Öko-Institut

**Final Report**

# Wood Waste Power Plants in Zimbabwe as options for CDM

## Part I
## Options for baselines and methodological issues related to CDM

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**List of acronyms and abbreviations**

| | |
|---|---|
| AFBC | Atmospheric Fluidized-Bed Combustion |
| AIJ | Activities Implemented Jointly |
| AOSIS | Alliance of Small Island States |
| BAU | Business As Usual |
| CC | Combined-Cycle |
| CDM | Clean Development Mechanism |
| CER | Certified Emission Reductions |
| COP | Conference of the Parties |
| DG | Directorate General |
| DNR | Department of Natural Resources |
| DoE | Department of Energy |
| EIT | Economies in Transition |
| EM | Environmental Manual for Power Development |
| ERU | Emission Reduction Units |
| FC | Forestry Commission |
| FCCC | Framework Convention on Climate Change |
| FSC | Forest Stewardship Council |
| GDP | Gross Domestic Product |
| GEF | Global Environmental Facility |
| GEMIS | Global Emission Model for Integrated Systems |
| GHG | Greenhouse Gas |
| GoZ | Government of Zimbabwe |
| GTZ | Deutsche Gesellschaft für Technische Zusammenarbeit GmbH |
| IEA | International Energy Agency |
| IFC | International Forestry Commission |
| JI | Joint Implementation |
| MET | Ministry of Environment and Tourism |
| MVP | Monitoring and Verification Protocols |
| NGO | Non Governmental Organization |
| NPV | Net Present Value |
| ODA | Official Development Assistance |
| OPEC | Organization of Petroleum Exporting Countries |
| PAD | Project Appraisal Document |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PCDD | Polychlorinated dibenzo[p]dioxins |
| PCDF | Polychlorinated dibenzofurans |

| | |
|---|---|
| PCF | Prototype Carbon Fund |
| PCN | Project Concept Note |
| ROI | Rate of Return on Investment |
| SADC | Southern African Development Community |
| SAPP | South African Power Pool |
| TEQ | Toxic equivalents |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environmental Programme |
| UNFCCC | United Nation Framework Convention on Climate Change |
| ZESA | Zimbabwe Electricity Supply Authority |
| ZPC | Zimbabwe Power Company |

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## Foreword

Since the beginning of this year, the Clean Development Mechanism (CDM) of the Kyoto Protocol (UNFCCC 1997) can be used to support developing countries in achieving sustainable development and to assist Annex 1 Parties in achieving compliance with their quantified emission limitation and reduction commitments under the Protocol. However, the Protocol has not yet entered into force, and detailed rules and guidelines for the CDM are still subject to agreement. Thus many investors, notably in Germany, hesitate to commit themselves to CDM projects. The aim of the German government is that the Kyoto Protocol enter into force in the year 2002. It is essential that CDM rules are agreed swiftly, in order that investors cast aside their hesitance and developing countries profit as soon as possible from CDM projects in their sustainable development processes. It remains to be seen whether agreement can already be forged at the upcoming COP 6. At all events, the debate on rules and guidelines is in full swing.

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH - German Technical Cooperation - is an active participant in this debate. Since 1993, acting on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), GTZ has supported developing countries in implementing the UNFCCC. GTZ's inputs to the debate are a result of the experience gained in the programme on “Measures to Implement the UNFCCC”, which to date has involved some 25 projects in 20 developing countries.

The current phase of our climate change programme supports, as a focus, capacity building on CDM issues in developing countries. Part of this involvement is the elaboration of pre-feasibility studies for possible CDM projects with the intention to assist our partners in the South in having partly developed projects at hand for potential CDM investors. Furthermore, the case studies will help to shape rules and guidelines for the CDM. The study on the wood waste power plant in Zimbabwe has concentrated on the baseline issue.

The Oeko-Institut conducted this study with great commitment on behalf of GTZ. The findings of particular in chapter 7 are an innovative step for the methodological advancement in determining CDM baselines. The case studied, the grid connection of a renewable energy power plant, has demonstrated with great detail the wide variety of possible baseline options. The input from an earlier work supported by the GTZ in the Southern Africa namely the study on “Options for Climate Change under Power Pooling in Southern Africa” made the detailed and realistic assessment of baselines possible.

By presenting this report, we hope to assist the CDM in achieving its ambitious goals.

Holger Liptow January 2000

GTZ, Department 44

## Executive Summary

Within the framework of German technical cooperation for Zimbabwe, GTZ supports Zimbabwe Power Company, ZPC, a private company and wholly owned subsidiary of the Zimbabwe Electricity Supply Authority (ZESA). ZPC is developing new power generation projects in Zimbabwe and identified wood waste power generation plants in cooperation with the timber industries as options for the development of technically, economically and environmentally viable power generation.

GTZ contracted Öko-Institut to conduct a study with the following objectives:

- To assess the technical and financial feasibility studies of the project;
- To evaluate whether the project would be eligible as a CDM project;
- To analyse the environmental, social and economic impacts of the project;
- To analyse the baseline of the project, i.e. the situation that would have occurred without the project;
- To estimate the potential greenhouse gas emissions reductions that could be achieved by the project;
- To analyse the possible benefits with regard to financing of wood waste power generation plants that could accrue from CDM.

This report covers the evaluation of the wood waste power generation project as a CDM project whereas a separate report contains the detailed assessment of the technical and financial feasibility of the project.

### Project description

The project area is located in the Eastern Highland of Zimbabwe. Three companies (Border Timber, Forestry Commission, Wattle Company) are operating timber plantations and sawmills in this area. The operation of sawmills produce considerable amounts of wood waste (sawmill dust, wood chips off-cuts and bark). In total, wood waste residues are estimated to be about 750,000$m^3$ from sawmills annually. At present, less than 10 % of this waste volume is used to generate heat for the timber-drying kilns whereas 90% of the residues are burnt at the sawmills.

The timber companies in cooperation with the Zimbabwe Power Company (ZPC) are considering the installation of wood waste power cogeneration plants of 3 and 3.5 MWe at two sawmill sites. The plants would supply steam for the sawmill kilns, power for the sawmill's own use and would feed surplus power into the national grid. Several direct benefits at project level would occur:

- The wood waste residues are currently burnt resulting in uncontrolled (and unknown) emissions. The wood waste power plants contribute to an environmentally sound disposal of wood waste and create economic benefits from the waste products.
- Reduction of greenhouse gas emissions as renewable energy replaces fossil electricity production.

- The project would ensure continuity and stability of power supply to the sawmill which experience occasional voltage drops connected with damages to motors and installations.

The study analysed if the wood waste power plant projects would be eligible as CDM projects and estimated the potential emission reductions that could be achieved by a 3.5 MWe wood waste cogeneration plant. The project assessed the CDM criteria contained in the Kyoto Protocol and in submissions from Parties under the UNFCCC. Recognising that no final CDM criteria and rules have been developed, the analysis of a broad set of criteria indicated that the wood waste power plants in Zimbabwe would comply with the requirements. Detailed analysis is presented in chapter 4 (assistance in achieving sustainable development), chapter 5 (climate change effectiveness), chapter 6 (environmental additionality), chapter 9 (behavioural additionality) and chapter 10 (financial additionality).

**Environmental additionality of emission reductions - CDM project baselines**

The project activities shall provide reductions in emissions that are additional to any that would occur in the absence of the certified project activity. For this purpose a baseline needs to be established representing the situation in the absence of the project activity. The emission baseline is the basis for calculating the emission reductions to be certified.

The emissions of each project and each baseline can be broken down to output or activity level (e.g. electricity generated) and the emission rate (emissions per output). For many projects the baseline activity level will be the same as the activity level that is monitored during the project's lifetime. The baseline output level cannot be higher than the CDM project output level[1]. For some cases the baseline activity level may be lower than the project activity level. This implies that one part of the baseline estimate – the output level - is always "dynamic"[2], i.e. it changes over the lifetime of the project and cannot be predicted exactly before the project's implementation. This type of operation uncertainty is a key feature of any investment project and cannot be avoided completely. The key difference between the project estimate and the baseline estimate is the emission rate, i.e. the greenhouse gas emissions per output.

**Matrix of choices for baseline emission rates**

The study aimed to provide a clearly structured approach to describe different possible ways of baseline setting. For this reason a matrix of choices for baseline emission rates has been developed providing a structure to analyse the individual decisions that need to be taken with the establishment of a baseline Figure 1.

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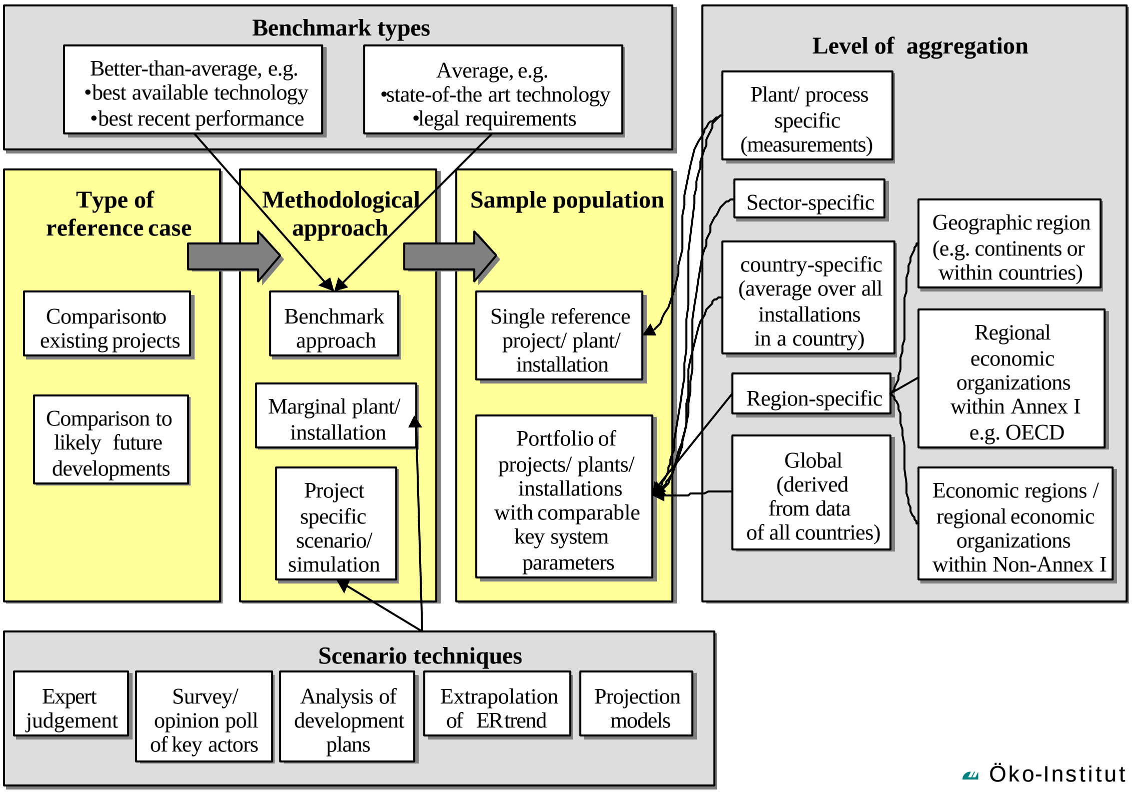
1 It is not realistic to assume that production output would be higher in the absence of the CDM project.

2 The term "dynamic" benchmark is used in literature in different meanings, see for example Michaelowa 1999a.

The first general choice for baseline estimates – the ***type of reference case*** - is whether the project is compared with the **present** situation in absence of the project or with a **future** development without the project.

Several **methodological approaches** can be chosen to describe the situation without the project. The **benchmark approach** fixes a **standardized** emission rate against which the project is compared. Additionality is assumed to be satisfied as long as the CDM project shows an emission rate improvement over the benchmark. The choice of the benchmark approach seems always related a comparison with existing projects as benchmarks in general are derived from present performances of installations.[3] A main difference of benchmark types is whether they reflect the average situation, such as state-of-the-art technology or existing legal requirements, or whether they are based on a better-than-average situation.

*Figure 1 Matrix of choices and assumptions for baseline selection*




The project could also be compared with a **marginal plant or marginal installation**. In this approach, the project's output replaces the output of the marginal plant/ installation.

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3 Approaches in literature differ with regard to this assumption. Michaelowa (1999) or Lazarus et al. (1999) describe that benchmarks are either derived from historical trends or forecasts. The broader use of the term benchmark for comparative values derived from existing installations or historic trends and also for projected data does not take into account that the underlying methods to derive the benchmark differ considerably between these approaches.

The marginal approach can be developed for the present situation as well as for the future.[4] The key characteristic is that an individual marginal plant is chosen for comparison with the project. There are different possibilities to select the marginal plant, a common method is that the least-cost alternative to the project's installation is chosen.

A third possibility would be to construct a **scenario** that reflects the future development of emission rates. For this purpose a wide variety of scenario techniques could be applied to gather the basic data for the scenario, such as expert judgement (e.g. experts from the host government), a survey or opinion poll with key actors (a more transparent form of expert judgement) or development plans could be analysed. Extrapolation of the historical trend or projection models – the most sophisticated methodology - could also deliver the scenario data.

Another key choice is related to the **sample population**, that is used as basis of the baseline emission rate, i.e. if the CDM project is compared with a single reference installation or with the average of a portfolio of projects or installations with comparable system parameters.

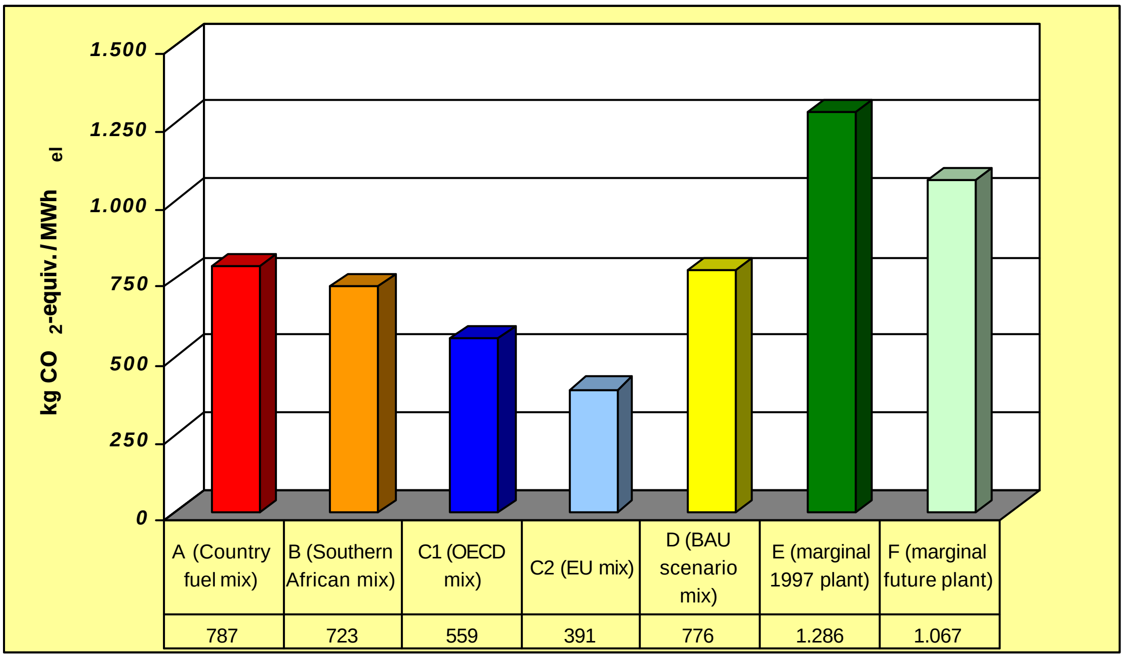
***Level of aggregation***

In all cases where the baseline emission rate is derived from a portfolio of projects or installations (benchmarks and scenarios) project developer have to choose the **level of aggregation** that is appropriate for the baseline emission rate. The level of aggregation could cover a sector, a region within a country, a country, a region encompassing several countries, or all countries.**Selection of baselines for wood waste power plants in Zimbabwe**

For the baseline of the wood waste power plant it is necessary to calculate a baseline emission rate that reflects the emissions from electricity generation in the absence of the project. In total, **seven different baselines have been constructed to demonstrate a range of possibilities of choice** (see section 6.2).

[4] Unfortunately no common definition of marginal exists and this term is applied in many different ways, e.g. sometimes as synonym for additional.

*Figure 2 Options for baseline emission rates for electricity generation in Zimbabwe*




Source: Öko-Institut

The decision matrix from Figure 1 was used for the description of each baseline to explain the choices of the specific approach. Figure 2 summarizes the results of the different options for baseline emission rates.

The comparison shows that for the wood waste power plant in Zimbabwe, the OECD average fuel mix and the EU average fuel mix are the lowest baseline emission rates of all different approaches. For Zimbabwe it would not be favourable to choose these benchmarks compared to national or Southern African regional benchmarks. However, for Non-Annex I countries with a high share of renewable energy in the fuel mix (especially hydro) the OECD average would be more favourable than the country-specific benchmark. If the choice of the level of aggregation is left to the Parties participating in the CDM, they will opt for the most favourable benchmark, in some cases using the OECD average in other cases a national average. This will result in rather arbitrary calculations of the baseline emission rate. If policy makers do not take decisions with regard to the level of aggregation for benchmarks, they will opt for the principle "pick the most favourable emission rate you can find trying all possible aggregations". The **level of aggregation of benchmarks** should be **related to the level at which direct effects of the CDM project occur**. Otherwise it also seems doubtful that the benchmark is consistent with Article 12.5 (e.g. the OECD benchmark).

For the wood waste plants, the highest emission reductions would result from the approach using the marginal present plant as reference case. If the Parties are allowed to choose between the marginal plant approach and a country-specific benchmark or a scenario approach projecting the future fuel mix, they will always opt for the marginal approach if fossil technology with high emission rates would qualify as marginal. For project validators and certifiers the **marginal approach will be difficult to verify** as the choice will be based mainly on expert judgement and cost data. Both types of information are difficult to assess with regard to their reliability.

