COLUMBIAN PROJECT PORTFOLIO IN THE ENERGY SECTOR UNDER CDM

-SUMMARY-

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SUMMARY

The developing countries are bound to increase their greenhouse-gas emissions significantly in the coming years as their energy consumption grows to meet the needs of economic development. Although these countries' share of atmospheric greenhouse-gas concentrations is small, and their prime concern is to achieve economic development and alleviate poverty, they can still help to reduce the risk of climate change, specifically through emission-reducing actions having no negative effect on their development.

The 1992 United Nations Framework Convention on Climate Change (UNFCCC), signed by many developing nations, has established a series of minimum commitments, such as preparing and updating inventories of greenhouse-gas emissions and drawing up plans and programmes for reducing emissions.

The Kyoto Protocol, adopted in 1997 by the Fifth Conference of the Parties, has established a Clean Development Mechanism (CDM)[a] as an international measure for reducing greenhouse-gas emissions. The CDM is a cooperative mechanism primarily intended to help developing countries attain sustainable development.

In this context, the present study proposes a method for formulating CDM projects according to existing guidelines and preparing a generic portfolio of CDM-eligible projects for reducing emissions in Colombia's energy sector[b]. This study is a continuation of two previous ones prepared by the Colombian Academy of Exact, Physical and Natural Sciences (ACCEFYN) with the cooperation of the GTZ (Gesellschaft für Technische Zumammenarbeit - German Technical Cooperation): ***Greenhouse-Gas Inventory***[1] and ***Options for Reducing Emissions***[2]. The Academy team shall keep abreast of future developments regarding the CDM's conceptual, methodological or operational aspects. Its aim in doing so is to see Colombia contributing to emission reductions and undertaking timely, competitive action at international level to develop CDM projects.

The developed countries tend to regard the Clean Development Mechanism as a further means of reducing their greenhouse-gas emissions, inasmuch as this task is less costly

[a] In Spanish: Mecanismo de Desarrollo Limpio (MDL).
[b] The formulation and implementation of projects of this nature is the responsibility of the Ministries of the Environment and Mines and Energy, as well as the National Planning Department, among others. Consequently, the Academy's proposal is presented not in place of action by Colombian state institutions but as a contribution by the country's scientific and technical community to discussions on an issue of such importance.

in developing countries than in their own. By contrast, developing nations like Colombia see the CDM as a new form of financial assistance for promoting sustainable development, technology transfers and equity. However, a major problem for some developing countries seeking to benefit from this mechanism is the lack of capacity for formulating and running suitable projects.

Colombia, acting through its Environment Ministry, has punctually conducted a study to review and analyze strategies for CDM implementation in Colombia.[3] The Ministry was assisted in this work by the World Bank, the Swiss Government, and the Academy (assisted in turn by GTZ of Germany). The study analyzes the present status and potential development of the emission-reduction market,[c] domestic competitivity, and the potential benefits of participating in CDM projects. It also proposes strategies for achieving the mechanism's development potential in Colombia. The following are the main strategies considered by the Environment Ministry's study:

* Undertaking institutional design to maximize CDM benefits.
* Strengthening institutional capacity.
* Developing Colombian capacity for formulating CDM projects.
* Developing risk-management alternatives for CDM projects in Colombia.
* Evaluating funding options for unilateral CDM projects.

The present study describes a methodology devised for evaluating and formulating CDM projects in the energy sector. On the basis of information contained in previous studies,[1,2] four technologies were selected for development and application of the methodology (Table 1).

Table 1. Selected technologies

SUPPLY SIDE	DEMAND SIDE
Wind power Cogeneration Photovoltaic solar energy conversion	Fuel switching in industry

[c] This emission-reduction potential is based on the findings of the study ***Options for Reducing Greenhouse-Gas Emissions in Colombia***.

CDM PROJECT ELIGIBILITY

For a project to be considered eligible for CDM implementation, two fundamental conditions laid down in the Kyoto Protocol have to be met:

- The project must provide real, measurable, certifiable emission reduction, that is, it must be additional (Art. 12 (5b) and (5c); and
- It must be conducive to sustainable development.

