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CDM implementation in Brazil's rural and isolated regions: the Amazonian case

Kamyla Borges da Cunha · Arnaldo Walter · Fernando Rei

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Abstract There is a growing understanding that energy services play a crucial role in underpinning efforts to achieve the UN Millennium Development Goals (MDG) and in improving the lives of poor people. Brazil remains challenged in regard to a number of social issues, notably poverty reduction in isolated areas, where access to electricity is as poor as their population. In the Amazonian region, most people have no access to electricity, or else have only a precarious supply. Due to several economic and technical reasons, many cities have old, inefficient diesel generators. In such a scenario, CDM (Clean Development Mechanism) can be an instrument both to mitigate climate change and to promote sustainable development in these remote areas, thereby contributing to the achievement of the MDGs in Brazil. However, CDM implementation in Brazil is still restricted to a few types of projects (such as sugar cane bagasse cogeneration and landfill gas use), mostly proposed by big companies and hardly ever directed to the Amazon region. The main objectives of this article are to assess the potential of CDM as a possible tool to promote electricity access to the poor rural population in the Amazonian region, and to discuss the main reasons why it has not become a reality so far.

1 Introduction

In September 2000, heads of state and governmental representatives of 191 countries met at the United Nations (UN) and adopted the Millennium Declaration. The Declaration outlines

K. Borges da Cunha (✉) · A. Walter
FEM & NIPE/State University of Campinas,
DE/FEM/Unicamp, PO Box 6122, 13083-970 Campinas, Brazil
e-mail: kamyla@fem.unicamp.br

A. Walter
e-mail: awalter@fem.unicamp.br

F. Rei
SENAC – São Paulo, Avenida do Café n.298,
Jabaquara/São Paulo, SP CEP: 04311-000, Brazil
e-mail: fernandorei@ig.com.br

the central concerns of the global community – peace, security, development, environmental sustainability, human rights and democracy – and articulates a set of interconnected and mutually reinforcing goals for sustainable development. Although energy is not explicitly mentioned in any of the Millennium Development Goals (MDG), there is a growing understanding that energy services play a crucial role in underpinning efforts to achieve the MDGs and in improving the lives of poor people across the world, since the lack of access to affordable, reliable, and environmentally-benign energy sources is a severe constraint on development.

Brazil has made significant progress toward achieving the MDGs, but remains challenged with regard to a number of social issues, notably poverty reduction in rural and isolated areas. Most of the poorest rural populations, living mainly in the Brazilian Northeast and North (Amazon) regions, have no access to electricity services due to socio-economic, geographic and environmental factors. It is estimated that 90% of the families living in these regions have an income of less than US$ 100 per week – in most cases much less – , and 80% of the population live in rural areas. In five of the nine states belonging to the Legal Amazon Area[1] the cost of grid extension is very high; moreover, there are geographic constraints such as large rivers and forests, besides environmental constraints defined by law.

In 2003 the federal government launched the *Luz para Todos* program (Light for Everyone), with the aim of extending electricity access to an additional 12 million people until the end of 2008. The program is based on the concept that universal access to electricity is essential to social and economic development of rural and isolated communities, to poverty alleviation, and to income increase. It requires that power generation and distribution companies submit an annual electricity expansion plan to the government. In order to achieve the planned expansion goals in rural and isolated areas, most of these companies turn to diesel generators, mainly because of the low capital cost relative to the up-front cost of renewable alternatives, whose implementation in rural areas still faces important barriers, most of them related to economic, technological and socio-cultural aspects.

However, due to the emissions of greenhouse gases (GHG) from diesel consumption, renewable energy technologies (RETs) should be contemplated as an option to promote electricity access to isolated communities. It is important to consider to which extent the Clean Development Mechanism (CDM) could contribute to overcoming economic constraints of RETs compared to the traditional option of electricity generation based on diesel oil.

This paper has the main objectives of assessing the potential and eligibility of CDM to promote electricity access to the isolated Amazon region, and discussing the main reasons why this potential has not been exploited. In order to achieve these aims, this paper has been organized in the following way. First, it addresses the relationship between poverty alleviation and electricity access, particularly in the Amazon region. Second, it discusses the feasibility of RETs as alternatives to conventional technology based on diesel oil. Finally, it investigates whether CDM can be instrumental in overcoming the barriers faced by RETs.

[1]'Legal Amazon' is a socio-geographic division of Brazil comprising the states of the Amazon river basin, including Northern Region states (Rondônia, Acre, Amazonas, Roraima, Pará, Amapá and Tocantins), the state of Mato Grosso (belonging to the Midwest Region), and part of Maranhão (belonging to the Northeast region).

The use of RETs in the isolated Amazon region is analysed in view of the requirements of Kyoto Protocol, such as actual reduction of (GHG) in the long-run, the contribution of RETs to the sustainable development, and the additionality associated with CDM[2] input. It should be remembered that CDM is a project-specific mechanism, i.e., all eligibility criteria should be met for each project. The intention of the authors, nonetheless, is to analyse the feasibility of CDM projects using RETs in isolated Amazon regions.

2 Human development goals and energy access: the case of the Amazonian isolated region

Although not explicitly set as a Millennium Development Goal, electricity access for the poor has been recognized as one of the most important issues towards development or, at least, to poverty alleviation (Fulkerson et al. 2005). Porcaro and Takada (2005) point out that electricity services, such as water heating, lighting and refrigeration, can improve the quality of life and the provision of basic services such as education and health care. Table 1 summarizes the importance of energy services to achieving the MDGs.

2.1 Poverty and electricity access in Brazil

The relationship between electricity access[3] and poverty alleviation in Brazil is not direct, but it exists. Clearly, affordability is a very important issue as poverty alleviation is not merely achieved with physical access to electricity. An indication of the relation between electricity consumption and quality of life is found in Fig. 1, where the Human Development Index (HDI; 2000 basis) and the total electricity consumption per capita for 177 countries and 27 Brazilian states are shown.

With regard to the correlation between HDI and per capita electricity consumption, Brazilian states are similar to most countries with medium development level. Only the Federal District (city of Brasília and surrounding area) and four Brazilian states in the South and Southeast regions had a HDI slightly above 0.80 in 2000. These five states have the highest electrification levels in the country, 97.9–99.7%, and just two of them have a significant share of its population living in the rural area (Rio Grande do Sul and Santa Catarina, with 18.4 and 21.3%, respectively).

As of 2000, the last year for which official data is available, it was estimated that about 6.5% of the Brazilian population (11 million out of 168 million people) were not provided with electricity services. Table 2 presents the electrification level in the year 2000, showing the distribution by household and by population.

There are substantial variations among the different regions of the country regarding access to electricity. According to Goldemberg et al. (2004a), only 68% of the rural population in the Northeast region has access to electricity, compared to 98.7% of the urban population of the Southeast region. These figures refer just to the accessibility to electricity, regardless of quality of service and affordability. The poorest regions in the country, which have the worst HDI – North and Northeast – , are those with the lowest rates of electricity access, as shown in Table 3 and in Fig. 2. However, it can be concluded from the

[2]In this assessment, the criterion of voluntary participation was not included because it concerns the proof that countries participating in the CDM project are Kyoto Protocol signatories.

[3]As outlined in the Introduction, access to electricity is understood from a perspective of physical and also economic feasibility.

Table 1 Linkages between energy services and the Millennium Development Goals

Goal	Importance of energy to achieve the goal
Eradicate extreme poverty and hunger	Access to affordable energy services enables enterprise development Lighting permits income generation beyond daylight hours Machinery increases productivity Local energy supplies can often be provided by small-scale, locally owned businesses Clean, efficient fuels reduce the large share of household income spent on cooking, lighting, and keeping warm Energy for irrigation helps increase food production and access to nutrition
Achieve universal primary education	Energy can help create a more child-friendly environment (e.g., access to clean water, sanitation, lighting), thus improving attendance at school and reducing drop-out rates Lighting in schools helps retain teachers Electricity enables access to educational media and communications in schools and at home Access to energy provides the opportunity to use equipment for teaching Modern energy systems and efficient building design reduces heating/cooling costs
Promote gender equality and empower women	Availability of modern energy services frees girls' and young women's time from day-by-day activities (e.g., gathering firewood, cooking inefficiently, crop processing by hand, manual farming work) Good quality lighting permits home study and allows evening classes Street lighting improves women's safety Affordable and reliable energy services offer scope for women's enterprises
Reduce child mortality	Indoor air pollution contributes to respiratory infections that account for many child deaths each year Gathering and preparing traditional fuels exposes young children to health risks and reduces time spent on child care Electricity enables pumped clean water and purification
Improve maternal health	Energy services are needed to provide access to better medical facilities for maternal care Excessive workload and heavy manual labour may affect a pregnant women
Combat HIV/AIDS, malaria and other major diseases	Electricity in health centres enables night availability, helps retain qualified staff and allows equipment use Refrigeration allows vaccination and medicine storage Energy is needed to develop, manufacture, and distribute drugs, medicines, and vaccinations Electricity enables access to health education media
Ensure environmental sustainability	Increased agricultural productivity is enabled through the use of machinery and irrigation Traditional fuel use contributes to erosion, reduced soil fertility, and desertification. Fuel substitution, improved efficiency, and energy crops can make exploitation of natural resources more sustainable Using cleaner, more efficient fuels will reduce GHG emissions Clean energy production can encourage better natural resource management Energy can be used to purify water or pump clean ground water locally

Source: Modi et al. (2006)

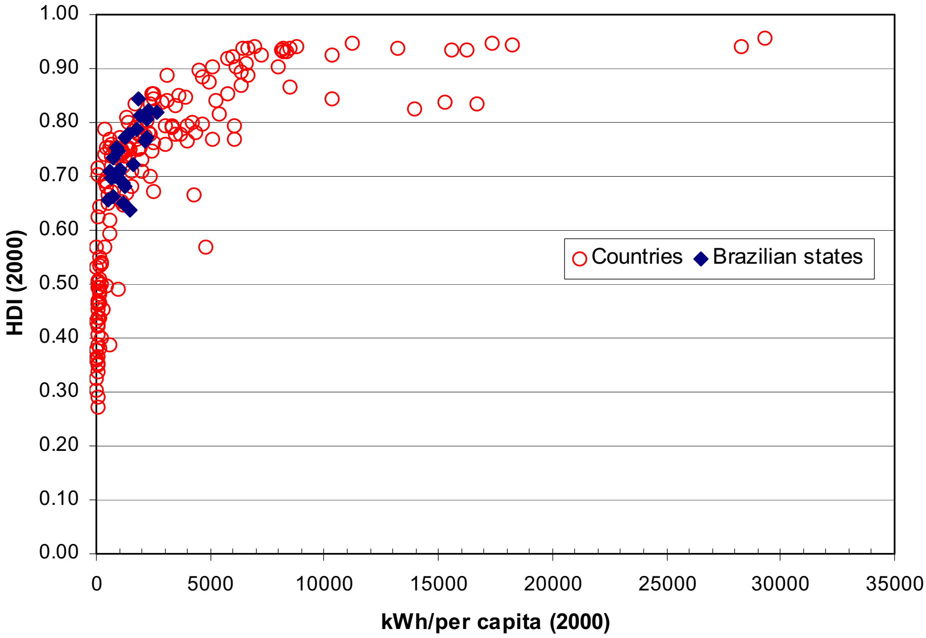

Fig. 1 HDI and per capita electricity consumption per capita for 177 countries and 27 Brazilian states

distribution of household electricity consumption presented in Table 2 that electrification in the poorest regions of the country is improving slightly.

Also according to Goldemberg et al. (2004c), 64% of the households without access to electric lighting have family incomes below 70 US dollars per week,[4] placing most of them under the poverty line. De Gouvello and Maigne (2003) point out that the concept of poverty is a composite of several predicaments; both the low income and the deficiencies in basic services can be culprits for the lack of proper subsistence conditions. Thus, poverty alleviation in rural areas depends, among other measures, on the expansion and improvement of a wide range of public services, including education, health care, access to good quality water, and lighting.

