Annex 1. Progress Report to GEF Secretariat

REPORT ON THE BRAZIL: EXTERNALLY FIRED COMBINED CYCLE - ADVANCED TECHNOLOGY FOR CO-GENERATION PROJECT

Background

Most sugar mills in the world produce electricity and/or steam using bagasse. Generally the main concern at the mills is to dispose of the bagasse and produce just enough energy to meet internal needs during the processing season, which in Brazil lasts some 7 months. Thereafter the sugar mill shuts down for cleaning and repairs. In many cases mounds of bagasse are incinerated or simply accumulate for years posing a fire and infestation hazard for the mill. Studies show that the use of energy efficient advanced power generation technology can result in the export of at least *five times* the amount of electricity that a typical mill consumes after satisfying all of the mill's steam and electricity needs. Bagasse could therefore become an abundant and stable source of renewable energy, rather than a nuisance for mill owners and an issue for the global environment.

The Global Environment Facility (GEF) supports new technology commercialization projects under its former Operational Program (OP) 7 category. Aside from the use of an advanced technology, such projects require significant changes in the way an industry operates. In the case of EFCC this includes the setting up of new partnerships to build a power plant that would operate all year round. EFCC represents IFC's largest to-date Council approval for a single project ($ 44 million to fund a project estimated to cost over $ 177 million It holds the promise of helping leapfrog Brazil's sugar mill and power sectors to a higher level of environmental sustainability.

The EFCC proposal that was approved by Council envisaged funding the Project in two tranches:

1. **Tranche I(US$ 3 million of GEF funds):** To be used for activities towards induction of a strategic equity partner, appropriately co-financed by the Project sponsor, and
2. **Tranche II (US$ 41 million of GEF funds**): For the finalization of components of project finance and capital cost buy-down.

This particular structure was used because the project sponsor[1] was seen as financially weak and unable to take the project to financial close without an established strategic partner[2]. Tranche I activities were designed to help the sponsor find an appropriate partner who could take the project to financial close, while Tranche II funds were to be used to take a "first-of-its-kind" EFCC cogeneration facility to financial close, alongside a partner willing to provide equity and co-financing.

In approving the project, Council confirmed that:

[1] The project sponsor is Hague International – a small US based company that had developed the EFCC technology and configuration.
[2] The strategic partner in this instance would be a well established company or entity that had the capability and experience to co-finance and provide equity for a large infrastructure project with a capital layout over $ 170 million.

(a) any replication of this project should be conditional upon an independent evaluation of the project;

(b) tranche 2 of the project should be circulated to Council prior to CEO endorsement, subject to the standard procedures for CEO endorsement; and

(c) the project should be subject to rigorous GEF pipeline management procedures by the GEF Secretariat and the World Bank. In this context, Council requested a status report for this project for the November 2007 Council Meeting, at which point the Council will decide whether adequate progress has been made towards achievement of financial closure.

An update note was submitted to the GEF Secretariat in November, 2007. Since IFC now has additional details including some significant progress in establishing the financial and institutional partnerships, this note is being provided as a more current update for circulation to GEF Council.

Objective and Rationale

The project hosted in Brazil, includes the design, financing, and construction of the, "first-of-its-kind," 80MW, 250 tons/hr. of steam, Greenfield cogeneration facility, using the Externally Fired Combined Cycle ("EFCC") system, a proprietary system of Hague Environmental Power ("Hague"). The initiative would also explore replication possibilities for the technology, trying to define the path towards economic and financial sustainability. Projected costs for the whole project are in the range of $177 million.

