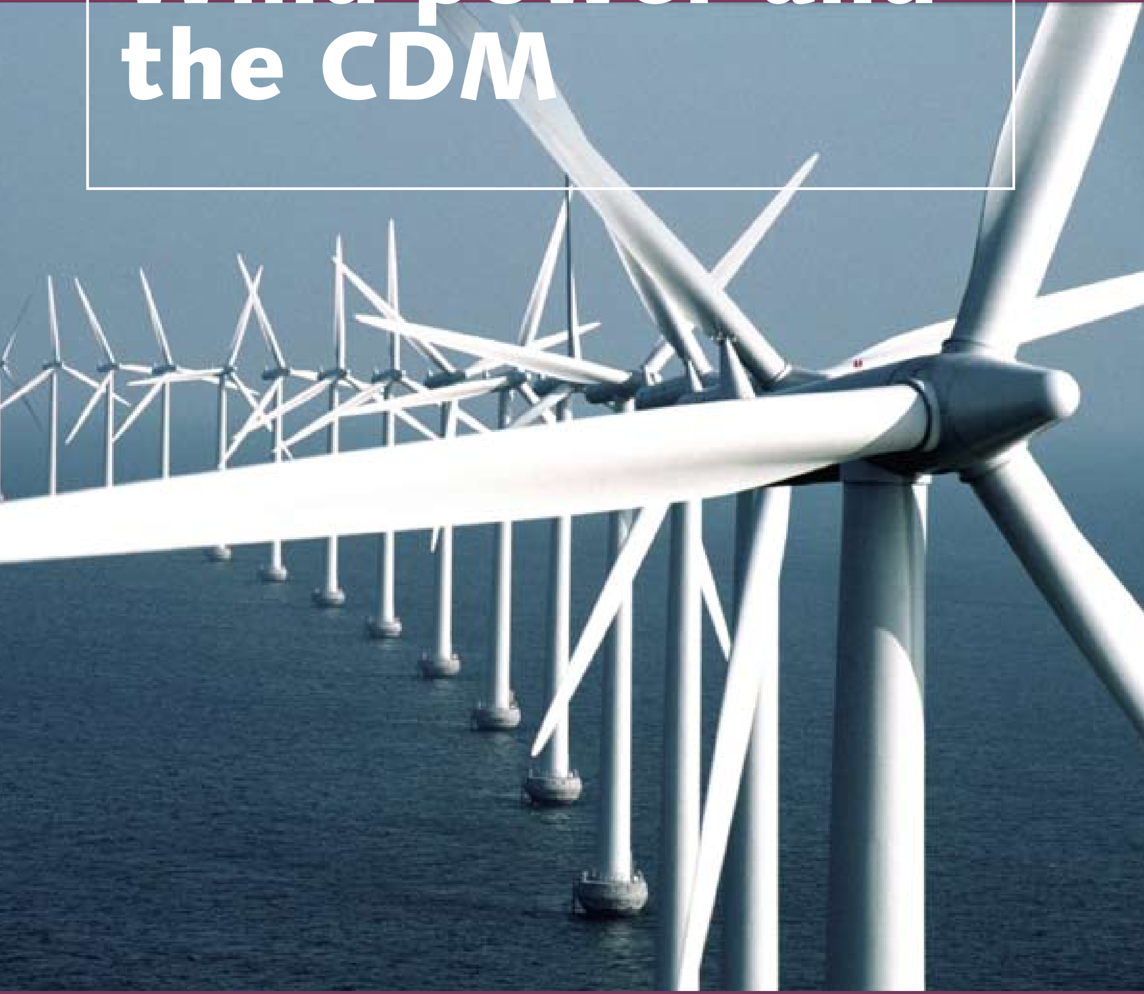
Wind power and the CDM



Wind power and the CDM

Emerging practices in developing wind power projects for the Clean Development Mechanism

Energy for Development
Risø National Laboratory
Denmark

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Preface

This document was developed in collaboration between staff of two departments at Risø National Laboratory – the Systems Analysis Department and the Wind Energy Department – through the networking arrangement "Energy for Development". The work was carried out in the broader context of the project "Capacity Development for the CDM" being implemented by the UNEP Risø Centre (see www.cd4cdm.org) as well as the Wind Energy Department's engagement in wind energy research both locally in Denmark and worldwide (see www.risoe.dk/vea).

The draft document was kindly reviewed by Dr Sudhir Sharma, of the Asian Institute of Technology in Bangkok, who made many helpful suggestions for improvement. We are most grateful to Dr Sharma for his contribution. Any opinions, interpretations and conclusions expressed in this report are however those of the authors.

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1. General Introduction to the CDM and Baselines

1.1 The CDM and CDM Project Criteria

The Clean Development Mechanism (CDM) was one of three mechanisms established by the Kyoto Protocol in 1997 to meet the Climate Convention objective of stabilizing greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The other two mechanisms are Emissions Trading and Joint Implementation, both of which are not applicable to developing countries. The CDM has two objectives; first to assist non-Annex I parties[1] in achieving sustainable development and in contributing to the ultimate objective of the Climate Convention, and the second to assist Annex I parties[2] with commitments under the Protocol in reducing greenhouse gas emissions to comply with their reduction targets.

Six main GHGs are covered by the Kyoto: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6). The Protocol allows Annex I countries the option of meeting the target through reductions in the emission of one or more of these GHGs. Some activities in the land-use change and forestry sector, such as afforestation and reforestation, that absorb carbon dioxide from the atmosphere, are also included in the Protocol.

It is intended that through emission reduction projects, the CDM would stimulate international investment and provide the essential resources for cleaner economic growth in developing countries.

Negotiations continued after Kyoto to develop the guidelines and modalities for implementing the CDM. The Marrakesh Accord of 2001 includes the guidelines for implementing the CDM and the other two mechanisms. The CDM provides opportunity to Annex I countries, including their private sector companies to reduce emissions in developing countries and then count these reductions towards their reduction commitments.

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[1] Non-Annex parties are mostly developing countries. List can be referred to in the Climate Convention.

[2] Annex I parties include developed countries and countries in transition, who have commitments for emission reductions under the Climate Convention.

1.1.1 Certified emission reductions (CERs)

The CDM allows an Annex I party to implement a project that reduces greenhouse gas emissions or, subject to constraints, removes greenhouse gases by carbon sequestration in the territory of a non-Annex I Party. The resulting Certified Emission Reductions (CERs) can then be used by the Annex I Party to help meet its emission reduction target. The project can be initiated by a developing country also, in which case they need to find a buyer for CERs. This is termed as unilateral CDM.

1.1.2 Administration

The CDM is supervised by the Executive Board (EB), which itself operates under the authority of the Conference of Parties[3]. The Executive Board is composed of 10 members, including one representative from each of the five official UN regions (Africa, Asia, Latin America and the Caribbean, Central Eastern Europe, and OECD), one from the small island developing states, and two each from Annex I and non-Annex I Parties.

The Executive Board accredits independent organizations – known as operational entities – that will validate proposed CDM projects, verify the resulting emission reductions, and certify those emission reductions as CERs. Another key task of the EB is the maintenance of a CDM registry, which will issue new CERs, manage an account for CERs levied for adaptation and administration expenses, and maintain a CER account for each non-Annex I Party hosting a CDM project.

1.1.3 Participation

In order to participate in CDM, the participating countries should have ratified the Kyoto Protocol and established the National CDM Authority in their countries. Annex I Parties need to meet additional requirements such as commitments for reductions under the protocol, national system for the estimation of greenhouse gases, annual inventory of GHGs, national registry and an accounting system for the sale and purchase of emission reductions.

1.1.4 Project eligibility

The Kyoto Protocol also specifies several criteria for CDM projects. Three of these, specifically indicated are:

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[3] *Conference of Parties is referred to the countries that are signatories to the Climate Convention.*

1. Voluntary participation by the parties involved in the project;

2. The emissions reductions need to be real and measurable;

3. Reductions in emissions from a CDM project need to be additional; i.e. reductions would not have occurred in the business as usual (or baseline) scenario. The additional greenhouse gas reductions are calculated with reference to a defined baseline.

1.1.5 Additionality

It is necessary that project developers address the additionality issue in a transparent and systematic fashion. The Marrakesh Accord stipulates that a CDM project activity is additional if GHG emissions are reduced below those that would have occurred in the absence of the activity; the baseline for the project. This requirement is often referred as environmental additionality in the CDM literature. In practice this has been operationalised through criteria such as;

- that the project is not duplicating a common practice
- that the project is less economically attractive
- that the project exceeds legal or policy requirements (for example, for efficiency, pollution levels etc.)
- that the project uses more advanced technology with higher performance uncertainty, than the normal practice in the country
- that the project can not be implemented in normal course due to barriers
- other quantitative or qualitative assessments related to the project additionality

The Executive Board has developed an "additionality tool", which is described in details in chapter 5. This tool has been used in many proposals for new baseline methodologies.

1.1.6 Sustainable development

Although sustainable development (SD) is an important objective of any CDM project, it has not been defined in the eligibility criteria for CDM projects. It has been left to the host countries (individual developing countries) to define and stipulate sustainable development criteria for the CDM projects in their countries. The EB only needs a certification by the host country that the project meets their

SD criteria. In general, CDM projects should assist developing countries in reaching some of their economic, social, environmental, and sustainable development objectives, which could be as follows:

- Social criteria: The project improves quality of life, alleviates poverty, and improves equity.
- Economic criteria: The project provides financial returns to local entities, results in positive impact on balance of payments, and transfers new technology.
- Environmental criteria: The project conserves local resources, reduces pressure on the local environments, provides health and other environmental benefits, and meets energy and environmental policies.

1.1.7 Other criteria

Other elements of a CDM project that host countries may normally include as screening criteria are: compliance with existing political and legal frameworks; compatibility with local priorities; comments by local stakeholders directly and indirectly involved with the project; local availability of qualified human resources and adequate institutional resources; and the potential for local institutional enhancement and national capacity building. Since transaction costs may increase with too many requirements, host countries need to make an optimum choice between transaction costs as a result of increased requirements and benefits from the project.

1.2 National Value and Benefits

The basic principle of the CDM is simple: developed countries can invest in low-cost abatement opportunities in developing countries and receive credit for the resulting emissions reductions, thus reducing the cutbacks needed within their borders. While the CDM lowers the cost of compliance with the Protocol for developed countries, developing countries will benefit as well, not just from the increased investment flows, but also from the requirement that these investments advance sustainable development goals. The CDM encourages developing countries to participate by promising that development priorities and initiatives will be addressed as part of the package. This recognizes that only through long-term development will all countries be able to play a role in protecting the climate.

From the developing country perspective, the CDM can:

- Attract foreign capital for projects that assist in the shift to a more prosperous but less carbon-intensive economy;

- Encourage and permit the active participation of both private and public sectors in sustainable projects;
- Provide a tool for technology transfer, if investment is channelled into projects that replace old and inefficient fossil fuel technology, or create new industries in environmentally sustainable technologies; and,
- Help define investment priorities in projects that meet sustainable development goals.
- Specifically, the CDM can contribute to a developing country's sustainable development objectives through:
    - Transfer of technology and financial resources;
    - Sustainable ways of energy production;
    - Increasing energy efficiency & conservation;
    - Poverty alleviation through income and employment generation; and,
    - Local environmental side benefits

Sustainable development benefits could include reductions in air and water pollution through reduced fossil fuel use, especially coal and oil, but also extend to improved water availability, reduced soil erosion and protected biodiversity. For social benefits, many projects would create employment opportunities in target regions or income groups and promote local energy self-sufficiency. Therefore carbon abatement and sustainable development goals can be simultaneously pursued.

1.2.1 Eligible projects

The CDM projects can be from following categories:

- End-use energy efficiency improvements
- Supply-side energy efficiency improvement
- Renewable energy; for example wind, solar, small hydro, biomass etc.
- Fuel switching
- Agriculture (reduction of CH_4 and N_2O emissions)
- Industrial processes (CO_2 from Cement etc., HFCs, PFCs, SF_6)
- Sinks projects (only afforestation and reforestation)

In addition to this, sink projects involving afforestation or reforestation are also allowed to meet the targets for the first commitment period (2008-2012). However, Annex I Parties can add CERs generated from sink projects only up to 1% of their 1990 emissions for each year of the commitment period.

1.2.1 Small scale projects

Transaction costs in the CDM can be high, making small projects unviable. Transaction costs refer to additional costs incurred in a CDM project, from start to the finish, including sale of CERs. For various stages of a CDM project, refer CDM project cycle in Chapter 4. Taking cognizance of this, the Marrakesh Accord established a fast track for small-scale projects. The small-scale projects defined by the Accord are:

i. Renewable energy project activities with a maximum output capacity equivalent of up to 15 megawatts (or an appropriate equivalent);
ii. Energy efficiency improvement project activities which reduce energy consumption, on the supply and/or demand side, by up to the equivalent of 15 GWh per year;
iii. Other project activities that both reduce anthropogenic emissions by sources and directly emit less than 15 kilo tonnes of carbon dioxide equivalent annually;

The Executive Board of the CDM has defined modalities and procedures for these projects. Simplified procedure for baselines and monitoring has been prepared by the Board (http://cdm.unfccc.int/pac/howto/SmallScalePA/ssclistmeth.pdf). The transaction cost is also expected to be reduced through bundling of projects.

Additionality for small-scale projects: A small scale CDM project is considered additional (as explained above) if it is not expected to get implemented, in absence of the CDM, due to any of the following barriers, listed in the Simplified Modalities and Procedures for the Small-scale CDM project activities. Project participants need to provide suitable explanation for this.

i. **Investment barrier**: A financially more viable alternative to the project activity would have led to higher emissions; it implies that the CDM project is less attractive from financial perspective and hence would not get implemented in the baseline scenario although it would result in net reduction in emissions.
ii. **Technological barrier**: A less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity

and so would have led to higher emissions; it indicates that the technology used in the CDM project is an advanced technology, which may not be used in normal course due to higher risks in terms its performance and it has low market penetration rate.

iii. **Barrier due to prevailing practice**: Prevailing practice, or existing regulatory or policy requirements, would have led to the implementation of a technology with higher emissions. This means that existing regulatory and policy requirements allow higher emissions and hence there is no incentive for the CDM project in the baseline.

iv. **Other barriers**: Without the project activity, for another specific reason identified by the project participant, such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources, or capacity to absorb new technologies, emissions would have been higher.

1.2.1 Financing

The Kyoto Protocol also specifies that the public funding for CDM projects should not result in the diversion of funds for official development assistance. The Board has left this to the Annex I countries to declare that this indeed is the case for the CDM projects undertaken by them. The CERs generated by CDM projects will be subject to a levy–known as the "share of the proceeds"– of 2%, which will be paid into an adaptation fund to help particularly vulnerable developing countries adapt to the adverse effects of climate change. Another levy on CERs will contribute an amount (still to be decided) to the CDM's administrative costs. The CDM projects in least developed countries are however exempt from the levy for adaptation and administrative costs.

Crediting periods for CERs: The emission reductions achieved through the CDM projects in the 2000-2008 period can be used towards meeting the commitments in the first five-year commitment period, i.e. 2008-2012. Two alternative approaches to eligible crediting periods are identified in the Marrakesh Accord from November 2001:

- A crediting period of seven years that may be renewed no more than twice. It is necessary that, for each renewal, the CDM's executive board is informed that the original baseline is still valid or has been updated; or

- A crediting period of ten years with no option of renewal.

The first alternative may be preferable for wind power projects because their project lifetimes often exceed ten years. This alternative allows for updating of the data used in setting the baseline, but it apparently does not allow for a change of the baseline approach itself. On the other hand, a ten-year lifetime provides certainty to the project developer.

Project boundary and emissions leakage: The project boundary should encompass all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the CDM project activity. Emissions leakage is defined as the increase in emissions which occur outside the boundary of a project, and which is measurable and attributable to the CDM project. Leakage could reduce the amount of net emissions from CDM projects. Internationally, much attention is being paid to emissions leakage. The guidelines for small-scale CDM projects specify that for renewable energy projects (such as wind), the leakage calculation is required only if the renewable energy technology equipment is transferred from another activity.

1.3 Baselines

1.3.1 Definition of the baseline

The Marrakesh Accord (MA) defines the baseline for a CDM project activity as *the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity. A baseline should cover emissions from all gases, sectors and source categories (as described in MA) within the project boundary.*

Therefore, the level of GHG emissions that would have occurred in the absence of a CDM project activity is considered as the baseline of that activity. In other words, it is the best guess as to what would have happened in the absence of a CDM project activity. According to the Kyoto Protocol, an emission reduction needs to be 'additional to any that would occur in the absence of the certified project activity'. Thus the situation that represents 'the absence of the certified project activity' is the baseline scenario.

1.3.2 General guidelines for establishing baselines

The Marrakesh Accord provides the following guidelines for the CDM project activities:

- The baseline shall be defined on a project-specific basis taking into account relevant national and/or sectoral policies and circumstances, such as sectoral reform initiatives, local fuel availability, power sector expansion plans, and the economic situation in the project sector.

- In the case of small-scale CDM project activities, the baseline shall be in accordance with simplified procedures developed for such activities.

- Choice of approaches, assumptions, methodologies, parameters, data sources, key factors and additionality shall be made in a transparent and conservative manner to take into account uncertainties.

- The baseline may include a scenario in which future anthropogenic emissions by sources are projected to rise above current levels, due to the specific circumstances of the host party.

- In choosing a baseline methodology for a project activity, project participants shall select from among the following approaches the one deemed most appropriate for the project activity, taking into account any guidance by the executive board, and justify the appropriateness of their choice:

  (a) existing actual or historical emissions, as applicable; or

  (b) emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment; or

  (c) the average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category.

The project participants should submit new baseline methodologies to the CDM Board for approval.