Table 2 Permanent private households and permanent population in urban and rural areas (million) – 2000

	Permanent private households			Permanent population		
	Total	Urban	Rural	Total	Urban	Rural
Total	44.78	37.37	7.41	169.87	137.93	31.95
With electric lightning	42.33	37.04	5.29	157.46	135.74	21.72
Without electric lightning	2.45	0.33	2.12	12.41	2.18	10.23
Electrification level (%)	94.54	99.11	71.47	92.69	98.42	67.69

Source: Instituto Brasileiro de Geografia e Estatística (IBGE) 2006

[4]Minimum wage is 350 R$, the equivalent of US$ 162 (at the rate of exchange of 15th September 2006). It means that 64% of the families without electricity have a monthly family income below 325 US$.

Table 3 Comparison of national regions regarding household electricity consumption, lack of access to electricity services and HDI

Region	Share of electricity consumption 2004[a] (%)	Share of electricity consumption 2000[a] (%)	Non-connected private permanent households in rural areas[b] (%)	HDI[c]
North	5.2	4.7	60.9	0.725
Northeast	15.8	14.9	38.4	0.676
Southeast	54.7	57.6	11.0	0.791
South	16.8	15.6	8.4	0.807
Mid-West	7.5	7.2	26.8	0.793

[a] Source: Balanço Energético Nacional (BEN) 2005

[b] Source: Instituto Brasileiro de Geografia e Estatística (IBGE) 2006 (reference year: 2000)

[c] Source: United Nations Development Program (UNDP) 2004 (reference year: 2000)

Moreover, the improvement of these basic services depends on regional economic development and governance, among other factors. Indeed, the issue of access to electricity, particularly in Brazil's North and Northeast, is part of a much broader and more complex picture of uneven regional development in the history of the country. In fact, these two regions have benefited the least from the growth of Brazilian economy (Goldemberg et al. 2004c).

Although providing electricity access is just one out of many measures to reduce poverty, its indirect benefits to poor and rural communities must be recognized. As pointed out by Goldemberg et al. (2004c), electricity is crucial to the development of rural regions in isolated communities, but the supply of electricity by itself is not sufficient to ensure the development of a region. It is also necessary to create appropriate economic conditions for the local population to use the energy productively, in order to afford the high cost of the electricity itself.

Indeed, considering data from the year 2000 for about 5,500 municipalities in Brazil, the correlation of the HDI with the share of households with access to electricity service is just 0.667,

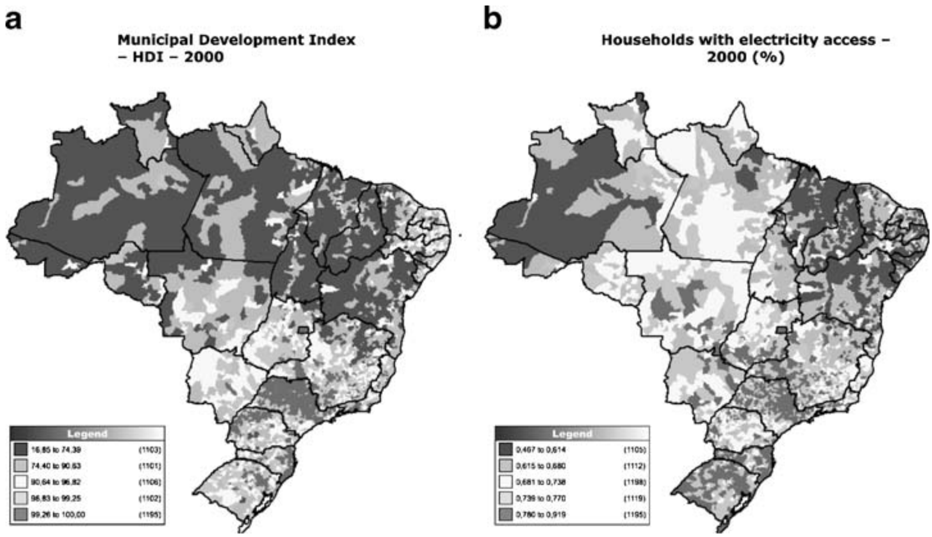

Fig. 2 Municipal Human Development Index and households with electricity access – 2000. Source: United Nations Development Program (UNDP) 2004

whereas the correlation of the HDI with the share of households with refrigerator in operation is 0.899. On the average, 93.5% of the Brazilian households have access to electricity services, but just 81.9% of the households have refrigerators in operation. It is clear that, for the quality of life, even more important than access to electricity is the access to the energy service itself.

2.2 Amazonian isolated region: energy and socio-economic profile

Based on data from the Ministry of Mines and Energy (MME), Valois and Cartaxo (2004) pointed out that approximately 2.6 million inhabitants of rural areas in the North of Brazil had no access to electricity in 2003. For Schmid and Hoffmann (2004), the electric exclusion of the North region is aggravated by the geographic isolation of its communities. This region encompasses five states (Amazonas, Amapá, Acre, Rondônia, Roraima) and part of another two (Pará and Mato Grosso), and is home to the Amazon rain forest, with its highly diversified fauna and flora, and the world's largest river basin. Most of the 3.1 million km^2 of the Isolated Amazon Region is under legal protection as environmental reserves, national parks, and indian and extractive reserves (Silva and Cavaliero 2001).

The long distances to the load centres of the National Interconnected System, as well as the geographic, environmental and legal constraints of the region, are factors that hamper and, in some cases, prevent the grid extension. As a result, electricity is supplied by decentralized or isolated systems.

According to Teixeira and Cavaliero (2005), the isolated systems of the Amazon region fall into three categories: state capitals, other cities, and dispersed communities. Thermal power plants owned by federal utilities predominantly supply state capitals. Local grids supplied by small- and medium-size thermal power units run by diesel provide the second category. The third category, due to its dispersed and low-income characteristics, is either supplied by small diesel generators, or does not have access to electricity at all.

