GLOBAL ENVIRONMENT FACILITY

Brazil

Biomass Integrated Gasification/Gas Turbine Project

Project Document

This Project Document has been edited to facilitate public dissemination.
The original is on file in the GEF Office at UNDP Headquarters in New York.

ABBREVIATIONS AND ACRONYMS

BIG/GT	Biomass Integrated Gasification/Gas Turbine
CESP	Companhia Energetica de Sao Paulo
CHESF	Companhia Hidroeletrica do Sao Francisco
CIENTEC	Fundacao de Ciencia e Tecnologia do Rio Grande do Sul
CVRD	Companhia Vale do Rio Doce
GEF	Global Environment Facility
IPT	Instituto de Pesquisas Tecnologias de Sao Paulo
MC	Management Committee
MOU	Memorandum of Understanding
mWh	Megawatt-hour
NTB	Non-Traditional Business Division (Shell International)
SCT	Secretariat for Science and Technology
UNEP	United Nations Environment Programme

UNITED NATIONS DEVELOPMENT PROGRAMME

GLOBAL ENVIRONMENT FACILITY

Project of the Government of Brazil

Title:	Biomass Integrated Gasification/Gas Turbine Project
Number:	BRA/92/G31/A/1G/99
Duration:	Three years
Project Site:	Brazil
UNDP Sector:	Energy
Subsector:	New and Renewable Sources of Energy
Government Implementing Agency:	Secretariat for Science and Technology
Executing Agency:	World Bank
National Cooperating Agency:	Brazilian Cooperation Agency (ABC)
Estimated Starting Date:	September 1992
UNDP/GEF Inputs:	US $7.7 million

Brief Description:

This project will assist in:

- Establishing a globally replicable prototype unit on a commercial scale for cogeneration of electricity based on the gasification of wood chips or sugarcane bagasse
- Reducing global warming by lowering carbon dioxide (CO_2) emissions.

This project represents Phase II of a three-phase programme:

Phase I: Pre-feasibility study by a consulting firm, BRASCEP, in coordination with several parties.

Phase II: This project is designed to resolve important engineering, business, economic and financial aspects, resulting in the preparation of the engineering design, including technical specifications, for the establishment of a commercial demonstration plant.

Phase III: Construction of gasifier/turbine demonstration plant.

A. CONTEXT

1. Description of subsector

Ninety-five percent of Brazil's electricity is produced from hydroelectric power, making it foremost among countries in the use of renewable energy resources. In addition, nearly 30 percent of its gross domestic primary energy consumption is derived from biomass products.

The country's best hydroelectric opportunities have been exploited already, mainly in the central, southeast, and south of Brazil. Future hydroelectric potential is greatest in the north, notably in the Amazon Basin. However, the implementation of power projects in this area may be restricted on economic as well as environmental grounds.

Among available non-renewable power generation options, coal-fired steam generation based on domestic coal appears to be attractive only as a regional energy source to be exploited in the south of the country. Thermal generation using local natural gas or heavy fuels too is somewhat limited because local reserves are both scarce and small, with the sources often located at great distances from the centers of consumption. In addition, conventional thermal generation alternatives may be highly polluting because they emit CO_2 and other greenhouse gases.

Given the economic, technical and environmental constraints on developing these energy resources, the potential for the incremental use of biomass in generating power seems very promising. An important energy resource in many countries, gasified biomass would reduce global warming because it is neutral in CO_2 emissions over the whole growing and burning cycle.

Of the nearly 30 percent of Brazil's gross domestic primary energy production based on biomass, about half is commercially produced through sustainable yields from short rotation crops of eucalyptus forests and plantations. These provide energy inputs for the ceramics, steel, pulp and paper industries. Brazil has already developed and implemented a major programme to substitute alcohol for gasoline, and a large part of its automobile fleet runs on ethanol-based engines.

2. Host country strategy

The Brazilian power sector has a comprehensive environmental master plan, officially approved by the government and endorsed by the World Bank (Loan 2720-BR). This plan is fully operational and aims at minimizing adverse environmental and social impacts from ongoing and future projects by:

- Undertaking a large number of environmental studies and impact evaluations at the inventory and feasibility stages of planning for power projects
- Identifying the least damaging environmental and social options
- Assuring the highest environmental and social standards in any projects licensed for construction.

However, the number and capacity of environmentally safe and economically viable hydroelectric power schemes to be developed in the next decades is somewhat limited.

Brazil's main power utilities are all federal or state-owned companies. More than 90 percent of their production is based on hydraulic resources, and they are structured to implement and manage large, long-term projects.

The instability of Brazil's economy over the last decade has created major difficulties for these companies. Today, most of them are undergoing an adjustment process to overcome severe financial problems.