Hague claims that the EFCC system is 75% more thermally efficient than alternative bagasse fired high pressure steam boiler/turbine power plant designs available to the sugar industry in Brazil. The EFCC system, which is yet to be proven commercially, is an extension of the gas fired combined cycle that makes it possible to utilize solid fuels by moving the combustion process from the gas turbine to an external source of thermal energy at atmospheric pressure. The attractiveness of the EFCC is due to its high thermal efficiency, which translates into it being able to export a significant portion of the power generated from the bagasse after meeting the sugar mill's internal needs for steam and electricity. High efficiency conventional power generation technology that employs high pressure steam generation and a steam-driven turbine generator is capable of exporting no more than 55% of the amount of electricity that the EFCC produces for export after satisfying the sugar mills' energy needs.

Brazil is a particularly good candidate to host the first commercially operated EFCC co-generation project. The Government of Brazil is committed to materializing its renewable energy potential and has set a target in which renewable energy sources are expected to account for 10% of total electricity generation by 2022. Currently, approximately 84 million tonnes of bagasse are available as an energy resource in the country. By the end of the next 10 to 12 years, the amount of bagasse is expected to grow to over 110 million tonnes per year, of which 46% could be feasibly utilized as the primary fuel for power plants that employ the EFCC technology.

This would result in the addition of over *3,600 MW of power generating capacity producing almost 24 million MW-hours of electricity annually* from a single sugar industry initiative (over 3% of the forecasted demand in Brazil).

In June, 2005, the EFCC project was approved for GEF funding of $44 million in two tranches by the GEF Council. Initially the proposed location for the plant was the Costa Pinto sugar mill in Piracicaba, Sao Paulo State, Brazil. However, for a host of reasons, discussed in subsequent sections, the current plan is to partner with Energias do Brasil (EnBr), and work towards the application of EFCC in one or more Greenfield bagasse based generation facilities planned for commercial operations in the 2011 to 2014 timeframe.

The Business Case

Commercializing EFCC technology entails achieving the following outcomes:

- Demonstrating the operational, environmental and economic viability of EFCC technology
- Reduction in the cost of EFCC technology for a second generation of plants

A. Key Risks:

In order to achieve the required outcomes the following risks must be understood and mitigated:

(a) Technology Risk in EFCC – Perceived and Actual:

EFCC technology is based on one key principle – the use of a combined cycle[3] technology by operating a GT with clean filtered air that has been heated under pressure using a Turbine Air Heater (TAH). The bagasse based flue gases from the TAH exhaust are then used in the ST. The heat recovery cycle from the ST is optimized by a Turbine Control Valve (TCV) that can cater to the varying steam needs of the sugar mill. In the off-season electricity production and export is maximized, while during the period of mill operations, host needs of steam and power are met before sending power into the grid. Thus the EFCC configuration has been designed to maximize power production from a given amount of feedstock, while meeting host needs for power and steam.

The TAH and TCV are the two components of this combination that are new and therefore not commercially proven. The rest of the configuration consists of "off-the-shelf," power plant equipment that a power developer would be familiar with, but which present some perceived risks for a sugar mill that is used to dealing with low to medium pressure STs for internal needs. Preparation for financial close must therefore include funding activities that:

- provide stakeholders sufficient assurance on the risk envelope around the TAH, TCV and any additional new components, and

[3] A combined cycle uses a steam turbine (ST) - gas turbine (GT) combination to maximize thermal efficiency through "waste" heat recovery from the GT and use it in the ST for power production. Having process heat needs (as in the sugar mill) increases overall thermal efficiency of the system. The overall limiting factor is that a GT requires a clean fuel such as natural gas or naphtha.

- reduce the risk perception on those elements of risk that come simply from unfamiliarity with existing proven modes of power generation (i.e. GT and BoP[4])

The key new technology risk lies with the TAH. This is a ceramic heat exchanger which uses normal heat transfer principles to heat pressurized, filtered clean air from bagasse boiler flue gases at atmospheric pressure. The TAH design is to have filtered air at 14.7 bars, which corresponds to the pressure ratio needed for the gas turbine operation (11/1). While the TAH manufactured by Hague has operated under commercial conditions, the pressure used for these industrial applications has been close to atmospheric. Thus, when used in the power generation mode, the higher pressure has not been applied under commercial conditions. However, Hague International draws comfort from the tests performed under the USDOE funded clean coal program in Kennebunk Maine. Under this initiative a 5MW test facility was set up using a TAH system with the flue gases being provided by coal burning – a far more corrosive and dirty fuel than bagasse. The initiative was discontinued after change in US administration, and the Maine facility has now been dismantled.

