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Clean Development Mechanism in Brazil: an instrument for technology transfer and the promotion of cleaner technologies?

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ABSTRACT

This paper evaluates the contribution of 75 Clean Development Mechanism (CDM) projects for technology transfer initiatives and for promotion of adoption of cleaner technologies. A documentary content analysis model was developed to acquire secondary data from the 75 Project Design Documents. Technology transfer as a benefit has only 28% share and not more than 21% of the projects led to implementation of cleaner technologies. In conclusion, CDM projects in Brazil have not encouraged a cleaner model of development through cooperation among industrialized and developing countries, as they were expected to do.

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1. Introduction

The Kyoto Protocol divides countries into annexes, according to the stipulation or non-stipulation of mandatory targets for greenhouse gas (GHG) emission reduction. Countries that have reduction targets comprise Annex I, which consists of two subgroups – Annex II, composed of industrialized nations most of which are also in the Organization for Economic Co-operation and Development (OECD), and the countries called “Transition Economies”, covering Eastern Europe and most countries of the former Soviet Union. The “Non-Annex I” countries, category that comprises developing countries, of which Brazil is part, have no targets set for the first commitment period of the Protocol, i.e. the period between 2008 and 2012 (Senado Federal, 2004).

This international environmental agreement encourages the use of Flexible Mechanisms to facilitate the fulfillment of commitments agreed upon by the industrialized countries, members of Annex I. Among these mechanisms, there is the Clean Development Mechanism (CDM), the subject of this article, which enables industrialized countries to reach their individual goals through projects implemented in developing countries (Trigueiro, 2005).

As defined in Article 10 of the Kyoto Protocol, the CDM consists of an international public policy with a twofold objective: globally reducing GHG emissions while promoting access to and enabling the transfer of environmentally safe technologies in developing countries. Assuming that the implementation of cleaner technologies is considered to be the most effective strategy for minimizing the effects of climate change and encouraging a cleaner model of development, this study aims to evaluate the contribution of 75 CDM projects in Brazil, which received carbon credits by 2007, for transferring and producing cleaner technologies.

Concerning methodology, data collection for this study was preceded by bibliographical survey of specialized literature. The database for this work was built with secondary data collected from Project Design Documents (PDD) of 75 out of the 135 projects approved by the Executive Board for CDM Projects in Brazil, which had been issued carbon credit certificates from the *United Nations Framework Convention on Climate Change* (UNFCCC) by December 31st, 2007. Table 1 shows how the research sample was defined.

This 75-project sample was randomly picked in such a way that all CDM project categories executed in Brazil by then could be proportionately represented, at least 50% of all projects for each category. A documentary content analysis model was developed to acquire secondary data from the PDDs. The methodology and results presented in this paper are part of the preliminary findings of a work-in-progress research project entitled “The use of CDM projects by Brazilian companies”, sponsored by Brazil's National

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Table 1
Research sample.

Project category	Approved by 2007	Research sample
Energy industry and other industries	68	39
Animal manure and landfills	41	21
Hydroelectric and other renewable energy plants	26	15
Total	135	75

Council for Scientific and Technological Development (CNPq). This paper was structured into four parts, as follows: (1) the relevance of the theme and objectives are introduced. Then, (2) a brief literature review is presented, containing the key concepts of this study. After that, (3) the results obtained are described and discussed. Finally, (4) concluding remarks are given, taking into consideration the still nascent Brazilian CDM projects contribution for transferring and producing cleaner technologies and also highlighting the importance of increasing the number of academic work in Brazil that deal with this relevant subject.

2. Literature review

Different technology and learning sources, of either internal or external origins, are used by organizations to launch new products, improve processes, adopt new organizational management methods and increase competitiveness (Tigre, 2006). Economic growth has been determined, to a large extent, by the ability to use new technologies, be they local or foreign (Lenzi, 2006). For Rosemberg (2006), strong sustainable development is a reflection of a continuous change in industry branches and their related products. Currently, cleaner technology transfer is of strategic and competitive relevance to promote sustainable development in countries. Schneider et al. (2008) note that transferring technology is essential for the promotion of environmentally sound technologies for a country's development.