Additionality

No criteria have yet been clearly defined for evaluating additionality in the context of CDM.

Though additionality is not yet a closed issue, a project's environmental additionality will depend on the following three separate requirements:

- Formulation and justification of a baseline;
- Formulation and justification of the project; and
- Determination of emission reduction.

Emission reduction is the difference between base-case emissions and the project's emissions.

Once the project has passed the test of environmental additionality, the question arises whether the project is feasible in the existing circumstances on account of its economic advantages, or whether it will require incentives, available under CDM, for its implementation. Justification of economic additionality requires an answer to the question: Why should the project not be undertaken without the extra incentives provided by certified emission reductions (CERs)? Analysis of the answer should take into account technological, know-how, cultural and institutional barriers.

Although the Kyoto Protocol is not explicit on this point, several parties to the Convention believe that financial additionality needs to be introduced as an eligibility criterion for CDM projects. They consider that projects should be financially additional. Accordingly, projects that are currently financially viable and attractive, and therefore not financially additional in the context of CDM, should be excluded from CDM application.

Another aspect that is of importance to development of the mechanism is the building-up of national capabilities for formulating and evaluating projects and subsequently implementing and monitoring them.

Sustainability

Sustainability criteria are being introduced at international level. But no practical guidelines have yet been drawn up or adopted on how to deal with sustainable development at project level. It is commonly agreed that sustainability criteria should be three-dimensional, embracing social as well as environmental and economic aspects.[4]

BASELINE

The baseline is the virtual emission scenario that would occur, according to energy-sector forecasting, in the absence of any projects designed to reduce emissions (specifically CDM projects). To determine the baseline for a specific project, the emission scenario has to be estimated for the "no-project" case. This scenario is then taken as the base for calculating the emission reduction to be certified.

It should be noted that no criteria, rules, modalities or methodologies for estimating CDM baselines have yet been established at international negotiations.

Negotiation documents refer to the following approaches:

- Project-by-project baselines
- Sectoral baselines
- Standard baselines by project category
- National baselines

Baselines for energy projects in Colombia

In order for the baseline scenario to be in line with CDM and AIJ general directives at international level, recommendations made by OECD and IEA were taken into account, as were USIJI's methodology guidelines. The base scenario is intended to be environmentally feasible, transparent, verifiable, simple and low-cost, and to provide potential investors and others with a reasonable degree of certainty.[5]

In this context, the Baseline has been developed on the basis of the National Expansion Plan's chapter on Transmission (1999 update),[6] which considers several scenarios for the short term (ST 1998-2003) and the long term (LT 2003-2010).

The analyses were carried out by means of stochastic simulations of the system's operations, using a dual dynamic stochastic programming model.[d] The simulations contained a hundred hydrological series obtained from the system's historical data for the past fifty years, including minimum operating levels calculated for the rainy season of 1998 and the dry season of 1998-1999.

Details of the methodology applied

Forty-three thermal generating plants were considered for the projection scenario previously described as ST1 and LT5, some of them already in operation and others projected for the period 2000-2010. Using models for analyzing investment and simulation of hydrothermal dispatch, different alternatives were examined for supplying power demand, and estimates were made of average fuel consumptions, the system's energy performance, and changes in reservoirs. On the basis of this fuel-consumption simulation and taking into account IPCC/OECD/IEA emission factors,[7] equivalent CO_2 emissions were estimated for each plant, in t/GWh.

With this information a multiproject Baseline was determined for power generation in Colombia. Figure 1 shows the weighted average equivalent CO_2 emissions, by amount of energy generated, for each kind of power-plant technology, and also for the fuel-mix consisting of all the thermal plants (excluding the hydroelectric ones). The reason for fuel-mix emission estimate is the load curve (Figure 2). Since the cost of dispatch from plants is variable and is made up almost entirely of the cost of fuel, the change from one technology to another affects the whole system of generation, that is, it affects the order of merit of all plants in the system. So, for example, if renewable energy plants are introduced into the system, they should be attributed the same priority as hydroelectric plants, displacing the more inefficient, higher emission thermal plants.