In the isolated communities supplied by small diesel generators, electricity provision is precarious, expensive and environmentally inappropriate. It is well known that the generators, most of them very old, generally operate at low loads and very low efficiency. This fact, compounded by high fuel acquisition and transportation costs, results in very high operational costs, incompatible with the low income of the communities being supplied. In most cases the cost of electricity generated by diesel exceeds 300 US$/MWh. Figure 3 presents the approximate cost of diesel that is part of the cost of electricity produced in isolated systems, considering the price paid per litre of diesel in 2005 by an utility in Amazon state, and the specific consumption of 290 l/MWh – the average for diesel systems in 2005. Diesel cost constitutes the bulk of the electricity costs, and for the case shown in Fig. 3 the average fuel cost is 228 US$/MWh, leading to an electricity cost of about 280–290 US$/MWh. Some utilities pay as much as 25% more for the diesel, and specific consumption frequently is as high as 350–400 l/MWh; in such cases the cost of electricity can reach 500 US$/MWh.

These high electricity generation costs of the isolated systems are paid, to a large extent, by a system of subsidies kept by the Brazilian government through a tax charged to all electricity consumers within the national interconnected system, called Fuel Consumption Account (CCC – *Conta de Consumo de Combustíveis*). CCC was originally created in 1973. It is defined as a "financial reserve to cover fossil fuel costs, working as a compensation account through which an apportionment will be made of the benefits and costs of consuming such fuels in thermal plants belonging to concessionaires with their electric systems partially or totally connected to the South-Southeast interconnected system."

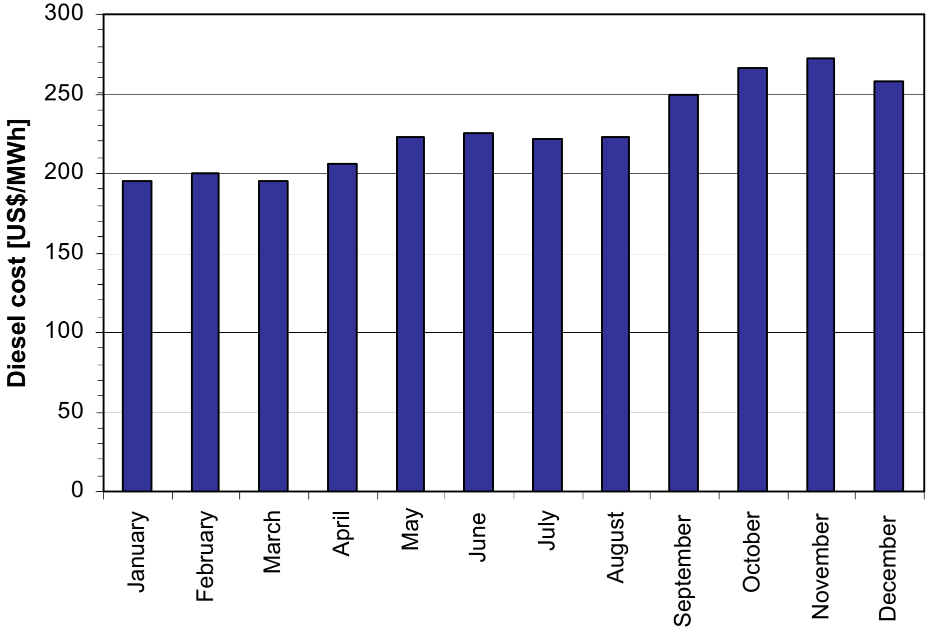

Fig. 3 Typical diesel cost on electricity produced in isolated systems in 2005. Source: based on ELETROBRAS 2006

In 1993 CCC was split into three distinct accounts, one for each system: CCC-North/Northeast, CCC-South/Southeast/Midwest, and CCC-ISOL for isolated systems. The Brazilian regulatory agency for electric energy, ANEEL, defined each of them in 1999 and determined that the resources of CCC-ISOL would be directed to covering the costs of fossil fuels used for thermal generation in isolated systems, reimbursing expenses exceeding the cost of generating the same amount of energy by hydropower plants, i.e., the cost of hydraulic energy that would replace the thermal energy if the electric systems were entirely interconnected.

According to Souza and Santos (2003), 70% of the acquisition costs of diesel are covered by CCC. In 2005, the total amount of resources provided by the CCC to cover the costs of fossil fuel acquisition for isolated systems was about US$ 1.5 billion (ELETROBRAS 2006).

From an environmental perspective, power generation in the isolated systems produces impacts in a local or even a global scale. According to Schmid and Hoffmann (2004), diesel fuel is inadequately transported and stored, causing soil and water contamination and introducing risks of explosion, for example. Besides, the combustion of diesel fuel emits pollutants and GHG – albeit in low amounts in terms of global GHG emissions. The total annual diesel consumption in the isolated areas is shown in Table 4. Variations are due to the tendency of switching from diesel to fuel oil in some utilities, the arrival in some regions of electric transmission lines, and the extension of the electricity access in recent years.

Thus, in order to provide electricity access to isolated systems of the Amazon region as a means of achieving the MDGs, it is also necessary to overcome the challenge of deploying cleaner, affordable and socially inclusive energy sources.

Table 4 Diesel consumption (million litres) and CO_2 emissions ($MtCO_2$/year) in the isolated systems (million litres)

Year	1999	2000	2001	2002	2003	2004	2005
Consumption (Ml)	1,301.4	918.3	866.3	903.6	691.6	874.6	1,009.8
CO_2 emissions	3.47	2.45	2.31	2.41	1.85	2.33	2.69

Data include diesel consumption in some isolated regions outside the Amazon region

Source: ELETROBRAS (2006)

3 Renewable energy technologies (RET): an alternative to fossil fuels

Renewable energy technologies (RETs) appear as a suitable alternative to address this challenge. As Goldemberg et al. (2004b) appropriately noted, renewables diversify the energy supply markets, help assure long-term supply, reduce GHG emissions, and potentially can create new jobs and opportunities for rural communities. Essentially, RETs can be important tools for poverty alleviation – as long as the population can afford the electricity, and the supply itself can induce economic activities. Regarding the latter point it should be noted that solar photovoltaics, for instance, do not offer a large contribution to income generation.

For the isolated systems of the Amazon region, renewables can gain even more relevance due to the fragility of the region's ecosystem, which demands special attention to sustainable practices, as well as to the local potential for deploying RETs. Information about the potential for RETs in the Amazon region is presented in Table 5.

