CLASSIFICATION OF BASELINE METHODS AND DATA REQUIREMENTS

The following baseline data matrixes are intended to be used as a practical reference tool to assist project developers and policy makers participating within the EU funded project (B7-6200/99-14/DEV/ENV SUSAC) called - Start up Clean Development Mechanisms in ACP Countries – under the EU Environment Budget Line B7-6200 identify the most appropriate baseline methods for Clean Development Mechanism Projects. The following tables identifies data and computer software requirements for state of the art baseline methods as currently discussed in the current literature.

The different baseline reviewed within the matrix's include three project specific approaches, three standardised approaches and the hybrid approach. These approaches are summarised in the following table. Definitions of terms are provided in an Annex to this paper.

Summary of Different Baseline Approaches

Baseline Approach	Description	Calculation of Annual Credits
Project Specific:		
- Investment Analysis - Control Groups - Scenario Analysis	For all project specific methods, baselines are determined on a case by case basis with project specific measurements or assumptions for key parameters.	Difference between assumed project emissions and estimated baseline emissions.
Standardised		
- Benchmarks	Baseline is equivalent to a 'performance standard' that is standardised at a certain level (regional, national, international etc)	Difference between assumed project emissions and inferred baseline emissions.
- Technology Matrix	Baseline emissions are specified per technology, e.g. on a rate basis such as t CO_2-GWh.	Project activities would only qualify for credits if emissions (per unit activity or output) were under the performance standard. Credits would be based on the difference between project emissions and the performance standard.
- Top down scenario	Economic/energy model calculates national baseline limit and then project specific limits are set by political decision.	Difference between the assumed project emissions and the inferred baseline emissions.
Hybrid	Baseline determined in a hybrid fashion, with some key parameters project-specific and other standardised. Number and level of standardised parameters varies with project.	Difference between assumed project emissions and estimated baseline emissions.

Sources: Adapted from IEA Ellis 1999 and PCF 2000

It should be noted that baselines are still in the process of development and certain issues concerning their application remain unresolved. Since the objective of this paper is to provided guidance regarding how to apply state of the art baselines these issues have not been discussed directly, but are noted here for reference purposes:

- When should a baseline be revised?
- How long can a project generate credits ?
- Should a distinction be made between a new plant/technology and a refurbishment when calculating baselines?
- How to calculate leakage?

ANNEX A: DEFINITIONS OF TERMS

Acronyms

- GHG – Green house gases.
- INCA – Model for investment calculations
- LEAP – Model developed by the Stockholm Environment Institute for energy environment planning and greenhouse gas mitigation analysis.
- MARKAL – Name of software for modelling energy .
- MESAP - Modular Energy System Analysis and Planning software.
- NPV – Net Present Value
- PlaNet – Energy system simulation model
- PROFAKO – Operational planning for electricity and district heat
- RES – Reference Energy System.
- Times – Energy system optimisation model

Glossary

- **Annex I Parties –** The developed countries listed Annex I to the Convention a legally non-binding commitment to reduce their greenhouse gas emissions to 1990 levels by the year 2000. They have also accepted quantitative emission targets for the period 2008-12 as Annex B of the Kyoto Protocol. They include the 24 original OECD members, the European Community and 14 countries with economies in transition.

- **Annex II Parties –** The developed countries have a special obligation to help developing countries with financial and technological resources. They include the 24 original OECD members in 1992.

- **Annex B Parties -** The developed countries listed in Annex B of the Kyoto Protocol have committed themselves to quantitative targets for the period 2008-12. Annex B countries include all OECD countries except Korea and Mexico, Bulgaria, Estonia, Lithuania, Romania, Russian Federation, Slovakia and the Ukraine.

- **Baselines –** Methodology for calculating what emissions would have been if the CDM project did not occur. Baselines vary according to their degree of standardisation. Project specific baselines are the least standardised whilst benchmarks are the most standardised, often using one figure as a baseline for an entire industrial sector. e.g. the power sector.

