Joint UNDP/World Bank Energy Sector Management Assistance Program

Activity Completion Report

No. 054/86

Country: SRI LANKA

Activity: INDUSTRIAL ENERGY CONSERVATION: PREFEASIBILITY STUDIES FOR SELECTED INDUSTRIES

MARCH 1986

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

The Joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP), started in April 1983, assists countries in implementing the main investment and policy recommendations of the Energy Sector Assessment Reports produced under another Joint UNDP/World Bank Program. ESMAP provides staff and consultant assistance in formulating and justifying priority pre-investment and investment projects and in providing management, institutional and policy support. The reports produced under this Program provide governments, donors and potential investors with the information needed to speed up project preparation and implementation. ESMAP activities can be classified broadly into three groups:

- Energy Assessment Status Reports: these evaluate achievements in the year following issuance of the original assessment report and point out where urgent action is still needed;
- Project Formulation and Justification: work designed to accelerate the preparation and implementation of investment projects; and
- Institutional and Policy Support: this work also frequently leads to the identification of technical assistance packages.

The Program aims to supplement, advance and strengthen the impact of bilateral and multilateral resources already available for technical assistance in the energy sector.

Funding of the Program

The Program is a major international effort and, while the core finance has been provided by the UNDP and the World Bank, important financial contributions to the Program have also been made by a number of bilateral agencies. Countries which have now made or pledged initial contributions to the programs through the UNDP Energy Account, or through other cost-sharing arrangements with UNDP, are the Netherlands, Sweden, Australia, Switzerland, Finland, United Kingdom, Denmark, Norway, and New Zealand.

Further Information

For further information on the Program or to obtain copies of completed ESMAP reports, which are listed at the end of this document, please contact:

Division for Global and Interregional Projects
United Nations Development Program
One United Nations Plaza
New York, N.Y. 10017

OR

Energy Strategy and Preinvestment Div. II
Energy Department
World Bank
1818 H Street, N.W.
Washington, D.C. 20433

SRI LANKA

INDUSTRIAL ENERGY CONSERVATION:

PREFEASIBILITY STUDIES FOR SELECTED INDUSTRIES

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CURRENCY EQUIVALENT

US$1.00 = Rs. 25 (Rupees)

ENERGY CONVERSION FACTORS

1 tonne of oil equivalent (toe) = 10.0 million kcal
= 39.68 million BTU

Fuel	Toe per tonne
Petroleum	
crude oil	1.03
LPG	1.06
gasoline/naphtha	1.09
kerosene/Av turbo	1.06
diesels	1.05
fuel oil	0.98
bitumen	0.89
Coal	0.65
Fuelwood	0.40
Charcoal	0.65

Electricity is converted to tonnes of oil equivalent in this report on the basis of thermal generation replacement at 302.42 toe/GWh.

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SUMMARY

Overview

1. This report presents the results of prefeasibility studies of potentially highly profitable opportunities to improve the efficiency of energy use in 16 industrial plants, one hotel and one hospital in Sri Lanka. 1/ Funded under the joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP), the prefeasibility studies were carried out as part of an ongoing government of Sri Lanka program to promote energy conservation in industry. As the next step in this program, the government is now seeking donor funds to take the studies to the feasibility level. The total funds sought to complete the feasibility studies amount to approximately US$1.3 million.

2. The simple economic payback for the various projects identified by the prefeasibility studies ranges from 0.9 years to 3.5 years. Taking all the projects together, the simple economic payback is 1.8 years. The low payback periods indicate that the more rigorous financial and economic rates of return analyses at the feasibility level will not exclude the projects proposed and may, in fact, identify additional projects. Most of the individual projects proposed in this report are of low risk. Before investing in energy efficiency equipment in three of the public corporations studied (the Ceylon Steel Corporation, the Paranthan Chemicals Corporation, and the Ceylon Plywood Corporation), however, an overall review of each corporation's operations, comparative advantage, and incentive framework should be carried out in order to address the issues of economic and financial viability.

3. In anticipation of donor support, the government is making institutional arrangements such that on completion of the donor funded feasibility studies the investment phase of the industrial energy conservation program can proceed. It is expected that, on completion of the feasibility studies, initial investments of US$9.1 million will be required. 2/

1/ This report was prepared on the basis of the results of a visit to Sri Lanka in May-June 1984 by Messrs. A. Streicher (specialist in industrial energy conservation, consultant), T. Bleakley (specialist in industrial energy conservation, consultant), and G. Gaskin (World Bank). Messrs. G. Gaskin and N. King (World Bank) were the authors of the text.

2/ Subsequent to the completion of the prefeasibility program, some companies have started to implement the prefeasibility recommendations. Details of the current investment requirements can be obtained from the government coordinating agency, the Energy Efficiency, Demand Management and Conservation Task Force (EDMAC).

Energy Conservation in the Industrial and Commercial Sectors in Sri Lanka

4. Foremost among Sri Lanka's options for reducing its oil import bill, which absorbed about 39% of export revenues in 1983, is energy conservation in industry and commerce. It has been estimated that a concerted energy efficiency improvement program focusing initially on the largest energy users in the industrial and commercial sectors could result in oil savings on the order of US$24 million within three or four years and improve the electricity supply/demand balance at a relatively low investment cost. Recognizing the financial attractiveness of cutting operating costs through energy conservation, several private firms in Sri Lanka have already embarked on their own energy demand management programs. For the majority of private firms and in particular for public corporations, however, there has been relatively little action in this area. This is due to a lack of: (a) general awareness of the benefits of energy conservation, (b) expertise with respect to recent conservation technology, and (c) financing.

The Government's Program to Promote Conservation

5. In view of this lack of action, in 1982 the government established the Energy Efficiency Demand Management and Conservation Task Force (EDMAC) in the Ministry of Power and Energy. EDMAC has designed and begun implementing an energy conservation program for industry and commerce. By mid-1984, EDMAC had held energy conservation seminars for industry management, and, with USAID assistance, trained 45 Sri Lankan engineers in energy conservation and analyzed the technical and economic feasibility of conservation investments in two industrial plants.

6. The government then requested ESMAP assistance for prefeasibility studies to continue identifying possible savings in selected enterprises. These industries were chosen on the basis of: (1) their higher than average energy consumption, (2) having EDMAC trained engineers who could participate in the work, (3) the replicability of the work in similar plants, and (4) their willingness to participate. The 18 companies account for about 15% of total 1983 final consumption of oil and electricity in industry and commerce, and include both private and government-owned corporations. Financial viability is an issue in three of the latter (the Ceylon Steel Corporation - CSC, the Ceylon Plywood Corporation - CPC, and the Paranthan Chemicals Corporation - PCC). The government subsidies required by public enterprises such as CSC place a heavy burden on the central budget. A recent World Bank study of

industrial and trade policies in Sri Lanka 3/ made a strong case for undertaking a fundamental rationalization of the industrial sector, supporting in particular the government's recent emphasis on credible financial performance by public enterprises. In line with this approach, CSC, CPC, and PCC need to be reviewed to ascertain whether there is a comparative advantage for these industries in the Sri Lankan context. These analyses should be carried out by teams of the appropriate technical, financial and economic specialists. Substantial investment in energy efficiency equipment in these three corporations should await the outcome of these reviews.

Results of the Prefeasibility Studies

7. The prefeasibility studies identified possible energy conservation projects which involve work ranging from low-cost measures (e.g., changes in operational procedures) to more expensive investments (e.g., waste heat recovery systems). Energy efficiency will be financially highly attractive to the companies involved, whose total energy costs can be cut by almost 25%, giving savings of US$4.2 million a year for a total investment of about US$9.1 million.

8. From the country's point of view, the aggregate energy savings which could be achieved by this level of investments is about 18,000 toe per year, or about 4% of the 1983 final consumption of oil and electricity in industry and commerce. The simple economic payback for the total investment is 1.8 years. Economic and financial analysis was simplified in line with the prefeasibility nature of this work. The low payback periods indicate that the results of the more rigorous financial and economic rates of return analyses at the feasibility level will not diminish the effectiveness of the projects proposed. The feasibility studies may, in fact, identify additional projects. Of even greater significance than the actual level of savings, however, is the catalytic role of these projects in promoting further energy conservation activities in other industries. This will be achieved both through the projects' demonstration value and the building up of local expertise. Even the feasibility studies are designed to maximize this transfer of technology by making use of the services of local energy conservation consultants and ensuring that plant personnel, particularly energy managers and EDMAC trainees, take an active part in the studies.

9. The feasibility studies themselves will cost US$1.3 million in all (Table 1), which gives a rather high ratio of front-end to project costs (14.3%). This is because it is probable that these studies will

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3/ Selected Issues of Industrial and Trade Policies in Sri Lanka (Report No. 4795-CE), World Bank, January 1984.

turn up additional, financially attractive conservation possibilities, because certain conservation measures requiring little or no investment will be implemented in the course of the studies, and in particular because the feasibility studies include a technical assistance package which involves training Sri Lankans in industrial energy conservation. Donor agencies can finance one or several feasibility studies, which require funds for both local and foreign costs. Studies with similar technology have been grouped into more cost effective packages.

The Overall Framework for Industrial Energy Conservation in Sri Lanka

10. A successful program to achieve financial and economic savings through energy demand management (i.e., conservation and interfuel substitution) must consist of several interrelated elements:

(a) appropriate government actions to create an economic environment which provides incentives to rationalize energy use;

(b) technical assistance to identify and evaluate attractive energy demand management opportunities at the company level; and

(c) financial arrangements to fund viable demand management activities.

11. In addition to providing technical assistance in evaluating conservation possibilities through its EDMAC program, the government has also increased industry's incentive to conserve energy by raising petroleum prices and power tariffs. With respect to financing, EDMAC has initiated discussions with the National Development Bank and the Development Finance Corporation of Ceylon. These institutions have indicated an interest in receiving assistance to set up the institutional arrangements required to make funds available for viable conservation projects identified in the feasibility studies. The government should ensure that such a financing mechanism is in place by the time the feasibility studies have been completed.

Table 1: SUMMARY OF FEASIBILITY STUDIES IDENTIFIED AND OF SIMPLE PAYBACKS OF ASSOCIATED ENERGY CONSERVATION PROJECTS

Company	Feasibility Study Cost a/ Total	Simple Payback of Associated Project Financial	Economic
	('000 US$)	(years)	
Ceylon Steel Corporation	260	1.3	0.9
Ceylon Plywood Corporation	75	2.8	1.9
National Paper Corporation	210	3.2	2.9
Richard Pieris & Company Ltd.	12	1.2	1.5
Prima Ceylon Ltd.	40	1.0	1.2
Ceylon Tobacco Company Ltd. b/	--	3.0	3.5
Pugoda Textile Mills	75	1.7	1.4
Ceylon Gass Company	125	1.8	2.1
Sri Lanka Rubber Manufacturing Co.	23	1.7	0.9
Dunagha Coconut Producers Cooperative Society	13	2.0	n/a c/
Mattakelle State Tea Plantation	23	1.5	n/a c/
Lever Brothers b/	--	n/a	n/a
Paranthan Chemicals Corporation d/	100	6.0	n/a
Hotel Lanka Oberoi b/	--	<1.0	n/a
Colombo General Hospital f/	100	n/a	n/a e/
British Ceylon Corporation	75	1.1	n/a e/
Associated Motorways g/	--	--	--
Ceylon Ceramics Corporation g/	--	--	--
Total g/	1,289	2.2	1.8

"n/a" means "not applicable" for reasons explained in the footnotes.

a/ Includes foreign and local consulting costs and 25% contingency for metering installations.

b/ These companies have implemented their own energy conservation programs and do not require technical or financial assistance. For information, the simple paybacks of possible investments in energy efficiency in these companies are given here for the cases where they could be calculated on the basis of the prefeasibility studies.

c/ For these industries, conservation measures involve saving fuelwood. Given the difficulties involved in determining the economic value of wood, only financial paybacks were calculated in these cases.

d/ Improving the energy efficiency in this plant would require a complete retrofit. Given the extent of the work involved, only the financial payback has been estimated. The cost given for the feasibility study is an upper limit.

e/ Due to a lack of sufficiently detailed data on energy efficiency in these facilities, paybacks will be established by the feasibility study in the Hospital's case, and only financial paybacks were estimated for British Ceylon.

f/ Feasibility study includes plant installation cost on the order of $90,000.

g/ At the request of the government, details on the Ceylon Ceramics Corporation and on Associated Motorways, Ltd. do not appear in this report. They should be requested directly from those two companies. The totals in this table, however, do include the figures for those companies. Only a financial payback was calculated for Associated Motorways.

12. As EDMAC pursues the next step in its program, i.e., the feasibility studies, three policy issue related to energy demand management in Sri Lanka should be considered further. The first of these is the need to ensure that EDMAC keeps playing a strong leadership role in this area, acting as a catalyst for conservation work. The second is the question of incentives for rationalizing energy use. Recent increases in energy prices, technical assistance in project identification, and availability of financing may not prove sufficient to influence a satisfactory number of enterprises to implement conservation measures. In this case, the general operating environment for energy conservation, and in particular the incentive structure for both private and public entities, should be examined more closely. Finally, special attention should be paid to the issue of substituting wood for petroleum in industries. EDMAC should coordinate any promotion of such a use of wood with the Ministry of Lands and Land Development's ongoing work to define a strategy in the forestry sector. For areas of existing or impending wood shortage, the costs and benefits of this type of substitution to the economy should be examined. Industries should consider investing in wood plantations to meet their own energy needs.

Structure of This Report

13. After a description in Section I of the present report of EDMAC's ongoing industrial energy conservation program and the scope of ESMAP assistance to it, Section II presents a brief overview of Sri Lanka's industrial sector and in particular of its energy consumption. Section III provides a more detailed picture of each enterprise studied, including highlights of its energy situation and identified conservation options. A summary analysis in Section IV of the costs and benefits of these potential energy conservation projects is followed by a presentation in Section V of the feasibility studies now required to further define the projects. For quick reference, a comprehensive list of possible conservation measures, with their respective costs, benefits and simple paybacks can be found, by company visited, in Annex 1. Finally, Annex 2 consists of the consultants' detailed report on each enterprise, covering its history, production, markets, finances, plans and energy situation. These individual reports discuss each firm's energy consumption, costs, and demand management organization. In addition, they analyze the costs and benefits of each company's potential conservation projects and present terms of reference for the required feasibility study.

I. INTRODUCTION

Background

1.1 Sri Lanka's energy situation had deteriorated dramatically by the end of the 1970's. The marked improvement in economic performance after 1978 brought with it a rapid increase in the demand for commercial energy. As the rate of growth of domestic energy production (hydropower) actually declined during this period, the economy's oil import requirements increased by about 60% between 1977 and 1981 and, because of the 1979 doubling of oil prices, the proportion of non-oil export earnings 4/ devoted to importing petroleum rose from 11% to 41%. The net import bill peaked in 1982, consuming almost half of non-petroleum export earnings, and fell slightly in 1983, to about 39% of non-oil export earnings.

1.2 An energy assessment mission 5/ in June 1981 concluded that a concerted energy efficiency improvement program, focussing initially on the largest industrial and commercial energy users, could result in substantial oil savings ($24 million per year by 1984/85) and improve the electricity supply/demand balance at a relatively low investment cost. The main constraints that needed to be overcome were the absence of an effective institutional framework for carrying out this task and the need for technical support in conducting energy audits and the other pre-investment work. The mission also recommended a number of changes to the structure and level of energy prices to complement this demand management effort. Since the energy assessment, a number of enterprises, particularly private ones, have set up their own energy demand management programs. Overall, however, the initiative taken by both private and public enterprises in this area has been limited, in spite of the attractive potential financial savings. In addition to reflecting the lack of technical expertise, especially with respect to recent technology, this has been due to an unfamiliarity with the possible benefits of conservation and a lack of financing for the required capital investments.

4/ Production from Sri Lanka's oil refinery does not match domestic demand. Consequently, Sri Lanka re-exports petroleum products, including fuels produced in excess of this demand and bunker sales.

5/ The final report of that mission, Sri Lanka: Issues and Options in the Energy Sector (Report No. 3794-CE) was issued in May 1982 as part of the joint UNDP/World Bank Energy Sector Assessment Program. A subsequent update, Sri Lanka: Energy Assessment Status Report, was issued in January 1984 as part of the UNDP/World Bank Energy Sector Management Assistance Program.

The National Energy Demand Management and Conservation Program (NEDMCP)

1.3 Following up on the World Bank/UNDP energy assessment report of May 1982, the government of Sri Lanka embarked upon an industrial energy conservation program. In October 1982, the Energy Efficiency Demand Management and Conservation Task Force (EDMAC) was established in the Ministry of Power and Energy under the supervision of the Senior Energy Advisor to the Minister (the President of Sri Lanka). Although EDMAC has been focussing its efforts on energy conservation in industry, it has also been instrumental in setting up a special cell in the Ceylon Electricity Board (CEB) to reduce power system losses, in reviewing electricity and petroleum pricing policies, and in examining options for energy savings in transport (with ESMAP assistance). 6/

1.4 In collaboration with the Ministry of Industries and Scientific Affairs and other government energy institutions, EDMAC has launched a four phase energy demand management and conservation program for industry and commerce. The program's goal is to achieve energy savings of up to about US$20 million per year within three years. The four phases were designed as follows:

Phase I: informational campaign to promote energy conservation among company executives and plant managers.

Phase II: training of plant engineers in the technical and financial evaluation of conservation possibilities.

Phase III: identification, analysis, financing and implementation of specific conservation projects in large, key industries.

Phase IV: dissemination, i.e., promotion of energy conservation among middle and small size industrial and commercial enterprises, and establishment of energy conservation as a self-sustaining activity in industry and commerce.

1.5 By mid-1984, EDMAC had completed Phases I and II and initiated Phase III. Promotion of energy conservation under Phase I included a two week introductory course for senior energy managers in large private and public sector establishments, and a half-day Senior Executive Seminar for over 150 heads of large enterprises and senior ministry officials. Under Phase II, EDMAC, with USAID assistance, trained a core group of plant engineers in energy demand management. Forty-five Sri Lankan engineers,

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6/ All these programs are described in greater detail in "National Energy Demand Management and Conservation Program (NEDMCP)" by Mohan Munasinghe, Sri Lanka Government Report, April 1984.

chosen from the largest energy consuming industries, both public and private, have attended EDMAC training courses. These engineers represented companies which accounted for 60% of the total energy consumed by industry and 13% of the nation's energy requirements. The courses involved classroom instruction and in-plant training, including complete energy audits by 32 of the participants of two industrial facilities, the Sri Lanka Tyre Corporation and the Thulhiriya Textile Mills.

1.6 These two audits have led to starting in on Phase III of the demand management and conservation program, the identification and eventual implementation of specific conservation projects. On the basis of the audits and with USAID assistance, EDMAC has completed detailed engineering, financial, and economic feasibility studies on the rehabilitation of the steam generation and distribution systems in each plant. The studies identified total investments of US$1.9 million, with a simple payback period of less than two years.

Scope of ESMAP Assistance

1.7 The EDMAC/USAID courses created a cadre of trained Sri Lankan engineers, but both they and their companies required practical assistance in proceeding with the evaluation of conservation possibilities in their various plants. Accordingly, and at the request of the government, the joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) assisted EDMAC in carrying out prefeasibility studies in 16 individual plants, one hospital and one hotel.

1.8 Prior to site visits by the consultant teams under ESMAP, plant engineers trained at the courses collected basic data required for the pre-feasibility studies. The teams, consisting of EDMAC engineers and the consultants who had assisted EDMAC in running the training courses, visited the 18 facilities in the summer of 1984. In keeping with the objective of estimating the size and cost of potential energy savings before deciding to proceed with a more detailed evaluation at the feasibility level, each plant visit lasted only between one half and two days. On the basis of the results, the consultants, with the assistance of EDMAC staff, drafted a report on each facility, covering the company's background, plant production and markets, its energy use, and its potential for energy conservation. Each report describes the scope and cost of possible conservation measures. Having been reviewed by the companies in question and ESMAP staff at the World Bank, these prefeasibility studies are featured here in final form in Annex 2. In addition to identifying possibilities for saving energy, these studies provide terms of reference for the feasibility studies which now need to be carried out in each facility in order to design the conservation projects which will achieve these savings. This ESMAP document presents the results of these prefeasibility studies so that EDMAC can use them in seeking international donor assistance in funding the feasibility studies, which constitute the next step in EDMAC's program.

Further Government Actions to Promote Conservation

1.9 The government has started taking steps to ensure that on completion of the feasibility studies adequate funds will be available to carry out viable projects. EDMAC has initiated a dialogue on energy conservation with the National Development Bank and the Development Finance Corporation of Ceylon. These institutions have indicated an interest in receiving assistance to set up the administrative procedures required for expediting the financing of these projects.

1.10 In addition to establishing EDMAC to initiate an energy conservation program and taking steps to secure funding for conservation projects, the government has also increased industry's incentive to conserve energy by modifying its petroleum and power pricing policies. Petroleum prices were raised in July 1983 to reflect higher costs and the devaluation of the Rupee. An important structural change was the virtual elimination of the general subsidy on kerosene. To protect the purchasing power of lower income households, the value of kerosene stamps, provided to about half of the population, was also raised at the same time. This increase in the price of kerosene also permitted the CPC (Ceylon Petroleum Corporation) to increase industrial diesel prices which had not been increased for fear of substitution by cheap kerosene. This increase in the price of diesel has already resulted in a shift by industries to the use of less costly, heavier fuels. Petroleum prices in Sri Lanka are now broadly in line with international prices. With respect to electricity, the rationalization of tariffs in mid-1982 brought their structure more in line with long-term marginal supply costs. Moreover, capacity charges for electricity, which had been artificially low, were tripled to reflect the actual cost of delivering peak power requirements. This has encouraged major consumers to install power factor correction equipment, thereby improving their consumption efficiency and reducing distribution and investment costs for the power company.

Policy Issues Requiring Further Attention

1.11 In funding the 18 prefeasibility studies discussed in this report, the UNDP/World Bank ESMAP assistance was intended to further industrial energy conservation in Sri Lanka within the context of a coherent strategy devised by EDMAC. This report therefore presents the results of these studies and makes recommendations as to the implementation of the required feasibility studies, but does not provide an in-depth analysis of the overall framework for energy conservation in Sri Lanka. It is clear that the government has made significant progress towards promoting energy conservation through both institutional reforms and changes in policy. As EDMAC pursues its program, three policy related points need to be raised: (a) maintaining EDMAC's leadership role and (b) incentives for both private and public sector enterprises to take conservation measures and (c) the economics of interfuel substitution with respect to wood.

1.12 In view of the significant potential benefits of energy conservation to the economy, there is a need for EDMAC to keep playing a strong catalytic role in this area. Recent increases in energy prices, EDMAC's promotional work, technical assistance in project identification, and availability of financing may not prove sufficient to influence a satisfactory number of enterprises to implement conservation measures. In this case, the general operating environment for energy conservation, and in particular the incentive structure for both private and public enterprises, should be examined more closely. Such an analysis would suggest further possible policy decisions to promote conservation, for example changes in government fiscal policy in the case of private companies and direct incentives to managers in public corporations. Finally, special attention should be paid to the economics of substituting wood for petroleum in industries. EDMAC should coordinate its analysis of this issue with the Ministry of Lands and Land Development's ongoing work to define a strategy in the forestry sector (see para. 3.6).

II. OVERVIEW OF THE INDUSTRIAL SECTOR

Sector Description

2.1 In 1982, manufacturing industry 7/ output accounted for about 15% of Sri Lanka's GDP at factor prices. Based on a manufacturing survey for the same year, value added by industrial groups can be broken down as follows: food, beverages and tobacco, 33%; chemicals, petroleum and rubber, 29%; non-metallic mineral products other than petroleum, 13%; fabricated metal products, machinery and transport equipment, 12%; textiles, wearing apparel and leather industries, 7%; and others, including paper and wood products, 6%. Excluding petroleum products, which are in essence re-exports of surplus refined products, manufacturing industry exports made up 27% of the total value of exports in 1982. The main industrial exports are garments (19% of the total 1982 value of non-oil exports), food, beverages and tobacco (3%), and leather, rubber, wood and ceramics (3%). Garments have a high import content in raw materials used, an estimated 66% in 1982.

2.2 Industry consists of 28 public sector corporations, about 9,000 registered private factories, and over 20,000 unregistered small and cottage industries. Excluding petroleum, the state sector produced about 38% of value added in industry in 1981 In addition to petroleum, state corporations play a major role in the wood, paper, and basic metals industries. Private production is heavily concentrated in garments, and in the food, beverage and tobacco subsector.

2.3 A recent World Bank study of industrial and trade policies in Sri Lanka 8/ analyzed the problem of manufacturing public enterprises. The study identified aspects of these firms which have been detrimental to their financial viability, causing many of them to become a strain on the government budget. A case was made for undertaking a fundamental rationalization of the industrial sector. A first step in this process would be for the government to formulate a coherent overall industrial strategy, clearly articulating the objectives of public enterprises and government's involvement in them as part of that strategy. Supporting the government's recent emphasis on credible financial performance by the

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7/ As described below (Section III), ESMAP prefeasibility studies for energy conservation were also carried out in agroindustries (e.g., a coconut processing plant and a tea estate), and in commerce (e.g., the Lanka Oberoi Hotel). However, most of the work was concentrated on manufacturing industries. In view of this, this sectoral overview will focus on manufacturing industries.

8/ <u>Selected Issues of Industrial and Trade Policies in Sri Lanka</u> (Report No. 4795-CE), World Bank, January 1984.

public enterprises in order to reduce the burden they impose on the central budget, the study recommends a three pronged approach to these firms: (1) shutting down the small number of corporations which can be proven not to be economically viable, (2) selling to the private sector the public enterprises which already appear able to compete in the market, and (3) gradually exposing the remaining enterprises, which constitute a majority of all such firms, to market competition in order to establish their viability. To carry this out, the study proposes an integrated list of reforms aimed at changing the incentive environment of public enterprises, thereby promoting market competitiveness through greater efficiency in these firms. The ESMAP assistance in energy conservation provided to public enterprises should be seen as part of this overall approach in that it seeks to improve the financial performance of these corporations by cutting their energy costs, thereby making their products more competitive. However, it should be clear that these energy efficiency improvements do not substitute for the more fundamental reforms that are needed.

Energy Consumption in Industry and Commerce

2.4 According to the UNDP/World Bank energy assessment report, the industrial and commercial sector was responsible for about 30% (1.07 million toe) of Sri Lanka's total, final energy consumption and about 36% (548 thousand toe) of national final demand for oil and electricity in 1980. More specifically, it accounted for 60% of electricity sales, 27% of direct petroleum consumption and a quarter of all the fuelwood used in the country. Industrial energy consumption was also found to be heavily concentrated in a relatively small number of companies. Since 1980, the industrial and commercial sector's direct consumption of oil and electricity has dropped and its concentration has been less pronounced because: (a) the fertilizer plant has not been operating continuously and (b) the Cement Corporation, another heavy consumer, converted to using coal. Total industrial and commercial final consumption of oil and electricity in 1983 is estimated at 510,000 toe, or about 30% of the country's total, final demand for those types of energy in that year. 9/

9/ The toe equivalent of electricity is calculated on a thermal generation replacement basis. Final consumption excludes distribution losses but includes transformation losses, which are allocated on a prorated basis between the various consuming sectors.

III. RESULTS OF THE PREFEASIBILITY STUDIES

Overview of the Industries Involved in the Prefeasibility Studies

3.1 As the next step in its overall program to promote energy conservation in industry and commerce, EDMAC selected 16 of the country's larger industries, a large hotel and a hospital for the ESMAP prefeasibility studies. These companies accounted for about 15% of total, final consumption of oil and electricity consumption in industry and commerce in 1983. They were chosen for their higher than average consumption of energy, for having EDMAC-trained engineers who could participate in the work, for the replicability of indentified conservation measures in similar plants, and for their interest in participating. As a result of the prefeasibility studies, most of the industries are now candidates for feasibility level work and, eventually, capital investment.

3.2 The companies involved in the prefeasibility studies included both private and government-owned corporations. All of the facilities visited had at least one engineer who had attended the EDMAC/USAID training course. In general, the private firms were in a relatively sound financial position. Overall, they were well managed with respect to energy efficiency and were aware of possible energy efficiency improvements. The Ceylon Tobacco Company (CTC), for example, has established a specialized consulting subsidiary to assist other companies in energy auditing and engineering. The ESMAP prefeasibility work identified potential energy conservation projects in the following private firms: Lever Brothers (Ceylon) Ltd., Prima Ceylon Ltd., Hotel Lanka Oberoi, and CTC. Subsequent to the ESMAP visit these four companies are already undertaking their own self-financed programs and except for Prima Ceylon require no financial or technical assistance.

3.3 In contrast, financial viability is an issue in three of the government-owned corporations (i.e., the Ceylon Steel Corporation -CSC, the Ceylon Plywood Corporation - CPC, and the Paranthan Chemicals Corporation - PCC). There is presently no analytical basis for judging whether these three industries have a comparative advantage in Sri Lanka, taking into account the need to make optimal use of Sri Lanka's resources. In line with the recommendation of the recent World Bank study of industrial and trade policies in Sri Lanka to rationalize the country's industrial sector, it is recommended that the technical, financial, and economic aspects of these three corporations be thoroughly reviewed in order to address this question of economic and financial viability. This analysis should cover in particular the management and incentive difficulties faced by these enterprises. Further substantial investment in energy efficiency equipment at CSC, CPC, and PCC should await the outcome of these reviews.

3.4 Past efforts to increase energy efficiency in government-owned corporations, though varied, has generally been limited. Some industries have taken initiatives to save energy, and many of them have broached the institutional problem by appointing energy managers or convening regular meetings of the directly concerned staff. Overall, however, there is little awareness of conservation techniques in state corporations, and those responsible for energy often have other duties that take priority over energy activities. Both financial assistance to the government-owned industries and technical assistance to their plants' engineering staff will therefore clearly be required in most cases. This assistance will be required to carry out the feasibility projects identified in this report and to implement those projects which prove viable. Each company has reviewed its prefeasibility study, presented in full in Annex 2, and is anxious to receive assistance.

Company Profiles and Possible Conservation Projects

3.5 The paragraphs below present brief profiles of the companies, both state-owned and private, which require financial and/or technical assistance. These profiles are drawn from the detailed evaluations in Annex 2. 10/ The profiles provide an overview of the companies' situation and in particular, an idea of their capability to implement energy efficiency projects. The highlights of each company's energy situation and of its options for improving energy efficiency, as determined by the prefeasibility studies, are also presented here. A comprehensive list of possible conservation measures, with their respective costs, benefits and simple paybacks can be found in Annex 1 for each company visited. 11/ The costs and benefits of the possible

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10/ At the request of the government, detailed information on the Ceylon Ceramics Corportion (CCC) and Associated Motorways, Ltd. (AM) is not published in the present report. The results of the energy efficiency prefeasibility studies on these companies are therefore not presented in Annex 2, nor are the companies profiled in this section. Donors interested in obtaining information on CCC and/or AM should contact those companies directly.

11/ Excluding Lever Brothers, Hotel Lanka Oberoi, Colombo General Hospital, Associated Motorways and the Ceylon Ceramics Corporation. The first two of these have established their own energy conservation programs and require no technical or financial assistance. The costs and benefits of each of the possible conservation projects were not analyzed in any detail for them. In the case of the hospital, a lack of adequate energy use data made it impossible to estimate the costs and benefits of each of the identified potential projects. These costs and benefits will therefore be established by the feasibility study. See footnote 10 with respect to Associated Motorways and The Ceylon Ceramics Corporation.

energy efficiency projects and their aggregate effects are discussed further in Section IV, while Section V deals with the cost and the implementation of the feasibility studies now required to better define these projects.

3.6 It should be noted that the prefeasibility study results have brought up an issue which requires further attention in terms of national energy policy. This is the substitution of wood for oil. In the case of several firms (including the National Paper Corp., Richard Pieris and Co. and the Sri Lanka Rubber Manufacturing Co.), replacing oil with fuelwood is suggested as a potentially attractive option from a financial viewpoint, and one that merits study at the feasibility level. Currently, there are only local shortages of wood in Sri Lanka. It is widely agreed, however, that the country is being deforested. If this continues at the present rate, the production potential of Sri Lanka's forests will be significantly reduced within 30 years, with adverse environmental consequences and severe localized shortages before that.

3.7 Given the need for measures to arrest this trend, the ongoing IDA Forest Resources Development Project (Cr. 1317-CE) includes the preparation of a Forestry Sector Master Plan. This is being coordinated by the Planning Unit in the Ministry of Lands and Land Development. The plan is being formulated on the basis of, among other inputs, a forest inventory and a wood market and demand study. This study covers the structure, geographical distribution and magnitude of the demand and the market for wood and wood-based products. It aims at identifying wood products, markets, prices and current supply systems. Under the IDA Forestry Project, a detailed five year investment program will also be drawn up to start implementing the Master Plan.

3.8 In defining energy demand management policies and programs, EDMAC should take advantage of this forestry sector planning effort. Specifically, any promotion of the use of wood as a petroleum substitute should be coordinated with the Ministry of Lands and Land Development's overall strategy for dealing with the fuelwood and forestry issue. Before encouraging such a use of wood in areas of existing or impending shortage, special attention should be paid to its costs and benefits to the economy. From the point of view of the individual firms considering burning wood for fuel, the question of the availability and cost of wood over the life of the equipment involved should be analyzed as part of the proposed energy demand management feasibility studies. The firms should also consider investing in planting wood to meet their energy needs, as this could be an economically viable option under certain conditions. For example, investment in fuelwood plantations has been supported by IDA to substitute fuelwood for petroleum products in Sri Lanka's tea industry. 12/

12/ This is being carried out under the Tree Crop Rehabilitation (Tea) Project (Cr. 818-CE) and the Tea Rehabilitation and Diversification Project (Cr. 1240-CE).

Ceylon Steel Corporation (CSC)

3.9 As Sri Lanka's only steel mill, this company produces mainly for the domestic construction and metal markets. The state-owned mill faces financial difficulties due to high production costs and competition from cheaper imported products. CSC has taken a number of energy saving initiatives and has a nominal energy manager. In view of the significant potential for further energy cost reduction in CSC, staff need to be assigned on a permanent basis to energy management activities. CSC is the largest single consumer of oil and electricity of the 18 facilities visited, accounting for almost 20% of these facilities' total 1983 consumption of those types of energy. It is estimated that about 25% of CSC's total energy bill could be saved annually by measures (e.g., improvement of mill operations, electric demand control, reheat furnace improvements) with a simple financial payback of 1.3 years.

Ceylon Plywood Corporation (CPC)

3.10 CPC operates several facilities in Sri Lanka, including sawmills and plywood, chipboard, and furniture factories. CPC's production is very dependent on local conditions. The corporation, whose chief engineer acts as energy manager, has undertaken several successful efforts to cut energy bills, including the full substitution of wood waste for oil in boilers, the reduction of electric peak demand, and correction of the power factor. Recently CPC received assistance from SIDA in conducting a detailed energy audit, which had not yet taken place at the time of the ESMAP prefeasibility study. Results from the latter indicate that US$400,000 worth of energy savings could be achieved annually by measures (e.g., installation of air heaters, electric load management, power generation from wood waste) with an average simple financial payback of 2.8 years.

National Paper Corporation (NPC)

3.11 The state-owned NPC has three mills, one of which, at Embilipitiya, was visited. The mill produces paper products from rice straw exclusively for the domestic market. The Embilipitiya mill recorded a before-tax profit of Rs. 4.4 million (US$0.18 million) in 1983, on a turnover of Rs. 249 million (US$10 million). An assistant mill engineer has been placed in charge of energy savings. Several steps have already been taken to conserve energy, and a study is underway to examine the feasibility of generating on-site power to cut electricity costs. NPC's paper may be overdried. An increase in its moisture content by 1% would save about US$250,000 per year at no cost. Several other measures, including improvements in the boiler room and waste heat recovery from the paper machines, would reduce Embilipitiya's total energy bill by 15%, with an average simple financial payback of less than one year. The installation of a new multifuel boiler with cogeneration would cut the total bill by another 28%, but the financial payback for this project would be 4.7 years.

Richard Pieris and Company Ltd.

3.12 This company's Arpico factory produces rubber and plastic goods as well as steel furniture. Most of the products are for the domestic market, exports accounting for roughly 6% of sales. With the exception of FY1981-1982, Richard Pieris and Company has made steady profits during this decade. The company is in a relatively sound financial position, and is considering modernization and expansion plans, including the installation of a wood-fired boiler to meet anticipated production increases. According to the ESMAP prefeasibility study, a wood-fired boiler with a lower rated capacity than the one being considered by the company would cut Richard Pieris and Company's energy bill by over 25%, with a financial payback of 1.3 years. Improving the steam generation and distribution system would reduce the bill by another 6%, with a financial payback of less than one year.

Paranthan Chemicals Corporation (PCC)

3.13 PCC is a state industrial concern involved in the manufacture and distribution of salt-based heavy chemicals, particularly caustic soda and chlorine. The company produces for the domestic market, where demand has historically been much higher for caustic soda than for chlorine. This has restricted plant production because the two chemicals must be produced at fixed ratios to each other, and it would not be economically justified to produce caustic soda if the associated chlorine could not be sold. PCC's activities are managed by its own resources without government subsidy. While it has been making reasonable profits in the past, the company now finds itself in a poor financial situation. The major problems facing the Paranthan plant stem from its obsolescence, the high cost of retrofitting with more efficient equipment, and the low domestic demand for chlorine. Paranthan's size is well below world scale, and it is not clear that a facility of its capacity could compete effectively with imports. Improving PCC's energy efficiency would entail a complete retrofit, with a simple financial payback of 6 years. The issue of the industry's economic and financial viability should be resolved before proceeding with such extensive work.

Prima Ceylon Ltd.

3.14 The private, foreign-held Prima Ceylon Ltd. plant produces flour solely for use in domestic markets. The plant is in excellent condition and well maintained, and the company is in a sound financial position. Plant management is actively seeking methods to reduce energy consumption at the mill and energy conservation efforts are part of the day-to-day assignments of the electrical department engineers. While Prima Ceylon has the financial resources to implement economically sound energy conservation projects, it will require technical assistance to review its complex conservation options. These range from boiler modifications to waste heat recovery to load management planning. Combined annual savings could reach about US$170,000 for an investment of the same amount.

Colombo General Hospital (CGH)

3.15 CGH is placed under the Ministry of Colombo Hospitals and Family Health. The hospital is in a very poor financial situation but copes admirably within overall budgetary constraints. Internal funds are available only for critical improvement programs. There are three electrical engineers from CEB (Ceylon Electricity Board) attached to the hospital, but there is no formal energy management organization or budget. The principal energy conservation initiative to date has been the gradual replacement of incandescent bulbs with fluorescent tubes. Various measures (repairing gas leaks, using gas stoves, installing air-tight doors, installing an LPG system) would cut hospital fuel costs by at least 20%, with financial paybacks of approximately one year. The capital cost of these measures has been included in the proposed feasibility study so that, once the study has verified their economic viability, the measures can be implemented immediately. Given the lack of detailed energy consumption data at the Hospital, the feasibility study will also establish the costs and benefits of further measures, including major retrofitting. A modernization and expansion program for the Hospital, including the installation of a new, all-electric laundry, has been proposed under Finnish assistance. It is critical that energy efficiency be considered in this and all such programs. Oil-using thermal equipment should be installed instead of electric equipment in this case and whenever possible. In terms of useful energy, fuel can be two to three times less expensive than electricity. The lower investment cost of electrical equipment is not justified on a life-cycle cost basis. The feasibility study will address this issue so that, in its expansion, the Hospital can minimize its energy costs.

British Ceylon Corporation (BCC)

3.16 BCC is categorized as a government-owned business undertaking. Its plant produces coconut oil, soaps, disinfectants, talcum powers and steel drums for the domestic and export markets. Exports accounted for roughly one-third of total sales in 1982. Although the plant is old and generally in poor condition, the company was profitable through the first three years of this decade, even in the face of the international and domestic recession. There is a staff member in the engineering department who is in charge of energy conservation efforts. It is likely that 20-25% of BCC's total energy consumption could be saved through an adequate conservation program, but there were insufficient data to accurately evaluate the benefits of several of the possible conservation projects which were identified. Opportunities for saving energy at BCC include boiler improvement, replacement of various steam ejectors, and installation of capacitors. The projects whose benefits could be estimated (replacement of some of the steam ejectors and installation of capacitors) would save about US$30,000 with a payback of a little over one year. The proposed feasibility study, which includes an energy audit, would provide the necessary information for a comprehensive evaluation of BCC's energy saving options.

Pugoda

3.17 The operation of this government-owned textile mill is contracted out on a profit sharing basis to an Indian management firm. Pugoda sells cloth solely to the domestic market. Exports are gained indirectly through selling to garment manufacturers who in turn sell to the major western markets. According to management, the company was expected to show a profit in the financial year 1983-84. The chief engineer and his subordinate engineer are responsible for energy conservation activities. While the plant is generally well run and energy conservation activities receive good attention, specific energy consumption remains high, indicating scope for further energy cost reduction. Energy conservation projects acceptable to the corporation (i.e., with a maximum payback of about 2 years) are: (1) waste heate recovery, (2) capacitor installation, (3) chiller operation improvement, and (4) burner controls. These measures will reduce the annual energy bill by about 10%.

Ceylon Glass Company, Ltd. (CGC)

3.18 CGC is the only manufacturer of glass containers in Sri Lanka, and has captured 70% of the domestic market. Imports account for the balance of the market, because CGC does not produce certain sophisticated containers and does not accept orders for small quantities. The company's past financial situation has been good. However, in 1983 it suffered a loss due to kiln reconstruction costs. CGC may also suffer a loss in 1984, but should become profitable again in 1985. While no energy management organization exists at present, the company is considering setting up an "energy cell" which will be led by a senior engineer. A variety of measures, in particular insulation of CGC's furnace, could reduce the firm's energy bill by about 25%, with financial paybacks of less than two years.

Sri Lanka (Ceylon) Rubber Manufacturing Company, Ltd.

3.19 This privately-owned company uses natural rubber latex as a raw material to produce technically-specified grades of block rubber for export and also centrifuged latex for local use. The company recorded profits in both 1982-83 and 1983-84. With regard to energy conservation, the factory has been considering improving the power factor through the installation of correction equipment. Although this measure is indeed recommended on the basis of the prefeasibility study, it appears that most of the possible energy savings at the rubber factory would come from substituting wood for diesel oil through the installation of a multifuel air heater. This measure alone would cut the plant's energy costs by an estimated 40%, with a financial payback of under two years. However, while a wood-fired (or multifuel) air heater seems technically feasible, it has not been tried in Sri Lanka. As part of the feasibility study, a suitable air heater would therefore have to be designed and installed. This testing of the heater's technical, economic and financial viability should be done in conjunction with the Rubber Research Institute.

Dunagha Coconut Producers Cooperative Society

3.20 This plant produces copra, dessicated coconut and coconut oil. It is wholly owned by a cooperative society of coconut plantation owners. About 90% of the coconut oil is sold for use on the local market, while copra is sold to both the local and export markets. Dessicated coconut is mainly exported. The cooperative, which employs a professional management staff, is financially sound, has little long-term debt and has generated considerable cash which is held in fixed deposits. The plant's capacity for manufacturing dessicated coconut has recently been expanded by 50%, the expansion being entirely self funded. No energy conservation activities have yet been undertaken at the plant. The plant consumes wood as well as diesel oil and electricity. Possible conservation projects include: (1) power factor correction, (2) sterilizer improvements, and (3) improvements to air heaters and dryers. This last item would reduce the plant's wood consumption. Up to about 40% of annual fuel costs could be saved through investments, with an overall financial payback of two years.

Mattakelle State Tea Plantation

3.21 This plantation has a completely self-contained factory for the manufacture of tea and also processes tea from adjacent plantations. About 90% of the tea grown in Sri Lanka has an export market. There have been no extensive energy conservation activities at the Mattakelle Estate, which consumes electricity, fuel oil, and fuelwood. There seems to be a large scope (between 15 and 50%) for energy cost savings in tea estates in general. Options identified at Mattakelle include: (1) design of new wood-fired air heaters, (2) use of dryer waste heat for drying fuelwood, and (3) substitution of biogas for wood as a fuel for cooking on the estate. Together these measures would cut energy costs by 20%, for an overall financial payback on the required investments of one and a half years.

IV. COSTS AND BENEFITS OF THE POSSIBLE ENERGY CONSERVATION PROJECTS IDENTIFIED IN THE PREFEASIBILITY STUDIES

4.1 As seen in Section III, the prefeasibility studies identified possible energy conservation projects which involve work ranging from low-cost measures (e.g., changes in operational procedures) to more expensive investments (e.g., waste heat recovery systems). The methodologies for the financial and economic analysis of these projects were simplified in line with the prefeasibility nature of the studies. As an initial project filtering mechanism, simple financial and economic payback periods were calculated. The calculation of the economic payback differs notably in that the economic value of average annual benefits was estimated taking the opportunity costs of electricity and fuel oil into account. Sensitivity analyses of each project's economics were not carried out. Table 4.1 summarizes for all the facilities visited, except Lever Brothers, the potential projects together with their costs, benefits and simple paybacks.

4.2 The combined energy bill for the 18 companies studied was found to be about US$18.4 million in 1983. The projects identified would reduce total energy costs to the industries by approximately US$4.2 million, or almost 25%. A total investment of US$9.1 million would be required to yield this level of savings. Taking all the projects together, the payback period is 2.2 years financial and 1.8 years economic. Table 4.1 shows how short the payback period is for the majority of projects, which indicates that nearly all of them should provide high rates of return at the feasibility level. From the point of view of the individual companies, these identified projects are therefore financially attractive in that they will increase the firm's competitiveness through reduced energy expenditures.

4.3 The aggregate energy savings which could be achieved by this level of investments is estimated at 18,000 toe per year. This amounts to about 4% of the 1983 consumption of oil and electricity in industry and commerce. In addition, the successful implementation of these projects will serve as a catalyst to further promotion of energy conservation in other firms, both through the projects' demonstration value and the building up of local expertise. In this regard, there are already encouraging signs, such as CTC's consulting subsidiary (para. 3.2), that some private sector organizations will offer energy audit and conservation services to industry in the near future. The enrollment of local consultants in the feasibility studies will provide a mechanism for technology transfer and strengthening of local technical skills.

4.4 The dissemination of conservation technology is particularly important in the case of agro-industries. The proposed conservation work on the Dunagha coconut processing plant and the Mattakelle Tea Plantation, for example, can be readily applied to similar facilities. In fact, the tea, coconut, and rubber research institutes should work together with local specialized engineering and consulting firms to develop appropriate, cost-effective conservation techniques for commercialization throughout agro-industry.

Table 4.1: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS a/

Company/Corporation	Candidate Projects	Project Cost ('000 US$) Total	Foreign	Local	Average Annual Financial Benefit ('000 US$) Total	Foreign b/	Local	Simple Payback (years) Financial c/	Economic d/
Ceylon Steel Corp.	Improvement of mill operations, electric demand control, reheat furnace improvements, melting shop rehabilitation and hot analysis of billets	1,095	620	475	868	704	164	1.3	0.9
Ceylon Plywood Corp.	Dust extraction system improvement; installation of air heaters; steam system rehabilitation; electric load management, electricity generation from wood waste	1,116	959	157	403	265	138	2.8	1.9
National Paper Corp.	Instrumentation; boiler improvements; waste heat recovery from dryers; reduction of pulping energy requirements; rehabilitation of the chemical recovery plant, new multi-fuel boiler/cogeneration	3,673	2,938	735	1,142	1,019	123	3.2	2.9
Richard Pieris & Co. Ltd.	Steam system improvement; installation of new wood-fired boiler	220	188	32	181	163	18	1.2	1.5
Paranthan Chemicals Corp.	Plant retrofit with new equipment	906	n/a	n/a	152	n/a	n/a	6.0	n/a
Prima Ceylon Ltd.	Boiler improvement; waste heat recovery from diesel engines; load management	170	136	34	171	154	17	1.0	1.2

Company/Corporation	Candidate Projects	Project Cost			Average Annual Financial Benefit			Simple Payback	
		Total	Foreign	Local	Total	Foreign b/	Local	Financial c/	Economic d/
		('000 US$)			('000 US$)			(years)	
Colombo General Hospital	Miscellaneous housekeeping measures; major retrofitting	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
British Ceylon Corp.	Boiler improvement; replacement of steam ejectors and installation of capacitors e/	31	28	3	29	24	5	1.1	n/a
Pugoda Textile Mills	Waste heat recovery; capacitors; chiller operation improvement; burner controls	154	114	40	90	76	14	1.7	1.4
Dunagha Coconut Producers Cooperative	Power factor correction; sterilizer and air heater improvements	35	13	22	17	8	9	2.0	n/a
Ceylon Glass Co., Ltd.	Instrumentation; furnace insulation; automatic controls; burner replacement and waste heat recovery	383	281	102	215	193	22	1.8	2.1
Mattakelle State Tea Plantation	Improvement of air heaters; wood drying and generation of biogas	34	2	32	23	5	18	1.5	n/a
Sri Lanka Rubber Manufacturing Co., Ltd.	Power factor correction; installation of a multifuel air heater	26	2	24	15	13	2	1.7	0.9
Hotel Lanka Oberoi	Electric load demand management; improved lighting efficiency; boiler housekeeping; improved kitchen energy use	70	n/a	n/a	100	n/a	n/a	<1.0	n/a

Company/Corporation	Candidate Projects	Project Cost Total	Project Cost Foreign	Project Cost Local	Average Annual Financial Benefit Total	Average Annual Financial Benefit Foreign b/	Average Annual Financial Benefit Local	Simple Payback Financial c/	Simple Payback Economic d/
		('000 US$)			('000 US$)			(years)	
Ceylon Tobacco Co.	Steam system rehabilitation and waste heat recovery; installation of a multifuel boiler	124	84	40	40	36	4	3.1	3.5
Associated Motorways f/	Various measures	-	-	-	-	-	-	-	-
Ceylon Ceramics Corp. f/	Various measures	-	-	-	-	-	-	-	-
Totals f/		9,145			4,092			2.2	1.8

a/ Excludes Lever Brothers (Ceylon), Ltd. (requires no assistance in conservation; costs/benefits of possible projects not estimated). The cost of the feasibility study for each project is given in Table 5.1 and discussed in Section V. "N/A" means not applicable for the following reasons: Paranthan Chemicals - given the extent of the work, only the figures given were estimated;
Colombo Hospital - various energy-saving measures already identified and with paybacks of about one year should be implemented during the feasibility study. Given the lack of detailed energy consumption data, the study should also establish the costs and benefits of further measures, including major retrofitting.
British Ceylon - given the lack of detailed data, only financial paybacks were calculated;
Dunagha Cooperative and Mattakelle Plantation - conservation involves fuelwood. Given the difficulties involved in the economic pricing of wood, only financial paybacks were calculated;
Hotel Lanka - requires no assistance in conservation. The figures, given for information, are an estimate of the conservation potential.

b/ EDMAC estimates that the foreign content of electricity is 70% of market price and that the foreign content of oil is 90% of market price.

c/ Total cost/average annual financial benefits.

d/ Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5% of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:
-- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
-- Opportunity cost of fuel oil = 75% of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

e/ Due to insufficient data, the figures apply only to the replacement of some steam ejectors and capacitor installation.

f/ At the request of the government, details on Associated Motorways, Ltd. and the Ceylon Ceramics Corp. do not appear in this report. They should be requested directly from those two companies. The totals in this table, however, do include the figures for those two firms. Only a financial payback was calculated for Associated Motorways.

4.5 As the EDMAC conservation program progresses, the resulting reduction in the oil import bill and improvement in the electricity supply/demand balance will come at a small cost to the government. With limited resources, EDMAC is making this program extremely attractive from a cost/benefit point of view.

V. THE FEASIBILITY STUDIES AND THEIR IMPLEMENTATION

5.1 The next step to be taken towards achieving the energy savings identified in the prefeasibility studies entails evaluating these possible projects at the feasibility level. Terms of reference for these feasibility studies have been drawn up for most of the 18 industries visited, as appropriate, 13/ and can be found in Annex 2. Table 5.1 summarizes the costs of the studies and shows related investment costs and simple paybacks. For any given company, the cost listed in the table corresponds to the feasibility work required before implementing the conservation measures listed for that company in Table 4.1.

5.2 The total cost of the feasibility studies is US$1.3 million for total investments of US$9.1 million. The ratio of front-end to project costs is high (14.3%) for two reasons. First, given the prefeasibility nature of the work, the consultant teams visited each plant only on a "walk-through" basis. As a result, estimates of potential energy savings for each plant are considered to be on the conservative side. It is probable that the feasibility studies will turn up other, financially attractive conservation possibilities. Secondly, the cost of the feasibility studies covers benefits other than just the detailed evaluation of the investment projects. For example, certain conservation measures (e.g., improved "housekeeping" practices) which require little or no investment will be implemented in the course of the feasibility studies. In addition, by involving former EDMAC trainees, other company staff, and EDMAC engineers as specified in the terms of reference in Annex 2, the feasibility studies are designed to ensure the transfer of technological know-how. This training component is indispensable for the implementation of investment projects in specific plants and also for promoting industrial energy conservation in the country as a whole.

13/ i.e. there are no terms of reference for feasibility studies for Lever Brothers, Hotel Lanka Oberoi, Ceylon Tobacco Company, Paranthan Chemicals Corp., Ceylon Plywood Corp., Associated Motorways or Ceylon Ceramics Corporation. The first three companies have their own conservation programs and require no technical or financial assistance. In PCC's case, the issue of the industry's viability needs to be resolved before proceeding with conservation feasibility studies. No terms of reference were prepared for CPC because SIDA expected to conduct a detailed energy audit of the facilities shortly after the ESMAP mission. Finally, Associated Motorways and the Ceylon Ceramics Corporation should be contacted directly with respect to work concerning their respective plants.

Table 5.1: SUMMARY OF COST OF FEASIBILITY STUDIES

Company	Feasibility Study Cost a/ ('000 US$)	Associated Investment Cost ('000 US$)	Simple Payback for Associated Investment: Financial (years)	Simple Payback for Associated Investment: Economic (years)
Ceylon Steel Corporation	260	1,095	1.3	0.9
Ceylon Plywood Corporation	75	1,116	2.8	1.9
National Paper Corporation	210	3,673	3.2	2.9
Richard Pieris & Company Ltd.	12	220	1.2	1.5
Prima Ceylon Ltd.	40	170	1.0	1.2
Ceylon Tobacco Company Ltd. b/	-	124	3.1	3.5
Pugoda Textile Mills	75	154	1.7	1.4
Ceylon Glass Company	125	383	1.8	2.1
Sri Lanka Rubber Manufacturing Co.	23	26	1.7	0.9
Dunagha Coconut Producers Cooperative Society	13	35	2.0	n/a
Mattakelle State Tea Plantation	23	34	1.5	n/a
Lever Brothers b/	-	-	n/a	n/a
Paranthan Chemicals Corporation	100	906	6.0	n/a
Hotel Lanka Oberoi b/	-	70	<1.0	n/a
Colombo General Hospital c/	100	n/a	n/a	n/a
British Ceylon Corporation	75	31	1.1	n/a
Associated Motorways d/	-	-	-	-
Ceylon Ceramics Corporation d/	-	-	-	-
Total d/	1,289	9,145	2.2	1.8

* "n/a" means "not applicable" for reasons explained in footnote a/ of Table 4.1 or in footnote b/ below.

a/ Includes foreign and local consulting costs and 25% contingency for metering installations.

b/ These companies have implemented their own energy conservation programs and do not require technical or financial assistance. For information, the simple paybacks of possible investments in energy efficiency in these companies are given here for the cases where they could be calculated on the basis of the prefeasibility studies.

c/ Since financial and economic paybacks for some conservation measures at the hospital were calculated to be about one year, it was decided that no feasibility study was required for them. Other possible conservation projects (major retrofitting) at the hospital do require a feasibility study to establish their viability. The cost of the required feasibility study (US$100,000) therefore includes the capital cost of the measures which could be implemented at the time of the study (see Annex 2).

d/ At the request of the government, details on the Ceylon Ceramics Corporation and on Associated Motorways, Ltd. do not appear in this report. They should be requested directly from those two companies. The totals in this table, however, do include the figures for the companies. Only a financial payback was calculated for Associated Motorways.

Table 5.2: CONSULTANT REQUIREMENTS AND GROUPING OF FEASIBILITY STUDIES

Feasibility Studies	Consultant Requirements
Individual Studies	
Ceylon Steel Corporation	Foreign expert - electric furnaces Foreign expert - energy efficiency in steel production Foreign or local expert - economic/ financial analysis
Ceylon Ceramics Corporation	Foreign expert - tunnel kilns Foreign or local expert - economic/ financial analysis
Ceylon Plywood Corporation	Foreign expert - energy efficiency Local expert - energy efficiency Foreign or local expert - economic/ financial analysis
National Paper Corporation	Foreign expert - paper production/ efficiency Local expert - energy efficiency Foreign or local expert - economic/ financial analysis
Ceylon Glass Company	Foreign expert - glass production/ efficiency Foreign or local expert - economic/ financial analysis
Pugoda Textile Mills	Foreign expert - textile production/ efficiency Local expert - energy efficiency
Paranthan Chemical Corporation	Foreign expert - caustic soda, chlorine/efficiency Foreign or local expert - economic/ financial analysis
Studies To Be Grouped	
Firms to be Studied as One Group	Core Team to Carry Out Grouped Studies
Prima Ceylon Sri Lanka Rubber Manufacturing Co. Dunagha Coconut Producers Cooperative Society Mattakelle State Tea Plantation Colombo General Hospital British Ceylon Corporation Associated Motorways	Foreign expert - industrial energy efficiency Local expert - industrial energy efficiency Foreign or local expert - economic/ financial analysis

5.3 The cost of the individual feasibility studies vary from US$12,000 to US$260,000. While the time required to complete each study varies over a wide range, it would take on the average about two months for a team of four people to finish a given study. To minimize the duration and costs of the studies through the more efficient use of foreign consultants' time, small studies should be grouped together and carried out concurrently as one study. On the larger, more complex feasibility studies such as in the case of Ceylon Steel Corporation, the Ceylon Ceramics Corporation and the National Paper Corporation, the individual technical experts required will be so specialized that grouping these studies will not be feasible. Groupings of feasibility studies and consultants required are shown in Table 5.2.

5.4 Project management will be the responsibility of the consultant selected. However, close cooperation with each company's EDMAC trained engineer is essential. EDMAC will have overall responsibility to review and report on the progress of the various studies. EDMAC's coordinating and reporting role will be important for the follow-on stage when finance for funding the capital investment will be required. On completion of the investment stage EDMAC will monitor and report on the various projects' performances.

5.5 The timing for those projects which will be grouped together is more crucial than for the larger feasibility studies. Consultants responsible for grouped projects will have to prepare detailed work schedules which minimize their lost time. Seasonal factors will influence the load factor of agriculturally based industries and will need to be considered so that the feasibility studies will reflect the seasonal nature and therefore energy saving potential of the plant.

5.6 Consultants will make preliminary visits to the plant to identify where energy metering equipment will be installed; temporary metering equipment will be provided by the consultant. After installation of the metering equipment and preliminary analysis of the data, the consultants will start the feasibility study.

5.7 The financial and energy savings which will result from the conservation projects to be defined by these feasibility studies are of significant interest in themselves to the enterprises and to the government. The projects are of even greater interest from the country's point of view as a set of pilot projects for further conservation work in industry and commerce. The feasibility studies are therefore designed to maximize the transfer of technological expertise. The terms of reference for them (Annex 2) emphasize making use of the services of local energy conservation consultants (e.g., CTC Services), and making sure that plant personnel, particularly energy managers and EDMAC trainees, take an active part in the studies. For the feasibility studies and ensuing projects to be successful, the various plant managers will have to guarantee the full-time services of their EDMAC trained engineer. The foreign consultants should be fully briefed on the key role they will have to play in facilitating this technology transfer. These consultants will be providing on-the-job training to the staff they are working with on the feasibility studies. In addition, after reviewing the initial metered plant data and prior to starting the feasibility study itself, they should conduct a short, formal in-house training program in the plant.

5.8 To capitalize on the feasibility studies and maintain the momentum of EDMAC's conservation program, the government should ensure that a financing and project monitoring program will be in place by the time the feasibility studies are complete. As previously noted (para. 1.9), the government has started to address this question.

SUMMARY OF POSSIBLE CONSERVATION PROJECTS FOR EACH FACILITY VISITED a/

a/ Excluding Lever Brothers, Hotel Lanka Oberoi, Colombo General Hospital, Associated Motorways and the Ceylon Ceramics Corporation.

CEYLON STEEL CORPORATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(Total 1983 energy bill: Rs. 85 million)

Project	Cost (Rs. 000) Total	Cost (Rs. 000) Foreign	Cost (Rs. 000) Local	Average Annual Financial Benefit (Rs. 000) Total	Average Annual Financial Benefit (Rs. 000) Foreign a/	Average Annual Financial Benefit (Rs. 000) Local	Simple Payback (years) Financial b/	Simple Payback (years) Economic c/
Scrap densification: improved manual sizing	250	--	250	500	350	150	0.5	0.1
Scrap preheating from furnace stack gases	6,500	3,000	3,500	1,500	1,050	450	4.3	1.8
Replacement of existing "hot" tundish for new "cold" tundish	500	50	450	5,000	4,500	500	.1	less than 1 month
Oxygen injection	5,000	1,000	4,000	2,500	1,750	750	2.0	1.0
Instantaneous quality analysis of billets	2,000	1,500	500	3,000	2,700	300	0.7	0.8
Improvement of mill operations	2,000	1,000	1,000	2,000	1,800	200	1.0	1.0
Control of maximum electrical demand	5,200	4,700	500	5,200	3,640	1,560	1.0	0.5
Improvements to reheat furnace								
o Insulation	2,000	1,500	500	500	450	50	4.0	4.7
o Waste heat usage	1,800	1,000	800	500	450	50	3.6	3.7
o Automatic burner control	2,100	1,900	200	1,000	900	100	2.1	2.7
Total	27,350	15,650	11,700	21,700	17,590	4,110	1.3	0.9

Mid-1984 exchange rate: 1 U.S. dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70% of market price and that the foreign content of oil is 90% of market price.

b/ Total cost/average annual financial benefits.

c/ Estimates taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5% of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- o Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- o Opportunity cost of fuel oil = 75% of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

CEYLON PLYWOOD CORPORATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(Estimated 1984 energy bill: Rs. 14.5 million)

Project	Cost (Rs. 000) Total	Cost (Rs. 000) Foreign	Cost (Rs. 000) Local	Average Annual Financial Benefit (Rs. 000) Total	Average Annual Financial Benefit (Rs. 000) Foreign a/	Average Annual Financial Benefit (Rs. 000) Local	Simple Payback (years) Financial b/	Simple Payback (years) Economic c/
Dust extraction and system improvements	1,350	1,215	135	363	254	109	3.7	5.0
Replacement of steam heat exchangers with air heaters	800	0	800	1,100	770	330	0.7	immediate
Steam system rehabilitation	500	250	250	600	--	600	0.8	N/A
Electrical load management	250	0	250	1,000	700	300	0.25	immediate
Electricity generation from wood waste gasifier	25,000	22,500	2,500	7,000	4,900	2,100	3.6	1.9
Total	27,900	23,965	3,935	10,063	6,624	3,439	2.8	1.9

Mid-1984 exchange rate: 1 U.S. dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70% of market price and that the foreign content of oil is 90% of market price.

b/ Total cost/average annual financial benefits.

c/ Estimates taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5% of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- o Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- o Opportunity cost of fuel oil = 75% of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

NATIONAL PAPER CORPORATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(Total 1983 energy bill: Rs. 63.6 million)

Project	Cost (Rs. 000) Total	Foreign	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign a/	Local	Simple Payback (years) Financial b/	Economic c/
Energy audit instrumentation	700	620	80	1,900	1,500	400	0.4	0.5
Boiler improvement	1,000	800	200	1,400	1,260	140	0.7	0.9
Black liquor recovery system	N/A			N/A			N/A	N/A
Waste heat recovery from paper dryer	5,000	4,000	1,000	5,250	4,725	525	0.9	1.1
Reduction of pulping energy requirements	120	20	100	1,000	900	100	0.1	0.1
Reduction of drying requirements	0	0	0	1,000	900	100	Immediate	Immediate
New multi-fuel boiler/ cogeneration	85,000	68,000	17,000	18,000	16,200	1,800	4.7	3.6
Total	91,820	73,440	18,380	28,550	25,485	3,065	3.2	2.9

Mid-1984 exchange rate: 1 U.S. dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70% of market price and that the foreign content of oil is 90% of market price.

b/ Total cost/average annual financial benefits.

c/ Estimates taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5% of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- Opportunity cost of fuel oil = 75% of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

RICHARD PIERIS & COMPANY LTD.: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(1983 Energy Bill: Rs. 13.5 Million)

Project	Cost (Rs. 000) Total	Foreign	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign a/	Local	Simple Payback (years) Financial b/	Economic c/
Improving steam distribution system	500	200	300	780	700	80	0.6	0.6
New wood-fired boiler	5,000	4,500	500	3,744	3,370	374	1.3	1.7
Total	5,500	4,700	800	4,524	4,070	454	1.2	1.5

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70% of market price and that the foreign content of oil is 90% of market price.

b/ Total cost/average annual financial benefits.

c/ Estimates taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5% of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- Opportunity cost of fuel oil = 75% of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

PARANTHAN CHEMICALS CORPORATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(1983 energy bill: Rs. 18.0 million)

Project	Cost (Rs. 000) Total	Foreign	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign	Local	Simple Payback (years) Financial a/	Economic
Plant retrofit with new equipment b/	22,650	n/a	n/a	3,800	n/a	n/a	6.0	n/a
Total	22,650	n/a	n/a	3,800	n/a	n/a	6.0	n/a

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

n/a: not applicable or not available.

a/ Total cost/average annual financial benefits.

b/ Given the extent of the work involved and questions as to PCC's economic viability, only the total cost, the total average annual financial benefits, and the simple financial payback were estimated.

PRIMA CEYLON LTD.: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(1983 energy bill: Rs. 77.4 million)

Project	Cost (Rs. 000) Total	Cost (Rs. 000) Foreign	Cost (Rs. 000) Local	Average Annual Financial Benefit (Rs. 000) Total	Average Annual Financial Benefit (Rs. 000) Foreign a/	Average Annual Financial Benefit (Rs. 000) Local	Simple Payback (years) Financial b/	Simple Payback (years) Economic c/
Boiler modifications								
o Retrofitting boilers	1,250	1,000	250	2,100	1,890	210	0.6	0.7
Diesel engine waste heat recover (boiler)	3,000	2,400	600	2,175	1,960	215	1.4	1.7
(Organic Rankine cycle)	(66,000)	(59,400)	(6,600)	(9,180)	(6,425)	(2,755)	(7.2)	(3.9)
Total d/	4,250	3,400	850	4,275	3,850	415	1.0	1.2

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70 % of market price and that the foreign content of oil is 90 % of market price.

b/ Total cost/average annual financial benefits.

c/ Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 % of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- o Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs, Rs. 2.0 (US$0.08)/kWh for market price.
- o Opportunity cost of fuel oil = 75 % of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

d/ Excluding Organic Rankine Cycle, likely to be considered a too capital-intensive project.

BRITISH CEYLON CORPORATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS

Project	Cost (Rs. 000) Total	Foreign	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign a/	Local	Simple Payback (years) Financial b/	Economic c/
Improved boiler performance c/	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Replacement of steam ejectors for oil deodorization	375	338	37	500	450	50	<1.0	n/a
Replacement of steam ejectors for chilling water c/	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Installation of capacitors	400	360	40	216	151	65	1.9	n/a
Total	775	698	77	716	601	115	1.1	n/a

Mid-1984 exchange rate: 1 U.S. dollar = Rs. 25.

n/a: not applicable or not available.

a/ EDMAC estimates that the foreign content of electricity is 70% of market price and that the foreign content of oil is 90% of market price.

b/ Total cost/average annual financial benefits.

c/ Due to a lack of sufficiently detailed data on energy efficiency at BCC, only financial paybacks were calculated, and the costs and benefits of two of the conservation projects identified as possible could not be estimated with sufficient reliability.

PUGODA TEXTILE MILLS: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(Total 1983 energy bill: Rs. 28 million)

Project	Cost (Rs. 000) Total	Cost (Rs. 000) Foreign	Cost (Rs. 000) Local	Average Annual Financial Benefit (Rs. 000) Total	Average Annual Financial Benefit (Rs. 000) Foreign a/	Average Annual Financial Benefit (Rs. 000) Local	Simple Payback (years) Financial b/	Simple Payback (years) Economic c/
Heat recovery devices	1,200	960	240	700	630	70	1.7	2.1
Installation of a capacitor for power factor control	240	216	24	288	202	86	0.8	0.5
Reducing energy consumption in the chiller unit	800	400	400	370	260	110	2.2	0.9
Automatic control of the burners	1,600	1,280	320	888	800	88	1.8	2.2
Total	3,840	2,865	986	2,246	1,892	354	1.7	1.4

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70 % of market price and that the foreign content of oil is 90 % of market price.

b/ Total cost/average annual financial benefits.

c/ Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 % of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- Opportunity cost of fuel oil = 75 % of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

DUNAGHA COCONUT PRODUCERS COOPERATIVE SOCIETY: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(1983 energy bill: Rs. 1.1 million)

Project	Cost (Rs. 000) Total	Cost (Rs. 000) Foreign	Cost (Rs. 000) Local	Average Annual Financial Benefit (Rs. 000) Total	Average Annual Financial Benefit (Rs. 000) Foreign a/	Average Annual Financial Benefit (Rs. 000) Local	Simple Payback (years) Financial b/	Simple Payback (years) Economic c/
Installation of power factor correction	40	32	8	48	34	14	0.8	0.4
Improvement to sterilizer								
o Insulation	10	6	4	12	11	1	0.8	0.9
o Replacing burner	175	140	35	168	151	17	1.1	1.3
Waste heat recovery from dryers	150	135	15	100	0	100	1.5	N/A
Efficiency improvements in air heaters	500	0	500	108	0	108	4.6	N/A
Total	875	313	562	436	196	240	2.0	N/A

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

N/A: Not applicable

a/ EDMAC estimates that the foreign content of electricity is 70 % of market price and that the foreign content of oil is 90 % of market price.

b/ Total cost/average annual financial benefits.

c/ Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 % of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- Opportunity cost of fuel oil = 75 % of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

CEYLON GLASS COMPANY, LTD. (RATMALANA FACTORY): SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(1983 energy bill: Rs. 23.1 million)

Project	Cost (Rs. 000) Total	Foreign	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign a/	Local	Simple Payback (years) Financial b/	Economic c/
Improvements in instrumentation	625	563	62	435	392	43	1.4	1.8
Insulation of furnance	5,000	3,500	1,500	2,890	2,600	290	1.7	2.0
Automatic air/fuel ratio control	800	720	80	580	522	58	1.4	1.7
Burner replacement	1,800	1,440	360	870	783	87	2.1	2.8
Recovery of waste heat from flue gases	1,350	810	540	600	540	60	2.25	2.4
Total	9,575	7,033	2,542	5,375	4,837	538	1.8	2.1

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70 % of market price and that the foreign content of oil is 90 % of market price.

b/ Total cost/average annual financial benefits.

c/ Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 % of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- o Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- o Opportunity cost of fuel oil = 75 % of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

TEA ESTATES: MATTAKELLE STATE TEA PLANTATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(1983 energy bill: Rs. 2.9 million)

Project	Cost (Rs. 000)			Average Annual Financial Benefit (Rs. 000)			Simple Payback (years)	
	Total	Foreign	Local	Total	Foreign a/	Local	Financial b/	Economic c/
Design of new wood-fired air heaters (2 numbers)	600	0	600	472	118	354	1.3	0.8
Use of dryer waste heat for drying firewood	60	0	60	24	0	24	2.5	N/A
Use of biogas	200	50	150	85	0	85	2.4	N/A
Use of mini and micro hydro-power systems to serve four estates*	(30,000)	(18,000)	(12,000)	(4,800)	(3,360)	(1,440)	(6.25)	(2.8)
Total	860	50	810	581	118	463	1.5	N/A

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

N/A: Not applicable

a/ EDMAC estimates that the foreign content of electricity is 70 % of market price and that the foreign content of oil is 90 % of market price.

b/ Total cost/average annual financial benefits.

c/ Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5% of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- Opportunity cost of fuel oil = 75 % of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SRI LANKA (CEYLON) RUBBER MANUFACTURING COMPANY LTD.: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(Total 1983 energy bill: Rs. 640,000)

Project	Cost (Rs. 000) Total	Foreign	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign a/	Local	Simple Payback (years) Financial b/	Economic c/
Power factor correction	50	40	10	76	53	23	0.6	0.3
Use of a multifuel air heater with crumb rubber dryer	600	0	600	313	272	31	1.8	1.3
Total	650	40	610	389	335	54	1.7	0.9

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70 % of market price and that the foreign content of oil is 90 % of market price.

b/ Total cost/average annual financial benefits.

c/ Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 % of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US\$0.14)/kWh vs. Rs. 2.0 (US\$0.08)/kWh for market price.
- Opportunity cost of fuel oil = 75 % of market price, or US\$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

CEYLON TOBACCO COMPANY, LIMITED (CTC): SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(1983 energy bill: Rs. 8.6 million)

Project	Cost (Rs. 000) Total	Cost (Rs. 000) Foreign	Cost (Rs. 000) Local	Average Annual Financial Benefit (Rs. 000) Total	Average Annual Financial Benefit (Rs. 000) Foreign a/	Average Annual Financial Benefit (Rs. 000) Local	Simple Payback (years) Financial b/	Simple Payback (years) Economic c/
Steam system rehabilitation and waste heat recovery	600	360	240	260	234	26	2.3	2.5
Installation of a multifuel boiler	2,500	1,750	750	742	668	74	3.3	3.8
Total	3,100	2,110	990	1,002	902	100	3.1	3.5

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

a/ EDMAC estimates that the foreign content of electricity is 70 % of market price and that the foreign content of oil is 90 % of market price.

b/ Total cost/average annual financial benefits.

c/ Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 % of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- Opportunity cost of fuel oil = 75 % of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

Annex 2: Detailed Prefeasibility Study Results by Corporation/Company Visited

a/ The government has requested that detailed information on the Ceylon Ceramics Corporation and Associated Motorways, Ltd. not be published. Donors who are interested in details of energy efficiency investment opportunities in these two companies should contact the respective companies directly.

CEYLON STEEL CORPORATION

Summary

The Ceylon Steel Corporation (CSC) is currently facing financial difficulties owing to high production costs and competition from cheaper imported products.

Extensive discussions with CSC management and a visit to the plant indicate that there is substantial potential for energy cost reduction. It is estimated that up to Rs. 22 million could be saved annually (about 25% of CSC's total energy bill) for an investment of Rs. 27 million -- that is, a simple financial payback of 1.3 years (see Exhibit A). Shutting down the melting operation would improve profitability substantially.

An overall review of CSC's operations, comparative advantage, and incentive framework should be made in order to resolve the issue of the Corporation's financial viability. Substantial investments in energy efficiency equipment should await the outcome of such a review.

Exhibit A
Ceylon Steel Corporation: Summary of Possible Energy Conservation Projects
(Total 1983 energy bill: Rs.85 million)

Project	Cost (Rs.000) Total	Foreign*	Local	Average Annual financial Benefit (Rs.000) Total	Foreign 1/	Local	Simple payback (years) Financial 2/	Economic 3/
Scrap densification: improved manual sizing	250	—	250	500	350	150	0.5	0.1
Scrap preheating from furnace stack gases	6,500	3,000	3,500	1,500	1,050	450	4.3	1.8
Replacement of existing "hot" tundish by new "cold" tundish	500	50	450	5,000	4,500	500	.1	less than 1 month
Oxygen injection	5,000	1,000	4,000	2,500	1,750	750	2.0	1.0
Instantaneous quality analysis of billets	2,000	1,500	500	3,000	2,700	300	0.7	0.8
Improvement of mill operations	2,000	1,000	1,000	2,000	1,800	200	1.0	1.0
Control of maximum electrical demand	5,200	4,700	500	5,200	3,640	1,560	1.0	0.5
Improvements to reheat furnace								
o Insulation	2,000	1,500	500	500	450	50	4.0	4.7
o Waste heat usage	1,800	1,000	800	500	450	50	3.6	3.7
o Automatic burner control	2,100	1,900	200	1,000	900	100	2.1	2.7
TOTAL	27,350	15,650	11,700	21,700	17,590	4,110	1.3	0.9

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.
*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).
1 EDMAC estimates that the foreign content of electricity is 70 % of market price and that the foreign content of oil is 9% of market price.
2 Total cost/average annual financial benefits.
3 Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:
 o Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price
 o Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly & Company.

CEYLON STEEL CORPORATION

1. Background

CSC, the only steel mill in Sri Lanka, is located at Athurugiriya. Phase I of the mill, consisting of a furnace and rolling mill using imported billets and a wire mill, began operating in 1965. Feasibility studies were initiated in 1958 under the Soviet protocol for economic assistance. Phase II, which consists of a 60,000 tonne/year melting shop using domestic scrap, was commissioned in 1982 following 7 years of study, and was financed by the USSR.

Process description. The process consists of two separate operations -- the melting operation and the reheat/rolling operation. The melting shop consists of a 25 tonne/heat 15-MVA electric arc furnace of Soviet manufacture, with water and oil cooling systems. Voltage is 11 kV, and current is regulated by thyristors. Scrap, which is purchased on the island, is sized and then baled prior to introduction into the furnace. The melting operation lasts 4 to 5 hours, although the design duration is 2 hours and 55 minutes. When the temperature reaches 1,680°C, the "heat" is ready for casting and poured into a 25-tonne capacity ladle that in turn feeds a four-chambered tundish, preheated for 2.5 hours by 1500 sec furnace oil. The liquid steel then flows to the continuous caster located underneath. The billets are discharged vertically and then turned horizontally prior to reaching a conveyor. At this stage, billets are cooled by spray water (no heat recovery). After cutting/sizing, billets are placed in a storage area, where they are subject to quality tests.

The second operation, which is located approximately 1,000 feet from the melting shop, consists of a reheat furnace and a rolling mill. Both cold billets from the storage area and imported billets are processed in the reheat furnace, which can handle up to 100,000 tonnes/year (28 tonnes/hour). In the reheat furnace, billets are heated to 1,250°C-1,350°C. After reheating, billets are driven to the rolling mill, where they are rolled to the required profile. About seven different profiles and various dimensions within each profile are available.

Rolling production peaked in 1980 at 57,000 tonnes and decreased to 42,300 tonnes in 1981, 25,000 tonnes in 1982, and about 26,000 tonnes in 1983. Production in 1984 is not likely to be better. The melting shop, which started operation in mid-1982, produced 6,230

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tonnes in 1982 and 9,329 tonnes in 1983. There was no melt during the first 4 months of 1984 (see Exhibit 1).

Markets. All products are sold on the domestic market, where they compete with products from Singapore, India, South Africa, and other Asian countries. Major market segments are construction and metal fabrication.

Organization. See energy management organization.

Employment. Employment, which reached a maximum of about 3,000, is now about 1,000 because of the production drop. Approximately 300 are maintenance personnel.

Financial situation. As a result of increasing competition with low-cost imports of billets and rolled products, CSC's financial situation has deteriorated over the past 3 years. In 1980, with a record production of 57,000 tonnes, profits were Rs. 24.3 million. In 1981, production decreased to 42,300 tonnes, and CSC had profits of Rs. 5.5 million. Production plunged in 1982 to 25,000 tonnes, the lowest in more than 10 years, and losses totaled Rs. 24.7 million. In 1983, production was 26,000 tonnes and losses Rs. 62.9 million, bringing the total losses carried forward (after adjustment) to Rs.112.7 million. By commissioning Phase II, instead of improving financial performance by eliminating the purchase of imported billets, CSC increased its losses, as the cost of producing billets was higher than purchasing them in the international market. It is clear that the government will have to make crucial decisions about CSC's future operation.

Project evaluation criteria. For many years, the amount of foreign exchange saved was the key element in project evaluation. Now, following guidelines issued by the Ministry of Industry, CSC evaluates projects on the basis of their ability to generate sufficient cash to fund repayment.

Existing plans for modernization/expansion. As of May 1984, no capital investment was under consideration at CSC because of the financial situation. Current efforts are aimed at improving the efficiency of existing operations, with emphasis on lowering production costs by minimizing down time.

Exhibit 1

Production (tonnes)

		Rolling mill	Drawn wire	Galvanizing	Welded mesh	Foundry	Melting shop (tonnes/melts)
1981	January	3,729	260	193	48	53	
	February	2,970	407	170	75	41	
	March	901	965	183	128	31	
	April	682	467	160	42	24	
	May	3,930	583	183	68	26	
	June	3,925	582	46	30	32	
	July	6,782	1,028	114	72	53	
	August	3,912	747	179	128	43	
	September	1,375	716	175	78	29	
	October	1,714	559	279	26	22	
	November	4,752	581	215	107	28	
	December	4,332	165	198	77	24	
	Total	39,004	7,060	2,095	879	406	
1982	January	2,149	65	60	48	40	
	February	1,152	391	125	38	40	
	March	2,782	326	23	115	60	
	April	1,121	3	0	0	21	
	May	3,756	62	24	3	61	214
	June	1,808	139	22	10	85	868
	July	2,001	228	55	0	52	801/38
	August	1,270	275	45	0	36	994/52
	September	1,218	371	69	1	44	596/33
	October	1,557	257	39	8	34	950/50
	November	3,682	504	5	61	45	1,156/55
	December	871	314	28	49	7	651/32
	Total	23,367	2,935	495	361	475	6230/
1983	January	2,368	277	69	45	20	335/18
	February	2,686	124	48	46	43	457/13
	March	2,029	64	28	50	45	1,378/70
	April	1,702	14	0	7	24	716/37
	May	2,461	14	0	37	42	1,001/58
	June	2,534	0	0	0	58	1,532/78
	July	1,673	0	0	0	1,934	957/52
	August	0	337	52	11	31	812/49
	September	4,269	32	23	45	83	1,108/58
	October	2,251	459	0	0	18	1,033/
	November	1,330	54	27	17	42	
	December	1,168	338	199	64	15	
	Total	24,465	1,713	506	321	420	9,329/
1984	January	278	256	99	85	13	
	February	2,356	81	58	47	21	
	March	2,084	81	0	0	21	
	April	795	6	0	4	6	

SOURCE: Ceylon Steel Corporation.

Major problems facing facility. CSC's major problem is its poor financial performance resulting from high production costs and competition from cheaper, and sometimes higher quality, imports. Billet production costs currently range from Rs.6,000/tonne, when there are no production problems, to Rs.9,000/tonne in other cases. Of the Rs.9,000/tonne in costs, about Rs.3,200 is for energy (electricity and furnace oil), Rs.1,400 for scrap, and the balance for other materials, labor, and financial cost. Import prices of similar billets are about U.S. $240/tonne plus 5 percent duty, or roughly Rs.6,300/tonne. Unless production is maintained at a high level (say, 150 tonnes/day), production costs at CSC are significantly higher than import prices. As it will be difficult for CSC to cut costs significantly through reduced employment and reduced scrap cost, energy use represents the prime target of cost-cutting programs. It is shown later that energy cost reductions can reach U.S. $20/tonne, or about 6 percent of total production costs.

2. Energy Situation

Major energy-using equipment. The major energy-using equipment comprises the electric arc melting furnace (15 MVA), the reheat furnace (70 GJ/hr), the boilers (about 4.5 tonnes of steam/hour, or 16.2 GJ/hour) for oil atomization and various metal surface treatments, and the rolling mill. The rolling mill is the largest user of electricity (20 MVA installed capacity). Furnace oil is used in the reheat furnace by six burners with steam atomization. Steam is produced by two boilers at 200°C; only one boiler operates at a time. The reheat furnace is equipped with a recuperator for air reheating at 150°C-200°C.

Energy consumption. Total annual fuel oil consumption rose from 1.23 million gallons in 1971 to 1.9 million gallons in 1981. Oil consumption in 1982 was down to 1.7 million gallons, and in 1983, consumption was 1.6 million gallons (see Exhibit 2). Electricity consumption increased from 21.17 GWh in 1979 to 28.1 GWh in 1983 with the commissioning of Phase II (electric arc furnace). Maximum demand reached 18.4 MVA.

Energy prices. In 1983, the price of furnace oil was Rs.4,600/tonne (1500 sec), and the average overall price of electricity was about Rs.2 (consisting of Rs.052/unit, a 110-185 percent fuel adjustment

Exhibit 2

MONTHLY ENERGY CONSUMPTION ROLLING MILL 1982/1983

1982

Month	Consumption of Fuel Oil (TOE)	Consumption of Electricity (TOE)	Total Energy Consumption (TOE) Fuel + Electricity	Production in M/T	Energy Index TOE/MT
January	[illegible].57	213.90	405.47	2149.55	0.189
February	283.82	279.43	563.25	1151.55	0.489
March	336.25	352.41	688.66	2778.66	0.248
April	87.30	175.34	262.64	1120.58	0.234
May	303.50	269.84	573.34	3755.76	0.153
June	334.91	324.20	659.11	2542.50	0.259
July	222.13	138.07	860.20	1123.18	0.766
August	239.55	151.12	390.67	576.40	0.678
September	263.35	235.12	498.47	1488.17	0.335
October	260.79	252.07	512.81	1557.37	0.329
November	357.43	290.63	648.06	3682.38	0.176
December	277.43	291.04	568.47	870.94	0.653
TOTAL			6631.15	22797.04	.2908

Source: Ceylon Steel Corporation

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Exhibit 2 Continued

MONTHLY ENERGY CONSUMPTION ROLLING MILL 1982/1983

1983

M O N T H	Consumption of Fuel Oil (TOE)	Consumption of Electricity (TOE)	Total Energy consumed (TOE) Fuel & Elec-tricity	Production in M/T	Energy Index TOE/MT
January	320.18	324.04	644.22	2368.37	0.272
February	311.69	245.84	557.53	2680.75	0.208
March	273.81	262.93	536.74	2028.88	0.265
April	247.05	191.19	438.19	1702.44	0.257
May	284.15	263.06	547.21	2520.32	0.217
June	297.84	290.79	588.63	2566.05	0.229
July	230.78	205.05	435.83	3365.20	0.130
August	59.37	125.76	185.13	-	0.0
September	367.42	343.37	710.79	3909.65	0.182
October	387.65	294.46	682.11	2251.44	0.303
November	254.10	279.48	534.08	1304.39	0.409
December	229.15	239.98	469.13	1168.30	0.402
T O T A L			6329.59	25865.72	0.2447

Source: Ceylon Steel Corporation

-/rp

surcharge, and a Rs.90/kVA demand charge). As a result, the total 1983 energy bill was roughly Rs.85 million (including melting) (total 1983 sales were Rs.322 million), up from Rs.17 million in 1979, when production was about double the 1983 level (but without the melting operation).

Supply characteristics. CSC management mentioned no specific problems related to furnace oil and electricity supply. CSC gets its power directly from the Laxapana power plant.

Specific energy consumption. At the melting shop, electricity consumption for melting alone ranges between 800 and 900 kWh/tonne, versus a design consumption of 600-700 kWh/tonne and a consumption of 450-500 kWh/tonne in most efficient electric arc furnaces (Japan, Sweden). Total electricity consumption for the melting shop, including ancillary consumption (e.g., scrap preparation, casting, conveyor), is between 1,300 and 1,500 kWh/tonne. Fuel consumption in the melting shop is 55 gallons/heat (25t) or 0.3 GJ/tonne.

Fuel consumption by the reheat furnace ranges between 14.5 and 18.0 gallons/tonne. Electricity consumption by the rolling mill shop, including the reheat furnace, ranges between 320 and 450 kWh/tonne, which seems high compared with international standards (200 +/-50 kWh/tonne).

Energy management organization. An energy manager was appointed following recommendations from the Ministry of Industry. However, the energy manager, who reports to the additional general manager, has other important duties (chief service engineer) that take priority over energy activities. As a result, there is no permanent staff assigned to energy management activities. Such a permanent function would be desirable if projects proposed in this report are being implemented.

Past energy conservation activities. Over the last 4 years, a number of initiatives have been taken to reduce energy costs. These initiatives include: a switch from 800 sec furnace oil to heavier and cheaper 1500 sec; improved maintenance of economizers in the boiler; improved insulation and operation of furnace reheat; repair of steam and compressed air leaks; and development of an energy index that is discussed by plant staff and management every 2 weeks (this energy index measures the specific furnace oil and electricity consumption per tonne produced over the period).

3. Energy Conservation Potential

Based on a field visit conducted on May 29, 1984, there appears to be significant potential for conservation in both the melting shop and the rolling mill. Unfortunately, the distance between the two operations exceeds 1,000 feet, which results in high heat losses during the transportation of hot billets from one area to the other. However, because of multiple technical problems in the melting shop and long lead times required for quality control (several hours), billets are currently stored for long periods of time before processing in the rolling section, and the mill does not operate continuously. CSC hopes to solve this problem in the near future.

Possible projects in the melting shop include:

- Scrap densification
- Scrap preheating from furnace stack gases
- Replacement of the existing hot tundish by a new "cold" tundish
- Oxygen injection
- Instantaneous quality analysis of billets.

Projects in the rolling mill consist of:

- Technical and operational improvements of the rolling section
- Power factor correction in the rolling section
- Improvement of the reheat furnace and associated steam boilers.

Each of these projects is presented in more detail below, and the costs, benefits, and implementation characteristics are estimated. If all the suggested projects are implemented, energy savings in the melting shop can reach 15 percent and in the rolling mill, 25 percent, resulting in a cost reduction of approximately U.S. $20/tonne of final product.

3.1 Potential Energy Conservation Projects in the Melting Shop

3.1.1 Scrap densification. At present, scrap is cut manually into 20-inch pieces and then compacted. Up to three batches are necessary for a 25-tonne heat, resulting in a melting duration of 4-5 hours versus less than 3 hours in similar operations elsewhere. The scrap densification project entails (a) the installation of a new, small baling press to allow a single loading operation (bucket) and consequently reduce heat losses resulting from opening the furnace roof, and (b) improved manual sizing.

a. New, small baling press

Cost

Foreign: Up to Rs.10 million
Local : Rs.1 million
Total : Rs.11 million.

Savings. Detailed thermal calculations are necessary to specify savings, but preliminary estimates indicate that 5 percent of the electricity used by the furnace could be saved, or 40 kWh (Rs.80) per tonne. This figure corresponds to annual savings of up to Rs.1.2 million at projected capacity utilization factor of 600 heats or 15,000 tonnes per annum (average annual production of the melting plant is expected to be 10,000-12,000 tonnes).

Payback. 10 years or more.

Therefore, this project will not be retained.

b. Improved manual sizing

Cost. Using more labor to cut and size the scrap (down to 5-inch pieces) would cost about Rs.250,000 in foreign exchange (simple cutting equipment) and about Rs.30,000 to Rs.50,000 in labor annually.

Savings. Assuming a 2-percent reduction in the amount of electricity currently used, about Rs.500,000 could be saved annually.

Payback. 7 months.

Implementation. Minor training will be required.

3.1.2 **Scrap preheating from furnace stack gases.** Roughly 100 kWh/tonne* are recoverable from furnace stack gases. The project entails installing a simple recovery system (with gas post-combustion chamber) and building a steel chamber to allow scrap preheat. Based on similar projects carried out elsewhere, a conservative estimate for actual savings at CSC would be 50 kWh/tonne.

Cost. Based on a similar project currently being implemented in the Philippines, not more than Rs.6.5 million, if manufactured locally (three to five times more if imported).

Savings. Up to 50 kWh/tonne of melted steel, or Rs.1.5 million annually at the projected capacity utilization (15,000 tonnes/year).

Payback. 4.3 years.**

Implementation. Implementation would take 6 to 9 months and could be done by mill staff under foreign specialist guidance.

3.1.3 **Replacement of existing "hot" tundish by new "cold" tundish.** Molten steel is currently poured from the bucket into a four-section "hot" tundish preheated by furnace oil for an arbitrary 2.5 hours. Melting shop management indicated that this operation was a source of waste, as they had no standard preheating time to refer to, and about 2 gallons of furnace oil were used per tonne of steel. The project suggested by management would entail installing a new tundish system with a special refractory that would require no preheating.

Cost. The initial project investment fixed cost (for hardware) -- all local -- is estimated at Rs.0.5 million, excluding refractory costs.

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*Based on heat balances developed by Nikko in Japan, up to 20 percent of energy input (or about 170 kWh/tonne) is available in sensible heat of exhaust gases, and about 60 percent of this heat can be recovered.

**This is a conservative estimate, as other benefits such as savings in electrode consumption would also occur and are not accounted for.

Savings. Taking into account differences in refractory costs between "hot" and "cold" and fuel savings, CSC estimates that Rs.8,000 per melt could be saved, or roughly Rs.5 million annually (U.S. $13/tonne).

Payback. 1 month.

Implementation. Plant management indicated that the tundish could be made at the mill itself in about 1 month, with no disruption of operations. No foreign assistance is required, except for initial instruction in installation of the new refractories.

3.1.4 Oxygen enrichment (oxyfuel burner). Injecting oxygen into the melt is a proven means of saving electricity.

Cost. If oxygen is purchased locally (from Ceylon Oxygen Company, which has excess capacity) and stored in a special tank, the project cost would be Rs.5 million/year. If CSC wished to operate its own oxygen plant, the investment cost would be much higher, about Rs.20 million.

Savings. Based on international experience, 10 percent of the electricity used could be saved, or 80 kWh/hr, corresponding to about Rs.2.5 million. Corresponding oxygen consumption would be about 30 Nm^3/tonne.

Payback. About 2 years if oxygen is purchased locally and more than 10 years if CSC installs its own oxygen plant,taking into consideration the high cost of electricity used to produce the oxygen.

Implementation. Initially, the installation of the local oxygen system would take 2 to 3 months, and no production disruption is anticipated. Foreign consultant requirements would be about 1 to 2 man-months.

3.1.5 Automatic analyzer for instantaneous quality measurement of billets. Such a system is required to allow direct and immediate transportation of hot billets to the reheat furnace.

Cost. About Rs.2 million (to be estimated by specialists).

Savings. Assuming that heat loss is reduced from 100 to 20 percent between the melting shop and reheat furnace, about 10 gallons of furnace oil could be saved per tonne produced, or about Rs.200/tonne (U.S. $8), corresponding to annual savings of Rs.3 million.

Payback. 8 months.

Implementation. No production disruption is expected.

3.2 Potential Energy Conservation Projects in the Rolling Mill

3.2.1 Improvement of mill operations

Description. There are many delays in milling operations that are termed "technological" delays by the managerial staff. The inability to quickly move the billets through the various rolling stages is the result of:

- A mismatch of rolling speed and billet properties
- Poor spacing of profile rolls
- Incorrect operation of rolling mill.

The net result of these delays is, first, a reduction throughput from its design value, and second, non-uniform throughput in the billet heating furnace, leading to high fuel oil consumption. In addition, electricity consumption is increased because mills are sometimes run without load during delays.

Hence, an energy conservation project in this area would require a complete analysis of rolling mill operations, including reasons for delays and down time. Also, waste minimization would be considered. Additional training of skilled supervisory and managerial staff would be a necessary part of this project. Foreign consultants are also expected to be needed to properly analyze mill operations.

Cost. Foreign: Rs.625,000-Rs.1 million; local: Rs.500,000-Rs.1 million. Foreign costs will include payments to consultants and funds for training key personnel. Local costs will include local counterpart funds for consultants and funds for training other personnel.

Savings. It is conservatively estimated that reheat furnace fuel consumption can be reduced by 10 percent. The savings per year would thus average 100,000 gallons of furnace oil at Rs.4.46/liter, or a total of approximately Rs.2 million per year.

Payback. The simple payback for this measure would be about 1 year.

Implementation. The implementation of this measure would require 2 years, as follows:

Study by foreign consultants	2 months
Training of local staff abroad	8 months
Training of lower level staff locally	1 year.

A specialist consultant familiar with problem-solving in steel rolling mills (if possible, with special reference to Russian plants) would be required for this study.

3.2.2 Control of maximum electrical demand

Description. The total installed capacity of this mill is around 20 MVA in Stage 1 and a projected 36 MVA in Stage 2, of which 18 MVA is currently installed, for a total of 38 MVA. Power factor correction was originally to be carried out by means of a large synchronous compensator that could handle a projected load of about 60 MVA. At the present time, the maximum demand is usually on the order of 6.5-18 MVA when Stage 1 alone is operating, although demand rises to about 18-20 MVA when the melting shop (Stage 2) is also operating.

The overall plant power factor is probably no better than about 0.85 at present. Hence, a project to improve the power factor to around 0.98 or more for the entire plant, with sufficient turndown capability to cater for periods of operation at low throughput rates, would be very worthwhile.

Cost. Considering continued operation at around 36 MVA and an existing power factor of 0.85 corrected to 0.98:

Ratio of capacitor MVA to actual MW	= 0.45 (from tables)
Capacitor actual kVAR	= 36 x 0.85 x 0.45 = 13 MVA

Cost = Rs.5.2 million.
(Cost per kVAR = Rs.400.).

Savings. Reduction in maximum demand = 36 - ((36 x 0.85)/0.98) = 4.78 MVA; savings per year = Rs.5.162 million.

Payback. The payback for this measure would be about 1 year.

Implementation. Prior to implementation of the measure, it is recommended that an audit of the electrical system be carried out, with special reference to power factor and maximum demand, to determine the optimum method of effecting power factor improvements. This study should take into account prolonged operation at low throughput rates and also operation of individual stages.

This study can be undertaken by a combined team of factory engineers and local consultants specializing in power factor correction. Foreign consulting services would be necessary only with regard to the use of synchronous compensators.

The following implementation schedule is anticipated:

Audit of electrical system and technical specification	4 months
Procurement and installation of equipment	1 year.

3.2.3 Improvements to reheat furnace

Description. There are currently significant heat losses from the furnace walls, owing to poor insulators, escape of hot gases, and general deterioration of the furnace. By completely reinsulating the reheat furnace with a high-quality material of the correct thickness, it would be possible to decrease oil consumption by about 7 percent (i.e., about 1 gallon of fuel oil per tonne of billets heated). Insulation would be of ceramic fiber or other material that gives a similar performance.

One steam boiler is used to atomize fuel oil for the reheat furnace while the other boiler is on standby. Waste gases from the reheat furnace pass into a ceramic recuperator, which heats incoming combustion air to around 150°C. However, the exhaust from the recuperator is still quite hot, around 300°C. Currently, this heat is wasted in discharge to the atmosphere through the flue. Also, there is an older watertube boiler that is currently standing idle.

Hence, the waste gases could be ducted into the watertube boiler for steam raising. Supplementary firing with oil may still be necessary to achieve the final steam temperatures and pressures required. The quality and temperature of waste gas from the reheat furnace vary, owing to difering throughput of billets. Thus, the burner used for supplementary firing must be capable of following the varying heat input from the waste furnace gases. For this purpose, the burner should have a high turndown ratio between high and low fire and should also have an automatic off-on capability for periods when there is substantial heat input from the waste gases alone. The existing burners, therefore, will have to be replaced by new burners.

Furthermore, valves and ductwork would be required to control the waste gas flow from the recuperator. Placing an additional heat recovery device in the path of the flue gases will cause additional back pressure at the reheat furnace end. Due consideration must be given to system design to ensure that pressures in the furnace remain within correct limits at all times. Additional ID fan capacity may be needed to this end.

Control of air/fuel ratios for the burners on the reheat furnace itself is presently carried out manually. Such control leads to enormous difficulties if the furnace firing rate must vary with load and with discharge rate to the rolling mill. Yet a load following capability, if achieved, will result in very significant savings in fuel oil.

This type of load following capability can be easily achieved by installing automatic controls (preferably of pneumatic type for reliability considerations) for all the burners on the furnace, which would precisely control air/fuel ratios throughout a significant turndown range. Prior to fitting such an automatic system, it would be worthwhile investigating optimum furnace performance for different billet throughput rates. The automatic control system can then be specified to suit these conditions. After fitting the automatic control system, further optimization could be carried out by controlling furnace pressures and by progressively reducing billet final temperatures.

Cost.

Insulation of reheat furnace	Rs.2.0 million
Installation of waste heat gas recovery device using existing boiler	Rs.1.8 million
Automation of furnace burner controls	Rs.2.0 million.

Insulation of reheat furnace

Savings. By improving the insulation of the furnace, estimated savings of about 1 gallon/tonne could be achieved. Annual savings, assuming a production rate of 25,000 tonnes, would equal 25,000 gallons of oil or Rs.500,000.

Payback. 4 years.

Installation of waste heat recovery device

Savings. Similarly, the furnace oil saved by using waste heat in the flue gases is estimated at 1 gallon per tonne of steel. Annual savings for 25,000 tonnes of output would equal 25,000 gallons of oil, or Rs.500,000 per year.

Payback. 3.6 years.

Installation of automatic burner controls

Savings. By introducing automatic burner controls, a conservative estimate of around 2 gallons of furnace oil per tonne of steel could be saved, on a year-round production basis. Annual savings for annual production of 25,000 tonnes would equal 50,000 gallons of furnace oil, or Rs.1 million.

Payback. Approximately 2 years.

Implementation. The insulation of the reheat furnace would require 4 months for technical specifications, and procurement and installation would take up to 1 year. For waste heat recovery, an in-depth study and technical specifications would require 5 months and require foreign assistance; procurement, fabrication, and installation would require 1 year. Automation of furnace burner controls would require 2 months of consulting work, 3 months for technical specifications, and 6 months for procurement and installation.

Conclusions

CSC could save up to 20-30 percent of current energy consumption through these projects, with cost savings of up to Rs.1,000/tonne. As a result, CSC's competitiveness with imports would be improved. If all projects are implemented, a total investment of about Rs.27 million would be required. Corresponding expected savings would be on the order of Rs.22 million, for an overall simple payback of about 1.3 years.

As part of conducting feasibility studies for these candidate projects, a detailed analysis (including energy audit) of the rolling mill and the melting shop is necessary. Local staff and management have already collected significant operational data and should work very closely with the expert conducting the analysis. This analysis, which should be conducted by a steel specialist familiar with energy improvement issues and Soviet steel-making processes, would require about 3 man-months on-site plus 1 to 2 months for report preparation. On the basis of the recommendations, CSC should move quickly to implement financially acceptable projects. Particular attention should be given to the anticipated production levels in both melting and rolling sections, as lower capacity factors mean proportionally longer paybacks and lower returns on investments.

4. Terms of Reference

A detailed production and energy analysis of the rolling mill and the melting shop should be conducted. On the basis of this analysis, the consultants will conduct the feasibility studies when required.

4.1 Scope of the Study

In the melting shop, the study should primarily focus on:

- Scrap composition (e.g., more ferrous materials) (3.1.1)*
- Scrap preparation (sizing, baling, loading) (3.1.1)
- Furnace electric system (e.g., design, voltage) (3.1.2, 3.1.4)
- The tundishes (3.1.3)
- Balance of the shop (continuous casting, conveyor).

For each key area of improvement described in Section 3.1, the consultants will prepare detailed energy and mass balances, where required, based on actual representative measurements, as these data will be needed to evaluate accurately project benefits.

In the rolling mill:

- Direct transportation of hot billets from the melting shop to the reheat furnace (3.1.5)
- Mill operation (delays) (3.2.1)
- Electric load management (3.2.2)
- Reheat furnace (3.2.3)
- Boilers (3.2.3).

On the basis of the results of this analysis, the consultants will identify potential projects, estimate costs and benefits, and evaluate the financial and economic performance of each project. Recommendations for implementation will be provided. On the basis of these economic and financial analyses, the consultants will rank proposed projects according to donor's guidelines, and may group them into the following three categories:

*This number refers to the relevant section in the text.

1. Low-cost/no-cost projects with less than 1 year payback

2. Minor retrofits with individual capital costs of less than Rs.500,000 and paybacks between 1 and 3 years

3. Major process modifications.

The impact of each project on CSC's cash flow should be assessed.

In each category, projects requiring detailed feasibility study will be identified and justification provided (e.g., magnitude of capital investment, degree of risk, number of options).

4.2 Feasibility Studies

For each one of the projects identified above (likely to include most of the projects identified in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (including demand and market projections)

2. Technical options

3. Cost and performance assumptions

4. Financial analysis

5. Economic and social analysis

6. Implementation

Appendices.

Each feasibility study should be discussed with EDMAC prior to submission to CSC.

4.3 Team and Project Duration

The study team should comprise:

- One or two foreign expert(s) specializing in steel processes with more than 10 years' experience in the industries and knowledge of Russian electric steel-making, with specialization in steel production and furnaces

- Two to three additional local energy specialists, including former EDMAC trainees and the CSC energy manager.

The production and energy (audit) analysis should take about 3 man-months on-site, plus 1-2 months for report preparation.

The feasibility studies should be undertaken by the foreign expert(s) in collaboration with the CSC energy manager, other personnel from CSC (general manager, financial manager), and EDMAC.

The level of effort envisioned for the feasibility studies is between 9 and 16 man-months.

Associated costs are about U.S. $50,000-$60,000 for the production and energy (audit) analysis and U.S. $150,000-$200,000 for the feasibility studies.

CEYLON CERAMICS CORPORATION

The government has requested that detailed information on the Ceylon Ceramics Corporation not be published. Donors who are interested in details of energy efficiency investment opportunities in this corporation should contact it directly for information.

CEYLON PLYWOOD CORPORATION

Summary

Ceylon Plywood Corporation's (CPC's) Salawa factory faces financial difficulties. The corporation has undertaken several successful efforts to cut energy bills, including the full substitution of wood waste for oil in boilers, the reduction of electric peak demand, and correction of the power factor. Additional fuel-saving projects may be hard to justify financially.

By late summer of 1984, SIDA expects to conduct a detailed energy audit of the facility and install new instrumentation. The audit findings and an overall review of CPC's operations, comparative advantage, and incentive framework must indicate to donor agencies that the factory's future operation will be healthy before any energy efficiency project can be undertaken. As work is already under way by SIDA, no terms of reference are provided beyond possible project prefeasibility analysis. The prefeasibility analyses conducted after plant visits show that about Rs.10 million in energy costs can be saved for a total investment of Rs.28 million (see Exhibit A).

Exhibit A

Ceylon Plywood Corporation: Summary of Possible Energy Conservation Projects
(Estimated 1984 energy bill: Rs.14.5 million)

Project	Cost (Rs.000) Total	Cost (Rs.000) Foreign*	Cost (Rs.000) Local	Average annual financial benefit (Rs.000) Total	Average annual financial benefit (Rs.000) Foreign[1]	Average annual financial benefit (Rs.000) Local	Simple payback (years) Financial[2]	Simple payback (years) Economic[3]
Dust extraction and system improvements	1,350	1,215	135	363	254	109	3.7	5.8
Replacement of steam heat exchangers with air heaters	800	0	800	1,100	770	330	0.7	immediate
Steam system rehabilitation	500	250	250	600	---	600	0.8	N/A
Electrical load management	250	0	250	1,000	700	300	0.25	immediate
Electricity generation from wood waste gasifier	25,000	22,500	2,500	7,000	4,900	2,100	3.6	1.9
TOTAL	27,900	23,965	3,935	10,063	6,624	3,439	2.8	1.9

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

N/A: Not applicable.

*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1]EDMAC estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2]Total cost/average annual financial benefits.

[3]Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefit. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price
- Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly and Company.

CEYLON PLYWOOD CORPORATION

1. Background*

CPC operates several factories in Sri Lanka, including sawmills and plywood, chipboard, and furniture factories. The factory at Salawa, Avissawella, was visited. It began operating in 1969 and consists of four units: sawmill, chipboard manufacture, plywood manufacture, and furniture manufacture.

The plant was financed by contributions from Romania and Czechoslovakia. Many machines are old and were made in countries from which it is almost impossible to get spare parts, except for some equipment manufactured in Italy.

Process description. The production flow at the four units is shown in Exhibit 1.

Timber is sawn into planks and dried in a timber yard at the sawmill. Some of the planks are sold and some are used in the furniture unit. Waste from the sawmill is chipped and used as fuel in the steam boilers.

Timber is barked at the plywood factory and made into plywood sheets. The sheets are dried in steam-heated dryers for approximately 10 minutes at a temperature of approximately 150°C. The dryer heat is regulated manually. When the drying process is finished, three small plywood sheets are joined together using electric heat to make one large sheet. Then, three large sheets are pressed together to produce the final plywood product. Much of the plywood produced is used to make tea chest "building kits." Some of the plywood is used in the furniture factory.

The interiors from the logs used in the plywood manufacturing process are raw material for chipboard manufacture. Two 200-kW chippers cut the interiors into chips, which are stored in silos and later dried in a steam-heated dryer. The chips are mixed with a binder, pressed, and conditioned for several days in the factory.

Among the items manufactured in the furniture unit are doors, chipboard writing desks and veneered chipboard.

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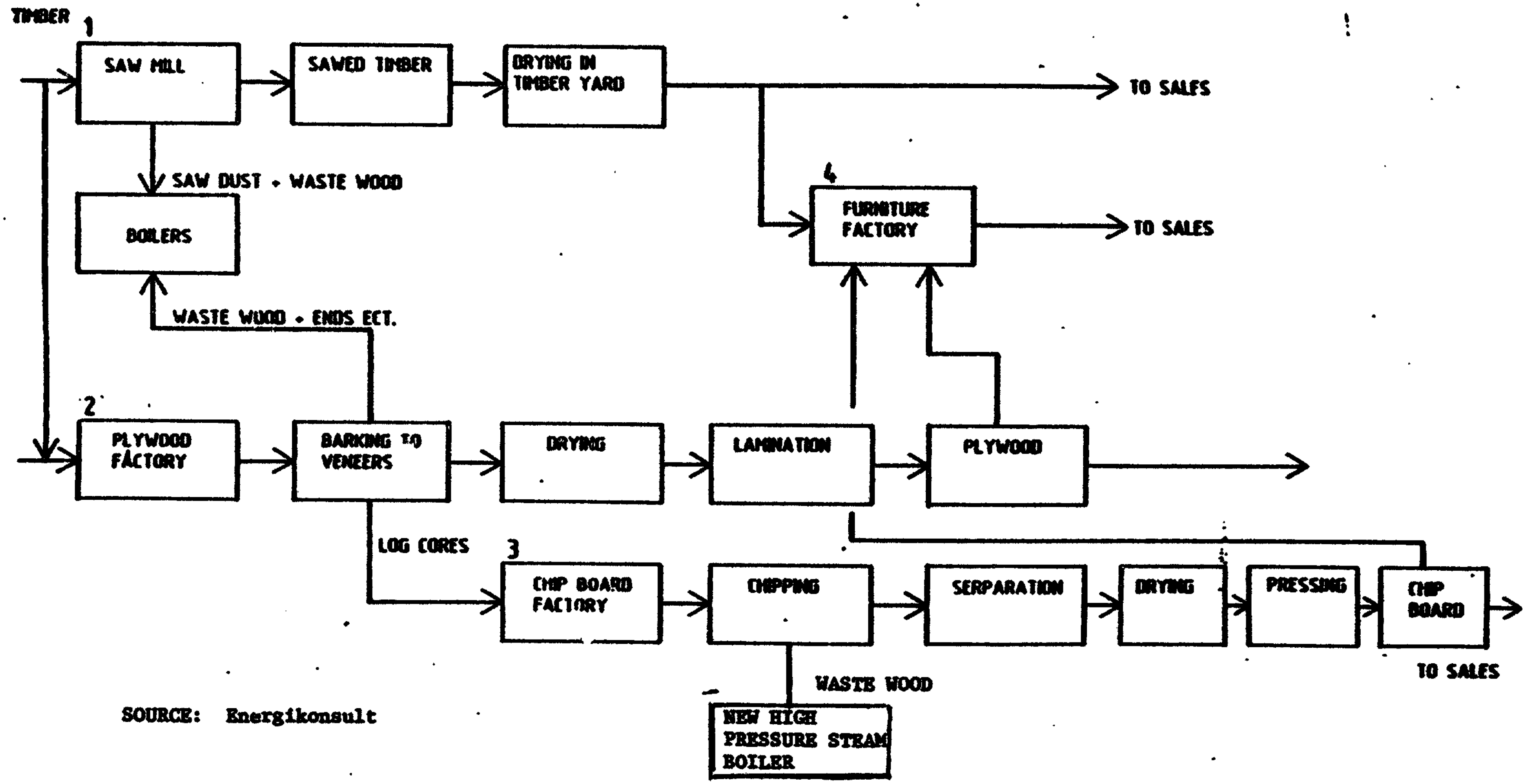
* Background information comes in part from 1983 SIDA report.

Exhibit 1

PRODUCTION AT THE CEYLON PLYWOODS CORPORATION



SOURCE: Energikonsult

CEYLON PLYWOOD CORPORATION

Production. Production of plywood, chipboard, furniture, and sawmill products was very erratic between 1980 and 1983 owing to market conditions, in particular to variations in large construction projects (see Exhibit 2). Salawa's 1983 production was less than half of plant capacity, with total sales of Rs. 101 million (see Exhibit 3). Production costs are presented in Exhibit 4. Energy costs account for about 9 percent of total variable production cost.

Markets. CPC's production is very dependent on local market conditions. Large public contracts were very limited in 1983 and early 1984, causing production to plunge. In addition, competition with imports has increased substantially in recent years.

Organization. Both the chief engineer, who also acts as the energy manager, and the plant manager answer to the factory manager and his deputy. Both share responsibilities for day-to-day factory operations and supervise the senior engineer, the boiler house engineer, and the electrical engineer.

Project evaluation criteria. The major criteria used by CPC are similar to that used by other public corporations, i.e., ability to repay loans (projected cash flow position).

Existing plans for modernization. CPC has no firm plans for modernization or expansion. However, Swedish and Finnish technical assistance programs are currently under consideration.

Exhibit 2

Production Statistics -- 1980

Month	Plywood factory (square meters)	Chipboard factory (cubic meters)	Furniture factory (currency -- Rs.)	Sawmill (cubic feet)
January	127,690	483	2,306,361	7,899
February	142,839	503	4,175,691	8,830
March	186,520	636	5,066,844	11,951
April	52,405	--	742,236	146
May	83,712	238	947,571	8,481
June	78,857	249	749,806	7,488
July	36,381	84	842,917	8,705
August	183,034	606	5,063,821	9,803
September	227,011	633	5,765,662	13,570
October	187,027	606	4,987,465	13,151
November	174,819	580	5,397,689	13,540
December	91,285	602	2,413,340	8,673
Total	1,601,580	5,220	38,459,403	112,177

SOURCE: Ceylon Plywood Corporation.

Exhibit 2 (continued)

Production Statistics -- 1981

Month	Plywood factory (square meters)	Chipboard factory (cubic meters)	Furniture factory (currency — Rs.)	Sawmill (cubic feet)
January	97,053	284	2,800,460	10,040
February	69,294	155	1,031,655	8,720
March	95,799	238	2,465,135	6,119
April	17,072	3	280,055	--
May	70,564	118	417,900	1,585
June	40,188	155	210,715	1,981
July	92,283	575	157,428	11,195
August	66,683	353	799,594	104
September	171,716	561	1,519,329	4,491
October	196,724	638	1,750,968	2,908
November	244,559	637	1,264,349	4,799
December	225,164	636	449,165	505
Total	1,387,099	4,453	13,146,743	52,447

SOURCE: Ceylon Plywood Corporation.

Exhibit 2 (continued)

Production Statistics -- 1982

Month	Plywood factory (square meters)	Chipboard factory (cubic meters)	Furniture factory (currency -- Rs.)	Sawmill (cubic feet)
January	235,604	627	353,965	258
February	155,587	520	680,605	605
March	220,323	647	1,765,142	243
April	29,392	72	318,695	--
May	96,580	166	550,969	875
June	138,278	318	282,035	176
July	172,775	563	2,341,125	150
August	190,112	192	2,293,130	21
September	201,907	656	1,656,226	1,267
October	176,210	355	441,670	1,233
November	261,900	671	1,780,597	1,891
December	267,452	502	671,942	1,564
Total	2,146,120	5,289	13,136,101	8,283

SOURCE: Ceylon Plywood Corporation.

Exhibit 2 (continued)

Production Statistics — 1983

Month	Plywood factory (square meters)	Chipboard factory (cubic meters)	Furniture factory (currency — Rs.)	Sawmill (cubic feet)
January	50,784	—	671,942	1,418
February	176,773	—	1,730,229	1,788
March	290,451	551	2,293,294	13,383
April	127,094	400	1,191,815	7,523
May	197,095	1,847	2,294,436	6,390
June	218,048	—	1,771,472	10,386
July	108,015	297	307,215	6,718
August	115,194	112	1,187,812	2,801
September	243,569	274	3,987,618	2,909
October	233,585	34	1,915,901	1,726
November	284,843	527	3,922,740	2,195
December	229,761	321	3,656,034	3,358
Total	2,275,212	2,700	24,930,508	60,595

SOURCE: Ceylon Plywood Corporation.

Exhibit 3

Production (Quantity and Value),
Salawa Factory, 1983

	Unit	Quantity	Value (Rs.)
Hot press production	m^2	2,088,953	—
Tea chests — full	sets	828,850	39,359,143
Tea chests — half	sets	269,700	12,460,818
Rejected panels	nos.	721,100	1,802,750
Plyboards	m^2	12,068	730,089
Chipboard (3/4 eqt.)	m^3	2,615	14,858,853
Doors	nos.	40,334	19,246,490
Furniture and other	Rs.	—	12,569,137
Total value			101,027,280

SOURCE: Ceylon Plywood Corporation.

Exhibit 4

Total Production Cost
(Rs.)

	Plywood	Furniture	Chipboard	Sawmill
1980	42,157,716	31,728,358	10,038,832	7,199,319
1981	50,777,232	19,730,631	15,535,255	6,103,856
1982	62,556,479	23,708,601	22,787,958	--
1983	67,663,021	27,716,785	15,912,219	7,219,599

SOURCE: Ceylon Plywood Corporation.

CEYLON PLYWOOD CORPORATION

2. Energy Situation

Two old boilers are used for steam generation and can be fired on oil or wood. The front portion of the boilers is oil-fired and the rear portion is wood-fired. Each have a maximum capacity of 7 tonnes of steam/hour for fuel oil and 7 tonnes of steam/hour for wood fuel, yielding an individual maximum capacity of 14 tonnes of steam/hour.

Oil consumption has been reduced from 60,000 British imperial gallons/month in 1970 to approximately 10,000 British imperial gallons/month in 1983 (see Exhibit 5). The reduction was achieved by firing larger quantities of wood waste and by paying stokers a bonus when oil consumption was low. Approximately 200 cubic meters of fuel wood/month are purchased at Rs. 750/tonne, and approximately 1,600 cubic meters/month of factory wood waste are consumed, for a total of 1,800 cubic meters/ month.

The two boilers are equipped with superheaters. As there is no need for superheated steam in the factory, the temperature of the steam is reduced using water. As a result, corrosion, leakage, pressure surges, and tension cracks have developed in the superheater.

One of the boilers is fitted with an economizer and has a thermal efficiency of 70 percent. The other boiler, which has no economizer, has an efficiency of about 60 percent. The boilers and burners are old, and the measuring instruments fitted on the boilers were not working.

To better exploit wood wastes, a steam boiler (0.5 tonnes/hr) was recently installed in the chipboard factory to generate high-pressure steam (10 bar) for the presses. Thus, the old boilers no longer have to generate high-pressure steam; as a result, they can operate almost completely on wood wastes.

Electricity. Installed electricity capacity is 5,000 kVA, but maximum demand is only 1,400 kVA and average demand is 900 kVA. The power factor is 0.95. Major electrical equipment includes eight dust extraction fans (40-75 kWh each), dryer fans (3 fans x 14 dryers x 7.5 kW), chippers, cutters, and air compressors.

Monthly electricity consumption is about 500,000 kWh (see Exhibit 6).

Energy management organization. See Section 1.

Exhibit 5

Energy Consumption: Ceylon Plywood Corporation (Kosgama)

	1983		1982	
	Furnace oil (liters)	Electricity (kWh)	Furnace oil (liters)	Electricity (kWh)
January	48,735	438,700	54,562	531,400
February	7,200	384,600	76,680	508,300
March	12,600	527,500	62,887.5	481,300
April	60,592.5	475,000	47,340	267,801
May	37,350	368,833	52,380	364,900
June	4,410	450,333	112,207	384,800
July	78,322.5	441,800	150,975	78,400
August	46,327.5	287,333	47,092.5	88,700
September	24,165	602,200	104,329.2	37,210
October	4,072.5	357,934	56,000.9	552,500
November	30,757.5	510,334	70,074.9	443,300
December	171,203.4	425,667	34,685.6	377,800

SOURCE: Ceylon Plywood Corporation.

Exhibit 6

Electricity Consumption:
Salawa Plant

		Units	Value
1983	January	438,700	591,560
	February	384,600	541,483
	March	527,500	747,030
	April	475,000	680,700
	May	442,400	654,100
	June	675,500	884,706
	July	662,700	903,668
	August	431,000	806,772
	September	602,200	1,087,490
	October	357,934	728,458
	November	510,334	999,314
	December	425,667	819,838
1984	January	352,600	702,553
	February	354,200	674,954
	March	559,534	973,229
	April	336,467	630,674
Total		7,536,336	12,426,529

SOURCE: Ceylon Plywood Corporation.

CEYLON PLYWOOD CORPORATION

Energy conservation activties. The major energy conservation activity undertaken by the Salawa plant has been the reduction of oil consumption. As a result of financial incentives given to boiler operators (up to Rs.800/month) and low factory activity, oil consumption dropped to almost zero in the spring of 1984.

Capacitors (900 kVAr) were installed in 1984 at a cost of Rs.450,000, with a payback of less than 1 year. Other projects recently implemented include a training scheme for dryer operators and an electric peak load reduction (through better scheduling of water pumps).

A series of other projects is currently under consideration, including: (1) the installation of a new wood-fired boiler for the cogeneration of thermal energy and electricity; (2) the use of direct air heating in lieu of steam heating; (3) the installation of individual fans for dust extraction; and (4) the separation of compressed air circuits for operation and cleaning.

3. Energy Conservation Potential and Possible Projects

As a result of the plant management's energy conservation activities, the only purchase energy will soon be electricity.. Further reduction of fuel use (mostly wood wastes) is technically feasible (through boiler improvements, steam system rehabilitation, and dryer improvements), but not financially justified, as wood wastes have a very low market value, if any at all. Consequently, electricity reduction is considered a prime objective at the factory.

SIDA experts will complete a detailed energy audit of the factory in July/August and install some instrumentation. SIDA's recommendations for energy conservation projects should be integrated with those mentioned below.

Following the plant visit and discussions with factory management and headquarters staff in Colombo, five projects were retained for further consideration:

1. Dust extraction and system improvements
2. Replacement of steam heat exchangers with air heaters
3. Steam system rehabilitation
4. Electric load management
5. Electricity generation from wood waste gasifier.

Each project is presented in more detail below.

3.1 Dust Extraction and System Improvements

Description. There is a large installed fan capacity for the purpose of dust extraction in all three sections of the factory (i.e., the plywood unit, chipboard unit, and furniture unit). The largest capacity -- about 250 kW -- is in the furniture unit. Of this capacity, about 200 kW are in use for 8 hours each day, and 55 kW are in use for a total of 16 hours each day.

The fans operate at full capacity, even when only one or two production machines are in use. Such operation results in a considerable waste of electricity, as the required air flow for dust extraction from one or two machines is much less than the total capacity of the fans.

It is recommended that variable speed operation of the dust extraction fans -- by gearboxes or mechanical devices -- be investigated. A thyristor type control system is preferable, because solid-state equipment would be more robust and durable. Also, overall efficiency would be higher than with a mechanical device.

With such a control system, fans would be operated at lower speeds whenever only a few production machines were in use. While continuous speed modulation may be impossible even with a solid-state system, a sufficient number of discrete speeds can be provided to permit much better matching of fan speed and machine operation. An integral part of this conservation measure would be the fitting of dampers or valves to each machine inlet to stop the fans when the machines are not in operation.

Costs. A thyristor control on fans with an aggregate power of 255 kW would cost an estimated Rs.1.35 million (90 percent foreign).

Savings. Savings in electricity consumption are conservatively estimated at about 20 percent:

- Electricity savings = 180,000 kWh per year
- Cost savings = Rs.363,000 per year.

Payback. The simple payback is 3.7 years.

Implementation. Technical study and specifications would take 3 months, and procurement, installation, and commissioning would take 1 year.

3.2 Replacement of Steam Heat Exchangers With Air Heaters

Description. The three plywood veneer dryers in the plywood unit use hot air heated in steam heat exchangers. The steam heat exchangers consume about 70-75 percent of the total steam generated in the main boiler. The wood fuel is prepared by peeling machines mounted behind the dryers. The machines produce about 750-800 cubic meters/month of waste veneer pieces, which meets the heating requirements of one dryer.

The air for the dryers should be heated by means of the wood fuel, without the intermediary step of using steam. An air heater could be installed between one of the dryers and the peeling machines.

Because low thermal inertia could lead to overheating of the air, it is worth considering the use of a chipping plant, silo, and an automatic chip feeder leading into the air heater furnace. The risk of overheating could be minimized by maintaining a positive pressure on the clean air side of the air heater. The temperature could be effectively controlled by an automatic damper that spills hot air to the atmosphere.

Costs. This system could be wholly fabricated locally, using designs that are employed in the plantation sector.

The cost is estimated to be Rs.800,000.

Savings. Savings of electricity would be greater than those of fuel. The savings of electricity achieved by eliminating transport of veneer to the chipping unit in another building is estimated at 120 kW.

However, additional power of about 50 kW has to be provided to drive a small chipping plant and the FD fan for the dryer:

- Net electricity savings = 70 kW per hour = 550,000 kWh/year
- Cost savings = Rs.1.1 million per year.

Payback. The simple payback is 0.7 years.

Implementation. A feasibility study should be carried out by a consultant with participation of factory engineering staff. The feasibility study would require 4 months, and the fabrication, procurement, installation, and commissioning would require 8 months.

3.3 Steam System Rehabilitation

Description. The steam distribution and condensate recovery systems were seen to be in a poor state, owing to such problems as lack of insulation and steam leaks. A complete rehabilitation is recommended, with special attention paid to matching machine heating loads with steam supply. In this way, better process control could be achieved, which would result in significant cost savings.

Cost. The cost of rehabilitation is estimated at about Rs.500,000 (half local, half foreign).

Savings. Improvements in production processes would save an estimated 4 percent of fuel cost: annual cost savings = Rs.600,000 (purchased wood waste at Rs.750/tonne).

Payback. The simple payback would be 10 months.

Implementation. This measure could easily be carried out by factory personnel themselves. The technical study would take 2 months, and procurement and installation would take 6 months.

3.4 Electrical Load Management

Description. Because thermal energy is generated almost wholly from waste wood, electricity represents the major expense for externally supplied energy. Thus, plant management should study the use of load management by staggered starting of machines and factory section, and by automatically or manually switching off non-essential machinery at peak load periods. Organizational and managerial changes to reduce idle running of machinery could also be introduced.

Costs. Costs would be associated only with operation and maintenance changes and are estimated at Rs.250,000 (all local).

Savings. Based on experience gained in similar situations, the minimum savings in peak demand that could be achieved by introducing these measures are estimated at 10 percent per year: annual cost savings = Rs.1 million.

Payback. The simple payback would be 3 months.

Implementation. This measure can be implemented by factory management and engineering staff alone. The technical study would take 3 months, and implementation would take 1 year for the complete scheme.

3.5 Electricity Generation from Wood Waste Gasifier

Because purchased electricity costs Rs.11 million annually, several options can be studied to produce power on-site. Based on the load curve profile, the optimum size for the system is between 500 and 1,000 kW. In this range, biomass gasifiers are more economical than steam cycles, as they require lower capital costs and achieve slightly higher efficiencies (20 percent versus 15-17 percent).

A suggested system for power generation is of a wood-waste gasifier with gas cleaning and cooling, low-Btu gas-fired reciprocating engine with electrical generator, and feedstock dryer fired by engine exhaust gases and some of the raw gas. Several systems of this kind and size are available from the United States, Germany, Belgium, and France. Typical project characteristics are given below.

Cost (for 800 kWe net):

- Investment: Rs.25 million, installed (90 percent foreign)
- Annual O&M costs: Rs.2 million (8 percent foreign)
- Fuel cost: 0*-Rs.3.9 million, based on 1 tonne/hour at 35 percent moisture, before drying, at Rs.600/tonne, 6,500 hours/year.

Savings. The system would save Rs.2/kWh, resulting in annual savings of Rs.13 million, including any excess sold to CEB or other customers (internal needs only are about Rs.11 million/year).

Payback. Based on Rs.7-11 million net savings/year, the simple payback would be 2.3-3.6 years.

Implementation. One month for installation and start-up. No production disruption.

Comments. Other configurations may be analyzed, including a heat gasifier that produces only hot air for dryers (through a heat exchanger) in lieu of steam and hybrid electric-hot air systems.

All feasibility studies would require a total of about 12 man-months; costs, depending on the involvement of the UNIDO expert, other foreign consultants, and local consultants, would range between U.S. $55,000 and $75,000.

*If additional wastes are available at no cost.

NATIONAL PAPER CORPORATION

Summary

The Embilipitiya paper mill, which produces paper products of various qualities from rice straw, is a good candidate for an overall energy conservation program. Before proceeding with such a program, however, an audit of the mill is recommended to explain, in particular, the high specific thermal and electric energy consumption, which cannot be attributed solely to the use of rice straw. After the audit, several projects are likely to be strong candidates for energy conservation, including improvements in the boiler room and waste heat recovery from the paper machines. An estimated Rs.9.5 million (15 percent of the total bill) can probably be saved with an initial investment of Rs.6.8 million (see Exhibit A).

Other measures, such as the use of wood instead of rice straw as raw material and the installation of a new multifuel boiler with steam turbine, could increase potential savings to Rs.35 million annually, or 55 percent of the current fuel bill. The required investment would be more than Rs.120 million, very high by National Paper Corporation standards. Many issues remain to be addressed before such large projects are considered, and detailed feasibility studies are recommended.

Exhibit A:

NATIONAL PAPER CORPORATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(Total 1983 energy bill: Rs. 63.6 million)

Project	Cost (Rs. 000) Total	Foreign*	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign 1/	Local	Simple Payback (years) Financial 2/	Economic 3/
Energy audit instrumentation	700	620	80	1,900	1,500	400	0.4	0.5
Boiler improvement	1,000	800	200	1,400	1,260	140	0.7	0.9
Black liquor recovery system	N/A			N/A			N/A	N/A
Waste heat recovery from paper dryer	5,000	4,000	1,000	5,250	4,725	525	0.9	1.1
Reduction of pulping energy requirements	120	20	100	1,000	900	100	0.1	0.1
Reduction of drying requirements	0	0	0	1,000	900	100	Immediate	Immediate
New multi-fuel boiler/ cogeneration	85,000	68,000	17,000	18,000	16,200	1,800	4.7	3.6
Total	91,820	73,440	18,380	28,550	25,485	3,065	3.2	2.9

Mid-1984 exchange rate: 1 U.S. dollar = Rs. 25. N/A: Not applicable

*Foreign costs include engineering and design costs (roughly 10 to 15% of total project foreign costs).

1/ EDMAC estimates that the foreign content of electricity is 70% of market price and that the foreign content of oil is 90% of market price.

2/ Total cost/average annual financial benefits.

3/ Estimates taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5% of CIF value for this type of equipment, unused labor force, etc)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- o Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs. 3.5 (US$0.14)/kWh vs. Rs. 2.0 (US$0.08)/kWh for market price.
- o Opportunity cost of fuel oil = 75% of market price, or US$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

Source: Hagler, Bailly & Company.

NATIONAL PAPER CORPORATION

1. Background

Sri Lanka's state-owned National Paper Corporation (NPC) has three mills.

The original pulp and paper mill was established in 1956 at Valaichchenai in the eastern province of Sri Lanka. Its capacity was originally 10,500 metric tonnes/year, and its products were mainly printing and writing paper of 50 gsm to 180 gsm in weight.

A second mill was commissioned on the same location in 1973, increasing the overall capacity to 20,500 tonnes/year. The main products are paper and paperboard in weights from 50 gsm to 650 gsm. Rice straw, wood pulp, and waste paper pulp are used for paper making in the mills.

Since the Valaichchenia output was insufficient to satisfy the domestic market, the government decided to erect a third mill at Embilipitiya in the southern part of the country (about 175 km south of Colombo). The new mill has an output of 15,000 tonnes/year.

All major raw materials except paddy straw have to be transported from Colombo and other parts of the island.

Process description. The paper mill at Embilipitiya comprises two plants, a pulp mill and a paper mill.

The pulp mill has a capacity of 38.8 tonnes of bleached pulp/day, with approximate energy consumption of 22,000 kWh per day. The pulp is cooked in a series of five batch digesters with a capacity of 5.5 tonnes per day of paddy straw. The cooking liquor is a solution of caustic soda ($NaOH$) with a strength of 120 grams/liter. Cooking time is approximately 2.5 hours under a constant pressure of 7.5 bar and a temperature of 170°C. The standard temperature and pressure are achieved and maintained by steam supplied at a rate of 5 tonnes/cook. The cooked pulp is blown from the digester into a tank with a capacity of 110 cubic meters at a pressure of 4 bar. The steam in the digester is condensed, and the hot condensate is used to heat fresh water up to 65°C by means of a heat exchanger. The cooked pulp is then washed in three stages, screened in three stages, thickened, and stored. Bleaching is carried out in three stages: chlorination, extraction, and hypo chlorination. The average consumption of steam

NATIONAL PAPER CORPORATION

and power/tonne of bleach pulp is 5-6 tonnes of steam and 650 kWh/tonne.

The paper machine has a finished paper capacity of 65 tonnes/day, with energy consumption of approximately 1,050 kWh/tonne. The pulp is treated in two groups of dryers that use an average of 3 tonnes of steam/tonne of finished paper.

The stock for the process is prepared by using bleached paddy straw pulp produced at the pulp mill and imported beach pulp, whose proportions depend on the quality of final products.

Imported pulp makes up more than 30 percent of the pulp used in most grades of paper produced at the mills.

Production (1980-1983)

Year	Machine production (tonne)	Finished production (tonne)
1980	9,706	8,765.3
1981	8,651	8,110.0
1982	8,662	8,069.1
1983	9,736	8,844.0

Production cost. Depending on the quality of paper produced and the production conditions, manufacturing costs vary between Rs.17,000 and Rs.28,000, compared with expactory sale prices of Rs.27,000 to Rs.38,000. Depreciation and overheads account for about Rs.10,000/tonne. Profits per tonne vary from Rs.2,000 to Rs.10,000/tonne. For example, in April 1984, the total "machined cost" (direct cost) per tonne of preliminary paper was Rs.18,163 (U.S. $726/tonne), of which straw pulp accounted for 37.5 percent, imported pulp 26.6 percent, chemical additives 7.2 percent, and steam and power 21.5 percent (see Exhibit 1).

Straw pulp is produced at a cost of Rs.7,500 to Rs.8,500/tonne, depending on the operating conditions. Straw, which is purchased at Rs.250/tonne, accounts for 27.5 percent of total direct pulp cost, caustic soda accounts for 40.6 percent, and energy (steam and power) for 20.1 percent (see Exhibit 2).

Exhibit 1

NATIONAL PAPER CORPORATION - EMBILIPITIYA
COST STATEMENT

PAGE NO: 9
STATEMENT NO: 8

PAPER MAKING APRIL 1984

STATISTICS	THIS MONTH Budget	THIS MONTH Actual	YEAR TO DATE Budget	YEAR TO DATE Actual
Operating (Days/Hrs)	21/504	25/315.2	93/2232	50/641.32
Output per Day/hour (Tonne)	40.6/1.69	30.8/2.44	41.6/1.69	30.5/2.38
Production for Month (Tonne)	854	769.96	3778	11524.99
Total Cost (Rs.)	16000979.50	13817190.77	70786534.78	27581929.58
Cost Per Tonne (Rs.)	18736.51	17945.34	18736.51	18086.63

ITEMS COST	UNIT	THIS MONTH QTY.	THIS MONTH VALUE	PER TONNE QTY.	PER TONNE VALUE	YEAR TO DATE TOTAL QTY.	YEAR TO DATE TOTAL Rs. CTS.
Straw pulp Bl.	Tonne	449.49	5246729.91	0.58	6814.29	867.70	9794079.36
Broke	Tonne	38.5	154000.00	0.05	200.01	81.9	327600.00
U.B.K. Pulp. Bl.	Tonne					42.5	690008.00
Imported Pulp (Short Fibr & L. Fib.)	Tonne	281.97	3721197.90	0.37	4832.98	532.89	7276933.58
FURNISH			9121927.81	100.0	11847.28		18097621.73
Alum	Kgs.	96000	454080.00	124.68	589.75	182400	862752.00
Clay	Kgs.	27000	52110.00	35.07	67.68	48940	94454.20
Rosin	Kgs.	26100	469800.00	33.9	610.16	58275	1048950.00
Statch	kgs.	1500	27420.00	1.95	35.61	1910	34914.80
Dyes	Kgs.	28.85	5915.28	0.04	7.68		5915.28
ADDITIVES	Kgs.		1009325.28		1310.88		2046986.28
Machine clothing			333731.28		433.44		648362.56
Other Mat.			7855.88		10.20		13999.00
Water 000'	Litre	115494.6	169722.28	150.0	220.45	228749.6	358053.83
Steam 000'	Kgs.	3620.6	1521019.38	4.7	1975.45	7166.4	299 1930.87
Power 000'	Kwts.	842.78	1487551.60	1.09	1931.99	1767.87	3116145.12
Direct Labour			87949.96		114.23		165243.93
Indirect Labour			18982.67		24.65		37515.29
Repairs & Maint.			59124.63		76.79		106070.67
CONVERSION			3685937.68		4787.10		7437321.57
TOTAL :			13817190.77		17945.34		27581929.58

DISTRIBUTION (GRADE)	T OMNL	FURNISH + ADDITIVES COST	CONVERSION	TOTAL	MAC INLD PNL COST TONNE
Printings	355.02	4748718.71	1699549.91	6448263.62	18163.10
Duplicatings	53.33	709377.32	255300.35	964677.67	18088.04
Bank and Bonds	63.97	852695.95	306235.95	1158931.90	18116.80
Typewriting	277.09	3551037.52	1326479.91	4877517.43	17602.65
Manifold	20.55	269423.59	98376.56	367800.15	17897.82
TOTAL	769.96	10181253.09	3685937.6	13817190.77	17945.34

SOURCE: National Paper Corporation

Exhibit 2

NATIONAL PAPER CORPORATION - EMBILIPITIYA
COST STATEMENT
PULPING STRAW APRIL 1984

PAGE NO. 07....
STATEMENT NO. 07....

STATISTICS :		THIS MONTH Budget	THIS MONTH Actual	YEAR TO DATE Budget	YEAR TO DATE Actual
Total Production(Unbl.)	Tonne	533	474.07	2359	989.06
Total Cost	Rs.	4971824.00	3991721.82	22004752.00	7932464.97
Cost per Tonne	Rs.	9328.00	8420.11	9328	8020.21
Pulp Yield	%.	30	31.44	30	31.58
Number of Cooks	Nos.	273	247	939.73	518
Yield Per Cook	Tonne	1.95	1.92	1.95	1.91

	THIS MONTH UNIT	QTY.	VALUE	PER TONNE QTY	PER TONNE VALUE	YEAR TO DATE QTY	YEAR TO DATE VALUE
PULPING MATERIALS :							
Paddy Straw	Tonne	1508.03	1091600.07	3.18	2302.61	3131.64	2262630.79
Caustic Soda	Tonne	166.40	1614545.86	0.35	3405.71	337.02	3269916.02
T O T A L :			2706145.93		5708.32		5532546.81
O P E R A T I O N							
Other Materials			323.43		0.68		1156.22
W a t e r '000	Litres	80423	111864.70	169.57	235.97	143423	223777.76
Steam '000	Kgs.	1171.3	492064.85	2.47	1037.96	2384.4	995297.55
Power '000	Kwt.	174.64	308261.77	368.38	650.25	356.19	627866.35
Direct Labour			73048.62		154.09		142390.38
Indirect Labour			16839.64		35.52		32476.00
Repaires & Maint.			283172.88		597.32		376953.90
T O T A L :			1285575.89		2711.79		2399918.16
GRAND TOTAL			3991721.82		8420.11		7932464.97

	Tonnes	Rate	Value
Op. Work in Process	26.17	7652.07	200254.67
Add. Production for the Month	474.07	8420.11	3991721.82
LessClosing Work on Process	19.13	8420.11	161076.70
T O T A L : To Bleaching	481.11	8378.33	4030899.79

KEJ/VEW.

SOURCE: National Paper Corporation

Overall, energy costs represent 30 percent of paper production costs.

Markets. All paper is used in the domestic market.

Employment. The mill currently employs about 1,000 people. The organization is depicted in Exhibit 3 and 4.

Financial situation. Embilipitiya turnover was Rs.205 million in 1982 and Rs.249 million in 1983. Recorded losses in 1982 were Rs.32 million, but in 1983, the mill had a Rs.4.4 million before-tax profit.

Project evaluation. Like most state corporations placed under the Ministry of Industry, NPC considers the impact of any project on its after-tax and before-tax cash flow to be the key criterion in project selection, as required by the Ministry.

Existing plans for modernization/expansion and major problems facing the facility. The major modernization project -- the substitution of wood pulping for straw pulping -- is being considered for a feasibility study. Switching to wood would eliminate the major mill problem -- the manfunctioning of the chemical recovery system (CRS). The CRS malfunctions because the silica in the rice straw plugs the black liquor incinerator. Thus, most of the polluting effluents (black liquor) are discharged, creating a growing environmental problem.

In addition, more steam has to be generated from the oil-fired process boilers than expected, because the CRS waste heat recovery boiler seldom produces more than 4 tonnes of steam per hour, although its design capacity is 9 tonnes.

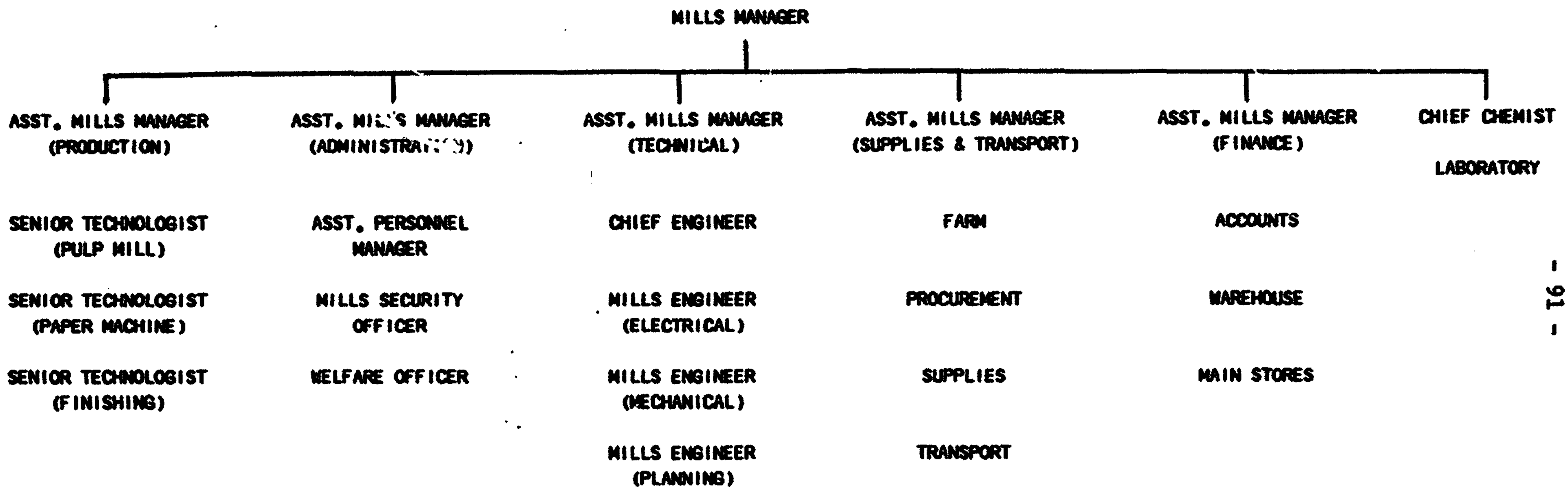
2. Energy Situation

The plant uses large amounts of oil and electricity. The oil used is mainly furnace oil, which is burned in two boilers that generate 18 tonnes of steam/hour. One boiler is run continuously.

The total electricity requirement for the Embilipitiya mill is about 4,600 kVA. The NPC buys its electricity from the Ceylon Electricity Board.

Exhibit 3

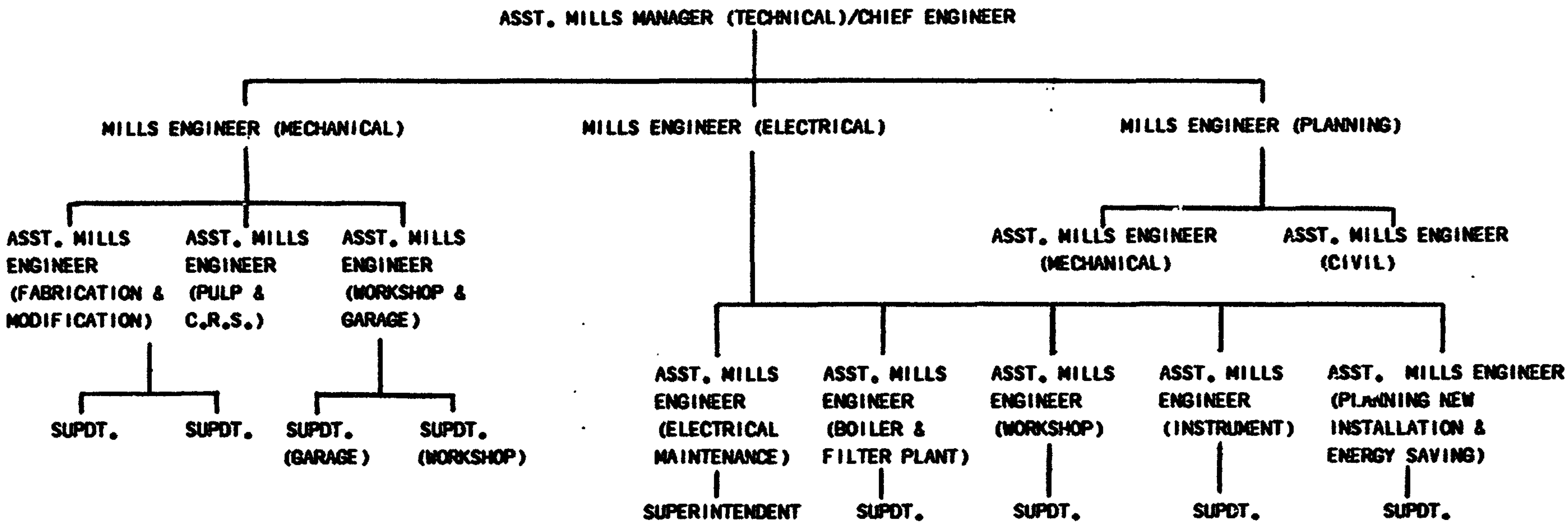
MILLS ORGANIZATION



SOURCE: National Paper Corporation

Exhibit 4

EMPLOYMENT - (ENGINEERING)



ASST. MILLS MANAGER/ CHIEF ENGINEER	-	01
MILLS ENGINEER	-	02
ASST. MILLS ENGINEER	-	01
ASST. ENGINEER	-	09
SUPERINTENDENT	-	04
PLANT SUPERINTENDENT	-	02

SOURCE: National Paper Corporation

The incoming voltage of 33 kV is transformed to 11 kV, 3.3 kV, 440 V, and 380 V.

Seven AC motors in the paper machine work on 3.3 kV. All the other L.T. motors and the thyristor-controlled system work on 440 V, while 380 V is used for the mill lighting systems.

The power factor is maintained at 0.9 by using three sets (each 800 kVAr) of automatic capacitor banks connected only to 440 V supply.

Power consumption of mills. The power consumption of the mills is as follows:

- Paper-making plant = 40,000 kWh/day
- Pulping plant = 20,000 kWh/day
- Steam generation = 1,500 kWh/day
- Water purification = 9,000 kWh/day
- CRS = 7,000 kWh/day
- Housing colony = 800 kWh/day.

Steam requirements. Steam is required to generate saturated steam for the mechanical equipment in the pulp and paper mills:

- 3.5 tonnes/hr at 12 atmospheres
- 11.0 tonnes/hr at 3.5 atmospheres.

Boiler plant. There are two automatic fire tube boilers for the generation of saturated steam in the Embilipitiya mills. Each boiler has a capacity of 18 tonnes/hour, 11 atmg operating pressure. Maximum demand is 23 tonnes/hour and average demand is 17 tonnes/hour.

Technical data for each boiler unit

- Heating surface: 350 m^2
- Maximum permissible operating pressure: 14 kgf/cm^2
- Maximum continuous rating: 18,000 kg/h
- Feedwater temperature: 102^oC
- Heat of generation: 566.2 kcal/kg

- Water capacity up to low water level: 29.75 m^3

- Fuel: heavy oil.

The boiler structure consists of the cylindrical boiler shell, the front and rear shell ends, the built-in fire tube with an internal water-cooled flue-gas reversing chamber, and the seamless flue tubes of the second and third boiler passes. The structure is electrically welded throughout. The boilers are designed as packaged units, complete with feeding and oil-firing systems.

Oil-firing equipment comprises two rotary-cup burners of the pressurized type with integral atomizing blower and built-on three-phase motor of 7.5 HP, 440 V. Sri Lankan furnace oil 1500 is used (net calorific value is 10,000 kcal/kg). The average consumption of furnace oil per tonne of steam is 65-75 liters.

Steam distribution. The saturated steam generated in the boilers flows through the main steam pipes to the individual steam distributors. The main steam pipe and the connection to the steam distributor have been designed for the operation of both boilers. The output pressure of steam is 11 bar. There are two steam headers. One header supplies low-pressure steam to the pulp mill, the chemical recovery section, and the chemical preparation plant. The other steam header supplies high-pressure steam to the digester house, the feedwater tank, and the oil preheater. The steam line coming from the waste heat boiler in the chemical recovery section is also connected to this header. In addition, low-pressure 3.6 bar steam is supplied to the paper machine through this header using a throttle valve.

<u>Steam distribution per hour</u>

- Pulp mill: 5.5 tonnes

- Paper machine: 8 tonnes

- CRS: 2.3 tonnes

- Feedwater preparation: 2 tonnes

- Oil per heating: 2 tonnes

- Total steam production (both boilers): 18 tonnes.

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Consumption by process

- Pulping plant: between 5 and 7 tonnes of steam per tonne of pulp
- Paper-making plant: between 3 tonnes and 5 tonnes per tonne of paper
- Other purposes: 2 tonnes of steam/hour
    - Pollution control -- to CRS: 3 tonnes/hour; from CRS: 6 tonnes/hour.

Fuel and electricity use and prices (1980-1983)

	Fuel		Electricity	
Year	Quantity (liters)	Value (Rs.)	Quantity (liters)	Value (Rs.)
1980	6,115,130	20,971,200	20,255,837	12,922,639
1981	5,927,160	25,427,526	18,514,750	22,935,968
1982	6,396,966	27,442,984	17,319,200	31,000,000
1983	6,660,667	30,058,230	20,059,750	33,231,635

Supply Characteristics

Furnace oil. Furnace oil is supplied by the Petroleum Corporation and must be transported from the main city of Colombo more than 175 km from the factory. As there is no railroad line, oil is transported in tank trucks. The present cost of transport per 100 liters of oil is about Rs.16.

Specific Energy Consumption

Paper machine consumption only. Fuel consumption per tonne of paper is 300 liters, and electricity consumption per tonne of paper is 1,050 kWh. Overall specific energy consumption is 600 liters of furnace oil, and 2,000 kWh per tonne of paper (see Exhibit 5).

Energy management organization. At present, there is one assistant mill engineer in charge of planning, new installation, and energy savings, and he is assisted by one superintendent.

Exhibit 5

Production and Specific Energy
Consumption: Embilipitiya, 1983

Month	Paper production (million tonnes)	Fuel oil (liters/tonne)	Power (kWh/tonne)
January	917.80	741	2,084
February	884.83	722	2,105
March	670.19	797	2,151
April	284.127	745	2,770
May	288.22	916	2,541
June	1,019.23	722	1,966
July	1,053.12	713	2,023
August	1,008.28	697	2,848
September	1,063.98	700	2,074
October	1,358.73	698	1,904
November	618.16	607	1,972
December	512.83	488	2,197

SOURCE: National Paper Corporation.

The following steps have been taken to conserve energy: (1) Boiler working pressure reduced from 14 bar to 12 bar, (2) furnace oil grade 1000 changed over to 1500, (3) digester installation work under way.

Existing plans. The annual electricity bill is about Rs.35 million, and a study is underway to examine the feasibility of generating power on-site to cut electricity costs (see Exhibit 6).

3. Energy Conservation Potential and Possible Projects

Although the plant seems to be in very good condition (fairly recent, well maintained, proven German equipment except for the CRS, and clean), specific energy consumption is high; at 600 liters of furnace oil and 2,000 kWh/tonne of paper produced, total primary energy consumption is about 1.12 tonnes of oil equivalent (toe)/tonne. Standard international performances are about half that level. The two major reasons for the high consumption at Embilipitiya are:

- The use of rice straw instead of wood, which results in a higher pulping energy requirement
- The non-recovery of the calorific value of the black liquor because of CRS malfunctioning.

These two reasons explain most of the overconsumption, the balance resulting from minor energy inefficiencies such as too much excess air and excessive pulping pressures and temperatures.

Based on the plant visit and discussions with management conducted on May 30th and June 6th, 1984, an energy audit of the mill is highly recommended to identify and evaluate possible energy conservation projects.

Energy audit. The audit should be conducted by a team of four people, including:

- A Sri Lankan specialist in thermal energy auditing (e.g., from EDMAC, NERDT, CTC Services)
- A Sri Lankan specialist in electricity auditing (from EDMAC or CEB)

Exhibit 6

Electricity Charges

		Unit rate (Rs.)	Surcharge (percent)	Maximum demand rate
1980	January-September	.24	--	17
	October	.60	23	20
	November	.60	50	20
1981	February	.60	110	20
	April	.60	195	20
	May	.60	160	20
	June	.60	85	20
	August	.60	15	20
	October	.60	65	20
	November	.60	35	20
	December	.60	130	20
1982	February	.60	210	20
	March	.60	241	20
	April	.60	283	20
	May	.60	186	20
	June	.52	110	90
	November	.52	110	90
1983	January-July	.52	110	90
	June-December	.52	185	90

Fuel prices

1980	Rs.4.29/liter
1981	Rs.4.29/liter
1982	Rs.4.29/liter
1983 (August)	Rs.4.54/liter

SOURCE: National Paper Corporation.

- A foreign specialist familiar with the German process used at Embilipitiya (VOITH)

- Embilipitiya energy manager.

The audit is likely to require 2 weeks of on-site work (four people) plus 3 weeks for report preparation (two people) for a total of 14 man-weeks.

Audit cost. Local audit costs would be Rs.50,000, and foreign costs would be U.S. $20,000.

Instrumentation. Prior to the audit, and above and beyond the portable instrumentation needed, some fixed instrumentation should be purchased and installed, including:

- 1 steam flow meter for the cooker
- Several thermometers.

Steam flow meters in the boiler room and in the papermaking section should be recalibrated prior to the audit.

Cost. About Rs.150,000, of which 80 percent would be foreign cost.

Savings. The savings are difficult to estimate. Experience has shown that about 3 percent of total plant energy has been saved in similar facilities following installation of proper instrumentation. Benefits would then be on the order of Rs.1.9 million.

Payback. On the above basis, payback would be 4 months.

Projects. On the basis of discussions held with management, several possible feasibility studies have been selected and are likely to be confirmed by the audit. These projects are:

- Boiler efficiency improvement

- Black liquor recovery system rehabilitation

- Waste heat recovery from the paper machine

- Reduction of pulping energy requirements

- Reduction of drying requirements
- Wood pulping
- Installation of new multifuel boiler with cogeneration.

3.1 Boiler Improvement

Calibration of Burner

Description. At present, the boilers do not have proper steam flow meters installed. To carry out energy conservation on a continuous basis, both steam and oil flow must be accurately determined. Hence, flowmeters for these purposes should be installed and calibrated several times a year.

The air and oil flow controls for the oil burners are linked together by means of mechanical connections. It would appear that oil and air flows have not been properly adjusted against each other for a long period. Factory staff should be trained in the proper adjustment of oil and air flow controls by a specialist from the burner manufacturer. The proper control of air flow in relation to oil flow at all loads is very important in minimizing boiler fuel consumption.

Economizer/air preheater. Economizers and air preheaters can be fitted to the boilers to reduce fuel costs. Estimates of costs and benefits are given below.

Cost. Rs.1 million (80 percent foreign), for the two boilers.

Possible fuel savings.* Rs.1.4 million/year.

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*Assumptions: Flue gas temperature = 220°C. Economizer/air preheater outlet temperature = 170°C. Flue gas flow at inlet to boiler = 9,400 m^3/hour = 2.6 m^3/second per fan = 5.2 m^3/second. Gas flows in the stack = 5.2 x (273 + 220)/(273 + 35) = 8.32 m^3/second. Energy available = 8.32 x 1.2 x (273 + 35)/(273 + 220) x (220 - 170) x 1.01 = 315 kW, corresponding to annual fuel savings of 300 tonnes of fuel at Rs.4.66 per liter or Rs.1,400,000.

Payback. 0.7 years.

3.2 Black Liquor Recovery System

Rehabilitation. The chemical recovery system (CRS) is the major area of inefficiency at the mill, as it has never operated properly on a continuous basis. The viable operation of the system goes beyond energy efficiency, as the major role of the CRS is pollution control; it is not intended for energy recovery per se for chemical recovery, because the plant is too small to regenerate chemicals at a competitive price. The German contractors and consultants have tried repeatedly to make the system work, but the high silica content of the rice straw poses an as yet unsolved slagging problems in the kiln. Alternative solutions for black liquor disposal could include the use of an atmospheric fluidized combustor and conversion to biogas. Because an atmospheric fluidized bed boiler would cost about Rs.50 million, it is unlikely to be financially justified. Adoption of the biogas solution would not only render the existing CRS useless (the initial capital investment was about U.S. $7 million in 1978) but would require several million additional Rs. However, environmental considerations rather than energy conservation alone (although the biogas could be used as a boiler fuel and meet perhaps 20 percent of total fuel requirements), may justify the project.

3.3 Waste Heat Recovery From Paper Dryer

The warm, moist air that is exhausted from the paper machine hood at 57°C is close to saturation and contains about 25 percent of the energy of the steam input, the balance being the heat of the steam condensate, the sensible heat of the paper sheet and the various convection and conduction losses. Based on waste heat recovery projects undertaken in similar plants, up to 40 percent of this energy, representing 1,080 tonnes of oil annually, could be saved.

The waste heat recovery system would consist of a two-stage heat exchanger. The first stage, which could be a heat wheel (preferably hygroscopic) or a flat plate heat exchanger, would be used to preheat dryer make-up air; the second stage, which would operate at lower temperature, could be used to prepare warm water or preheat boiler make-up water. A conservative estimate of savings would be 546 tonnes of oil annually (20 percent of steam input to the paper machine).

Cost. Rs.5 million, of which 80 percent is foreign.

Savings. Rs.5.25 million.*

Payback. 11 months.

Implementation. Implementation would require about 2 months. There would be no need to stop operations; a system bypassing conventional stacks could be installed.

3.4 Reduction of Pulping Energy Requirements

Mill staff is currently trying to reduce steam pressure and temperature (170°C) at the rice straw cooker to reduce energy consumption. To determine the optimal operating conditions, a series of laboratory tests should be conducted prior to reducing temperature and pressure too far under actual operating conditions, as one batch is worth a great deal in terms of production equivalent.

Cost. Such tests could be conducted at CISIR at a cost of not more than Rs.20,000 for labor, plus the cost of building the laboratory-scale cooker, estimated at about Rs.100,000 with instrumentation, provided steam

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*Waste heat recovery from exhaust gases. Assumption: Humidity of air entering dryer is 80 percent, humidity of air leaving is 90 percent. From psychrometric chart, pickup of moisture = 0.4 - 0.029 kg/kg dry air = 0.4 kg/kg dry air. Total flow from fan = 38 m^3/second. Energy flow in the dry air alone = 38 x 1.2 x 1.01 x ((57 + 51)/2) - 34) = 921.12 kW. Energy flow in latent heat of water = 2,115 kW(1). From furnace oil, considering overall efficiency is 65 percent = 287 kg/hour of fuel oil. Fuel consumption per hour in the boiler at 15 tonnes/hour steam generated = 1,373.6 kg/hour(2). Ratio of (1) to (2) is 21 percent. Estimated turnaround heat from exhaust gas = 21 percent/2 = 10.5 percent of total heat in boiler. Fuel savings = (1,373.6 x 0.105 x 24 x 300/1,000) = 1,080 tonnes of fuel/year. In value = Rs.5.24 million per year (on the basis of 24 hours/day x 300 days of operation per year).

is available. (All costs are local, except the cooker materials).

Savings. Assessing that 10 percent could be saved in that stage, annual fuel cost savings would reach up to Rs.1 million based on a current consumption of 3.5 tonnes of steam/hour.

Payback. One and one-half months.

3.5 Reduction of Drying Requirements

The audit should determine whether the paper is over-dried, as an increase in the moisture content of 1 percent could result in savings of 0.3 tonnes of steam/ tonne of paper or about Rs.1 million/year, at no cost. As there is no instrument available to measure moisture content in paper, the audit team should bring along such a device.

3.6 Wood Pulping

A feasibility study is currently under review. Preliminary discussions seem to indicate that wood pulp will be much more expensive than straw pulp (Rs.70,000/tonne versus Rs.11,000/tonne).

3.7 Installation of New Multi-Fuel Boiler With Cogeneration

NPC management is considering the installation of a new multifuel boiler producing 25 tonnes of steam per hour at 16 bar; the boiler would run primarily on wood with cogeneration of electricity (5 MW, extraction condensing).

After extensive discussions on-site and in Colombo headquarters, it appears that several issues remain to be addressed prior to making such a capital-intensive decision.

First, the availability of fuel wood is still in question and prices are high. While NPC has access to some fuel wood plantations, running both the pulping and steam generation (with cogeneration of power) would require up to 200 tonnes/day or 70,000 tonnes/year. Total yield from all wood plantations in the country is not expected to exceed 150,000 tonnes annually (10 million cubic feet). In view of the large amount of wood involved, the costs and benefits of this measure to the economy should be analyzed before proceeding with it. The possibility of investing in fuelwood plantations should also be assessed.

Current prices of fuelwood to Embilipitiya are very high -- RS. 360/m^3 or almost Rs. 1,000/tonne. At this price, fuelwood is marginally attractive at best when compared with fuel oil at Rs. 4,922/tonne; when net heat values and additional investment are accounted for, fuelwood with a 45 percent moisture content would cost the equivalent of Rs. 4,000/tonne of oil, or only 20 percent cheaper.

Second, if wood is available in limited quantity, it should be dedicated to pulping. Such a process change would result in a substantial decrease in steam requirements (steam peak demand would be around 15-18 tonnes/hour as opposed to 23 tonnes/hour today) because of lower steam pulping requirements and implementation of the steam conservation projects described above, and more importantly, because the CRS plant is likely to run satisfactorily on this kind of black liquor. Therefore, a 20 tonnes/hour boiler would probably be sufficient.

Third, peak electricity demand, which is currently about 4,000 kVA, can probably be reduced to 3,500 kVA with some load management techniques. In any case, sizing the electrical generating system in the congeneration plant should not be based on maximum electricial load, but should result from an overall financial optimization process. Based on international experience in this area, not more than 2 MW should be produced from a 20 tonne/hour boiler and probably 1-1.5 MW to meet base load alone.

Finally, the investment is likely to be in the Rs. 75-100 million range, which is a very large capital project by NPC standards. Extreme care should thus be exercised in proceeding with this project, and a detailed feasibility study should be undertaken first. Based on data gathered on similar systems installed elsewhere, it is possible to provide some preliminary cost and savings for such a project.

Cost and savings. The total investment would be Rs. 85 million (80 percent foreign). The following are cost components:

- Current fuel cost (oil) = Rs.30 million.
- Fuel cost with project = 35,000 tonnes of wood x price of wood (45 percent moisture).
- Additional O&M costs = Rs.9 million/year.
- Savings from electricity generation: 1,500 kWh x 8,000 hours x Rs.2 = Rs.24 million.

Net annual savings = (a - b - c + d).

- At Rs.1,000 per tonne of wood: Rs.9 million (simple payback = 10 years)
- At Rs.500 per tonne of wood: Rs.27 million (simple payback = 3.1 years).

Average benefits: Rs.18 million/year.

Conclusions

A feasibility study would take about 3 months to be conducted by either a specialized foreign firm or a specialized local firm. In the first case, the study would cost about Rs.1 million. In the second case, the cost would be four to five times less; the local firm should cooperate closely with EDMAC so that it can benefit from the project financial evaluation model developed by USAID and recently transferred to EDMAC.

4. Terms of Reference

4.1 Energy Audit

A detailed energy audit of the Embilipitiya paper mill should be conducted, consisting of the following successive steps:

4.1.1 The consultants will conduct a preliminary energy audit (also called survey) or "PEA" to collect historical data on (a) detailed energy use, (b) production, (c) energy-using equipment, and (d) technical personnel available on-site for energy efficiency work. The PEA should not take more than 4 man-days to perform. (See EDMAC's energy auditing manual for more details on conducting a PEA.)

4.1.2 On the basis of the PEA, the consultants will decide, in agreement with plant management, which fixed instrumentation should be installed prior to conducting the detailed energy audit and which areas deserve most attention.

The following areas are likely to be candidates:

- Boilers
- Dryers
- Pulping section
- Chemical recovery system
- Electric system.

Mass and energy balances will be prepared, when required, for several representative operating conditions.

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide NPC with the following information for each option:

- Description
- Estimated cost in foreign and local currency with sources of information and range of confidence
- Estimated savings in physical units and financial (i.e., at market prices) and economic (i.e., at true cost to the economy) values
- Implementation schedule and recommendations.

4.2 Team and Project Duration

Energy audit. The audit should be conducted by a team of four people, including:

- A Sri Lankan specialist of thermal energy auditing (from EDMAC, NERDT, CTC Services, etc.)
- A Sri Lankan specialist of electricity auditing (from EDMAC or CEB)

NATIONAL PAPER CORPORATION

- A foreign specialist familiar with the German proces used at Embilipitiya (VOITH)
- Embilipitiya energy manager.

The audit is likely to require 2 weeks of on-site work (four people) plus 3 weeks for report preparation (two people) for a total of 14 man-weeks.

Audit cost. Local audit costs would be Rs.50,000, and foreign costs would be U.S. $20,000.

The feasibility studies should be undertaken by the foreign expert in collaboration with the NPC energy manager, other personnel from NPC, and EDMAC.

The level of effort envisioned for the feasibility studies is between 9 and 16 man-months, and the associated costs are U.S. $100,000-$150,000, excluding the feasibility study of the black liquor recovery (already done and under review) and the feasibility study of the cogeneration option, which would cost an additional U.S. $100,000 but is not recommended at this time.

RICHARD PIERIS & COMPANY LTD.

Summary

Richard Pieris & Company's Arpico factory produces rubber and plastic products and assembles steel furniture. An energy audit is required at the Arpico factory because of the many questions surrounding boiler operations at the plant. There are also unresolved issues concerning the projected levels of steam demand through the remainder of the decade.

While Richard Pieris & Company is in a relatively sound financial position, sizable investments (e.g., a proposed wood-fired boiler) are eligible for funding from a donor organization. For example, improving the steam generation and distribution system could save about Rs.4.5 million for a total investment cost of Rs.5.5 million (see Exhibit A).

Exhibit A

Richard Pieris & Company Ltd.: Summary of Possible Energy Conservation Projects
(1983 energy bill: Rs.13.5 million)

Project	Cost (Rs.000) Total	Cost (Rs.000) Foreign*	Cost (Rs.000) Local	Average annual financial benefit (Rs.000) Total	Average annual financial benefit (Rs.000) Foreign[1]	Average annual financial benefit (Rs.000) Local	Simple payback (years) Financial[2]	Simple payback (years) Economic[3]
Improving steam distribution system	500	200	300	780	700	80	0.6	0.6
New wood-fired boiler	5,000	4,500	500	3,744	3,370	374	1.3	1.7
TOTAL	5,500	4,700	800	4,524	4,070	454	1.2	1.5

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1] EMMAC estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2] Total cost/average annual financial benefits.

[3] Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using EMMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price
- Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly & Company.

RICHARD PIERIS & COMPANY LTD.

1. Background

Plant history. Richard Pieris & Company's Arpico factory is located in Nawinna, Maharagama, roughly 5 miles from downtown Colombo. The factory was built 36 years ago and expanded in stages. The factory produces rubber and plastic goods as well as steel furniture. Rubber products include retreaded tires meant for the domestic market and rubber bands and car mats made for foreign markets.

Process description. The wide variety of products made by Richard Pieris & Company employs many different processes. Some products like steel furniture consume very little energy. Others, including rubber tires, are the major energy users in the plant.

In the production of rubber products, the natural rubber latex and additives are sent through Branbury mixers. For rubber bands, the mixture is extruded in a tubular form and sliced to form the band. For tires, steam- and electrically-heated cylindrical moulds are used to form the tire.

Markets. Richard Pieris serves both domestic and foreign markets. Export items include rubber bands, rubber mats, rubber balls, rubber thimblettes, microcellular sheets, camel back, and rubber components for the automotive industry. Products for the domestic market include retreaded tires, plastic goods, and steel furniture. Export markets account for roughly 6 percent of sales.

Financial situation. With the exception of fiscal year 1981-1982, Richard Pieris & Company has made steady profits during this decade (see Exhibit 1). The improved performance in 1982-1983 has continued through the present with the end of the worldwide recession. Sales of factory products account for roughly 85 percent of the total turnover for Richard Pieris & Company.

Existing plans for modernization/expansion. Plant management is considering replacing older, less efficient tire moulding equipment with newer moulds. Some electrically-heated moulds would be replaced with steam-heated moulds, so while the more efficient equipment would require less steam per mould, total steam demand might increase. Since plans for the new equipment place the moulds in a different location, a new steam

Exhibit 1

Richard Pieris & Company Ltd.:
Financial Situation
(Rs. 000)

	1982-1983	1981-1982	1980-1981
Turnover (sales)	189,261	153,404	136,769
Profit after tax	6,132	(7,723)	5,510
Total fixed assets*	53,817	56,731	44,876
Current assets*	71,704	68,429	70,104
Current liabilities*	72,872	69,228	63,903

*At end of fiscal year, March 31.

SOURCE: Richard Pieris & Company annual reports.

distribution and condensate return system would be required.

Also, the plant is currently refurbishing an incinerator. When placed in service, the incinerator will burn waste rubber products during one shift per day. Low-pressure steam at roughly 2,000 lb/hr will be produced.

Plant management is also currently considering installing a wood-fired boiler with a 10,000 lb/hr capacity to meet anticipated production increases of up to 10 percent annually.

2. Energy Situation

Major energy-consuming equipment. Richard Pieris & Company Ltd. operates three boilers to provide steam to the Arpico factory. Two of the boilers are relatively small, vertical Cochrans (2,600 and 1,800 lb/hr, respectively). The third boiler is a 6,750 lb/hr packaged unit. All three boilers are manually operated and fired on 800 second oil. Furnace oil consumption averages approximately 136,600 liters per month at a cost of Rs.650,000/month.

The company purchases electricity from the Ceylon Electricity Board (CEB), although standby diesel generation is also available. Electricity use is mainly for motive power, although there are some resistance heating applications. The major consumers of electricity in the Arpico factory are the rubber goods and plastics departments.

3. Energy Conservation Potential

The current maximum demand for steam in the Arpico factory is 6,000 lbs/hr. Average demand is 5,500 lbs/hr. The Arpico factory is currently using all three of its boilers to meet average demand. Since the combined capacity of all three boilers is 11,150 lbs/hr (the packaged boiler alone is 6,750 lbs/hr), there is no explanation for why all three boilers are needed to meet average demand.

Furnace oil expenditures during the period October 1983 through January 1984 ranged from Rs.592,000 to Rs.700,000, averaging Rs.650,000. At Rs.21.60/gallon, 30,100 gallons of furnace oil (or 136,600 liters) is consumed in the average month. With an efficiency of 55 percent, roughly 8.25 kg of steam are produced for each liter of oil, so that 1,127,000 kg of steam (or 2,485,000 lbs) are produced in a given month. With a 12-day-on, 2-day-off schedule, the 4, 31-day months would average roughly 600 working hours each (adjusted for holidays). Average steam production is then calculated to be 1,878 kg/hr, or 4,140 lbs/hr. These numbers indicate that the estimate of 5,500 lbs/hr average steam demand is probably accurate and not too low.

There is currently one fuel flow meter to all three boilers, as well as one common steam flow meter away from the boilers. Water flow to the boilers is monitored and, according to plant management, corresponds closely to measurements given by the steam meter. Plant management has estimated the efficiency of the three boilers combined at 55 percent.

The very low boiler capacity utilization (5,500 lbs/hr average demand must be met by firing the full plant capacity of 11,150 lbs/hr) may be caused by underfiring of the packaged boiler. This would also help explain the low overall efficiency. It is possible that some difficulty with the boiler's fuel pump is causing reduced flow and consequently less steam production in the most efficient boiler. In any event, fuel flow and water flow meters should be placed on the packaged boiler to determine its steam production and overall fuel efficiency. We would not be surprised to discover that the packaged boiler could meet the plant's entire steam demand after minor modifications.

Assuming that current steam demand and efficiency estimates are correct, and the Arpico factory is consuming 5,500 lbs per hour of steam, on average at 55 percent efficiency, there is an opportunity to improve energy efficiency by installing a new wood-fired boiler. A new boiler would have to take into account the following factors:

1. The refurbishing of the plant's incinerator will provide 2,000 lbs/hr of low-pressure steam. This steam will initially be available for only one shift per day, owing to the lack of waste fuels to burn. Other sources of waste should be vigorously investigated.

2. The anticipated installation of newer, more efficient moulding equipment in a different

location than the current equipment will require an entirely new (and more efficient) steam distribution system.

3. The conversion to newer moulds will actually increase steam demand by an anticipated 1,000 lbs/hr (plant estimate) as the electrically-heated moulds are replaced with steam-heated moulds.

4. Improvements to the current oil-fired packaged boiler may significantly boost its efficiency and steam production. The lower-efficiency vertical Cochran boilers could possibly be shut down if the efficiency and steam production of the larger packaged boiler were increased.

The new steam distribution system would cost an estimated Rs.500,000 and result in a 10-percent savings in steam consumption. This would reduce the peak steam demand to 5,400 lbs/hr from 6,000 lbs/hr. And if the peak steam demand could be scheduled during the time the incinerator is operating, the peak steam demand from boilers could be lowered to almost 5,000 lbs/hr. The addition of new moulding equipment to replace some electrically-heated moulds will increase steam demand by 1,000 lbs/hr to a total peak demand estimate of 6,000 lbs/hr of steam. Consequently, we suggest that a new wood-fired boiler with a rated capacity of 7,500 lbs/hr be considered.

Preliminary estimates indicate that the new wood-fired boiler would have a total installed cost of Rs.5 million and a simple payback of roughly 1.3 years (see Exhibit 2). The question of the availability and cost of wood over the life of the boiler should be addressed in the feasibility study. The possibility of investing in fuelwood plantations should be considered in this analysis. If the plant is operating in an area of existing or impending fuelwood scarcity, the economic costs and benefits of increased wood use should be examined more closely.

4. Terms of Reference for Richard Pieris & Company Ltd.

A detailed energy study of the Arpico factory focusing on steam generation, distribution, and end use should be conducted, consisting of the following successive steps:

4.1.1 The consultants will first conduct a preliminary energy audit (also called survey) or "PEA" to collect historical data on (a) detailed energy use, (b) production, (c) energy-using equipment, and (d) technical personnel available on-site for energy efficiency

Exhibit 2

New Wood-Fired Boiler (7,500 lb/hr)

	Rupees
Total installed cost*	5,000,000
Current annual fuel cost for oil boilers	7,800,000
Annual fuel cost after installing wood boiler - wood (80%) -- 2,496,000** - oil (20%) -- 1,550,000 Total	4,056,000
Annual fuel savings	3,744,000

Simple payback: 1.3 years

*Manually fed Indian or British design.
**Based on wood available at Rs.600/metric tonne.

SOURCE: Hagler, Bailly & Company.

work. The PEA should not take more than 4 man-days to perform. (See EDMAC's energy auditing manual for more details on conducting a PEA.)

4.1.2 On the basis of the PEA and immediately thereafter, the consultants will decide, in agreement with plant management, which fixed instrumentation — if any — should be installed prior to conducting the detailed energy audit and which areas deserve most attention.

The following areas are likely to be candidates:

- Boilers
- Steam distribution
- Steam-using systems.

Mass and energy balances will be prepared, when required, for several representative operating conditions.

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide Richard Pieris & Company Ltd. (RP&C) with the following information for each option:

- Description

- Estimated cost in foreign and local currency with sources of information and range of confidence

- Estimated savings in physical units and financial (i.e., at market prices) and economic (i.e., at true cost to the economy) values

- Implementation schedule and recommendations.

The audit should focus on:

1. Quantifying the efficiencies and steam production rates of each of each of the three boilers currently in operation

2. Recommending methods to increase the production rate of the oil-fired packaged boiler to rates closer to its design capacity

3. Investigating the option of obtaining additional wastes to fire the incinerator on a more continuous schedule

4. Projecting steam demand in the plant over the next 10 years by incorporating anticipated demand increases for products and changes in specific energy consumption

5. Investigating the option of purchasing a wood-fired boiler (to be sized based on the steam demand estimates) to be the primary supplier of steam for the plant.

Details about audit requirements are given in EDMAC's energy auditing manual. The final product will be a practical implementation plan acceptable to RP&C management. The plan can be organized in several phases:

- Phase one: low-cost/no-cost measures (housekeeping) requiring little or no expense

- Phase two: minor retrofits that require limited capital expenditures but are highly profitable

- Phase three: major projects requiring large capital expenditures and long lead times.

On the basis of the audit results, the consultants will undertake a series of feasibility studies for the projects that are too complex, risky, or capital-intensive to be fully analyzed within the audit.

4.1.3 For each one of the retained projects (likely to include boiler replacement as outlined in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (including demand and market projections)

2. Technical options

3. Cost and performance assumptions

4. Financial analysis

5. Economic and social analysis

6. Implementation

Appendices.

Each feasibility study should be discussed with EDMAC prior to submission to RP&C.

4.2 Team and Project Duration

The energy audit team should comprise one or two auditors, possibly including former EDMAC trainees and the RP&C energy manager.

The full audit should take about 1 man-month on-site, plus 2-3 weeks for report preparation.

The feasibility studies should be undertaken by the consultant in collaboration with the RP&C energy manager and other personnel from RP&C (general manager, financial manager).

The level of effort envisioned for the feasibility studies is about 3 man-months for the steam system, including the wood boiler. The associated cost is U.S. $7,000-$12,000, all local, as local consulting companies (e.g., CTC Services) are very experienced in these types of studies.

LEVER BROTHERS (CEYLON) LTD.

Summary

Lever Brothers (Ceylon) Ltd. Colombo plant is both well-maintained and well-managed. Energy conservation efforts consistently receive high priority, and emphasis is now being placed on developing less energy-intensive processes. The technical staff at Lever Brothers is one of the finest in Sri Lanka.

The financial situation of the Lever Brothers plant is currently very strong and projected to remain so for the foreseeable future. The company is not currently in need of major financial or technical assistance from donor organizations. It is quite capable of effective energy management, based on its sound financial, managerial, and technical strengths. The skills and abilities at Lever Brothers could be very useful to other Sri Lankan industries.

LEVER BROTHERS (CEYLON) LTD.

1. Background

Plant history. The Lever Brothers plant in Colombo was built in 1940. Excellent management and maintenance have kept the facility in fine condition. Most of the major equipment is less than 10 years old. The plant produces a wide variety of consumer products for the domestic market, including soaps, detergents, toiletries, shampoos, toothpastes, and edible fats.

Process description. Because of the wide variety of products, the processes employed are very different. The plant is really an aggregation of many smaller, individual "plants" or departments. Most departments are located in separate but adjoining facilities and have separate metering equipment for both steam and electricity.

Edible oils is the largest energy-consuming department in the plant. Oils are hardened by bubbling hydrogen through the unsaturated oil. To reduce the possibility of explosion, oxygen levels are first reduced in batch reactors by sparging the oil with hydrogen. After hydrogenation, the unsaturated oils are deodorized to obtain better flavor and odor.

Soap is produced by the continuous saponification of oils. Bar soap is stamped and packed at the factory.

Other products -- including toothpaste and other personal products -- are made in small quantities and are not major energy consumers.

Markets. Lever Brothers produces consumer goods entirely for the domestic market. Demand for the company's products has been increasing steadily in recent years, and future market growth is expected to be roughly 10 percent annually.

Employment. Lever Brothers currently employs roughly 1,400 people in its Colombo plant. Organization in the plant has a product line focus.

Financial situation. A privately held concern, the financial situation of Lever Brothers is confidential. Apparently, energy conservation efforts are not restricted by a lack of capital. The company is firmly committed to energy efficiency in its operations and has shown a distinct willingness to invest wherever and whenever the economics are favorable.

Existing plans for modernization/expansion. There are no plans for modernizing or expanding the facility. Plant management is quite aware, however, that the next stage in reducing energy consumption will come through process modifications and improvements. Based on product and process development activities, plant operations are continuously being refined and improved.

Major problems facing the facility. There are no major problems facing the Lever Brothers consumer products plant.

Energy management organization. There is no energy manager or energy organization at Lever Brothers. However, meetings are held every 6 weeks to discuss any energy-related activities and to review progress.

2. Energy Situation

Major energy-using equipment. Lever Brothers has three boilers fired on 1,000 second furnace oil. Two of the boilers are 18,000 lb/hr packaged units with combustion efficiencies of 80 percent. The third is a smaller (12,000 lb/hr) unit that is far less efficient; this boiler is currently not in operation. The two more efficient boilers meet the plant's steam requirements.

The plant produces its own hydrogen for use in hardening edible oils in a 300-kVA electrolyzer. The electrolyzer has a maximum hydrogen production capacity of 50 cubic meters/hr. It currently operates at less than capacity, producing an average 25 cubic meters/hr of hydrogen. (The corresponding amount of oxygen currently vented could be recovered and sold to the steel corporation for injection in the electric furnace.)

Production and specific energy consumption figures are shown in Exhibit 1.

3. Energy Conservation Potential

The plant is generally in fine condition. Although built some 40 years ago, the equipment in the plant is relatively new and very well maintained. There is some room for improved housekeeping, but management is generally well aware of these issues and is continuously performing the simpler energy conservation efforts. As a

Exhibit 1

Annual Production and Electricity Consumption

	1981	1982	1983	1984*
Tonnes of product**	26,215	29,090	33,194	11,588
kWh (thousand)	4,160	4,820	5,340	1,640
kWh/tonne of product	167.2	165.7	161.0	141.8
Edible oil production and furnace oil consumption				
Tonnes of oil produced	18,561	21,032	23,261	
Gallons of furnace oil consumed	879,796	944,133	978,176	
Gallons of furnace oil/ tonne of oil processed	47.4	44.9	42.05	

*January-April.
**Includes all plant products.

SOURCE: Lever Brothers.

LEVER BROTHERS (CEYLON) LTD.

result, recent specific energy consumption has been decreasing year after year (see Exhibit 1).

One possible area for energy improvement could lie in the plant's use of hydrogen. Hydrogen is produced in a 300-kVA electrolyzer and is piped roughly 100 meters to the building producing edible oils. The piping is flanged in some spots, with long runs welded together. Since the hydrogen is metered only as it leaves the electrolyzer, no current estimate is available as to whether hydrogen losses through the flanged connections are appreciable. Because of the low molecular weight of hydrogen, diffusion through gaskets sometimes results in significant losses. Plant management is planning to introduce hydrogen meters at the point of use.

The hydrogen is used in the edibles department for hardening various oils. Currently, oil (e.g., coconut, palm, soya) is transferred under nitrogen pressure to a 5- or 2.5-tonne tank where any excess oxygen is removed by purging the oil with hydrogen. Nitrogen is not used for purging because of its current limited availability, which may change. The reactor is heated to 100°C, and after the oxygen level has been reduced to 2-3 percent, the reactor is placed under 40 psi hydrogen pressure. The heat of reaction as the hydrogen saturates the oil carries the temperature to 125°C. After the reaction is completed, the saturated oil is pumped out of the reactor to the stage where the oil is refined. It is possible that up to 30-40 percent of the hydrogen produced in the electrolyzer is either lost in transit or used to purge oxygen from the reactor. More efficient use of hydrogen may be possible, although careful attention must be paid to the considerable safety hazards that this gas presents.

The installation of hydrogen meters at the end-use location will be completed shortly, which should give plant management a better view of hydrogen use in the hardening operations. After additional data are available, some improvements may be possible.

Other possible energy improvements at the Lever Brothers plant tend to be process-related rather than equipment-related. The plant's energy efficiency for the processes it currently employs is high, so the next step facing plant management is to reduce energy-intensiveness by altering the processes themselves.

LEVER BROTHERS (CEYLON) LTD.

The plant plans to install a new 18,000 lb/hr packaged boiler by mid-1985. Production continues to escalate at roughly 10 percent annually, with corresponding increases in energy demand. With 1983 furnace oil consumption at nearly 1 million gallons during 7,500 working hours, average steam demand was roughly 15,500 lbs/hr. Peak demand requires the operation of both 18,000 lb/hr boilers. A third efficient boiler of the same size and design as the two existing boilers would allow rotation of duty among the three. An 18,000 lb/hr packaged oil-fired boiler would cost roughly Rs.9 million, fully installed (the boiler alone would cost about Rs.4 million).

4. Terms of Reference for Lever Brothers (Ceylon) Ltd.

Lever Brothers does not require technical or financial assistance in its energy conservation efforts.

PARANTHAN CHEMICALS CORPORATION

Summary

Paranthan Chemicals Corporation (PCC) is faced with many difficulties. The caustic/chlorine plant is outmoded in both design and energy efficiency and is not currently competitive in comparison with world-scale plants. It is not clear if any level of investment would guarantee that PCC could produce caustic/chlorine at costs beneath import prices of the chemicals.

PCC's energy efficiency can only be increased by completely retrofitting the plant, at a cost of at least US$906,000. PCC's poor financial situation would require full funding from a donor organization. Before proceeding with a feasibility study of retrofitting, the question of the economic viability of a domestic caustic/chlorine industry and in particular of PCC's plant should be settled by an overall technical economic, and financial review of PCC's operations, comparative advantage, and incentive framework.

PARANTHAN CHEMICALS CORPORATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS
(1983 energy bill: Rs. 18.0 million)

Project	Cost (Rs. 000) Total	Foreign	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign	Local	Simple Payback (years) Financial a/	Economic
Plant retrofit with new equipment b/	22,650	n/a	n/a	3,800	n/a	n/a	6.0	n/a
Total	22,650	n/a	n/a	3,800	n/a	n/a	6.0	n/a

Mid-1984 exchange rate: 1 US dollar = Rs. 25.

n/a: not applicable or not available.

a/ Total cost/average annual financial benefits.
b/ Given the extent of the work involved and questions as to PCC's economic viability, only the total cost, the total average annual financial benefits, and the simple financial payback were estimated.

1. Background

Plant/company history. PCC is a state industrial concern involved in the manufacture and distribution of salt-based heavy chemicals. The plant was originally intended for the manufacture of caustic soda, chlorine for D.D.T., and sulfuric acid. However, declining domestic demand for D.D.T. changed the original plans for using the plant's chlorine production.

The caustic soda/chlorine plant construction at Paranthan was completed in 1957. The entire plant and machinery, together with power engines, was supplied by Messers Von Roll S.A. of Zurich, Switzerland. The electrolytic cells were Denora-type diaphragms having productive capacity of 5 tonnes of caustic soda per day. Byproducts like table salt, hydrochloric acid, ferric chloride, zinc chloride, and bleaching liquid were introduced subsequently.

Power supply to the factory was obtained from the national grid in 1973. Previously, PCC generated its own electricity needs. The production capacity of the plant was doubled in 1976 with the commissioning of a second electrolytic cell house and auxiliary plants.

Location and process description. The plant was located at Paranthan in northern Sri Lanka mainly because of the proximity to readily available supplies of salt. Salt is transported to the factory by truck. The saturated neutral brine solutions are made and after purification are fed continuously to the electrolytic cells at a controlled fixed rate. Caustic and chlorine are produced when the saturated salt solution is electrolyzed by direct current. The cells are operated at current load of 3,000 amps and are connected in series. The voltage across each cell is 3.5 to 4.5 volts.

The electricity supply from the national grid is converted into direct current required for electrolysis using rectifiers. The product of electrolysis are chlorine gas, hydrogen gas, and dilute caustic liquid. Both chlorine and hydrogen gas are separately removed from cells for further processing. The cell liquid contains 10 percent of caustic and unelectrolyzed salt discharged from cell. The caustic is concentrated to 50 percent solution by evaporating excess water. The caustic evaporator plant employs a double effect evaporating system with steam as the heating medium.

PARANTHAN CHEMICALS CORPORATION

During the process of concentrating the caustic, unelectrolyzed salt present in the cell liquid crystalizes. This salt is known as evaporator salt. Part of the hydrogen produced at cell is used as fuel in the table salt drying process. Chlorine gas from the cells after cooling and scrubbing with water is dried in a series of drying towers using concentrated sulfuric acid as the drying agent. The dried gas is compressed to high pressure in chlorine compressors and chilled in a refrigeration plant that liquefies the chlorine gas.

The hydrogen from the cells and part of the chlorine before drying are burnt in an acid synthesis/absorption plant where the hydrochloric acid is absorbed in water to produce a 33 percent hydrochloric acid solution.

Ferric chloride and zinc chloride are produced by reacting vent chlorine gas with iron rust and zinc scrap, respectively, in water.

Production. Annual production has been based on the existing plant capacity and the demand for chlorine. Chlorine demand has historically been well below caustic demand. This often restricts plant production because caustic and chlorine must be produced at fixed ratios to each other. In addition, it would not be economically justified to produce caustic if the associated chlorine could not be sold. Production figures for 1980-1983 are shown in Exhibit 1.

In 1980, the major production setback was mainly due to power cuts imposed by the Ceylon Electricity Board (CEB). In addition to this power supply curtailment, there was labor unrest resulting in a strike that lasted almost 10 months. The fluctuation in the demand for chlorine resulted in curtailment of production with partial or complete shutdown of the plant as well.

Organization. The chairman and the board of directors operate PCC from Colombo, where the main accounting functions, import and trading of caustic soda, and other staff functions are also carried out. The senior executives attached to the head office are chairman/managing director, general manager, and assistant general manager. At the factory, the main departmental managers under the factory head are the chief engineer and production manager. The maintenance department reports to the chief engineer and coordinates the activities such as workshops, plant maintenance, electrical, and civil. Each of these sections has a section head, who

Exhibit 1

Production, 1980-1983
(Tonnes)

	1980	1981	1982	1983
Caustic	1,827	1,728	1,407	1,424
Liquid chlorine	1,456	1,338	845	902
Hydrochloric acid	982	979	624	563
Ferric chloride	123	107	117	90
Zinc chloride	75	58	46	31
Table salt	521	497	365	520

SOURCE: Paranthan Chemicals Corporation.

are engineers assisted by a superintendent, assistant engineers, and foreman (see Exhibit 2).

Markets. The demand for caustic soda is far in excess of production capacity at the factory. As a result, substantial quantities of caustic soda are imported. The production of chlorine is in response to the demand by the two major domestic sectors: paper industries and water treatment. Byproducts are produced to meet demand. Demand estimates supplied by PCC are shown in Exhibit 3.

Financial situation. PCC's activities are managed by its own resources without subsidy from the government. PCC has been making reasonable profits until recently. However, PCC is now losing money because of uncompetitiveness with imports. Other financial information is given in Exhibit 4.

Existing plans for modernization/expansion. There are no immediate plans for the expansion of the factory of modernization of the technology. However, expansion of the caustic/chlorine industry in Sri Lanka by building a new plant is under consideration.

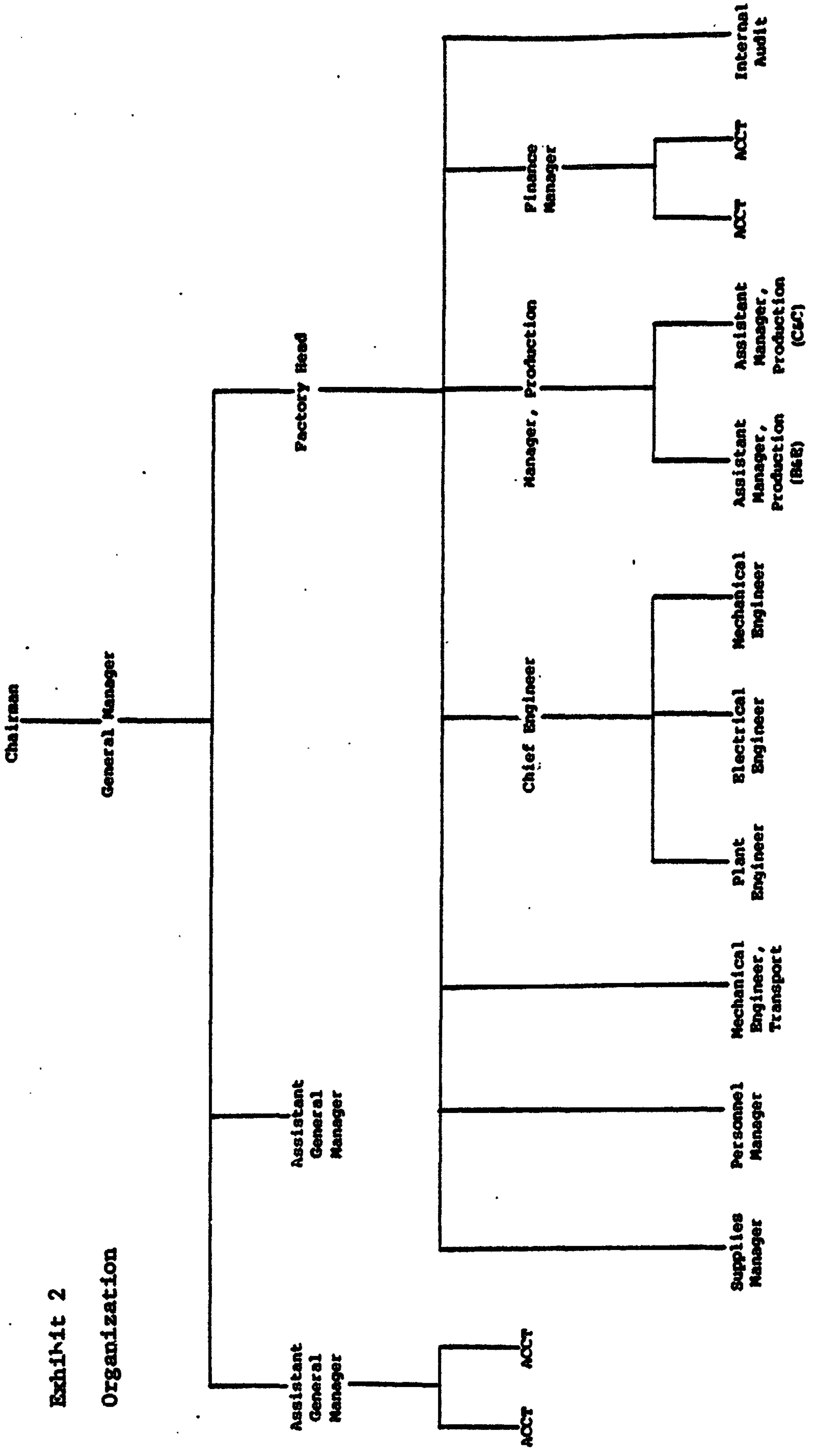
Major problems facing the facility. The major problems facing the Paranthan Chemical Corporation are twofold. First, the plant is obsolete and inefficient. While retrofitting the plant with a new, more efficient technology is feasible, the cost may be prohibitive. Second, demand for chlorine in domestic markets restricts the size of the facility and its production to levels well below world scale. It is not clear that a facility as small as Paranthan could compete effectively even with more efficient equipment.

2. Energy Situation

Major energy-using equipment. The boilers to produce steam for the caustic evaporation and the rectifiers to supply direct current for electrolysis are the major non-electric energy consumers at Paranthan. There are two manually operated boilers, each with a capacity of 6,750 lbs/hour. These boilers are vertical three-pass firetube boilers. They are provided with superheating coils to operate at pressures of 120 psi (8 bar). There is also one automatic boiler with a capacity of 10,000 lbs/hour. It is a horizontal, three-pass firetube boiler with an operating pressure of 120 psi (8

Exhibit 2

Organization



SOURCE: Paranthan Chemicals Corporation.

Exhibit 3

Estimated Demand, 1980-1983
(Tonnes)

	1980	1981	1982	1983
Caustic	9,000	9,000	9,000	9,230
Chlorine	1,500	1,800	1,800	1,560
Hydrochloric acid	960	1,500	1,600	1,320
Table salt	600	900	900	720
Ferric chloride	120	600	120	180
Zinc chloride	180	120	60	96

SOURCE: Paranthan Chemicals Corporation.

Exhibit 4

Financial Situation, 1980-1983
(Rupees)

	1980 actual	1981 actual	1982 actual	1983 actual
Fixed assets	26,084,840	27,603,976	25,089,160	27,973,176
Current assets	22,810,740	21,902,343	22,754,290	38,953,400
	48,895,580	49,506,324	47,843,450	66,926,582

SOURCE: Paranthan Chemicals Corporation.

PARANTHAN CHEMICALS CORPORATION

bar). There are provisions for preheating the fuel up to 90°C by steam.

There are two rectifiers used to convert alternating current (AC) to direct current (DC) for electrolysis. The first rectifier is West German manufactured (AEG). The second rectifier is English (Westinghouse). Each has a capacity of 792 kW. Maximum operating voltage and current are 240 V and 3,300 amps. Both rectifiers are silicon diode-type rectifiers, their voltage and current controlled by automatic transformers.

Energy use, prices, and specific energy consumption for Paranthan are shown in Exhibits 5, 6, and 7. The variations in specific energy consumption (see Exhibit 7) reflect changes in production level and mix.

Energy management organization. The senior of the two electrical engineers at the factory has been assigned as energy manager. The other electrical engineer and three foremen are assisting in this energy conservation program in addition to their normal day-to-day work.

3. Energy Conservation Potential and Potential Projects

The major problems facing Paranthan stem from the old, inefficient equipment it currently operates, the high cost of retrofitting the facility, and the relatively small domestic demand for chlorine. By world scale standards, PCC is very small.

To make the plant more efficient, a complete retrofit would be necessary. The two old electrolyzers would have to be replaced with a single, larger electrolyzer capable of 9,000-10,000 amps. Also, the 120 diaphragm cells would have to be replaced by roughly 50 larger, more efficient cells. The new cells would have an average lifetime of 27 months, in comparison with the 7-month average lifetime of the diaphragm cells currently in use. Specific energy consumption would decrease from 3,061 kWh per ton NaOH to an estimated 2,150 kWh per ton of NaOH with the implementation of these proposed changes. The simple payback for this project would be roughly 6 years (see Exhibit 8).

In our estimation, however, these costs are probably understated. The overall condition of the plant would most probably require additional investment to obtain

Exhibit 5

Fuel and Electricity Used

	1980	1981	1982	1983
Electricity (kWh)	10,116,385	9,800,605	9,373,740	8,124,218
Fuel (furnace oil) (liters)	1,446,980	1,368,740	1,121,260	1,024,847

SOURCE: Paranthan Chemicals Corporation.

Exhibit 6

Fuel and Electricity Prices

	1980	1981	1982	1983
Electricity (Rs./KWh)	--	1.40	1.25	1.60
Fuel (Rs./liter)	4.40	4.40	4.40	4.87

SOURCE: Paranthan Chemicals Corporation.

Exhibit 7

Specific Energy Consumption

	1980 average	1981 average	1982 average	1983 average
Fuel (furnace oil in liters/ton of NaOH)	701	738	773	712
Electricity (DC kWh/ ton of NaOH)	3,150	3,230	3,254	3,061

SOURCE: Paranthan Chemicals Corporation.

Exhibit 8

Paranthan Chemicals Corporation:
Plant Retrofit with New Equipment,
Rs.(000)

Cost of new rectifier* (f.o.b.)	7,500
Shipping	750
Tariff	1,650
Total cif cost of rectifiers	9,900
Installation	400
Total installed cost of rectifiers	**10,300**
Diaphragm cells (50 @ Rs.175 per)	8,750
Shipping	875
Tariff	1,925
Total cif cost of cells	11,550
Installation	800
Total installed cost of cells	**12,350**
Total installed capital cost	**22,650**
Annual electricity savings (30 percent of current costs)	3,750
Less: annual cost of replacing new cells	5,500
Plus: annual cost of replacing old cells	5,550
Net annual savings	**3,800**

Simple payback: 6 years.

*Equipment costs supplied by Paranthan Chemicals Corporation.

SOURCE: Hagler, Bailly & Company.

more efficient operations. Improvements in boiler operations, for instance, would be necessary.

4. Terms of Reference for Paranthan Chemicals Corporation

As stated above, demand for chlorine in the domestic market restricts the size of PCC's facility and its production to levels well below world scale. It is not clear that such a small plant can compete effectively with imports. This issue should be resolved before proceeding with the complete retrofitting, at a minimum cost of US $906,000, needed to make PCC energy efficient. In particular, the following questions need to be addressed:

- Production costs required for the Sri Lankan caustic/chlorine industry to be competitive with imports
- Production levels required to obtain these costs
- Domestic demand projections for caustic/chlorine for the next 20 years
- Initial investment required to make the caustic/chlorine industry (whether PCC's plant or a new one) competitive in Sri Lanka
- Subsequent levels of investment that would be required to maintain the plant
- Complete cost/benefit analysis of making versus buying in the caustic/chlorine industry.

In view of this basic problem, terms of reference were not prepared for a feasibility study on retrofitting the plant for energy efficiency. If the caustic/chlorine industry is indeed considered to be economically viable and a commitment is made to keeping PCC operating so that retrofitting becomes advisable, such a feasibility study would cost at most US$100,000.

PRIMA CEYLON LTD.

Summary

The Prima Ceylon Ltd. mill located on the east coast of Sri Lanka near Trincomalee is superbly maintained and in excellent condition. Plant management is actively seeking methods to reduce energy consumption at the mill and has the financial resources necessary to implement any economically sound conservation efforts.

Prima Ceylon does not require financial assistance from donor organizations. However, technical assistance may be required. The energy conservation options facing Prima Ceylon are complicated, and the plant could benefit from technical expertise from an outside organization. Projects identified for further feasibility studies include switch from diesel to heavier oil in boilers and waste heat recovery from diesel generators. Combined savings could reach Rs.4.2 million per year for a total investment cost of about Rs.4.3 million, with an average payback of 1.1 years (see Exhibit A).

Exhibit A

Prima Ceylon Ltd.: Summary of Possible Energy Conservation Projects
(1983 energy bill: Rs.77.4 million)

Project	Cost (Rs.000)			Average Annual financial benefit (Rs.000)			Simple payback (years)	
	Total	Foreign*	Local	Total	Foreign[1]	Local	Financial[2]	Economic[3]
Boiler modifications								
o Retrofitting boilers	1,250	1,000	250	2,100	1,890	210	0.6	0.7
Diesel engine waste heat recovery (boiler)	3,000	2,400	600	2,175	1,960	215	1.4	1.7
(Organic Rankine cycle)	(66,000)	(59,400)	(6,600)	(9,180)	(6,425)	(2,755)	(7.2)	(3.9)
TOTAL**	4,250	3,400	850	4,275	3,850	425	1.0	1.2

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1] [illegible] estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2] Total cost/average annual financial benefits.

[3] Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using [illegible] guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. \$0.14)/kWh vs. Rs.2.0 (U.S. \$0.08)/kWh for market price
- Opportunity cost of fuel oil = 75 percent of market price, or U.S. \$144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

**Excluding ORC, likely to be considered too much a capital-intensive project.

SOURCE: Hagler, Bailly & Company.

PRIMA CEYLON LTD.

1. Background

Plant/company history. The Prima Ceylon Ltd. plant at China Bay was built in 1980 in response to the need for efficient domestic production of flour. Prior to the erection of the Prima Ceylon mill, flour was produced domestically by small, less efficient mills and imported from various sources. The Prima Ceylon mill can produce flour at not only lower cost, but also better quality. By agreement with the Sri Lankan government, the private, foreign-held plant (headquarters in Singapore) will be handed over to Sri Lanka after 20 years of operation.

The plant itself was designed and built by Buhler, a major Swiss engineering and construction firm. Production started in September 1980. Less than 4 years later, the plant remains in excellent condition.

Location/process description. The Prima Ceylon plant is located on a large natural harbor near Trincomalee on the east coast of Sri Lanka. Wheat, bran, and pollard from around the world are brought to the plant on ships from which they are off-loaded by two large pneumatic blowers. These blowers literally suck the grain out of the holds of the ships. The grain is weighed and transported by covered conveyors to storage silos. In the storage silos, cool air is circulated through the pollard to maintain low temperatures. The cool air is produced in a small chiller with an 18-kW compressor.

From the silos, wheat is transported to the processing plant where offal is filtered out of the wheat for use in animal feed. In various stages, tramp metals, rubbish, and assorted undesirable materials are removed from the grain. Wheat is sent to roller mills where it is ground into flour and transported to a packing station. Pollard is treated somewhat differently in that it is pelletized for use as feedmeal. During pollard pelletization, low-pressure steam is directly applied. The pelletization process is the only operation in the plant that uses steam.

Organization. The Prima Ceylon plant has both a factory and district manager on location. Under the factory manager comes the line supervision tasks: production, maintenance, and electrical departments. The district manager controls the staff organizations: accounting, shipping, and personnel. Both the factory manager and the district manager report to the general manager in Colombo. Ultimately, all parties are responsible to corporate headquarters in Singapore.

Markets. Flour is produced by Prima Ceylon at the direction of the Sri Lankan government solely for use in domestic markets. Flour leaves the plant by ship, lorry, and truck to various points around the country.

Pelletized pollard is produced both for the domestic and export markets. Contract arrangements for the products are made by the Singapore headquarters.

Employment. The mill has an employment of roughly 400.

Financial situation. Plant personnel were not at liberty to discuss the financial situation of this privately-held concern, but it would be safe to say that Prima Ceylon is in a sound financial position.

Existing plans for modernization/expansion. The mill was designed and built with the intention of making a 25 percent capacity expansion relatively easy, and such a project is still under consideration.

Major problems facing the facility. There are no major problems facing the facility. Emphasis is now being placed on running the mill more efficiently and reducing costs where appropriate. The objective is to maximize return within the time allotted before the plant turns over to the Sri Lankan government. All investment opportunities take this time frame into consideration.

Energy management organization. There is no separate organization in the plant with the expressed, sole duty of monitoring and reducing energy consumption. The Electrical Department now has responsibility for both boiler operations as well as the plant's substantial electrical requirements. Energy conservation efforts occur as part of the day-to-day assignments of the engineers in the Electrical Department.

2. Energy Situation

Prima Ceylon spends between Rs.4 million and Rs.5 million monthly on energy in its China Bay mill. Electricity costs account for almost 95 percent of the mill's total energy costs. The power requirements are met by either purchasing electricity from CEB or by producing electricity in diesel generators owned by the plant. In 1983, slightly less than half of the plant's power needs were supplied by CEB; the remainder was produced and consumed internally (see Exhibits 1-3).

Prima Ceylon has five diesel generators in total: two 3-MVA generators and 3 smaller 1-MVA generators. In 1983, these generators produced 17 million kWh of power using 4.58 million liters of diesel fuel, or 3.316 kWh/liter of diesel. At the current automobile diesel fuel cost of Rs.8.7/liter, internally-produced electricity costs Rs.2.62/kWh, well above the CEB price. This does not include the cost of lube oil, maintenance, or other operating costs. Consequently, Prima Ceylon buys power from CEB as long as CEB can provide it. During the drought season, Prima Ceylon must use its diesels more frequently.

The electrical equipment are mainly motors of a variety of ratings, numbering close to 1,000. The approximate breakdown is as follows:

kVA	Number of motors
less than 20	800
20-50	100
50-100	6
100-500	9

Apart from these motors, an estimated 200 kVA is needed for air conditioning, lighting, and other services such as cooking. Most of the motors are in continuous operation except for the largest motors above 50 kVA.

Prima Ceylon also operates two 4-tonne, automobile diesel-fired boilers. Low-pressure steam (6-8 bar) is used in the plant's pelletizing operations. In 1983, nearly 500,000 liters of diesel fuel was consumed in the plant's boilers.

3. Potential for Energy Conservation

The potential for energy conservation at Prima Ceylon ranges from boiler modifications to waste heat recovery devices to load management planning. These projects are discussed in further detail below.

Exhibit 1

Prima Ceylon: Fuel Consumption and Costs, 1981 and 1982

	Quantity	Cost (Rs.)
1981		
Electricity:		
Generated (liters auto diesel)	43,223	265,389
Purchased (kWh)	22,539,040	25,912,370
Boilers (liters auto diesel)	122,509	752,205
Vehicles (liters auto diesel)	24,910	152,947
1982		
Electricity:		
Generated (liters auto diesel)	1,757,298	10,789,809
Purchased (kWh)	18,896,400	28,590,859
Boilers (liters auto diesel)	334,847	2,055,960
Vehicles (liters auto diesel)	76,480	469,587

SOURCE: Prima Ceylon.

Exhibit 2

Prima Ceylon: Fuel and Oil Consumption from
0700 January 1, 1983, to 0700 January 1, 1984

Fuel Consumed (liters)	
Generators	4,578,875
Boilers	495,832
Transport	70,524
Miscellaneous	3,965
Total	5,149,196
Total units generated (kWh)	17,074,751.5
Total units purchased (kWh)	16,286,000
Total hours steamed (hours)	5,998
Total fuel received for 1983 (liters)	5,186,100
Opening balance as at 0700 hrs on January 1, 1983 (liters)	5,758,839
Total	5,758,839
Total consumption for 1983 (liters)	5,149,196
Closing balance as at 0700 hrs on January 1, 1984 (liters)	609,643

Lube oil consumed for generators during 1983 (liters):

Rimula X 40	28,842
Omala 220	1,045
Turbo Oil 78	50
Dromus B	25
Total	29,962

SOURCE: Prima Ceylon.

Exhibit 3

Cost of Fuel During 1983 at Prima Ceylon

From March 4, 1983 -- 2,456,390 liters @ Rs.7.02 per liter.

Units generated: 10,387,659.5 kWh. Total cost: Rs.17,243,857.80.

From July 27, 1983, to January 1, 1984 -- 2,100,000 liters @ Rs.8.49 per liter.

Units generated: 5,115,317 kWh. Total cost: Rs.17,829,000.00.

Lube oil consumption per kWh: 1.689 ml.

SOURCE: Prima Ceylon.

3.1 Boiler Modifications

Prima Ceylon has two 4-ton/hour Loos boilers of German manufacture. Only one of these boilers operates at a given time, with the second boiler operating as a back-up. Both boilers are fired on automobile diesel fuel oil and operate in the range of 6-8 bar with an on/off controller attached to a pressure transducer. The boilers are very well insulated and in excellent condition. While Prima Ceylon has never attempted to determine their efficiencies (because they do not have the required instrumentation), they are apparently very high. For both boilers, feedwater is preheated by the direct application of steam. Air is not preheated. The exhaust temperature of the stack is not measured, nor is any waste heat recovered.

Accurate measurements have been taken of the diesel fuel consumption in the boilers. Though there are no steam meters, water flow to the boilers before filtering is measured. In 1983, 495,832 liters of diesel fuel was consumed in the boilers, while water consumption was 9,468 cubic meters (before accounting for plant estimates of 15 percent filtering losses). As a result, Prima Ceylon would estimate 16.2 kg of steam are raised for each liter of diesel fuel oil. The theoretical maximum at the calorific fuel value for diesel of 9,400 kcal/liter is approximately 14.7 kg/liter. At an estimated efficiency of 85 percent, the best Prima Ceylon could hope for would be 12.5 kg steam per liter of diesel fuel oil. Consequently, Prima Ceylon's current estimates of 16.2 kg of steam per liter of diesel indicates that either the water meter gives too high a reading or there are greater losses in filtering than anticipated.

In 1983, Prima Ceylon operated the boilers for a total of 5,998 hours for an average fuel consumption rate of 82.7 liters/hour. Consequently, the average steam production was 1,090 kg/hour. This would imply the two 4-ton boilers are oversized. While pelletizing is not a continuous operation, careful production planning could lower peak steam requirements.

Clearly, substantial fuel cost savings could be obtained if the automobile diesel fuel were replaced with a heavier oil (e.g., 800 second oil), or even industrial diesel. The speed of the diesel engines is the key element in this regard. Automobile diesel oil costs Rs.8.70/liter, while 800 second oil costs Rs.4.50/

liter. Industrial diesel costs Rs.5.5/liter. It may be possible to retrofit the Loos boilers to fire heavier oil, or -- in the event retrofitting proves impossible -- the purchase of an entirely new furnace oil-fired boiler may prove economical. Roughly 30,000 liters of waste lubrication oil could also be burned in a furnace oil boiler. These waste oils cannot currently be burned in the diesel boilers.

The total installed cost of a packaged, 2-tonne (2,400 lb/hr) furnace oil-fired boiler is estimated at Rs.2,395,000, of which 80 percent is foreign cost (see Exhibit 4). Assuming 90 percent of the annual consumption of roughly 500,000 liters of diesel could be replaced with furnace oil (a diesel back-up boiler would account for the remaining 10 percent), annual fuel savings would reach Rs.1.89 million. Simple payback would be 1.3 years.

The cost of retrofitting the Loos boilers to fire furnace oil is slightly more difficult to estimate. Prima Ceylon had previously investigated this option and determined that it was not economically justified. We are not as certain. We estimate that replacing the burners or one of the boilers coupled with full installation would cost Rs.1.25 million, of which 80 percent is foreign cost (see Exhibit 5). Annual fuel cost savings of roughly Rs.2.1 million would result in a simple payback of 0.6 years.

3.2 Diesel Engine Waste Heat Recovery

Prima Ceylon currently generates roughly half of its power requirements using diesel generators. It has two 3-MVA generators and three 1-MVA generators that produced 17 million kWh in 1983. The two large 3-MVA generators are located side-by-side and produced 15 million kWh of the company's 17 million kWh internally generated power.

There are two possible options for increasing the plant's energy efficiency with regard to the operation of the diesel engines. First, it may be possible to use the waste heat from the diesels to produce low-pressure steam, eliminating the need to use the boilers. Second, it may be possible to use the waste heat to drive an organic rankine cycle to produce additional electricity. There are a number of such systems in

Exhibit 4

New Furnace Oil Boiler
(Rs. 000)

2 ton furnace oil boiler, f.o.b.	1,350
Transportation (15 percent of f.o.b. cost)	200
Tariff (20 pe. cent)	270
Cost of boiler, c.i.f.	**1,820**
Installation	
New furnace oil pump	250
New furnace oil tank	125
Installation	200
Total installed boiler cost	**2,395**
Current fuel cost: 500,000 liters diesel @ Rs.8.7/liter	4,350
Fuel cost with new boiler	
Diesel (10 percent operating time for back-up)	435
Furnace oil* (450,000 liters @ Rs.4.5/liter)	2,025
Total annual fuel saving	**1,890**

Simple payback: 1.3 years.

*A lower furnace oil boiler efficiency is offset by a corresponding increase in calorific value of furnace oil relative to diesel. Also, 30,000 liters per year of waste lubrication oils could be burned in the furnace oil boiler.

SOURCE: Hagler, Bailly & Company.

Exhibit 5

Retrofitting Boilers from Diesel Oil to Heavier Oil

Total installed cost of new burners, heating equipment, pumps, and storage tank	1,250,000
Current cost of diesel fuel (500,000 liters @ Rs.8.7/liter)	4,350,000
Cost of fuel oil after burner change (500,000 liters @ Rs.4.5/liter)	2,250,000
Annual fuel cost savings	2,100,000

Simple payback: 0.6 years.

*Waste lube oil from the diesel engines can also be burned after changing burners. Consequently, the boiler after retrofitting is assumed to be 6 percent less efficient (30,000 liters of lube oil/500,000 liters of diesel) than the auto diesel boiler.

SOURCE: Hagler, Bailly & Company.

operation both in industrial plants (e.g., refineries) and on ships, mostly in the United States and Israel.

The waste heat recovery boiler (WHRB) would have a total installed cost of Rs.3 million (80 percent foreign) and a simple payback of 1.4 years (see Exhibit 6). The organic Rankine cycle (ORC) would cost roughly Rs.66 million (90 percent foreign) and have a simple payback of 7.2 years (see Exhibit 7).

Since many of these projects are interrelated, it is advisable that Prima Ceylon first study the feasibility of retrofitting the diesel engines so that they can be fired on 800 second oil. Such modifications have been made in other countries on similar engines. Currently, the cost per kWh of running the engines on automobile diesel oil is greater than the cost of buying power through the national grid. If, however, the engines could be fired on 800 second oil or industrial diesel, the cost of producing electricity in-house could be sharply reduced. If the generating costs are lowered substantially, a waste heat recovery boiler could provide all of the plant's steam requirements if the generators were run continuously. The objective of the plant should become to develop a scenario in which it would be cheaper to produce electricity rather than buy it.

3.3 Load Management Activities

Production scheduling for the pelletizing department. The department comprises four pelletizing machines driven by 175 kW motors. Production in this department is not continuous and is never run at full capacity. Further, the electrical loads at the jetty are on only when loading/unloading activities are in progress, and the load is fairly high and is comparable with the load at the pelletizing department. Thus, it is possible to schedule this department to run only when loading/unloading activities are not present.

It is suggested that a complete study of non-continuous loads be carried out by the electrical engineers of the factory, and the possibility of rescheduling their operations should be investigated. A comprehensive scheme should be drawn up in consultation with the production manager. The loading schedule for the non-continuous loads should be drawn up a few days ahead. The chief electrical engineer or his deputy should be appointed

Exhibit 6

Waste Heat Recovery Boiler

Total installed cost, 3,000 lb/hr WHRB	3,000,000
Annual diesel boiler fuel savings, liters	250,000
Annual cost savings (Rs.8.7/liter)	2,175,000

Simple payback: 1.4 years.

Hagler, Bailly & Company.

Exhibit 7

Organic Rankine Cycle
(Rs. 000)

Total installed cost*	66,000
Annual additional electricity production, kWh**	5,100
Annual savings (Rs.1.8/kWh)	9,180

Simple payback: 7.2 years.

*1,500-kW ORC.
**Thirty percent of the plant's 17 MM kWh internally generated power.

SOURCE: Hagler, Bailly & Company.

as the manager for this scheme and should execute it in close collaboration with the production departments.

4. Terms of Reference for Prima Ceylon Ltd.

Prima Ceylon Ltd. has excellent opportunities for energy conservation, and they can be easily identified (see previous section). Therefore a detailed energy audit is not required. It is recommended that technical assistance be acquired by Prima Ceylon to **conduct feasibility studies** in the following areas:

1. Retrofitting the Loos boiler to fire a heavier oil than automobile diesel

2. Retrofitting the diesel generators to fire heavier oils

3. Installing a waste heat recovery device on the diesel engines in the form of a waste heat recovery boiler or an organic Rankine cycle.

Section 3 provides background for the analysis.

Also, the consultants will assist Prima Ceylon in developing load management activities at the mill. These activities will focus on scheduling the loading/unloading and pelletizing operations to minimize peak electricity demand. A plant re-start plan after supply disruptions from CEB will also be developed by the consultants in conjunction with the Prima Ceylon staff. It is not believed at this time that a full audit is necessary, although implementation of the above actions may raise additional issues that will need to be addressed.

For each one of the retained projects (likely to include most of the projects identified in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (including demand and market projections)

2. Technical options

3. Cost and performance assumptions

4. Financial analysis

5. Economic and social analysis

6. Recommendations

   Appendices.

The cost of the feasibility studies is estimated at U.S. $20,000-$40,000, depending on the involvement of local consultants.

HOTEL LANKA OBEROI

Summary

The Hotel Lanka Oberoi (HLO), which is the single largest non-industrial electricity user in Sri Lanka (with more than 10 GWh annually), has a substantial potential for both electricity and fuel oil consumption reduction, representing probably more than 10 percent of total energy used. Recognizing this, the hotel management has recently contracted with a local specialized engineering firm to conduct a detailed audit in early July 1984 to develop a comprehensive conservation program. The cost of the audit and subsequent feasibility studies and investments will all be borne by the parent corporation. Therefore, it has been concluded with management that the hotel did not need any external financial assistance nor any detailed terms of reference, as work is already underway with a competent private firm.

HOTEL LANKA OBEROI

1. Background

The HLO is the largest and most luxurious five-star hotel in Sri Lanka. Located in central Colombo, about 30 kilometers from the Colombo International Airport, HLO first opened in 1976 with about 110 rooms. In November 1983, a new wing was commissioned, bringing the total number of rooms to 600. The hotel hosts many other facilities, including six restaurants, five bars, numerous sports facilities, banquet and conference rooms, and a business center.

Performance. Since its inauguration, HLO has maintained a high occupancy rate. For example, the rate of occupancy (defined as the percentage of rooms occupied to the number of rooms available) in 1981 and 1982 remained at about 90 percent. In 1983, however, because of the July political disruptions and the commissioning of the new wing in November, this rate had dropped to 37 percent by the end of the year. In 1984, the average rate of occupancy is likely to be in the 50-percent range, or about 8,000 room-days occupied monthly.

Employment, financial situation, and project evaluation. Confidential.

Future plans. As HLO has just completed its expansion to 600 rooms, no other major expansion project is contemplated for the short term.

Major problems facing the facility. The major problem that HLO will face in the future will be that of maintaining sufficient levels of occupancy to keep profits in line with the past performance. Indeed, a large number of new rooms will be made available in Colombo in coming years with the opening of four major international hotels (Taj, Meridien, Ramada Renaissance, and Hilton), and it is not likely that demand will be able to match supply for some time.

2. Energy Situation

HLO is one of the major energy users in Sri Lanka, with a total annual bill of more than Rs.30 million. It is by far the largest non-industrial electricity consumer.

Major energy-using equipment. The electrical equipment consists primarily of four 400-tonne refrigeration chillers, of which three operate at the same time, requiring up to 350 kW. Chillers consume about 60 percent of the total electricity used by the hotel. Other large electricity users include eight 60-hp pumps for cooling systems. Total electricity peak demand is about 2,100 kVA, the balance being used by multiple fans, kitchen lighting, and miscellaneous equipment.

Furnace oil is used in two boilers, sized at 9,000 lb/hr, 10 bar, using 1,000 sec oil. They are fitted with economizers and flue gas scrubbers. Their efficiency is not known precisely because hotel engineering staff do not have the necessary equipment, but is probably around 75 percent. Most condensates are returned to the boiler, and a waste heat recovery device using flash condensate steam preheats sanitary hot water, which is then heated by steam to about 80°C.

Diesel oil is used when standby generators are run (two Mitsubishi generators rated at 1,140 kVA each).

Fuel and electricity used. As shown in Exhibit 1, annual electricity consumption was about 11.5 GWh and furnace oil consumption, about 750 tonnes for the period between April 1983 and March 1984. These figures cover the capacity increase from 300 to 600 rooms by late 1983. Taking into account the period from October 1983 to May 1984 (i.e., 8 months with 600 rooms available), monthly consumption per room-equivalent comes to 1,810 kWh and 121 liters of oil. These figures correspond to a total annual energy use per square foot of about 28 kWh and 81,000 Btu (760 ft^2/room-equivalent). Both numbers are slightly higher than for comparable hotels in the United States, for example (20 kWh and 77,000 Btu), which can be partly explained by the very large common areas.

Fuel and electricity costs. As a commercial customer, HLO pays higher rates than industry for electricity. Demand charge runs at Rs.150/kVA (versus Rs.90 in industry), and 1 kWh costs Rs.2.2 on the average, including fuel adjustment charge. Overall, one unit of power costs slightly more than Rs.2.5.

Furnace oil costs Rs.5.5/liter, the same price as for industry. HLO's total annual fuel bill is around Rs.4.5 million.

Energy management organization and activities. HLO has recently initiated monthly energy management meetings (the first was held on May 7, 1984), where the general

Exhibit 1

Electricity and Furnace Fuel Consumption from April 1983 to March 1984

Electricity consumption

Month/year		Units	Amount (Rs.)
April	1983	671,120	1,334,681.60
May	1983	763,480	1,523,446.40
June	1983	826,960	1,683,292.80
July	1983	700,000	1,484,000.00
August	1983	1,204,280	3,042,558.40
September	1983	875,180	2,230,610.40
October	1983	1,055,300	2,663,684.00
November	1983	966,440	2,477,883.20
December	1983	1,067,840	2,728,675.20
January	1984	1,152,780	2,916,738.40
February	1984	983,420	2,519,397.60
March	1984	1,130,000	2,906,288.00
Total 1 year*		11,396,800	27,511,253.00
April	1984	1,176,000	2,980,880.00
May	1984	1,163,180	2,946,050.00

*Rs.2.41/kWh.

Furnace fuel consumption

Month/year		Liters
April	1983	52,132.5
May	1983	52,670.5
June	1983	54,418.5
July	1983	66,131.8
August	1983	55,749.2
September	1983	56,734.5
October	1983	63,945.0
November	1983	63,328.5
December	1983	70,463.5
January	1984	67,805.0
February	1984	74,801.0
March	1984	83,286.0
Total 1 year		761,465.0
April	1984	85,571.0
May	1984	71,410.0

SOURCE: Hotel Lanka Oberoi.

manager, chief engineer, and other relevant partici-pants meet. Meeting minutes are published to outline actions to be taken. For example, the first meeting emphasized the accelerated replacement of incandescent bulbs by fluorescent lights and discusses the use of automatic/microprocessor or clock control systems for lighting and air conditioning.

3. Energy Conservation Potential and Potential Projects

Based on a rapid visit conducted on June 2, 1984, and discussions with the chief engineer, it appears that there is room for energy cost reductions at HLO, both in electricity and furnace oil use. The visit also re-vealed that equipment was of good manufacture, in good running condition, and that some improvements were tak-ing place, mostly in electrical safety, thermal insula-tion, and lighting retrofit.

Some metering equipment exists, but not enough data were available to estimate efficiency of key items such as chillers and boilers. For example, there is no indi-vidual oil and water flowmeter or thermometer for boil-ers. Therefore, given the magnitude of the energy bill, an energy audit is a required prerequisite to project identification. Recognizing this, the chief engineer recently proposed to hotel management to have an energy audit conducted by a competent local consult-ing firm, CTC Services (a subsidiary of Ceylon Tobacco Company). This proposal was accepted bv the board on June 6, 1984.

Based on the visit and experience gained in other coun-tries, it is estimated that about 5 to 10 percent of the electricity bill and 10 to 15 percent of the fuel bill could be saved. Cumulative cost savings could thus reach Rs.2-3 million annually. Candidate projects are likely to include:

- Comprehensive electric load demand management
- Lighting efficiency improvement
- Boiler housekeeping (air/fuel control, insula-tion)
- Kitchen energy use improvement (limiting the use of electricity)

HOTEL LANKA OBEROI

- Laundry energy use improvement (limited scope)
- Electric peak shaving using diesel generating sets.

These projects are not discussed further as the audit is planned to take place in July and will identify costs and benefits of all potential projects by midsummer.

It is anticipated that about Rs.1.5-2 million will be required to achieve savings levels mentioned above, for an overall simple payback of less than 1 year.

COLOMBO GENERAL HOSPITAL

Summary

The Colombo General Hospital is in a very poor condition with respect to its energy situation, but is achieving miracles in coping with overall budgetary constraints. Because of the lack of sufficiently detailed consumption records, the vast area covered by the facilities and the lack of sufficient available technical and specialized staff, a detailed audit is required. Considering the opportunities in energy use efficiency improvements and fuel switch (e.g., electricity to gas or oil), it is possible to cut hospital fuel costs by at least 20 percent in the short term and at low cost. Once the proposed feasibility study has verified the economic viability of the measures required to achieve these savings, they can be implemented immediately. Capital costs for these measures have accordingly been included in the cost of the feasibility study (US$100,000). The study should take about four man-weeks, excluding the time required for the capital investments which are to be undertaken immediately. It will also establish the costs and benefits of further energy-saving measures, including major retrofitting. Meanwhile, it is of utmost importance to consider energy efficiency in all modernization/expansion programs, such as the one currently proposed under Finnish aid in particular. It is contemplated to install a new all-electric laundry. Such a project should imperatively be modified to use fuel, either town gas or furnace oil, rather than electricity.

COLOMBO GENERAL HOSPITAL

1. Background

History. The Colombo General Hospital (CGH) is more than 120 years old and has been continuously expanding since. CGH is now a decentralized unit of the Colombo group of hospitals and is placed under the Ministry of Colombo Hospitals and Family Health, which was created in 1979. Many organizations have contributed to its expansion and multiple renovations, including the Bank of Ceylon, the Lions Club, and various foreign organizations.

Description. CGH occupies about 12.5 ha of land in the center of Colombo and has a current capacity of more than 2,300 beds, of which only about 75 beds are for paying patients; the rest are for non-paying patients. However, occupancy often exceeds capacity, and temporary facilities must be available to meet high demand. On June 5, for example, there were 2,515 non-paying patients and 74 paying patients.

CGH is a surgical and medical hospital with 8 intensive-care units (fully air-conditioned) with 53 beds and 7 operating theaters. Additional details are provided in the appendix.

Staffing and organization. CGH employs about 3,300 people, of which approximately 300 are medical officers and 900 are nurses. CGH is headed by a superintendent who is assisted by a deputy superintendent. Maintenance activities are under the administrative officer, who reports to the deputy superintendent.

Financial situation. The hospital is in a very poor financial situation, and no internal funds are available for any non-critical improvement program. Because of this difficult situation, CGH owes more than 1 year's electricity fees to CEB. Total 1983 budget was Rs.115 million, but expenses exceeded revenues.

Project evaluation. Because of CGH's inability to finance any project, project evaluation is not performed on an economic merit basis; rather, projects are undertaken when absolutely needed.

Existing plan for modernization/expansion. A four-phase modernization and expansion program has been proposed under Finnish assistance. Money has been allocated to Phases I and II, which will deal primarily with infrastructure. In Phase I, which includes provisions for new sterilizer units, laundry, and a new 400-bed orthopedic unit, an overall revamping of the utilities, including energy-using systems, is included (see appendix for details).

2. Energy Situation

Major energy-using equipment. CGH uses mostly electricity and town gas. Electricity is used for (1) air conditioning of operating theaters, intensive-care units, mortuary, and telecommunication centers, (2) water heaters and sterilizers (six operating out of a total of ten), cooking (about half of the requirements), and other general services such as elevators (eleven units), and (3) lighting (mostly fluorescent tubes). Town gas is mostly used for cooking in unsophisticated stoves and for some other minor applications (e.g., laboratory tests).

Fuel and electricity used. Monthly electricity consumption runs at about 490,000 kWh, with very little seasonal variation. The total annual bill is about Rs.11 million (see Exhibit 1). Town gas consumption is 290,000 ft^3 per month, at a cost of Rs.88,000/month.

Total electricity and gas expenses (Rs.12.5 million) represent approximately 11 percent of total hospital operating costs, which amounted to Rs.115 million in 1983. These figures are very low by international standards, with an average of 6.5 kWh and 4 ft^3 of gas per patient-day.

Energy management organization and conservation activities. There are three electrical engineers from CEB attached to the hospital, but no formal energy management organization or budget. The engineers' duties are essentially in maintenance and repair. The major energy conservation initiative has been gradual replacement of incandescent bulbs with fluorescent tubes.

The major problems facing energy conservation activities result from the total lack of funds available for this purpose and the large number or ministries and organizations involved in any decision. For example, modifying the doors of the air-conditioned rooms to reduce leakage would require the cooperation of three ministries.

Exhibit 1

Electricity Statistics

Month/year		Units (kWh)	Amount (Rs.)
January	1983	500,000	802,500/-
February	1983	490,942	791,086/92
March	1983	493,707	794,570/82
April	1983	492,282	793,027/32
May	1983	493,626	794,468/76
June	1983	492,067	792,504/42
July	1983	492,419	792,947/94
August	1983	493,000	1,015,520/-
September	1983	493,866	1,017,010/86
October	1983	493,129	1,015,750/59
November	1983	493,391	1,017,224/61
December	1983	492,340	1,014,401/40
January	1984	489,508	1,009,558/68
February	1984	493,279	1,016,007/09
March	1984	490,931	1,011,992/01
April	1984	488,879	1,008,472/83

SOURCE: Colombo General Hospital.

3. Potential for Energy Conservation

While some individual projects can easily be identified, it is recommended to conduct an energy audit of the facility. Such an audit could be conducted by a foreign expert in conjunction with CEB and local consultants trained by EDMAC/USAID. It is likely that the audit would recommend, among others, the following measures:

- o Repair gas leaks
- o Use only gas-fired stoves in the kitchen
- o Install LPG tank
- o Replace existing doors of air-conditioned rooms with improved, air-tight doors to reduce losses.

To implement all of the above projects, not more than Rs.2.5 million, including the audit, would be required; savings could reach Rs.2-3 million annually (mostly electricity through air conditioning improvements), yielding an average payback of approximately one year. This estimate is very rough as no efficiency data was available, but represents about 20 percent of the total energy bill. Experience in other hospitals in better condition has shown that such a savings rate can easily be achieved.

In addition, it is strongly recommended to install fuel-using thermal equipment when possible instead of electric equipment, as part of Phase I of the Finnish-assisted master plan for hospital improvement and expansion. For example, the envisioned laundry unit should use petroleum products, not electricity, to generate steam. In terms of useful energy, fuel can be 2 to 3 times cheaper. The lower investment cost would not be justified on a life-cycle cost basis.

4. Terms of Reference for Colombo General Hospital

A detailed energy audit of CGH is required. To conduct the detailed energy audit, the consultants will successively:

1. Conduct a preliminary audit (also called survey) or "PEA" to collect historical data on (a) energy use and rate of occupancy, (b) energy-using equipment, and (c) technical personnel available for energy efficiency work on-site. This preliminary audit shall not take more than 3 man-days to perform (see EDMAC's energy auditing manual for more detailed directions to perform the PEA).

COLOMBO GENERAL HOSPITAL

Specific attention should be given to the technical and economic efficiency of (a) using town gas versus light furnace oil, and (b) using town gas or furnace oil in lieu of electricity.
After the preliminary audit verifies the economics of the following four retrofits, the consultants shall proceed to carry out the required work: (1) repairing gas leaks; (2) using only gas-fired stoves in the kitchen; (3) installing an LPG tank; and (4) replacing existing doors of air-conditioned rooms with improved air-tight doors to reduce losses. The capital costs of these retrofits shall be included in the cost of the feasibility study.

2. On the basis of the findings of the PEA, the consultants will, in collaboration with local technical staff, undertake a detailed audit of these areas which deserve an instrumented analysis. It is likely that the following areas will be of prime importance:

- o Kitchen
- o Air conditioning
- o Town gas distribution
- o Sterilizers (to a lesser extent).

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide CGH with the following information for each option:

- o Description

- o Estimated cost in foreign and local currency with sources of information and range of confidence

- o Estimated benefits in physical units, financial (i.e., at market prices), and economic (i.e., at true cost to the economy) values

- o Implementation schedule and recommendations.

More details about the audit requirements are given in EDMAC's energy auditing manual. The final product shall be a practical implementation plan acceptable to CGH management that can be organized in several phases:

COLOMBO GENERAL HOSPITAL

- o Phase one: low cost/no cost measures (housekeeping) requiring little or no extensive expense;

- o Phase two: minor retrofits, requiring some limited capital expenditures, but highly profitable;

- o Phase three: major projects requiring large capital expenditures and long lead time.

It is estimated that the audit and report preparation should take between 6 and 8 man-weeks, excluding the time required for repairing the gas leaks, installing the LPG tank, and installing air-tight doors. Results should be quickly made available to the Finnish aid organization to be included in its modernization plan. Training of technical staff should also be included in its project (efficient air conditioning in particular). The total cost of the feasibility study (including the capital costs of repairing the gas leaks and installing the LPG tank and air-tight doors) is US$100,000.

APPENDIX (excerpts from Finnish project)

Electrical Networks

General

The area of the CGH consists of several buildings of various ages. Owing to this discrepancy in ages, there are also great differences in the condition and scope of the electrical, as well as the telecommunications, systems in the buildings, as well as in different parts of the hospital site.

Since hardly any records were kept while the electrical and teletechnical connections were installed, repaired, and replaced during the different construction periods of the hospital area, only the main components and connections of these networks can be presented in the distribution drawings. However, as these connections are in a rather poor condition as a whole, they need in any case to be replaced for most parts as the renovation proceeds. This is the only practical way to guarantee safe and continuous service of these vital functions.

The electrification and the telecommunication equipment are in accordance with the BSS standards (at least in the newest buildings). The installations in the renovated and in the new buildings should also meet the same standards to minimize the number of required spare parts and to facilitate maintenance and repair work.

The 11-kV Distribution Network

The CGH area has a middle voltage distribution network of its own (11 kV, 50 Hz), and the area will mainly obtain its 11-kV supply (substation No. 76 of the hospital area located near the Medical Intensive Care Unit) from the 33/11-kV Primary Substation D near Welikeda. In addition, the 11-kV supply has been secured by substation No. 14 of the primary substation D. Another standby supply has been brought to satellite stations No. 26 from satellite station No. 19 of the primary substation A. There are five transformer stations in the hospital area; however, satellite station No. 263 supplies only locations outside the area.

COLOMBO GENERAL HOSPITAL

The transformer capacity of the area is as follows:

Station no.	Transformer capacity (kVA)	Peak load
76	2 x 750	--
25	2 x 500	--
26A	500	--
76A	500	--

The 0.4-kV Distribution Network

The 0.4-kV supply to the hospital area has mainly been via external feeder pillars. Only the biggest sporadic loads have been supplied directly from the transformer station.

The low-voltage parts of all transformers have been connected to one or more transformers, either directly via transformer centers or feeder pillars. This has been done to secure the necessary functions during eventual power breaks or maintenance/failure of the transformer/medium-voltage equipment, and also to restrict the size and amount of the standby units. In this way, a relatively secure power supply has been guaranteed together with the reserve power machines.

Reserve power capacity of the area is as follows:

Supply area of the standby power machine	Power (kVA)	Peak load (kW)
Main operating theater and NCOT	150	--
Accident service: operating theater and recovery units	36	--
Central blood bank (not used at present)	50	--

The 0.4-kV distribution network is presented in drawing no. 15, attached.

Auxiliary Services

The auxiliary services are the services needed to support the medical activities of the CGH (e.g., laundering, sterilization). These services function at a reasonable level in some sectors (e.g., catering services), while certain other sectors (e.g., central storage facilities, archives) are practically nonexistent. This is due to the manner in which the hospital has grown, in which process some service units, such as the central kitchen, have been constructed recently to cope with the present day demand for catering, while some services are still run in a very disorganized and outdated way (e.g., laundering, which is done manually). As a result, an overall functional network of auxiliary services to satisfy the medical demands does not exist. The existing units are working in difficult conditions and need updating and integration with eventual new units to be established, as well as with the other functions of the hospital.

Functional Difficulties

Laundry Services

Laundry services for linen, textiles, sterile textiles, etc. are primitive and outdated. There is neither a building nor equipment for this purpose at the hospital site. For instance, washing for the operating theaters, the neurosurgical unit, and Wards 39 and 40 is done manually at the central washing area, which houses six bathtubs and a water supply connection. Similar smaller units are scattered around the hospital area. The linen and textiles are dried outside, either by hanging on clotheslines or by spreading them on the grass. Due to the washing methods, the quality of wash is poor; the loss of linen is also frequent. During the rainy season, the drying of linen is a problem. The sometimes-poor quality of water and the shortcomings in the supply also cause occasional inconveniences. Small volumes of linen are washed outside the hospital premises by the Prison Department and a private contractor. The unsatisfactory laundry services have also been considered a potential cause of hospital infections.

Instrument Service and Sterilization Facilities

Instruments are presently sterilized at three different places at the hospital site:

- The Central Service and Sterilization Department (CSSD), with seven high-pressure sterilizers (autoclaves), of which two to three are functioning

- The Outpatient Department, with one autoclave

- The Accident Service, with two autoclaves.

It has often proved difficult for these units to supply the hospital with enough sterile dressings and instruments due to the breakdowns of machinery and the shortcomings in the water supply. Together with their inconvenient location (the first two are located at the far sides of the site) and the long transportation distances along crowded walkways, it is difficult to meet even the minimum hygienic standards set for sterilized instruments and dressings used in operations. The availability of disposable articles is limited, and the cost of their use is too far beyond the financial resources to be considered a permanent solution. A central sterilization unit adjoining the laundry with easy access to the main operating facilities is essential for efforts to decrease the rate of postoperative infections.

Staff Accommodations

The lack of staff quarters in general and the accommodation of house officers in particular are problems at CGH. There are 175 house officers and 75 consultants attached to the hospital. Some quarters have been restored on the first floors of the Radiology Department Building and the old Administration Building. The St. Peters Nurses' Quarters houses approximately 50 nurses in very old premises. The main Nurses' Quarters accommodates approximately 150 nurses (total nursing staff at CGH is approximately 850). Sharing accommodations are provided for about 60 senior house officers and 32 interns in bachelor quarters half a mile away at Barnes Place. More than half of the doctors currently reside 10 to 15 miles from the hospital. The lack of accommodations has been considered one reason for the lack of, for example, nursing personnel. There is a staff housing project under construction next to the hospital site. After completion of this project, there will be 20 flats for married couples and 96 rooms for singles. However, this will only partly ease the demand.

Staff Canteen

There is a central canteen on the second floor of the modern kitchen used by the staff. The other canteen (in Building 71A), run cooperatively, serves both personnel and visitors at the rate of about 2,000 per day. As these cannot cope with the demand, some additional capacity is needed.

Central Kitchen

The central kitchen is one of the more modern buildings at the hospital and, in principle, works satisfactorily. I has three separate cooking areas and ancillary storage facilities. It caters separately for three categories: paying patients, averaging about 75; non-paying patients, averaging 2,500; and minor staff, averaging about 1,500 at each meal. Breakfast, lunch, and dinner are provided. Food distribution is done by food trolleys allocated to each ward. Patients' relatives are not served food by the hospital. The foodstuffs are supplied by the Marketing Department and the Fisheries Corporation. Cooking is done both by gas and electricity. In addition to the usual minor maintenance requirements of the buildings, the need for constant repair of gas leakages, the poor ventilation, and the lack of exhaust fans are the cause of some inconvenience.

Electrical Networks

The CGH area belongs to the supply district of the Welikeda 33/11-kV primary substation D in Colombo City. The main switch station of the hospital area is ring substation No. 76 of station D. The 11-kV supply of the area has been secured in addition by two auxiliary supplies.

Despite the securing of the 11-kV supply, there are rather frequent power breaks in the area. Great attention, therefore, should be paid to the capacity and the technical condition of the standby power machines to be able to guarantee the continuity of the necessary functions even during power breaks. The present transformer capacity might be enough to cope with the current loading situation, but new buildings and renovation will require additional transformer and generator capacity.

The internal electrical installations in the older buildings are inadequate and in bad condition. Lighting has been provided even in larger spaces at least partly by incandescent lamps, which increase power consumption and the need for maintenance because of poor efficiency and the short lifespan of the lamps. Nursing staff work is complicated in the older buildings by, among other things, the small number of socket outlets, which also makes use of technical auxiliary equipment difficult.

Adequate illumination levels required by nursing and teaching purposes should be taken into consideration when designing lighting and other electrification for the new buildings and for the renovations, so that adapting new auxiliary equipment for teaching and nursing will be possible.

To improve the safety of patients and personnel, a fire alarm system should be installed in the multi-story buildings.

A transformer station and a standby generator will be built in Phase I to serve the buildings to be constructed at that time, as well as later phases of construction. The transformer and the generator room will be located at one end of the new central storage building.

The power capacity of the transformer to be procured in Phase I will be 750 kVA. The ring main unit will be extendable with another unit, which allows a second transformer to be added later.

The power capacity of the standby generator to be procured in Phase I will be 110 kVA. this generator can also provide reserve power supply for the Emergency Service Building in Phase II.

When rearranging the yard areas, the feeder pillar near the Kynsey Place may have to be moved. It is also necessary to reinforce the existing power distribution network within the CGH area to meet the additional power demand.

CEYLON TOBACCO COMPANY, LIMITED (CTC)

Summary

Ceylon Tobacco Company is undoubtedly a leader in energy efficiency in Sri Lanka, which has lead them to establish a specialized consulting subsidiary, CTC Services, to assist other companies or organizations in energy auditing, consulting, and engineering, with a special emphasis on the use of local fuels.

This report presents some additional projects CTC should consider to cut even further its energy bill. These projects include mainly improved steam line insulation, waste heat recovery on dryers, and installation of a new multifuel boiler. CTC does not require any foreign assistance to implement these projects if they are found financially justified. Several projects should be investigated further by CTC Services, mainly the rehabilitation of the steam system and the installation of a new multi-fuel boiler (see Exhibit A).

Exhibit A

Ceylon Tobacco Company, Limited (CTC): Summary of Possible Energy Conservation Projects
(1983 energy bill: Rs.8.6 million)

Project	Cost (Rs.000) Total	Cost (Rs.000) Foreign*	Cost (Rs.000) Local	Average Annual financial benefit (Rs.000) Total	Average Annual financial benefit (Rs.000) Foreign[1]	Average Annual financial benefit (Rs.000) Local	Simple payback (years) Financial[2]	Simple payback (years) Economic[3]
Steam system rehabilitation and waste heat recovery	600	360	240	260	234	26	2.3	2.5
Installation of a multifuel boiler	2,500	1,750	750	742	668	74	3.3	3.8
TOTAL	3,100	2,110	990	1,002	902	100	3.0	3.5

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1]ENMAC estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2]Total cost/average annual financial benefits.

[3]Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using ENMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price
- Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly & Company.

CEYLON TOBACCO COMPANY, LIMITED (CTC)

1. Background

Plant/company history. The history of CTC dates back to 1927, when British American Tobacco Company (Ceylon) Limited began manufacturing cigarettes and smoking tobaccos in Sri Lanka.

Elephant, a brand of Thomas Bear and Sons Limited, was the first cigarette to be manufactured. The factory, which was at Bloemendhal Road, Kotahena at that time, was moved to the present building at 176, Sri Ramanathan Mawatha in 1940. The old factory is now used for storage.

CTC was incorporated as a Rupee Company in March 1932 and took over the business previously carried on by British American Tobacco Company (Ceylon) Limited. The new company acquired the trademarks, trade names, brands, and good will associated with the business, and was engaged in the manufacture and distribution of cigarettes and smoking tobaccos.

In August 1955, CTC became a public company with the issue of shares in the local market. The company also acquired the entire business of Godfrey Phillips Ltd. in Sri Lanka and the Maldive Islands, together with the assets associated with Sri Lanka and the right to manufacture "Godfrey Phillips" brands in Sri Lanka.

The Godfrey Phillips factory at Skinners Road North (renamed George R de Silva Mawatha) was thereafter converted into an office block and was vastly extended in the late 1970s. This block is now the registered office of the company and of its subsidiaries.

The leaf division's green leaf threshing plant and its offices were constructed in Mawilmada, Kandy in 1953. With the transfer of the cleaning and classifying plant from Colombo factory to Kandy a few years ago, the buildings have been extended and more modern machinery have been installed.

For many years, tobacco was imported for the manufacture of cigarettes. However, in 1940, the company participated in experiments in the production of flue-cured tobacco in Sri Lanka. The gradual increase thereafter in the quantity and quality of Virginia-type tobacco grown in the island resulted in the reduction of imports year by year.

CEYLON TOBACCO COMPANY, LIMITED (CTC)

The importation of tobacco has now ceased. Indeed, the company has been exporting tobacco leaf since 1967.

In 1974, a research station was set up for research in leaf growing, training of field staff, and activities regarding the development of tobacco cultivation areas. These activities were further improved with the construction of the research laboratory in the leaf division, head office premises. In this well-equipped, modern laboratory, research is now conducted on the tobacco and the finished product.

The company began to diversity its activities in 1973-1974. Thereafter, it started the processing and export of non-tobacco products, such as sesame seed and essential oils. It launched three major diversification projects -- the Orchid Project in 1978, the Mahaweli Agricultural Project in 1979, and the Thriposha Program in 1980.

CTC has four subsidiary companies -- namely, Colombo Distributors, Ltd., CTC Services, Ltd., CTC Exports, Ltd., and CTC Briquettes, Ltd. The CTC Services, Ltd. is mainly engaged in the management activities of the groups' diversification projects and also carry out commercial operations in energy and alternative fuels (including energy auditing).

Plant location. The leaf processing factory is in Kandy, and it is called the Green Leaf Threshing Plant (GLT Plant). The manufacture of cigarettes and pipe tobacco takes place at the Colombo factory. Main leaf growing areas are in the Central regions and toward the North East and South East.

Process description. Tobacco is a seasonal crop and in Sri Lanka, mainly grown by a multitude of small-scale farmers. They feed their crop to bigger tobacco barn owners/farmers who cure the leaf, usually in wood-fired tobacco-curing barns. This process reduces moisture from between 30-50 percent in the field to 16-19 percent moisture content. Thereafter, the farmers grade their produce according to the color and texture of the cured leaf and transport to the respective depots run by the company. These are purchased, packed into bales, and transported to the GLT Plant in Kandy.

At the plant in Kandy, the tobacco leaf goes through a cleaning and classifying process, at the end of which the stem is separated from the rest of the leaf. Both

CEYLON TOBACCO COMPANY, LIMITED (CTC)

these are then sent through conditioning and redrying machines, using hot air and steam to achieve a final uniform moisture content of around 10 percent. The lamina, the threshed leaf, and the stems are baled in hydraulic presses and sent to Colombo for storage prior to manufacture of cigarettes.

At the Colombo factory, the manufacturing operation commences with the movement of bales of stem and lamina from the leaf storage points to the leaf reception room. From this room, the bales are moved into the production process. The number and grades of the bales required on a particular day are determined by the blend to be processed on that day.

As the bales are moved from the leaf reception, they are weighed mainly for the purpose of calculating the excise duty payable. Presently, the company pays excise duty at the rate of Rs.341/kg. This works out to over Rs.8 million/working day.

Thereafter, the bales are put through an initial conditioning process using steam and moved to the primary manufacturing department for the primary processes in the manufacture of cigarettes. By means of these processes, the lamina and steam, which are treated and conditioned separately, are finally converted into cut tobacco with a moisture content appropriate for the manufacture of cigarettes. This cut tobacco is thereafter loaded blend-wise into containers called skips and stored in the cut tobacco stores, which maintain a relative humidity around 68 percent.

The cut tobacco is fed to the machines in the cigarette-making department for the manufacture of cigarettes by means of a pneumatic process. Some cigarette-making machines produce plain cigarettes, and the others, filter-tipped cigarettes. The rates of production range between 2,000-2,500 cigarettes per minute.

The filter, which is manufactured separately in the filter rod room, is interpolated into the cigarette-making process by means of a filter rod attachment in the cigarette-making machine. The filter is made out of a substance called acetate tow.

The completed cigarettes are placed on trolleys which are then left in cigarette conditioning cupboards to attain the correct moisture content before they are packed for distribution to the market. The cigarette conditioning cupboard maintains a relative humidity around 45 percent.

Four processes could be identified in the cigarette packing department; namely, packing, wrapping, parcelling, and casing. Cigarettes are packed in 10s to 12s in shell and slide packets, hinged-lid packets, and soft cup packets, depending on the brands and marketing requirements. The cigarette packets are then parcelled into cartons and then loaded into cases or boxes. A case or box is normally packed with 10,000 cigarettes and is referred to as a mille. Thereafter, the cases or boxes are conveyed to the manufactured stock godown, where they are stored until purchased and collected by the distributors.

Continous quality checks are carried out at every stage of manufacture. These include not only tests on the tobacco, cigarettes, and packets, but also on the quality of the materials used. The aim is to ensure that the produce reaching the consumer is of optimum quality.

Employment. The factory employs 1,100. The maintenance division comprises about 5 managers, 15 supervisors, and 100 workmen. The leaf division employs 650. The maintenance division comprises 3 managers, 5 supervisors, and 50 workmen. The CTC(S) employs 240.

Financial situation (Rs.000's). The turnover in 1982 was 2,994,832 and 3,490,395 in 1983. The profit before taxation in 1982 was 125,117 and was 131,405 in 1983. The profit after taxation in 1982 was 59,811 and was 72,967 in 1983.

Project evaluation criteria. Three criteria are considered: (1) Increase product output/quality. (2) Reduce energy/operational costs. (3) Improve plant efficiency.

Existing plans for modernization/expansion. Cigarette manufacturing and quality control are continuously being reviewed and modernized. While specific plans are confidential, for the purposes of this report, we can say that major changes in energy consumption are not foreseen in the near future.

Major problems facing the facility. Space is a major problem. Factory was designed in early 1950s for a production less than half the present demand. Hence, there is pressure in machinery storage/accommodation

CEYLON TOBACCO COMPANY, LIMITED (CTC)

space. Because of production demands, it is also difficult to remodel buildings and relocate machinery in the most logical manner to suit the present demands.

2. Energy Situation

Major Energy-Using Equipment Characteristics

The major energy-using equipment comprise four boilers and electrical equipment.

Boiler (04 Nos). Boiler No. 01 is a Cochran spheroid with a steam output, 3,600 (rated) and [illegible],200 (normal) lbs/hr at 100 psi. Boiler No. 02 is a Cochran, serial no. 18381 with a steam output of 1,000 lbs/hr (rated) and 600 lbs/hr (normal) at 100 psi. Boiler No. 03 is a Cochran, serial No. 17056 with a steam output of 1,000 lbs/hr (rated) and 900 lbs/hr (normal) at 100 psi. Boiler No. 04 is a Wee Chieftan (package) with a steam output of 6,000 lbs/hr (rated) and 4,500 lbs/hr (normal) at 150 psi. Boiler No. 04 is operational daily. When not operational, Boiler No. 01 and one of 02 or 03 has to be operated.

All the above boilers consume furnace oil 1000 R seconds viscosity. Tobacco conditioning cylinders (02 numbers) consume approximately one-third of the steam generated. Tobacco driers (02 numbers) consume 60 percent of the steam generated. Stand-by power generator of capacity 01 MW consume 45 gallons/hr auto diesel. Electric motors consume 80 percent of electrical energy. All motors are rated below 50 hp. Air conditioners, heaters in machines, fans and lighting consume the balance of 20 percent of electrical energy.

Fuel and Electricity Used (1980-1983)

CTC factory - Colombo

Year	Electricity units (kWh)	Furnace Oil (liters)
1980	3,105,740	588,333
1981	3,326,400	596,273
1982	3,606,300	580,348
1983	3,157,100	462,262

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Fuel and Electricity Prices (1980-1983)

Petrol prices (per liter) for the period 1980-1983 were Rs.10, Rs.12, Rs.13.50, and Rs.15, respectively. Diesel prices (per liter) for the same period were Rs.4.62, Rs.6.75, Rs.8.13, and Rs.10, respectively. FFO prices (per liter), again for the same period, were Rs.4.30, Rs.4.30, Rs.4.74, and Rs.5, respectively. The electricity-industrial tariff (in kWh unit rates cents) for the period 1980-1983 were 60, 60, 52, and Rs.3, respectively (plus fuel adjustment and demand charges).

Supply Characteristics

Three transformers, 500 kVA, 11,000/400 volts, 3-phase 50 Hz. FFO: 500 gallons/day. Petrol: 1,000 liters/ month. Diesel: 300 liters/month. FFO is supplied in 2,000 gallon bowsers once a week from Ceylon Petroleum Corporation.

Factory storage capacity is 11,000 gallons of FFO and 8,000 gallons of diesel. A minimum stock of 75 percent of full capacity is maintained.

Specific Energy Consumption (Fuel/Electricity)

As shown in the table below, significant progress has been made in reducing specific energy consumption during the last few years.

Year	Electricity kWh/ million cigarettes	FFO liters/ million cigarettes
1980	597	114
1981	600	113
1982	622	100
1983	555	78

Energy Management Organization

The organization is depicted below:

COMPANY ENERGY COORDINATOR

ENERGY MANAGER FACTORY

ENERGY MANAGER GLT PLANT

ENERGY MANAGER FIELD

CEYLON TOBACCO COMPANY, LIMITED (CTC)

Energy Conservation/Fuel Switching
Activities Past/Present/Future

Electrical. The following steps have been taken to conserve electric power:

a. Overall power factor improved from 0.7 to 0.95, thus reducing the maximum demand by 225 kVA and making a saving of Rs.90 x 225 = Rs.20,250/ month.

b. By fixing Bablec energy-saving devices to a bank of 20 fluorescent tubes, 10-15 percent energy savings has been achieved. Five more units have been ordered to be installed in the future.

c. Energy-efficient motors have been installed in almost all the machinery and equipment. Oversized motors have been replaced with correct sized motors.

d. Machinery operations have been scheduled to avoid peak demands.

e. A/C units, lights, and fans are switched off when not used. Timber and thermostatic controls are incorporated in A/C units.

Steam. Projects have included rationalization of steam distribution, improved condensate recovery system, more effective use of boiler house instrumentation, and fuel usage monitoring. These projects have resulted in overall fuel savings of about 15 percent. Feasibility studies are underway for installation of a multifuel boiler which will burn factory waste and other combustible fuels.

Waste heat recovery from flue gas, driers, air compressors will be taken into consideration in the future under energy-saving activities.

Compressed air ring main has been improved by eliminating bends and installing moisture traps. Line leaks have been eliminated.

Program of changing to diesel vehicles continues. A great interest has been shown at management and supervisory level to ensure more efficient transport operations.

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Entire layout of the primary manufacturing departments has been moved with rationalization of equipment to increase output and conserve energy. A gas roaster and redryer have been discontinued, and cigarette drying has been eliminated with a large energy saving. However, cupboard is operated during extreme weather conditions. The CTCM will be removed in the near future, and a new tobacco conditioning line will be introduced using less steam and electricity.

3. Energy Conservation Potential and Possible Projects

In spite of the progress made to date, it is still possible to cut energy costs further. Several possible projects are presented below.

3.1 Project Laundry List

Insulation of boiler walls and feed water tanks: By improving insulation of these two items, plant saving can be made in boiler fuel consumption.

Repair of steam leaks from feedwater tank: Fitting a flash vessel to recover steam from the feedwater tank condensate inlet would reduce steam loss.

Insulation of pipe work: This measure involves improving the insulation of the steam distribution and condensate return pipe work.

Installation of a boiler stack gas economizer: Installation of this device will enable utilization of available sensible heat in the stack gas for the preheating of boiler feedwater.

Conversion to firing on coir fibre dust (CFD) briquettes: It is possible to convert two of the older Cochran boilers to firing on this material. Because of low boiler efficiency, however, this proposal needs further investigation.

Installation of a new multifuel boiler: This boiler would be fired on solid fuels, such as coir fibre dust and combustible wastes from the plant. Fuel oil would be burned as a standby fuel.

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Solar preheating of boiler feedwater: Solar panel system to be used to heat boiler feedwater prior to entering to the boiler.

Recovery of heat from process plant exhaust air: Heat recovery from exhaust air can be used to preheat clean air at the inlet to the dryers and the tobacco conditioning units.

Waste heat recovery from a new chilled water plant: If a new chiller is installed, a system in which waste heat is recovered from chiller condensate can be considered.

3.2 Specific Projects With Preliminary Costs and Benefits

Steam System Rehabilitation and Waste Heat Recovery

Description. The steam generated in boilers is used mainly for drying and direct injection in the primary processing departments. Boiler walls, steam distribution, and condensate return pipes return feedwater tanks, etc. need surface insulation upgraded and improved.

Drying is carried out mainly by using hot air that is heated up to the correct temperature by means of steam heat exchangers, attached to each dryer. After a single pass, the hot air is extracted, sent through cyclones and baghouses for cleaning, and then discharged to the atmosphere. The temperature of the hot air discharged is between 60°C to 80°C in the three main dryers. As such, a significant amount of heat can be recovered from these hot air streams and used to preheat incoming fresh air to dryers. Recirculation of air is not recommended because of tobacco dust in the discharge air streams. Hence, it is recommended that a heat wheel, plate-type heat exchanger, or other recovery device be used for this purpose.

Cost. It is estimated that a heat recovery device operating on exhaust from all three dryers will cost Rs.600,000 installed (60 percent foreign).

Savings. On the basis of measured temperatures and air flows, it is estimated that annual savings from heat recovered in three discharged hot air streams would be about Rs.260,000. Simple payback = 2.3 years.

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Implementation. Technical study and assessment = 5 months. Procurement, installation, and commission = 8 months to 1 year.

Installation of a Multifuel Boiler

Description. Another possible conservation project for this factory would be to replace existing oil-fired boilers with a purpose built multifuel boiler. This boiler could burn coir fibre dust and also combustible wastes available at the plant. These wastes, which have a high fuel value, are currently burnt in an incinerator with no heat recovery device. Fuel oil would be used as a standby fuel in the multifuel boiler. This factory will not consider the use of firewood because it considers that it would be politically and environmentally unacceptable in the present context in Sri Lanka.

Cost. It is estimated that the new multifuel boiler would cost Rs.2.5 million installed (70 percent foreign).

Required quantity of coir fibre dust briquettes = 2.5 tonnes/hour. The annual fuel cost would be Rs.2,465,100 on CFDB versus Rs.3,207,600 on furnace oil. Savings = Rs.742,500 per year. Simple payback = 3.3 years. If all wastes are burned in the boiler, simple payback would drop to less than 2 years.

4. Terms of Reference

Terms of reference for future work are not given here as CTC clearly has in-house capability to study and implement all projects suggested above and does not require assistance from international donor organizations. CTC should ask CTC Services, its subsidiary, to develop a detailed work plan for in-house implementation.

BRITISH CEYLON CORPORATION (BCC)

Summary

British Ceylon Corporation is a government-owned business undertaking producing coconut oil, soaps, other personal products, and steel drums. The plant has been located on the same Colombo site for over 100 years.

While some energy conservation projects were tentatively identified, data availability was particularly poor. A complete energy audit is required to provide the necessary data.

BRITISH CEYLON CORPORATION: SUMMARY OF POSSIBLE ENERGY CONSERVATION PROJECTS

Project	Cost (Rs. 000) Total	Foreign	Local	Average Annual Financial Benefit (Rs. 000) Total	Foreign 1/	Local	Simple Payback (years) Financial 2/	Economic 3/
Improved boiler performance 3/	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Replacement of steam ejectors for oil deodorization	375	338	37	500	450	50	<1.0	n/a
Replacement of steam ejectors for chilling water 3/	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Installation of capacitors	400	360	40	216	151	65	1.9	n/a
Total	775	698	77	716	601	115	1.1	n/a

Mid-1984 exchange rate: 1 U.S. dollar = Rs. 25.

n/a: not applicable or not available.

1/ EDMAC estimates that the foreign content of electricity is 70% of market price and that the foreign content of oil is 90% of market price.

2/ Total cost/average annual financial benefits.

3/ Due to a lack of sufficiently detailed data on energy efficiency at BCC, only financial paybacks were calculated, and the costs and benefits of two of the conservation projects identified as possible could not be estimated with sufficient reliability.

BRITISH CEYLON CORPORATION (BCC)

1. Background

British Ceylon was incorporated in 1918. The plant, located in the central section of Colombo, has been on the same site for over 100 years. Public shareholding continued through 1972, when the Sri Lankan government took over the plant. BCC is now categorized as a government-owned business undertaking (GOBU).

The plant makes a variety of products. Coconut oil from copra, toilette and laundry soaps, disinfectants, talcum powders, and steel drums.

Process description. Coconut oil is produced at BCC in the traditional manner. Copra is purchased from various sources, stored, and sent through disintegrators. From the disintegrators, the mashed copra is transported to cooking kettles. BCC has three lines of cooking kettles in parallel with 2 stages in each line. After the cooking kettles, the copra is sent through expellers which squeeze out the oil. The oil is filtered and pumped either to storage or directly to the port for shipment. The residue from the expellers, poonac, is used as feedmeal.

The oils can be deodorized if desired. In the deodorization process, vacuum is used to remove impurities from the oil. Steam ejectors requiring 250 psi are used to draw vacuum on the deodorizing tanks.

Coconut oil also goes through a neutralization step. Caustic soda is used as the acid neutralizing agent. After neutralization, water is removed by heating the jacketed reactor to 100°C and placing the reactor under 25-27 inches Hg vacuum. Water is condensed and drained off. The oil is then cooled and sent to storage.

Soaps are made in a batch process at BCC. Caustic soda, tallon, and coconut oil are mixed in large tanks. Boiling, cooling, washing, and reheating cycles are repeated over a period of 4 days per batch. Live steam is injected directly into the tanks for both mixing and heating purposes.

After the bulk soap is formed, it is sent to the Mazoni machines which cool, mix, cut, and stamp the soap into bars. Chilled water is used as the coolant. Steam ejectors are used to draw vacuum and chill the water.

Production. Production quantities and costs for BCC for the years 1980-1983 are shown in Exhibit 1.

Markets. Local and export sales for BCC's oil mill, oil refinery, soap factory, provender plant (poonac, poultry feed), and drum plant are shown in Exhibit 2. Export markets accounted for roughly one-third of BCC's total sales in 1982.

Financial situation. The financial situation of BCC is shown in Exhibit 3. BCC was profitable through the first 3 years of this decade, even in the face of the international and domestic recession.

Project evaluation criteria. No clear set of financial criteria are used to evaluate energy investment opportunities. There is no finance manager and but one accountant at BCC. It is difficult to determine whose authority is required to implement energy investment opportunities. Plant personnel were unaware of the procedures necessary to obtain funding for energy projects.

Existing plans for modernization/expansion. There are no current plans at BCC for plant modernization or expansion efforts.

Major problems facing facility. The plant is extremely old and generally in poor condition. The soap factory has apparently been operating at a loss in recent years due in part to the technical obsolescence of some of the equipment. The soap factory may be closed in the future.

2. Energy Situation

Major energy-using equipment. BCC operates four boilers fired on 1500 second oil. Two of the boilers are relatively large units, 21,120 lbs/hr and 17,250 lbs/hr, respectively. The remaining two boilers are smaller: an 8,000 lb/hr packaged boiler and a 2,000 lb/hr vertical Cochran. The three largest boilers are fully automatic.

No economizers, air preheaters, or oil preheaters are used on the boilers. There are oil, water, and steam flow meters for each boiler. Even so, BCC does not have individual efficiency data. Steam is used both

Exhibit 1

BCC Production, 1980-1983

	1980		1981		1982		1983	
	Production (kilograms)	Cost (rupees)	Production (kilograms)	Cost (rupees)	Production (kilograms)	Cost (rupees)	Production (kilograms)	Cost (rupees)
Oil mill	15,855,000	108,038,394	19,361,300	120,767,438	27,371,950	149,465,239	10,005,000	—
Soap factory	5,366,042	62,373,959	4,747,633	74,225,782	3,557,642	69,317,819	3,877,423	—
Oil refinery	1,385,495	16,986,379	1,221,245	18,868,270	975,964	17,868,669	779,821	—
Provender plant*	19,340,000	22,469,276	14,128,800	29,697,698	6,834,700	26,165,621	7,266,609	—
Drum plant	204,311	7,248,727	111,304	9,719,371	192,386	12,454,782	165,391	—

*Poonac and poultry feeds.

SOURCE: British Ceylon Corporation.

Exhibit 2

BCC: Local and Export Sales
(Thousands of rupees)

	1980		1981		1982	
	Local	Export	Local	Export	Local	Export
Oil mill	245,446	21,783	58,929	19,665	67,542	90,963
Soap factory	61,375	105	74,091	304	64,061	143
Oil refinery	14,231	3,426	16,704	3,534	14,725	3,998
Provender plant	25,415	--	36,256	--	30,024	--
Drum plant	7,158	1,752	11,513	2,222	8,863	--
	353,625	27,066	197,493	25,725	185,215	95,104

SOURCE: British Ceylon Corporation.

Exhibit 3

BCC Financial Situation, 1980-1982
(In Rupees)

	1980	1981	1982
Profitability			
Net profit before tax	426,484	4,581,855	756,937
Capital employed	38,287,193	35,281,609	75,316,876
Net sales	165,964,726	198,473,527	243,041,353
Liquidity			
Current assets	86,029,607	105,496,141	125,799,751
Current liabilities	56,923,584	82,030,150	110,986,195
Indebtedness			
Bank loan and overdraft	28,505,983	50,002,704	55,706,906
Other long-term loans	5,549,366	3,549,366	1,549,366

SOURCE: British Ceylon Corporation.

for indirect heating (cooking kettles) and direct heating (batch soap manufacturing).

When oil is being deodorized, the steam is generated at 250 psi to drive the steam ejectors. When oil is not being deodorized, steam is produced at 150 psi.

Average electricity demand at BCC is roughly 950 kVA. Peak demand exceeds 1,000 kVA. There is no power factor correction equipment used, and plant personnel estimate the power factor is in the range of 0.7-0.8. Standby diesel generators capable of 625 kVA are available in the case of supply descriptions, which are now infrequent in central Colombo.

Fuel and electricity used. BCC fuel consumption data for 1981 and 1982 are shown in Exhibit 4. Specific energy consumption is shown in Exhibit 5. It is difficult to relate these numbers to international standards because of the multiple products made at BCC.

Energy management organization. There is no energy management organization at BCC. One person in the engineering department is in charge of energy conservation efforts.

3. Energy Conservation Potential and Potential Projects

Despite the lack of sufficient data, it is likely that 20 to 25 percent of total energy consumption could be saved through an adequate conservation program. Four projects have been identified as possible energy conservation investment opportunities:

1. Improving boiler performance through the addition of an economizer

2. Replacement of the steam ejectors used in oil deodorization with liquid ring vacuum pumps

3. Replacement of the steam ejectors used to chill water for soap cooling with a small chiller unit

4. Installation of capacitors to improve the plant's power factor.

Exhibit 4

Fuel and Electricity Used

	1981	1982
Purchased electricity (kWh)	2,306,390	2,746,383
Petrol (liters)	26,668	26,255
Diesel (liters)	23,122	27,117
Furnace oil (liters)	2,840,210	1,185,360

SOURCE: British Ceylon Corporation.

Exhibit 5

Specific Fuel Consumption

	1981	1982
Purchased electricity (kWh/mt)	58.5	70.9
Petrol (l/mt)	0.68	0.68
Diesel (l/mt)	0.59	0.70
Furnace oil (l/mt)	72.0	30.6

SOURCE: British Ceylon Corporation.

Unfortunately, the few data available at BCC on fuel consumption were not sufficiently complete to make evaluation of the projects straightforward and easy. Most certainly an energy audit is required at BCC to obtain a more complete understanding of energy conservation potential there.

Addition of economizers. Individual boiler efficiencies and stack temperatures are not known. Consequently, the economic advantages of installing an economizer are difficult to determine without conducting a full audit.

Replacement of the steam ejectors used in oil deodorization with a liquid ring vacuum pump. The steam ejectors are used only when oil is being deodorized. Plant personnel did not have figures concerning either steam consumption of the ejectors or how often they were used. Consequently, it is impossible to estimate if the replacement of the steam ejectors would prove economic. Generally, the more the ejectors are used, the more attractive replacement will appear. The use of steam jets is basically an inefficient method for deodorizing if they have to be used frequently. The cost of a vacuum pump fully installed would be about Rs.375,000 (90 percent foreign). Operating benefits cannot be estimated without conducting an energy audit, but could represent up to 5 percent of furnace oil used, or about Rs.500,000 annually. Payback is probably about 1 year.

Replacement of the steam ejectors used to chill water for soap cooling with a small chiller unit. Based on experience gained in similar operations and given the relatively high cost of steam, it is likely that this measure would deserve a detailed study. Again, a full audit is required before the benefits of such a project can be accurately determined.

Installation of capacitors. BCC currently operates with a power factor in the range of 0.75-0.80. The installation of capacitors would increase the power factor to over 0.90. Total installed cost for 1,000 kVAr of capacitors would be Rs.400,000 (90 percent foreign). Savings would be about 10 percent of annual demand charge, or Rs.90,000 x 12 x 0.2 = Rs.216,000. Payback would be 1.8 years.

4. Terms of Reference for British Ceylon Corporation

British Ceylon Corporation operates a very old, energy-inefficient plant in central Colombo. As an example, soap production appears very inefficient.

A complete energy audit is required at BCC to provide the data necessary to evaluate accurately the costs and benefits of proposed energy conservation projects. The energy audit should focus primarily on the efficiency of soap operations, oil deodorization, and boiler performance.

4.1 Energy Audit

A detailed energy audit of the BCC factory should be conducted, consisting of the following successive steps:

4.1.1 The consultants will conduct a preliminary energy audit (also called survey) or "PEA" to collect historical data on (a) detailed energy use, (b) production, (c) energy-using equipment, and (d) technical personnel available on-site for energy efficiency work. The PEA should not take more than 4 man-days to perform.

4.1.2 On the basis of the PEA, the consultants will decide, in agreement with plant management, which fixed instrumentation should be installed prior to conducting the detailed energy audit and which areas deserve most attention.

The following areas are likely to be candidates:

- Boilers
- Steam distribution and utilization
- Steam ejectors
- Oil deodorization
- Power factor
- Electric load management.

Mass and energy balances will be prepared, when required, for several representative operating conditions.

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide BCC with the following information for each option:

- Description

- Estimated cost in foreign and local currency with sources of information and range of confidence

- Estimated savings in physical units and financial (i.e., at market prices) and economic (i.e., at true cost to the economy) values

- Implementation schedule and recommendations.

On the basis of the audit results, the consultants will undertake a series of feasibility studies for the projects that are too complex, risky, or capital-intensive to be fully analyzed within the audit (e.g., steam ejector replacement).

4.1.3 For each one of the retained projects (likely to include most of the projects identified in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (including demand and market projections)

2. Technical options

3. Cost and performance assumptions

4. Financial analysis

5. Economic and social analysis

6. Implementation

Appendices.

Each feasibility study should be discussed with EDMAC prior to submission to BCC.

4.2 Team and Project Duration

The energy audit team should comprise:

- A foreign expert specializing in soaps and oils with more than 5 years' experience in the industry
- One to two additional auditors, possibly including former EDMAC trainees and the BCC engineer.

The full audit should take about 1 man-month on-site, plus 1 month for report preparation for a total cost of U.S. $20,000-25,000.

The feasibility studies should be undertaken by the foreign expert in collaboration with BCC and EDMAC immediately following the audit.

The level of effort envisioned for the feasibility studies is between 3 and 6 man-months for a cost of U.S. $35,000-50,000.

PUGODA

Summary

Pugoda is a government-owned textile mill operated by an Indian contract management firm. The plant consists of two main operations: the spinning and weaving section and the finishing department. The plant is generally well run, and energy conservation activities receive excellent attention.

Six potential energy conservation projects were identified. Some of these could be easily implemented by plant management. Other projects require further investigation and may require that Pugoda obtain technical assistance. If all recommended projects are implemented, total savings could reach 20 percent of current energy bill (Rs.6 million) for a total cost of around Rs.8 million (see Exhibit A for a subset of possible projects).

Exhibit A

Pagoda Textile Mills: Summary of Possible Energy Conservation Projects
(Total 1983 energy bill: Rs.28 million)

Project	Cost (Rs.000)			Average Annual financial benefit (Rs.000)			Simple payback (years)	
	Total	Foreign[a]	Local	Total	Foreign[1]	Local	Financial[2]	Economic[3]
Heat recovery devices	1,200	960	240	700	630	70	1.7	2.1
Installation of a capacitor for power factor control	240	216	24	288	202	86	0.8	0.5
Reducing energy consumption in the chiller unit	800	400	400	370	260	110	2.2	0.9
Automatic control of the burners	1,600	1,280	320	888	800	88	1.8	2.2
TOTAL	3,840	2,856	984	2,246	1,892	354	1.7	1.4

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

[a]Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1]ENERCON estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2]Total cost/average annual financial benefits.

[3]Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using ENERCON guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price
- Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly & Company.

PUGODA

1. Background

Plant/company history. This plant was built with assistance from the Republic of China and commenced commercial operation in 1974. The government of Sri Lanka owns the plant through the National Textile Corporation. However, in keeping with the private-sector orientation of the present government, management of the mill was handed over in 1981 to an Indian firm, Lakshmi Textiles Ltd of South India. Profits are shared between the managing firm and the National Textile Corporation.

In 1982, Phase II of the project, a complete finishing plant, also constructed by the Peoples Republic of China, was brought into commercial operation.

Plant location. This factory is located in the village of Pugoda, which is off the main road to the regional town of Avissawella, and lies about 35 miles southeast of Colombo.

Process description. This plant consists of two main operations, the spinning and weaving section and the finishing section.

The spinning and weaving section has 25,296 spindles and 600 looms and has the capacity to produce 40,000 metres per day of grey cloth. Standard combing, cording, spinning, ring spinning, weaving, and sizing techniques are used. Only a small quantity of steam is used in this plant for the sizing of cloth.

The capacity of the finishing plant is on the order of 53,000 metres/day, higher than that of the spinning and weaving plant, so that processing of grey cloth purchased from outside could also be carried out. Of this capacity, approximately 18,000 metres are dyed, about 7,000 bleached, and the rest is printed.

In the finishing plant, printing is carried out on a rotary printer. Dying and bleaching are done on open jiggers. There are three process lines, each devoted to the three different finishing processes. The finishing plant is the major consumer of steam, taking about 90 percent, for a variety of purposes.

Production. Monthly production of finished products is around 100,000 kg.

Markets. Cloth is sold by this factory, solely in the domestic market. However, they export cloth indirectly by supplying to garment manufacturers who export to the major western markets. The company hopes to increase their share of this market by introducing artificial blends into their product range.

Employment and operation. Total employment in the factory is 2,280, inclusive of all grades. The factory operates on three shifts, 24 hours per day. The spinning section operates 343 days in the year. The weaving and finishing sections operate 292 days in the year.

Organization. The chief engineer and his subordinate engineer are responsible for energy conservation activities. No energy manager has been appointed as yet.

Financial situation. The Indian management of the plant considered that the overall financial situation is confidential. However, they mentioned that the company is at the breakeven point and would be profitable in the financial year 1983-1984. The contract between the Sri Lankan government and the Indian management firm is on the basis of a 1/3 share of the profits to the Indian company, 2/3 share to the government.

The company presently operates with a bank overdraft of Rs.80 million. There is no long-term debt.

Project evaluation criteria. At the present time, most projects would be evaluated on achieving a payback within 1 or 2 years. Priority would be given to projects that improve quality or increase production, but energy conservation projects would also be considered. The management contract expiration date (1987) dictates the low payback period requirements.

Modernization/expansion. There are no immediate plans for modernization/expansion, in view of the fact that the finishing section was only brought into production in 1982.

Major problems facing the facility. The major problem is the frequent unscheduled electric power supply interruptions. At the present time, the company does not have a standby generator for the production plant, though one is available for the housing estate. The purchase of a standby generator capable of operating the whole facility is being considered.

The other area that might be termed a problem is the diversification of production to better serve the market. For this purpose, the company will be producing cotton polyester blends especially for the garment export industry.

2. Energy Situation

Pugoda Textile Mills consume large amounts of furnace oil for steam raising and power for mechanical purposes.

Major energy-using equipment. Pugoda operates six boilers, of which three are small. In usual operation, 2 x 6.5 tonnes of steam/hour boilers are in operation and are being converted from 1,000 to 1,500 sec oil. Combustion efficiency has been measured at 80-82 percent. Overall boiler efficiencies are not known. There is some combustion air preheating.

Electricity peak demand is 1,690 kVA, of which 350 is for finishing. Major electrical equipment consist of four motors of 150 kW, of which two are running continuously for air conditioning (not for comfort).

Fuel and electricity consumption. Monthly furnace oil consumption varies from 220,000 liters to 300,000 liters, depending on production (see Exhibit 1). For the twelve months between June 1983 and May 1984, total annual furnace oil consumption has been about 2.5 million liters (2,330 tonnes), at a total cost of around Rs.11.5 million. Total fuel bill, including diesel oil, is around Rs.13 million.

Monthly electricity consumption is about 650,000 kWh and maximum load 1,690 kVA. Total electricity bill, including demand charge, is approximately Rs.15 million.

Total annual energy bill is therefore about Rs.28 million.

Specific energy consumption. The most relevant specific energy consumption is the average furnace oil consumption per kg of finished product, which stands at about 2.2 kg of furnace oil per kg of finished product. This value is high by international standards (usually between 1 and 2 kg of oil/kg of product), indicating scope for substantial energy cost reduction.

Exhibit 1

Pugoda Production Statistics (June 1983 - May 1984)

Month	Production in kgs. (finishing)	Oil consumption (liters): Weaving preparation: Furnace oil	Oil consumption (liters): Weaving preparation: Diesel	Oil consumption (liters): Finishing: Furnace oil	Oil consumption (liters): Finishing: Diesel	Power consumption, kWh (finishing)
June 1983	76,611.5	16,950.157	1,135.79	200,475	13,439	64,854
July 1983	69,056.9	16,080.833	349.13	163,545	3,551	52,865
August 1983	Nil	--	--	--	--	1,800
September 1983	34,653.8	18,079.022	628.13	94,171	3,272	36,573
October 1983	102,788.0	23,690.42	28.86	160,984	196	53,551
November 1983	104,947.2	24,328.00	0	225,997	0	77,057
December 1983	132,290.71	22,394.5	0	249,955	0	85,793
January 1984	131,234.58	24,478.355	0	251,421	0	87,797

Month	Production in kgs. (finishing)	Weaving furnace oil	Spinning furnace oil	Finishing furnace oil	Power consumption, kWh (finishing)
February 1984	94,454.59	25,932	1,500	217,293	76,352
March 1984	130,045.87	26,035	5,330	275,109	92,057
April 1984	79,535.82	20,188	3,911	174,700	60,297
May 1984	102,300.547	21,770	3,578	200,352	71,391

SOURCE: Pugoda Textile Mills.

3. