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Ministry of Energy,
Water and Communications

Study on Grid Connected Electricity Baselines in Malaysia

The Clean Development Mechanism (CDM) Capacity Building Project

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Executive Summary

This work builds on previous baseline studies carried out in 2003. The results of this study are based on the most recent version (as of 3 December 2004) of the Approved Consolidated Baseline Methodology (ACM0002). This approved methodology can be applied to grid-connected electricity generation projects that use renewable sources. It is not applicable to project activities that involve switching from fossil fuels to renewable energy.

The data used for the calculations comes from official sources. Therefore, the results of this study can be made publicly available. However, some information such as fuel consumption and efficiency data of power plants are confidential and will be for restricted circulation.

The study determines the baseline emission factor expressed in tonne of CO_2/MWh. This factor is calculated by the so-called Combined Margin, consisting of the Operating Margin and Build Margin factors. The Operating Margin is derived using two of the four methods outlined in ACM0002, namely the Simple OM and Simple Adjusted OM methods. The data available for the most recent 3 years (2002, 2003 and 2004) were used.

The results of the baselines based on ACM0002 are summarised as follows:

Peninsular Malaysia: 0.631 kg CO_2/kWh
West of Sabah: 0.647 kg CO_2/kWh
East of Sabah: 0.800 kg CO2/kWh
Sarawak: 1.116 kg CO_2/kWh

The baselines for the small-scale project and biomass were also developed using the “Simplified Baseline and Monitoring for Selected Small Scale CDM Project Activity” methodology. The baseline calculations are similar with ACM0002 except that only one most recent year (2004) data was used.

The results of the baselines based on Type 1.D are summarised as follows:

Peninsular Malaysia: 0.655 kg CO_2/kWh
West of Sabah: 0.727 kg CO_2/kWh
East of Sabah: 0.800 kg CO2/kWh
Sarawak: 1.157 kg CO_2/kWh

In this study, the CO_2 emission were calculated using a conservative method where by average efficiency for specific power plants obtained from the Energy Commission were used to calculate the CO_2 emissions. The main reasons of using these data sources are to reduce the data inconsistency, uncertainty and to obtain realistic baselines results. Moreover, the data is publicly available

1.0 Introduction

In the 2003 Danida-funded project "Capacity Building on CDM in Malaysia", preliminary work was carried out to determine the electricity baseline in each of the three regions, namely Peninsular Malaysia, Sabah and Sarawak. The study used CDM Executive Board – approved methodology for small-scale projects. In summary, the following emission figures were determined as the baseline for the three regions in Malaysia:

Peninsular Malaysia
0.6 kg CO_2/kWh

Sabah:

Up to end-2005:	0.80 kg CO_2/kWh
From 2006:	0.55 kg CO_2/kWh

Sarawak:
Two sets of values have been derived:

Up to end-2006:	0.87 or 0.76 kg CO_2/kWh
From 2007:	0.78 or 0.62 kg CO_2/kWh

These results were presented in several workshops to key stakeholders only.

On 3 September 2004, the CDM – Executive Board issued Version 1 of "Consolidated Baseline Methodology for Grid-connected Electricity Generation from Renewable Sources". The version has been updated on 3 December 2004 which is referred to as Version 2 of ACM0002 (http://cdm.unfccc.int/methodologies). The methodology has some similarities with the baseline methodology for small scale projects that has been used to develop the baseline for the electricity sector in 2003, but the main differences between this first version and the finally approved methodology (ACM0002) are as follows:

i. Dispatch data analysis should be considered as the first methodological choice;
ii. Introduction of Simple adjusted operation margin where by the load duration curve is required to determine whether the low-cost/must-run sources are operating on margin.
iii. ACM0002 requires 3-years of data to determine the emission factors instead of data for just one year.

It should also be noted that the small scale methodology can still be used for those projects that have an installed capacity below 15 MW. This study also presents updated results of the baselines using the small scale methodology (see Chapter 6), since it is very similar to the combined margin as indicated

under ACM0002. This will be especially of interest for small scale projects that use biomass energy, since ACM0002 cannot be applied to biomass electricity projects.

2.0 Objectives

The purpose of this study is to update the currently available electricity for Malaysia, by adjusting it to the international developments. The existing electricity baseline has been updated by using an approved baseline methodology and the most recent data available for the electricity sector. This report documents the principles and calculations of the baselines for grid connected electricity sector projects for Peninsular Malaysia, Sabah and Sarawak. The baselines for the electricity sector in these three regions will be presented. The results will be applicable to grid-connected electricity generation from renewable sources such as small-scale projects in Malaysia, as mentioned under the applicability criteria of the baseline methodology used.

The methodology used is based on the Approved Consolidated Baseline Methodology ACM0002, dated 3 December 2004. The applicability criteria will discussed in Section 3.1.

Note that the results in this report can be used for actual projects that meet the applicability criteria as listed above. In order to use the results, each project proponent will have to justify its choice of baseline and why it is applicable for the specific project activities. This involves describing step-by-step how the methodology for determining the baselines is applied. This specific process will also be described in the sections below. These sections can be used by project proponents in their specific Project Design Documents (PDD's).

3.0 Discussion of Methodology

In the submission for CDM in a proposed project activity, the choice of methodology must be justified, and a detailed description of the methodology given. The methodology will take into account project boundaries.

The methodology described and used in this report is typical, and is given as a guide to the use of actual steps to be taken in specific project activities. It is a summary and extract of relevant sections of ACM002.

3.1 Applicability

This methodology is applicable to grid-connected renewable power generation project activities, which include

- Run-of-river hydro power plants, and hydro power projects with existing reservoirs where the volume of reservoir is not increased
- Wind power
- Geothermal power
- Solar power
- Wave and tidal power

The methodology is not applicable to project activities involving the use of biomass or switching from fossil fuel to renewable energy or to generate electricity. In the latter case, the baseline may be the continued use of fossil fuels at the site.