Baseline development is arguably the most conceptually and technically difficult step in developing a CDM project. GHG emissions are a function of output/activity level; energy intensity of the output; and carbon intensity of the energy and can be represented as;

GHG emissions = Project output * energy use/output * GHG emissions/energy use

A change in one or more of these components - e.g., reducing the activity level; enhancing energy efficiency; or switching to cleaner fuels - would affect the overall amount of GHG emissions from a project. Wind power projects will in general address the third component of this equation.

The first step in the GHG assessment of an energy supply project is to forecast or project the future supply, the mix of generation resources or types, and the energy demand for the entire lifetime of the CDM project. Wider national, regional or even global economic trends that may affect a project could also be reflected in the baseline scenario.

The implications of various policies and measures, national as well as international, are often reflected in baselines. It is often appropriate to attempt to include the likely future consequences of significant policies and measures, action plans, restructuring plans, etc., for a sector in the baseline. It is recommended to follow a conservative approach to future government policies. It seems that the best one can do is to reflect the likely effects of government policies that are already being implemented or have a high likelihood of implementation. It is therefore wise to take into account a country's track record in the area of policy implementation when forecasting the expectable effects of government policies. Assuming that government policies will be completely implemented and will fully achieve their stated goals will seldom be a credible assumption.

It is important to apply a well-defined and consistent approach or methodology when developing a baseline for a CDM project. The method should be rigorously and consistently applied, the necessary data and information should be collected and employed, and the assumptions used in calculating the baseline should be stated explicitly. Importantly, this makes it possible for other parties, such as independent verifiers of projects and other interested parties, to re-calculate and check the soundness of the baseline.

Project developers should use country or region specific data from verifiable sources. If local data is not available IPCC default should be used. IPCC default data should also be used if they result in a more conservative estimate. The IPCC data is contained in the Intergovernmental Panel on Climate Change (IPCC) *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*.[4]

1.3.3 Baselines

The baseline methodologies are still evolving as project developers can submit new methodologies for approval by the CDM Executive Board. Several baseline methodologies have been submitted to the Board; a list of approved methodologies, and recommended for approval can be referred at http://cdm.unfccc.int/methodologies. These methodologies can be used for similar projects and new methodologies can be proposed for other projects based on various baseline approaches.

In the baseline literature several baseline concepts have been discussed: "static and dynamic baselines"; "project specific" and "standardized baselines"; and "national", "sectoral" and "project" level baselines. However, MA recognizes only project specific baselines, these concepts have not been elaborated here.

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[4] *On IPCC emission factors, see IPPC, 1997. http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm.*

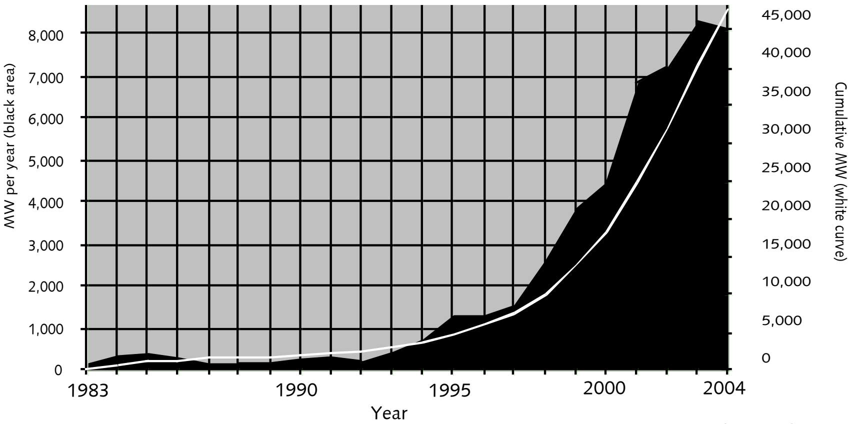
Approved baseline and monitoring methodologies: The procedures for the submission and consideration of proposed new methodologies are given in the Marrakesh Accord (clause 38) document. The Executive Board has so far approved only two methodologies that are applicable to full-scale wind projects (see Chapter 5)

2. Introduction to Wind Energy Projects

2.1 Introduction

Wind power is today a mature technology, which at windy sites is economic and competitive with conventional power generation technologies, in particular when taking into account the environmental impact. At the end of 2004 there were more than 73,800 wind turbines installed world wide corresponding to about 47,900 MW accumulated capacity (Figure 2.1).

Figure 2.1: Annual & cumulative global wind energy development 1983-2004 [1]



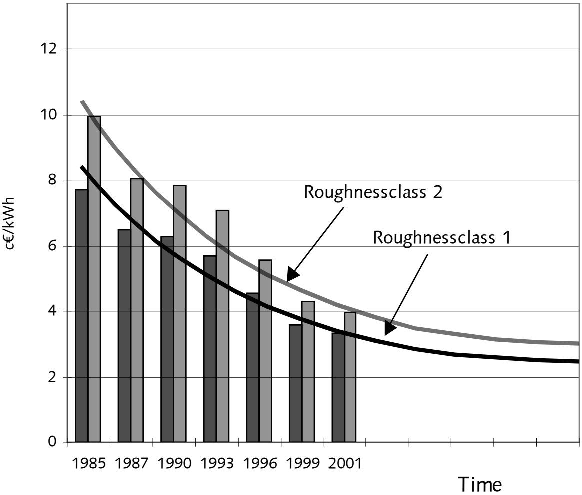
Source: BTM Consult - March 2005

The distribution of the 47,900 MW by continent is:

Americas	7,391 MW	(USA 6,750 MW)
Europe	34,725 MW	(Germany, Denmark and Spain 27,995 MW)
Asia	4,850 MW	(India 3,000 MW)
Australia + NZ	588 MW	
Africa	234 MW	
Rest of the World	112 MW	

As it appears approximately 80% of the total global capacity was implemented in only five (5) countries: Germany, Spain, USA, Denmark and India. The largest manufacturing capacity is based in Denmark, Germany and Spain. The technological development within wind energy has been extraordinary since 1980, increasing the size of the largest commercially available wind turbines from 50 kW to about 4500 kW (with prototypes up to 6MW or larger planned). The development has dramatically reduced the cost per kWh produced from wind (see Figure 2.2). The figure shows a comparison of cost data from Denmark and experience curves with a learning rate of 13 to 17%. This means that the cost of wind energy is reduced by 13 to 17% when the installed wind generating capacity worldwide is doubled. In the period 1985 to 2001 this was the case every three years. In view of the continued market growth, the on-going up-scaling to larger sizes, and the new concepts already on the drawing board, it seems that the cost-efficiency of wind turbines will continue to improve.

Figure 2.2: The development in specific cost of generating power from the wind (Eurocent/kWh) compared to experience curves. From Morthorst, P.E.: Economics of Wind Power, Risø International Energy Conference 19-21 May 2003 [6].



These perspectives and the globally growing environmental concern have lead governments to encourage and plan for wind energy development. In 1999 and 2002 Greenpeace and the European Wind Energy Association (EWEA) published Blueprints for Wind Power Development – Wind Force 10 and Wind Force 12 [2] – which suggested a target of 10% (and 12% respectively) of the world's electricity to be generated from wind by 2020. The target was set in order for wind power to make a significant impact on CO_2 emissions savings. The report demonstrates that a total of 1.3 million MW of wind power can be installed worldwide by 2020, producing 3,000 TWh or more than the total electricity consumption in Europe today.

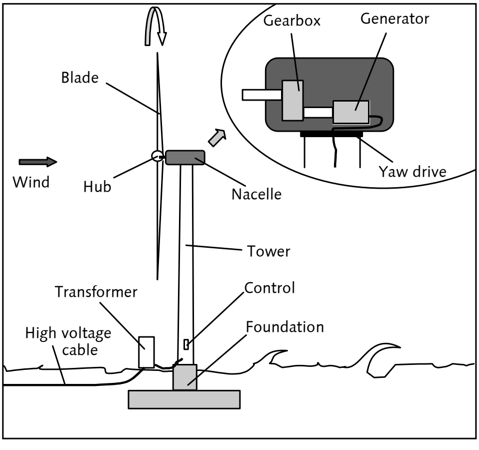
The Wind Force 12 scenario demonstrates that wind power is capable of supplying 12% of the world 's electricity within two decades, even if overall demand increases over that period by two-thirds. This would involve cumulative savings of approximately 11,000 million tones of CO_2. In order to reach 12% of the electricity consumption, much higher wind energy penetrations than 12% must be realized in the windiest regions of the world such as e.g. Northern Europe with its great resources and several large new projects being developed. Aspects of the technological background and some perspectives for large grid connected as well as small wind turbines in isolated grids are presented in this chapter.

2.2 Wind Energy Technology

2.2.1 The typical wind turbine

Wind turbines transform kinetic energy in the wind to electricity. Almost all commercial wind turbines are 'horizontal axis' machines with rotors using 2 or 3 airfoil blades. The rotor blades are fixed to a hub attached to a main shaft, which turns a generator – normally with transmission through a gearbox. Shaft, generator, gearbox, bearings, mechanical brakes and the associated equipment are located inside the nacelle on top of the tower, see Figure 2.3. The nacelle also supports and transfers structural loads to the tower, together with which it houses all automatic controls and electric power equipment.

Figure 2.3: A sketch of a modern wind turbine



The wind turbine automatically yaws the nacelle to the direction facing the wind for optimal energy production. The turbines are stopped at very high wind speeds (typically 25 m/s) to protect them from damage. Rotors may operate at constant or variable speed depending on the design. Modern MW-size machines are all variable speed concepts. Typical rotor speeds at rated power range from 15 revolutions per minute and up – a factor, which influences the visual impact. The larger the rotor the lower the rotational speed in order to keep the blade tip speed in the optimal range – 60-80 m/s. Power output is automatically regulated as wind speed changes to limit loads and to optimise power production. The present "state of the art" of large wind turbines have:

- power control by active stall or pitch control (in both cases pitching blades) combined with some degree of variable speed rotor, and
- a two-speed asynchronous generator, or a gearless transmission to a multipole synchronous generator and power electronics.

Wind turbines range in capacity (or size) from a few kilowatts to several megawatts. The crucial parameter is the rotor diameter – the longer the blades, the larger the area swept by the rotor and thus the volume of air hitting the rotor plane. At the same time the higher towers of large wind turbines bring rotors higher above the ground where the energy density in the wind is higher. Totally, larger wind turbines have proven to be more cost-efficient due to improvements in designs and economics of scale, but also with a higher energy production per swept m^2, due to the higher towers and better aerodynamic design.

2.2.1 Future design – trends and possibilities

The trend is towards even larger machines especially for offshore applications, whereas the present size range (500 –2000 kW) seems quite appropriate for on-land applications – especially where land availability is not a problem and in places with lack of large cranes and other equipment for the very large machines above 2000 kW.

From research it is estimated that wind turbine blades in principle could be doubled in length using today's technology and materials. Wind turbine units could thus grow 4-5 times in terms of nominal kW capacity, but the development of application of wind turbines is not solely linked to the success of the up-scaling effort. There are many wind turbine designs already on the market, but there is still plenty of scope for innovation and technological development. The main R&D investment is today spent in up-scaling the best selling products, which all are 3-bladed, up-wind machines with stiff tower and rotor. In order to reduce the top-weight (nacelle and rotor) new design methods and better design tools are developed. Further development of new and more flexible design concepts reducing the wind turbine weight considerably is however possible and will most certainly be seen in the future for wind turbines for on-land applications. The resulting cost reduction may reach 25% within the coming 10 years if concepts with more flexible rotor structure, transmission and power conversion are introduced. In order for this to happen, the market situation must make it potentially attractive for the industry to pursue new concepts and research must be invested.

2.3 Wind Energy Potential

When considering the installation of a wind farm, the single most important parameter is the wind speed. As the power output is proportional to the wind speed raised to the third power a doubling of the average wind speed leads to an increase of the power in the wind by a factor of eight (8), so even small changes in wind speed can produce large changes in the power production and thus in the economic performance of a wind farm. Detailed and reliable information about variation of wind speeds and direction over the year is therefore vital for any prospective wind power development. Initial assessment of the wind resource available at a given site involves the study of data from nearby weather stations and specialist computer software, which is able to model the wind resource [3], [4]. To assist in this process, national, regional and local "wind atlases "have been produced [5]. If a particular site appears promising for wind farm development, detailed site-specific measurements are carried out through the erection of a meteorology mast, for measuring wind speed and wind direction at different heights. Depending on the terrain 30 to 50 m masts are typically applied, with 2 or more instruments in heights above 10 m above ground level.

2.4 Project Development

2.4.1 Wind power applications

Applications of wind turbines may be categorised as indicated in Table 2.1, which also shows the unit size of wind turbines that are typically applied in the different categories.

Table 2.1. Categorisation of wind power systems.

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

Following a decision on extending the electricity production capacity by one or more wind farms one has to decide where to place the wind farms (siting), the size of the wind farms (sizing) and the optimum layout of the wind farms.

The size of a wind farm is often determined with respect to a number of constraints, such as: planning legislation; local and national development plans and policies; land availability, access and transport infrastructure; power system – present and future situation; wind turbine size; financing; electricity market; and environmental impacts.

Economic and financial optimum choice of wind farm size for society and investors at given conditions may vary for different sites, hence, sizing and siting are integrated activities. Furthermore, sizing involves aspects that may not easily be quantified in monetary terms.

The site selection for a wind farm most often ends up being a comparison of selected candidate sites with respect to issues such as: the possibility to obtain planning authorization and approvals; successful outcome of local hearings; potential wind energy production; environmental costs and benefits; sustainability, assumptions, uncertainties and risks; availability of land and infrastructure; power system development; investments and investors; design safety, reliability and lifetime; wind farm and power system operation and maintenance and economic and financial viability.

The wind farm layout may be determined according to different principles. No single layout concept is universally acknowledged as ideal and preferred, and no universally true automatic method to determining optimal wind farm layouts is therefore available. There are tools that can assist the analyses and could or should be applied as a part of the development and optimization exercises, but there is no way around human judgment – at least when it comes to aesthetics and visual impact.

As an example, the Middelgrund offshore wind farm outside the harbour of Copenhagen, was first planned as a straight line, but due to aesthetics grounds changed to an arch as shown on Figure 2.4.

Figure 2.4: The Middelgrund offshore wind farm located just outside Copenhagen consists of 20 x 2 MW Bonus wind turbines (2000).

Other examples are the early and famous wind farms in California that were often built in very regular patterns. In the United Kingdom, some of the wind farms are placed in an irregular pattern, required by legislation due to constraints on visual impact.

The main steps in the development of a wind farm:

- Wind measurements & data management
- Wind resource assessment
- Site selection
- Sketch design for power system analysis
- Feasibility study
- Environmental Impact Assessment (EIA)
- Power Purchase Agreement (PPA)
- EPC bidding, evaluation and contracting
- Construction
- Operation & Maintenance

When planning to apply for Certified Emission Reductions (CER) additional development steps are added – see chapter 4 on the CDM project cycle.

Projects becomes larger – utilities and leading energy companies enters the market
Projects around the world are getting bigger, making it more common for larger companies to become wind energy developers. Such major players are better able to handle the logistics and necessary financing aspects. Several of the new developers are subsidiaries of power utilities, especially as wind energy becomes more and more attractive from an economic point of view. Even in countries like Denmark and Germany, originally known for their dispersed and small developments, there is now a trend towards larger projects. Offshore projects will also call for a shift in that direction.

The shift from markets with dispersed development, such as Denmark and Germany, to more project oriented markets, already seen in the US and Spain, will lead to larger projects. The larger projects will require larger and financially stronger players, and utilities will play a major role in the transition of the structure of the industry. There will be joint forces among the so-called wind farm developers and the utilities in the future.

The Danish development was different from the beginning, due to a large "co-operative" customer segment. By the end of 2002, around 85% of the 3,000 MW installed in Denmark was owned by small individuals and co-operatives, and just 15% left to the utilities. During 2003, however, the utilities developed more than 80% of the 218 MW added that year.

Some examples of new big international players on customer side are:

Florida Power & Light (FPL), USA operates/own some: 2,500 MW

Iberdrola S.A, Spain, operates/own around: 1,800 MW

EHN S.A, (Spain), Energy E2, (DK), Endessa S.A, (Spain), NUON, (NL) are utilities which have more than 500 MW in operation each.

2.4.1 Large grid connected wind farms

At present the size of new machines being installed in wind farms on land or offshore is in the range 500-4500 kilowatts. Table 2.2 lists the biggest machine from each manufacturer of the top 7 suppliers worldwide (2004).

Table 2.2. List of the biggest (newest) wind turbine from each manufacturer of the top 7 suppliers worldwide. The name indicates nominal (maximum output) generator rating and rotordiameter.

Manufacturer (top 7 suppliers)	Wind turbines
Vestas (Denmark)	V90m – 3 MW
NEG Micon (Denmark)	NM 4.2 MW/110m
Enercon (Germany)	E-112 – 4.5 MW
Gamesa (Spain)	G-83m – 2.0 MW
GE Wind (USA)	3.6 MW/104 m
Bonus (Denmark)	2.3 MW/82.4m
Nordex (Germany)	N80m/2.5 MW

Other suppliers of both large and small wind turbines – some of which with quite different designs – exist from around the world, e.g. Ecotecnia (Spain), Repower (Germany), Lagerwey (Holland), Mitsubishi (Japan).

The focus and the big market potential today are within large wind turbines. It is a race among the leading suppliers to supply larger and more efficient machines sooner than the competitors for the large-scale and offshore applications. The largest wind farm in the world at present is the King Mountain Wind Ranch in Texas consisting of 214 1.3 MW Bonus wind turbines (278 MW).

