THE CLEAN DEVELOPMENT MECHANISM (CDM)

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ANALYSING THE FINANCIAL VIABILITY OF POTENTIAL CDM PROJECTS, AND ASSESSING ASSOCIATED SUSTAINBLE DEVELOPMENT IMPACTS FOR SOUTH AFRICA

DECLARATION

This serves to declare that this thesis is original and has never been submitted before, at any academic institution, for any requirement except for the purpose of serving as:

A partial fulfilment of the requirements for the degree of
Master of Science in Applied Sciences (Energy and Development Studies),
Faculty of Engineering and Built Environment, University of Cape Town.

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Date: 03-03-2003

ABSTRACT

A growing concern regarding the limitation inherent in the 1992 United Nations Framework Convention on Climate Change (UNFCCC) for encouraging prompt global action on climate change has been key in vitalising climate change negotiations. The UNFCCC process has triggered further negotiations and related international forums on climate change that eventually led to the birth of the Kyoto Protocol in 1997. This outcome represents a legally enforceable strategy for reinforcing the UNFCCC. Being among the first key climate change regime milestones, the Kyoto Protocol was adopted to enable a working environment for international co-operation against the threat of climate change to humanity. To this end, incorporates carbon emissions reduction instruments known as 'flexibility mechanisms' to achieve the overall objective of '...stabilisation of greenhouse gas concentrations in the atmosphere ...' (UNFCCC 1992). Of the four climate change mitigation implementation instruments (or mechanisms), the Clean Development Mechanism (CDM) stands out as the only one relevant for the developing world.

The thesis investigates the potential for the CDM to both protect and promote the indigenous development policy objectives of the Southern project-host countries in the context of a new paradigm of *sustainable development*. The CDM would support local capacity building and provide a tool for enabling technology reception in the South; and would set up a unique arrangement by which the Northern parties will have access to more cost-effective avenues in fulfilling their climate commitments than pursuing domestic measures.

The core of the rationale behind the thesis stems from a need for expanding the insight into how the CDM will achieve its primary purpose of enhancing *sustainable development* for developing country-based participants. Austin *et al* (1999) reviewed this question for three other developing countries (i.e. Brazil, China and India), in an effort to enhance the insight into measuring *sustainable*

development outcomes arising from the CDM. The thesis employs a South African socio-economic development context for investigation. The thesis also assesses how supporting CDM-driven activities will be worthwhile, from an economic standpoint, for potential project investors or developers in developing countries. The thesis investigates the investment (or financial) performance of CDM projects by comparing the impact, on a project's Internal Rate of Return (IRR), of incorporating an associated *carbon investment* component within a conventional project investment framework. For this, it focuses on four of the country's potential energy sector climate mitigation projects as case studies for its investigation.

From a South African perspective, the main findings of the thesis are that, the country's political as well as socio-economic profile reflects an economy with the potential for attracting significant, *carbon*-driven, development investments from the North. This economy's energy sector offers significant development-related climate change mitigation investment opportunities: an empirical insight into the structure of the economic system of South Africa attributes high levels of national (and even beyond) GHG emissions to the energy supply sector with a particular reference to the electricity production industry. The national government, through climate change the political leadership of the Department of Environmental Affairs & Tourism (DEAT), has taken significant steps in fulfilling its political mandated to provide an enabling environment, and therefore, clearing the way for streamlined introducing of climate change mitigation projects through the CDM-based investment infra-structure. In showcasing the potential of the CDM, on the basis of its two intrinsic twin objectives highlighted in *section 2.5*, the four case studies in the thesis provide examples of both important hypothetical and working scenarios of climate change mitigation investments in local development initiatives within the context of sustainable development – these include: Wind Power Production (Case Study 1), SHS Rural Electrification (Case Study 2), Industrial Energy Efficiency (Case Study 3) and Efficient Energy Performance Housing (Case Study 4). A further aspect, which is crucially important in as far as the thesis is concerned, is that the case studies also reveals CDM's unique character of being

sensitive to the issue of sovereignty, which is especially mostly crucial in most unstable (politically and economically) African nations. This is illustrated by the fact that the case studies prioritise their development interventions in accordance with the government's traditional (or indigenous) policy aspirations and goals.

The *Wind Power Generation Project* as well as the *SHS Rural Electrification* case study provides, fairly significantly, demonstration of *technology transfer* – this is a newly geared policy strategy for further enhancing climate change-linked opportunities for CDM investments in the South -- see Davidson (2002c) for a further perspective on of *technology transfer.* In terms of the thesis, all the four case studies would impartially fulfil the objective of *technology transfer* if their interventions including: installation of SWH's, SHS's, CFL's, insulated ceilings, state-of-the-art passive solar housing and industrial energy efficiency have not incorporated local beneficiaries-focused capacity development measures – such a condition would, from a policy planning standpoint, impede the post-project maintenance as well as replication of 'transferred' innovations. This raises a fundamental challenge for both project developers investors and development policy-makers. For this, both public- and private sector-based CDM stakeholders would need to put in place efficient, integrated measures that will oversee North-South 'transfer' of sustainable energy and related development technologies and services for the beneficiaries.

On part of the investors, the case studies has shown that the CDM would play a vital role in enhancing the economic (or financial) attractiveness of carbon-driven investments for local investments. On top of this, as Table 8 illustrates, the results of the financial sensitivity of the case studies also reveals that the different combinations of 'change (or increase) in the price of carbon' and 'choice of baselines options' would have a significant bearing on the financial output (i.e. IRR values) of investments. This shows how important it would be as to both how international market forces would respond to CDM and which 'baseline

development' path potential North-South project stakeholders would adopt for amassing significant *carbon*-based returns on investments.

DEDICATION

For the very spirit that has always defined their both unreserved and committed support for my education; and for their understanding of the costs that accompanied one's academic engagement towards the achievement of this study, I here wish to dedicate this thesis to my parents:

Goitsemodimo & Tsetsana

"... ke a leboga batlhaping le bagwaketsi."

ACKNOWLEDGEMENTS

Like 'birds of seasonal migration' faced by patches of mountains over which to cross, one could not have asked for a more challenging experience in developing this thesis. Not only an individual effort to accomplishing such a quest would have been inadequate, but also it would have hardly provided a competitive human capital. I am humbled with an overriding sense pride as I am extending handful of acknowledgements to the following contributors; and also wish to salute them for their invaluable support to my studies. Their contributions have collectively defined a significant *sustainable development* benefit not for the thesis also for an array of academic as well as public communities to whom it will prove resourceful.

Prof. Ogunlade Davidson	– thesis and research support
Prof. Anton Eberhard	– masters study resources support
Dr. Tim James	– text layout
Ms. Christel Kalil	– writing editing
Mr. Andrew Marquard	– tutorial support
Mr. M. Mogomotsi & Family	– computer support
Mr. Randall Spalding-Fecher	– thesis supervision
Dr. Debbie Sparks	– text editing

LIST OF ACRONYMS USED

AA's	Assigned Allowances
AGBM	Ad-hoc Group on Berlin Mandate
°C	Celsius degree
C	carbon
CDF	Clean Development Fund
CDM	Clean Development Mechanism
CER's	Certified Emissions Reductions
CFL's	Compact Florescent Lights (or Lights)
CGCT	Combined Gas Cycle Turbine
CH_4	methane
CO_2	carbon dioxide
COP	Conference of Parties
COP/MOP	Conference of Parties serving as Meeting of Parties
DANCED	Danish Cooperation for Environment & Development
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals & Energy
DNA	Designated National Agency (or Authority)
EB	Executive Board
EDG	Energy & Development Group
EDRC	Energy & Development Research Centre
EU	European Union
GDP	Gross Domestic Product
GEAR	Growth, Environment and Reconstruction

GEF	Global Environment Facility
GHG's	greenhouse gases
GJ	gigajoule
GWh	gigawatt-hour
HFC's	hydro fluorocarbons
IGCCS	Integrated gasification combined cycle/supercritical
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
Kg	kilogram
kWh	kilowatt-hour
L	litre
LULUCF	Land Use & Land Use Change Forestry
MJ	megajoule
MtC	metric-tonne carbon
MW	megawatt
MWh	megawatt-hour
N_2O	nitrous oxide
NCCCC	National Climate Change Co-ordinating Committee
O&M	operational & maintenance costs
OE	Operational Entity
PDD	Project Design Document
PV	photovoltaic
RAPS	Rural Area Power Solutions
Rm	Rand (in millions)
SHS	Solar Home System

SSN	SouthSouthNorth
SWH	Solar Water Heater
T&D	transmission and distribution losses
TMP	Thermal Mechanical Pulping
UNCHE	United Nations Conference on Human Environment
UNCSD	United Nations Commission on Sustainable Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UV	ultra violet
W	watts
WCC	World Climate Conference

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1. INTRODUCTION

1.1 The Emerging Climate Change Regime: A Brief Overview

In December of 1997, in Kyoto, Japan, government delegations from around the globe attended a negotiating forum. This forum marked an important step in the direction towards the formation of the climate change regime. The main aim of this meeting of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) was to find ways to avoid potential negative impacts of emerging climate change. This was achieved with the establishment of a new international environmental agreement, the Kyoto Protocol to the UNFCCC. The purpose of the Kyoto Protocol is to support fulfilment of the UNFCCC's ultimate objective, which entails:

> *... stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [i.e. human-induced] interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to naturally to* climate change*, to ensure that food production is not threatened and to allow economic development to proceed in a sustainable manner (UNFCCC 1992).*

The Kyoto Protocol would seek the engagement of industrialised countries, in the North, to support development initiatives in developing countries, the South. In promoting these engagements, the CDM would bear the incentives of 'carbon reduction credits' for the northern countries (as well as the corporate sector entities). The north (i.e. the industrialised countries) could use these *credits* against their individual commitments of limiting greenhouse gas (GHG) emissions.

1.2 The Objective of the Thesis: A Southern Climate Co-operation Perspective

The Kyoto Protocol is still not in force. It is expected to be legally operational early 2003, which shall be immediately after a period of 90 days following the

entry of the fifty-fifth (55th) instrument of ratification. As a matter of principle, this benchmark requires ratification by industrialised countries that account for a minimum of 55% of the 1990 emissions (UNFCCC 1998: Article 25). South Africa has achieved significant strides in a number of political engagements since the recent birth of its democratic regime. In addition to having become a Party to the UNFCCC and later showing its political commitment to the Kyoto Protocol, the country has been widely labelled as one of the most aspirant candidates for prompt CDM-driven sustainable climate activities on the continent. Among other factors, South Africa owes this climate change attraction to the structure of its economy, and its fossil fuel intensive energy systems in particular. Based on this background, the objective of this thesis is to assess how and to what extent the CDM will benefit South Africa as a CDM host country. Further, it investigates how carbon revenue accrued from potential CDM projects will impact on the project financial viability from a perspective of project developers.

1.3 Thesis Organisation

The thesis presents the development of its investigation in six chapters starting with this introduction – that is, Chapter 1. The remaining chapters provide the literature review, (Chapter 2); a prospectus, which serves the introduction to the case studies for the thesis (Chapter 3); presentation of the results of the case studies' financial analysis (Chapter 4); presentation of potential *sustainable development* impacts linked to the individual cases studies (Chapter 5); and finally the conclusion (Chapter 6).

2. LITERATURE REVIEW

2.1 The Fundamentals of the Climate Change Regime: A Historical View

The UNFCCC represents one of the first and most significant international environmental agreements ever to be adopted. For this reason, this convention is a symbol of 'success on a multilateral consensus', most importantly for the international political community. The UNFCCC was borne out of a need for addressing the world's environmentally unsustainable growth, which recent scientific research has shown to have negative anthropogenic influence on the global climate system. This was documented by the Intergovernmental Panel on Climate Change (IPCC) in their reports of 1990 and 1995.

However, climate change is not a subject of the recent past. Its history can be traced back to as far as the early nineteen century. A French scientist, Jean Baptiste Fourier, first described one important element of the natural global climate system, the *natural greenhouse effect* – the next section elaborates this at a length. Not long after this, a Swedish chemist, Svante Arrheneus, wrote that a '...growing volume of carbon dioxide emitted by the factories of the Industrial Revolution was changing the composition of the atmosphere ...' (Grubb *et al* 1999: 4). This was the first indication of the responsibility of fossil fuel based economic development for climate change.

2.2 Scientific Basis of Climate Change

2.2.1 The Natural Greenhouse Effect: A Support for a Living Environment

The sun emits solar energy in the form of ultra-violet (or UV) radiation to the earth, a large part of which reaches the earth's surface. Of this radiation, only a small amount is absorbed by the surface while the remaining unabsorbed quantity is reflected back into the atmosphere – this process is referred to as *back-radiation* (Jansen 1999: 13). During the process of reflection (of solar radiation)

from the Earth's surface, the on-coming short-wave UV radiation is transformed into long wavelength radiation, known as *infrared* radiation. Because the atmosphere is more permeable to short wavelength radiation than it is to a long wavelength radiation (Jansen 1999: 13), only a small amount of heat-carrying *infrared* radiation escapes beyond the atmosphere – the rest is trapped in the near surface atmospheric layers.

The natural presence of greenhouse gases (GHG's) such as water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are known for their ability to absorb *infrared* radiation. Through this activity, these gases trap heat in the atmosphere. It is important to note that these gases are required for the *natural greenhouse effect.* This phenomenon has maintained global temperatures at the levels necessary for the survival of all life. Jansen (1999: 12) notes that the observed mean temperature of 15 °C (i.e. Celsius degree) near the surface would be as low as -18 °C if it were not for the *natural greenhouse effect*.

2.2.2 Enhanced Greenhouse Effect: Human-Induced Climate Change

In the wake of the eighteenth-century Industrial Revolution, which was predominantly limited to the north, there was a huge deterioration in the quality of the atmosphere. The literature shows that GHG emissions from an extensive dependence on fossil fuels for energy procurement can be seen as directly attributing a significant share to this outcome (IPCC 2001a: 36). Through the increasing rates in emissions into the lower atmosphere, the GHG's have been accumulating, which has resulted in higher concentration levels.

According to the IPCC (2001b: 7), the past twenty years has seen fossil fuels burning activities contributing about 70% of the increased CO_2 concentration in the atmosphere; the remaining 30% has predominantly been coming from land-use change activities such as deforestation. The source further indicates that this output (of CO_2) has been responsible for 60% of the human-induced (or

anthropogenic) climate change, while CH_4 (also released from fossil burning and activities such as agriculture) has accounted for only 20% (IPCC 2001b: 39-42). These records provide a few of the key implications suggesting discernible human influence on the global climate system (IPCC 1995: 5); and 'production and use of fossil fuels has been identified as the single most important element of this influence, contributing 75% of the ... [global atmospheric impact]' (Davidson: 2002a: 145).

The role of the *natural greenhouse effect* has been enhanced through human-induced carbon emissions, and for this reason, the *enhanced greenhouse effect* is leading to human-induced climate change. The average near surface global temperature over the last century has increased by 0.6 °C at a rate of 0.15 °C per decade with the 1990's being the warmest decade and 1998 the warmest year in the recorded history (IPCC 2001a: 26). However, of the six recognised GHG's, three, which include hydro fluorocarbons (HFC's), sulphur hexafluoride (SF_6) and perfluorocarbons (PFC's), have made a relatively smaller contribution to human-induced climate change. These three trace GHG's, which have evolved commonly as by-products of current-day, modern technological practices, are all recent in relation to the three major others (mentioned in *sub-section 2.2.1* above).

2.3 The Origin of the UNFCCC

Both the UNFCCC and the Kyoto Protocol together have contributed a crucial dimension to the development of environmentally considerate, integrated socio-economic development planning agenda for the future. The development that led to the two international environmental protocols can be traced to as far back as 1972 (Simmonds & Spalding-Fecher 1999: 10). It was during this time that the United Nations Conference on Human Environment (UNCHE) took place in Stockholm, Sweden. This conference inspired courage and set a vision for enhancing the integrity of the global environment. The essence was to call for securing equity of development for the future, particularly the future of both humanity and the environment.

By 1979, the first World Climate Conference (WCC) drew the worlds' attention to changing trends in climate patterns. One of the highlights of this meeting was its call on international political leadership to "*...foresee and prevent potential man-made change in the climate that might be adverse to the well-being of humanity*" (Simmonds & Spalding-Fecher 1999: 10). Less than a decade later on, in 1988, a collaborative partnership between UNEP and the World Meteorological Organisation (WMO), one of leading major milestones in the development climate change regime formation, established the Intergovernmental Panel on Climate Change (IPCC). This collaboration represents one of the early key role-playing developments pertaining to matters concerning both the global climate and humanity. The IPCC, a body made up of scientists with high-level expertise, was borne out of a need to draw the attention of the international political leadership to the issue of climate change. In 1990 the IPCC published its First Assessment Report (FAR) in which it proclaimed that '...the rising concentration of carbon dioxide and other greenhouse gases in the atmosphere were caused by human activities and would cause global temperatures to rise, with accompanying climatic changes' (Grubb *et al* 1999: 5). This statement had an enormous influence on the urgency of international negotiations on climate change. The United Nations General Assembly (UNGA) was in charge of preparations for the development of the UNFCCC.

