EF Calculation Report - Honduras

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2008 Emission Factor Calculation Report for the Republic of Honduras

Contents

1. Introduction

The purpose of these notes is to present the results from the estimation of the emission factor for the electric system of the Republic of Honduras, in line with the methodological guidance determined by the UNFCCC[1].

The period under analysis goes from 2006 to 2008, being these the last three years with statistical information regarding the national interconnected system (NIS). This set of information will allow us to estimate the *ex-ante* emission factor for year 2008.

The calculations presented next follow the guidelines and the order established in the latest version to date of the "*Tool to calculate the emission factor for an electricity system*"[2].

[1] United Nations Convention on Climate Change (www.unfccc.int)
[2] Version 1.1; available at http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v1.1.pdf

It is strongly recommended to see the "User Manual for the calculation of the Emission Factor for an electric grid" for a more detailed technical discussion, as well as the attached Excel spreadsheet with the tables and formulas used in the consultancy.

2. The Honduran Interconnected System

2.1 Institutional framework[3]

Despite the reforms introduced by the Electricity Law of 1994[4] , which defined an institutional structure and industrial organization for the electric power industry that contains the basic elements of the standard model used practically worldwide to promote an efficient and sufficient power supply, the Empresa Nacional de Energía Eléctrica (ENEE) has remained the most important institution related to almost every aspect of the energy market, from planning and regulation to generation to distribution. ENEE is conducted by a Board of Directors presided by the Secretary of Environment and Natural Resources (SERNA[5]). Other members of the board include the Secretary of Transportation, Household and Public Works, Secretary of Finance, Secretary of Industry and commerce and a representative from the private sector, among others.

Generation in Honduras is open to both private and public facilities, which are allowed to sell their generation to large consumers or directly to ENEE. As to transmission, public and private operators are allowed to build and own their own lines. However, in practice ENEE is the main responsible for transmission operations since this entity is the responsible for the Dispatch Center, which coordinates dispatch according to the hourly generation cost. Finally, although the 1994 reforms required privatization of the distribution system, the latter were never achieved and therefore ENEE remains the only energy buyer and the entity in charge of distribution to small consumers. Therefore, power purchase agreements (PPA) between private generators and ENEE have become the main instrument in this vertically integrated energy market.

2.2 Baseline scenario

The grid emission factor focuses on two specific aspects of the baseline scenario. These two aspects comprise the electricity that, in the absence of the proposed project activity, would have been delivered to the grid by:

a) Other plants currently in the grid[6], or
b) New additions to the system[7]

[3] This subsection is based on "*Honduras: Power Sector Issues and Options",* World Bank, July, 2007
[4] Ley Marco del Subsector Eléctrico (1994)
[5] In spanish, Secretaría de Recursos Naturales y Ambiente
[6] This aspect is captured by the Operating Margin Emission Factor.
[7] This aspect is captured by the Build Margin Emission Factor.

The Honduran grid capacity is mostly provided by thermal power plants that burn fossil fuels in order to generate electricity. Actually, 63% of the total grid capacity is provided by this kind of technology (Table 2). Renewable energies conform the remaining 37%. In particular, hydro power plants provide 33% of the overall capacity. However, there two interesting facts that need to be stressed. The first one is that 89% of total hydro capacity comes from public facilities (Table 3), which is explained by the fact that there are no large-scale private hydro generators. The second fact is that almost the entire set of private hydro plants consists of registered (small-scale) CDM projects.

Table 1 - Share of overall nominal capacity by type of facility and technology (2008)

Ownership	Hydro	Biomass	Fossil Fuels	Total
Public	31%	0%	0%	31%
Private	4%	3%	62%	69%
Total	35%	3%	62%	100%

Source: ENEE - http://www.enee.hn/publicaciones.htm

Table 2- Share of nominal capacity of each type of technology by type of facility (2008)

Ownership	Hydro	Biomass	Fossil Fuels	Total
Public	87,6%	0,0%	0,1%	31%
Private	12,4%	100,0%	99,9%	69%
Total	100%	100%	100%	100%

Source: ENEE - http://www.enee.hn/publicaciones.htm

Respect recent additions, the majority of the latter have been CDM projects as well. If we exclude these from the list[8], we have that the prevalent technology is thermal –mainly, plants burning fossil fuels- and to a lesser extent, biomass (see Figure 1).

The tables above show that thermal is both the prevalent technology in the country *and* the most common choice when it comes to new additions, and such is the baseline situation in which the project is expected to take place. A quantitative estimate of these two aspects of the current scenario is presented next.

[8] As suggested by the tool/methodology

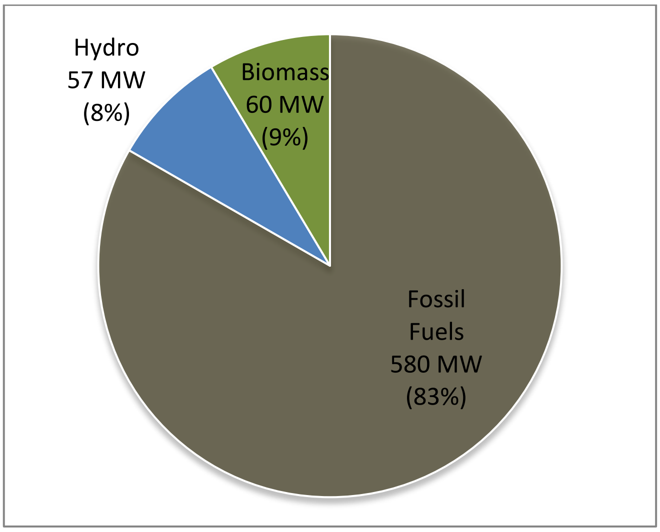
Table 3 – Recent additions to the grid (last five years – total: 697 MW)

Unit Name	Capacity[9] (MW)	Entry date	Technology
Envasa	8	2008	Fossil Fuels
Celsur	14	2008	Biomass
San Carlos (CDM)	2,3	2008	Hydro
Green Valley	10	2007	Fossil Fuels
Chumbagua	7	2007	Biomass
Cortecito (CDM)	3,2	2007	Hydro
Cuyamel (CDM)	7,8	2007	Hydro
Ecopalsa (CDM)	1	2007	Biomass
La Glorias (CDM)	5,8	2007	Hydro
Cuyamapa (CDM)	12,2	2006	Hydro
Azunosa (Inv. Hondureñas)(CDM)	4	2005	Biomass
Cahsa	25,8	2005	Biomass
Cececapa (Congelsa) (CDM)	2,856	2005	Hydro
Yojoa (CDM)	0,63	2005	Hydro
Enersa	259	2004	Fossil Fuels
Elcatex	21,8	2004	Fossil Fuels
Lufussa III	267,4	2004	Fossil Fuels
Babilonia (Energisa)	4	2004	Hydro
La Esperanza (CDM)	12,76	2004	Hydro
Laeisz NACO	13,5	2004	Fossil Fuels
Río Blanco (CDM)	5	2004	Hydro
Tres Valles (CDM)	7,8	2004	Biomass

Source: ENEE - http://www.enee.hn/publicaciones.htm

[9] Al año 2008

Figure 1 - Recent additions during the last five years by technology type (total: 697 MW)



Source: Author's elaboration based on ENEE data presented on Table 3

3. The 2008 Emission Factor for the Honduran National Interconnected System

3.1 General introduction and information used

The "Tool to calculate de emission factor for an electricity system" states that the baseline emission factor must be estimated as the weighted average between an operating margin emission rate (EF_{OM}) and a build margin emission rate (EF_{BM}). The first of these rates captures the project's effect on the operation of the power plants that are already part of the grid, while the latter accounts for the project's effect on the construction of new power plants. The weighted average of these two effects is known as the combined margin emission factor (EF_{CM}).

Broadly speaking, two pieces of information need to be gathered in order to estimate the different EF's. The first one is **net energy generation** by the different units in the NIS. The second set of information required is fuel consumption by each of the units that burn fossil fuels in order to generate electricity. Both data needs to be gathered for the last three years with available information, which in this case are 2006, 2007 and 2008.