Simultaneously, a movement toward sustainable management of the environment is occurring in Brazil, as in most parts of the world. While tariffs are still far below the levels required to bring new commercial investment into the power sector, a new energy policy incorporating commercial pricing is being discussed. The policy, pursued by the Brazilian federal government, is intended to achieve an overall average tariff of $67 per megawatt-hour (mWh) by the end of 1992. (Overall average tariff is defined as the total revenue received divided by the total amount of energy (mWh) sold.) Presently this figure is around $48 per mWh. There is an urgent need for new investment in the power sector in the near future, with at least part of it being in the form of private capital.

Most of the new hydropower projects have costs that are much higher than the old ones, mainly in terms of transmission expenses. Overall generation and transmission costs greater than $50 per mWh are expected on new projects.

These factors, combined with the growing demand for electricity, have led to a search for new responses to meet the needs of the future. The outcome of all these factors will inevitably be:

- Adoption of realistic tariffs

- New investment in the power industry, mainly from the private sector

- Adoption of more environmentally benign technologies.

Large amounts of energy can be obtained from plantation wood and other biomass sources. Studies have shown that Biomass Integrated Gasification/Gas Turbine (BIG/GT) power generation technology compares favorably with Brazil's hydro resources in terms of its cost and overall energy potential. Biomass power can also contribute substantially to the decentralization of electricity production. Thus BIG/GT technology holds great potential for the Brazilian power sector.

3. Prior or ongoing assistance

In 1984 Brazil conducted preliminary studies on biomass gas as fuel for generating electricity with gas turbines. Further research by Shell International, General Electric and Princeton University concluded that recently developed aero-derivative gas turbine technology, combined with the efficient use of biomass, could yield substantial amounts of electric power at reduced environmental degradation levels and competitive costs.

Recent studies by Princeton University and Companhia Hidroeletrica do Sao Francisco (CHESF), a federal utility in Brazil's northeast, have shown that a considerable amount of electricity (about 19,700 mW) could be developed in the northeast at costs below the expected 1994 marginal system costs. At the same time, some 240,000 new jobs could be created in the area.

Biomass gasification programmes by other organisations are listed below:

- During the 1970s, Fundacao de Ciencia e Tecnologia do Rio Grande do Sul (CIENTEC), conducted extensive laboratory and pilot plant gasification research (including pressurized gasification up to 20 bar) and testing of various kinds of wood and agricultural residues.

- Instituto de Pesquisas Tecnologias de Sao Paulo (IPT) has developed a research programme on biomass gasification. While the programme includes some laboratory and atmospheric pilot testing, its major focus has been on developing gasification software simulation. Interest in the technology has been shown by various companies in the country including COPERSUCAR, a large cooperative enterprise operating in the sugarcane industry, and a similar entity based in northeast Brazil.

- In early 1980, Companhia Energetica de Sao Paulo (CESP) developed a programme to produce methanol from wood biomass and has been involved in wood gasification for some time.

- On the international front, Sydkraft has joined with Ahlstron of Finland to put forward a 6 megawatt electrical (mWe) BIG/GT cogeneration demonstration plant in Varnamo. The Finnish electric utility, Imatran Voima Oy (IVO), has started working on a modified version of the biomass gasifier steam-injected gas turbine cogeneration cycle to take advantage of the moisture in wet biomass.

- In the United States, the Department of Energy launched a new initiative in 1990 to carry out research and development (R&D) on BIG/GT technology. Information released by the department indicates that BIG/GT has been selected for a large-scale demonstration project. Also in the United States, the state of Vermont, through its Department of Public Services, has shown interest in a programme demonstrating the commercial viability of BIG/GT technology.

These various initiatives indicate that the use of biomass as a primary source for electricity production, using a modern conversion technology, has both technical and commercial potential.

4. Project preparation

All project participants contributed to the development of Phase I, which was comprised of a detailed pre-feasibility study.

This work was coordinated by BRASCEP, a leading Brazilian engineering consulting firm. It was funded by the Rockefeller Foundation. Administrative and technical services were provided by the Environmental Enterprises Assistance Fund. A number of companies made specific contributions:

- BRASCEP carried out engineering studies, coordinated information received from the participants, and prepared the intermediate report to the Global Environment Facility (GEF) which was reviewed by all the project participants.

- CHESF, the regional utility serving the probable project site areas, provided a representative who chaired the technical committee, carried out preliminary site selection screening, and provided technical inputs and data on linking the BIG/GT plant with the transmission system.

- CIENTEC, a national laboratory, undertook technical review tasks and various laboratory analyses related to gasification process technology.

- ELETROBRAS, the national holding company of electrical utilities, participated in technical review sessions and contributed to studies concerning broader project management and organizational issues. ELETROBRAS also made a formal commitment regarding the terms on which power from the BIG/GT project would be purchased.

- Shell International contributed substantial information based on the experience of its Non-Traditional Business Division (NTB) in London. This information formed the technical backbone of the conceptual engineering in Phase I. NTB assisted in coordinating the information requested from European equipment manufacturers, as well as in the preparation of the Phase I final report to the GEF. Shell Brasil contributed to the wood supply studies, preparation of the Memorandum of Understanding (MOU), and studies of the Phase II management structure.

In addition, a number of potential equipment suppliers provided commercial and technical inputs to support project studies. These included Ahlstrom, General Electric, Lurgi, Rolls Royce, Steward & Stevenson, Studsvik, Uhde and its local Brazilian affiliate Interuhde, and United Technologies.

B. PROJECT JUSTIFICATION

1. Project summary

The main objectives of this project are:

- To reduce global warming by offsetting CO_2 emissions which would otherwise be produced by conventional thermal generation

- To help in establishing a globally replicable demonstration technology on a commercial scale for cogenerating electricity, based on the gasification of wood chips or sugarcane bagasse.

This project is designed to demonstrate the commercial viability of using biomass as a feedstock for power generation through the BIG/GT concept. The project will determine the suitability of biomass energy in developing countries, and the possibilities it offers for commercial activity in regions with low economic potential.

This project will constitute the second phase of a three-phase programme. Phase II, to be financed by a $7.7 million grant from the GEF, is designed to resolve important engineering, economic and financial aspects of the overall project. The engineering component includes the adaptation of new gas turbines for biomass gas of low calorific content, as well as the determination of optimal gasifier design and operational parameters. This phase will result in the preparation of the conceptual engineering design, including comprehensive technical specifications.

If Phase II clearly indicates the project's feasibility, Phase III will be submitted for GEF consideration. The third phase will comprise the construction of the BIG/GT demonstration equipment (estimated cost: $70 million, of which $23 million will be in the form of a GEF grant). It is expected that this final equipment package will be awarded through competitive bidding among worldwide gasifier/turbine manufacturers based on their compliance with established specifications and guaranteed feedstock/fuel characteristics.

2. Problem to be addressed and the present situation

Technology development

Gasified biomass is expected to be an efficient and environmentally sound technological contribution towards solving the energy problem. However, using gasified biomass with relatively low calorific value to generate power through gas turbines has not yet been demonstrated commercially.

This innovation is designed to efficiently convert low-value biomass residue and plantation wood fuel into electricity in gas turbines. Specifically, the technology will adapt new generation aero-derivative gas turbines to use low BTU (British Thermal Unit) gas derived from biomass crops, thereby combining carbon sequestration with high-efficiency electric power generation. Innovation in the gasifier coupled with the gas turbine includes adaptation of commercial fluidized bed gasifiers at high or atmospheric pressure to gasify wood chips, thus meeting full generator load gas supply requirements at required gas quality specifications.

Biomass residues and carbon

More than 2 billion tons of biomass residues from agriculture and the forest industry are produced annually throughout the world. These residues are left to rot, or are incinerated or burned in inefficient energy recovery systems. In either case, roughly all of the vegetal carbon is oxidized directly or indirectly to CO_2.

Net CO_2 fixation is a balance between gross photosynthesis and CO_2 losses during plant respiration. Respiratory losses vary between 25 and 75 percent of gross photosynthesis; 40 percent is a generally accepted approximation. The global net product of plant photosynthesis is 120 billion tons of dry biomass per year. This contains 60 billion tons of carbon and is the equivalent of more than five times the present world energy demand. Although biomass contributes to more than 10 percent of the primary energy input - according to commercial energy statistics - it constitutes a significant but inefficiently exploited resource. Indeed, the overall energy efficiency of traditional uses of biomass fuels is just a few percent, if any. BIG/GT technology could considerably broaden the scope for commercial recovery of this underutilized source of renewable energy.

3. Expected end-of-project situation

The BIG/GT technology will have the following notable features:

- High efficiency, even in relatively small power plants
- Relatively low investment cost, even for small-scale operations
- Competitive small-scale power generation
- A choice between labor intensive or mechanized methods for feedstock supply with consequent potential for high rural employment
- Minimal adverse environmental impact.

BIG/GT power plants could be fired either by crops grown specifically to serve as fuel or by residues from existing agricultural or forest industry activities. Over the full cycle of plantation growth and combustion, biomass power generation would be broadly carbon neutral to the atmosphere. The production of electricity from crops grown as energy sources would have two distinct and important effects related to atmospheric carbon:

- Trees planted on grasslands or other non-forest ecosystems transfer carbon from the atmosphere to the biota creating a carbon inventory that is substantially greater than before. This represents a single impact on the atmospheric carbon reservoir which ceases at the onset of sustainable cropping.

- Sustainable cropping yields a flow of renewable energy which can be substituted for fossil-based power generation on an indefinite basis. Assuming that one-third of the global residues resource was economically recoverable through new technology, about 10 percent of current global electricity demand (10,000 terawatt-hour (tWh) per annum) could be generated. Some estimates put the recovery potential from bagasse and forest industry residues alone as high as 500 tWh per year (5 percent of global power consumption), at costs competitive with existing power sources.

4. Target beneficiaries

This project will provide immediate benefits to the people of Brazil by providing a competitive, renewable and environmentally acceptable source of energy.