- **Better Than Average Emission Level** are set to avoid over-crediting when setting standardised baselines. Calculation of a better than average could be according to one of the following methods:

  a) *Percentile Average* These are based on a relative definition of good performance. The distribution of facilities in terms of carbon intensity is established, and a better than average criteria for good performance is set, such as the 25th percentile.
  b) *Performance Standards* Simply establish an acceptable level of good practice for fuel types. This would require little data collection but would require political consensus on a definition of good performance.

- **Carbon Dioxide Equivalent (CO_2 eq)** refers to all GHG gases in terms of CO_2 climatic relevance. For example, methane (CH_4) is 20 times more damaging than CO_2, and therefore 1 ton of CH_4 = 20 ton of CO_2 eq.

- **Certified emission Reductions (CER) –** Clean Development Mechanism projects should lead to incremental greenhouse gas emission reductions compared to an agreed emission baseline. These emission reductions are certified and the certified units may be used by Annex I Parties to meet their targets. Ownership of the CERs generated from a CDM project is subject to agreement between investor and host country Parties. 1 credit is = to a reduction of 1 metric ton of CO_2 equivalent

- **Credit Discounting -** a method used to increase the stringency of a benchmark by scaling down the number of credits for projects by a factor based upon the liklihood of non-additionality. This method can be used if a project is considered to have a high risk of gaming or free riding.

- **Emission Factor** - is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. For example, estimating how much CO is produced from distillate oil combustion. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e. g., kilograms of particulate emitted per mega-gram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i. e., a population average). The general equation for emission estimation is:

  $$E = A \times EF \times (1 - ER/100)$$

  where:
  E = emissions,
  A = activity rate,
  EF = emission factor, and
  ER = overall emission reduction efficiency, %.

  ER is further defined as the product of the control device destruction or removal efficiency and the capture efficiency of the control system.

- **Free Riding –** when credits are claimed but do not reflect a real reduction in greenhouse gas emissions.

- **Gaming -** occurs when there are exaggerated claims for credits.

- **Greenfield –** the development of a new facility.

- **Green house gases** – Greenhouse gases act like the glass of a green house, trapping heat near the earth's surface that result in climate changes. The Kyoto Protocol restricts emissions of six greenhouse gases. They are carbon dioxide (CO2), methane (CH4), nitrous oxide (NO2), hydrofluoro carbons (HFCs) perfluoro carbons (PFCs) and sulphur hexafluoride (SF6).

- **Internal Rate of Return (IRR)**
  The internal rate of return is the discount rate that makes the present value of the investment's costs and payoffs add up to 0.

- **Leakage –** is the indirect effect of emission reduction policies or activities that lead to a rise in emissions elsewhere.

- **MESAP -** The software can be used to store data such as technologies, emissions factors, inputs, outputs, energy genertaion processes and can be used to generate scenarios or comparative analysis. MESAP can work with existing models such as LEAP or MARKAL.

- **Net Present Value (NPV) -** Net Present Value calculates the profitability of a project. It is calculated by summing the present value of the net benefits for each year over a specified period of time and then subtracting the initial costs of the project. A positive NPV means that the project generates a profit, while a negative NPV means that the project generates a loss.

  Present Value of any one income amount = (Income amount) / ((1 + Discount Rate) to the a power)

  Where the discount rate is the same as the interest rate. A positive net present value means this investment is better. A negative net present value means your alternative investment, or not borrowing, is better.

- **Reference Case** refers to the technology or project that is considered to represent emissions that would occur should the CDM project not be developed.

- **Reference Energy System (RES):** RES is a graphical method for depicting an energy system by indicating links between commodities (i.e. all kinds of energy forms and materials) and processes (ie what converts commodities into other commodities).

- **Scenario:** A scenario predicts a situation that is likely to occur in the future. Scenarios can be developed by using either historic data, or extrapolating from current data or on the basis of expert opinions.

- **Quantified Emissions Limitation and Reduction Commitments –** Legally binding targets and timetables under the Kyoto Protocol for the limitation or reduction of greenhouse gas emissions for developed countries.