During 1990, the World Climate Conference (WCC) convened the second of its two historical meetings. Among the important outputs of this forum, was the emphasis on the need for a global focus on climate change. The most important factor behind the urgency with which these preparations were made, was the urgency of meeting the deadline of June 1992, which was when the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil would take place. The objective was to make the most use of the opportunity to lobby for greater political support from the government delegations that attended the UNCED – commonly referred to as the Rio Earth Summit. A few months later, on the 23rd of March 1993, the UNFCCC was adopted (Simmonds & Spalding-Fecher 1999: 11).

2.4 The Kyoto Protocol: Trading Principles and Flexibility Mechanisms

2.4.1 The Rationale for Trading

The Kyoto Protocol aims to set up cost-effective investment opportunities, which would encourage the potential industrialised country Parties to modify their patterns of economic production. This would set the stage for an enabling environment for these Parties to meet their GHG reduction targets. The main aim is for these Parties to achieve an average 5.2% reduction of GHG emissions relative to the 1990 emissions levels. Because fulfilling their climate commitment at home would be more expensive than mitigation options in developing countries, and that emissions reduction impacts resulting from carbon offset activities would be the same globally, irrespective of where a carbon-offset activity will have been carried out, it would make an economic sense for trading in *carbon* emissions reductions. Such reductions – technically, *Certified Emissions Reductions* (or *CER's*) – will represent commodities with an economic value based on their size (i.e. the tonnes of 'reduced carbon emissions' acquired through participation in a climate mitigation project activity. This would give the industrialised countries the opportunity to exchange investment input cost effectively for carbon credits, which they would need to comply with the climate commitments. Specific trading options are discussed below.

2.4.2 The Principle of 'Flexibility': Optimising the Opportunity for Compliance with the UNFCCC

The principle of 'flexibility' was established mainly to ease the compliance costs of the Annex I countries to climate change commitments. Three forms of flexibility have been defined, which include geographic (i.e. the *where*), time (i.e. the *when*) and scope (i.e. the *what*) flexibility. Although these forms of flexibility carry relatively the same weight in terms of their significance, the CDM is largely concerned with the former. The geographic flexibility is anticipated to bear a significant economic and development implications both for potential host and investor country parties. For this reason, and that it reflects to be mostly dovetail with the fundamental purpose of the CDM, thesis provides, to a greater extent, an

analytical consideration this flexibility form in *section 2.11*. While on this aspect, it is worth mentioning that such a climate change compliance approach/flexibility, which was primarily designed to stimulate a leading Northern role for action on the global threat of changing climate. However this did not get to go down well with respect to Southern country delegations; and, for this reason, it was apparent from this quarter, that a tension surrounding such a 'stat of affairs' was already beginning to mount. Some feared that the North, through the flexibility mechanisms, with particular reference to the CDM, would delay the compensation for the negative global environmental changes and, therefore, '...postpone necessary changes [in their economic] activities ...' (Skea 1999: 357). The source (i.e. Skea 1999: 357) further points out, however, that 'flexibility principle' could contribute to a range of measures for greater upliftment in capacity development in the South.

2.4.3 The Geographic (or the 'where') Flexibility

The basic feature of the geographic flexibility is to provide for a trading platform through which the industrialised countries would be able to fulfil their commitments outside their national boundaries. Through this arrangement the Northern governments as well as related private-sector investors would be able to exchange tradable carbon credits of various types. In addition to the CDM, other geographic flexibility mechanisms include the *Bubble* (i.e. Joint Fulfilment), *International Emissions Trading* and *Joint Implementation*. The former, defined under *Article 4*, was designed to allow for a collective and shared responsibility by a defined group of countries for fulfilling their commitments under the Kyoto Protocol. The European Union (EU) provides the only such recognised, economic integration organisation. Comprising 15 country-members, the EU would be expected to pursue a mutually shared, common interest in '...re-distributing emission commitments around ...Member States ...' in accordance with the principle of international burden sharing (Skea 1999: 361). As with the *Bubble*, *International Emissions Trading (Article 17)*, provides a non-project level arrangement for international carbon trading. Its purpose is to provide for trading between the industrialised countries. This flexibility mechanism would enable an

industrialised country with higher emissions than its Assigned Allowances (AA's) to buy AA's from another industrialised country with surplus of AA's. The incentive is that a buying country party will buy AA's where it is less expensive than pursuing climate abatement activities on shores (or domestically). A further aspect is that this incentive would lead to industrialised countries with lower carbon mitigation costs increasingly investing in more energy and resources efficient activities for greater economic gains. Buying more AA's would be beneficial to the buyers as they would avoid otherwise high cost domestic climate change compliance measures.

Contrary to the CDM, which would provide for North-South 'technology transfer' of development opportunities, *Joint Implementation (Article 6)* would offer opportunities limited only to the North. Constituting a basic distinction between these two Kyoto mechanisms, this feature impart an advantage for CDM attraction for the purpose of achieving both enhanced climate change compliance and sustainable development advancement. One other perspective on this (attraction) for international corporate domain, is that provides the most geographically comprehensive of all the Kyoto flexibility mechanisms, and, too, the only one that includes the developing world. For potential Southern participants in the climate change regime, the most inspiring as well as appealing feature is that CDM would have the potential for globalising the market for *sustainable development* opportunities for vulnerable developing world-based economies.

2.5 Evolution of the Clean Development Mechanism (CDM)

Towards the end of May in 1997, the Brazilian delegation forwarded a proposal for consideration by the Ad-hoc Group on Berlin Mandate (AGBM). This Group was set up two years earlier (which was in 1995) at the first Conference of Parties (COP-1). The purpose of the AGBM was to oversee the co-ordination of the processes on the building of what was to stand as the Kyoto Protocol (Grubb *et al*

1999: 52). During the seventh (7^{th}) in the series of eight sessions just before the third Conference of Parties (i.e. COP-3), the Brazilian delegation forwarded a proposal, which they had named the Clean Development Fund (CDF). The CDF proposal aggravated concerns within the negotiations over possible punitive actions on the Northern industrialised countries. Estrada-Oyuela (1998: 24) points out that the developing world requested compensation for the increase in their economic vulnerability from climate change. The justification was that, despite the developing nations never having been part of historical contributions to climate change, hard-hitting effects (of this historical impact) had been and would continue to increase the current level of 'development stress' on already vulnerable developing economies. Against this background is likely such a situation would expand the North-South polarity of the global natural and related energy resource wealth.

It was on this basis that the CDF was to be mobilised: industrialised nations would contribute financial compensation for adverse impacts related to their carbon emissions. The objective was to develop a stock of financial resources for development, which would be channelled towards climate adaptation efforts in the South. This produced a deadlock of views between the North and the South (over global differentiated environmental responsibilities and, apparently, related social retributions). During the eighth (8^{th}) negotiating session, which was convened in October 1997, the *status quo* eventually got to reaching its turning point when a reconciliatory international co-operative 'implementation mechanism' was agreed upon and finally sealed in the pre-Kyoto negotiating text (Grubb *et al* 1999: 64). In December the Kyoto Protocol was adopted at COP-3, in Kyoto, Japan; and the *Article 12* of this international strategic environmental treaty (i.e. the Kyoto Protocol) defined the CDM. The second of the ten (10) constitutive provisions of this *Article* stipulates that the CDM '...shall ...assist Parties not included in Annex I in achieving *sustainable development* and in contributing to the ultimate objective of the Convention ...' (UNFCCC 1998: 16). It further states that this multi-lateral strategic policy instrument will '...assist Parties included in Annex I in achieving compliance with their quantified emission limitation and

reduction commitments ...' (UNFCCC 1998: 16) – this all, is the fundamental purpose as well as the aims of the CDM.

2.6 South Africa: Engaging with the UNFCCC

Although South Africa was not part of the earlier processes of climate change regime development (of which the 1992 UNFCCC marked one of the first key milestones for the future of an international environmental policy-making agenda), the country has achieved a few significant milestones since it has come on board the development of global climate regime planning. In August 1997, the South African government made its commitment to climate concerns clear with its ratification of the UNFCCC (Davidson & Tyani 2001: 7). This development meant that the country would be recognised as a legitimate candidate for getting on board a bandwagon against climate change, and for CDM. Further, the country would automatically have a firm international footing for subsequent international treaties within amid of the UNFCCC. In addition to the policy question of the 'climate change legitimacy', has added value to its political vocation on climate change by proactively setting up an enabling environment for national institutionalisation of the CDM regime. From the thesis' perspective, this would represent an already 'paid-up price' for a streamlined CDM-related investment implementation for South Africa and the government in particular.

Due to its fossil energy intensive economy, South Africa has attractive carbon offset opportunities for potential CDM investments. The government has also demonstrated a great deal of political will in providing its supportive role and spearheading initiative towards a development of sound national CDM investment and institutional environment. As the core part of overall a national climate change regime setting, the Department of Environmental Affairs & Tourism (DEAT) was chosen as the country's focal point and political window for international climate change engagements and related affairs. The Department has, on serving this capacity, immediately achieved a significant milestone with respect to pursuing its climate change mandate: it has established the National

Climate Change Co-ordinating Committee (NCCCC), which represents a national inter-departmental advisory body for climate change (Rukato *et al* 2000: 4; Davidson & Tyani 2001: 7). The latter co-authors further note that, the NCCCC has played a vital role in a drive towards the ratification of the Kyoto Protocol by the South African government.

2.7 Climate Change Challenges and Prospects for South Africa

The development of economic modernisation, through industrialisation, provided an important step in the advancement of the living conditions of the world's society. However, such a change in technology, industry and other economic modernisation and related developments has been fuelled with mainly fossil sources for energy. The approach through which this historical development path was driven, characterised a narrow corridor of development policy planning with much attention singly focused on growth. It is for this reason that a historical, prolific upsurge in the world's fossil fuelled-economic growth has been the mainstay behind current socio-economic development and modernisation. Such a development path meant and, therefore, upheld to preclude other development imperatives such 'environmental management' and 'social equity', which are currently proving to be equally key components of a pluralistic and integrated development planning approach.

Part of the pre-eminent interest in climate change debates is the demand for Northern countries to lead the way in enhancing the potential for an environmentally sustainable *transfer* of climate adaptation technologies and associated development to the South. The crucial issue is the fact that the absence, or lack of incentives for greater Northern participation would suggest further Southern economic vulnerability with the potentially appalling global warming effect linked to climate change; and this might even suggest to increasingly threaten human life in the South. To the extent to that Africa will be affected, it is expected that populations across the continent could be faced with

even more challenging and frequent weather occurrences. For South Africa, which is known for its low level of fresh water supplies; and for bearing not only an environmentally sensitive south-western ecological area, but also the world's highly bio-diversified Fynbos biome[1], climate change will have significant negative impacts (Kiker 2000: 12). This constitutes an important policy implication for South Africa: its participation in climate change regime would not only guard against its social susceptibility to extreme weather conditions, but climate change would bring along bulk opportunities for otherwise elusive socio-economic development benefits within the context of *sustainable development*. Against this background, the overall objective of South Africa's both active contribution to and participation in the development of the climate change regime is to achieve greater institutional capacity development. This would add value to efforts geared to enhance CDM investments in development initiatives.

[1] South Africa has seven (7) botanically defined plant regions, which are technically referred to as *biomes*.

2.8 Climate Change Mitigation in the Energy Supply Sector

This section provides a perspective on possible mitigation options and measures that could be employed as strategic responses to negative effects of human-induced climate change. Although most of these technologies have been applied in many parts around the world (but usually for reasons not related to climate change objectives), they are anticipated to form key elements of a drive towards delaying or weakening potential impacts of climate change. To this end, the CDM would provide the conduit through which to optimise *sustainable development*-informed 'transfer' to and the security of enhanced socio-economic welfare in the South. Carbon emissions reductions linked to such innovations will serve to demonstrate the potential of and, therefore, justifying the institutionalisation of the CDM regime as a strategy that would support improvements in the country's social and economic development.

2.8.1 Fossil Energy Options & Measures

Although, in the near- to medium-term future, integrated energy policy planning and related institutional development interventions would lead to climate friendly production as one of the major *sustainable development* prospects, fossil fuels will continue to dominate the sources of energy supply (IPCC 2001b: 34). For this reason, environmentally sustainable fossil energy-based production activities as result of improved and new energy efficient technologies would be extremely crucial. The *Integrated Gasification Combined Cycle/Supercritical (IGCCS)* represents the introduction of advancement in coal-fired energy production. This technology is currently providing an economically viable option for GHG mitigation objectives. However, a high-level competence of this option will dependent mainly on its conversion efficiency. The *Combined Gas Cycle Turbines (CGCT)* has proven to have a wide range of application in countries with an abundant primary supply of gas. This option also provides a both technically and economically opportunity that promise greater climate change mitigation benefits. As with the IGCCS, the effectiveness of the CGCT would rely on its high level of energy

efficiency (IPCC 2001b: 34). The source (i.e. the IPCC) further elaborates that this option has a proven potential in competing with the already established coal-based energy production facilities in the markets with respect to its capacity in the medium future. The latest of model of this technology comes with 60% conversion efficiency (IPCC 2001b: 34). *Decentralised Combined Heat and Power (D-CHP) Systems* offer more efficient energy conversion technologies for space heating in commercial buildings and manufacturing (IPCC 2001b: 34) achieving '...fuel utilisation, of up to 80-90% ...' (IPCC 1996: 39) compared to a conventional application or technologies. This will contribute significantly to the world's anticipated 60% increase in efficiency power production in the long term (IPCC 1995: 38).

Fossil Fuel Switching involves switching from high carbon content fuels (such as coal) to fuels with lower carbon content (such as natural gas). According to the IPCC (1995: 38), natural gas has the lowest CO_2 emissions per unit of energy of all fossil fuels at 14 kgC/GJ (i.e. kilogram carbon per gigajoule) – oil and coal have an emission intensity of 20 kgC/GJ and 25 kgC/GJ, respectively. This option is likely to surpass many other measures for climate change mitigation in terms of its availability or accessibility. Depending on the nature of the market, it is expected that this option would contribute substantially in reducing emissions to levels well below those linked to business-as-usual scenarios. One of state-of-the-art technical measures for reducing emissions of GHG pollution from coal-fired power production comes with *decarbonisation*. This coal-fired technology comprises a technique by which GHG's are drawn out of the flue gas as smoke passes through the smoke stacks of a power station. However, extensive and widespread application of this measure has been obscured largely by its inherently high technical and economic costs. Despite this, it is still at its experimental stage and, for this reason, would require much more time to get significantly established. The costs of implementing this measure typically ranges between $80-150 per tonne of saved carbon emissions. Moreover, through a large-scale undertaking, this measure could save up to 85% of CO_2 from fossil fuel burning (IPCC 1996: 5).

2.8.2 Alternative (or Renewable) Energy Options & Measures

In contrast to the fossil fuel-based options, discussed in the sub-sections above, energy production based on harnessing natural, renewable resources opens a new chapter on a *sustainable development*-focused approach to energy supply procurement. Renewable energy consists of *solar*, *hydro*, *wind* and *biomass*. The main drive behind an increased commercial use of such alternative, pollution free energy sources, is based on the need for a shift towards an environmentally benevolent economic grow and development path. In addition, this is aimed at setting an enhanced access of the Southern economies to affordable cleaner energy technologies and other innovative development services. However, because of their relatively high economic costs (of installation), and potentially negative local socio-ecological impacts (arising from their large-scale development) (IPCC 2001b: 34), and, also often requiring medium-to-high technical capacity for both exploiting and managing, renewable technologies have generally had limited application. It is likely that this trend will continue for a while, and this would lead to a formidable challenge for these technologies to emulate their currently well-established fossil-based counterparts in terms of globally dominating an access to the markets. However, in some places like in Asia, hydropower technologies have proven their greater potential for approaching competitive market levels in the near future. This is only one among the first indications that '...further opportunities [in the future would] exist beyond those [currently] anticipated to contribute to reducing CO_2 equivalent emissions' (IPCC 2001b: 35).

2.9 Climate Change Mitigation in the Energy Demand Sector

Contrary to the two preceding sub-sections, which focus on supply sector options, this sub-section shifts its focus on to the energy demand (or consumption) sector. Unsustainable energy consumption in three major demand sectors including industry, buildings (i.e. commercial & residential) and transport, is responsible for

high level of GHG emission. Energy efficiency constitutes the most important criterion for both efficient and economical energy use patterns for the entire demand sector. GHG emissions attributed to these sectors, are due to poor end-use efficiency with a special reference to industrial manufacturing, residential and commercial energy services. Transport is increasingly becoming important insofar as the currently soaring of carbon emissions rates are concerned. This effect has of late become even more prominent with the fast growing demand for road transport; most significantly in the face a growing importance of climate change as being among the most topical subject in the current-day international multilateral debate. Anecdotal insights and general expectations suggest major atmospheric pollution-related problems attributable to the transport proliferation.

