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The Challenge of Limiting Greenhouse Gas Emissions Through Activities Implemented Jointly in Developing Countries: A Brazilian Perspective

Emilio L. La Rovere

**Environmental Energy
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**THE CHALLENGE OF LIMITING GREENHOUSE GAS EMISSIONS
THROUGH ACTIVITIES IMPLEMENTED JOINTLY IN DEVELOPING COUNTRIES:
A BRAZILIAN PERSPECTIVE**

**Emilio Lèbre La Rovere
Professor, PPE/COPPE/UFRJ
Energy Planning Program
Institute for Research and Graduate Studies in Engineering
Federal University of Rio de Janeiro, Brazil**

November 1998

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Jack Fitzgerald, Project Manager

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Table of Contents

Abstract	1
1. Introduction	2
2. Generic Issues Concerning Joint Implementation Between Annex I and Non-Annex I Countries	3
2.1 Threat of Continuing Increase in GHG Emissions as a Result of Emissions Credits	4
2.2 Risk of Increased Future Abatement Costs in Non-Annex I Countries	5
2.3 Uncertainty of Baselines	6
2.4 Risk of "Leakage"	6
2.5 Cost Effectiveness	6
2.6 Secondary Environmental Impacts and Benefits	7
2.7 Secondary Economic and Social Impacts and Benefits	7
2.8 "Additionality" of Funds	7
2.9 Technological Dependence	8
2.10 Institutional Issues	8
2.11 Loss of Sovereignty	9
3. Four Case Studies of GHG Emissions Strategies in Brazil	9
3.1 Forest Conservation	10
3.2 Afforestation Schemes	13
3.3 The Ethanol Program	15
3.3.1 Carbon Emissions Reduction Through the Use of Ethanol and Bagasse ..	17
3.3.2 Assessment of Future Avoided CO ₂ Emissions Resulting from the Ethanol Programme	18
3.3.3 The Future of Ethanol Production in Brazil	21
3.4 Electrical Energy Conservation	22
4. Concerns about Joint Implementation: Lessons and Possible Solutions from Brazilian Case Studies	27
4.1 Threat of Continued Increase in Global CO ₂ Emissions	27
4.2 Increased Future Abatement Costs in Non-Annex I Countries	28

4.3	Uncertainty of Baselines	29
4.4	Risk of "Leakage"	30
4.5	Cost Effectiveness	30
4.6	Secondary Environmental Impacts and Benefits	31
4.7	Secondary Economic and Social Impacts and Benefits	32
4.8	"Additionality" of Funds	33
4.9	Technological Dependence	35
4.10	Institutional Issues.....	36
4.11	Loss of Sovereignty.....	36
5.	Conclusions and Recommendations.....	37
5.1	Recommendations for JI/AIJ in Brazil.....	37
5.2	General Conclusions and Recommendations.....	39
6.	Acknowledgements	40
7.	References	40

List of Tables

Table 1.	Amazon Deforestation and CO ₂ Emissions.....	10
Table 2.	Avoided CO ₂ Emissions Resulting from Use of Ethanol as a Fuel, 1996.....	17
Table 3.	Avoided CO ₂ Emissions Resulting from Use of Bagasse as a Fuel, 1996.....	18
Table 4.	Net Avoided CO ₂ Equivalent Emissions Resulting from Use of Ethanol and Bagasse as a Fuel, 1996	18
Table 5.	Abatement Costs Related to Extending the Ethanol Program in Brazil (\$1990).....	21
Table 6.	Energy Savings, Avoided Carbon Emissions and Abatement Costs of Electricity Conservation Measures - Abatement Scenario 1-2010	24
Table 7.	Energy Savings, Avoided Carbon Emissions and Abatement Costs of Electricity Conservation Measures - Abatement Scenario 2, 2025	25
Table 8.	Summary of Issues/Concerns about JI and Possible Solutions.....	37

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Emilio Lèbre La Rovere
Professor, PPE/COPPE/UFRJ
Energy Planning Program
Institute for Research and Graduate Studies in Engineering
Federal University of Rio de Janeiro, Brazil

ABSTRACT

This paper addresses, from the Brazilian perspective, the main problems with Joint Implementation/Activities Implemented Jointly (JI/AIJ) between industrialized (Annex I) and developing (non-Annex I) countries, as defined by the United Nations Framework Convention on Climate Change (UNFCCC). Four possible GHG emissions abatement measures are presented for Brazil: forest protection, reforestation projects for carbon sequestration or charcoal manufacturing, use of ethanol produced from sugar cane as a car fuel, and electrical energy conservation through an increase in end-use efficiencies. These four case studies form the basis of a discussion regarding the validity of developing countries' concerns about JI/AIJ. Recommendations are offered for overcoming the present shortcomings of JI/AIJ in developing countries. The primary conclusion is that Annex I countries' funding of JI/AIJ projects in developing countries in return for GHG emissions credits is not the best means to implement the UNFCCC. However, JI/AIJ projects can be a productive means of preventing global climate change if combined with other measures, including GHG emissions reduction targets for all countries involved in JI/AIJ projects and limits on the percentage of industrialized countries' emissions reductions that can be met through projects in developing countries.

KEY WORDS

Activities implemented jointly / joint implementation / forest protection / afforestation / reforestation/ charcoal / ethanol as a fuel / energy conservation / greenhouse effect / Brazil

1. INTRODUCTION

The United Nations Framework Convention on Climate Change (FCCC), signed in Rio de Janeiro during the 1992 United Nations Conference on Environment and Development, calls for limiting the emissions of greenhouse gases (GHGs) to a level that does not cause global climate change but permits sustainable development (U.N., 1992). Because industrialized countries have caused most of the GHG emissions since the Industrial Revolution, the FCCC recognizes that these countries should take the lead in limiting GHGs. Developing countries, however, must curb GHG emissions as their economies expand in the long term although they are currently not required to do so in the FCCC or the subsequent protocol agreed to in Kyoto, Japan in December 1997.

The FCCC defines joint implementation (JI) as a way for one country to support reduction of future GHG emissions in another country. Because the costs of reducing GHG emissions vary widely among countries, a country whose own mitigation options are costly might prefer to invest in less expensive GHG abatement measures in another country. However, the countries involved in such a transaction need a method to account for and share the costs and benefits of these measures.

When both countries involved in a JI effort are bound to defined GHG reduction targets, the benefits of a GHG mitigation effort in the recipient country could be shared with the investor country in the form of credits for avoided GHG emissions; these credits could be counted toward the investor country's emissions reduction target. An agreement for target emissions reductions for each industrialized (Annex I) country participating in the FCCC was reached at the Conference of Parties (COP) in Kyoto, Japan in December, 1997. The Kyoto agreement also established a new mechanism that appears to provide for JI-like mitigation projects or activities between Annex I and developing countries.

JI is particularly controversial for partnerships between Annex I and non-Annex I countries because of the lack of GHG emissions reductions targets for non-Annex I countries. Other political, technical, and financial concerns have also been raised. These concerns, acknowledged

at the first COP in Berlin in 1995, led to establishment of a pilot period for JI activities. Activities undertaken during the pilot period are referred to as Activities Implemented Jointly (AIJ) and involve cooperation among Annex I countries; non-Annex I countries can participate on request. No credits will be awarded for GHG emissions reductions during the pilot phase. The results of AIJ will undergo comprehensive review before the end of the decade (U.N., 1995).

This paper focuses on four potential GHG emissions abatement case studies for Brazil in order to discuss key issues regarding JI/AIJ between Annex I countries and Brazil. Section 2 of the paper reviews generic concerns about JI/AIJ projects in developing countries. Section 3 presents four case studies of possible GHG emissions abatement measures for Brazil: forest protection, reforestation for carbon sequestration and/or charcoal manufacturing, ethanol production from sugar cane for transportation fuel, and electrical energy conservation through increased end-use efficiencies. Section 4 relates the concerns about JI/AIJ expressed in Section 2 to the case studies from Section 3. Finally, the conclusion summarizes recommendations for overcoming the current concerns regarding JI/AIJ between industrialized and developing countries generally and in Brazil specifically.