ANNEX B: WORKED EXAMPLES

Annex B provides worked baseline calculations for investment analysis, control group, scenario analysis, benchmarks and technology matrix methods. The examples have been taken from the Öko Institute report on "Wood Waste Power Plants in Zimbabwe as Options for CDM" (2000) and the Prototype Carbon fund – Baseline study for the Greenhouse Gas Component of the Liepaja Regional Solid Waste Management Project (1999) and a soon to be finished report by IER on Morocco.

1. Example illustrating Investment Additionality

The proposed CDM project in Liepaja would introduce a state-of-the-art waste management system to the Liepaja region including remediation of existing landfill sites and the operation of energy cells for methane capture and utilisation. The proposed techniques would meet modern international sanitary landfill standards in regard to environment, operational and hygienic conditions, and would include the separation of waste, recycling, and improved management.

The baseline for the Liepaja project was determined using the investment analysis method based on the economic internal rate of return (IRR) as key indicator. The methodology, ***in this example***, relies on the behavioural assumption that the objective of the Liepaja City Council is to minimise the increase in the tariff (user fee) for waste collection and disposal for the inhabitants of the Liepaja region while allowing the municipal waste management company to make a profit and while complying with legal, political, technical, economic, social and environmental requirements and constraint.

The first step in determining the baseline according to the investment method is to list all technical alternatives that would provide the required waste management service to the region of Liepaja and eliminate those alternatives that violate at least one of the above constraints. In a second step, the remaining project alternatives will be ranked and compared on the basis of their IRR without, of course, considering any carbon value. To allow a comparison, the tariff for all project alternatives was set at the current level for the analysis. The alternative with the highest IRR will be selected as baseline.

A range of different options and alternatives were studied during project preparation and in the feasibility study, including waste disposal at the municipal and regional level, a number of siting options, sanitary landfill with and without land fill gas capture and with and without the addition of sludge. These are discussed in more detail below.

Simple Landfilling (status quo)

Simple landfilling in open dumpsites, as currently practised at the 27 sites in the Liepaja region (with the large site at Skede and a medium size site at Grobina accounting together for 94% of total waste volume), could theoretically be continued. However, the environmental impacts of present solid waste management practice in the project area do not comply with the environmental requirements in Latvia. As the result, surface and ground water pollution from the largest landfill Skede already causes serious impact to the Tosmare lake and can cause potential threat to the drinking water quality. To control further contamination of ground and surface water bodies at least remediation and a new sanitary landfill is needed. Remediation of the existing landfill at Skede is also considered necessary. The status quo does also not comply with Latvia's Municipal Solid Waste Management Strategy (MSWMS), which Latvia is now vigorously implementing throughout the country (Table 1). The status quo is therefore not an acceptable nor a possible baseline since the Latvian government is poised to enforce minimum environmental standards also in the Liepaja region (see below).

Table 1 – Regional Waste Management Projects in Latvia (population)

Project under implementation	**Project under preparation**	**Project foreseen but yet not started**
Greater Riga (1 million)	South Latgale (240,000)	Tukumus, Jurmala (120,000)
Ventspils (61,000)	Maliena (90,000)	Saldus, Dobele, Kuldiga (120,000)
Liepaja (150,000)	East Latgale (124,000)	Jelgava, Bauska (160,000)
North Vidzeme (200,000)		Jekabspils, Madona, Aizkraukle (150,000)

Simple landfill with methane capture

Existing practice of landfilling is unacceptable due to impacts on surface and ground water (see above). Methane capture would not mitigate these concerns and therefore simple landfills (status quo) with methane capture would not be acceptable to meet national environmental standards and goals and cannot be claimed as baseline.

