER revenues can provide the additional revenue stream that enables wind to become financially viable.

Figure 23: Comparison of the Effects of Increasing Electricity Tariffs on IRRs of the Reference Case Wind Energy Project, with and without Capital Subsidy



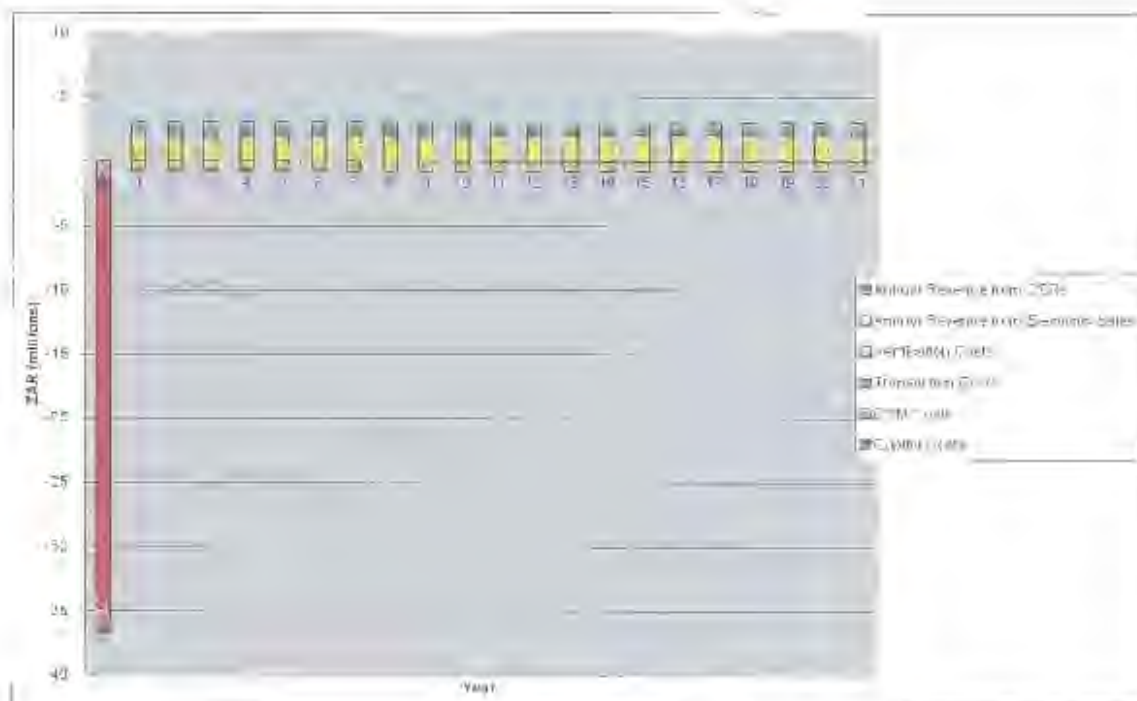
6.3 Financial Analysis of a Wind Energy CDM Project

6.3.1 Financial Analysis with CER Revenues

In order to carry out the financial analysis with CER revenues, the CER revenue was calculated. The assumed CER price was multiplied by the annual avoided emissions figure to ascertain the annual revenue from CERs. This revenue was added to annual revenue from electricity sales.

CER revenues were assumed to be received from year 1 only. Transaction costs were added to capital costs in year 0, and verification costs added to O&M costs from year 1. Hence, the cash flow for the reference case with CER revenues reflects the additional revenue and costs. CER revenues in the cash flow in **Figure 24** were calculated using an assumed CER price of €9/tCO₂. Verification costs are so small (R35,000 per annum) that they are hardly visible in **Figure 24** below. They are present, as a cost, stacked beneath O&M costs.

Figure 24: Cash Flow for the Reference Case Wind Energy Project with CER Revenues (author's calculations)



The analysis considered the sensitivity of the reference case wind energy project to:

- Baselines
- Transaction costs
- CER prices

6.3.2 Sensitivity to Baselines

Different baselines were considered, since the baseline in most countries has a significant impact on the financial viability of a CDM project (Ringius et al, 2002). However, in South Africa, which is *currently* reliant on one form of fuel, coal, the baselines are quite similar. Hence, the difference between the baseline scenarios, with regards to their effects on the financial viability of wind energy projects, is negligible – for all three scenarios, the IRR is calculated to be 11%. **Table 18** shows the three scenarios discussed in **Section 5.2.1**, and their effects on the IRR for a 5.2MW wind energy project with CER revenues at an assumed €9/tCO₂ and bulk electricity tariffs of 19c/kWh.

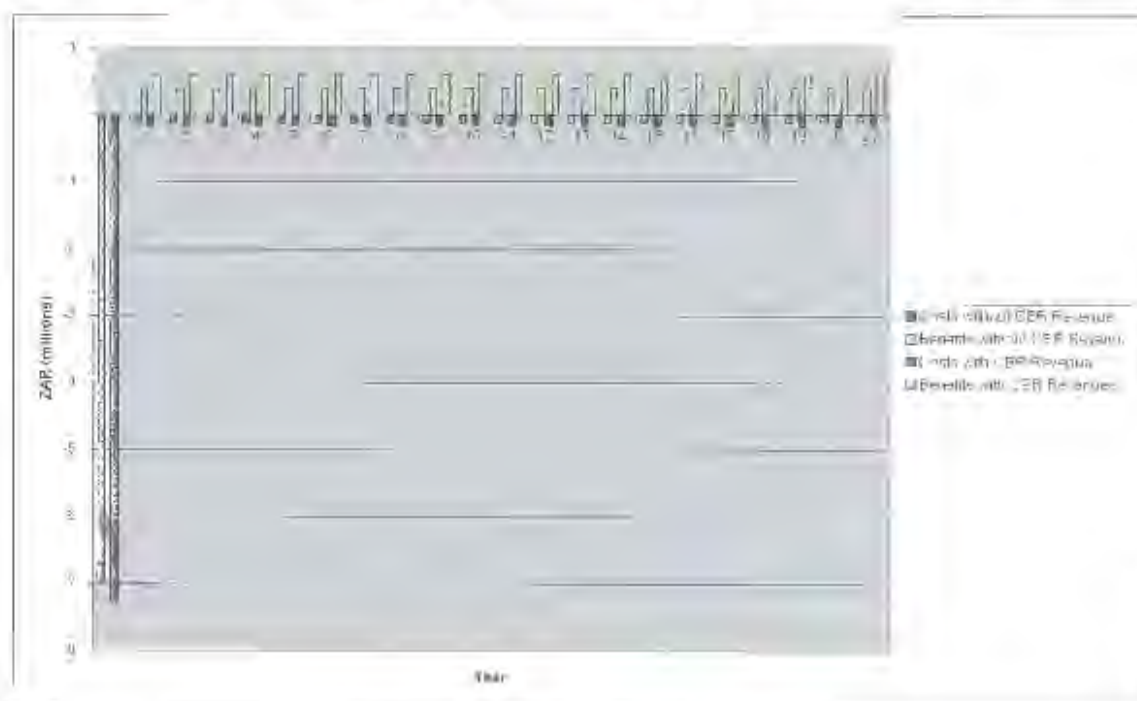
Table 18: Effects of Baseline Scenarios in South Africa on the Reference Case Wind Energy Project (author's calculations)

Baseline Scenario	Baseline (kgCO ₂ /kWh)	Avoided Emissions over Project Life (tCO ₂)	IRR with CER Revenues (%)
All grid (Eskom plants)	0.963	322.419	11
Recent plants (Majuba)	1.08	361.592	11
Near future plants	0.7113	238.148	11

6.3.3 Sensitivity to Transaction Costs

Transaction costs are also important, since they impact on the upfront investment costs of a project. They are of most significance to small-scale projects (<15MW), where the costs of setting up, registering and monitoring a CDM project can form a substantial portion of the capital costs. In the case of micro wind (<1MW), these costs are very significant. Upfront costs can be offset against future CER revenues creating a positive effect on the cash flow of the project over its lifetime. **Figure 25** compares cash flows for a theoretical 1MW wind energy project with CER revenues (and associated transaction and verification costs) and without.

Figure 25: Cash Flows for a 1MW Wind Energy Project with and without CER Revenues



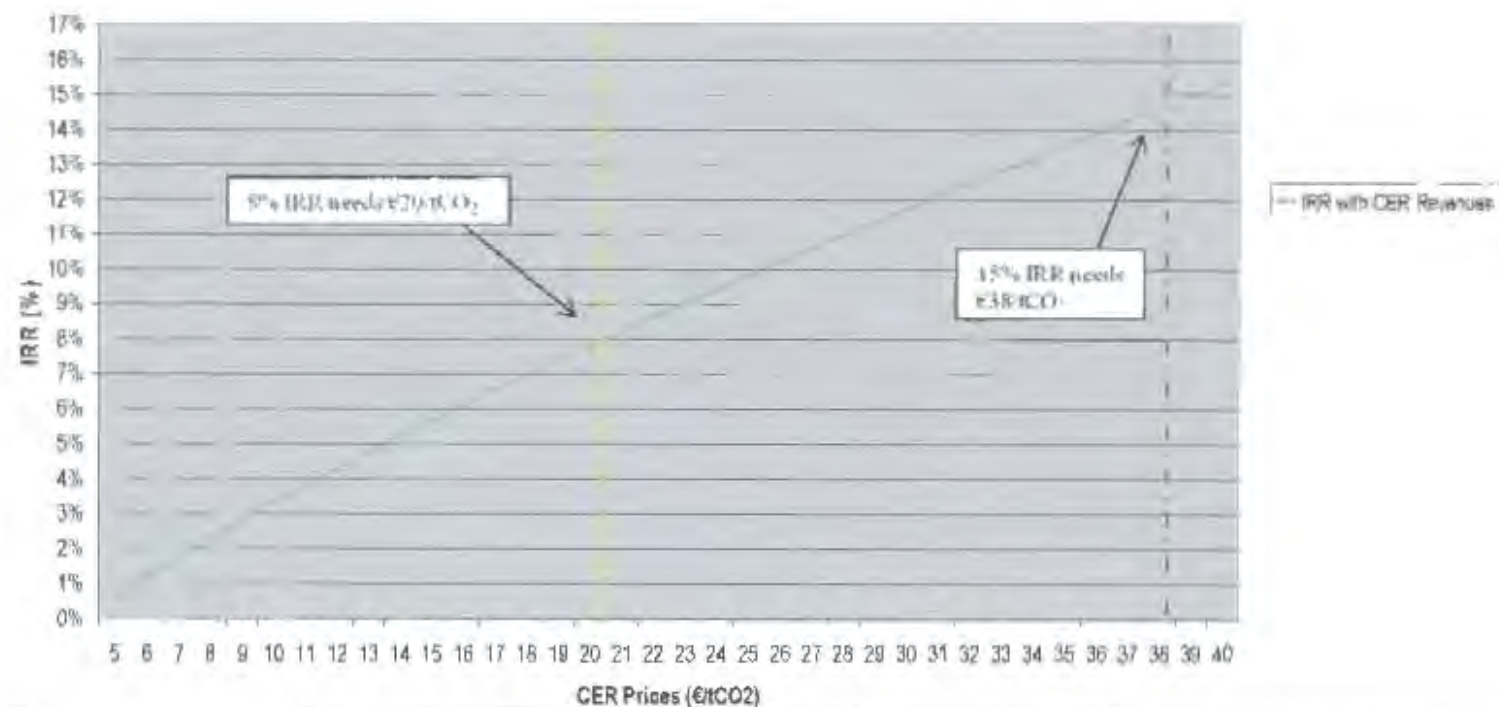
Small scale projects can reduce their transaction costs through bundling. In this way, the costs are spread over several projects. However, the subsequent CER revenues are still received *per project* (Avis, 2006). Small scale projects cannot “bundle out” or scale up to become one large scale project – although they can go through the more expensive large-scale process (Cartwright, 2006).

6.3.4 Sensitivity to CER Prices

The financial analysis with CER revenues show that the financial viability of the reference case wind energy project increases as CER prices (in €/tCO₂) increase – see Table 19 and Figure 26. The assumed bulk electricity tariff for this calculation was the RHD One rate of 18.7c/kWh (rounded to 19c/kWh). With this tariff, an IRR of 8% is reached when the CER price is €20/tCO₂. For an IRR of 15%, the CER price needs to be €38/tCO₂. This suggests that if a project is reliant on the CDM for financial viability, a forward price of €38/tCO₂ needs to be secured and budgeted for.

Table 19: Data from Financial Analysis with CER Revenues (author's calculations)

CER Price (€/tCO ₂)	IRR with CER Revenues
5	1%
6	1%
7	1%
8	2%
9	2%
10	2%
11	4%
12	4%
13	5%
14	5%
15	6%
16	6%
17	7%
18	7%
19	7%
20	8%
21	9%
22	9%
23	9%
24	9%
25	10%
26	10%
27	11%
28	11%
29	11%
30	12%
31	12%
32	12%
33	13%
34	13%
35	14%
36	14%
37	14%
38	15%
39	15%
40	15%

Figure 26: Effects of Increasing CER Revenues on IRRs of the Reference Case Wind Energy Project

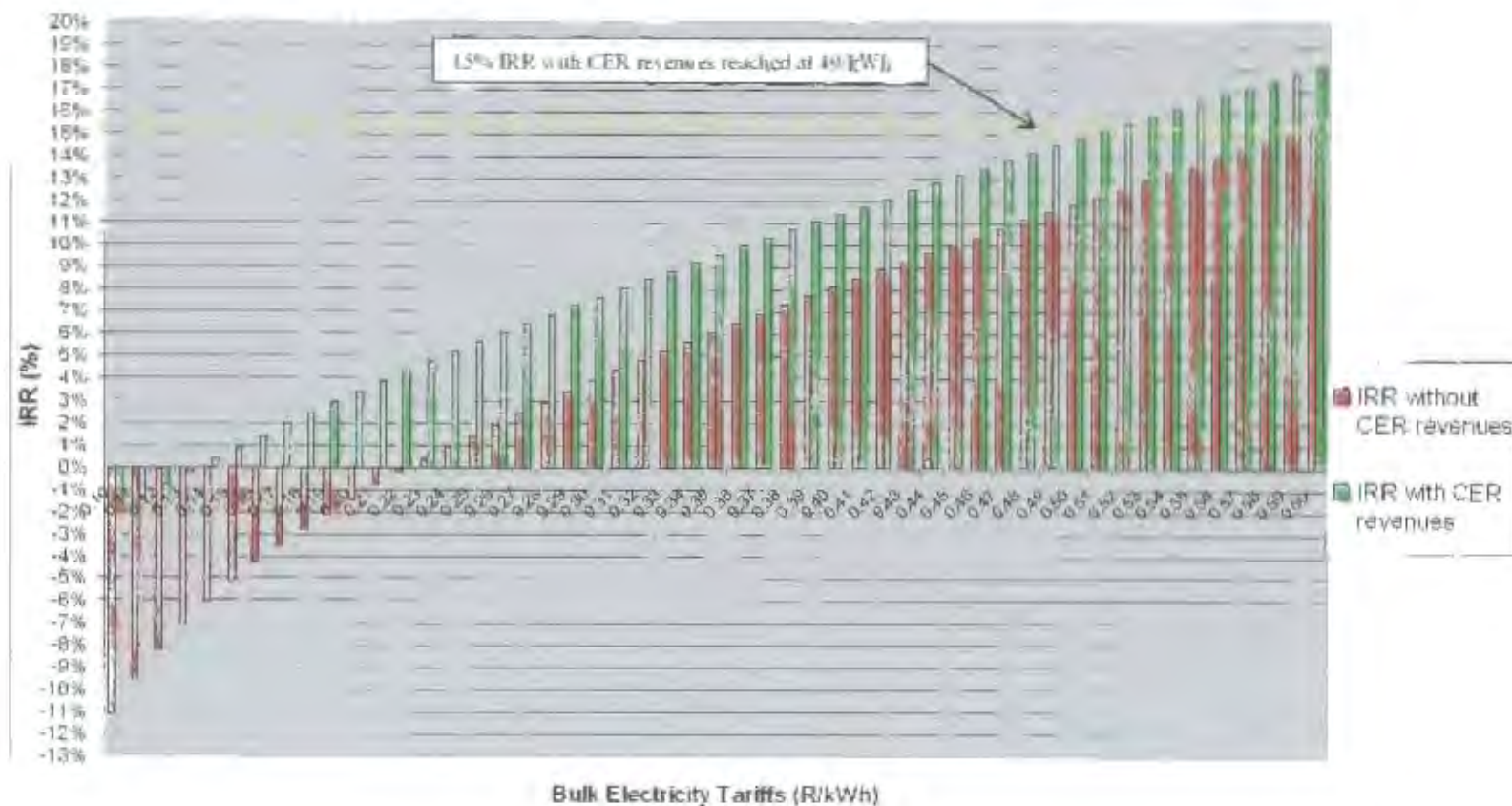
Current CER prices in the compliance market for projects in the Western Cape are estimated to be in the range €5-14/tCO₂ – see **Table 14** for price estimates from CDM specialists. If wind energy projects are able to negotiate a bulk electricity tariff of 38c/kWh – as Darling Wind Farm and the CCT have agreed in their PPA (37.5c/kWh) – a much lower CER price is needed to achieve IRRs far greater than the Darling Wind Farm's hurdle rate of 8%. A CER price of just €20/tCO₂ would achieve an IRR of 15%. This is a more realistic forward price to negotiate. **Table 20** shows how today's CER prices affect the reference case's IRRs, accounting for the project's ability to sell electricity at a rate of 37.5c/kWh.

Table 20: Effects of Today's CER Prices on IRRs of the Reference Case, with a Bulk Electricity Tariff of 37.5c/kWh (author's calculations)

CER Price (€/tCO ₂)	IRR with CER Revenues
5	9%
6	9%
7	10%
8	10%
9	11%
10	11%
11	11%
12	12%
13	12%
14	12%
20	15%

Using an assumed CER price of €9/tCO₂, the difference the CDM makes to IRRs for a 5.2MW project is shown in **Figure 27**. To achieve 8% IRR a bulk electricity tariff of 30c/kWh is needed. For 15% IRR, 49c/kWh is required. These compare to 38c/kWh and 56c/kWh respectively, for projects with no CER revenues. In other words, CER revenues are equivalent to an additional 7-8c/kWh for the reference case wind energy project.

Figure 27: Additional IRR created by CER Revenues for the Reference Case Wind Energy Project (author's calculations)



6.3.5 Financial Analysis with CER Revenues and REFSO Capital Subsidy

The financial analysis showed that the REFSO capital subsidy made a slight difference to the viability of wind energy projects. However, as an upfront subsidy administered within South Africa and not QDA from an Annex I country, it could be used to cover the transaction costs of establishing a CDM project. The minimum project size eligible for the REFSO capital subsidy is 1MW. A 1MW project could gain a full capital subsidy of R250,000, which could cover most of the R300,000 transaction cost for a small scale project. For the 5.2MW reference case, it is possible to apply for a capital subsidy of R1.3 million. Even if the full capital subsidy was not awarded, a subsidy could cover the transaction costs. This would enable small scale projects to register as CDM projects and gain the benefits of CER revenues.

Figure 28 and Table 21 show the effects of increasing bulk electricity tariffs, and compares the IRRs of projects with no financial mechanisms, those with the REFSO capital subsidy, those with CER revenues, and those with both. Hurdle rates are in bold.

Obviously, a combination of the REFSO capital subsidy and CER revenues produces the best results at all bulk electricity tariffs. CER revenues have a greater impact than the REFSO capital subsidy. The capital subsidy means that hurdle rates of 8% and 15% are reached at bulk electricity rates 2-3c/kWh less than those required when no subsidy is present. In contrast, CER revenues are equivalent to a 7-8c/kWh decrease.

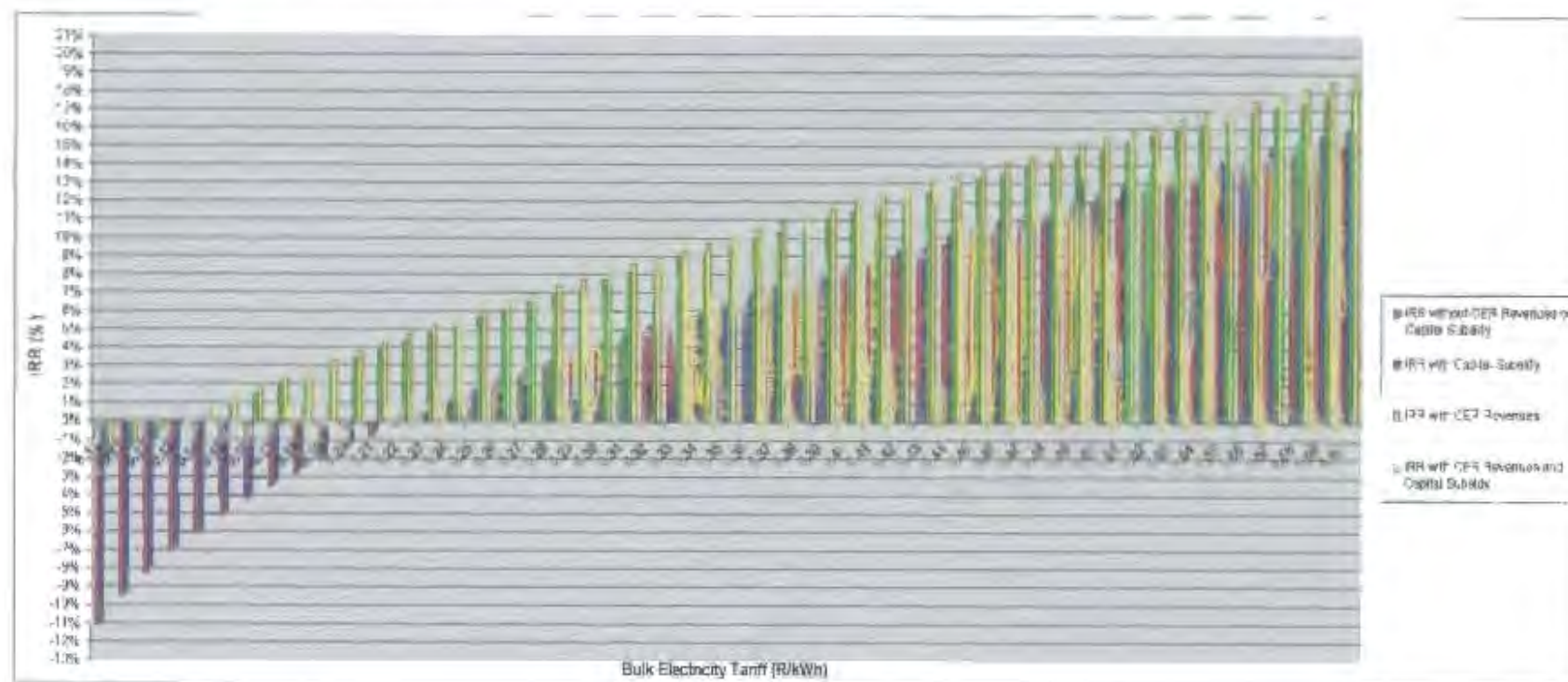
Table 21: Comparison between IRRs of the Reference Case for Four Financial Analysis Scenarios (author's calculations)

Electricity Tariff (c/kWh)	IRR without CER Revenues or Capital Subsidy	IRR with Capital Subsidy	IRR with CER Revenues (at 9c/tCO ₂)	IRR with CER Revenues and Capital Subsidy
10	-14%	-11%	-2%	-2%
11	-13%	-9%	-1%	-1%
12	-6%	-8%	-1%	0%
13	-7%	-7%	0%	0%
14	-5%	-6%	0%	1%
15	-5%	-5%	1%	1%
16	-4%	-4%	1%	2%
17	-4%	-3%	2%	3%
18	-3%	-2%	2%	3%
19	-2%	-2%	3%	3%
20	-1%	-1%	3%	4%
21	-1%	0%	4%	4%
22	0%	0%	4%	5%
23	0%	1%	5%	5%
24	1%	1%	5%	6%
25	1%	2%	5%	6%
26	2%	2%	5%	7%
27	2%	3%	6%	7%
28	3%	3%	7%	7%
29	3%	4%	7%	8%

Figure 28 clearly shows the different effects of CER revenues and the capital subsidy. CER revenues make a significant positive difference to IRRs of 3-9% while the capital subsidy adds 1% at most. The difference is most striking for bulk electricity tariffs of R15-21c/kWh. At these tariffs, CER revenues can make IRRs positive, while the capital subsidy cannot. However, the capital subsidy can add positively to the effects of CER revenues, and a combination of the two creates the best results in terms of IRRs.

Bulk electricity tariffs are negotiated between an IPP and a buyer. Hence CER revenues and/or the REFSO capital subsidy could enable projects to be financially viable when the buyer is offering a lower tariff (c/kWh) than the project needs to reach its hurdle rate.

Figure 28: Comparison of the Effects of Increasing Bulk Electricity Tariffs on Reference Case – Comparing Financial Analysis without CER Revenues or Capital Subsidy, to Financial Analyses with Capital Subsidy, with CER revenues, and with both Capital Subsidy and CER Revenues (author's calculations)



6.3.6 Financial Analysis of Current Wind Energy Projects in the Western Cape

Assuming an average bulk electricity rate equivalent to that which is suggested for RED One – 18.7/kWh – CER revenues will make a difference of a few percent to projects being developed in the Western Cape. Table 22 summarises the findings, using a CER price of €9/tCO₂. It compares nine projects in the Western Cape: Klipheuwel; the Darling Wind Farm (Phase I and Phase II); Southern Cape; St Helena; Lambert's Bay; Saldanha; Beaufort West; Langefontein²⁶.

Table 22: The Impact of CER Revenues on IRRs for Wind Energy Projects in the Western Cape (author's calculations)

Project	Project Capacity (MW)	IRR without CER revenues (%)	IRR with CER revenues (%)	Change in IRR (%)
Klipheuwel	3.10	-2.30	1.64	+4.94
Darling Phase I	5.2	-2.30	1.76	+5.09
Darling Phase II	17	-2.30	2.94	+5.24
Southern Cape	30	-2.30	2.98	+5.28
St Helena	40	-2.30	2.90	+5.20
Lambert's Bay	45	-2.30	3.00	+5.30
Saldanha	45	-2.30	3.00	+5.30
Beaufort West	50	-2.30	3.00	+5.30
Langefontein	115	-2.30	3.02	+5.32

There is only a small difference between the projects. Avis (2006) maintains that a wind project must pass a 5MW threshold in order to attract CDM investment and start recovering costs. This simple comparison between projects in the Western Cape shows that the CDM can make a positive difference of around 5% IRR to those projects that have a capacity of more than 3MW. Significantly, CER revenues ensure that IRRs become positive. Without CER revenues, the IRRs for all projects are negative.

Table 23 compares the same nine projects and their IRRs, including calculations for REFSO capital subsidy. In all cases the capital subsidy makes a positive difference of less than 1% compared to IRRs when it is not present.

²⁶ Data is taken from DME (2003a) (see Table 6) and Chown (2006).

Table 23: The Impact of REFSO Capital Subsidy on IRRs for Wind Energy Projects in the Western Cape (author's calculations)

Project	Project Capacity (MW)	IRR without CER revenues or capital subsidy (%)	IRR with capital subsidy (%)	IRR with CER revenues (%)	IRR with both CER revenues and capital subsidy (%)
Klipphenwiel	3.16	-2.30	-2.00	2.64	3.01
Darling (PI)	5.2	-2.30	-2.00	2.79	3.17
Darling (PII)	13	-2.30	-2.00	2.94	3.33
Southern Cape	30	-2.30	-2.00	2.98	3.36
St Helena	40	-2.30	-2.00	2.99	3.37
Lamberts Bay	45	-2.30	-2.00	3.00	3.38
Sidmunda	45	-2.30	-2.00	3.00	3.38
Beaufort West	50	-2.30	-2.00	3.00	3.38
Laagfontein	115	-2.30	-2.00	3.02	3.40

There are several reasons why the capital subsidy makes only a small difference. Firstly, the cash flow technique calculates an IRR for the entire lifetime of the project. The capital subsidy is paid up front and is limited to no more than 20% of capital costs (which cannot be greater than R100 000 000). This limit means that large scale projects are ineligible for funding. Secondly, for a small scale project such as the reference case used in this financial analysis, the capital subsidy only amounts to 3.6% of capital costs. Third, the amount allocated by REFSO for the subsidy is too small to make a major impact on a project's viability (van den Berg, 2006 and Chown, 2006). Fourth, although this is not reflected in the financial analysis, the criteria for projects to obtain capital subsidy contracts are very stringent, and will hinder project developers from applying (DME, 2005a and Hagemann, 2006).

gain CER revenues, then wind can be competitive with coal. However, it is likely that coal producers will cross-subsidise from existing, amortised coal plants, thereby continuing to keep coal prices low (van den Berg, 2006). If this happens, wind cannot be competitive with coal. Furthermore, it is unlikely that IPPs will set hurdle rates as low as 8% without some form of upfront subsidy. There remains a significant gap between the 49c/kWh required to achieve an IRR of 15% for wind and the LRMC of coal (25-30c/kWh).

The REFSO capital subsidy is not significant enough to encourage project developers to aim for IRRs of 8%. **For the reference case, the REFSO capital subsidy was found to make a positive change in IRRs of 0-1%, with and without CER revenues.** This amounted to decreased bulk electricity tariffs of 2-3c/kWh. These figures are much smaller than those calculated for the difference made by CER revenues, but they are not insignificant. For very marginal projects, the subsidy does have the potential to make a project viable. However, the REFSO budget is only enough to support 56MW of RET capacity and the project criteria are limiting.

For the reference case to achieve an IRR of 15%, assuming the RED One bulk electricity tariff of 18.7c/kWh, a forward price of €35/tCO₂ is needed. This is much higher than current CER price estimates that range between €5/tCO₂ and €14/tCO₂. In order to negotiate more profitable CER prices, as well as PPAs, project developers need to minimize the risks of wind energy.

The financial analysis clearly showed that mechanisms beyond the CDM and REFSO's capital subsidy are necessary to make wind energy projects not only financially viable, but also competitive with coal-fired electricity generation. For wind energy projects in the Western Cape, the balance of costs and CER prices do not yet compete with the low costs of coal-fired electricity generation. This is largely the result of high upfront costs, which require finance and amount to R36.4 million for year 0 for the reference case. O&M costs for wind, which are 6c/kWh from year 1, are less than the generating costs of coal – 9.3c/kWh (Eberhard, 2005). However, the capital costs have to be repaid during the project lifetime. The cost of finance was not included in the financial analysis in this research, and further analysis is required.

Both CER revenues and the REFSO capital subsidy make a positive difference to the IRRs of wind energy projects. The former is more effective.

7. CONCLUSION AND RECOMMENDATIONS

The Western Cape was an interesting case study, which allowed for an exploration of the relationship between wind power and the CDM. Financial analysis, a literature review and interviews with specialists were used to consider the main research question: *“Can carbon trading under the CDM help the financial viability of wind energy projects in the Western Cape and what does this signify for future wind energy developments?”* The research objectives helped to answer this question.

(1) Examine why wind energy is worth investing in

From the literature, wind energy resources in the Western Cape were found to be ‘good’. The nine wind energy projects discussed in this thesis have a combined annual generation potential of 1,023GWh. Hence, these projects could provide approximately 4.7% of current electricity consumption in the province (22,000GWh) and 8.5% of consumption in the CTMA (12,000GWh).

(2) Consider what mechanisms exist to support wind energy and what barriers limit investment

The literature review and interviews suggest that wind power *is* being pursued in the province, largely by IPPs. This raises issues around the restructuring of the ESI, the introduction of RED One, and the need to create an enabling environment for private power generators. Furthermore, while national policy and provincial strategy reflect government’s commitment to reducing climate change, there remain barriers to benign RETs such as wind. The largest of these is the low cost of coal-fired electricity generation. At current prices, wind energy cannot be competitive with coal without additional financial mechanisms. There are a large number of financing options available to wind energy projects.

(3) Identify the financial costs and benefits involved in wind energy projects in the Western Cape

Globally, the costs of wind energy technology are falling, making wind an increasingly attractive option to add to the energy mix. Current capital costs in South Africa were found to be approximately R7,000/kW installed and O&M costs totalled about 2% of this upfront investment. A major benefit is electricity sales. It is thought that RED One will pay IPPs around 19c/kWh for electricity. Eskom currently pays IPPs 10-11c/kWh for electricity onto the grid. Additional benefits considered included the REFSO capital subsidy, which offers R250/kW installed. REFSO made only a slight positive change to wind energy project – IRRs 0-1% higher. CER revenues, which depend on the CER price negotiated, were considered in detail.

(4) Establish how much carbon revenue a wind energy project in the Western Cape receives

Carbon revenue relates to the annual avoided emissions created by a project multiplied by the CER price. CER prices were found to be in the range €5-14/tCO₂, from the literature review and interviews with CDM specialists. The price is affected by risk factors and the conditions of the ERPA.

(5) Analyse whether carbon trading under the Clean Development Mechanism (CDM) can help the financial viability of wind energy projects in the Western Cape

Using findings from **research objectives (1) to (4)**, a financial analysis was carried out, which assessed whether carbon trading under the CDM can help the financial viability of wind energy projects in the Western Cape. The results show that CER revenues made a positive difference of 13-21% to the reference case. When IRRs for the reference case with CER revenues are compared with those without, they are shown to improve by 2-9%, depending on the bulk electricity tariff negotiated in the PPA. At an assumed average CER price of €9/tCO₂, bulk electricity tariffs needed to achieve IRRs of 8% and 15% are 7-8c/kWh lower than those required for projects without CER revenues. CER revenues brought the bulk electricity tariff down to 30c/kWh, if the hurdle rate is set at 8% IRR. Significantly, this is close to the estimated LRMC of coal (25-30c/kWh). This suggests that wind energy could be competitive with coal-fired electricity generation if the externalities associated with coal are internalised and new generating capacity increases generating costs.

(6) Recommendations for Future Wind Energy Projects

The discussion and analysis in this research points to the following recommendations:

- CER revenues could make green electricity more attractive to consumers by reducing the premium paid for electricity from wind energy projects. Wind energy projects can supply individual households, organisations and high profile events. If conscientious consumers are willing to pay a premium for green electricity, and they are able to choose their supplier – which should be possible under a restructured ESI and EDI – then IPPs can sell directly to their customers for a price that ensures a profitable return.
- If wind can compete with conventional supply during peak hours, through system management of variability, consumers are more likely to consider purchasing green electricity. CER revenues can bring down the premium to 49c/kWh (for IRRs of 15%), which is 5c/kWh less than the WEPs energy rate for peak electricity in high demand season (55c/kWh). Improved system management of variable sources of energy will help in this regard.
- Greater public awareness could raise demand for renewable energy, creating a willingness to pay a premium for green electricity.
- As experience with wind increases, learning rates will improve, which should reduce the perceived risks of a project. Better CER prices and PPAs can be negotiated if the risk factors of a project are minimised. Further government investment at a national or provincial level in demonstration projects would help provide much needed wind resource data and encourage technology learning.
- Advice and support for projects at a provincial and local scale is also vital. RD&D projects should help to provide data and project role models.
- Small scale wind energy projects can be bundled to ease the CDM process. However, this may require co-ordination and advice by an overseeing organisation.
- Micro-wind should be considered for households, businesses, industry and events, especially given current supply problems. An RO similar to that in the UK would

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- Micro-wind should be considered for households, businesses, industry and events, especially given current supply problems. An RO similar to that in the UK would

encourage use of home wind energy systems in return for payment that covers the avoided use of grid electricity.

- Given the clustering of good wind resources near the coast, offshore wind resources and energy potential should be researched further for the province.
- The REFSO capital subsidy could be used to help early wind energy projects cover CDM transaction costs – especially small scale projects (larger than 1MW, but less than 15MW).
- Rather than REFSO delivering a capital subsidy, it could establish a form of FIT that sets a price for renewable energy. Funds could be used to support the REDs and municipalities, enabling them to pay a premium for green electricity and distribute it at an affordable price (or at least a smaller premium) to customers. This would be effective now that there is a national medium term target in place. Given the current supply problems in South Africa, an FIT is likely to be a long term target.
- RED One should incorporate renewable energy into its portfolio, setting a target for its share of the energy mix. REDs can negotiate PPAs that allow wind energy projects to be profitable.
- There should be continued restructuring of the ESI to give IPPs easier access to the market.
- The EIA and other approval processes must be eased through the implementation of wind energy strategies and spatial planning in the Western Cape. Some strategies are already under way.
- New and accurate wind resource assessments are needed in order to plan for wind in the Western Cape and reduce costs for small scale projects, which currently need to carry out their own detailed site assessments.
- The avoided costs of coal must be reflected in the price charged for electricity to allow alternative forms of energy to compete. An *economic* evaluation of wind would be beneficial.
- Wind should be combined with other RETs to create portfolios of renewable energy that provide an effective energy mix specific to the Western Cape's natural energy resources.

The problem with pursuing wind energy in the Western Cape continues to be its high cost relative to coal-fired electricity supply. However, the CDM offers wind energy projects an opportunity for an additional revenue stream, which can raise the IRRs of a wind energy project and lower required bulk electricity tariffs. If the costs of coal-fired generation also increase, wind energy could become competitive with coal, and attractive to more than 'conscientious' investors. The success of wind energy internationally and the potentially good wind resources in the Western Cape, point to the expansion of the wind industry in the province. Furthermore, national policy and provincial strategies have begun to lay the foundations for the expansion of the wind industry.

Until the cost of coal increases, the approval processes for wind energy are eased, and the ESI is fully restructured to allow for competition from IPPs, wind cannot be financially viable even with CER revenues and a REFSO capital subsidy. This research suggests that CER revenues can make a positive difference to the financial viability of wind

energy projects in the Western Cape, but that wind energy projects require additional financing to be profitable.

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APPENDIX A: Statistics associated with each wind station in the Western Cape and the surrounding area for the development of a Wind Resource map (CSIR, 2006c)

Station Name	Province	Station Number	Minimum (m/s)	Maximum (m/s)	Mean (m/s)	Std Dev (m/s)	Radius (km)
BLAUFORT-WES	Western Cape	0092081 5	1.00	15.00	5.04	0.85	50
CAPE TOWN TABLE BAY	Western Cape	0020774 4	1.30	16.10	4.00	1.13	00
CAPE TOWN WO	Western Cape	003117843	0.00	30.20	6.63	2.41	40
LERES EXULSION	Western Cape	0063807 2	0.50	12.00	2.00	0.95	50
DEELBEK	Western Cape	0040192 4	3.20	10.50	5.02	0.43	40
GEORGE WO	Western Cape	0012661 7	0.40	13.00	3.00	0.91	30
HERMANUS	Western Cape	000038057	0.00	10.20	1.09	1.20	30
KNYSNA	Western Cape	0014123 3	0.30	6.20	1.74	0.56	40
LAINGSBURG	Western Cape	0045642 0	0.00	16.00	3.84	1.00	30
LAMBERTSBAAI			0.80	9.30	4.23	0.66	
NORTIKR	Western Cape	0083572 8					30
LANGEBAAWEG WO	Western Cape	0061298 8	4.50	11.30	6.88	0.52	40
MALMESBURY	Western Cape	0041388 0	0.80	10.00	4.14	1.25	40
PAARL	Western Cape	0021823 0	0.00	14.60	3.27	1.34	40
PLETTENBERGBAAI	Western Cape	0014545 4	0.00	14.50	3.07	1.52	40
PORTERVILLE	Western Cape	0041841 X	0.00	18.70	4.03	1.33	30
RIVIERSONDEREND			0.00	8.80	2.86	0.68	
TYGBRIJCK	Western Cape	000176199A0					40
ROBBENELAND	Western Cape	0020618 X	1.30	12.70	4.07	0.79	40
SIMONSTAD KAAPPLAAT	Western Cape	0014891A5	2.30	20.50	6.05	2.62	00
STILBAAI	Western Cape	0010682 0	1.20	14.10	4.14	0.83	50
STRAND	Western Cape	0005609 8	0.00	17.80	3.53	1.60	40
STRUISBAAI	Western Cape	00013108A7	0.80	10.10	4.73	0.53	75
VILLERSDORP			0.20	15.90	2.67	1.19	
VYFBOOM	Western Cape	0006243 X					40
WORCESTER	Western Cape	0022729 X	0.00	12.40	3.00	1.32	50

The model used to gain this data was the Wind Atlas Analysis and Application Programme (WAsP) model, which was developed by the RISO National Laboratory in Denmark. This model estimates mean annual wind speeds in m/s at 10m above ground level. Several parameters were set:

- data from automatic weather measuring stations – managed by South African Weather Service (approximately 100 stations)
- roughness values – derived from 1996 National Land Cover database
- 20m contour elevation information – taken from Surveys and Mapping 1:50,000 map sheet series

For more details see the Wind Resource pages of SARERD (accessible from CSIR, 2006a).

APPENDIX B: Interviewees and Comments

Wind Energy Project Developers		
AIM: to understand developers' economic decisions and to source data for economic analysis		
Name	Organisation	Comments
Imi Fletcher	Wind Business Support (UK)	• Contacted via email • Provided useful links
Sidart Mahan	Management Capital	• Interview completed 3 March 2009 Notes: • Considers onshore wind the way forward as onshore/offshore wind are "eyesores" although possible in the long term in South Africa • CDM can make a positive difference, but needs to be combined with government subsidies (price linked, as in the UK) • Deregulation of the electricity industry will help • Green market is minimal in South Africa
Hartmann Schlager	Malaga Wind Power	• Contacted 3 March 2009 • Unavailable for comment - says Darling Wind Farm about to be implemented
Kevin Payne	New Energy Technologies	• Contacted 27 February 2009 • Very interested in onshore urban wind
Luis Kuhnhold	EP Alternative Energy (IEA)	• Interview completed 1 December 2008 • Provided useful links Notes: • What potential exists for wind power (onshore and offshore) development in South Africa? • What market are you aiming at – can you help support developing communities?