[d] In Spanish, MPODE: Modelo de programación dinámica dual estocástica.

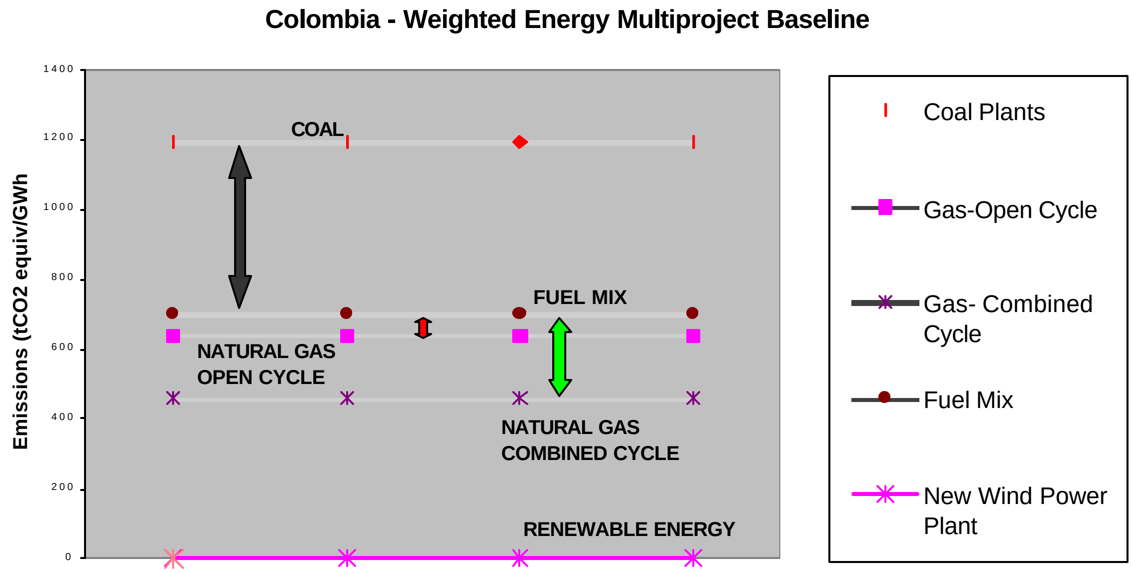

Figure 1. Multiproject weighted average baseline for Colombian energy sector

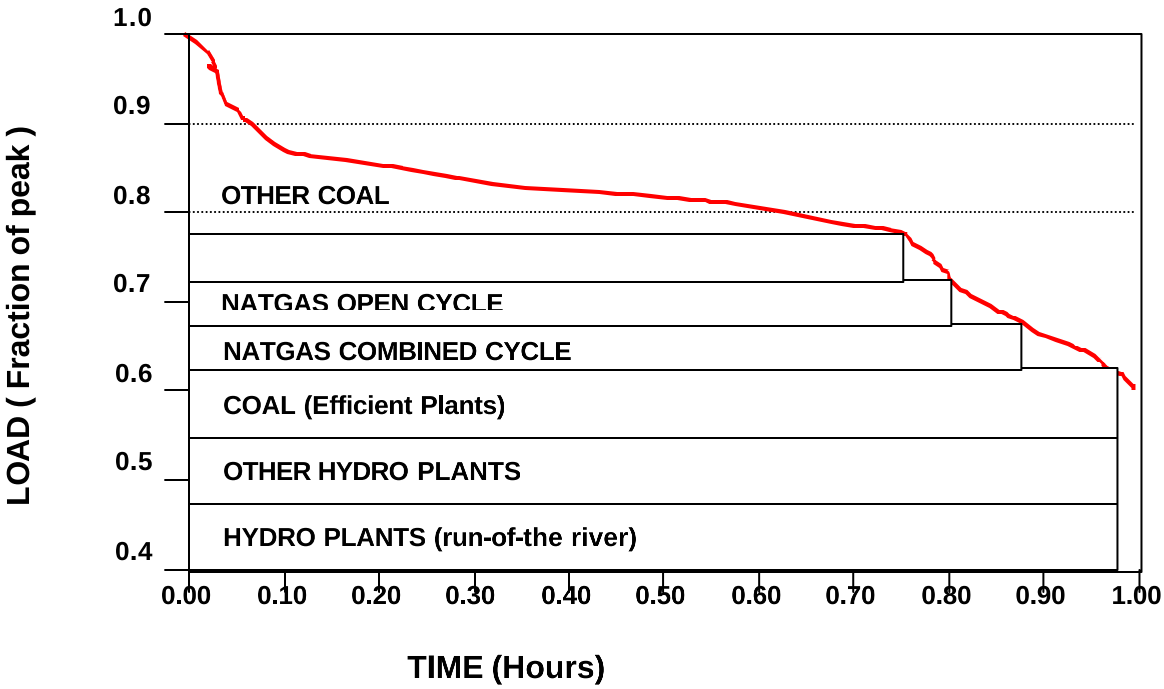

Figure 2. Load curve of Colombia's power generation system

According to this curve, the generating base consists of hydroelectric and efficient coal-fired plants, followed by combined-cycle gas plants. Next come open-cycle gas plants and coal-fired plants, competing according to their respective efficiencies. Lastly, at the peak there are the coal-fired plants with the lowest efficiency and hence the highest cost of power generation.

Baseline for thermal end-use projects

A multiproject base scenario has also been prepared for thermal end-use fuel consumption, taking into account the trend in recent years to decarbonize fuels, that is, to use fuels producing less CO_2 per unit of thermal energy released. IPCC's emission coefficients[7] are an indicator of emissions per gross GJ released. Each specific technology has a transformation efficiency (gross GJ to useful GJ) by which the emission index has to be divided. Figure 3 shows emissions per gross GJ released, for the different fuels used in supplying thermal energy in Colombia.

Depending on the particular technology, the emissions have to be divided by the respective efficiency. Emission reduction is therefore the combined effect of switching to a lower emission fuel (as in the switch from any of the fuels mentioned to natural gas) and improving the equipment's efficiency).

Uncertainties

The baselines determined in this study are subject to different kinds of uncertainties.

Political uncertainty. This refers to uncertainties regarding the country's environmental and energy policies. For instance, the use of fuels like Castilla crude that emit other toxic substances such as heavy metals may become prohibited. This would make it necessary to switch equipment to natural gas, for example.

Economic uncertainty. Projections of fuel consumption, and hence emissions, are made with indices of economic growth as variables. Colombia is going through a downturn and it is not clear when the situation will become reversed.

Technological uncertainty. The proposed technologies are widely known abroad. Some have been studied and put into operation in Colombia: for example, the use of solar cells to generate electricity. In the case of others, such as wind power, the resource has not yet been fully evaluated. Regarding the remaining technologies in general, there has been little practical experience with their use and limited information on them.

