The CDM guidebook

A RESOURCE FOR CLEAN DEVELOPMENT MECHANISM PROJECT DEVELOPERS IN SOUTHERN AFRICA

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Preface

The *CDM guidebook* is directed at smaller-scale local partners in Clean Development Mechanism (CDM) projects – small businesses, non-governmental organisations and community based organisations – to empower them to put forward project ideas, particularly ideas with a development focus. While large companies generally have the resources and skills to devote to project development, smaller companies and institutions might not.

The *CDM guidebook* bridges the gap between general introductions to the CDM and more technical manuals on project design and greenhouse gas assessment. It covers project design only, not implementation, and it points project developers to detailed resources, where appropriate. On monitoring and verification, for example, it summarises monitoring protocols rather than duplicating their detail. Although this book is not everything a project developer needs to design and report on a CDM project, it does provide a comprehensive overview of how to get there.

The international negotiations on the CDM are in constant flux, as are the needs of project developers. This book should therefore be seen as a work in progress. This first edition will be revised in 2003, to incorporate changes in the international rules and feedback from local project developers.

The *CDM guidebook* is part of the CDM Capacity-Building Project for South Africa, led by the Minerals and Energy Policy Centre in Johannesburg, in collaboration with the Energy and Development Research Centre at the University of Cape Town. The project, funded by the Sustainable Energy Programme of the Shell Foundation for a three-year period, is building project design capacity among a variety of potential CDM project developers in South Africa and also contributing to CDM monitoring capacity. It will share the lessons learned with project developers in SADC countries and elsewhere.

The *Guidebook* is not a South African government document, nor does it claim to represent the views of any government in the region. All omissions and errors are solely the responsibility of the editor and the Energy and Development Research Centre.

Please send your comments and suggestions to Randall Spalding-Fecher (randall@energetic.uct.ac.za) or Robert Maake (robert@mepc.org.za).

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Acronyms used

AIJ	Activities Implemented Jointly
CDM	Clean Development Mechanism
CER	certified emissions reduction
CFL	compact fluorescent lamp
DEAT	Department of Environmental Affairs and Tourism
DSM	demand-side management
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
IRR	internal rate of return
LULUCF	land use, land-use change, and forestry
NCCC	National Committee on Climate Change
NGO	non-governmental organisation
NPV	net present value
UN	United Nations
UNFCCC	United Nationals Framework Convention on Climate Change

1
Introduction to the CDM

In the next few years the industrialised world will bring investment to developing countries specifically to fund environmentally friendly, development-oriented activities which reduce greenhouse gas (GHG) emissions. The 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) resolved to reduce emissions of GHGs such as carbon dioxide and methane on a global scale. One strategy in the Protocol is the Clean Development Mechanism (CDM), which allows industrialised countries with emission reduction commitments to meet part of their commitments by investing in projects in developing countries that reduce GHG emissions. The CDM helps the industrialised countries of the North meet their emissions targets by earning 'credits' for their contribution to the Southern (developing) countries' emissions reductions. For countries in the South, the benefit is that activities that reduce the combustion of fossil fuels (coal, oil, gas, kerosene) or reduce methane emissions (from landfill sites, for example) or improve land-use patterns (such as reforestation) will be able to attract additional investment. This investment, which is directly related to the extent that emissions are reduced, could make such businesses in the South more viable.

The basic requirements of a CDM project are therefore twofold: it has to meet certain measurable environmental criteria, and it has to fit in with the host country's development priorities. The host country benefits from positive environmental improvements like reduced air and water pollution and less land degradation, and from social improvements like the creation of new jobs.

1.1 Why worry about climate change?

The sun's energy falls continuously on the earth. Some of this energy is reflected back into space by the earth's atmosphere, but most of it passes through the atmosphere to warm the earth's surface. The energy from the earth's warming is emitted as infra-red radiation, and is absorbed by water vapour, carbon dioxide, and other naturally occurring GHGs that hold heat in the atmosphere. All life depends on this natural greenhouse effect. If the GHGs did not slow down the release of the infra-red radiation back into space, the earth would be too cold to support life.

Since the industrial revolution, humans have been adding huge quantities of GHGs to those naturally in the atmosphere. As the concentration of these gases increases, they retain more heat energy. This has led to increases in average global temperature – widely known as global warming – and other major changes in the climate system. The Intergovernmental Panel on Climate Change (IPCC), a body of over 3000 leading scientists working in climate change research, stated in its 2001 report that 'there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities'. These changes are happening faster than any purely natural process, and the impacts are expected to be unprecedented. Higher temperatures combined with changes in rainfall and water run-off will profoundly affect both natural and human systems. Some of the changes predicted are reduced food security, loss of life due to catastrophic floods, homelessness, submerging of land due to sea-level rise, and increased deaths from diseases such as malaria. Countries with few resources will have the least capacity to adapt, and are the most vulnerable.

What human activities cause GHG emissions? Carbon dioxide (CO_2) is responsible for 70-72% of the impact (IPPC 2001a), primarily through the burning of fossil fuels but also due to rapid deforestation. Methane (CH_4) is responsible for about 20% of the GHG impact. It is released from fossil fuels (gas pipeline leaks and coal mines), from agriculture (rice and cattle farming), and industry. Nitrous oxide (N_2O) is responsible for 6-7% of the GHG impact, through agricultural fertilisers, industrial processes and burning fossil fuels. The remaining trace gases come from industrial processes. To confront this vast global problem, therefore, we have to change one of the most fundamental activities of industrial economies – the burning of fossil fuels. This means changing many aspects of our lives: transport systems, methods of generating electricity, how efficiently we use energy of all kinds, industrial and agricultural practices. Reducing the emissions of GHGs, or promoting their increased absorption by vegetation, is called mitigation; all CDM projects are mitigation projects.

The international community first acknowledged climate change as an important global issue in 1992, when it adopted the UNFCCC at the Rio de Janeiro Earth Summit. The Convention set targets for industrialised countries to stabilise their emissions, although these were not legally binding. Growing evidence of human influence on climate change and the possible irreversible nature of its impacts led the international community to adopt the Kyoto Protocol in 1997. The Protocol contains legally binding emission targets for the industrialised countries, although widespread concern by industrialised countries over the costs led to the Protocol including a great deal of flexibility on how to meet targets. The time period for targets was stretched from one to five years, and the CDM and other mechanisms were introduced for trading emissions with other countries.

1.2 The rationale for carbon trading

GHGs mix uniformly in the earth's atmosphere. Unlike sulphur dioxide or low-level ozone, carbon dioxide and other GHGs have the same impact on climate everywhere in the world. It does not matter, therefore, where we begin to reduce net emissions. This fact provides the economic justification for international co-operation on climate change projects and project-based emissions trading. International co-operation makes economic sense because emissions reduction in developing countries generally cost less than in industrialised countries. In Figure 1.1, the difference between the marginal reduction cost for the investor (industrialised country) and the host (developing country) is shown by the amount marked 'Surplus'. The host country and investor country can share the surplus so that both benefit.

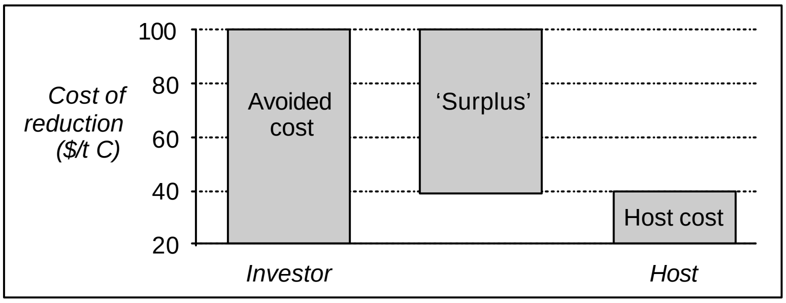


Figure 1.1: Marginal cost of reduction in investor and host country

1.3 What is the CDM?

The Kyoto Protocol includes two project-based mechanisms for international mitigation efforts: the CDM, between an industrialised and a developing country, and Joint Implementation, between two industrialised countries (in this context 'industrialised' or Annex I countries include the countries of Eastern Europe and the former Soviet Union). A CDM project is a development project, driven by market forces, that reduces GHGs. In a CDM project, an investor from an industrialised country supplies capital or technology, based on the future value of certified emission reduction units (CERs), also known as carbon credits, which measure the reduction of GHGs in the developing country. The procedure starts with the industrialised country keeping a regularly updated inventory of its emissions. The country may choose to allocate its national target (set by the Kyoto Protocol) across a number of domestic emitters, in much the same way that resources such as fishing rights or logging rights are allocated. A domestic emitter can meet its allocated target through mitigation activities within the country, or make use of the two Kyoto Protocol project-based flexibility mechanisms. The CDM allows the emitter to invest in a project in a developing country or buy CERs from someone who has invested in such a project. Under the CDM all parties benefit – the host country is assisted in achieving sustainable development, the owner of the project receives financial and technological assistance, and the emitter in the industrialised country receives carbon credits.

Developing countries already have experience in projects relevant to climate change like energy supply, demand side management, fuel switching, and forestry. These projects typically use equity and debt to raise capital, and produce financial returns for the investor (Figure 1.2). CDM projects are different because they include another kind of input – carbon investment. The project generates carbon credits with monetary value. Additional financial resources flow to the project to gain carbon credits (Figure 1.3). This finance is different from equity investments made for financial returns, even if these are made by the same investor.

The project must also generate sustainable development benefits for the developing country as a whole, even if these benefits do not accrue directly to the project developer. While it is not always clear how these benefits are to be measured, they are a fundamental component of CDM projects.

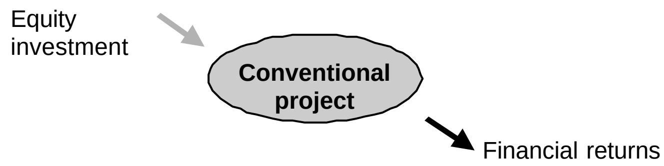


Figure 1.2: Conventional investment project inputs and outputs

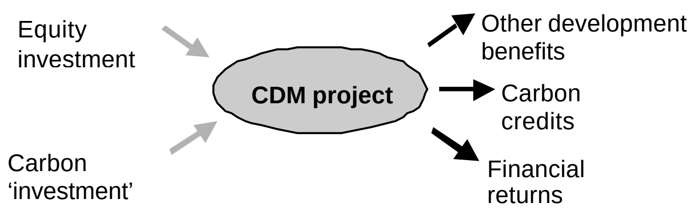


Figure 1.3: CDM project inputs and outputs

1.4 What kinds of projects qualify as CDM?

What projects in South and Southern Africa could attract CDM investments? Table 1.2 indicates a wide range of possibilities.

Table 1.1: Projects that could attract CDM investments

Sector	*Project/activity*
Energy supply	Gas-fired power generation
	Cleaner-coal power generation technology
	Hydro-electricity to replace coal-fired power stations
	Co-generation (biomass or fossil-fuel based)
	Renewable electricity (e.g. wind, photovoltaics, biomass) and other renewable energy (e.g. biogas)
	Switch of synthetic fuel feedstock from coal to gas
	Use of forest and agricultural wastes to generate electricity and heat
Manufacturing	Conversion of boilers from coal to gas

	Industrial energy efficiency
	Structural change to less energy- and emissions -intensive industries
Mining	Industrial energy efficiency
	Reducing methane emissions from coal mines
	Control of coal dump fires
Agriculture and forestry	Afforestation and reforestation (during the first, 2008-2012, commitment period)
	Improved management of natural woodlands (not yet included in the CDM)
	Control of fires (not yet included in the CDM)
Transport and communications	Improved public transport
	Improved urban planning and traffic management
	Improved vehicle efficiency
	Vehicle fuel switching
	Switching from road to rail transport
Residential, commercial and government buildings	Energy-efficient appliances
	Solar water heating
	Fuel switching in households and commercial boilers
	Energy efficient building design
	Energy management

1.5 When can we start?

Most countries expect to ratify the Kyoto Protocol by the end of 2002, and the Protocol itself is likely to come into effect in 2003. CDM projects, if they are approved, may be able to claim credits before this date, even while the institutional structures for the CDM are being set up. By building capacity and starting project development now, countries can improve their chances of building successful CDM projects. Developers in Southern Africa are already beginning to put forward pilot project ideas, and a number of donors are funding feasibility studies. This book is part of the process of getting the CDM off to a good start in Southern Africa.

2
The CDM project cycle

All Clean Development Mechanism projects go through a project cycle. Some steps in this cycle are the same as for any other investment project – such as raising finance and implementing the project. What is different for CDM are the special requirements of qualifying and overseeing the project as a bona fide CDM project. This chapter provides an overview of the steps of the CDM project cycle, some of which are explored in detail in later chapters. We begin with some key concepts: CDM eligibility rules, additionality, and baselines.

2.1 Eligibility

Technology

These criteria are used to eliminate technologies that are considered outside of the CDM. So far, only nuclear power projects have been specifically excluded. Small-scale renewable energy and energy-efficiency projects receive favoured treatment. They will be subject to simpler rules currently being developed by the CDM Executive Board.

Contribution to sustainable development

One purpose of the CDM is to assist developing countries to achieve sustainable development. The developing country's government is responsible for screening projects according to this criterion, and for excluding those not consistent with its sustainable development goals. Sustainable development is a broad concept that includes environmental sustainability, economic development, and social equity. The 1987 Brundtland Commission defined sustainable development as 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). While everyone agrees that sustainable development is desirable, there are differences in how it is understood. Much of this stems from different interpretations of what is to be sustained. Some consider that sustainability applies to the resource base itself, while others focus on the wellbeing of people and their livelihoods deriving from the resource base. These differences reflect biases of scientific disciplines as well as ideological differences (Redclift 1992).

Although there is no universal consensus on a definition, there has been progress on establishing what sustainable development means in practice. Agenda 21, adopted at the Rio Earth Summit of 1992, outlined a set of key indicators for sustainable development. These have been adopted by a large number of countries. The key Agenda 21 indicators are integration of conservation and development, satisfaction of basic needs, provision for social self-determination, cultural diversity and maintenance of ecological integrity (UN 1992). The UN Commission on Sustainable Development has gone a step further and developed a set of more than 100 indicators. These are listed on the website www.un.org/esa/sustdev/worklist.html.

The criteria for sustainability for one community will not necessarily apply to another, so each country has to develop its own sustainable development agenda. Most developing countries have not elaborated their agendas in a systematic way, which means that the sustainable development part of a CDM assessment has to be relatively subjective at this stage. There are, however, a number of frameworks for an initial checklist. An example is the list of criteria used by the SouthSouthNorth Project, a Dutch-funded initiative that has screened pilot CDM projects in South Africa, Brazil, Indonesia and Bangladesh (see Thorne (2001) for an example of the screening in South Africa). The Commission on Sustainable Development has compiled a working list of 134 indicators, including social, economic, environmental and institutional aspects of sustainable development (CSD 1995). Other criteria, specific to land-use, land-use change and forestry (LULUCF) projects, have been compiled for this sector (Makundi 1997). In countries where detailed case studies for GHG emissions projects have been reported, sustainable development indicators reflect their national development objectives. In Zimbabwe, Botswana, Mauritius, and Thailand, sustainable development indicators include: financial and social costs, local air pollution, income distribution, health impacts, and employment generation (Halsnaes & Markandya 2001). While South Africa does not yet have an approved list of sustainable development indicators, its economic, social and environmental policies reflect its vision of sustainability. The criteria for sustainability are likely to be close to national priorities expressed in policy and strategy documents. These are presented in Chapter 7, CDM in South Africa.

2.2 Additionality criteria

Additionality tests are designed to prevent credits going to projects that would happen even without the CDM – such interventions are called 'free rider' credits. There are two types of additionality testing:

- Environmental additionality – real, measurable and long-term emissions reductions that are additional to any reductions that would have occurred in the absence of the certified project activity.
- Financial additionality – funding for the CDM project must be additional to official development assistance, including contributions to the Global Environmental Facility.

To pass the environmental additionality test, the project developer has to identify and document measures that reduce emissions, while excluding measures that would have been introduced anyway. One way to motivate for environmental additionality is to show that the technology to be used is the best available under the circumstances and better than the typical technology. Technology comparisons can be made at local, national, and regional levels, against pre-established benchmarks. In South African projects, for example, one might look to SADC technical standards and policies as well as local ones.

Financial additionality, the second key requirement, means that project financing has to be additional to funds already allocated by the investor country to official development assistance. The principle here is that CDM projects should not divert or decrease already scarce development aid. The financial additionality criterion includes bilateral official development assistance and multilateral grant funding. The challenge in interpreting the financial additionality criterion is that official development assistance from many Northern countries is already falling, so it is difficult to judge whether money is being diverted. Some practitioners argue that the financial additionality constraint should not apply to the financing of feasibility studies or to the monitoring and capacity building aspects of CDM projects.

What about projects that are financially viable – on paper at least – without carbon credits? Would not these projects have happened anyway, and therefore not be environmentally additional? Possibly, but project developers can still motivate for additionality if CDM activities help to remove barriers that would have prevented implementation. Such barriers would include technology availability, lack of staff training, high investment risks, and poor management capacity. Project developers have to argue convincingly that a carbon investment and technology transfer package can help to overcome these barriers. One such barrier, to take an example from South Africa, is the lack of a policy framework to support independent renewable electricity ventures, even those that are potentially profitable. At present there is no guarantee that electrical power generated by independent producers will be bought by Eskom, South African's only power transmission utility. Examples of barriers are:

- lack of in-house technical or financial capacity to analyse energy efficiency opportunities;
- poor managerial incentives;

- high technical risks or lack of host country demonstration of a particular new technology or process;
- split incentives between energy provider, paying customer, and end-user;
- lack of familiarity with performance contracting and energy service company models of third party financing;
- limited access to favourable finance on the part of local investors.

Project developers can use the list of barriers given in Table 3.1 to motivate for the kinds of barriers that their CDM project would help to remove. The larger policy question is whether projects with attractive financial returns would be better undertaken with domestic funding, reserving CDM funds for projects that the host country could not finance on its own.

Table 3.1: Barriers that could be addressed by CDM investment

Potential barriers	*Examples*
Technological	Risks for provision of the technical service for equipment
	Technical risks – technology performance, resource availability
	Technology has never been demonstrated in the host country
Organisational/ legal	Substantial obstacles to receiving direct investment
	Policies the subsidise coal, natural gas, or heat
Financial	Lack of long-term risk capital
	High cost of capital
	Exchange rate risks
	High transaction costs and risk of not recovering pre-investment costs
	Demonstration of new business model (e.g.energy service company)
Market	Raw material supply risks
	Unpredictable price trends

2.3 Baselines

Baselines are estimates of what future emissions would be *without* the CDM project intervention. Setting baselines is complicated by the uncertainty which is unavoidable when making projections into the future. A baseline cannot be verified after the CDM project has taken place, but its underlying assumptions can be monitored. In setting a baseline, there has to be a compromise between stringency and inclusiveness. Stringency is necessary to minimise the possibility of 'free rider' credits, while inclusiveness allows for more project types and greater credits.

Each CDM project has to develop its own baseline, and this can be a significant transaction cost for the project. Methodologies are being designed that will allow several projects to use the same baseline, although multi-project baselines will only be applicable to some project types. The CDM Executive Board is compiling a directory of CDM project methodologies, which should help to reduce transaction costs. Certain small-scale projects will be permitted to use simplified baseline methodologies to save costs.

2.4 The project owner

The project owner is the primary developer of the project, who develops the project design document. The owner, usually situated in the host country, may be the host government, a government department, a branch of local government, a private company or NGO, or a consortium of owners under the umbrella of a project developer. Generally the owner will be a company wishing to raise investment capital through reducing emissions at its site. This can be done by selling emission reductions in the form of CERs to an investor in a Northern country. The owner will usually be advised by one or more technical advisers. The project itself may be a single activity or a bundle of activities. Once the project owner has found a

Northern investor, the investor and owner can collaborate, in which case the new 'owner' will be the partnership of the investor and the host country owner. In many cases, however, the purchaser of the carbon credits does not have an equity stake or any other involvement in the project.

2.5 Steps in the CDM project cycle

- *Project identification and design*: the project owner identifies an opportunity for a CDM project and develops a project design document which includes a baseline estimate and an analysis of the net carbon emissions reductions.
- *Host country approval*: International acceptance of a CDM project first requires approval at the national level, consistent with the country's domestic laws and policy priorities.
- *Third party validation of project design and baseline*: To ensure that later verification of performance will provide certified credits, the project design document, and especially the baseline, have to be validated by an independent third party before implementation.
- *Registration*: Once a project is validated and approved by the host country, it is registered by the CDM Executive Board.
- *Financial structuring:* Finances are then secured. The investors provide capital investment in the form of debt or equity. These investors may or may not be the carbon buyers who will pay for certified credits on delivery.
- *Implementation and operation*: The project is built, commissioned, and begins operation.
- *Monitoring*: Project performance, including baseline conditions, is measured by the project developer in the commissioning process and during on-going project operation.
- *Third party verification of project performance*: An independent third party verifies project performance against the validated design and baseline, in order to approve certification.
- *Certification and issuance*: Based on the host-country approval, the validated project design and baseline, and the verified project performance, CERs are certified and issued by the CDM Executive Board.

Figure 2.1 illustrates these steps and the various parties involved.

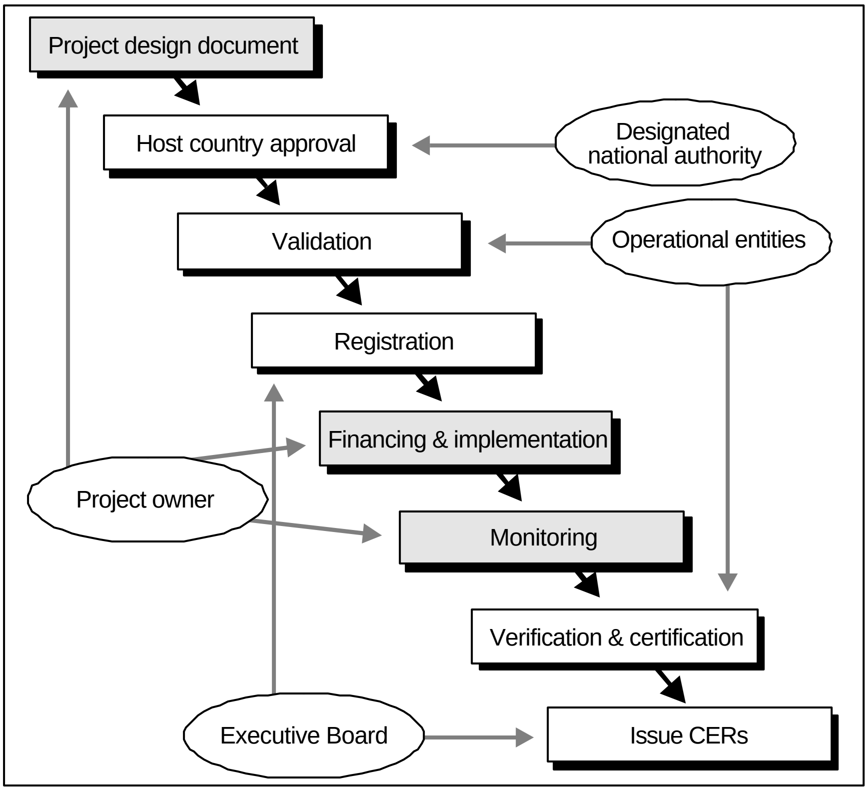


Figure 2.1: Interactions involved in a typical CDM project and actors responsible

Project identification and design

The project design document is where the CDM project starts. It is drawn up by the owner and advisers in a form similar to a business plan, and is a formal document which has be presented in the format detailed in the CDM reference manual (reproduced at the end of this book). It has to contain:

- a technical description of the project;
- the proposed baseline methodology;
- the proposed method for calculating net emissions reductions;
- an explanation of how the project activity meets additionality requirements;
- information on environmental impacts and possible impact assessments;
- sources of financing and a demonstration that the funding is additional;
- stakeholder comments;
- a monitoring plan.

Host country approval

The next step is for the owner to present the project design document to the designated national authority – a government department of the host country. Its tasks are described in the rules for the CDM. The designated national authority must provide a formal letter of approval of the project, confirming how the project will assist the host country to achieve its sustainable development goals. To gain designated national authority approval, the owner has to ensure that the project design document meets all the requirements of the design template. The host country should have a framework within which the designated national authority can assess the project's contribution to sustainable development.

Validation

Presenting the project design document for validation is generally the first official step after the design document is approved by the host country. Validation is the process of assessing the assumptions and plans in the project design document, including the baseline, the methods of estimating emissions reductions, and the monitoring plan. Validation is undertaken by an operational entity, whose role is much like that of an auditor validating financial statements. The operational entity reviews the documents submitted by the project owner and does additional research if necessary. This could include a substantive technical review of any aspect of the project design document. The operational entity has a twofold task in the CDM project cycle: first, to validate the design document, and, later in the process, to verify the emissions reductions. The operational entity's evaluation of the design document includes checking the calculations and assumptions of the document. The operational entity also publishes the project design document, so that all stakeholders have the opportunity to comment.

Operational entities are chosen on the basis of their technical expertise and experience with carbon mitigation and relevant technologies. The Executive Board of the CDM acts as an accreditation agency, evaluating and approving applications from institutions that apply to act as operational entities. To be accredited, operational entities should have expertise in certification procedures, a professional code of practice, and independence and no conflict of interest with owners. Auditors, accountants, law firms, and institutions with experience in energy project evaluation are most likely to apply to become operational entities.

In the validation process, the operational entity tests the design document against a list of requirements. These are that:

- the project is approved by the designated national authority;
- the parties to the project are eligible to participate in the CDM;
- the project activity is eligible under the CDM;

- comments by stakeholders have been considered;
- an environmental impact assessment has been conducted, and its results included;
- the project baseline complies with the principles established in the Kyoto Protocol;
- the project will result in a reduction of emissions against the baseline;
- monitoring and verification procedures are in place.

The validation report is made public, and serves as a recommendation to the CDM Executive Board to register the project.

Registration

Registration of the project design document is a function of the CDM Executive Board. This is normally a formality once the operational entity has validated the project. The process provides countries which are signatories to the UNFCCC with the opportunity to call for a review of the proposed registration.

Financing and implementation

Financing methods vary from project to project, depending on their financing structure (described below in section 2.6: Project architecture). Once the project design document has been approved, and all matters relating to the financial and legal structure completed, the owner can proceed with implementing the project.

Monitoring

The monitoring plan is part of the project design document (for further details, see Chapter 6). The monitoring plan should include:

- the data needs and data quality required for calculating emissions for the project;
- the method of collecting data on emissions, measured against the baseline, including quality assurance and quality control;
- methods for calculating emission reductions from the data collected, including adjustment for exogenous factors such as weather, production levels, and operating hours;
- the independence of the monitoring organisation and its relationship to the project owner.

The actual emissions from the project are periodically monitored or estimated from monitoring results by the project participants over the life of the project. By comparing actual emissions with the baseline, the emissions reductions achieved by the project are calculated, and the CERs quantified.

Verification, certification and issuance of CERs

The measurement of emissions reductions must be verified by an independent party (the operational entity), based on the validated project design document and monitoring results. The verification process confirms whether the project has performed as planned. Table 2.1 shows the differences between validation, monitoring, verification and certification.

Table 2.1 Comparison of project validation, monitoring, verification and certification
Source: Swisher (2001a)

Process	*Purpose*	*Timing*	*Inputs*	*Output*
Validation	Determine if project as designed would produce valid CERs	After project development, before project implementation	Project design, baseline study, monitoring and validation plan, host country review	Validation of project design complying with Kyoto Article 6
Monitoring	Measure project performance	Periodically during project operation	Data from ongoing measurements	Measured results of project performance
Verification	Verify the amount of reduction that is valid and measured	Periodically during project operation	Validation report, results of monitoring	Verification of claimed emission reductions
Certification	Final acceptance of project CERs	After monitoring and validation is complete	Validation and monitoring and validation report	Approval of certified CERs

Public participation

CDM projects require more public or community participation than other development projects. 'Public' refers here to the range of stakeholders who participate in, or are affected by, any facet of the project. Public participation happens at various levels during the design and development of the CDM project. At the local level, comments and inputs from communities, with a description of how they will be involved, are required for the project design document. Capacity building of communities may be necessary, especially if people benefitting from the project are expected to change their behaviour or community practices. Most CDM projects are subject to environmental impact assessments during the design phase. Here the national requirements of such assessments will apply, and these almost always include public processes. Public comments in the early project design steps may also need to be included.

At an international level, all stakeholders will be able to examine and comment on the validation report for the project before it is sent to the CDM Executive Board. They will also be able to challenge the registration of CDM projects sent to the Executive Board. The sustainable development requirement of the CDM is in part measured by the participation of communities and interested parties, because public participation and capacity building are a necessary part of sustainable development. This contribution is measured by various indicators. Besides satisfying sustainable development criteria, the CDM project should conform with any existing policies or national commitments under other international agreements. If the CDM project impinges on prior commitments, the impact of this needs to be evaluated and taken into consideration in eligibility considerations and in credit apportionment among stakeholders.

2.6 Project architecture

Project architecture can be divided into four broad categories: unilateral, bilateral, multilateral, and open (Baumert et al 2000). These provide the investor and project owner with a number of flexible approaches. Each has a bearing on the project cycle, on financing, and on import/export arrangements.

Unilateral architecture

In unilateral architecture, the project owner takes on all the risk of design and implementation, including the risk that the CERs issued will be saleable in the 'carbon market'. The owner uses their own capital resources to fund the project, and sets out to recoup their investment, together with a viable profit. This model assumes that developing countries will be allowed to own CERs, and at present there is no explicit rule against this.

Bilateral architecture

In bilateral architecture, the owner collaborates from the outset with an industrialised country investor. Two financial models can be used in bilateral architecture: credit agreement and equity investment. In the credit agreement option, the investor buys the CERs ahead of their issuance, so is really an advance purchaser rather than an investor in the conventional sense. In the equity investment option, the investor takes an equity share in the project in return for a share of CERs, together with a share of the profits or losses of the project. Whether or not the investor takes an equity stake, they may want to be involved early on in the design and implementation of the project. What motivates such an investor is that purchasing the CDM project's credits will be cheaper than any action that can be taken to reduce the equivalent amount of GHGs in their own country. The CERs will accrue to the investor country's emissions target.