2.9.1 Industrial Energy Options & Measures

Despite the fact that industrialisation and related unsustainable industrial activities have been responsible for the largest part of the historical global GHG emissions – which has led to anthropogenic (or human induced) climate change –, there has been a decreasing trend in emissions from the industrially matured economies in the north (IPCC 1996: 31). The interesting in dimension of this turnout, is that such (emission rates) decreases have had less (if anything) to do with reasons of climate change objectives than with the current economic infra-structural maturation of the Northern industrialised nations. Upon this stage (of saturated development) economies would usually tend to shift away from energy-intensive production patterns towards more services-laden energy and other related economic modernisation activities. Industry constitutes the dominant emitter of global GHG pollution of these three major energy demand sub-sectors with the transport sector, although growing very rapidly, providing the least contributor to global GHG emissions. In 1995, industry accounted for 43% of the total global fossil fuel CO_2 emissions, with buildings and transport being responsible for 31% and 22% respectively (IPCC 2001b: 24 & 33).

Energy Efficiency has become the single most established industrial energy management measure that could play a key role as industrial measure for mitigating climate change. Along with reducing energy costs, industrial GHG emissions would be reduced by substantial amounts through long-term emphasis on energy efficient technologies for industrial activity. The IPCC (2001b: 33) estimates that by 2010, about 300 MtC (i.e. metric-tonne carbon) to 500 MtC reductions would be achieved through pursuing both established and considered industrial energy efficiency measures. *Improved Material Management* provides the next most plausible option among the most likely industrial climate change mitigation interventions. This may, among other approaches, involve the increased industrial employment of state-of-the-art material management, and deployment of high-level technical capacity; and the development of the policy framework aimed at revitalising emphasis on material less use and more recycling. *Technology Substitution* comprises the replacement of more out-of-date industrial energy conversion technologies and related equipment with more advanced environmentally friendly and economically sound innovations. Significant climate mitigation implications of this measure rests mainly with the need to incorporate, in a sustainable economic development planning, pertinent industrial development policies for climate change. As with the case for supply sector – discussed in *sub-section 2.8.1* above –, *Fuel Switching* provides also an important carbon emissions mitigation option for the industrial sector: it (*fuel switching*) would mainly be concerned with shifting away from heavy dependence on high carbon content energy sources (e.g. coal) towards cleaner (or low carbon), environmentally sustainable sources (such as natural gas). This option is most likely to contribute to the economic potential of newly designed (or imported), environmentally sensitive industrial fuel-use technologies, which would be expected to maximise exiting industrial opportunities for substantial carbon emissions reduction not only within the industry sector, but also across the entire energy demand sub-sectors.

2.9.2 Buildings (Commercial & Residential) Energy Options & Measures

The buildings sub-sector, which comprises both the commercial/institutional buildings and residential dwellings, provides the second largest source of GHG emissions in the demand sector. For estimates, the buildings sector was '...responsible for one-third of the global energy [use] and associated carbon emissions ...' (IPCC 1996: 13, 2001b: 24). Attributable to the North, as the source further indicates, this amounted to '...about 75% global buildings energy use ...', which resulted in 1.9 Gt (i.e. gigatonne) of carbon emission. It is estimated that the technical potential of the combination of both current technologies and future related innovations would lead to energy-related CO_2 emissions levels being reduced down to 27% in 2010 (from 31% emissions levels linked to 1995) (IPCC 2001b: 24). Energy service improvement measures and other climate change mitigation-related innovations in the buildings (or commercial and residential) sub-sector would promote a widened use of energy efficient appliances in view to consolidating current housing development measures bolstered for enhancing improvements in the building technology.

Improved Housing Development Technology offers a climate mitigation option through which it would be expected to realise an enhanced efficient energy performance housing that would lead significant residential health as well as other related environmental benefits. A crucial aspect to such an innovative housing approach would be to promote a widened application of efficient housing measures, which might include: passive-solar housing designs (e.g. appropriate building orientation), introduction of appropriate housing planning and regulatory policy instruments. Other improved housing development measure may include application of '...integrated building design, the application of photovoltaic systems' (IPCC 2001b: 24) as well as the development of efficient housing modelling for medium-to-high standard dwellings. *Emphasis on Use of Efficient Energy Performance Household Appliances* offers one other housing development approach, which is also expected to bear significant climate mitigation implications; this option is aimed at mainstreaming affordable energy efficient

lighting as well as space heating services both in residential dwellings and commercial/institutional buildings. For the purpose of climate change with specific reference to the household sector, this measure would employ greater use of renewable energy-based household technologies, which mostly include, among others, Solar Home System (SHS), Solar Water Heater (SWH) as well as Compact Florescent Light (CFL) technologies. Anecdotal insight suggests that the buildings sector would achieve most of its climate mitigation benefits from energy savings through use of state-of-the-art commercial building equipment. A few such energy-efficient technologies considered to be key in a drive towards this end, include air- and ground-based electrical heat pumps, air-source heat pump water heaters; and efficient air conditioners, lighting appliances and related control systems; and efficient household-based electronic devices. As with in industry sub-sectors, *Fuel Switching* would also be of paramount importance to (residential) buildings sector: it will be concerned basically with switching between household fuels, for instance, shifting away from paraffin and charcoal use, respectively, to gas and kerosene (Kituyi 2000: 21) for major household services (e.g. cooking lighting, and both interior and water heating). This option would, in addition to providing both socially and technical acceptable technological innovations, foster economically accessible opportunities with an overriding objective of reversing urban and rural poverty. A further objective would be importantly concerned with improvement in the energy-related household health and safety for both the urban and rural beneficiaries.

2.9.3 Transport Energy Options & Measures

Improved Vehicle Fuel-Consumption Efficiency would provide an important climate mitigation measure, especially, in the face of rapidly increasing trends in the demand for transport (the road-based transport sector in particular). These trends have, to a relatively significant extent, implied an increased use in transport fuels. As almost all of the energy procured in the entire transport sub-sector is derived from fossil-based sources (e.g. crude oil resources) – there no widely established application of renewables-based transport fuels yet --, *vehicle fuel efficiency* would provide a crucial measure as an option for curbing transport-

related GHG emissions. For this reason this option would contribute significantly to avoided global GHG emissions linked to the transport component of the entire demand sector. *Fuel Switching* from petrol in light-duty vehicle (LDV's) to alternative sources such natural gas and propane have a significant technical potential to reduce 'full-fuel-cycle' emissions by 30% at the most (IPCC 1995: 4). *Hybrid Gasoline-Electricity Combustion Technology* is currently approaching wide application levels in quite a few countries around the globe, would be aimed at as one of the plausible steps to foster opportunities for more efficient carbon emissions reductions from the sub-sector; therefore playing a very crucial for climate change purposes. Such opportunities would include emissions free transport-fuel combustion technologies such as hydrogen fuel-cells (Europa 2002: website; IPCC 2003: website); and, in interest of greater climate change benefits, it would be crucial to engage continual on unearthing further opportunities to enhance both the technical and market potential of such engine technologies designed to run on energy harnessed from hydrogen resources. However, although the technical potential of these technologies has already proven to be significant relatively in most countries, they are proving to be economically unviable for exploitation in the South; and this trend is likely to continue until the near-to-medium future.

2.10 Land-Use and Land-Use Change Forestry (LULUCF)

Land-Use and Land-Use Change Forestry (LULUCF) promises to be an important area for integrated climate change policy and development planning. It has grown to become one major academic as well as policy focus with the increasing importance of the climate change regime, more so in late years of its development. LULUCF draws its attention as well as a large part of its attraction from contributing, though to a limited extent, a significant share of global CO_2 emissions as regarding the human-induced climate change. Deforestation constitutes a significant source of global CO_2 whereby it is responsible for 20% of non-CO_2 GHG emission (e.g. CH_4 and N_2O) (IPCC 2001b: 34). Agriculture, which

constitutes one of key components of the LULUCF sector, accounts for 4% of the global CO_2 emissions (IPCC 2001b: 34). However, despite the general global dominance of CO_2 emissions over the rest of the GHG's, CH_4 predominates atmospheric pollution linked to the agricultural domain. Climate change response measures for LULUCF will hinge largely around prioritising measures for areas including *Improved (Technical) Agricultural Practices & Management*, and *Increased Forestation & Reforestation Investments*. The crucial part surrounding agricultural sub-sector, which requires much focus for climate chance objectives, is the energy efficiency of the existing agricultural technologies and related institutional infra-structural parameters. The IPCC (2001b: 34) has brought to light that, not so much has been achieved in terms of gains in the improved technological efficiency agricultural practices that emphasis on widely enhanced bio-technological development would be prove very crucial. The main objective for this would be to accelerate positive climate change-related development implications. For this reason, which overrides the fact that they were not (adequately) provided for in the Kyoto Protocol; and despite the general fear that they would result in unsustainable environmental practices, carbon sequestration (or sinks) projects were eventually allowed in the CDM under the 'Bonn Agreement' reached at the second session of COP-6 (or COP-6.5), which was held in Germany, in July, 2001 (Winkler *et al* 2001: 5). Hence, as the source further indicates, carbon emissions reduction had been perceived, by the developing world country delegations, as a Northern issue.

2.11 The Clean Development Mechanism (CDM): Analytical Consideration

2.11.1 CDM Project Development Cycle

The investments that will be driven by the CDM will have additional steps in the project cycle compared to conventional project investment. The CDM project cycle will include: *Developing Project Pipeline (or Idea)*, *Government Approval*, *Validation*, *Registration*, *Financing & Implementation*, *Monitoring* and, finally,

Verification & Issuance of CER's (Spalding-Fecher 2001: 8; 2002d: 5-12). These project development stages are discussed below.

Developing Project Pipeline (or Idea): This constitutes the earliest step in the development of projects, which involves identification, or conceptualisation, of project idea (Goldblatt 2001: 8). This would usually be followed by the development of the Project Design Document (PDD). The owner of the project (or the project developer) who, under basic CDM conditions would be represented in a partnership involving a Northern investor party (Spalding-Fecher 2001: 7), would lead the formulation of the project (often in line with rules laid by domestic national CDM office). The PDD would serve to provide more like a comprehensive 'statement of intent', detailing relatively all aspects fundamental for setting a point-of-departure for the entire project development. A few of the integral aspects of such a document, would include the proposal of the baseline scenario, the monitoring plan for emissions reduction as well as an outline of *sustainable development* envisages. The PDD would also need to reflect on the financial mechanism for the project (Spalding-Fecher 2001: 7).

Host Country Government Approval: The outset of stage is marked by forwarding of project application (with copies of the PDD), by the project owner), to the host country government for assessment. Under the CDM regime, the government, which will be represented by the DNA, will conduct the approval of proposed projects in accordance with an agreed *guidance document,* containing well-defined rules and guidelines (Goldblatt 2001: 9). Concerned mainly with both the co-ordination and communicating of all matters pertaining to climate change, the DNA, would be administering the national GHG inventory as well as developing and managing the records of all project applications received. Depending on the criteria used, the government would decide on either the approval or disapproval of the of the project application. This will be informed by the relevancy of the contents of the PDD on the basis of the project selection criteria put in place.

Validation: Following project approval by the DNA, the approved project application would then be passed on to the Operational Entity (OE) for validation. The OE is one of CDM's institutional arms whose role would be to independtly evaluate the consistency, or validity, of steps employed by the government for approving the project (Spalding-Fecher 2001: 9). Such an appraisal activity, would be conducted against a number of principle requirements, key of which would pertain to the proximity of government approval with CDM project screening framework; and whether the proposed baseline and monitoring scenario credibly plausible; and whether the project document has embrace and is consistent with relevant Environmental Impact Assessment (EIA) framework's objectives (Spalding-Fecher 2001: 9). Furthermore, validation may look into steps taken in the design of approval framework for proposed projects. To ensure high credibility of the validation processes, it would be crucial that the EB-accredited OE entities do not hold any interest in the projects. This is highly crucial because of the fact that such a scenario might lead to perverse engagement among the involved parties, which, in turn, might eventually undermine the objectiveness of the validation criteria as well as the integrity of the CDM in the public face.

Registration: This stage constitutes the third in the CDM project development cycle. It is necessary because of the fact that just prior to project implementation, the project will first need to be registered. The process will be effected by the OE in consultation with the Executive Board (EB) of the CDM – see *section 2.14* below for more elaboration on CDM institutions. The purpose registration is generally to keep proper control and management of database for all CDM projects. An important aspect of registration, would be that none of the project stakeholders (including the beneficiaries) would hold some reservation about the project and, for this reason, there can be an '…opportunity to call for a review of the proposed [project] registration' (Spalding-Fecher 2001: 9).

Financing & Implementation: At the start of the project, the developers would secure financial sources as well as related planning over a project's productive

life. This will be different across individual projects depending on the project developers' business objectives and the CDM model (or architectural design) agreed upon between the stakeholders (Spalding-Fecher 2001: 9) – these models are discussed below. If project developers secure a prominent financing source as well as sound business plan, it is likely that the project will lead not only to a prosperous business enterprise, but also to a sustainable development endeavour.

Monitoring: Throughout the life cycle of a project, the stakeholders would continually monitor carbon emissions reduction impacts of the project. It would be expected that monitoring would be carried out regularly (i.e. between fixed intervals) through the project's crediting life, which would make this stage the longest stage of the project cycle. The process of monitoring would entail physical measurement of changes as they occur. In addition to the monitoring of carbon emission reductions, *sustainable development* impacts (e.g. job creation and capacity development) would be integral features of monitoring. All the data on the project impacts (either directly or indirectly linked to project implementation) would serve the basis for determining the overall avoided emissions (measured in tonnes). Such GHG emissions reductions will be expressed in terms of CER's as generated by the project. Determining the CER's will be based on a principle of comparing the emissions reduction impacts against a pre-determined reference case (or the baseline), which will have been included in the PDD.

Verification & Issuance of CER's: As with the second project development stage (i.e. *Validation*), *Verification* would be the responsibility of an independent third-party entity (i.e. the OE) (Spalding-Fecher 2001: 10). As the source further indicates, the OE will most likely comprise either legal or auditing professionals (bearing a high profile track record). This will stage would be concerned mainly with post-implementation appraisal of project's sustainable development impacts. The primary objective behind, is the eventual crediting of the both carbon emissions mitigation and *sustainable development* achievements linked to the project. The main role of *Verification* would be to review particularly the integrity

of the project's monitoring report(s). This process would involve an across-the-board review of all the project information including all periodic audits, project documentation as well as on-site inspections and interviews (Baumert *et al* 2000: 5). A resulting report will certify the positive impacts of the project. Such an act would be regarded as a proof of the fact the project has fulfilled one of basic CDM operational principles: that is, *additionality*[2] (to what would have happened anyway in terms of advancing both environmental and development innovations); and, therefore, affirming the project's success on its envisaged climate change as well as *sustainable development* objectives. Following this development, therefore, the EB would issue the CER's to the concerned project ownership; and such an ownership would in most instances be represented by the partnership of a number variously participating stakeholders.

However, issuance of the CER's would have to be preceded by a public review of the project - an activity that will be conducted by the OE in conjunction as well as consultation with the EB. The purpose of this exercise would be mainly to allow the public (or beneficiaries) an access the information about the development benefits linked to the project – this will include related *carbon* impacts. This exercise would be crucial, firstly, for the principle of 'transparency' upon which the CDM is based; and, secondly, for identifying whether there is any sign of public concern from the beneficiaries prior to awarding the CER's to the successful project developers.

2.11.2 CDM Architecture: Models for Investment

The regime, or system, of the CDM will comprise a number of different approaches to carbon investment in terms of the type of project ownership or partnership between variously positioned participating stakeholders. Such investment approaches, or models, would include *Unilateral-*, *Bilateral-*,

[2] *Additionality* would be concerned with the benefits, linked to a project, beyond those that would have been achieved under normal circumstances (or a baseline scenario) – see Meyer 1999.

Multilateral-, *Hybrid-* and *Open-CDM* (Baumert 2000: 3-10). The following sub-sections (or paragraphs) focus closely on each of these models.

Unilateral-CDM: Provision 5(a) of the Kyoto Protocols' Article 12, sets the basis for a unilateral investment arrangement for the CDM. The provision states that CER's would accumulate from projects approved on voluntary grounds '... by each Party involved' (UNFCCC 1998: 16). Generally, this suggests that the host-country government, or a private sector entity from the same country, could be entitled to a unilateral engagement in a CDM activity with the objective of generating the CER's. Under the *Unilateral-CDM* scenario, the developing country-based project developers would be the sole 'project participants' as well as financial supporters for the investment. This arrangement implies that the host country project developers will take on all the risks associated with the project – to be more explicit, they would assume the responsibility for project financing as well as being the sole owners of sales of CER's. Although not any of Northern interactions will be provided for under this model, the host country project owners will eventually sell their gained CER's to the North. A further aspect is that, even though projects would not rely on international support for investment implementation under this model, the terms pertaining to all the stages in CDM project cycle will still need to be adhered to. A distinguishing aspect in this regard will revolve around the ownership of the CER's as well as other carbon revenue-related benefits – all these will be awarded to and hence be under the full shareholding entitlement of the host country developers (Spalding-Fecher 2001: 10). Host country project developers will potentially use the credits acquired for realising extensive revenue for their projects.