2. GENERIC ISSUES CONCERNING JOINT IMPLEMENTATION BETWEEN ANNEX I AND NON-ANNEX I COUNTRIES

A number of concerns about JI/AIJ schemes have been expressed in the literature (see, for example, CNE, 1994). We summarize the main concerns from a Brazilian perspective, which are:

- the threat of continued increase in global GHG emissions as developed countries receive emissions credits from investing in abatement projects in less developed countries (see Section 2.1)
- the problem of investor countries taking advantage of the least expensive abatement options in recipient countries, leaving the recipient countries with only costly options to fund on their own in the future (see Section 2.2)

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- the uncertainties associated with calculating how much future GHG production is avoided by an abatement project and thus with fairly awarding emissions credits for a project (see Section 2.3)
 - the difficulty of monitoring whether "avoided" GHG emissions have simply been shifted to other locations - referred to as "leakage" (see Section 2.4)
 - the difficulty of calculating the cost effectiveness of an abatement project (see Section 2.5)
 - the difficulty of quantifying secondary environmental impacts of a project (see Section 2.6)
 - the difficulty of quantifying secondary social and economic impacts of a project (see Section 2.7)
 - the difficulty of verifying that monies directed to abatement projects in non-Annex I countries are not being diverted from existing or previously committed aid (see Section 2.8)
 - the problem of recipient countries becoming dependent on investor countries for technology related to abatement projects (see Section 2.9)
 - the need to develop a management structure for abatement projects in recipient countries (see Section 2.10)
 - the risk of a country's loss of sovereignty over territory that is set aside as a preserve in order to reduce GHG emissions (see Section 2.11)

2.1 Threat of Continuing Increase in GHG Emissions as a Result of Emissions Credits

Annex I countries have little incentive to change their current wasteful patterns of consumption if they can meet their emissions reduction commitments through emissions credits acquired from abatement projects sponsored in non-Annex I countries. Emissions credits could permit Annex I countries to avoid addressing their own GHG problems by investing in cheap and/or profitable abatement opportunities in less industrialized countries. In addition, the development of low-carbon technologies in Annex I countries and the transfer of these technologies to non-Annex I countries would likely slow down if Annex I countries could reduce emissions by investing

instead in abatement abroad. In this scenario, non-Annex I countries would have little incentive to pursue lifestyles other than their current GHG-emissions-intensive ones.

If emissions credits are available to investors and no targets are approved for limiting GHG emissions in Annex I countries, global GHG emissions could increase as these countries receive credits for investments in GHG abatement in non-Annex I countries. (This increase in emissions in an investor country as the result of credits gained from a project funded in another country is an example of what is called "leakage.")

Even though an agreement on targets for Annex I countries was reached at the December, 1997 Kyoto conference of parties (COP) to the UNFCCC, non-Annex I countries are still be free to increase their GHG emissions. This "grace period" for developing countries offers an opportunity for the complex negotiations still necessary regarding JI/AJ. These negotiations could profit from the example of the Montreal Protocol to ban chlorofluorocarbons (CFCs); in response to the Montreal agreement, industrialized countries have taken the lead in banning CFCs within their own borders to meet definite targets and deadlines. After a grace period, developing countries are now following that lead.

2.2 Risk of Increased Future Abatement Costs in Non-Annex I Countries

If investors from Annex I countries are allowed to tap GHG emissions reduction opportunities in non-Annex I countries, these investors will most likely seek the cheapest projects. When developing countries are required to further reduce emissions in order to meet future GHG targets, only the most expensive abatement measures may remain. The international market is currently full of capital from developed countries looking for short-term profit in developing countries. However, investors are often unwilling to face the large up-front costs, long payback periods, and important risks associated with investing in renewable energy production, energy conservation, and development and demonstration efforts.

2.3 Uncertainty of Baselines

The amount of GHG production avoided by JI/AIJ projects is estimated by comparison to a baseline projection of the growth in GHG emissions that would occur in the absence of the projects. The wide variety of possible future development paths in non-Annex I countries means that there are large uncertainties about what this baseline should be (Hourcade et al., 1996).

2.4 Risk of "Leakage"

The actual GHG emissions reductions from a JI/AIJ project are uncertain because emissions-generating activities may simply be shifted to another location. In some cases (e.g. logging activities), emissions may even be shifted to another country. Tracking this "leakage" of emissions internationally or over vast geographical regions within a country requires substantial monitoring and verification efforts (La Rovere and Embree, 1996).

2.5 Cost Effectiveness

The costs of GHG emissions avoided by JI/AIJ projects are affected by technical, economic, and financial factors. An example of a technical concern is that a technology may not perform as well in one country as in another. An example of an economic factor is the somewhat arbitrary choice of discount rate and time horizon for project evaluation.

A large financial factor is the cost of the continuous monitoring and verification that JI/AIJ projects will require. These expenses, added to other transaction costs, can substantially affect a project's total cost. The general perception that the cost of GHG abatement in developing countries is lower than in industrialized countries may be false once monitoring and verification costs are included. Industrialized countries have within their borders GHG abatement options with low and even negative costs; although these "no regret" options may be culturally or politically unpopular, they should be pursued before options in non-Annex I countries that will require costly monitoring and verification to ensure that emissions credits are fairly awarded. A number of case studies support this view (Fritzsche, 1994; Jackson, 1994, CNE, 1994).

2.6 Secondary Environmental Impacts and Benefits

In addition to reducing GHG emissions, JI/AIJ projects may have secondary impacts on environmental phenomena such as biodiversity, emission of other pollutants (SO_x, NO_x, CO, HC, etc.), and opportunity costs of using natural resources. In some cases, secondary impacts of JI/AIJ projects may be felt in both investor and recipient countries. For instance, if a Scandinavian country helps an eastern European country retrofit a coal-fired power plant, acid rain in the investor country will probably be reduced along with CO₂ and local atmospheric pollutant emissions in the recipient country. In this case, the investor country may be motivated to undertake the project at least in part because of the acid rain benefits. Because negotiation of emissions credits depends on accounting for the project's costs and benefits, such "hidden" benefits need to be accounted for and can complicate the negotiation process.

2.7 Secondary Economic and Social Impacts and Benefits

Some secondary social and economic impacts of mitigation projects may be negative, such as transaction costs or concentration of income in certain sectors of society. Others may be positive, such as employment generation, foreign currency savings, and technology development and/or transfer. The potential for dissemination of projects and expansion of markets worldwide should also be considered when measuring secondary benefits. The difficulty of quantifying the costs and benefits of these impacts suggests the need for a multicriteria approach.

2.8 "Additionality" of Funds

The 1995 COP decided that "the financing of AIJ shall be additional to the financial obligations of parties included in Annex II to the Convention within the framework of the [FCCC] financial mechanism (GEF)² as well as to current official development assistance (ODA) flows" (U.N., 1995).

Additionality of funds is complicated in practice but simple in principle: funds for JI/AIJ projects should be in addition to rather than a reallocation of existing foreign aid. However, developing countries fear that JI/AIJ will turn out to be a means for developed countries to set new conditions for ODA. At the same time, potential investor countries are concerned about paying for projects that would have been undertaken anyway in developing countries anyway, even without aid from abroad.

Complicating the issue of additionality is the 25% decrease in ODA during the past four years. JI/AIJ schemes could compensate for this decrease, but if JI/AIJ funds simply return total aid to the level of four years ago, this funding cannot genuinely be considered additional (La Rovere, October 1996).

2.9 Technological Dependence

Governments of recipient countries need to insure that abatement projects include development of domestic industries and skills so that the long-term maintenance of the projects can be provided by the recipient country. JI/AIJ projects should not make recipient countries dependent on investor countries for technology and support, nor should projects provide opportunities for investor countries to "dump" obsolete technology in recipient countries.

2.10 Institutional Issues

Recipient countries need an institutional management structure for JI/AIJ projects. Management involves: assessment of projects from economic, social, technological, and ecological viewpoints, including GHG emissions reductions and other secondary costs/benefits; a method for official government acceptance of the terms of projects, especially the sharing of emissions credits; and monitoring and verification of projects. Developing countries generally lack institutions to handle these management tasks, which means JI/AIJ projects will have to fund development of these institutions (La Rovere and Embree, 1996).

2.11 Loss of Sovereignty

Some JI schemes that protect land, animals, or vegetation in a given region may mean that the recipient country cannot use these protected natural resources; this situation raises concerns about the loss of national sovereignty over the protected area and the problem of accounting for lost opportunity costs.