The return for the investor will come out of the CERs (and, if an equity investment has been made, out of profits). The investor may also be motivated by other strategic factors such as getting a foothold in a particular region or energy sector, favourable public relations, undercutting the competition, minimising a tax burden, or speculating on future prices of carbon. The investor may share the flow of CERs with the owner or with the host country. The investor who is a 'carbon buyer' and the investor who is a strategic equity partner can be the same or different organisations. The funds provided by the investor may be only a portion of the overall capital cost of the project. The advantage of bilateral architecture for the project owners is that from the outset they have a ready source of development capital. They have a partner who may offer more than money, by contributing technology and expertise. The disadvantage is that the owners may be less able to determine the design and details of the project on their own terms, and may get locked into an unfavourable price for the carbon credits.

Multilateral architecture

In multilateral architecture, several investors form a fund to finance multiple CDM projects, or portfolios of projects. A number of investors from industrialised countries join together and form a CDM fund, and in this way spread their risk over a number of projects. The fund then chooses and manages investments in a number of CDM projects. CERs flow to the fund, and the benefits are distributed pro rata to the group of investors. Multilateral architecture has the advantage for investors that they can combine forces and spread risk. They do not need to take the risk of financing and developing the project themselves as in the bilateral model.

Open architecture

Open architecture is a combination of the other three, using elements of each as appropriate. An example would be host country investors and institutions forming a national CDM fund and developing CDM projects, thus combining elements of the unilateral and multilateral approaches. Another open architecture example would be a fund initiated by a developing country that supports a broad portfolio of CDM projects and then sells shares in the fund to investors, similar to emissions trading under the Kyoto Protocol. Another possibility would be for a CDM fund to team up with a major investor in a more bilateral approach.

2.7 Share of proceeds

In every CDM project there is a sharing of proceeds. CERs, financial benefits, and other benefits may be shared on various levels. Certain obligatory sharing is required by the Kyoto Protocol in the form of levies for administration and levies for the Adaptation Fund which assists developing countries to adapt to the adverse effects of climate change. The share of proceeds to cover CDM administration and the Adaptation Fund will be a fixed percentage (e.g. 2% of CERs for adaptation).

3
Estimating emissions reductions

Because a CDM project must reduce GHG emissions, the quantification of GHG reductions has to be thoroughly understood by project developers. This chapter explains the conceptual issues behind GHG accounting, and gives guidance on the steps to estimate emissions reductions. Examples are given from the energy sector and the land use/forestry sector.

The Kyoto Protocol stipulates that CDM project activities should result in emissions reductions relative to a baseline. The baseline, set during the validation stage of the CDM project, quantifies 'what would have happened' with GHG emissions in the absence of the project. Actual emissions of the project are then compared to the baseline to determine emissions reduction credits. To estimate GHG emissions reductions, therefore, we first need to understand a number of conceptual issues: baselines, additionality, equivalence of different GHGs, leakage, project boundaries and permanence of emission reductions. We can then move to specific analytical steps, and examples.

3.1 Conceptual issues

The CDM reference manual being developed by the UNFCCC states that the project developer should estimate the emissions from the project on-site compared to an appropriate baseline (except when electricity is being displaced, in which case we look at emissions from power stations). The project developer should also consider whether there could be any impacts on emissions outside the project boundary. Figures 3.1 and 3.2 illustrate the concepts of baselines and environmental additionality. The lines OB and OP show GHG emissions without-project and with-project over time. Both OB and OP are estimated prior to start of the project. The difference between the two lines, B-P, represents the additional GHG emissions reductions that the CDM project could claim. The point O represents emissions in the base-year (and should not be confused with baseline emissions represented by the line OB).

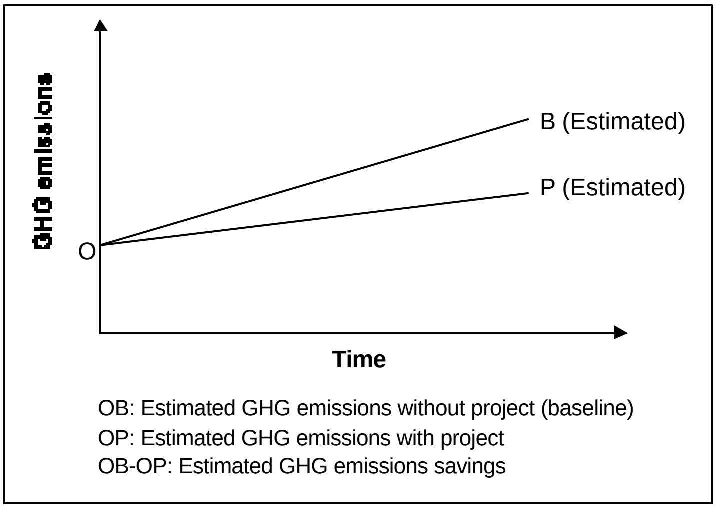
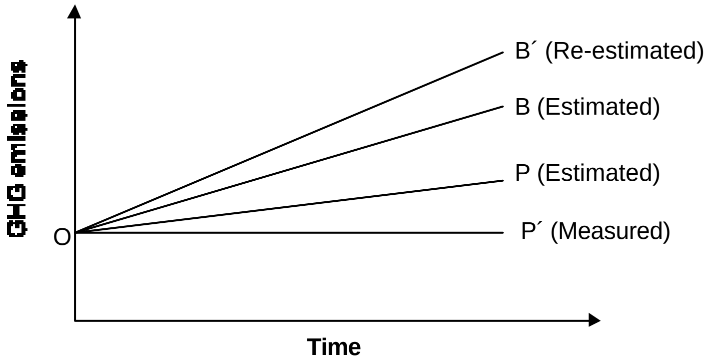


Figure 3.1: Emissions baseline and projected emissions

During the implementation of the project, the emissions are measured, verified, and reported periodically. These emissions are shown by the line OP´. CERs are credited according to emissions reduced compared to a baseline – represented by the difference between the lines OP´ and OB at any point in time.

There may also be a provision to estimate the baseline again during the course of the project. In this case, the line OB´ shows such a new baseline, incorporating adjustments to the pre-implementation baseline OB. The CERs to be claimed by the project would then change to OB´- OP´.



OB: Estimated GHG emissions without project (baseline)
OP: Estimated GHG emissions with project
OB-OP: Estimated GHG emissions savings

OB´: Re-estimated GHG emissions without project (baseline) (after monitoring and verification)
OP´: Measured GHG emissions with project after monitoring and verification)
OB´-OP´: Measured GHG reductions (after monitoring and verification)

Figure 3.2: Comparing actual emissions to a baseline

3.1.1 Global warming potentials

Often we have to estimate the emissions of more than one GHG, so we need to know the relative impact (called the radiative forcing) of different gases. Global warming potentials take different strengths into account, enabling the analyst to show the relative importance of different GHG emissions. The direct global warming potential of methane, for example, is defined as the cumulative direct effect on the atmosphere's energy budget resulting from a one kilogram release of methane, relative to the direct effect of a one kilogram release of carbon dioxide – for methane, this is estimated to be 21 times over a 100 year period. The global warming potentials for the gases covered under the Kyoto Protocol are given in Table 3.1.

Table 3.1: Global warming potentials
Source: Houghton et al (2001)

GHG	*Global warming potential over 100 years (tonnes CO_2-equivalent/tonne GHG)*
Carbon dioxide	1
Methane	21
Nitrous oxide	310
Halofluorocarbons	120-12 000
Perfluorocarbons	7 850
Sulphur hexafluoride	34 900

3.1.2 Baselines for CDM projects

Uncertainties in baselines cannot be eliminated, because it is never possible to prove 'what would have happened otherwise'. Baselines for CDM projects should:

- be environmentally credible, to provide long-term benefits emissions reductions benefits;
- be transparent and verifiable by a third party;
- be simple and inexpensive to draw up (low transaction costs);
- provide a reasonable level of credit certainty for CDM investors.

There are trade-offs among these criteria. For example, if the baseline level is set higher than the emissions level that would happen otherwise, an artificially high number of emissions credits would be generated. This would mean that more projects would be eligible for CDM status and the cost of credits would be lower, but it would also increase the number of 'free riders'. If, on the other hand, the project baseline is set lower than the emissions level that would happen otherwise, the emissions credits per project would be artificially small. The low baseline would limit the number of eligible projects, and may even disqualify some climate-friendly projects. The low baseline would most likely reduce the number of profitable projects and increase the cost of emissions credits from projects that do qualify. Baselines can be classified as: one project only ('project-specific'), applicable to a range of projects in a sector ('multi-project'), or a combination of the two ('hybrid'). There is also the possibility of aggregated nation-wide baselines ('top-down') (Phul 1998). We return to baselines later in this chapter.

3.1.3 Leakage and spillover

Leakage is a measurable emissions increase that is caused by the project, but is outside of a CDM project boundary or timeframe. Leakage occurs when system boundaries are drawn in such a way as to ignore some emission changes caused by the project. In some cases there can be a positive leakage (known as spillover) if the CDM project leads to reduced emissions elsewhere, or after the project ends. Sources of leakage vary according to project type and according to which emission sources or effects are components of the project baseline. Leakage may be influenced by the type of baseline used. An example would be a physical displacement of the baseline technology to a location where a more modern and efficient technology was intended to be used, but where technology was chosen because it was readily available and possibly cheaper (Liu & Rogers 2000). A more common example would be a large CDM project lowering the price of its products or services, and so increasing the demand. For instance, a large energy-efficiency programme may decrease the price of electricity and increase the total demand for power. The fuel emissions offset by the project would then be reduced by the increase in emissions from the additional demand. Similarly, a large afforestation project may depress the market price for timber, thereby increasing demand for timber products and reducing net carbon reductions. Another example would be a project to reduce deforestation displacing the pressure on forest resources to somewhere else outside the project boundary.

Positive leakage or spillover could happen when CDM project technology is emulated by other projects in the same country or elsewhere, through a demonstration effect. If this replication of technology is planned, the spillover may be termed an intended consequence of the project, or market transformation (Vine & Sathaye 1999). CDM project developers who adopt innovative technology may also patent it and market it to other producers. An example of a spillover in the LULUCF sector would be if products from sustainably managed afforestation projects replaced products from unsustainably managed forests. If the reduction of deforestation outside the CDM project boundary reduces total emissions from the country, this should be considered as spillover. On the other hand, if the CDM project displaced subsistence farmers from the project area, and these farmers engaged in deforestation in other areas, the additional emissions would have to be counted against the project as leakage.

To measure the emissions impacts, it may be necessary to monitor changes in emissions outside the official project boundary, bearing in mind that widening the monitoring domain will entail greater costs. The secondary impacts of a project are likely to be modest in the beginning, and the monitoring of such impacts may not be a priority – for small-scale projects they may even be insignificant. In such circumstances, the project developer may be justified in disregarding these impacts and simply focussing on energy savings and direct emissions reduction. As the project becomes larger and more linked to market transformation, however, these impacts may become significant and may have to be evaluated.

Box 3.1: Project spillover case study: compact fluorescent lamp technology

A group of utilities in the New England area of the USA (New England Electric System, Inc, Boston Edison, Northeast Utilities, Eastern Utilities Associates and Commonwealth Electric System) contracted with a consulting firm to assess the effect of demand-side management (DSM) programmes on the residential market for compact fluorescent lamp (CFL) technology and quantify the spillover effects of their residential DSM programmes.

Evaluation methods: The study included telephone surveys of participants and non-participants, interviews with representatives of major manufacturers of CFLs and retailers, and a review of statistical and secondary sources on shipments, sales, and residential saturation of CFLs.

Three methods were used to estimate spillover:

- A comparison of saturation of CFLs between households in the sponsors' territories and those in non-programme areas (in the US Midwest and South).
- Spillover estimates based on analysis of customer self-reports within the programme areas.
- Discrete choice modelling, which yields estimates of net programme savings including spillover.

Evaluation findings: The three methods yielded similar (all within 7%) net-to-gross ratios. The discrete choice modelling was chosen as the superior methodology, compared to the other two. The model estimated spillover savings at 27% of gross programme savings. The researchers also identified: (1) changes in the behaviour of manufacturers which accelerated the market penetration of CFLs; (2) indicators that these changes were likely to persist in the face of the current decline in utility DSM activity; and (3) evidence that the above changes were attributable to utility DSM efforts and, in some cases, to the efforts of the sponsors in particular.

Source: Xenergy (1995)

3.1.4 Free riders

Carbon reductions can be effected by participants who would have taken the same actions if there had been no CDM project. These participants are called ‘free riders.’ The carbon savings associated with free riders are not truly ‘additional’, because it cannot be said that they ‘would not have occurred otherwise’. Free riders can be regarded as an unintended consequence of a CDM project, and their input should, if possible, be included in the estimation of the baseline. Free ridership can be evaluated either explicitly or implicitly. The most common evaluation method is to ask participants what they would have done in the absence of the project. Based on answers to carefully designed survey questions, participants are classified as free riders or assigned a free ridership score on a sliding scale. Another method of developing explicit estimates of free ridership is to use discrete choice models to estimate the effect of the programme on customers. The discrete choice is the customer’s decision whether or not to implement a measure. The discrete choice model estimates the effect of various characteristics, including project participation, on the tendency to implement the measures.

3.2 Estimating energy and industry emissions

In the energy supply and demand sectors, a project developer has to take several steps to estimate future emissions, both for the baseline and for the CDM project. These steps are described below. (A useful reference to a full estimating procedure for emissions in these sectors is the IPCC’s (1996) *Guidelines for national inventories*. This includes a workbook section with step-by-step instructions and examples, as well as relevant reference data such as emissions factors for different fuels).

Step 1: Establish the project boundary

Determining the physical and conceptual project boundary is the first step in estimating emissions for both the baseline and the CDM project. The project boundary consists of the temporal and spatial domain within which the GHG emissions are estimated and monitored. This domain may vary for different aspects of the project. The boundary should be defined in such a way that it minimises the possibility for leakage and identifies all of the relevant sources and sinks for all GHGs impacted by the project. A physical boundary and monitoring domain, to be set at the validation stage, can be assumed to be placed around the project site for estimates and monitoring activities.

Emissions are then calculated as a function of (1) output or activity level, (2) energy intensity or efficiency, and (3) carbon intensity, using the following equation:

$$\text{Emissions} = \text{Project output} \times \text{energy use/output} \times \text{GHG emissions/energy use}$$

Step 2: Project future activity levels for baseline and project

In most cases, one will first need to estimate the activity levels that would occur both with and without the project – e.g. how much water heating, effluent pumping, electricity generation, or freight transport. Changes in activity levels may occur because of growing population within the project area, increasing incomes, changes in relevant policies, or simply increases in demand for the service being provided. Understanding the drivers of demand for services is essential when making a reasonable projection of activity levels. Historical trends may be useful, but are not sufficient to give an understanding of what is likely to occur in the future. The project developer must estimate how activities will change under the CDM project.

Step 3: Use energy intensity to project future energy use

Energy intensity is the amount of energy use per unit of output – for example the amount of energy used per tonne of steel produced, or per passenger kilometre travelled. Energy intensity is related to the technology used for a particular service – from vehicles to home appliances to industrial boilers. For both the project and the baseline, projecting future energy use requires an understanding of how the technology is likely to change. Are more cost-effective new technologies being introduced? Is it likely that older technologies will be replaced? Because of these technologies, the future energy intensity for the project estimate will not be the same as for the baseline. Project developers should look for sectoral analyses of historical trends and projections of technological change to support their case for changing energy intensity.

Step 4: Use emissions factors to project future emissions

Once we know the demand for different energy types, we need to know the quantity of GHGs emitted per unit of energy used – also called the emissions factor of a fuel. This is usually expressed as tonnes of carbon dioxide equivalent per unit of energy. The exception to this rule is an energy source such as electricity, where there are primary energy losses (and hence additional emissions) in the production of the energy carrier. For a fuel such as coal, we can simply multiply the demand for coal use by the emissions factor for coal. For electricity, we need to know how much coal or other fuel was used to produce the electricity. (This process is described in more detail in the next section, along with methodological tools for developing electricity baselines). If there are emissions of gases other than carbon dioxide, they can be converted to the carbon dioxide equivalent by multiplying by the global warming potential of the gas. Once we know the changes in energy use and the type of energy used, we can convert this to total GHG emissions.

If the fuels used in the baseline and project estimates are different, then the emissions factor used to convert energy into GHG emissions will also be different. This will be the case with fuel-switching projects, or projects that change an existing mix of fuels. Energy-efficiency projects, on the other hand, will use the same emissions factor for the baseline and project estimates.

In principle, any of the three components in the equation above can be altered to meet the CDM objective of reducing emissions. Producing less of the same output would be one way, although it may not meet sustainable development criteria. A decrease in output via recycling is an example. The second factor, energy use, can be improved by reducing the energy intensity through a variety of actions. Another intervention would be to use less GHG-intensive fuels, such as renewable fuels or natural gas, thus changing the value of the third factor, the carbon intensity. If a CDM project used natural gas in place of coal in a power plant, this would improve energy efficiency and at the same time reduce the carbon content of the fuel.

3.3 Estimating emissions – the special case of electricity

Estimating the GHG emissions from projects supplying electricity to the grid, or from end-use electricity efficiency projects, requires a baseline emissions factor, which is essentially a multi-project baseline. Establishing a multi-project baseline for an electricity supply system provides CDM project developers with the information to calculate the carbon emissions (kg CO_2/kWh) which they expect to avoid. It also provides the means to calculate the carbon credits claimed once the project is under way. To calculate the emissions factor we have to find the types of power plants whose construction or use would be avoided by the CDM project, and then estimate the carbon emissions avoided by their reduced operation.

There are several advantages to establishing a national or regional baseline emissions rate for electricity. The first is that it would substantially reduce the transaction costs of CDM projects, since individual project developers would not have to do the analysis. Secondly, having a standard that is agreed nationally can improve the consistency and credibility of the baseline, and hence the value of the CERs.

Once a baseline scenario for energy demand and supply has been developed, the next step is to estimate changes in emissions caused by the CDM project. In the local area case, it is relatively simple to estimate the emissions that would occur had the CDM project not existed. In the case of grid-connected electricity it is more difficult. One would need to estimate the time of day the electricity was offset, and then evaluate the mix of power plants that might have supplied electricity at that time. The electricity generation offset from this mix of power plants would then be used to estimate the offset GHG emissions.

For electricity supply systems dominated by one or two fuel types, establishing emissions factors is manageable. For systems with multiple fuels and complex dispatch schemes, it is a more challenging task. Electricity systems are typically managed by a dispatch order – the order of priority in which each unit of generation capacity is selected for operation during a given time interval. Traditionally, resources are ranked by their variable costs (mostly fuel costs) to determine the most economic dispatch order at any given time. The most expensive resource operating at a given time is the marginal resource, and will vary with the system load. In South Africa, the marginal resource during peak times is generally hydroelectricity and/or pumped storage, and during off-peak hours it is probably coal-fired power (or even nuclear power). Utilities develop an expansion plan – the schedule of power-supply investments to deliver sufficient electricity, including a reserve margin – to meet forecast future demand at the least cost, taking into consideration the timing of demand. This plan, and a knowledge of the dispatch order, are important for understanding the emissions factor for grid electricity.

There are several approaches to establishing emissions factors for electricity (Swisher 1998). One way is to estimate an average emissions factor for the entire supply system, and assume that this factor applies to all avoided electricity, regardless of the time of day and season when it is avoided. The problem with this method is that the generation mix – and hence emissions – can change dramatically according to season and even during the course of the day. A second method is to use the emissions factor of the marginal generating plant (Meyers et al 2000). While this avoids the problem of averaging, the marginal resource changes over time, so it can be difficult to define and may need a computer model to estimate. One way to simplify this is to get the national utility to publish a set of emissions factors by time of day and season. To make their estimate transparent and open to verification, the utility could use data for the previous year to estimate the factors for the current year (see Box 3.2). A third method is to look at the expansion plans of the utility, – or, in a deregulated market, of a Ministry – and assess what marginal capacity will be avoided by the project. This is particularly important if the project is of sufficient size to displace a unit of generating capacity.

Box 3.2: Estimating emissions from electricity production using MAGPWR

An easy-to-use model known as MAGPWR (marginal avoided GHG – power) has been developed for estimating emissions factors for a multi-project baseline for the electric power sector (Meyers et al 2000). MAGPWR simulates the combination of power plants that would be displaced by the electricity saved or generated by a CDM project. The model is primarily intended for small-to-medium size projects that affect operations at the margin – assuming that this marginal resource does not change significantly over the course of the project. The model balances simplicity of use with the need for accuracy in granting carbon credits. It requires a relatively small amount of data, and is easy to understand. It could be used by a national energy agency, or any entity with responsibility for CDM.

The MAGPWR model uses data about a utility company's system operation, including the system load duration curve which provides the hourly load over a period of a week. It requires information about the types of generation used to meet the indicated load and the amount of electricity supplied to the grid or not drawn from the grid during the week. For more sophisticated analysis, if the load duration curve or CDM project output has significant seasonal or diurnal variations, the load duration curve may be drawn for particular seasons or for peak and off-peak hours. The model can be used by any CDM project to estimate the amount of emissions that would be offset by its electricity supply or reduced electricity use.

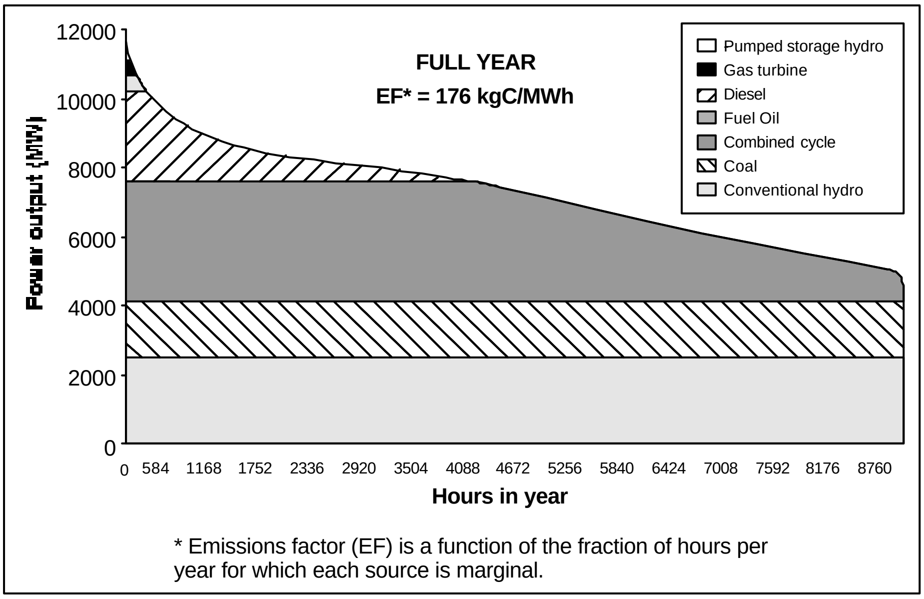


Figure 3.3: Typical load curve for an electricity generation system with multiple fuels
Source: Meyers et al (2000)

3.4 Estimating LULUCF emissions and storage

For LULUCF, only two activities are eligible for CDM – afforestation and reforestation. Afforestation is the planting of trees on lands which have had no forests on them for at least 50 years. Reforestation is the re-conversion of deforested land to forest land through direct intervention.[1] So far there are no standard methodologies for CDM projects in the LULUCF

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[1] The definitions adopted by the July 2001 negotiations (UNFCCC 2001) are:

- 'Afforestation' is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.

sector, although the IPCC is currently working on this. We describe here methods of estimating carbon storage for the two eligible LULUCF activities, with some examples.[2]

To undertake carbon accounting of LULUCF projects, we need first to consider the important carbon pools. These are:

- standing biomass: the existing vegetation at the project site;
- new biomass: additional vegetation (newly planted trees) on the site because of the project, or because of natural changes in the land;
- harvested biomass: biomass that it stored in products such as timber, paper and pulp;
- soil carbon.

For each project, we need to consider which carbon pools are likely to change from the baseline, because not all will necessarily change significantly, and not all can be measured easily. For afforestation and reforestation projects, the most important changes will be in new biomass and in harvested biomass products. If the land has a moderately high carbon density, which means that it is neither degraded land nor grassland, then we must also include changes in the standing biomass. Soil carbon, while very significant in absolute terms, can be difficult to measure. For many cases, soil carbon will not change significantly over time (Swisher 1997). An example of a LULUCF calculation is given at the end of this book.

Step 1: Type of activity to be implemented – afforestation or reforestation

The methodology for afforestation and reforestation projects is the same: both involve an increase in carbon density on a specific piece of land. The area to be afforested or reforested may be grassland, rangeland, degraded wasteland, agricultural land, or swampland. The standing biomass carbon density may change over time, either through natural changes on the land or possible disturbances in the future.

Step 2: Define the boundaries of the project

The project developer should define the geographical location for the CDM project. Even if wood products are to be exported out of the vegetation area, this will not affect estimates of carbon benefits, because the rate of decay of wood products is relatively slow. The time boundaries (project duration) should also be defined, since there may be GHG effects beyond the project's lifetime.

Step 3: Describe the baseline characteristics of the project area

To understand how the carbon density will change with the project, we must first understand conditions such as vegetative history, climate, weather (especially rainfall and temperature), general landscape, soil type and nutrient status. These factors are all relevant to the baseline.

Step 3.1: Describe the key characteristics of the baseline scenario

A baseline for a LULUCF project is a projection of the changing carbon profile of the vegetation and soil in the project area in the absence of the CDM project. The baseline ecosystem may include grasslands, shrublands, degraded woodlands, and transitional vegetation. The baseline therefore describes all land use and land-use changes which influence the carbon density in the area, including socio-economic factors.

- 'Reforestation' is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989

[2] In this sector, GHGs are mostly carbon dioxide, methane and nitrous oxide, and any methods used must be able to project reductions in all these gases. Significant portions of this chapter are based on material from Sathaye and Venida (2001), Oko-Institut (2000), Randall et al (2001), Sathaye, Makundi and Andrasko (1995).

Step 3.2: Quantify the baseline carbon density

Carbon density includes biomass from trees and other vegetation, as well as soil carbon. There are two methods for estimating the biomass carbon density (tC/ha), and the project developer has to decide which of these is more appropriate for the project area. The more accurate but more data-intensive method is destructive sampling. This involves taking biomass and soil samples from the site and performing field and laboratory measurements to determine the amount of carbon in soil, roots, and above-ground live and dead biomass, expressed as tonnes of carbon per hectare (tC/ha). The second method is ecosystem inventory sampling. This involves taking biometric data from a few samples, then estimating the carbon stock in the stemwood per hectare. By developing relevant coefficients or applying existing ratios for biomass in the various carbon pools, the data is used to estimate the total carbon density. This method is less data-intensive but less precise than destructive sampling (see Chapter 6).

Step 3.3: Estimate biomass density and carbon, both below and above ground

Here the estimation procedure depends on the long-term purpose of the forest. There are two possibilities – either planting trees without harvesting (known as plant and store), or planting trees for wood products other than fuelwood, which provide long term carbon storage. The first type of forest provides an environmental service like soil and water conservation, swamp reclamation, or carbon sequestration. This type of forest is expected to remain stable indefinitely, and will do so if adequate management measures like fire protection are implemented.

To estimate the carbon stock of a standing forest at any point in time, the following formula is used:

$$\text{Total carbon density (t/ha)} = CC \times SV \times AS \times TA \times DW \times WD + C_{soil}$$

Where:
- CC = carbon content of biomass (%)
- SV = stemwood volume (m^3/ha)
- AS = above-ground biomass / stemwood volume ratio
- TA = total biomass / above-ground biomass ratio
- DW = dry to wet biomass ratio
- WD = wood density (t/m^3)
- C_{soil} = soil carbon (t/ha) (see below)

Step3.4: Estimate stock of soil carbon down to a defined depth

Soil carbon is typically estimated to a particular depth, depending on the expected depth of carbon accumulation or depletion. There is considerable uncertainty in the literature on soil carbon content and the factors that affect it. As a percentage of total carbon benefit, soil carbon is more significant where the vegetation carbon is low. Where soil carbon data is not available, data from other areas with similar conditions may be used. Swisher (1997) presents a simple rule-of-thumb approach to long-term average soil carbon densities. The soil carbon densities for common land-use conditions can be estimated as fractions of natural soil carbon in the same climate (Houghton et al 1987; Brown et al 1989). The formula is:

$$Csoil = N_s \, CS_{nat}$$

where:
- C_{soil} = soil carbon (tC/ha)
- CS_{nat} = natural forest soil carbon (tC/ha)
- N_S = 0.50 for steep and highly erodible areas
- N_S = 0.75 for pasture, cropland and fallow woodland
- N_S = 0.90 for logged or secondary forest and timber plantations
- N_S = 1.00 for natural forest management, forest restoration and agroforestry

An estimate of the carbon storage in the soil of natural forests in tropical bio-climatic zones, as a function of climate, can be calculated by (Brown & Lugo 1982):

$$CS_{nat} = 154 \exp(-0.45\, Z)$$

where: Z = Average annual temperature / rainfall ratio (°C-year/dl)

These formulae can be used to show how carbon density is changing over time. The data should come from measurements of the project area, or from cross-sectional data on similar species or ecosystems. The estimated carbon density in the baseline should include the rate of biomass degradation or growth, if this is known.