2.4.2 Offshore wind farms

Offshore projects have just recently taken MW-scale turbines in use. Many of the early projects were equipped with turbines of 500 – 600 kW. Those projects were pilot projects, necessary for building up the special competencies and experiences of working in the offshore environment. The major driver for continuing up scaling of offshore turbines is the cost benefit from minimising the number of foundations.

Today (end 2003) the total installed offshore capacity is 530 MW of which Denmark has installed 75% (398 MW), UK 64 MW and the Netherlands, Sweden and Ireland share the rest.

The offshore capacity almost doubled in 2003, and in 2004 around 250 MW of new installation is expected. On short term UK is estimated to be the most important market for offshore installation, while some 5 years ahead Germany is likely to be the dominating market for offshore installation of wind turbines.

2.4.3 Environmental impact assessment

Wind turbines produce energy without pollution, eventually leading to a reduction in the emission of carbon dioxide, nitrogen oxide and sulphur dioxide. The use of wind energy may therefore contribute to reduce global climate change, acid rain and other serious environmental problems.

Although the environmental impact of wind energy obviously is lower than that of conventional energy sources, there are some potentially negative effects on the environment, especially when it comes to establishing large wind farms of several hundred large wind turbines. Over the years the main environmental concerns when constructing wind farms have been visual impact, noise and the risk of bird-collisions.

Today noise is dealt with in the planning phase and normally it possesses little problems to build wind turbines close to human settlements. The visual effects of wind turbine may, however, create some controversy, as some people believe they are having a severe negative visual impact of the landscape, while others find them beautiful.

The impact on plants and animals is not very well established despite a sizable number of studies, but as it is with most power plants a certain amount of disturbance to flora, fauna birds and mammals will happen. Still the largest concern is on bird strikes and associated effect on bird population and migration paths. It is not only the turbines that constitute a danger to the birds, associated utility structures in particular the power lines that connect the wind turbine farm to the electrical grid possess a danger to birds as they can collide with the cables or get electrocuted when landing on the towers.

Figure 2.5: Erection of a wind turbine at the Nysted offshore Wind Farm (72 x 2.3 MW Bonus) commissioned in 2003

2.5 Stand-alone systems[5]

In areas where there is no grid the prevailing needs and conditions for project development are very different. There are generally two methods of supplying energy to rural areas, grid extension and the use of diesel generators. In remote areas both options can be exceedingly expensive, grid electrification costing upwards of $3000 per connection or a continued reliance on expensive diesel fuel. Including renewable technologies in the power supply-mix can lower the life cycle cost of providing power to rural areas. However, since renewable technologies, other than biomass technologies, are dependent on an intermittent resource that is not dispatchable, the combination of a low cost renewable technology with a more expensive dispatchable technology may provide the most applicable alternative.

Power systems using multiple generation sources can be more accurately described by the title "hybrid power systems", and can incorporate different components such as production, storage, power conditioning, and system control to supply power to a remote community.

The classic hybrid systems include both a DC bus for the battery bank and an AC bus for the engine generator and distribution; however recent advances in power electronics and system control are making small single AC bus systems more cost effective. The renewable technology may be attached to either the AC or DC bus depending on the system size and configuration. These power systems can range in size from a few kilowatt-hours (kWh)/day to many megawatt-hours (MWh)/day.

In the following subsections three figures are provided to describe the three general types of wind-hybrid power systems. The first, Figure 2.6, illustrates a small conventional DC based power system providing AC power using a power converter, secondly Figure 2.7 shows a small power system focused around the AC bus and lastly, Figure 2.8 a larger AC coupled power system.

2.5.1 DC based hybrid systems for small remote communities

Figure 2.6 illustrates a small conventional DC based power system providing AC power using a power converter. The use of smaller renewable based hybrid systems has grown in use as small wind technology increases in usability and PV decreases in cost. Most of these systems have used a topography were the DC battery bus is used as a central connection point. Generally small winds turbines generate DC current, which is applied to the DC bus at the voltage of the battery bank. Energy is either stored in the battery or converted to AC through an inverter to supply the load. The use of the battery bank smoothes out wind turbine power fluctuations and allows energy generated when there is wind to supply a load at a later point in time. In cases where guaranteed power is required, a dispatchable generator,

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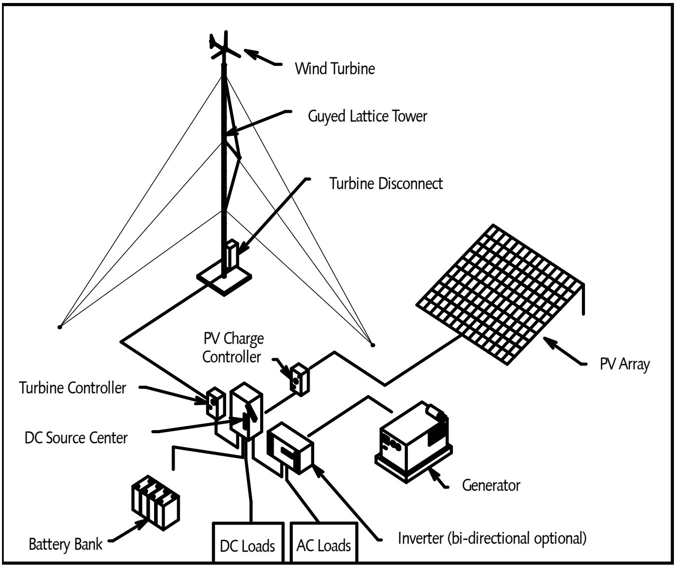
[5] *Based on P. Lundsager and E.I. Baring-Gould: Isolated Systems with Wind Power, chapter 16 in 'Wind Power in Power Systems' edited by Thomas Ackermann, John Wiley & Sons Ltd, UK*

typically diesel, propane or natural gas can also be installed to provide the load and charge batteries in the prolonged absence of renewable based generation.

Figure 2.6: DC based renewable power system

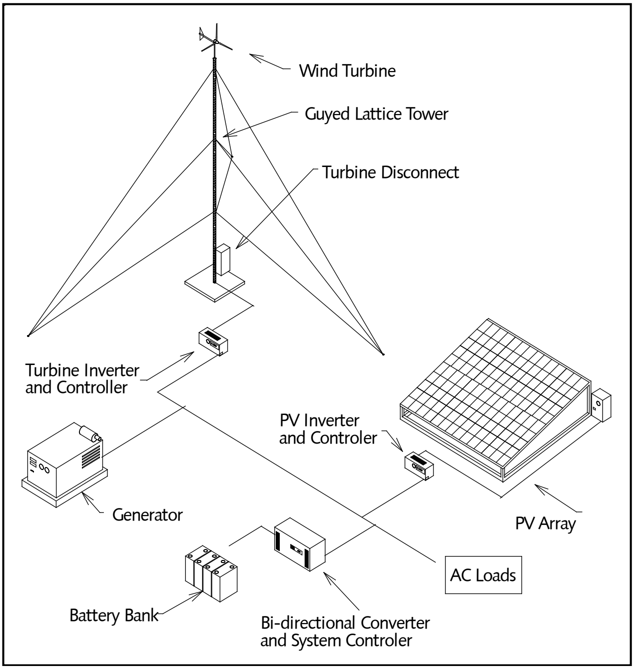


More information on system using DC architecture can be found in Baring-Gould et al. (2001), Baring-Gould et al. (2003), Jimenez et al. (2000) and Allerdice et al. (2000).

2.5.2 AC based hybrid systems for small remote communities

Recent improvements in power electronics, control and power converters have led to the rise of a new system topology, and Figure 2.7 shows a small power system focused around the AC bus. These systems use small, generally DC based generation components, PV and wind, connected through a dedicated smart inverter to the AC distribution grid. A battery is used to smooth out power fluctuations but also includes its own dedicated power converter.

Figure 2.7: AC based renewable power system



The prime advantage of this topology is its modularity, allowing the connection or replacement of modules when additional energy is needed. Secondly it steps away from the need to co-locate all components where they can be connected to a DC bus allowing each component to be installed at any location along the micro-grid. These systems generally use system frequency to communicate the power requirements between the different generation and storage modules. The two disadvantages of systems using this topology are its cost and the use of sophisticated technology that will be impossible to service in remote areas.

An additional issue is that all energy being stored must pass first from the point of generation to the AC device and then through the rectifier of the battery dedicated power converter.

It must then be inverted again prior to use resulting in three power conversion cycles compared to only one for systems using a DC based topography. Thus in systems in where large amounts of energy storage is expected, such as PV systems designed to provide evening lighting loads, this technology may result in higher system losses.

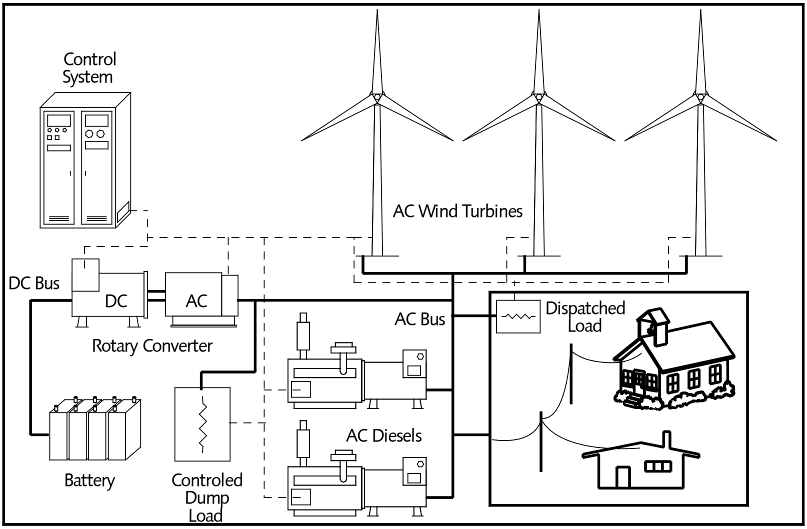
2.5.3 Wind / diesel systems

Larger power systems are focused around the AC bus and incorporate both AC connected wind turbines and diesel engines. Figure 2.8 shows a larger AC coupled Wind / Diesel power system.

A technically effective Wind / Diesel system supplies firm power, using wind power to reduce fuel consumption while maintaining acceptable power quality. In order to be economically viable the investment in the extra equipment that is needed to include wind power, including the wind turbines themselves, must be recouped by the value of the fuel savings and other benefits. As the ratio of the installed wind capacity to the system load increases, the required equipment needed to maintain a stable AC grid also increases, forcing an optimum amount of wind power in a given system. This optimum is defined by limits given by the level of technology used in the system, the complexity of layout chosen, and the power quality required by the user. For this reason the optimal design must be based on careful analysis, not simply the maximum amount of wind energy possible.

Because of the large number of isolated diesel mini-grids in both the developed and developing world, the market for retrofitting these systems is substantial. This market represents a substantial international opportunity for the use of wind energy in isolated power supply. To meet this market an international community has formed, committed to sharing the technical and operating experience to expand recent commercial successes.

Figure 2.8 Typical large Wind / Diesel power system



3. Financial Evaluation and Impact of Carbon Financing

CDM projects produce both conventional project output and carbon benefits (CERs). The value of carbon benefits and its impact on project viability are influenced by several factors such as the amount of CERs generated by the project, the price of CER and the transaction costs involved in securing CERs.

3.1 Quantity of CERs

The amount of CERs generated by the project depends on the greenhouse gas displaced by the project and the crediting period selected.

Renewable energy and energy efficiency projects displace carbon intensive electricity and/or heat generation. Grid-based or off-grid projects that displace more carbon intensive coal and diesel fuels generate more CERs than those that displace natural gas. Projects that capture methane and other greenhouse gases produce more CERs since the global warming potential (GWP) of methane and other gases are several times higher than that of carbon dioxide. Methane's GWP is 21 times, nitrous oxide is 310 times, hydrofluorocarbons (HFCs) range from 140-11,700 times, perfluorocarbons (PFCs) is on average 6,770 times and sulphur hexafluoride is 23,900 times higher than carbon dioxide.

The total CER generated is determined by the selected crediting period. The Marrakesh Accord specifies two options for project developers: 7 years with twice the option of renewal (totalling 21 years) or, 10 years without renewal.

3.2 Price of CERs

The price of CERs is determined in the carbon market. The global carbon market consists of diverse greenhouse gas reduction transactions and can be broadly classified as follows:

- Project-based or baseline and credit system. Emission reductions are created and traded through a given project or activity. CDM and JI are examples of the project-based system where CERs and ERUs are generated respectively.

- Allowance market or cap and trade system. Emission allowances are defined by regulations at the international, national, regional or firm level. Examples of allowance market include the Emissions Trading under the Kyoto Protocol (global), EU Emission Trading System or EU ETS (regional), the UK and the Danish trading systems (national), and BP and Shell internal trading (firm).

Most of market volume transactions are project-based, and the emissions reductions credits are intended either for Kyoto Protocol or non-Kyoto compliance. Buyers have various motives in engaging transactions in the global carbon market. Risk minimization objectives could be classified as follows: i) immediate compliance in the national markets where buyers seek to comply with existing legislative obligations and constraints; ii) Kyoto pre-compliance where buyers expect the project to be registered under either JI or CDM; iii) voluntary compliance where buyers aim to use the emission reductions to meet part of their voluntary targets; and iv) retail schemes where buyers wish to be climate-neutral in order to demonstrate their social responsibility or promote particular brand. In addition to risk minimization, other objectives include the following: i) learning by doing, ii) experimenting with diverse contract structures, iii) influencing policy, iv) broadening the envelope of flexibility, v) public relations, and vi) goodwill (PCF, 2003).

The fragmented nature of the global carbon market generates differentiated prices for emissions reductions as shown in Table 3.1. Allowance markets generate high emission reduction prices since the delivery risks are believed to be minimal. Though JI and CDM are both project-based, PCF pays higher prices for ERUs since JI are supported by Host Country Agreements and Assigned Amount Units, which reduces PCF's exposure to risks. ERUPT however in its January 2003 tender for JI projects have specified a price range similar to C-ERUPT tender for CDM projects.

Table 3.1: Carbon Emission Reduction Prices (per tonne CO_2eq.)

Project-Based		Allowance Markets
Clean Development Mechanism	**Joint Implementation**	
PCF1 • US$3.0-3.5 • premium of US$0.5 per tonne of CO2e for projects with developmental components (Colombia Wind Farm) C-ERUPT2 (maximum prices) • renewable energy – €5.5 • biomass energy - €4.4 • energy efficiency - € 4.4 • fuel switch and methane - € 3.3 • average price - €4.73 Finish Government4 • small-scale - €2.47-3.2	PCF[5] • US$ 3.5-4.0 ERUPT[6] • First tender average price - € 8.46 (closed in April 2001) • Second tender average price - €4.78 (closed in March 2002) • Third tender - expected price range - €3.0-5.0[7] (closed in January 2003) Denmark-Romania JI[8] • estimated price range €5.40-8.10	Regional • EU-ETS8 €5.0-7.0 (indicative price); € 13.059 (forward price in Jan 2004); € 7.1710 (forward price in Apr 2004) National • UK-ETS11 – Bid price £1.75, offer price £2.25 Firm • BP Emissions Trading Scheme12 (Scheme discontinued in 2001) average in 2000 – US$7.6 average in 2001 – US$39.63

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[1]PCF Annual Report 2002; [2]C-ERUPT Tender Document 2002; [3]Carbon Market Europe (March 21 2003); [4]http://global.finland.fi; [5]PCF Annual Report 2002; [6]Environmental Finance (February 2003); [7]GHG Market Trends 2/2003; Carbon Market Europe (March 7, 2003); [8]Carbon Market Europe (May 2 2003); [9]Evolution Markets LLC (Jan 2004); [10]Carbon Market Europe (April 15 2004); [11]Carbon Market Europe (August 15 2003); [12]ww.bp.com/files/15/Climate_Change_2001_performance_1541.pdf

The pricing of CERs is highly speculative. The PCF considers several parameters in determining its price in the PCF's carbon purchase agreement. Moreover, certain project parameters command price premiums under the PCF program. These include: i) the existence of government guarantees, ii) project generation of social benefits, and iii) the exclusion of preparation costs in the total project cost. Among the CDM projects being contracted by PCF, a price premium of US$ 0.5 per tCO_2eq. has been offered to the Colombia Jepirachi Wind Farm sponsors for the delivery of activities that improve the social conditions of the local indigenous population that hosts the project.

In C-ERUPT program, prices are also differentiated according to technology type. CER from renewable energy project forms the reference price (maximum price of EUR 5.5 per CER). CERs from sustainable grown biomass projects as well as from energy efficiency projects are priced 20% lower (maximum price of EUR 4.5) while those from fuel switching and methane recovery projects are 40% cheaper (maximum price of EUR 3.3).

At present there is no single CER price but differentiated according to risks, technology type and social development components. The current PCF CER rate ranges from US$3 to 4 per tonne of CO_2; under the CERUPT program, it revolves around US$ 4 to 4.5 per tonne of CO_2. The CER price differentiation could evolve into the following categories: i) CERs from projects that fulfil the WWF Gold Standard, ii) CERs from projects with community development features, iii) CERs from standard projects, and iv) long-term and temporary CERs from forestry projects (Michaelowa, A., CDM Monitor, March 11, 2004).

Several economic models forecast a single carbon price since these models assume a competitive and unfettered markets. With the US presence in the GHG market, these models projected a very high carbon prices. After the Bonn Agreement and Marrakesh Accord, and with the absence of the US in the market, these models projected low carbon prices. In reality, the carbon markets are fragmented and prices generated by these markets are differentiated. In a recent GHG market analysis, Natsource (2002) forecasts prices for project-based carbon emission reductions (both JI and CDM markets) to vary from US$3 to 5 for the period 2002-2005, US$2.5 to 9.0 during 2005-2007, and US$5 to11 from 2008-2012.

3.1 Transaction Costs

Transaction costs are those that arise from initiating and completing transactions to secure CERs. These consist of pre-operational costs (or upfront costs), implementation costs (i.e. costs spread out over the entire crediting period), and trading costs (Table 3.2). Pre-operational costs include direct expenses for search, negotiation, validation, and approval. Implementation costs are those incurred for monitoring, certification, and enforcement while trading costs are those incurred in trading CERs such as brokerage costs and costs to hold an account in national registry.

PCF's pre-operational transaction costs amounts 229 thousand Euros (265 thousand dollars) while Ecosecurities (2002) estimates the minimum up-front transaction cost at around 70 thousand Euros (£42,000) (Table 3.3).

Table 3.2: CDM Transaction Costs

	Transaction Cost Component	Description
Pre-implementation phase	Search Costs	Costs incurred by investors and hosts as they seek out partners for mutually advantageous projects
	Negotiation Costs	Includes those costs incurred in the preparation of the Project Design Document that also documents assignment and scheduling of benefits over the project time period. It also includes expenses in organizing public consultation with key stakeholders.
	Baseline determination	Development of a baseline
	Approval costs	Costs of authorization from host country
	Validation Costs	Costs incurred in reviewing and revising the Project Design Document by operational entity
	Review Costs	Costs of reviewing a validation document
	Registration Costs	Registration by UNFCCC Executive Board/JI Supervisory Committee
Implementation Phase	Monitoring Costs	Costs to collect data
	Verification Costs	Costs to hire an operational entity and to report to the UNFCCC Executive Board/Supervisory Committee
	Review Costs	Costs of reviewing a verification
	Certification Costs	Includes costs in the issuance of Certified Emission Reductions (CERs for CDM) and Emission Reduction Units (ERUs for JI) by UNFCCC Executive Board
	Enforcement costs	Includes administrative and legal costs incurred in enforcing transaction agreements
Trading	Transfer Costs	Brokerage costs
	Registration Costs	Costs to hold an account in national registry

Source: Michaelowa, A., Stronzik, M., Eckerman, F., and Hunt, Alistair, 2003.

The CDM Executive Board has determined the registration fee for CDM projects. Table 3.3 shows that the small CDM projects get a lower registration fees.

Table 3.3: Registration fee for CDM projects

Annual CO2-eq. reduction	Fee in US$
<=15,000	5.000
>15,000 and <= 50,000	10.000
>50,000 and <=100,000	15.000
>100,000 and <=200,000	20.000
>200,000	30.000

Several studies show that the transaction cost per tonne of CO_2 for large projects is very small or even negligible while that for small-scale projects is quite significant. Given this, it is obvious that investors would prefer large-scale projects. Fast-tracking small-scale projects (simplifying the procedures and standardizing the information and reporting requirements) not only reduces transaction costs but also improves project financial viability. According to Ecosecurities (2002), fast-tracked procedures lead up to around 67% reduction in transaction costs.

Table 3.4: CDM Transaction Cost Estimates

	Project Cycle	Ecosecurities, 2002 (£)	PCF (US $)	SGS (Euro)
Pre-operational Phase Design	Preparation and review		40,000	
	Baseline Study	12,000 – 15,000	20,000	
	Monitoring Plan	5,000 – 10,000	20,000	
	Environmental Assessment	-		
	Stakeholder Consultation	-		
	Approval	-		
	Validation (full scale)	10,000 – 20,000	30,000	6,000-20,000
	Validation (small-scale)			2,500-4,000
	Consultation and project appraisal		105,000	
	Legal and Contractual Arrangements	15,000 – 25,000	50,000	
Operational Phase	Sales of CERs	5% - 15% of CER Value		
	Adaptation Levy[1]	2% of the CER value annually		
	Risk Mitigation	1%-3% of CER value annually		
	Verification	5,000 per audit	25,000 (initial) 10,000-25,000 (periodic) 10,000-20,000 (periodic supervision)	2,500-15,000
	Executive Board Administration	To be determined (X% of CER value)		

[1] Projects in least developed countries are exempted from the 2% adaptation levy.

Sources: Ecosecurities, 2002; PCF presentation COP 8, Side Event, New Delhi, 24 October 2002. SGS Presentation Singapore 1 November 2004.

3.2 Impact of CERs on Project Feasibility

The net financial gain derived from the sale of CERs is the difference between the project CER value and the transaction costs. There are three elements that influence the net impact of CERs on project profitability: value of CERs (low CER value implies low net benefits), overall transaction costs (high transaction costs yield low net benefits), and up-front transaction costs (high upfront payments could also result in low benefits). Project developers generally expect *up-front* transaction costs within the range of 5 to 7% of the net present value of the revenue or *total* transaction costs around 10 to 12% of the net present value of revenue (Ecosecurities, 2002).

A positive net financial gain means that CER revenues improve the financial viability of the project. Table 3.5 presents the impacts of carbon financing to the proposed 60 MW Wind Farm project in Zafarana, Egypt. For the CER price scenarios of US$3 and 10 per tonne of CO_2 equivalent, the project's net present value increases by 173% and 588% respectively. The project's internal rate of return increases by 1.04 and 3.38 percentage points while the return of equity rises by 2.73 and 8.24 percentage points for the respective CER price scenarios.

Table 3.6 shows the impact of CERs on IRRs in selected projects. The effect of CER cash flow on project IRRs vary by project type. The impact of CERs on wind power project IRR is relatively small (few percentage points increase) while it is substantially important for fugitive methane capture projects. More CERs are generated by methane capture projects since the global warming potential of methane is 21 times that of carbon dioxide. This makes methane capture projects relatively attractive to CDM project developers. In fact, for the first 45 projects submitted to the CDM Executive Board for methodology review, 27% (12 projects) are methane gas capture projects.

Table 3.5: Impact of carbon financing on the proposed 60-MW Zafarana Wind Farm Project in Egypt

Economic Indicators	Without carbon finance	With carbon finance	
		US$3 per tonne CO2eq	US$10 per tonne CO2eq
Internal Rate of Return	5.63%	6.67%	9.01%
Net Present Value	US$2,954,117	US$8,065,191	US$20,320,777
Return on Equity after taxes	19.10%	21.83%	27.34%

Note: Financial and economic data are given in Appendix 3.1

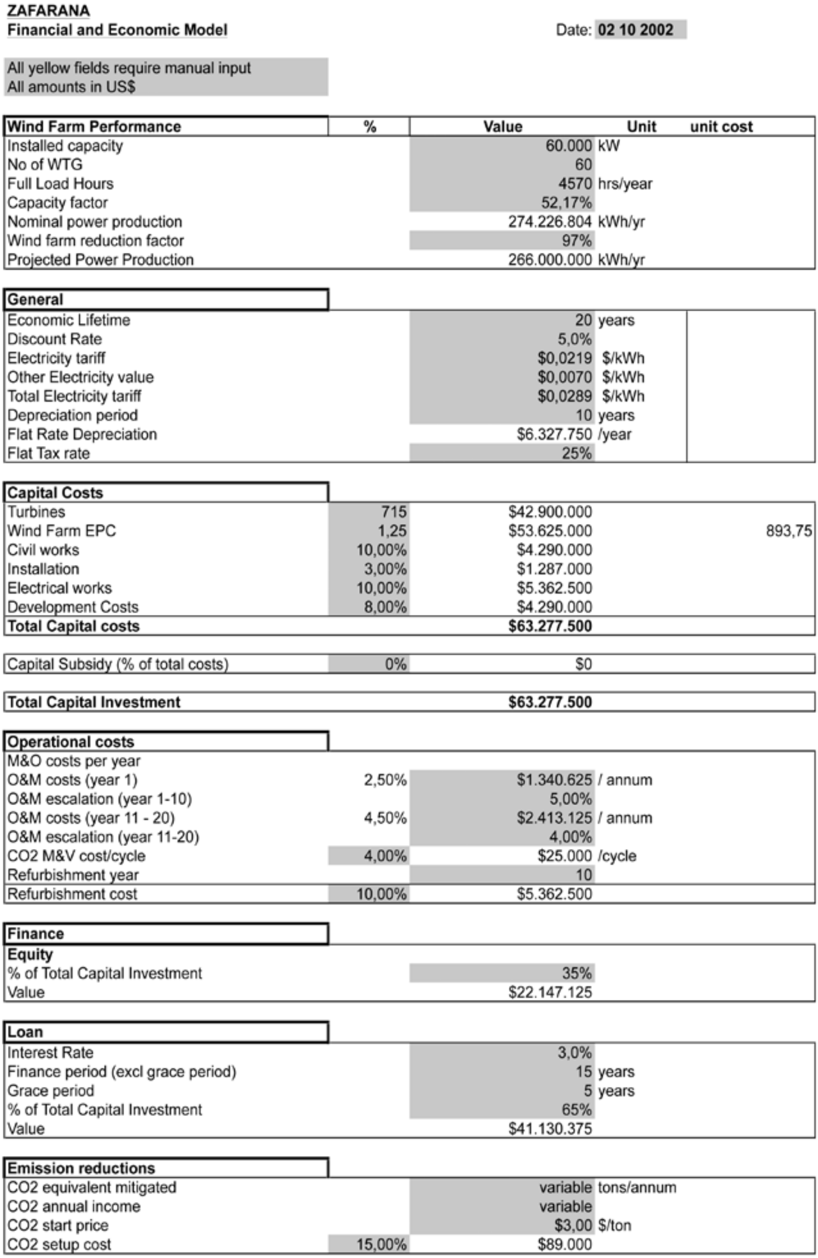
Source: Ringius, L., Grohnheit, P.E., Nielsen, L.H., Olivier, A., Painuly, J., and Villavicencio, A. 2002. Wind Power Projects in the CDM: Methodologies and Tools for Baselines, Carbon Financing and Sustainability Analysis. Risoe National Laboratory.

Table 3.6: Impact of CERs on project IRR

Country	Project	IRR without carbon finance (%)	IRR with carbon finance (%)	Change in IRR (%)
Costa Rica	wind power	9.7	10.6	0.9
Jamaica	wind power	17.0	18.0	1.0
Morocco	wind power	12.7	14.0	1.3
Chile	Hydro	9.2	10.4	1.2
Costa Rica	Hydro	7.1	9.7	2.6
Guyana	Bagasse	7.2	7.7	0.5
Brazil	Biomass	8.3	13.5	5.2
India	solid waste	13.8	18.7	5.0

Source: PCF Annual Report 2001

Appendix 3.1: Zafarana: Financial and Economic Model



ZAFARANA
Financial and Economic Model

Date: **02 10 2002**

All yellow fields require manual input
All amounts in US$

Wind Farm Performance	%	Value	Unit	unit cost
Installed capacity		60.000	kW	
No of WTG		60		
Full Load Hours		4570	hrs/year	
Capacity factor		52,17%		
Nominal power production		274.226.804	kWh/yr	
Wind farm reduction factor		97%		
Projected Power Production		266.000.000	kWh/yr	

General				
Economic Lifetime		20	years	
Discount Rate		5,0%		
Electricity tariff		$0,0219	$/kWh	
Other Electricity value		$0,0070	$/kWh	
Total Electricity tariff		$0,0289	$/kWh	
Depreciation period		10	years	
Flat Rate Depreciation		$6.327.750	/year	
Flat Tax rate		25%		

Capital Costs				
Turbines	715	$42.900.000		
Wind Farm EPC	1,25	$53.625.000		893,75
Civil works	10,00%	$4.290.000		
Installation	3,00%	$1.287.000		
Electrical works	10,00%	$5.362.500		
Development Costs	8,00%	$4.290.000		
Total Capital costs		**$63.277.500**		

Capital Subsidy (% of total costs)	0%	$0		
Total Capital Investment		**$63.277.500**		

Operational costs				
M&O costs per year				
O&M costs (year 1)	2,50%	$1.340.625	/ annum	
O&M escalation (year 1-10)		5,00%		
O&M costs (year 11 - 20)	4,50%	$2.413.125	/ annum	
O&M escalation (year 11-20)		4,00%		
CO2 M&V cost/cycle	4,00%	$25.000	/cycle	
Refurbishment year		10		
Refurbishment cost	10,00%	$5.362.500		

Finance				
Equity				
% of Total Capital Investment		35%		
Value		$22.147.125		

Loan				
Interest Rate		3,0%		
Finance period (excl grace period)		15	years	
Grace period		5	years	
% of Total Capital Investment		65%		
Value		$41.130.375		

Emission reductions				
CO2 equivalent mitigated		variable	tons/annum	
CO2 annual income		variable		
CO2 start price		$3,00	$/ton	
CO2 setup cost	15,00%	$89.000		

4. The Project Cycle

In order to get the credits (the CERs) for the reductions of greenhouse gas emissions caused by the wind project, the project participants must get the project approved by the Executive Board (EB). The general rules for CDM projects were agreed in Marrakesh in 2001, where the first EB was elected to supervise the CDM. EB is responsible for developing the specific CDM-rules, which are now operational for many categories of projects.

This section describes the steps needed to take a wind power CDM project through this process and the risks existing in each step. The 14 steps are shown in table 4.1. The decisions the project participants have to take and the task they have to do in order to complete the project cycle are presented. The steps follow the CDM project cycle shown on figure 1. The CD4CDM "CDM Information and Guidebook" (http://cd4cdm.org/publications.htm) contains a section where the project cycle is explained in detail.

The key terms used has been defined by the EB in the "Glossary of CDM terms" which is part of the "Guidelines for completing the Project Design Document" to be found on the Reference-Document part of the UNFCCC CDM web site. Project developers can also find help in the "Guidance/Clarification" documents on the site.

Table 4.1: The steps to take in order to follow the CDM project cycle

1 Develop a project idea
2 Decide whether the project is small-scale or full-scale
3 Decide whether it is a unilateral project or choose a project participant in an Annex I country
4 Contact the DNA in the country to ask for local eligibility criteria and procedures
5 Start to develop the Project Design Document (PDD)
6 Choose an approved baseline and monitoring methodology or suggest a new one
7 Invite local stakeholders to make comments on the project
8 An agreement must be written on how the CERs generated will be split among the project participants
9 Choose a Designated Operational Entity (DOE) to validate the PDD
10 The DOE will ask the involved DNA´s for approval letters
11 Hopefully no request for project review at request for registration at the EB
12 Project implementation and monitoring
13 Select a DOE to verify and certify the emission reductions
14 Issuance of the CERs

The steps listed in Table 4.1 are explained abowe.

1) *Develop a project idea.*

Only countries that have ratified the Kyoto Protocol (see the UNFCCC web site), and have established a Designated National Authority (DNA) (see the UNFCCC CDM web site) are eligible to participate in a CDM project.

For wind projects, a region should be chosen where wind projects are not established on normal market conditions in order to avoid that the project is declared as non-additional. In order to proceed in the project cycle enough wind measurements and pre-feasibility studies must have been done.

2) *Decide whether the wind project is small-scale or full-scale.*

An electricity generating wind project can be eligible as a small-scale CDM project if the installed capacity is less than 15 MW. Standardized baselines making the workload smaller for the project participants exist both for grid connected turbines (Type I.D.), for off-grid electricity producing turbines (Type I.A.), and for wind-powered pumps (Type I.B.). For a wind/diesel unit this limit is applied only to the renewable (wind) component of the project. (See "Simplified modalities and procedures for small-scale CDM project activities" in the document part of the UNFCCC CDM web site.)

Bundling is allowed for small-scale projects. Bundling will reduce the transaction cost because a large number of small projects can be combined in one PDD. Projects can be bundled and still considered small-scale as long as the total size is below 15 MW limit.

Debundling a large CDM project greater than 15 MW into consecutive small-scale parts is not eligible to be a small-scale CDM project. A proposed small-scale project activity shall be deemed to be a debundled component of a large project activity if there is a registered small-scale CDM project activity or an application to register another small-scale CDM project activity:

- with the same project participants;
- in the same project category and technology/measure; and
- registered within the previous 2 years; and
- whose project boundary is within 1 km of the project boundary of the proposed small-scale activity at the closest point.

3) *Decide whether it is a unilateral project or choose a project participant in an Annex I country.*

There have been many discussions on the issue of unilateral projects at the COP meetings. However, now the EB has decided, that the registration of a CDM project can take place without an Annex I Party being involved at the stage of registration. Before the CERs can be issued a letter of project approval from an Annex I Party is needed.

In the approval letter, a Party can authorize private and/or public entities to participate in CDM projects.

4) *Contact the DNA in the country to ask for local eligibility criteria and procedures.*

Each developing country has the responsibility to determine the national criteria to be used to confirm that the project assist the country in achieving sustainable development. The country has to establish a Designated National Authority (DNA) to do this work. The official list of existing DNAs is on the UNFCCC CDM web site. Normally the DNA will have a web site describing the local rules and the procedures to follow.

In some countries it is a good idea to get a preliminary project approval based on a Project Idea Note (PIN).

5) Start to develop the Project Design Document (PDD).

The CDM-PDD presents information on essential technical and organizational aspects of the project activity and is the key input into validation, registration and verification of the project.

The PDD must be submitted in English, and the PDD template on the UNFCCC CDM web site must be used. However, the PDD template is available in all six official languages of the UN. (A special PDD template exists for the small-scale CDM projects).

The second version of the PDD template must be used. The content of the PDD is shown in table 4.2. The main change compared to the first version is the deletion of the two annexes, which have been used to describe new baseline and monitoring methodologies. The two annexes are now available as separate forms. The guidance text, which before was a part of the PDD, has now been taken out in a separate document.

Table 4.2: the new PDD

A. General description of project activity
B. Application of a baseline methodology
C. Duration of the project activity/Crediting period
D. Application of a monitoring methodology and plan
E. Calculation of GHG emission by sources
F. Environmental impacts
G. Stakeholders' Comments
Annex 1. Contact information on participants in the project activity
Annex 2. Information regarding public funding
Annex 3. Table: Baseline data

Below we give a short overview of the content of the PDD according to the sections shown in Table 4.2 (see chapter 5 for more information on baseline and monitoring methodologies and on how to use the PDD for wind projects).

(A) The purpose of the project activity its emission reduction and its contribution to sustainable development must first be described in a short and easily understandable way. The project participants must be listed and the location of the project activity should be mentioned. Public funding of the project activity must be mentioned. An affirmation must then be given in Annex 2 that it does not result in a diversion of Official Development Assistance (ODA).

(B+D) Refer to the UNFCCC CDM web site for the title and details of the approved baseline and monitoring methodology applied to the project. A justification for the choice of methodology and how it is applied must be given. The baseline for a CDM project is the scenario that reasonably represents the emissions of GHGs that would have occurred in the absence of the CDM project.
Here the explanation is given how and why the project is additional and therefore not in baseline scenario.

(C) The crediting period of the project must be chosen: Either a period of 10 years or a period of 7 years that can be renewed two times – here there is a risk in choosing the 3 times 7 years because the baseline might no longer be valid or the project might no longer be additional after the 7 years.

(E) In this section the calculation of the GHG emissions is presented for the CDM project, the baseline and the difference between the two represents the emission reduction of the project activity. The leakage must be estimated (leakage is defined as the net change of anthropogenic emissions of GHGs which occurs outside the project boundary, and that is measurable and attributable to the project activity). A table containing the key variables, parameters, and data sources used in the baseline calculation must be supplied in Annex 3.

(F) The project participants must submit to the DOE documentation on the analysis of the environmental impacts of the project activity and, if those impacts are considered significant by the project participants or the host Party, undertake an environmental impact assessment in accordance with the procedures required by the host Party.

(G) A brief description on the process on how comment by local stakeholders have been invited and compiled.

6) Choose an approved baseline and monitoring methodology or suggest a new one.

In the PDD it must be stated which approved full-scale methodology, or which standardized small-scale methodology type was used. A list of approved methodologies can be found on the UNFCCC CDM web site. The baseline and monitoring methodologies always come in pairs.

If none of the approved methodologies fit to the project a new methodology can be proposed. A special cycle has been developed by the EB for this:

- The project participants use the two templates at the UNFCCC CDM home page to describe the new baseline methodology (CDM-NMB) and the monitoring methodology (CDM-NMM).
- The new methodology is given to a DOE together with a draft PDD using the methodology. The DOE will forward the methodology to the EB.
- The EB will send these documents to their Methodology (Meth.) Panel, which will select two experts from their roster of expert to do a desk review of the new methodologies. At the same time the documents will be made publicly available for comments.
- Based on the desk reviews, public comments, and if requested, additional technical information from the project participants, the Meth. Panel will prepare their preliminary recommendations regarding the approval of the methodology.
- The project participants will get 10 days to submit clarifications and changes required to the Meth. Panel.
- The Meth. Panel then forwards their final recommendation to the EB. This is made public together with the two desk reviews and the public comments.

- If the methodology is approved, the Meth. Panel will reformat the methodology and it is made public in the list of approved methodologies on the UNFCCC CDM homepage.

7) Invite local stakeholders to make comments on the project.

An invitation for comment by local stakeholders shall be made in an open and transparent manner, in a way that facilitates comments to be received from local stakeholders and allows for a reasonable time for comments to be submitted. In this regard, project participants shall describe the project activity in a manner, which allows the local stakeholders to understand the project activity, taking into account confidentiality provisions of the CDM modalities and procedures. These comments must be incorporated into the PDD.

There will later be a second round of comments. When the DOE is validating the PDD it will be put on the Internet for 30 days (a link from the UNFCCC CDM web site will be established) to allow interested parties at the local, national and international level to comment on it. The DOE must also make the comments publicly available.

It is important to be aware that these comment are of great importance, and that they can prohibit a project from getting approved.

8) *An agreement must be written on how the CERs generated will be split among the project participants.*

The PDD contains no information about how to share the CERs created by the project. The project participants should make such a written statement on how to share the CERs, when an agreement with an Annex I Party is made.

9) Choose a Designated Operational Entity (DOE) to validate the PDD.

Only an entity that has been accredited by the EB for this purpose can be used. On the UNFCCC home page it can be seen the sectoral scopes a DOE has been allowed to validate. Wind power falls under scope no. 1: Energy Industries.

The DOE will check whether the project participants have send to it the required environmental impact documentation.

There is a risk that the DOE does not accept the project activity as a CDM project; in that case the DOE must explain the reasons for non-acceptance. The DOE will also inform the project participants of the confirmation and date of submission of the validation report to the EB. The DOE will forward the PDD together with the approval letters from the Parties involved, an explanation of how it has taken due account of the comments received, and a request for registration in the form of a validation report to the EB. The CER contact letter will also be included. Also this validation report must be made public.

There is a risk that the EB will reject the project – this could happen if a Party involved in the project activity or three members of the EB request a review of the project within 8 weeks after the receipt of the request for registration.

10) *The DOE will ask the involved DNAs for approval letters.*

The DOE will ask the DNAs in the participating countries for letters stating that they are participating voluntarily in the project (one should not forget the DNA in the Annex I country). It is also necessary that the DNA in the host country confirms that the project assist it in achieving sustainable development. The DNA should state that the county has ratified the Kyoto Protocol.

This written approval is also the DNA's authorisation of specific entity(ies') participation as project proponents in the specific CDM project activity.

11) *Hopefully no request for project review at request for registration at the EB.*

Three members of the EB or a Party participating involved in the project can request a review of the project activity. The Executive Board shall consider, at its next meeting, this request and either decide to undertake a review of the proposed project activity or register it as a CDM project activity.

The review by the EB shall be finalized no later than at the second meeting following a request for review. Here the EB must decide whether:

(a) To register the proposed project activity; or
(b) request the DOE and project participants to make corrections based on the findings from the review before proceeding with registration; or
(c) reject the proposed project activity

12*) Project implementation and monitoring.*

The projects participants are responsible to following the monitoring plan in the PDD for the project. The monitoring plan needs to provide detailed information related to the collection and archiving of all relevant data needed to

- estimate or measure emissions occurring within the project boundary
- determine the baseline, and
- identify increased emissions outside the project boundary.

13) *Select a DOE to verify and certify the emission reductions.*

It is allowed to choose the same DOE that did the validation of the project only for small-scale CDM projects. The project participants can ask for verification whenever they like; there will of course be a trade-of between the cost of certification and the time period between them.

The DOE will verify that the monitoring methodology and the monitoring plan have been implemented correctly and check the information in accordance with the provisions of the verification. (The data monitored and required for verification are to be kept for two years after the end of the crediting period or the last issuance of CERs for the project activity).

The DOE can conduct on-site inspections, interviews with project participants and local stakeholders etc. The DOE will inform the project participants of any concern related to the conformity of the actual project activity and its operation with the registered PDD. Project participants shall address the concerns and supply additional information.

The DOE will send a verification report and a letter certifying the emission reductions from the project to the project participants, the Parties involved and the EB. These reports shall be publicly available.

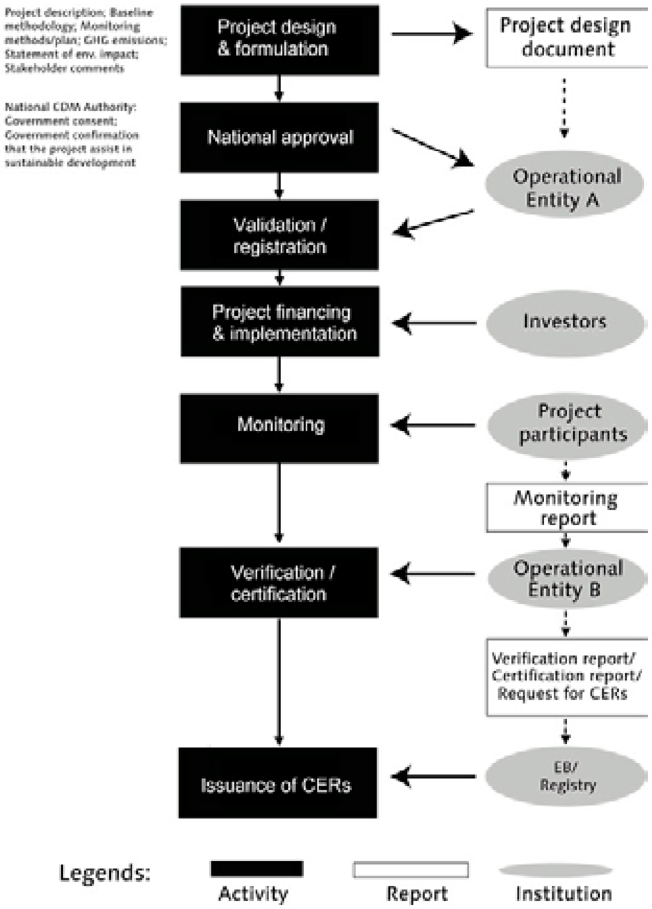
14) *Issuance of the CERs*

Again at this last point in the project cycle there is a risk. The CERs will be issued in less than 15 days after receipt of the certification report unless a Party involved in the project activity or at least three members of the executive board request a review of the proposed issuance of CERs. Such a review shall be limited to issues of fraud, malfeasance or incompetence of the DOE.

The issued CERs will first be placed in the pending account of the EB. The CDM registry administrator (which is the UNFCCC Secretariat) will then move 2% of the CERs to the account used to assist developing country Parties that are particularly vulnerable to the adverse effect of climate change to meet the costs of adaptation, and move an amount, yet to be decided by the COP, to cover the administrative expenses of the CDM.

The rest of the CERs will then be forwarded to the registry accounts of Parties and project participants involved according to their request.

Project cycle for the CDM



5. Preparing a Project Design Document

The Project Design Document (PDD) is a key and required document in the process of preparation and implementation of a CDM project. The contents of the PDD are standardized and have been specified by the Executive Board. The project developer, while preparing a PDD, needs various types of data and information. The purpose of this chapter is to give a brief description and guidance on the type and nature of data that would go into each of the PDD chapters, with special focus on wind energy CDM projects. Preparing an accurate and comprehensive PDD requires, among other things, the use of right and adequate data and information. Once an understanding of the nature and use of data and information is established, the process of data collection and information gathering becomes less time consuming or more straightforward, which ultimately contributes to a reduction in the transaction cost associated with PDD preparation process. This cost represents a relatively large share of the CDM project's total transaction cost. Although the chapter as well as this manual focus on wind energy CDM projects, the guiding points outlined in this chapter, and indeed in the whole manual, will be also useful to project developers of other types of CDM projects.

The chapter is structured in such a way that each chapter and annexes of a PDD will be presented in terms of the data to be inputted for wind energy CDM projects. In order to give some hands-on examples for data and information used in wind energy CDM projects, the Project Design Documents (PDDs) for NM0036 Zafarana Wind Farm, Egypt, are used as example. The PDD template is available at the UNFCCC's CDM web site: http://cdm.unfccc.int. Guidelines for completing the PDD can also be found at this website. It contains a PDD glossary and the specific guideline text, which was included in the first version of the PDD.

The contents of a PDD are standardized and have been set by the Executive Board. Given that the CDM is an evolving process and the Executive Board is constantly making new decisions, it is possible that the Executive Board may again modify the contents of the PDD in the future. It is hence recommended to follow the meetings and decisions by the Executive Board. The current contents of a PDD are as follows:

Chapter A: General description of project activity

Chapter B: Application of a baseline methodology

Chapter C: Duration of the project activity/Crediting period

Chapter D: Application of a monitoring methodology and plan

Chapter E: Estimation of GHG emission by source

Chapter F: Environmental impacts

Chapter G: Stakeholders comments

Annex 1: Contact information on project participants in the project activity

Annex 2: Information regarding public funding

Annex 3: Baseline information

Annex 4: Monitoring plan

It should be mentioned that the PDD for small-scale CDM projects have the same chapters but less annexes (no Annex 3 and no Annex 4). Generally, the PDD for a small-scale CDM project is simpler than the standard PDD for an ordinary CDM project.

Chapter A. General description of project activity

In this chapter, the project is described in short, including information about the project's participants. Based on the format provided by the Executive Board, such description covers the following aspects of the CDM project:

1. Title of the project activity. Indicate the version number and date of the document

2. Description of project activity: Explain the purpose of project activity and the opinion of the project participants on how the project contributes to the sustainable development in the host country.

3. List the project participants

4. Project location. Project location should include name of city or town

where the project will be implemented. Other regional location coordinates may also be relevant including a map of where the project is in relation to other similar projects (if any) in the country or the region. A project map could usually be obtained from either local authorities in the host country or the project proponents prepare a new map.

5. How GHG emission reductions will be reduced through the project? This would require a description of the type of the technology to be used in the project. In case of the wind project, information on the wind turbine's manufacturer, type and capacity of turbines to be used, and some background information on where these turbines have been used in other locations in the world could be included. It may also be relevant to insert a brief table describing the technical specifications of the turbines. This information could typically be obtained from the technology provider or the wind turbines manufacturer. In this section it also has to be explained that the project is not a baseline option. Here it might be useful to provide a brief description of wind-based generation in the host country and also policies and regulations that affect the choice of wind as energy source. This provides the context for explaining why the proposed project is not a baseline project. If significant wind capacity exists it might be useful to point out the difference in the present project with existing wind projects.

6. Make a brief explanation of how and how much the GHG emissions are reduced in the crediting period, and why the project is additional (why the emission reductions would not occur in the absence of the project).

7. Mention any public funding for the project and whether it results in diversion of Official Development assistance (ODA).

Chapter B: Baseline methodology

The chosen project baseline methodology tells the project developer how to calculate the GHG emissions in the baseline scenario (a business-as-usual scenario) and compare it with the expected or estimated (*ex ante*) emissions from the CDM project itself. The difference between the two levels of emissions is the amount of emission reductions achieved by the project and for which CERs should ultimately be claimed. Therefore, the baseline methodology section is by far the most critical section of a PDD, as it demonstrates how the calculation of the amount of CERs is done and hence the whole project economics. It is what will "make or break" the project. At the same time, the project proponents are expected to be **conservative in the estimate of baseline emissions** when approaching the issue of project baseline. This may be difficult given that the maximization of the emissions reductions from the project will positively influence the project economics. However, exaggerated or over-estimated emission reductions will almost certainly lead to the rejection of the project by the EB. In general, the project proponents need to conservative while at the same time reflecting a realistic estimation of the emission reductions from the project.

In addition, the project proponents should be, as much as possible, **transparent** in the way the PDD is prepared and in presentation of data. Calculations, such as emission factor calculations for power plants, where all data and figures used to reach the emission factor figures are presented, should be transparent. The ultimate objective of presenting this data is to enable the reviewer of the PDD to conduct the same calculations on his own and reach the same results as presented in the PDD. Any assumptions made should be clearly stated with a justification for the assumption.

For small-scale renewables, indicative baseline methodologies were provided at an early stage by the EB and have been presented later in this chapter. In general, the baseline methodology selected by the project proponents will be influenced by the scale of the project, availability of data in the host country, and, as mentioned above, the national circumstances.

The primary difficulty for a wind CDM project proponent when dealing with the baseline issue is to be able to calculate "whether the avoided generation (what would have happened without the CDM project) is on the Build Margin (i.e. replacing a facility that would have otherwise been built) and/or on the Operating Margin (i.e. affecting the operation of current and/or future power plants)" (Kartha, 2002). However, with the ACM0002 approved consolidated methodology this issue can be settled easily by taking an averaging approach (combined margin approach).

Small-scale Wind

If the total installed capacity in the project is less than 15 MW it is a small scale CDM project.

If the small-scale wind project is off-grid, it will typically be combined with another power generation technology, such as diesel in the form of a hybrid power system. In this case, the simplified indicative baseline methodology provided by the EB is Type I.A (Renewable Energy – Electricity Generation by User). Here the calculation of the emission coefficient is very simple: "a default value of 0.9 kgCO_2 eq/kWh, which is derived from diesel generation units, may be used." See the UNFCCC's CDM web site for more details on the simplified indicative baseline methodologies for small-scale CDM projects.

In the case of small-scale grid-connected wind projects, the indicative baseline methodology under Type I.D can be used: For a mini-grid the EB has given a table where the emission coefficient varies between 0.8 to 2.4 kgCO_2 eq/kWh depending on the size in kW and the load factor. For a normal grid connected small-scale wind projects the required methodology is either the weighted average of the current generation mix or the combined margin method. The "**Combined margin**" emission coefficient is the average of the emission coefficient for the "Approximate operating margin" and the "Build margin".

> The "Approximate operating margin" is the weighted average emission (in $kgCO_2eq/kWh$) of all generating sources serving the system, excluding hydro, geothermal, wind, low-cost biomass, nuclear and solar generation.
>
> The "Build margin" is the weighted average emission (in $kgCO_2eq/kWh$) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of most recent 20% of existing plants or the 5 most recent plants.
>
> (See the Essaouira wind power project example below; it uses the combined margin approach)

Large-scale wind
For large-scale wind projects (over 15 MW), the Executive Board has approved three baseline methodologies so far. These are:

1. Approved consolidated baseline methodology ACM0002: "Consolidated baseline methodology for grid-connected electricity generation from renewable sources."
    1. Approved baseline methodology AM0005: "Small grid-connected zero-emission renewable electricity generation"
    2. Approved baseline methodology AM0019: "Renewable energy projects replacing part of the electricity production of one single fossil fuel fired power plant that stands alone or supplies to a grid"

Section B of the PDD must start with a reference to which of the approved baseline on the UNFCCC web page is being used in the project. It must be justified that the proposed project activity meets the applicability conditions under which the methodology is applicable.

One of the wind projects submitted to the EB, "Essaouira wind power project" in Morocco uses the consolidated methodology ACM0002. This methodology uses the **combined margin** approach.

If the low-cost/must run power plants constitute less the 50% of the total grid generation, the **operating margin** emission coefficient is calculated in the same way as for small-scale grid-connected projects: the amount of fuel used in all the power plants (excluding the low-cost/must run power plants, like hydro power) is multiplied by the respective emission factors of the fuels and divided by the total electricity delivered to the grid from the plants.

No CO_2 emissions reduction can be claimed for reducing electricity import, the emission coefficient must be zero for imports.

The operating margin can be calculated, using a 3-year average, based on the most recent statistics. In the Essaouira wind power example the average results for the operating margin in 2001-2003 is 0,733 tCO_2/MWh.

To calculate the **build margin**, the *ex-ante* methodology as for small-scale projects can be used. The "build margin" is the generation-weighted average emission factor (tCO_2/MWh) of the power plants on build margin. The build margin consists of the group, which comprises larger electricity generation between generation from five most recently built power plants and most recently built power plants that comprise 20% of the system generation. However, in the first crediting period there is another option for calculation of the Build margin: The calculation can be done *ex-post*: i.e. the build margin can be updated every year in the first crediting period. This can be a good idea if it is known that high CO_2 emitting plants will be built in the coming years.

In the Essaouira wind power example the build margin was calculated to be 0,752 tCO_2/MWh. The emission coefficient varies using in this project is therefore:

0.5 * 0,733 tCO_2/MWh + 0,5 *0,752 tCO_2/MWh = 0,743 tCO_2/MWh

The data of the plants used in the calculation (and the calculation itself) should be shown in Annex 3 to the PDD.

Another wind project submitted to the EB; "Huitengxile wind farm project" in China uses the approved methodology AM0005. This methodology is only applicable to projects below 60 MW, and only for system not dominated by zero carbon emitting plants. This methodology also uses the combined margin approach. The operating margin is calculated as in ACM002, but the build margin can only be calculated *ex-ante*.

Boundary
The Chinese case includes only the power plant in the North China Power Grid, because this can be dispatched without significant transmissions constraints with neighbouring grids.

In the Moroccan case the whole country grid is included because it is interconnected. Since Morocco is importing electricity from Spain and Algeria, this must be taken into account.

Additionality
This very important section must use the baseline methodology to show that the project is additional, i.e. it would not have happened without the CDM.

Projects using methodology **ACM0002** must use the "Tool for demonstration and assessment of additionality" (available on: http://cdm.unfccc.int). The five (six) steps the project must pass in this tool in order to be additional are shown in the flowchart (Figure 5.1) and explained below:

<u>Step 0</u> is used only if the starting date of the CDM project activity falls between 1 January 2000 and the date of the registration of the first CDM project activity (18th January 2005), bearing in mind that only CDM project activities submitted for registration before 31 December 2005 may claim for a crediting period starting before the date of registration.

In order to be approved evidence must be provided that the incentive from the CDM was seriously considered in the decision to proceed with the project activity. This evidence shall be based on (preferably official, legal and/or other corporate) documentation that was available to third parties at, or prior to, the start of the project activity.

<u>Step 1:</u> Here the project and all plausible and credible alternatives that deliver outputs and services with comparable quality must be mentioned. The alternative(s) shall be in compliance with all applicable legal and regulatory requirements. If an alternative does not comply with all applicable legislation and regulations, then show that, based on an examination of current practice in the country or region in which the law or regulation applies, those applicable legal or regulatory requirements are systematically not enforced and that non-compliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration.

Project participants can now choose between step 2 (investment analysis) and step 3 (barrier analysis) or do both.

<u>Step 2</u> determines whether the proposed project activity is the economically or financially less attractive than other alternatives without the revenue from the sale of certified emission reductions (CERs).

<u>Step 3</u> establish that there are barriers that would prevent the implementation of the type of proposed project activity from being carried out if the project activity was not registered as a CDM activity. Such barriers may include, among others:

Investment barriers, other than the economic/financial barriers in Step 2 above, *inter alia*:

Debt funding is not available for this type of innovative project activities.

No access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented.

Technological barriers, inter alia: Skilled and/or properly trained labour to operate and maintain the technology is not available and no education/training institution in the host country provides the needed skill, leading to equipment disrepair and malfunctioning;

Lack of infrastructure for implementation of the technology.

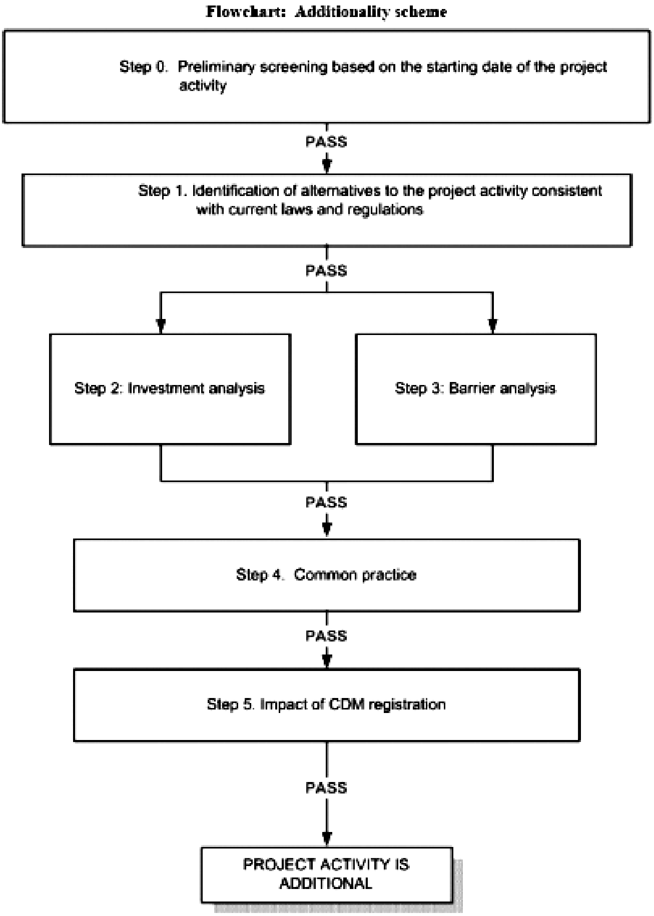
Barriers due to prevailing practice, inter alia: The project activity is the "first of its kind": No project activity of this type is currently operational in the host country or region

It is important also to demonstrate that the barriers that prevent implementation of the proposed CDM project do not prevent the implement the other baseline projects.

Step 4. (common practice analysis) The above generic additionality tests shall be complemented with an analysis of the extent to which the proposed project type (e.g. technology or practice) has already diffused in the relevant sector and region. This test is a credibility check to complement the investment analysis (Step 2) or barrier analysis (Step 3). An import point to highlight here is that if wind projects are common in the country, how the proposed CDM wind project is different from the existing wind power projects.

Step 5 Explain how the approval and registration of the project activity as a CDM activity, and the attendant benefits and incentives derived from the project activity, will alleviate the economic and financial hurdles (Step 2) or other identified barriers (Step 3) and thus enable the project activity to be undertaken.

Figure 5.1: Project Additionality Tool



At the end of section B, include contact information on the person/entity who made the baseline calculation.

The procedure for projects like the "Huitengxile wind farm project" using approved methodology **AM0005** is similar to the additionality tool mentioned above. It includes however only the three last steps: Barrier analysis, common practice analysis, and impacts of CDM registration.

For **small-scale wind projects** the additionality is a barrier test. Project participants shall provide an explanation to show that the project activity would not have occurred anyway due to at least one of the following barriers:

(a) Investment barrier: a financially more viable alternative to the project activity would have led to higher emissions;

(b) Technological barrier: a less technologically advanced alternative to the project activity involves lower risks due to the performance uncertainty or low market share of the new technology adopted for the project activity and so would have led to higher emissions;

(c) Barrier due to prevailing practice: prevailing practice or existing regulatory or policy requirements would have led to implementation of a technology with higher emissions;

(d) Other barriers: without the project activity, for another specific reason identified by the project participant, such as institutional barriers or limited information, managerial resources, organizational capacity, financial resources, or capacity to absorb new technologies, emissions would have been higher.

Chapter C: Duration of the project activity/crediting period

In this section, the project proponents present the crediting period selected for the project (10 years or 7x3 years). The starting date and the operational lifetime of the project activity must also be stated.

The selection of a crediting period for the project is typically agreed upon between the buyer of Certified Emission Reductions (CERs) and host countries' project proponents.

Chapter D: Monitoring methodology and plan

Purpose of this section is to present the approach to be adopted in monitoring the project during its implementation. The approved monitoring methodology used will always be the one coming in conjunction with the approved baseline methodology. The key objective of this monitoring is to record and document on a regular basis the amount of electricity produced by the project. The project participants use this data the to calculate the amount of emission reductions that took place on an *ex post* basis. In the verification stage the Designated Operational Entity (DOE) will control that the monitoring methodology was followed.

In this section, the project proponent would also need to elaborate on the justification for selecting the monitoring methodology being proposed, emissions from the project, potential leakage (in case, for example, of when using turbines that used to be installed in another project).

For wind projects, the monitoring approach will typically entail recording the electricity production amounts from the wind farm on a regular basis through reading and recording the data from the meters installed on each wind turbine. The purpose here is to measure how much electricity was exported to the grid by the wind farm, in the case of grid-connected wind. For off-grid applications, it is also needed to record and document the amount of electricity produced by the CDM project. The metering system and the responsible for the monitoring must be mentioned. At the end the entity determining the monitoring plan must be mentioned._

The proposed or adopted monitoring methodology need to take into consideration the crediting period used in the project and the terms of sale of CERs from the project, as both will affect the frequency of the monitoring being done.

The local project partners in the host country would be expected to conduct this on-site project monitoring and hence need to be involved or consulted regarding the monitoring methodology to be proposed in the PDD. Accurate and reliable monitoring would require the presence of technicians in the project site trained on meter reading and documentation in a way that would facilitate the verification process by the DOE. Remember that all instruments must be calibrated.

Chapter E: Calculation of GHG emission by source

This section of the PDD presents the calculations using the methodology mentioned in section B to find the GHG emissions from the baseline and the amount of reductions in these emissions.

1. Estimation of GHG emissions from the project activity: The boundary is defined to include those emissions that are related to direct on-site activities. These emissions are zero for wind projects, because the emissions during the construction are negligible.

2. **Leakage** The project proponents need to address the issue of leakage from the project and decide whether leakage occurs due to the CDM project. For wind projects there will normally not be any. It should be mentioned that the issue of leakage in the case of small-scale CDM projects should only be considered if the wind turbines used in the project are used, and not brand new, equipment.

3. The calculation of the emissions from the baseline should now be shown:

The emission coefficient is measured as kilogramme of CO_2 emitted per kWh. For the **Operating margin**, the following two equations are used:

1. Total CO_2 emission for operating margin plants =
*Fuel consumption for plants (TJ) * CO_2 emission factor (tCO_2 /TJ) * Fraction Of Carbon oxidized*

Once the total CO_2 emissions for the operating margin is found, it is then plugged in the following equation to get the CO_2 emission factor for the operating margin:

2. CO_2 emission factor for operating margin =
Sum of CO_2 emission for Operating Margin (tCO2)/Total grid electricity generated by Operating Margin (MWh) = ________ ***tCO_2/MWh***

For the **Build margin**, the total CO_2 emissions for build margin plants =
*Fuel consumption for plants (TJ) * CO_2 emission factor (tCO_2 /TJ) * Fraction of Carbon oxidized*

CO_2 emission coefficient for the Build Margin =
Sum of CO_2 emission for most recent 5 plants (tCO_2)/Total grid electricity generated by most recent five plants (MWh) = ________ ***tCO_2/MWh***

The equations require that the following data be obtained:

a. Fuel consumption for each plant per year.
b. Net calorific value for the fuel used in each power plant, which could be obtained from the Ministry of Energy or other relevant local authority.
c. CO_2 emissions factor (from IPCC Guidelines).
d. Fraction of carbon oxidized (from IPCC Guidelines).

To calculate the combined margin, use the following equation:

CO_2 emission coefficient for **Combined margin** (tCO_2/MWh) =
[CO_2 emission factor for the operating margin + CO_2 emission factor for the build margin]/2

Finally, the baseline is then calculated by multiplying the combined margin emission factor by the annual production of electricity from the CDM project (say from the wind farm):

CO_2 emission = Electricity produced and exported to the gird by the wind farm

(MWh/year) * CO_2 emission factor (tCO_2/MWh)

Chapter F: Environmental impacts

Wind farm projects are typically known to have limited impact on the environment. In this section, the project developer presents information showing how the wind farm will affect the surrounding environment both during the construction and the operation phase. Specifically, the project developer needs to present in this section the impact of the wind farm in terms of:

a. Noise pollution.
b. Visual impacts
c. Interference with communication.
d. Land use.
e. Impacts on birds.

If the host country requires an Environmental Impact Assessment (EIA) for the CDM project, its conclusion should be included in this section, together with all references.

Chapter G: Stakeholders' comments

The project proponents should in this section describe the type of stakeholder consultations that were conducted (in which the local communities were briefed on the project) and how the project will impact the lives of the local community. The EB expects that the local communities affected by the CDM project be adequately informed about the project activities, and its influence on their daily lives as well as the long-term effects of the project on the locality.

Annex 1: Contact information on participants in the project activity

In this section, information about the project participants is inserted. Examples of the information to be included here are:

- Names and contact information of the staff members of the DNA in the host country who are most familiar with the project.
- Contact information of the project developer(s) including the local partners in the host country who are participating in project implementation, and the buyer of the CERs in the Annex-I country.
- Contact information of the entity(s) that provided financing for the project (both the core financing and the CER financing).
- Contact information for local and international consultants who were hired by the project developers to assist with the project preparation.
- Contact information of the Designated Operational Entity(s) that will be contracted for validation and then verification (if this info is available).

Annex 2: Information regarding public funding

This section of the PDD should include explanation regarding the source (s) of financing for the project. It is required that the funding for CDM projects should not come from Official Development Assistance (ODA).

Annex 3: Baseline information

As mentioned above in the section on Chapter B, a table can be inserted here with the power plant data and the calculation of the emission coefficient.

For the existing power generation grid, the following elements should be presented (preferably in a tabular format) for each of the power generation facilities connected to the grid:

1. Name of Power Plant.
2. Type of technology used in the plant (e.g. combined cycle, gas turbine, hydro, etc.).
3. Year the plant became operational.

4. Generation capacity of the plant (MW).
5. Net power production from each plant and totals (MWh).
6. Fuel consumption (TJ).
7. kg CO_2 /kWh for each plant and for the totals

Reference for the source of default figures used in the analysis should also be mentioned in this section. The following are examples of default values that could have been used in a wind project PDD:

- Default value for Net Calorific Value, which is obtained from the IPCC Inventory Guideline.

- The Fraction of C oxidized (oxidation factors) and how it was identified while taking into consideration the fuel composition for fossil fuel plants in the country (e.g. percentage in natural gas vs. crude oil). The IPCC Inventory Guideline gives guidance on this.
- The CO_2 emission factor which is measured in terms of kgCO_2/GJ for the different types of fossil fuels used in the power generation facilities. Once again, the IPCC Inventory Guideline can be used.
- Other information that will be obtained from the electric utility or the power generation facilities and are needed in the baseline analysis are:
    - Fuel consumption according to technology used, and electricity generation according to technology used (for the operating margin).
    - Fuel consumption according to technology used, and electricity generation according to technology used for recently built facilities (for the build margin).
    - Amount of electricity produced by the project or the wind farm and exported to the grid (MWh/year).

Finally, a bibliography of the references used in the preparation of the PDD could also be inserted here.

Annex 4: Monitoring plan

Additional material not included in section D can be placed here.

7. Comparison of Different Baseline Methodologies, The Case of Zafarana Wind Power Project

7.1 Baselines for Zafarana Wind Park

Based on a study done at the UNEP Risø Centre, this chapter tries to illustrate the difference between the GHG reductions and the CERs obtained using different baselines.

Different types of baselines and baseline approaches, including those identified in the Marrakesh Accord were presented in the earlier chapters. The Marrakesh Accord identifies three different categories of baselines—standardized baselines, project-specific baselines, and simplified baselines for small-scale CDM project activities. Since the Zafarana project does not fall in the category of small-scale projects, it will require either project-specific or standardized baselines. Only standardized baselines approach has been illustrated in this chapter.

Although methodologies for setting standardized baselines have not been specified in the Marrakesh Accord, different approaches to standardized baselines are outlined, which can be translated into different standardized baselines for CDM projects. This chapter illustrates standardized baselines for the 60 MW Zafarana Wind Power Project. In the case of an electricity supply project like Zafarana, that will not replace an existing power plant, it is difficult to establish a unique project specific baseline. This is because grid-connected projects may replace a mix of (inefficient) plants, and it is difficult to identify a specific project or emission profile that a CDM project will replace. Further, as mentioned earlier in Chapter 1, a project specific baseline approach often requires use of models to capture the system, and is often data intensive. For a project specific baseline approach for Zafarana, refer to Ringius et al. (2002),[6] which uses a simulation model for Egypt's electricity grid. Thus, standardized baselines in the case of electricity supply project like Zafarana are more relevant. Another possibility that the Zafarana wind plant may actually replace the plant which otherwise is most likely to come-up exists. This is because electricity demand is expected to increase in Egypt over a period of time. ,

For a specific project activity, the Marrakesh Accord specifies three baseline ap-

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[6] *Lasse Ringius, Poul Erik Grohnheit, Lars Henrik Nielsen, Anton-Louis Olivier, Jyoti Painuly, and Arturo Villavicencio, "Wind Power Projects In The CDM: Methods And Tools For Baselines, Carbon Financing And Sustainability Analysis", 2002 (http://uneprisoe.org/reportbooks.htm).*

proaches. These are; (a) Existing actual or historical emissions, as applicable; (b) emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment; and (c) average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category. At the time of writing this report (January 2005), the EB had already approved three baseline methodologies for renewable energy projects based on these three approaches, which cover wind projects also. The approved methodologies are;

(a) Baseline methodology AM0005: applies to small grid-connected zero-emissions renewable electricity generation. The approach refers to the criterion "emissions from a technology that represents an economically attractive course of action taking into account barriers to investment". It applies to only projects less than and equal to 60 MW, and hence applicable to this case study. Since it applies to only small electricity capacity additions to grid, a 50:50 default weighing of the build and operating margins[7] has been suggested.

It should be noted that Japan Bank for International Cooperation actually submitted a methodology for Zafarana wind farm project (not cleared by the EB), but it was for 120 MW project. See Appendix 6.1 for details.

(b) Baseline methodology AM00019: applies to renewable energy projects replacing a part of the electricity production of one single fossil fuel fired power plant that stands alone or supplies to a grid. The approach refers to the criterion "existing actual or historical emissions as applicable".

Since no single fossil fuel power plant can be identified in this case study, this approach is not applicable.

(c) Consolidated baseline methodology ACM0002: applies to grid-connected electricity generation from renewable sources. The approach refers to both the above criteria; "existing actual or historical emissions as applicable" and "emissions from a technology that represents an economically attractive course of action tak-

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[7] *The build margin emission factor for this purpose is defined as the generation-weighted average emission factor of the selected representative set of recent power plants represented by the 5 most recent plants or the most recent 20% of the generating units built. The operating margin emission factor is defined as the generation-weighted average emission factor of all generating sources serving the system, excluding zero or low-operating cost power plants (renewable plants), based on the latest year data.*

ing into account barriers to investment". Method to calculate build and operating margins has been given.

It needs to be mentioned here that besides two above criteria, the Marrakesh Accords has one more criterion for the baseline methodology; "*average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category".* This has been used in calculating build margin in the approved methodologies (AM0005 and ACM0002). So far, there is no approved baseline methodology using only this criterion.

7.2 A menu of Baselines for Zafarana

The baseline approaches discussed below with specific reference to the Zafarana wind farm consider the above approved methodologies also, wherever applicable.

(i) "Existing actual or historical emissions, as applicable": Historical emissions can be from an identifiable individual fossil fuel power plant, which is replaced by the renewable plant (as the methodology AM 0019 specifies), or from all the plants connected to the grid (similar to the approach in the methodology ACM002). In the case of the Zafarana wind plant, emissions from all plants operating in the Egyptian power systems could be considered. It is obvious that this approach assumes that the new power plant replaces average emissions of the entire power system in the country. In the current case it means that the electricity dispatched by the Zafarana wind farm replaces average emissions of the entire Egyptian power system. Therefore, average emissions per unit of electricity (t CO_2/ MWh) of the entire electricity system (all plants and fuels) in Egypt were used in calculating the emissions savings in this case.

This method places more emphasis on the past and could neglect recent trends that may be more relevant in the context of likely additions to the grid in absence of the proposed wind farm. In countries where past emissions have been high (i.e., plants used carbon intensive fuels and were inefficient), this approach will yield relatively higher emissions savings from the proposed plant. Conversely, if the past emissions were low (i.e., plants used low carbon or non-carbon fuels, and were relatively efficient), it will yield relatively lower emissions savings.

Egypt had a mix of 79% thermal plants and 21% hydro power plants[8] and 145 MW of wind energy plants had been added by 2004. There was no electricity generation from wind-energy plants in 1999-2000 (the year for which data was available from Egypt, and used in this study). Most of the thermal plants operate on a mix of natural gas (NG) and heavy fuel oil (HFO). Assuming that relevant historical

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[8] *http://www.eia.doe.gov/emeu/cabs/egypt.html*

emissions are from thermal plants only, a variation of the above approach that considered "all plants excluding renewable (hydro) plants" was also computed. It seems plausible that the qualifier "as applicable" justifies this procedure.

*(ii)"**Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment**"*: This approach focuses on the emissions from recently added plants and expected future trends. It is based on the view that investments in specific energy technologies in a country reflect their respective economic attractiveness. In most cases, this approach may be similar to the "technology on the margin" approach found in the literature on baselines, i.e. the technology last employed or employed for the last few plants. However, in many cases investments in several technologies (e.g., hydro, gas, coal, and wind based plants) may be made simultaneously in a country. In such cases, it may be difficult to identify a specific technology and to decide what constitutes an "economically attractive course of action."

In the case of Egypt, national experts identified natural gas (which is used to fuel boilers running steam turbines) as the economically attractive technology that is likely to be employed in the future.[9] Accordingly, this choice was used in calculating one of the baselines.

In case more than one technology (e.g., coal in addition to natural gas) would constitute an economically attractive course of action, it might seem necessary to consider a mix of technologies. This would be even more challenging if renewables, such as hydropower, were among the attractive technologies.

*(iii) "**The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is among the top 20 per cent of their category**"*: This approach could be considered to refer to what is discussed under "recent additions" in the baseline literature. However, recent additions vary depending on how it is interpreted. Some of the possibilities in case of an on-grid renewables project may include the following five options:

(a). **All fuels:** In this approach, average emissions from the previous five years of additions of all type of power plants to the electricity system are estimated. Recent additions indicate the trend and, hence, may reasonably approximate the plant that would be replaced by the renewable plant.

(b). **All fuels but renewables:** Renewables could be excluded from recent additions in order to account for those power systems that have a disproportionate share of renewables in the system, and also to avoid punishing those who took early action to adopt renewable. Exclusion of renewables

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[9] NREA/Risø National Laboratory, "Pre-feasibility Study for a Pilot CDM Project for a Wind Farm in Egypt" (December 2000: ENG2-CT1999-0001, preliminary draft), p. 45.

seems to be acceptable to the EB (as evident from method suggested for calculation of simple operating margin in ACM0002), but only for systems where renewables (or low operating costs plants) have less than 50% share in generation. The argument seems to be getting baseline as close to the real as possible.

(c). **Fuel specific:** In this approach, average emissions of the last five years of additions of fuel-specific plants to the grid are estimated. HFO/NG and LFO/NG based plant were the main additions to the grid in the Egypt over last five years. Therefore recent additions based on HFO/NG and LFO/NG (both separately) were considered for the baseline.

(d). **Base load plants only:** In this approach, the average emissions of recently added base load plants would be used to set a baseline. Thus, in the present case, this approach would assume that the electricity generated by the wind plant replaces electricity generated by base load plants, and the baseline would reflect average emissions of recently added base-load plants. But since it is unlikely that wind energy would displace low-cost, must-run base-load plants, this approach is not followed here.

(e) **Peak plants only:** The approach follows from the opposite assumption, namely that the new plant only replaces peak load plants. But, as documented in Chapter 5, this is equally unlikely to be true in the case of a wind farm. Consequently, it was not estimated in this study.

This approach (iii above) has been used to calculate build margin in the approved methodologies ACM0002 and AM0005. Hence the variations discussed in this approach may be of limited interest, but could be considered to propose new baseline methodologies, if need arises.

Next, the various baselines for the Zafarana project listed above, excluding (iii) (d) and (e), were calculated. These approaches can all be expected to approximate the emission savings achieved, i.e., the amount of CO_2 that the 60 MW wind plant in Zafarana would reduce. It is obvious that due to its peculiar electricity generation characteristics and due to the size of the plant, it is not possible to identify one specific existing or future plant that would be replaced by the wind farm. Hence, a range of estimates, based on various approaches, is necessary. Yet, as long as we know how much power the plant will generate and dispatch, the amount of power that will be replaced is certain. This information has been obtained from a wind atlas of the region and from the wind farm's technical parameters. If there are no grid bottlenecks, all the power generated by the wind farm can be evacuated.[10]

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[10] *Evacuation refers to transmitting the power generated for further usage.*

Based on the relevant parameters, it was estimated that the 60 MW wind plant in Zafarana would annually replace 268 GWh, including auxiliary losses.[11]

For all cases, it needs to be ensured that their performance is among the top 20 per cent in their category. One option is to categorize the plants based on their fuel usage. A list of all the power plants in Egypt is included in Appendix 6.2. The following plant categories can be distinguished:

- plants using HFO/NG as fuel;
- plants using NG as fuel (LFO/NG plants only use NG since LFO use is negligible in Egypt);
- plants using only HFO as a fuel; and
- plants using renewable energy sources (mainly hydro power).

To simplify, and also because it seemed clear from a cursory observation that efficiency differences (indicated by gram of HFO/NG consumed/kWh) did not correlate well with the type of fuel used, only two categories are considered in this study. These are:

- plants using oil (HFO, LFO) or gas (NG) or a mix of oil and gas (HFO/NG, LFO/NG, or HFO/LFO/NG) as fuel; and
- plants using renewable (mainly hydro).

A list of top 20 per cent plants (least consumption of fuel/GWh) in Egypt using oil and gas fuels is included in Appendix 6.2.The list has been used to select the plants for estimating average emissions for the last five years' additions for the baselines (iii) (a)-(c) above.

As shown above, it is possible to construct a variety of baselines using various provisions of the Marrakesh Accords. However, with the introduction of consolidated methodology ACM0002, many of these simple approaches may be of only theoretical interest. This is because; (a) ACM0002 represents current interpretation of various baseline provision of the Marrakesh Accord by the EB, and (b) the approved methodologies (AM0005 and ACM0002) indicate that each provision of the Accords could be qualified / supplemented with the provisions from others. Also, in the approved methodologies, efforts have been made to reach as close to the seemingly real baseline (on the date of PDD submission) as possible. Introduction of combined margin approach, suggestions to use load duration curve and electricity despatch data indicate this.

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[11] *See note (a), Table 6.1..*

(vi) Baseline using approved consolidated baseline methodology ACM0002: The emission factor calculations have to be made using the combined margin (CM) approach, which is a combination of operating margin (OM) and build margin (BM) factors.

The operating margin emission factor (EF_{OM}) needs to be calculated using one of the following four options;

- Simple OM. It is generation-weighted average emissions per electricity unit (tCO_2/MWh) of all generating sources serving the system, excluding low operating cost and must run power plants. It can be used where low cost / must run resources constitute less than 50% of total grid generation, which is the case here. It is same as "historical/ all plants excluding renewables" approach mentioned earlier. Recent three years average has been suggested to calculate the OM.
- Simple Adjusted OM. This separates of low-cost / must run power sources to consider their impact on emission factor, if they operate on margin also. It requires plotting load duration curve and contribution from low-cost power sources. It was not considered here due to non-availability of the data.
- Average OM. It can be used only if low cost/ must run resources constitute more than 50% of the total grid generation. It is calculated as the average emission rate of all power plants. It is same as "historical / all plants " discussed earlier. However, considering the requirement of renewable percentage in the total generation, it is not applicable in case of Zafarana.
- Dispatch Data Analysis OM. This OM is calculated using detailed (hourly) despatch data from various power stations and is preferred option by the EB. It is however very data intensive, and not used here due to non-availability of data.

The build margin emission factor (EF_{BM}) is generation-weighted average emission factor (tCO_2/MWh) of the power plants on build margin. The build margin consists of the group, which comprises larger electricity generation between generation from five most recently built power plants and most recently built power plants that comprise 20% of the system generation.

The baseline emission factor (EF_y) is then weighted average of the operating margin emission factor and build margin emission factor. The default weights have been suggested as 50% for both, making it as a simple average of the two emission factors.

In the case study here, ACM0002 was used- simple OM was calculated; build margin consisted of six recently built plants (as they contributed more than 20% to the annual generation), and baseline emission factor was calculated. It was used to calculate emissions reductions. See Appendix 6.2, Table 6.6 for details.

(v) Baseline using approved baseline methodology AM0005: This is a subset of the consolidated methodology ACM0002 discussed earlier. The baseline emission factor is a weighted average (weights 50% each) of operating margin and build margin emission factors. Operating margin consists of all generating sources, excluding zero or low operating cost power plants. The build margin is same as in case of ACM0002. The consolidated methodology ACM0002 has options (and encourages) to use more sophisticated data (such as load duration curves, hourly despatches etc.), and hence capable of delivering baselines that would seem close to real. In absence of detailed data, the option that allows use of available data is same as AM0005 prescribes. Therefore, application of AM0005 in this study gives same result as ACM0002.

The CO_2 emission reductions from the Zafarana plant according to the various baseline approaches are included in Appendix 6.2.The results are summarized in Table 6.1.

The amounts of CO_2 saved over 10 years vary from 1,475,000 tons to 1,843,000 tonnes. This is a difference of about 25 per cent. Obviously, if the crediting period is increased from 10 years to 20 years, the amount of emission reductions increases two-fold.

7.1 Revenues from CERs

How much revenue should a host country, or an investor, expect to earn from the sale of the CERs generated by the Zafarana wind farm? Not only is the level of CO_2 emission reductions uncertain (due to the uncertainty of the baseline) but also the price at which the CERs could be sold is uncertain.

The implications of the different baselines and of a medium-low price of $2 and a high price of $10 per tonne of CO_2 (based on current trends and estimates) are presented in Table 6.2. For the 10-year crediting period, the revenue realization ranges from 3-18.4 million dollars. For a 20-year crediting period, the range is, obviously, the double of that. Although some of the difference in revenue realization is attributed to different baseline approaches, the five-fold increase in the CER price has major CER revenue implications.

Table 6.1: Baseline emissions for Zafarana 60 MW wind farm project.

Baseline type	Emissions of CO2		Total CO2 (1000 tons)	
	tCO2/GWh	tCO2/yra	Crediting period 10 yrs	Crediting period 20 yrs
Historical/all plantsb	549.6	147,513	1,475	2,950
Historical/all plants except renewable (hydro)	686.8	184,337	1,843	3,687
Last five years of additions/all fuels (top 20%)	593.6	159,322	1,593	3,186
Last five years of additions/all fuels excluding renewable (top 20%)	632.9	169,870	1,699	3,397
Last five years of additions/LFO/NG plants only (top 20%)	583	156,477	1,565	3,130
Last five years of additions/ HFO/NG plants only (top 20%)	663.7	178,137	1,781	3,563
Economically attractive option/NG Plantc	676.1d	181,465	1,815	3,629
Historical (excluding renewables) / Economically attractive option (Methodology AM0005 and ACM0002)	684.73	183,508	1,835	3,670

a. Egyptian experts recently estimated the net annual energy production from the Zafarana wind farm to 266 GWh. See NREA/Risø National Laboratory, "Pre-Feasibility Study for a Pilot CDM Project for a Wind Farm in Egypt" (October 2001: Report ENG2-CT1999-001), p. 7. At an assumed availability of 97%, this will replace a gross production of 1.04*266GWh*0.97 = 268 GWh in the system (4% accounts for auxiliary and other losses).

b. Given only for comparison purposes. Following the methodology ACM002, this baseline is no more applicable for Zafarana.

c. NG used in a boiler for a steam turbine plant. Egyptian experts have suggested this as the preferred option in Egypt.

d. Based on Egyptian fuel consumption data, CO2 emissions have been calculated as follows:
Unit fuel consumption in g/kWh times net cal. value of fuel times the carbon emission factor times fraction of C oxidized (223*54.32*15.3*0.995/1000*44/12=676.1).

The implications of the choice of crediting period has been discussed elsewhere also. As mentioned earlier, in the case of the "3*7 years option", the baseline may be reviewed after each seven-year period. However, to simplify, it is assumed that the baseline does not change. The emission reductions by the Zafarana wind plant have been calculated for the entire project life of 20 years.

With a 10% discount rate, the range is from 1.8 million dollars to 11.2 million dollars for the crediting period of 10 years. It can be seen that baseline approaches alone can make a difference of about 25 per cent in revenue realization (which ranges from 2.95 to 3.69 at $2 per ton). The highest difference of 25 percent occurs between two approaches that consider historical/all plants, one with hydro included, and the other hydro excluded. Similar calculations can be made for the 20-year crediting period and for other discounting rates.12

Table 6.2: Revenue implications of different baseline approaches and CO_2 prices for Zafarana.

Baseline-type	CO2 savings from the CDM project (1,000 tons)		Revenue at different CO2 prices (mill. US$)			
	10 year crediting period	20 year crediting period	10 year crediting		20 year crediting	
			$2/ ton	$10/ ton	$2/ ton	$10/ ton
Historical/all plants	1,475	2,950	2.95	14.75	5.9	29.5
Historical/all plants except renewable (hydro)	1,843	3,687	3.69	18.43	7.37	36.87
Last five years of additions/all fuels (top 20%)	1,593	3,186	3.19	15.93	6.37	31.86
Last five years of additions/all fuels excluding renewable (top 20%)	1,699	3,397	3.4	16.99	6.79	33.97
Last five years of additions/ LFO/NG plants only (top 20%)	1,565	3,130	3.13	15.65	6.26	31.3
Last five years of additions/ HFO/NG plants only (top 20%)	1,781	3,563	3.56	17.81	7.13	35.63
Economically attractive option/ NG plant	1,815	3,629	3.63	18.15	7.26	36.29
Historical (excluding renewables) / Economically attractive option (Methodology AM0005 and ACM0002)	1,835	3,670	3.67	18.35	7.34	36.70

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12 The discount factors for discounting rates of 5% and 10% for a 20-year lifetime are 0.62 and 0.43, respectively. For a 10-year lifetime, discount factors are 0.77 and 0.61, respectively.

7.2 Which Baseline to Select?

When several baselines look plausible, project developers may need to make a selection and justify their choice. It should be expected that a developer would select the alternative that is most simple, provides the highest returns, and is easy to justify meeting Marrakesh criteria. In most cases, one of the approved methodologies is expected to be chosen, although new methodologies can be submitted for the EB's approval based on peculiarities of specific cases.

It is clear from Table 6.2 that the baseline "historical/all plants except hydro" provides the highest revenue earnings, followed by the "economically attractive option/NG plant" option. Various variations of "recent additions" rank below "commercially attractive option" but above "historical/all plants", which provides the lowest revenue earnings. This is due to the inclusion of renewables plants in the "all plants" category. The ranking of the alternatives may vary depending on the mix of the plants and their vintage. Thus, a baseline following the "recent additions" approach may be attractive if renewables were predominant in the past but thermal resources were added more recently. Not that some of these options may not be acceptable after more well-specified baseline approaches have been determined by the CDM executive board. It is obvious that approved consolidated baseline methodology ACM0002 will be the most likely approach in this case. Results of the approach are close to "historical all plants, excluding renewables. Other approaches do not go into details such as operating and build margin, and are only for illustration purposes.

In the initial stage of a CDM project, it may be best if the project developer makes an inventory of all the possible baselines that meet the guidelines and specified criteria. An elementary check can indicate relative attractiveness of each baseline. The proposed baseline for the project can be selected depending on availability of expertise and data, and cost of development (if submitted as a new methodology). As far as the crediting period is concerned, a longer time horizon (of 20 years) looks attractive. In reality, the option would depend on factors such as lifetime of the project, perceived risk and complexity in updating the baseline, and the revenue sharing arrangement with the host. Finally, it can be said that the project developer should select the most plausible or realistic baseline. If several, equally plausible baselines exist, the baseline generating the largest amount of emission reductions could be selected. In general, a conservative baseline approach has been advised by the experts.

7.3 Conclusions

The Marrakesh Accord provides some approaches for standardized baselines for a project like Zafarana. Several baselines can be constructed using the guidelines. Some methodologies have been approved by the EB for renewable energy projects like Zafarana. These methodologies can be used to develop baseline for the project. New methodologies can also be proposed based on peculiarities of specific cases. The CDM executive board is charged with the further development of detailed guidelines for the future. The approaches illustrated here include historical emissions, emissions from recent plants, economically attractive option, and the baseline using approved methodology (AM0005 and ACM0002). When deciding to propose a new methodology, it will be important that the project developer takes into account the level of complexity, conservatism (that is, in uncertain situations one underestimates the baseline in order to preserve the environment), availability of data, expected return, transaction costs, and available expertise for setting the baseline.

7.4 Monitoring

The only data needed is electricity exported to the grid by the plant. This can be easily metered.

Appendix 6.1.

A Comparison with the Zafarana Wind Power Plant Project, Arab Republic of Egypt (120 MW) Methodology under consideration with the CDM Executive Board (PDD submitted by Japan Bank for International Cooperation)[13]

The methodology suggested by Japan Bank for International Cooperation (JBIC) for the project draws heavily from the OECD/IEA paper[14] on baseline methodology for electric power projects. The OECD/IEA methodology suggests a mix of 'Historical' and 'Recent Additions' approach. The reason cited is that any power plant connected to the grid has impact on the existing supply, and thus the new plant has impact on the '**operating margin'** (i.e. on the electricity dispatched by the plants under operation). Therefore, 'historical' plants needs to be considered in calculating CO_2 emissions coefficient (CO_2/kWh) that the new plant would replace. It further argues that among these operating plants (historical), the low running cost, must run plants should be excluded from the list while calculating the CO_2 coefficient. This is because, such plants will always run, and never be replaced by the new plant. In effect, hydro and wind plants (that have low running costs) get excluded from the list in calculating the CO_2 coefficient. Thereafter, the OECD/IEA methodology argues that any new plant is expected to impact **'build margin'** also, since it would substitute recent plants / plants also, that would have been otherwise built. For that, it considers last 20% additions to the grid (or last 5 plant, whichever most recent). The CO_2 emission factor for the recent additions is also calculated. Thereafter, since the new plant impacts both operating and build margin, it is considered on 'combined margin' and a weighted average of the two emissions factors (corresponding to operating and build margin) is taken. The weight given in the PDD is 1:1 and 1:0.6 (as an alternate scenario, arguing that since wind energy generation is volatile, its weight is only 0.6 in the build margin).

The overall result of the approach is that the emissions calculated would between the two cases of Table 6.1; Historical/all plants except renewable (hydro), and Last five years of additions/all fuels (top 20%).

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[13] *See NM0036 on http://cdm.unfccc.int/methodologies/process*

[14] *Practical Baseline Recommendations for Greenhouse Gas Mitigation Projects in the Electric Power Sector, OECD/IEA, 2002.*

Appendix 6.2

Table 6.3: List of all power plants in Egypt. 1999/2000.

Power Station	No. of units	Installed capacity (MW)	Fuel type	Commissioning date	Gross generation (GWh)	Net generation (GWh)	Fuel consumption rate(g/kWh)	Peak load (MW)	Load factor (%)	Efficiency (%)
Shoubra (st)	4x315	1260	HFO/NG	1984-85-88	7410	7100	225.8	1195	71	38.8
Cairo West (st)	4x87.5	350	HFO/NG	1966-79	1722	1618	252.2	348	56	34.8
Cairo West (ext)	2x330	660	HFO/NG	1995	3277	3178	217.9	660	57	40.3
Cairo South (c.c. 1)	3x110+4x60	570	NG/HFO/LFO	57-65-1989	3173	3101	224.5	528	68	39.1
Cairo South (c.c. 2)	1x110+1x55	165	LFO/NG	1995	1154	1134	184.3	174	75	47.6
Wadi Hof (gas)	3x33.3	100	LFO/NG	1985	107	106	383.4	92	13	22.9
El Tebbin (gas)	2x23	46	LFO/NG	1979	53	53	358.6	40	15	24.5
El Tebbin (st)	3x15	45	HFO	1958-59	224	229	374.7	42	67	23.4
Demietta (c.c.)	9x125	1125	LFO/NG	1989-93	7379	7275	183.6	1185	71	47.8
Talkha (c.c.)	8x24.2+2x45	283.6	LFO/NG	1979-80-89	1353	1329	243	283	54	36.1
Talkha (st)	3x30	90	HFO	1966-67	35	29	426.3	33	12	20.6
Talkha (210) (st)	2x210	420	HFO/NG	1993-95	2247	2083	240.9	421	61	36.4
Kafr El Dawar (st)	4x110	440	HFO/NG	1980-84-86	1788	1665	263.1	310	65	33.3
Mahmoudia (gas)	4x45	180	LFO/NG	1981-82	89	89	361.7	149	7	24.3
Mahmoudia (c.c.)	8x24.5+2x56	308	LFO/NG	1983-95	1568	1548	207.9	312	57	42.2
Damanhour (300) (st)	1x300	300	HFO/NG	1991	1614	1564	217	300	61	40.4
New Damanhour (st)	3x65	195	HFO/NG	1968-69	693	651	258.1	192	41	34
Old Damanhour (st)	2x15	30	HFO	1960	NA[1]	NA	NA	NA	NA	NA
Damanhour (c.c.)	4x24.2+1x56	152,8	LFO/NG	1985-95	849	838	193.2	155	63	45.4
El Siuf (gas)	6x33.3	200	LFO/NG	81-82-83-84	251	249	378.8	100	29	23.2
El Siuf (st)	2x26.5+2x30	113	HFO	1961-69	516	480	309.3	80	74	28.4
Karmouz (gas)	2x12.5	25	LFO	1980	1	1	421.6	9	11	20.8

Table 6.3 continued

Power Station	No. of units	Installed capacity (MW)	Fuel type	Commission-ing date	Gross generation (GWh)	Net generation (GWh)	Fuel con-sump-tion rate (g/kWh)	Peak load (MW)	Load factor (%)	Efficien-cy (%)
Abu Kir (st)	4x150+1x300	900	HFO/NG	1983-84-91	4299	3992	227.2	897	55	38.6
Sidi Krir (st)					1206	1138	226.3	610	22	38.8
Akata (st)	2x150+2x300	900	HFO/NG	1985-87-86	5528	5257	214.6	900	70	40.9
Abu Sultan (st)	4x150	600	HFO/NG	1983-84-86	2932	2705	250	589	57	35.1
Suez (st)	4x22+1x97	185	HFO	1965-91	478	425	294.8	118	46	29.8
El Shabab (gas)	3x33.3	100	LFO/NG	1982	119	119	346.8	88	16	25.3
Port Said (gas)		64	LFO/NG	1984-1977	35	34	374.6	42	10	23.4
Arish	2x33	66	HFO	2000	253	227	297.2	66	44	29.5
Zafarana (wind)	31x0.6	19	Wind	2000						
Walidia (st)	2x300	600	HFO	1992-1997	2649	2504	228.4	612	49	38.4
Korimat (st)	2x627	1254	HFO/NG	1999	5068	4884	218.6	1180	49	40.1
Assiut (st)	3x30	90	HFO	1966-67	538	484	290.6	90	68	30.2
High Dam	12x175	2100	Hydro	1967	10889	10723		1980	63	85.1
Aswan Dam 1	7x40	280	Hydro	1960	1549	1509		265	66	83.2
Aswan Dam 2	4x67.5	270	Hydro	1985-86	1850	1843		270	78	90.8
Esna	6x15	90	Hydro	1995	352	347		82	49	82.0
Nag Hammadi	3x1.7	5	Hydro	1942	19	19		5	40	84.8
Total Thermal					58628	56089	225.6	9394	71	38.9
Total Hydro					14659	14441		2559	65	85.5
Total Wind					23	22		17	18	

Source: Appendix G of the report "Pre-feasibility Study for a Pilot CDM Project for a Wind Farm in Egypt, New and Renewable Energy Agency, Egypt, and Risø National Laboratory, 2001". The data supplied by New and Renewable Energy Authority (NREA) and Egyptian Electricity Holding Company (EEHC).

Note: 1. NA = not available.

Table 6.4: Top 20 per cent plants (least consumption of fuel/GWh) in Egypt using oil and gas fuels[a]

Power Station	Commissioning date	Fuel type	Gross generation (GWh)	Fuel consumption rate (g/kWh)	HFO fraction	HFO used (tons)	NG used (tons)	Carbon emissions (tons)
Cairo West (ext.)	1995	HFO/NG	3,277	217.9	0.3	214,217	499,841	539,839
Cairo South (c.c. 2)	1995	LFO/NG	1,154	184.3	0	0	212,682	153,179
Demietta (c.c.)	1989-95	LFO/NG	7,379	183.6	0	0	1,354,784	975,748
Mahmoudia (c.c.)	1993-95	LFO/NG	1,568	207.9	0	0	325,987	234,784
Damanhour (300) (st)	1991	HFO/NG	1,614	217	0.3	105,071	245,167	264,785
Damanhour (c.c.)	1985-95	LFO/NG	849	193.2	0	0	164,027	118,136
Akata (st)	1985-87	HFO/NG	5,528	214.6	0.3	355,893	830,416	896,868
Total			21,369			675,181	3,632904	3,183,339
Average Emissions (C tons /GWhb)								148.97

a. Historical-Top 20 per cent using HFO, NG, LFO or a mix of these fuels (i.e., all plants excluding hydro)

Table 6.5: Historical/all plants.

Power Station	Fuel type	Gross generation (GWh)	Fuel consump. rate (g/kWh)	HFO fraction	HFO used (tons)	NG used (tons)	Carbon emissions (tons)
Shoubra (st)	HFO/NG	7410	225.8	0.3	501953	1171225	1389937
Cairo West (st)	HFO/NG	1722	252.2	0.3	130287	304002	360771
Cairo West (ext)	HFO/NG	3277	217.9	0.3	214217	499841	593180
Cairo South (c.c. 1)	NG/HFO/ LFO	3173	224.5	0.3	213702	498637	591752
Cairo South (c.c. 2)	LFO/NG	1154	184.3	0	0	212682	175875
Wadi Hof (gas)	LFO/NG	107	383.4	0	0	41024	33924
El Tebbin (gas)	LFO/NG	53	358.6	0	0	19006	15717
El Tebbin (st)	HFO	224	374.7	1	83933	0	70464
Demietta (c.c.)	LFO/NG	7379	183.6	0	0	1354784	1120326
Talkha (c.c.)	LFO/NG	1353	243	0	0	328779	271881
Talkha (st)	HFO	35	426.3	1	14921	0	12526
Talkha (210) (st)	HFO/NG	2247	240.9	0.3	162391	378912	449669
Kafr El Dawar (st)	HFO/NG	1788	263.1	0.3	141127	329296	390788
Mahmoudia (gas)	LFO/NG	89	361.7	0	0	32191	26620
Mahmoudia (c.c.)	LFO/NG	1568	207.9	0	0	325987	269572
Damanhour (300) (st)	HFO/NG	1614	217	0.3	105071	245167	290949
New Damanhour (st)	HFO/NG	693	258.1	0,3	53659	125204	148585
Old Damanhour (st)	HFO			1	0	0	0
Damanhour (c.c.)	LFO/NG	849	193.2	0	0	164027	135640
El Siuf (gas)	LFO/NG	251	378.8	0	0	95079	78625
El Siuf (st)	HFO	516	309.3	1	159599	0	133988
Karmouz (gas)	LFO	1	421.6		422	0	354
Abu Kir (st)	HFO/NG	4299	227.2	0.3	293020	683713	811389
Sidi Krir (st)		1206	226.3	0.3	81875	191042	226717
Akata (st)	HFO/NG	5528	214.6	0.3	355893	830416	985487
Abu Sultan (st)	HFO/NG	2932	250	0.3	219900	513100	608916

Table 6.5 continued

Power Station	Fuel type	Gross generation (GWh)	Fuel consump. rate (g/kWh)	HFO fraction	HFO used (tons)	NG used (tons)	Carbon emissions (tons)
Suez (st)	HFO	478	294.8	1	140914	0	118302
El Shabab (gas)	LFO/NG	119	346.8	0	0	41269	34127
Port Said (gas)	LFO/NG	35	374.6	0	0	13111	10842
Arish	HFO	253	297.2	1	75192	0	63126
Zafarana (wind)	Wind						0
Walidia (st)	HFO	2649	228.4	1	605032	0	507942
Korimat (st)	HFO/NG	5068	218.6	0.3	332359	775505	920321
Assiut (st)	HFO	538	290.6	1	156343	0	131254
High Dam	Hydro	10889					
Aswan Dam 1	Hydro	1549					
Aswan Dam 2	Hydro	1850					
Esna	Hydro	352					
Nag Hammadi	Hydro	19					
Total		73267			4041810	9173999	10979568
Average Emissions (C tons /GWh)							149,86
Average Emissions excluding renewables (C tons/GWh)							187.34

Table 6.6 Operating and Build margin emission factor calculations

Build Margin Calculations								
Recently Built 5 Plants								
	Commis-sioning date	Fuel type	Gross gene-ration (GWh)	Fuel consump-tion rate (g/kWh)	HFO fraction	HFO used ton	NG used ton	Carbon emissions tons
Cairo West (ext)	1995	H.F.O/N.G	3277	217.9	0.3	214217	499841	593180
Talkha (210) (st)	1993-95	H.F.O/N.G	2247	240.9	0.3	162391	378912	449670
Walidia (st)	1992-1997	H.F.O	2649	228.4	1	605032	0	507942
Korimat (st)	1999	H.F.O/N.G	5068	218.6	0.3	332359	775505	920321
Arish	2000	H.F.O	253	297.2	1	75192	0	63126
Total			13494					
20% of grid generation			14653.4					
Build Margin- Recently Built 20% Emissions[1]								
Cairo West (ext)	1995	H.F.O/N.G	3277	217.9	0.3	214217	499841	593180
Talkha (210) (st)	1993-95	H.F.O/N.G	2247	240.9	0.3	162391	378912	449670
Mahmoudia (c.c)	1983-95	L.F.O/N.G	1568	207.9	0	0	325987	269572
Walidia (st)	1992-1997	H.F.O	2649	228.4	1	605032	0	507942
Korimat (st)	1999	H.F.O/N.G	5068	218.6	0.3	332359	775505	920321
Arish	2000	H.F.O	253	297.2	1	75192	0	63126
Total			15062			1389191	1980245	2803811
Build margin emission factor (Average emissions tons C/GWh)								186.15131
Operating margin emission factor (c/GWh) (all plants but renewable)								187.34
Weighted average (50% weight each of OM and BM emission factors)								186.74514
Carbon emissions								50047.699
CO2 emissions								183508.23

[1] as per ACM0002, larger of the two is to be considered. Hence, his was considered for build margin calculations.

Table 6.7: Calorific values used.

Net Cal. Value	(TJ/000 ton)	C (t C/TJ)	Fraction oxidized	Conversion factor tC/000t
HFO	40.19	21.1	0.99	839.5289
LFO	43.33	20.2	0.99	866.5133
NG[a]	54.32	15.3	0.995	826.9405

a. For NG, values are not given in IPCC. Natural gas has a value of about 39MJ/cum and a density of 0.718 kg/cum. This gives 39*/718 = 54.32 TJ/th tons as calorific value.

Note: Data available from Egypt gives only one figure for fuel consumption (g/kWh) for the HFO/NG power plants. Since variation in carbon coefficient (about 840 C t/th. ton for oil and 827 C ton/th. ton for NG) is not large, assumption about ratio of HFO and NG used in the plant may change the carbon emissions only marginally. Based on consumption data of HFO and NG, all HFO/NG plants were assumed to use HFO and NG in 30:70 ratio. Egyptian experts confirmed this.

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Further Reading: Selected guidelines for project development.

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