3. FOUR CASE STUDIES OF GHG EMISSIONS STRATEGIES IN BRAZIL

There are no JI/AII projects in Brazil to date. The Brazilian government has taken an official stand against JI projects that award emissions credits to investors from Annex I countries. However, the potential for curbing future increases of GHG emissions in Brazil is estimated to be large. Some GHG mitigation options can be "win-win" opportunities, fostering sustainable development in Brazil while reducing the risk of global climate change. JI/AII could provide Brazil with the financial support needed to adopt such measures (see La Rovere et al., 1993).

A wide variety of GHG emissions abatement measures could be considered in Brazil. The four case studies described in this section are types of strategies rather than specific projects. Costs and avoided GHG emissions for each strategy will change substantially depending on the scale of the projects, e.g., regional or national.

The four types of GHG mitigation strategies discussed are: forest protection, reforestation projects for carbon sequestration or charcoal manufacturing, ethanol production from sugar cane for use as car fuel, and electricity conservation through an increase in end-use efficiency. Each strategy is discussed in terms of the generic concerns presented in Section 2 for JI/AII projects between Annex I and non-Annex I countries. Although this paper analyzes these abatement measures in Brazil, similar mitigation options could apply elsewhere, particularly in other Latin American countries.

3.1 Forest Conservation

The majority of carbon emissions in Brazil come from land-use changes, particularly deforestation of tropical areas. Table 1 illustrates changes in the rate of deforestation in the Brazilian Amazon and the resulting changes in GHG emissions between 1978 and 1991. The sharp decrease in the rate of deforestation between 1989 and 1991, when the annual amount of cleared land area fell by half, has reversed. Data from Brazil's National Institute of Space Research (INPE) show that between 1992 and 1994 the pace of deforestation increased again to 1.4 million hectares per year. INPE's recently released estimates indicate a jump in 1995 to 2.9 million hectares, then 1.8 million hectares in 1996, and 1.3 million hectares in 1997. The CO₂ emissions from this rate of deforestation are two to three times higher than those from Brazil's energy system.

Table 1. Amazon Deforestation and CO₂ Emissions

Year	Area '000 ha	Area %	Annual Increase '000 ha	Annual Emissions Mill.tons C	% of World Emissions
1978	15,291	3.1			
1988	37,763	7.7	2,247	310-450	4.4-6.2
1989	40,143	8.2	2,380	330-480	4.6-6.6
1990	41,525	8.5	1,381	190-270	2.7-3.8
1991	42,635	8.7	1,110	150-220	2.2-3.1

Source : Reis, 1992

Some authors believe that the conservation of forests at their mature size represents a carbon sink (Rocha, 1996). However, the dominant scientific position is that once forest size reaches equilibrium, the net carbon emissions balance is approximately zero (IPCC, 1996). Thus,

protecting forests creates a carbon sink only if we assume it prevents future deforestation of the area. This is the implicit assumption behind many JI/AIJ projects, such as the CARFIX project in Costa Rica (USIJI, 1996).

Conservation of Brazilian national parks and forests to protect them from illegal deforestation could be undertaken through JI/AIJ projects in Brazil, especially in the Amazon region. However, if all current preserved areas including Indian reserves are added together, they represent more than 10% of the Brazil's 850 million hectares. It is already nearly impossible for the government to allocate the resources needed to enforce the protection of these huge areas, particularly in the Amazon region where basic infrastructure is lacking.

Curbing carbon emissions from deforestation would also require appropriate incentives to private farmers to stop clearing trees, which they do in order to expand their agricultural and animal husbandry activities. From the 1960's to the 1980's, farmers received the opposite incentives: federal grants were given for the acquisition and clearing of Amazon forest land to encourage new productive activities. This policy was aimed at increasing the Amazon region's integration into the national economy because Brazil's military government feared losing control over the territory. Incentives to clear Amazon forests were cut in the early 1990's; recently, the law was changed to require farmers to preserve at least half the forested area on their land. However, enforcement of this law is difficult, as noted above.

Purchasing and preserving private forest land and improving the policing of preserves will be attractive options for JI/AIJ projects because these activities are not as costly as other possible GHG abatement strategies in Brazil. Land protection projects could claim substantial avoided GHG emissions for very low abatement costs, as has been true in other Latin American countries (e.g., 3.5 US\$ / t C for the CARFIX project).

However, determining the actual CO₂ emissions avoided by forest preservation depends on the assumptions made regarding how much time would have elapsed before the forest was destroyed had it not been protected (see Hourcade et al., 1996). In addition, the factors behind deforestation

are still poorly understood. In some cases, deforestation is directly associated with the use of firewood or charcoal as an energy source; in other cases, it results from expansion of agricultural activities. The lack of agrarian reform to allow access to farm land encourages Amazon farmers to continually move and clear new forest areas. Logging also causes deforestation in the Amazon along with other activities, such as large-scale mining, hydropower, and cattle raising projects, that require new roads, which open up access to new forest areas that are cleared and burned.

From a purely macroeconomic viewpoint, agriculture, cattle raising, and logging in the Amazon region together constitute a very small part of Brazil's Gross Domestic Product (GDP). However, discontinuing these activities would have such large social, cultural, and political impacts that it is probably impossible. In particular, the expansion of the agricultural frontier by clearing forest is a practice that has become deeply rooted in Brazil since colonial times. It would be at least as difficult to change as consumption patterns in developed countries. In the process of evaluating JI/AIJ projects and emissions credits, it is important not to implicitly place more value on the resistance to lifestyle changes in developed countries than in less developed ones.

There are huge uncertainties about the rate of future deforestation in the Amazon. If future economic growth follows the example of Europe and North America, very little forest will be left in the long run. However, a cross-section analysis of the deforestation level to date in different areas of the Brazilian Amazon shows a bell-shaped curve, with deforested areas stabilizing at no more than 25 % of the total forest in an area (Reis, 1993). This analysis suggests that a "saturation point" is reached, at least with the current motivations and methods associated with deforestation, long before all trees in an area are cleared.

The large uncertainties regarding future deforestation in Brazil and other developing countries are a strong argument against assigning avoided carbon emissions for forest protection projects. In addition, monitoring to prevent displacement of deforestation activities to another area ("leakage") would be extremely difficult (see La Rovere and Embree, 1996). Forest conservation projects are thus not good candidates for JI/AIJ projects. This does not mean that Brazil's forests should not be protected but rather that forest protection should be pursued through programs

addressing global biodiversity and the local environment, as discussed in the Intergovernmental Panel on Forests, instead of through JI/AIJ projects seeking to create carbon sinks.

3.2 Afforestation Schemes

Given appropriate soil and climate conditions, afforestation programs can create efficient carbon sinks in tropical areas where modern technology and the use of fast-growing species can permit sequestration of as much as 10 tons of carbon per hectare, per year (10 t C/ha/y). Abatement costs are reasonably low, between 3 and 26 US\$ / t C (Hall, 1995). Even lower costs have been recorded in natural forest regeneration projects. The potential for afforestation programs to create CO₂ sinks is illustrated by the FLORAM project proposed in Brazil (IEA, 1990).

The FLORAM project aims to fight environmental degradation in all parts of Brazil except the Amazon region. Using native species or eucalyptus where appropriate, FLORAM's afforestation efforts are intended to achieve both environmental preservation and economic goals, such as supplying feedstock to pulp and paper plants. The proposed afforestation of 20 million hectares during a 30-year period could absorb 5 billion tons of carbon from the atmosphere. In other words, this single national afforestation program could be a sink for about 4% of the estimated 115 billion total tons of surplus carbon accumulated in the atmosphere to date (La Rovere, 1992).

The FLORAM project would cost 22.5 US\$ billion. Such a project would seem a natural candidate for JI/AIJ even though it was not conceived primarily to create a carbon sink. FLORAM illustrates the potential confluence of interests between national sustainable development efforts and efforts to prevent global climate change.

Afforestation projects such as FLORAM would need to provide for perpetual renewal of tree plantations if trees are to be harvested (e.g., for use in pulp and paper plants, for furniture or for building material). In addition, the usefulness of projects like FLORAM for GHG abatement is increased if the biomass from afforestation is used to replace fossil fuels or firewood that would have been obtained from deforestation. Countries like Brazil that have steel mills fueled by

charcoal would benefit greatly from afforestation programs, which, coupled with renewable charcoal production in efficient kilns, could supply the steel industry's large energy needs with almost no net carbon emissions.

About 25% of current pig iron production in Brazil is fueled by charcoal, but only 30% of the charcoal consumed by the steel industry comes from afforestation schemes. Independent producers using mud kilns with very low yields manufacture the majority of the charcoal, contributing to the deforestation of large areas mostly in the state of Minas Gerais, and in the Carajas pole in the Eastern Amazon where the primary charcoal source is forest cleared for agricultural purposes.

Massive afforestation programs could create renewable sources of wood and charcoal to serve future steel industry needs. Afforestation could be coupled with the adoption of modern kilns, which consume less wood than older kilns per ton of charcoal manufactured. It has been estimated that using all the output from the afforestation of 20 million hectares (the area designated in the FLORAM project) with eucalyptus could meet 80% of the Brazilian steel industry's charcoal needs in the year 2025, assuming that charcoal-based production increases to 34% of the country's total steel production. Avoided CO₂ emissions could reach 90 million tons of C per year in 2025 under this scenario (La Rovere et al., 1993).

Coke is also used to fuel steel production in Brazil, so the cost per ton of avoided carbon emissions through the substitution of renewable charcoal for coke depends on assumptions about the long-term price of coke in the international market. Current coke prices are low because of inexpensive exports from Asian countries (mainly China). If these low prices continue until 2025, GHG abatement costs would range between 80 to 100 US\$ / ton C (La Rovere et al., 1993).

Many recently privatized, charcoal-based steel manufacturers in Brazil are converting their facilities to burning coke because of environmental, social, and economic pressures against the industry's current, unsustainable supply of charcoal from deforestation. Charcoal manufacture

by independent producers is criticized not only for environmental reasons but also because those employed by the kilns work in poor conditions, often with limited rights. Meanwhile, policy decisions are also encouraging the move away from the current system. The state of Minas Gerais has banned the use of charcoal from deforestation after the end of the decade. The state environmental agency controls the origin of charcoal through certificates of renewable production.

From a strictly economic viewpoint, charcoal from deforestation is more profitable than renewable charcoal in the short term, and imported coke at current low prices is still cheaper. Moreover, the security of the supply of renewable charcoal can be a problem if forest plantations are not replanted. Although Brazil currently has an impressive 6.5 million hectares of planted forests, the subsidies that supported this afforestation effort have been cut. Afforestation projects must be sustained if Brazil is to make the transition to a sustainable steel industry using renewable charcoal. Afforestation can be shown to be cost effective and socially acceptable in the long run. However, it involves higher up-front costs, larger investment requirements, and residual negative social and environmental impacts during its startup period, compared to continuing to use charcoal from deforestation or imported coke. JI/ AIJ schemes could help overcome these short-term barriers to a transition to renewable charcoal use in Brazil's steel industry.

3.3 The Ethanol Program

After nearly 20 years, Brazil's Ethanol Programme remains the largest commercial application of biomass for energy production and use in the world. It has demonstrated the technical feasibility of large-scale ethanol production from sugar cane for use as car fuel. There are, however, social and economic concerns about the program. La Rovere & Audinet (1993) and La Rovere (September 1996) analyze the Ethanol Programme with regard to increasingly important local and global environmental concerns. The program was originally justified in large part by the cost of foreign oil. Since oil prices fell sharply in the 1980's, the major argument for the ethanol program has become its contribution to reducing air pollution and GHG emissions from automobiles.

The Ethanol Programme's environmental benefits have been assessed using a Markal-like (linear optimization) model to define the ranges and costs of curbing greenhouse gases if the program is extended. Since the introduction of sugar cane plantations by the European colonists during the 16th century, Brazil has been an important producer and exporter of sugar. Turning Brazil's sugar industry to the production of ethanol was the government's answer to the decline in international sugar prices and the increase in the cost of foreign oil after 1973. Idle production capacities and existing distilleries were shifted from producing sugar to producing ethanol. Since the program began in 1975, ethanol production from sugar cane has increased from 0.6 Gt (billion liters) to 13.74 Gt per year.

Initially, vehicles were switched to gasohol (containing 20% ethanol), which did not require engine modification in most cases. However, after a second oil crisis, the emphasis shifted to vehicles using pure ethanol. The Brazilian automotive industry (mainly comprising branches of major European and American car makers) made the minor technical changes required to produce cars that could run on pure ethanol. This phase of the program was funded through soft loans from the Brazilian government. Tax reductions made the prices of ethanol and ethanol-powered cars very attractive. Today, 4.3 million ethanol-powered cars consume 9.47 Gt of ethanol per year, and 4.27 Gt of ethanol is used to produce gasohol for the rest of the country's cars.

The sharp decrease in oil prices on the international market during the mid-1980's seriously reduced the Ethanol Programme's cost effectiveness. The government stopped funding the building of new distilleries, so production capacity became limited. Incentives for the consumption of ethanol were continued, however, and consumption continued to grow although at a slower pace. The combination of limited capacity and growing consumption led to an ethanol supply crisis in 1989 -90, which considerably damaged the program's credibility. The percentage of ethanol-powered new cars sold diminished from almost 100% in 1988 to nearly zero in January, 1997. The continuation of the Ethanol Program is in serious question today. Its survival now depends upon adequate foreign investment based on its global environmental benefits. It would, therefore, be a good candidate for support from a JI/AIJ project.

3.3.1 Carbon Emissions Reduction Through the Use of Ethanol and Bagasse

The net avoided GHG emissions from sugar-cane ethanol and bagasse in Brazil have been well assessed by Macedo (1997). Although energy is required to produce ethanol, a large supply of cane bagasse is available to fuel the process; the availability of bagasse added to the energy content of the ethanol produced result in a positive overall energy balance. The carbon absorbed by the sugar cane as it grows compensates for the carbon released when bagasse and ethanol are used as fuel. On average, autonomous distilleries (which produce ethanol) now have an annual bagasse surplus of 12%, which they sell to other industries. For distilleries coupled to sugar mills (which produce sugar, with residual ethanol production) the average annual bagasse surplus is 5%. Accounting for bagasse used to replace fuel oil and for the ethanol consumed by cars, both of which represent avoided CO₂ emissions, Macedo (1997) presents the results summarized below in Tables 2, 3 and 4, with 1996-97 as a base season.

Table 2. Avoided CO₂ Emissions Resulting from Use of Ethanol as a Fuel, 1996

	Ethanol Product Billion liters/year	Replaced Gasoline Billion liters/year	Avoided Release* Million ton C/year
Anhydrous **	4.27	4.44	3.37
Hydrated***	9.47	7.58	5.76
Total	13.74	12.02	9.13

* 0.76 kg C / liter of gasoline** 1 liter of anhydrous ethanol substitutes for 1.04 l of gasoline in the 22 % blend

*** 1 liter of hydrated ethanol

Source : Macedo, 1997

Table 3. Avoided CO₂ Emissions Resulting from Use of Bagasse as a Fuel, 1996 (M tons/year)

Uses of bagasse	Bagasse Use 50 % moisture	Fuel Oil Replaced (*)	Avoided Carbon release (**)
Sugar production	28	4.9	4.2
Ethanol product	37	6.5 (***)	(5.5) (***)
Fuel, other sectors	7	1.2	1.0
Total	76	6.1 (***)	5.2 (***)

(*) Low Heat Value (LHV) of wet bagasse : 7.74 MJ/kg; boiler efficiency of 74 %

(bagasse) and 82 %, related to LHV

(**) Fuel oil: 0.86 kg C / kg of fuel oil

(***) Using bagasse as fuel for ethanol production is not considered avoiding fuel oil burning and carbon release; if bagasse was not available as a byproduct of ethanol production, boilers in distilleries would burn fossil fuels, generating GHGs. However, if ethanol were not produced in the first place, there would be no carbon emissions generated to produce it. So the GHG emissions "saved" by burning bagasse are not truly avoided emissions.

Source : Macedo, 1997

Table 4. Net Avoided CO₂ Equivalent Emissions Resulting from Use of Ethanol and Bagasse as a Fuel, 1996

	Million tons C equivalent / year
Fossil fuel use in the agro-industry	+ 1.28
Methane emissions (cane burning)*	+0.06
N ₂ O emissions from soil**	+0.24
Ethanol substitution for gasoline	- 9.13
Bagasse substitution for fuel oil	-5.20
Net contribution (carbon uptake)	-12.74

* 6.5 kg methane / hectare, ** 1.7 kg N₂O / hectare year

Source : Macedo, 1997

3.3.2 Assessment of Future Avoided CO₂ Emissions resulting from the Ethanol Programme

A modeling exercise by La Rovere et al. (1993) built two different energy scenarios, one with and one without CO₂ abatement, for similar basic assumptions about population, oil prices, and

economic growth to the year 2025. The exercise, based on a Markal-like model, optimized energy supply to meet demand, which was simulated as consistent within a general equilibrium macroeconomic model (minimization of the cost of energy supply under constraints). In the baseline scenario (without abatement), the price of petroleum was assumed to reach \$24/bbl in the year 2010 and \$28/bbl in 2025. In the abatement scenario, the price of petroleum was limited to \$21/bbl in the year 2010 and \$23/bbl in 2025 because of assumed environmental restrictions on its use worldwide.

La Rovere and Audinet (1993) used the same modeling framework, with a baseline and a GHG abatement scenario, to assess future CO₂ avoided emissions from the Ethanol Programme. The baseline scenario assumes the rates of energy supply and demand in 1990 will continue until 2025. If the present trend continues, the Ethanol Programme would be phased out. All new cars would be gasohol powered, with the proportion of anhydrous alcohol in gasoline being maintained between 0 and 10%. The number of cars powered by pure ethanol would gradually decrease as the current fleet is scrapped and alcohol production is frozen and ceases altogether by the year 2010.

In the second scenario, the Ethanol Programme is extended in order to counteract global climate change. Ethanol production from sugar cane is assumed to strongly increase; gasohol is assumed to contain 22% ethanol, and 30% of cars are assumed to be fueled by pure alcohol in the year 2010. The effect of doubling the share of ethanol-powered cars to 60% of the total fleet in 2025 is also assessed. Excess electricity from ethanol production would be supplied to the power grid by distilleries with high-efficiency cogeneration projects fueled by bagasse.

Reductions in ethanol production costs are assumed as the result of an increase in the productivity of sugar cane per hectare. Two thirds of the production cost of ethanol is the agricultural cost of growing sugar cane. Until 2010, agricultural productivity is assumed to increase throughout Brazil to the current maximum yield of the most efficient sugar cane refineries in the state of Sao Paulo. Between 2010 and 2025, no additional productivity gains are assumed to occur. These assumptions are conservative. Gross estimates of increases in land used for sugar cultivation are based only on land where sugar is grown to be used in ethanol

production, assuming the following average yields: 75 tons/ha/year of sugar cane; 72 liters ethanol per ton of sugar cane.

A comparative analysis of the results of the baseline and abatement ethanol program scenarios is presented in Table 5. These results clearly indicate the Ethanol Programme's potential role in curbing the increase of CO₂ emissions in Brazil. Reductions of between 8 and 10 % of CO₂ emissions can be obtained by the year 2010 at reasonable costs: 25.5 US\$ / ton C, assuming oil prices as low as or lower than 2.1 US\$ / ton C or only a modest increase in oil prices. This analysis shows the sensitivity of CO₂ abatement costs to changes in energy prices. Continuing to increase ethanol production and the number of cars fueled by ethanol until 2025 avoids a substantial additional amount of CO₂ (77 to 81 M ton C / year). These avoided emissions represent more than twice the estimated CO₂ emissions that could be avoided by Brazil's energy system during the same time period. But the incremental costs of achieving this reduction in CO₂ emissions from the energy system would also be much higher, ranging from 81.1 to 106.5 US\$ / ton C, depending on oil prices.

Table 5. Abatement Costs Related to Extending the Ethanol Program in Brazil (\$1990)

Oil prices (\$/bbl)	low				high			
	21		23		24		28	
Years	2010		2025		2010		2025	
Scenarios	1	2	1	2	1	2	1	2
Annual Cost (G\$)	182.8	183.3	351.1	359.8	185	185	359.5	365.8
% Increase	-	0.3	-	2.8	-	0	-	1.7
Annual Carbon Emissions (MtC)	209.3	188.4	439.4	358.5	206	188.7	438.0	361.1
% Decrease	-	-10.0	-	-18.4	-	-8.4	-	-17.6
Abatement Cost ((\$/tC)	-	25.5	-	106.5	-	2.1	-	81.1
Total Ethanol Production (Gl/y)	-	24.3	-	110.9	-	24.3	-	110.9
Increase in Land for Cane (Mha)	-	2.3	-	16.5	-	2.3	-	16.5

Source: La Rovere and Audinet, 1993

The picture will look much more promising if future technological innovation leads to greater-than-assumed gains in ethanol production. Macedo (1997) reports that cane productivity between 1985 and 1995 increased from 75 to 80.4 tons/hectare/year, and overall industrial conversion efficiency increased from 72 to 85.4 l ethanol/ton cane. This increase in yields reduces by 20% +the abatement cost figures above, leading to costs between 1.7 and 20 US\$ / ton C in 2010 and between 65 and 85 US\$ / ton C in 2025.

3.3.3 The Future of Ethanol Production in Brazil

Ethanol production will be constrained to the extent that distilleries shift their emphasis toward making sugar. The market for cane sugar will probably shrink in the long run because of increased production of synthetic sweeteners, however, so clear, energy-related policy goals and incentives are necessary to prevent an increase in sugar production and corresponding decrease in ethanol production in the short run.

The positive social effect of employment generation in rural areas for ethanol and ethanol-related sugar production (one million direct jobs and three times more indirect jobs) will be reduced as the amount of sugar cane that is harvested mechanically increases. Mechanical harvesting now brings in about 20% of the 273 million tons of sugar cane harvested in Brazil each year; this figure is expected to increase to about 50 % of the annual harvest during the next eight years, according to Macedo (1997). Mechanical harvesting has the advantage of bringing in more of the cane plants' tops and leaves, which are usually left in the field and burned when the cane is harvested by hand. Harvesting rather than burning tops and leaves will reduce atmospheric pollution (and also allow for increased natural fertilization of sugar cane fields). This increased availability of biomass ("barbojo") could add considerably to the power surplus produced by distilleries and sold to Brazil's power grid. The overall cost effectiveness of the ethanol program would improve substantially from this increase in fuel.

Current ethanol production of 9.47 billion liters/year fuels 4.3 million cars but is being phased out because Petrobras, the state-owned oil company, is cutting ethanol subsidies. This phaseout of subsidies followed the breakup of Petrobras' monopoly. JI/AIJ schemes could pick up where these subsidies left off in order to sustain Brazil's ethanol program as a strategy for mitigating GHG emissions.

3.4 Electrical Energy Conservation

A large potential exists in Brazil for the adoption of more efficient end-use technologies to reduce electricity consumption. PROCEL, the electricity conservation program of the electric utility Eletrobras, has identified opportunities to increase end-use energy efficiency through energy-efficient lighting, high-efficiency motors with adjustable speed drives, and efficient refrigerators.

The long-term economic and environmental impacts of these end-use energy conservation measures were assessed in a modeling exercise carried out by La Rovere et al. (1993). All the measures were cost effective, with incremental costs lower than the long-term marginal costs of expanding power generation. These options were not included in the baseline modeling scenario,

which assumed only autonomous technical change, so they are "no-regret" mitigation measures, with zero or negative abatement costs.

There is a large controversy about "no-regret" options for mitigating climate change. Mainstream economists may find it difficult to accept the idea of negative abatement costs. Most "top-down" modelers argue that "hidden" costs (e.g. transaction costs) of these mitigation measures have not been properly taken into account. Hidden or not, these costs arise in the real world because of a variety of market imperfections, which tend to be larger in developing countries than in industrialized ones (see Hourcade et al., 1996).

Tables 6 and 7 show the key results for end-use energy conservation measures, obtained using two different abatement scenarios for the years 2010 and 2025, compared to a baseline scenario with no abatement.