The current global institutional arena shows that there are more channels and mechanisms for technology transfer today than there were one century ago. Thus, transfer processes are increasingly faster. The Kyoto Protocol has become a landmark for favoring the occurrence of this process, specifically from resourceful nations to those with fewer resources – only developing countries can participate as hosts of CDM projects, generating Certified Emission Reductions (CERs), which are mainly acquired by developed nations.

To give better theoretical support to this study, the concept of technology transfer used was consistent with the assumptions presented by Dechezleprêtre et al. (2009) and the principles established by the Intergovernmental Panel on Climate Change (IPCC) (2000). To this extent, it is understood that technology transfer may occur in three different ways: a) transfer of equipment; b) transfer of knowledge or c) transfer of both equipment and knowledge. In cases where technology transfer does not occur from an Annex I country to a Non-Annex I country, as specified in the three possibilities above, technology could be replicated domestically – equipment and/or knowledge are employed within the CDM project host country (Dechezleprêtre et al., 2009).

Ellis et al. (2007), Blackman (1999) and Rosemberg (2006) argued that, in technology transfer cases, there is preference for host countries with good geographic features and good development levels, human capital and infrastructure. To this extent, it appears that many CDM projects are developed in Brazil, India, Mexico and China because, as well as meeting the aspects stated in the previous paragraph, these countries have mastered many first world technologies (Seres, 2007).

This may also be legitimated by Article 10 of the Kyoto Protocol, particularly in item (c), according to which technology and its transfer are part of the scope of this macro policy, as the Parties shall:

> Cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries, including the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or are in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer of, and access to, environmentally sound technologies (Senado Federal, 2004).

The technology transfer issue has been present for a long time in the global environmental agenda, playing a central role in North-South ecopolitics. It brings with it the idea of knowledge transfer from the more developed countries (North) to the least developed countries (South). This premise reveals that countries with already established knowledge and expertise in environmentally sound technologies should transfer them to countries with little or no installed technological capacity, to reduce the knowledge and training gap that exists between North and South in terms of technology matters (Esty e Ivanova, 2002 and Le Prestre, 2005).

However, this view ignores the asymmetries that exist between countries of the South, regarding training capacity and technological development. These elements differ significantly among southern countries. Specifically in the Brazilian context, there are consolidated or almost consolidated technological capabilities in fields such as renewable energy, biofuels and biomass. The idea of transferring environmentally sound technologies through CDM projects is losing its meaning and may end up favoring the old development models, focused on exportation, by the North, of environmentally outdated end-of-pipe technologies. This kind of environmental technology contributes little to the clean development of countries that host CDM projects, since it focuses on managing and remediating negative environmental impacts of production processes and not on prevention and eco-efficiency of natural resources.

Environmental technologies can be divided between end-of-pipe pollution control technologies and cleaner technologies. The first does not change the production system, but introduces additional technological systems that capture pollutants in order to reduce their negative impact on the environment. Cleaner technologies, in turn, do not seek to treat pollution after it has been produced. It actually seeks to avoid or reduce such emissions in advance. It is focused on dealing with the causes of environmental degradation and not with its consequences. Cleaner technologies are based on the principle of prevention, while the end-of-pipe technology, which conceptually is also considered environmentally sound, is guided by the principle of reaction (Lenzi, 2006).

Cleaner technologies can be characterized as the adoption of any change or transformation for reducing or eliminating, at source, the production of any pollution while rationalizing natural resource usage, valuing the concept of 3Rs: reduce, reuse and recycle.

According to studies developed by Schneider et al. (2008), CDM projects that focus on end-of-pipe technologies present fewer risks related to technology transfer than projects that promote cleaner production practices, because while the former use off-the-shelf equipment and knowledge already mastered, the latter need technological innovation and the promotion of new knowledge and new ways of learning. This viewpoint was endorsed by Wilkins

(2002) who also documented the higher financial risk of CDM projects that promote technological innovation to support environmentally friendly practices.

Through the Inter-ministerial Commission on Climate Change (CIMGC) – the Designated National Authority (DNA) responsible for the approval of Brazilian CDM projects – Brazil could favor the inclusion of cleaner technologies fostering as one of the conditions for project approval, in the criterion regarding training and development of the country, as seen in Article 10, item (c) of the Kyoto Protocol. Thus, the CIMGC would be able to influence the extent of such technology transfer and development, allowing the CDM projects to contribute to the development of cleaner technologies, focused on prevention of pollution and on eco-efficiency – not only based on end-of-pipe pollution control, with no technological innovation.