The project is especially important for the country's northeastern region, which is poor and in need of rural job opportunities. Within the next ten years it will also become the first region to have fully tapped its hydro resources. For this reason CHESF, as the bulk supplier of electricity in the northeastern region, is in a unique position among participants in this project. It has been interested in the success of BIG/GT technology for some years, and its representatives, who have been key participants in the organization of the working group, are among the leaders of the project.

5. Project strategy and institutional arrangements

The project has been divided into three parts. A detailed pre-feasibility study has been prepared by a consulting firm, BRASCEP, identified by the government of Brazil through its Secretariat for Science and Technology (SCT) and financed through the Rockefeller Foundation. The second phase of the project will prepare the way for the establishment of a commercial demonstration plant.

Two project teams, A and B, will be selected to develop integrated BIG/GT systems. They will work in parallel, but entirely independent of one another. Each project team will be led by a gasifier manufacturer responsible for system integration, process optimization and process guarantees. The gas turbine manufacturer in each project team will be independently responsible for the development of its engine for low BTU gas combustion and gasifier air extraction as agreed with the gasifier manufacturer. The gasifier manufacturer will be responsible for achieving gas quality specifications as agreed with the gas turbine manufacturer.

Only in the latter stages of Phase II will the final selection be made between the two project teams on the basis of technical readiness, technical performance and commercial bids.

Given the time and funding constraints defined by the GEF, it is felt that this arrangement will provide a major stimulus for technical innovation, while at the same time offering the greatest

likelihood that a commercially viable BIG/GT system will be ready for implementation in Phase III. The selection of Studsvik to lead Project Team B in the development of an atmospheric BIG/GT system provides considerable assurance in this regard.

A strong competitive element is inherent in all stages of Phase II:

- The selection of project team leaders
- The ongoing process by which the leaders of Project Teams A and B specify component equipment items and manufacturers to maximize their chances of proceeding to Phase III
- The selection process, in the latter part of Phase II, between Project Teams A and B.

Project participants envisage that equipment developers will be selected for participation in Phase II on the basis of their systems and equipment, technical excellence, and interest in contributing to the technical development work. The value of the seed money to be provided for Phase II has been determined by the GEF, and it is intended that the total available funds will be apportioned among the equipment developers. This allocation of funds has been fixed on the basis of the gross requirements of each developer, together with an assessment of the proportion of funds that would need to be provided in grant form to secure full participation.

Due to the lack of commercial interest from Rolls Royce and United Technologies, the level of competition among the gas turbine suppliers is less than ideal. If the technical strategy (aero-derivative versus industrial turbine) outlined in Section 6.4 of the final report of Phase I is followed, there is little option but to accept General Electric as the gas turbine supplier for both project teams.

By subsidizing capital costs and ensuring that the utility power purchase agreement pays prices equivalent to the avoided economic costs, a private sector consortium should have sufficient profit potential to maximize plant operating time. In the long term, with proper technology transfer, as well as realistic energy pricing policies, this proposed power generation from biomass gas should become technically, financially, and economically viable.

6. Reasons for UNDP/GEF financing

The GEF mandate is to help foster sustainable technologies which are close to commercial viability or are otherwise socially beneficial. This project is intended to make a significant contribution to limiting the accumulation of atmospheric CO_2, which is one of the aims of the GEF.

The project will provide the basis for the development of a broad action plan to substitute biomass (mainly wood chips and sugarcane bagasse) for fossil fuels, first in Brazil and later in other countries.

Brazil, with a per capita income of about $2,100, is experiencing an annual growth in electricity demand of 4 percent. Biomass could play an important role in meeting the country's

future electricity supply requirements in an environmentally benign manner. The potential for growth of this technology is very large because the electricity produced through biomass will be competitive with power generated from fossil fuels. In addition, the project will generate ancillary benefits, such as increased rural employment.

The project's greatest significance, however, lies in the potential for replication of the demonstration plant on a commercial scale, not only in Brazil, but in other countries with appropriate biomass resources. Biomass, efficiently converted to electricity, constitutes one of the few large-scale electricity supply options in any future carbon-constrained global growth scenario. Moreover, there is already a market for the proposed technology. Bagasse and crops grown as energy sources constitute an economic alternative to fossil fuels and are commonly used for electricity cogeneration in developing countries.

This project will help reduce CO_2 emissions in electricity generation by replacing conventional fuels (coal, diesel and bunker C) with gasified biomass. Expanded and more efficient use of biomass has enormous potential for reducing net CO_2 emissions by displacing fossil fuels in many parts of the world. In addition, the project will provide a powerful incentive for tree production. In their growth phase, trees fix or sequester carbon, thus offsetting CO_2 emissions and reducing global warming.

GEF funding will serve a catalytic role for further funding of this technology, both from official and private sources. Without GEF resources, private industry would perhaps be unlikely to pursue this technological development due to the commercial risks involved.