Generation information is made publicly available by ENEE. As this is an official source, this information was used[10]. Regarding fuel consumptions, ENEE only publishes data for public facilities, and therefore information for private generators was obtained upon request to each of them via electronic mail. This information was delivered to the consultant firm by SERNA and was therefore treated as official data.

[10]In Spanish: "Empresa Nacional de Energía Eléctrica" (www.enee.hn)

Once the information was collected, calculations proceeded according to the methodological tool. The results are presented in the following sections.

3.2 Operating Margin Emission factor

The calculation of the operating margin emission factor ($EF_{grid,OM,y}$) is based on one of the methods presented in the following table.

Table 4- Methods for OM EF estimation

Method	*Specifications*
(a) Simple	Excludes low-cost (renewable)/must-run (coal, nuclear) resources; can only be used if the latter constitute less than 50% of total grid generation. Uses annual data for generation and fuel consumption.
(b) Simple adjusted	Variation of the simple OM for grids where generation from low-cost/must-run units comprises more than 50% of total generation. The power units (including imports) are separated in low-cost/must-run power sources and other power sources. Although it uses the same data considered for the simple method, the estimation of the adjustment demands hourly data for generation for each type of technology.
(c) Dispatch data analysis	This is the most accurate option. However, requires handling of a massive volume of hourly data and knowing the exact merit order for each hour of the year. In practice, it can only be calculated in real-time by dispatch centers.
(d) Average	Calculated as the average emission rate of all power plants serving the grid, *including* low-cost/must-run power plants. By doing this, it results in a lower emission factor.

The OM emission factor is determined according to option "a" (simple OM) from the "Tool to calculate the emission factor for an electricity system". This choice is justified since low-cost/must run resources constitute less than 50% of the total generation mix in Honduras[11] and no hourly information is available to use option (c) Dispatch data analysis[12].

The operating margin for the simple method is obtained by dividing emissions from all the plants serving the grid (except for low-cost/must-run units) among the net generation provided by the same plants. In the Honduran case, the excluded plants are renewable (low-cost) and coal (must-run). This leaves only plants running on bunker and/or diesel.

[11] See the Excel book, sheet "DATA y OM", cells I54 (2006), J54 (2007) and K54 (2008).
[12] Detailed information is presented on the Annex.

According to the available information, it may be calculated:

- Based on data on fuel consumption and net electricity generation of each power plant (Option A), or
- Based on data on net electricity generation, the average efficiency of each power unit and the fuel type(s) used in each power unit (Option B), or
- Based on data on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system (option C)

Considering that fuel consumption data was made available by the respective facilities, option A was chosen.

The simple OM emission factor for each year y (hereafter, $EF_{grid,OMsimple,y}$) is calculated as follows:

(1) $$EF_{grid,OMsimple,y} = \frac{\sum_{i,m} FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{\sum_{m} EG_{m,y}}$$

$FC_{i,m,y}$ is the amount of fuel i (in thousand gals) consumed by power source m in year y; *"m"* refers to the power sources delivering electricity to the grid (not including low-operating cost and must-run power plants[13]); $NCV_{i,y}$ is the net calorific value (energy content) per mass unit[14] of fuel i (TJ/10^3 tons); $EF_{CO2,i,y}$ is fuel i´s carbon dioxide content (tCO_2/TJ), and $EG_{m,y}$ is the electricity (in MWh) delivered to the grid by source m.

The upper part in expression (1) is the sum of the emissions in each one of the plants in set m. In turn, these are obtained by multiplying their fuel consumption by the coefficient NCV x EF, which "translates" fuel consumption into its CO_2 emissions equivalent. These emissions and energy generation is presented in the following tables:

Table 5 - Fuel consumption and emissions in the OM

Fuel	Consumption (10^3 gals)			Density (tons per gal) (IV)	*NCV x EF* (tCO_2 per 10^3 tons) (V)	Emissions (tCO2) (2005 to 2007) ((I)+(II)+(III))*(IV)*(V)
	2006 (I)	2007 (II)	2008 (III)			
Bunker	213.284	226.184	228.004	0,00375885	3.005	7.539.072
Diesel	3.963	1.874	3.255	0,0032074	3.006	87.647
Total						7.626.719

Source: Author's estimations based on information provided by the respective facilities

[13] According to the tool, electricity imports must be included in the set *m* with a zero emission factor. This implies that no fuel consumption is assumed for imported generation.