**The BAU scenario (Baseline D)** is probably one of the **approaches most consistent with the terms of the Kyoto Protocol as** it represents the development of the sector without the project and **takes into account future changes.** Additionality in the future is likely to be guaranteed as well as at present. Even if the assumptions used for the BAU scenario approach involve uncertainties, the overall uncertainty of the baseline estimate is considerably lower than in the baselines that no account of future developments whatsoever. The approach is less transparent and less simple than previous ones.

The comparison shows that a **ranking of different approaches is difficult** as the baseline approaches are **based on different rationales.** For example, the marginal plant approach and the BAU scenario approach are different concepts of addressing the situation without the project. **In theory, both concepts represent valid ways of assessment.**

**A high degree of consistency with the terms of the Protocol** would **imply preferences** to the use of **baselines approaches** that take into account **future developments**. The other possibility would be to use a fixed emission rate based on present data as a benchmark over a certain period of time and to update this benchmark regularly. This would be even more precise than the BAU scenario but would increase uncertainties for the project developers. This shows that the **ranking of baseline approaches** is **closely connected to the general decision on the revision and updating of baseline emission rates** during the project's lifetime.

### Electricity imports

Currently about 45% of Zimbabwe's electricity requirements are supplied by electricity imports from South Africa and Mozambique. It is not clear how the situation of electricity imports should be dealt with in baseline calculations. In the view of the CDM host country, it might be interesting to only account for the domestic emissions. The omissions of imports would result in "leakage" from energy projects. This problem of electricity imports is relevant in (electrically) integrated regions. Accounting for, or not accounting for imports could considerably change the emission rates estimated in a business-as-usual scenario. The inclusion of imports in scenario approaches would be difficult and expensive as scenarios would have to extend over several countries.

### Life-cycle emissions

The EM model[5] used for the calculations in this report is able to perform calculations

[5] The EM "**E**nvironmental **M**anual for Power Development" is both a database for information on environmental and cost aspects of energy and transport technologies, and an analysis tool to compare these aspects in scenarios. The EM database is especially compiled for technologies in Developing Countries, and a couple of country databases is available. The EM analyzes and compares airborne and greenhouse gas emissions, solid wastes, and land use, as well as internal and external costs associated with the

with and without life-cycle emissions, for example the model can estimate upstream fuel-cycle emissions. Both types of calculations have been performed for five baselines. For the wood waste power plant example, the inclusion of life-cycle emissions would add about 4-5% to the baseline emission rate. The issue of accounting for upstream emissions could occur in many project types, for instance in fuel switching projects where coal may be connected to lower upstream emissions compared to gas or in biomass projects where considerably energy input may be used for fertilization and transport of fuel. Upstream emission of CDM projects only then become relevant if they occur in Non-Annex I Parties. If life-cycle emissions would be taken into account in the CDM baselines, they would need to be tracked to the country of origin and project developers would need to check if this country belonged to Annex I or Non-Annex I. It is recommended that project developers should **check the project with regard to effects on upstream emissions** and **report** possible effects and changes **in a qualitative way.** But it seems preferable that life-cycle emission should not be included in the baseline estimate.

### Economic value of emission reductions

The economic value of the certified emissions reductions from the CDM project will depend on the price the investor can achieve on the market for greenhouse gas emission reductions. The markets for GHG offsets are just emerging, and no experience exist with CER trading. For this study several price scenarios have been calculated with prices for ranging from 1 US$/t $CO_2$, 10 US$/t $CO_2$ and 20 US$/ t $CO_2$, taking the BP Amocos internal offset price as an upper price limit. The price level of 1 US$/ t/$CO_2$ reflects the estimates in the lowest range.

A low value of CERs would result in an annual benefit from CERs of US$ 7,000 to US$ 24,000 accumulating to US$ 92,000 to US$ 306,000 during the first commitment period. The BP Amoco's offset price of 20 US$/t $CO_2$-equiv. would lead to a benefit ranging from US$ 141,000 per year (US$ 1.8 million for 2000-2012) to US$ 471,000 (US$ 6.1 million for 2000-2012). This calculation clearly **indicates the enormous pressure from investors and host countries in the direction of high baseline emission rates. For the high CER** price (= BP Amocos internal offset price), **a maximum difference in economic benefit of US$ 4.4 million occurs during the first commitment period between the lowest baseline and the highest one**. And this report analyses a rather small project.

### Crediting time

The total amount of emission credits for the projects will depend mainly on the time during which credits are allowed to accrue. Thus, to maximise emission credits it would be the best to choose the longest lifetime possible. Technical lifetime of the project was

investment and operation of all kinds of energy and transport technologies, including their life-cycles. EM can be downloaded at www.oeko.de/service/em/index.htm.

estimated to be 15 years based on technical lifetime provided in technical literature.

**Financial benefit from Certified Emission Reductions**

At present, investors for the wood waste power plant project are lacking. CERs will be generated during the whole crediting period agreed for the project. To asses the present value of the CERs that will be generated in the future, the value has to be discounted.[6] For the project in Zimbabwe a static discount rate of 12.5 % was assumed. Taking into account the discount rate, a crediting time of 15 years and CER values of 1, 10 and 20 US$/t $CO_2$ the Net Present Value (NPV) of the different baseline options were calculated (see chapter 8.2). For the wood waste power plant the NPV varies from US$ 45,000 to US$ 3.1 million depending on the baseline approach and the offset price. The contribution of CERs to financing of the investment would be lower than 1% if CER price is low and baseline C2 (EU benchmark) is applied.With CER prices of US$ 20 per ton of $CO_2$ and baseline E (present marginal plant), the benefit from CERs would amount to 58% to the financing of the overall investment of the project (see section 8.2).

[6] Payments in the future do have a lower value at present. To make future payments comparable to present values methods the concept of Net Present Value (NPV) has been applied. According to this concept all future payments are discounted by a discount rate to make the various options comparable to each other.

# 1 Introduction

Within the framework of German technical cooperation for Zimbabwe, GTZ supports Zimbabwe Power Company, ZPC, a private company and wholly owned subsidiary of the Zimbabwe Electricity Supply Authority, ZESA. ZPC is developing new power generation projects in Zimbabwe and identified wood waste power generation plants in cooperation with the timber industries as options for the development of technically, economically and environmentally viable power generation.

GTZ contracted Öko-Institut to conduct a study with the following objectives:

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- To estimate the potential greenhouse gas emissions reductions that could be achieved by the project;
- To analyse the possible benefits with regard to financing of wood waste power generation plants that could accrue from CDM.

This report covers the evaluation of the wood waste power generation project as a CDM project whereas a separate report contains the detailed assessment of the technical and financial feasibility of the project.

## 1.1 Project description

The project area is located in the Eastern Highlands of Zimbabwe. Three companies (Border Timber, Forestry Commission, Wattle Company) are operating timber plantations and sawmills in this area. In total, these companies produce about 87 % of Zimbabwe's output of sawn timber. The operation of sawmills produces considerable amounts of wood waste (sawmill dust, wood chips, off-cuts and bark). Sawmills produce about 750,000$m^3$ wood waste residues sawmills annually. At present, less than 10 % of this waste volume is used to generate heat for the timber-drying kilns whereas 90% of the residues are burnt at the sawmills.

The timber companies, in cooperation with the Zimbabwe Power Company (ZPC), are considering the installation of wood waste power cogeneration plants. The plants fuelled with wood waste residues would supply steam for the sawmill kilns, power for the sawmill's own use and would feed surplus power into the national grid. Several direct benefits at project level would occur:

- The wood waste residues are currently burnt, resulting in uncontrolled (and unknown) emissions. The wood waste power plants contribute to an environmentally sound disposal of wood waste and create economic benefits from the waste products.

- Reduction of greenhouse gas emissions as renewable energy is used for electricity production.
- Electricity generation for sale to ZESA for the grid and as a contribution to the reduction of the domestic power deficit in Zimbabwe.
- Improvement of the power supply of the sawmills which experience occasional voltage drops connected with damages to motors and installations at the sawmills. The project would ensure continuity and stability of power supply to the sawmills.
- Provision of steam for sawmill operations.

Two locations next to operating sawmills - Nyanga and Chimanimani - have been considered for the installation of cogeneration plants with capacities of about 3 to 3.5 MWe based on fuel availability.

The Nyanga plant will use wood residues from Nyanga Sawmill owned by the Wattle Company, one of the largest sawmills in Zimbabwe. The wood waste residues will fuel a power generation plant with a capacity of 3.5 MWe. At the same time the cogeneration plant will supply the sawmill with steam needed in the kilns to dry the rough sawn timber. A similar plant, Chimanimani Plant, is planned in the South Eastern Highlands of Zimbabwe, which will use wood residues from a sawmill owned by the Forestry Commission (FC).

The Nyanga Wood Waste Power Plant will be owned and developed by a company that is planned to be formed by the Wattle Company, Zimbabwe Power Company (ZPC) and a third investor. ZPC is a private company that has been set up by the national utility, Zimbabwe Electricity Supply Authority (ZESA), to develop and invest in commercially viable power generation projects and began operations in 1999.

The Chimanimani Wood Waste Power Plant will be owned and developed by the Forestry Commission, ZPC and a third investor. FC is a parastatal under the MET that is active in commercial forestry, timber processing and manufacture of timber products.

The wood processed in the sawmills originates from plantations surrounding the sawmills. Planted species are various pine species (*Pinus patula*, *Pinus elliotti*, *Pinus taeda*), gum and other hardwood. The certification process of sustainable management of plantations by Forest Stewardship Council (FSC) has almost been completed.

# 2 Project background

## 2.1 Zimbabwe's Energy sector

The Zimbabwean energy mix is dominated by fossil fuels. Zimbabwe produces about six million tonnes of coal per year, more than half of which goes into the electricity sector. The only major non-fossil energy source is hydro-electricity. In 1995 coal power plants generated 68 % of electricity, whereas hydro power was responsible for 32% (DG for Energy 1998). Energy imports currently account for about 45 % of Zimbabwe's power requirements (ZPC and FC 1999). Zimbabwe currently has a domestic power generation deficit, and industries face damaging short-falls in power.

Power generation produces more than 48% of Zimbabwe's greenhouse gas emissions, the second largest contributor is industry with 15 %, followed by agriculture (11 %) and transport (13 %) (MET 1998). Total greenhouse gas emissions from fuel combustion in 1994 have been estimated at 19,700 Gg $CO_2$-equivalents.

Official projections show that energy use will double by the year 2010 and will increase by factors of 3 and 4 by 2030 and 2050 respectively (MET 1998). Between 2030 and 2050 a decrease in per capita energy consumption is expected, due to energy efficiency improvements. $CO_2$ emissions are expected to increase by 150 % by the year 2010 and by 250% and 300% by the year 2030 and 2050 respectively (MET 1998).

## 2.2 Zimbabwe's Forestry sector

Of Zimbabwe's total land area of 39 million hectares, 20.5 million hectares are indigenous forest while 140,000 hectares are commercial forest plantations (MET 1998) with an increase of 1 % annually (MET 1997). Annual timber intake by sawmills is around 900,000 $m^3$. The plantation base comprises softwoods (pines) and hardwoods (mainly eucalyptus). Zimbabwe's forest resources account for about 3 % of the Gross Domestic Product (GDP) (Government of Zimbabwe, 1997). Forest industries employ about 16,000 people, and the gross value of processed forest industrial products exceeds US $40 million a year. The contribution of plantations to wood production in Zimbabwe is around 50 % (Kanowski 1997).

Deforestation is one of the major environmental problems facing Zimbabwe. About 70,000 to 100,000 ha of forest is cleared every year according to UNDP (1997). This source reports that forest cover is declining at a rate of 1.5 % per year (UNDP 1997). However, Zimbabwe's initial national communication under the UNFCCC concludes that, in total, forest regeneration rates exceed depletion rates (MET 1998). The main causes of deforestation include increasing demand for land for agricultural development and dependence on wood as fuel in the rural areas. Timber on private land and in commercial forests is usually not available for energy supply to households. The non-private forest area has much lower forest regeneration rates with only 0.94 tonnes/ha/year mean annual increase as opposed to 4.1 tonnes/ha/year estimated for forests belonging to private commercial farms (MET 1998).

## 3 The Clean Development Mechanism (CDM)

Article 12 of the Kyoto Protocol (UNFCCC 1997) establishes the Clean Development Mechanism (CDM) which allows transfers of certified emission reductions (CERs) accruing from project activities in Non-Annex I Parties (= developing countries) to Annex I Parties. Annex I Parties can use the CERs for compliance with their quantified emission limitation and reduction commitments under Article 3 of the Protocol. Certified emission reductions can be created beginning in 2000 and can be used for compliance with the limitation and reduction commitments in the commitment period from 2008 to 2012.

The most important criteria for project activities under the Clean Development Mechanism (CDM) are those that can directly be derived from Article 12 of the Kyoto Protocol. Article 12 provides the following criteria, that are relevant for the first steps of project planning[7]. Each project activity should:

- assist Non-Annex I Parties in achieving sustainable development;
- provide real, measurable and long-term benefits related to the mitigation of climate change; and
- provide reductions in emissions that are additional to any that would occur in the absence of the certified project activity.

At present no further agreed operationalization of Article 12 criteria are available. Negotiations with regard to Article 12 continue, and decisions are planned to be taken at COP-6 in November 2000. The latest document with views from Parties on the criteria and modalities of the Kyoto Mechanisms is the note of the chairman of the Contact Group on Mechanisms from 5 November 1999[8].

In the following sections the operationalization of the Protocol criteria is developed with regard to the project in Zimbabwe. Special attention is paid to the criteria and project requirements included in the submission of the European Union and in the submission of G77[9], as these Parties would be the participants in the analysed project. It can be assumed that the Parties would like to comply with the criteria they have established in their proposals in international negotiations. At the same time proposals from other Parties will also be discussed in order to check the project against the broadest set of criteria currently available, to ensure that all possible future aspects will be assessed.

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7 Article 12 provides additional criteria, e.g. voluntary participation approved by each Party involved. It is assumed that approval can be achieved if analysis demonstrates project benefits for the project partners involved. No further assessment of this criterion can be undertaken at this early stage.

8 Informal paper, no official status as FCCC document. The note summarizes submissions from Parties (FCCC/SB/1999/MISC.10, Add.2 and Add.3 and the synthesis of proposals in document FCCC/SB/1999/8 and Add.1) (UNFCCC 1999 a-e)

9 G77 includes developing country Parties as well as OPEC countries.

## 4 Assistance in achieving sustainable development

G77 and China propose that sustainable development priorities must be set by national authorities and that the developing country Party where the CDM project activity is proposed to be set up shall be the sole judge for deciding whether that project activity meets its national sustainable development objectives and priorities.

According to the proposal of G77 and China, eligible project activities, apart from meeting sustainable development priorities, must ensure access to the environmentally-sound technology needed by the developing country Party participating in the CDM project activity. G77 and China, AOSIS and India proposed in addition that project activities should lead to the "transfer of state-of-the-art, environmentally sound technology".

In the view of the EU the Non-Annex I Parties confirm the contribution to sustainable development by showing that project activities

- are consistent with all relevant international agreements relating to sustainable development to which the Parties involved are signatories;
- assist in achieving sustainable development, taking into account its economic, environmental and social conditions according to its own priorities and needs and the need to minimize adverse environmental, social and economic effects, taking account of existing guidance for sustainable development and;
- contribute to the ultimate objective of the Convention.

A regional African workshop on CDM requested that in Africa more attention should be paid to the avoidance of future emissions than to the mitigation of present emissions (IEA/UNEP 1998). The same workshop discussed indicators and proposed the UNDP Human Development Index to measure the benefits of a given project in terms of its impact on emissions and its additionality.

In the study the following criteria will be assessed with regard to the contribution to sustainable development:

- consistency with national priorities for sustainable development
- consistency with relevant international agreements relating to sustainable development to which the Parties involved are a party;
- minimization of adverse environmental effects
- access and transfer of state-of-the-art, environmentally sound technology
- avoidance of future emissions.

In the following sections these criteria are discussed at the project level.

## 4.1 Minimization of adverse environmental effects

### 4.1.1 Non-GHG emissions

Besides $CO_2$, the combustion of wood residues emits the following substances: ash, aerosols, soot, $NO_x$, CO, hydrocarbons, hydrogen chloride and $SO_2$. Polycyclic aromatic hydrocarbons (PAH), dioxins and furans (PCDD and PCDF) may also occur.

Emissions of these substances occur with and without the wood waste power plant. At present, wood waste residues are burnt in beehive incinerators as shown in Picture 1. Wood residues are transported to a covered, cone-shaped installation where they are incinerated at the bottom. Emission measurements of this uncontrolled incineration process have not been conducted, thus process-specific emission factors are not available.

*Picture 1 Current practice of burning wood waste residues at Nyanga sawmill*

Source: Öko-Institut

For the evaluation of the CDM project it is important to analyse whether non-GHG emissions decrease or increase with the installation of wood waste power plants compared with the existing burning practices.

The combustion behaviour of wood and the resultant quantity of emissions are affected by wood type, wood moisture, fuel size, boiler performance, air supply rate and air guidance. Wood type, wood moisture and fuel size are similar for the current practice and the wood waste plants. But the project introduces a controlled combustion process and changes air supply rate and air guidance. In general, prerequisits for low-pollution combustion are (according to VDI 1999):

- Maintenance of a minimum combustion temperature in the combustion chamber and burnout zone of about 800 °C;
- Ensuring a thorough mix of fuel gas and combustion air;
- Facilitating sufficient dwell time for the fuel gas in the combustion chamber and burnout zone.

All three fundamental requirements will improve if the installation of the wood waste plants replaces the current practices that do not control any of these aspects.

The poorer the combustion, the larger the proportion of tar, soot and particles. The wood waste power plant improves the combustion process and reduces particulate emissions. Nevertheless the untreated gases will inevitably contain ash, and measures for dedusting should be installed. The following types of waste gas dedusters are used for wood firing systems (VDI 1999):

- Gravity separators can achieve emission values of 0.15 $g/m^3$ for plants with capacities up to 5 MW.
- Electrostatic filters are more efficient in emission reduction and achieve values of 10 to 50 $mg/m^3$.
- Fabric filters achieve even better results than electrostatic filters of less than 10 $mg/m^3$ , but operation is restricted to certain technical conditions.

If dedusting measures are installed, the pollution situation will improve considerably, regardless of the technical option chosen in the project.

The $NO_x$ emissions from wood depend on the combustion temperature and the oxygen concentration of the combustion chamber. In systems firing untreated wood, $NO_x$ emissions are generally low (VDI 1999) and no additional secondary measures to reduce nitrogen oxides are recommended.

Hydrogen chloride and hydrogen fluoride emissions only occur in traces in untreated wood (VDI 1999). Polycyclic aromatic hydrocarbons (PAH) occur with incomplete combustion. Therefore their emissions will be reduced with the controlled and more complete combustion process compared with the beehive incinerators used at the moment. PCDD and PCDF have also been detected with the combustion of untreated wood. Emissions greater than 0,1 ng I-TEQ per $m^3$ can occur with unfavourable burnout conditions (high CO emissions) (VDI 1999). High moisture content of the wood (> 20%) reduces the combustion temperature and increases CO emissions as well as PAH and dioxins. Therefore the wood residues used as fuel should be as dry as possible.

In general, suitable measuring and control equipment is essential to achieve low emissions. Such equipment aims to achieve constant heat output of the plant even with an irregular combustion process, and thus not only reduces emissions, but also improves the efficiency of the process. All modern wood waste power plants will be installed with measuring and control equipment. For the CDM project it is essential that personnel is trained how to operate the plant to achieve optimal burning conditions. Increasing capacity building with the plant installation is indispensable, and future non-GHG emissions will depend more on appropriate training of staff than on the choice of the exact technical equipment.

No additional monitoring of non-$CO_2$ emissions during the project's lifetime seems to be required if the project is performed as a CDM project, because emissions generally will be lower than in the case of continuation of current practices.

### 4.1.2 Environmental impact assessment

The wood waste power plants will be installed at the sawmill sites. Industrial activities with emissions to air and water are already occurring and have been analysed in Environmental Impact Assessments prior to the construction of the sawmills.

*Sawmill*

Environmental impact assessment (EIA) was conducted for the sawmills. The EIA report for the Chimanimani sawmill was provided by the companies (EIA 1994). The main environmental problems connected with the sawmill operation are dust emissions and water protection. A dust collector was installed. Water samples are monitored, but impacts on water quality of ground water and river systems have not been detected. Emissions from incinerators for wood waste have not been considered in the EIA.

*Plantations*

The EIA for the sawmill also covers the plantation management practices. The following elements are reported: FC has a follow-up system for continuous monitoring of the present status of the forests. Indigenous forest will not be affected by the project. To avoid negative impacts the owner is taking the following steps:

- A buffer zone is left on steam banks to avoid damages.
- Different skidding systems are used in different terrain conditions to avoid erosion problems.
- All clear-felled areas are replanted within a year.
- Despite favourable soil conditions erosion is monitored using control plots.

### 4.1.3 Sustainable management of timber plantations

In the context of the Protocol's aim to minimize adverse environmental effects, it is important to assess whether sustainable management procedures are applied in the plantations. Both plantation sites are currently under the status of certification for sustainable plantation management by the Forest Stewardship Council (FSC). For the Chimanimani plantations the final review was to take place in November 1999, leading to a certificate at the end of the year. For Nyanga (Wattle), the compilation of information for the FSC certification has begun, and a final review is expected for mid-2000. If FSC certification is awarded for plantation forestry the following provisions have to be fulfilled:

- Establishment of management objectives and management plans
- Provision of rationale for rate of annual harvest and species selection.
- Environmental safeguards based on environmental assessments.
- Plans for the identification and protection of rare, threatened and endangered species.
- Description and justification of harvesting techniques and equipment to be used.
- Research and data collection needed to monitor yield, growth rates, regeneration and condition of the forest, composition and observed changes in the flora and fauna and environmental and social impacts of harvesting and other operations.
- Written guidelines to control erosion; minimize forest damage during harvesting, road construction, and all other mechanical disturbances; and protect water resources.
- A proportion of the overall forest management area, appropriate to the scale of the plantation and to be determined on regional standards, will be managed so as to restore the site with a natural forest cover.
- Measures will be taken to maintain or improve soil structure, fertility and biological activity. The techniques and rate of harvesting, road and trail construction and maintenance, and the choice of species shall not result in long term soil degradation or adverse impacts on water quality, quantity or substantial deviation from stream course drainage patterns.
- Measures shall be taken to prevent and minimize outbreaks of pests, diseases, fire and invasive plant introductions. Integrated pest management will form an essential part of the management plan, with primary reliance on prevention and biological control methods rather than on chemical pesticides and fertilizers.
- Plantations established in areas converted from natural forests after November 1994 normally shall not qualify for certification. Certification may be allowed in circumstances where sufficient evidence is submitted to the certification body that the manager/owner is not responsible directly or indirectly for such conversion.

FSC criteria comprise all relevant issues with regard to sustainable plantation management. FSC certification would therefore guarantee sustainable management procedures. With regard to plantation development and sawmilling, MET has established checklists in the Environmental Assessment Guidelines for major activities, major environmental issues and typical impacts (MET 1997). Project partners have not provided management plans for the plantations to Öko-Institut, but pre-assessment reports for FSC certification were available. The pre-assessment report confirms the implementation of sustainable management principles, even if some issues were addressed where FC need to improve current practices (SGS Forestry 1999).

## 4.2 Consistency with national priorities for sustainable development

*Energy sector*

The wood waste power plants are consistent with national priorities in the energy sector, as the Government of Zimbabwe wants to increase the use of renewable energies, and also with regard to current deficits in energy supply.

*Forestry sector*

Key forest legislation in Zimbabwe includes the Forest Act and the Communal Land Forest Produce Act. As a part of Zimbabwe's National Strategy for the sustainable management of forests, the following programme elements inter alia have been put into place to address the problem of deforestation (Government of Zimbabwe 1997):

1. Improved environmentally sound harvesting practices;
2. Afforestation programmes;
3. Increased agroforestry activities;
4. Promotion of non-consumptive use of forest resources;
5. Value added secondary processing of forest products were explored at the community level;.
6. Increasing the capacity of the Forestry Commission in monitoring deforestation and changes in the vegetation cover;
7. Increasing production of tree seedlings, from 4.5 million in 1992, with 74 % raised in the community, to 7 million in 1994, with 80 % produced at community based nurseries, in line with the strategy to decentralize this activity and to involve communities in reforestation.
8. Formation of an NGO-based working group on woodlands. This group is a think-tank of four NGOs, the SAFIRE, the ENDA, the Biomass User's Network and ZERO, who meet periodically to discuss woodland management issues in Zimbabwe. One of their activities has been to hold consultations to formulate a woodland management policy for the country.

Thus, afforestation and plantations in general are in line with the national strategy for forestry.

## 4.3 Socio-economic impacts

As described in the introduction, forest industries employ about 16,000 people in Zimbabwe, and the gross value of processed forest industrial products exceeds US$ 40 million a year. The contribution of plantations to wood production in Zimbabwe is around 50 %. The sawmills contribute significantly to regional employment. 400 – 500 persons are directly employed in the operation of the Chimanimani mill and its related logging operations (EIA 1994). It is expected that additional employees would be needed for the plants.

The use of wood residues would lead to more efficient use of the existing plantations in an important sector of Zimbabwe's economy. This will lead to socio-economic benefits with regard to income and higher efficiency in the use of natural resources.

*Leakage*

Competing land use needs could lead to leakage effects. If area used for commercial timber production is not available for agricultural purposes, pressure may be shifted to areas that are deforested. At the national level competing land uses are important problems, and especially fuel use in private households competes with forest conservation. This problem occurs mainly in more densely populated areas. In the project area there are no consumers of wood residues . The area has low population figures and therefore competing land uses will not occur according to the project partners in Zimbabwe.

## 4.4 Technology transfer

The project would lead to the transfer of state-of-the-art, environmentally-sound technology. At present no wood waste residue plants exist in Zimbabwe. The Nyanga or Chimanimani plants would be the first of their kind in the country. No sawmill is currently using wood residues for electricity generation. There is the possibility of the technology spreading to other sites in Zimbabwe and the Southern African region (City of Murare 1998).

## 4.5 Consistency with other international agreements relating to sustainable development

Taking into account the management and technical options chosen, the project is also consistent with relevant international agreements relating to sustainable development.

# 5 Climate change effectiveness: real, measurable and long-term emission reductions

According to the Kyoto Protocol climate change effectiveness must be in terms of real, measurable and long-term benefits related to the mitigation of climate change at the project level. This criteria is addressed by taking into account the additional reduction in emissions at the CDM project level against the baseline for the CDM project activity.

The aspect of **real** benefits has not been further determined by the Parties in the submissions. Real emission reductions may be proven in the course of the project performance with verification of the project and certification of CERs.

In the chairman's note from November 1999 the term "real" is interpreted as *"The emission reductions related to the project activity will be recognized as real if the greenhouse gas emissions from the projects can be shown to be less than the project baseline"*. This definition overlaps with environmental additionality criteria, as will be explained later, and would therefore reduce the number of criteria. It is not likely that it was the intent to provide two different criteria with the same factual content under Article 12.

Thus "real" is interpreted in such a way, that emission reductions and the performance of the project have to be proven and verified by independent third parties on implementation of the project . With this interpretation, the criterion does not have to be taken account of in this study.

The benefits related to the project activity will be recognized as **measurable**, if the level of greenhouse gas emissions from the project and the level of greenhouse gas emissions from the baseline can be estimated with a reasonable degree of uncertainty. The emission reductions of the project can be measured on the basis of the electricity produced by the wood waste power plants. In the following sections sensitivity analysis is used to assess the influence of assumptions used in the estimation of project and baseline emissions. This analysis will provide more detailed information with regard to uncertainty.

The emission reductions related to the project activity will be recognized as **long-term** if the emission reduction persists over an appropriate period of time, taking into account the difference in the lifespans of different CDM project activities. AOSIS defines the long-term criterion as "project activities shall be based on the best available long-term option, taking into account local and national needs and priorities."[10]

The wood waste cogeneration plants will provide benefits over the entire lifetime of the plants as renewable energy is used. This should qualify for compliance with the criterion of long term.

[10] FCCC/SB/1999/8 see UNFCCC 1999d.

# 6 Environmental additionality of emission reductions - CDM project baselines

The project activities shall provide reductions in emissions that are additional to any that would occur in the absence of the certified project activity. For this purpose a baseline needs to be established representing the situation in the absence of the project activity. Greenhouse gas emissions from the project need to be lower than the project baseline. The emission baseline shall reflect the "no project" scenario and is the basis for calculating the emission reductions to be certified. Modalities, rules or criteria have not yet been established in international negotiations, and agreed methodological guidance with regard to the setting of CDM baselines is lacking.

In the negotiation texts, the following approaches for baseline setting are mentioned:

- Project-by-project baselines[11]
- Sectoral baselines[12]
- Standard baselines for project categories[13]
- Baselines at national level[14]

In literature further approaches have been developed, such as benchmarks, technology matrix, or a hybrid or multi-project approach (Ellis and Bosi 1999, Michaelowa 1999b).

This chapter aims to provide a clearly-structured approach to describe different possible ways of baseline setting. The approach highlights the different choices or decisions that need to be taken with the establishment of a baseline.

## 6.1 Disaggregation of the baseline estimate

The emissions of each project and each baseline can be broken down to output or activity level (e.g. electricity generated) and the emission rate (emissions per output)[15]. The comparison of the emissions between baseline and project project consists basically of the following equations for each year of the project lifetime:

$$\text{Equation A: Project emission level} = \text{output level}_{project} \times \text{emission rate}_{project}$$

$$\text{Equation B: Baseline emission level} = \text{output level}_{baseline} \times \text{emission rate}_{baseline}$$

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11 Costa Rica, G77 and China, Republic of Korea, Sierra Leone, South Africa,

12 Costa Rica

13 Republic of Korea

14 Sierra Leona and South Africa

15 Disaggregation of the project into sub-systems in which greenhouse gas emissions occur is also supported by Puhl (2000)

For each year in which credits accrue (from year 1 until year n) the project emissions are subtracted from the baseline emissions resulting in the emission reduction to be certified:

$$\text{Emission reduction} = \sum_{i=1}^{n} \left( \text{baseline emission level}_i - \text{project emission level}_i \right)$$

### 6.1.1 Activity level

For many projects the baseline activity level will be the same as the activity level that is monitored during the project's lifetime. For example, in the case of a project increasing the efficiency of a plant, the production output of the baseline would be established in accordance with the project's output. For many projects equation B therefore can be transformed to:

$$\text{Equation B: Baseline emission level} = \text{output level}_{\textbf{Project}} \times \text{emission rate}_{\text{baseline}}$$

The difference in the final estimate results from the difference in the emission rate per unit of output between baseline and project. The baseline output level cannot be higher than the project output level. At the beginning of the CDM project, project developers take assumptions with regard to the development of the project's output as well as for the baseline. During the project lifetime the output is monitored and reported annually (for example, in the case of the wood waste power plants, the electricity generated). The baseline emission estimate is recalculated annually with the activity data from the actual project performance.[16]

*Box 1 - Baseline activity level lower than project activity*

For some cases the baseline activity level may be lower than the project activity level, for example for greenfield projects implementing an activity that did not exist before the CDM project. There may be situations where the realistic situation in the absence of the project would not be another project with different emission rates but the situation that no activity at all would have been implemented. In this case, the baseline emission estimate would be zero, and the project would not qualify as a CDM project. If a considerably smaller project would have been implemented, the baseline activity level would be lower than for the project.

Refurbishment projects may be connected to an expansion of the installation, for example improvement of efficiency of a district heating system may be related to a further extension of the system. In this case it may be more realistic to disaggregate the project into two separate parts, one taking into account the efficiency improvement on the basis of the maximum output of the old system, the other comparing the new part of the system with the heating situation the expansion has replaced.

[16] Begg et al. (1999) and Brodmann (2000) also recommend that feasibility data should not be used in the calculation of emission reductions and that emission reductions should be calculated annually based on the reported output and fuel used, as this limits opportunities for gaming and the risk for crediting a project which may fail.

A procedure establishing a fixed level for the baseline output would risk enormous gaming as the poorest project implementation (for example, the project operates only during some days of the year) would receive the most credits. This implies that one part of the baseline estimate – the output level - is always "dynamic", i.e. it changes over the lifetime of the project and cannot be predicted exactly before the project's implementation. This type of uncertainty to operation is a key feature of any investment project and cannot be avoided completely. But the project developer can influence the level of uncertainty connected with the output level. The greater his experience with project implementation in specific countries, the more realistic assumptions on real performance of a project he can develop. In this view, the discussion on "dynamic" and "static" baselines is reduced to the choice of a "fixed" or "revised" baseline emission rate, as the baseline activity level will in any case be dynamic.

### 6.1.2 Matrix of choices for baseline emission rate

The key difference between the project estimate and the baseline estimate is the emission rate, i.e. the greenhouse gas emissions per output. The establishment of the baseline emission rate depends on many choices and assumptions. The key choices and assumptions are explained in Figure 3.

***Type of reference case***

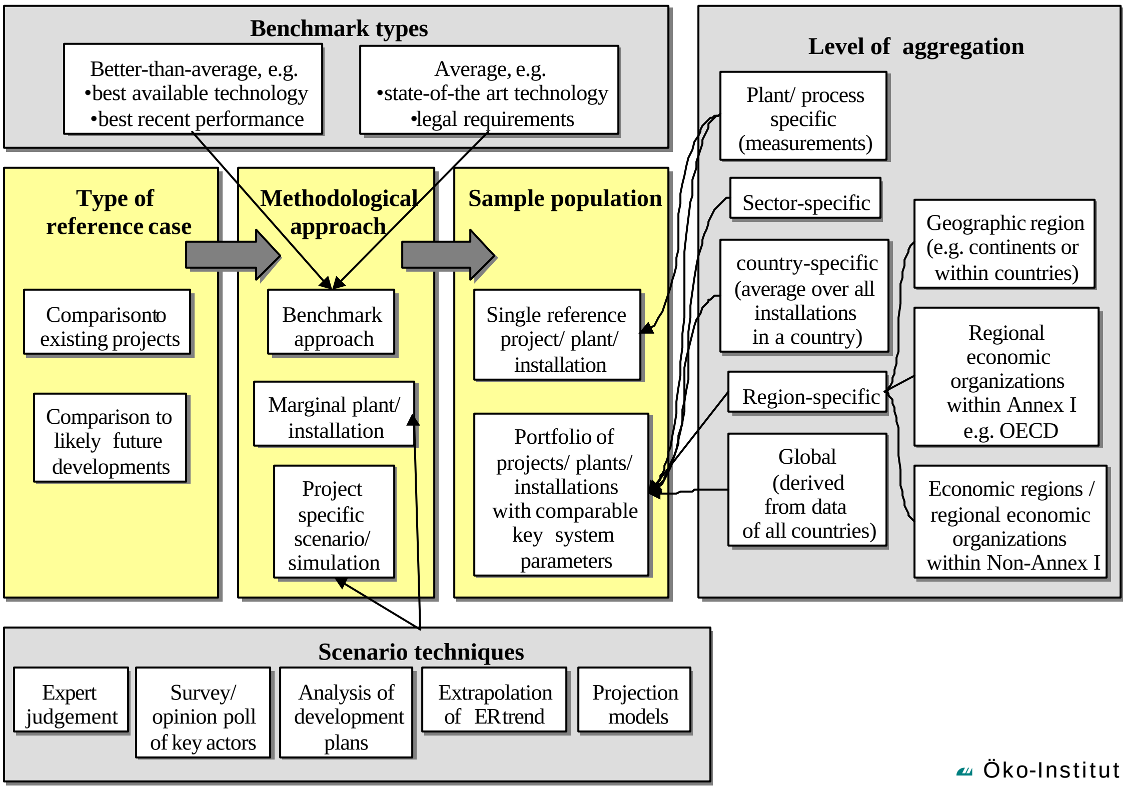
The project could be compared with the present situation without the project or with a future development without the project. This seems to be a first general choice for baseline estimates.

***Methodological approach***

Several methodological approaches can be chosen to describe the situation without the project. The **benchmark approach** fixes a **standardized** emission rate against which the project is compared. Additionality is assumed to be satisfied as long as the CDM project shows an emission rate improvement over the benchmark. The choice of the benchmark approach seems related to the choice of comparison with existing projects, as benchmarks often are derived from present performances of installations.[17] A benchmark could be projected, but this would lead to a scenario approach. A main difference of benchmark types is whether they reflect the average situation, such as state-of-the-art technology or existing legal requirements, or whether they are based on a better-than-average situation. Different possibilities exist to describe the better-than-average situation, for example the best available technology could be chosen, the best recent installation, or "better" could be defined as a determined percentage that is added to the average over-all performance of a specific type of installation.

[17] Lazarus et al. (1999) use the term benchmark also for projected standardized emission rates. The broad use of the term benchmark suggests that further differentiation with regard to the methodologies used to derive the benchmark is necessary to clarify the discussions. Because of considerably different underlying methods and techniques in this study the scenario approach was regarded as a separate methodological issue.

*Figure 3 Matrix of choices and assumptions for baseline selection*




The project could also be compared with a **marginal plant or marginal installation**. In this approach, the project's output replaces the output of the marginal plant/ installation. In an economic analysis, the marginal plant in this case is usually the plant with the highest cost per unit output. The key characteristic of the marginal approach is that an individual plant is chosen for comparison with the project. The marginal approach can be developed for the present situation as well as for the future.[18] A future marginal approach would need to be based on a scenario to identify which installation would be the marginal one in the future.[19] But as for the present marginal approach, only an individual installation would be used for comparison.

A third possibility would be to construct a **scenario** that reflects the future development of emission rates. For this purpose a wide variety of scenario techniques could be applied to gather the basic data for the scenario, such as expert judgement (for example experts from the host government), a survey or opinion poll with key actors (a more transparent form of expert judgement) or development plans could be analysed. Extrapolation of the historical trend or projection models – the most sophisticated method -

18 Unfortunately no common definition of marginal exists, and this term is applied in many different ways, e.g. sometimes as synonym for additional.

19 A least-cost approach for the future marginal plant would identify the alternative future investment with lowest costs compared with the project.

could also deliver the data for the scenario. It is possible to use several of these techniques at the same time.

***Sample population***

A key choice is related to the sample population, that is used as basis of the baseline emission rate. The benchmark approach or the marginal plant approach could compare the project with a single reference installation that fits the criteria of the specific approach. For example, if the benchmark is determined as the best recent performance of a specific plant type, the project would be compared with a single reference installation. Apart from this approach, the average of a portfolio of projects or installations with comparable system parameters is used in many cases for the baseline emission rate. A portfolio of projects could be used together with the benchmark approach and the scenario approach. In most cases the portfolio covers all installations in a defined area.

***Level of aggregation***

In all cases where the baseline emission rate is derived from a portfolio of projects or installations (benchmarks and scenarios) project developers have to choose the level of aggregation that is appropriate for the baseline emission rate. The level of aggregation could cover a sector, a region within a country, a country, a region encompassing several countries, or all countries. A region could be defined by geographic as well as by economic features. For example, Peru proposed to use a benchmark approach for baseline setting that uses OECD averages for baseline emission rates.[20]

## 6.2 Selection of baselines for wood waste power plants in Zimbabwe

For the wood waste power plant the situation in the absence of the project would be that sawmills in Zimbabwe would continue to incinerate the wood waste in the beehive incinerators, no electricity would be generated using the wood residues and this electricity would not replace electricity from the grid generated by other fuels. For the baseline it is necessary to calculate a baseline emission rate that reflects the emissions from electricity generation in the absence of the project.

For the wood waste power plant projects a total of seven different baselines have been constructed to demonstrate a range of possibilities of choice. In the present situation where no specific rules and guidelines are adopted, many different approaches can be chosen. The decision matrix from Figure 3 is used in the description of each baseline to explain the choices of the specific approach. The choices of the specific baseline are marked in red to provide the reader with a clear understanding of the differences between the options.

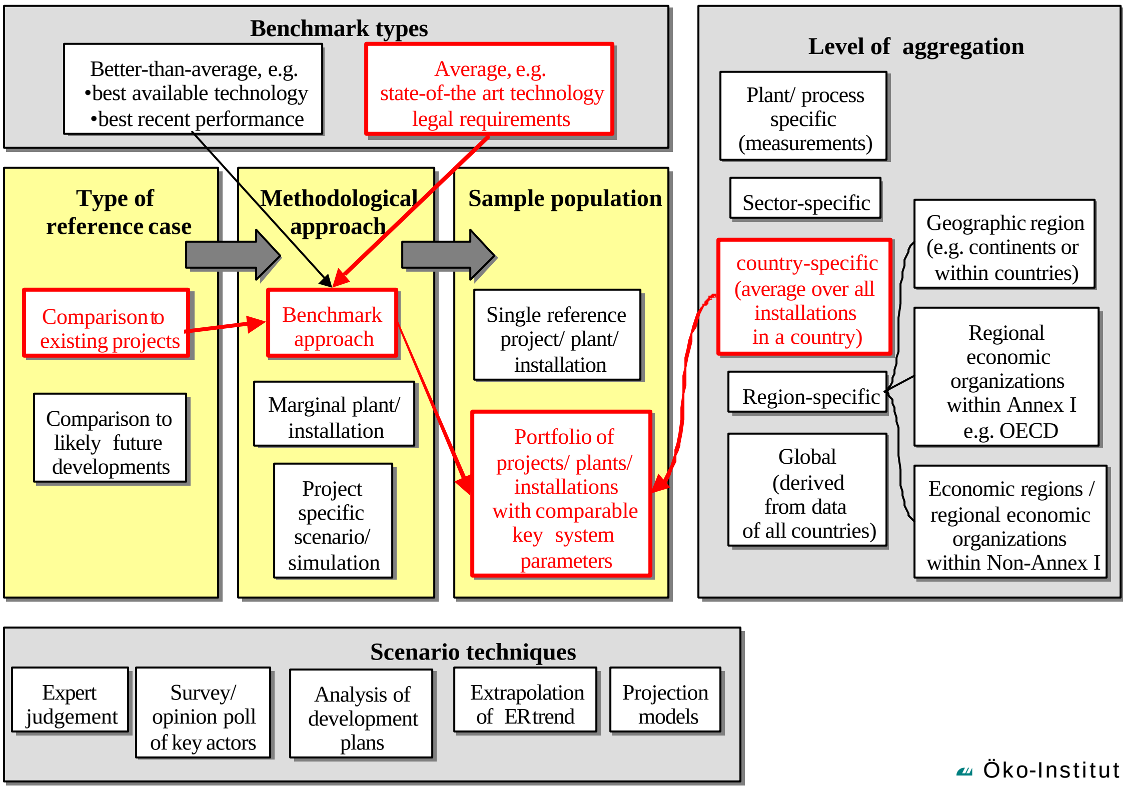
The seven options selected have been discussed in expert workshops, papers or pro-

[20] See FCCC/SB/1999/MISC.3/Add.1 Submission of Peru on the work programme on mechanisms of the Kyoto Protocol. "The difference between project emission levels and the OECD average will be converted in emission reduction units (ERUs) or certified emission reductions (CERs), for the benefit of the Annex I country, as appropriate."

posed during negotiations. Because of data availability some options have been excluded. For example, no detailed analysis of the feedback of the whole ZESA electricity generation and transmission system regarding local generation in the Eastern Highlands is yet available. Therefore a regional baseline for the area of the project sites was not included. Detailed historic data on $CO_2$ emissions were not available and would require additional calculation efforts, thus extrapolation of trend was not performed.

## Baseline A

*Figure 4 Matrix of choices for baseline A – country-specific benchmark*




*Description*

In **baseline A** the project is compared with the emissions from the **average present generation mix** in Zimbabwe. This means the baseline emission rate is derived from existing projects. The emission rate derived from the present fuel mix of Zimbabwe's power generation in this case has the function of a benchmark which is based on a portfolio of projects, that is the average fuel mix of the power generation in Zimbabwe.

*Rationale*

The electricity generated by the wood waste power plants replaces electricity generated by other fuels. The average fuel mix is a measure to describe the emission rate in the absence of the project. The approach does not take into account future changes in the national fuel mix and provides fixed emission rates over the project's lifetime unless a revision of the baseline emission rate is conducted. In this regard it does not fully take into account the development that would have taken place in the absence of the project.

*Data sources and constraints*

For baseline A, data of the 1997 generation mix was used as given in the Southern African SAPP-GHG Mitigation Study (SC 1999). In this study business-as-usual (BAU) scenarios, and greenhouse gas emissions from the power sector are provided for the

Southern African Development Community (SADC) including nine southern African countries. Table 1 shows the structure of the electricity generation in 1994 (SC 1999).

*Table 1 Structure of electricity generation in Zimbabwe in 1994*

| **Power plant** | **Fuel type** | **Capacity [MW]** | **Efficiency [%]** | **Electricity generation [GWh]** | **Emission rate [kg $CO_2$-equiv./ MWh]** |
|---|---|---|---|---|---|
| Hwange I | coal | 456 | 31.9 | 4,816 | 1,219 |
| Hwange II | coal | 400 | 31.9 | | |
| Bulawayo | coal | 110 | 26.5 | 320 | 1,462 |
| Munyati | coal | 110 | 22.0 | 200 | 1,768 |
| Harare | coal | 115 | 22.0 | 104 | 1,755 |
| Diesel plant | diesel | 3.7 | n.a. | n.a. | n.a. |
| National average thermal plants | | 1,195 | | 5,440 | 1,450 |
| Kariba South plant | hydro | 666 | | 2,096 | - |
| Total | | 1,861 | | 7,536 | 875.6 |

Source: SC 1999

The generation mix is part of the SAPP database for the Environmental Manual (EM)[21] which was used to determine the emissions per generation unit. Data for 1997 are projected data. The latest figures published by international organisations are from 1996. Table 2 shows the emission rates derived from national data (SC 1999) in comparison with emission rates derived from international data.

*Table 2 Greenhouse gas emission rates in baseline A*

| **Year** | **Source** | **Unit** | **$CO_2$-equiv.** | **$CO_2$** | **$CH_4$** | **$N_2O$** |
|---|---|---|---|---|---|---|
| **1997** Emission rate | SC 1999 Projection | [kg/MWh] | 787 | 777 | 0.017 | 0.029 |
| **1995** Emission rate | OECD/IEA 1998c,d | [kg/MWh] | 1,006 | 996 | 0.017 | 0.029 |

Source: Öko-Institut, OECD 1998c, OECD 1998d

The establishment of baseline A is simple with regard to data requirements. International sources can be used if national data is lacking. There is a time lag of data availability. National data may differ from international data bases which may create confusion in the validation, verification and certification process.

21 For description of the EM model see footnote 5

*Uncertainties*

The approach is quite precise during the early years of the project, but uncertainties increase considerably during the project's lifetime because the fuel mix is expected to change more and more over time.

*Transparency*

The baseline establishment is transparent and easy to assess if data sources are provided.

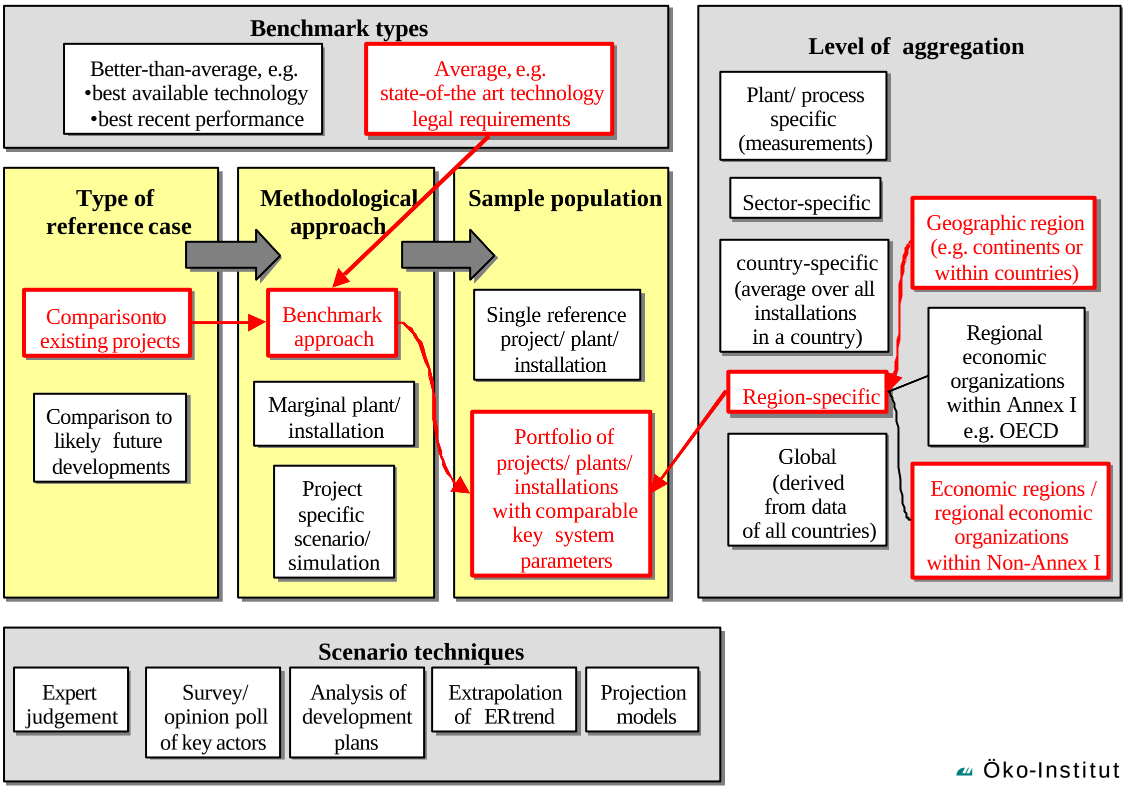
*Leakage – electricity imports*

Currently about 45% of Zimbabwe's electricity requirements are supplied by electricity imports from South Africa and Mozambique (ZPC and FC 1999, p.4 , Government of Zimbabwe 1999, p.8). Imports increased considerably in recent years from 3% in 1989/90 to 21% in 1993/1994 and up to 44% in 1997/1998. Zimbabwe participates in the South African Power Pool, a distribution network between nine African countries. The SADC Energy Protocol and the Southern African Power Pool agreements have been signed in 1997 by all Southern African Development Community (SADC) countries. At the regional level and in the medium term there is a surplus of generating capacity in particular in Mozambique, Zambia (hydro) and South Africa (coal thermal), and other countries face capacity deficiencies like Zimbabwe.

It is not clear how the situation of electricity imports should be dealt with in baseline calculations. The omission of imports and their effects in neighbouring Non-Annex I countries would result in "leakage" from energy projects. The more precise approach would be to calculate an emission rate of the fuel mix as a weighted average based on domestic production and imports. For the project developer this approach is more complicated, as data from three countries are required.

**Baseline B**

*Figure 5 Matrix of choices for Baseline B – Southern African regional benchmark*




*Description*

Baseline B applies a benchmark approach, i.e. it uses a standardized emission rate against which the project is compared. The **benchmark averages data from existing plants** in all countries forming part of the **Southern African Development Community** (SADC)[22].

*Rationale*

Political settlements and resolution of military conflicts in the SADC region, which occurred in the early 1990s, and the transformation of the region into a Community have opened up scope for regional integration which would enable collective decision making on energy policy in the Southern African region. Of significance to this study are the SADC Energy Protocol and the Southern African Power Pool (SAPP) agreements which by 1997 all Southern African Development Community (SADC) countries have signed. SAPP will greatly increase the scope for regional electricity exchange, although power trading in the region has been going on since the 1950s. The main rationale for power pooling is an economic one. Trading in electricity on a regional basis helps even

22 SADC includes the following countries: Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe and Democratic Republic of Congo.

out supply/demand imbalances, increases the security of supply and creates economies of scale. In addition, power pooling reduces the problem of indivisible single investment options that may be too large for one country. The driving force behind the creation of SAPP are the power utilities in the region, which see an opportunity to improve the reliability and availability of their supplies while at the same time reducing their costs. The development of the SAPP supports the establishment of a regional benchmark including all SADC countries, as the power pool integrates the individual decisions on expansion of power supply in a common framework at regional level.

The approach does not take into account future changes in the SADC fuel mix and provides fixed emission rates over the project's lifetime unless a revision of the baseline emission rate is conducted. In this regard it does not fully take into account the development that would have taken place in the absence of the project. Zimbabwe is not connected to all countries of the SADC. Exchanges may only occur with some countries of the SADC. In this regard the regional benchmark does not represent the real situation in Zimbabwe.

*Data sources and constraints*

Data for 1994 from the Southern African SAPP-GHG Mitigation Study (SC 1999) was used to get the data on $CO_2$ emissions from electricity generation. As this study does not provide the total electricity generation for all SADC countries, data from international statistics was used. Several SADC member states are not included in the international data sets, but summarized as "other Africa". Therefore only countries where figures are available have been included in the regional emission rate.[23] The establishment of baseline B is more difficult with regard to data requirements than baseline A, as more countries are involved. The SAPP should be able to provide necessary data annually. International sources can be used if national data is lacking. Table 3 summarizes $CO_2$-equivalent emission rates for different plant types of the region and Table 4 shows the regional emission rate.

*Uncertainties*

The approach is quite precise during the early years of the project, but uncertainties increase considerably during the project's lifetime because the fuel mix is expected to change more and more over time. The changes that may occur in the region are probably greater than at national level, resulting in greater uncertainties than with the country-specific benchmark.

*Transparency*

The baseline establishment is transparent and easy to assess if data sources are provided.

*Leakage – electricity imports*

In the regional benchmark electricity trade is automatically included and covered.

[23] Five from twelve countries have been excluded (Lesotho, Botswana, Malawi, Namibia, Swaziland)

*Table 3* *$CO_2$-equivalent emission rates for 1994 by fuel type and plant sizes for Southern African Development Community*

| | $CO_2$-Equivalent [kg/MWh] | Efficiency [%] |
|---|---|---|
| **COAL** | | |
| Large: > 300 MW | 1,200 – 1,273 | 31.9 – 35.5 |
| Medium: 100 – 300 MW | 1,462 – 1,768 | 23 – 26 |
| Small: < 100 MW | 1,132 – 1,707 | 23 – 35 |
| Small AFBC[24] | 1,472 | 35.5 |
| **DIESEL** | | |
| Large: > 10 MW | 1,029 – 1,440 | 25 – 35 |
| Medium: 1 – 10 MW | 1,275 – 1,530 | 30 |
| Small: < 1 MW | 1,708 | 25 |
| **GAS** | | |
| Large combined cycle: > 70 MW | 505 – 689 | 44 |
| Medium combined cycle 20 – 70 MW | 479 | 44 |
| Small combined cycle: < 20 MW | 453 - 505 | 44 |

Source: SADC 1999, Table 4.4

*Table 4* *Baseline B: Regional greenhouse gas emission rates for Southern African Development Community in 1994*

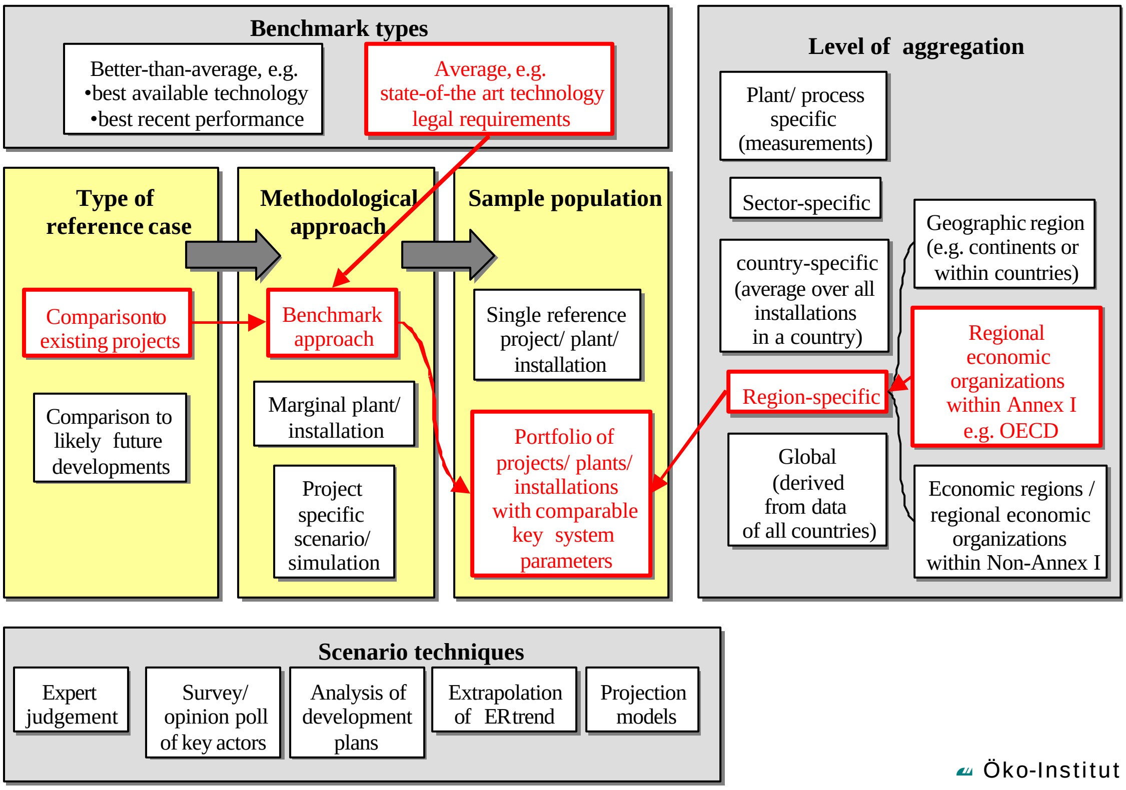
| | $CO_2$-equiv. | $CO_2$ | $CH_4$ | $N_2O$ |
|---|---|---|---|---|
| Emission rate [kg/MWh] | 723 | 714 | 0.018 | 0.026 |

Source: SADC 1999

[24] AFBC = atmospheric fluidized-bed combustion

**Baseline C**

*Figure 6 Matrix of choices for Baseline C – regional benchmark OECD and EU*




*Description*

Similar to baseline B, baselines C1 and C2 apply **benchmark approaches**, but they are derived from different regions. Baseline C1 reflects the fuel mix of electricity generation of all **OECD countries**, baseline C2 reflects the fuel mix of electricity generation of all **EU Member States**.

*Rationale*

The basic idea of comparing emission rates of developing countries with OECD averages was proposed by Peru during the negotiations. The additionality assumed is that the projects in Non-Annex I Parties need to be better than the average OECD emission rate. This is a simple approach for setting a benchmark for baselines. But it is questionable if this benchmark type is consistent with the Kyoto Protocol. Article 12.5 requires that the CDM project is additional to any that would occur in the absence of the certified project activity. It is not true that the OECD emission rate for power generation would be valid for Zimbabwe if the project would not occur. The Protocol language clearly refers to the situation of a specific project activity. This seems to exclude benchmarks at some high level of aggregation without relationship to the project activity.

In addition to the OECD average emission rate, the emission rate for the average fuel mix from electricity generation in the EU was calculated to get a second estimate of a benchmark representing Annex I Parties.

*Data sources and constraints*

Table 5 shows the baseline emission rate for the OECD average and the EU average. The OECD estimate is derived from data of the International Energy Agency (OECD/IEA 1998c,e). The estimate of $CO_2$ from electricity generation in Europe is based on data from DG Energy (1998). Neither of the data sources provides data for $CH_4$ and $N_2O$ emission rates from electricity generation. The emission rates applied are averaged default emission rates of the Tier 2 approach from 1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual, Table I-15. Most recent data available for the calculations are data for 1996. Benchmarks at a more aggregate level will generally not be available for actual years. There is a time lag of two to four years because compilation of international data by international agencies is a time consuming process.

*Table 5 Greenhouse gas emission rates in baseline C1 and C2*

| | $CO_2$-equiv. [kg/MWh] | $CO_2$ | $CH_4$ [kg/MWh] | $N_2O$ |
|---|---|---|---|---|
| OECD average (1996) Emission rate | 559 | 556 | 0.071 | 0.006 |
| EU average (1996) Emission rate | 391 | 387 | 0.071 | 0.006 |

Sources: DG Energy 1998, OECD/IEA 1998c, OECD/IEA 1998e

*Uncertainties*

The approach is quite precise during the early years of the project, but uncertainties increase considerably during the project's lifetime because the fuel mix is expected to change more and more over time. The changes that may occur in the OECD/EU are probably greater than at national level, resulting in larger uncertainties than with the country-specific benchmark.

*Transparency*

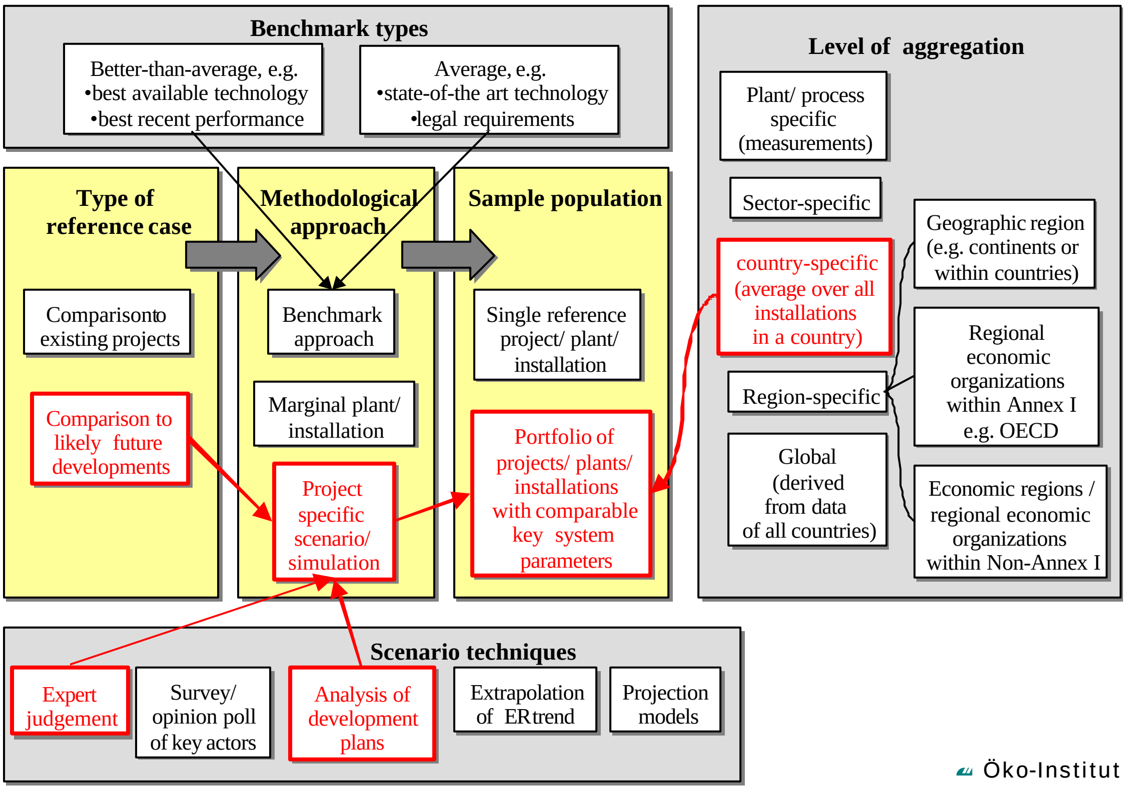
The baseline establishment is transparent and easy to assess if data sources are provided. Only data from documents with international distribution and easy access were used.

*Leakage – electricity imports*

Electricity imports are not relevant for this benchmark approach as it does not consider at all the circumstances of the project.

## Baseline D

*Figure 7 Matrix of choices for Baseline D – BAU scenario*




*Description*

In baseline D the project is compared with the emissions from the future generation mix in Zimbabwe based on a business-as-usual (BAU) scenario for the electricity generation of Zimbabwe.

*Rationale*

The scenario is probably the approach most consistent with the language of the Kyoto Protocol. The BAU scenario represents the development of the sector without the project. In comparison to previous examples, timing issues are addressed and additionality in the future is likely to be guaranteed as well as at present. The BAU scenario is often country-specific, but regional scenarios (for example for the SADC countries) are also published.

*Data sources and constraints*

The 2020 business-as-usual (BAU) scenario from African SAPP GHG Mitigation Study (SC 1999) and SAPP database of the EM model[25] was used for the calculations. Significant growth of electricity demand is projected for Zimbabwe. Southern African SAPP

25 For description of the EM model see footnote 5

GHG Mitigation Study expects a demand increases by a rate of 2.7 from 1997 to 2020 (SC 1999, Fig 5.12). Zimbabwe's maximum demand was 1,925 MW in 1997 and is expected to reach 2,039 MW by 2000 and 3,243 MW by 2010. This is an average growth of 106 MW per year until 2010.

Refurbishment work at Kariba hydro station is currently in progress and will result in an addition of 84 MW to the present capacity of 666 MW at Kariba hydro plant. System expansion is planned through the construction of new coal-fired stations at Gowke North (1200 MW) ($3 \times 350$ MW in 2004, 500 MW in 2007) and Hwange 7&8 ($2 \times 300$ MW in 2001 and 2003). Batoka Gorge is the next hydro site in the national electricity development plan. Plans are to commission the first unit of 200 MW by 2010 and install 200 MW per year till the total capacity is 800 MW in 2014. Electricity imports will stop in 2003 when existing contracts end. Table 6 shows the expansion plans for electricity generation until 2020 as taken into account in the BAU scenario (SC 1999).

*Table 6 Planned power capacity expansion in Zimbabwe*

| Power plant | Fuel Type | Capacity [MW] | Start |
|---|---|---|---|
| Hwange 7 | Coal | 300 | 2001 |
| Hwange 8 | Coal | 300 | 2003 |
| Gokwe North Project | Coal | $3 \times 350$ | 2004 |
| Gowke North | Coal | 500 | 2007 |
| Kariba South plant | Hydro | 84 | 2000 |
| Batoka Gorge Hydro-Electric Schemes | Hydro | 800 MW | 2010 - 2014 |

Source: SC 1999, section 5.2

It is difficult to judge if these electricity expansion plans will be realised. The economic environment in Zimbabwe is unfavourable, the most important problem for all expansion plans is the availability of investment capital. Lack of investment capital and changing energy prices are likely to result in revisions of investment plans. This is a general problem when published plans of the host country are used. They may be written to accelerate development and to encourage investment, though the planned projects will not always fully materialize. This problem was also addressed by GEF related to baselines for incremental costs (GEF 1996). GEF recommended to draw on various sources to construct and agree on a reasonable baseline. This may be difficult in practice as the host country's government will provide the national plans but may not be willing to provide contradictory documents from other sources.

The BAU scenario used for baseline B takes into account the expansion projects as described in Table 6. As the contribution of different plants to total electricity generation will change over time, the emission rate will also change. Table 7 shows the changes in emission rates that have been assumed in the BAU scenario.

*Table 7 Greenhouse gas emission rates in BAU scenario for Zimbabwe*

| **Emission rate [kg/MWh]** | **2000** | **2005** | **2010** | **2015** | **2020** |
|---|---|---|---|---|---|
| $CO_2$-equivalent | 756 | 852 | 840 | 744 | 688 |
| $CO_2$ | 747 | 842 | 831 | 735 | 680 |
| $CH_4$ | 0.017 | 0.019 | 0.019 | 0.016 | 0.015 |
| $N_2O$ | 0.028 | 0.023 | 0.031 | 0.027 | 0.025 |

Source: SC 1999

A more simple approach would be to calculate the average greenhouse gas emission rate of the BAU scenario. The averaging period should be consistent with the period of the CDM project.

*Uncertainties*

Uncertainties are lower in this approach compared to previous baselines. It takes into account future developments, so far as they can be foreseen.

*Transparency*

The approach is less transparent than previous ones. Many assumptions and data have been considered in constructing the BAU scenario and it is difficult to report all of them in the baseline study. But reference to published projections considerably improves transparency.

*Leakage – electricity imports*

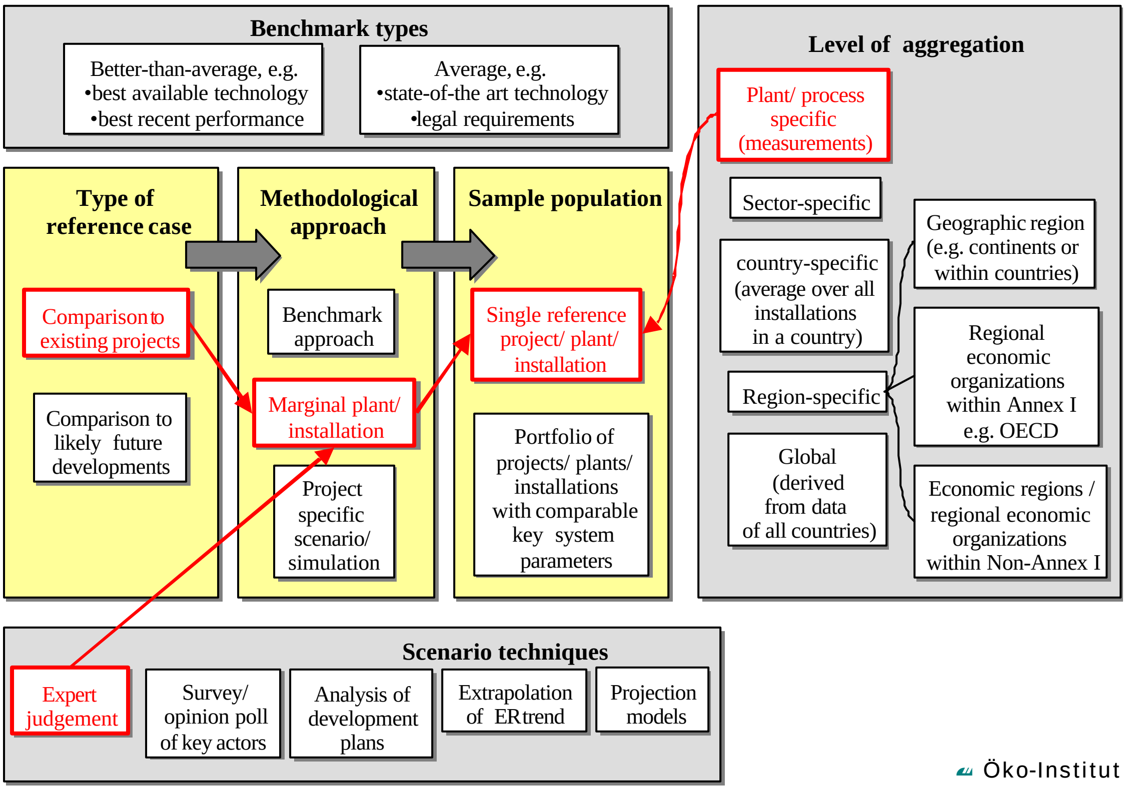
For the purpose of simplicity, no distinction has been made between the domestic and the imported shares of electricity generation in calculations of baseline D. The complexity of the scenario approach increases considerably if electricity imports are taken into account, as the project developer would need to construct a scenario across three countries, leading to increasing costs and work burden. The CDM host country may provide national data and projections, but other governments would need to be contacted to gather additional data. Besides, the BAU scenario assumes that electricity imports will stop in 2003 when supply contracts expire. This assumption supports the simpler approach, that does not consider electricity imports.

*Other issues*

In small countries large energy generation projects could have considerable impacts on the total national greenhouse gas emissions. The establishment of a business-as-usual scenario for such a project will be very difficult, as national circumstances and most of the relevant indicators would change completely.

**Baseline E**

*Figure 8 Matrix of choices for Baseline E – present marginal approach*




*Description*

Baseline E presents the **marginal approach** in which the project is compared to a **existing marginal plant**.

*Rationale*

The concept behind this approach is that the project's output replaces the output of the marginal plant. Often in an economic analysis the marginal plant is the one with the highest cost per unit output (least-cost approach). No consistent definition of "marginal" exists; apart from the economic definition of marginal, other interpretations are possible and analysis at micro- or macro-level can be performed. The marginal plant concept considers the additionality at the plant level and compares the project with the most likely other plant that would deliver electricity in the absence of the project. For energy supply projects developers need to take into account load characteristics of project and to choose a marginal plant with similar characteristics. For example, in Germany base-load plants include nuclear, lignite and hydro plants, medium load includes coal and peak load plants are mainly gas and pump-storage hydro plants.

*Data sources and constraints*

Option E was discussed with ZESA during the visit, resulting in the assumption that under current operation conditions the most likely marginal plant (least-cost approach) would be the coal-fired Hwange 2 station, or a mix of the smaller refurbished plants in Bulawayo, Harare and Munyati, due to their relatively high short-term running costs, resulting from their low electric efficiencies. For simplicity, the Bulawayo plant was assumed to be marginal, because its specific emissions are in the range of the other plants. Again, the plant and fuel characteristics were based on the SAPP database of the EM model[26] (Table 8). The wood waste power plants would deliver base load electricity which is consistent with the choice of the marginal plant.

The emission rate of baseline E is considerably higher than the emission rates of previous approaches as it only includes a coal plant, whereas other emission rates describe Zimbabwe's fuel mix, that includes hydro generation.

In this study, the choice of marginal plant was based on the expert judgement of the host country's experts. It may be difficult to get data to clearly support and justify a specific choice of a marginal plant. Should the marginal plant be hydro (which seems unlikely as operation costs are usually lower for hydro plants compared with coal plants), the greenhouse gas emission rate would be around zero. Thus the choice of the marginal plant type can considerably influence the baseline result.

*Table 8 Baseline E: Emission rates for marginal plant options in 1997*

| Option | $CO_2$-equiv. | $CO_2$ | $CH_4$ | $N_2O$ |
|---|---|---|---|---|
| | [kg/MWh] | [kg/MWh] | | |
| Hwange 2 | 1,067 | 1,054 | 0.024 | 0.039 |
| Munyati | 1,536 | 1,518 | 0.034 | 0.056 |
| Harare | 1,547 | 1,528 | 0.034 | 0.057 |
| Bulawayo | 1,286 | 1,271 | 0.028 | 0.047 |

Source: SC 1999

*Uncertainties*

The marginal approach is connected with high uncertainties and high risk of unrealistic assumptions. A single plant gets the status of the reference project and the choice of this plant greatly influences the resulting emission rate. It seems difficult to achieve an objective judgement on the marginal plant without any bias in favour of higher emission rates.

Uncertainties of baseline E are also high with regard to future developments. For example, an existing marginal coal plant, chosen as baseline, may end production soon after the project start. With the shutdown of this plant, no further coal plants would exist in the country. Even in this situation the project would be compared against an inefficient

[26] For description of the EM model see footnote 5

coal plant. This is a theoretic example, but it highlights the problems of the concept. Therefore project developers, using the present marginal plant approach, should describe the age of reference plants and the time they are expected to operate.

*Transparency*

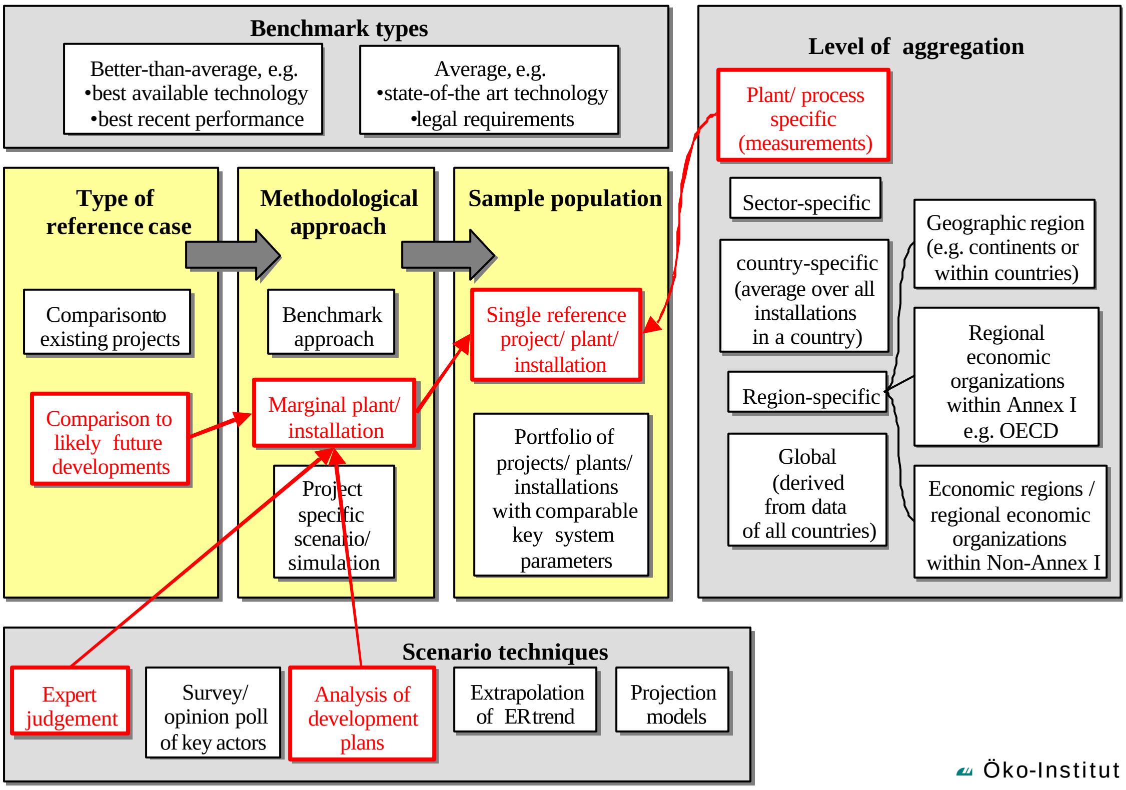
Data that allows the judgement of "marginal", i.e. cost data for all existing plants may not exist or may be difficult to get. If the analysis mainly focus on expert judgement, the choice is not transparent.

*Leakage – electricity imports*

The marginal concept usually does not take into account imports, but imports could easily be included in the concept. For example, also imports could be identified as the electricity the CDM project replaces.

## Baseline F

*Figure 9 Matrix of choices for Baseline F – future marginal approach*




*Description*

**Baseline F** presents the marginal approach in which the project is compared to **future marginal plant**. In this approach, the project's output replaces the output of the future marginal plant.

*Rationale*

The concept behind this approach is that the project's output replaces the output of the marginal plant. At the same time it takes into account timing, i.e. future changes are taken into account. The same definition of "marginal" applies, i.e. the marginal plant is the one with the highest cost per unit of output. The marginal plant concepts considers the additionality at plant level and compares the project with the most likely alternative plant that would deliver electricity in the absence of the project at any future point in time. Energy supply projects developers need to take into account load characteristics of the project and to choose a marginal plant with similar characteristics.[27]

27 A second option for the future marginal plant would be to consider only the new future plant installations. In this case, the definition of the future marginal plant would be inverse, i.e. the alternative new plant with lowest investment costs (therefore the one that is most likely to be realized).

*Data sources and constraints*

Option F was discussed with ZESA during the visit, resulting in the assumption that the most likely marginal plant will be one of the future additions of domestic coal-fired thermal capacity, namely the Hwange 7/8 plants (2 x 300 MW) or the Gokwe North complex (4 x 300 MW) which are to be built in the BAU scenario in the period to 2004. Baseline calculations assumed that one of these coal plants would be the marginal plant. This assumes that the existing older Hwange plants, as well as the smaller refurbished plants in Bulawayo, Harare and Munyati, will be replaced by the new coal plants. Furthermore, imports from South Africa (coal-fired generation), and Mozambique/Zambia (hydro generation) are assumed to be contracted on a “take-or-pay” basis, so that these options are unlikely to be marginal to the overall generation system.

Comparable to baseline E, the emission rate of baseline F is considerably higher than the emission rates of previous approaches as it only includes one coal plant (Table 9).

*Table 9 Baseline F: emission rates for marginal future plants*

| Option | $CO_2$-equiv. | $CO_2$ | $CH_4$ | $N_2O$ |
|---|---|---|---|---|
| | [kg/MWh] | [kg/MWh] | | |
| Hwange 7/8 | 1,067 | 1,054 | 0.024 | 0.039 |
| Gowke | 1,005 | 993 | 0.022 | 0.037 |

Source: SC 1999

*Uncertainties*

In this study the choice of marginal plant was based on expert judgement of the host country's experts. The future marginal approach seems quite arbitrary as cost data for planned projects would be needed as a basis for judgement. Economies in developing countries often face rapid changes and disruptions, and projections of future marginal installations seem to involve great uncertainties. On the other hand, the approach tries to take into account future changes and uncertainties, and is therefore generally more precise than baselines using an emission rate derived from existing plants or installations.

*Transparency*

If the analysis mainly focus on expert judgement, the choice is not transparent. Large amounts of cost data may decrease transparency.

*Leakage – electricity imports*

Electricity imports can easily be taken into account in the analysis as explained above.

### 6.2.1 Summary of results for baseline emission rates

Table 10 and Figure 10 summarize the results from the previous sections.

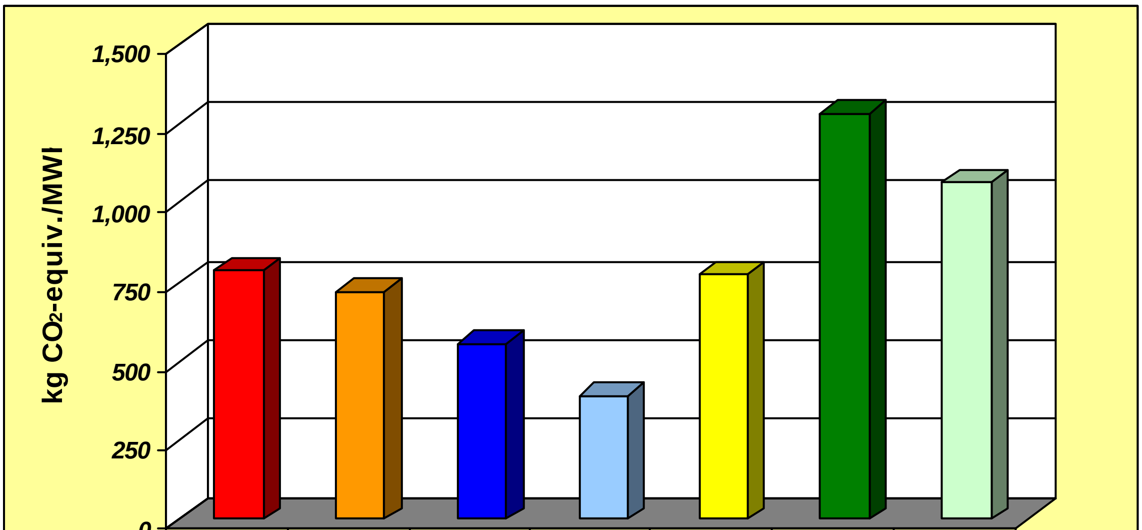
*Table 10 Summary of baseline approaches*

| | Description | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|
| | | Emission rate kg $CO_2$-equiv /MWh | | | | |
| **Baseline A** | Country-specific present fuel mix | 749 | 749 | 749 | 749 | 749 |
| **Baseline B** | Present fuel mix Southern Africa | 723 | 723 | 723 | 723 | 723 |
| **Baseline C1** | 1996 fuel mix OECD | 559 | 559 | 559 | 559 | 559 |
| **Baseline C2** | 1996 fuel mix EU | 391 | 391 | 391 | 391 | 391 |
| **Baseline D** | BAU scenario future fuel mix | 756 | 852 | 840 | 744 | 688 |
| **Baseline E** | Marginal existing plant | 1,286 | 1,286 | 1,286 | 1,286 | 1,286 |
| **Baseline F** | Marginal future | 1,066 | 1,066 | 1,066 | 1,066 | 1,066 |

Source: Öko-Institut

The comparison shows that for the wood waste power plant in Zimbabwe the OECD average fuel mix and the EU average fuel mix are the lowest baseline emission rates of all different approaches. The OECD average is one of the proposals from Parties in the UNFCCC negotiations. For Zimbabwe it would not be favourable to choose this benchmark compared to national or Southern African regional benchmarks. However, for Non-Annex I countries with a high share of renewable energy in the fuel mix (especially hydro) the OECD average would be more favourable than the country-specific benchmark. If the choice of the level of aggregation is left to the Parties participating in the CDM, they will opt for the most favourable benchmark, in some cases using the OECD average in other cases a national average. This will result in rather arbitrary calculations of the baseline emission rate. If policy makers do not take decisions with regard to the level of aggregation for benchmarks, they will opt for the principle "pick the most favourable emission rate you can find trying all possible aggregations". Policy makers could decide that a comparable approach for comparable projects in different countries should be applied by all Parties. The selection should be based on the rationale of the different levels of aggregation and consistency with the requirement of Article 12.5 (the project should be additional to any that would occur in the absence of the certified project activity). The level of aggregation of benchmarks should be related to the level at which direct effects of the CDM project occur. Otherwise it seems doubtful that the benchmark is consistent with Article 12.5.

*Figure 10 Options for baseline emission rates for electricity generation in Zimbabwe*




| A (Country fuel mix) | B (Southern African mix) | C1 (OECD mix) | C2 (EU mix) | D (BAU scenario mix) | E (marginal 1997 plant) | F (marginal future plant) |
|---|---|---|---|---|---|---|
| 787 | 723 | 559 | 391 | 776 | 1,286 | 1,067 |

Source: Öko-Institut

The highest amount of emission reductions would result from the approach using the marginal present plant as reference case. The lowest and highest estimates of the baseline emission rate differ by the factor of 3.3; this means that for the wood waste power plants in Zimbabwe this approach would lead to certified emissions reductions 3.3 times higher than the EU benchmark. Compared with the BAU scenario approach it delivers emissions reductions 165% higher. If the Parties are allowed to choose between the marginal plant approach and a country-specific benchmark or a scenario approach projecting the future fuel mix, they will always opt for the marginal approach if fossil technology with high emission rates would qualify as marginal. For project validators and certifiers the marginal approach will be difficult to verify, as the choice will be based mainly on expert judgement and cost data. Both types of information are difficult to assess with regard to their reliability. Thus the potential for gaming seems to be higher with this approach than with others.

The BAU scenario (Baseline D) is probably one of the approaches most consistent with the terms of the Kyoto Protocol, as it represents the development of the sector without the project and takes into account future changes. Additionality in the future is likely to be guaranteed as well as at present. Even if the assumptions used for the BAU scenario approach involve uncertainties, the overall uncertainty of the baseline estimate will be considerably lower than in the baselines that take no account of future developments whatsoever . The approach is less transparent and less simple than previous ones. Many assumptions and data are used in constructing BAU scenarios, and assessment of the scenarios may be difficult. In the case of Zimbabwe this approach was not more complicated because different scenarios had recently been constructed by ZESA.

The comparison shows that a ranking of different approaches is difficult, as the baseline approaches are based on different rationales. For example, the marginal plant approach and the BAU scenario approach are different concepts of addressing the situation without the project. In theory both concepts represent a valid way of assessment. Ranking of these two options is a difficult task.

The criteria of additionality to any that would occur in the absence of the certified project activity is in favour of approaches that take into account future developments, such as the future marginal approach or the BAU scenario. The "absence of the certified project activity" is a dynamic situation which cannot be properly assessed with an emission rate reflecting only the situation before the start of the project. A high degree of consistency with the terms of the Protocol would imply preferences to the use of baselines approaches that take into account future developments. The other possibility would be to use a fixed emission rate as a benchmark over a certain period of time, and to update it regularly. This would be even more precise than the BAU scenario, but would increase uncertainties for the project developer. This shows that the ranking of baseline approaches is closely connected to any general decision on the revision and updating of baseline emission rates during the project's lifetime.

The possible choices of baselines often depend on the data availability in a specific country. In Zimbabwe reliable projection data and actual data were available in the form of results from other recently-completed projects. Other data, for example disaggregated historical energy data was more difficult to obtain. Project developers may need a certain degree of flexibility of baseline approaches to take into account the specific data availability.

## 6.3 Cross-cutting issues for baseline setting

There are several aspects that need to be considered in the future baseline discussion:

### 6.3.1 Electricity imports

Currently about 45% of Zimbabwe's electricity requirements are supplied by electricity imports from South Africa and Mozambique (ZPC and FC 1999, p.4 , Government of Zimbabwe 1999, p.8). The country participates in the South African Power Pool, a distribution network of nine African countries. At the regional level and in the medium term there is a surplus of generating capacity, in particular in Mozambique, Zambia (hydro) and South Africa (coal thermal), and other countries face capacity deficiencies similar to those in Zimbabwe. The import contracts for electricity will expire in the year 2003. Considering the high actual share of imports in Zimbabwe, future emissions from power production will depend greatly on the amounts of imports. As long as no new contracts exist, it will be difficult to project the future situation.

It is not clear how the situation of electricity imports should be dealt with in baseline calculations. For the purpose of simplicity, in baseline A (country-specific fuel mix) the country-specific fuel mix was calculated based on data of domestic generation, neglecting the role of imports. In the view of the CDM host country, it might be interesting to account only for domestic emissions. As the effects on power generation in other Non-Annex I countries are not accounted for in this approach, the omission of imports would result in "leakage" from energy projects. This problem of electricity imports is relevant in (electrically) integrated regions. Accounting for, or not accounting for imports could considerably change the emission rates estimated in a business-as-usual scenario. The inclusion of imports in scenarios would be difficult and expensive. Imports are not relevant for benchmark approaches at a higher level of aggregation (e.g. Southern African regional fuel mix). For the marginal plant approach, imports – if they are relevant – should be taken into consideration as one possibility of marginal power supply.

### 6.3.2 Life-cycle emissions

The EM model[28] used for the calculations is able to perform calculations with and without life-cycle emissions; for example, the model can estimate upstream fuel-cycle emissions. The data presented in previous sections do not take into account upstream emissions. Both types of calculations have been performed for five baselines. Figure 11 and Table 11 present the results. For the wood waste power plant example the inclusion of life-cycle emissions would add about 4-5% to baseline emission rates. Upstream emissions mainly result from the extraction and transport of fossil fuels. At the project level, life-cycle emissions are not relevant as no fertilizer is used for timber production and as the residues accrue at the sawmill site from timber processing.