7. Special considerations

The provision of $7.7 million by GEF for Phase II of this project was made on the understanding that an additional $23 million would be sought in Phase III if promising results warranted continuation. The $23 million would subsidize the high initial capital costs from this first-of-a-kind plant. Because the last available opportunity for GEF Participants to consider a request for Phase III funding will be in December 1993, all funding and supporting documentation must be submitted to the World Bank and the GEF no later than September 1993. This timing constraint will require that the gasifier and consulting engineering firms be contracted immediately and start work on an accelerated basis.

A technically competent and highly coordinated team of industrialists, government and utilities participants, within and outside of Brazil, has produced the Phase I pre-feasibility report. This nine-month effort permitted the participants to integrate their respective knowledge and capabilities, and develop a strong working relationship. Given the severe time constraints, it is imperative to the overall success of the project that the momentum gained in Phase I be continued into Phase II.

This project has been approved by UNDP subject to the provision of resources to carry out a substantive analysis of the potential socioeconomic and environmental impacts of widespread industrial plantation in the northeast. This analysis must be effected during Phase II of the proposal, possibly with outside funding. Every effort must be made to secure adequate resources to clarify the

potential risks and impacts on the environment and on the local population of widespread plantation development.

8. Coordination arrangements and management structure

The United Nations Development Programme (UNDP) is responsible for the administration of the project and the disbursement of GEF funds in accordance with the agreement reached with the World Bank.

The Secretariat for Science and Technology (SCT) will be the executing agency responsible for the technical execution of the project. SCT will sign a technical assistance contract with the UNDP to this effect.

The funds provided by the GEF are to be used in payment of specific tasks to be executed by various organizations in order to successfully meet the objectives of Phase II. These organizations will be contracted directly by the UNDP after review by SCT. Similarly, the payment of the services provided by these organizations, after approval by the SCT, will be made directly by the UNDP.

Project participants, as potential equity investors in the BIG/GT demonstration plant, desire to retain a sufficient degree of technical control over the Phase II process to justify their continued support and contributions to the project. They recognize, however, that the SCT is fundamentally responsible to the UNDP for the technical execution of the project.

In order to provide support to the SCT in meeting its obligations, the participants will form a Management Committee (MC) to act as an advisory body to the SCT and ensure that proper technical, administrative and commercial controls are instituted. The role of the MC and the contributions and responsibilities of each of the participants are defined in an MOU signed by the SCT and the participants. The MC will retain technical control of the project and will be comprised of a representative of the SCT and each of the participants. The MC will be responsible to the SCT.

A project coordinator will be contracted as prime contractor and will be the executive arm of the MC. The MC will appoint one of its members as a full-time project manager responsible for all technical and administrative activities as defined in the MOU. The project manager will be directly responsible to and report to the MC. In general, the participants will not be reimbursed for their services, but an account of services rendered will be maintained.

9. Memorandum of Understanding

In accordance with UNDP procedures the Brazilian government, represented by the SCT, will accept responsibility for the technical execution of the project. To enable the SCT to discharge these responsibilities:

- The SCT will appoint the chairman of the MC

- The SCT representative on the MC will have the right of veto on matters which clearly impair the SCT's ability to fulfill its contractual obligations to the UNDP or clearly do not comply with Brazilian law

- All participants will be signatories to the MOU.

The MOU is a straightforward, legally binding, contractual document that is considered sufficient by the SCT and the participants to define their individual responsibilities during Phase II.

At this stage, it would be premature for the project participants to contemplate a formal arrangement such as a joint venture. Only after successful completion of Phase II, when the BIG/GT demonstration has been shown to be both technically feasible and commercially viable, will this step be considered. The incorporation of a company in Brazil, particularly with shareholders as disparate as the group which constitutes today's participants, will be a lengthy and complicated exercise. A looser arrangement is required to effectively carry out the objectives of Phase II and ensure satisfactory controls to efficiently administer the technical activities.

The engineering services company will play a key role in Phase II working under the direction of the MC's project manager. Some tasks have been foreseen at the early planning stage and have been included explicitly in the activity schedule and budget of the engineering services company. One of the company's key tasks throughout Phase II will be to set up, monitor, control and document the two equipment development programmes being carried out under the leadership of the gasifier manufacturers and with the gas turbine manufacturer(s). The engineering services company will also be responsible for agreeing to a programme of work, and the time and cost associated with each major component task.

At regular intervals, the engineering services company will monitor progress, report back to the project manager and supervise any redirection of effort considered necessary by the project manager or the MC. Documentation on the technology will be maintained in readiness for the basic engineering work in the latter part of Phase II. The engineering services company will also be responsible for the coordination of the participants' specific contributions to the project.

10. Counterpart support capacity

The SCT has had a special assistant for the rational uses of energy, including supply and demand aspects, since the beginning of this government (April 1990). This special assistant has been directly involved in biomass energy and advanced gas turbines for eleven years. During his tenure, he has coordinated related governmental policies and programmes including:

- The Rational Energy Production and Use Group, an interministerial group composed of five members, three of whom are National Secretaries of Energy, Economy, and Science & Technology, and two of whom are members of the private sector. This group provided general guidelines to PROCEL (the Electricity Conservation Programme) and CONPET (the Petroleum Conservation Programme).