Other conditions are that the geographic and system boundaries for the relevant electricity grid can be clearly identified and information on the grid is available. Please note that the methodology can also be applied to grid connected electricity generation from landfill gas capture to the extent that the approved methodology for landfill gas project activities (ACM0001) is combined with it for calculating the methane avoidance component of landfill gas projects.

3.2 Project Boundary

In order to calculate the emission reductions from a proposed project activity it is necessary to define from which activities emissions have to be measured and included in the calculations. This is also referred to as defining the project boundary. The emissions from all activities included in this project boundary have to be measured and calculated. ACM0002 indicates that the project shall account for CO_2 emissions from electricity generation in fossil fuel fired power plants that is displaced due to the project activity. This implies that for example emissions related to the construction of the power plant or emissions related to the distribution and transportation losses are excluded from the project boundary and do not have to be accounted for.

The spatial extent of the defined project boundary for ACM0002 shall be the project site and all power plants connected to the electricity system that the CDM project power plant is connected to.

A *project electricity system* is defined by the spatial extent of the power plants that can be dispatched without significant transmission constraints. A *connected electricity system* is defined as a (regional) electricity system that is connected by transmission lines to the project electricity system and in which power plants can be dispatched without significant constraints.

As for Malaysia, the main electrical grid systems can be divided into 3 main electrical systems based on regions namely Peninsular Malaysia, Sabah and

Sarawak. Each of these main grids is not interconnected with each other. Therefore the baseline calculations will be calculated based on individual regions and their electricity system.

The project boundary has to be assessed in terms of the emission sources and spatial extent.

Project Boundary for Peninsular Malaysia

- Emission sources: the emissions sources of the project activity have to be taken into account. For the applicable renewable energy projects as stated earlier the CO_2 emission are zero and have not to be taken into account.

- Spatial extent: The Peninsular Malaysia grid is an interconnected grid system. Therefore, all power plants that can be dispatched to the grid without transmission constraints have to be included in the project boundary. The grid operator in Peninsular Malaysia (Tenaga Nasional Berhad) is a net exporter of electricity to Thailand and Singapore with a total export of 817.3 GWh in 2004. The export electricity is included in the electricity generation data for the calculation of the baseline emission rate for Peninsular Malaysia. However if Tenaga Nasional Berhad is the net importer of electricity from connected electricity system in Thailand or Singapore the emission factor is 0 tons CO2 per MWh (total imported electricity).

Project Boundary for Sarawak

- Emission sources: the emissions sources of the project activity have to be taken into account. For the applicable renewable energy projects as stated earlier the CO_2 emission are zero and have not to be taken into account.

- Spatial extent:. The Sarawak main grids lie along the coastal area or western region of Sarawak and is an interconnected grid system connecting Kuching to Miri. The rest of the state consists of isolated mini-grid systems which are not connected to the other grids. Also, the main grids in Sarawak are not interconnected with Sabah or Peninsular Malaysia. Therefore, all power plants that can be dispatched to the grid without transmission constraints have to be included in the project boundary.

Project Boundary for Sabah

For Sabah, the electricity grid system can be subdivided into 2 main grids namely West Coast Grid and East Coast Grid. Both grids are not interconnected between each other.

- Emission sources: the emissions sources of the project activity have to be taken into account. For the applicable renewable energy projects as stated earlier the CO_2 emission are zero and have not to be taken into account.

- Spatial extent: The West Coast Grid is an interconnected grid system. Therefore, all power plants that can be dispatched to the grid without transmission constraints have to be included in the project boundary. As for East Coast Grid an emission factor or baselines of 0.8 kg CO_2/KWh has been used. This because all operational power plants are currently using diesel or fuel oil. According to the the "Indicative Simplified Baseline and Monitoring Methodologies for Selected Small-Scale CDM Project Activity Categories" by the Executive Board, the factor of 0.8 kg CO_2KWh can be used in this case.

<u>3.3 Baseline Determination</u>

The baseline methodology ACM0002 prescribes that the baseline emission factor (EF_y) is calculated as a Combined Margin (*CM*). The Combined Margin consists of a combination of the Operating Margin (*OM*) and the Build Margin (*BM*) factors, according to the following three steps.

Step 1 – Calculation of the Operating Margin emission factor (OM)

The Operation Margin (OM) refers to adjustments in the existing grid mix due to the project activity. The planning horizon is rather short-term. Therefore, the short term marginal costs (the operating costs for the last unit produced by a plant to meet the demand) are relevant. The emissions produced by the plants, which are on the margin, are taken to calculate the OM

The ACM0002 consolidated methodology provides four options to calculate the Operating Margin, namely

(a) Simple OM, or
(b) Simple adjusted OM, or
(c) Dispatch Data Analysis OM, or
(d) Average OM.

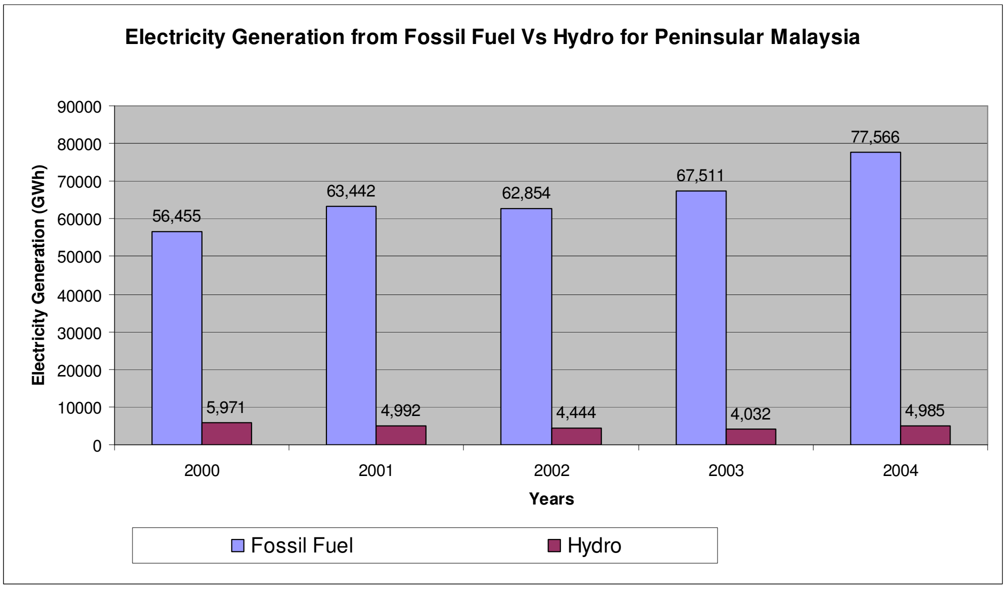
This study uses both the Simple OM and Simple adjusted OM method to determine the baselines for Malaysia. Undertaking a dispatch data analysis (the preferred methodological option) was considered as well. However, after having talked to TNB Transmission, System Planning it was deemed not possible to use this option, because the data is not readily available from the relevant authorities. Moreover, it is time consuming in order to obtained and analyse the data.