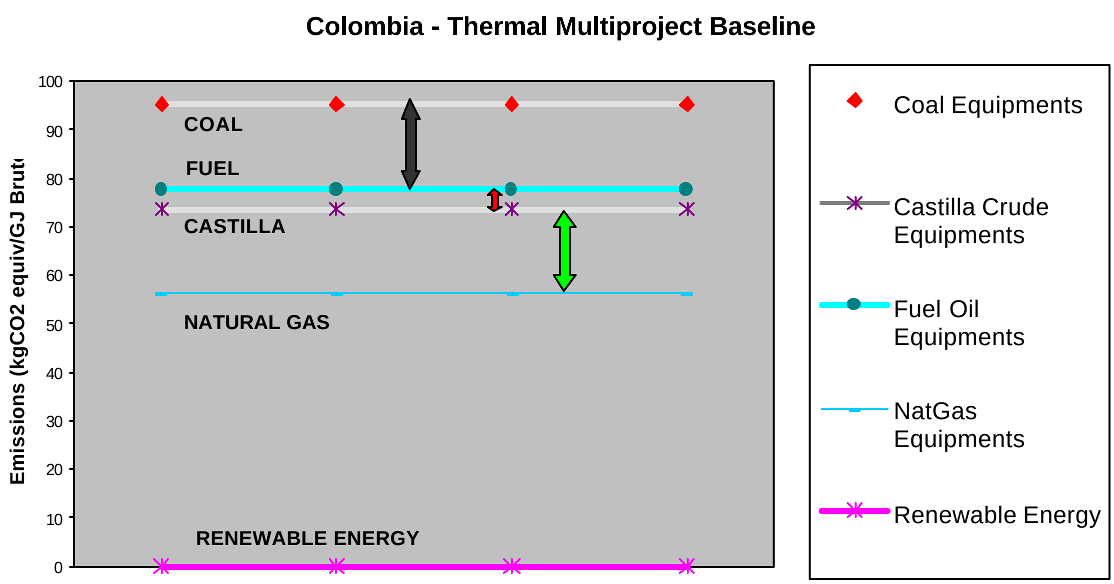

Figure 3. Emissions from different fuels, per gross GJ

METHODOLOGY FOR EVALUATING CDM ENERGY PROJECTS

Evaluation of CDM projects requires not only the conventional technical and economic assessment, but also consideration of the reduction in greenhouse-gas emissions over the project's life, relative to the established reference scenario or baseline. The economic consequences of emission reduction must also be taken into account. These are usually the extra cost of energy generated by the new technologies relative to the old, and the possibility of obtaining extra income from the potential sale of CERs. The extra cost of energy arises from the extra cost of equipment for reducing final energy consumption.

The proposed methodology is applied at the prefeasibility stage of projects with a CDM dimension, which involves assessing their emission reduction (environmental additionality) and economic viability, taking into account economic and financial mechanisms such as sale of CERs, soft loans and others under development.

The methodology used has provided an evaluation model based on incremental analysis, that is, comparing the present situation with the project situation, by evaluating the economic and environmental benefits that implementation of the project would produce. The model can assess the sensitivity of net present value (NPV) to change in technical and economic parameters. Specific packets have been developed for each one of the technologies evaluated using EXCEL[e].

Information for the energy model comes in each case from actual data on Colombian installations, or localities (in the case of renewable resources). Equipment and other costs are taken either from Colombian projects or from overseas projects duly adapted to the country's conditions.

PROJECT PORTFOLIO

No Uniform Reporting Format (URF) exists as yet for CDM projects. For this study, the URF established for AIJ (Activities Implemented Jointly) has been adopted and modified to fit CDM needs and this study's purposes and information level.

The general conditions for financial evaluation are: Currency: US$; Discount rate: 8%; Project evaluation period: 15 years. The value of CERs is assumed to range from US$0 to US$22. Fuel cost is the current fuel price in Colombia. The evaluation also takes into account the investment costs (including all Colombian taxes), the costs of engineering, project development (permits and licences), feasibility study, training and contingencies, as well as operating, maintenance and transaction costs in both the investment and operation stages. Risk is covered by environmental insurance.

For all projects, emission reduction is estimated by using the Baseline developed by the Academy as described above.

Wind power plant at Cabo de la Vela (Guajira, Colombia)

This project involves the feasibility study, design, construction and operation of a wind-power plant, initially of 22.5 MW, in the vicinity of Puerto Bolivar, in La Guajira Department, in northern Colombia. The plant would be connected to the National Transmission System to meet a fraction of the country's energy demand. It is meant to help reduce greenhouse-gas emissions by displacing thermal power plants using fossil fuels.

Previous studies conducted so far, the plant would generate 74 GWh/year and require the construction of a 110 kV transmission line 7 km long.