- Energy Conservation Commissions in all public buildings and factories that have a monthly energy consumption above a certain minimum level.

- A project to install a gas or steam turbine in a sugar mill distillery in the state of Alagoas, in northeastern Brazil.

- An energy conservation programme for the building which houses the major executive governmental offices in Brasilia.

- A proposal in twelve different energy areas to reduce energy consumption.

In Phase I, the SCT committed $120,000 for a project in Alagoas using sugarcane bagasse as an input to electricity generation. The special assistant has been involved in this project since its beginning in June 1991.

ELETROBRAS has committed $14,520, CIENTEC has committed $155,534, and CHESF has committed $124,330 to Phase I of the project. CHESF has also assigned one of its engineers to engage in post-graduate studies at Princeton University in order to study under Dr. Robert Williams, one of the leading developers of BIG/GT technology.

Shell International and Companhia Vale do Rio Doce (CVRD) are two plantation growers that have participated in the formulation of the project and have entered into preliminary review of their sites as candidates for the project. Shell International has committed $110,479 and CVRD has committed $28,470.

The government and local Brazilian institutions have thus long demonstrated their interest and skill in developing BIG/GT technology. Their individual commitments, codified in the MOU, indicate their strong support for successfully implementing this project and sustaining its results.

C. DEVELOPMENT OBJECTIVES

1. Main development objectives

The project has two global development objectives, both of which provide important environmental benefits:

- *Short-term objective:* To establish a globally replicable prototype unit on a commercial scale for the cogeneration of electricity based on the gasification of wood chips or sugarcane bagasse. No native forests will be used in fulfilling this objective.

- *Long-term objective:* To reduce global warming by lowering CO_2 emissions which otherwise would be produced by conventional thermal generation.

2. Social and environmental objectives

In addition to these key objectives, the project will serve as the basis for developing a broad action plan to substitute biomass, mainly wood chips and sugarcane bagasse, for fossil fuels, initially in Brazil and later in other countries. In addition, the project will provide a powerful incentive for tree production, and a consequent reduction in CO_2.

The extent to which this form of biomass energy could help to meet global power demand, and hence have an impact on the carbon cycle, will depend largely on the technical and commercial performance of BIG/GT plants (mainly thermal efficiency, availability and specific investment costs); advances in biotechnology, plant husbandry and harvesting which enhance the economics of energy crops relative to fossil fuels; and the extent to which the perceived threat of global warming is translated into carbon taxes or other restrictions on the consumption of fossil fuels.

As a rough guide, however, energy afforestation programmes totalling 100 million hectares in the tropics or sub-tropics would be capable of supplying more than 30 percent of current global electricity demand.

In addition to these key environmental benefits, the Brazilian BIG/GT demonstration may produce other social benefits consistent with the broad mandate of the GEF by:

- Generating employment and income growth in rural areas and providing a focus for sustainable development, especially in the northeast
- Providing evidence that afforestation for energy production can help to economically decentralize electricity production
- Improving opportunities for private capital in this sector
- Creating long-term programmes related to wood production and improving sugarcane industry standards to fully realize the inherent potential of these industries
- Giving further economic support to existing industries that are already using biomass as a substitute for fossil fuels.

A twenty-year development programme aimed at covering up to 5 percent of northeastern Brazil with plantations for energy would result in:

- A steady flow of investment of approximately $1.7 billion
- An increase in installed capacity of approximately 1,000 mW through the construction of ten to twenty new BIG/GT plants each year
- Approximately 12,000 new direct employment opportunities per year, totalling 240,000 new jobs over the twenty-year period

- An incentive for the development of better and stronger universities and research institutes dedicated to biomass use

- A powerful push for the use of the BIG/GT technology in the sugarcane industry.

Within the sugarcane sector, the introduction of the BIG/GT technology will create a substantive increase in competitiveness, an incentive to employ better skilled personnel in factories and distilleries, and an opportunity to reduce off-season lay-offs.

Preliminary studies (based on investment costs of $1,200--$1,300 per kW and a 40 percent efficiency) have shown that successful BIG/GT conversion systems using biomass as feedstock would be able to supply the same amount of energy as fossil fuel-based technologies. They would also require less than 40 percent of the investment presently foreseen for hydropower plants in northeastern Brazil.

If these findings are confirmed by a demonstration project, the introduction of BIG/GT would produce a long-term savings of around $5 billion in northeastern Brazil alone.

D. IMMEDIATE OBJECTIVES, OUTPUTS AND ACTIVITIES

IMMEDIATE OBJECTIVE 1

Development and testing of gas turbines suitable for biomass gasification and gas cleaning equipment.

Output 1.1

A gas turbine refurbished to burn gas of low heat value of the type produced by biomass air blown gasification. This will include engineering specifications and fabrication, testing a new combustion system and adaptation of its control system.