The issue of upstream emissions could occur in many project types: for instance in fuel-switching projects, where coal may be connected to lower upstream emissions (e.g. coal from South Africa open mines) compared to gas (imported from Russia), or in biomass projects, where considerable energy input may be used for fertilization and the transport of fuel.

Within the framework of the UNFCCC (e.g. guidelines for greenhouse gas inventories) a scheme of accounting is used, that is based on the territorial principle.[29] Emissions are accounted for at the source in the countries where they occur. The country of consumption of an output (e.g. electricity) is not taken into account. For consistency within the Convention and the Protocol it would be preferable to use comparable accounting rules for the CDM, which would mean not accounting for upstream emissions for the project and in the baseline.

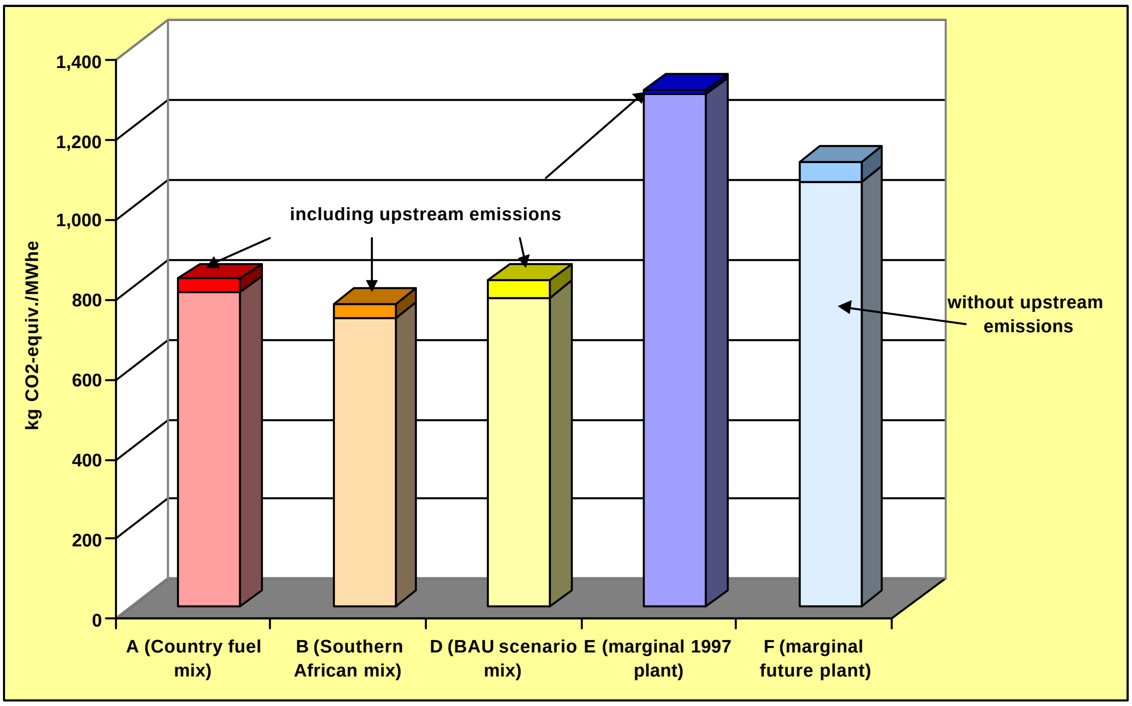
Apart from this general principle several other reasons exist for not accounting for life-cycle emissions in baselines and projects. If upstream emissions occur in Annex I Parties, they are accounted for in Annex I greenhouse gas inventories. Upstream

[28] For description of the EM model see footnote 5

[29] With some exceptions regarding the new Kyoto gases.

emission of CDM projects only then become relevant if they occur in Non-Annex I Parties. If life-cycle emissions would be taken into account in the CDM project, they would need to be tracked to the country of origin, and project developers would need to check if this country belonged to Annex I or Non-Annex I. No default factors or data for upstream emissions could be used to avoid double counting with Annex I greenhouse gas inventories.

*Figure 11 Baseline emission rates including life-cycle emissions*




Source: Öko-Institut

*Table 11 Baseline emission rates including life-cycle emissions*

| | emission rate kg $CO_2$-equiv./MWh | |
|---|---|---|
| | Without upstream emissions | Including upstream emissions |
| Baseline A (Country fuel mix) | 787 | 822 |
| Baseline B (Southern African mix) | 723 | 757 |
| Baseline D (BAU scenario mix) | 776 | 820 |
| Baseline E (marginal 1997 plant) | 1,286 | 1,297 |
| Baseline F (marginal future plant) | 1,067 | 1,114 |

Source: Öko-Institut

In addition, reliable data with low uncertainties for upstream emissions do not exist in many cases. Generic data have been developed by Öko-Institut for GEMIS- and EM-models but these data often represent upstream emissions for Annex I Parties. Data availability would be a serious problem for project developers.

Project developers should check the project and baselines with regard to effects on upstream emissions and report possible effects and changes in a qualitative way. But it seems preferable that life-cycle emission should not be included in the baseline estimate.

### 6.3.3 Impact of CDM projects on the national baseline in small countries

In small countries large energy generation projects could have considerable impacts on the total national greenhouse gas emissions. The establishment of a baseline for such a project will be very difficult as national circumstances would be completely changed with regard to actual conditions. The projection of the economic effects of such a project will turn out to be extremely speculative, as basic indicators will be changed with the implementation of a single project. Large CDM projects, with regard to their effect on emission reduction, may also change baselines for other CDM projects considerably. This is not the case for the wood waste cogeneration projects considered in this study, but should be taken into account in the general discussions on CDM baselines.

Revisions of baseline emission rates during the crediting time are problematic in the case of CDM projects with large impacts. For example, if a single CDM project in the electricity generation sector changes the national fuel mix considerably, revisions of the baseline emission rate would lead to the further effect, that the CDM project would need to take into account its own project effects as baseline, resulting in non-additionality. Such cases may be relevant in small Non-Annex I countries that have often installed low electricity generation capacities.

### 6.3.4 Dynamic versus static baselines

As explained earlier the terms dynamic and static baselines are used in this report for baseline emission rates with periodic revision (dynamic) and for baseline emission rates without revision (static). Simple recommendations for dynamic or static are not possible, as these issues are closely linked to other rules and procedures for baseline setting. The aim of revisions of baseline emission rates is the reduction of deviation between estimated baseline emission rates and the real future development of emission rates.

Many approaches address the same aim as revisions. For example, a short crediting period would also lead to decreasing uncertainties concerning baseline emission rates. Baseline approaches based on scenario techniques (e.g. working with different techniques) may result in baseline emission rates close to the real development, whereas benchmarks based on present data may differ largely from reality the longer the crediting period is. If revisions are needed to limit uncertainties and to ensure some linkage to real development, it is important what kind of decisions will be taken on baseline methodologies and crediting period.

# 7 Emission reductions from wood waste power plants

For the wood waste plant project it can be assumed that no $CO_2$ emissions occur with the electricity generation. $CO_2$ emitted from the wood waste plants was sequestered before by sawmill timber plantations. Related to national greenhouse gas inventories, IPCC guidelines recommend that net release of carbon from biomass energy use should be taken into account if the total carbon embodied in standing biomass (e.g. forests) is declining in the long term. As sustainable management practices are applied (see section 4.1.3), such long-term decline seems not to be evident for the project.

However, non $CO_2$ emissions - $CH_4$ and $N_2O$ – need to be accounted for as project emissions. Emission factors for $CH_4$ and $N_2O$ from Environmental Manual (EM) database for wood waste power plants of similar capacity have been used for this calculation.[30] The emission rate regarding non-$CO_2$ greenhouse gases was estimated to be 0.006 kg $CO_2$-equiv./MWh.

Table 12 provides the calculation of emission reductions that result from the wood waste power plant projects in Zimbabwe for three different baseline options (C1 = OECD benchmark, D = BAU scenario, E = present marginal) and for three different levels of output. The medium activity level represent the assumptions on future output of the feasibility studies for the project. Availability[31] of the wood waste power plant of 3.5 MWe was assumed to be 60 % resulting in an annual production of about 18,400 MWh. German plant constructors familiar with the project assumed that availability could be as high as 85 %. The high activity level estimate was based on this assumption. In addition a worst case scenario was calculated assuming a very low availability of 50 %.

*Table 12 Emission reductions for different activity levels of wood waste power plants*

| Activity level | | Baseline C1 | Baseline D | Baseline E |
|---|---|---|---|---|
| | MWh/year | kt CO2-equiv./year | | |
| **low activity level** | 15,330 | 8.57 | 13.01 | 19.76 |
| **medium activity level** | 18,396 | 10.28 | 15.64 | 23.74 |
| **high activity level** | 26,061 | 14.57 | 22.21 | 33.68 |

Source: Öko-Institut

The comparison in Table 12 shows that for the wood waste power plants the possible changes in output, that may occur when the project operates, are less important with regard to the certified emission reductions that can be achieved than the choice of the baseline emission rate. Emission reductions for the lowest activity level differ by a fac-

[30] Emission rate for $CH_4$: 34.59 kg/TJ and for $N_2O$: 3.458 kg/TJ

[31] Availability includes the sum of operation time and the stand-by availability time.

tor of 1.7 from those at the highest level. However, between the low and high options for baseline emission rates the difference is a factor of 2.3.

For the following calculations of emission reductions for all different baselines the medium activity level, that is the output with 60% availability, was used. Table 13 shows the emission reductions depending on the baseline option chosen. The annual emission reductions that can be achieved by the wood waste power plant range from 7 to 24 kt of $CO_2$-equiv. per year. For the first commitment period (assuming the project would start in 2000) a total emission reduction from 92 to 309 kt $CO_2$-equiv. could be obtained.

*Table 13 Emission reductions for different options of baseline emission rate for wood waste power plants in Zimbabwe*

| | | **emission reductions** | |
|---|---|---|---|
| | | kt CO2-equiv./year | kt CO2-equiv./2000-2012 |
| **Baseline A** | BM country-specific | 15.00 | 195.03 |
| **Baseline B** | BM Southern Africa | 13.82 | 179.63 |
| **Baseline C1** | BM OECD | 10.16 | 132.14 |
| **Baseline C2** | BM EU | 7.07 | 91.96 |
| **Baseline D** | BAU scenario | 15.64 | 203.32 |
| **Baseline E** | marginal present | 23.74 | 308.63 |
| **Baseline F** | marginal future | 20.38 | 264.95 |

Source: Öko-Institut

# 8 Economic value of emission reductions

The economic value of the certified emission reductions from the CDM project will depend on the price the investor can achieve on the market for greenhouse gas emission reductions. The markets for GHG offsets are just emerging, and no experience exist with CER trading. It is unclear how the market will develop and what prices CERs may achieve; experimentation and speculation dominate the present situation.

Literature provides differing estimates with regard to the future market price. Yamin (1998) quotes Haites, that more recent information suggests prices ranging from less than US$ 1 to about US$ 3 per ton $CO_2$ although some higher estimates such as the one of US$ 18-23 per ton is used by the US Council of Economic Advisors. For Hassing and Mendis (1998) the range of values for GHG offsets extends from less than US$ 1 per ton of carbon (0.27 US$/t $CO_2$) to over US$ 50 per ton (13.5 US$/t $CO_2$). BP's preliminary internal market price in the company-wide trading scheme is US$ 20 per ton $CO_2$. The internal trading price within BP Amoco is derived from the pilot phase where only 12 business units participated, and the price is expected to change when the trading scheme will be extended to all 140 business units of BP Amoco (Knoedel and Glocker, BP Germany, personal communication).

For this study several price scenarios have been calculated with prices for CERs of 1 US$/t $CO_2$-equiv., 10 US$/t $CO_2$-equiv. and 20 US$/ t $CO_2$-equiv., taking the BP internal offset price as an upper price limit. The price level of 1 US$/ t/$CO_2$ reflects the estimates in the lowest range.

*Table 14 Economic value of CERs from wood waste power plants for different price assumptions*

| Period | | one year | | | 2000 - 2012 | | |
|---|---|---|---|---|---|---|---|
| **Price of CER in US$ per t CO2-equiv.** | | **1** | **10** | **20** | **1** | **10** | **20** |
| | | - 1000 US$ - | | | | | |
| **Baseline A** | BM country-specific | 14 | 144 | 287 | 187 | 1866 | 3731 |
| **Baseline B** | BM Southern Africa | 13 | 132 | 264 | 171 | 1714 | 3427 |
| **Baseline C1** | BM OECD | 10 | 102 | 203 | 132 | 1321 | 2643 |
| **Baseline C2** | BM EU | 7 | 71 | 141 | 92 | 920 | 1839 |
| **Baseline D** | BAU scenario | 15 | 150 | 300 | 195 | 1947 | 3895 |
| **Baseline E** | marginal present | 24 | 235 | 471 | 306 | 3060 | 6120 |
| **Baseline F** | marginal future | 20 | 195 | 390 | 254 | 2536 | 5071 |

Source: Öko-Institut

Table 14 presents the economic value of CERs dependent on the CER price. Calculations have been performed for the annual benefit as well as for the total benefit during the first commitment period. After the first commitment period, future development of the CDM and the market price of CERs will depend on the future commitments of Annex I Parties. Any assumptions on commitments of Annex I Parties are pure speculation, therefore calculations have only been performed for the first commitment period even if project lifetime may extend longer.

A low value of CERs would result in an annual benefit from CERs of US$ 7,000 to

US$ 24,000 accumulating to US$ 92,000 to US$ 306,000 during the first commitment period. BP Amoco's offset price of 20 US$/t $CO_2$-equiv. would lead to a benefit ranging from US$ 141,000 to US$ 471,000 annually (US$ 1.8 milion to 6.1 million for 2000-2012). This calculation clearly indicates the enormous pressure from investors and host countries in the direction of high baseline emission rates. For the high CER price a maximum difference in economic benefit of US$ 4.4 million occurs during the first commitment period between the lowest baseline and the highest one. And this report analyses a rather small project.

The second message from Table 14 is the simple fact that the market price of CERs is clearly the most important factor influencing the investor's decision to participate in the project. The market price will be related to the price of parts of assigned amount[32] traded under the international emission trading system. If traded "hot air" inflates the price for $CO_2$ reductions, the incentive for investors to implement CDM projects will be small.

## 8.1 Crediting time

The total amount of emission credits for the projects will mainly depend on the time during which credits are allowed to accrue. Thus, to maximise emission credits it would be the best to choose the longest lifetime possible. At the moment, no guidance with regard to the definition of crediting time[33] is available. AIJ projects had widely differing crediting times, even for similar project types (Ellis 1999).

Several approaches for crediting timeline can be chosen:

1. The **technical lifetime** of the project. Data for the technical lifetime could be gathered from plant manufacturers, but it is uncertain if this information will be valid for conditions in Zimbabwe, as technical lifetime depends on maintenance, climatic influences etc.. Technical sources estimate lifetime of biomass plants at 10-20 years (Marutzky 1999). For financial calculations Flaig (1998) uses 15 years for biomass plants, while Obernberger and Hammerschmid (1999) give 20 years for technical lifetime for biomass cogeneration plants. An estimate of 15 years for the technical lifetime of wood waste power plants in Zimbabwe seems to be a realistic choice.
2. The **commercial lifetime**, that is the period of depreciation of power plant projects. The problem for the projects in Zimbabwe is that the depreciation period is negotiated between government and project investors, and there is no information available concerning realistic periods. If commercial lifetime should be used to define the crediting period of the project, depreciation periods need to be standardized. For the wood waste power plants a period of 5 years may be an appropriate estimate for the depreciation period.

32 Parts of assigned amount (PAA) may be the trading unit under the Protocol as proposed by some Parties

33 crediting time = period in which CDM credits accrue

3. The **pay-back time of loans** used for a project. No commercial loans for the projects would be available in Zimbabwe, thus the approach of regarding the pay back time as crediting period does not work for the project under consideration .

Ellis and Bosi (1999) discussed standards for project lifetimes, for example numerical limits for different project categories. This approach seems useful as the definition of the crediting time is highly arbitrary. The Dutch government used standardised crediting periods for different project types during the AIJ pilot phase.

## 8.2 Financial benefit from Certified Emission Reductions

Investors for the wood waste power plant project are lacking. According to the feasibility studies the joint venture for the project should comprise three partners: the ZPC, the Wattle Company in the case of the Nyanga plant, the Forestry Commission in the case of the Chimanimani plant, and an unknown third investor.

ZPC, Wattle Company and the Forestry Commission are willing to operate the plants. Wattle and the Forestry Commission will also provide the site for the plant and provide guaranteed fuel delivery, whereas the joint venture will provide steam to Wattle Company or the Forestry Commission in the case of realization of the cogeneration plants. Furthermore ZPC will provide a share of 30 % of the equity. Wattle Company and the Forestry Commission will not contribute equity. They will contribute to the joint venture in kind (site, building etc.). Another investor would have to contribute 70 % of the projected equity.

CERs from the project could considerable increase the attractiveness of the wood waste power plant project to foreign investors. A private investor from Annex I Parties could either use CERs for compliance with domestic commitments (if his government imposed quantitative commitments at a national level) or trade the CERs on the offset market.

CERs will be generated during the whole crediting period agreed for the project. To asses the present value of the CERs that will be generated in the future, the value has to be discounted.[34] For the project in Zimbabwe a static discount rate of 12.5 % was assumed. The discount rate equals the assumed interest rate for the commercial loan for the project.[35] Taking into account the discount rate, a crediting period of 15 years and CER values of 1, 10 and 20 US$/t $CO_2$, the Net Present Value (NPV) of the different baseline options has been calculated (Table 15).

[34] Payments in the future do have a lower value at present. To make future payments comparable to present values methods of financial mathematics like the concept of Net Present Value (NPV) could be applied. According to this concept all future payments are discounted by a discount rate to make the various options comparable to each other.

[35] Basler und Partner (1999, p. 39) assume a discount rate of 12 % for the evaluation of a quite similar CDM project in Slovakia.