Option d) Average OM is not applicable to Malaysia; this method can only be used:

- where low-cost/must run resources constitute more than 50% of total grid generation and detailed data to apply option (b) is not available, and
- where detailed data to apply option (c) above is unavailable.

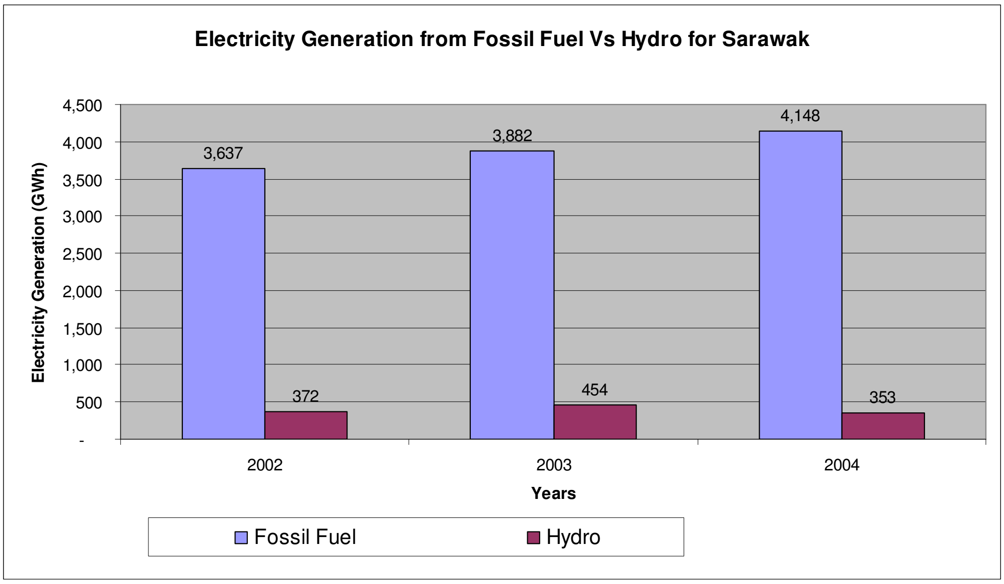
The analysis of the baselines was then carried out using a) Simple OM and b) Simple Adjusted OM because the low-cost/must run resources in Peninsular, Sarawak as well as Sabah constitute less than 50%. As shows in Figure 1.1, 1.2 and 1.3.

Figure 1.1 : Electricity Generation from Fossil Fuel Vs Hydro for Peninsular Malaysia



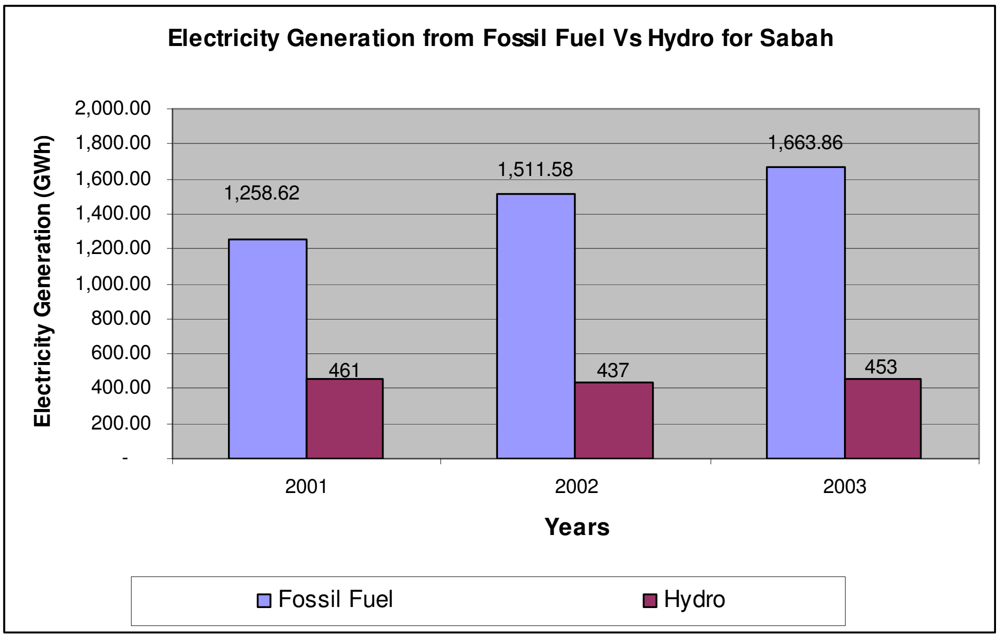
Source: Energy Commission & Tenaga Nasional Berhad (2004)

Figure 1.2 : Electricity Generation from Fossil Fuel Vs Hydro for Sarawak



Sources: *Sarawak Electricity Supply Corporation (2004)*

Figure 1.3 : Electricity Generation from Fossil Fuel Vs Hydro for Sabah



Sources: *Energy Commission and Sabah Electricity Sdn. Bhd. (2004)*

When calculating the Simple Adjusted OM, it was found that the results for the Simple OM will produce the same to the Simple Adjusted method. This is due to the fact that low-cost/must-run sources constitute less than 50% of the total grid generation, and it can be demonstrated by the Simple OM that the low-cost/must-run sources do not operate on margin. See also section 4.3.2 below. The rest of this study and the calculations of the baseline will therefore

only focus and be based on the Simple Operating Margin, presented as Option a) in ACM0002.

