

CURRENCY EQUIVALENTS

Exchange Rate: \$1.00 = MRs 15.5
 \$0.0645 = MRs 1.00

WEIGHTS AND MEASURES

<u>Metric</u>	<u>British</u>
1 ha	2.47 acres
1 km	0.62 miles
1 kg	2.2 pounds
1 metric ton	2,205 pounds

ABBREVIATIONS AND ACRONYMS

BEDP	Bagasse Energy Development Program
CEB	Central Electricity Board
GEF	Global Environment Facility
GET	Global Environment Trust Fund
IBRD	International Bank for Reconstruction and Development
SDR	Special Drawing Rights
UNDP	United Nations Development Program

GOVERNMENT OF MAURITIUS FISCAL YEAR

July 1 - June 30

MAURITIUS

SUGAR BIO-ENERGY TECHNOLOGY PROJECT

GRANT AND PROJECT SUMMARY

Borrower: Government of Mauritius (GOM)

Beneficiaries: The Mauritius Sugar Authority, the Union St. Aubin Sugar Factory and the Central Electricity Board

Amount: GET SDR 2,310,000 (US\$3.3 million equivalent) -

Terms: Grant

Objectives: To finance components under the **Sugar Energy Development Project** which address technology development and institutional strengthening to support adoption of existing and future sugar bio-energy technologies.

Financing Plan:
(SEDP)

(US\$ million)

Source:	Local	Foreign	Total
GET	.7	2.6	3.3
IBRD	-	15.0	15.0
Other foreign sources	.2	22.9	23.1
Local	13.7	-	13.7
Total	14.6	40.5	55.1

Economic Rate of Return: Not applicable.

Staff Appraisal Report : Mauritius Sugar Energy Development Project Report No. 10037-MAS, dated January 29, 1992

Map: IBRD No. 19358R- Mauritius Sugar Estates

MAURITIUS

SUGAR BIO-ENERGY TECHNOLOGY PROJECT

Background

1. Since sugar was introduced in Mauritius in the seventeenth century, it has been the mainstay of the economy. While its relative contribution to the Gross Domestic Product has been declining, it remains the largest net foreign exchange-earning sector. A viable sugar industry is, therefore, essential to continued growth and social stability. The Government and the private sector sugar industry agree that growth from within the sugar sector has to come increasingly from enhanced use of the sugar by-products. Use of bagasse--the fibrous material separated during cane crushing--and other sugar cane residues offers the industry the opportunity to increase its value added and diversify revenue sources, reduce the country's dependence on imported fossil fuels, meet a rapidly expanding demand for electricity at low cost, and reduce overall air emissions from the power sector by displacing fossil fuels. A successful partnership between the Government and the sugar industry has produced a blueprint to realize this opportunity.
2. In August 1991, the Government formally adopted the Bagasse Energy Development Program (BEDP) the implementation of which will be guided by a BEDP Management Committee consisting of representation from the sugar industry, government and local research organizations. The BEDP envisages investments in power production and sugar mill improvements of US\$80 million over an eight year period. These investments would be required to effectively capture available bagasse, with coal as a supplementary off-season fuel, for production of electricity, and are coordinated within an overall least-cost energy capacity expansion plan. Second, BEDP sets out a comprehensive institutional and policy framework. This framework defines the principles and modalities for energy contracting and pricing of electricity by the public utility, the Central Electricity Board (CEB), from independent power suppliers. The policy has been established that such power is to be purchased by the public utility at the economically efficient energy price; the latter to be based on the cost CEB would have incurred in producing power from its marginal unit (a 24 Megawatt diesel plant) were it not to have access to electricity produced at independent bagasse and coal fired power plants. Third, BEDP establishes priorities for technology development to promote efficient utilization of sugar biomass for energy production, emphasizing cane tops, leaves and trash. The program will be implemented through the cooperation between the industry, government and local research organizations. The outcome of the program of trials and experiments is expected to guide industry investments in expanding biomass energy development into the next century.
3. Increased use of sugar biomass as energy in Mauritius will have significant environmental benefits. Cane residues are now being wasted--bagasse is burnt inefficiently in factories as a means of disposal, and cane tops, leaves and trash disposed of on some cane fields. The conversion of such wasteful practices into efficient use for electricity production would eliminate air emissions, including greenhouse gases, associated with the displaced fossil fuels. An environmentally beneficial strategy of substituting domestic renewable biomass fuels for imported fossil fuels is consistent with the Government's emphasis on development policies that will reduce future costs of environmental degradation. Directives for such policies were established in 1988. A National Environmental Action Plan has been adopted, the Department of Environment has been established within the Ministry of Environment and Quality of Life to support its implementation, and the Environmental Protection Act of 1991 provides the legislative mandate for implementing governmental policies. However, regulations for implementing the Environmental Protection Act, including those for Environmental Impact Assessments, have yet to be established. Standards for air emissions will initially be set on the basis of foreign norms. As data on actual emissions and air quality become available these initial

standards and regulations are expected to be modified. The Bank has assisted the Government in developing the above institutional and legislative framework. Its implementation is now being supported under the Bank-financed Environmental Monitoring and Development Project (Ln 3277-MAS) and under the UNDP-financed project Institutions for Environmental Management (UNDP MAR 189/009).

4. The Government has requested GET and IBRD assistance in launching the BEDP. In response, the proposed **Sugar Energy Development Project** aims to: (a) expand bagasse generated electricity production over a five year period from 70 to 120 gigawatt hours by constructing a bagasse and coal fired power plant at the Union St. Aubin Sugar Factory in southern Mauritius and improving the efficiency of sugar mills in generation and use of steam; (b) promote efficient use of biomass fuels from the sugar industry for energy production through technology development and training; and (c) strengthen the management and coordination of BEDP by fostering effective collaboration between the public sector and the sugar industry. All three objectives serve the goal of expanding the use of low carbon emitting sugar cane residues for production of electricity in Mauritius, with its consequent displacement of high carbon emitting fossil fuels. They are therefore directly related to the Global Environment Facility (GEF's) scientific objective of reducing global warming. GET support for achieving the objectives would be provided under a proposed **Sugar Bio-Energy Technology Project**. This Memorandum summarizes the objectives, main features, implementation arrangements, benefits and risks of the proposed project, taking into account its role in the Sugar Energy Development Project.

Project Objectives and Salient Features

5. The GET project is designed to directly and indirectly support all of the above objectives of the Sugar Energy Development Project. The specific objectives for the GET project are: first, to develop or locally adapt technologies for handling and processing sugar cane residues emphasizing cane tops, leaves and trash; and second, to strengthen the management and coordination of BEDP implementation by fostering collaboration between the public and private sector in the management of program implementation. The technology development part of the project is expected to extend the production possibility frontier for sugar biomass energy. This will provide a base for planning a second generation of investments in sugar biomass energy development in Mauritius beyond bagasse and the year 2000. The institutional support will ensure effective management of the technology development activities. Its main purpose, however, is to help integrate the private sector's plans and decisions to invest in power cogeneration with the decisions of national energy planners and the load management requirements of the public utility. By emphasizing such integration the project will help bring the private sector's investment decision to fruition. This emphasis is essential, given that the absence of coordination and consultation between the public and private sectors on issues of planning, pricing and energy contracting has proven to be the major barrier to expanded generation of electricity from crop residues throughout the world. Investments in power plants and improved mill efficiency are by themselves viable in the context of national economic costs and benefits. Also, they are financially attractive at efficient energy prices. Concessional financing of these investments is therefore not justified.

6. One of GEF's objectives is to demonstrate in suitable contexts the global significance of technologies, techniques and policies for addressing potentially important global environmental problems, in this case global warming. A central aim of GEF is to encourage project design with the greatest replication possibilities to maximize the impact on global environmental objectives. The potential savings in greenhouse gases from the Mauritian power sector alone are limited by overall demand and the size of the population. However, because of its international reputation as an efficient

sugar producer, Mauritius provides an ideal global laboratory for testing techniques for agronomically sustainable sugar cane harvesting and energy use. Replication of the Mauritius program for biomass energy development would enhance the impact on the global warming objective. To this end, the proposed project emphasizes international dissemination of project results based on the demonstration of successful program implementation.

Components and Implementation

7. The proposed five-year project at a total cost of US\$3.3 million consists of three main components: (a) development and adaptation of technologies for biomass energy production (US\$1.6 million), (b) training of technical staff of bagasse-and-coal plants (US\$0.3 million); and (c) support for BEDP management and coordination, including environmental monitoring (US\$1.4 million). The GET would fund the total cost of the project, involving expenditures for the equipment and vehicles needed for the technical studies, civil and mechanical works, laboratory expenses, consultant services, short term training courses and study visits, and expenditures for an international workshop. A summary of project costs and financing plan, amounts and methods of procurement and a disbursement schedule, presented in the broader context of the Sugar Energy Development Project, are shown in Schedules A and B. A timetable of key processing events is in Schedule C. Component contents and implementation arrangements are summarized below with further details in two Technical Annexes (Annexes 1 and 2).

(a) Development of Bio-Energy Technology

8. Two studies, involving trials and experiments, would be carried out. The **Biomass Energy Technology Study (US\$1.4 million)** (Annex 1, Part A) would determine the technical, financial and economic feasibility of utilizing cane tops, leaves and trash for power production. Building on results from other countries, it would assess the available cane residue base, determine the productivity of alternative systems for recovering residues and evaluate agronomic effects of removal of residues from the field, assess the feasibility of alternative systems for handling and burning residues in factory and effects on the sucrose and energy balances, and evaluate the impact of air emissions under alternative scenarios of burning of cane in field and biomass in factory. The study would be managed by a team of local experts drawn from four sugar factories scheduled to participate in the trials, the Ministry of Agriculture, the Mauritius Sugar Authority, the University of Mauritius, and the Mauritius Sugar Industry Research Institute. The team would be supplemented by consultants covering engineering design and technical specifications for a pilot factory and an agro-business evaluation of study results.

9. Following recent experimental work in the Dominican Republic, Hawaii, Puerto Rico and Thailand on the use of cane residue for power production, the proposed Mauritian study will be the main experimental work to get underway over the medium term. The Mauritian study team would visit the above countries to finalize the study program and establish arrangements for applied research collaboration. Also, an international workshop would be held in Mauritius in early 1994 to review the study results with international research collaborators and other interested parties. Such a workshop would broaden the interpretation of the results of the study. This would assist the Mauritian sugar industry in deciding on implementation of study recommendations. Also, the workshop would effectively disseminate the study results to the international sugar and cane power community.