[e] EXCEL is a Microsoft registered trademark.

According to our Baseline, if the project displaces coal-fired plants, it is expected to reduce greenhouse-gas emissions by 88,179 tonnes of CO_2 equivalent a year.

The project's 15-year net present value (NPV) is US$840,905, evaluated at a discount rate of 8%. Its internal rate of return (IRR) is 8.49%. The payback period is 8.95 years. The cost of generated energy is US$0.04911/kWh. The short-term selling price of generated energy is assumed to be US$0.045/kWh and the CER price US$20/t CO_2 equiv. The project is therefore **environmentally and economically additional.**

This project in particular and the harnessing of Colombia's wind-power potential in general are in line with government policy on development, energy, environment and technology.

Cogeneration projects

Sectoral studies have been conducted in Colombia on cogeneration for both the industrial[8] and tertiary[9] sectors of the economy. Individual studies have also been prepared for various industries, though so far only few of the many proposed and evaluated projects have been implemented.

The evaluated projects have been for hotels and hospitals of different capacities, located in different parts of the country. Evaluations have shown that for hotels with some 200 rooms, current occupancy rates of 50%-60%, and cogenerating units of 200 kW or less, the projects are not generally viable because the investment cost depends strongly on the capacity of the cogenerating plant (see Hotels in Tables 2 and 3).

The four hospitals considered have effective cogeneration capacities ranging from 250 kW to 500 kW. In their case, the economic viability of projects with no economic support (CER at US$0/t CO_2 equiv.) is usually found to be very weak and uncertain. CER values of about US$10 to US$20 are needed to make the projects viable (see Hospitals in Tables 2 and 3). The findings point to a regional tendency: projects are more readily viable if they are located at low elevations, in a suitable energy and economic environment in which the fuel currently used in the boiler is costly compared with a cheap natural gas.

The cogeneration potential of Colombia's industrial sector has been estimated by previous studies at 248 MW (technical potential) and 177 MW (economic potential),[10f]

[f] In Cartagena a 4.3 MW open-cycle turbogas cogeneration unit has been in operation for the past two years.

but that of the tertiary sector at 30 MW. However, the country's economic conditions are no longer what they were when those potentials were determined.

Table 2. Technical features of the cogeneration projects studied

	Type	City	Electricity Demand	Thermal Energy Demand	Fuel		Cogeneration Plant Capacity	Energy generated
			kWh	MBtu	Current	Project	kW	kWh
1	Hotel 1	Bogotá	869,000	5,690	Castilla crude	natural gas	137	801,146
2	Hotel 2	Barranquilla	869,000	5,690	fuel oil	natural gas	137	804,080
3	Hospital 1	Medellín	2,932,410	12,245	Castilla crude	natural gas	478	2,805,478
4	Hospital 2	Barranquilla	2,932,410	12,245	fuel oil	natural gas	478	2,805,478
5	Hospital 3	Bogotá	2,163,720	20,020	Castilla crude	natural gas	250	1,467,300
6	Hospital 4	Barranquilla	2,163,720	20,020	fuel oil	natural gas	250	1,467,300
			11,930,260	**75,910**				**10,150,782**

Table 3. Economic and emission features of cogeneration projects studied (CER: US$10/t)

	Type	Plant Investment	Other Investment	NPV	IRR	Current	Project	Reduction
		US$	US$	US$	%	tCO2 eq./year	tCO2 eq./year	tCO2 eq./year
1	Hotel 1	213,377	41,049	-216,741		1,161	1,033	128
2	Hotel 2	147,594	37,760	-31,758	4.96	1,191	1,035	156
3	Hospital 1	432,892	52,024	24,313	8.85	3,243	2,088	1,155
4	Hospital 2	415,430	51,151	175,389	13.94	3,308	2,094	1,214
5	Hospital 3	275,117	44,256	90,868	12.57	3,458	2,854	604
6	Hospital 4	251,980	43,099	214,247	18.9	3,565	2,930	635
		1,736,390	**269,339**	**256,318**		**15,926**	**12,034**	**3,892**

The above analysis shows that **switching by this group of hotels and hospitals, as a whole is additional.**

Fuel switching in industries in Bogota

Industries and other users in the central region of the country use a fuel called Castilla crude, whose heat properties are comparable to those of fuel oil but which has high contents of sulphur, heavy metals and particles. Switching from this fuel to natural gas would bring environmental benefits to the country's industrial cities.