Sanitary landfill

Sanitary landfilling with leachate control would meet all local environmental concerns. It would meet all local regulations for solid waste treatment and all EU standards but one. As indicated in Section 2.1, Council directive 1999/31/EC of 26 April 1999 on the landfill of waste envisages that LFG should be collected and utilised or burned from existing and new landfills. Although Latvia is not obliged to meet EU standards in the period until accession is completed, the country has already harmonised its standards for waste treatment with EU standards as of February 1999 with the exception of LFG capture. Government regulations and planned laws seek to enforce LFG capture after December 31, 2012. Therefore, a sanitary landfill without LFG collection and utilisation appears to be a possible baseline scenario.

In fact, Table 1 show that Latvia is pursuing quite an ambitious program of building regional sanitary landfills in line with the intentions of the MSWMS. It should also be noted that LFG collection and flaring/energy utilisation have not been implemented in any of the waste management projects except in the Riga case where a GEF grant was made available for this purpose. Latvian municipalities do not use own resources or borrow for LFG collection, since this appears too expensive and unaffordable – a situation which is reflected in the recent clarification of Latvian waste management law (Regulation 56), which does not require gas collection before 2013.

Sanitary landfill with methane capture

This option meets EU accession requirements and exceed requirements of purely local consideration for solid waste treatment. Although LFG collection and utilisation may not be required for some time in Latvia, the Liepaja region authorities could choose to collect and utilise methane from the landfills, if this were to improve the economic performance of the project. A sanitary landfill with methane utilisation is a possible baseline.

Municipal or regional solutions

Despite potential savings in transportation costs, the continued maintenance of several smaller landfills is not cost-effective and would increase the risk of environmentally unsound practices. If existing landfills were to be upgraded to meet sanitary landfill standards, the small municipalities would be unable to afford the related investment costs. Furthermore, a regional solution is consistent with the NSWMS and the overall gist of administrative reform, and the regional municipalities agreed to this solution already at the commencement of project preparation.

Incineration

The construction of a waste incinerator for the Liepaja region could be a possible waste management strategy. Waste incineration would avoid methane emissions but release CO2 from organic matter. However, as Table 2 shows, waste incineration is a very expensive technology that is usually only an option if land for landfilling is not available. The availability of ready landfill sites in the region of Liepaja and the economic situation in Latvia makes incineration not viable it is therefor not a baseline option.

Table 2 – Cost of waste management options (indicative figures)

Technology options	**Cost per ton (US$)**
Incineration	95-110
Bio-reactor	65-80
Composting	35-45
Sanitary landfill	20-25

Recycling, bio-reactors, composting

Recycling, bio-reactors and composting of organic waste could be a possible technology to be utilised in the Liepaja waste management system. Recycling of inert material would have no impact on methane emissions and is part of the energy cell project. The proposed plan for waste transportation and recycling was designed to minimise transportation costs, taking into account waste volumes and recycling habits as studied in a pilot project on waste separation at the household level. Ordinary composting would decompose organic waste without methane emission. However, as Table 2 shows, bio-reactors and composting are also relative expensive technologies and therefore outside of the affordability range. In many contexts large scale composting operations have been proven to be impractical for household waste from an economic and environmental point of view. Such composting operations are not very reliable and can have a negative impact on air quality and human health. Composting of the waste is considered infeasible.

Energy Cells

Energy cells are a relatively simple, yet advanced waste management technology that is being used by Sweden (e.g. in Malmo) and other Scandinavian countries and is now commercially available. Energy cell technology is often more expensive than disposing the waste in a sanitary landfill. However, energy cells provide an environmentally-superior solution that may turn out to be more cost effective when the reduction in waste volumes and the use of LFG for heat and/or power production is factored in. The energy cell technology is therefore a possible baseline option.

Plausible baseline options

As indicated, simple landfilling (with or without methane capture) is not sufficient to meet national environmental standards and was eliminated as a baseline option. Incineration was not considered appropriate due to its high costs. Bio-reactors and composting of the waste is also relatively expensive and not really feasible as a large scale operation. As a result, the following project options appear to meet the mandatory requirements and must be considered candidates for the baseline:

- Regional sanitary landfill without LFG capture.
- Regional sanitary landfill with LFG capture but without methane utilisation.
- Regional sanitary landfill with LFG capture and with methane utilisation.
- Energy cells in various configurations.