The potential for RETs in Amazon region is reasonably good, but not quite so as previously imagined. This is mainly due to the following facts: the potential for small hydro and wind plants is limited to some areas; the high up-front cost of PV is a constraining factor; and biomass still requires technological development. In addition, the local population prefers diesel-based plants, because it is a well-known system. Thus, the deployment of RETs within the energy markets of the isolated communities still faces many barriers.

3.1 Barriers to implementation of rets in the Amazonian region

A formidable barrier to implementation of RETs in Amazonian isolated areas is their high up-front capital costs. Even assuming substantial technological developments and the

Table 5 Potential for renewable energy sources in Amazonian region

Source	Characteristics
Biomass	Residues are the most abundant biomass source in a dense forest like Amazon. Vegetable oils can also be produced. Supply costs are reasonably low. Technical requirements are a matter of concern. Vegetable oil or gasified biomass can be used in engines, but further technological development is required.
Small Hydropower Plants (SHP)	In Brazil SHP must range from 1 to 30 MW and the flooded area should be smaller than 30 km^2. Although the region has numerous rivers, the potential is not available everywhere. Specific features of each location make energy assessment, environmental impact assessment, design and construction very time-consuming.
Wind energy	Potential is limited to few regions, such as the coasts of Amapá and Pará states, and eastern Roraima.
Solar photovoltaics (PV)	Annual solar radiation is reasonable. However, PV solar cells are still expensive.

Source: Schmid and Hoffmann (2004).

progressive deployment rate of RETs in the energy market as a whole, electricity generation costs would still remain incompatible with the region's income level. Table 6 presents estimates of electricity generation costs for some RETs. Parameters used for calculations were taken from the literature, considering the higher values of investment cost in a given range. Investment costs should be compared with figures presented by Schmid and Hoffmann (2004) for diesel generators in Amazon region, which vary in the 380–830 US$/kW installed range, for generators in 5–100 kW range.

Besides being economically less attractive, some RETs are still in an early development stage, or have not yet reached a level of maturity sufficient for commercial production. According to Goldemberg et al. (2004b), some difficulties still persist regarding the technical capability of small-scale systems.

As outlined in previous sections, the existence of the CCC (Fuel Consumption Account) is one of the main reasons why renewable sources are not economically feasible and competitive as compared to fossil fuels. At first sight, the extension of CCC to renewable sources can lead to discussions about the feasibility of implementing renewable energy technologies in Amazonian isolated systems. However, isolated systems hide a much deeper complexity. According to Silva and Cavaliero (2001), isolated systems typically have generation plants (including the small generators) approaching the end of their useful life, and CCC benefits have been used only for purchasing fuel, as the electricity producers constantly experience crises and have no possibility of investing in improvements.

Although CCC benefits have been extended to renewable energy sources, few producers actually claimed them from the regulatory electricity board. This indicates that the legal measure has hardly had any influence on local realities. Resistance to promoting renewable sources is in part due to socio-economic conditions in the region. Although eligible for CCC, renewable sources are still not perceived as economically attractive.

Furthermore, as Teixeira and Cavaliero (2005) aptly pointed out, the inclusion of natural gas as one of the energy sources to be subsidized by CCC reduces the expectation of subrogation of renewable energy sources for electricity generation in the Amazon isolated regions, because natural gas would become economically more feasible, especially in view of the proven reserves in the region.[5] Due to the barriers and challenges to renewable energy sources as a means of promoting access to and improvements in electricity services in the Amazon region, the role of the State is indeed essential, not only in managing the

Table 6 Costs of different RETs deployed in remote areas

Technology	Installation costs (US$/kW)[a]	Generation costs (US$/MWh)	Annual CP[b]	Useful life	O&M (US$/MWh)[b]
Solar photovoltaics	10,600	775,5	35%	8 years	5.0
Micro-hydro power plant	3,500	139.7	50%	15 years	3.0
Wind (onshore)	2,200	200.3	25%	12 years	15.0

[a] Figures based on Haug (2004) and Junginger et al. (2004).

[b] Figures based on Pfeifenberg et al. (1998).

In all cases, discount rate=15% per year.

[5]In the Urucu region (Amazonas State), the second largest national reserve of natural gas has been discovered. The gas is currently piped to Coari city through the Urucu-Coari pipeline. Two pipelines are already under construction in the Amazon region: Urucu-Porto Velho (to supply the capital of Rondônia State) and Urucu-Juruá.

subsidies but mainly in carrying out public policies towards universal electricity access and promotion of renewable energy sources. In this respect, four federal programs should be mentioned: Light in the Countryside (*Luz no Campo*), Light for Everyone (*Luz para Todos*), PRODEEM (Municipalities and States Energy Development Program) and PROINFA (Renewable Electricity Incentive Program).

3.2 National programs: universalization of access and renewable energy promotion

Light for Everyone was launched in 1999 aiming to address the stagnation in rural electrification after the power sector reforms started in 1992. According to Goldemberg et al. (2004c), off-grid connections have not been made under the program mainly because of the high investment costs. The authors hold that the program's weakness was its lack of incentive for low-cost grid connections or off-grid projects. Until 2002, 480 thousand connections had been made, and another 125 thousand were in progress. By the end of 2003, the Light in the Countryside program was incorporated into Light for Everyone, whose goal is to achieve universal electricity access, bringing electricity to more than 12 million people by 2008. This program is coordinated by the Ministry of Mines and Energy, and benefits from the participation of the federal utility, ELETROBRAS, and state companies. The program budget is US$ 4.1 billion, of which US$ 2.9 billion are provided by the federal government (Ministry of Mines and Energy (MME) 2006).

Although not directly focused on poverty alleviation goals, the Light for Everyone program was launched by the government as a measure to improve socio-economic conditions. As expressed in the program website,[6] one of the objectives of the government is to use electricity access as a vector for social and economic development of rural and poor communities, with indirect positive effects on poverty reduction (Ministry of Mines and Energy (MME) 2006).