Bilateral-CDM: A bilateral CDM architectural design, or model, would allow for North-South co-operation for both the initial project development and the subsequent life-long project implementation. Unlike the arrangement under the unilateral model, *Bilateral-CDM* model, which represents the basic CDM architectural scenario, would provide for additional Northern financial and

technical input towards a host country carbon offset project activity upfront, rather than after issuance of CER's (Yamin 1998: 55). As the reference term for this model might imply, the partnership would be limited to only two country parties. Under a bilateral model, project participants from the two countries would handle the project transactions without much of EB's corporate oversight. Even though, this partnership would still be subject to the CDM's regulatory policies and related policy measures. A crucial feature, will apply not for a bi-lateral CDM arrangement, but for all CDM models, is that, both the DNA (representing the host country government) as well as the EB accredited OE, will be in place to ensure that the system is legitimate and transparent, and that the development interests of the beneficiaries (or the local communities) are fairly served.

Also under the *Bilateral-CDM,* the project stakeholders would have the opportunity of choosing between the two alternative capital investment options, which would include, the *Credit Arrangement Option* and *Equity Investment Model* (Spalding-Fecher 2001: 10). As the source further indicates, under the *Credit Arrangement Option*, Northern country-based investors would acquire the rights to CER's up-front on the basis of an agreement before the project is implemented. Under the alternative capital investment strategy, which is the *Equity Investment Model*, the project developers would, in addition to providing to the project for additional capital requirements (e.g. the *carbon investment*), contribute part of the project's *equity investment* component of the overall project capital. The Northern capital investors would, therefore, be entitled not only to CER's, but also to a share of the financial returns from the project.

Multilateral-CDM (or Portfolio CDM): The essence of a multi-lateral approach to CDM investment is to provide an enabling environment for a portfolio of potential participants to channel investment resources towards a single international fund for the CDM. In this case, potential Southern host governments, or even non-government organisations (NGO's), would suggest and forward an inventory of cost-effective carbon offset opportunities to such an international, multilateral

CDM financial bureaucracy. Similarly, potential Northern CDM investors would channel their investment inputs towards such an international, multi-interest, institutional infrastructure for eligible projects. This arrangement, resembling an international consortium, or a mutual interest fund, would be under both the administrative and policy oversight of the EB. This means that, unlike with the arrangement under the *Bilateral-CDM*, all project transactions entered into would be under the direct control of the international CDM Fund and, therefore, this financial resources institution would oversee the transactional engagements between Northern investor and Southern CDM project participants. The challenge for the *Multilateral-CDM*, especially with reference to the principles behind its management, would be to maintain a balance between protecting both the economically as well as politically weaker parties and formulating the efficient investment policies pertinent to the portfolio CDM Fund such that potential prompt Northern investments are not discouraged. Stringent, monopolistic policies for the portfolio Fund, would tend to turn away potential Northern investors (Baumert *et al* 2000: 5). Based on this insight, it is apparent that a more decentralised multilateral approach would be more sensitive to investment-funding policies (and corporate interests) of a wide range of potential Northern investors. The World Bank-owned Prototype Carbon Fund (PCF) might provide a just practical model of a decentralised *Multilateral-CDM*.

Hybrid-CDM: At this point, this provides the fourth of the five CDM models in the thesis. In contrast to the *Multilateral-CDM*, the *Hybrid-CDM* model focuses more on the diversification of investment channels through which to source carbon investments towards the international CDM fund. The primary purpose of this model is to cultivate an integrated CDM operational system that would involve a set of combined elements of the *Unilateral-*, *Bilateral* as well as *Multilateral-CDM* model (Baumert *et al* 2000: 7). Fundamentally, the aim of a hybrid arrangement would be to provide for a pluralistic (or multi-strategic) CDM investment regime, where different combinations of CDM models would co-exist in the form of a single structure. A diversified CDM investment regime would mobilised an array of

often remote, yet significant, corporate resources not only for promoting, but also to foster a widely enhanced opportunities for of a successful CDM operation.

Open-CDM: As opposed to relatively restrictive arrangements under the models discussed above, the *Open-CDM* would provide a more dynamic system by incorporating these individual models (including the hybrid version of CDM design) under a single umbrella, or an open system. Each of these previous individual models when taken separately, would best suit a limited range of interests for potential CDM host countries and as well as their likely private sector entities (Buamert *et al* 2000: 8), thereby precluding some potential participants from carbon offset activities. Therefore, the advantage of the *Open-CDM* is that it would overcome the limits of access to participation (that might be experience under any of the models discussed above). To this end, an open scenario would forge an enabling environment for any of different combinations of all CDM models (as discussed above) to operate in parallel. This will allow potential participants with different investment and project development capacities to opt for suitable arrangement for CDM investment, which would dovetail with their variously angled, or limited, investment potential for positive economic outcomes.

2.12 The Clean Development Mechanism and Sustainable Development: A General Perspective

As mentioned earlier that the core *sustainable development* attribute of the CDM will entail mobilisation for socio-economic advancements in the developing countries that would host CDM investments. To achieve this goal, guiding policy measures to meet the aspirations of potential host developing nations would have to be put in place. Such a *sustainable development* guideline is to be built around four (4) pillars, or dimensions, of sustainability that include *social*, *environmental*, *economic*, and *technological sustainability* (Spalding-Fecher & Simmonds 1999: 6-7). This entire section elaborates on the *sustainable development* fabric of an envisaged climate change regime and related future implications for the South.

Such future implications would, through a sustainable development policy planning, foster the embracement of the host country development priorities in an integrated policy agenda with a shift in economic patterns from both a socially and environmentally non-benevolent growth path towards a more sustainable culture. In an effort to reflect on the fact that the North-South 'transfer' of development advancements and other related policy innovations would not only be plausible under the CDM, but also be significantly achieved, the thesis highlights on a few key *sustainable development* areas on which the CDM is geared to have a bearing. Also, this includes an elaboration on the nature as well as the level of extent of the CDM's on these development areas (or dimensions).

The Brundlandt Commission defines *sustainable development* as '...development which meets the needs of the present without compromising the ability of the future generations to meet their own needs' (WCED 1987). The fact that there is currently '... no internationally accepted definition of [*sustainable development*]' (Rukato 2001: 1-2) makes the definition less pragmatic. For this reason, the thesis deploys this definition in a re-conceptualised refinement such that it purposefully suits the basic country-level development intents of the CDM. To this end, the thesis discusses potential *sustainable development* indicators and related assessment criteria as nominated on the basis of a host country government's development policy goals. A country-specific approach to prioritising host government's development aspirations would be fundamentally important both for the CDM itself and a climate change activity host nation given the fact that the aspect sovereignty is a seriously sensitive political issue, especially, among Africa countries (Rukato 2001: 1-2).

2.13 Sustainable Development and Impacts Assessment Criteria: A South African Context

An integrated policy process for *sustainable development* is currently being developed in South Africa. This process is based on the already existing

government policy documents. These include the White Paper on Energy Policy, the National Environmental Management Act (NEMA), the Reconstruction & Development Programme (RDP), and the Growth, Environment and Reconstruction (GEAR) programme. In addition, the United Nations Commission on Sustainable Development (UNCSD) has developed a general list of *sustainable development* criteria based on which, host developing country-based development policy makers would formulate their respective *sustainable development* policy frameworks (Davidson & Tyani 2001: 10).

It is important to note that development policies driven by climate change objectives would require emphasis on shifting towards a cleaner production. Since the South Africa economy is based largely on intensive use of fossil fuels, it would mean that having to reduce emissions, most industries (because of evidently unsustainable energy procurement practices throughout the entire energy demand sector, especially the industry transport and buildings sub-sectors) might face the threat of having their current patterns of economic activities being constrained unless they start anticipating institutionalisation of energy efficiency culture as well as a widened application of clean energy sources. From a social perspective, a strikingly noticeable feature of the country's economy is the lack of affordable access to basic energy services (and related local human capacity development) by most of the poor urban and rural sector of the population – a large part of this sector is linked to the previously disadvantaged majority. Despite the government's progressive endeavour to bridge the socio-economic gaps among the poor communities, the development legacy of the past has not fully been addressed. Eskom, South Africa's single largest national power producer; and one of Africa's few global top electricity utilities, provides more than 95% the country's electricity supply (NER 2000: 2). It controls national power generation capacity market with coal supporting 92% (Batidzirai *et al* 1998: 84). The remaining less than 5% of electricity supply comes from both private and municipality generators. However, even with such a large electricity industry, there are communities throughout all the nine provinces of the country that are still without opportunities of access to basic energy services. This gap is

mostly pronounced in the rural sector. Currently, about '... 51.5% of [the country's] rural households... do not have access to electricity ...' (SANCCC 2000: Executive Summary, pp. ix). Kwa-Zulu Natal provides the least electrified province with 49.8% un-electrified households (NER 2000: 18). Occupying the opposite extreme end (of the spectrum of provincial electricity access), is the Western Cape with 20.3% un-electrified households (NER 2000: 18).

At the same time, achieving tangible development outputs with regard to fulfilling the UNFCCC, through modifying global patterns of economic activities (in curbing carbon emissions), would constitute a significant challenge for CDM investments. A prominent part of the challenge would be eased and, therefore, potentially be overcome through definition and subsequent development of appropriately standardised *sustainable development baselines* – a background reference case against which CDM development impacts will be appraised. Too, such an innovative development would provide instrumental bridge with respect to the sustained operational efficient of the CDM in pursuit of its twin objectives (i.e. cost-effective climate mitigation and sustainable development acceleration) for South Africa. A further aspect of baseline scenarios will be to affirm whether the arising benefits linked to the CDM are really characteristically long-term as well as being *additional* to what would have otherwise turned out without a CDM-based project intervention (Meyer 1999: 3). Adding more value to CDM's distinction over its conventional project investment equivalent, this principle (of CDM operation) – the *baseline additionality* – will be concerned not only with the host country development goals, but also with a number of other issues of interest including investment efficiency, emissions reduction and other related economic achievements for the developers. The following paragraphs each discusses one the four major *sustainable development* dimensions including: *Social, Environmental*, *Economic* and *Technological Sustainability*.

Social Sustainability: Social inequity in South Africa is evident. A large part of this legacy, which is still apparent, may be attributed to the previous Apartheid

government under the rule of the then National Party (NP). This provides the primary challenge of the overriding effects poverty for the democratic government established in 1994 with the African National Congress (ANC) assuming power. For this reason, poverty alleviation has always been and would continue to be this government's top priority on its political mandate. Because of potentially substantial synergy between exacerbated local socio-economic uncertainties associated with lingering poverty impacts and the severity of global climate warming, pursuing *sustainable development*-inclined growth path through addressing global climate change concerns would precipitate existing equity development measures aimed leveraging the adaptive capacity of climate change susceptible Southern country economies. Similarly, tackling poverty by reversing the local ecological externalities arising from it, and constraining possible economic causes associated with it, would lead to significant beneficial outcomes for the local environment's ecosystems in terms of, for instance, biodiversity resilience (James & Spalding-Fecher 1999: 3) as well as the improved quality of the local aquatic systems. Generally, social objectives of *sustainable development* would be significantly served if development in local institutional and human capacity building can be substantially accelerated, which it is likely to continue remaining impractical without CDM-channelled development investment support. With a community-fused, participatory development approach to poverty alleviation, the CDM would add to reinforcing existing policy measures geared to bridge the gap in current local technical capacity imbalances and related '... human and institutional... [lags] to operate, manage and maintain clean technologies' (James & Spalding-Fecher 1999: 5).

Environmental Sustainability: The second sustainability dimension of *sustainable development* concerns itself with the integrity of the environment and, therefore, with all the impacts that have an influence on it. Aiming at reduction of local or even sub-regional air pollutants that have direct health impacts and are among a few pre-eminent precursors of the atmospheric *acid rain*, would be to significant benefits of the South African national public. So far *acid rain*, or the sulphur-dominated emissions of atmospheric acidic pollution, has not been a serious

concern for South Africa. Acid pollution, particulate matter, and low level ozone (O_3) are known to have cost many lives in other countries around the world, especially in heavily industrialised country cities. Citing Smith, Reddy *et al* (1996: 39), however, indicates that '... more than 90% exposure [to particulate air pollution] occurs in developing countries...', two-thirds (i.e. two-out-of-three) of which occurring in rural indoor areas. From a climate change objective a proactive action will be import in the face of pre-emptive measures. Aspects relating to safety as well as sustainable energy and material use patterns constitute a few of the most crucial attributes of *environmental sustainability* objectives. The CDM regime would oversee the development of environmentally sound as well as socially uplifting technologies for the local communities. By contributing to the enhancement of energy efficiency measures, the CDM would have positive ancillary environmental impacts, especially, in the areas of water conservation and biodiversity protection. Both embracing and prioritising the *environment management* as one of key parameters of an integrated development policy as well as agenda planning, would be very crucial for South Africa's currently relatively increasing environmental vulnerability. According to Hood (2001: 1), the country has, as of late, been experiencing chronic (and sometimes acute) water shortage levels. Further, the source indicates that country's rich botanical diversity has increasingly been threatened by unusual weather variability with seven (7) of its floral kingdoms being substantially reduced in the medium future due to frequent extreme hot temperatures and prolonged periods of droughts. Adding to the 'weight' of such a likely looming 'dark cloud', which might potentially threaten the generally buoyant health of the country's economy, are empirical indications of the fact that South Africa's agricultural is being undermined by reduced soil fertility as a result of changes in chemical regime of the soil. This effect might lead to a hindered healthy growth of a variety of agricultural crops. All of such effects would get aggravated with impacts of climate change.

Economic Sustainability: Despite the fact that South Africa is one of the leading economies on the continent, the country is, however, still experiencing high levels

of unemployment. While 50% of the population is living under economic conditions below 'poverty line', 37% is without employed (World Factbook 2002). For this reason, the *sustainable development* economic objectives of the CDM would be focused on cultivating diverse community-based market opportunities for local entrepreneurs as well as widening the scope of capacity development relevant for both the increasing growth and development demand for the economy. This would contribute significantly to the government's efforts of increasing the Gross Domestic Product (GDP) growth rate to 6% – this is the target for GEAR. Growth in GDP, would constitute one of fundamental economic objectives of *sustainable development*, would provide one of top range priority criteria for assessing domestic growth and related development innovations linked to CDM projects (Thorne & La Rovere 1999: 24-25). Other economic indicators would include, among others, an improved cost-effectiveness of production (James & Spalding-Fecher 1999: 5); reduction in foreign exchange needs, and in government spending on public services (these would be the measure of the *sustainability of the balance of payments*) (SSN 2001a & b); and, lastly but least, the creation of small business opportunities such the Small, Micro and Medium Enterprises (SMME's) (Thorne & La Rovere 1999: 24).

Technological Sustainability: Within the climate change policy context, the term, "technology", is employed for refers to a range of conceptual areas including the physical equipment employed for a specific development purpose; policies and measures aimed at achieving envisaged sustainable energy end-use patterns (and related environmental performance innovations); and even including human parameters such as cultural values (and related social practices and preferences) needed for an eased incubation and long-term sustenance of a 'transferred' technology. Therefore, *transfer* of foreign technology would be significantly sustainable as well as efficiently effective upon a condition that all these attributes are embraced as integral part of a planned *technology transfer* systematisation and development. For this reason, CDM-supported development project initiatives might lead to *hot air* – contextually meaning: production of outputs devoid of tangible *sustainable development* benefits – if such

development projects can compromise culturally valued amenities and other related social imperatives attached to the beneficiaries. The same (*hot air*) can be true for increased social benefits due to constrained or lack of human technical capacity development input measures, which might prove considerably instrumental in clearing the way for *technological compatibility* in the face of possible hostile cultural encounters from local beneficiaries. Another important indicator for technological sustainability would be an increase in *technological self-reliance* by the local communities, which tends to show significant correlation with an improvement in the sustainable use of natural resources (Thorne & La Rovere 1999: 25).

2.14 CDM Institutional Issues for South Africa

The CDM system comprises several key institutions, which include the *Conference of Parties serving as Meeting of Parties to the Kyoto Protocol* (COP/MOP), the Executive Board (EB), the Operational Entity (OE) as well as the Designated National Authority (DNA). Both the COP/MOP, which is the supreme body of the CDM, and the EB, would constitute international, multilateral bureaucratic bodies within the CDM system. While the COP/MOP would be engaged mainly with functions pertaining to overall policy making, review and oversight (UNFCCC 1998: Article 13), the EB, which is expected to meet more frequently per year, would be charged with carrying out the executive management and policy related regulatory functions for the CDM (e.g. approval of project registration; regulating on the introduction of new methodologies for baselines and monitoring scenarios; and, consulting on as well as serving as the convenor of the issuance of CER's).