10. The objective of the second study, the **Bagasse Transport Technology Study (US\$0.2 million)** (Annex 1, Part B) is to improve the cost effectiveness of bagasse transport through trials aimed at reducing capital costs, increasing the load per trip, and efficient transport scheduling. The direct responsibility for carrying out the Bagasse Transport Technology Study would be left with the

management of the Rose Belle Sugar Estate. The implementation of both studies would be supervised by the BEDP Management Committee, assisted by the BEDP Coordination Unit (para. 12). The Management Committee would approve work programs and the budget for the studies and be responsible for the dissemination of results, including the organization of the international workshop for biomass energy technology. The office of the UNDP Resident Representative in Mauritius would be asked to sponsor this workshop.

(b) **Training**

11. Cogeneration of power at sugar factories using sugar biomass fuels and more sophisticated boiler equipment requires strengthening of managerial and technical skills of power plant personnel. The project would provide for 32 person-months of training for managers, engineers, chemists, fitters, welders, electricians, and boiler and turbo-alternator operators from the Union St. Aubin Power Plant. The training program would be planned, implemented, and evaluated by the management of the power plant, in coordination with the BEDP Coordination Unit, and would be completed in time to commission the plant in 1994. Details of the training program are in Annex 1, Part C.

(c) **BEDP Management and Coordination**

12. **BEDP Coordination and Environmental Monitoring (US\$1.1 million)** (Details in Annex 2). The BEDP Management Committee will plan and monitor BEDP implementation, including environmental impact, advise on policy revisions, manage the program's technology and human resource development activities, assist CEB and private power producers on energy pricing and contracting, and disseminate program information and results. The Mauritius Sugar Authority, an agency under the Ministry of Agriculture, Fisheries and Natural Resources, has been appointed as the secretariat to the Management Committee. It was established in 1984 to coordinate industry groups and advise the Ministry on sugar industry policy and planning. Supported by the Bank-financed Sugar Industry Project (para. 18) the agency has implemented its mandate with increasing efficiency and is gaining the trust of the private sector. A BEDP Coordination Unit, including an Environmental Monitoring Cell, would be established in the Authority to assist the Management Committee in implementing its assigned responsibilities. Project support for the above institutional arrangements would involve consultant services, administrative services, logistics support (office equipment and vehicles), and training.

13. The Environmental Monitoring Cell would have two responsibilities under the project. First, it would monitor the implementation of agreed mitigation plans by the power plant at Union St. Aubin, and other bagasse-and-coal fired power plants. It would advise on any modifications of such plans that may be justified to ensure environmental objectives. Second, based on directives from the Department of Environment, the Environmental Monitoring Cell would monitor environmental discharges to the air, water and land by the sugar industry. This would facilitate the continuing review and appropriate adjustments to air emission standards as required under the National Environmental Protection Plan. Annual work programs would be established in close coordination with the Department of Environment of the Ministry of Environment and Quality of Life and the development of the national environmental monitoring program. In the longer term, the role and functions of the Environmental Monitoring Cell are expected to be absorbed in the organizational structure of the national environmental monitoring program which now is in its early stage of establishment.

14. **Support to the Central Electricity Board (US\$0.3 million)**. Under the project, CEB would embark on an expanded program for contracting with independent power producers for bulk purchase of electricity. Also, CEB is expected to enter into contractual agreements with such producers for the

supply of coal. To facilitate smooth implementation of such contracts, the project would strengthen CEB's technical skills in boiler management and coal handling and quality analysis by providing support for training (6 person-months) and the extension of CEB's proposed laboratory for fuel quality analysis to enable the laboratory to adequately meet the requirements for such analysis in respect to coal.

Sustainability

15. The Government and the industry have taken a major step to initiate a comprehensive program for biomass energy development. The success of this initiative and the sustainability of the program depend on Government maintaining policies on efficient energy pricing and contracting and on continued effective collaboration between the public and private sectors in program implementation. Also, to support continued investments in cogeneration infrastructure using sugar biomass, the development of bio-energy technology has to go forward. These requirements for sustainability are precisely the focus of proposed project activities for technology and institutional development. Also, project conditionality (para. 21) is designed to ensure that the private sector's continued need for incentives is safeguarded

16. A major component of the proposed project involves technology development through experiments and trials. These are discrete and time-bound activities expected to be completed by early 1994. The project, however, is expected to establish a workable model for further cooperation between Government, industry, and non-governmental organizations in other areas of bio-technology development, such as storage and handling of bagasse for use in power production in the off-season.

Lessons From Previous IBRD Involvement

17. The main experience from completed Bank-financed projects in the agricultural sector is that the project design needs to carefully integrate investments with policy and institutional reforms. Under the two completed operations (the Tea Project Cr. 239-MAS, and the Rural Development Project, Cr. 419-MAS), problems in public sector operations helped shift focus to the potential in the private sector through creation of an appropriate business environment. These lessons helped the Bank orchestrate a series of interventions with a major effect on the restructuring of the sugar industry. Under two Structural Adjustment Loans, major policy reforms were introduced to improve incentives and efficiency. Consensus building was pursued through intensive dialogue with the Government and the private sector during the preparation of a comprehensive sugar sector report. The Bank helped through its Technical Assistance Project in the preparation of the Sugar Action Plan.

18. Assistance for the implementation of the Plan was provided under the Bank-financed Sugar Industry Project (Ln. 2728-MAS). The project's main objectives are to increase the productivity of resources and strengthen the financial performance of the industry through policy reform, and to maintain social stability in the industry by increasing transparency and preparing the Mauritius Sugar Authority for its role in policy planning and coordination. The project, now in its sixth and final year, has successfully implemented these objectives and supported investments by private sector mills in rehabilitating factories and upgrading technology at a total cost of about US\$25 million during 1987-91. The planning of BEDP has flowed out of the Sugar Action Plan building on the improved business environment generated through policy reforms taken under the Sugar Industry Project. The proposed GET financed project would bring the implementation of the Sugar Action Plan a step further, reinforcing public-private sector collaboration through its focus and project design.

Rationale for GET Funding

19. The rationale for GET funding of sugar bio-energy technology development is directly linked to the potential impact of such development on the substitution of renewable energy sources for fossil fuels. Sugar crop biomass available worldwide for energy is about one billion tons per year (bagasse, cane tops, leaves and trash) and may be expected to increase threefold by the middle of the next century. Only a fraction of this energy is currently used. One widely proposed strategy for reduction of greenhouse gases is to replace all coal use by biomass by 2050, in which case sugar cane residues could provide 13 percent globally of the required biomass fuel. Cane tops, leaves and trash are almost equivalent to bagasse in terms of potentially available tonnage and energy value. Sustainable technologies for harvesting and use of these residues for energy is the focus of the proposed Mauritian program. The GEF would be well placed to promote the international application of the applied research program.

20. GET funding for institutional support for management and coordination of BEDP implementation is justified based on the direct and indirect capture of global benefits that such services will enable. First, the BEDP Coordination Unit would manage the project's technology studies. These research and development activities are of a non-proprietary nature, designed to maximize the substitution of low carbon emission bio-fuels for higher carbon fossil alternatives. Second, the Unit would perform a third-party broker function to facilitate conclusion of power sales agreements between private bagasse cogenerators and CEB as well as constructive collaboration between the parties. GET support would help reduce high transaction costs associated with the creation of an effective forum for such collaboration. Lastly, by serving as a focal point for the gathering and sharing of techniques for sugar biomass utilization, the BEDP Coordination Unit would monitor, evaluate and report on project performance and promote the international dissemination of the Mauritian experience. This role is central to achieving GEF's global replication aims.

Agreed Actions

21. The project constitutes an integral part of the Sugar Energy Development Project. Conditions of effectiveness of the proposed IBRD loan for the latter project are: (a) the execution by CEB and the Union St. Aubin Sugar Factory of contracts covering the purchase of electricity and sale of coal on terms and conditions satisfactory to the Bank; (b) submission of appropriate documentation, satisfactory to the Bank, demonstrating that the proposed power plant investment, based on the completed feasibility study is technically, financially, economically, and environmentally viable, and that an overall financing package has been secured; and (c) appointment of a BEDP Coordinator within the Mauritius Sugar Authority with qualifications and on Terms of Reference satisfactory to the Bank. Satisfactory completion of the above actions is essential in demonstrating the Government's commitment to BEDP implementation, hence the justification for cross effectiveness under the GET grant. Other key actions agreed during negotiations include: (a) the Government passing GET funds as grants to the Mauritius Sugar Authority (US\$3.0 million) and CEB (\$0.3 million); (b) submission to the Bank by September 30, 1992 of an Annual Work Program, covering all project components for the period up to June 30, 1993, and including a staff support plan for the BEDP Coordination Unit, satisfactory to the Bank; (c) submission by the Government of draft reports on the Biomass Energy Technology Study and the Bagasse Transport Technology Study to the Bank for review by January 31, 1994 and January 31, 1993, respectively; and (d) completion of a joint Mid-Term Review by June 30, 1994.

Environmental Aspects

22. The GET project would indirectly, through BEDP management and coordination, support the implementation by the private sector of investment decisions to construct bagasse and coal power plants. The Environmental Assessment of the Sugar Energy Development Project, focusing on the construction of a bagasse and coal power plant at the Union St. Aubin Sugar Factory, concludes that the proposed investment is environmentally superior to the alternative of CEB constructing a diesel plant near Port Louis. Total acid gases and greenhouse gases would be less than with another diesel plant. Particulate emissions would increase from burning coal, but abatement measures would keep such increments to a minimum. Air quality analysis shows that the impact from the proposed facility at Union St. Aubin would not affect public health or welfare, nor would the facility endanger vegetation near the project site or the vegetation and wildlife in the neighboring Black River Gorge Forest Reserve. The Environmental Assessment was carried out as a joint effort between the Government, the sugar industry, and local research organizations. Also, it reflects the outcome of consultations with several local environmentally oriented non-government organizations. A summary of the Environmental Assessment Report, including details of proposed mitigation measures, is attached (Annex 3). It was presented to the Executive Board of Directors on December 19, 1991.

23. The Environmental Monitoring Cell in the BEDP Coordination Unit would oversee the implementation by the management of the Union St. Aubin Power Plant of the proposed mitigation plan and establish an air quality monitoring program for emissions from the sugar industry. The latter is considered essential as an input to the National Environmental Action Plan, leading to the establishment of national emission standards. Appropriate arrangements are being put in place under the National Environmental Action Plan to establish a national program for monitoring air quality. Within this program priority will be given to coverage of the Black River Gorge Forest Reserve, the environmental importance of which in terms of its biodiversity is internationally recognized.

Benefits

24. The prospect of concessional funding from GET has served to highlight the environmental significance of the BEDP. As such it has already effectively helped to catalyze international donor support for BEDP investments. This is evident from the considerable interest that international and bilateral funding agencies have expressed to the Government and sugar industry in Mauritius for supporting the BEDP. Effective mobilization of such funding, however, is dependent on the establishment of a policy and institutional framework to support private sector investments; hence, the incentive for the Government to complete such a framework (which was done in August 1991). GET, together with World Bank support, would further help to bring about timely implementation of the policy framework (para. 21).