Activities for Output 1.1

1.1.1 Prepare technical specifications for gas turbine refurbishment.

1.1.2 Contract required engineering services.

1.1.3 Implement required gas turbine modifications.

1.1.4 Test the final systems implemented.

1.1.5 Monitor the development and test the gas turbine.

Output 1.2

Development of the fuel plant engineering process, including fuel preparation, fuel feeding and drying, gasification and gas cleaning; and integration of these systems with the gas turbine and steam turbine generation sets.

Activities for Output 1.2

1.2.1 Prepare technical specifications for process engineering services.

1.2.2 Select suppliers capable of providing the required process engineering services.

1.2.3 Contract the required process engineering services.

1.2.4 Characterize the biomass fuel.

1.2.5 Test the fuel gasification engineering process.

1.2.6 Develop the final conceptual design of the plant.

1.2.7 Detail cycle analyses.

1.2.8 Define the main operational parameters of the plant.

1.2.9 Define the basic specifications of the main equipment of the plant.

1.2.10 Define the plant auxiliary monitoring and control systems.

IMMEDIATE OBJECTIVE 2

Development and specification of the basic engineering and process work for the gasification plants.

Output 2.1

Basic engineering design of plant comprised of:

- Elaboration of plant layout
- Detailed flow diagrams for all plant systems
- Detailed one-line diagrams for plant electrical systems
- Conceptualization of plant control and monitoring systems

- Specification of main plant equipment and construction activities necessary for launching a competitive bidding process.

Activities for Output 2.1

2.1.1 Select a site for the pilot plant construction.

2.1.2 Define the micro-localization of the plant.

2.1.3 Survey the main characteristics of the selected site, including terrain, water sources, meteorological data and infrastructure.

2.1.4 Develop the engineering services.

2.1.5 Prepare specifications.

2.1.6 Monitor the process engineering and gas turbine development.

Output 2.2

A complete set of information on the gasification and gas cleaning system that was not chosen. This information, including test results, process engineering and basic specifications of its main equipment, will permit a decision to be made on further development of this system.

Activities for Output 2.2

Same as Activities for Output 1.2.

IMMEDIATE OBJECTIVE 3

Selection of the site for building the pilot plant and development of the necessary environmental assessment studies.

Output 3.1

Environmental studies, including the analysis of possible project impact on air quality, water and other natural resources; definition of environmental monitoring systems, and proposals for environmentally safe plant waste disposal.

Activities related to Output 3.1

3.1.1 Develop preliminary environmental studies of the pre-selected sites.

3.1.2 Design monitoring system for assessing the impact of the project on the environment.

3.1.3 Characterize the plant wastes and propose alternatives for their disposal.

3.1.4 Obtain the necessary licenses for plant construction.

IMMEDIATE OBJECTIVE 4

Elaboration of a plan for developing Phase III, including the development of pre-investment economic studies, proposal of institutional and organizational arrangements, elaboration of contract proposals for fuel supply and energy sales, and joint-venture agreements.

Output 4.1

Elaboration of the plan for Phase III (construction of plant) comprising the formulation of a detailed workplan, time schedule, budget and identification of necessary resources to implement the demonstration plant.

Activities for Output 4.1

4.1.1 Identify and collect the information required for the construction of the plant.

4.1.2 Identify and recruit the necessary consulting services for elaborating the pre-investment and basic engineering studies.

4.1.3 Prepare a first draft of Phase III plan.

4.1.4 Present and discuss Phase III plan with national and international funding agencies.

4.1.5 Formulate strategies for Phase III implementation, monitoring and management.

Output 4.2

Fuel supply and energy sales contracts discussed and prepared to be signed at the beginning of Phase III.

Activities for Output 4.2

4.2.1 Formulate contract proposals to be signed with possible wood supplier.

4.2.2 Develop studies for defining wood prices.

4.2.3 Develop studies for defining prices for energy sales (tariffs).

4.2.4 Present and discuss contract proposals with ELETROBRAS/CHESF.

Output 4.3

Pre-investment economic and financial studies required for Phase III plan, comprising profitability evaluations, economic and financial projections, and sensitivity analysis.

Activities for Output 4.3

4.3.1 Prepare preliminary financial and economic project analyses based on the proposed conceptual design of the plant and the estimated wood and energy prices.

4.3.2 Define a preliminary financing (equity and commercial debt) plan.

4.3.3 Prepare a preliminary set of financial projections based on the business plan derived from the structure, contractual arrangements and prices.

Output 4.4

Joint-venture agreements to be signed by the project participants, which will comprise the definition of business structure, role of each partner and relationships among participants.

Activities for Output 4.4

4.4.1 Analyze and define the project business structure.

4.4.2 Define the equity share of each participant.

4.4.3 Define rights, authority and responsibilities of the participants.

4.4.4 Identify and prepare the legal contracts to be signed by the participants.

E. INPUTS

Total inputs required to carry out the project's activities are presented in Section D above.

The budget in Section J indicates a funding requirement of $14 million to $15.9 million for Phase II. Of this sum, GEF will contribute $7.7 million. The remainder will be provided by significant cost-sharing by project participants and equipment developers. Some downsizing of the workplan which will not significantly affect the project is also planned.