Pearson (2007) stressed the importance of developing cleaner technologies that reduce production costs for corporations and local governments, instead of CDM projects that solely promote end-of-pipe practices. According to this author, projects that promote cleaner production practices have no significant carbon credit price differentiation and generate small amounts of carbon credits, while projects, such as landfills, generate large carbon credits, due to an end-of-pipe biogas burning practice.

For Lagrega et al. (1994), the more the technologies and practices of cleaner production tend to reduce waste emissions, the more they are related to reduction, at source and to relevant changes in the core of production processes. The more these practices relate to waste treatment from production processes, the more they will tend to be end-of-pipe practices. This statement is illustrated in Fig. 1. It shows the various types of environmental strategies that an organization can take to prevent and/or reduce pollution. The more the environmental strategy is focused on activities from the right side of the chart, the more the technologies and practices will tend to be end-of-pipe, while the more the strategy is focused on activities seen to the left, the more processes are focused on reducing waste at source and preventing pollution, thereby contributing to achieve a cleaner model of production.

In pursuit of waste reduction, at source, companies tend to innovate in their own productive processes through loss elimination, not only reducing environmental impacts, but also production costs. Therefore, the repetition of such strategies can lead to greater use of cleaner technologies, leading to a double dividend, through which companies become more competitive and society as a whole benefits from the reduction of environmental impacts (Kiperstok, 2003).

In addition, it should be taken into consideration that organizational and technological changes caused by cleaner technology promotion in firms and countries contribute to solving the apparent compatibility dilemma between economic growth and environmental protection. Thus, it is expected that society can benefit from clean development while the private sector profits for exporting a new product derived from its core business: the carbon credit. Based on all these arguments, CDM may work as a viable option for a sustainable relationship between sustainable economic growth and sound environmental protection, by using cleaner technologies as tools.

3. Presentation and discussion of results

The results reflect the analysis of 75 Brazilian CDM projects that by December 2007 had already received marketable CERs from UNFCCC. Taking into consideration this sample of projects and the key concepts presented in the literature review, this work attempts to verify if the Kyoto Protocol, through its CDM projects, has helped to promote cleaner technologies in Brazil.

Table 2 summarizes the analysis model employed to classify and statistically analyze the available data. It is divided into two main analysis dimensions: CDM and environmentally sound technology.

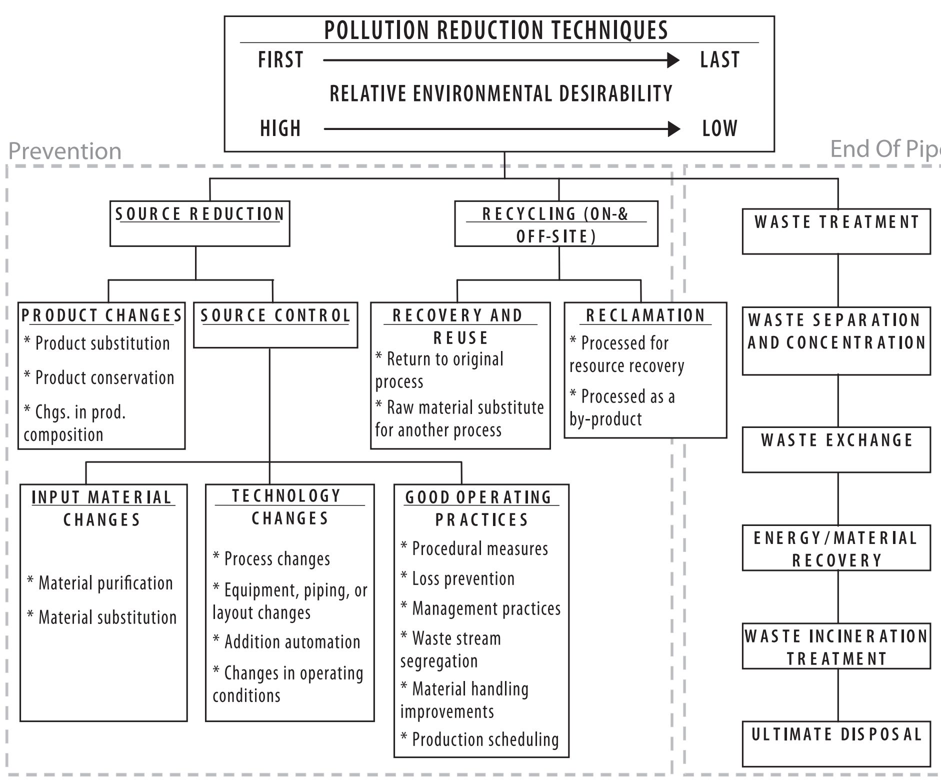

Fig. 1. Pollution reduction techniques.