25. The Sugar Energy Development Project, of which the GET funded project would constitute an integral part, has multiple benefits. On the agricultural side, the diversification by the sugar sector into electricity production would strengthen the sector financially and make it less vulnerable to shocks in the sugar market. On the energy side, bagasse and coal plants, the least-cost option for power generation, would save the country foreign exchange (US\$2 million annually at full project development), and would mobilize private sector resources into infrastructure investments. The economic internal rate of return of the proposed power plant investment, estimated conservatively at 18 percent, highlights the gains from using a local renewable biomass fuel with essentially no alternative uses, instead of imported fossil fuel, to generate electricity. Environmentally, and in comparison to the alternative of CEB establishing another diesel fired power plant, the project would reduce acid gases (sulfur dioxides and nitrogen oxides) from about 4000 t/year to 1000 t/year (75

percent reduction), and greenhouse gases in the form of carbon dioxide from 75,000 t/year to 60-67,000 t/year (10-20 percent reduction) dependent on the coal burning efficiency of the new power plant. The GET-supported project through its institutional support component would help bring about all of the above benefits. These benefits are expected to expand in the longer term as a result of the emphasis under the GET project on development of technology for use of cane tops, leaves and trash for power production.

Risks

26. Achievement of the objectives of the GET project is subjected to the risks of the Sugar Energy Development Project. These risks are considered acceptable given that project design and up front conditionality are formulated to reduce risks of project implementation failure. Nevertheless there are the risks that, first, delays in implementation of the BEDP policy framework would induce the private sector to postpone investments, and second, timely financing of the power plant would not be forthcoming. The first risk is addressed by the conditions of effectiveness for the Bank loan and the GET grant as well as by the GET project's support for the management and coordination of BEDP. This support emphasizes the continuation of the Bank's role in fostering collaboration between the public sector and the sugar industry. If the risk materializes and the industry were to postpone the power plant investment, CEB would go ahead with its alternative slow-speed diesel plant, and the establishment of the Union St. Aubin power plant would slip into the 1995 slot in the energy expansion path. The second risk--lack of timely financing for the power plant--is not a serious risk given the current level of donor interest. In the event it were to occur, the proposed Bank loan would not become effective, leaving the possibility open for renegotiation of such financing.

27. The technical complexity of the project and the industry's capability to implement it are not considered risks given that the production technology is well established and the industry has a proven record of technical efficiency. Also, the Mauritian sugar industry has earned international recognition for its capacity in advancing sugar technology. Risks of incremental air emissions having adverse impact on population, vegetation and wildlife have been estimated as acceptable, but monitoring arrangements would be put in place to ensure that environmental objectives are not jeopardized.

Attachments:

Schedules
Technical Annexes

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SUGAR ENERGY DEVELOPMENT PROJECT
(GET Components in bold)

PROJECT COST SUMMARY ^{a/}

Component	Rs. M			US\$ M		
	Local	Foreign	Total	Local	Foreign	Total
A. Establishment of Power Plant						
Engineering Services	-	23.6	23.6	-	1.5	1.5
Construction of Power Plants	72.0	267.8	339.8	4.6	17.3	21.9
Bagasse Transport	0.4	7.4	7.7	0.0	0.5	0.5
Subtotal	<u>72.4</u>	<u>298.8</u>	<u>371.2</u>	<u>4.7</u>	<u>19.3</u>	<u>23.9</u>
B. Improvement in Mill Efficiency	98.3	182.6	280.9	6.3	11.8	18.1
C. Technology & Staff Dev.						
Bagasse Transport & Tech. Dev.	0.7	1.2	1.9	0.1	0.1	0.1
Biomass Energy Tech. Dev.	7.4	11.5	18.9	0.5	0.7	1.2
Training Prog. for Power Plant Oper.	-	3.6	3.6	-	0.2	0.2
Subtotal	<u>8.2</u>	<u>16.2</u>	<u>24.4</u>	<u>0.5</u>	<u>1.0</u>	<u>1.6</u>
D. BEDP Program Management						
BEDP Coordination & Env. Monitoring	2.1	12.8	14.9	0.1	0.8	1.0
Inst. Support to CEB	<u>1.1</u>	<u>3.4</u>	<u>4.6</u>	<u>0.1</u>	<u>0.2</u>	<u>0.3</u>
Subtotal	<u>3.3</u>	<u>16.2</u>	<u>19.5</u>	<u>0.2</u>	<u>1.1</u>	<u>1.3</u>
TOTAL BASELINE COSTS	182.1	513.8	695.9	11.7	33.1	44.9
Physical Contingencies	18.2	50.4	68.6	1.2	3.2	4.4
Price Contingencies	62.4	160.9	223.3	1.7	4.1	5.8
TOTAL PROJECT COSTS	<u>262.6</u>	<u>725.1</u>	<u>987.9</u>	<u>14.6</u>	<u>40.5</u>	<u>55.1</u>

a/ Figures may not add up exactly because of rounding.

FINANCING PLAN
(US\$ million)

Components	IBRD	GET	Other Foreign Sources	Local ^{a/} Sources	Total
Establishment of Power Plant	-	-	23.1	5.6	28.7
Improvement in Mill Efficiency	15.0	-	-	8.1	23.1
Technology and Staff Development	-	1.9	-	-	1.9
BEDP Coordination & Env. Monitoring	-	1.4	-	-	1.4
TOTAL	15.0	3.3	23.1	13.7	55.1

a/ Includes local financing institutions, industry, and Government.

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SUGAR ENERGY DEVELOPMENT PROJECT

Procurement Methods Covering Components
Funded by IBRD and GET
(US\$ million)

Category/Item	Procurement Method ^{1/}			Total
	ICB	LCB	Other ^{2/}	
1. Civil Works		.15 [.15]		.15 [.15]
2. Sugar Mill Machinery and Equipment			15.00 (15.00)	15.00 (15.00)
3. Vehicles & Misc. Equipment			1.31 [1.28]	1.31 [1.28]
4. Consultant Services			1.00 [1.00]	1.00 [1.00]
5. Training			.82 [.82]	.82 [.82]
6. Incremental Administrative Costs			.05 [.05]	.05 [.05]
TOTAL		.15	18.18	18.33
(IBRD Funding)			(15.00)	(15.00)
[GET Funding]		[.15]	[3.15]	[3.30]

^{1/} Figures shown in parenthesis () and brackets [] are estimated to be financed under the proposed IBRD Loan and the GET Grant, respectively.

^{2/} Millers' commercial practices for category 2, shopping and limited international bidding for category 3. (ICB = International Competitive Bidding; LCB = Local Competitive Bidding)

Disbursements

Category	Amount of Loan Allocated (US\$ million)	% of Expenditures to be financed
<u>IBRD Loan</u>		
Equipment and Machinery for Sugar Mill	15.00	100% of foreign expenditures
<u>GET Grant</u>		
Equipment and Vehicles	1.30	100% of foreign expenditures and 65% of local expenditures for imported items procured locally
Civil Works	0.15	100%
Technical Assistance and Training	1.80	100%
Incremental Administrative Costs	<u>0.05</u>	100%
TOTAL	<u>13.30</u>	

Estimated Disbursements (US\$ million)

IBRD Fiscal Year	<u>93</u>	<u>94</u>	<u>95</u>	<u>96</u>	<u>97</u>
IBRD Annual	2.1	2.1	3.0	3.8	4.0
Cumulative	2.1	4.2	7.2	11.0	15.0
GET Annual	0.9	1.3	0.7	0.3	0.1
Cumulative	0.9	2.2	2.9	3.2	3.3
TOTAL Cumulative	3.0	6.4	10.1	14.2	18.3

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SUGAR ENERGY DEVELOPMENT PROJECT

Key Processing Events

- (a) Time taken to prepare project : 12 months
- (b) Project Staff : Lars Vidaeus, Gisu Mohadjer
C.N. Raghavan
- (c) First IBRD mission : November 1990
- (d) Appraisal mission departure : August, 1991
- (e) Date of Negotiations : January 15-16, 1992
- (f) Planned date of Effectiveness : June, 1992
- (g) List of relevant PCRs and Project Performance Audit Reports : Tea Development Authority Project (Cr. 239-MAS) Project Completion Report dated December 16, 1981. Rural Development Project (Cr. 419-MAS) PPAR No. 3988, dated June 22, 1982.

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SUGAR BIO-ENERGY TECHNOLOGY PROJECT

Technology and Staff Development

Part A. The Biomass Energy Technology Study

Background

1. Sugarcane biomass consists of four distinct fractions: the underground rhizome and roots facilitate the development of the ratoons; the stalk free of the top and leaves is the millable cane processed for sugar and bagasse; the green immature cane top and leaves removed from the cane during harvest is left in the field; and the dead and dry leaves, known as trash, are also left in the field. Except for a small portion used as cattle feed, the cane tops, leaves and trash (hereinafter referred to as cane residue) remain a generally unexploited resource.
2. It has been established that cane residue is almost equivalent to bagasse in terms of available tonnage and energy value at about 4500 kcal/kg (8100 BTU/lb). The potential use of cane residue for energy outweighs that of bagasse; unlike bagasse which is used in the sugar production process, the entire quantity of cane residue is available for use in energy production.
3. A number of issues have to be resolved prior to the commercial exploitation of cane residue, such as its harvesting and transport, environmental aspects, storage, boiler design, and fuel mix. In recent years important research has focused on these issues under the Biomass Energy Systems and Technology Project, sponsored by the United States Agency for International Development (USAID) and covering the sugar industry in Hawaii, Puerto Rico, Jamaica, Dominican Republic, and Thailand. South Africa has been engaged in similar research, and Mauritius has made some preliminary trial experiments on a small scale.
4. The Government of Mauritius and the sugar industry have jointly agreed under the Bagasse Energy Development Program (BEDP) that the coverage of research on sugar cane biomass utilization be expanded. ^{1/} In so doing the research program should draw on lessons learnt from experiments undertaken in other countries, and help to adapt available technologies to the Mauritian context.

Summary of Technological Research

5. Research has concentrated on the harvesting and storage of cane residue, an important issue due to the large biomass involved. Historically, the cane industry has relied on conventional agricultural harvesting machinery. Experiments in the Dominican Republic and Puerto Rico have

^{1/} High Powered Committee Report on Bagasse Energy Development, dated August 1991 (Annex XIV).

established that conventional foraging systems (hay rakes pulled by 70 HP tractors, forage harvester HP tractor and a chopper and blower) are technically and economically viable, but modifications are needed to suit local conditions. Regarding storage, required to assure year round firm supply of cane residues, recent experiments in Thailand proved both round and rectangular baling to be economical compared to the cost of oil. The experience in the Philippines proved that while the baling per se was successful, the experiment failed because there was no equipment to chop and shred the cane trash to feed the boilers properly. A main conclusion emerging out of these adaptive trials is that the optimal choice for a country will depend more on costs of labor and capital, size and configuration of the holdings and ability to service equipment than on technical feasibility.

6. The agronomic impact of removing trash from the cane field needs further research. Trash facilitates fertilization and irrigation, suppresses weed growth and soil erosion, conserves soil moisture in dry areas, and through decomposition adds to the general fertility of the soil. Experiments in Puerto Rico suggest that 30-50 percent of the cane residues need to be left in the field to maintain the organic content of the soil. The critical levels of residue retention for fertilization purposes needs to be established on an individual country basis on the basis of estimates of organic loss impact and costs of remediation.

7. The design of the process of converting cane residues to energy has to address several issues. Two key issues are: (a) the separation of field contaminants (stones, dirt, metal pieces) in the field as well as in the plant and (b) the design of the boiler to accommodate bagasse as well as cane residues. The USAID sponsored project (para. 3) found that while cane field residues can generally be burned in bagasse boilers without significant boiler modifications, mixing fuels posed problems. While a bagasse to residue mix of 6:1 created no problem in burning, a ratio of 1.2:1 created instability in the boiler.

Recent Experiments in Mauritius

8. Small scale laboratory and plant trials have been conducted in Mauritius by the University of Mauritius and the Sugar Technology Department of the Mauritius Sugar Authority in collaboration with private sector sugar mills. The first factory scale trial was held in the Highlands Sugar Estate, where about 15 tons of cane residues were shredded and fed into the mill tandems. The juice fraction and the fibrous portion were analyzed for characteristics, and the latter, mixed with bagasse, was burnt successfully in the boiler. The juice portion was analyzed for brix and pol, and the fibrous material for moisture content and calorific value. Similar experiments were repeated in two other estates, Medine and Beau Plan, with increasing quantities of cane residues (50 and 150 tons). The analysis of the fractions gave varying results, particularly as regards the moisture content, reflecting varietal and geographic differences.

The Proposed Biomass Energy Technology Study

9. Against the background of research in Mauritius and elsewhere, it is proposed to expand the scope of research for fuller experimentation on the most effective way of utilizing this biomass resource in Mauritius. In particular, it is proposed to combine the experimental approach of the USAID project with that of the South African research program, by harvesting the whole cane, that is without the separation of top and leaves, and feeding it to the milling tandem. If successful, this would solve the problem of harvest and transport. However, careful experimentation is required to study the effect on sugar production, boiler efficiency (and design), and field agronomy.

10. **Study Objective and Main Features.** The overall objective of the study is to determine the technical, financial and economic feasibility of utilizing cane residues other than bagasse for power production. The main components of the study to be conducted over an 18 month period, will therefore be to:

- (a) assess the available cane residue resource base for a variety of field conditions;
- (b) determine the productivity of alternative systems for recovering residues from the cane field, and evaluate the comparative economics of baling and transport of residue versus whole cane;
- (c) assess the feasibility of alternative residue handling systems required at the factory for preparation of the residue and use in boiler;
- (d) evaluate the agronomic effect of removal of the residue from the fields; and
- (e) evaluate the effects of alternative systems for utilizing residue in the mill on the sucrose and energy balances.

11. The study will focus on the evaluation of two alternate methods of handling the biomass. **Method A** will involve harvesting and transport of the whole cane to the factory, that is without the cane residues being separated and left in the field. At the factory, the experimental processing of the residue will be done in two streams: (a) separation of residue from the cane stalk, and after minimal shredding and homogenization feeding it to the boiler, with the cane stalks processed in the traditional manner through the milling tandem for sucrose recovery; (b) processing of whole cane in the milling tandem, and the combined cane residue and bagasse mass will be fed to the boiler. Under **Method B**, the cane will be harvested in the traditional manner that is with the cane tops leaves and trash separated from the cane stalk and left in the field. These field residues will be baled, loaded, and transported to the factory 3-5 days after the cane harvest, and fed to the boiler following the same procedures that would be applied to cane residue under Method A.

12. -Approximately one third of all cane fields in Mauritius are burnt before harvest, either to facilitate manual harvesting or to facilitate land preparation prior to replanting following the last cane ratoon. The evaluation of the two handling methods will therefore consider the impact of burning vs. non-burning of cane fields prior to harvest.

13. **Study Tasks.** The study will involve the following tasks as grouped in field experiments, factory trials, and overall feasibility evaluation and final report preparation:

14. The tasks related to **in-field experiments** include the following:

- (a) assessment of the mechanical and/or manual cane cutter output;
- (b) raking and winnowing of the trash - with local adaptations necessary to minimize the presence of contaminants;
- (c) cane loader output: experimental trials with whole stalk and chopped cane;

- (d) payload of the cane transport systems;
- (e) evaluation of agronomic impact of alternative cane residue recovery systems: soil nutrient status, weed control, soil conservation, moisture retention, soil properties etc; determination of the minimum level of residues to be left in the field, and the consequential maximum amount of cane residue available on an average per hectare for exploitation; and
- (f) assessment of alternative systems for baling of cane residue: rectangular vs. round bales.

15. The tasks related to in-factory trials include the following:

- (a) evaluation of the cane unloading, preparation and milling handling systems;
- (b) assessment of the quality (moisture, pol), calorific value, and combustion characteristics of the bagasse-cane residue bio-fuel mix in different proportions;
- (c) the effect on boiler performance and stability of different fuel mixes;
- (d) assessment of the quality and quantity of juice and its processing characteristics in relation to sucrose recovery; and
- (e) evaluation of alternative handling methods on the ultimate sucrose and energy balances.

16. The overall feasibility assessment, building on the findings under above tasks, will involve:

- (a) a comparative cost-benefit analysis of alternative residue handling and processing systems, and recommendations for implementation of preferred system;
- (b) analysis of the financial rate of returns to proposed investments based on projections of operating and investment costs for the preferred system;
- (c) evaluation of the economic costs and benefits of proposals for cane residue utilization for power production relative to those for thermal power production using fossil fuels; and
- (d) evaluation of the environmental impact of the proposed cane residue utilization and handling methods.

17. **Costs and Financing.** The cost of the study is estimated to be US\$ 1.4 M, including physical and price contingencies, of which US\$0.6 M will be foreign exchange costs and US\$0.9 M in local costs. These costs cover: (a) equipment and vehicles (US\$0.9 M); (b) study visit and expenditures for an international workshop (US\$0.3 M); (c) consultant services (US\$0.1 M); and (d) minor civil works, administrative services and study team allowances (US\$0.1 M). It is expected that funding for the study would come as a grant from the Global Environment Facility (GEF).

18. **Study Organization and Implementation.** The experiments will be undertaken at four different factories with cane from different agronomic and agro-climatic conditions: Belle Vue (North; drought prone), Union St. Aubin (South; wet and cyclone prone), FUEL (East) and Mon Desert Alma (Central). The experiments will spread over three stages. First, a one day trial run will be made in each factory every month during July-September 1992. Second, a continuous 15 day trial run will be made in the Union St. Aubin sugar factory. At these first two stages, the experiments will be restricted to the comparative evaluation of processing whole cane in the mill as against cane without the top and trash. Third, a pilot handling system will be installed at the UStA sugar factory to separate the residue from the millable cane, and to shred and convey the latter to the boiler on an experimental scale for a four-month trial during August-November 1993. Raking, baling, loading and transport of the field residues, in the case of traditionally harvested cane, will be studied.
19. The study will be conducted under the supervision of the Mauritius Sugar Authority (MSA), in association with the University of Mauritius, Mauritius Sugar Industry Research Institute (MSIRI), and the four private sector factories concerned. The Head of the Sugar Technology Department of the MSA will be the leader of a multi-disciplinary team that will be drawn from the University, MSIRI, the Ministry of Agriculture, Fisheries and Natural Resources, Ministry of Energy, Ministry of Labour, and the sugar industry. The study team will consist of a total of twelve persons: Head MSA's Sugar Technology Department (Team Leader), research assistants (2 each from MSIRI and the University), sugar process managers (one from each of the four factories), agronomist, economist, and financial analyst (from MSA or recruited as consultants).
20. The Study Team would report through the BEDP Coordinator to the BEDP Management Committee. The Management Committee would provide overall guidance, evaluate results and synthesize recommendations for follow up action. The Committee would depend on a small Task Force of senior Mauritian sugar industry experts for technical review of the progress and findings of the Study Team. A series of six meetings of the Management Committee/Task Force would be required to cover the inception report and the preliminary trials at the factories. A further eight meetings will be required to monitor the pilot handling system from design to evaluation during 1993.
21. To facilitate the planning of the study and prior to the start of field work, the Study Team Leader, accompanied by a representative from the Task Force, will be sent on a four week study visit to Hawaii, Jamaica, Dominican Republic, Puerto Rico, and Thailand to visit sugar estates where research work in this field has been undertaken, and to become familiar with programming and evaluation techniques and the latest advances in technology and equipment. A key objective of this study tour is for the Study Team Leader to review the proposed research program with colleagues in the countries mentioned, and based on such review make appropriate adjustments to the study plan. The visit will provide an opportunity to strengthen research collaboration between the Mauritian Team and its international counterparts and to establish channels for appropriate dissemination of the results coming out of the Mauritian program.
22. To further strengthen this aspect an **International Workshop on the Utilization of Cane Residues for Power Production** would be held in Mauritius at the beginning of 1994. The Study Team would present its findings and recommendations, in the form of a draft final report, for review and discussion by participants from international research teams engaged in similar research activities, the local and international sugar industry, and Government. The United Nations Development Program, through its Resident Representative in Mauritius, would be asked to sponsor the Workshop.

The detailed planning and organization of the Workshop would be carried out by the Management Committee and the BEDP Coordination Unit.

23. **Reporting:** The following reports would be prepared and submitted for review:

- (a) Inception Report (May 1, 1992)
- (b) Report on the trials in Stages I and II (November 30, 1992)
- (c) Proposals for the Pilot Systems Study (February 28, 1993)
- (d) Progress report (September 1, 1993)
- (e) Draft final report (December 31, 1993)
- (f) Final report (March 1994)

24. **Implementation Schedule:** The time schedule for the various activities under this component will be as follows:

- (a) Study tour/Training May-June 1992 (4 wks)
- (b) Stage I. Preliminary Trials
in four factories one day each
in each month: (12 in all) July-September 1992 (12 wks)
- (c) Stage II. A 15-day trial in
one factory October 1992 (2 wks)
- (d) Evaluation Report Stages I and II November 30, 1992
- (e) Design for the pilot residue
handling system; bid proposals February 28, 1993
- (f) Procurement, erection and
commissioning of the handling system July 31, 1993
- (g) Stage III. Pilot system operation August-November 1993
- (h) Evaluation and draft report preparation January 1994
- (i) International Workshop February 1994
- (j) Final Study Report March 1994

B. The Bagasse Transport Technology Study

Background

25. Bagasse in excess of a sugar factory's internal steam requirements can be saved for alternate uses, mainly for energy and paper and particle board production. In Mauritius, the only alternate use of bagasse is for energy production. In the absence of a centralized large power unit attached to a factory which can draw on the surplus bagasse of satellite factories, bagasse is generally incinerated as waste, since loose bagasse poses problems of disposal and is subject to spontaneous combustion.

26. The saving, handling and transportation of bagasse for power production to the grid is currently limited to a small quantity of about 20,000 to 25,000 tons a year. This quantity is supplied by three factories to the Flacq United Estates Limited (F.U.E.L.) sugar estate, which has installations for generating 20 MW of power year round from a bagasse-cum-coal fired power plant. A single factory (Constance), located six kilometers from F.U.E.L. supplies alone about 85 percent of the total amount of bagasse traded with F.U.E.L.

27. F.U.E.L.'s entire bagasse requirement (own and imported supplies) is utilized during the crop season with coal as the supplementary off-season fuel. The handling and storage systems are minimal, and bagasse is stored either in loose form or in bales prepared with simple baling presses. The transport of bagasse from supplying mills is done by tractor-trailer units, with improvised closed box-type bins loaded on to the trailer. The average load per trip is 12 tons. For about 150 days during the crop season, bagasse is transported at the rate of 100 to 150 tons per day by each of two tractor-trailer units operated by a private contractor.

28. In contrast to present bagasse transport practices, the proposed BEDP project encompasses transport of about 75,000 tons of bagasse from mills in the southern part of the island to the proposed bagasse and coal fired power plant at Union St. Aubin. Similar development are expected in the northern region once the proposed power plant at the Belle Vue sugar factory comes on stream. Given the role projected for bagasse in the national energy plan, a quantity of about 200,000 tons of bagasse would potentially require transport to three 20 MW power stations attached to sugar mills. This quantity would be utilized by the three factories during the crushing season, or within a short period thereafter. It is therefore not considered economical to transport bagasse over long distances, involving baling and storage for off-season use.

The Bagasse Transport Technology Study

29. **Objective and Main Features.** Transportation costs are high in Mauritius because of the limitations of the rural road net work (narrow roads, requiring small to medium size vehicles). Given the dependence of bagasse energy development on the importation by power plants of bagasse from neighboring mills it is essential to examine ways of handling, transport and storage of bagasse to reduce the cost of imported bagasse delivered to the boiler. The objective of the study is therefore to improve cost effectiveness of bagasse transport through a set of experiments and trials aiming at: (a) reducing capital costs in transport; (b) increasing the load per trip; and (c) utilizing slack time in traffic.

30. With this objective in mind, the study would undertake the following tasks:
- (a) Design of a dual purpose cane-cum-bagasse carrier. Currently cane is transported by the sugar estates in 40 to 60 hp tractors hauling an average of 7-10 tons of cane in a trailer. The bins used for loading bagasse are unsuitable for transport of unchopped cane from the fields. A 17-18 ton container capable of handling both bagasse and cane would be constructed, with the top closed to prevent bagasse from flying off into the open. An 80 hp tractor will be required for haulage. As the cost of such a tractor-container unit can be assigned two-thirds to cane haulage and one third to bagasse, there will be considerable savings through avoiding a separate bagasse-alone system.
 - (b) Densification of bagasse, to increase the trip load. Bagasse has normally a bulk density of 250 kg per cubic meter. It is proposed to use a hydraulic compactor to compress the loose bagasse in the trailer to at least 350 kg per cubic meter. The compacting of bagasse lowers the fuel costs by about 30 percent by reducing the number of round-trips for transport of bagasse.
 - (c) Transport of cane by day and bagasse by night.

31. **Organization and Implementation.** The trials and experiments would be undertaken by the Rose Belle Sugar Estate, under the supervision of the BEDP Coordination Unit and the BEDP Management Committee. The procurement, installation and testing of the equipment is expected to be completed by mid 1992. The trial runs of transport of bagasse will be held for about 75 to 90 days during the crushing season July-November 92. The management of Rose Belle Sugar Estate will be responsible for preparing a report to the BEDP Coordination Unit by February 1993, covering trials conducted and a comparative evaluation of results in terms of costs per ton of bagasse transported.

32. **Costs and Financing.** The capital cost of the study is estimated at US\$ 145,000 including contingencies, covering the acquisition of a compactor, a tractor trailer set and minor mechanical and civil works to modify the hauling unit. These costs would be met out of the expected GEF grant in support of BEDP Technology Development. The operating costs for the trials would be met by Rose Belle Sugar Estate.

C. Training Program in Support of Power Plant Operations

Background

33. With the F.U.E.L. sugar estate having operated a bagasse and coal fired power plant since 1985, Mauritius has experience of firm power co-generation from bagasse. The technical skill requirements under the proposed new power plant at Union St. Aubin, however, will be of a higher degree of sophistication given that this plant will involve high pressure boilers of 70 bars, as against 46 in F.U.E.L. and 25-30 in other sugar estates.

34. Local institutions are not geared to the training and turn-out of personnel with skills required for the operation and maintenance of such steam generation equipment. The F.U.E.L. estate has had considerable difficulties in proper operation and maintenance, leading in the last two years to major breakdowns in both the boiler and the turbo-alternator. Hence, it is critical for the success of the

investment under the BEDP to install a training scheme for personnel at various levels in the Union St. Aubin sugar estate.

Proposed Training Scheme

35. The management of the Union St. Aubin sugar factory will implement a training program involving staff in power plant operations, from the management level down to the technicians. The scheme will involve 28 person-months of training at a total cost of US\$ 270,000 including contingencies. It is envisaged that the costs of training be met out of the proposed GET Grant for Technology and Manpower Development in support of BEDP implementation.

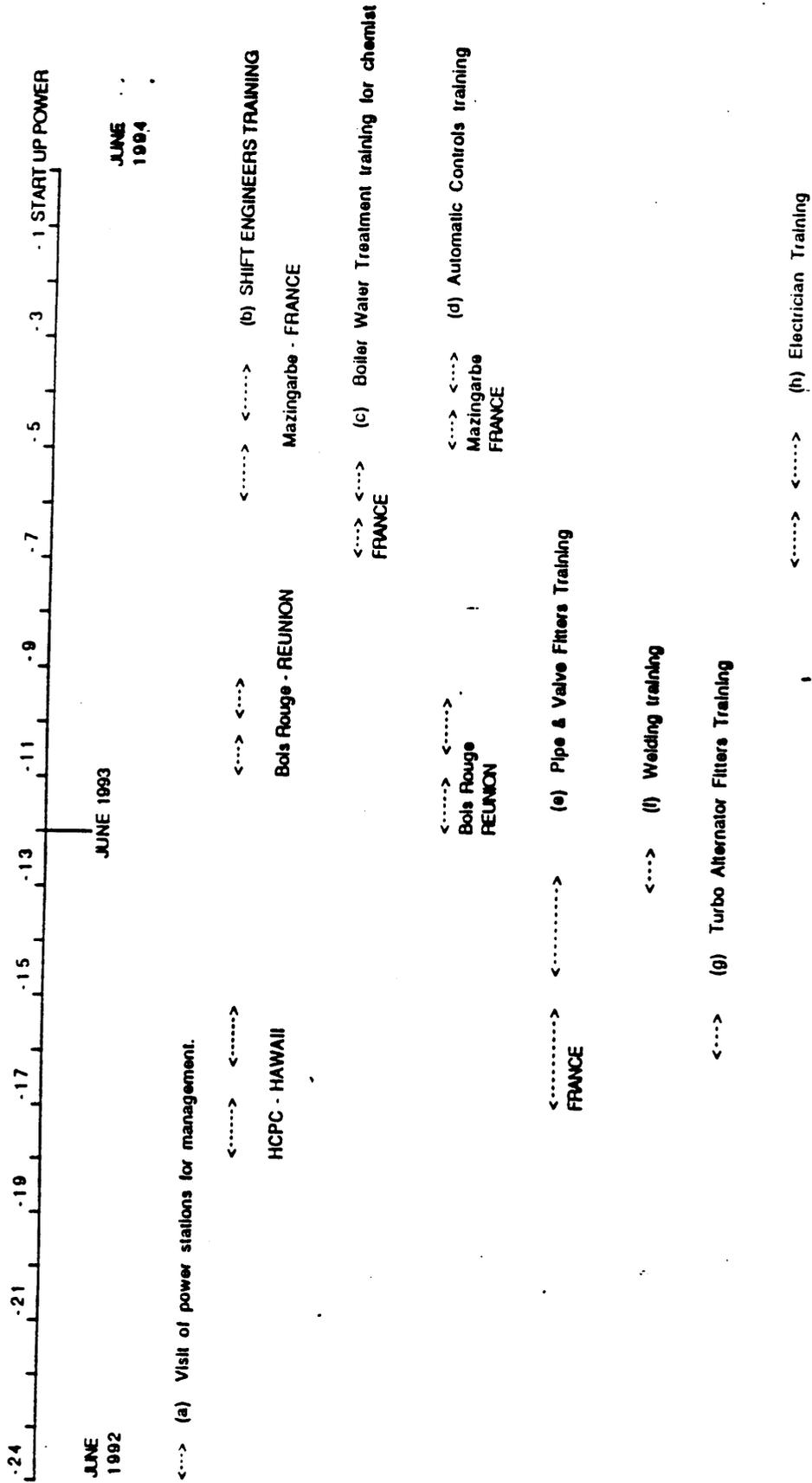
36. The training program will involve visits to and hands-on training at select stations abroad (Hawaii, Reunion and France) which are well experienced in power generation in sugar factories of the standards envisaged under the proposed project. It would be coordinated with the implementation of the investment in the power plant so that trained personnel are in position from the start of the plant, targeted for November 1994 (a chart showing the phasing of the proposed training is attached). More specifically, the program would involve the following components:

- (a) **Management training** will cover the visit of four persons for a period of one month each, to study the operations and management techniques in the Bois Rouge sugar mill, Reunion; HCPC sugar mill, Hawaii; and a coal power station at Mazingarbe, France.
- (b) **Shift Engineers (three persons) and one Production Manager** will have on-site technical training, 15 days for each in each of the above three stations (6 person months).
- (c) A **chemist** will have one month's training - two weeks in Mazingarbe, France and the rest in a suitable water treatment laboratory to be decided.
- (d) **Four boiler operators** will attend a month's training course in Mazingarbe, France. The course will focus on the operation of the automatic controls of high pressure boilers.
- (e) The scheme for the **technicians** in various disciplines will be as follows.
 - (i) Pipes and valve fitters course: four persons, four months.
 - (ii) Welding course for gas and electric welders will cover two trainees, for one month.
 - (iii) Three fitters will be trained at the turbine supplier's factory for a period of one month each.
 - (iv) Four electricians will be trained in France for a period of one month each.

37. The training scheme will be organized and monitored by the management of the Union St. Aubin's sugar company, but will be administered under the proposed project by the BEDP Coordination Committee. The first Annual Work Program for the project will include detailed arrangements for training, including: (a) the qualifications and experience of the candidates to be selected; and (b) detailed Terms of Reference for the courses to be covered.

Figure 1

**POWER PLANT MANPOWER TRAINING SCHEDULE (TENTATIVE)
MONTHS BEFORE STARTUP**



MAURITIUS

SUGAR BIO-ENERGY TECHNOLOGY PROJECT

Organizational and Management Arrangements for BEDP Coordination

Government Policy Directives

1. The implementation of the Bagasse Energy Development Program (BEDP) will be guided and supported by Government policy directives. Such policy directives cover energy pricing, regulations governing sale of electricity to the Central Electricity Board (CEB), fiscal policy measures impacting the viability of BEDP investments, and environmental controls. Based on an evaluation of progress in BEDP implementation relative to objectives and targets, the Government will through the Economic Subcommittee of the Cabinet periodically review the policy framework and as appropriate undertake revisions to this framework.

The BEDP Management Committee

2. A Management Committee will oversee and coordinate the implementation of the Government's action plan for bagasse energy development and ensure that the Government's policy directives related to BEDP are followed. The Committee will constitute the operational mechanism within Government through which to bring about effective integration of Government's policies affecting the sugar and energy sectors.

3. To this end, the Management Committee has been established with representatives from relevant ministries, parastatal agencies and the private sector. Specifically, the membership of the Committee comprises representatives from the Ministry of Finance (Chairman), Ministries of Agriculture, Fisheries and Natural Resources, Economic Planning and Development, Energy, Environment and Quality of Life, the Mauritius Sugar Authority (MSA), CEB, and the Development Bank of Mauritius. The industry is represented by the Mauritius Sugar Producers Association, the Mauritius Chamber of Agriculture, the Joint Economic Committee, and the Mauritius Cooperative Agricultural Federation. The Executive Director of the MSA serves as the Committee's Secretary.

4. The Management Committee will carry out the following tasks:
- (a) plan and monitor the implementation of BEDP and its individual project components, evaluate progress in the implementation of the investment program, assess the impact of government policy measures, and advise the Government on policy formulation related to BEDP, particularly on fiscal measures impacting the viability of BEDP investments;
 - (b) manage the Technology and Manpower Development Component of BEDP, involving the following tasks:
 - (i) administration of funds to be used for technology development and training;

- (ii) approval of annual work programs and disbursement of funds for individual subprojects for technology and manpower development;
 - (iii) coordination and organization of programs for training of industry manpower in skills required to support the implementation of BEDP, and fund such programs according to established criteria;
 - (iv) review of progress in the implementation of individual subprojects; and
 - (v) review and disseminate results of subprojects (see (e) below);
- (c) as required arrange for technical expertise in sugar and energy technology to support the technical appraisal of individual investment projects involving power plants and mill modernization for bagasse saving;
 - (d) assist the CEB and individual power producers to come to contractual agreements on power purchase which reflect the Government's policy directives regarding such contracts;
 - (e) serve as the focal point for dissemination of information and exchange of experiences related to the implementation of BEDP; organize annual workshops to review progress in BEDP implementation, involving the industry, the public sector, local and international financing institutions, and local and international agencies concerned with research in the areas of sugar and energy production or environmental management; and
 - (f) participate as required in negotiations with international lending institutions, establish specific criteria for the utilization of funds made available from lenders for BEDP, and certify the eligibility of individual BEDP projects for funding under financial intermediation arrangements, as such arrangements may be agreed upon with international lending agencies.

The BEDP Secretariat and Coordination Unit

5. The MSA has been appointed to serve as the Secretariat for the BEDP Management Committee. As such it will assist the Committee in undertaking the responsibilities outlined above. To enable MSA to undertake this task its organizational structure and staff resources need to be strengthened.
6. To this end, a BEDP Coordination Unit (CU) will be established in MSA, to be headed by a suitably qualified BEDP Coordinator reporting directly to the Executive Director of MSA (Terms of Reference in Attachment 1) and with its own administrative support services. Technical staff from MSA's various departments would be seconded to CU on a part time basis. Such secondment will necessitate the strengthening of the staff of the MSA in its technical and financial departments to ensure that progress in the regular work program of MSA is not impaired.
7. Similarly, suitable arrangements for secondment to CU of technical staff from other Government agencies, including the Ministries of Energy, Environment and Quality of Life, and

Agriculture, Fisheries and Natural Resources, and the CEB need to be secured. Furthermore, the BEDP Coordinator is expected to work out appropriate liaison modalities with the Bank of Mauritius, local financing institutions, the Mauritius Sugar Industry Research Institute, and the sugar industry.

Environmental Monitoring Cell

8. An Environmental Monitoring Cell (EMC) will be established within the BEDP Coordination Unit. It will consist of a principal environmentally trained professional (Head, EMC) and two technical assistants. This cell will be staffed with consultants or fixed term employees and will not form part of the regular establishment of MSA. Its tasks are to:

- (a) monitor the implementation by bagasse-and-coal fired power plants of agreed mitigation plans, and as appropriate advise on any modifications that may be appropriate to such plans to ensure that the environmental objectives underpinning such plans are not jeopardized; and to
- (b) establish and implement a program for monitoring of environmental discharges to the air, water and land by the sugar industry.

9. The justification for establishing EMC in MSA at this stage is two-fold. First, the national environmental monitoring program is presently being planned, and the detailed organizational arrangements and delegation of responsibilities for monitoring will evolve over time. In the meantime, environmental monitoring of BEDP implementation needs to proceed. Second, the national monitoring program needs to be based on emission standards. These standards in turn need to be determined partly with reference to information on present emission levels. MSA is best positioned to timely gather such information in respect of the sugar industry. In the longer term, the role and functions of the EMC is expected to be formally integrated with the organizational structure of the national environmental monitoring program.

10. The establishment of EMC and the programming of its work would be done in strict coordination and agreement with the Department of Environment of the Ministry of Environment and Quality of Life. In particular, such coordination will consider the need to integrate the work program of EMC with the proposed program of the Department of Environment (DOE) to develop a national monitoring program. Annual work programs of the EMC would be established and agreed with the DOE. Progress reports on the implementation of the work programs will be reviewed with DOE prior to submission to the Management Committee. All efforts will be made to avoid overlapping responsibilities and duplication of resources. The possibilities for EMC staff to use monitoring equipment presently being acquired for establishing a national monitoring program will be explored. The Terms of Reference of the Head, EMC, are in Attachment 2.

Attachments

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3/6/92

MAURITIUS

SUGAR BIO-ENERGY TECHNOLOGY PROJECT

Terms of Reference for BEDP Coordinator

Introduction

1. The Mauritius Sugar Authority (MSA) serves as the Secretariat for the Management Committee (MC) of the Bagasse Energy Development Program (BEDP). The BEDP Coordinator (hereinafter referred to as the Coordinator) will head a BEDP Coordination Unit in the MSA under the overall guidance of the Executive Director. The unit will effectively serve to assist the MC in its responsibilities which are to

- (a) plan and monitor BEDP implementation and its individual project components, evaluate progress in the investment program, assess impact of government policy measures, and advise the Government on policy formulation related to BEDP, particularly on fiscal measures impacting the viability of BEDP investments;
- (b) manage the Technology and Manpower Development Component of BEDP, involving the following tasks:
 - (i) administration of funds to be used for technology development and training;
 - (ii) approval of annual work programs and disbursement of funds for individual subprojects for technology and manpower development;
 - (iii) coordination and organization of programs for training of industry manpower in skills required to support the implementation of BEDP, and fund such programs according to established criteria;
 - (iv) review of progress in the implementation of individual subprojects; and
 - (v) review and disseminate results of subprojects (see (e) below);
- (c) as required arrange for technical expertise in sugar and energy technology to support the technical appraisal of individual investment projects involving power plants and mill modernization for bagasse saving;

- (d) assist the Central Electricity Board and individual power producers to come to contractual agreements on power purchase which reflect the Government's policy directives regarding such contracts;
- (e) serve as the focal point for dissemination of information and exchange of experiences related to the implementation of BEDP; organize annual workshops to review progress in BEDP implementation, involving the industry, the public sector, local and international financing institutions, and local and international agencies concerned with research in the areas of sugar and energy production or environmental management; and
- (f) participate as required in negotiations with international lending institutions, establish specific criteria for the utilization of funds availed from lenders for BEDP, and certify the eligibility of individual BEDP projects for funding under financial intermediation arrangements, as such arrangements may be agreed upon with international lending agencies.

Coordinator's Responsibilities

2. The Coordinator will be responsible directly to the Executive Director of MSA. The latter serves as Secretary on the MC, and the Coordinator's role is to assist the Executive Director in that capacity.

3. Hence, his main day to day responsibilities will be to:

- (a) establish a work program for CU based on MC's tasks as shown above;
- (b) mobilize human and other resources required to carry out the tasks within the established work program; such resources being accessible within CU, on secondment from MSA's other departments to CU, or on secondment to CU from other Government agencies;
- (c) program, coordinate, and oversee the work of CU staff and seconded staff; and
- (d) report to the Executive Director on the output and progress of CU's work program, as agreed with the Director.
- (e) liaise with the Sugar Technology Advisory Committee of the MSA as required.

Qualifications

4. The Coordinator position is a full-time position. It will be filled by a person who has the ability to effectively organize CU's work program and timely deliver its outputs to the Executive Director. The person should have the following qualifications:

- (a) formal training in either financial management, public administration, (or possibly sugar technology);

- (b) **demonstrated management experience at senior level within the public sector or industry;**
- (c) **ability to work in a multi-disciplinary environment and effectively interact with officials across agency lines; and**
- (d) **excellent oral and written communication skills.**

MAURITIUS

SUGAR BIO-ENERGY TECHNOLOGY PROJECT

Terms of Reference for Head, Environmental Monitoring Cell

Introduction

1. The Mauritius Sugar Authority (MSA) serves as the Secretariat for the Management Committee of the Bagasse Energy Development Program (BEDP). To enable MSA to execute this responsibility, a BEDP Coordination Unit will be established in MSA.
2. One of the responsibilities of the Management Committee is to ensure that Government policy directives regarding bagasse energy development are implemented. Such directives relate inter alia to environmental monitoring of BEDP implementation. Hence, an Environmental Monitoring Unit (EMC) will be established within the BEDP Coordination Unit.
3. The objectives for the EMC are to:
 - (a) monitor the implementation by bagasse-and-coal fired power plants of agreed mitigation plans, and as appropriate advise on any modifications that may be appropriate to such plans to ensure that the environmental objectives underpinning such plans are not jeopardized; and
 - (b) based on directives from the Department of Environment (DOE) and under the guidance of DOE establish and implement a program for monitoring of environmental discharges to the air, water and land by the sugar industry, and by doing so facilitate the continuing review of appropriate air emission standards required under the National Environmental Action Plan.
4. The EMC will be headed by a professionally trained environmental specialist, as a long term consultant, and two technical assistants.