3.3.1 Calculation of the Simple Operation Margin

The simple OM emission factor has been calculated based on a 3-year vintage (2002-2004).

The Simple OM is calculated as the generation-weighted emissions per electricity unit of all generating units serving the system, excluding low-operating cost and must-run power plants. Low operating cost and must run power plants include, typically, hydro, low cost biomass and geothermal. The OM is calculated as follows:

$$EF_{OM,simple,y} = \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_{j} GEN_{j,y}}$$

Where,

$F_{i,j,y}$ is the amount of fuel (mass or volume) *i* consumed by relevant power sources *i* in year(s) y,
j refers to the power sources delivering electricity to the grid not including low-operating cost and must run plants, including imports to the grid,
$COEF_{i,j}$ is the CO_2 emission coefficient of fuel (tCO_2/volume) taking into account the carbon content of the fuels used by the relevant power sources j and the percent oxidation of the fuel in year(s) *y*, and
$GEN_{i,j}$ is the electricity (MWh) delivered to the grid by source j.

The CO_2 emission coefficient $COEF_i$ is obtained from:

$$COEF_i = NCV_i \cdot EF_{CO2} \cdot OXID_i$$

where

NCV_i is the net calorific value of the unit of fuel i,
$OXID_i$ is the oxidation factor of the fuel,
EF_{CO2} is the CO_2 emission per unit of energy of the fuel i.

The Simple OM is calculated using the data of all operational fossil fuel fired power plants providing electricity to the grid for the years 2002, 2003 and 2004. For the baseline of Peninsular Malaysia 4 different options of data sources have been used to calculate the OM (see Section 5 below). Option 4 has been selected as the most

preferred data source. In this option, the calculation of OM were based on specific individual plant specific data as provided by the Energy Commission.

Table 1: Simple Operation Margin Result Based on Grids System, Data and Source

Grids System	**Data**	**Sources of Data**	**Build Margin (kg CO_2/kWh)**
Peninsular Malaysia Grid	Conservative Method	Energy Commission	0.580
Sarawak Grid	Real Data on fuel consumed and electricity generated	SESCO	0.985
West Sabah Grid	Real Data on fuel consumed and electricity generated	SESB and NEB	0.551

3.3.2 Calculation of the Simple Adjusted Operation Margin

The *Simple Adjusted OM.* emission factor ($EF_{OM,simple\ adjusted,y}$) is a variation on the previous method, where the power sources (including imports) are separated in low-cost/must-run power sources (k) and other power sources (j):

$$EF_{OM,simple\ adjusted,y} = (1-\lambda_y)\cdot\frac{\sum_{i,j} F_{i,j,y}\cdot COEF_{i,j}}{\sum_j GEN_{j,y}} + \lambda_y\cdot\frac{\sum_{i,k} F_{i,k,y}\cdot COEF_{i,k}}{\sum_k GEN_{k,y}}$$

where $F_{i,k,y}$, $COEF_{i,k}$ and GEN_k are analogous to the variables described for the simple OM method above for plants k; the years(s) y can reflect either of the two vintages noted for simple OM above, and λ_y were calculated as follows:-

$$\lambda_y\,(\%) = \frac{\text{Number of hours per year for which low-cost/must-run sources are on the margin}}{\text{8760 hours per year}}$$

where lambda (λy) should be calculated as follows (see figure below):

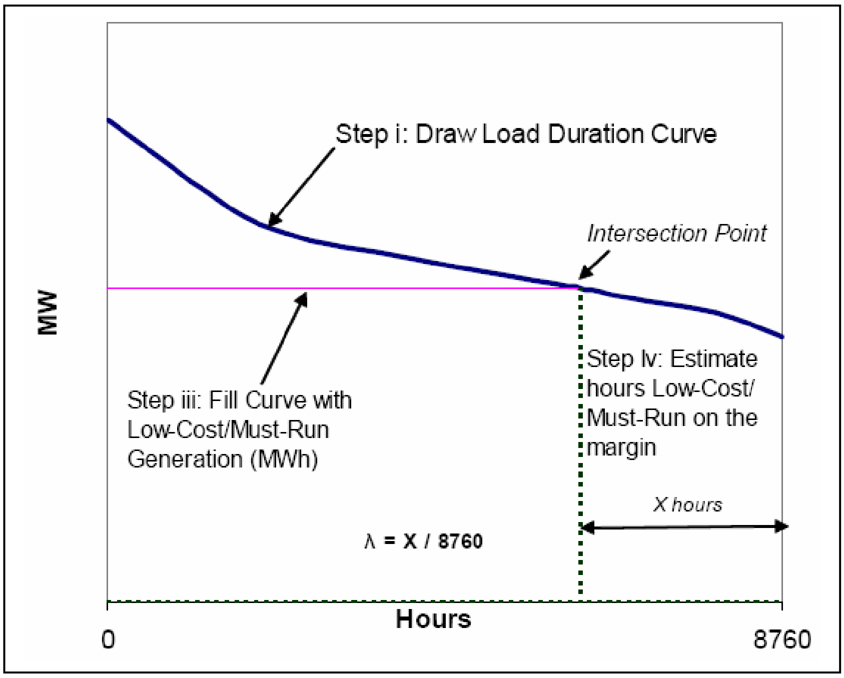
Step i) Plot a Load Duration Curve. Collect chronological load data (typically in MW) for each hour of a year, and sort load data from highest to lowest MW level. Plot MW against 8760 hours in the year, in descending order.