Step 4: Describe the CDM project characteristics – species to be planted, forest management, and products

Step 4.1: Quantify the carbon density for the project

The same methods and formulae used for estimating baseline carbon density are used to calculate the rate of change of carbon density under the CDM project, including accumulation of vegetation and, where relevant, soil carbon. A slightly more complex set of formulae is used for forests and plantations managed in perpetual rotation. For forests planted for long periods, covering many rotations, the following procedure is recommended. Before the maturity of the first area for harvest, estimate the accumulation of carbon by growth measurements to obtain stemwood volume (SV). Then use the formulae above to estimate the carbon stock for each crop. After reaching rotation age (the maturity age of the first planted crop) use the following formulae to estimate the total stored carbon per hectare:

Total carbon stored (tC/ha) = increased land carbon (tC/ha) + product carbon (tC/ha)

Increased land carbon (tC/ha) =
increased vegetation carbon (tC/ha) + increased soil carbon (tC/ha)

For vegetation carbon, assume that the plantation is operated in rotation indefinitely and that at least half the carbon in any individual plot is stored away indefinitely. If we assume that sufficient funds are available, and good management is practised so that carbon is not lost in the future, the formula for estimating the increased vegetation carbon is:

Increased vegetation carbon (tC/ha) = $C_v \div 2$

where: Cv (tC/ha)= net vegetation carbon sequestered over the rotation– i.e. vegetation carbon density before harvest less density after harvest

Vegetation carbon density before and after harvest are then estimated using a variation of the standing forest formula, but leaving out the soil carbon term, as follows:

Vegetation carbon density (t/ha) = CC × SV × AS × TA × DW × WD

where: CC = carbon content of biomass (%)
SV = stemwood volume (m^3/ha)
AS = above-ground biomass / stemwood volume ratio
TA = total biomass / above-ground biomass ratio
DW = dry to wet biomass ratio
WD = wood density (t/m^3)

For soil carbon, assume that all of the uptake through the rotation period stays in the soil.

Increased soil carbon (tC/ha) = C_s

where: C_s = net increase in carbon density, i.e. density at forest maturity less baseline scenario density (tC/ha)

Product carbon: If forest products are renewed continually, they can store a stock of carbon for an indefinite period. The amount of carbon stored in this form depends on the product life – the longer the product life, the more carbon stored. The amount stored over an infinite time-period will therefore increase with product life. The formula for estimating product carbon is:

Product carbon stored (tC/ha) = $(\Sigma\, Cp_i \times n_I) \div T$

where: Cp_i = carbon stored in product i (tC/ha)
n_i = useful lifetime of product i (yr)
T = rotation period (yr)

This formula assumes that the product decomposes instantly at the end of its life rather than continuously over its life.

While carbon can also be stored in decomposed matter, the amount is relatively small, and not likely to vary significantly between baseline and project. For this simplified procedure, decomposed matter is not included. [3]

Step 5: Calculate the total carbon stock (carbon sequestration)

The net change between baseline and project estimates is the difference in total carbon storage in the two scenarios. For perpetual rotation forests, use the following summary formula

$$\text{Total carbon stored per ha} = C_v \div 2 + C_s + (\Sigma Cp_i \times n_I) \div T$$

Step 6: Estimate leakage or spillover effects

If there is leakage or spillover, the amount of reductions from step 5 should be adjusted accordingly. The project developer has to describe the cause of the leakage or spillover, quantify it, then adjust the project emission reduction.

3.4.1 Emissions from biomass burning

If other GHGs are emitted in LULUCF projects (perhaps because of prescribed residue burning or the use of the biomass as a bio-fuel) the carbon dioxide equivalents can be estimated from the coefficients in Tables 3.2 and 3.3.

Table 3.2: Compound ratios of trace gases to total carbon and nitrogen in fuelwood burning
Source: Crutzen and Andreae (1990)

Compound	*Ratio*
Methane	0.012 to carbon
Carbon monoxide	0.060 to carbon
Nitrous oxide	0.007 to nitrogen
Oxides of nitrogen	0.121 to nitrogen

Table 3.3: Ratio of methane carbon (CH_4-C) to total carbon by fuel type
Source: IPCC (1995)

Fuel type	*C-CH_4/total C ratio*
Fuelwood	0.012
Agricultural residues	0.005
Dung	0.017
Charcoal combustion	0.005
Charcoal production	0.063

To convert the ratios to full molecular weights, the emissions of methane and carbon monoxide are multiplied by 16/12 and 28/12 respectively, and the emissions of nitrous oxide and nitrogen oxides are multiplied by 44/28 and 46/14 respectively. The ratios in the table above are approximate, depending on the actual proportions of nitrogen oxides emitted.

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[3] In perpetual rotation analysis, the carbon stored in the decomposed matter is estimated using this formula:

$$\text{Decomposing matter carbon stored per ha} = C_d \times t \div 2$$

where C_d = average annual carbon left to decompose per hectare and t = decomposition period

3.5 Developing a baseline

3.5.1 Project-specific baselines

Project-specific baselines evaluate emissions reductions from a particular project (as opposed to a group of similar projects) by using assumptions, measurements, and simulations specific to the project. In the energy sector, key parameters of the baseline would be changes in fuel or technology over the lifetime of the project. In carbon sink (LULUCF) projects, baseline parameters would include carbon accumulation per hectare per year in soil, vegetation and products, rates of biomass degradation, and emissions from displaced or complementary activities (leakage). Project-specific baselines can be subject to considerable uncertainty, which can make it difficult to estimate the environmental additionality of the project. The largest component of this uncertainty is the choice and timing of baseline fuel and technology options. One analysis (Begg et al 1999) has shown that using project-specific baselines to estimate emission reductions from retrofitting energy sector projects results in uncertainties as high as 80%.

Data requirements for project-specific baselines vary by project type. Initial reporting requirements for selected project types have been suggested by some analysts (e.g. MacDicken 1997; Vine & Sathaye 1999; Ellis 1999). These requirements are data-intensive, and may involve the monitoring of fuel and technology use over an extended period, both before and during the life of the project. Activities Implemented Jointly (AIJ) projects in Holland, for example, require information for twelve successive months prior to the start of the project in order to establish a baseline. Most project-specific baselines in AIJ pilot phases have been established by expert analysis of key parameters. Model simulations have also been used. The detail of data and underlying assumptions in AIJ projects submitted to the UNFCCC has varied significantly from project to project. The project-specific baseline approach has been used extensively in the AIJ pilot programme instituted in 1995. This experience has shown that the drawing up of these baselines has been expensive and time-consuming. The cost of establishing project-specific baselines has been estimated at 1% to 8% of total project costs (Puhl 1998). More importantly, project-specific baselines may lack transparency and consistency for the large-scale environmental effectiveness required for a CDM project. They are, however, the only currently approved process for setting baselines. Alternative approaches are being developed and are likely to become more important over time.

Box 3.3: Project-specific baseline example: solar home systems

Consider the determination of a baseline for a project that is installing solar home systems (solar photovoltaic panels to power lights, TV and radio) in rural areas in South Africa. We can take two possible baseline approaches. The one compares the solar home system to homes using candles, kerosene and batteries to provide lighting and entertainment; the other compares the solar home system to homes using grid electricity. Let us look at the baseline for displacing kerosene, candles and car batteries. The first step is to estimate how much kerosene and candles and battery charge are used, and then estimate what share of this will be displaced by the solar home system. The latter is not obvious – for example, households might choose to move kerosene lamps into other parts of the home after they have solar home system-powered electric lights.

From the available data, we can estimate that households use 6.7 litres of kerosene and 15 candles per month for lighting. To convert this into carbon emissions we use the energy content of each fuel and the emissions factor.

$$\text{Kerosene emissions} = 6.7 \text{ litres/month} \times 37 \text{ MJ/litre} \times 0.07 \text{ kg } CO_2\text{/MJ} \times 12 \text{ months/yr} = 212 \text{ kg } CO_2\text{/year}$$

$$\text{Candle emissions} = 15 \text{ candles/month} \times 3.45 \text{ MJ/candle} \times 0.07 \text{ kg } CO_2\text{/MJ} \times 12 \text{ months/yr} = 44 \text{ kg } CO_2\text{/year}$$

Battery charging must deliver the same amount of energy provided by the solar home system for TV and radio – in this case assume that the radio uses 11 kWh/year (3.6 W × 8.3 hrs/day × 365 days/year) and the TV uses 22 kWh/year (20W × 3 hrs/day × 365 days/year). Batteries are approximately 85% efficient at storing electricity when drawn down deeply. This means that when batteries are charged from the grid in a nearby town, they will need 39 kWh/hr (33 kWh / 0.85) to deliver 33 kWh at the home. If the losses in electricity transmission and distribution are 20%, this is equivalent to 48 kWh/year at the power station. Multiplying this by 0.84 kg CO_2 kg CO_2/kWh for electricity generation (see hybrids baselines example below) gives 40 kg CO_2/year. Total emissions for the baseline are thus 296 kg CO_2/year.

3.5.2 Multi-project baselines

Multi-project baselines are aggregated baselines often associated with activities at a sectoral or sub-sectoral level. These baselines are also known as benchmarks, activity indicators or intensity standards. In the energy and industry sectors, the baselines can be measured by carbon intensity per unit service (e.g. tonnes of carbon per gigawatt hour). In the LULUCF sector they can be measured by carbon sequestered or emissions reduced per unit area (tonnes of carbon per hectare) for various ecosystem or species types. Examples of possible standards are shown in Table 3.4.

Table 3.4. Energy-sector emission reduction technologies and possible baseline standards
Source: Swisher (2001a)

Carbon reduction strategy	*Possible reduction technology*	*Units of technical standards*
	Power supply	
Supply-side fuel switching	Coal to natural gas	tC/MWh generated
Power plant efficiency	Raise steam pressure	GJ/MWh or % efficiency
Distribution loss reduction	Power factor correction	losses as % of generation
Renewable generation	Wind power	tC/MWh in power replaced
	Industrial use	
End-use fuel switching	Fuel oil to natural gas	tC/MWh used
Process efficiency improvement	Alcoa process	MWh/tonne produced
Manufacturing efficiency	Motor control upgrades	product-specific MWh/unit
Biomass energy use	Wood, sugar residues	tC/MWh in power replaced
	Commercial use	
End-use fuel switching	Fuel oil to natural gas	tC/MWh used
Lighting efficiency	Efficient lamps, ballasts, luminaires, controls	average lumen/W, W/sq. m for different light levels
Heating and cooling efficiency	Heat pumps	MWh/sq. m – ^{o}C-day
Equipment efficiency	Auto-shutoff computer displays	MWh/year normalised by size, equipment capacity
	Residential use	
End-use fuel switching	Electric to natural gas	tC/MWh used
Lighting efficiency	Efficient lamps	average lumen/W, W/sq. m for different light levels
Heating and cooling efficiency	Building shell upgrades	MWh/sq. m – ^{o}C-day
Appliance efficiency	Sfficient refrigerator	MWh/year normalised by size, equipment capacity
Solar heating	Solar water heater	tC/MWh in power replaced
	Agricultural use	
End-use fuel switching	Diesel to electric	tC/MWh used
Irrigation efficiency	Efficient pumps, pipes	MWh/cubic meter
Solar/wind pumping	Photovoltaic pumps	tC/MWh in power replaced
Biomass energy use	Crop residues	tC/MWh in power replaced

Multi-project baselines can encompass differing levels of geographical or sectoral aggregation. At each level of aggregation, the baseline can be based on historical data or on projected data. At a disaggregated level, for any given technology, sub-sector or country, a multi-project baseline may require almost as much detail as a project- specific baseline. The level of aggregation desired, and the CDM opportunities available, will suggest local, national, or regional benchmarks. The smaller the geographical focus, the closer to project-specific conditions and the more expensive it is to determine the baseline. Regional baselines for certain technologies could reduce the cost significantly, and at the same time decrease the uncertainty of CDM investors. For example, a regional conversion efficiency for traditional charcoal kilns could be used in all Southern African countries with miombo woodlands.

Multi-project baselines are potentially simple, transparent, predictable and low-cost for the project developer once they are established. Compared to other baselines, they may also reduce gaming tendencies by projects, once they have been developed by a neutral party and approved by government. The main problem for multi-project baselines is how to define the baseline emission comparison level, which is the reference scenario for the appropriate sector and geographic boundary. Should this level reflect the host country average or the regional average? Should it reflect the most recently installed technology, or marginal technology, or the best equivalent system already installed in the host country? Or should the baseline level be determined by the most economically attractive system? A detailed example of a multi-project baseline is presented at the end of the *Guidebook*.

3.5.3 Hybrid baselines

By standardising the value of one or more components of a baseline, or by standardising the method by which they are estimated, we can increase the transparency and comparability between baselines of different projects, and so reduce the time and cost of establishing baselines. Baselines generated by standardising some parameters are called hybrid baselines. Hybrid baselines can reduce the wide divergence of projected emission reductions observed in similar projects. They do not necessarily result in similar projects generating identical emission credits, because there will be project-specific variations of certain parameters as well as different circumstances in each country.

Hybrid baselines are less aggregated and less standardised than multi-project baselines designed for particular sub-sectors. For example, in LULUCF projects, the accumulation of soil carbon can be assumed to be the same (tC/ha/yr) for different projects in the same ecosystem, but the vegetation carbon accumulation will be estimated at a project-specific level. Local and regional variability of the different baseline components determines the extent to which standardisation is feasible. Some components used to calculate baselines can be easily standardised, others not. For example, fuel emission factors could have a high potential for standardisation of carbon dioxide projects in the energy/industry sector, while being project-specific for the other GHGs. The development of standardised components for hybrid or multi-project baselines is normally carried out by experts working within an accepted framework.

Box 3.4: Hybrid baselines example: solar home systems

Let us return to the earlier example of solar home systems, and look now at the displacement of grid electricity by a solar home system. It is not sufficient to look at the output of the system and ask how much carbon an equivalent amount of grid electricity would release. This is because the grid services that a typical rural household would receive – even considering the lighting and entertainment services only – are not the same as what a solar home system would deliver. For lighting, almost all electrified homes in South Africa use incandescent lighting, whereas the solar home system package would come with CFLs that use 75% less electricity for the same light output. Secondly, homes connected to the grid would typically purchase second-hand colour televisions that would draw from 80 to 120 W power. The direct current monochrome sets for use with solar home systems use only 20 W.

Correcting for the efficiency of the appliances, the relevant grid-connected home would use 238 kWh per year for lighting and entertainment, as compared to 63 kWh for the solar home system home. We then consider transmission and distribution losses, so that we can know total emissions from the power station. Assuming rural transmission and distribution losses of 20%, this means that 238 kWh at the home is equivalent to 280 kWh at the power station.

So far the baseline has been project-specific. But when we turn to the emissions from grid-electricity, we use a multi-project baseline approach. Since electricity moves throughout the grid, it is not possible to say that one particular plant would be displaced – we must look at the whole grid and how it is changing. There are at least three ways to look at this:

1. The average carbon emissions from all grid electricity generation in South Africa.
2. The carbon emissions from the most recent plant additions – the marginal plants that could be displaced by a new power source.

3. The carbon emissions from the next few capacity additions – because in reality, if demand grows, a new power source will replace projected capacity additions, not existing ones.

Research (Winkler et al 2001) has shown that the carbon emissions intensity for the above three scenarios are:

1. Average for all of Eskom's power stations: 0.88 kg CO_2/kWh (this includes a small amount of hydro and gas).
2. Average for recent additions: 1.08 kg CO_2/kWh (the Majuba power station final units).
3. Average for planned additions (1997-2005): 0.84 kg CO_2/kWh.

Using baseline option 3, total avoided emissions per year would be 235 kg CO_2.

3.5.4 Static and dynamic baselines

Baselines can either be fixed for the lifetime of the project or revised during the project operation. Static baselines have the advantage of being predictable, and therefore reduce the uncertainty surrounding the credits generated from a CDM project. They are also less of an administrative, monitoring, and reporting burden than dynamic baselines. Because they require only one estimate of a baseline, they have lower transaction costs. Their disadvantage is that they may be inaccurate because the system that they describe – whether electricity generation, transport usage, or industrial energy demand – changes over time.

Dynamic baselines are re-estimated at intervals during the project's life. Once they are revised, all emission reduction credits from that time onwards are claimed against the new baseline. This allows the baseline to reflect more accurately the current 'best estimates' for the key parameters. Policy factors can also lead to the need for baseline changes. If a country shifts its policy towards renewable sources of electricity, for example, the average emissions per unit of electricity generated will decline sharply. This would require a change of any previously established baseline. Dynamic baselines can be adjusted downwards if the environmental performance of the sector or process improves. They ensure the continuing environmental additionality of a project more consistently than static baselines.

Because dynamic baselines result in a greater level of investor uncertainty than static baselines, they may attract less CDM investment. However, this uncertainty can be reduced if investors know exactly when, after what time interval, and based on what factors, the baseline is to be re-calculated. In the rules for the CDM, project developers have a choice between baseline periods. They can choose either a fixed period of ten years, or they can choose a period of seven years, renewable twice (up to 21 years in total), but only after possible revisions to the baseline. Project developers therefore need to weigh up the relative risks of baseline options and crediting periods.

Box 3.5: Baseline options for electricity in Zimbabwe

As an example, let us look at what baseline options would apply to a project to displace grid electricity in Zimbabwe. A project-specific baseline would, as nearly as possible, look at the electricity the CDM project would replace in a specific plant – or the marginal plant. A range of multi-project baselines are possible: the average emissions for Zimbabwe, the average for the Southern African region, or even the average for industrialised country power sectors. A multi-project baseline could also look into the future, at the projected average emissions from Zimbabwe's power sector.

Table 3.4 gives the implications of these different choices. Where baseline emissions are highest, the amount of possible CERs from a CDM project will also be the highest. In this case using the marginal plant would give the greatest number of CERs (Herold et al 2000).

Table 3.4: Emissions from different baseline approaches for power generation in Zimbabwe (kg CO_2-equivalent/kWh, 2010)

Source: Herold et al (2000)

	Baseline description	*Emissions (kg CO_2 equivalent/kWh)*
Baseline A	Average emissions; country-specific present fuel mix	0.749
Baseline B	Average emissions; regional (SADC) present fuel mix	0.723
Baseline C1	Average emissions; OECD 1996 fuel mix	0.559
Baseline C2	Average emissions; EU 1996 fuel mix	0.391
Baseline D	Average emissions; business as usual future fuel mix (country-specific)	0.840
Baseline E	Marginal plant emissions; existing fuel mix	1.286
Baseline F	Marginal plant emissions; future fuel mix	1.066

Further resources

IPCC (Intergovernmental Panel on Climate Change) 1995a. *Greenhouse gas inventory workbook: IPCC guidelines for national greenhouse gas inventories*, Vols 1 & 2. Paris: IEA/OECD.

Makundi, W R 2001. Potential and cost of carbon sequestration in the Tanzanian Forest Sector. *Mitigation and adaptation strategies for global change*, 6(3-4): pp 335-353.

Sathaye, J & S Meyers 1995. *GHG mitigation assessment: A guidebook.* Environmental Science and Technology Library. Dordrecht: Kluwer.

Halsnaes, K, J M Callaway & H J Meyer 1998. Economics of GHG limitations: Methodological guidelines. UNEP Collaborating Centre on Energy and Environment, Roskilde.

World Bank 1998. GHG assessment handbook. World Bank Environment Department, Washington.

4
Financial and economic analysis of CDM projects

CDM project developers need a good understanding of how carbon credits affect the financial viability of their projects. A CDM project will generate more income than a normal investment, but it will also incur more costs, such as the cost of monitoring. This chapter explains how to estimate the financial impact of carbon revenue on an energy investment.

4.1 Components of the cash flow

The basic technique of financial analysis is to construct a cash flow reflecting all the costs and revenues relating to the project. The cash flow consists of the following components:

Capital costs

Capital costs are all capital expenditures required to establish the project. For large projects, capital expenditures may be spread over several years. Capital costs include both general investments and the purchase of equipment specifically to reduce GHG emissions. Future replacement and rehabilitation costs are also part of capital costs.

Operating costs

Operating costs are divided into fixed costs and variable costs. Fixed costs, also called overheads, are costs incurred regardless of how many units are produced – for example rentals, salaries, and depreciation. Variable costs are costs that vary with the project output – for example, the cost of more fuel to produce more units of electricity.

Revenues

Revenues depend on the nature of tariffs and other product and service prices. They may include initial fees, monthly fixed charges, and charges proportional to sales. For non-energy projects, revenues could include service charges and sales of products like timber. Income from the sale of CERs is also part of revenues.

Interest payments and depreciation

Depreciation must be accounted for in the overheads. If the discount rate used reflects the cost of capital (debt servicing costs + returns to equity investors), then interest need not be included separately – it will be incorporated into the discount rate. If we are estimating the internal rate of return, however, we should include interest costs in the cash flow.

4.2 Discounting

Money today is worth more than money in the future – and not just because of inflation. If I have R100 today, I can put it in a savings account and it will be worth (at 15% interest) R115 in a year's time. Generally, even without inflation, people prefer money today to money in the future. This is not just because of the possibility of investing money today, but also because of the risk of whether future payments will happen. Some special situations of very low or zero interest rates during deflationary periods have been experienced, but these are few and far apart. The time value of money can be expressed mathematically as a function of the discount rate (r). In the case of the R100 becoming R115, the discount rate was 15%. Discounting is used to express future sums of money in terms of a base year. In this way future sums can be converted to present value and vice versa. Suppose we incur a cost, V_n, in the future, n years from now. The present value of this cost, PV, can be expressed as:

$$PV = V_n / (1+r)^n$$

or in its continuous discounting form as:

$$PV = V_n e^{rn}$$

where: PV = present value of costs
r = discount rate
n = number of years
V_n = value in year n
e = base of natural logarithms

We can convert a series of values spread over a number of years, to a single present value. This can be expressed as the sum of the present values of each future value, which for a total of T years is:

$$PV_{all} = \sum_{1}^{T} PV_n = \sum_{1}^{T} \frac{V_n}{(1+r)^n}$$

The discount rate

The discount rate represents the time value of money. Each person or organisation has their own discount rate, depending on their time preferences and the marginal utility for money. These factors depend on what they can do with their resources. Government (social) discount rates are generally lower than private (market) rates. Large companies generally use their own discount rates for project analysis, and this rate reflects their opportunities, willingness to take on risk and perceptions of inflation. Interest rates at a bank should always be higher than inflation. The difference between the nominal discount rate and inflation is known as the real discount rate. Expressed formally, the real discount rate is:

$$r_{real} = (1 + r_{nom}) \div (1+ inf) - 1$$

where: r_{real} = real discount rate
r_{nom} = nominal discount rate
inf = inflation rate

If a nominal discount rate is used, all prices must be expressed in current terms, without adjusting for inflation. If a real discount rate is used, all prices must be expressed in constant terms, that is with adjustment for inflation.

Project lifetime and residual value

The project developer must choose a lifetime for the CDM project. Usually the lifetime chosen is the expected lifetime of the assets. If the lifetime chosen is longer than this, replacement costs must be factored in. In some cases, given appropriate maintenance and rehabilitation, assets can be useful for many years. The crediting lifetime of a CDM project may be limited to ten years or 21 years, according to the latest rules. At the end of the project lifetime, the assets will probably have a residual value, meaning they can still be sold on the market. If the project lifetime is reasonably long, this residual value can be ignored. If there have been asset replacements during the course of the project, the assets are likely to have a reasonable residual value.

For a LULUCF project, the project lifetime depends on the growth and use of the biomass. The rotation age, which varies among species (or even within species in different sites) is a key factor in determining project lifetime. Due to the impermanence of carbon sinks, determination of a LULUCF project lifetime must include a clear specification of post-project conditions and responsibilities among the stakeholders. There may have to be a clause for revocation of carbon credits if the carbon is released back into the atmosphere after the project ends.

4.3 Net present value and internal rate of return

Two indicators of the attractiveness of a CDM project for the investor are net present value (NPV) and internal rate of return (IRR). The NPV is the present value of all cash flows, all costs and revenues, over the lifetime of the project.

$$NPV = \Sigma(PV(\text{annual cash flow}))$$

The NPV is the total financial value created by the project. To calculate the NPV we need the annual cash flows and the discount rate. The cash flow each year reflects the net impact of the benefits (revenues) and costs in that year. A project is considered financially viable if the NPV is positive. Figure 4.1 shows cash flow over a five-year period.

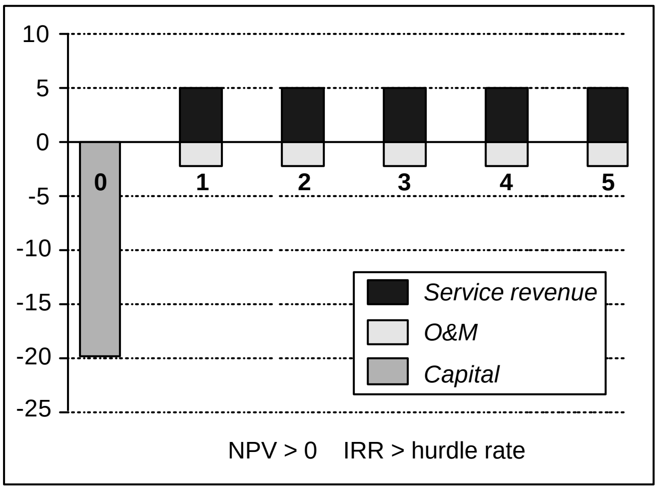

Figure 4.1: Typical project financial analysis

The discount rate which makes the NPV = 0 is the IRR. When the discount rate equals the IRR, NPV is 0, and discounted costs equal discounted benefits. The IRR is useful because it can be compared with the cost of capital for the investor. If the IRR of a given project is greater than the investor's target rate (the hurdle rate) then the project is attractive. An investor would not normally choose to invest in a project if its IRR was below the hurdle rate. The IRR is commonly used as a measure of the profitability of an investment. An IRR of 15% means that an investment of R100 gives a yield (in present value) of R15. Most spreadsheet software has formulae for automatically calculating these parameters.

Sensitivity analysis

To check the sensitivity of the results, it is important to vary some of the key parameters between reasonable limits. For example, one could vary capital costs between -25% and +25% of the basic assumptions, and vary sales levels and other key variables by a similar range. The analysis can be highly sensitive to discount rates, so it is also important to test the results across a range of discount rates.

4.4 Nominal (current) prices and real (constant) prices

The difference between this year's rand and last year's rand is made up of two different price movements. The first is the 'nominal' price change caused by inflation. The second is the change in real price after correcting for inflation. The real price change must be considered in any financial analysis using real discount rates. To compare cash flows from different time periods, economists use price indices. The most commonly used price indices are the consumer price index and the producer price index. A CDM project analysis should choose between using nominal prices with discount rates that include inflation, or real prices with real discount rates. Usually the financial analysis is calculated in current prices, using a nominal discount rate to translate future cash flows into their present-day equivalent. If we do not need to include interest payments or depreciation, the analysis can be done at constant prices using a real discount rate. Most of the examples in this book are in real prices and real discount rates.

4.5 CDM-specific costs and revenues

CDM projects have both additional benefits and additional costs. The additional benefits are the revenues from carbon credits, discussed in detail later in this chapter. The additional costs are the costs of developing a CDM project document and having it approved, plus the cost of monitoring and verifying the emissions reductions. All these costs affect the returns to the investor. Adding the additional costs and additional benefits changes the cash flow graph, as shown in Figure 4.2.

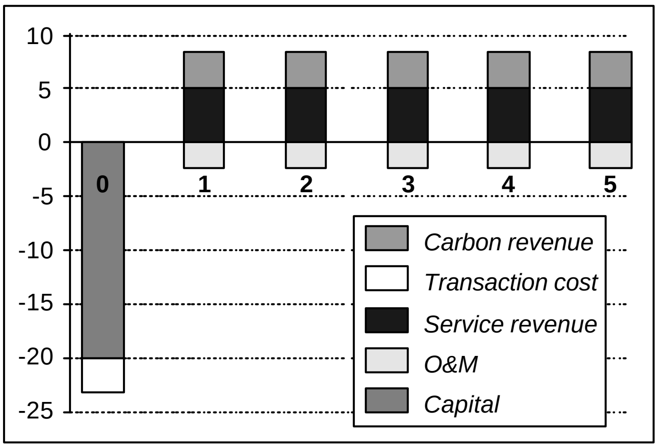

Figure 4.2: CDM project cash flows

If the additional CDM costs outweigh the carbon revenue, it would not make financial sense to invest in the CDM project. The project could still be attractive from a social perspective because of benefits like improved air quality, soil stabilisation, or water catchment services. Other benefits may compensate the project developer or the investor in other ways, such as tax rebates, subsidies, or amortisation of assets.

Transaction costs

CDM feasibility studies, baseline analysis, and monitoring and verification plans are all transaction costs that the project developer must bear. The time and money spent engaging with government officials to justify the project and seek project approval must be costed. These up-front transaction costs can be large. The evidence so far suggests that they can be in the range of thousands, even tens of thousands, of dollars. While some of these costs, for example the costs of developing the business plan, would be the same for a non-CDM project, many are extra costs associated specifically with the CDM eligibility process. There may be ways to reduce transaction costs by bundling smaller projects into larger ones, or spreading these costs over more CDM projects. The important thing is for the project developer to be realistic about the time needed to get the project off the ground. This time must be included in the financial analysis.

Monitoring and verification costs

A major additional cost is the cost of monitoring and verification. Project implementers do their own monitoring, but their results have to be verified by an internationally accredited operational entity. There is no way to avoid this cost. If a project is not properly monitored or the verification is not thorough, the CERs might not be valid. CER value will be directly related to investors' confidence that they represent real emissions reductions. The costs of monitoring vary according to the area of the project, the project scope, the methodology used, amount of training required, and other factors. Because CDM projects are still new, very few have had comprehensive monitoring, and it is difficult to estimate these costs. However experience in monitoring energy-efficiency projects and energy supply projects does provide some guidance.[4]

If a project already undertakes monitoring activities, the incremental costs of monitoring GHG emissions may be very small. For example, energy-efficiency projects monitored for performance contracting will already have a system in place to track energy savings, and the cost of converting this data into carbon savings data is negligible. LULUCF projects are normally monitored by management for biomass growth and health, and converting this data to CERs involves almost no further costs. A solar water heating project, on the other hand, would not normally be monitored for energy or water use. In this case, all of the monitoring costs will be additional costs which must be added to the CDM investment.

Carbon revenue

The main financial benefit of CER certification is that it generates carbon credits with a monetary value. For a given year, to calculate how much carbon revenue the project will receive, we use this formula:

Carbon revenue ($/yr) = carbon credits (tonnes/yr) × carbon price ($/tonne)

Annual carbon credits are calculated by:

Carbon credits = Baseline emissions – Actual emissions

For these formulas, other GHGs are converted to carbon dioxide-equivalence.