Table 2
Research analysis model.

Dimension	Component	Attribute
CDM	Category	Energy industry
		Landfills
		Chemical industry
		Manufactury industry
		Hidroeletricity
		Agriculture and waste handling and disposal
		Wind power
	Methodology	Cogeneration of power by sugarcane bagasse
		Hydroelectricity
		Animal waste management system
		Landfills
		Replacement of fuel oil with natural gas in power generation
	Technological benefits	Promoting national industry
		Professional training
		Technology transfer
		Creation of patents and innovation
		Optimization of the use of bagasse
		Industrial competitiveness
Environmentally sound technology	End-of-pipe	Waste treatment, separation, concentration, incineration and energy recovery
		On and off site waste recycling
	Cleaner technology	Waste source reduction with technology change
		Waste source reduction without technology change

Source: Author's own.

Within the CDM dimension, projects were classified by category, according to the nature of the project, as presented on the PDDs, by methodology employed, according to UNFCCC's approved CDM methodologies for measuring GHG emissions, and by the main technological benefits. Within the environmentally sound technology dimension, all projects were analyzed considering how the technologies used are classified, from an environmental standpoint, as either end-of-pipe or cleaner technology.

Initially, the distribution of CDM projects among categories was verified. Fig. 2 shows participation percentages of each category considered in this study. Data presented in Fig. 2 show that the projects related to Energy Industry (45%), Agriculture and Management of Waste Disposal (21%), Hydroelectricity (17%) and Landfills (5%) have a prominent position in the Brazilian CDM scenario and altogether represent 88% of the sample of projects reviewed. Through the analysis of the 75 project design documents (PDDs), the island countries (UK, Japan and New Zealand) appear as major buyers of CERs. If the Netherlands, a country below sea level, is added to the group of countries listed above, their share as buyers is even stronger. Regarding the hiring of consulting companies for the development of CDM projects, the analysis has shown that 92% of the projects examined were developed by the companies Ecoenergy, Ecoinvest, AgCert and Ecosecurities. One of the consequences of this concentration was the successive repetition of quotes, statements and, particularly, of the description of technologies in the PDDs analyzed. It is important to emphasize that none of these companies are Brazilian. Ecoenergy and Ecoinvest are American consulting companies and they were responsible for almost 60% of the CDM projects examined, reinforcing the view that even without government ratification of the Kyoto Protocol, private companies in the United States do realize the potential and importance of this emerging carbon market. AgCert and Ecosecurities are Irish companies with headquarters in the city of Dublin.

Fig. 3 shows that methods for cogeneration of power by sugarcane bagasse (AM00015) have as much as a 34% share of all UNFCC applied methodologies used in Brazilian CDM projects, which in Fig. 2 was included in the Energy Industry share. Over a third of CDM projects analyzed in this research are related to the purchase of boilers by sugar and alcohol plants, so that the sugarcane bagasse can be burned and the produced energy surplus can be sold to public power companies.

Since Figs. 2 and 3 are correlated, once again hydroelectricity (ACM0002), animal waste management system (AM0016) and landfill (ACM0001, AM0003 and AM0011) related projects have relevant percentage shares, respectively 17%, 21% and 5%. Other activities with more modest participation are related to projects for replacement of fuel oil with natural gas in power generation (AM0021 and AMS-III.B) at 5%, and for power cogeneration using biomass other than sugarcane bagasse (AMS 1.D and III.E), with a total 8% share. If the percentage of sugarcane bagasse cogeneration is added to the percentage of projects that use other biomass sources for power generation, such as rice hulls and wood, the total participation reaches 42% – nearly half of CDM projects studied. In most of these CDM projects, Brazil has already acquired enough knowledge and technological capabilities to develop them on its own, without actually importing technologies from abroad.