In the light of these changes, discussions have been held on how to provide financiers and EPC[5] contractors comfort on the performance of the TAH and TCV. While Hague is engaged in providing some solution to this, the following activities have been suggested as a means to provide some assurance:

- Testing of some heat exchanger tubes at high pressure at Hague International's in-house testing rig, and
- Opining by an independent engineer on the design of the TAH.

(b) **Institutional Changes and Capacities:**

As noted previously, a combined cycle power plant using natural gas as fuel is fairly common in the power sector, but is a novelty for a sugar mill. There are some key institutional barriers that prevent the movement of the industry towards such a system. These are outlined below:

- The power sector has a much higher capital intensity than a sugar mill, and therefore relies on leverage and a project finance structure to make return on equity attractive. As against this, the sugar sector has relied on corporate loans to the parent company and very little or no leverage at the project level. Such a structure favors low capital intensity projects, and hence the cheaper ST installations. It must be noted that the

[4] BoP – Balance of plant. This refers to all the ancillaries aside from the ST and GT that make up a conventional power plant.

[5] EPC – Engineering Procurement and Construction. EPC contractors are regularly used on a turnkey basis for the construction of power projects. Such contractors may sometimes provide the delivery "wrap" around the project construction. In complex cases, they could approach equipment suppliers or even insurers to provide pieces of such guarantees and take on the residual risk to provide the wrap. In the case of EFCC, it is critical to have a means to provide assurance to EPC bidders or other entities that maybe approached to provide assurance on the new equipment's performance. Hague International as equipment supplier does not have a significant enough balance sheet to provide such an assurance. At Council submission, it was already envisaged that a part of GEF funds could potentially be used to provide some form or collateral or guarantee to a potential risk taker such as a reinsurance company or an EPC contractor.

first EFCC installation has an even higher capital cost than a conventional combined cycle plant due to the untested components and the higher perceived risk of financing.

- The sugar industry works on a 7-month-on, 5-month-off schedule that is unsuitable for firm power supply into an external grid. It also poses a challenge for continuous supply of feedstock (bagasse) for the power generation unit that plans to operate year-round.
- Given the tradition of ST-based generation within a sugar mill, there are no existing financiable, arms-length bagasse supply agreements between a sugar mill and a generator. These would need to be developed with an appropriate hedging for supply risk, especially in the off-season and during unforeseen events that trigger force-majeure.
- Another outcome of the high capital intensity and regulated nature of the power sector is that it requires financiable long-term power purchase agreements, a series of permits and complex risk sharing arrangements along the supply chain[6]. This is a line of business that is distinct and different in characteristic from the sugar sector. Additionally, EFCC has significant technological complexity that needs to be factored into the project design and financing arrangements.

Based on the above points, a successful demonstration of EFCC entails putting in place the appropriate partners from the power, plantation, and sugar mill sectors. The roles for these entities have to be well defined and in keeping with their expertise. Additionally, as noted previously, the weak balance sheet of the technology provider (Hague International) poses a particular risk for obtaining financial closure on the project. GEF funds and judicious IFC intervention can assist in overcoming this.