How much is each credit worth? A key parameter is the price of carbon for the project lifetime.[5] It is difficult to predict what carbon prices will be, because there is not yet a market for CERs. However, one can get an indication from the emerging market in generic carbon offsets and also from the market for carbon futures and options. These markets indicate a high level of uncertainty in carbon trading. This uncertainty, and factors like the opportunity cost of GHG mitigation in non-CDM activities, is reflected in the relatively low prices for carbon: $0.6 to $3 per tonne of carbon dioxide, according to one recent survey (Natsource 2000).

Sometimes international debates affect the carbon price. One such debate concerns whether Russia will be able to trade its potentially very large surplus emissions allowances (‘hot air’). The withdrawal of the United States from the Kyoto Protocol process will reduce the demand for carbon credits, and hence lower prices. Another factor is whether a short-term shortage of supply of CDM projects and JI projects will influence the price of carbon. The impact on the price that the host receives after 2% of the credit volume is deducted for the adaptation levy and administrative expenses, known as ‘share of proceeds’, is also significant. At this stage, therefore, project developers need to do their analysis with a wide range of carbon prices, probably ranging from $3 to $10 per tonne of carbon dioxide, and they should not depend on carbon revenue to make their projects viable. An example of this is shown in Box 4.1. Until

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4 Some analysts estimate that the whole monitoring, verification and registration package could be 5-10% of the total project budget, and up to 20% of the cost of pilot projects (Sathaye 2001; US DoE 2000). Energy efficiency projects monitoring costs are 0.5-3.0% of the project budget for initial set-up and 0.1-0.5% of the total annual cost (US DoE 2000). These percentages, however, are highly dependent on project size. Monitoring involves many fixed costs, which suggests that the total monitoring cost may be similar across a wide range of project sizes. The share of the project budget is therefore likely to be much higher for small projects.

5 Global economic models provide a wide range of estimates of future carbon prices, based on assumptions about the marginal cost of abatement in each country. The studies reviewed by the National Strategy Study for the CDM in South Africa predicted prices from under $10/tC ($2.7/tCO_2) to almost $40/tC ($11/tCO_2) (Goldblatt 2001). These models, however, do not include transaction costs, nor do they reflect the rules about additionality or project eligibility. These could all reduce the size of the carbon market, but whether they would force prices up or down depends on the relative market power of buyers and sellers of CERs. A series of bottom-up and top-down modelling results surveyed by Bailie et al (2001) indicated some consensus on a price of roughly $20/tC ($5.50/tCO_2) for a market size of 440-480 MtCe. Again most of these studies do not reflect the transaction costs associated with CDM projects. More importantly, neither of these surveys reflect the loss of the largest buyer of CERs – the USA – from the market, since the USA withdrawal from the Kyoto Protocol in April 2001. The loss of USA demand for CERs and other carbon credits is likely to weaken prices.

the rules are clearer and the carbon market develops, it is best to view carbon revenue as a bonus rather than as the driver of an investment. This should change once the market becomes more stable.

Will carbon revenue make non-viable projects viable? If not, how will CDM projects create emissions reductions that 'would not have happened' otherwise? What is the link between risk, levels of return, and additionality? These are important conceptual questions regarding the CDM. There are no simple answers, because rates of return vary widely depending on the nature of the project and the competitive conditions (see Table 4.1). What is sufficient return for a stable economic environment with a proven technology will be insufficient for a riskier location with newer untried technologies. Many of the technologies that could be used for CDM projects are new. They represent greater risks, or greater perceived risks, for investors. Some renewable energy technologies, for example, face risks of small size, location, technology, dispersed customer bases, and lack of creditworthy customers.

Table 4.1: Economic viability of CDM projects
Source: Swisher (2001b)

Projects with negative rates of return	Clearly not viable without concessional financing resources or carbon offsets available Offset cost would be expensive
Projects with rates of return below normal market threshold	Probably not viable without concessional financing resources or carbon offsets available Offset cost would be moderate
Projects with rates of return above normal market threshold, but below risk premium for project type, technology, and country	Marginal with private finance only, viable with concessional finance or carbon offsets available Offset cost would be inexpensive
Projects with rates of return above normal market threshold, including applicable risk premium	Viable with private finance only; concessional finance unnecessary Carbon offsets precluded by lack of additionality

Box 4.1: Wind power as a CDM project

Some of the concepts in this chapter can be illustrated by the following example of a proposed small wind power station facility.

General description and technical data
The proposed project is a 5 MW grid-connected wind power facility, with a capacity factor of 33% and an annual output of 14 450 MWh. The economic life of the project is 25 years.

Baseline
Let us use a multi-project baseline, which makes sense for a grid connected electricity generation project. The wind power station will feed into the electricity grid, so we should look at what emissions from grid electricity in South Africa could be displaced. Since electricity moves throughout the grid, it is not possible to say that one particular plant would be displaced – we must look at the whole grid and how it is changing. There are (at least) three ways to look at this:

1. The average carbon emissions from all grid electricity generation in South Africa.
2. The carbon emissions from the most recent plant additions – the marginal plants that could be displaced by a new power station.
3. The carbon emissions from the next few capacity additions. If demand grows, the wind power station will replace projected capacity additions, not existing ones.

Research has shown that the carbon emissions intensity for these three scenarios are as follows:

1. Average for all of Eskom's power stations: 0.85 kgCO_2/kWh.
2. Average for recent additions: 1.08 kgCO_2/kWh.
3. Average for planned additions (1997-2005): 0.84 kgCO_2/kWh.

The project developer would motivate for baseline scenario 2, because this would yield the largest number of CERs.

Emissions for project scenario
None. There are no GHG emissions from wind power generation.

Estimated credits
The wind power facility will generate 14 450 MWh per year. Emissions savings from the three baseline scenarios are therefore:

1. 14 450 000 kWh x (0.85 kgCO_2/kWh – 0 kgCO_2/kWh) = 12 292 tCO_2 per year.
2. 14 450 000 kWh x (1.08 kgCO_2/kWh – 0 kgCO_2/kWh) = 15 630 tCO_2 per year.
3. 14 450 000 kWh x (0.84 kgCO_2/kWh – 0 kgCO_2/kWh) = 12 080 tCO_2 per year.

Financial analysis of project without CDM
Let us assume that the project developer can sell the electricity for 20 c/kWh (all figures in rands unless otherwise stated, and let us assume an exchange rate of R10=$1). The capital cost of the technology is R10 000/kW, for a total investment cost of R50 million. We assume that the annual operating and maintenance costs are 1.5% of the capital cost, or 3.6 c/kWh (R50m x 1.5% = R525 000 / 14 450 MWh = 3.6 c/kWh). For this example, let us include a donor capital grant of R20 million to buy down the capital costs.

Using a spreadsheet model, and simplifying the analysis to ignore corporate taxes, we find that the real IRR for this project, without considering carbon benefits, would be 6.1% – this is including the capital grant. This is probably well below the hurdle rate for most investors.

Financial analysis with CDM
For the CDM part of the financial analysis, we need to consider additional benefits (carbon revenue) and additional costs (developing the project and monitoring and verifying the emissions reductions). For carbon revenue, let us assume two scenarios with carbon prices of $3 and $10 per tonne carbon dioxide (R30 and R100) respectively, over the life of the project. (Some analyses suggest that prices may start low and rise over time, but for this example we will simplify to a steady price). The annual carbon revenue for each of the three baseline scenarios then works out as follows:

1. 12 292 tCO_2 per year x R30 – 100/tCO_2 = R0.37 – R1.23 m/year.
2. 15 630 tCO_2 per year x R30 – 100/tCO_2 = R0.47 – R1.56 m/year.
3. 12 080 tCO_2 per year x R30 – 100/tCO_2 = R0.36 – R1.21 m/year.

These three different baseline possibilities illustrate how different choices impact on carbon revenue.

It is relatively easy to track emissions reductions from grid-connected power supply, as long as the baseline is clear, so let us assume that monitoring and verification costs are 5% of the capital cost spread over the life of the project. This amounts to R100 000 per year (i.e. R50 000 000 × 5% ÷ 25 years = R100 000/year). We have not included other transaction costs, such as the costs of developing a CDM proposal and steering it through the government approval process. This is largely because these costs are so uncertain, but also because some concessionary funding for pilot projects is available.

IRR with and without CDM project
As we showed earlier, the IRR for this project, without making it into a CDM project, would be 6.1%. The table below shows the IRR given different assumptions about baselines and carbon prices. Not surprisingly, the price of carbon has a significant impact on the change in the IRR. At $3/tonne CO_2, the increase in IRR from carbon revenue – offset by monitoring and verification costs – is quite small.

Table 4.2: Impact of carbon prices and baselines on IRR

	IRR at alternative prices of carbon	
Baseline	*$3/tonne CO_2*	*$10/tonne CO_2*
1. Average for sector	7.3%	10.8%
2. Recent additions	7.7%	12.0%
3. Recent and projected additions	7.2%	10.7%

Another way to illustrate the impact of carbon prices is to ask how much they affect the net cost of generating electricity. The table below illustrates the change in the costs of generation from carbon revenue (without additional monitoring costs) given different carbon price and baseline assumptions. As a benchmark, typical wholesale electricity prices in South Africa are 10c-11c/kWh, while residential tariffs are around 30c/kWh.

Table 4.3: Impact of carbon revenue on cost of generation (SA c/kWh)

	Price of carbon	
Baseline	*\$3/tonne CO_2*	*\$10/tonne CO_2*
1. Average for sector	2.6	8.5
2. Recent additions	3.2	10.8
3. Recent and projected additions	2.5	8.4

4.6 The financing structure

In the example above, we assumed that all of the money to finance the CDM project came from equity investors. In reality, a wide range of financing options and structures can be used for CDM projects – loans, grants, leasing arrangements, and use of third party and government guarantees. While an analysis of the impacts of all these on CDM project viability is beyond the scope of this book, a few points are worth mentioning.

Using any finance other than equity can have a significant effect on the IRR, because this compares the annual profits to the initial equity investment rather than the total capital investment. If the project owners only invest a small amount of their own money, securing the rest of the capital through grants or inexpensive loans, their IRR will increase, even without a change in annual profits. Of course they would have to pay interest on the loans, which would offset the benefit of putting in less investment.

Where there is less equity investment by a project owner, the relative impact of carbon revenue is greater. An example would be a CDM project that received a host government grant that covered much of the capital cost. Because it is a grant and not a loan, the project owner would not pay interest. The project owner's equity would be relatively small, so even a moderate carbon revenue could significantly raise the IRR.

4.7 Credit sharing and carbon prices

Many developing countries have argued that they, as host countries, should also get a share of the CERs from CDM projects. Developing countries do not have emissions reduction targets, so it may be difficult for them to own, sell or hold onto their share of CERs. Currently there are no provisions in the Kyoto Protocol to allow developing countries to bank their credits for use against future commitments, in the way that industrialised countries can. Some stakeholders in Africa have raised the concern that if developing countries gave away all of the credits for inexpensive projects they would have difficulty meeting future commitments. They argue that even if developing countries did not bank their credits, they should be allowed to sell their share of CERs on the world market to raise funds for development.

Credit sharing cannot be separated from the cost of credits, since this cost is based on both the investment and the credits arising from the investment. An example from an AIJ project demonstrates this point. A coal-to-gas boiler conversion AIJ project was established in Decin, Czech Republic (JIQ 1995). The project included two emissions reduction components: switching the fuel of district heating boilers from coal to gas, and co-generation of electricity and heat from gas. Three US electric utilities then invested \$600 000 out of a total project cost of \$9 058 000. The total emissions reductions from the project were 608 952 tonnes CO_2, with 133 829 tonnes from the fuel switch and 475 125 tonnes from setting up co-generation.

As Table 4.4 shows, the cost of the credits depends on which investment generates which credits. The investors could argue that without their incremental investment, the project would not have happened. According to this logic, the investors should receive all of the credits, which works out at a cost of \$0.99/tonne CO_2. The host, on the other hand, could argue that credits should be divided in proportion to investment. If \$9 million dollars produces 600 000 tonnes of emissions reduction, then every tonne costs \$14.87. According to this line of reasoning, the US investors should receive only 40 336 tonnes of emissions reduction credits for their $600 000. To make matters more complicated, if the global market price for carbon was $3 per tonne of carbon dioxide, the investors would want at least $600 000/$3 = 200 000 tonnes of emissions reduction credits, which is much greater than the amount based on their share of the investment.

Table 4.4: Impact of credit sharing on investor cost of credits

Carbon credits received (tonnes CO_2)	*Cost per tonne of credits ($/tonne CO_2)*
608 952 – total	0.99
133 827 – due to fuel switch	4.48
475 125 – due to co-generation	1.26
40 336 – based on share of total investment	14.87

Further resources

General financial and economic analysis

Davis, M & T Horvei 1995. Handbook for the economic analysis of energy projects. Energy and Development Research Centre, University of Cape Town.

Examples of CDM project analysis

Meyers, S, J Sathaye, B Lehman, K Schumacher, O van Vliet & J Moreira 2000. Preliminary assessment of potential CDM early start projects in Brazil. Lawrence Berkeley National Laboratory, Berkeley.

Spalding-Fecher, R, H Winkler & L Tyani, 2001. Economics of CDM – Training materials. Available at www.edrc.uct.ac.za.

Climate change mitigation project financial and economic analysis

Clark, A & R Spalding-Fecher 1999. Financial protocol for South Africa's climate change mitigation assessment. Energy & Development Research Centre, University of Cape Town.

Sathaye, J & S Meyers 1995. *GHG mitigation assessment: A guidebook.* Environmental Science and Technology Library. Dordrecht: Kluwer.

Halsnaes, K, J M Callaway & H J Meyer 1998. The economics of GHG limitations: Main reports – Methodological guidelines. UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark.

5
Carbon revenue, investor risk, and attracting CDM investment

Risk analysis and risk management are part of any business venture. If risks can be managed, the investor breaks even; if some risks do not materialise, the investor makes more profit. The market value of CERs depends on 'additional' emission reductions that have to be independently verified. The investor has to therefore include technical and qualification risks in any calculations. The future value of CERs is reduced by the risks of credit qualification and technical success, which both lower the present values of emission reductions (Edwards 1999).

Risk cannot be avoided, but it can be estimated. Suppose, for example, that investors seeks to purchase future CERs for a coal-bed methane extraction project. The investors estimate that 500 000 tonnes of carbon dioxide-equivalent emissions reductions can be generated over the project's ten-year lifetime. They estimate the probability of technical success of the project is 75%, that 65% of the estimated GHG emissions reductions will qualify for CER crediting, and that the average market value of a CER over the project lifetime will be \$10/tonne of carbon dioxide in real terms. What price could the investors offer the project developer? Let us simplify the calculation by assuming that the CERs are all delivered ten years in the future. The current value of CERs can then be calculated:

$$CV = \frac{(FV \times Q \times n \times P_{success} \times P_{qualify})}{(1+r)^n}$$

Where: CV = current value (\$)
FV = future value (\$)
Q = Annual quantity of CERs (tonnes)
$P_{success}$ = probability of technical success
$P_{qualify}$ = probability of credit qualification
r = discount rate
n = time in future when credits are delivered (n)

For this example, let us assume these values:

FV = \$10/tonne
Quantity = 50 000 tonnes
Probability of technical success = 0.75
Probability of credit qualification = 0.65
r = discount rate =10%
n = 10

$$\text{then } CV = \frac{\$10/\text{tonne} \times (500\,000 \text{ tonnes}) \times (0.75) \times (0.65)}{(1+0.10)^{10}}$$

$$= \$2\,437\,500 \div 2.59 = \$940\,000 \text{ or } \$1.88/\text{tonne}$$

This calculation shows that if the investors use a real 10% discount rate, they will offer no more than $1.88 per expected CER today for the future right to the credits. The calculation takes into account the time-value of money, by discounting future revenues against the prevailing discount rate. In reality, however, a portion of the CERs would be sold each year. If we assume that an equal amount is sold each year, then the amount the investors would be willing to pay is given by the following equation:

$$CV = \sum_{1}^{t} \left[\frac{(FV \times Q \times P_{success} \times P_{qualify})}{(1+r)^{n}} \right]$$

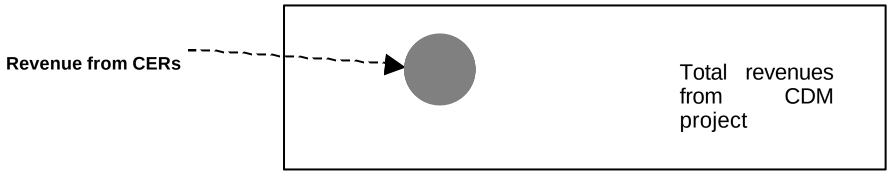
Where: T = number of years the project will deliver CERs
and all other variables are as defined as above

For this example, the resulting price paid for the CERs works out to $3.00 per tonne. It is higher because the investors get more of the CERs sooner. If the probabilities of technical success and qualification were 100%, the value of the CERs would be $6.14 – double the price when risk is included. This points to the need for project developers to do a careful sensitivity analysis, and to understand how these risks can be quantified and mitigated.

5.1 Risk management planning

What types of risks will CDM projects face? How can project developers avoid their negative impacts? CDM projects can generally be classified as high risk because of the unique risks of GHG emissions trading, over and above the standard financial risks of any commercial venture. Standard financial risks include changes in inflation and interest rates, energy and forest product prices, taxes, changes in land use policies and commercial factors affecting forest products. A risk mitigation plan, showing how these risks are to be managed, must therefore be included in any feasibility study. Risk mitigation management involves identifying the range of risks and evaluating their relative importance with regard to both revenues and technical performance; developing strategies and instruments for avoiding, mitigating, sharing or transferring risks; monitoring risks over the project lifetime and putting in place mechanisms for crisis management; documenting performance and actions during the course of the project for insurance and legal purposes

The risk mitigation plan will depend very much on how strongly carbon revenues influence total revenues. The greater the carbon revenues, the higher the risks that are unique to the CDM project (See Figure 5.1). Consider, for example, the risks regarding the retrofitting of streetlights in a large municipality. Carbon revenues here are likely to be small, as the benefits will flow mainly from energy savings and other cost savings. But when carbon reduction is a larger share of the revenues of a project, the risks are higher. An example would be the recovery and flaring of landfill methane gas, or using the methane for an industrial process. Another larger share example would be a land-use project without commercial forest products, which might have almost 100% of its revenue coming from carbon credits.



A: Street lighting retrofit

B: Landfill methane recovery and flaring

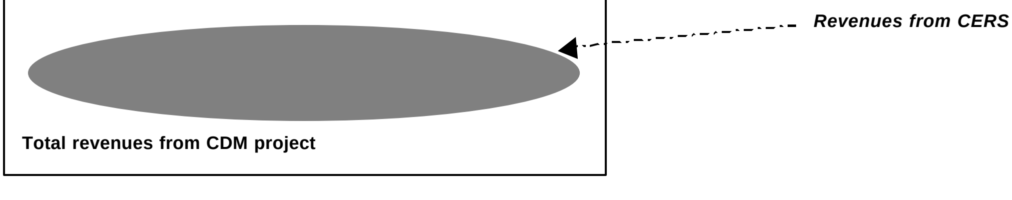


Figure 5.1 Relative importance of CERs to total project revenue

5.2 Key risks facing CDM projects

CDM projects face a great variety of risks. These include: changing global climate change policies, lack of coherent national policies, uncertain CER market values, political risks, environmental risks, inability to predict operating and transaction costs, and cash flow difficulties. Perhaps the most complex risks are legal risks, as the framework for CDM property rights is still evolving. All these risks have to be added to the traditional risks of project finance and joint ventures between parties in different countries. Project risk profiles change over time.

- **Technical risks:** Lower than expected technical performance results in fewer emission credits. Technical risks include the type of technology used (or species, for forest projects), climatic variability, scheduling delays, availability and quality of contractors and labourers, access to materials and spare parts, cost overruns, problems related to the use of new technology, and natural or human-caused calamities such as forest fires, pests, diseases, and floods.
- **Policy risks:** These are risks arising from policy shifts at both national and international levels. At national level, environmental regulations or energy policies could change dramatically – examples are levels of subsidies on fossil fuels, new regulations for emission standards, and tax changes. Such changes could render a project 'non-additional', and hence ineligible, even in the short period between design and approval. They could also prevent the project from being implemented. Even after a project has been approved, policy shifts could affect the validity of a particular baseline and reduce future credits.
- **Market risks:** These risks are tied to fluctuations in the carbon market, such as average prices for CERs and related emission credits. If there are large time gaps between an initial investment and the final sale of CERs, price fluctuations and the effects of market distortions such as collusion could dramatically affect carbon revenue. The price for CERs can also be significantly affected by speculation in the futures market for carbon.
- **Liability risk:** One of the parties – investor, seller, or independent certifier – has to be legally liable for errors in the calculation of emission reductions or any fraudulence in reporting. Much of this liability risk would shift from developer to certifier after the verification/certification process. However, if too much liability is placed on certifiers, a robust market for CERs is unlikely to develop. Liability risk also includes the unlikely possibility that a CER transaction is invalidated due to lack of compliance by one of the governments involved in the CDM project. If a country is not complying with its Kyoto Protocol obligations, CER transactions may be invalidated.
- **Credit risk:** The creditworthiness of the parties regarding loans, bonds, guarantees, leases, and insurance policies is a potential risk. For example, a contractor in an engineering, procurement and construction contract may require that the borrower make available cash guarantees before implementing part of the CDM project. The creditworthiness of the purchaser or broker is therefore an important factor for the developer to consider.
- **Country/political risk:** These risks are associated with major political changes or other country-specific characteristics. They cannot be anticipated or controlled, and they can result in significant economic loss. Examples of such risks are: the expropriation of property; the imposition of new taxes, tariffs, or export restrictions; currency devaluation and foreign exchange restrictions; taxes on repatriation of profit or debt servicing; and corruption. Country risk can also include differences in the legal and business systems in the two countries. Mitigation of this risk depends largely on the investor's knowledge and experience of the working environment of the host country.
- **Environmental, health and safety risk:** This risk comes from adverse impacts on the environment, whether intended or not. It includes the occupational health and safety of the employees of the CDM project. Environmental costs may include: fines and penalties for pollution, the cost of preparing an environmental impact assessment and obtaining any

necessary permits, cleanup costs for contaminated sites, and the costs of an environmental audit. Environmental impact assessments usually include provisions for adverse environmental impacts and estimates of the likely costs of those actions.

- **Qualification risk:** This risk would include reducing the crediting lifetime of the project due to policy changes or methodological uncertainties in measuring GHG reductions. Another possibility would be a CDM project becoming ineligible for crediting after it has commenced but before it is formally approved.
- **Force majeure:** This refers to any unforeseen natural disasters – lightning, earthquakes, floods, fires – that could seriously jeopardise the success of the project, or lead to major liability for the developer. The surest way to mitigate force majeure risk is through insurance coverage, although technical measures such as fire protection can somewhat reduce the risk. The insurance is relatively inexpensive and may in any case be a requirement for borrowers of third party finance.

5.3 The risk mitigation matrix

The confidence of investors increases if the developer demonstrates a proactive attitude toward mitigating risks. A risk matrix is a useful tool to demonstrate this. It should include the following elements:

- the categories of risk in question;
- the exact nature of the risks;
- which parties are most affected by the risks;
- all mitigation strategies adopted to counter those risks;
- the financial or other consequences of any mitigation instruments and strategies.

Table 5.1 lists common risks facing CDM projects through various examples. The last column proposes instruments or strategies for mitigation.

Table 5.1: Example of risk mitigation matrix

Type of risk	*Examples*	*Risk mitigation instruments*
Technical risks	Construction and/or operating costs are higher than expected due to inexperience or complications with use of new technology. Delay in implementation due to lack of availability of raw materials or spare parts and/or unreliable contractors.	Performance Bonds and completion guarantees by suppliers, contractors, and sub-contractors. Commercial & export credit guarantees. Incentives incorporated into contracts for timely completion.
Market risk	Estimated carbon values used in financial models are too high, resulting in insufficient cash flow for ongoing project implementation. Global economic and technological growth is slower than expected, reducing the market price of CERs.	Development of more reliable market forecasts and carbon revenue models. Hedging or 'locking in' of future CER prices through financial derivatives, although a fixed contracted price could also be lower than future market values.
Liability risks	An error in emission reduction calculation is discovered and challenged after a project has been certified and CERs have been transferred. Host country non-compliance with UNFCCC/Kyoto Protocol regulations Investor country non-compliance with emissions reduction commitments, and possible trading restrictions.	Explicitly distribute liability risks in contractual arrangements. Government to enact national legislation outlining liability of independent certifiers. Specialised emissions reduction insurance. Financial derivative structures such as forwards and options.
Political/	Host country revokes CDM project	Memoranda of Understanding with host

country risk	approval without sufficient cause. Host country joins Annex I of the UNFCCC, rendering all CDM projects invalid. Destruction of project due to political uprising or related local tensions.	country government. International political risk insurance. Commercial insurance and export credit guarantees. Local licensing or registration of the project and buy-in of local stakeholders through public participation and local content and labour. Participation of international or bilateral investment agencies, such as the World Bank, Multilateral Investment Guarantee Agency, and Overseas Private Investment Corporation. Portfolio approach on the part of carbon investors.
Environ-mental, health & safety risk	Contamination discovered on project site prior to implementation. Project approval by host country or CDM Executive Board withdrawn after evidence of negative environmental impact or threat to cultural heritage. Sub-contractor violates existing permitting requirements or causes a toxic spill.	Understanding of the legal framework and any legislation governing environmental liability that relates to project. Covenants and indemnity clauses inserted into contracts. Require that an environmental procedure or audit is a condition for making available co-financing or other services. Environmental risk insurance. Force Majeure insurance and covenants in contractual arrangements. Environmental performance bond posted to municipality or province. Specialised emissions reduction insurance.
Qualifi-cation risk	Fewer than expected emission reductions are verified and certified as CERs than are technically achievable. Possible 'discounting' of CERs to CDM projects because of large methodological uncertainties in offset measurement. Delay in certification of project's emissions reductions, resulting in fewer than expected CERs.	Third-party verification of emission reductions and validation of baseline and key methodological assumptions prior to certification by CDM Executive Board as required by CDM rules – this can mitigate other risk categories as well. Lobbying of policy-makers and environmental negotiators. Specialised emissions reduction insurance.
Force majeure	Project destroyed in natural disaster, such as severe flooding.	Specialised insurance. Covenants and indemnity clauses inserted in contracts.

5.4 Emissions reduction insurance

New types of insurance tailored to cushion the unique risks of carbon projects are emerging as the carbon trading market begins to mature. This insurance can be used to guarantee the value of CERs sought by an investor, making it easier for a co-financier to commit to a CDM project. The exact nature of these insurance policies depends on the risk addressed and on who takes out the policy. The insured party could be the project developer, the investor, a government body, or an enterprise conducting a voluntary emissions limitation programme. One US company, Aon Environmental Solutions offers project developers coverage that guarantees transfer of a minimum amount of carbon credits from a particular CDM project to their credit buyers (*Environmental finance* 2000). Aon and other insurance houses such as Swiss Re and Munich Re are developing new insurance coverage to reduce policy and country risks linked to CDM projects. These are marketed mainly to potential CDM investors.

A different insurance strategy would be to assemble a diversified portfolio of CDM projects and use this to create a CER reserve fund. This way the country or investor would be self-insuring themselves by keeping some CERs in reserve in case particular projects within the portfolio were not successful.

5.5 Other risk mitigation strategies

A low-cost and effective strategy to mitigate a wide range of risks is to ensure local participation and endorsement of a CDM project. Such a strategy would include lobbying, public hearings, training and capacity building, sourcing a large percentage of local content and labour, and building local incentives into the implementation and monitoring stages. Sharing the CERs from the project with the local community should also reduce the risks. Structuring CERs as options can limit qualification risks to the project developer. This does mean, however, that lower revenues from the carbon abatement component of the CDM activity are likely. A project developer may guarantee delivery of a minimum level of CERs to an investor. If more CERs are produced, the developer may reserve the right to cancel the agreement once the minimum has been fulfilled. Alternatively, a contract could be structured so that the investor receives the first allotment of CERs (an annual amount up to a specified date), after which any CERs produced become the property of the project developer and/or the host country government. Project developers could try to get written assurances from the host country government that no taxation will be applicable to CER transactions for a specified limited period. Better still, they could try to get a permanent tax exemption.

5.6 Legal and contractual issues

GHG credits are a new business paradigm. Legal frameworks for investing and trading in emission credits are not yet developed, either nationally or internationally. In the absence of clear laws and policies concerning property rights of emissions, investors and project developers face risks concerning the legal ownership of carbon credits (Petsonk 2000). In this sense all CDM projects face high legal risks. These risks can be hedged by negotiating contracts on carbon credit ownership as early as possible in the project. Currently there are no standard procedures, although NGOs, governments, and lawyers have proposed a number of formulae. The parties concerned must negotiate an equitable allocation based on the proportions of finance involved, including contributions in kind. But such contracts should not define the emission reduction credits too narrowly, in case policy changes and emissions assets other than CERs become important (Danish & Rotter 2000).

Contracts that set out ownership and transferability of emission credits may exist between two or more private entities, and may also involve governmental entities. In fact, early inclusion of government entities would lower the risk of future disputes between government and investors over the eventual assignment of emission rights. In drafting these contracts, parties may be able to use elements of traditional business contracts such as joint venture agreements, build operate and transfer contracts, risk service contracts, and government concessions to private industry (Worika & Waelde 2000). They may also be able to draw on the large number of energy service agreements and performance contracts for energy service projects.

The parties drawing up the contract need to stipulate exactly how emissions credits will be achieved, and with whose technical and financial resources. The rights and obligations of each party should be clear. These rights may include the option to sell CERs to third parties or to the secondary market for emission credits (Danish & Rotter 2000). The contract should take into account legal frameworks and statutes in both the host country and the investing country. Finally, the contract should specify the insurance coverage on the project, and include information on the risks and terms of the insurance coverage. A developer may be able to secure 'title insurance' to protect against conflicting claims of ownership (Petsonk 2000).

As for any international business transaction, an increase in the number of investors, transferors, and transferees greatly increases the legal complexity. Contracts for emissions credit transactions should therefore clearly stipulate the location, legal system, and governing rules for the adjudication and resolution of disputes between the parties. The legal frameworks of the host country should be examined to ensure that these agreements will not be overruled (Petsonk 2000). As a final resort, a mediator like the International Centre for the Settlement of Investment Disputes or an academic institution can be specified.