Table 3 – Alternatives considered for Skede and Grobina

Alternative		Comments
Alternative A: Skede		
A1-A	Gas extraction from existing landfill, combined with energy cells, without addition of sewage sludge	Income from electrical energy. Attractive option with positive rate of return. Examined further in the detailed financial and economic analysis.
A1-B	Gas extraction from existing landfill, combined with energy cells, with addition of sewage sludge	
A2-A	Gas extraction from existing landfill, combined with energy cells, without addition of sewage sludge	Income from gas. Sale of gas appears infeasible (lack of customers) and not as financially attractive as the use of gas for power generation
A2-B	Gas extraction from existing landfill, combined with energy cells, with addition of sewage sludge	
A3	Gas extraction from existing landfill	Income from electrical energy. Not as attractive as either Alternative A1, A2 or A4
A4	Landfilling without gas extraction	Most attractive NPV of the waste treatment options without consideration of the greenhouse gas emissions. The Baseline for the PCF project
A5	Closing of the landfill	No income stream from this alternative. This cost is incorporated in all alternatives for Grobina (Alt. B)
A6	Closing of the landfill with gas extraction and flaring	No income stream other than those from carbon credits to offset the costs incurred to recover gas. Including this alternative for the case of Alternative B1 for Grobina is explored further for the detailed economic and financial analysis
Alternative B: Grobina		
B1-A	Gas extraction from energy cells, without addition of sewage sludge	Income from electrical energy. Attractive option with positive rate of return. Examined further in the detailed financial and economic analysis.
B1-B	Gas extraction from energy cells, with addition of sewage sludge	
B2-A	Landfilling without gas extraction	Positive return but not as attractive as Alternative A1, A4 (for Skede) or B1 for Grobina.
B2-B	Landfilling with gas extraction	

Table 3 summarises the feasible alternatives that were identified so that the next step is to calculate the base cost and revenue stream for all studied alternatives including the following:

- Investment cost on the site.
- Investment cost for vehicles and containers.
- Staff, operation and maintenance costs on the site and for collection of waste.
- Cost of closing down regional dumps.
- Cost of closing down the Skede landfill (A5) in case of B1 and B2.
- Cost of the upgraded access road in case of B1 and B2.
- Costs for providing water supply to the Skede summer colony in case of A1 - A4.
- Revenue from sale of gas and/or electricity: 22.5 Ls/MWh for electricity, based on the law requiring the utility to buy LFG-generated electricity at 1.5 times the price of imported electricity of Ls 14/MWh.
- Revenue from the tariff for waste collection, treatment and disposal: 1.5 Ls/m^3. The current level was chosen for all alternatives as the politically preferred level. This tariff level was used in the financial calculation for all alternatives in order to allow for a consistent ranking of the alternatives.

The results of the financial and technical analysis of the different options are summarised in Table 4. Consideration of incomes from the sale of gas is not included in the table, because it was ranked as infeasible; it would also be economically inferior to electricity production. As Table 4 shows, comparison of IRRs makes A4 seem to be the best baseline option. However, accounting for social and environmental constraints leads to the selection of B-2A as the best option at the Grobina site.

Table 4 – Investment and rate of return for selected alternatives at Grobina and Skede [(a)]

	Skede			Grobina					
Item / Alternatives	A1-A (excluding sludge)	A1-B (including sludge)	A4 (base case: sanitary landfill)	B1-A (excluding sludge)	B1-B (including sludge)	B1-A, A3 (incl. gas at Skede, excl. sludge)	B1-B, A3 (incl. Gas at Skede, incl. Sludge)	B2-A (base case: sanitary landfill)	B2-B (sanitary landfill incl. gas coll.)
Total cost in US $	11508	12152	7602	13496	14140	14003	14618	8831	10630
Grant finance in US $ (b)	7830	7830		8020	8020	8693	10400		
IRR without carbon benefits (c)	2.6%	2.3%	7.3%	0.4%	0.2%	0.7%	1.0%	3.2%	1.3%
NPV without carbon benefits (d)	(2980)	(3276)	(600)	(4370)	(4632)	(4304)	(4168)	(1921)	(4252)
Reduction in Carbon									
2001-2012 Ton C	99119	111975		79836	92692	99119	111975		61051
2001-2020 Ton C	185486	207691		161060	183266	185486	207691		123164