(c) Role Definition and Appropriate Partnering:

As outlined above, many players and industries will need to be involved in the successful demonstration of this technology. Complex risks have to be parsed and managed between different entities, and in such an enterprise clear role definition is a must. After significant discussion, it was agreed that IFC could not play the role of a lead developer (to avoid conflict of interest as GEF Executing Agency), and that Hague International was not an appropriate developer (given its weak financial situation) for a $177 million project. In addition, there was a potential conflict in their role as technology supplier and a lead developer. Based on these considerations, IFC identified a need for a financially strong lead developer who could deliver a project of this size and complexity. At GEF Council submission, the GEF funding was therefore split into two tranches:

1. <u>Tranche I (US$3 million of GEF funds)</u>: Funds activities towards induction of a strategic equity partner, appropriately co-financed by the project sponsor, and
2. <u>Tranche II (US$41 million of GEF funds)</u>: Includes finalization of the components of project finance and capital cost buy-down.

[6] Risk must be shared between multiple parties such as project owners, operators, EPC contractors, insurers, as well as parts suppliers.

B. GEF Council approval and Progress to Date:

During Tranche I, the Project was to seek to carry out the tasks necessary to ready the Project for the induction of lead developer. Envisaged activities under this tranche were stated in the submission document as follows:

- Independent engineer's technology and preliminary project review
- Plant system definition, thermal performance at full and part load, overall heat and mass balance, sensitivity analyses, control protocol, mechanical arrangement, and site plan
- Negotiation of EPC agreement including sourcing plan and subcontractor quotations by subsystem on principal hardware and services
- Gas turbine subsystem design adaptation for external firing including turbine control valve, high pressure piping, and turbine air heater
- Gasifier subsystem definition and certification testing
- Applications for permits and licenses and patent fees
- Negotiation of power purchase and fuel supply (bagasse and natural gas) agreements
- Negotiation of insurance placement, and debt and equity commitments

Tranche I expenses were expected to reach US$6 million, of which US$3 million will be funded by the GEF and the remaining co-financed by the sponsor. Once activities under Tranche I had reached certain milestones, IFC was to confer with the GEF CEO to decide upon release of Tranche II. The key requirement for approaching the GEF CEO for endorsement of Tranche II was to be the induction of an appropriate equity partner into the Project company, with a clear understanding that all tasks under Tranche II funding would require co-financing from the Project company sponsors. In addition, by the time the Project team seeks the GEF CEO endorsement of Tranche II, the following specific milestones (which were to act as triggers) were to have been achieved and demonstrated to the GEF Secretariat:

- Commitment letter and term sheet from strategic equity partner willing to co-finance Tranche II activities
- Satisfactory independent engineer's technology assessment and preliminary project review
- Implementation plan for EPC, including clear specification of notice to proceed conditions and progress milestones
- Letter of intent from potential EPC contractor/s in response to implementation plan
- Letter of intent to purchase power
- Letter of intent to supply natural gas
- MOU to supply bagasse and facility site by host and arrangement for off-take of steam and power by host
- Letter of interest and term sheet for providing insurance cover

This structure was approved by the GEF Council in June 2005, and thereafter IFC initiated discussions with Hague International as well as Cosan, the likely host for the power generation unit. Key issues revolved around role definition, co-financing, as well as the search for a lead developer. IFC also approached GE in order to find out their level of interest as a potential equity partner. Based on these discussions, the following conclusions were reached:

- GE while willing to supply turbines and other equipment to the project, with full warranties, was an unlikely equity partner,
- Cosan, while willing to be a participant was not a likely lead developer, but was also unclear on what role it should take on. Unfamiliarity with the power sector and project finance, as well as comfort with conventional steam turbine generation were significant hurdles to overcome, especially if EFCC was to be located on an existing plantation in Piracicaba, that had existing generation,
- There was a need to identify a lead developer from the power sector, such that the economics and operation of the EFCC unit could be managed like a power plant,
- Hague International needed to become comfortable with the role of technology supplier, and define a revenue model that allowed for an arms length relationship on equipment procurement,
- IFC's own role was one of facilitating and convening the different partners, and the GEF funds provided IFC with a unique currency at the negotiating table. However, IFC was not going to play the role of a developer, and Hague must either find a partner willing to co-finance tranche 1, or be able to provide co-financing themselves.