[14] Notice that the original fuel consumption data provided by the facilities is expressed in gals. These are converted to mass units (by means of a coefficient D_i) before multiplying by the rest of the coefficients.

Table 6 – Generation by the plants in the operating margin's set m (2006 - 2008)

Año	Generation[15] (MWh)
2006	3.777.642
2007	3.946.294
2008	4.052.663
Total	11.776.599

Source: ENEE

The operating margin emission factor is obtained as the quotient between the 7.63 million tCO_2 and the 11.78 millions MWh generated by the plants in set *m*. The result is **0,6476** tCO_2/MWh.

3.3 Build Margin emission factor

The BM emission factor calculation follows the indications on Step 4 of the "Tool to calculate the emission factor of an electricity system". Again, a group "*m*" is chosen. This time, the set *m* consists of[16] either the (i) five most recently–built power *units* or (ii) the capacity additions to the electricity system that comprises 20% of the system generation and that have been built most recently. The alternative which comprises the largest annual generation[17] must be chosen. CDM projects are again excluded from this set[18].

The BM emission factor for each year *y* is obtained as the generation-weighted average of the unit's emission factors:

(2)
$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \cdot EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

where the CO_2 emission factor for each power unit *m* ($EF_{EL,m,y}$) is given by:

(2')
$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \cdot NCV_{i,y} \cdot EF_{CO2,i,y}}{EG_{m,y}}$$

[15] Includes energy imports
[16] It is important to stress that this is not the same group *m* used in equation (1)
[17] As stated in the Methodological tool "Tool to calculate de emission factor for an electricity system" Version 01.1 (pag.12)
[18] Unless units with more than 10 years have to enter the BM, in which case CDM projects must be included.

$FC_{i,m,y}$, $NCV_{i,y}$, $EF_{CO2,i,y}$ and $EG_{m,y}$ are analogous to the variables described for the simple OM method above[19] in equation (1). This procedure is algebraically equivalent to adding up the emissions in set m and dividing them among the total electricity generated by the latter. This is presented in the table below, resulting in a build margin emission factor of 0.6181 tCO_2 /MWh.

Table 7 – Build Margin Emission factor estimates

Units in set "*m*"	**Entry date**	**Category**	**Fuel**	NCV x Efi x D ($tCO2/10^3$ tons)	**Gen. (MWh)**	**Fuel Cons. (10^3 gals – 10^3 tons)**	**Emis. (tCO2)**	**(tCO2 por MWh)**
Envasa	2008	Low Cost/Must-Run	Coal	485,56 (D=1)	6.882	7,048	3.422	0,50
Celsur	2008	Low Cost/Must-Run	Biomasa	0,0000	78.257		0	0,00
Green Valley	2007	Fossil Fuel	Fuel Oil	11,2950	25.043	1,502	16.966	0,68
Chumbagua	2007	Low Cost/Must-Run	Biomasa	0,0000	8.302		0	0,00
Cahsa	2005	Low Cost/Must-Run	Biomasa	0,0000	39.443		0	0,00
Enersa	2004	Fossil Fuel	Fuel Oil	11,2950	1.507.156	88.994	1.005.178	0,67
Enersa (Cont.)	2004	Fossil Fuel	Diesel	9,6403		379	3.656	0,67
Total					1.665.082		1.029.222	0,62
% total Gen					26%			*EF BM*

Source: ENEE and plants in the grid

3.4 Combined margin emission factor

Once the $EF_{grid,OM,y}$ and $EF_{grid,BM}$ are estimated, the combined margin emission factor (EF_{CM}) is obtained according to the following expression:

(3) $$EF_{grid,CM,y} = \omega_{OM} \cdot EF_{grid,OMsimple} + \omega_{BM} \cdot EF_{grid,BM,y},$$

with $\omega_{OM} + \omega_{BM} = 1$

where $EF_{grid,OMsimple}$ is the generation-weighted average of the $EF_{grid,OMsimple,y}$ for the last three years with available information, as presented on (1').