None of the above suggestions are meant to replace professional legal advice. Legal and contracting issues for CDM projects are complex and are likely to increase in importance over time as the market matures and the potential for disputes between parties grows.

5.7 Attracting CDM investment

CDM projects can attract investment from two sources – finance for conventional or traditional outputs (such as electricity or timber), and finance for the carbon credits, the CERs. Given the current poor liquidity of the carbon credit market, investors are more likely to be interested in traditional finance, with CERs seen as a possible bonus. As the carbon market matures, however, specialised carbon investors may emerge with the CERs as their primary motivation.

The first step toward securing third party finance is an investment profile. This is both a marketing tool and a preliminary feasibility study. It should demonstrate in a concise way (no more than five pages) that the project is financially and technically feasible, a relatively safe investment which will generate a solid return. The investment profile should include a brief market assessment. For example, if the CDM project involves the installation of solar home systems in rural areas, the investment profile should include a forecast of the size of the market, current demand for electricity, market penetration rates, and consumer willingness to pay. There should be some explanation of the technology, its cultural appropriateness and its likely acceptability. Finally there should be a description of how the infrastructure will be maintained and and serviced. In compiling the investment profile, the project developer should be conservative, avoiding understating of costs and not being over-optimistic about benefits. Two financial analyses should be presented – one with and one without the carbon revenue. The investment profile should include a preliminary sensitivity analysis showing how emission reductions might change under different assumptions and inputs.

Some examples of sensitivity analysis would be:

- If the price of electricity were to increase by, say, 15% because of forthcoming power sector restructuring, how would this affect the emissions reductions predicted?
- If average wind speeds used to predict wind power generation capacity to displace coal-fired electricity were too optimistic, what effect might this have on avoided emissions?
- If 25% of the predicted emission reductions became ineligible due to changes in the approved baseline or some other assessment factor, how would that affect the NPV of the project?

The investment profile is not the same as the project design document. They contain similar information, but not in the same presentation. The project design document follows an official format and aims to provide the essential information for government, the CDM Executive Board, and Operational Entities to assess the project's compliance with international and national CDM guidelines. The investment profile, on the other hand, aims to secure interest from potential investors and convince them of the financial viability of the project. The investment profile should be tailored to the needs of the targeted investor, but a basic format can still be followed. A number of organisations, including the World Business Council for Sustainable Development, have put forward templates for investment profiles. The following format is based on one by Trexler and Associates, a US-based emissions brokerage house:

SAMPLE INVESTMENT PROFILE

I. Project name, location, and sponsors

- Contact information
- Roles of various sponsors
- Basic background information and qualifications of sponsors

II. Project description

- History of project
- GHG mitigation potential
- Technology to be employed
- Market assessment

III. Monitoring & verification plans

- Strategy for monitoring GHG emission reductions over the project lifetime and independent verification of reported savings

IV. Project status

- Status of development, feasibility work, funding, sponsorship, government approval, AIJ/CDM project approval

V. Development impacts

- Description of how project contributes to sustainable development in host country
- Estimation of non-GHG related environmental and social benefits

VI. Expected emissions reductions over project lifetime

- Provide a table or spreadsheet if GHG emission reductions differ annually
- Specify exact measurements to be used (tonnes of carbon dioxide equivalent)
- Supply conversion factors used to change other measurements (e.g. energy savings) to carbon dioxide equivalent emissions

VII. Baseline and additionality assumptions

- Explain how baseline emissions and emission reductions were calculated. What assumptions were made and why?
- References to figures provided and experts consulted for calculations
- Include validation report on baseline if available, as well as any decisions on future revisions of baseline

VIII. Timeframe/delivery date

- Anticipated years of CER delivery and time needed to bring project to implementation phase once funding is received.

IX. Project costs and revenues over time

- Provide a table or spreadsheet with cash flow analysis
- State any relevant financial metrics: NPV, IRR, net revenues, discounted payback periods
- Financial assumptions used (inflation, exchange rates, interest payments)

X. Cost efficiency evaluation[6]

- Net present value of project costs
- Project cost per tonne of reduced/sequestered carbon dioxide
- Provide discount rate and project lifetime assumptions.
- Sensitivity analysis of credits delivered and the costs of those credits given possible changes in financial costs, baseline revisions, and technical performance of project

XI. Terms and conditions

- If offering carbon offsets for sale at a specific price, state the desired price or price range per ton of carbon dioxide

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[6] This will depend on the share of project costs expected to be covered by a carbon offset investment and the percentage of the resulting emission reductions whose title is transferred to the outside investor.

- State the largest and smallest increment of offset that can be purchased.
- Basic terms and conditions of sale (including preferred transaction structure).

5.8 The feasibility study

While the investment profile is a tool to market the project, the CDM feasibility study contains a much more detailed assessment of the project's potential and risks. It provides in-depth information on financial returns, methodology, and assumptions used to estimate GHG emissions reductions. For the feasibility study, the sensitivity analysis of the investment profile should be expanded to include more variables. Other financial information, such as a cash flow analysis and a risk mitigation plan, should also be presented. A feasibility study should include a budget for all the stages of implementation. This is more detailed than the CDM project cycle presented earlier, because it includes a range of activities that the project developer must undertake in parallel with the official UNFCCC process:

- project identification, screening, facilitation, and contracting;
- preparation of feasibility study, marketing profile, and technical assessment;
- due diligence and environmental impact assessments, if necessary;
- project approval by host country and CDM Executive Board;
- negotiation of any relevant contracts, such as energy sales or savings performance contracts;
- obtaining of financing;
- detailed project design;
- construction, equipment delivery and installation, and implementation;
- ongoing operations and maintenance;
- monitoring, verification, and certification; and
- loan servicing costs.

5.9 Sources of financing

The range of possible investors in CDM projects is broad because of the many different motives for the investment. Investors could be any of the following:

- national governments, especially governments of industrialised countries;
- export credit agencies and other financial bodies from industrialised countries;
- international financial institutions such as the World Bank;
- regional multilateral development banks;
- private companies from industrialised countries;
- 'green', or socially responsible 'ethical' funds;
- environmental brokerage houses;
- environmental non-governmental organisations;
- philanthropic organisations and international foundations.

The roles and expectations of these investors will be shaped by different motivations. For example, a foundation or NGO may invest in a CDM project with a motive to 'retire' CERs and put them out of commercial circulation. In this case, the investor is not interested in market potential or even in the emissions reductions, but is motivated by the sustainable development benefits. A large multinational corporation, on the other hand, may view a CDM project as a means to create markets for its products or to cover an emissions liability in its home country. A corporate investor of this kind may play a more active role in project implementation, and is likely to favour projects with low capital costs per expected CER output.

Governments

The Kyoto Protocol is a treaty among national governments who have undertaken to meet their GHG emissions targets. Most countries will try to devolve the responsibility for this to the private sector. The best way for a government to guarantee compliance under the Kyoto Protocol would be to have a reserve supply of CERs on hand. This would act as an insurance against the country exceeding its allowable emission limits.

Governments have already started investments similar to the CDM through AIJ projects, which take place between industrialised countries and economies in transition or developing countries. Key AIJ investor countries include the United States, the Netherlands, Sweden, Australia, Switzerland, and Norway. Japan, the United Kingdom and Germany are also potential key investors, despite their having sponsored few AIJ projects to date. It is possible that some countries will disband their AIJ programmes altogether once the CDM is launched, but it is also possible that these programmes will be restructured to invest in CDM opportunities. Many countries are only just beginning to examine their national climate policies and strategies, and have not yet found the right balance between private and state-driven approaches to carbon investments. Some countries might invest in CDM programmes that deliver CERs directly into the hands of the government itself, as a form of political insurance. For all these reasons, governments and their development assistance programmes should not be ruled out as sources of finance, even if grant aid is limited to only supporting activities as training. The Netherlands' CER Procurement Tender is one recent example of a government acting as an investor.

International financial institutions

The World Bank was one of the first to undertake carbon emission trading through its support of AIJ projects and through the development of a pooled carbon investment fund. Its $145 million Prototype Carbon Fund allocates finance to AIJ and CDM projects as equity investments, in return for a contractually agreed upon volume of CERs. The emissions credits are then distributed to investors in the Fund, which include five governments and several private companies (mainly electric utilities). Recently the shareholders approved increasing the Prototype Carbon Fund funds to $180 million.

The Fund adopts relatively conservative guidelines for investment. It looks for high quality projects, guided by the following questions:

- Does the project generate relatively low-cost emission reductions?
- Are the expected costs for monitoring and independently validating those reductions reasonable, given the project size?
- Is the 'additionality' test clearly met positively?
- Is host country support been approved, or likely, or relatively easy to obtain?
- Is the project a renewable energy project? (preference is given to these)

The Prototype Carbon Fund tends to focus on World Bank-sponsored and International Finance Corporation-sponsored projects. Another fund linked to the World Bank, the Multilateral Investment Guarantee Agency, offers assistance in the form of credit guarantees for up to 15 years of the lifetime of a project. The Agency also offers political risk insurance for up to 90% of an investment, up to a total of US $50 million.

Corporations

For companies in most Northern industrialised countries, it costs more to comply with domestic GHG regulations than to invest in overseas CDM projects for carbon credits. A CDM project is, for these companies, a way to better manage environmental risks and related capital expenditures. Companies may also invest in carbon to enhance their corporate image or to gain 'climate-neutral' status.

Private companies can finance CDM projects in different ways. A large company in the industrialised world could finance a CDM project undertaken by one of its subsidiaries in a developing country. It could also finance a CDM project in a developing country as a way of entering the market in that country. An alliance of similar corporations could form a pooled carbon investment fund which would then allocate CERs to shareholders. Private corporations can invest in CDM projects indirectly, by sponsoring work in universities and NGOs. This could be motivated by public relations concerns, but also by a genuine interest in such projects. The level of activity of a private corporation in the CDM depends on a variety of factors. Foremost is the company's direct domestic GHG emissions liability. But other factors may be equally critical; for example:

- Does the company have the internal capacity and resources to undertake a bilateral CDM investment?
- Would the transaction costs for obtaining CERs be lower if an emissions broker were used, or if the company participated in a pooled investment structure, such as the World Bank Prototype Carbon Fund?
- How important is the public relations image that might accrue to the company from direct participation in a CDM project?
- Can direct participation in a CDM activity open new doors for the company in export markets, or demonstrate a new type of technology?
- Is environmental technology or alternative energy a part of the company's core business focus?
- Does the company wish to gain first-hand experience in CDM project development before deciding which mechanism for obtaining emission allowances is best?

Companies will invest in CDM projects that meet their emissions liability at the lowest cost. This means projects with high cost-efficiency, and projects that require minimal time and effort to verify emissions reductions.

Carbon funds

A number of banks and specialised financial institutions have established carbon funds. Carbon funds pool capital and risk in the search for safe, low-cost emission reduction credits. They are more like buyers' clubs for emissions credits, rather than financial securities like mutual funds or unit trusts. For example, the Dexia Group, a Belgian investment banking concern, established a carbon fund in 1999 with co-investment from the European Bank for Reconstruction and Development. The Dexia Group is currently interested mainly in emissions reductions from countries in Eastern Europe. Carbon funds will probably finance projects with a high cost-efficiency. They are unlikely to contemplate investing in a CDM project that has not already obtained approval from appropriate national authorities. For the same reasons, projects that carry high transaction costs are likely to be passed over in favour of more straightforward projects.

Emissions brokers

Unlike traders, brokers do not necessarily actively buy and sell, or at least not for themselves. They facilitate transactions between buyers and sellers. Using a broker not only saves time, it gives a realistic market perspective on CER pricing. More complex deals may require the expertise of a broker to develop the right transaction structure to benefit both parties. Brokers charge a commission on transactions, either structured as a flat fee or as a success fee related to the profits of structuring an agreeable deal. Already there are some specialised environmental brokerage houses which sell financial products related to GHG emissions. The first step for the project developer is a verbal or signed confirmation indicating the price. The broker then approaches potential investors to find out their interest in purchasing carbon credits. Other investors can counter with higher prices, giving the project developer a possibility of revising the price or accepting a counter-offer. This process continues until the market satisfies the needs of both buyer and seller. Forward contracts and call options are the most common transactions facilitated by brokers at present. Recent prices for these mechanisms per tonne of carbon dioxide have ranged from as low as $0.25 to as high as $5.

Strike prices (prices for immediate purchase) have generally ranged from $1.25 to $10. No average is really meaningful, however, because these figures reflect different timeframes, different reliabilities of emission reductions, and different negotiated transactions. To protect the buyer, a due diligence process is undertaken, similar to what happens in normal project finance. This means that the seller retains all risk and may be obliged to purchase insurance if the project fails to deliver the amount of contractually guaranteed CERs.

Commodity traders

Future traders in CERs will operate according to the same basic principles as stock or commodity trading. Taking a long-term approach, they will seek to profit from market fluctuations and arbitrage opportunities over time. As with any stock purchase, they will seek to buy low and sell high. Both traditional and online trading methods are likely to be used. Private investors, companies, and CER suppliers will probably buy and sell CERs in regularly scheduled auctions.

Foundations and NGOs

Philanthropic organisations and NGOs are potential funders of CDM activities, although it is more likely that their role will be in supporting implementation. In a number of AIJ projects, NGOs and philanthropic organisations have funded aspects of project implementation. The Dutch government established the FACE Foundation in the mid-1990s with funding from the Dutch electric power industry, to invest in and experiment with carbon projects in developing countries involving afforestation and forestry management. The World Wildlife Fund, the Nature Conservancy, and a number of other large environmental NGOs have been active in managing similar forestry and agricultural carbon projects in Latin America. In South Africa, NGOs such as the International Institute of Energy Conservation have developed climate change projects aligned with sustainable development priorities.

Local commercial banks

Carbon finance from local capital markets should not be entirely excluded, as local investors may be more comfortable helping a CDM project based in their own country. Borrowing costs from local banks will probably be lower, especially for smaller-scale projects. Borrowing in local currency further reduces the risk of exchange rate devaluation, inflation, and the costs of currency conversion. The Development Bank of South Africa has expressed an interest in financing climate change and sustainable energy projects. Given a sound feasibility study and some education and encouragement, commercial banks in South Africa could be persuaded of the benefits of investing in CDM projects.

5.10 Marketing to investors

Any project seeking investment has to be adequately prepared and confident of success. Project developers should know which parameters are most certain and which are still subject to risk. Before going to market with a project, developers should prepare themselves as follows:

- Assess needs and timeframe adequately.
- Identify reasonable price parameters for the carbon credits.
- Develop a selling strategy with an ideal transaction volume and ideal selling price. Assess the project's current and future cash flow position and your tolerance for higher risk thresholds. For example, is an immediate payment most desirable, or can you hold out for larger returns?
- Consider appointing a consultant, lawyer, or market agent who can act in good faith on your behalf. An objective resource person will prove invaluable in developing a strategic plan and in facilitating complex transactions with foreign brokers and investors.
- Establish a methodology to calculate emission reductions and project baselines. This is one of the issues most under a project developer's control. Your methodology should conform to the evolving rules of the CDM, and should balance the need for clear additionality with the desire to secure more credits.

- Secure support and cooperation of the host country government through letters of endorsement or preliminary statements of intent before marketing the emissions. Until the South African government CDM approval body is in place, the Department of Environmental Affairs and Tourism should be approached for project cooperation and letters of support.
- Engage a third party organisation to validate the project design document, verify the emission reductions, and provide any assistance you will need for doing the monitoring.
- Where possible, propose more than one project to an investor, or seek to bundle together a number of smaller projects of the same nature to create economies of scale.

Further resources

Danish, K W & J C Rotter 2000. Developing contracts for GHG emission offset projects in developing countries. *NR&E* (Winter 2000): 1-6. Available at www.ceruleanconsultants.com/resources.html.

Worika, I & T Waelde 2000. Contractual precedents for implementing the flexible mechanisms under the Kyoto Protocol. At www.gasandoil.com/goc/speeches.

Nicholls, M 2000. Equity analysts count on credits. *Environmental finance*, December 2000: 8.

Barannik, A 2001. Providers of financial services and environmental risk. In Bouma, J J, M Jeuceken & L Klinkers (Eds), *Sustainable banking: The greening of finance*. Sheffield: Greenleaf: 247-267.

Emissions Marketing Association. At www.emissions.org.

6
The project monitoring and verification plan

All CDM projects require monitoring and verification before they are issued with CERs, to confirm that the project delivers what it said it would. The monitoring and validation procedure is spelled out in the original project design document, and has to be validated before the project commences. This chapter provides an overview of methods and trade-offs between different monitoring and verification approaches, and gives data requirements and indicators for each approach.[7]

6.1 Project boundary and the monitoring domain

The monitoring and validation process requires that emissions are monitored within clearly defined physical and conceptual project boundaries. The physical/conceptual area to be monitored is called the monitoring domain. The monitoring domain has to allow for monitoring of onsite and offsite emissions, impacts, leakages, spillovers and socio-economic costs and benefits. All these should be stated clearly in the monitoring plans for both the baseline and project implementation.

The monitoring domain can vary for each factor being monitored. For example, for fuel use and emissions on the project site, it is usually sufficient that the monitoring domain is the physical boundary of the site. For emissions related to the use of electricity supplied by the grid, the monitoring domain would be the physical boundaries of the project site as well as those of all the power plants supplying electricity to the project. (For practical purposes, an estimated emissions factor for the power grid, allowing for the seasonal and daily fluctuations of electricity supply, is needed). The monitoring domain may also be extended by socio-economic and environmental impacts, such as when the construction and operation of a large CDM project impacts on neighbouring areas.

Box 8.1: Monitoring and verification – definitions

Monitoring is the measurement of all factors associated with a CDM project – carbon stocks, GHG emissions, socio-economic and environmental benefits, and costs. The objectives of monitoring are to inform interested parties about the performance of a project, identify measures that can improve project quality, make the project more cost-effective, improve planning and measuring processes, and be part of a learning process for all participants (De Jong et al 1997).

Monitoring is the responsibility of the project developers. The monitoring plan must specify what variables are to be monitored to estimate emissions for both the project and the baseline. For example, if a LULUCF project baseline demanded periodic measurements of changes in soil carbon, this would fall under monitoring. For a CDM lighting project, one would monitor the number of energy-efficient light bulbs installed and their use.

Monitoring estimates the project's impact on GHG emissions, and non-emission (environmental, economic, social) impacts. Monitoring may include re-estimations of the baseline, leakages, and spillovers. In this sense, CDM project monitoring incorporates what is often called monitoring and evaluation in energy projects (Vine, Sathaye & Makundi 2000).

[7] This chapter benefited greatly from material in Sathaye and Venida (2001) and Vine, Sathaye and Makundi (1999).

Verification, unlike monitoring, is done by an outside party, and establishes whether the measured GHG reductions actually occurred. It provides the basis for certification. As described in Chapter 2, verification is similar to a financial audit because it is carried out by an objective accredited party known as an operational entity, accredited by the CDM Executive Board.

6.2 The monitoring plan

A monitoring plan must be included in the project design document. Its purpose is to make sure that the project will meet independently verifiable criteria. The monitoring plan needs to include:

- relevant project performance indicators;
- data needed for indicators, and an assessment of data quality;
- methodologies used for data collection and monitoring;
- assessment of the appropriateness of the methodologies;
- quality control provisions for methodology, recording and reporting; and
- a description of how the data will be used to calculate emissions reductions.

6.2.1 Performance indicators

For CDM energy projects, the primary performance indicators are energy produced or saved, and emissions reduced relative to the baseline. Other indicators could be emissions factors, time of day and season for energy saving, and the mix of fuels avoided on site (where grid electricity is involved, in power plants as well). In a low-income household efficient lighting project, for example, the primary data would be the number of CFLs and the lighting electricity consumption per household. In a LULUCF project, primary data would be carbon accumulation rate and rates of release though oxidation and decomposition. The table below illustrates the minimum required performance indicators for energy projects.

Table 6.1: Performance comparisons and measurements required for monitoring and verification of carbon offsets in energy projects
Source: Swisher (2001b)

Energy technology	*Comparison between baseline and project case*	*Required measurements*
Renewable energy supply (solar, wind, hydro, geothermal)	*Baseline:* fossil fuel supply *Project:* renewable energy system (generally electric)	*Baseline:* carbon fuel intensity *Project*: energy supplied
Biomass energy conversion	*Baseline:* fossil fuel supply *Project:* biomass production and conversion to fuel/electricity	*Baseline:* carbon fuel intensity *Project:* energy supplied and net terrestrial carbon storage
Fuel-switching (supply-side)	*Baseline:* fossil fuel supply *Project:* cleaner fuel supply (e.g. coal to natural gas)	*Baseline:* carbon fuel intensity *Project:* energy supplied and change in carbon intensity
Fuel-switching (demand-side)	*Baseline:* fuel or electric energy end-use *Project:* change between fuels or between fuel and electricity	*Baseline:* carbon fuel intensity *Project:* energy use, change in efficiency and carbon intensity
Energy-efficiency measures	*Baseline:* fuel or electric energy end-use *Project:* more efficient end-use technology	*Baseline:* energy end-use and carbon fuel intensity *Project:* change in energy use

6.2.2 Data and data quality

The data needed relates to the performance indicators. Energy has to be disaggregated by source into electricity, coal, natural gas, biomass and petroleum products. The quantity (kg) and heat content (GJ/kg) of these fuels is required. Data is also needed on emissions factors of the fuel, in order to estimate the total emissions reductions. The monitoring plan would also indicate where this data should be collected, and the location of reference sites that might serve as a dynamic baseline or as a check on leakage estimates.

For a LULUCF project, data requirements depend on the project type. The formulae for calculating carbon storage indicate what data is required:

- carbon content of biomass;
- additional stemwood volume;
- above-ground biomass to stemwood volume ratio;
- total biomass to above-ground biomass ratio;
- dry to wet biomass ratio;
- wood density;
- vegetation carbon density before harvest;
- soil carbon density at forest maturity less baseline scenario density (tC/ha);
- carbon stored in different wood products;
- the useful lifetime of the wood products or their decay rate.

Many of these variables may have been standardised in the project design document, and may have already been subject to validation. If so, they would not need to be monitored. For example, the project design document could include standard assumptions for above-ground biomass to stemwood volume ratio, total biomass to above-ground biomass ratio, dry to wet biomass ratio, and wood density. In this case we would only need to monitor stemwood volume to estimate the change in vegetation carbon density.

The quality of the data will depend on the type of data sources, and whether these are primary or secondary data. Primary data collection is influenced by the sample size, the desired precision and the quality of instruments used. In forestry projects, data may combine remote sensing and onsite survey measurements, together with cross-sectional data from comparable ecosystems and standard parameters like wood density or carbon content.

6.3 Data collection methodologies for energy projects

The monitoring plan must describe the appropriate method used to collect data. For an energy project like a wind turbine, collection of data with a single kWh meter would be sufficient to determine the amount of electricity produced or delivered. For more complex projects, where the machines are dispersed, or for a large industry where only part of the electricity load is displaced by the CDM project, data may have to be sampled to ensure that the project is performing as planned.

Several methods are available for collecting data on energy-efficiency projects – engineering calculations, surveys, modelling, end-use metering, on-site audits and inspections, and utility bill data. If data collection requires sampling of many end-use points, appropriate methods include basic statistical models, multivariate statistical models, and integrative methods. In more simple cases, end-use metering, engineering calculations or utility bills should be sufficient. Each approach has advantages and disadvantages, as shown in Table 6.1, depending on the project and the stage of its life cycle. Using more than one method can be informative – conducting different analyses in parallel and integrating the results gives a robust evaluation. The monitoring plan should specify the various analytical methods used through the life of the project. It should account for the financial constraints, staffing needs, and availability of data sources.

Table 6.2: Advantages and disadvantages of data collection and analysis methods
Source: Vine and Sathaye (1999)

Methods	*Advantages*	*Disadvantages*
End-use metering	The most accurate method for measuring energy use. Most useful for data collection, though may not isolate CDM project intervention.	Can be very costly. Small samples only. Requires specialised equipment and expertise. Possible sample bias. Difficult to generalise to other projects. Does not, by itself, calculate energy savings. Difficult to obtain pre-installation consumption.
Short-term monitoring (periodic measurement of energy use or production)	Useful for projects with relatively stable and predictable operating characteristics. A relatively accurate method.	Limited applicability. Using this method alone, energy savings cannot be calculated.
Engineering methods (using algorithms to estimate impacts, e.g. simulation tools)	Relatively quick and inexpensive for simple engineering methods. Most useful as a complement to other methods. Useful for baseline development.	Relatively expensive for more sophisticated engineering models. Need to be calibrated with onsite data. By themselves, these methods are not good for evaluation of spillover.
Basic statistical models	Relatively inexpensive and easy to explain. Useful where the CDM project has many participants.	Assumptions need to be confirmed with survey data and other measured data. Limited applicability. Cannot evaluate peak impacts. Large sample sizes needed.
Multivariate statistical models	Can isolate project impacts better than basic statistical models.	Same disadvantages as for basic statistical models. Relatively more complex, expensive, and harder to explain than basic statistical models.
Integrative methods	Relatively accurate. Combines two or more methods described above. Most CDM projects will need this type of approach	Relatively more complex, expensive, and harder to explain than some of the other models.

There is no one methodology that is best for all projects or for all stages of a particular project. In selecting methods, one should take into account whether the power load is constant, variable, or variable but predictable. One should also consider whether the production schedule is known (timed on/off schedule) or unknown and variable, and whether sampling is required. The appropriate approach depends on the type of information wanted, the value of information, the cost of the method, and the stage and circumstances of project implementation. Hirst and Reed (1991) and the International Performance Monitoring and Verification Protocol (US DoE 2000) discuss how to choose and combine different methods. In some contexts, certain methods may be difficult to implement. For example, even where meters exist for measuring electricity use, these may be tampered with and therefore not provide reliable information. In such cases, one needs to combine end-use metering, monitored data, and statistical methods to monitor electricity savings.

Power stations are relatively easy to monitor because output is almost directly related to fuel consumption. A gas-fired power station, for example, has to report its output and nominal capacity to the Regulator each year, so this information would be public knowledge. If fuel consumption is also reported, the calculation of project emissions is simple. For efficient lighting in low-cost housing, on the other hand, monitoring lighting use across a large number of households would be expensive, especially since electricity savings per home are small. Appropriate monitoring in this case would be a combination of modelling, spot checks through energy surveys, and limited technical monitoring.

6.4 Data collection methodologies for LULUCF projects

The monitoring of LULUCF projects can vary in complexity, depending on the pools involved, the size of the project, and the time period. The monitoring and validation frequency is usually linked to the distribution schedule of carbon credits to stakeholders. A reforestation project may last three years, but carbon sequestration will continue beyond the implementation period, and so, therefore, will the monitoring frequency. Monitoring frequency also depends on the carbon pools affected by the project, because each carbon pool has a different rate of change. This applies particularly to the above-ground biomass pools, which go through relatively rapid changes. Monitoring of carbon pools should be done on an annual basis initially. Sampling is usually necessary to monitor these pools.

Soil monitoring, although relatively more complex and expensive, can be carried out in annual or multi-year periods. The difficulty with soil carbon measurements is that the 'signal-to-noise' ratio is fairly small, so it is quite difficult to measure real, long-term changes in soil carbon due to the CDM project. The project design document should clearly state which approach will be taken to soil carbon, and whether it will be monitored or not. Records should be kept on disturbances at the sites, whether these are human-made disturbances like thinnings or natural disturbances like pest infestation. For forest products, the demand for wood products is a function of socioeconomic and market conditions as well as normal replacement. Annual monitoring of the amount of wood products at the source should be done, as well as periodic consumption surveys. Decay rates can be established in the project design document or monitored periodically. Conditions change over time, so evaluation should be made of the project's lifetime. The project lifetime depends on the type of carbon pool affected (whether soils or above-ground woody biomass) and the probability of natural or human-made disturbances like fires. If a project area is likely to undergo serious changes within ten years, the long-term carbon storage could be in jeopardy. The value of reduced emissions in this case would be less than those from projects with longer project lifetimes and more reliable future management regimes.

The methods of monitoring and evaluation should be used to estimate the net flows of carbon as accurately as practical, accounting for all significant sequestration and emissions. Forestry activities change through time, and the measurement of carbon flows must account for changes, from the time a forest is established until it is removed by harvest or natural disturbance. If a forest is removed for some unforseen reason in the future, then the carbon that has been stored is lost. This makes LULUCF projects different to energy projects. In energy projects, once emissions are avoided we can be certain that they were avoided. The measurement of a LULUCF project's carbon fixation requires specialised tools and methods, drawn largely from experience with forest inventories and ecological research. Measuring carbon accumulation depends on the desired precision and cost effectiveness. Monitoring systems should be built upon standard biomass measurement approaches, using commonly accepted principles of forest inventory, soil science and ecological surveys. Four general monitoring approaches can be used, sometimes in combination, to monitor carbon fixed through forestry projects (MacDicken 1997): modelling; remote sensing (with ground-truthing); research studies; and inventory analysis, including surveys, wood production, wood use, end products, and forest inventories.

Modelling

Modelling the impacts of forestry practices on carbon flows into and out of forest carbon sinks is an effective way of estimating annual carbon flows. Models of this kind start from an estimate of carbon stock for a specific forest type at a specific site. Then, using information from forest practices, the modeller develops estimates of annual carbon flows. This approach relies on a number of simplified assumptions, including number of trees planted, initial stocking rates, mean annual stemwood volume increments, a biomass multiplier factor, and harvest rates (Makundi et al 1995). From these assumptions one can then estimate the amount of sequestered carbon.

Models need to be calibrated periodically with measured data and with other approaches. For example, volume-based approaches which estimate forest productivity by timber volume should be compared with approaches such as allometrically derived carbon estimates that incorporate relationships between physiological variables like tree diameter, height, weight and carbon content (Hamburg et al 1997). The accuracy of these methods depends on many factors, including the precision of the equations and the homogeneity of the forest. Some models are already available for standard treatments like tree planting on agricultural land. In general, field measurements are preferred to standard tables and computer models, because site-specific field studies provide higher quality data, which gives them more credibility. The cost of field studies is inevitably higher.