The Light for Everyone program has also absorbed the main government-sponsored off-grid electrification program, called PRODEEM. Established by law in 1994, the main objective of PRODEEM was to provide electricity to isolated communities from local renewable energy sources as a means to promote sustainable development. The program focused on the acquisition of energy and water pumping systems mostly using solar photovoltaic cells. According to the Ministry of Mines and Energy (2006), the program has acquired more than 6,700 energy and pumping systems, bringing benefits to more than 350,000 people, mainly in the Northeast region.

However, PRODEEM has been suffering from serious problems, such as lack of capacity building in unprepared and disorganized communities; absence of cost recovery schemes, leading to a lack of funds for maintenance and unsustainable service; and lack of responsibility of local communities and States for the installed systems (Goldemberg et al. 2004c).

The only federal program that envisages the expansion of electricity generation by alternative renewable energy sources, PROINFA,[7] does not cover isolated systems. Indeed, Cavaliero and Silva (2003) say that the decision to exclude isolated systems from the benefits of this program must be reconsidered, given the importance of alternative renewable energy sources for the isolated systems.

In view of the realities of isolated systems in the Amazon region – marked on one hand by electricity deprivation and predominance of small and inefficient diesel generators, and

[6] http://www.mme.gov.br/luzparatodos.

[7] Launched by law in 2002, its main objective is increasing the share of electricity generation from biomass, wind and small hydropower (SHP) in the national electric grid.

on the other by insufficient incentives to the introduction of renewable energy sources – the Clean Development Mechanism (CDM) emerges as a tool to promote renewable energy technologies both in the communities which no electricity access, and as a replacement for those currently supplied by diesel generators.

4 CDM: a tool to promote renewable energy technologies in Amazon isolated systems

The Clean Development Mechanism is defined in Article 12 of the Kyoto Protocol as a mechanism for flexible implementation with the purpose of (a) assisting Parties not included in Annex I of UNFCCC in achieving sustainable development and in contributing to the ultimate objective of the Convention, and (b) assisting Parties included in Annex I in complying with their quantified emission limitation and reduction commitments. Under the CDM, non-Annex 1 Parties are allowed to benefit from project activities in Certified Emission Reductions (CERs), and Annex 1 Parties may use the CERs accruing from such project activities to contribute to compliance with their quantified targets. According to the Kyoto Protocol and Marrakech Accords, in order to participate in the CDM a project must fulfil the following eligibility criteria: (1) voluntary participation;[8] (2) real, measurable and long-term benefits; (3) additionality; and (4) sustainable development practices. Activities that verifiably reduce emissions or sequestrate carbon, as compared to a reference scenario called baseline, are potentially eligible as CDM projects.

Thus, implementation of RETs in Amazon region isolated systems, compared to the baseline scenario of existing small diesel generators, or to the universalization of access to electricity using this fossil fuel, could in principle be considered eligible as a CDM project.

4.1 Eligibility criteria for CDM in the context of Amazonian isolated areas

Because CDM is a project-based mechanism, each individual project is checked for fulfilment of eligibility criteria. Thus, as previously mentioned, the aim of this paper is to discuss how feasible CDM can be for the promotion of RETs in the isolated systems of Amazon region.

4.1.1 Real, measurable and long-tem benefits

As mentioned above, most of the electricity generation in the isolated systems of the Amazon region is based on fossil fuels, mainly diesel. Hence, any activity replacing these generators by others emitting less GHG, such as renewable energy sources, would be a benefit. As shown in Table 4, in 2005 carbon dioxide emission associated to diesel consumption for electricity generation in isolated regions was estimated to be 2.7 million tonnes/year.

4.1.2 Additionality criterion

In order to qualify as a CDM activity, a project must demonstrate that the proposed emission reduction is additional. The additionality criterion requires that GHG emission

[8] The voluntary participation criterion will not be discussed, bearing in mind that Brazil is signatory to the Kyoto Protocol.

reductions would not occur in the absence of the CDM project activity. In other words, for a CDM project be certified it must prove that it contributes to emission reduction or carbon sequestration as compared to a baseline scenario.

In the Amazon isolated regions, the analysis of the additionality criterion has to be divided into two distinct cases: communities already supplied by diesel generators, and those lacking electricity services. In the first case, the baseline scenario would be the use of the inefficient diesel generators, bearing in mind the already mentioned barriers to the introduction of renewable energy technologies:

- Economic barriers: Despite their potential, renewable energy technologies still demand high investment costs, incompatible with the income of the inhabitants and the financial capabilities of local energy companies.
- Corporate barriers: After the power sector reforms, regional energy companies have had negative balance sheets due to several reasons, such as bad management, high non-payment rates by consumers, high operational and maintenance costs, and insufficient CCC subsidies. Besides, in spite of the availability of CCC subsidies, investments in renewable energy technologies are not given a high priority by local utilities (Cartaxo et al. 2001).
- Technological barriers: some technologies are not fully commercial, increasing the perceived risk for private investments. Besides, some technologies are more complex to operate and maintain than diesel generators.
- Institutional barriers: Given the very low income of the populations, there seems to be no possibility of charging unsubsidized prices for the energy. In addition, CCC subsidies, though available to cover some renewable energy sources, are still mostly directed to buying diesel fuel, making RET a less attractive investment as compared to subsidized diesel generation.

A preference for diesel can be taken as the most likely scenario for those regions still without any access to electricity services. In this case, the Light for Everyone program and the universalization goals of the Government should be considered in setting the baseline (Ministry of Mines and Energy (MME) 2006).

4.1.3 Sustainable development

The Kyoto Protocol assigns the task of defining the concept and extent of sustainable development to each host country, thus allowing it to be done in accordance with national strategies and principles. On the national level, this is assigned to the Designated National Authority, which in Brazil is the Interministerial Commission on Global Climate Change. The Commission has already established the sustainable development criteria in Annex III of Resolution 1,[9] of 2003.

Annex III establishes that project participants must prove whether and how the project activity contributes to sustainable development in the following aspects: local environmental sustainability; development of working conditions and net job creation; income distribution; training and technological development; and regional integration and interconnection with other sectors.

[9]Resolution 1 of the Interministerial Commission on Global Climate Change – the Designated National Authority in Brazil – is the norm defining Brazilian criteria of sustainable development for CDM mechanisms developed in the country, in agreement with the Marrakech Accords, which establish that each project host country should define these criteria.