Although the OE might need to operate in more than one country, the DNA's operation will generally be limited to national level. The OE, which would comprise auditing professionals accredited by the EB, will be mainly responsible for checking the legitimacy and integrity of key project documents. This will be needed primarily for validation of project design document (PDD) as well as to verify of the results of project monitoring (with respect to both carbon emissions

reduction and *sustainable development* input). The DNA will represent the host country government, and will be responsible for approving projects as well as matters pertaining to both climate change and the CDM. An overall expectation is that the Department of Environmental Affairs and Tourism (or DEAT) as well as Department of Trade & Industry (DTI) will be jointly engaged in the bureaucracy of the DNA for South African in endeavour to pursue national institutionalisation of the CDM. This envisage, however, contrasts the earlier implication highlighted in *section 2.6*, which relates to the fact that DEAT would assumed a sole and leading responsibility for national corporate engagements pertaining to global climate change action (Rukato *et al* 2000: 4). A few of the bases for this had been DEAT's early milestone achievements relating to the development of *sustainable development* framework criteria and to precipitating institutional capacity development in both project and national 'baseline' development.

2.15 Recent CDM Milestones

Determination of regional representation in the EB and subsequent appointment of members to assume office, which took place at the seventh Conference of Parties (or COP-7), in Marrakech, Morocco, marked a few of the key recent milestones in preparing for the entry of the Kyoto Protocol into force. Membership to the EB is based on a proportional representation of all of the UNFCCC's regions with a member and an alternative from each. These regions include Annex I, non-Annex I, Africa, Eastern Europe, Asia, the Alliance of Small Islands States (AOSIS) and the Latin America (Winkler *et al* 2001: 3). The other prominent dimension late trends pertaining to CDM-based climate change regime development relates to recent clarification on the eligibility of LULUCF sector climate change mitigation activities. Project types eligible for the CDM with respect to LULUCF sector of the climate change regime would include only afforestation and reforestation projects. Activities pertaining to preventing deforestation have been precluded for the first commitment period 2008-2012. Further, the EB has approved simplified '... rules allow for the fast-tracking of small-scale projects implementing renewable energy (less than 15 MW) and energy efficiency (less than 15 GWh [i.e. gigawatt-hour]

per year), some of which have potential for delivering sustainable development benefits' (Winkler *et al* 2001: 4). As for nuclear-based projects, these will not be allowed under the CDM.

3. PROSPECTUS TO THE CASE STUDIES

3.1 Introduction: Brief Background and Methodological Approach

A number of South African potential carbon emissions abatement projects in the energy sector have been conceived of their potential for *sustainable development*, and are now being tested for their eligibility for operating under the CDM. The idea for this has been to lead preparations for an enabling environment for CDM investment activities. Proactive development of project pipeline will help put South Africa in an advantageous position once the Kyoto Protocol enters into force.

This chapter introduces the case studies on potential CDM energy projects, and provides a background overview of each of these projects. Before getting into much details of projects' introduction, it is important at this point to highlight that none of these projects are about CDM proposal yet. As part of its methodological approach, the thesis only employs them as examples (or likely case studies) for illustrating the potential that the CDM might have both for carbon-driven investments and *sustainable development.* For this reason, these projects have not yet been approved by the government or finally proposed for the CDM (e.g. Mondi energy efficiency project, Case Study 3, is yet to take place). Nevertheless, they are potentially eligible for the CDM and appropriate for demonstrating how the CDM would fare when, or if, the Kyoto Protocol gets into legal operation. The description of the case studies follows the same pattern for each, which includes: *project title and location*; *project proponents (or sponsorship)*; *project context, purpose and objective*; *technical assumptions*; and *financial assumptions*.

The following case studies are discussed:

i. **Case Study 1:** *Darling Wind Farm Project* – wind-based grid electricity production;

ii. **Case Study 2:** *NUON/RAPS Solar Home System Electrification Project* – solar (photo-voltaic) rural household electrification;

iii. **Case Study 3:** *Mondi-Merebank Industrial Energy Efficiency Project* – improves energy efficiency in paper production; and

iv. **Case Study 4:** *Khayelitsha Household Energy Performance Upgrade* – improves energy efficiency in low-income urban residential sector.

3.1.1 Case Study 1: Darling Grid-Connected Wind Power Generation Project

Note:- The thesis bases the data for financial analysis of this case study on Spalding-Fecher (2002b).

Title & Location: The wind power generation case study is based on a project called the *Darling Wind Power Demonstration Project*. This project is located in a rural area near Darling, which is situated in the Western Cape about 80 km (i.e. kilometres) north of Cape Town (Hodes *et al* 2001: 20). In 1996, the Oelsner Group, which is a local energy and development company, decided to harness the wind energy in this area for production of electricity. This decision was prompted mainly by the significant potential of the wind in this area. This was also supported by findings from pre-feasibility studies, which have affirmed that the wind regime on the Darling farm bears a significant energy potential; and, for this, reason, it was adequate enough to support the production of electricity.

Proponents/Sponsorship: This project would be a collaborative initiative led by a privately owned Independent Power Producer (IPP) company, the Oelsner Group & IBR Ruethlien holding 75% ownership share. The remaining 25% share would be owned by AN Windenergie GmbH (a German-based investment engineering company), the Development Bank of Southern Africa (DBSA) and the Darling municipality (du Mhango & Ntambi 2000: 3).

Context, Purpose & Objective: Despite the fact that wind application for electricity production is now becoming common in many countries around the globe, this technology will be serving as the first wind energy demonstration initiative for South Africa. For this reason, the main objective of the project is to demonstrate the potential to harness the wind's primary energy for generating electricity: this will be an energy production, or procurement activity that is free of GHG emissions. In addition, project developers would raise awareness to both the civil and industrial sector with a view to setting a basis for technical capacity development. This would contribute to enhancing the market potential not only for the wind power, but also for a range of technically feasible and environmentally sound renewable energy technologies.

Technical Assumptions: Initially, this project was planned to be a 600 MW facility. However, financial constraints forced the project to be downsized to a 5 MW facility. Nevertheless, the project would be a two-phase enterprise, which would see the initial as well as the second phase each installing four (i.e. x 4) 1.3 MW generation units (Hodes *et al* 2001: 20). Therefore, this development will, at full capacity, be a 10 MW facility. This facility would have a load factor of 36% with an annual energy output of 31 500 MWh (i.e. megawatt-hour) (Spalding-Fecher 2002a: 2). This output is based on average wind speed of 7 m/s (i.e. meters per second) on the site (du Mhango & Ntambi 2000: 2). The project will be connected to the national electricity grid and, for this reason, will displace emissions linked to Eskom's grid-based power stations – this will serves as a multi-project baseline (or standard emissions benchmark). A few of standard benchmark options have been determined on the basis of three different approaches national baseline development. From project developers' perspectives, and assuming that they would be able to choose the most advantageous baseline (because of its potential to generate most CER's), the second emissions standard (or benchmark), is therefore, use was used in the spreadsheet analysis – see a brief descriptive overview of these baseline options under *methodology* in Chapter 4.3. The project would have an economic life of 25 years

Financial Assumptions: The first phase of the project is estimated to cost a total of R40 million. This takes into account all the capital requirements that the project would need for the initial 5MW facility. Since the thesis focuses on the total 10 MW facility, most of the costs scaled up for the 5 MW plant are adjusted accordingly to equivalent 10 MW financial requirements (Spalding-Fecher 2002a: 3). Table 1 show the costs for the 5 MW investment as well as associated percentage adjustments with respect to the 10 MW investment; and Table 2 shows related technical and economic assumptions

Table 1: Costs Adjustment for the 10 MW Facility Relative to the 5 MW Facility

Items	**Estimated Costs for 5 MW facility**	**Relative Costs for 10 MW facility**
Project planning	R4.5 million	150%
Environmental Impact Assessment	R0.17 million	150%
Technical Documentation	R0.06 million	150%
Roads construction	R0.29 million	200%
Foundations construction	R2.7 million	200%
Equipment (turbines)	R34.2 million	200%
Sundry	R1.07 million	200%
O&M costs per year	R0.65 Million	100%

The sponsors would to contribute 33% *equity investment* to the total capital. A loan would be arranged to complement the total investment capital at a real interest rate of 8% (Eskom 2001). In an effort to secure viable financial returns on the investment, the project developers have proposed an electricity price of 0.38 R/kWh for a financially viable power purchase agreement (PPA). This price level is considerably exorbitant compared to the cost currently charged for the municipalities. However, the National Electricity Regulator (NER) has indicated that the national power utility, Eskom, could rapidly increase its electricity tariffs

in the near future, which would make the price proposed by project developers become more competitive (Hodes *et al* 2001: 22). Estimates of the additional costs for CDM transactions were estimated by Spalding-Fecher (2002a: 5). According to the source, baseline study estimates would amount to R56 000 assuming the project can use exiting results for the baseline study (i.e. using a multi-project baseline); costs of staff time spent for interacting with government during approval process would cost R30 000; and verification cost is estimated at R20 000 per year.

Table 2: Table of Assumptions: Case Study 1 – Wind Power Production

I. Basic Project (or Baseline) Assumptions (i.e. 'without CDM')		
Technical & Economic Assumptions – Costs & Benefits		
Items	*Values*	*Units*
Equity portion of capital	33	%
Dept portion of capital	67	%
Dept cost (real)	8.4	%
Estimated costs for 10 MW plant (relative to 5 MW)		
Project Planning & Impact Assessment	4.8	Rm
Mechanical Preparations (roads & foundations)	3.0	Rm
Turbines (and other equipment)	68.6	Rm
Sundry	2.1	Rm
Interconnections	0.5	Rm
Grid connections	0.2	Rm
Debt/Loan due to investors	53	Rm
Overheads (or O&M)	2.57	Rm/yr
Potential energy output	35 000	MWh/yr
Price of electricity	0.38	KWh/yr
Project's economic life	25	yrs

II. Carbon Offset Project Assumptions: 'with CDM' Component		
Economic Assumptions: Carbon Costs		
Items	*Value*	*Units*
Project development cost – for multi-project benchmark (i.e. without baseline study)	0.06	Rm
Verification Cost	0.02	Rm/yr
Monitoring Cost (for Std baseline scenario)	0	R

3.1.2 Case Study 2: Solar Home Photovoltaic Electrification Project

Title & Location: This project is titled *NUON/RAPS Solar Electrification Off-Grid Concession Project*. NUON is a Dutch-based power utility company with RAPS being a South Africa based rural energy service and advocacy institution. This project will focus mainly on rural communities of Kwa-Zulu Natal Province.

Proponents/Sponsorship: This project is in line with the government's policy priority of uplifting the standard of living of the low-income segment of the population. It is for this reason that this project would receive both the political and financial support from the national government. A further basis is that, the South African national Department of Minerals & Energy (DME) has commissioned both NUON and RAPS to jointly implement this project for which it will it has promised to provide substantial capital subsidy for each housing unit within the concession area.

Context, Purpose & Objective: This project aims to provide affordable access to electricity using solar energy and related services to the rural poor in this region. Being a solar-powered household electrification concession, the project will be a decentralised (i.e. non-grid) renewable energy supply intervention. About 70% of rural households in the region are still without electricity (Hodes *et al* 2001: 6), which shows the backlog of communities that have not been reached through

national mass electrification by Eskom during the past decade. Therefore, this project will offer the opportunity of addressing such a long-standing problem.

Technical Assumptions: The project developers aims at electrifying a total of 50 000 households over the first 5-8 years of the 21-year modelling period for the project. Each household will receive a 50 W peak power SHS unit, which would provide the monthly electricity of 5 kWh. A set of four (4) CFL's will come as part of an overall SHS package per household. In addition to the CFL's, the energy provided by a SHS unit would be adequate to run a low power monochrome television (i.e. *black & white* TV) with a power load of 20 W as well as a 3.6 W radio. Because this project will not be connected to the national grid, its baseline would relate to the displacement of household fuels. However, despite having given the concession for off-grid electrification in remote rural communities, the government's long-term plan is to extend the grid to all remote areas (Spalding-Fecher 2002c: 79). For this reason, the thesis assesses the carbon emissions reduction potential of the project in relation to both the grid and household fuels baseline.

For displacing grid electricity, an intervention for which use of a standard or 'multi-project' baseline scenario would often be plausible, one needs to compare the power output of a SHS for supporting a specific level of household energy services with the grid energy delivered for equivalent energy services levels.

To achieve a realistic comparison, differences in the types of energy services between the two cases need to be understood. Such differences, for instance, relate to the fact that, using a CFL technology requires only 25% of energy consumed by an incandescent bulb for the same level of service. Furthermore in most cases, typical grid-based rural entertainment services are provided with appliance requiring high power load (e.g. 80-100 W for colour TV). As might be evident from an anecdotal insight, *black & white* TV, which is mostly used in non-electrified households, requires relatively substantially low power input. After correcting for the efficiency of the appliances, the rural energy service level that

the SHS delivers with 64 kWh per year, is equivalent to the services supported by grid electricity delivered at a rate of 304 kWh per year.

For displacing household fuels, which would usually require using 'project-specific' baseline scenario, project developers would need to know the share of energy from household fuels that a SHS could displace as well as the services that the fuels can deliver. For lighting, however, equivalent lighting services supported by the SHS would lead to exaggerated values, especially, with particular reference to candle lighting. This is because, as Spalding-Fecher (2002c: 81) indicates, the poor quality of lighting services from candles is such immense that it would require more than 200 candles to achieve the lighting service given by a set of four (4) CFL's. For this reason, candle displacement would lead to a negligible (but not zero) gain in avoided carbon emissions – and this might affect level of level of CER's produced. On the basis of this insight, it will sensible to assume lighting benefits as a contribution to *sustainable development* by the project. For entertainment, energy from dry cells and car batteries supporting equivalent SHS energy service level is 64 kWh per year at the plant. This final delivered energy level represents the product of a daily 3.2 hours of energy use per year and the energy capacity (expressed in kilowatt-hours) of the fuels.

Financial Assumption: The total cost of the project per household will be R3 930. The CFL's would be replaced every 6 years at the cost of R240 for all homes. As for batteries, they would last for up to three years before needing to be replaced at a cost at R340. The government has pledged a subsidy of R3 500 per household, 97% portion of which will be given to the concessionaires (Spalding-Fecher 2002b: 5-6). The project will charge the beneficiaries a monthly flat rate of R51 (or R58 with *Value-Added-Tax* included), which is equivalent to R9.30 per kilowatt-hour. Annual maintenance costs for the project would amount to R60 per year. The baseline study would cost R250 000, in which case a survey would be conducted over 500 households at the cost of R500 per household – this cost no amount (i.e. costs of baseline study = 0) if a standardised, multi-project baseline

is employed. Time of government approval is expected to cost R30 000. Monitoring and verification, respectively, would cost the project R250 000 and R20 000 per year over the project's economic life span (Spalding-Fecher 2002b: 6) – monitoring expenses are high because of requirements of household survey for the project. Both the technical and economic information given above (for the SHS electrification project) is summarised in Table 3.

Table 3: Table of Assumptions & Intermediate Results: Case Study 2 – SHS Electrification

I. General Technical Assumptions			
Household Appliances & Energy levels			
Appliances	Load *(W)*	Use *(hrs/day)*	Energy Efficiency *(%)*
CFL	7	3	75
TV (black & white)	20	3	80
TV (colour)	100	_	_
Radio	3.6	8	_
Household Fuels			
Energy sources		*Energy content*	*Emissions factor*
Paraffin		37 MJ/L	0.02 kg C/MJ
Candles		3.45 MJ/candle	0.02 kg C/MJ
Batteries (car battery)		1.295 MJ/charge	0.1 kg C/MJ
Batteries (PM9)		0.08 MJ	_
II. Basic Project (or Baseline) Assumptions – 'without' CDM			
Technical and Economic Assumptions – Costs			
Items		*Value*	*Units*
Project size		50 000	houses
Project's life		20	yrs
Capital per household		3 930	R/house
Subsidy per household		3 400	R/house
Debt-Equity ratio		50	%
Dept cost		11	%
SHS peak load		50	W
SHS energy output		5	kWh/month

Number of CFL's per SHS	4	bulbs
Technical & Economic Assumptions – Benefits		
Items	*Value*	*Units*
Connection fee	100	R
Electricity tariff (excluding VAT)	51	R/month
Energy services charges	9.1	R/kWh
Energy Service levels: Grid and Fuels Energy Sources		
Intermediate Results for Delivered Grid Energy (Based on Equivalent Fuels Energy Levels)		
***Items** (or Services)*	**Power Load** *(W)*	**Use** *(hrs/day)*	**Energy** *(kWh/yr)*
Lighting (CFL's: x4)	112	3	122.6
Radio	3.6	8	10.5
TV (colour)	100	3	109.5
Total delivered energy	216	_	243
Overall total energy (at busbar)			304
III. Carbon Offset Project Assumptions – 'with CDM' Component			
Technical & Economic Assumptions (Costs)			
Items	*Baseline Scenarios*		
	Standard baseline	*Fuels baseline*	*Units*
Project development	56 000	250 000	R
Monitoring	0	250 000	R/yr
Verification	0	50 000	R/yr
CDM-related Energy Levels			
Items (or Services)	*Load (W)*	*Use (hrs/day)*	*Energy (kWh/yr)*
Lighting (CFL's: x4)	28	3	31
Radio	3.6	8	11
TV (colour)	20	3	22
Total energy delivered	52	_	63
Results: Fuels Displacement (%)			
Fuels	*Paraffin (L/month)*	*Candles (units/month)*	*Car Battery (charges/month)*
Displacement	100%	100%	100%

3.1.3 Case Study 3: Mondi-Merebank Industrial Energy Efficiency Upgrade Project

Note:– As indicated earlier on, in the introductory section of this chapter (i.e. *section 3.1*), this project is not officially proposed. This case study demonstrates the industrial energy efficiency intervention of the CDM drawing on Motivational Report (on CDM feasibility studies) by SouthSouthNorth (2001a). The SouthSouthNorth (SSN) is a network institutional organisation operating in four (4) Southern, or developing world nations including Bangladesh, Brazil, Indonesia and South Africa, where the latter represents the central office.