Remote sensing

Remote sensing (aerial photography or satellite imagery) and ground-based measurements (ground-truthing) are used to monitor land area changes, map vegetation types, delineate strata for sampling, and assess leakage and baseline assumptions. Attempts to estimate biomass from remote sensors have generally been costly and have given mixed results (MacDicken 1997). Remote sensing is a primary source of data only for very large projects and for monitoring ecosystem changes in baseline and leakage across large areas. An international system for monitoring land cover change has been proposed (Skole et al 1997). This system includes studies in specific locations for field validation, and accuracy assessments for large area analyses. It is useful for evaluating project impacts if integrated with the research studies approach.

Research studies

The research studies approach uses intensive data collection and analysis methodologies to test research hypotheses. It can provide useful detailed monitoring estimates for determining how much carbon is sequestered by projects in each pool, but it is usually more costly than other monitoring activities (MacDicken 1997). The research approach can include biomass studies using destructive sampling, or wood characteristics such as useful lifetime and decomposition studies. It can also use the dynamics of land use to determine patterns of baseline land use change.

Destructive sampling is the oldest methodology for estimating biomass density. It requires the selection of representative sites in the ecosystem, usually a few square meters each. All the vegetation is uprooted and measured for volume, weight at different moisture contents, proportions of components like branches, stem and roots, and chemical composition. Measurements of parameters in the soil profile, including soil carbon, are usually done at the same time.

Inventory analysis

Inventory analysis covers several methods: surveys, monitoring of wood production, wood use and end products, and forest inventories. In this approach, surveys of CDM project activities are conducted to see what LULUCF measures were actually implemented. The surveys provide useful data for the evaluation of carbon reduction, especially if combined with other approaches. The method of monitoring wood production, use, and end product data is also used to develop accurate baselines and project assessments. Records are kept to show what happens to the wood once it is felled, or when trees and branches die. Dead wood is regularly collected and measured, and its use recorded.

Commercial-scale carbon inventories can be performed at virtually any level of precision desired. They assess the difference in each carbon pool for project and non-project (or pre-project) areas over a period of time. By comparing changes in the project area to changes in pools unaffected by project activities (control sample plots), the monitoring effort can assess the impact of the project on carbon storage. Detailed biomass measurement methods can be applied to various pools (MacDicken 1997).

6.5 Monitoring vegetation carbon in LULUCF projects

For purposes of monitoring, 'vegetation carbon' can be broken down into above-ground woody biomass, below-ground woody biomass, and annual plant biomass.

*Above-ground woody biomass***.** To monitor above-ground wood, trees are usually measured standing, except at the time of thinning or felling, when they are measured on the ground. Volume is the most common measurement. The three most frequently used parameters are stem diameter at breast height (dbh), basal area at breast height, and tree height. These parameters provide an estimate of stem volume. Allowances should be made for branches and tops, otherwise above-ground volumes can be underestimated by 15-50%. Likewise roots must be considered, otherwise total volumes can be underestimated by as much as 70%, depending on species and biome (World Bank 1994).

For carbon sequestration, total above-ground volume is required. This can be derived from a statistical analysis of measured stem volume using biometric methods. These measurements are then converted to estimates of total standing stock using the formulae given earlier.

Below-ground woody biomass. Roots contribute to the build-up of organic soil carbon. They can be measured in the sample plots, and also where trees are felled outside the project area. These measurements give the ratio between above- and below-ground woody biomass. The ratio varies significantly among species and among rooting mediums (Makundi 1995; Brown 1996).

Calculating carbon storage in woody biomass. Once total tree volume or weight has been estimated, it is converted into organic carbon weight. There is very little variation in chemical composition among different wood species. On an ash-free, moisture-free (bone-dry) basis, about 50% of wood by weight is carbon, 6% is hydrogen, and 44% is oxygen. Density and moisture content, on the other hand, vary considerably – coniferous wood species are generally much less dense than hardwood species. Density is determined by weighing pieces of wood of known dimensions, subtracting the weight of water, and dividing the dry weight by the volume. Moisture content is measured by weighing the wet wood from the field and then re-weighing it after it has been oven-dried. Alternatively, a moisture content meter can be used to read the moisture content directly.

Carbon storage in annual plants. As renewable resources, crop residues and forest residues can substitute for fossil fuels, but they are usually a relatively small component of the additional carbon that can be stored on a land-use project. Samples of crop residues are weighed in the same way as wood, and their moisture content determined.

Crop residues have large variations in ash content, so their ash content needs to be determined. This is done by completely burning known bone-dry weights of residues and weighing the remaining ashes. The carbon content and energy value are measured directly using a bomb calorimeter, but average values can be a good approximation – on an ash-free, moisture-free (bone-dry) basis, 46% of crop residues by weight are carbon.

Soil carbon. Soil is normally a greater store of carbon than biomass tissue. The highest carbon is found in forest soils, followed by grassland soils and arable agricultural soils (Bouwmann 1990). However, it is often difficult to measure changes in soil carbon over time accurately, because the 'signal-to-noise' ratio is fairly low.

The build-up of organic carbon in the soil is measured at the project site, down to a known depth, usually 30 cm below ground level (MacDicken 1997). Ideally, soil samples should be taken each year at permanent sample sites selected for different classes of age and land use. Then, using standard laboratory methods, the soil nutrients (especially carbon and nitrogen) are determined. The potentially high cost of measuring soil carbon means that it is less frequently monitored than vegetation pools.

Forest products. The long-term effectiveness of carbon sequestration depends on the uses of the wood produced. The more durable the wood product, the greater the project's carbon storage effect, in both medium and long term. Logs, pulpwood, cordwood and chips should be recorded and monitored. Given the inherent difficulty in knowing the exact end-use of wood products after they leave the CDM project area, it is best to determine the proportion of timber converted into different products, and then use general default values to estimate their average lifetime and decay rates (EcoSecurities 1998). If wood is used as firewood, there will be lower GHG impacts than if the wood is left to decompose.

The advantages and disadvantages of various vegetation monitoring methods are summarised in Table 6.3. The use of these methods will vary according to the size of project area and the purpose of the CDM project, depending on whether the project is being used to create or replant forests, supply energy, or provide wood products. One can classify monitoring techniques by the forestry project type, as shown in Table 6.4. Monitoring costs depend on what information is needed, what information and resources are already available, the size of the project area, and the monitoring methods to be used. The cost of monitoring a forestry project has been estimated at 8.5% of the total project cost in India, and for similar projects in Southern Africa, around 10% of the total cost (Ravindranath & Bhat 1997).

Table 6.3: Advantages and disadvantages of different forestry monitoring methods
Source: Vine et al (2000)

Method	*Advantages*	*Disadvantages*
Modelling	Relatively quick and inexpensive. Most useful as a complement to other methods.	Relies on highly simplified assumptions. Needs to be calibrated with onsite data.
Remote sensing and ground-truthing	Used primarily for temperate forests, although this experience could be transferred to other forests. Useful for monitoring leakage.	Has not been used to measure carbon. Can be quite expensive. Difficult to measure volume as opposed to area.
Research studies	Detailed monitoring. Relatively accurate.	Usually more expensive than other methods.
Inventory analysis	Useful for determining what is actually implemented and for tracking end-use of wood products. Flexible in selection of methods and precision. Peer reviewed and field tested systems available. Control plots can be used to calculate net carbon sequestration.	As with research studies, may be more expensive than other methods.

Table 6.4: LULUCF forestry monitoring methods by project type
Source: Vine et al (2000)

Methods	*Carbon sequestration and storage*		*Carbon substitution*
	Small	*Large*	*(biomass energy)*
Modelling	×		
Remote sensing and ground truthing		×	
Research studies	×		×
Inventory analysis	×	×	×

Note: × indicates applicability

6.6 Monitoring and validation quality assurance and quality control

Implementing data collection is both an art and a science. Merely adhering to the minimal standards contained in the CDM monitoring plan is no guarantee of doing a professional job. Table 6.5 lists quality assurance guidelines for monitors and verifiers to show how methodological issues and potentially difficult issues have been addressed. The guidelines cover the issues and difficulties associated with each method of data collection and analysis. The quality assurance guidelines should be viewed as practice and reporting standards, rather than as prescriptive methodological standards. They require monitors to describe how key issues were addressed, but they do not lay down specific ways of doing this. The methods must be shaped by the interaction of the CDM project situation, the data, and the monitor. The guidelines to be used in the monitoring and verification process should be specified in the project design document. They will be subject to validation before the project commences.

The quality assurance guidelines are applied in three ways. First, they are included in the CDM monitoring plan in the project design document, so that monitors know that they are accountable for a sound analysis. Second, the verifiers use the guidelines so that the CDM Executive Board, government stakeholders, and others can review verification reports and quickly assess whether the monitor has addressed the methodological issues. This is important, since most stakeholders do not have the time nor the personnel to scrutinise detailed monitoring reports. Information on how the monitors addressed the methodological issues should be contained in the technical appendix of the monitoring and verification report. Finally, the quality assurance guidelines serve to create a common language of communication among project developers, monitors, verifiers, policymakers, and other stakeholders.

Table 6.5: Quality assurance issues for data collection and analysis methods
Source: Vine and Sathaye (1999)

	Engineering methods	*Basic statistical models*	*Multivariate statistical models*	*End-use metering*	*Short-term monitoring*	*Integrative methods*
Calibration	×					×
Data type and sources	×	×	×	×	×	×
Outliers		×	×			×
Missing data		×	×	×	×	×
Triangulation			×			×
Weather		×	×			×
Engineering priors			×			×
Interactions	×	×	×			×
Measurement duration				×	×	×
Sample and sampling		×	×	×	×	×
Specification and error			×			×
Collinearity			×			×
Comparison group		×	×			×
Note: × indicates applicability						

Monitors and verifiers have to consider the issues involved in each method. Examples of such issues are:

- Calibration: were the input assumptions and calculated results of engineering models compared and adjusted to actual data?
- Data type and sources: what was the source of the data and the methods used in collecting data?
- Outliers: how were outliers and influential observations identified and handled?
- Missing data: how was missing data handled?
- Triangulation: if more than one estimate of savings was calculated, how were the results combined to form one estimate?
- Weather: what was the source of weather data used for the analysis?
- Engineering priors: what was the source of prior engineering estimates of savings?
- Interactions: for example, how was the interaction between heating and lighting addressed?
- Measurement duration: what was the duration and interval of metering?
- Sample and sampling: what kind of sampling design was used?

- Co-linearity: if two or more variables were highly correlated, how were they treated?
- Specification and error: what kind of errors were encountered in measuring variables and how were these errors minimised?
- Comparison group: how was a comparison group defined for estimating net savings?

6.7 Community participation in monitoring and validation

One of the primary goals of CDM is sustainable development. The success and sustainability of CDM projects depends to a large degree on whether they provide socio-economic benefits to local communities. A project is only likely to be successful if there is local participation in project design, planning, implementation and review. Focusing only on GHG impacts presents a misleading picture of what is needed to make a CDM project work. The motivation and commitment of local participants will be influenced by both direct and indirect project benefits. A diverse group of stakeholders (government officials, project managers, non-profit organisations, community groups, project participants, and international policymakers) is involved in climate change projects and concerned about their multiple impacts. Forestry projects in particular are generally rural-based, so the institutional, technical and contractual conditions likely to encourage long term sustainability must involve surrounding communities. In the same way, community-based energy projects like solar water heating and solar home systems need the participation of communities. CDM contracts may contain provisions leading to zero CERs, for both host country and investor, if a project does not last as long as expected. The participation of local communities from the beginning in the development and implementation of a project will help to ensure its longevity. This consideration may outweigh a longer design process, or a longer implementation process, and higher transaction costs. Project longevity will also increase by encouraging local people to participate in operations and maintenance, and to provide spare parts and equipment and other technical expertise.

Further resources

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7
CDM in South Africa

7.1 CDM opportunities in South Africa

Given the importance of sustainable development in the CDM approval process, project developers should understand that political considerations and public participation have to be important elements of their strategy. They should attempt to address barriers such as reluctance by local financial institutions to lend money to projects using new technologies. Investment in CDM projects in South Africa will come mostly from the private sector, although government has an important role to play in directing this investment toward sustainable development priorities. Concerning technology eligibility, nuclear projects are the only technologies that are clearly excluded from the CDM. Some projects are given fast-track prioritisation, and subject to less vigorous screening. Fast-track approval applies to smaller-scale renewable energy and energy-efficiency projects, where transaction costs might negatively affect project viability. Small-scale is defined by the UNFCCC as 'renewable electricity projects less than 15 megawatts, energy efficiency projects less than 15 gigawatt hours/year, or other projects displacing less than 15 kilotonnes of carbon per year'.

In power generation sectors, there is a move towards greater use of natural gas instead of coal as the sole fuel. Natural gas is likely to form a larger percentage of South Africa's fuel mix in the medium term, so project developers would have to motivate additionality based on the barriers to using gas. They could show how a project would help bring gas on-line sooner, or propose technologies that are more efficient than current regional or international standards. This is important because gas-fired power might also be included in the emissions baseline for electric power generation (see Winkler et al 2001). New coal technologies, such as advanced pulverised coal combustion and atmospheric and pressurised fluidised bed combustion, are generally more expensive than Eskom's current coal plants. They are not in current short-term forecasts, so they may also be able to pass the additionality screens – although, if they are more energy intensive, they might actually increase emissions.

Converting industrial boilers from heavy fuel oils or diesel to biomass from forestry waste and biogas are attractive options. While these projects have been implemented successfully in other countries, they have not been tried in South Africa. Again, project developers could ask what barriers might prevent these projects being implemented in normal economic conditions.

A number of energy-efficiency projects have been identified by the International Institute of Energy Conservation, the Energy Research Institute, the Energy and Development Research Centre, Green Buildings for Africa, and others. Several applications of energy-efficiency have been tested in South Africa and shown to deliver significant GHG emissions reductions with relatively quick economic payback periods. They also address sustainable development objectives. These options range from industrial demand-side management in lighting, heating, and cooling operations, to designing thermally optimal housing units for low-income households. However, implementation, even for large companies, is often hindered by barriers that reduce investment returns and increase financial payback periods. There are a few examples underway, such as an industrial energy efficiency project at an Iscor steel plant, and several small-scale energy efficiency interventions in low-cost housing. However, for the most part such interventions are not happening in South Africa.

In the transport sector, emissions could be reduced by switching to buses using alternative fuel (compressed natural gas), promoting better transport infrastructure including commuter vehicle sharing, and techniques to improve emission control and fuel economies. Relatively few government policies are in place to promote these activities, and current transport infrastructure is not conducive to more energy-efficient transport.

7.2 Sustainable development criteria for South Africa

At the time of going to press, South Africa had not yet formalised its CDM screening criteria regarding sustainable development. In the absence of official criteria, this section summarises sustainable development priorities relevant to the CDM from South African policy documents, and gives an example of project-screening from the national Climate Change Country Study.

Although government policy has evolved beyond the 1994 Reconstruction and Development Programme (RDP), the RDP programmes and targets are still relevant in many sectors. These include:

- constructing 200 000 new houses a year to begin addressing a backlog of three million houses;
- providing 20-30 litres of clean water per person per day within 200m of each dwelling;
- adequate sanitation arrangements;
- electrification of an additional 2.5 million homes by the year 2000 and the electrification of all schools and clinics, using off-grid technologies if necessary;
- providing universal access to telecommunications services;
- a coherent programme of land reform;
- developing an effective publicly-owned passenger transport system; and
- universal satisfaction of nutritional requirements, and reform of the public health system.

Further sustainability criteria can be found in the White Paper on Energy Policy (DME 1998):

- increased access to affordable energy services;
- improving energy sector governance;
- stimulating economic development;
- managing energy-related environmental impacts; and
- securing energy supply through a diversity of energy sources.

Successful CDM projects have to prove that they can address at least some of the social and political priorities of the country. Areas of importance in South Africa would include:

- promoting equity and access to affordable energy;
- supporting renewable energy and energy efficiency;
- developing cleaner technology;
- creating employment;
- providing local environmental benefits;
- providing macro-economic benefits, such as foreign exchange generation; and
- supporting the involvement and development of community-based organisations.

These objectives can be translated into indicators at a project level, as shown in Table 7.1.

Table 7.1: Policy priorities and impact indicators

Policy priorities in general development programme	*Examples of indicator / impacts of project*
Promote economic growth	Macroeconomic indicators e.g. GDP growth
Create employment	Impacts on employment for different socio-economic groups
Promote access to affordable energy	Population with improved energy supply in rural areas
	Cost of commercial energy provided by project
Provide local environmental benefits	SO_2, NO_x and particulate emissions
	Health status of end-users
Forest expansion and conservation	Increased forest area and decline in forest degradation

Because the CDM by its nature is investor-driven, it is much more likely that CDM projects will take place if government actively supports their development. While stringent project criteria can screen out undesirable projects, special efforts have to be made to attract desirable CDM projects. The formal CDM investment screening criteria for South Africa is likely to build on those used for existing conventional development projects by government and government-linked institutions in the country. For example, the Development Bank of Southern Africa appraisal process gives priority to projects that maximise racial equity, gender equality, sustainable job creation, appropriate technology, community participation, and environmental sustainability. The Public Works Department has similar objectives in its procurement policy – to promote participation by emerging enterprises in public procurement activity, increase employment opportunities, empower communities and individuals from previously disadvantaged sectors, and provide skills training for previously disadvantaged people.

The environmental management principles contained in the 1998 National Environmental Management Act also include criteria for sustainable development. The Act states that 'equitable access to environmental resources, benefits and services to meet basic human needs and ensure human well-being must be pursued and special measures may be taken to ensure access thereto by categories of persons disadvantaged by unfair discrimination'. The Act lists 20 environmental principles to guide government. One of them is that government will not give permission for any environmental intervention without properly assessing its impact on the environment, socio-economic conditions and cultural heritage. Regulations for the carrying out of Environmental Impact Assessments for certain prescribed activities are given in the 1989 Environmental Conservation Act.

The South African Climate Change Country Study Mitigation Component included an evaluation of mitigation projects against a set of sustainable development indicators that spanned economic, social, environmental, technological and institutional concerns (James & Spalding-Fecher 1999). These indicators were developed through a research process and input from stakeholders in project workshops. A summary of these criteria and how they could be measured is presented in Table 7.2. In the absence of official sustainable development indicators, they give project developers a sense of what kind of information should be presented in a CDM design document.

Table 7.2: Evaluation criteria used in SA Climate Change Country Study

	Indicator	*Typical reporting requirements*
1	Reduction in GHG emissions	Tonnes carbon equivalent
2	Local environmental impact	
	Soil conservation and biodiversity	Degree of erosion, acidity, salinisation or other toxicity, and species diversity
	Water resources and biodiversity	Chemical and biological loads, habitat impacts

	Indicator	*Typical reporting requirements*
	Air quality: non-GHG emissions	Tonnes of particulates, sulphur dioxide, ozone, nitrogen oxides
	Leakage	Tonnes increase in carbon emissions outside project boundary
3	Cost-effectiveness	Dollars or rands per tonne of carbon emissions reduction over the life cycle of the project
4	Macro-economic impacts	
	Impact on trade balance	Current rands
	Impact on GDP	Current rands, and as % of total GDP
	Impact on inflation	% points of inflation
	Emissions return on initial investment	Dollars or rands capital investment per tonne of carbon emissions reduction
	Impact on international competitiveness	Change in unit cost of production
5	Social impacts	
	Social equity and poverty alleviation	Job and wealth creation in specific poor and disadvantaged communities
	Job creation	Numbers, types, gender and racial spread of jobs
6	Institutional and administrative capacity	Administrative burden, training needs and barriers
7	Technological feasibility	Availability of in-country skills, inputs, experience and support

7.3 South African climate change structures

South Africa is planning to establish a CDM Office before the World Summit on Sustainable Development in August 2002. For now, the Department of Environmental Affairs and Tourism (DEAT) deals with climate change and CDM issues, although the Department of Trade and Industry and other departments are also likely to be involved in the CDM office. The DEAT's Climate Change Office is part of the Chief Directorate for Environmental Quality and Protection. The contact person is:

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Given the interdisciplinary nature of climate change, the South African government has set up an interdepartmental working group on climate change to promote government co-ordination and integration. The Governmental Committee on Climate Change includes representatives from the Departments of Minerals and Energy, Water Affairs and Forestry, Agriculture, Transport, Housing, Finance, Health, and Trade and Industry. To involve stakeholders more fully in climate change policy making, the DEAT set up a National Committee on Climate Change (NCCC) in 1996, as an advisory body to the Minister of Environmental Affairs and Tourism. The committee is made up of representatives from national and provincial government departments, NGOs and community-based organisations, business and industry, parastatals, labour, and the research community. The committee's primary objective is to advise the Minister on national issues related to climate change. Its tasks are to communicate key issues to the various constituencies represented, assist in the development of national policy, and oversee the South African Country Studies Programme. While the NCCC offers policy support to the DEAT, it has no administrative capacity of its own, relying on its members and the DEAT for administrative support. This limits its capacity to manage the ongoing demands of a climate change strategy. Within the NCCC, there are caucuses for major stakeholder groups, such as the Business Caucus on Climate Change and the NGO Caucus on Climate Change, that often formulate sectoral positions prior to debates within the NCCC or international negotiating sessions. The caucuses are linked to associations and organisations within their sectors.

The CDM office, when established, is likely to perform a number of functions, including:

- establishing project application guidelines to ensure that proposed projects conform to national programme objectives and international UNFCCC standards, while minimising the volume and complexity of proposals;
- developing project evaluation criteria and procedures, including specific national priorities or exclusions, additionality criteria, monitoring and validation criteria and requirements for host-country government approval and allocation of certified emission reductions;
- establishing a project review and approval process, including requirements, procedures, and deadlines for receipt, evaluation and approval of project proposals;
- building local awareness of the programme in order to disseminate information about project guidelines and evaluation procedures, and generating interest and new activities;
- marketing the programme internationally, via both diplomatic and commercial channels, in order to increase recognition of project opportunities in South Africa and attract potential investors;
- overseeing the monitoring, verifying and reporting of project results, including tracking developments in international monitoring and validation standards and reporting to the Subsidiary Body for Scientific and Technical Advice under the UNFCCC; and
- participating in international policy debates and UNFCCC negotiations, in order to communicate the country’s interests and support its priorities and concerns (Swisher 2001b).

Further resources

South African First National Communication to the UNFCCC (2002). Department of Environmental Affairs and Tourism (can be obtained from Climate Change Office)

South African National Strategy Study on the CDM. Chapters 5 & 6. (can be obtained from Climate Change Office)

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APPENDIX A
Examples of CDM projects in Southern Africa

This appendix presents examples of pilot CDM projects and concepts in Southern Africa. Some are more detailed versions of examples presented earlier in this book. They are provided as illustrations only, and do not reflect the opinions or decisions of Southern African governments or specific project developers.

1. Multi-project baseline: electric power generation in South Africa

This example is based on an analysis of the South African power sector by the EDRC, in collaboration with Lawrence Berkeley National Laboratory in the USA (Winkler et al 2001). Three key issues have to be decided upon before calculating any multi-project baseline for the power sector. The first decision is which set of plants to include in the reference scenario. For each plant, the essential data is the fuel input (in GJ per year) and the electrical output (in TWh per year). Combining this information with the calorific value of the fuel and its carbon content, we can calculate the carbon intensity measured in mass of carbon per unit of energy produced, or kg C/kWh.

The second issue concerns the set of plants with which the potential CDM project should be compared? Does a new gas plant need to perform better than the average power station in the whole sector, better than the average fossil-fueled plant, or better than other gas-fired plants? These comparisons can be applied to different sub-sets of the plants in the baseline. The CDM project can be compared to other plants using the same fuel ('fuel-specific'), to all fossil fuel-fired plants ('all fossil'), or to the whole electricity generation ('sector-wide'). Obviously the fuel-specific comparison only applies if there is a plant in the baseline using the same fuel as the CDM project.

The third decision is whether to compare projects against average, better-than-average, or best plants. Once the carbon intensity of the plants in the reference scenario is known, we can construct increasingly stringent benchmarks – from weighted average, to 25th percentile, to 10th percentile, up to the best plant, as shown in Figure A1. One would expect the carbon intensity of these benchmarks to be lower – in other words, the CDM project will have to show progressively lower carbon intensity to still receive CERs.

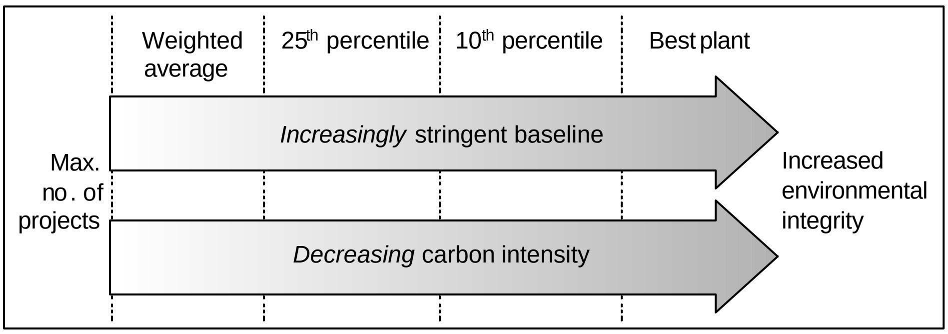

Figure A1: Baseline stringency and environmental integrity

Figure A2 shows a 'near future' reference scenario – plants coming on line in the past five and next five years. The graph shows a near future baseline with each plant's carbon intensity (kg CO_2/kWh) shown against the share of generation (Twh).

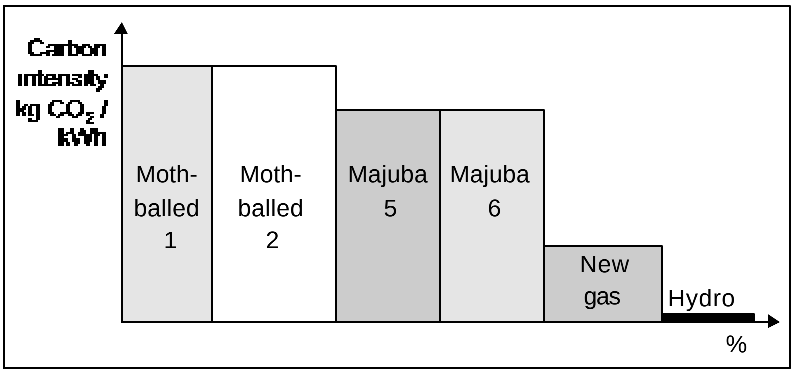

Figure A2: Near future reference scenario

Table A1 shows the baseline intensities – both energy and carbon intensity – given the units included in the 'near future' baseline. No energy intensity is reported for the sector, since this concept has different meanings for fossil fuel plants and plants using renewable energy sources. There is no 'fuel' for hydropower, so no fuel-specific intensities are reported. For the purposes of this analysis, we assume that the carbon intensity for hydropower is zero, although this may well not be the case (WCD 2000). The carbon intensity for gas is calculated from the fuel input and electrical output of one station only ('new gas'). Carbon intensity represents the baseline for CDM projects; energy intensity is reported for information only.

Table A1: Energy and carbon intensities for the near future baseline

				*Weighted average***	*Percentile 25%*	*Percentile 10%*	*Best plant*
Fuel specific	Energy intensity	MJ/kWh	Coal	11.72	10.90	10.46	10.46
			Gas	6.55*	6.55*	6.55*	6.55
	Carbon intensity	Kg C/kWh	Coal	0.330	0.307	0.295	0.295
			Gas	0.100*	0.100*	0.100*	0.100
All fossil	Energy intensity	MJ/kWh		0.259	0.100	0.100	0.100
	Carbon intensity	Kg C/kWh		0.270	0.128	0.100	0.100
Sector wide	Carbon intensity	Kg C/kWh		0.228	0.052	0.000	0.000

Notes: * = Based on one plant only
** = Weighted average of plants in reference scenario, not all SA plants

The benchmarks become more stringent from left to right, as expected. However, the coal-specific carbon intensity is identical, whether one uses the 25th percentile, 10th percentile or best plant. This is because several of the coal units included in the baseline are identical in performance. Natural gas has much lower carbon intensity than coal – and this constitutes the best plant and 10th percentile for the 'all fossil' comparison. The zero carbon intensity sector-wide reflects the inclusion of imported hydro and the assumption that it is zero-emitting. The baseline becomes more stringent as one moves from fuel-specific to 'all fossil' and 'sector-wide' comparisons, because 'all fossil' adds in natural gas, and the sector adds the imported hydro, bringing down the weighted average carbon intensity.

As can be expected, the weighted average carbon-intensity of the plants in this reference scenario is lower, at 0.228 kgC/kWh, than the average for all plants. Eskom reports that the total electricity produced in 2000 was 189 307 GWh (net) (Eskom 2000a) and that total carbon dioxide emissions from coal-fired power stations were 161.2 million tons of carbon dioxide (Eskom 2000b). The reported carbon intensity is 0.85 kg CO_2/ kWh (Eskom 2000b), which converts to 0.232 kg C/kWh. This means that the average carbon intensity of the current mix of Eskom plants is less than 2% higher than that of the reference scenario of 'near future' plants. For gas, the fuel-specific carbon intensity is lower than the all-fossil or sector-wide intensity, which includes carbon-intensive coal. The weighted average and percentiles for gas are based on one plant only. While it may be mathematically more correct to base such measures on more gas plants than the one plant included here, the value of the single plant is included across all, because this is how one would compare the project.

Additional references:

Eskom 2000a. Annual Report 2000. Sandton, Eskom. www.eskom.co.za

Eskom 2000b. Environmental report 2000: Towards sustainability. Sandton, Eskom.

WCD (World Commission on Dams) 2000. Dams and development: A new framework for decision-making. London, Earthscan Publications.

2. Wood waste power plant in Zimbabwe

This project uses wood waste from sawmills for power generation to replace electricity from the grid. The biomass source is softwood plantations which are sustainably managed, implying that there are no net carbon dioxide emissions. However, use of the waste for power production will generate some methane (34.59 kg/TJ) and nitrous oxide (3.46 kg/TJ) (EM, 2000). The emission rate for non-carbon dioxide GHGs was estimated at 0.006 kg CO_2-equivalent/MWh. The calculation is done for three activity level scenarios depending on assumptions of plant availability (operation and stand-by time). The activity levels are low, medium and high, estimated at 50%, 60% and 85% availability levels respectively. The CDM emissions levels are deducted from the baseline scenarios to give net emissions reductions.