*Table 15 Sensitivity of the Net Present Value of Certified Emission Reductions*

| **Price of CER in US$ per t CO2-equiv.** | **1** | **10** | **20** |
|---|---|---|---|
| | | - 1000 $US\$_{1999}$ - | |
| Baseline A - BM country-specific | 95 | 952 | 1904 |
| Baseline B - BM Southern Africa | 87 | 874 | 1749 |
| Baseline C1 - BM OECD | 67 | 674 | 1348 |
| Baseline C2 - BM EU | 47 | 469 | 938 |
| Baseline D - BAU scenario | 99 | 994 | 1987 |
| Baseline E - marginal present | 156 | 1561 | 3123 |
| Baseline F - marginal future | 129 | 1294 | 2587 |

Source: Öko-Institut

For the wood waste power plant the NPV varies from US$ 45,000 to US$ 3.1 million. The latter result is equivalent to 67 times the first result. The additional contribution of CERs to the financing of the overall investment would be lower than 1 % if the EU benchmark is used and the price of CERs is low. With CER prices of US$ 20 per ton of $CO_2$ and baseline E, the benefit from CERs would contribute 58 % to the financing of investment in the project. If assumed that a foreign investor will provide the lacking capital (70 % of the equity ) and that all CERs are transferred to this investor, the value he gets from CERs is 8 US$/t $CO_2$ for the highest baseline emission rate and 26 US$/t $CO_2$ for the lowest baseline.

Although the range of the potential NPV of CER created in the project it still very broad, analysis shows that CERs could contribute significantly to the overall attractiveness of the project. However, this potential could only be achieved if the sound economic feasibility of the overall project, including the value of the CER, is conveyed to potential foreign investors. The attractiveness to foreign investors will also depend on the sharing of credits that will have to be agreed between the host country and the investor.[36]

[36] Discussion on credit sharing is provided in Michaelowa et al., 1999a

## 9 Behavioural additionality

Section 6 describes methods and decisions in selecting the appropriate baseline. Behavioural aspects of project additionality, especially free riders, are not addressed. The different approaches outlined do not answer the question whether the project would have been implemented in the same way without the CDM incentive. The requirement of additionality of emission reductions to any that would occur in the absence of the certified project activity in Article 12.5 of the Kyoto Protocol seem to require an analysis of investors' behaviour in the absence of CDM credits. Whereas Article 12.5 of the Protocol directly leads to the question "Would the investment occur without the revenue from CDM carbon credits?", it does not address the timing of this occurrence. The circumstances of the investment may not lead to the implementation at present, but probably at some time in the near future.

This issue has been addressed under the term of financial additionality (see for example Michaelowa et al. 1999b) in the past, as financial criteria and indicators such as the rate of return on investment are used to describe the behaviour of investors in a reliable way. Meyers (1999) proposed "behavioural additionality" as a better term. This proposal is adopted in this report as the behaviour of investors is the key issue of analysis. With his new term Meyers automatically includes other aspects of investors' behaviour besides financial criteria, such as barriers to investment.

Several Parties see the need for behavioural additionality as eligibility criteria for CDM projects in their submissions to the UNFCCC secretariat. In their view projects need to be additional to commercial-viable investment[37], thus financially profitable projects are excluded as non-additional.

Financial attractiveness is an indicator to judge the probability of investments. If a project clearly is not financially attractive it can be assumed that it would not have happened without incentives from CDM. The closer an investment comes to financial attractiveness, the more difficult it becomes to judge whether the investment would take place without CDM credits.

Different methodological approaches exist to judge financial attractiveness. One method is the comparison of the internal rate of return on investment capital (ROI) with a target rate of return the investor requires for this project type. If the project does not achieve the rate of return the investor requires under the circumstances of the project, it is not profitable. This approach requires a default rate of return, which often does not exist. Companies have different default ROIs for different types of projects and requirements may differ across companies. For example, RWE – one of the major German energy companies - uses target ROIs from 9% to 20% for different business branches (RWE 1999). In markets with high risks, as is the case with Zimbabwe, it is even more difficult to get information on default rates of return used by investors.

[37] submissions of EU, G77 and China, Costa Rica and Republic of Korea

Another method to analyse financial attractiveness is the incremental cost approach. For this approach the net present value (NPV) of the wood waste power project would need to be compared with the NPV of a baseline project, more precisely the NPV of the baseline needs to be subtracted from the NPV of the project[38]. If the resulting incremental costs are negative, the project achieves a financial benefit compared with the baseline and would not qualify as additional. Chomitz (1998) discusses the application of behavioural models to predict whether the proposed project would have been spontaneously undertaken in preference to the baseline project.

These methodological approaches are equivalent to some of the approaches discussed under environmental additionality. In the benchmark approach for environmental additionality, no specific baseline project is defined. Therefore the incremental cost approach would not be consistent with the chosen concept. The corresponding method for assessment of behavioural additionality for these approaches would be comparison with a target rate of return, which could also be viewed as a benchmark approach.

However, the marginal plant approach defines a specific baseline project. In this case the same baseline project can be used to assess behavioural additionality with the incremental cost approach. But this approach also allows the use of a benchmark for the assessment of financial attractiveness. Thus, the marginal plant approach is consistent with both methods used for financial attractiveness, whereas the benchmark approach has more rigid consequences for the possible methods of assessing behavioural attractiveness.

This leads to a clearer differentiation between "project-specific" baseline approaches and other baseline approaches. Taking into account the methods and results discussed in this report, the *project-specific approach* uses a specific baseline (marginal) project. Emission reductions as well as financial attractiveness are compared between two different specific projects. Such an approach has been applied for Swiss AIJ projects (Basler und Partner 1999). Both approaches are considerably different methodologically, as well as with regard to information and data requirements and uncertainties compared to baseline approaches using aggregated data (either benchmarks or simulations). Figure 12 summarizes the key differences.

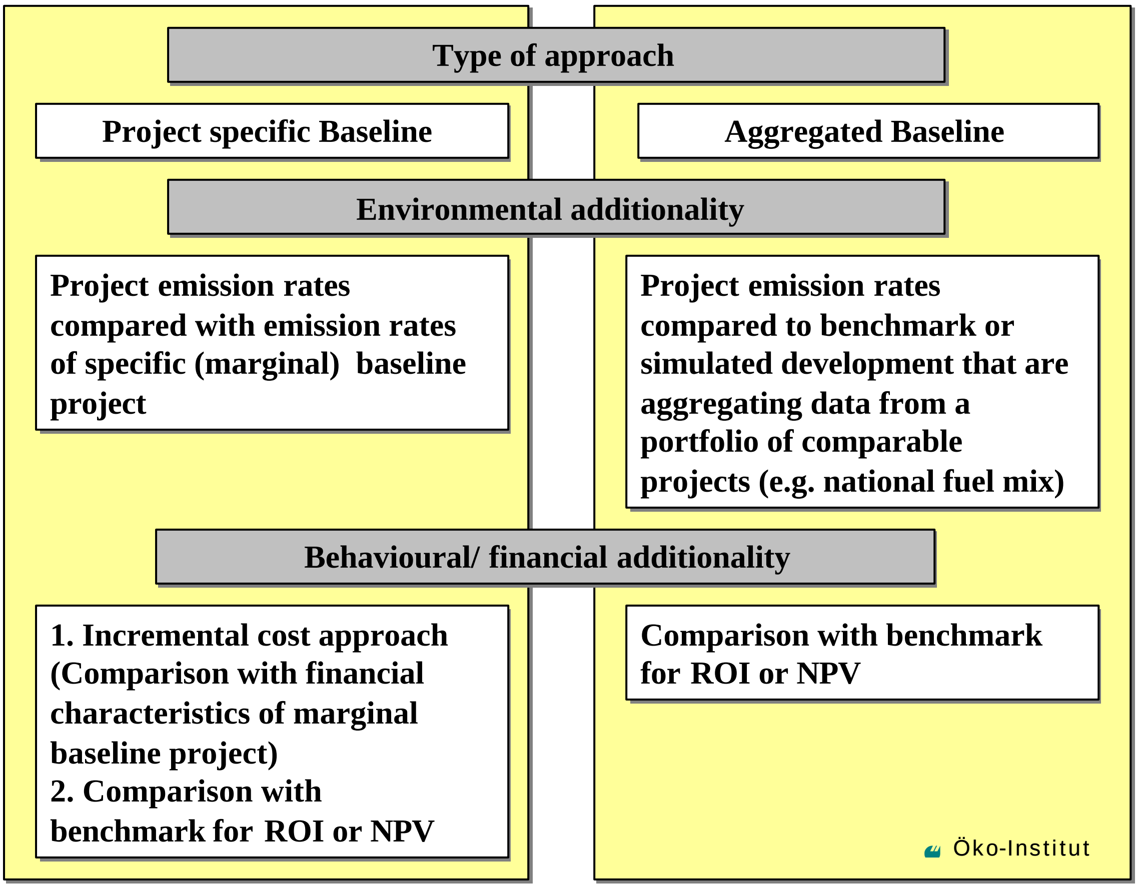
It is important to note that the incremental cost approach has consequences for the possible choices of environmental baselines. For this approach a specific baseline project is needed to compare financial data. For reasons of consistency the same baseline project should be used for the analysis of environmental additionality. Therefore, all other possible aggregated baseline approaches are excluded as not consistent with the decision in favour of the incremental cost approach.

For the wood waste power plant in Zimbabwe we tried to use both approaches to assess the financial attractiveness of the project. The equity rate of return on investment of the wood waste power plant project (without CDM) was estimated to be about 6% (ZPC

[38] Instead of NVP, ROI could also be used for comparison between the two projects.

1999)[39]. This ROI would not qualify as a financially attractive project, even if no information on target ROI of investors is available for Zimbabwe in the energy sector. The ROI is lower than the usual target ROIs used in Annex I countries, and it can be assumed that financial risks in developing countries would lead to stronger requirements with regard to financial attractiveness.

*Figure 12 Characterization of different baseline approaches with regard to environmental and behavioural additionality*




The analysis becomes more difficult if future developments are taken into account. Profitability of the project largely depends on ZESA's future electricity tariffs. With the present tariff structure, ZESA is not able to meet its operational costs. The accumulated deficit on current operations presently stands at around US$ 115 million (Government of Zimbabwe 1999, p. 37). Especially the electricity imports from South Africa and Mozambique that are paid in US$ threaten the solvency of ZESA (Government of Zimbabwe 1999, p.8). Inadequate reserve margins and lack of investment in transmission and distribution have followed the pressing economic situation of ZESA. Despite the costs for ZESA the government has limited tariff increases in order to reduce the impact

39 More detailed information with regard to the financial parameters of the project is contained in part II of the report.

on overall national inflation. This shows that Zimbabwe's economy is facing a severe macro-economic crisis. Reforms and drastic changes, especially with regard to privatization in the energy sector, are likely in this situation. If such changes occur, the project may become financially attractive.

The incremental cost approach requires a comparison of NPV with the NPV of a specific baseline project[40]. The question for the baseline project is: If the wood waste power plant is not installed, which other project will the investor implement? In the special case of the wood waste power plant the results of the incremental cost approach depend on the perspectives of the different project participants:

First, the perspective of one of the investors and project developers – Zimbabwe Power Company – is described. For ZPC the question is which alternative investment in power generation would take place. Two different approaches can be chosen. One assessing the least-cost-marginal plant at the national level (baseline F), the other possibility would be to consider ZPC's development plants and to select a realistic option for alternative investment. Apart from the wood waste power plant projects, the ZPC development plan (ZPC 1999) contains only small hydro plants taking into account of comparable size, costs and load characteristics. If a small hydro project is chosen as the financial baseline project, environmental additionality would also need to be assessed for this project in addition to the baseline options already calculated. It can be assumed that no emission reductions would occur in this case, as the hydro plant does not emit $CO_2$.[41] This approach would lead to the conclusion that the wood waste power plants would not create certified emission reductions.[42]

From the perspective of Wattle Company and Forestry Commission, the owners of timber plantations and sawmills and participants in the project joint venture, the situation looks different. They would not invest in any other power generation project at all, because their interest is not an increase of power capacity in Zimbabwe, but to achieve economic benefits from wood waste residues. The baseline project would be "no project" or the construction of a chipboard factory using the residues. This would provide different results with regard to financial additionality. This shows that the incremental cost approach – even if it uses a fairly simple concept – in special situations can become complicated in project reality when different participants are involved.

In addition, the wood waste power plant example shows that the two possible approaches (benchmark and incremental costs)[43] to assessing financial attractiveness provide valid answers to the same question, but the answers could be contradictory. It is difficult to find arguments that clearly rank one approach above the other.

40 ROI could also be used for comparison.

41 The hydro plant may emit $CH_4$ and $N_2O$ in considerable quantities depending on the specific circumstances.

42 It is not possible to apply the incremental cost approach, as cost data for other projects are not available.

43 There may be other approaches not covered in this report

The problems outlined in this section might lead to the consequence that the question "Would the investment occur without the revenue from CDM carbon credits?" should be addressed in a qualitative way by project developers if more precise methods cannot be applied.

## 10 Financial (source) additionality

Financial additionality has also been interpreted with regard to the sources of project funding: Project funding under the CDM in this interpretation should be additional to funding provided through official development assistance (ODA), the Global Environment Facility (GEF) and other financial commitments of the Parties included in Annex I[44]. As project investors are not yet available in this project phase, the project funding cannot be assessed against this criterion. The financing plan in the feasibility study of Chimanimani Plant considers GTZ, GEF, or UNDP as possible sources of grant financing of the project. If this would be the case, it is likely that the project cannot comply with the criterion of additionality to ODA and GEF funds.

For the Prototype Carbon Fund (PCF) the World Bank operationalized the criterion of financial additionality with regard to funding alternatives (World Bank 1999). Projects of the PCF should be designed to be complementary with the goals of the GEF. At present the GEF supports both short-term response measures and long-term operational programmes in the climate change focal area. Two of these long-term operational programmes deal with removal of barriers for the implementation of efficient technologies and for renewable energy technologies, while the third operational programme focuses on the reduction of long-term costs of low greenhouse gas emitting technologies. Once a prospective project for the Fund's pipeline has been identified the Project will first be reviewed by the Secretariat of the GEF to determine its GEF eligibility. Only if it is determined that the Project will not receive GEF financing, will it be considered for financing by the PCF.

[44] Decision 5/CP.1 "Activities implemented jointly under the pilot phase" requires that the financing of activities implemented jointly shall be additional to the financial obligations of Parties [...] as well as to current official development assistance (ODA) flows (UNFCCC1995), see also submission of India and Republic of Korea on CDM

## 11 Monitoring and reporting of emission reductions

Systematic and periodic monitoring should be part of the project design when it is developed as a CDM project. In their submissions to UNFCCC some Parties request the establishment of a monitoring plan. For the World Bank's Carbon Fund project-specific Monitoring and Verification Protocols (MVP)s have been developed (Heister 1999).

The IEA/ UNEP Workshop on CDM in Africa concluded (IEA/ UNEP 1998) with regard to monitoring, verification and certification, that sustainable development objectives should be incorporated in the processes of monitoring, verification and certification. At the same workshop participants were concerned with the lack of competence to carry out these activities in African countries. This was seen as an important capacity building objective in relation to the CDM in Africa.

Monitoring will be relatively easy in this project as emission reductions depend on the generated electricity in MWh, therefore actual energy generation has to be monitored, but it can be assumed that this will be the case (as the electricity is sold to ZESA) and that the monitoring of greenhouse gas emission reductions will not be difficult.

Environmental impact assessment already requires the monitoring of important environmental and social effects of the sawmills, and monitoring data will automatically include the wood waste power plants. Further monitoring requirements have already been established for the management of timber plantations.

As explained in previous chapters, the project will lead to a considerable decrease in other pollutants as uncontrolled burning in beehive incinerators will stop. Therefore it does not seem to be necessary to monitor additional pollutants.

## 12 Investors for CDM projects

No foreign investor is available at present for the wood waste residue power plants. The implementation of the power plant projects as CDM projects may provide additional incentives for investors, because they will receive certified emission reductions from the project activities. Nevertheless it would be necessary to contact potentially-interested companies and institutions. The search for investors goes beyond the scope of this project, but some information should be provided with regard to possibilities that could be further explored.

Several companies participated in biomass cogeneration projects under the AIJ pilot phase. The partners involved in these projects could also be interesting partners for the Zimbabwe plants. A list with contact details of the relevant AIJ project partners was provided with the interim report.

The World Bank has initiated the global carbon fund for projects that aim to reduce greenhouse gas emissions (World Bank 1999). Specific Project Portfolio Criteria have been developed that include the following elements:

1) A broad balance will be achieved in the number of projects undertaken in EITs and in developing countries and that, considering potential projects identified prior to the establishment of the Fund, emphasis should be directed initially at the development of projects in developing countries;

2) A major emphasis should be directed at the development of projects in the area of renewable energy technology, such as - but not limited to - geothermal, wind, solar and small-scale hydro energy projects;

3) No less than approximately 2 % nor more than approximately 10 % of the Fund's assets should be invested in any one project;

4) No more than approximately 20 % of the Fund's assets should be invested in projects in the same host country;

6) No more than approximately 25 % of the Fund's assets should be invested in Projects using the same technology.

The wood waste power plant project complies with all criteria, thus the Prototype Carbon Fund could be a possible source of finance in addition to private investors.

### 12.1 Activities in Zimbabwe

To develop the prospective projects further, it is suggested that a joint MOTE/MET Stakeholder Workshop should be organized in either Harare or Mutare. In this workshop the results from this study, as well as the revised feasibility studies, should be presented, and the input from Zimbabwe's government to the CDM should be made available also. It would be necessary to secure participation of possible CDM “funders” (e.g. foreign investors or their representatives)

To support the private sector involvement (from in- and outside of Zimbabwe) under a CDM scheme the Government of Zimbabwe (GoZ) should clarify and actively communicate its position towards such CDM projects, and in so doing might be willing to

- agree on a list of relevant criteria to assess the sustainability of CDM options from a national perspective (if possible, broken down by sectors);
- agree on a list of national indicators for these criteria (if possibly, simple checks – if quantified: including thresholds);
- discuss and agree on a position regarding the distribution of any "share of the proceeds" from CDM projects (Article 12.8 Kyoto Protocol);
- agree on publishing the names of the relevant institutions (and persons within) who are responsible focal points for the CDM;

These issues should be discussed and agreed upon the earliest time possible, and should be made available to the (national and international) public.

## 13 References

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