Step ii) Organize Data by Generating Sources. Collect data for, and calculate total annual generation (in MWh) from low-cost/must-run resources (i.e. $\sum k\ GENk,y$).

Step iii) Fill Load Duration Curve. Plot a horizontal line across load duration curve such that the area under the curve (MW times hours) equals the total generation (in MWh) from lowcost/must-run resources (i.e. $\sum k\ GENk,y$).

Step iv) Determine the Number of hours per year for which low-cost/must-run sources are on the margin.. First, locate the intersection of the horizontal line plotted in step (iii) and the load duration curve plotted in step (i). The number of hours (out of the total of 8760 hours) to the right of the intersection is the number of hours for which low-cost/must-run resources are on the margin. If the lines do not intersect, then one may conclude that low-cost/must-run sources do not appear on the margin and λy is equal to zero. Lambda (λy) is the calculated number of hours divided by 8760.

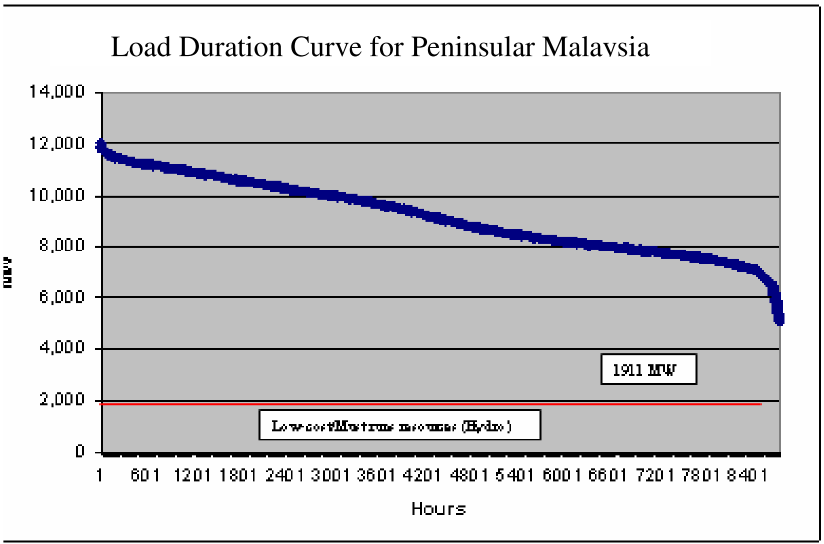
Figure 2: Illustration of Lambda Calculation for Simple Adjusted OM Method



The Lambda (λy) calculation for the Simple Adjusted OM is to determine whether the low-cost/must-run resources (Hydro) are operating at margin. The lambda calculation shows that there is no intersection of the horizontal line plotted (low-cost/must-run resources) in step (iii) and the load duration curve plotted in step (i) for all main grids in Malaysia namely Peninsular Malaysia, West Sabah and Sarawak as illustrated in Figure 3, 4 and 5.

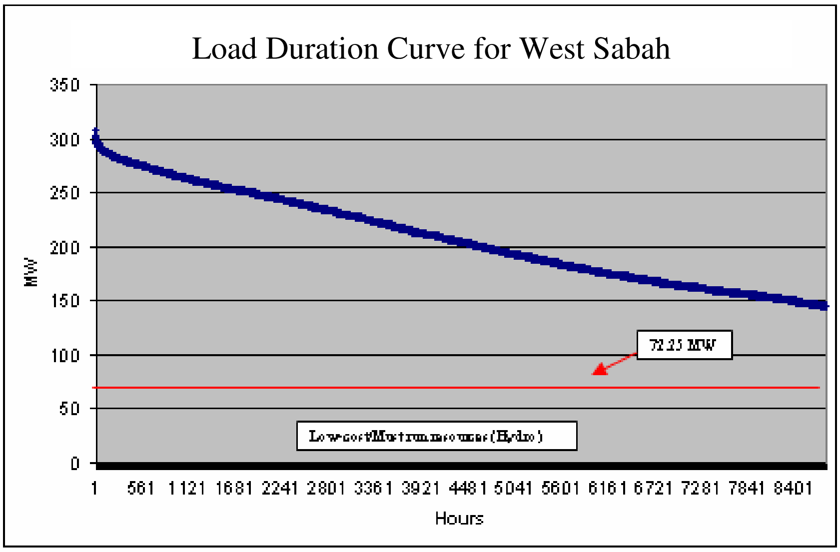
These results indicate that the low-cost/must-run resources are not operating at margin at any hours in a year for all 3 of the main grids. Hence the values of lambda are zero for all 3 main grids. As a result, the Simple Adjusted OM will produce the same results as Simple OM.

Figure 3: Load Duration Curve and Low-Cost/Must-Run Resources (Hydro) for Peninsular Malaysia.



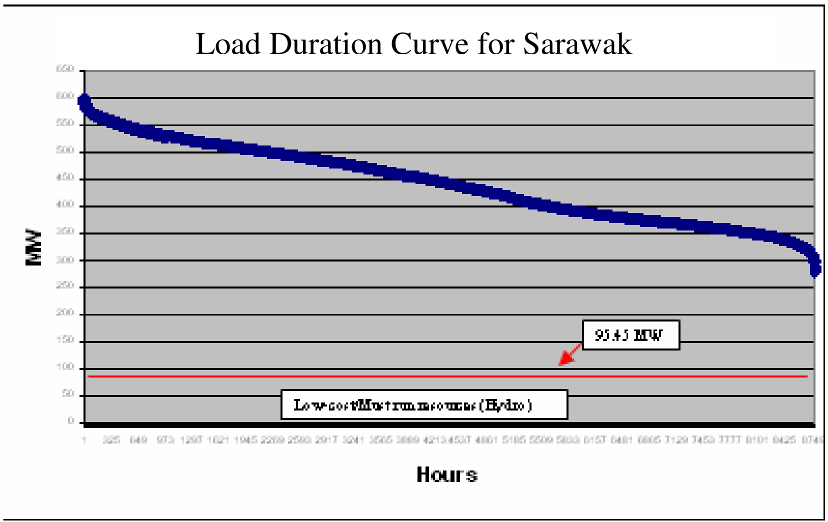
Source: Tenaga Nasional Berhad (2004)

Figure 4: Load Duration Curve and Low-Cost/Must-Run Resources (Hydro) for West Sabah



Source: Sabah Electricity Sdn. Bhd. (2004)

Figure 5: Load Duration Curve and Low-Cost/Must-Run Resources (Hydro) for Sarawak



Sources: *Sarawak Electricity Supply Corporation (2004)*

Step 2 – Calculation of the Build Margin (BM)

The Build Margin (BM) stands for the investment alternatives in other sources of electricity. The planning horizon is rather long-term. Planned projects may be entirely displaced or only delayed by the project and it also represents the trend or types of technology and fuels used for new installed capacity power generation.