Table 6. Energy Savings, Avoided Carbon Emissions and Abatement Costs of Electricity Conservation Measures - Abatement Scenario 1-2010

Energy Conservation Options	Total Electricity Savings billion kwh/y	Total Avoided CO ₂ Emissions million ton C	Total Incremental Cost - Million 1990 US\$	Average Abatement Cost in 1990 US\$ / ton C
INDUSTRY				
Lighting	2.3	0.2	-61	-307
Heating	6.8	0.7	-184	-263
Motors	21.2	2.1	-571	-272
Power Generation Savings	20.5	2.0	-552	-276
SERVICES				
Lighting	21.9	2.2	-588	-267
Air Condition	5.5	0.5	-147	-294
Refrigerators	4.6	0.5	-125	-250
DOMESTIC				
Lighting	4.3	0.4	-115	-287
Water heat.	4.1	0.4	-110	-275
Refrigerators	8.3	0.8	-222	-278
TOTAL	99.5	9.8	-2675	-273

Source : La Rovere et al, 1993

Table 7. Energy Savings, Avoided Carbon Emissions and Abatement Costs of Electricity Conservation Measures - Abatement Scenario 2, 2025

Energy Conservation Options	Total Electricity Savings billion kwh/y	Total Avoided CO ₂ Emissions million ton C	Total Incremental Cost - million 1990 US\$	Average Abatement Cost in 1990 US\$ / ton C
INDUSTRY				
Lighting	3.9	0.6	-155	-259
Heating	11.6	1.8	-467	-259
Motors	36.1	5.7	-1,448	-254
Power Generation Savings	34.9	5.5	-1,400	-254
SERVICES				
Lighting	43.9	6.9	-1,759	-255
Air Condition	11.0	1.7	-440	-259
Refrigerators	9.3	1.5	-374	-249
DOMESTIC				
Lighting	4.6	0.7	-186	-265
Water heat.	4.4	0.7	-178	-254
Refrigerators	9.0	1.4	-359	-256
TOTAL	168.8	26.5	-6765	-255

Source: La Rovere et al, 1993

There are several barriers to the diffusion of efficient end-use technologies in Brazil; these include financial constraints, inadequate pricing policies, and insufficient managerial skills, as well as risk aversion and lack of information. JI/AIJ schemes could help overcome these barriers by facilitating the transfer of appropriate technology from the investor country to Brazil while producing a number of secondary benefits such as reduced pollution and increased rural employment.

However, the Brazilian government has been unwilling to consider end-use efficiency measures for JI projects that offer emissions credits because most electricity in Brazil (about 95%) is currently generated by hydropower, which does not produce GHGs, so measures that save

electricity would not reduce GHG emissions significantly (see La Rovere et al., 1997). In 1995, the Brazilian power sector's emissions were only 11.5 million tons of CO₂ (3.1 million tons C) for a total installed capacity of more than 50,000 MW. Electricity savings are only an effective GHG mitigation strategy in Brazil if they avoid the construction of future thermal power plants, which is unlikely on a large scale for at least 10 years. Eletrobras' "Decennial Plan for Power Generation, 1997-2006" calls for more than 26,000 MW supplied by new hydropower capacity during the next 10 years compared to 7,637 MW from fossil fuel plants (see La Rovere et al., 1997). Thermal power plants are likely to be natural-gas fired under the adjustment policy for the power sector promoted by multilateral financial agencies (see La Rovere, forthcoming).

Typical calls for proposals for JI projects that award emissions credits look at avoided GHG emissions in the short term only. However, short-term abatement costs for electrical energy conservation projects are distorted in Brazil where hydropower is the dominant source of electricity in the short term but thermal power is likely to increase in the long term. Thus, abatement cost figures for end-use conservation technologies are more favorable in the mid and long run, as seen in Tables 6 and 7, which are based on assumed future construction of thermal power plants as demand increases and hydropower becomes more scarce.

In addition to large uncertainties about the Brazilian power sector's baseline, there is concern about additionality of funds for JI/AIJ schemes to support energy conservation. In the past, multilateral financial agencies have been a major source of capital for Brazil's hydropower projects. These funds are diminishing as agencies increasingly focus on development of thermal power, especially natural gas, which in Brazil's case would mean an increase in CO₂ emissions. New programs by the World Bank and the Global Environment Facility (GEF) have been announced to support renewables and energy conservation. However, 70% of Brazil's huge hydropower potential remains to be tapped, so funding would need to be at levels comparable to the large amounts provided by financial agencies during the 1960s and 1970s. JI/AIJ projects could construct hydropower plants as abatement options in the sense that these plants avoid new fossil-fuel fired capacity. However, such JI/AIJ funds could be seen as replacing shrinking funds previously provided for these projects by international financial agencies rather than providing new, "additional" funds.

4. CONCERNS ABOUT JOINT IMPLEMENTATION: LESSONS AND POSSIBLE SOLUTIONS FROM BRAZILIAN CASE STUDIES

In this section, we relate the generic concerns about JI/AIJ from section 2 to the four Brazilian case studies described in section 3. We propose a number of possible solutions inspired by analysis of the situation in Brazil; additional solutions may be appropriate in other countries. In considering the analysis below, it may be useful to bear in mind that, practically speaking, renewable charcoal sources for the steel industry and continued support of the ethanol program are probably the first programs that would be undertaken in Brazil because they are in the most danger of disappearing and would be difficult to revive once they ended.

4.1 Threat of Continued Increase in Global CO₂ Emissions

If emissions credits were awarded for any of the four case study projects, global CO₂ emissions could continue to increase as long as definite target emissions levels have not been set. Binding commitments to target GHG emissions limits should be made by all parties before emissions credits are awarded for JI projects. Developing countries will need a reasonable grace period before they are obligated to GHG emissions limits. There is disagreement about a fair duration for this grace period, with deadlines proposed from the beginning to the middle of the next century.

A possible way to handle emissions credits for JI projects during this grace period is an alternative suggested by the example of Denmark and other Scandinavian countries. This approach involves limiting the share of total Annex I countries' GHG emissions reductions that could come from JI schemes in developing countries. In addition, a minimum reasonable level of GHG abatement should be required from Annex I countries within their own borders. Emissions reductions at home and emissions credits from projects in non-Annex I countries could also be combined with trading of carbon credits among Annex I countries. To illustrate this approach to achieving emissions reductions, imagine an Annex I country meeting its GHG emissions reduction targets by means of the following combination:

-
- up to 10% emissions reductions from JI schemes for credits in developing countries;
 - 50% or more from abatement measures within the country's own borders;
 - up to 40 % from JI schemes for credits in other Annex I countries, or, alternatively, up to 20% from JI schemes for credits in countries with economies in transition (Annex II countries) and up to 20 % in other Annex I countries.

The above figures are purely illustrative; combinations of credits could be negotiated in relation to the length of the grace period during which developing countries will not have binding emissions reduction targets. Longer grace periods could be traded for the acquisition by Annex I countries of larger shares of carbon credits from JI schemes in non-Annex I countries. A schedule of progressive increases of the allowed share of carbon credits could correspond to increasingly long grace periods.

Annex I countries must prove their commitment to limiting their own GHG emissions without attempting to avoid changes in lifestyle and consumption patterns at home by seeking emissions credits in developing countries. Appropriate mitigation actions in investor countries would encourage investments in renewable energy sources, energy efficiency, research and development to reduce carbon emissions, and other economic and technical moves to prevent global climate change.

4.2 Increased Future Abatement Costs in Non-Annex I Countries

In Brazil, "no-regret" emissions abatement options and forest protection projects are the mitigation measures that could be targeted by Annex I countries looking for "cheap" emissions credits. Other options for GHG mitigation in Brazil are clearly more costly. However, these seemingly inexpensive projects may have "hidden" transactions costs. The opportunity costs of forest preservation are also still relatively unknown. Research is necessary in forest areas that are already protected to explore sustainable productive activities, such as manufacture of pharmaceuticals and cosmetics, from resources in preserves. Knowledge of Amazon forest ecosystems is so limited that monumental, long-term research efforts are needed.

Limiting the use that Annex I countries can make of emissions credits from developing countries would help to address the concern that Annex I countries will take all the "cheap" abatement options in a developing country and leave behind the expensive ones. Criteria could also be established that require an abatement project to ensure the opening up of future abatement options in the developing country. For example, a forest protection project could be accompanied by biotechnological research on more productive ways of using the protected forest resources, or institutions that are developed for one JI energy conservation project could then be enlisted to make subsequent energy conservation measures feasible.

In other words, "sustainability" of abatement potential in developing countries should be considered as part of JI/AIJ projects. This criterion could be enforced by the UNFCCC or by whatever office/ department in the developing country's government is responsible for overseeing JI/AIJ schemes.

4.3 Uncertainty of Baselines

There are large uncertainties about what would happen for each of the four case studies in Brazil over the long term in the absence of GHG mitigation activities. The future of the forces behind Amazon deforestation is not only uncertain but also out of the government's control, involving the livelihood and cultural habits of the region's inhabitants. In contrast, policy decisions could shape the future of afforestation and ethanol production. Energy conservation activities involve participation of a number of social actors; shifts in habits and lifestyles may be required to reduce electricity consumption.

Long-term uncertainties could be accounted for by the use of multiple baselines to predict future development in Brazil. Two dramatically different sets of assumptions could be developed to define the extremes of the range within which future development is likely to fall, including the range of possible GHG emission reductions and their costs. Use of two baselines allows uncertainty to be explicitly accounted for, which is preferable to trying to arrive at a single "best guess" value.

Uncertainty is unpopular in the real world; investors in JI/AIJ projects will want to know in advance what they will be paying per ton of avoided emissions of carbon and how many credits they will get. The range of costs and possible credits represented by dual baselines could be the basis for negotiating a compromise between recipient and investor countries.

4.4 Risk of "Leakage"

"Leakage" of GHG emissions can be a serious problem in forest conservation projects because these projects do not address the driving forces behind deforestation, which can simply continue elsewhere in the Amazon's huge forested areas. Afforestation schemes for renewable charcoal production can be accompanied by increased carbon emissions if production of less expensive charcoal from deforestation increases. It is difficult to prevent the steel industry from using deforestation charcoal, given its lower cost and the size of Brazil's forests. And even optimistic scenarios do not predict that renewable charcoal supply will meet the steel industry's entire demand during the next 30 years. So carbon emissions from deforestation will continue for a significant period of time. This kind of leakage should be taken into account when calculating the net carbon savings of afforestation compared to baseline cases such as the full conversion of the steel industry to coke.

Boundaries within which a project may be assessed may be local, regional, national, or international. These boundaries should be carefully established to account for possible GHG emissions leakage. In theory, one cannot fully avoid the risk of leakage in the case of forest protection/land-use projects. The only way to fully insure against leakage would be to ban forest protection projects from consideration for JI/AIJ schemes that offer emissions credits.

4.5 Cost Effectiveness

Cost effectiveness is a serious concern in the cases of the ethanol program and afforestation schemes in Brazil because these two projects have higher abatement costs than forest protection and end-use conservation measures. The higher costs of ethanol and afforestation have, however, been well tested in real-world, large-scale experiments, and these costs are steadily

decreasing. Uncertainty about the cost and performance of forest protection and energy conservation projects is much higher than for the other two cases. The cost effectiveness of forest protection programs becomes questionable if baseline uncertainties and potential leakage are taken into account. If "hidden" costs are estimated, energy conservation measures shift from "no-regret" to "small-regret" options but remain more cost effective than any energy supply-side options.

A careful analysis of uncertainties about the performance of projects and the impact of these uncertainties on abatement costs is very important in determining cost effectiveness. Performance uncertainties can be treated in the same way proposed in section 4.3 for baseline uncertainties: through creation of two opposite scenarios, in this case describing the extreme limits of the project's technical performance. Sensitivity analysis should be done for key economic parameters such as time horizons and discount rates used in cost/benefit assessments. A precise definition of the cost concepts used is necessary to account for the range of estimated "hidden" costs; in some cases (e.g., energy conservation measures) hidden costs can have considerable effect on overall cost effectiveness. The use of two extreme sets of assumptions means that the results can be expressed in terms of ranges rather than single values.

4.6 Secondary Environmental Impacts and Benefits

Of the four case studies considered for Brazil, energy conservation measures have only negligible negative impacts but strong positive impacts as they reduce local and regional effects of power generation. The ethanol program improves air quality in cities; the negative environmental effects of ethanol production have been considerably reduced during the program's history. Forest protection projects offer soil conservation benefits and can contribute to biodiversity and the stability of local climates. Afforestation schemes improve local environments by making use of degraded land and preventing soil loss and erosion.

The environmental impact of JI/AIJ projects should be fully assessed as part of the project selection process. Priority should be given to "win-win" opportunities that foster sustainable development at local, regional, and national levels in the recipient country while simultaneously

mitigating the risk of global climate change. Multicriteria analysis should be used to evaluate trade-offs among positive and negative impacts of projects.

4.7 Secondary Economic and Social (Impacts and Benefits)

Of the four strategies presented in the case studies for Brazil, end-use energy conservation offers the greatest economic and social benefits: net employment growth (large numbers of jobs created in industry and services versus high capital intensity of power generation); foreign currency savings from avoiding fossil fuel imports; transfer, adaptation, and development of up-to-date technologies; and benefits to all consumers of electricity and users of electric appliances.

The ethanol program has already created a large number of direct and indirect jobs in rural areas, but its potential to create future employment is expected to decrease as mechanical harvesting of sugar cane increases. Expanded use of its byproducts such as bagasse and "barbojo" for power generation could create new jobs for skilled workers. The ethanol program has also allowed for important foreign currency savings (so far estimated at US\$ 27 billion) by reducing dependence on imported oil. Sustaining ethanol production would mean supporting an indigenous technology. However, the program also contributes to the concentration of wealth by transferring subsidized resources to car owners (a social minority in Brazil) and ethanol producers.

Afforestation schemes create jobs in rural areas and avoid foreign currency expenditures for imported coke. Afforestation could also support indigenous technological development in the form of improved kilns for charcoal production. Byproducts of charcoal production, including tar, methanol, and acetic acid, could also be recovered for use as feedstocks in the chemical industry.

Forest protection projects do not offer significant positive social and economic impacts; in fact, they involve opportunity costs of still unknown magnitude. These programs displace forest dwellers and affect their livelihoods; the economic costs of this displacement may not be offset by the benefit of carbon sequestered.

When candidates are selected for JI/AIJ schemes, priority should go to sustainable development projects that also mitigate the risk of global climate change. Ultimately, this means that so-called secondary social and economic benefits should be seen as primary, and mitigating global climate change should be seen as secondary, placing the goals of FCCC in the broader context of the United Nations Conference on Environment and Development (UNCED) quest for sustainable development.

4.8 "Additionality" of Funds

All four strategies described in the case studies for Brazil are potentially entitled to benefit from and have been supported in the past by international sources of funding. If these traditional funding sources now decrease or deny support to these projects, leaving them to JI/AIJ instead, it could be argued that the JI/AIJ funds are not "additional." History offers many examples of foreign aid that is committed but not delivered. JI/AIJ should not be an excuse for reducing other funds that have been committed to developing countries.

One example of the risk of unfulfilled commitments to developing countries is the mandate of the Pilot Program funded by the G-7 countries through the World Bank and the Commission of the European Union to "collaborate with the Brazilian government in a comprehensive pilot program to counteract the threats to the tropical forests in that country" (Smeraldi, 1997). The initial budget for this program shrank from US\$ 1,566 million in 1990 to US\$ 250 million in 1995. The G-7 contribution was reduced to US\$ 50 million and the Brazilian government was to contribute US\$ 25 million; the rest must come from "bilateral agreements and cofinancing" (Smeraldi, 1997). From Brazil's perspective, JI/AIJ funding for Amazon forest protection could be seen not as "additional" but as replacing the G-7 Amazon protection monies that were committed but not delivered.

Brazil's ethanol program and afforestation schemes have been avoiding carbon emissions since the 1970s. The FCCC clearly states that developing countries must be compensated for the "agreed full incremental costs" incurred to limit their GHG emissions (UN, 1992). Even if we

concede that the concept of "incremental costs" is controversial, it is difficult to accept that they do not exist at all for ethanol and afforestation given the current low prices of gasoline and coke. Future JI/AIJ schemes supporting these abatement measures could then be seen at least partly as compensation for incremental costs rather than as additional funds.

Brazil's ethanol program benefited in the past from a World Bank loan (US\$ 250 million of the total investment of US\$ 11 billion in the program). The World Bank could fund continuation/expansion of the program. Energy conservation measures are also included in a project being negotiated by Eletrobras with the World Bank and the GEF. Given the low current capital flows from these institutions to the Brazilian power sector, it is not clear to what extent future JI/AIJ funds would be considered additional.

A complete solution to the problem of additionality would involve:

- an appropriate level of and mechanism for funding of FCCC;
- a substantial increase of capital flow from multilateral financial agencies to support investment in abatement options by developing countries;
- an increase in ODA to the much-discussed level of 0.7% GDP from Organization for Economic Cooperation and Development (OECD) countries to developing countries.