Energy Strategists and Consultants		
AIM: to understand opportunities and challenges for financing wind energy		
Name	Organisation	Comments
Rob Benda	Amagula Green Power	• Contacted – in reply
Mark Brylchens	Sustainable Energy Africa	• Interview completed 3 March 2009 Notes: • A strategic plan for the Western Cape (Cape Town Energy Strategy) finalised. Sustainable Energy Strategy under DEADP in process. Sustainable Infrastructure Plan. The second considers wind as good. The first considers wind as bad • The provincial government's view is short term. It looks for the "low-hanging fruit" (DSM and solar water heaters). • It is better to promote a medium/long term view ("the middle road"), which says: wind is vital, should be investing in small scale demonstration projects in order to soften the market for wind; but wind should not be the mainstay of the market.
Dawn Clifton	Indee and Gengas Eco-Energy	• Interview completed 29 March 2009 Notes: • Government moving towards introducing a FIT

	- not thinking about wind until at least 2012 - Developing 3 private wind energy projects in the Western Cape - CDM can make a difference if the financing structure is in place - VOM is perhaps a simpler, better alternative because it lacks the transaction costs and stringent guidelines of CDM, but CDM has a better reputation – better still is the Gold Standard - Decisions are about to be made about the structure of the REDs - Western Cape target for renewable energy is likely to be 15% by 2020 - As a small project developer, cannot afford to hold on for a better CER price – project must be bankable as early as possible - Micro-scale wind combined with other RETs for specific property developments is a good option - A lot of wind farm development is happening in land restitution locations (ex-government land), where communities need a development plan
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CDM Strategists and Consultants**AIM:** to understand the role of carbon financing under the CDM

Name	Organisation	Comment
Jonathan Ayis	Ecosecuritys (UK)	- Interview completed 10 March 2006 - See Appendix C for notes
John van den Berg	CDM Africa	- Interview completed 28 February 2006 - See Appendix C for notes
Aanna Cuthywright	PACE (Parallax)	- Interview completed 6 March 2006 - See Appendix C for notes
Steve Thorne	SouthSouthNorth	- Interview completed 9 March 2006 - See Appendix C for notes
Emily Tyler	SouthSouthNorth	- Interview completed 7 March 2006 - See Appendix C for notes

Other Contacts

Name	Organisation	Comment
Dave Allen	Lee Cup Ltd	Provided links to reports on CER price trends
Janet Bodenstern	Environmental Evaluation Unit, University of Cape Town	Information on Drafting Wind Farm EIA
Kilian Hagemann	IMD Students, University of Cape Town and More Renewables (Pty) Ltd	Developing a new wind atlas for South Africa using WARP model
Christofel Robinson	Provincial Government of the Western Cape	Details of the Integrated Energy Strategy for the Western Cape
Rashidiyah Wagge	Department of Environmental Affairs and Planning, Provincial Government of the Western Cape	Details of the Strategic initiative to introduce commercial land-based wind energy developments in the Cape West Coast

APPENDIX C: Detailed Notes from Interviews with CDM Strategists and Consultants

**1. Johan van den Berg (JvdB)
CDM Africa**

Date: 28 February 2006 **Place:** Mowbray, Cape Town
Telephone: 021 425 5055

What is the role of carbon financing in wind energy projects?

- ✓ It helps, but it can't make it viable
- ✓ It makes a project less unprofitable
- ✓ Need to find a way to access the spot carbon market *and* lock in prices (government guarantee) – this would bring wind near break-even point

Darling Wind Farm

(JvdB is the legal advisor)

- ✓ EIA took 8 years
- ✓ It *might* happen in 2006, but so far nothing has been built

Funded by: Donor funding (30%)

Most of the rest was Central Energy Fund, who were reluctant, but cabinet passed down a directive to invest since it is a demonstration project
Some of the remainder came from Global Environmental Fund (GEF), who underwrote the Cape Town Unicity purchase of green electricity at 37.5c/kWh (“about double the *brown* rate”)

Annual Avoided Emissions (2005)

Small scale = 0.96 kgCO₂/kWh

Large scale = 0.892 kgCO₂/kWh

These are still close to figures in previous Eskom financial reports – and reflect emissions caused by the grid (broadly). Specifically they refer to the avoided emissions that can be claimed by a small/large scale CDM project. Darling Wind Power (DWP) was unable to be a CDM project because it received donor funding. Had DWP become a CDM project it could have claimed: annual generation (approx. 15GWh per annum) multiplied by the above quoted figures. This would create approximately 13,000 tCO₂e per annum, worth about R70/tCO₂e per annum (€9/tCO₂e per annum) in the forward market and R200/tCO₂e per annum (€27/tCO₂e per annum) in the spot market.

Annual Generation = c13MW/year (could be nearer to 15MW/year)

Price of Bulk Electricity = 18c/kWh

(e.g. paid by a large manufacturer direct from Eskom)

- Most end-users buy from the municipality (or in the future, REDs).
- Residential users pay 27-28c/kWh.

Electricity from Darling:

- ✓ CCT will pay 37.5c/kWh – that's with capital subsidised by 30%
- ✓ What does 100% investment need? c55c/kWh in order to make a project viable
- ✓ There is a BIG gap between 55c/kWh (or 37.5c/kWh) and 18c/kWh (actually paid)

Can the CDM help?

Forward price:

- A *future* price – an “over-the-counter” (OTC) price established privately between two parties for delivery in the future
- *Not quite a future* is an exchange traded price for delivery in the future
- An exchange guarantees delivery, while an OTC includes counterparty risk and the balance sheet of those you deal with must be considered
- Fixed, therefore it can be budgeted for
- c€9/tCO₂e
- A project's profit depends on the forward price
- @ €9/tCO₂e:
$$9/1000 = 0.009 \times 8 \text{ (€:ZAR)}$$
$$= 7.2\text{c/kWh}$$

Spot Price:

- The price now, today
- A risk for the bank, etc since there is no guaranteed price (or profit)
- Banks do not generally take risks – hence, without a locked-in forward price banks would decline to advance project finance; they might advance funding if the lender can back the project with a balance sheet and stand surety for it
- c€25/tCO₂e (has been <€29/tCO₂e)
- @€25/tCO₂e
$$25/1000 = 0.025 \times 8 \text{ (€:ZAR)} = 20\text{c/kWh}$$
$$\text{or } 7.2\text{c/kWh} \times 3 = 21.6\text{c/kWh}$$

It would be useful (perhaps even “essential”) to find out what the forward price has to be before a project is viable.

The CDM can help, but one has to get through the registration process first, only then are investors interested. Money spent on CDM is “on risk” because it is pre-financial close. Some investors come in earlier, but then negotiate lower CER prices as compensation for the added risk.

Transaction Costs:

- Between R300,000-R600,000 per project, *if* there are approved methodologies
- Wind will always have methodologies and therefore is not a problem
- They are not a problem in the long term – e.g. a 10MW project (small scale) will make cR100million to R300million. What is R300,000 in the long term? The problem is that they have to be paid upfront.
- There are two ways to cover the transaction costs:
 - i. CDM buyer can pay upfront and then pay less for CERs (e.g. c€5/tCO₂e)
 - ii. Project developer covers costs and CDM buyer pays more for CERs

EU Penalties:

- Under the EU ETS, EU Annex I countries will be charged €40/tCO₂e emitted over target until 2008, then €100/tCO₂e.
- This could push CER prices up as they become more valuable commodities.
- There is the potential for CER prices to go beyond €40/tCO₂e – not sure when exactly.

Role of Government:

- Need to pick up the tab.
- Government could buy CERs directly at a price that is needed to absorb risk – this would be outside the CDM, and is a nice thought, but unlikely to happen!
- Government could introduce an FIT, asking for 5% power from RETs.
- The current REFSO capital subsidy, managed by DME is “negligible” because funds are very small (only cR5million/year).

“In the absence of appropriate legislation, CDM is the best option.”

New coal plants will probably need PPAs of around 25-30c/kWh, which narrows the gap between coal and wind. “However, Eskom will cross-subsidise from existing, amortised plants and thus can afford to sell new power at less, shutting wind out again. On the other side the 1000MW peaking power plants planned for Atlantis and Mossel Bay are likely to command about 118c/kWh – while wind cannot be *turned on* in peak it does place things in perspective.”

General comments:

Other wind projects in South Africa are still being developed and are far from implementation.

South Africa is an oddity because of its cheap electricity. Elsewhere in Africa, electricity costs more.

A major goal is that projects *must* be bankable.

2. **Anton Cartwright**
Promoting Access to Carbon Equity (PACE)
Date: 6 March 2006 **Place: Cape Town**
Telephone: 084 780 3450

What is the role of carbon financing in wind energy projects?

- ✓ It helps, but too late. The upfront costs are still prohibitive.
- ✓ CDM is not the answer, but it does help people to focus on the opportunities.

CER Prices:

- Range between €9-10-11/tCO₂.
- This is a spot price that is negotiated around the table between sellers and buyers.
- This price is ticking up, since there are more buyers than sellers globally.
- A forward price is a promise or a guarantee of CERs.
- Financial houses are trading *promises* at c€26/tCO₂ (see Point Carbon). In other words, financial houses take on the risks and manage them.
- When a project goes to the market (timing) is key. The later the better, in order to get a better price – because the risk is less and the CERs are more tangible.
- A project developer needs to take a good package to the table, with all the basics in place (answers to all the ‘how, what, when’ questions).
- Investors want early procurement.
- Two factors: RISK + COST

Risk:

- Key issue is the *ratio factor*. If you have x credits coming online, how many of these can you guarantee to sell? The more the better, therefore managing this ratio is important.
- Three categories of risk:
 - i. Project level
 - ii. Meta level – national (DNA, country commitment to Kyoto, local government capacity, political unrest, etc)
 - iii. National level – currency, geo-political risk, etc; this underlies all other risks; South Africa’s current International Credit Rating, which affects the price at which banks can borrow money and the rate international financiers will lend to projects (including CDM projects), is currently B- (see, for example, <http://www.fitchratings.com/>).