Responsibilities of Head, EMC

5. The Head, EMC, will report through the BEDP Coordinator to the Executive Director of MSA, the latter serving as the Secretary to the BEDP Management Committee. The Head's overall responsibility is to ensure that the objectives for EMC are effectively accomplished.

6. The Head EMC, will be responsible for establishing and implementing EMC's work programs and associated budgets with reference to three general areas, namely:

- (a) monitoring of the implementation by power plants of mitigation plans agreed to ensure minimum levels of emissions and effluent, covering: (i) emissions of particulate and gases; (ii) water quality; (iii) solid waste disposal; and (iv) occupational safety and health;
- (b) air monitoring, involving stack sampling (using standard isokinetic procedures) and ambient air quality (using high volume sampling) to be performed primarily for particulate matter; such monitoring to cover the appropriate sampling procedures the entire sugar milling sector; and
- (c) integration of the findings under (a) and (b) into the implementation of the National Environmental Action Plan, particularly as it relates to the establishment of emission standards.

7. The Head, EMC, will carry out his/her responsibilities in close coordination and liaison with the Department of Environment (DOE) within the Ministry of Environment and Quality of Life. Work programs and associated budgets shall be agreed with the DOE prior to submission to the BEDP Management Committee. Similarly, progress reports shall be reviewed with DOE prior to presentation to the Management Committee.

Qualifications

8. The Head, EMC, is a full time position. It will be filled by a person with the following qualifications:

- (a) formal training in environmental science, chemical ecology, atmospheric science or water pollution control;
- (b) demonstrated experience in air and water sampling techniques, and chemical analysis of pollutants; and
- (c) ability to work in a multi-disciplinary environment and effectively interact with officials across agency lines.

MAURITIUS

SUGAR BIO-ENERGY TECHNOLOGY PROJECT

Proposed Establishment of Bagasse and Coal Power Plant at the Union St. Aubin Sugar Factory Environmental Assessment - Summary ^{1/}

Project Objectives

1. The objective of the Bagasse Energy Development Program (BEDP) and the implementation of its first phase at the Union St. Aubin Sugar Sugar Factory is to provide additional generating capacity of 22MW and supply about 136 GWH of electrical power in 1994. Without the project, the incremental energy demand in Mauritius would have to be met through the establishment of a 24MW diesel fired electricity generating plant operated by the Central Electricity Board (CEB). Also, bagasse would continue to be wastefully burnt by sugar factories rather than used for power generation. Hence, a key aspect of the proposed project is to capitalize on the opportunity for converting wasteful use of an indigenous renewable biomass fuel into efficient use for production of electricity.
2. With the project, bagasse rather than being wasted would be used for firing the power plant at Union St. Aubin during the crop season, using coal during the intercrop season. Bagasse would replace diesel during July-December while coal would replace diesel during the remainder of the year. The incremental net reduction in total fuel burnt, brought about by the project (i.e. "with project" requirements less "without project" requirements), is represented by the quantity of diesel which CEB would use to fire its diesel plant during the period July-December (estimated at about 14,000 tons annually).

Environmental Policy and Regulations

3. Mauritius lacked a national environmental policy for the protection of the environment and natural resources until November 1988. At that time the Government adopted an outline policy setting forth environmental goals, directions and guidance. The National Environment Commission was established to coordinate environmental policies, and has since approved a National Environmental Action Plan and a White Paper on National Environmental Policy. A Department of Environment was established within the Ministry of Environment and Land Use (now Ministry of Environment and Quality of Life) as an administrative agency in support of the implementation of the National Environmental Action Plan.

^{1/} A full environmental assessment is provided in "Report on the Environmental Assessment for the Bagasse Energy Development Program - Union St. Aubin Sugar Mill", issued by the Government of Mauritius' Technical Committee on Bagasse Energy Development in September 1991.

4. In July, 1991 the Mauritian Parliament enacted the Environment Protection Act of 1991. This Act provides the legislative mandate implementing governmental policies. It provides authority for enforcement, environmental impact assessments, spill and environmental emergencies, national environmental standards, coastal and marine management, and a national environment fund.

5. The establishment of regulations for implementing the Environmental Protection Act, including those for Environmental Impact Assessments, is now being initiated. There are therefore at this stage no specific quantitative standards for air emissions, effluent discharges, noise, and solid waste disposal that apply to the proposed BEDP project. The Environmental Assessment of the project has therefore been done with reference to recognized environmental standards of developed countries (USA, EC) and of the World Bank.

Assessment Scope and Objectives

6. The Environmental Assessment was expected to focus on activities incremental to the project, namely: (a) the construction and operations of the proposed Union St. Aubin power plant; (b) road transportation by sugar companies of up to 80,000 tons of bagasse to Union St. Aubin from neighboring mills in the southern part of the country during crop season (July-December) and of about 30,000 tons of coal by CEB from Port Louis to Union St. Aubin during the intercrop season; and (c) investments by neighboring mills in modernization of their mills to free up bagasse for sale to the Union St. Aubin Sugar Factory.

7. The main objectives of the Environmental Assessment were therefore to:
- (a) assess the incremental environmental impact of firing greater amounts of bagasse at Union St. Aubin during June through December and the potential environmental impacts of firing coal during January to May, concentrating on air pollutant emissions, bagasse and coal transport, water use, wastewater discharges and ash disposal;
 - (b) evaluate the proposed project against the alternative diesel project;
 - (c) provide a model for assessing the environmental impact for subsequent BEDP projects;
 - (d) recommend potential mitigation measures to be assessed in detail during the feasibility study; and
 - (e) recommend an environmental monitoring program.

B. Evaluation of Project and Alternatives

8. The environmental assessment indicates that compared to the alternative investment project (the diesel plant) the proposed investment in the bagasse-cum-coal plant investment would:

- (a) reduce acid gases (sulfur dioxides and nitrogen oxides) from about 4000 t/year to 1000 t/year, and green house gases in the form of carbon dioxide (CO₂) from 75,000

tons/year to 60,000-67,000 tons/year (depending largely on the coal burning efficiency of the new power plant) with additional reductions of nitrous oxide emissions;

- (b) double the particulate emissions from 1100 t/year to 2100 t/year without any pollutant control measures, as a result of burning coal in the off season rather than diesel, but that with the proposed air pollutant control measures proposed (see para. 9(b) below) the projected increase would be from 300 t/year to 520 t/year; and
- (c) increase the solid waste from ash residuals of coal burning.

9. The evaluation of alternative designs of the proposed project related to control of air emissions, water use, waste water treatment and disposal, and solid waste disposal concluded that:

- (a) the costs of removing gaseous pollutants beyond that of specifying fuel quality would be extremely high and do not warrant consideration of alternative controls;
- (b) a spray chamber of the kind locally used was suggested as an appropriate cost effective **minimum** control for containing particulate emissions (expected particulate removal efficiency of 75 percent);
- (c) the use of low-contaminant process waste waters for the cooling towers should be investigated with the view to avoiding wastewater discharges and provide water conservation; and
- (d) recycling of bagasse as a soil supplement should be continued rather than discharging into the sea; coal ash may be used in cement block manufacturing or for road construction, and should not be used for soil supplement or as landfill without prior leachate testing.

10. The overall conclusion of the EA is that the bagasse-and-coal project is environmentally superior to that of the diesel alternative. Impact analysis on air emissions suggested that the probability of affecting the greatest number of people with the greatest emissions is higher for the diesel project. It further showed that maximum impact on ambient air quality would be lower than the World Bank Guidelines and the USEPA and EEC standards. While water use under the proposed project is expected to be higher than under the diesel alternative, recycling and treatment can be introduced. However, the general area of the project site has an abundance of water. Solid waste associated with the project would be greater than under the alternative, but would find useful recycling opportunities. Finally, the proposed project will lower current emissions of air pollutants since bagasse currently burnt efficiently in mills without air pollutant controls would be burned at the Union St. Aubin power plant using pollutant controls.

C. The Affected Environment

11. The project site is on a gradually sloping plain between two rivers about a kilometer's distance to the south coast on the island. Within a 5 km radius of the project site, the vegetation is

dominated by sugar cane. Since there are no native forests remnants around the plant site, it can be presumed that impacts on native wildlife in the immediate vicinity will be insignificant.

12. There are, however, forests remnants to the north-west of the site which are combined with adjacent lands to create the 2400 ha Black River Gorges Forest Reserve. ^{2/} An area within this part, located some 7 km from the proposed power plant site, encompasses all of Mauritius' remaining original forests, has the island's highest diversity of endemic plants and is regarded as a most important habitat for endemic birds. The importance of preserving the biodiversity of the park resources is internationally recognized.

13. The Environmental Assessment undertook to carefully model air quality impacts within an area of 4 km of the project site and within the Black River Gorges Forest Reserve, following guidelines and air dispersion models approved by the Environmental Protection Agency of the United States. The results indicate that air quality impact would not affect public health or welfare. Regarding impact on the National Park area, the Environmental Assessment finds that the expected maximum sulfur dioxide concentrations in the park would be a small fraction of the concentration expected to cause injury to the natural vegetation. The phytotoxic effects from SO₂ and NO₂ on the natural vegetation would be negligible. No effects to agricultural crops is expected from the predicted emissions.

14. Since the predicted maximum ambient air pollution concentrations are well below the known effect levels for vegetation, no habitat loss and subsequent effects to wildlife are expected to occur given the data available for modelling of air quality impact. No effects to the biodiversity and endangered species of the area will occur from air emissions from the proposed facility. Impact on water resources will be negligible and no adverse impact to the aquatic resources of the river systems is anticipated.

15. The analysis of transportation impacts (bagasse and coal transport) concludes that individual road users will be virtually unaffected by either bagasse or coal transport. To minimize the impact of transporting coal from Fort George through the Port Louis area, such transport should occur outside rush hours. To assure optimal traffic safety when hauling bagasse, transport should occur only during day time, and trucks be covered.