If the above three requirements were met, then JI/AIJ schemes could provide developing countries with truly additional funds for mitigating the risk of climate change. Current trends in the international arena are, however, very different. Industrialized countries prefer bilateral agreements with developing countries, if possible through private companies rather than official governmental bodies, which has resulted in a considerable weakening of international institutions, including the U.N.

This increasing gap between the reality of the international arena and the above three proposed solutions to the additionality problem is sometimes used to dismiss these solutions as unrealistic. The problem from the viewpoint of developing countries is the inconsistency between resolutions approved in international meetings that recognize these three requirements as

desirable and the perspective of industrialized countries that these resolutions do not constitute binding commitments and can be broken.

An important step toward clarifying the issue of additional funding would be a quantification of the current and future promised capital flow between Annex I and non-Annex I countries, accounting for all the different funding sources and the targets/programs they support. Any JI/AIJ funds that go beyond this total could be considered additional.

4.9 Technological Dependence

Regarding concerns that developing countries could become technologically dependent on investor countries through JI/AIJ projects, criteria for approval of JI/AIJ schemes could include evaluating the involvement of recipient country institutions in the transfer, adaptation, and development of technology introduced from abroad to implement abatement options. The definition of technology should include hardware and software, institution building, and development of regulations and other measures to overcome non-economic barriers to mitigation strategies.

Incentives could be offered for abatement projects that include an emphasis on developing and transferring needed new technologies to recipient countries. Many low-carbon technologies such as renewable energy technologies could benefit from early introduction in developing countries where the potential for renewable energy is greater than in industrialized countries. Widespread dissemination of these technologies in developing countries could lead to economies of scale in their production and thus to cost reductions that would increase the potential for subsequent adoption of these technologies in industrialized countries.

4.10 Institutional Issues

The need for institution building in Brazil is greater for forest protection and energy conservation than for the ethanol program or afforestation schemes. Ethanol and afforestation are already handled by well-established institutions, including private enterprises. Forest protection and energy conservation, however, present complex monitoring and verification needs. Satellite imaging can be used to monitor forest conservation, but verification of leakage is difficult, as discussed in section 4.4. The current fragility of public institutions dealing with deforestation in the Amazon region is well known. For electric energy conservation measures, it is difficult to determine to what extent GHG emissions are avoided because it is unclear whether power that is saved would have come from a hydro plant, which does not create GHGs, or a thermal plant, which does.

Brazil needs to create or select a central national office or department to handle assessment, official approval, monitoring, verification, and reporting for potential AIJ schemes. So far, the government has been opposed to any AIJ projects in the country. Costa Rica's experience of creating a national "focal point" to deal with AIJ could be used as a model to help Brazil create the necessary institutional structure, with support from the UNFCCC Secretariat. An institution designated or created to handle JI/AIJ projects in Brazil could also foster sustainable development projects, and offer the institutional support needed to act on the U.N.'s Agenda 21 goals for pollution reduction programs.

The creation of new institutions should be avoided; support should be sought from development banks and other governmental agencies involved in assessment and follow-up of investment and research projects.

4.11 Loss of Sovereignty

Loss of sovereignty is relevant to forest protection projects in Brazil, where forests set aside represent a loss of natural resource potential in the name of international objectives. This issue is

particularly sensitive in the Amazon, given the history of misunderstandings between the Brazilian government and the international community regarding sovereignty in the region.

A simple way to address sovereignty concerns would be to ban forest protection projects from eligibility for JI/AIJ. Or, if these projects were funded by JI/AIJ, project contracts could provide for sustainable productive activities in protected areas, including support for development of appropriate technology to this end, with periodic evaluation of results.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Recommendations for JI/AIJ in Brazil

Table 8 summarizes the concerns about JI/AIJ in Brazil and proposed solutions to them.

Table 8. Summary of Issues/Concerns about JI and Possible Solutions

Issues/Concerns	Possible Solutions
- Undermines the ultimate objective of the FCCC - Shifts focus away from efforts to change lifestyle and consumption patterns in Annex I countries, which means no incentives for developing countries to follow a less wasteful development path - Slows development of low carbon technologies	- Operate within global context of binding commitments - Limit the share of GHG emissions reductions that Annex I countries can claim from JI projects in developing countries. Also, define share of projects that can take place in other Annex I countries and, of that, in countries with economies in transition
Cheap abatement options in developing countries being exhausted	- Same as above (limit number of JI projects in non-Annex I countries) - Make abatement "sustainable" by establishing minimum criteria for tapping abatement potential in developing countries through JI (i.e. project must facilitate new abatement options in the future through technology transfer)
Project baselines are uncertain because of the wide spectrum of possible development paths in non-Annex I countries	Build multiple baselines, using at least two extreme sets of scenario assumptions, to cover the range of reasonable possibilities
- Risk of "Leakage" - Project leakage can occur over a large area, presenting a significant problem for monitoring and verification needs	- Establish project monitoring boundaries carefully to account for leakage - Ban land-use projects for from eligibility for JI because leakage cannot be fully avoided

JI projects might not be as cost effective as they seem - Some project types are new and have untested costs - There are technical, economic, and financial project uncertainties - Macroeconomic differences and uncertainties can be heightened in developing countries	Carefully analyze the uncertainty about project performance and its effect on abatement costs, expressing results as a range rather than single value Define precisely the cost concepts used to account for "hidden costs" and the boundaries of their estimates
Projects may have secondary environmental impacts and/or benefits that should be considered	Conduct full environmental impact assessment for JI projects Aim for "win-win" opportunities that foster sustainable development while mitigating climate change
Projects may have secondary economic and social impacts and/or benefits that should be considered	Aim for "win-win" opportunities that foster sustainable development while mitigating climate change
Issues/Concerns	Possible Solutions
Although funding "additionality" is required of JI projects, it is hard to ascertain and developing countries fear that JI will add conditions from Annex I to non-Annex 1 countries.	The Solution requires 3 steps : - Fund the financial mechanism of the UNFCCC to an appropriate level - Substantially increase the capital flow from multilateral financial agencies to support investment in abatement options by developing countries - Increase ODA from OECD to developing countries to 0.7 % of GDP
Loss of sovereignty is a concern, particularly for land-protection projects which may mean that recipient countries cannot use their natural resources, and for projects with a low level of participation by the recipient country, which may increase technological dependency on the investor country	Ban projects that require setting aside preserved areas and preventing use of its natural resources or permit such projects only if they include sustainable development projects within the protected areas To foster technological self-reliance, criteria for JI approval should include institutional arrangements for the transfer, adaptation, and development of technology for abatement options
A management framework for JI is needed in host countries to address the various stages of JI projects. There is a general lack of such institutions in developing countries	Create a "focal point" in developing countries to handle the assessment, approval, monitoring, and verification of JI projects

5.2 General Conclusions and Recommendations

The primary conclusion is that Annex I countries' funding of JI/AIJ projects in non-Annex I countries in return for GHG emissions credits is not the best means to implement UNFCCC. A major concern is that such projects could actually divert attention from essential efforts in Annex I countries to change wasteful lifestyles and consumption patterns. Clear recognition by Annex I countries of their responsibilities is necessary to help overcome developing countries' suspicious attitude toward JI for emissions credits. The first concrete step toward this end was provided in the Kyoto Protocol through the establishment of GHG emissions reduction targets in Annex I countries. The fulfillment of these commitments must now be enforced, monitored, and verified. If GHG emissions reduction within Annex I countries are substantive by the years 2008-2012, this will pave the way for negotiating the timing and magnitude of emissions reductions targets for developing countries.

Ji/AIJ projects can be a means of preventing global climate change, but they cannot substitute a desired increase in ODA, the establishment of a fully funded and developed financial mechanism for UNFCCC, and an adequate capital flow from multilateral funding agencies to developing countries.

The focus of discussion regarding JI/AIJ schemes should be shifted from the amounts of GHG emissions avoided by individual projects in the short term to the mid- and long-term positive effects of creating a framework that can address concerns about JI schemes for credits in developing countries. Once these concerns are addressed, solutions to technical issues will be easier to find.

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1 Annex II countries are Organization for Economic Cooperation and Development (OECD) countries.

2 Global Environmental Facility

3 autonomous technical change occurs without price or policy inducements.