According to ACM0002, project participants can choose between two given options for calculating the Build Margin for the project. These include:

1. Option 1 takes an *ex ante* approach, based on the most recent information available on plants already built, and the sample plants are the five most recently built, or capacity additions comprising at least 20% of system generation. Ex-ante refers to the period before the proposed project activity is starting;

2. Option 2, in the 1st crediting period, the Build Margin is calculated *ex post* for the year in which the actual project generation and associated emission reductions occur, and for subsequent periods, the build margin is calculated *ex ante.*

3.3.3 Calculation of Build Margin

In our study, Option 1 is selected and the Build Margin emissions factor (BM) is calculated as the generation-weighted average emission factor of the 5 most recently built plants, using the following formula:

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_{m} GEN_{m,y}}$$

The final results of Build Margin are showed in Table 2 below. Please refer to Annex 2 for the details calculation of BM.

Table 2: Build Margin Result Based on Grids System, Data and Source

Grids System	**Data**	**Sources of Data**	**Build Margin (kg CO_2/kWh)**
Peninsular Malaysia Grid	Conservative Method	Energy Commission	0.681
Sarawak Grid	Real Data on fuel consumed and electricity generated	SESCO	1.246
West Sabah Grid	Real Data on fuel consumed and electricity generated	SESB and NEB	0.744

Step 3 - Calculation of the baseline emissions factor

The final step in applying the consolidated methodology for the baseline determination is to calculate the baseline emission factor. This is calculated as the weighted average of the emissions factor of the OM and the BM. The formula that is used to calculate this weighted average emission factor is as follows:

$$EF_y = w_{OM} \cdot EF_{OM,y} + w_{BM} \cdot EF_{BM,y}$$

3.3.4 Calculation of Combined Margin

The emissions factors of the OM and BM are weighed equally, each 50%, by default, although different weights may be used with appropriate justification. For the results of this study for the three regions in Malaysia, the OM and BM are weighed equally. The final results of Combined Margin are follows:-

Table 3: Combined Margin Results Based on Grids System

Grids System	**Combined Margin ($kg\ CO_2/kWh$)**
Peninsular Malaysia Grid	0.631
Sarawak Grid	0.967
West Sabah Grid	0.647
East Sabah Grid	0.800

4.0 Data collection and assumptions

The baseline has been calculated using data on the average efficiency for specific power plants as obtained from Energy Commission. Several data assumptions have been made in order to calculate the electricity baseline. These assumptions were based on two main reports namely TNB Fuel Specifications and IPCC. Tables 4a – 4b present the data assumptions and values used in the baselines calculation together with the sources of data.

Table 4a : Emission Factors Based on Fuel Types

Emission Factors			Unit
Coal tonnes	=	0.094	t C02/GJ
MFO tonnes	=	0.077	t C02/GJ
Gas (GJ)	=	0.056	t C02/GJ
Diesel/Distillate tonnes	=	0.073	t C02/GJ

Source: IPCC, 1996

Table 4b : Oxidation Factors Based on Types of Fuel (in %)

Oxidation Factors		
Coal tonnes	=	0.98
MFO tonnes	=	0.99
Gas (GJ)	=	0.995
Diesel/Distillate tonnes	=	0.99

Source: IPCC, 1996

4.1 Leakage

Leakage is defined as the net change of anthropogenic emissions by sources of greenhouse gases (GHG) which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity.

For most renewable energy projects, including hydro and biogas to electricity in Malaysia no potential sources of leakage will be identified. However, for projects involving the use of biomass, leakage maybe identified due to the fact that the biomass used results in extra emission related to transporting the biomass. For example, when using the Empty Fruit Bunches (EFB) from more than one mill that have to be transported to the site where the power will be generated. Such emissions have to be quantified. It will depend on each individual project whether such leakage is applicable or not. Because this issue is project specific, it is not further considered in this study.

5.0 Calculation of baselines in Malaysia

The calculation the fuel consumption per plant based on assumptions on plant efficiency provided by the Energy Commission. Please note however, that the data on plant efficiency used and provided by the EC are data as reported to the EC by the specific plant operator. The data reported to EC are the efficiency as per original design of the power plant. Therefore, these can be considered conservative. This section presents the results of applying ACM 0002.

5.1 Baseline for Peninsular Malaysia

The calculation of "Operation Margin" is based on the generation-weighted emissions per electricity unit of all power plants generating units serving the grid system in Peninsular Malaysia. This excludes the generation from "Hydro" as a must-run/ low-costs fuel source. The data available for the most recent 3 years are the years 2002, 2003 and 2004. These 3 years of historical data are illustrated in Table 5 below:

Table 5: Simple Operation Margin for Peninsular Malaysia

Years	Generation (GWh)	CO_2 Emission (tonnes)	Baselines (kg CO2equ/kWh)
2004	77,566	48,808,151	0.629
2003	67,511	37,833,007	0.560
2002	62,854	34,604,511	0.551
Average Operation Margin for 3 years			0.580

Sources : Energy Commission (2004)

The "Simple Operation Margin" has been calculated based on the average of 3 years of historical data and is (0.629+0.560+0.551)/3 or 0.580 kg CO_2/kWh.