(a) For details please refer to the PCF report (1999) (b) Revenues from the sale of carbon are not treated as a grant. (c) The economic internal rate of return (IRR) and the corresponding net present value (NPV) include, where applicable, revenue from the sale of electricity generated from the captured methane. (d) Negative NPV in brackets.

In terms of the baseline scenario, the analysis presented in Table 4 shows the following:

- The economic analysis of the alternatives as per comparison of IRRs without carbon benefits indicates that Alternative A4 (sanitary landfill at Skede without LFG collection) is the most cost effective alternative. This alternative would, therefore, be the first choice for the baseline. The Environmental Impact Assessment, however, found environmental (endangered biodiversity, possible ground water contamination) and social (summer colony) problems with the Skede site, which excludes the Skede alternatives as a possible the baseline scenario.
- Alternative B2-A (sanitary landfill at Grobina without LFG collection) is the second most cost effective alternative without accounting for carbon benefits. ***The emissions that are generated from this type of plant then represent the baseline for the proposed project.***

2. Examples for Scenario Analysis and Control Group (Marginal Plant) Baseline Calculations

The Öko Institute report describes different baseline options for a wood waste electricity generation project. It is assumed that the wood waste plant project has no CO_2 emissions since waste plant project has no CO_2 emissions since CO_2 emitted from the wood waste plants was sequestered before electricity generation occurs at the sawmill timber plantations. According to IPCC guidelines, the net release of carbon from biomass energy should only be taken into account if the total carbon embodied in standing biomass (e.g. forests) is declining in the long term. In Zimbabwe, sustainable forest management is applied to the source of wood for the proposed wood waste electricity plant and therefore CO_2 emissions are considered to be zero.

However, non- CO_2 emissions of methane (CH_4) and Nitrous monoxide (N_2O) need to be accounted for. Therefore emission factors for CH_4 and N_2O were taken from the Environmental Manuel database developed by GTZ. (See Oko Institute website: http://www.oeko-institut.org). Using these figures it was estimated that the wood waste plant would generate 0.006 kg CO_2 equivalent /MWh. Given that the wood waste electricity plant will be 3.5 MW in size and will run at medium capacity i.e. 60% the annual production of electricity is expected to be approximately 18,396 MWh/year which will give approximately **110 t CO_2** equivalent per year (ie. 18,396 x 0.006 = 110,376 kg per year).

2.1. Scenario Analysis

The scenario used in the Öko Institute report was the business as usual (BAU) scenario for electricity generation. The scenario was projected using data from the African SAPP GHG Mitigation Study by the Southern Centre for Energy and Environment (1999). This study expects an electricity demand increase by a rate of 2.7 from 1997 to 2020. 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 (Öko:2000).

In order to estimate the BAU scenario, it is necessary to consider planned new capacity. The report notes the following plans for capacity up until 2010.

Table 5

Power Plant	**Fuel Type**	**Capacity (MW)**	**Start**
Hwange 7	Coal	300	2001
Hwange 8	Coal	300	2003

Gokwe North Project	Coal	3 x 350	2004
Goweke North	Coal	500	2007
Kariba South Plant	Hydro	84	2000
Batoka Gorge Hydro	Hydro	800	2010-2014

It is difficult to judge if these electricity expansion plans will be realised. The economic environment in Zimbabwe is unfavourable and a likely obstacle to realising new capacity will be restrictions on investment capital. Lack of investment capital and changing energy prices are likely to result in revisions of investment plants. This is a general problem when published plans of host countries are used. It is there recommended that more than one source of information is used to confirm investment plans in new capacity.