The project reviews a group of companies located in Bogota currently operating with Castilla crude. It evaluates the possibility of replacing this fuel by natural gas to reduce CO_2 emissions. The companies' individual consumption of Castilla crude ranges from 102,445 gal/month to 541,704 gal/month; the equivalent consumption of natural gas would be between 440,936 m^3/month and 2,331,558 $m^{3/}$month. Table 4 lists consumptions by company.

Relative to the Baseline determined by this study, emission reduction for the twelve companies is expected to be equivalent to 90,732 tonnes of CO_2 per year. Since emission reduction in each company depends on the amount of fuel substituted, it will range between 20,873 t/year for the first company and 3,947 t/year for the last.

The project is in the prefeasibility stage and has been determined to be additional and sustainable.

Actual measurable long-term emission reduction by company is summarized in Table 5. The total amount of greenhouse-gas emissions reduced per year is equivalent to 90,732 tonnes of CO_2.

The price of Castilla crude is US$2.87/MBtu and that of natural gas US$3.19/MBtu. Initial investment costs include those of converting the equipment to natural gas and the cost of the necessary piping. The evaluation has also taken into account the costs of engineering, project development (permits and licences), feasibility study, training and contingencies. Transaction costs in both the investment and operation stages and operating and maintenance costs have also been included. The CER rate is assumed to be US$22/t CO_2 equivalent. Costs have been taken from the technical literature on projects carried out in Colombia.

Table 4 presents figures of current fuel consumption by each of the twelve companies and the costs each would incur by switching from Castilla crude to natural gas.

Table 4. Fuel consumption and the costs of switching from Castilla crude to natural gas, for twelve companies.

	Fuel Consumption		***Internal Network Costs***			***Investment Costs***		
Company No.	Base Castilla crude consumption gl/month	Equiv. Natural Gas Consumption m3/month	Long m	Cost US$	Cost US$/m	Conversion US$	Plant Investment US$	Other Investment US$
1	541,704	2,331,558	300	27,692	92	153,846	181,538	12,557
2	308,772	1,328,990	100	9,231	92	30,769	40,000	5,480
3	215,422	927,203	650	35,231	54	358,974	394,205	23,190
4	213,029	916,900	80	7,385	92	76,923	84,308	7,695
5	181,433	780,911	261	31,722	122	102,564	134,286	10,194
6	165,444	712,092	150	13,846	92	51,282	65,128	6,736
7	138,828	597,531	300	23,077	77	61,538	84,615	7,711
8	137,631	592,379	70	3,051	44	92,308	95,359	8,248
9	123,509	531,596	200	8,718	44	143,590	152,308	11,095
10	123,509	531,596	150	15,385	103	61,538	76,923	7,326
11	102,924	442,997	250	12,821	51	41,026	53,846	6,172
12	102,445	440,936	80	3,487	44	102,564	106,051	8,783
	2,354,648	**10,134,688**		**191,645**		**1,276,923**	**1,468,568**	**115,188**

The findings of each company's financial analysis are presented in Table 5 under the appropriate indicators, together with each company's emissions before and after switching to natural gas.

Table 5. Financial data regarding the switch from Castilla crude to natural gas by twelve companies.