Title & Location: This case study is based on a 'proposal' for the Mondi-Merebank Industrial Energy Efficiency Upgrade project (SSN 2001a). Merebank is situated south of Durban in an area commonly referred to as South Durban Industrial Area. Mondi *Pulp & Paper* (Pty) Limited will be the host of this project and, therefore, oversee its implementation for the entirety of its economic duration.

Proponents/Sponsorship: This consortium would include Mondi (Pty) Ltd, Jaakko Poyry, and a Scandinavian-based supplier of the equipment for the project. Mondi, being a fully privately owned subsidiary of Anglo American, will be the main stakeholder in the project and, for this reason, be responsible for the overall management of the project. Striving to become one of the world's largest paper suppliers, the company is targeting an annual turnover of R7.3 billion (SSN 2001a: 1). Jaakko Poyry will be more engaged in the co-ordination as well as consulting, while the Scandinavian stakeholders will be concerned particularly with the supply of the new technology required for the project.

Context & Objective: The core business of Mondi is the production of pulp for paper, an activity for which operational functions are done entirely through the mechanical grinding of wood using the Thermal Mechanical Pulping (TMP) technology. This technology's operational process has, however, now become obsolete because it leads to large waste of energy from pulping, which

undermines the economic competitiveness objective of the company. At the same time, highly intensive energy use has contributed to negative local environmental impacts such as air pollution. The objective for upgrading the existing TMP is to improve its performance so as to achieve reduced environmental impacts as well as improving the company's image. The intervention will prioritise on energy efficiency across different stages in the TMP upgrade intervention, which will last for 20 years.

Technical Assumptions: With the TMP Upgrade, the project aims at capturing 224 000 tonnes of wasted steam from production of 140 000 tonnes of pulp per year. To produce 0.5 million tonnes of paper annually, a pulping activity requires 319 500 tonnes of steam. This implies that, with the TMP Upgrade intervention, the on-site powerhouse will only have to produce the balance of 95 500 tonnes of steam. Since 7 tonnes of steam can be produced by burning 1 tonne of coal at Merebank, the plant would be able to save about 32 000 tonnes coal per year. The TMP Upgrade will reduce electricity consumption by 10% from 2.2 MWh to 2 MWh per tonne of pulp. This would also lead to substantial electricity savings per year. Milling (i.e. mechanical pulping) activity is based on electric motors, which draw from 110 MW of power.

Financial Assumption: This intervention would require capital investment for R300 million. The cost of generating steam – that is, the overheads, which includes water used, coal purchases as well as other pulp production-related operational and maintenance charges – would amount to R35.25 per tonne. During the project's life, Mondi will be purchasing electricity at R160/MWh (or R0.16/kWh) from Durban Metro's electricity services department. Part of financial benefits for Mondi linked to the project, would relate to the reduction in the annual cost of ash disposal. Mondi pays R54 for each tonne of ash disposed. The costs pertaining to the monitoring (of carbon emissions reductions) and the verification (of these impacts) are estimated at 3% of the project's initial investment and 0.1% of the annual operational costs, respectively (Spalding-Fecher 2002e: 101).

Table 4 summarises these assumptions in terms of both technical and economic requirements and outputs for the project – i.e. Mondi TMP upgrade.

Table 4: Assumptions & Intermediate Results: Case Study 3 – Industrial Energy Efficiency

Basic project Assumptions ('without CDM')		
Items	*Value*	*Units*
Investment capital	300	Rm
Project's size	20	Yrs
Steam production per tonne of coal	7	tonne/tonne coal
Steam generating (i.e. O&M) costs	35.25	R/tonne steam
Baseline Thermal Mechanical Pulping (TMP)		
Production of pulp per year	140 000	Tonne/yr
Required steam production per year (for the level of pulp production)	319 500	tonne/yr
Baseline energy consumption per tonne of pulp produced	2.2	MWh/tonne
Cost of electricity	0.16	R/kWh
Cost of ash disposal per tonne	54	R/tonne
CO_2 emission rate per tonne of coal burnt	2.0	$kgCO_2$/tonne
CDM Assumptions: Additional costs		
Items	*Value*	*Units*
% CDM investment development costs – relative to the investment capital	1.0	%
% Monitoring & Verification – relative to total Annual O&M costs	0.1	%

3.1.4 Case Study 4: Khayelitsha Housing Energy Performance Upgrade

Title & Location: This project is called *Khayelitsha Low-cost Urban Housing Energy Performance Upgrade* based on Candidate CDM Project report (SouthSouthNorth 2001b). It is will be located in Kuyasa, a low income community situated in Khayelitsha, a few kilometres northeast of the Cape Town Metropolitan centre. Kuyasa is Town 2 of an on-going *greenfield* housing development initiative. This

development is still in the first of its two planned phases. The second phase is expected to commence soon afterwards in Town 3, which would be situated alongside Kuyasa.

Proponents/Sponsorship: This project would be a joint venture between the Cape Town Unicity's Department of Environment, Energy & Development Group (EDG) and SSN. As the primary stakeholder, the municipal authority would be more concerned with both the local environmental and social attributes of the project, while EDG and SSN would oversee the core project development and implementation as well as other related technical needs pertaining to the CDM.

Context & Objective: The status quo regarding South Africa's socio-economic development bears a distinctive historical characteristic with particular reference to the national energy domain. The most noticeable feature is the divide in services and income between the affluent and the poor particularly in relation to energy. The energy divide between the two groups is underlined by the fact that the low-income population segment has limited basic energy services. To bridge this gap, policy makers must devise measures to reduce the barriers to accessing affordable energy services and end-use technologies to institutionalise an enhanced energy efficiency culture as well as promoting other clean energy related capacity and development measures among the low-income population. This project will provide an opportunity for contributing to overcoming such a massive challenge as facing South Africa. Towards realising this objective, the project would provide of environmentally sustainable energy services in a low cost urban housing development.

Technical Assumptions: As indicated above, this project will be integrated into greenfield housing development drive to improve housing standards for the low-income residential sector. Driven by CDM objectives, the project would deliver efficient thermal performance housing measures and improved appliances to a

total of 2 309 households. For baseline purposes, it is estimated that households within the area of the project currently have a pre-paid meter for one plug point, which supports a 75 W light bulb that used for 3.2 hours per day. The houses would have no insulation or ceiling and a single-layered iron roof leads to very poor thermal performance. Each household has one cold-water tap with a basin in one and a toilet. The two rooms are separated by a partition. Given these baseline conditions, it is estimates that each household would reach energy consumption of about 390 kWh per year for space heating. The project will be modelled over 21 years, during which period the intervention will engage the following three areas:

i. A pair of CFL's with the power output of 19 W – such an efficient end-use lighting technology requires 75% less energy relative to its conventional lighting counterpart, a 75 W incandescent bulb. An additional advantage with the CFL technology is that it can last for much longer up to 8 000 hours (i.e. 7 years) – an incandescent light can live for only 1000 hours (which is equivalent to 9 months);

ii. Supplying and fitting an insulated ceiling, which would be expected to reduce the baseline space heating energy consumption by 50%;

iii. Supplying a SWH, which would use a back up of grid electricity and would save 60% of electricity normally used by an electric hot-water tank (or geyser). This would come with a fitting for one shower and a tap.

Financial Assumption: On top of the cost of a house, the project intervention would cost R3 882 per housing unit. All three areas of project intervention would have higher initial costs compared to the baseline scenario. For instance, installation of a SWH would cost about of R3 500 versus R1 000 for electric hot-water tank. About R54 would be charged for CFL's as opposed to R3.6 for an incandescent light bulb. As for space heating, the installation of insulated ceiling would cost an additional R1 376 per household. CDM-related costs to the project (for instance, project design document and approval, monitoring and verification) would be in the range of 10% of the project's total investment budget (Sathaye

cited by Spalding-Fecher 2002e: 101). All these technical and economic data are tabulated below – in Table 5.

Table 5: Assumptions and Intermediate Results: Case Study 4 – Efficient Energy Performance Housing

I. Baseline: General Technical Information and Economic Assumptions		
Items	*Values*	*Units*
Lighting use rate	3.2	hrs/day
CFL's life span	8 000	hrs
Incandescent bulb's life span	1 000	hrs
Price of incandescent bulb	3.6	R
Ann replacement cost of incandescent bulb	3.6	R/yr
Electricity cost per household *(source: NER 2000)*	0.26	R/kWh
Annual maintenance cost geyser (relative to the capital)	8	%
Energy required per shower (i.e. for heating 100 litres of water)	12.6	MJ/shower
Energy conversion factor	3.6	MJ/kWh
Number of showers per day	3	Shower/ day
Cost of space heating (no installation input)	0	R
Costs of Electric hot-water tank (installation)	1 000	R
Energy efficiency of electric hot-water tank	70	%
II. Project Investment 'Without CDM' Component		
Intermediate Results: Technical Assumptions and Costs per Household		
Items	*Values*	*Units*
Capital per household	4930	R
Project's economic life span	20	yrs
Project's size	2 309	housing units
CFL's load (x2)	0.038	kW
Cost of space heating (ceiling & insulating technologies installed)	1 376	R
Cost of SWH	3 500	R

Energy consumption per day: water eating	37.8	MJ/day
Technical assumptions		
Annual SWH maintenance cost (relative to the capital)	5	%
Energy efficiency of SWH	70	%
CFL's life expectancy (at daily use rate of 3.2 hrs)	7	yrs
Total cost of CFL's (x2) *(source: SSN 2001)*	108	R
III. Project with CDM: Investment Assumptions		
Items	*Values*	*Units*
Project design development – (relative to investment capital) (source: *Spalding-Fecher 2002e*)	3	%
Monitoring & Verification – (relative to project's annual overall expenditures) (source: *Spalding-Fecher 2002e*)	0.5	%

4. FINANCIAL ANALYSIS OF THE CASE STUDIES

4.1 Introduction

If appropriately managed, and due to its two distinctive investment attributes, which include emphasis on the cost-effectiveness of the project (for the investor) and an additional financial input, or *carbon investment* (for the project host party), the CDM would attract a range of development-focused market investments to the South. This would, nevertheless, depend on how the current global markets would respond to the corporate dimension of the CDM. This chapter provides an analysis of CDM impacts on the financial performance of the four energy case studies. The thesis conducts the financial analysis in a way to reflect the perspective of the investors or project developers for the case studies.

4.2 Methodological Approach

The interest of the thesis in the financial output of the case studies relates to the view (or hypothesis) that the case studies' financial performance would improve with the introduction of *carbon investments* to their overall basic project investments. The objective here has been for thesis to establish whether the projects would be economically to the potential investors (attractive as result of incorporating the CDM).

In accomplishing this, this thesis employed the Excel spreadsheet for the analysis. This includes assessment of two different accounting tools: the Net Present Value (NPV) and the Internal Rate of Return (IRR). The NPV represents the 'discount rate' (used for analysis) and the financial value of all the future annual cashflows (i.e. costs and benefits) of a project over its entire economic life discounted (or brought forward) to the present (Spalding-Fecher 2001: 33). The IRR is closely related to the NPV in a sense that the IRR represent a discount rate when net cashflow value of costs is equal to the net related value of benefits – in a nutshell,

the IRR is the same as the NPV = 0. Because the IRR compares directly to the '... cost of capital for the investor, or any other benchmark rate that the company targets' (Spalding-Fecher 2001: 33), it proves purposely useful for use given the purpose the thesis. This target benchmark, which is often referred to as the *hurdle rate*[3], provides the basis for determining the extent of a project's attractiveness; and also provides for the idea of how such an economic status change with the influence of additional *carbon investment* under the CDM. The thesis adopted this procedure and principles as part of its methodological approach to the case studies. This next section (i.e. *section 4.3)* presents general technical and economic assumptions as well as results of financial analysis for the case studies, while *section 4.4* will be providing an overall summary of the entire financial analysis (including the results of the sensitivity analysis).

4.3 General Assumptions and Financial Analysis Results for the Case Studies

Despite the fact that much has been achieved in terms of rules for operation and institutional policies for the CDM, the price of CER's has not finally been agreed upon yet. However, the literature suggests three price levels, which include: US$1, US$3 and US$6 per tonne of CO_2 (Spalding-Fecher 2002a: 4; 2002c: 85). It is assumed that the carbon price will increase by 5% annually for the economic duration of each project. For the purpose of assessing how the projects will respond to different price regimes, the thesis conducts sensitivity analysis on these price levels and compares the resulting IRR's for each case study. The exchange rate is taken as 8.5 Rand per US dollar – this was the rate in 2001, the year for which all the data and costs are given.

Standard baseline options (or national emissions factors) have been determined on the basis of three different approaches or categories of energy consideration.

[3] The *hurdle rate* refers to a targeted return rate that project developers or investors demands on their investments.

These national baseline emissions benchmarks, as Winkler *et al* (2002) indicate, include:

i. 0.85 $kgCO_2/kWh$ (average for all Eskom's power stations);

ii. 1.08 $kgCO_2/kWh$ (based on the most recently built plants, which, in this case, are final generation units from Majuba power station); and

iii. 0.91 $kgCO_2/kWh$ (weighted average recent and planned additions between 1997-2005)

As highlighted in chapter 3, the thesis assumes that project developers would be able to most advantageous baseline, therefore, opts for the second emissions standard, or benchmark – i.e. 1.08 $kgCO_2/kWh$. This is what the developers would opt for in the interest of their economic objectives since this benchmark has the potential for generating most of he CER's. For final energy delivered for end-use, transmission and distribution (T&D) losses are taken into account, which amount to 20% in terms of rural grid electricity delivery; and 10% in terms of urban electricity delivery. As adopted in COP-7, in Marrakech, Morocco, carbon levy or surcharge, amounting to 2%, will be charged on *share of proceeds* linked to CER's sales from the projects for contribution to an adaptation fund. Table 6 provides a overview summary of general assumptions cutting across all four case studies while Table 7 shows intermediate technical and economic data, as obtained from spreadsheet analysis, for each individual case study

Table 6: General Assumptions Common to All Four Case Studies

Items	***Values***	***Units***
Currency exchange rate	8.5	R/$
1. Price of carbon	1	US$/tonne CO_2
2. Price of carbon	3	US$/tonne CO_2
3. Price of carbon	6	US$/tonne CO_2
Annual carbon price increase rate	5	%
Energy conversion factor	3.7	MJ/kWh
Surcharge on carbon sales	2	%

T&D efficiency (rural)	80	%
T&D efficiency (urban)	89	%
Grid emissions factor (based on Majuba latest capacity additions)	1.08	$kgCO_2/kWh$

Table 7:Table of Intermediate Results for the Case Studies

I. Wind Power Case Study: Intermediate Results			
Total investment capital		82	Rm
Electricity sales per year		13.3	Rm
Baseline emissions per year		42 472	tonne CO_2/yr
Net carbon sales per year		2.12	Rm/yr
II. SHS Electrification Case Study: Intermediate Results			
Total cost (without CDM)		196. 5	Rm
Dept portion of the capital		13.3	Rm
Equity portion of the capital		13.3	Rm
Overheads per system		470	R/SHS/yr
Overheads per unit energy		7.0	R/kWh
Baseline Fuels Energy Levels			
Services & Consumption	*Paraffin (L/month)*	*Candles (units/month)*	*Battery (charges/month)*
Lighting (CFL's: x4)	6.7	15	_
TV & Radio (*both run on battery energy*)	_	_	7.6
Energy consumption per year	2975	621	118
Emissions per unity energy delivered (kg CO_2/MJ)	218	46	44
Total baseline emissions linked to household fuels			307
Annual Carbon Emissions			
Scenarios	*Grid baseline*	*Fuels baseline*	*CDM*
Emissions level	16 406	15 371	0