Based on these discussions, IFC and Hague International negotiated and signed an MoU on July 27, 2007.

C. Introducing Energias do Brasil:

In the last quarter of 2007, IFC was informed that a potential lead developer had been identified by Hague International. This was Energias do Brasil (EnBr) – a company with investments in electricity generation, distribution and commercialization in four important Brazilian states – Sao Paulo, Espirito Santo, Mato Grosso do Sul, and Tocantins. Energias de Portugal, one of the largest European electric sector operators, is the controlling shareholder of EnBr, which started listing on the Sao Paulo Exchange's Novo Mercado in July 2005. At the end of 2006, the company held interest in ventures representing 1,018 MW of installed capacity. It also has a substantial distribution business in Brazil that serves more than 3.1 million customers, and distributed 23.9 thousand GWh of electricity in 2006.

A significant part of EnBr's generation is in hydro, and it is currently engaged in the development of a 700 MW coal fired units in northern Brasil. EnBr is also engaged in an aggressive initiative to expand its renewable generation capacity and is soon to announce a new subsidiary called Enernova, that will focus exclusively on alternate power generation.

In the area of biomass (bagasse) based generation in Brazil, Enernova or EnBr are developing the Investimento Verde Project which plans to build four ethanol distilleries, associated with four combined heat and power plants in southwestern Brazil in the State of Mato Grosso do Sul. This will be done through a series of 4 plants designated InVerde 1 through 4. A more detailed description of these projects is provided below. This is based on information received from EnBr's independent engineering firm – Termoconsult.

Investimento Verde Projects

Each of the four plants of the Investimento Verde Project will have the following characteristics:

1. **Ethanol Capacity**. Each plant will produce 1.8 million liters per day of anhydrous ethanol during the in-season, for which the plant will utilize 3.5 million metric tons of cane sugar.

2. **Power Plant I.** Each ethanol plant will have a power plant associated with it to generate the entirety of the ethanol plant's steam and electric power requirements when the ethanol plant is running during the in-season. Steam and power requirements for each InVerde plant will be 250 tonnes per hour and 25 MW per hour, respectively.

3. **Power Plant II.** Each associated power plant will produce more electric power than the ethanol plant requires, which power will be sold to the Brazilian grid:
   - **Conventional Steam Cycle**. If a conventional steam cycle is used, each power plant will permit the sale of 470 GWh per year.
   - **Hague EFCC.** If the power plant utilizes the Hague EFCC, the projected sale of energy will be 740 GWh per year.

4. **Schedule for Operation**. The project calls for InVerde-01 to be in operation in 2011, InVerde-02 in 2012, Inverde-03 in 2103 and Inverde-04 in 2014.

5. **Sugar Cane Supply.** Each of the InVerde plants will require about 50,000 hectares of land planted with sugar cane. The fields where the cane will be planted are not currently used for sugar cane growing.

6. **Ethanol and Power Sales.** Ethanol production will be sold to traders under 15-year contracts. Exportable electricity will be sold in Brazilian government auctions under 15-year contracts.

7. **Technology.** Due to time constraints, InVerde-01 will utilize conventional high pressure boilers and steam turbine generator, with provision to burn bagasse and sugar cane trash as fuel. The Hague EFCC is expected to be a competitive alternative for utilization in the other three projects, InVerde-02, InVerde-03 and InVerde-04, if the investor, Enernova, is convinced of the feasibility, reliability and competitiveness of the technology. To that end Enernova intends to evaluate the Hague EFCC.

The feasibility and reliability of the Hague EFCC must be assessed so Enernova can assume the risks associated with the first commercial application of the process. Assuming technical and financial conditions can be met, InVerde-02 will use the Hague EFCC technology.