	Finnancial Indices			**Emissions**		
Company	**NPV**	**IRR**	**Payback Period**	**Current**	**Project**	**Reduction**
No.	**US$**	**(%)**	**(yr)**	**Ton CO2 eq/year**	**Ton CO2 eq/year**	**Ton CO2 eq/year**
1	-26,445	5.6	9.4	76,685	55,812	20,873
2	47,503	22.2	4.2	43,711	31,813	11,898
3	-321,929	NA	>15	30,496	22,195	8,301
4	-4,087	7.3	8.5	30,157	21,948	8,209
5	-57,430	0.5	14.3	25,684	18,693	6,991
6	2,400	8.6	7.9	23,421	17,046	6,375
7	-18,479	4.5	10.1	19,653	14,303	5,350
8	-28,483	3.0	11.3	19,483	14,180	5,303
9	-91,284	NA	>15	17,484	12,725	4,759
10	-14,345	5.0	9.7	17,484	12,725	4,759
11	674	8.2	8.1	14,570	10,604	3,966
12	-48,036	0.0	15.0	14,502	***10,555***	3,947
	-559,941			**333,331**	**242,599**	**90,732**

The switch to natural gas by this group of companies as a whole produces the following indicators:

- Emission reduction per million gallons of Castilla crude: 38,533 t CO_2 equiv.
- Investment per tonne of CO_2 equivalent reduced: US$17.46
- Loss of NPV through emission reduction: -US$6.2/t CO_2 equiv.

The financial analysis assumed that emission reductions would be sold at a rate of US$22/t CO_2 equiv. reduced.

The above analysis shows that **switching by this group of industries, as a whole is additional.**

Photovoltaic systems for rural communities

The project involves an integrated system supplying electricity to a typical rural community in a remote region of the country not connected to a grid.[e] The community consists of 13 households, a health-care post and a rural school. It is provided with the services of electric lighting and radio, as well as street lighting from 6 pm to 9 pm. There is also a community TV station. The system supplies AC electricity via inverters through a mini-grid. The number of people attended is about 120, including the schoolchildren.

The typical project is located in the Department of Vichada [11g], where the average annual solar radiation is 5.3 kWh/m^2. The peak power is 2,750 Wp, supplied by 55 modules, each of 50 Wp. Thus, the amount of renewable energy generated, after taking losses into account, is 4,753 kWh.

Relative to the Baseline, the expected reduction in greenhouse-gas emissions is 5.98 tonnes of CO_2 equivalent per year because the project displaces gasoline plants.

Information on costs has been taken from projects implemented in Colombia.[11] The project's 15-year net present value is US$-18,550, evaluated at a discount rate of 8%. Its internal rate of return is 0.73%. The payback period is 14.46 years. The cost of generated energy is estimated at US$1.105/kWh. The short-term selling price of generated energy is assumed to be US$1/kWh, and the CER price US$20/t CO_2 equiv.

[g] Vichada was taken as an example because a similar system to that described was installed in 1995 and has been in operation since then.

The project is not viable in the conditions in which it has been analyzed. Generation costs are over US$1/kWh, which is the short-term selling price.

It is important to point out that income from sale of CERs, despite being set at US$20/t, has no bearing on the project's viability, because of the limited amount of emission reduction.

The above analysis shows that **use of photovoltaic systems is additional**.

CONCLUSIONS

The main conclusions of this study are:

- Since operation of the Clean Development Mechanism has not yet been established, discussion of the subject needs to be closely followed.
- A more precise definition and methodology need to be established for the baseline.
- The multiproject scenario developed in this study is a proposal in this connection and has the advantage of being clear, plausible and transparent.
- The projects described in this study are only some of the CDM opportunities open in Colombia.
- Viability of the projects depends heavily on the local economic environment, price stability, climatic conditions, and the equipment's operating characteristics. Income from the sale of CERs or other economic incentives play a very large part in making the projects viable.
- Countries like Colombia should regard the CDM as an opportunity for obtaining financial assistance for sustainable development and the transfer of know-how.
- For Colombia to gain a competitive advantage over other countries, it will be necessary both to promote an appropriate institutional development, and to improve the country's capacity for formulating, evaluating, promoting, implementing, following up and monitoring projects.

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