Table A2: Emission reductions for different activity levels against different baselines
Source: Herold et al (2000)

CDM activity level (availability)	*Output level*	*Baseline C1 – 1996 OECD fuel mix*	*Baseline D – Business as Usual scenario*	*Baseline E – Marginal existing plants*
	(MWh/year)	(Kt CO_2-equivalent/year)		
Low	15 330	8.57	13.01	19.76
Medium	18 396	10.28	15.64	23.74
High	26 061	14.57	22.21	33.68

The results show the sensitivity of the credited emissions reductions to the baseline selection. If the wood was grown specifically for this project, then the amount of emissions reduction will have to include the carbon sequestered by the plantations in the first rotation, as estimated by the LULUCF calculations.

3. Short rotation forestry project

This example shows how a forestry project in East Africa could generate CDM credits. Key assumptions are presented in the two tables below, including standard parameters that can be used for LULUCF projects. The baseline ecosystem is a degraded but stable miombo woodland, with non-declining soil carbon.

Table A3: Parameters and assumptions for baseline scenario, short rotation community forestry project

Source: Makundi (2001)

Parameters	
Soil carbon (tC ha^{-1})	45
Vegetation biomass ($m^3 ha^{-1}$)	32.5
Above-ground/stemwood biomass ratio	1.57
Total/Above-ground biomass ratio	1.25
Wood density (t/m^3)	0.89
Vegetation biomass (t dry biomass ha^{-1})	57
C density (%)	0.53

Table A3: Parameters and assumptions for short rotation community forestry project

Source: Makundi (2001)

Parameters	
Available area (ha)	1.7×10^6
Species	*Eucalyptus (maidenii, saligna, microcorys, globulus), Leucena leucocephala, & Melia spp.,*
Average mean annual increment ($m^3 ha^{-1} yr^{-1}$)	36
Merchantible volume/stemwood[1]	1.1
Stemwood /above-ground biomass[2]	1.2
Total vegetation/above-ground[3]	1.3
Wood density[4]	0.65
C density[5]	0.48
Soil carbon (t C $ha^{-1} yr^{-1}$)	1.0
Rotation age (yrs)	8
Vegetation biomass (t $ha^{-1} yr^{-1}$)	40
Average product lifetime (yrs)	17
Decomposition time (yrs)	8

Notes:

1 Stemwood measured excludes tops and buttress
2 Above ground includes branches, associate vegetation, detritus, etc
3 Total vegetation includes below ground biomass
4 Average for 3 common species (P. patula, elliottii and caribaea)
5 Average for pines and cypress

The emission reduction estimate is done using the method explained above for a project managed in perpetuity. The results are given in Table A4.

Table A4: Carbon sequestration potential at equilibrium for short rotation community forestry project
Source: Makundi (2001)

Pool (t C ha^{-1})	
Vegetation carbon	77
Soil accumulation	8
Decomposing matter	28
Forest products	34
Total mitigation pool	147
Mitigation + baseline soil carbon	192
Baseline Pool	75
Net mitigation potential	117

4. Natural gas-fired power station

This example is for illustration only, and does not reflect an actual CDM pilot project proposal.

Type of project and location: Grid-connected combined cycle natural gas fired power station

Stage of project, and time required for completion: There is discussion underway in South Africa about a new gas-fired power station. Once the proposal is complete, tenders will be sent out for constructing the power station, and the owner would have to apply to the National Electricity Regulator for a licence. The power station could be in place by 2005, or possibly earlier if approval is received.

Expected lifetime of project: The power station life would be at least 25 years, which reflects the level of gas reserves well as the trends in technology costs.

Brief project outline: The introduction of natural gas into South Africa has been under discussion for many years, because of the high dependence on coal for electric power generation (92%). The natural gas fields in Namibia (Kudu), Mozambique (Pande, Temane), and off the west and southern coasts of South Africa all provide potential resources if pipelines can be constructed. This project was set up to conduct a feasibility study for a 1 100 MW output natural gas combined cycle power station. The gas might also be used by industrial and residential users, but that is outside the scope of this example.

South Africa has had excess electric generating capacity for some time, and this situation is likely to continue until 2007. This project could be on line before then. The power station would have a 53% lifetime average efficiency, and lifetime availability of 91%, and would operate at a load factor of 70%. The station output is expected to be 6200 GWh per year, and consume roughly 900 million cubic metres of natural gas.

Baseline scenario

Because the gas-fired power station will feed into the national electricity grid, we need to analyse what emissions from grid electricity in South Africa could be displaced. Since electricity moves throughout the grid, it is not possible to say that one particular plant would be displaced – one must look at the whole grid and how it is changing. There are (at least) three ways to do this:

1. the average carbon emissions from all grid electricity generation in South Africa;
2. carbon emissions from the most recent plant additions –the marginal plants that could be displaced by a new power station;
3. the carbon emissions from the next few capacity additions – because in reality, if demand grows, a new power station will replace projected capacity additions, not existing ones.

Previous research shows that the carbon emissions intensity for the three scenarios given above are as follows:

1. Average for all of Eskom's power stations: 0.85 kgCO_2/kWh (this includes a small amount of hydro and gas).
2. Weighted average for recent additions: 1.08 kgCO_2/kWh (the Majuba power station final units).
3. Weighted average for planned additions (1997-2005): 0.84 kgCO_2/kWh (Majuba, re-commissioning old coal stations, more imported hydro, and possible gas somewhere in South Africa).

Obviously, 'planned additions' is the most subjective, since we can not know precisely what will happen (even if published in utility planning documents).

Projected CDM scenario

Based on the above data, we would expect the emissions intensity of the gas power station to be 0.37 kgCO_2/kWh, or less than half of the baseline benchmarks. This plant performance is based on known technologies and operating conditions, and standard emissions factors and heat content factors for natural gas.

Assuming the power station generates 6200 GWh/year, the annual reductions for the three baseline scenarios would be as follows:

1. 6 200 000 000 kWh x (0.85– 0.37 kg CO_2/kWh) = 2976 kt CO_2
2. 6 200 000 000 kWh x (1.08–0.37 kg CO_2/kWh) = 4402 kt CO_2
3. 6 200 000 000 kWh x (0.84–0.37 kg CO_2/kWh) = 2852 kt CO_2

Power stations are relatively easy to monitor because their performance is almost directly related to fuel consumption. The power station would have to report its output and nominal capacity to the Regulator each year in any case, and this would be public knowledge. As long as fuel consumption was also reported, the project emissions would be clear.

Whether the benchmarks used accurately reflect the development path of the sector, however, is another question. For example, Eskom (the electricity utility) may decide not to reinstate mothballed power stations and to rather rely solely on additional imported hydropower to meet additional demand. The benchmark baseline would then be too generous, because the project would be receiving more credits than the actual impact it had on the power system emissions. This raises the difficult question of whether periodic adjustments of baselines would be required.

Financial analysis

Typical capital costs for a natural gas combined cycle power station are $445/kW, while operating and maintenance costs are approximately $3.8 per MWh. The fuel costs are uncertain, given the cost of the pipeline and the potential for other customers in South Africa. For this example, we use R96 per MWh as the fuel cost, which already takes into account the operating efficiency of the power station. Monitoring and verification of power station emissions is relatively straightforward, and we may estimate this as 2% of the capital cost, spread over the life of the project.

On the benefits side, we assume that the developer can sell power for an average of R0.18 per kWh over the life of the project (even though current prices are lower than this). For carbon revenue, we can consider three possible scenarios of $2, $8 and $14 per ton of carbon. Note that an exchange rate of R10/US$ is used for these calculations. The total capital costs for the project are therefore R4 895 million, with annual energy costs of R595 million, operations and maintenance costs of R236 million, and monitoring and verification costs of R3.9 million. Annual revenue from electricity sales would be R1 116 million. Carbon revenue would range from R58 to R407 million.

IRR for the project without the CDM is 3%. IRR with the CDM is shown below, based on the price of carbon and the benchmark used.

Table A5: Internal rate of return at different carbon prices and baselines

Benchmark/ price	*$2*	*$8*	*$14*
0.84	5%	9%	14%
0.85	5%	10%	14%
1.08	6%	12%	18%

5. Energy-efficient lighting in low-income housing

As an extension of the Efficient Lighting Initiative, a major municipality in South Africa is considering installing 300 000 energy efficient CFLs in low-income housing.

Brief project outline: Energy-efficient lighting has been identified as a highly cost-effective way to reduce growth in energy consumptions and related emissions, while assisting poor consumers by freeing disposal income. This CDM project would build on the Efficient Lighting Initiative to extend the reach of the lighting programme further into low-income areas. In this example the municipality pays the full cost of the CFLs, and then passes them on to consumers for free. The CFLs have a power rating of 19W, and would replace incandescent bulbs using an average of 75W.

Expected lifetime of project: The CFLs would last for 8 000-10 000 hours, that is seven to nine years at 3.2 hours per day. The project would not include replacement bulbs, so it would last for eight years.

Baseline scenario: We use the same assumption about emissions from electricity as in the previous example.

Predicted CDM project scenario

The emissions savings would be related to the reduced electricity demand. CFLs use only about a quarter of the energy for the same lighting service. There would be no additional maintenance costs or operating expenses. Total avoided energy use would be the difference in the demand, multiplied by the number of bulbs, multiplied by the hours of use:

300 000 bulbs × (0.075 kW – 0.019 kW) × (3.2 hrs/day × 365 days/yr) = 19 600 000 kWh savings per year

Estimating emission reductions

Using the three different benchmarks, the annual avoided emissions would be the following:

1. Average all power stations: 19 600 000 kWh x 0.85 kg CO_2/kWh = 16 660 t CO_2
2. Recent additions: 21 168 t CO_2
3. Planned additions: 16 268 t CO_2

For the sake of simplicity, we assume that all bulbs are installed in the first year, and the project lasts for eight years (the average life of the bulbs).

Financial analysis

CFLs will be purchased in bulk for R27 each. They will displace incandescent bulbs normally purchased by consumers – although the municipality will not see this benefit. To estimate the emissions reductions, we would need to monitor the use of the CFLs, for example through customer surveys. Let us assume monitoring and validation is 10% of total capital costs, spread over the life of the project. Based on estimates for other demand-side management programmes, it is estimated that the programme overheads will cost about R50 000 per year.

On the benefits side, the municipality will avoid purchasing electricity from the utility, for which they currently pay 10c/kWh. For carbon revenue, we consider three possible scenarios of $2, $8 and $14 per ton of carbon dioxide. Note that an exchange rate of R10/US$ is used for these calculations.

The total capital costs for the project are therefore R8.1m, with annual programme costs of R50 000 and monitoring and validation costs of R101 000. Annual avoided electricity costs (a benefit) are R1 962 000. Carbon revenue would range from R450 000 to R2 240 000.

IRR for the project without the CDM is 17%. IRR with CDM is shown below, based on the price of carbon and the benchmark used.

Table A6: Internal rate of return by carbon price and baseline

Benchmark/price	*$2*	*$8*	*$14*
0.84	20%	35%	49%
0.85	21%	35%	49%
1.08	22%	41%	58%

6. Energy-efficient lighting for retail chain store

This example (Sathaye & Venida 2001) involves a large store chain that has been in business for over 30 years. Each of its stores uses about 100 kWh per day for lighting. Eighty stores will participate in the CDM project.

Estimation of emissions from electricity: Three approaches may be used to estimate the emissions factors and baseline emissions. One is to use the fuel mix and emissions factors for each type of power plant to estimate the composite emissions factor using a model like PROFORM.[8] The second approach is to estimate the emissions factor using a more sophisticated model such as MAGPWR, which models the actual demand and load curves for electric power over time and so takes into account the variability of emissions and cost during a given day and week. The third approach would be to use total emissions from all power plants, divided by total electricity output for each year of the project life, based on projections from the power company.

Description of parameters and assumptions used in the baseline scenario: Each of the 89 participating stores has an average of 120 incandescent light bulbs. About 20 of these lamps have limited space around them, or are used for a few hours a day; it would not be economical to replace them. This leaves 100 lamps in replaceable locations. The lamps are rated at 100 watts each. The total load is thus 10 000 W or 10 kW per store.

A preliminary survey of the stores shows that these bulbs are on for an average of about 10 hours a day, spanning the two to four hour peak electric power supply period for the utility company. The consumption per day per store is 100 kWh, which constitutes the baseline for the project.

The associated emissions are estimated using the fuel mix for power generation and emissions factors provided by the electric utility company. Based on the mix of power plants supplying electricity to the commercial sector in the city, the utility company states that the fuel mix will change from 25% coal and 75% natural gas in year 1 to 75% coal and 25% natural gas in year 3. The emissions factor for avoided electricity, calculated by dividing total power plant emissions by total output, is 176 kg C/MWh. This emissions factor is projected to increase in three years to 252 kg C/MWh as more coal power plants are brought on line by the utility. Information provided by the utility states that the transmission and distribution losses are 20%.

This information provides the emissions associated with baseline electricity use. Annual emissions for the 80 stores increase from 616 t C in year 1 to 883 t C in year three, and the cumulative emissions are 2249 t C.

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8 PROFROM is a Microsoft Excel spreadsheet based software programme developed to analyse the impact of carbon revenue on financial returns for a CDM project developer. It was developed by Lawrence Berkeley Laboratory in the USA, and can be obtained by contacting Steve Meyers at spmeyers@lbl.gov.

How do national policies influence the baseline?

National policies could influence the expansion plans of the local utility company as it is a government owned company, and its plans are subject to government budgetary approval. Expansion plans are revised every two years. In the past the fuel mix changed as new resources of natural gas were discovered. It is conceivable that the current coal supply plans may change in the future, which will change the baseline emissions.

Data and uncertainties:

The key data used in the baseline include:

- the number of estimated replaceable bulbs – 100, based on a survey;
- the number of stores that are included in the programme – 80, all open 365 days/year
- transmission and distribution losses – 20%;
- emissions factor – 176 kgC/MWh in year 1 increasing to 252 kgC/MWh in year 3.

Baselines are, by definition, hypothetical reference cases and are subject to a number of uncertainties. The uncertainties related to each of the major data sets include:

- Number of replaceable bulbs – unlikely to vary significantly, since this is based on a detailed survey of each store.
- Number of stores is not likely to change. The participating stores were designated by the chain as viable candidates for the CDM project. Should one of these stores shut down, the chain is likely going to replace it in the same area. In the unlikely event that a suitable candidate is not found, less emissions reductions would be claimed.
- The transmission and distribution loss of 20% is not expected to change in the next five years, according to the utility company.
- The emissions factors are provided by the utility company. These are subject to fluctuation, however, depending on the price of fuels and the type of fuel resources that become available in the next few years. It is conceivable that the emissions factors may not increase. The carbon credits claimed by the project, however, will depend on the emissions avoided when the project is operational and not on this estimated value.

Table A7: Technical, performance, price, and emissions data

Attributes	*Incandescent bulb*	*Compact fluorescent lamp*
Size	100 watts	30 watts
Cost (US $/bulb)	0.50	10
Installation Cost (US $/bulb)		1.0
Operation (hrs/day)	10	10

	Year 1	Year 2	Year 3
Number of stores	80	80	80
T&D loss	20%	20%	20%
Electricity price ($/kWh)	0.05	0.05	0.05
Carbon price ($/t C)	20	20	20
Generation fuel mix (%)			
Coal	25	50	75
Natural gas	75	50	25
Emissions factors (kg/MWh)			
Coal – carbon	25.8		
Natural gas – carbon	15.3		
SO_2 – coal	14.79		
NO_x – gas and coal	1.13		
Particulates – coal	6.91		

Table A8: Results of the estimation – Electricity use and emissions

	Year 1	*Year 2*	*Year 3*	*Cumulative*
Baseline:				
Electricity use (MWh)	2 920	2 920	2 920	8 760
Emissions (tons)				
Carbon	616	750	883	2 249
SO_2	146	292	437	875
NO_x	38	40	42	121
Particulates	68	136	204	408

Building on the baseline example, we can now estimate emissions reductions from the project.

Data and uncertainties:
The key data used in estimating the emissions reductions include:

- expected savings per bulb – 70% or 0.70 kWh/bulb/day, which is based on the number of hours of use, and the technical performance of the CFL; and
- emissions factor – 176 kg C/ MWh in year 1 increasing to 252 kg C/MWh in year 3.

The expected savings per bulb are based on specifications and field test data provided by the manufacturer. The manufacturer claims 75% savings per bulb. We expect these to hold, since the CFLs are hardened to sustain any damage that might be caused by voltage fluctuations. Further, the district has reliable and steady electricity supply and the utility company does not expect any deterioration. In order to guard against an unforeseen deterioration of supply and unlikely damage to the CFL bulb, however, let us downgrade the electricity savings from 75% to 70% in making an estimate of emissions savings. The results are shown in Table A8.

- Anthropogenic GHG emissions within project boundary attributable to the project: Project emissions are estimated to increase from 185 tC/yr in year 1, 225 in year 2, to 265 tC/yr in year 3.
- Anthropogenic greenhouse emissions outside the project boundary attributable to the project: None.
- Comparison of project and baseline anthropogenic GHG emissions: Baseline carbon emissions are estimated to be 616 tC in year 1 increasing to 750 tC in year 2 and 883 tC/yr in year 3.
- Emissions reduced during the specified period: The emissions reductions estimated are 431 tC/yr in year 1 which increase to 525 t C in year 2 and 618 tC/yr in year 3.

Table A8: Results of the estimation – Electricity use and emissions

	Year 1	*Year 2*	*Year 3*	*Cumulative*
Baseline:				
Electricity use (MWh)	2920	2920	2920	8760
Emissions (tons)				
Carbon	616	750	883	2249
SO2	146	292	437	875
Nox	38	40	42	121
Particulates	68	136	204	408

	Year 1	*Year 2*	*Year 3*	*Cumulative*
Project:				
Electricity use (MWh)	876	876	876	2628
Emissions (tons)				
Carbon	185	225	265	675
SO2	44	87	131	262
Nox	11	12	13	36
Particulates	20	41	61	123
Project – baseline:				
Electricity use (MWh)	2 044	2 044	2 044	6 132
Emissions (tons)				
Carbon	431	525	618	1 575
SO_2	102	204	306	612
NO_x	27	28	30	84
Particulates	48	95	143	286

APPENDIX B
Official UNCCC project design document

The project design document format for all CDM projects, taken from official UNFCCC documents, is reproduced here.[9] *While this may still be revised over the next year, the basic format is unlikely to change.*

1. The provisions of this appendix shall be interpreted in accordance with the annex ... on modalities and procedures for a CDM.

2. The purpose of this appendix is to outline the information required in the project design document. A project activity shall be described in detail taking into account the provisions of the annex on modalities and procedures for a CDM, in particular, section G on validation and registration and section H on monitoring, in a project design document which shall include the following:

   (a) A description of the project comprising the project purpose, a technical description of the project, including how technology will be transferred, if any, and a description and justification of the project boundary;

   (b) A proposed baseline methodology in accordance with the annex on modalities and procedures for a CDM including, in the case of the:

      (i) Application of an approved methodology:

      – Statement of which approved methodology has been selected;

      – Description of how the approved methodology will be applied in the context of the project;

      (ii) Application of a new methodology:

      – Description of the baseline methodology and justification of choice, including an assessment of strengths and weaknesses of the methodology;

      – Description of key parameters, data sources and assumptions used in the baseline estimate, and assessment of uncertainties;

      – Projections of baseline emissions;

      – Description of how the baseline methodology addresses potential leakage;

      (iii) Other considerations, such as a description of how national and/or sectoral policies and circumstances have been taken into account and an explanation of how the baseline was established in a transparent and conservative manner;

   (c) Statement of the estimated operational lifetime of the project and which crediting period was selected;

   (d) Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity;

   (e) Environmental impacts:

      (i) Documentation on the analysis of the environmental impacts, including transboundary impacts;

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9 FCCC/CP/2001/CRP.11 pp. 38-39

(ii) If impacts are considered significant by the project participants or the host Party: conclusions and all references to support documentation of an environmental impact assessment that has been undertaken in accordance with the procedures as required by the host Party;

(f) Information on sources of public funding for the project activity from Parties included in Annex I which shall provide an affirmation that such funding does not result in a diversion of official development assistance and is separate from and is not counted towards the financial obligations of those Parties;

(g) Stakeholder comments, including a brief description of the process, a summary of the comments received, and a report on how due account was taken of any comments received;

(h) Monitoring plan:

(i) Identification of data needs and data quality with regard to accuracy, comparability, completeness and validity;

(ii) Methodologies to be used for data collection and monitoring including quality assurance and quality control provisions for monitoring, collecting and reporting;

(iii) In the case of a new monitoring methodology, provide a description of the methodology, including an assessment of strengths and weaknesses of the methodology and whether or not it has been applied successfully elsewhere;

(i) Calculations:

(i) Description of formulae used to calculate and estimate anthropogenic emissions by sources of greenhouse gases of the CDM project activity within the project boundary;

(ii) Description of formulae used to calculate and to project leakage, defined as: the net change of anthropogenic emissions by sources of greenhouse gases which occurs outside the CDM project activity boundary, and that is measurable and attributable to the CDM project activity;

(iii) The sum of (i) and (ii) above representing the CDM project activity emissions;

(iv) Description of formulae used to calculate and to project the anthropogenic emissions by sources of greenhouse gases of the baseline;

(v) Description of formulae used to calculate and to project leakage;

(vi) The sum of (iv) and (v) above representing the baseline emissions;

(vii) Difference between (vi) and (iii) above representing the emission reductions of the CDM project activity;

(j) References to support the above, if any.

APPENDIX C

World Bank prototype Carbon Fund templates

These templates are presented here as useful examples of how to present a CDM project idea. They are not official UNFCCC documents. They are publicly available on the PCF website www.prototypecarbonfund.org.

Project Idea Note for

[Project Name]

[Project Sponsor]

Date submitted:

1. Project Proponent

1.1. Name of Organisation:

1.2. Organisational Category (Government/Government Agency/Municipality/Company/ NGO):

1.3. Address:

1.4. Contact Person:

1.5. Phone/Fax:

1.6. E-mail:

1.7. Function of Proponent in the Project (Sponsor/Operational Entity/ Intermediary/Technical Advisor):

1.8 Project Sponsors (please list all). Please provide details of the lead sponsor(s) including previous experience with similar project and technologies and summarise the financial results for the last fiscal year. Please provide corporate rating from S&P and/or Moody's, if available.

2. Type of Project

2.1. GHGs Targeted (CO_2/CH_4/N_2O/HFCs/PFCs/SF_6):

2.2. Type of Activities (Abatement/CO_2 Sequestration):

2.3. Field of Activities (Renewable Energy/Alternative Energy/Energy Efficiency/Demand Side Management/Fuel Switching/Land Use, Land Use Change and Forestry):

2.4. If the project is hydropower, please provide the dam and reservoir size in metric dimensions.

3. Location of Project

3.1. Region (Africa/East Asia & Pacific/South Asia /Europe & Central Asia/Middle East & North Africa/Latin America & the Caribbean):

3.2. Country (including the status of Kyoto Protocol ratification):

3.3. City:

3.4. Brief Description of Location:

4. Expected Schedule

4.1. Earliest Project Start Date:

4.2. Current Status (Under Discussion/ Planning / In Preparation/ Advanced in Preparation, i.e. already discussed with government):

4.3. Time Required Before Becoming Operational:

4.4. Project Lifetime:

5. Financing Sought

5.1. Project Financing:

5.1.1. Estimate of total project cost in US dollars:

5.1.2. Financing (other than PCF) to be sought or already identified:

5.2. Requested PCF Contribution:

5.3. Expected Schedule for PCF Contribution: [*Please Note:* PCF contribution is provided, in principle, on delivery of Emission Reductions, but some up-front financing may be provided to support project implementation]

5.4. Brief Description of Other Financial Considerations:

6. Technical Summary of Project

Please provide a brief paragraph of maximum 10 lines for each of the below.

6.1. Objective:

6.2. Brief Description of Project:

6.3. Technology to be Employed:

6.4. Brief Description of Technology [*Please Note:* PCF only supports projects that employ commercially available technology. It would be useful to provide a few examples of where the proposed technology was previously used]:

7. Expected Environmental Benefits

Please provide a brief paragraph of maximum 10 lines for each of the below.

7.1. Estimate GHGs Abated/CO_2 Sequestered in 'tons of carbon equivalent' (show calculations):

7.1.1. before 2008:

7.1.2. during 2008 – 2012:

7.1.3. during entire project lifetime:

7.2. Baseline (or Reference) Scenario [Please describe what would otherwise occur in the absence of PCF contribution. The description should include alternatives available for the end-use or application that the proposal addresses and the reason why the baseline option is the one which would be implemented in the absence of PCF resources. Please refer to the PCF Implementation Note # 3: *Baseline Methodologies for PCF Projects*, which can be viewed or downloaded on the PCF website]:

7.3 If financial analysis is available for the PCF alternative proposed project, please describe

(a) forecast financial internal rate of return (FIRR) before injection of PCF funds

(b) forecast FIRR after injection of PCF funds (please note that the PCF intends to provide additional funding for the project, in principle, in the form of 'pay-on-delivery of Emission Reduction')

(c) Marginal cost of carbon abatement calculated on a

(i) full project lifecycle

(ii) Kyoto Protocol commitment period (2008-2012)

In all cases, please report key the assumptions in the analysis.

7.4. Specific Global & Local Environmental Benefits Expected:

7.5. Relevance for Host Country Socioeconomic and Environmental Priorities:

Project Concept Note

[Project Name]

[Project Sponsor]

Date submitted to PCF FMU:

Date of host country endorsement (Attachment: Letter of Endorsement):

Date circulated for clearance by PC:

Date approved:

PCF Project Number:

Note: Additional information required to develop PCN (from PIN), especially for Project Summary, 1.9, 3.5, 4.2, 5.5, 5.6, 6.5, 7.1, 7.2, 7.3, 7.4, 7.5, 7.7, 7.8, 7.9, 7.11, 7.14, 8.1, 8.2, 8.3. All relevant data and status should be updated.

Project Summary

S.1. Lead Project Sponsor [the project sponsor/entity who concluded the agreement with the PCF by Mandate Letter]:

S.2. Information on Project Sponsor [brief description including field of activities, corporate rating, experience in relevant projects]:

S.3. Information on National Focal Point for PCF [national focal point and ministry and/or organisation of the Host Country government which issues the Letter of Endorsement]:

S.4. Type of Project (JI or CDM; renewable energy, energy efficiency, or LULUCF) and Location:

S.5. Project Financing (in US$):

- Total project cost:
- Underlying finance (percentage for investor's equity/dept):
- PCF purchase of Emission Reductions sought:
- Purchase value of remaining potential Emission Reductions:

S.6. Estimated Emission Reductions (in tons of Carbon):

- before 2008 [Please indicate when the project will start generating Emissions Reductions]:
- during 2008 – 2012:
- during entire project lifetime [Please specify the project lifetime]:
- Estimated price of Emissions Reductions (for up to 2012/entire project lifetime in US$/t-C)

S.7. Major Potential Risks Associated with the Project:

S.8. Major Reasons for Recommendation:

Detailed Project Information

1. Project Proponent

1.1. Name of Organisation:

1.2. Organisational Category (Government/Government Agency/Municipality/Company/ NGO):

1.3. Address:

1.4. Contact Person:

1.5. Phone/Fax:

1.6. E-mail:

1.7. Function of Proponent in the Project (Sponsor/Operational Entity/Intermediary/ Technical Advisor):

1.8. Project Sponsors (please list all):

1.9. Project Sponsors' Capability in implementing the Project (e.g. credentials):

2. Type of Project

2.1. GHGs Targeted:

2.2. Type of Activities (Abatement/CO_2 Sequestration):

2.3. Field of Activities (Renewable Energy/Alternative Energy/Energy Efficiency/Demand Side Management/Fuel Switching/Land Use, Land Use Change and Forestry):

2.4. If the project is hydropower, please provide the dam (e.g. height, crescent length) and reservoir size in metric dimensions.