InVerde -01

1. **Schedule.** The schedule for InVerde-01 is as follows:

- **Due Diligence Investigation**. Agricultural, ethanol manufacturing and electric power generation due diligence investigations have been conducted since 2007, and should be concluded in the first quarter of 2008.
- **Engineering Services for Permits and Licenses.** Engineering and other activities required for permits and license requests will be conducted during the first half of 2008.
- **Power Sales and Fuel Supply Purchases.** Negotiations for sale of the electric power not required by the ethanol plant, and negotiations for sugar cane bagasse and trash purchases, are underway and will be concluded by the end of the second quarter of 2008.
- **Construction and Operation.** The plant will be designed and built during the three-year period from 2008 through the second quarter of 2010. Commissioning and startup is forecast to commence in mid-2010, and commercial operation will begin with the harvest of the 2011 cane sugar crop in May 2011.
- **Technology.** Due to the extremely tight schedule, Enernova has opted to use conventional technology for InVerde-01. Bagasse and field trash will be burned in boilers which drive steam turbine generators.

D. Combining the GEF Process with InVerde Project Due Diligence

It is clear from the description of tranche 1 activities under section B, and the due diligence activities undertaken by Termoconsult on behalf of EnBr, that there is movement in a similar direction, and a significant overlap in activities. If EnBr were to be inducted in as a partner, many of the goals envisaged under tranche 1 would already be achieved. In addition, it is worth noting the following:

- Even though InVerde 1 does not plan to use EFCC technology, it still helps alleviate many of the institutional risks outlined, and also helps to lay the groundwork for InVerde 2-4 which could use EFCC technology. Such groundwork includes partnering arrangements between plantation company for bagasse, ethanol plant for back-up fuel, and long term power purchase agreements into the grid,
- Tranche 1 activities, duly co-funded by EnBr could form an appropriate basis for moving forward with exploring viability of EFCC technology, very much in line with the GEF submission document. The structure of armslength relationship between the technology supplier and lead developer would be appropriately structured through an EPC contractor. IFC could play a pivotal role in ensuring progress in that goal,
- Due to the series of plants planned by EnBr, induction of EFCC technology in InVerde 2 or 3 could also meet the replication goals, especially if it was deemed that all GEF funds were not needed in the first EFCC demonstration, and that instead a tapering down of concessional support would get more than one EFCC demonstration in place.
- The GEF Council document has sufficient flexibility to allow for a change in milestones in keeping with revised goals of the project. Submission of a revised document to GEF CEO will include such changes.

CONCLUSIONS:

Based on the various considerations outlined, the next steps are:

- Proposing a revised list of activities for tranche 1. These activities will include those that directly relate to EFCC technology, as well as those that cater to the institutional changes needed, including long-term supply contracts for bagasse, as well as power purchase agreement development. EnBr is also taking a prudent view of fuel supply security by proposing pellitization of 40% of the fuel supply. This will likely take a few more weeks to finalize.
- It must be noted that EnBr has not yet committed that it will use EFCC technology for InVerde 2, 3, or 4, but discussions are underway with EPC contractor and Hague on what is needed for EFCC technology to succeed and be viable economically. This information has still not been provided to IFC. However, EnBr has provided a letter stating their interest in EFCC technology, and of taking up the role of lead developer exploring this technology in the context of InVerde projects. Thus, consistent with standard business practice and commercial negotiations, IFC believes that significant progress has been made towards identification of a strategic partner, and in moving the project towards a structure more amenable to financial close.

If the GEF Council concurs that significant progress has been made towards the tranche 1 goal of identifying a strategic partner, and in moving the project towards financial close, IFC proposes the following course of action:

  - Extension of the CEO endorsement milestone to June 30, 2008, in order to finalize project arrangements with EnBr (or a subsidiary such as Enernova) as the new lead developer.
  - Given the rapid development of the InVerde projects, IFC believes that within a year of that date it would be known whether to proceed to tranche II or whether EFCC technology will not be adopted by EnBr.