Costs:

Registration fee (per project) = US\$5,000 (unavoidable)

Transaction costs (per project) = €30,000 (not possible to reduce this)

Small Scale Projects:

- ✓ Project developers are hindered by:
 - i. Low CER prices
 - ii. Hurdles in the way
- ✓ Project developers cannot afford the upfront costs.

- ✓ Bundling: (cannot bundle out)
 - i. Local government manage portfolios
 - ii. Government would cover early costs, which would help clear cash flow issues (their incentive is to get hurdles out of the way and progress projects)
 - iii. Because they can sit with a collection of credits from more than one project, they can spread the risk across several projects
 - iv. In other words, government can ride the risks and make more attractive deals
- ✓ It is possible to take lots of small scale projects and go through the large scale market, but it is expensive.
- ✓ Government is to write the terms of reference for RETs, in order to cover the need to clear the additionality clause.
- ✓ The crediting period is 7-14-21 years (7 years, renewable twice).

CDM v's Voluntary Offset Market (VOM):

CER – under the CDM; a country allocates targets (e.g. to corporates); CERs are therefore needed to meet official targets.

VER (Voluntary Emission Reduction) – under the VOM; fewer administrative costs; but there are risk costs involved; the investor will require a due diligence study.

The two prices could *possibly* compete, but they are part of two entirely separate markets, which are likely to remain separate.

Questions to ponder:

- ? What hidden costs (undeclared) are involved in current energy production? How is current energy production subsidized?
- ? What will happen under REDs?
- ? How can IPPs access the grid?

3. **Emily Tyler**

SouthSouthNorth

Date: 7 March 2006

Place: Cape Town (by telephone)

Telephone: 021 425 1465

Costs:

- ✓ Costs are related to the *volume* of emission reductions (credits).
- ✓ They are also related to project size.

The nature of the methodology is therefore essential.

Costs are decreasing all the time as players learn more about the processes involved. All costs are related to the intricacies of the EU ETS.

Kuyasa:

- Small scale project.
- Cost R1.3million initially. Its replication cost is cR250,000.
- Therefore using an already existing methodology is key to bringing down the costs.

Large Scale:

Project costs = c€80,000 to complete the CDM process.

Transaction Costs:

- It matters *who* you sell to.
- If the finances of the project can hold the risk and sell credits every year (at the spot price), it is in their interests, because they will receive a better price.

Buying Forward:

- This rests on producing the number of credits that you say you will (e.g. an early landfill project only produced one third of the number of promised credits).
- An emissions reduction purchase agreement (ERPA) is important, but one must read the small print. If a project fails to deliver, an investor or project developer have recourse to certain actions, which depend upon who bears the risk.
- Generally ERPAs are more in favour of the buyer.

What is the likelihood of investors paying the upfront costs of a project?

- This is more likely if you are a government or a fund.
- Be very careful about the small print on ERPAs. They tend to include strict sustainable development criteria (most likely with small scale projects), although this is unlikely with wind energy.
- Potential funders include: Public/Development Banks (World Bank, DBSA (who has done very little at this stage), Asian Development Bank); private sector is less likely to get involved.

4. **Steve Thorne**
SouthSouthNorth
Date: 9 March 2006 **Place: Cape Town**
Telephone: 021 425 1465

CDM:

- The initial thought was to try to provide access to cheap finance (a bridge to finance) – e.g. through the DBSA, who could help to provide investment.
- Or to establish a quota and leave developers themselves to work out how best to go about it.
- Or to use bulk procurement methods, drawing on theories of supply and demand (e.g. US government buys expensive fridges in bulk therefore creating a massive demand and the price falls).
- The question was whether the mechanism should be multi/bi/uni-lateral. In the end, it became unilateral, which allows sellers to time their approach to the market and gain the best price for their CERs. In other words they are able to speculate on the market.

Covering Upfront Costs:

The real question is where do you put your money? Do you upstream funds and cover the costs of the initial investment?

“CDM in a way is covering the externality costs [of climate change].”

Non-carbon attributes are important too: socio-economic benefits; health benefits (this is many times more important than socio-economic benefits).

Credits:

TRECs – very new, emerging market in South Africa (Green X and AGAMA Energy are involved in trying to establish it).

VERs (offsets) – have to be retired immediately.

CERs – can be transferred (fungible), e.g. under the EU ETS.

Regulating the Market:

- There is a big push to regulate the market – e.g. the Gold Standard.
- Regulation could be extended to VERs too.

Wind Energy Projects:

Darling – looked into the CDM, but GEF offered to cover the incremental costs, which means that the project is unable to sell CERs.

Morocco – small scale project has been set up (<15MW); under the Climate Action Network?

Sustainable Development Criteria in South Africa:

- Established and managed by the DNA (within DME).
- From a jobs perspective, wind energy is very positive – renewable energy generation produces more jobs per unit of energy than other forms of power production.

- The private sector (as potential investors) fight sustainable development criteria because it increases the complexities of the system.
- Sustainable development is about technologies. It is a sovereign issue that is used as a *gatekeeping* method. It has no value or market. However, SouthSouthNorth is developing a 'development dividend' in order to try to give sustainable development some value.
- There is a fundamental clash of interests in that the south sees sustainable development as meaning development and foreign direct investment (FDI). Whereas the north sees sustainable development as relating to the environment.

5. **Jonathan Avis**
Ecosecurities (UK)
Date: 10 March 2006 **Place: Oxford, UK (by telephone)**
Telephone: +44 1865 297 492

South Africa:

The baseline is very carbon intensive.

This gives a boost to renewable energy projects.

Wind Energy Projects:

From experience with other wind projects (all large scale), the CDM can make approximately a 10% difference to wind projects.

E.g.: Essaouira, Morocco

Wigton Wind Farm, Jamaica

? Wind Farm, China

- CDM helps:
 - i. Overcome capital funding
 - ii. Decrease perceived risks
- Large scale wind farms work better, because of the economies of scale.
- Wind farms need to pass a 5MW threshold in order to be attractive to investors. It is only at this size that projects start to recoup costs.

Upfront Costs:

- It is possible to offset costs against future CER prices.
- Ecosecurities: are willing to take the risk on the futures market because they know how it works (where companies do not); will develop the CDM components of a project, meet third party costs and the upfront fee, offsetting it against the future revenue stream (at a lower CER price in order to recoup costs with interest).

CER Price:

Depends on...

- i. Risk (if a project is low risk, and there are guaranteed credits, it is possible to get close to the European price for CERs)
- ii. Conditions

There is a trade-off between holding on for a higher price or benefiting upfront. Small scale developers cannot take the risk of holding on, but big national power producers can.

Current prices:

- ETS = €20-30 (for the last six months or so)
- CER = generally much lower and very dependent on risks and conditions (sellers get a much better price if they can take guaranteed credits to the market)
- These two prices may converge slightly.

Bundling can decrease transaction costs, but not CER revenues – these remain as individual projects. It does make the CDM process easier.

The bundling of micro-wind (dispersed) could be a possibility.

Monitoring costs are very low for electricity projects because monitoring has to happen anyway!

CDM Market:

- Currently no market beyond 2012.
- Lead in times for projects are normally around 5 years.
- Lead in times are less for small scale projects.

VOM:

- It is possible to sell into the compliance market (CDM).
- Much smaller than the CDM.
- Generally concentrates on corporate social responsibility concerns.

Up until now, there has been a deficit of credits, which the carbon market has been “pretty good” at meeting.

To sum up:

- ✓ CDM can decrease the seed risks as well as the perceived risks.
- ✓ CDM can help to leverage other funds from financial organizations (especially if there is a reputable CDM organization involved).
- ✓ CDM can provide carbon credit revenues.

There is only a 10% improvement for wind projects through the CDM because viability has as much to do with electricity tariffs as with CERs.