Table 6: Build Margin for Peninsular Malaysia

Name of Projects / Fuel Types	Year Operation	Capacity, MW	Total Generation, MWh	CO2 Emission (t CO_2)
1. Janamanjung Power Plant/Coal	September-03	2070	12,289,662	11,299,338
2. GB3 Power Station/Gas	March 2003	640	4,246,276	1,957,087
3. Panglima Power Station/Gas	April-03	720	5,577,858	2,758,729
4. Perlis Power Station/Gas	April-03	650	5,328,046	3,229,780
5. SKS Prai Power Station	June-03	350	2,113,703	872,175
Total			29,555,545	20,117,109

Source: Energy Commission (2004)

The calculations of "Build Margin" are based on the weighted average emissions of the 5 most recently installed power plants in Peninsular Malaysia. The total output generated by these 5 plants in 2003 is more than 20% of the total system generation in Peninsular Malaysia (20,055,350 MWh out of the total 82,550,893 MWh or 24%). The Build Margin for Peninsular Malaysia is calculated as follows

CO_2 Emissions divided by the total generation = 20,117,109 ton CO_2 / 29,555,545 MWh or 0.681 kg CO_2/kWh.

Finally the "Combined Margin" is calculated by averaging the "Simple Operation Margin" with the "Build Margin". Therefore the "Combined Margin" is (0.580 + 0.681)/2 or 0.631 kg of CO_2/kWh.

5.2 Baseline for Sarawak

The backbone of Sarawak grids is the 275 kV transmission connecting Kuching to Miri with distance of 765 km. These main grids lie along the coastal area or western region of Sarawak.

Plants outside the grid provide less than 5% of the state's energy and these are either small diesel generating sets or mini-hydro plants. These plants have

been excluded from the calculation as they are considered to be outside the project boundary because they are not interconnected.

Table 7: Simple Operation Margin for Sarawak

Years	Generation (MWh)	CO_2 Emission (tonnes)	Baselines (kg CO_2/kWh)
2002	3,399,755	3,189,323	0.935
2003	3,442,379	3,293,360	0.954
2004	3,794,315	4,059,609	1.067
Average Operation Margin for 3 years			0.985

Sources : Sarawak Electricity Supply Corporation (2004)

The average baseline for 3 years historical data is (0.935 +0.954 +1.067)/3 or 0.985 kg CO_2/kWh.

To calculate the “Build Margin” data on the most recent information available on plants already built has been used. The sample plants included in the BM are the five most recently installed plants providing power to the grid. The capacity additions should comprise at least 20% of the total system generation. The total output generated and supplied to the grid by these 5 plants in 2004 is more than 20% of the total system generation in Sarawak (2,471,273 MWh out of the total 4,147,510 MWh which is almost 60%.

Therefore the “Build Margin” for Sarawak is (3,079,795 tonnes CO_2/2,471,273 MWh) or 1.246 kg CO_2/kWh. The higher value of “Build Margin” is mainly due to the fact that the 3 most recent power plants built were all coal fired power which significantly increases the emission figures as illustrated in Table 8.

Table 8: Build Margin for Sarawak

Name of Projects / Fuel Types	Year Operation	Capacity, MW	Total Generation, MWh	CO_2 Emission (t CO_2)
1. Sejingkat Power Station (SESCO)/Coal	Jul-04	55	248,325	
2. Sejingkat Power Station (SESCO)/Coal	Jan-04	55	191,246	734,540
3. Sejingkat Power Station (SPC) IPP/Coal	May-98	100	640,188	1,190,282
4. Bintulu Power Station (SPG-IPP)/Gas	Jan-99	220	1,197,128	988,234
5. Bintulu Power Station (SESCO)/Gas	Aug-97	32	194,386	166,739
Total			**2,471,273**	**3,079,794.76**

Sources : Sarawak Electricity Supply Corporation (2004)

The “Combined Margin” is calculated by averaging the “Simple Operation Margin” with the “Build Margin”. Therefore the “Combined Margin” for Sarawak is (0.985 8 + 1.246)/2 or 1.116 kg CO_2/kWh.

5.3 Baseline for West Sabah

Power transmission in Sabah can be divided into 2 main grids namely the West Coast Grid and the East Coast Grid. Both of these grids are not interconnected. The West Coast Grid serves the populated western coastal region of Sabah.

Independent power producers own several plants, with capacity ranging from less than 10 MW each to 15 MW, and are fuelled by residual fuel oil. Gas is being used in a 120 MW open cycle gas turbine plant as well as in a small gas turbine cogeneration plant in Labuan Island, connected via 132 kV sub marine cable to Beaufort, which is on the West Coast Grid.

Table 9 : Simple Operation Margin for West Sabah

Years	Generation (MWh)	CO_2 Emission (tonnes)	Baselines (kg CO_2/kWh)
2002	1,358,813	554,321.13	0.408
2003	1,489,763	796,698.47	0.535
2004	1,516,198	1,074,465.32	0.709
Average Operation Margin for 3 years			0.551

Sources : Sabah Electricity Sdn. Bhd. & National Energy Balance (2004)
Notes:
- Data on MWh and fuel consumption(aggregate) for SESB Power Plants are provided by SESB.
- Data on MWh produced and fuel consumption for IPPs are provided by NEB for the years 2002 & 2003. For 2004 data on MWh for IPPs are provided by SESB and the fuel consumption is calculated based on efficiency provided by Energy Commission

The average baseline of Simple Operation Margin for 3-year vintages for the West Sabah grid is (0.408 + 0.535 + 0.709 /3 or 0.551 kg CO_2/kWh.)

The calculation of "Build Margin" for West Sabah is based on the five most recent plants added to the grid. This is equal to 20% of the total grid generation system. The total capacity in 2004 was 1,966,192 MWh and the total output generated by these 5 plants is more than 20% of the total system generated in 2004 (1,303,192.84 MWh out of the total 1,966,192 MWh). The ratio between the newly installed plants generation with grid generation system is 66%.