According to data collected from the PDDs, Fig. 4 shows the technological benefits that were produced due to the development

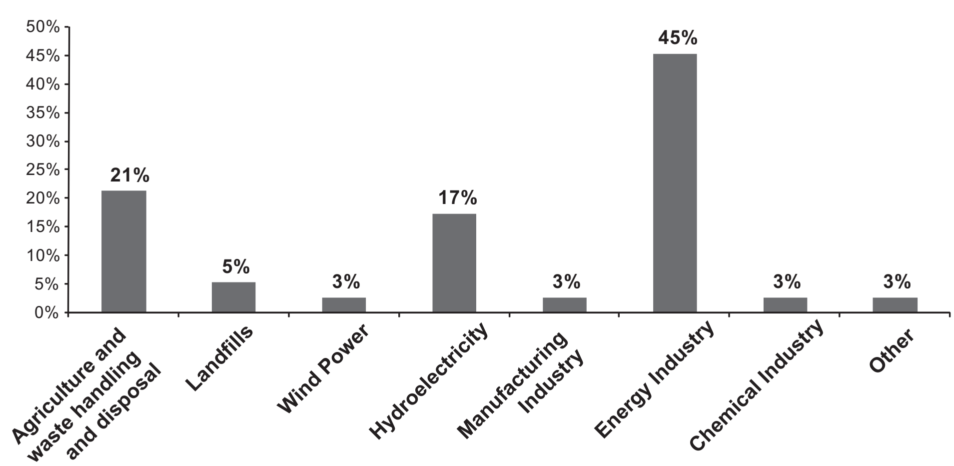

Fig. 2. Categories of Brazilian CDM projects analyzed.

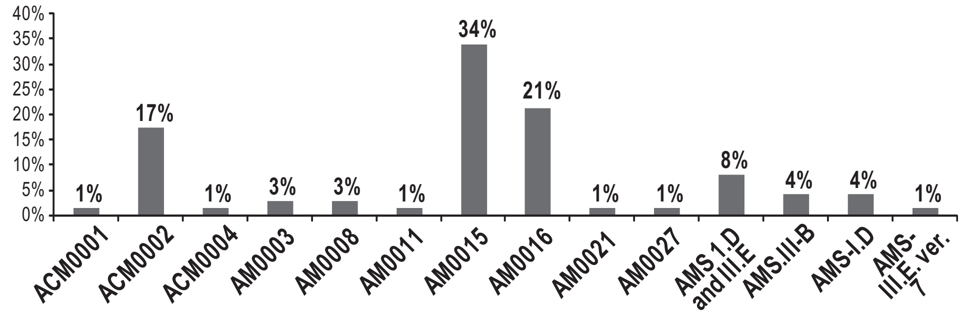

Fig. 3. Methodologies of the Brazilian CDM projects analyzed.

of CDM projects. It is evident with the data presented in Fig. 4 that the greatest technology-related contributions in the studied CDM projects were: promoting domestic industry (60%) and professional training (48%). The financial resources derived from the sale of CERs were used to purchase or refund expenses with equipment and professional training.

Another datum observed in Fig. 4 is technology transfer as a technological benefit (28%), indicating that, even though Brazil is still regarded as a developing country, it has considerable technological expertise in the many sectors that were targeted by CDM projects. However, this datum also shows that, in Brazil, CDM projects stand out more for the transfer of financial resources than for encouraging the development of new cleaner technologies that reduce GHG.

The percentage share of technology transfer was predominantly determined by projects of swine waste handling and disposal, developed by AgCert, as indicated by Dechezleprêtre et al. (2009). In this study, all projects reviewed in this activity category were developed by AgCert and involved supplying knowledge and equipment for its implementation, demonstrating transfer of end-of-pipe technology, as stated by IPCC (2000) and as evidenced by Seres (2007).

Industrial competitiveness and the development of new patents and innovations, both cited in 4% of the projects as technological benefits, also support, to some extent, this paper's thesis that the development and transfer of cleaner technology in Brazilian CDM projects is incipient.

Profitability has become a strategic factor for the execution of CDM projects in Brazil, as a result of CER funding. What should be a tool for the promotion of pollution prevention and cleaner technologies and stimulation of sustainable development through environmental innovations has become merely an opportunity to purchase off-the-shelf equipment in order to implement end-of-pipe technologies.