APPENDIX D: International and Domestic Financing Organisations (adapted from DME, 2005b and DME, 2003d)

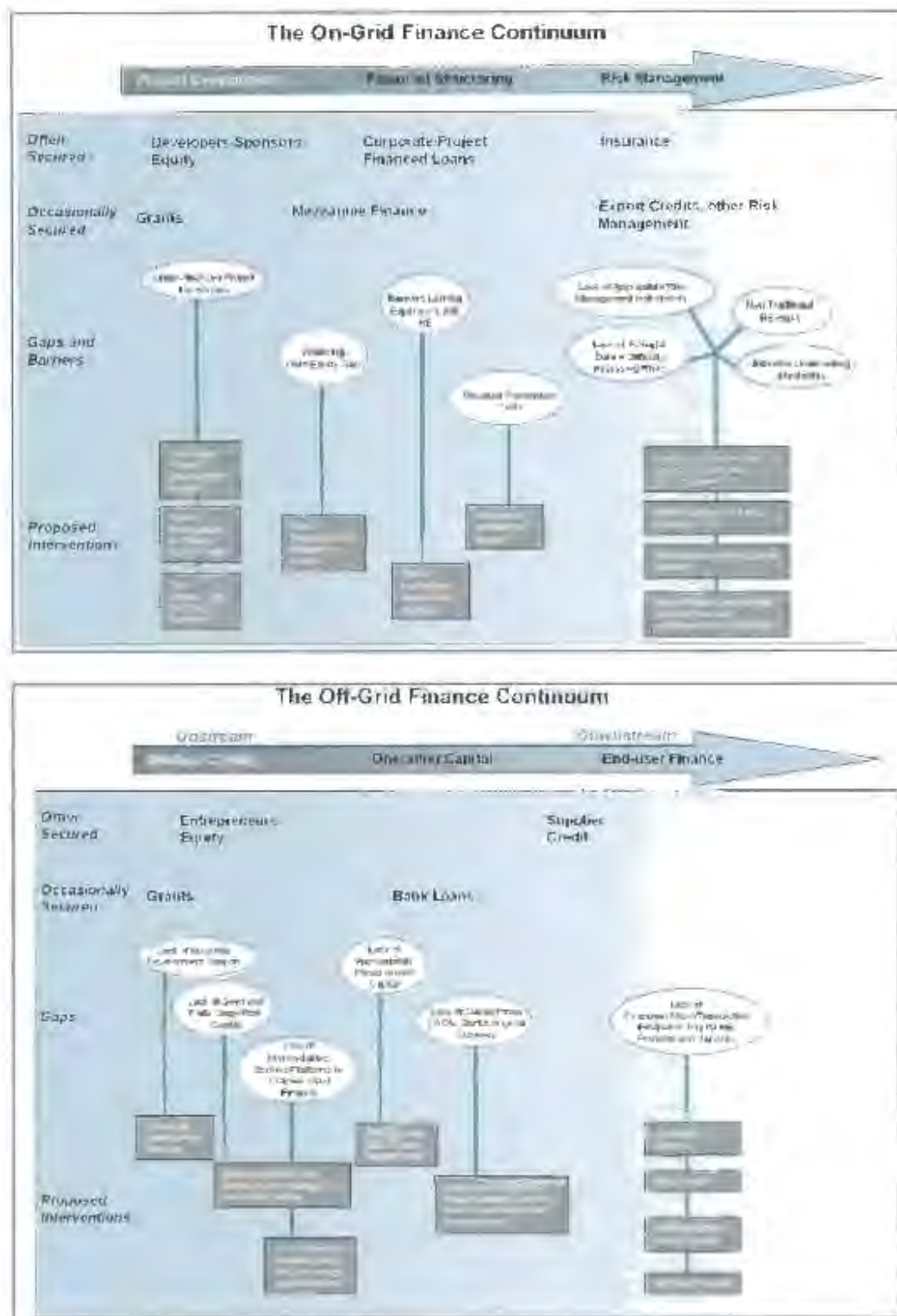
ORGANISATION	ACRONYM	WEBSITE	
International Agencies and Institutions			
Belgian Corporation for International Investment	SBI-FMI	www.dme-sbi.be	Provides medium to long-term co-financing for foreign investments made by Belgian companies.
Belgian Investment Company for Developing Countries	BIC	www.b-i-c.be	Development finance institution, supports the private sector (small to medium enterprises (SMEs)).
CDC Group	CDC	www.cdgroup.co.uk	Invests in businesses, specialist in power, specialized funds targeting SMEs.
Clean Development Mechanism	CDM	http://cdm.unfccc.int/	Allows developed countries to invest in renewable energy projects in developing countries, and trade carbon credits (see Section 6 for details).
Community Development Carbon Fund	CCF	http://carbonfinance.org/cdf/home.cfm	Links small scale projects in developing countries with companies, governments, foundations and NGOs.
Compañia Española de Financiación del Desarrollo	COFIDES	www.cofides.es	Cost-effective financial support for projects in developing/transition/emerging countries, where Spanish companies are involved as investors.
Danish International Development Assistance	DANIDA	www.danida.dk www.unq.dk/en/omdanida/developmentpolicy	South Africa eligible for limited mixed credits (www.mixed-credits.dk/) and the Private Sector Development Programme (PSD) (www.psdprogramme.dk/).
Danish International Investment Funds/Investment Fund for Emerging Markets	IFI/IFV	www.ifi.dk or www.ifv.dk	Co-finances projects – must be a private Danish co-investor.
Deutsche Investitions – und Entwicklungsgesellschaft mbH	DEG	www.deginvest.de	Specialises in long term project finance and corporate financing, invests in profitable projects that contribute to development and are ecologically and socially sustainable.

ORGANISATION	ACRONYM	WEBSITE	COMMENT
International Agencies and Institutions (cont'd)			
Finland Fund for Industrial Cooperation Ltd	FINFUND	www.finnfund.fi/en_GB/	Can finance local partners of Finnish companies or co-invest with other development finance institutions in projects that generate significant environmental/social benefits for her development cooperation partners
Global Environment Facility	GEF	www.gefweb.org/	Provides grant funding to help developing countries protect the global environment
International Bank for Reconstruction and Development	IBRD	www.worldbank.org/	Promotes sustainable development through loans, guarantees, and analytical/advisory services
International Centre for Settlement of Investment Disputes	ICSID	www.worldbank.org/icsid/	Helps to encourage foreign investment
International Development Association	IDA	www.worldbank.org/ida/	\$6.9 billion per annum in highly concessional financing to world's 81 poorest countries
International Finance Corporation	IFC	www.ifc.org/	Promotes economic development through the private sector - invests in sustainable private enterprises
Multilateral Investment Guarantee Agency	MIGA	www.miga.org/	Helps to promote foreign direct investment (FDI) in developing countries
Netherlands Development Finance Company	FMO	www.fmo.nl/	Supports the private sector in developing countries with capital/technical knowledge, aims to achieve maximum development impact and generate favourable return on investment
Nordic Development Fund	NDF	www.ndf.org/	
Nordic Investment Bank	NIB	www.nib.int/en/index.html	
Norwegian Investment Fund for Developing Countries	NORFUND	www.norfund.no/	Risk capital investments through profitable private enterprises in developing countries to create capital and employment, supports viable projects that balance social/environmental considerations

ORGANISATION	ACRONYM	WEBSITE	COMMENT
International Agencies and Institutions (cont'd)			
Prototype Carbon Fund	PCF	http://carbonfinance.org/pcf/	
Società Italiana per le Imprese all'Estero	SIMEST	www.simest.it	Promotes direct investments by Italian companies
Société de Promotion et de Participation pour la Coopération Economique	PROPARCO	www.proparco.fr	Private sector financing
Spanish Development Aid Fund (Instituto de Crédito Oficial (ICO))	FAD	www.ico.es/avc/programa.htm	
Swedfund International AB	SWEDFUND	www.swedfund.se	Offers risk capital and know-how for investments, aims to contribute to development of viable businesses
Wirtschaftsservice Gesellschaft mbH	AWS	www.aws-g.at	Assume financing and project risks of investments based on prospects for business enterprise and project concerned

ORGANISATION	ACRONYM	WEBSITE	COMMENT
South African Based Agencies and Institutions			
Central Energy Fund	CEF	www.cef.org.za	Potential co-investor – invested in Darling Wind Farm
Department of Trade and Industry	DTI	www.dti.gov.za	Offers investment support
Development Bank of South Africa	DBSA	www.dbsa.org	Supportive of developments in renewable energy generation
Empowerment Through Energy Fund	ETEF	www.ETF.co.za	Finances and develops entrepreneur owned/operated start-up and growth companies
Industrial Development Corporation	IDC	www.idc.co.za	Invests in energy projects including renewable energy generation – invested in Darling Wind Farm
Infrastructure Finance Corporation Limited	INCA	www.inca.co.za	Infrastructure debt fund
Investec Bank Limited		www.investec.co.za	UK-based bank focuses on renewable energy
Macquarie Bank Africa (Pty) Ltd		www.macquarie.com.au/about_macquarie/international_activities/africa_region.htm	Specialist investment banking and financial services
Standard Bank of South Africa Ltd		www.standard.co.za	Financial services company

APPENDIX E: On-Grid and Off-Grid Finance Continuums (Sonntag-O'Brien and Usher, 2004)



APPENDIX F: Eskom Power Stations in commission 31 March 2005 (Eskom, 2005a)

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