The baseline calculated for the BAU will change over time since the emissions will change as new capacity is included. Using the data in table 5 this will give emissions rates of:

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

The emission rates for CO_2 equivalent represent the baseline for the waste wood electricity generation plant. Emission reductions can be calculated by subtracting the baseline emission estimates from the emissions estimated for the waste wood electricity generation plant.

Therefore in 2000 the emission reductions per MWh will be 756 kg CO_2 equivalent –0.006 CO_2 equivalent = 755.994 Kg CO_2 equivalent/ MWh.

To calculate annual emissions simply multiply by total annual electricity generation. Therefore emission reductions would be: 755.994 X 18,396 MWh = 13,907,265. 624 kg per year. This is approximately equal to 13,907 t CO_2 equivalent per year. **Since one credit is equal to one ton of reduced CO_2 equivalent this is equal to 13,907 credits for the year 2000.** This increases to 15,673 credits in the year 2005 and decreases to 12,656 credits in the year 2020.

2.2 Control Group (Marginal Plant)

The marginal plant concept considers the project most likely to deliver electricity in the absence of the CDM project. Therefore for energy supply project, developers must consider load characteristics of the CDM project and choose a reference case that has 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 plants.

In this study by the Öko institute the marginal plant was selected on the basis of expert judgement of the host country's experts. An alternative approach to selecting the marginal plant would be to assess the least cost option. This is very similar then to investment analysis approach, but requires information on Internal Rate of Returns for existing plants rather than hypothetical options that are described by investment analysis baseline method. As a result a small refurbished coal plant in Bulawayo was assumed to be marginal. **This resulted in the marginal baseline emission rate being 1, 286 kg/MWh for the waste wood electricity generation plant.**

This emission rate will result in annual credits (one credit is equal to one ton of reduced CO_2), provided the baseline is not altered, of:

1,268 Kg CO_2 equivalent – 0.006 kg CO2 equivalent = 1,267 .994 CO_2 equivalent
1,267.994 Kg CO_2 equivalent X 18,396 MWh (annual generation) = **23,326 t CO_2 equivalent/year**

3. Examples Illustrating Benchmark and Technology Matrix Baseline Calculation

The following examples are taken from a draft report assessing renewable energy generation projects and their eligibility as CDM projects in Morocco (IER:2001) and shows how to develop a benchmark based on entire existing electricity capacity and how to develop a technology matrix.

3.1 Benchmark

Calculation based on Entire Existing Electricity Generation Capacity

A benchmark for the wind farms was established using national average performance figures using all existing electricity generation capacity. The benchmark is straightforward; transparent and easily revisable. In general however, baselines based on national averages are less credible than other benchmark approaches unless a better than average is established. However, there are several methods for calculating a better than average mark and selection of the best approach must be confirmed by the national CDM secretariats. The following table identifying energy sources in Morocco has been generated from the GTZ Environmental Manuel Database (1999).

	Data for 1996 +assumed present production of Gas CC turbine				
	Capacity	Operation	Genera-tion	Specific Emission	Total Emission
Technology/Plant	**MW**	**h/a**	**GWh**	**t/GWh**	**T**
Fueloil-ST-Mohammedia 1+2	300	3.787	1.136	783	889566,3
coal-ST-Mohammedia 3+4	300	3.787	1.136	985	1119058,5
Fueloil-ST-Kennitra 1-4	300	5.420	1.626	906	1473156
coal-ST-Jorf Lasfar I+II	660	6.683	4.411	857	3780038,46
coal-ST-Jerada 1-3	165	3.544	585	1057	618091,32
Fueloil-ST-Casablanca 2+3	120	2.563	308	890	273728,4
Existing Hydropower	500	1.250	625	30	18750
Combined Cycle Gas	470	6.000	2.820	374	1054680
Total	**2.815**		**12.646**		**9227068,98**
					Average 0.733

The value for the Specific Emission of 0.733 t / MWh is used to illustrate the consequences of this benchmark in terms of credit allocation for the wind farm.