CER's Generation – Economic Benefits			
	Standard (or grid) baseline	*Fuels (or Proj-specific) baseline*	*Units*
Carbon credits (or CER's)	16 406	15 371	kg CO_2/yr
Carbon sales per year	0.82	0.13	Rm/yr
III. Mondi Industrial Energy Efficiency Case Study: Intermediate Results			
Energy use and ash produced			
Baseline electricity consumption per year		308 000	MWh/yr
Equivalent electricity production per year at Eskom		346 067	MWh/yr
Coal burnt at Merebank per year		45 643	tonne/yr
Coal burnt per year at Eskom		160 468	tonne/yr
Total annual coal burnt		206 111	tonne/yr
Total ash produced at Merebank per year		6 162	tonne/yr
Economic/Financial Costs			
Cost of electricity per year		49.3	Rm/yr
Cost of ash disposal per year		0.3	Rm/yr
Cost of steam (or O&M) per year		11.3	Rm/yr
CO_2 Emissions			
Annual CO_2 emission from Merebank		0.09	Mil tonne CO_2/yr
Annual CO_2 emissions from Eskom (i.e. grid related)		0.4	Mil tonne CO_2/yr
Total annual CO_2 emissions		0.5	Mil tonne CO_2/yr
Project Intervention 'with CDM' Component			
Project Technical & Economic Input			
Items/Entries		*Values*	*Units*
Steam production with TMP-Upgrade per year		95 500	tonne/yr
Coal burnt at Merebank per year		13 643	tonne/yr
Coal savings per year at Merebank (linked to CDM)		32 000	tonne/yr
Coal burnt at Eskom per year		145 880	tonne/yr
Total coal burnt per year		159 523	tonne/yr
% ash reduction at Merebank (relative to reduced coal by weight)		14	%

Ash produced at Merebank per year	1 842	tonne/yr
Total ash avoided per year relative to the baseline	4 320	tonne/yr
Energy consumption per tonne of pulp with the (TMP-Upgrade)	2	MWh/tonne
Electricity consumption per year	280 000	MWh/yr
Cost of electricity per year	44.8	Rm/yr
Cost of ash disposal per year	0.1	Rm/yr
Cost of steam (or O&M) per year	3.4	Rm/yr
CO_2 Emissions		
Annual CO_2 emission from Merebank	0.03	Mil tonne CO_2/yr
Annual CO_2 emissions from Eskom	0.34	Mil tonne CO_2/yr
Total annual CO_2 emissions	0.37	Mil tonne CO_2/yr
CER's Production – Carbon benefits		
Items	*Value*	*Units*
CER's produced per year	0.1	Mil tonne CO_2/yr
CER's sales per year	4.8	Rm/yr
IV. Khayelitsha Efficient Energy Performance housing Case Study: Intermediate Results		
Baseline Project Costs per Household – i.e. without CDM		
Items	*Values*	*Units*
Baseline capital	1 007	R
Incandescent bulb life-expectancy (at the use rate of 3.2 hrs/day)	0.9	yrs
Incandescent bulbs (x2) load	0.15	kW
Total cost of incandescent bulbs	7.2	R
Energy consumption (for water heating) per day	37.8	MJ/day
Maintenance cost of hot-water tank per year	75	R/yr
Total annual cost	79	R/yr
Baseline Project Energy Consumption & Carbon Emissions		
Items	*Values*	*Units*
Space heating per year	391	kWh/yr

Lighting per year	175	kWh/yr
Water heating per year	5 475	kWh/yr
Total energy delivered for end-use	6 041	kWh/yr
Electricity costs	1 510	R/yr
CO_2 emissions (per household) per year	6 524	$kgCO_2/yr$
Project Technical and Economic input: 'with CDM' component		
Maintenance per year (for SWH)	12	R
Space heating	195	kWh/yr
Lighting	44	kWh/yr
Water heating (with SWH)	2 190	kWh/yr
Total (of the energy delivered per SWH)	2 430	kWh/yr
% electricity savings (relative to the baseline)	60	%
Cost of electricity per year	624	R/yr
CO_2 emissions per year (per household)	2 624	kg CO_2/yr
Technical and Economic Benefits – (Energy and Emissions Savings relative to baseline)		
Energy production saved (or avoided)	3 611	KW/yr
Cost of energy saved	928	R/yr
Production of CER's per year	3.9	tonne CO_2/yr
Sales of CER's per year	194.9	R/yr

4.4 Summary of Overall Results: CDM's Influence on Projects

The table 8 below provides the summary of the overall results of the four case studies. The table illustrates CDM's potential for increasing project's economic attractiveness for potential investors and project developers: the CDM enhances the IRR of carbon-driven investments versus conventional basic investments. The table also shows, that under a CDM-based investment scenario, more than one baseline options (i.e. different approaches for displacing conventional, or business-as-usual scenarios) can be employed depending on the nature of the project as well as the availability of relevant data. While baseline options can be broadly categorised into the two baseline alternatives: the project- (or fuels-

specific) and multi-project (or grid-based) baseline, the table reflects the possibility of different mixes between two basic baselines.

Table 8: Summary of Overall Results for Project *with* and *without a CDM* component

I. Projects' IRR without Carbon Investment				
Case Studies	***RAPS/NOUN SHS Electrification***	***Darling Wind Power Production***	***Mondi Industrial Energy Efficiency***	***Kayelitsha Energy Performance housing***
Project's IRR without CDM	25%	9%	-2%	17%

II. Sensitivity Analysis of the Case Studies: CDM Influence Across Different Carbon Prices					
Case Studies	***RAPS/NOUN SHS Electrification***		***Darling Wind Power Production***	***Mondi Industrial Energy Efficiency***	***Kayelitsha Energy Performance Housing***
Baseline Options	*Fuels Baseline*	*Grid Electricity*	*Grid Electricity & Multi-project Baseline*	*Proj-Specific & Grid Elec (i.e. related Emissions)*	*Proj-Specific & Grid Electricity*
1 US$/ tonne CO_2	24%	25%	10%	-1%	19%
2 US$/ tonne CO_2	25%	27%	12%	1%	21%
6 US$/ tonne CO_2	27%	29%	15%	3%	24%

For Case Study 2 – that is, the rural SHS electrification concession –, in addition to employing the multi-project grid-based baseline, the thesis conducted a separate application of the project-specific (or *household fuels*) baseline in which case, equivalent energy service levels from a SHS was determined for comparing associated emissions to those from the household fuels scenario. This case study, proves the CDM proves to be more significantly influential to the project's attractiveness using a multi-project baseline benchmark versus the project-specific scenario. However, relatively low IRR values obtained with the employment of project-specific baseline, justifies a potential emphasis on use of nationally standardised climate mitigation benchmarks for developers, especially, for economic reasons. Case Study 3, Mondi industrial energy efficiency project, has quite a low return even after CDM benefits. This means this investment would be more less attractive to the interests of potential investors, but it would benefit significantly from the carbon revenue. Based on this insight, Mondi presents the perfect example of principle *investment additionality*: which relates to the fact that this project is most unlikely to go ahead without the CDM; and it also appears unlikely even a 'with CDM' component from a project developers' perspective. The negative as well as the low positive IRR values, related to Mondi project, could be explained partially by the fact that while net basic project benefits would be almost 20% of the total project capital over the 20-year period, the CER's would contribute only 30% of the annual total revenue.

5. SUSTAINABLE DEVELOPMENT ASSESSMENT OF CASE STUDIES

5.1 Introduction

Since the advent of democracy in South Africa, the country's government has been pursuing the reversal of socio-economic imbalances brought about by the past system of Apartheid. Despite the recent strides in various development initiatives and related equity indicators, the effects of Apartheid are still widespread in some sections of the population across the country. As discussed in Chapter 2, *sustainable development*, a new paradigm for integrated development policy planning, promises to offer a socially, economically, ecologically as well as technologically integrated platform for improving equity across these fronts.

5.2 Methodology to Assess Sustainable Development for South Africa

In addition to drawing extensively on the general literature on the development of the climate change, the thesis explores a range of potential *sustainable development* assessment criteria for South Africa by basing on the government's currently existing national legislative instruments and policy documents. Development priorities for such a framework of criteria were highlighted in the literature review, in Chapter 2; and comparison of those national policy priorities with the UNCSD's list of 'standard sustainable development' criteria showed that there are fairly significant areas of compatibility for South Africa (in terms of suiting the country's socio-development context) – see Davidson & Tyani (2001: 10). Based on these criteria, the thesis pursues a qualitative assessment of the case studies for their *sustainable development* impacts as driven via the CDM investment regime. The main aim of the thesis is to explore the case studies' potential for potentially immensely advancing development benefits in alignment with the government's policy goals.

Government's long-term objectives of social equity and related capacity development innovations – which may be pertinent to other African economies – would be well served through *technology transfer*, a strategy for maximising climate change related development opportunities, which would be provided for through CDM project investments (Davidson 2002a: 150). The thesis has employed potential criteria that are mostly relevant to the context of South Africa for the individual case studies. Therefore, for each of the four broad *sustainable development* impact dimensions (i.e. social, environmental, economical and technological sustainability), this thesis uses different a range of sub-criteria that cut across case studies' context and development objectives.

5.3 Case Study 1 – Darling Wind Energy Project: Sustainable Development Impacts Assessment

5.3.1 Social Impacts

Social Equity & Employment Generation: In spite of the fact that they lack both the prior exposure to and appropriate capacity for accessing high skills, technical maintenance job related opportunities (potentially arising from the project), the project developers contemplate creating medium- to high-skill support infra-structure for promoting access to employment in the areas such as technical planning, marketing and servicing for the community (Hodes *et al* 2001: 25). This would provide major social and economic benefits to the local beneficiaries. *Capacity Building:* In the long run the project developers will seek to send local residents to Germany or Denmark for training in specific skills for the project while planning related educational training centre locally (Hodes *et al* 2001: 25). For this reason, the project would contribute significantly to the promotion of social equity and constitute a key drive towards this community's socio-economic upliftment, and, therefore accelerating poverty alleviation for the community. In addition, the project will serve as a demonstration exercise, which will be crucial for enhancing its familiarity to the local beneficiaries and promoting the potential for mainstreaming its entry into the domestic market in the country.

5.3.2 Environmental Impacts

The fact that this project will harness wind for power production, means that the production electricity will be free of GHG emissions and local pollutants, thus contributing to the *improved air quality* of the local as well as sub-regional environment. From the point of view of the status quo of the, the on local impacts on the environment, the feasibility study shows that this project will pose little risk of disrupting the life stock in terms of grazing, particularly when constructing roads and installing turbines and other related equipment. Although this project is anticipated to enhance this area's potential for attractive greater eco-tourism market, the project would have negative impacts on local biodiversity (Hodes *et al* 2001: 25). This is partly due to the fact that, being in close proximity to the coastal National Park, the turbines would interfere with paths of some rare birds species, which are resident to the Park. The potential problem of reduced *aesthetics* as well as the possible *noise* linked to the operation of the turbines could constitutes negative impacts on part of the residents staying close to the turbine field.

5.3.3 Economic Impacts

Creation of renewable energy market: This project expects to impact on the country's economy by contributing to the creation of local markets for renewable energy technologies as well as related energy services. In an attempt to enhance its potential for both incubation and replication in the country, the technology demonstration objective of the project, would help fostering the creation of market of wind technology, and, therefore, expands the opportunity of streamlining the establishment of entire renewable energy technologies in the country's economy. *Cost Effectiveness (linked to saving of losses on power supply distribution):* In addition to contributing to the country's national power generation capacity, this project would reduce power losses from long-distance transmission – i.e. from the far northern parts to the south-most part of the country (e.g. in Cape Town) – by decentralising the source of national electricity supply even if only with small amount of capacity. This (long-distance transmission) relates to the fact that most of Eskom's power stations are

concentrated in the Mpumalanga/Gauteng region in the north-eastern part of the country. Establishing local manufacture of wind power technology equipment, which forms part of the project developers' core project development agenda (Hodes *et al* 2001: 25), would be important for the country's economy in terms of *GDP Growth*. However, this may not be plausible in the short run given that the country is still in the stage of economic development (i.e. not fully economically developed). According to the source, at least fifty (50) turbines will need to be imported per year for having renewable energy industry significantly established locally. For this reason, the project developers will be importing the wind technology equipment from the overseas market, which, however, will impact negatively on the *balance of payments*.

5.3.4 Technological Impacts

Technology Transfer and Demonstration: This project would provide an important step for marketing the biodiversity security, environmental integrity and social upliftment related to wind power-based *technology transfer*. One of the technological successes of this project will be attributable to its contribution to the 'transfer' of capacity development and technological 'know-how' for the local communities and other potential sectoral beneficiaries across the country.

5.4 Case Study 2 – The Solar Electrification Project: Sustainable Development Impacts Assessment

5.4.1 Social Impacts

Poverty Alleviation: In addition to providing the immediate, core social benefit of access to improved energy services, this project promises a number of community infra-structural amenities and related economic development opportunities. In delivering improvements in the living conditions of the local rural poor, the project aims high at the creation of rural energy stores, more importantly, which will be owned by the local residents (Hodes *et al* 2001: 20). Beyond these prospects, the

proposed energy stores would serve the basis to further social development, which would include providing a 'one-stop' venue for promoting newly transferred, or delivered, cost effective electrical (and household fuels) technologies; and supporting local infra-structures for public education and training in household energy efficiency, efficient use and maintenance such social and technological innovations. As a few of previous rural electrification initiatives might have hardly succeeded, the main focus of the project with such basic socio-economic infra-structural services support will much be concerned with guaranteeing energy poverty alleviation as well as streamlining dissemination of affordable renewable energy technologies across rural residential sector. *Employment Generation:* One other crucial aspect related to the project's overall package of social objective concerns amassing significant employment opportunities for the beneficiaries from public-oriented participatory approach to this rural electrification venture (Hodes *et al* 2001: 20). *Technological Compatibility:* Because this project would encourage greater community involvement in its implementation, ensuring *technological compatibility* of newly installed innovation with the beneficiaries' cultural values and inherent social preferences would be key to not only to the success of this project, but to local capacity self-reliance and human development.

5.4.2 Environmental Impacts

Contribution to Improved Local Environmental Quality: Despite the fact that it would be unlikely for the use of wood energy source in the community to be displaced, the project would generally contribute to improving both in- and out-door air quality through lessening heavy household dependence on energy sources including paraffin and other household fuels. This would have profound health benefits for the residents as they would be exposed to relatively far less health risk. *Contribution to Improved Household Safety:* Improvement in energy-related household safety will be part of core environmental sustainability objectives for the project. This would most likely be achievable through displacement of high risk residential energy activities (especially in areas where children are frequent and abundant). Anecdotal daily experience reflects that

most unsafe residential energy-related activities include candle and paraffin burning mostly for lighting; and for cooking and heating, respectively – see Paraffin Safety Association of South Africa (PASASA) (2003: website) for statistical insight on household energy incidents in the country.

5.4.3 Economic Impacts

Impacts on the Balance of Payments: Reduction in the government's expenditure on foreign economic exchange would constitute positive impacts with regard to *balance of payment*. Achieving this prospect may not be plausible in the short-term as all of the SHS units will be imported from overseas markets – this will result in a negative impact in terms of the economic sustainability for the government. *Cost Effectiveness:* Besides the advantage that all the upfront costs of the intervention due to the beneficiaries will be covered through government housing development subsidy, related on-going costs will make this intervention relative more expensive and, therefore, less cost effective. However, the national government's Depart of Minerals and Energy has indicated a further support of monthly R40 subsidy (DME 2003) to the rural household beneficiaries so that the SHS intervention becomes more affordable for the beneficiaries – this will, however, impact negatively on the government's national expenditure savings. Nevertheless, depending on how much the beneficiaries will have paid before the intervention, this (monthly subsidy) might still have limited impacts in as far as making the service fees more cheaper would be concerned.

5.4.4 Technological Impacts

Technological Self-reliance: Despite the fact that the PV technologies that the project will introduce through this electrification drive are assembled locally, and that local community members would still not use fuels from out the community, technical measures for capacity building in both maintenance and management these technologies will be an important 'technological sustainability' input for in terms of the *technological self-reliance* attribute of the project for the local community.

5.5 Case Study 3 – Industrial Energy Efficiency Project: Sustainable Development Impacts Assessment

5.5.1 Social Impacts

Employment Generation: Due to its high technical nature, this project would lead to employment opportunities that will mostly require high-level technical skills for both its initial development implementation (e.g. equipment installation) and post-project technology maintenance and related resources management. For this reason, this industrial project intervention will contribute less significantly to under- as well as semi-skilled labour employment opportunities for the beneficiaries and for other neighbouring local communities in the surrounding areas.

5.5.2 Environmental Impacts

Reduction in Carbon and Local Pollutants Emission: The core 'environmental sustainability' potential of this project relates much to improvement in the air quality of the surrounding local areas. By contributing to reduction in wasteful industrial electricity and coal use, the project will impact significantly on both reduced GHG emission and other local energy-related air pollution. *Contribution to Improved Health:* Poor air quality, which has led to continuing atmospheric quality deterioration at Merebank (and surrounding localities), has noticeably had negative impacts on the health of these communities. Therefore, improvement in the health profile of the residents in these communities due to the project's intervention, will constitute an immeasurably high-level environmental sustainability' benefit for the inhabitants. *Contribution to Reduction in Road Wear:* Because this project would contribute to reduced coal consumption following the installation of the upgraded TMP at the plant, there would be less 'heavy-duty vehicle' (HDV) road transportation for ash disposal, thus, reducing the wearing off of high ways; and, furthermore, reduced steam production.