As suggested by the "*Tool to calculate the emission factor for an electricity system*", the default weights $\omega_{BM} = \omega_{OM} = 0.5$ were used.

The following are the results obtained:

[19] Again, fuel data is converted from gals to mass units before using formula (2')

Table 8 – Summary of the calculations

Operating Margin	Factor (I)	0,6476
	Weight (II)	0,5
Buid Margin	Factor (III)	0,6181
	Weight (IV)	0,5
Combined Margin = (I)*(II)+(III)*(IV)		**0,6329 tCO_2/MWh**

This concludes our calculations for the 2007 emission factor for the NIS of the Republic of Honduras. The ex-ante estimation for the grid factor in 2008 is 0,6329 tCO_2/MWh. In other words, *for each mega watt hour of energy generated by the Honduran grid, 0.63 tones of carbon dioxide are released to the atmosphere.*

Annex: Information and consulted sources

A) Data

Table 9 - SIN information

Nombre Unidad	Capac. 2008 (MW)	Entrada a la red	Combustible	Generación (MWh)			Comb.Fós.(Miles de gals o tons)		
				Año 1 (2006)	Año 2 (2007)	Año 3 (2008)	Año 1 (2006)	Año 2 (2007)	Año 3 (2008)
Envasa	8	2008	Coal			6.882			7,048
Celsur	14	2008	Biomasa			78.257			
San Carlos	2,263	2008	Agua (CDM)			15.828			
Green Valley	10	2007	Fuel Oil		30.724	25.043		1.811	1.502
Chumbagua	7	2007	Biomasa		3.822	8.302			
Cortecito	3,195	2007	Agua (CDM)		1.631	21.768			
Cuyamel	7,8	2007	Agua (CDM)		17.594	38.915			
Ecopalsa	1	2007	Biomasa (CDM)		2.482	2.859			
La Glorias	5,8	2007	Agua (CDM)		2.831	20.600			
Cuyamapa	12,2	2006	Agua (CDM)	14.009	50.306	52.517			
Azunosa (Inv. Hondureñas)	4	2005	Biomasa (CDM)	10.136	12.233	13.399			
Cahsa	25,751	2005	Biomasa	27.107	42.517	39.443			
Cececapa (Congelsa)	2,9	2005	Agua (CDM)	18.936	14.558	16.425			
Yojoa	0,63	2005	Agua (CDM)	1.347	1.866	2.246			
Enersa	259	2004	Fuel Oil	1.379.228	1.375.723	1.507.156	81.165	82.233	88.994
Enersa (Cont.)		2004	Diesel				183	260	379
Elcatex	21,8	2004	Fuel Oil	13.281	6.378	5.192	770	370	301
Lufussa III	267,4	2004	Fuel Oil	1.805.260	1.822.010	1.783.726	98.927	99.974	97.013
Lufussa III (Cont.)		2004	Diesel				44	19	23
Babilonia (Energisa)	4	2004	Agua	30.606	30.212	32.673			
La Esperanza	12,761	2004	Agua (CDM)	23.828	34.952	44.645			
Laeisz NACO	13,5	2004	Diesel	30.902	6.556	0	2.315	489	0
Río Blanco	5	2004	Agua (CDM)	38.372	34.421	35.045			
Tres Valles	7,8	2004	Biomasa (CDM)	26.506	21.473	22.261			
Nac de Ingenieros CTE.	20	2002	Diesel	309	3.749	11.719	0	301	883,7
La Grecia	12	2002	Biomasa	35.942	30.276	20.668			
Las Nieves	0,48	2002	Agua	1.514	996	1.312			
Nacaome	30	2002	Agua	32.405	42.674	41.788			
Lufussa Valle	80	1999	Fuel Oil	154.630	219.407	271.396	9.379	13.186	16.682
Lufussa Valle (Cont.)		1999	Diesel				20	31	3
Emce Choloma	55	1999	Fuel Oil	145.909	169649	210587,1	8.503	10.275	12.562
Emce Choloma (Cont.)		1999	Diesel				402	316	342
Aysa	8	1998	Biomasa	269	1.171				
Emce I / La Ceiba		1997	Fuel Oil	63.149	51.183	33.502	4.283	3.432	2.205
Emce I / La Ceiba (Cont.)		1997	Diesel				193	205	181
Lufussa I	39,5	1995	Diesel	8311	3.834	13.311	630	193	1.075
La Puerta (Gen_Elec + Hitachi)	33	1994	Diesel	1.105	330	2.860	176	61,4	368,4