Fig. 5 illustrates the distribution of the pollution reduction techniques developed and implemented in the 75 CDM projects included in this study, using Lagrega et al. (1994), shown in Fig. 1. Based on Fig. 5, it is possible to make statements at two levels: macro and micro. At the macro level, 29% of the projects adopted waste treatment techniques that are not desirable from a cleaner production standpoint, and 43% are internal/external processes of sub-product recycling. According to Lagrega et al. (1994), these techniques are more related to end-of-pipe practices than to cleaner production ones.

The results shown in Fig. 5 demonstrate the relevance of the waste treatment segment – landfill, swine manure treatment systems, nitrous oxide abatement technologies – (29%) in the Brazilian CDM market. On the other hand, more than 40% of the projects analyzed adopted practices for recycling waste from their own processes and external processes for the mitigation of GHG emissions. Within this group, 75% of the projects surveyed are of energy cogeneration from internal and/or external sugarcane bagasse recycling. Thus, the technology applied to these processes is completely focused on increasing power cogeneration through sugarcane bagasse burning. This technology was widely available in the Brazilian market before the advent of CDM. Therefore, CDM came as a great opportunity for sugar and ethanol plants to renew their industrial parks, contributing to increase profitability from CER selling. For CDM projects that use biomass as a source for energy cogeneration, waste elimination concerns fell into the background.

CDM projects related to development and/or implementation of practices of waste reduction at source, considered highly desirable from an environmental standpoint, made up a 28% share, as seen in Fig. 5. Therefore, of the 75 projects examined in this study, 21 have adopted practices that promoted waste reduction at source. For better understanding, these projects were divided into two separate categories: waste reduction at source with technological changes and waste reduction at source without technological changes. The former accounted for a 7% share and consisted of

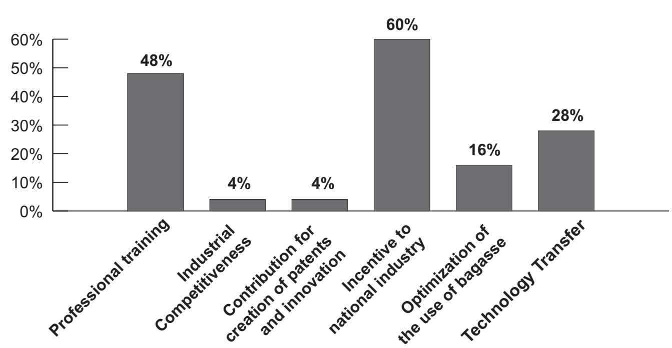

Fig. 4. Technological benefits.

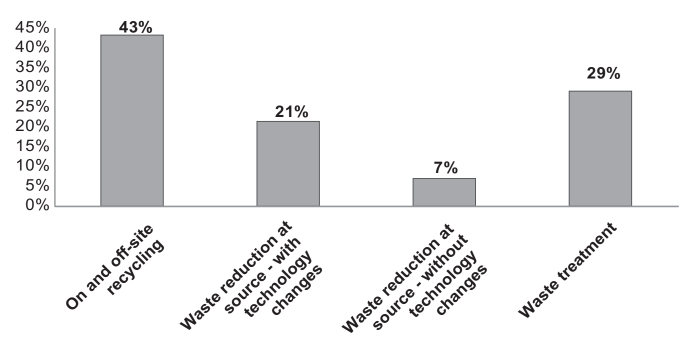

Fig. 5. Pollution reduction techniques in the Brazilian CDM projects. Note: the sum of percentages in Fig. 5 above is greater than 100% due to the fact that a given benefit was reported by more than one project.

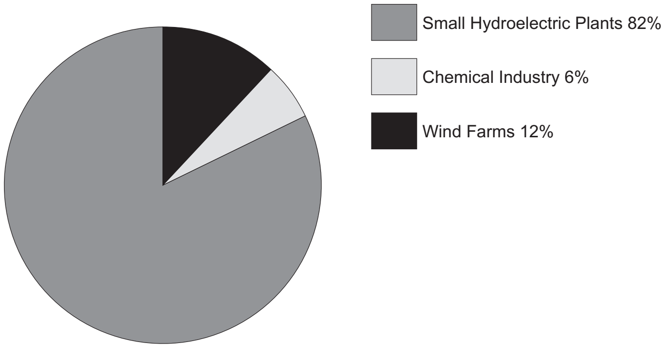

Fig. 6. Brazilian CDM projects with waste reduction at source and technological change.

replacing the non-renewable fuel oil with natural gas, a non-renewable but less polluting energy source. Therefore, even though these projects have, at source, waste reduction practices, the technologies developed and/or implemented still required the use of non-renewable resources. The environmental gain was in energy source purification, but the promotion of cleaner technology was hampered, since the resource used as replacement was still a finite one.