Greenhouse gas emissions from the development of the wind farm are negligible and for the purposes of calculating the baseline are considered to be zero. Therefore the emissions reductions can be calculated as by subtracting the reference emissions from the emissions from the wind farm.

Baseline Method	**TE / t CO_{2eq}**	**BE / t CO_{2eq}**	**TER = (TEW – BE) / (t CO_{2eq})**
Benchmark national average (all capacity)	0 t /MWh	0.733 t /MWh	- 0.733 t /MWh

Given that the wind farms are anticipated to have an annual capacity of 600, 000 MWh per annum, the total emissions reductions per annum will be 439, 800 t per year (i.e. 0.733 t CO2 x 600,000 MWh). . **Since one credit is equal to one ton of reduced CO_2, this results in annual credits of 439,800 per year, provided that the baseline is not altered.**

3.2 Technology Matrix

The technology matrix baseline is defined once the technology considered most likely to be installed should the CDM project not occur is identified. First a list of all technology options within the country should be listed noting the fuel type and efficiency. Then selection of which technology option is a suitable alternative to the CDM project must be made. Normally this will be done according to expert opinion. Specific emissions are determined according to the fuel type and the efficiency of the technologies used. Thereby figures for state of the art technology will be used. Ideally, the capacity of this reference case should be similar to the CDM project capacity and should contribute to the same load as the CDM project. Alternative technologies for electricity generation are given below:

Technology	**Capacity (MW)**	**Fuel**	**Efficiency**	**Investment Costs $/MW**	**Specific Emission (CO_2)**
Conventional Steam Cycles	300 –600	Coal	37 %	100,000	0.930 t /MWh
Gas turbine (simple)	25 – 100	Fuel oil	30 %	40,000	0.6900 t/MWh
Gas turbine (simple)	25 – 100	Natural gas	30 %	40,000	0.609 t/MWh
Combined cycle turbine	50 – 500	Natural gas	48 %	60,000	0.397 t /MWh
Dieselmotor large	5	Diesel	30 %	55,000	0.836 t/MWh
Dieselmotor small	0,05	Diesel	20 %	70,000	0.1,254 t/MWh

*
Source: Data from GTZ Environmental Manual Database (1999)

The case study to illustrate this baseline is a 38.1 MW hydro power plant scheme. For the purposes of calculating the baseline, it can be presumed that this plant will run at base load. Referring to the information in the table above, the most suitable reference technologies from the data for the hydro plant is a gas fired simple gas turbine since capacity and load are appropriate and additionally the location is suitable for gas supply. Therefore for the purposes of this report the **baseline emissions** case for the hydro plant will be **0.609 t/MWh.**

To translate these emission reductions into an estimate of annual credits for the project (provided the baseline is not altered) it is necessary to subtract the baseline emissions estimated from the CDM emissions estimate. Since hydropower plants have negligible emissions, (only those that occur during the construction of the plants)it is assumed that the plants have zero CO_2 emissions. The baseline emissions reductions can therefore be calculated as follows:

Baseline Method	**TEH / (t CO_{2eq})**	**BE / (tCO_{2eq})**	**TER = (TEH – BE) / (t CO_{2eq})**
Technology Matrix, emissions according to technology type	0 t /MWh	0.609 t /MWh	- 0.609 t /MWh

Since credits are usually awarded per year it is necessary to calculate how many MWh will be generated by the hydro scheme in order to calculate the number of credits that can be anticipated per year the calculation for total credits can be calculated by calculating total emission reductions per year. Using this calculation the results are presented in the table below:

Baseline Method	**Total Emission reductions/MWh**	**Total MWh per Annum**	**Total Emissions Reductions Per Annum**	**Total No. of Credits per year**
Technology Matrix (Gas fuelled gas turbine)	0.609 t /MWh	208,000	125,672 t (0.605 x 208,00)	125,672