Although unrelated to CDM projects, some field experiments (described below) by research centres to employ renewable energy technologies in the Amazon isolated systems have produced positive results relative to the above-mentioned sustainable development criteria.

In these projects, electricity access is being provided by decentralized biodiesel systems to small communities which themselves produce the vegetable oil. Two such examples can be adduced: a palm-oil-fuelled engine in Vila Boa Esperança, state of Pará, and an andiroba-oil-fired unit in an indian village (Reserva Extrativista do Médio Juruá), state of Amazonas. In both cases, a multi-fuel diesel engine is used, burning in natura vegetable oil. Funds for the oil extraction plant of Vila Boa Esperança came from the federal government (Goldemberg et al. 2004c).

The andiroba-oil-fired unit in the Médio Juruá extraction reserve project was developed under the Program *Trópico Úmido* (PTU), from the Ministry of Science and Technology, in Caruari city, Amazonas state. A 120-kVA biodiesel generator set was installed to supply electricity for a small vegetable oil communal industry during the day, and electricity services for households during the night. The use of electricity increased the vegetable oil production plant productivity, allowing the community to expand its economic activity beyond the low-productivity seed collection, resulting in job generation and local capacity building (Cavaliero and Silva 2003).

Besides demonstrating the importance of energy services to poverty alleviation, the improvement in quality of life and work conditions of the community also legitimates the establishment of a new electricity supply standard for the Amazon region based on environmentally low-impact and socially inclusive renewable energy sources.

Within this context, CDM can and should be used both as a tool to improve the existing power systems, and as a market instrument to give a more important role for renewable energy sources in promoting universal access. This strategy would, of course, result in lower levels of GHG emissions.

5 CDM in isolated Amazonian regions: a market role

With 182 CDM projects in different stages of the certification process at UNFCCC[10] as of September 2006, Brazil as a host country is second only to India in number of projects. Considering the estimated total annual emission reduction (22.8 $MtCO_{2e}$), Brazil is the third host country, after India and China (United Nations Convention on Climate Change (UNFCCC) 2006). However, among all projects, just six are for electricity generation at the Amazon isolated region.

Most Brazilian CDM projects are located in the Southeast region of the country, and are focused on the development of electricity cogeneration using sugar cane bagasse, landfill gas recovery and hydroelectricity; most of them aim to provide energy to the grid. Figure 4 shows the distribution of Brazilian CDM projects.

The lack of CDM projects to promote renewable energy technologies in the isolated systems of Amazon region, especially in dispersed communities, has to be understood more as a dynamic issue of the carbon market – both international and domestic – than as a technical matter. It is important to bear in mind that, despite being a potential tool to promote regional sustainable development, CDM is a market mechanism created to operate under the rules of supply and demand, and the cost/benefit ratio.

[10] Sixty-four were already registered as of 6th September 2006 (United Nations Convention on Climate Change (UNFCCC) 2006).

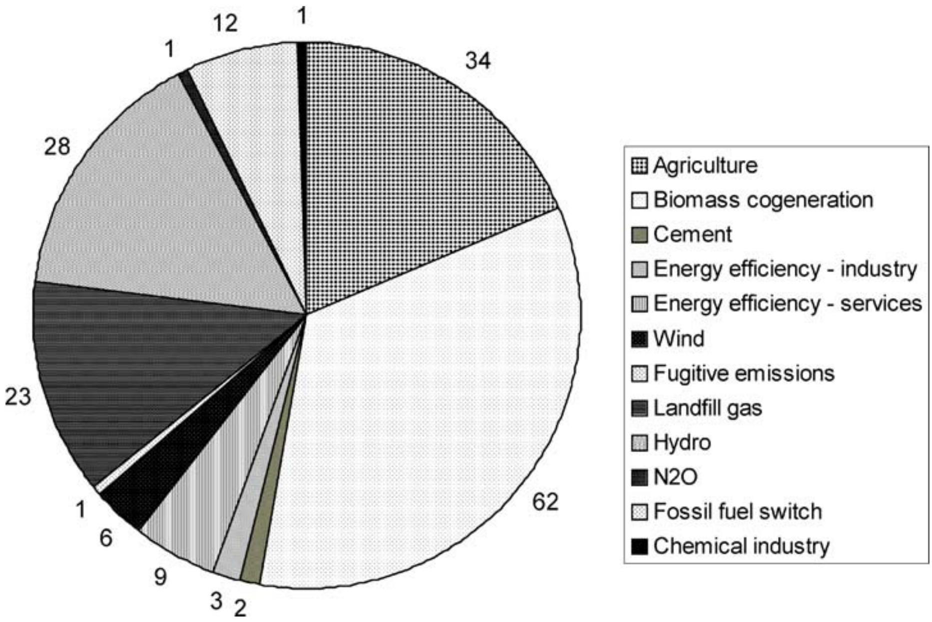

Fig. 4 Brazilian CDM projects – number of projects by type of activity – as of 06 September 2006. Source: United Nations Convention on Climate Change (UNFCCC) 2006

5.1 CDM: a market mechanism

The UNFCCC data (United Nations Convention on Climate Change (UNFCCC) 2006) show a significant concentration of projects by type and location. The bulk of projects are those that can be called low-cost and low-risk, and the majority of projects are hosted by a few countries. In fact, in September 2006, the registered projects of Brazil and India alone added up to 53% of the world total.

Ellis et al. 2006 state that countries expecting to generate the most credits from CDM projects to date are also often recipient of a significant proportion of total flows of foreign direct investment (FDI). This suggests that conditions that support CDM investment may be similar to conditions for the presence of FDI – essentially, stable political regimes, good economic environment, and institutional capacity of host countries. The authors also remark that most of the projects proposed to the UNFCCC are relatively low-cost projects based on commercial technologies, such as electricity generation (particularly from sugar cane bagasse), decomposition of HFCs, and reduction of CH_4 emissions from landfills or coal mines. Thus, like any other business activity, low-risk perception regarding countries and technologies are essential for CDM projects.

CDM is indeed a market mechanism, as it was conceived to be. Therefore, as stated by Egenhofer et al. (2005), rather than a sign of imperfection, the fact that the volume of CDM follows market opportunities is inherent in the design, and imbalances in project types are not a failure, but rather a result of this market-based approach. Markets exploit the possibility of arbitrage, hence the different cost potentials.

However, it turns out that the GHG market, by focusing on least-cost mitigation projects through CDM, no longer prioritises its legal target of enhancing sustainable development. According to Ellis et al. (2006), projects with dual sustainability and mitigation benefits do not necessarily offer the cheapest emission reductions, and are therefore unlikely to develop an important share of the activities generated under the current CDM. In other words, lower-cost options can be seen as a constraint for potential CDM projects that deliver higher-cost emission reductions but also have a higher long-term value in terms of project replicability, reduction of local pollution, technology development and transfer benefits and other sustainable development benefits. Thus, although sustainable development is one of the two purposes of the CDM, and a key concern to developing countries, the CDM only provides monetary incentives for the other, GHG-reduction (Ellis et al. 2006).

Brazil has a big potential for GHG emission reduction through CDM: its institutional structure is relatively well organized, it is one of the leaders in attracting direct foreign investment (Jung 2006), and participation of the national private sector as the main project proponent is growing (Sales and Sabbag 2006). Of course the domestic carbon market follows the same tendency of other countries, i.e., it is strongly biased in favour of low-cost, low-risk, massive-reduction projects.

This partially explains the predominance of on-grid electricity generation projects from biomass, mainly sugar cane bagasse, and landfill gas projects. In the first case, participant companies, mostly ethanol and sugar cane mills, already have the technological know-how, and the sale of CERs is often considered not the main source of income, but just a cash flow complement. In the second case, the proponents count on a substantial emission reduction at a relatively low investment cost. In both, risks are very low, especially financial and technological risks. Despite this general tendency, it can still be said in favour of these projects that at least they have a significant sustainable development component, contrary to many others.

By contrast, CDM renewable energy technology projects in the Amazon region individually offer modest emission reductions and demand high up-front investments. Indeed, most of the region's potential can only be used for small-scale projects, which despite requiring less bureaucracy, would not be attractive in terms of emission reduction and cost. The high implementation and maintenance costs of promoting renewable energy projects in the region, in addition to the other mentioned barriers – technological, corporate, institutional – make the CDM projects economically unattractive with regard to the resulting emission reductions. As prices of CERs have reached 10 Euro/tCO_2 (PointCarbon 2006), CDM is not able to surpass unaided the barriers of RETs.

Another factor to be considered are environmental legal requirements. As mentioned, Amazon isolated communities are dispersed and often located in protected environmental areas, where restrictive legal rules are in force, imposing more bureaucracy and formalities on project approval procedures.

Furthermore, isolated communities are often deprived of other basic services as well. If projects are to meet the criteria of sustainable development, they must go beyond merely satisfying environmental legal requirements, and include other actions capable of improving the inhabitants' quality of life, such as job creation and capacity building.

Thus, the modest flow of investment towards CDM projects in the region can be explained to a large extent by (1) the existence of other, cheaper project types with great potential to reduce emission; and (2) the complexity, high cost and relatively low potential for emission reductions of renewable energy projects in the region.

In cases such as the Amazon isolated regions, the aim of providing electricity – sustainably if possible – is the responsibility of governments, to be fulfilled by means of public policies and/or special programs. Programs under the CDM, as discussed during the COP/MOP 11 in 2005, are a very welcome alternative for this.

5.2 Decision on policies and programs under the CDM

In the decision on Further Guidance relating to CDM, paragraph 20 states that "local/regional/national policy or standard cannot be considered as a Clean Development Mechanism project activity, but that project activities under a programme of activities can be registered as a single clean development mechanism project activity" provided that CDM methodological requirements are met (United Nations Convention on Climate Change (UNFCCC) 2006).

According to this decision, programs can be considered a CDM project activity. Figueres (2006) explains that a CDM program could be defined as one in which emission reductions are achieved by multiple verifiable activities carried out over time as a result of a government measure or private sector initiative.

The same author highlights some of the characteristics of such a CDM program project activity: (1) it is a program based on private or public sector, put in place in order to provide an incentive for GHG mitigation actions; (2) the program results in a multitude of GHG reducing actions occurring in multiple sites, which could be located within one city, one region or across country; (3) the GHG reducing actions do not necessarily occur at the same time, but rather throughout the life of the program; (4) while GHG reducing actions can be implemented by one or more entities, the responsibility for designing the program and overseeing the execution of its various activities lies with the program agent or project participant (e.g., governmental institution, energy service company, etc.), and the program agent can have agreements with other participants for the distribution of CERs.

The combination of a CDM project with a government action aiming at deploying RETs in regions such as Amazon should be further exploited. In addition to providing access to electricity, it would encourage more sustainable ways of generating electricity. The extra income of the RECs would not be the solution to feasibility constraints, but it would contribute to cost reduction and risk perception minimization.

6 Conclusions

The paper discussed the potential of CDM as a tool to promote renewable energy technologies for electricity generation in isolated communities of the Amazon region and the potential of this mechanism to help achieving the MDGs. The relationship between CDM and MDGs becomes clear since renewable energy sources are environmentally less harmful from a global perspective, and can be socio-economically more inclusive.

The paper showed that renewable energy technologies still face substantial economic, technological, corporate and institutional barriers to their implementation, especially in such regions. While these barriers help CDM projects meet the eligibility criteria, at the same time they diminish the attractiveness of such projects in the eyes of the domestic and international carbon market.

Thus, the preference of investors for cheaper CDM projects with potential for large emission reductions, such as cogeneration and landfill gas, over renewable energy projects in the Amazon isolated communities, reveals the limitations of CDM, a mechanism created to promote sustainable development practices in developing countries, but operating under the market logic.

The possible inclusion of programs in the CDM portfolio would help minimize most of the constraints discussed in this paper. Of course this is not a panacea for the problems of access to electricity, and even less so for access to electricity services, but it certainly is a possibility deserving serious consideration for its applicability in the isolated system of the Amazon region.

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