E. Environmental Mitigation Plan and Monitoring Programs

16. An Environmental Monitoring Cell would be established under the BEDP Coordination Unit which is to effectively serve as the secretariat for the BEDP Management Committee. The purpose is to ensure that the mitigation measures recommended by the Environmental Assessment (para. 18-20) are implemented and to initiate a monitoring program for the sugar industry covering stack sampling, ambient sampling and water quality. This program would be based on directives from the Department of Environment and over time be formally integrated into the national program for environmental monitoring to be developed by the Department.

^{2/} Soon to be declared a National Park.

17. The Environmental Assessment concludes that based on available data and modelling results the proposed project will not have any significant adverse impact of the Black River Gorge Forest Reserve. However, given the environmental sensitivity of this reserve with its endemic flora and fauna it is essential that air quality monitoring and biosurveys and bioassays be carried out to evaluate actual impact during project implementation. The national air quality monitoring program, the planning of which is currently being initiated by the Ministry of Environment and Quality of Life, will consider the Black River Gorge Forest Reserve as a priority area for monitoring.

Mitigation Plan

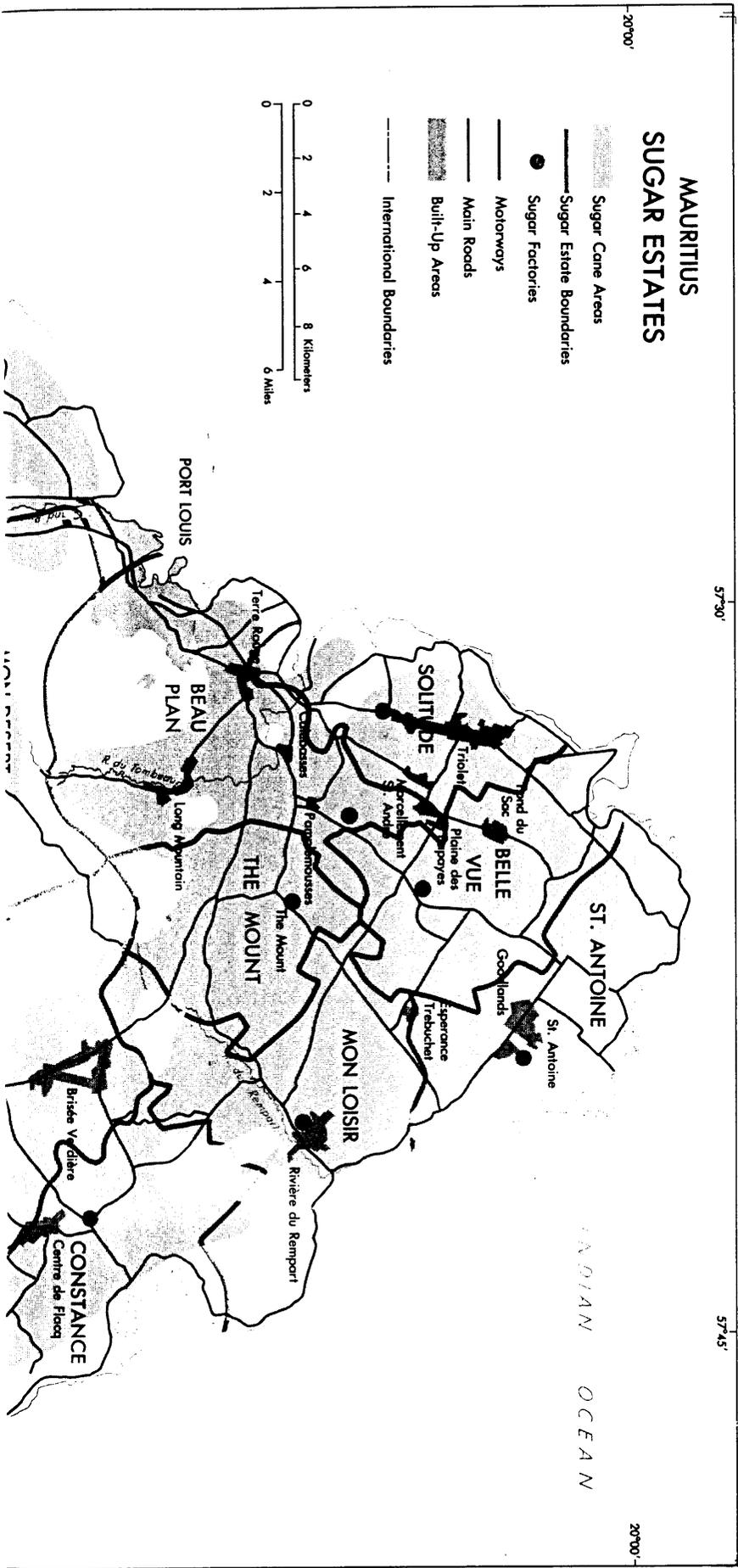
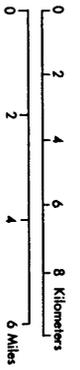
18. **Air Emissions.** The recommended minimum level of particulate control, i.e. 75 percent removal, will result in emissions in excess of World Bank guidelines. However, air quality impact analysis based on the minimum recommended air controls for the boiler shows that the impact from the proposed facility would not affect public health or welfare. It also predicts emission concentrations at levels which would make serious and significant damage to flora and fauna in the Black River Gorge National Park unlikely. No gaseous controls are recommended since both impacts and emissions are below World Bank guidelines and EC and USEPA air quality standards. Regarding fugitive emissions and dust, water spraying should be used in the coal storage areas to control dust at the Fort George storage area and the proposed storage site. Bagasse should be stored in enclosures at mills and covered when transported.

19. **Water and Solid Waste.** Alternative mitigation measures related to water use and treatment include: (a) use of silt screens and sedimentation basins to minimize soil erosion as a result of construction activities; (b) minimize adverse impacts of discharge of ground water from site dewatering by pumping water to a sediment settling pond prior to discharge; (c) adopt preventative construction management techniques to minimize impact related to release of oil products or hazardous materials during construction; (d) recycle plant water discharges for use in ash scrubber system; and (e) control coal pile runoff by lining the coal pile area and directing runoff to a small primary treatment system (addition of a caustic and a flocculent followed by settling prior to discharge).

20. Mitigation related to solid waste (i.e. ash, sludge and construction/operation debris) would include: (a) continuation of bagasse ash management as currently done, and an ash settling area to be constructed similar to the one used at Flacq United Estates Ltd. Sugar Factory; (b) recycling of coal ash either in the manufacturing of concrete products or used in road construction (asphaltic concrete); (c) land filling of demineralized sludge following neutralization of ph, while avoiding surface water drainage and known ground water production areas; and (d) recycling of debris.

MAURITIUS SUGAR ESTATES

-  Sugar Cane Areas
-  Sugar Estate Boundaries
-  Sugar Factories
-  Motorways
-  Main Roads
-  Built-Up Areas
-  International Boundaries



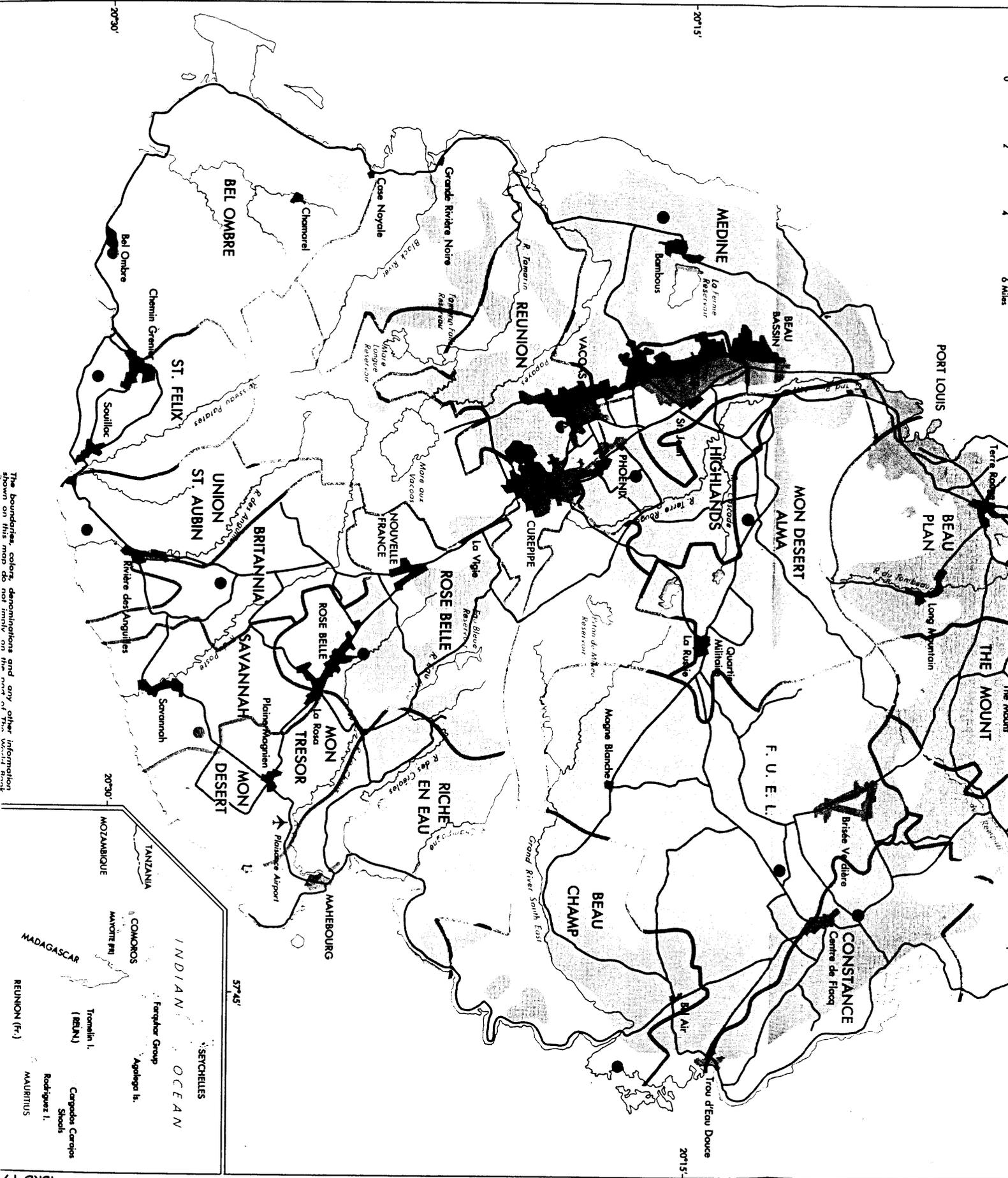
INDIAN OCEAN

20°00'

57°30'

57°45'

20°00'



The boundaries, colors, denominations and any other information shown on this map do not imply on the part of the World Bank.

6 Miles

THE MOUNT

INDIAN OCEAN

SEYCHELLES

IBRD 19