3. Location of Project

3.1. Region:

3.2. Country (including Kyoto Protocol status, i.e. signed and/or ratified):

3.3. City:

3.4. Brief Description of Location:

3.5. Sector Background:

3.5.1 Structure/organisation:

3.5.2 Sector policy/strategy:

3.5.3 Constraints (e.g. barriers/limitation which prevents the project sponsors in the sector to take advance action under the current situation):

4. Expected Schedule

4.1. Earliest Project Start Date:

4.2. Current Status (i.e. availability of feasibility study, level of technical design, host country endorsement, status of environmental impact assessment):

4.3. Time required before becoming Operational:

4.4. Project Lifetime:

5. Financing Sought

5.1. Project Financing:

5.1.1. Estimate of total project cost in US$:

5.1.2. Financing (other than PCF) to be sought or already identified:

5.2. PCF Purchase of ERs sought:

5.3. Expected Schedule for PCF Purchase of ERs:

5.4. Brief Description of Other Financial Considerations:

5.5. Status and estimated Timing of Financial Closure:

5.6. Key Parameters affecting Project Feasibility:

6. Technical Summary of Project

6.1. Objective:

6.2. Brief Description of Project:

6.3. Technology to be employed:

6.4. Brief Description of Technology:

6.5. Stakeholder Involvement:

7. Expected Environmental Benefits

A. Quantity of Asset

7.1. Project Boundaries:

7.2. Historical Emissions Data for Baseline Case:

7.3. Proposed Formula for calculating ERs within the Project Boundary and ERs outside the Project Boundary, which are attributable to the Project:

7.4. Projection of Baseline Emissions and ERs by the Project (over the operational life of the project):

7.5. Uncertainties associated with the Estimate (including potential leakage beyond the project boundaries):

B. Quality of Asset

7.6. Baseline (or Reference) Scenario:

7.7. Methodology applied (including what type of 'additionality' is satisfied):

7.8. Key Parameters used for Baseline Determination:

7.9. Proposed Crediting Time of the Project/Project Lifetime and Justification:

7.10. If Financial Analysis is available for the PCF Alternative Proposed Project, Please describe:

7.10.1. Estimated financial internal rate of return (FIRR) before injection of PCF funds

7.10.2. Estimated FIRR after injection of PCF funds

7.10.3. Marginal cost of carbon abatement calculated on a

(i) Full project lifecycle

(ii) Kyoto Protocol commitment period (2008-2012)

7.11. Key Variables Potentially affecting Future Credibility of Baseline:

C. Other Environmental Benefits

7.12. Specific Global & Local Environmental Benefits expected:

7.13. Relevance for Host Country Socioeconomic and Environmental Priorities:

7.14. Stage of Environmental and Social Review:

8. Risks and Uncertainty

8.1. Major Risks:

8.1.1. Baseline risk (including impact of alternative choices of additionality):

8.1.2. Other major risks (e.g. political risks, risks associated with sector strategy):

8.2. Risk Mitigation Measures

Remaining Risks and Uncertainty

APPENDIX D
Sources of finance and technical support

Organisations wishing to be listed in this section in future editions of the CDM Guidebook should contact the authors at randall@energetic.uct.ac.za

GOVERNMENTS AND NATIONAL JI/CDM PROGRAMMES		
UK Climate Change Challenge Fund	The UK Climate Change Challenge Fund provides flexible source of funding to help business and developing countries meet the challenges of climate change. It will finance projects that will help developing countries and economies in transition to build the capacity they need to combine healthy growth with low emissions of GHGs. £500,000 is allocated to the Fund each year and proposals are considered regularly. The Fund may consider funding feasibility studies and training activities.	Andrew Key Environment Policy Department Foreign and Commonwealth Office Tel: + 44 20 7270 4078 Fax: + 44 20 7270 4076. andrew.key@mail.fco.gov.uk
Swiss AIJ Pilot Programme	One of the more active AIJ programmes, the Swiss programme funds carbon offset projects that have obtained approval of the host country government.	Effingerstrasse 1 CH-3003 Berne Switzerland Tel: + 41 31 323 08 85 Fax: +41 31 324 09 58 swap@seco.admin.ch
Australian International Greenhouse Partnerships Office	The Australian International Greenhouse Partnerships (IGP) Programme provides funding opportunities for CDM projects with Australian participation. Over AU$6 million available. Priority will be given to project proposals that seek funding primarily for additional transaction costs related to GHG reduction considerations. AusAID, Australia's foreign aid programme, may be able to provide additional funding for capacity building and training activities.	GPO Box 9839 Canberra ACT 2601 Australia Fax: + 61 2 6213 7903
Netherlands CDM Programme/ SENTER	Under the Ministry of Economic Affairs, Senter acts as the primary agency for coordinating the Netherland's official climate change project work in developing countries. Senter will be responsible for coordinating government tenders for investing in CDM projects in the coming years through the ERU-PT programme, which has already put out a tender for investing in Joint Implementation projects.	Mr Adriaan Korthuis P.O. Box 30732 2500 GS Den Haag The Netherlands Tel. +31 70 361 04 95 Fax +31 70 361 05 02 www.senter.nl
Swedish National Energy Administration	Administers the Swedish program on AIJ on behalf of the Swedish government.	Jurgen Salay Swedish National Energy Ad ministration P.O. Box 310 SE-631 04 Eskilstuna SWEDEN Jurgen.salay@stem.se www.stem.se
U.S. Initiative on Joint Implementation (USIJI)	The main vehicle of the U.S. government to help facilitate and support the development of AIJ and related carbon offset projects internationally. Over three dozen projects in the energy, waste, agriculture, and forestry sectors have been approved by the USIJI thus far. Some have received funding for feasibility work and other technical assessments.	USIJI 1000 Independence Avenue, SW Washington, DC 20585 USA Tel: + 1 202 586 3288 Fax: + 1 202 586 3486

Canadian Office of Joint Implementation and CDM	Created by the Climate Change Action Fund, Canada's CDM & JI office was established to enhance Canada's capacity to take advantage of the opportunities offered by the CDM and JI. This includes financial support for activities that reduce emissions globally.	Canada's CDM&JI Office International Environmental Affairs Bureau Climate Change Division Department of Foreign Affairs and International Trade 125 Sussex Drive Ottawa, Ontario K1A 0G1 Canada Tel: +1 613 944 3032 Fax: +1 613 944 0064 cdm.ji@dfait-maeci.gc.ca www.dfait-maeci.gc.ca/cdm-ji/
Oregon Climate Trust	Non-profit organisation funded by five major electric utilities in the state of Oregon. Oregon legislation requires new fossil fuel power plants in the state to avoid, sequester, or displace a portion of their carbon dioxide emissions. The Oregon Climate Trust therefore provides funding for commercial carbon offset activities overseas and regularly puts out request for proposals for such investments.	Mark Burnett Executive Director Oregon Climate Trust 516 S.E. Morrison Suite 1200 B Portland, OR 97214 USA Tel + 1 503 238 1915 mburnett@climatetrust.org www.climatetrust.org

CARBON OFFSET INVESTMENT FUNDS

Dexia Group	Dexia Group and the European Bank for Reconstruction and Development have established a private equity fund to offer investors not just an equity return but the opportunity to earn emission reduction credits under the Kyoto Protocol flexibility mechanisms. The preliminary focus is on East/Central Europe.	Dexia Group Public Finance Division Pachecolaan 44 1000 Brussels Belgium Tel + 41 02 222 11 11 www.dexia.be
World Bank Prototype Carbon Fund	US $150 million pooled carbon offset fund managed by the World Bank Group. Will favor investments in projects that are already receiving financial support from the Bank.	Prototype Carbon Fund World Bank Group 1818 H Street, NW Washington, DC 20433 USA www.prototypecarbonfund.org

ENVIRONMENTAL AND ENERGY COMMODITIES BROKERAGE HOUSES

Natsource GHG Emissions Trading Desk	A leading over-the-counter broker of emission instruments. Buyers and sellers are matched, and their identities are disclosed only after an agreement on price has been reached.	Neil Cohn Principal Natsource 140 Broadway, 30th Floor New York, NY 10005 Tel: + 1 212 232 5305 Fax: + 1 212 232 5353 www.natsource.com
EcoSecurities, Ltd	A leading strategic consulting group and over-the-counter broker of emission instruments. Particularly active in carbon sequestration projects. EcoSecurities advises clients on all aspects of GHG mitigation in the forestry, energy, corporate and policy-making sectors.	Mark Stuart EcoSecurities, Ltd. The Delawarr House 45 Raleigh Park Road Oxford, OX2 9AZ, UK Tel: +44 1865 202 635 Fax: +44 1865 251 438 www.ecosecurities.com
Trexler & Associates, Inc.	Emissions broker, financial intermediary, and provider of specialised consultancy services related to carbon offset project development.	Mark Cherniack Manager, GHG Project Dvlpt. Trexler and Associates, Inc. 1131 S.E. River Forest Road Portland, Oregon 97267 USA

		Tel: + 1 503 786 0559 Fax: + 1 503 786 9859 E-mail: taa@teleport.com www.climateservices.com
The Carbon Trader	Australian brokerage house and consultancy that offers trading, risk management, emissions auditing, and other financial analysis services.	Alistair R G Paton Chief Executive Officer The Carbon Trader Level 1, 101 Sussex Street Sydney, NSW Australia 2000 Tel: +61 2 9239 4607 Fax: +61 2 9267 6066 email: argp@thecarbontrader.com www.thecardbontrader.com
Carbon Values	An emerging Norwegian financial intermediary and broker of carbon offset projects.	Jonas Sandgren Carbon Values AS Baerumsveien 473 1351 Rud Norway Tel: + 47 67 15 38 50 Fax: + 47 67 15 02 50 jsa@carbonvalues.com
Woodrising Consultants, Inc.	In addition to acting as a consultant on CDM and carbon offset project management and development, Woodrising also serves as a marketing agent and intermediary between investors in North America. Appears to have a specialisation in forestry and agricultural sequestration activities.	Neil Bird Associate Woodrising Consultants 83 Scott Street Belfountain, Ontario L0N 1B0 Canada Tel: +1 519 927 0548 Fax: +1 519 927 0549 nbird@woodrising.com www.woodrising.com
International Petroleum Exchange	Described as ‘Europe’s leading energy exchange,’ the IPE ultimately expects to structure a bilateral over-the-counter market and a secondary market with risk management and planning services for emission trades. IPE may also be the focal platform for a UK emissions trading exchange programme.	IPE International House 1 St Katharine's Way London E1 9UN, U.K. Tel: +44 20 7481 0643 Fax: +44 20 7481 8485 www.ipe.uk.com

REGIONAL DEVELOPMENT BANKS AND DIVISIONS OF MULTILATERAL AID AGENCIES

Development Bank of South Africa	Quasi-governmental financial institution with an active interest in lending to projects that promise a positive impact on South Africa’s environment and sustainable development.	Mr. Rob Short DBSA 1258 Lever Road Headway Hill Midrand South Africa Tel + 27 11 313 3911 Fax +27 11 313 3086 www.dbsa.org
African Development Bank	The African Development Bank normally does not co-finance projects to more than 25% of total capital costs. Loans generally are of 5-12 year maturities. May be particularly suitable for CDM projects involving infrastructure upgrades and large energy sector retrofits and related projects.	African Development Bank B.P. 1387 Abidjan 01 Cote d’Ivoire Tel +225 20 20 41 68 www.adb.org

Global Environment Facility/ Small Grants Programme	CDM additionality regulations preclude use of GLOBAL ENVIRONMENTAL FACILITY funds for CDM project implementation. However a small grant may be used for ancillary aspects of project feasibility or training, and climate change is one of the main areas for support. The small grants programme provides up to US $50,000 to eligible projects.	Ms. Jaana Rannikko UNDP Focal Point Global Environment Facility jaana.rannikko@undp.org Tel: + 232 2222 97 67 Fax: +232 2222 87 20 Guidelines and Documentation on GLOBAL ENVIRONMENTAL FACILITY Small Grants Program http://www.undp.org/sgp/

PRIVATE INDUSTRY & INDUSTRY ASSOCIATIONS

British Trade International	The Export Promoter for Energy and Environment is specifically responsible for promoting UK business opportunities through the Kyoto mechanisms. A possible intermediary between a CDM project developer and a UK industry investor.	Dr Jeff Chapman, Export Promoter – Energy and Environment British Trade International Tel: +44 20 7215 4278 Fax: +44 20 7215 4780 jefchap@aol.com www.bti.gov.uk
International Utility Efficiency Partnerships	Association of US electric utility companies that maintains an active programme to subsidise the development of carbon offset activities in other countries. Frequently solicits requests for proposals for IUEP investment in CDM related projects.	IUEP 701 Pennsylvania Ave., NW Suite 500 Washington, DC 20004-2696 USA Tel: + 1 202 508 5507 Fax: + 1 202 508 5360 www.eei.org
Wisconsin Electric Power Company	U.S. electric utility that has in the past co-financed carbon offset and AIJ projects.	333 West Everett Street Milwaukee, WI 53201 USA Tel: + 1 414 221 2449
Ontario Power Generation Inc.	Leading Canadian electric utility with a track record of purchasing and structuring carbon offsets and inter-pollutant swaps.	Ontario Power Generation Environmental Affairs 700 University Avenue Toronto, Ontario M5G 1X6 CANADA Tel + 1 416 592 4003 Fax + 1 416 592 4841 www.hydro.on.ca

ENVIRONMENTAL NON-GOVERNMENTAL ORGANISATIONS

Earthlife Africa Johannesburg **and Sustainable Energy and Climate Change Partnership**	The Sustainable Energy and Climate Change Partnership, a project of ELA Jhb in partnership with WWF Denmark, is an NGO-based initiative to promote and raise awareness of sustainable energy options and advocate for climate change mitigation policies.	Project Co-ordinator – Richard Worthington +27 11 339 3662 + 27 11339 3270 seccp@earthlife.org.za Earthlife Africa Johannesburg Branch (ELA Jhb) Lafras Heron – branch coordinator +27 11 782 6002 (tel/fax) lafras@earthlife.org.za P O Box 11383, Johannesburg, 2000
International Institute for Energy Conservation (IIEC)	An international NGO, with an active office in South Africa, that has facilitated the development of AIJ and carbon offset projects involving energy efficiency worldwide.	Madeleine Costanza IIEC-Africa 62A Fifth Avenue Melville Johannesburg 2092 South Africa Tel: +27 11 482 5990

		Fax: +27 11 482 4723 Mcostanza@iiec.cerf.org www.cerf.org/iiec
Environmental Defence Fund	Environmental Defence works to stabilise Earth's climate by reducing GHG emissions globally. Global and regional air quality is another major area of action. Has been active in policy development on the CDM and in legal issues surrounding project development.	1875 Connecticut Avenue NW Washington, DC 20009 USA Tel: + 1 202 387 3500 Fax: + 1 202 234 6049 www.edf.org
World Business Council for Sustainable Development	NGO concerned with developing business and industry responses to international initiatives and policy debates on climate change. Active in a joint program with UNDP to stimulate foreign investment in CDM projects.	Mr. Jasper Koch Climate and Energy Program WBCSD Geneva Switzerland Tel: + 41 22 839 3121 koch@wbcsd.ch http://www.wbcsd.org/cdm.htm
Stockholm Environment Institute (SEI)	International environmental NGO with significant experience in alternative energy project development and implementation in the Africa region.	Francis Johnson Sustainable Energy Programme Stockholm Environment Institute Lilla Nygatan 12 Box 2142 113 24 Stockholm Tel + 46 8 412 1430 Fax + 46 8 723 0348 Email: francis.johnson@sei.se www.sei.se

CONSULTANTS AND PROJECT ADVISORS

Energy & Development Research Centre	Research, consultancy and capacity building organisation active in a wide range of energy & climate change areas – including baselines, monitoring & verification, national and international policy	Professor Ogunlade Davidson Director, EDRC University of Cape Town Private Bag, Rondebosch 7701 South Africa Tel: +27 21 650 3230 Fax: +27 21 650 2830 Email: ogunlade@energetic.uct.ac.za www.edrc.uct.ac.za
Minerals and Energy Policy Centre	Research, consultancy and capacity building organisation active in energy & climate change. Areas include industrial and technology promotion, training courses for developers and policy makers.	Dr. Wilfred Lombe Director, MEPC Braamfontein Email: wilfred@mepc.org.za www.mepc.org.za
Energy Transformations	Consultancy on renewable energy and energy efficiency project design and implementation. Co-ordination and technical input to the South South North project, which is providing project development funding for CDM projects in South Africa.	Steve Thorne Director Energy Transformations 11 Firdale Avenue Tamboerskloof Cape Town, 8008. Tel: + 27 21 424 0880 Fax: +27 21 426 2164 Cell: +27 82 575 2056 Email: sjthorne@mweb.co.za steve@southsouthnorth.org
Cerulean Environmental Consultants	International consultancy offers a range of climate change policy and project advisory services. These include development of investment profiles and feasibility studies,	Glenn Stuart Hodes Principal Cerulean Environmental Consultants

	fundraising for climate and development projects, and facilitation of carbon offset transactions with investors.	319 Fifth Street S.E. Washington, DC 20003 Tel: + 1 202 544 4676 Tel S.A. + 27 82 840 6083 Email: info@ceruleanconsultants.co m www.ceruleanconsultants.com
Energy & Development Group CC **and Sustainable Energy Africa (Section 21 company)**	Sustainable energy consultancy involved in research, capacity building and implementation. Supports metro local authorities around developing CDM-linked projects.	Mark Borchers Energy & Development Group/Sustainable Energy Africa P O Box 261, Noordhoek, 7979 South Africa Email: admin@edg.co.za Tel +27 21 7892920 Fax + 27217892954
Enerwise Africa	Consultancy and research in energy, environment and global climate change. Assistance in identifying potential CDM projects and the development thereof. Marked expertise in human capacity and institutional building and policy formulation.	Joe Asamoah Director EnerWise Africa P.O.Box 101847 Moreleta Plaza 0167 Tel/Fax: +27 12 9970674 Email: joasa@mweb.co.za
Energy Research Institute	Research, consultancy and capacity building organisation active in industrial energy efficiency. Works with industry to develop CDM training and projects.	Professor Kevin Bennett Director, ERI Department of Mechanical Engineering University of Cape Town Private Bag, Rondebosch 7701 South Africa Tel: +27 21 650 3895 Email: kbennett@eng.uct.ac.za
CSIR Environmentek	GHG emissions Economic analysis of climate change issues Climate change vulnerability, particularly ecosystems and forestry Mitigation through land use Carbon accounting	Dr Bob Scholes Dr Martin de Wit CSIR Environmentek PO Box 395 Pretoria 0001 SOUTH AFRICA +27 11 841 2045 tel +27 11841 2689 fax bscholes@csir.co.za

APPENDIX E

Glossary

Adapted from Climate Change India Website www.climatechangeindia.com/climatechange

Abatement: A reduction in the total volume or intensity of emissions.

Activities Implemented Jointly: Introduced under the UN Framework Convention on Climate Change where industrialised countries meet their GHG emission reduction obligations by receiving credits for investing in emissions reductions in developing countries. This is the predecessor to the CDM and is also referred to as Joint Implementation. The AIJ pilot phase, however, did not include transfers of credits. Under the Kyoto Protocol, Joint Implementation has an alternative definition (see below).

Additionality: A requirement of the CDM under the Kyoto Protocol that the emission reductions associated with a GHG mitigation project exceed those that would have occurred in the absence of the project.

Afforestation: Planting of new forests on lands that have not been recently forested.

Annex B Countries: The 38 nations that are committed to quantified emissions limitations under the Kyoto Protocol. This list includes the industrialised nations and some of those with economies in transition.

Anthropogenic: Human-made. Used in the context of emissions that are produced as the result of human activities.

Banking: The saving of emission reduction credits for future use when their value may increase. The value of emission reduction credits may also decrease depending on market factors.

Baseline: The actual emissions profile or standard against which emissions from a climate change mitigation project can be compared to determine emission reductions.

Benchmark baseline approach: A set of stipulated baseline emission rates or factors against which emissions from a climate change mitigation project can be compared to determine emission reductions.

Biofuels: Organic materials, such as wood, waste, and alcohol fuels, burned for energy purposes.

Biogenic: Produced by the actions of living organisms.

Biomass: Materials that are biological in origin, including organic material (both living and dead) from above and below ground. Examples are trees, crops, grasses, tree litter, roots, and animals and animal waste.

Bubble: A geographic region or grouping of facilities for which all emissions and emission reductions are treated as aggregate.

Capital stock: Property, plant and equipment used in the production, processing and distribution of energy resources.

Carbon budget: The balance of the exchanges (incomes and losses) of carbon between carbon reservoirs (e.g. atmosphere and biosphere) in the carbon cycle.

Carbon cycle: Exchanges of carbon from reservoir to reservoir by various chemical, physical, geological, and biological processes. Usually thought of as the four main reservoirs of carbon interconnected by pathways of exchange. The four reservoirs, (regions of the earth in which carbon behaves in a systematic manner) are the atmosphere, terrestrial biosphere (usually includes freshwater systems), oceans, and sediments (includes fossil fuels). Each of these global reservoirs may be subdivided into smaller pools, ranging in size from individual communities or ecosystems to the total of all living organisms (biota).

Carbon dioxide: A colourless, odourless, non-poisonous gas (CO_2) that is a normal part of ambient air. Carbon dioxide is a product of fossil-fuel combustion. Although carbon dioxide does not directly impair human health, it is a GHG that traps the earth's heat and contributes to global warming.

Carbon dioxide equivalent: The concentration of carbon dioxide that would cause the same amount of radiative forcing as a given mixture of carbon dioxide and other GHGs. Carbon dioxide equivalents are generally computed by multiplying the amount (in kilograms) of the gas of interest (for example, methane) by its estimated global warming potential. Some analysts use 'carbon equivalent units' for convenience, defined as carbon dioxide equivalents multiplied by the carbon content of carbon dioxide (i.e. 12/44).

Carbon flux: See carbon budget.

Carbon sink: A reservoir that absorbs or takes up released carbon from another part of the carbon cycle. Vegetation and soils are common carbon sinks.

Carbon sequestration: The fixation of atmospheric carbon dioxide in a carbon sink through biological or physical processes, such as photosynthesis.

Certified Emission Reductions (CERs): Verified and registered units of GHG reductions from abatement or sequestration projects that are certified by the CDM.

Clean Development Mechanism (CDM): A market mechanism defined in the Kyoto Protocol (Article 12) as a project between an industrialised country and a developing county that provides the developing county with the financing and technology for sustainable development and assists the industrialised country in achieving compliance with its emission reduction commitments.

Certified tradable offsets: A tradable commodity representing tonnes of carbon dioxide sequestered in Costa Rican forests. This commodity has been certified by SGS of France, a leading global certifying agency. The certified tradable offsets that represent afforestation and reforestation projects are likely to have value in the CDM.

Climate: The average course or condition of the weather over a period of years, as exhibited by temperature, humidity, wind velocity, and precipitation.

Combustion: Chemical oxidation accompanied by the generation of light and heat.

Conference of Parties: The supreme body of the UN Framework Convention on Climate Change. Composed of representatives from 170 nations, it meets annually to promote and implement the convention.

Counterfactual: Represents what is expected to happen (business-as-usual scenario) without the implementation of a climate change mitigation project.

Deforestation: The removal of forest stands.

Dynamic baseline: An emissions baseline adjusted periodically to reflect a revised view of what would have happened in the absence of a climate change mitigation project.

Emissions: Anthropogenic (human-caused) releases of GHGs to the atmosphere, such as the release of carbon dioxide during fuel combustion.

Emissions coefficient/factor: A unique value for scaling emissions to activity data in terms of a standard rate of emissions per unit of activity (e.g. kg of carbon dioxide emitted per barrel of fossil fuel consumed).

Emissions leakage: A situation whereby emission reductions achieved as the result of a mitigation project are offset by increased emissions at a related site.

Emissions Reduction Units (ERUs): Verified and registered units of GHG reductions from abatement or sequestration projects that are certified under Joint Implementation.

Emissions trading: Pollutant emissions treated as a commodity and that have a price assigned based on an emissions cap and auction or other tool.

Externality: The cost or benefit of an activity not captured in the pricing mechanism of the market.

Financial barrier: An impediment preventing an otherwise economically-viable emissions reduction project from being initiated due to the lack of available capital. It may be used to argue the additionality of an emissions reduction project.

Flexibility mechanism: Market-based approach to reducing the cost of reducing emissions. The Kyoto Protocol includes three primary flexibility mechanisms: emissions trading, Joint Implementation, and the CDM.

Fossil fuel: Any naturally occurring organic fuel formed in the earth's crust, such as petroleum, coal, or natural gas.

Fuel cycle: The entire set of sequential processes or stages involved in the utilisation of fuel, including extraction, transformation, transportation, and combustion. Emissions generally occur at each stage of the fuel cycle.

Geothermal: Pertaining to heat within the earth.

Global Environment Facility: An independent international financial entity with the United Nations Development Programme, the United Nations Environmental Programme, and the World Bank as implementing agencies. The Facility provides funds to defray the added cost of making planned projects environmentally friendly.

Global warming potential: The instantaneous radiative forcing that results from the addition of one kilogram of a gas to the atmosphere, relative to that of one kilogram of carbon dioxide.

Greenhouse effect: A popular term used to describe the roles of water vapour, carbon dioxide, and other gases in keeping the earth's surface warmer than it would otherwise be. These radiatively active gases are relatively transparent to incoming short-wave radiation, but are relatively opaque to outgoing long-wave radiation. The outgoing radiation, which would otherwise escape to space, is trapped by GHGs within the lower levels of the atmosphere. The subsequent re-radiation of some of the energy back to the earth maintains higher surface temperatures than would occur if the gases were absent. Increasing concentrations of GHGs, including carbon dioxide, methane, and chlorofluorocarbons, enhance the greenhouse effect and cause global warming.

Greenhouse gases (GHGs): Gases such as water vapour, carbon dioxide, tropospheric ozone, nitrous oxide, and methane, that are transparent to solar radiation but opaque to long-wave radiation, thus preventing long-wave radiation energy from leaving the atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.

Historical baseline: GHG emissions in some period prior to the initiation of an emissions reduction project.

Historical benchmark: Uses past information about existing facilities to determine the average or median performance of a specific sector focusing on the sector as a whole or on information gathered from recent capacity additions.

Hydrocarbon: An organic chemical compound of hydrogen and carbon in either gaseous, liquid, or solid phase. The molecular structure of hydrocarbon compounds varies from the simple (e.g. methane, a constituent of natural gas) to the very heavy and very complex.

Hydrochlorofluorocarbons: Gaseous compounds that are derivatives of methane, contain chlorine and fluorine, and are used as aerosol, propellants and refrigerants.

Incremental cost: The additional cost that the Global Environmental Facility funds between the cost of an alternative project that a country would have implemented in the absence of global environmental concerns, and a project undertaken with global objectives in mind. It is a measure of the future economic burden on the country that would result from its choosing the Global Environmental Facility-supported activity in preference to one that would have been sufficiently in the national interest.

Intergovernmental Panel on Climate Change (IPCC): A panel established jointly in 1988 by the World Meteorological Organisation and the United Nations Environment Programme to assess the scientific information relating to climate change and to formulate realistic response strategies.

International Performance Measurement and Verification Protocol: Procedures that allow building owners, energy service companies and financiers of energy efficiency projects to evaluate the efficacy of energy-efficient technologies and to quantify energy savings.

Joint Implementation: An emission reduction project in one country that is financially supported by at least one other country. Prior to the Kyoto Protocol, joint implementation took the form of the current CDM. Under Kyoto, joint implementation would operate between two or more industrialised countries or economies in transition.

Knowledge barrier: An impediment preventing an otherwise economically-viable emissions reduction project from being initiated due to lack of technical knowledge or training. It may be used to argue the additionality of an emissions reduction project.

Kyoto Protocol: An international agreement reached at the Third Conference of Parties to the UNFCCC in December 1997. The agreement committed 38 industrialised countries to targeted emission reductions. The agreement has more than 160 signatories, but has yet to be ratified.

Monitoring is the measurement of all factors associated with a CDM project – carbon stocks, GHG emissions, socio-economic and environmental benefits, and costs – for the purposes of estimating greenhouse gas emissions, and is the responsibility of the project developer.

Methane: A hydrocarbon gas (CH_4) that is the principal constituent of natural gas.

Modified (hypothetical) baseline: An estimate of what GHG emissions would have been 'but for an emissions reduction project.' Allows for the control of factors beyond the project itself such as weather and demand growth.

Moral hazard or Gaming: The concept that some countries may keep in place inefficient and carbon-intensive regulatory energy policies in order to increase opportunities for CDM investment.

Natural gas liquids: Hydrocarbons in natural gas that are separated as liquids from the gas. Includes natural gas plant liquids and lease condensate.

Nitrous oxide: A colourless GHG naturally occurring in the atmosphere, with the formula N_2O.

Nitrogen oxides (NO_x): Compounds of nitrogen and oxygen produced by the burning of fossil fuels. They are not GHGs.

Non-Annex B Nations: Those signatories to the Kyoto Protocol that are not committed to quantified emission limitations. They include most of the less-industrialised countries.

Non-economic barriers: An approach to justifying additionality based on non-economic hindrances to project implementation such as lack of knowledge of project-related technologies.

Non-methane volatile organic compounds: Organic compounds, other than methane, that participate in atmospheric photochemical reactions.

Normative benchmarks: Baselines that represent an improvement on the average baselines to satisfy desired environmental, political, and economic objectives of the benchmarking process.

Ozone: A molecule made up of three atoms of oxygen. Occurs naturally in the stratosphere and provides a protective layer shielding Earth from harmful ultraviolet radiation. In the troposphere, it is a chemical oxidant, a GHG, and a major component of photochemical smog.

Ozone precursors: Chemical compounds, such as carbon monoxide, methane, nonmethane hydrocarbons, and nitrogen oxides, which in the presence of solar radiation react with other chemical compounds to form ozone.

Petroleum: Hydrocarbon mixtures, including crude oil, lease condensate, natural gas, products of natural gas processing plants, refined products, semi-finished products, and blending materials.

Photosynthesis: The manufacture by plants of carbohydrates and oxygen from carbon dioxide and water in the presence of chlorophyll, with sunlight as the energy source. Carbon is sequestered and oxygen and water vapuor are released in the process.

Project-specific baseline approach: Involves the tailoring of a separate baseline estimation methodology to each individual project, based on a detailed analysis of the project's defining characteristics.

Projected benchmarks: Based on expectations of future developments and changes to factors such as demand growth, market responses to resource pric es, capital stock turnover, sector restructuring, availability of capital, and policies relating to GHGs and other environmental objectives.

Radiatively active gases: Gases that absorb incoming solar radiation or outgoing infrared radiation, affecting the vertical temperature profile of the atmosphere.

Radiative forcing: The extent to which emitting a GHG into the atmosphere raises global average temperature.

Reforestation: Replanting of forests on lands that have recently been harvested.

Renewable energy: Energy obtained from sources that are essentially inexhaustible (unlike, for example, fossil fuels, of which there is a finite supply). Renewable sources of energy include wood, waste, geothermal, wind, photovoltaic, and solar thermal energy.

Sample: A set of measurements or outcomes selected from a given population.

Secondary effects: Additional, often unintended impacts, of a carbon offset project. These often include leakage.

Supplementarity: The degree to which emission targets must be reached through domestic action as opposed to the use of flexibility mechanisms.

Sustainable development: A broad concept referring to a society's need to balance the satisfaction of short and medium-term interests with the protection of the interests of future generations, from an economic, social and environmental perspective.

Technology matrix baseline approach: A set of technologies is pre-qualified as additional based on a consideration of their economics and current market penetration; stipulated benchmarks are then provided for each pre-qualifying technology as the basis for the estimated baselines.

Technology transfer: The process by which energy-efficient and climate-friendly technologies developed by industrialised or developing nations can be made available to other less-industrialised nations.

Uncertainty: A measure used to quantify the plausible maximum and minimum values for emissions from any source, given the biases inherent in the methods used to calculate a point estimate and known sources of error.

Validation: the process of assessing the assumptions and plans in the project design document, including the baseline, the methods of estimating emissions reductions, and the monitoring plan**,** undertaken by an accredited outside party called an Operational Entity.

Verification is done by an objective accredited party known as an operational entity, and establishes whether the measured GHG reductions actually occurred.

Water vapour: Water in a vaporous form, especially when below boiling temperature and diffused in the atmosphere.