Finally, the remaining project category was of waste reduction, at source, through changes in technology which accounted for a 21% share. In other words, of the 75 projects reviewed, 16 promoted technological changes in their production processes. Fig. 6 shows the distribution of these projects by subcategories of activity.

From Fig. 6, the predominance of Small Hydroelectric Plant projects can be seen (82%). These projects benefit small towns and farmers by supplying them with electricity generated by small hydroelectric plants. The benefits of these projects were twofold: firstly, the populations of these towns stop depending on non-renewable energy sources, such as diesel generators, and secondly, they spend less money on “importing” energy from large distant public power plants.

Wind farms and chemical industry subcategories in Fig. 6 have 12% and 6% shares, respectively. Even though wind farms are naturally very innovative and Brazil has great potential for harnessing this technology, it is very difficult to be competitive in a market dominated by hydroelectric power plants with distribution networks already installed and more competitive prices. In this case, CDM worked as an economic instrument to support the implementation of such projects, because the resources obtained from carbon credits, and also governmental subsidies, made the project feasible, operationally and financially.

The chemical industry project developed pioneering technology which replaced, within its manufacturing process, the CO_2 derived from fossil resources with another one, obtained from the sugar-cane juice, a renewable source. Not only did this project not receive technological support from developed countries, as the Kyoto Protocol advocated in its Article 10 item c, but it also endogenously developed and implemented an innovative cleaner technology.

4. Conclusions

This paper shows the preliminary results of work-in-progress research that sought to analyze CDM projects developed in Brazil as a means for evaluating the effectiveness of the Kyoto Protocol as an international environmental public policy to promote cleaner technologies. In this article, 75 Brazilian projects which received carbon credits until December 31st, 2007 were studied.

It is argued that, as well as establishing cooperation between countries that participate in CDM projects through the transfer of environmentally sound technologies, it is necessary that these countries contribute to the implementation of cleaner technologies, through cooperation between industrialized financing countries and host countries. Transferring environmentally sound technologies is not sufficient to promote clean development in Brazil, since these initiatives may be directed toward undesirable practices from a cleaner production standpoint, not effectively preventing wastes at their sources through the implementation of cleaner technologies.

Looking at the reality of the Brazilian CDM projects, one can affirm that this contribution is still incipient, as only 8% of the projects reported the creation of patents and of innovations and an increase in industrial competitiveness as important technological benefits gained by the host countries. Just 21% of them were characterized by changes of technology aimed at reducing pollutants at their sources.

Further analyzing the technological benefits generated by CDM projects, the aforementioned understanding of the Brazilian incipience is endorsed, since the two greatest benefits reported did not include technology transfer nor innovation, but professional training and incentives to domestic industry. Therefore, most of the financial resources generated by CDM projects were directed to financing or reimbursing the expenses for equipment and services already available in the Brazilian market, thereby reinforcing Pearson’s (2007) point of view that CDM fails to be an effective, market-driven solution to promote clean development.

This view is reinforced when we observed that more than a third of the projects surveyed are of energy cogeneration through sugar cane bagasse burning, a practice carried out even before the advent of CDM. More than anything, the existence of CDM projects in this industry served as a good opportunity to renew the industrial park with the increase of power cogeneration. Given the data discussed in this research, it appears that the CDM projects in Brazil are too modest to effectively achieve the fundamental goal of developing new technologies that, above all, seek to effectively reduce GHG sources and consequently to minimize global warming, within a cleaner model of development.

Finally, in order to continue this work-in-progress study, it is recommended to further evaluate the Brazilian CDM context, considering projects approved after December 31st, 2007. It is also recommended to compare Brazil and two of the other major CDM host countries (India, China and Mexico), taking into consideration their overall contribution to the promotion of cleaner technologies.

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