The "Build Margin" for Sabah is (969,970 tonnes CO_2/1,303.19284 MWh) or 0.744 kg CO_2/kWh. The lower value of "Build Margin" is mainly due to the fact that all the most recent power plants built were gas fired power plants which is significantly reduces the emission figures as illustrated in Table 10.

Table 10: Build Margin for West Coast Sabah

Name of Projects / Fuel Types	Year Operation	Capacity, MW	Total Generation, MWh	CO_2 Emission (t CO_2)
Powertron	1998	120	803,004.48	556,427
ARL	1996	50	53,369.82	37,733
Gantisan	1996	40	12,562.60	11,435
Patau-Patau GT3	1995	33	423,627.55	354,700
Melawa	1995	20	10,628.40	9,675
Total			**1,303,192.84**	**969,970**

Notes:
- Data on MWh per plant in the table are provided by SESB. The CO_2 emissions are calculated based on the plants efficiency as provided by the Energy Commission.

The "Combined Margin" is calculated by averaging the "Simple Operation Margin" with the "Build Margin". Therefore the "Combined Margin" for Sarawak is (0.550 + 0.744)/2 or 0.647 kg CO_2/kWh.

5.4 Baselines for East Sabah

The East Coast Grid serves the various smaller grids on the east coast which is connecting Sandakan to Tawau via 132 kV transmission lines. While the rest of the state contains isolated mini-grid systems which are not connected to this main grid in East Sabah. All power plants that serve the East Coast Grid are using diesel or fuel oil as a fuel.

Taking this into account and taking into account that it is not expected that any renewable energy project will be developed on the East Coast in Sabah with a capacity higher than 15 MW in the near future, it is recommended to follow the small scale guidelines here to develop the baseline (the "Indicative Simplified Baseline and Monitoring Methodologies for Selected Small-Scale CDM Project Activity Categories"). These guidelines indicate that for grids which only contain of diesel or fuel oil fired plants the emission factors or baseline of 0.8 kg CO_2/kWh can be used. This is the recommended figure for diesel generator systems for capacities greater than 200 kW (see also http://cdm.unfccc.int/Projects/pac/ssclistmeth.pdf).

5.5 Summary of Results

In summary, the following emission figures are used as the baseline for the three regions in Malaysia:

Simple Operation Margin
Peninsular Malaysia: 0.580 kg CO_2/kWh
West Sabah: 0.551 kg CO_2/kWh
Sarawak: 0.985 kg CO_2/kWh

Build Operation Margin
Peninsular Malaysia: 0.681 kg CO_2/kWh
West Sabah: 0.744 kg CO_2/kWh
Sarawak: 1.246 kg CO_2/kWh

Combine Operation Margin
Peninsular Malaysia: 0.631 kg CO_2/kWh
West Sabah: 0.647 kg CO_2/kWh
East Sabah: 0.800 kg CO_2/Kwh
Sarawak: 1.116 kg CO_2/kWh

6.0 Indicative Simplified Baseline and Monitoring Methodologies for Selected Small-Scale CDM Project Activity Categories

As discussed earlier in Section 3, ACM 0002 is not applicable to project activities that involve switching from fossil fuels to renewable energy at the site of the project activity, since in this case the baseline may be the continued use of fossil fuels at the site. As for this reason, the "Simplified Baseline and Monitoring Methodologies for Selected Small-Scale CDM Project Activity Categories" can be used to determine the baselines for small scale project and biomass being developed in Malaysia. The baseline calculations are almost similar with ACM0002 however only one most recent year data were used (2004).

The baseline is the kWh produced by the renewable generating unit multiplied by an emission coefficient (measured in kg CO_2equ/kWh) calculated in a transparent and conservative manner. The baseline is either the average of the "approximate operating margin" and the "build margin", or the weighted average emissions of the current generation mix. These terms are defined by EB as follows:

(a) The average of the "approximate operating margin" and the "build margin", where:

- (i) The "approximate operating margin" is the weighted average emissions (in kg CO_2equ/kWh) of all generating sources serving the system, excluding hydro, geothermal, wind, low-cost biomass, nuclear and solar generation;
- (ii) The "build margin" is the weighted average emissions (in kg CO_2equ/kWh) of recent capacity additions to the system, which capacity additions are defined as the greater (in MWh) of most recent 20% of existing plants or the 5 most recent plants.";

OR,

(b) The weighted average emissions (in kg CO_2equ/kWh) of the current generation mix.

In this study, "approximate operating margin" was used to calculate the baselines for three in Malaysia. The final results of "approximate operating margin" are follows:-

Table 11: Baselines Results Based for Three Regions in Malaysia

Grids System	Approximate Operation Margin (kg CO_2/kWh)	Build Margin (kg CO_2/kWh)	Average of Approximate Operation Margin and Build Margin (kg CO_2/kWh)
Peninsular Malaysia Grid	0.629	0.681	0.655
Peninsular Malaysia Grid* *(using most recent 20% of existing plants)*	0.629	0.781	0.705
Sarawak Grid	0.985	1.246	1.157
West Sabah Grid	0.709	0.744	0.727
East Sabah Grid	-	-	0.800*

Notes: *Selecting 20%, only Janamanjung Power Plant, Prai Power Plant and Perlis Power Plant have to be included in Build Margin.

**** For a system where all the generators use exclusively fuel oil and/or diesel fuel, default emission factor were used as given in Table I.D.1 as indicated in Appendix B of the simplified modalities and procedures for small scale CDM project activities***

9. References

- CDM Executive Board (3 December 2004): Approved Consolidated Baseline Methodology ACM002
- CDM Capacity Building Project (2003): Determination of Baseline for Malaysia
- Statistic of Electricity Supply Industry in Malaysia (2004), Suruhanjaya Tenaga.
- Performance of Power Station in Peninsular Malaysia and Sabah (2003), Jabatan Perbekalan Elektrik, Suruhanjaya Tenaga.