5.5.3 Economic Impacts

Savings on Public Expenditure: Reduction in the number of hospital cases due improved health of the local communities, would add to 'savings on public expenditures'. *Contribution to Industrial Competitiveness:* This project has the potential for contributing to the *cost effectiveness* of the plant's corporate activities, which would render it (i.e. this plant) to be more competitive in international 'pulp and paper' markets. *Impacts on the Balance of Payments:* This technological innovation, with which the project will aim at the displacement of the currently lingering energy inefficiency linked to existing TMP technology, will be imported from overseas suppliers. Therefore, this will suggests additional spending on 'foreign currency exchange' for the government. For this reason, the project would impact negatively on the *balance of payments*. Transferred technical capacity and related management expertise, along with this energy innovative industrial technology, would be key to prompt incubation as well as dissemination of this technology. Too, this would provide for an adequate technical support for clearing the way for enhanced entry into domestic industrial market of this technology and thereby enhancing the potential for *GDP Growth*.

5.5.4 Technological Impacts

Technological Self-reliance: Since the technology for this intervention will be imported, which, therefore, suggests it has a minimal exposure (of application) to a relatively wide range of domestic industrial demand, imparting *technological self-reliance* will not only be crucial to both reduced coal use and the burden on electrical and road infra-structure (SSN 2001a: 5), but also to the life-long sustenance and technological viability of the project; and even the project's economic life.

5.6 Case Study 4 – Khayelitsha Efficient Energy Performance housing: Sustainable Development Impacts Assessment

5.6.1 Social Impacts

Energy Poverty Alleviation: With the delivery of enhanced energy renewable based social services the poor, this project is expects to contribute significantly to the alleviation of energy poverty in the low-income urban residential sector. Owing to this prospect, the community of beneficiaries would be relieved of the burden of daily energy purchase and, therefore, be able to direct all their monthly savings towards other commodities and social amenities such as health, education and other economic needs (SSN 2001b: 5). Contribution to basic institutional and integrated development policy planning infra-structure for widening rural/urban access to environmentally sound household energy services, would by itself promote policy measures on shift in unsustainable growth practices from energy intensive to energy sensitive development. Such a development path would add value to stimulating *Public Education on Energy Efficiency and Conservation; Social and Environmental Integrity; and Awareness Measures on related Climate Change-related Development Imperatives:* To this end, this project, which is on energy conservation-based housing initiative, contemplates providing public education on efficient household energy use and related climate change-linked *sustainable development* innovations that would arise from such a measure. This would lead to awareness of more efficient household appliances and high techno-economic potential, clean energy resources, which might, therefore, help forging markets to a range of renewable technologies locally. *Employment Generation:* The resulting employment opportunities from this project will come with a number of ancillary social benefits including capacity building not only for local community beneficiaries, but also for the proposed local sub-contractors who would be expected to play an equitable active role in the installation of energy efficient housing technologies as well as promoting the socio-economic benefits of emphasised use of efficient household energy appliances. Core opportunities for employment for the community linked to the project will be arise mainly from areas including installation, maintenance and domestic manufacturing (of SWH's

as well as insulating building material and ceiling (SSN 2001b: 5). *Contribution to technological compatibility with indigenous social preferences:* All three areas of intervention (viz. efficient lighting, solar space and water heating) expect to be compatible with social preferences of the beneficiaries in terms of energy end-use practices from the standpoint of technological sustainability.

5.6.2 Environmental Impacts

Indoor Air Quality Improvement: By reducing the need for space heating with polluting fuels, the project intervention will *improve the indoor air quality* for the beneficiaries in the concession area. The project developers aim at achieving this through forging the culture of 'high energy end use efficiency' with respect to indoor thermal (or space heating) activities, which would indoor emissions intensity from narrowed multiple household fuel sources (mostly employed for cooking and warming purposes). *Improved Health Conditions of the Residents:* Displacement of paraffin, coal (and wood) burning through a shift towards renewable energy-based appliances by beneficiaries, would be crucial for minimising potential health encounters such as CO_2 poisoning and other respiratory tract related conditions (with particular reference to *pulmonary pneumonia*) (SSN 2001b: 5). Other impacts for 'environmental sustainability' linked to the project, would relate to improvement in household safety as pertaining to efficient energy end use patterns in the households; and to this end, the intervention would set the bases for designing measures to prevent frequent incidents of fire and other related costs of property.

5.6.3 Economic Impacts

Contribution to Economic (or GDP) Growth: On top of housing development being subsidised by the national government's Department of Housing, this intervention would add significant economic benefits to socio-economic development, thereby impacting positively on the country's macro-economic growth (SSN 2001b: 5), and hence contributing to *Growth in the GDP*. *Impacts on the Balance of Payments:* Although the project will employ locally manufactured equipment (for

the proposed renewable energy-based housing technologies), the CFL's will be imported. Therefore, this effect will have the project impacting negatively to the government's financial budget specifically with respect to the *balance of payments.* However, counter to this effect would be the fact that reduction in paraffin use by the beneficiaries due to the intervention, would lead to reduced local demand for petroleum products, thus enhancing the opportunity for their (i.e. petroleum) exports; this would ultimately, in it turn, contribute significantly to the sustainability of the *balance of payments*. Furthermore, while the project would lead to significant energy cost savings for the beneficiaries, state-of-the-art 'passive solar housing' designs would force reduction in high demand for energy during peak times. This would contribute to lessening the burden of *household energy expenditure*.

5.6.4 Technological Impacts

Technological Self-reliance: The project would support local industries, adapt technologies to local needs and strengthen domestic markets. The exception will be for CFL's, where limited local exposure and the lack of local manufacture would necessitate further support from the project for *technological self-reliance*.

5.7 Summary: Sustainable Development Impacts of the Case Studies

For the thesis, the assessment of the CDM case studies on their *sustainable development* impacts, corroborates the insights into CDM's potential for advancing development in the South, and from an empirical point of view for South Africa. In addition to amassing attraction from potential Northern investors for prompt CDM investment, South African political community has by virtue of instituting the NCCCC shown a politically inspired national preparation for as well as institutionalisation of the climate change regime with a fundamental goal of achieving greater development advancements.

Prominent potential contributions to *sustainable development* advancement, for South African public, linked to the case studies relate to: increase the creation (or generation) of employment opportunities across various sectors; improvement in the local and regional atmospheric air quality (for greater gains of accompanying public health benefits); enhancement in both technical and market potential of renewable energy sources and related efficient energy end-use technologies; and, which is rather most crucial, increase support for both *technological compatibility with cultural values and social preference;* and *related self-reliance* for the beneficiaries. For all these prospects, the CDM would contribute, potentially, an immeasurable difference, potentially, not only for South Africa; but also for Southern 'neighbouring' countries sharing common development aspirations for sustainable and equitable socio-economic development. Policy emphasis on affordable *renewables*-based energy services for alleviating rural energy poverty, as linked to CDM opportunities, would increase the country's national adaptation potential (to regional environmental impacts linked to the global climate change) in addition to increased reinforcement of related rural/urban human development upliftment measures.

However, there are also equally key challenges and related implications in face of policy and institutional implementation of climate change in general, and the CDM in particular. From a policy perspective, the challenges relate to current, limited infra-structural capacity with respect to economic, technological and institutional parameter, would constrain efforts aimed at clearing the way for streamlining development-oriented *technology transfer* from the North to the South African shores. Too, such an infra-structural constrain would have a significant bearing on *suppressed public demand (and incentives)* for increased development opportunities; and, therefore, further putting a ceiling on currently poor levels of development for a fairly significant part of the population – for further insight on the 'suppressed demand for the CDM', see Winkler and Thorne (2002: 413-429). Such a state of affairs would otherwise undermine the potential of the CDM to accelerate the advancement the government's traditionally anticipated (sustainable) development goals. For instance, on the basis of the case studies,

and in terms the framework criteria discussed in the earlier chapters of the thesis, the CDM would impact negatively the government's national budget due to the need to import technologies (and expertise) for projects from overseas markets – this will put a constrain on the national *balance of payments*.

From a technical and institutional perspective, capacity development challenges would to both maintenance and management of 'transferred' technologies; and the administration of corporate and policy-based CDM institutions. One of more unique challenges for the CDM would entail incorporating a new policy paradigm into an anticipated integrated development framework planning in steps to spearhead shift towards a sustainable growth path – see Davidson (2002b: 288). More importantly this should be carried out within the context of the UNFCCC's ultimate socio-environmental objective of climate change. At the same time installed development innovations should be cost-effective, generally, on the part of the beneficiaries: affordable, new energy technologies and services would constitute a crucial factor, more importantly, with regard to whether a project will succeed. Of more crucial importance, would be to put in place measures for safeguarding community-focused participatory approach to CDM project implementation so as to promote suitably relevant semi-skilled employment opportunities for local beneficiaries. However, for another challenging implication relating to CDM institutional policy management, although supporting for greater open-ended employment of semi-skilled labour, especially, for the purpose of reducing a fairly high rate of unemployment in the country, it crucial for the DNA to balance this social prospect by equally lavishing attention to other 'pillars' of *sustainable development's*. The table 10 below provides a coherent view, of potential key sustainability indicators (or criteria). Despite the challenges highlighted in the two paragraphs above, it illustrates both the potential depth and breadth of the extent that the CDM – which represents both an international and intra-nationally co-operative development strategy – would, harmoniously with the government's national traditional development priorities, contribute to *sustainable development* for South Africa. The *sustainable development* criteria discussed in the thesis literature review (i.e. Chapter 2), captures the national

development priorities as provided for in an array of already existing national legislative and policy documents.

For illustrative assessment of the case studies' nature of impacts in relation to these criteria, the thesis has methodological employed use of symbols/signs, which include: a *single-, double- and triple-plus* (+, ++, +++) sign; a *minus* (-) sign; a *plus-minus* (+/-) sign; and a *not-applicable* (n/a) sign. The legend explaining these signs is provided in Table 9 below.

Table 9: Legend of Symbols (or Signs) for Sustainability Impacts

Symbol/Sign for Sustainability Impacts	***Description of the nature and the level of sustainability impact for a particular criterion***
+	*"Low level positive contribution to Sustainable Development advancement for criterion in question".*
++	*"Medium level positive contribution to Sustainable Development advancement" for criterion in question".*
+++	*"High level positive contribution to Sustainable Development advancement for criterion in question".*
+/-	*"Mix of both positive contribution to one aspect; and non-additional impact on another aspect Sustainable Development advancement for the same for criterion in question".*
-	*"Negative or non-additional impact for Sustainable Development advancement for criterion in question".*
n/a	*"Criterion in question not applicable to, or relevant for, the particular case study in question".*

Table 10: Qualitative Assessment of Sustainable Development Impacts of the four Case Studies

Case Studies	***Wind Power Generation Project***	***SHS Electrification Project***	***Mondi Energy Efficiency Project***	***Efficient thermal Performance Housing***
Sustainability Indicators	***Social Impacts***			
Contribution to Employment Generation	+	+	+/-	+
Contribution to local capacity & public education	+	++	n/a	++
Contribution to poverty alleviation	+	++	n/a	+++
Local social compatibility of new technologies	+	+	n/a	+
Contribution to social equity	+	++	n/a	+
Sustainability Indicators	***Environmental Impacts***			
Contribution to emissions reduction	+++	+++	+++	+++
Biodiversity impacts	+/-	n/a	n/a	n/a
Contribution to local aesthetics	+/-	n/a	n/a	n/a
Contribution to household energy safety	n/a	++	n/a	+++
Contribution to household (or residential) health	n/a	++	+++	+++
Contribution to reduced road wear	n/a	n/a	+++	n/a

Contribution to sustainable use of natural resources	+	n/a	++	n/a
Sustainability Indicators	***Economic Impacts***			
Creation of local energy market	++	+++	n/a	++
Contribution to GDP growth	+	n/a	+/-	+
Sustainability of the balance of payments	-	-	-	+/-
Cost effectiveness	+++	+	+	+
Contribution to savings on public expenditures	-	-	-	++
Contribution to industrial competitiveness	n/a	n/a	+++	n/a
Contribution to less residential energy costs	n/a	+	n/a	++
Sustainability Indicators	***Technological Impacts***			
Contribution to technology demonstration	+++	++	n/a	+
Contribution to technological self-reliance	++	+	-	+

6. CONCLUSION

In the introduction (i.e. Chapter 1), the thesis reflected on the 1997 adoption of the Kyoto Protocol to the UNFCCC: this international multilateral treaty contains key mechanisms that would foster North-South co-operation to deal with climate change. Core part of the rationale behind the thesis has been to contribute to the development of these ideas and mechanisms outlined in the Kyoto Protocol, from a developing country's perspective. To this end, thesis has investigated the extent to which the Kyoto Protocol, through CDM-linked development funding, would foster a collaborative global climate change regime with objective of advancing *sustainable development*-based social, environmental, economic and technological innovations in the South. In addition, the thesis has explored the potential for the CDM as an economically competitive investment path for potential local investors in addition to their Northern-based counterparts.

From a South African perspective, the main findings of the thesis are that, the country's political as well as socio-economic profile reflects an economy with the potential for attracting significant, *carbon*-driven, development investments from the North. This economy's energy sector offers significant development-related climate change mitigation investment opportunities: an empirical insight into the structure of the economic system of South Africa attributes high levels of national (and even beyond) GHG emissions to the energy supply sector with a particular reference to the electricity production industry. The national government, through climate change the political leadership of the Department of Environmental Affairs & Tourism (DEAT), has taken significant steps in fulfilling its political mandated to provide an enabling environment, and therefore, clearing the way for streamlined introducing of climate change mitigation projects through the CDM-based investment infra-structure. In showcasing the potential of the CDM, on the basis of its two intrinsic twin objectives highlighted in *section 2.5,* the four case studies in the thesis provide examples of both important hypothetical and working scenarios of climate change mitigation investments in local development initiatives

within the context of sustainable development – these include: Wind Power Production (Case Study 1), SHS Rural Electrification (Case Study 2), Industrial Energy Efficiency (Case Study 3) and Efficient Energy Performance Housing (Case Study 4). A further aspect, which is crucially important in as far as the thesis is concerned, is that the case studies also reveals CDM's unique character of being sensitive to the issue of sovereignty, which is especially mostly crucial in most unstable (politically and economically) African nations. This is illustrated by the fact that the case studies prioritise their development interventions in accordance with the government's traditional (or indigenous) policy aspirations and goals

The *Wind Power Generation Project* as well as the *SHS Rural Electrification* case study provides, fairly significantly, demonstration of *technology transfer* – this is a newly geared policy strategy for further enhancing climate change-linked opportunities for CDM investments in the South -- see Davidson (2002c) for a further perspective on of *technology transfer.* In terms of the thesis, all the four case studies would impartially fulfil the objective of *technology transfer* if their interventions including: installation of SWH's, SHS's, CFL's, insulated ceilings, state-of-the-art passive solar housing and industrial energy efficiency have not incorporated local beneficiaries-focused capacity development measures – such a condition would, from a policy planning standpoint, impede the post-project maintenance as well as replication of 'transferred' innovations. This raises a fundamental challenge for both project developers investors and development policy-makers. For this, both public- and private sector-based CDM stakeholders would need to put in place efficient, integrated measures that will oversee North-South 'transfer' of sustainable energy and related development technologies and services for the beneficiaries.

On part of the investors, the case studies has shown that the CDM would play a vital role in enhancing the economic (or financial) attractiveness of carbon-driven investments for local investments. On top of this, as Table 8 illustrates, the results of the financial sensitivity of the case studies also reveals that the different

combinations of 'change (or increase) in the price of carbon' and 'choice of baselines options' would have a significant bearing on the financial output (i.e. IRR values) of investments. This shows how important it would be as to both how international market forces would respond to CDM and which 'baseline development' path potential North-South project stakeholders would adopt for amassing significant *carbon*-based returns on investments.

To conclude, although it appears beyond doubts that the CDM would significantly leverage both the financial as well as *sustainable development* potential of climate change mitigation projects activities, the onus rests with potential CDM host developing countries in creating an enabling environment for efficient *reception* of innovative development opportunities on their shores, delivered from the North through a CDM-supported *technology transfer* system. The institutional capacity necessary for the incubation of such prospects would be immensely incumbent upon both an appropriate environment-industry integrated policy infrastructure and related institutional fabric that would, among others, allow for efficient screening of proposed CDM projects for their eligibility. An enhanced local institutional capacity (e.g. DNA) will also need to institute as well as embracing associated regulatory parameters on CDM technicalities (e.g. *project-specific* and *multi-project baseline* development and project monitoring) into climate change-based development planning for the national integrity of the CDM. An overarching objective for such a policy imperative, would mainly be concerned with the security and further cultivation climate change-triggered energy investment opportunities for greater harvest of socio-economic development benefits linked to the CDM.

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