(Continues on Table 10)

Table 10 - SIN Information (concludes Table 9)

Nombre Unidad	Capac. 2008 (MW)	Entrada a la red	Combustible	Generación (MWh)			Comb.Fós.(Miles de gals o tons)		
				Año 1 (2006)	Año 2 (2007)	Año 3 (2008)	Año 1 (2006)	Año 2 (2007)	Año 3 (2008)
Santa Fe	5	1994	Fuel Oil	0	-60	245	0	1,27	22,7
Elcosa	80	1994	Fuel Oil	168.276	244.137	142.620	10.256	14.903	8.724
Ampac	10,1	1994	Fuel Oil		35	0			
Zacapa II (Cenit)	0,5	1994	Agua (CDM)	3.004	2.400	3.075			
Santa María del Real	1,2	1986	Agua	3.766	2.590	5.119			
El Cajón	300	1985	Agua	1.038.558	1.236.291	1.298.632			
El Níspero	22,5	1982	Agua	91.291	55.652	34.156			
Río Lindo	80	1971	Agua	586.313	520.644	474.543			
Cañaveral	29	1964	Agua	185.906	164.475	152.025			
Sub Total	1502,08			5.940.175	6.261.722	6.490.739			
Imports				7.282	12.639	45.307			
Total Inc. Imports				5.947.457	6.274.361	6.536.046			

B) Sources

Data on annual generation by the respective units was obtained from ENEE publications, which are ready available on its website. Fuel consumptions were obtained from ENEE for public facilities, the latter of which are available in the same bulletin. The only exception to this is the station "EMCE La Ceiba", since official statistics show zero consumption despite the fact that the unit provided positive generation in the same period. Data provided by the plant was used instead.

Fuel consumption by private generators was obtained directly by the respective facilities. For those plants selling surplus energy, average efficiency (in gals per MWh) was used in order to accurately estimate fuel consumption corresponding to the energy that was effectively delivered to the grid. This was the case for Green Valley, Elcosa and Elcatex. In all this cases, total fuel consumption was divided in total generation (grid + internal use) in order to obtain the efficiencies. This quotient was then multiplied by the energy delivered to the grid. For the specific case of Elcatex, the assumption of 58 gals per MWh was used since at the time of making this report, the plant had not provided its total generation information. The source for this assumption is http://www.energyinternationalinc.com/spanish/pdfs/proyectoelcatex.pdf

Other important issues worth mentioning include:

- ENEE buys a part of Lufussa's generation, and reports the latter as independent generation in public statistics under the name "LUFUSSA convenio ENEE". This generation was attributed to the plant Lufussa III (Pavana III), since according to the station's owner, almost 98% of the generation sold to ENEE comes from this plant. This does not affect the EF estimations.

- In 2006, ENEE statistics indicate zero fuel consumption for the unit "Nacional de Ingenieros" although the plant generated energy, as reported by the same official statistical source.

- 63.9 MW must be added to total system capacity reported in Table 10 in order to obtain the same result displayed in table 3 of the 2008 annual statistical report (ENEE). This capacity corresponds to the plants El Coyolar, Puerto Cortés I y II, Eda, Lean y Aguan, excluded from our sample because they remained idle during the entire period under study (2006-2008).

- "Ampac" only provided energy to the grid in 2007. Since this generation was very close to zero, the consumption was assumed for the latter.