Total estimated engineering personnel hours required for the labor-intensive Phase II is 28,850 hours over the twenty-four month period of this project.

F. RISKS

There are two major risks that could adversely impact the project in either Phase II or Phase III. The first risk is that electricity tariffs in Brazil may not be adjusted to reflect true avoided costs, which could inhibit the ability to attract investment capital for this or subsequent projects in Brazil.

The second risk is that a major technical obstacle could be unexpectedly discovered, requiring additional research and development. This could cause the December 1993 GEF approval window to be missed. Areas of particular concern are the gasifier and gas turbine.

G. PRIOR OBLIGATIONS AND PREREQUISITES

1. Prior obligations

The SCT, as the lead organization in Brazil responsible for the promotion of science and technological developments in the country, guarantees that all the technical information developed within this project and presented in its main reports will be fully available to any organization or company that requests it.

2. Prerequisites

GEF will allocate funds as indicated in the budget.

The government will identify counterpart personnel for project activities.

The project document will be signed by UNDP, and UNDP assistance will be provided only if the prerequisites stipulated above have been fulfilled or are likely to be fulfilled. When anticipated fulfillment of one or more prerequisites fails to materialize UNDP may, at its discretion, either suspend or terminate its assistance.

H. PROJECT REVIEW, REPORTING AND EVALUATION

The project will be subject to tripartite review (joint review by representatives of the government, executing agency and UNDP) at least once every twelve months. The first meeting will be held within the first twelve months of the start of full implementation. The national project coordinator and the senior project officer of the United Nations executing agency shall prepare and submit to each tripartite review meeting a Project Performance Evaluation Report (PPER). Additional PPERs may be requested, if necessary, during the project.

A project terminal report will be prepared for consideration at the terminal review meeting. It shall be prepared in draft sufficiently in advance to allow review and technical clearance by the executing agency at least four months prior to the review.

The project shall be subject to evaluation six months after the start of full implementation, eighteen months prior to the scheduled termination. The organization, terms of reference and timing will be decided after consultation between the parties to the project document, plus any associated United Nations agency.

I. LEGAL CONTEXT

A detailed legal memorandum covering the rules and procedures to be followed for this project is on file at UNDP Headquarters in New York. This memorandum covers such areas as: the general responsibilities of the government, UNDP and the executing agency; suspension or termination of assistance; and financial and accounting arrangements.

J. BUDGET

The project budget is attached.

COUNTRY : BRAZIL	Date: 11/05
Project Number: BRA/92/G31/B/10/99 Project Title : Biomass Integrated Gasification/Gas Turbine	Shadow Budget Last Revision: 11/05/93
Project Budget covering UNDP Contribution (in U.S. dollars)	

PROJECT COMPONENTS	TOTAL AMT M/M	1992 AMT M/M	1993 AMT M/M	1994 AMT M/M
*010 PROJECT PERSONNEL				
11 Experts:				
011-000 International Experts	210,204		150,000	60,204
	25.0		15.0	10.0
11-99 Subtotal (*)	210,204		150,000	60,204
	25.0		15.0	10.0
*15 Official travel:				
015-000 Duty travel	208,977	28,977	100,000	80,000
15-99 Subtotal (*)	208,977	28,977	100,000	80,000
*17 National Professionals:				
017-000 National consultants	200,000		100,000	100,000
	24.0		12.0	12.0
17-99 Subtotal (*)	200,000		100,000	100,000
	24.0		12.0	12.0
019 COMPONENT TOTAL (**)	618,181	28,977	350,000	240,204
	49.0		27.0	22.0
*020 SUBCONTRACTS				
021 000 Subcontract G7-modif.	1,650,000		987,800	662,200
022 000 Subcontract GASF/GAS	3,800,000		2,760,000	1,040,000
023 000 Subcontract Basic Eng	700,000		400,000	300,000
024 000 Subcontract Env Studies	100,000		70,000	30,000
025 000 Subcontract Ph. III	100,000		40,000	60,000
026 000 Subcontract Fuel/Supp	100,000			100,000
027 000 Subcontract Economic/Fin	50,000			50,000
028 000 Subcontract Join-Venture	50,000			50,000
029 COMPONENT TOTAL (**)	6,550,000		4,257,800	2,292,200
*040 EQUIPMENT				
04 000 Non-expendable equipment	30,000		30,000	
049 COMPONENT TOTAL (**)	30,000		30,000	
*050 MISCELLANEOUS				
053 000 Sundries	162,117	189	70,000	91,928
053 015 Operation	200,702		85,600	115,102
054 000 FIELD OFFICE SERVICES	138,000		69,000	69,000

059 COMPONENT TOTAL (**)	500,919	198	224,800	276,031
099 BUDGET TYPE TOTAL (***)	7,700,000 49.0	29,165	4,982,400 27.0	2,808,436 22.0
999 UNDP TOTAL (***)	7,700,000 49.0	29,165	4,982,400 27.0	2,808,436 22.0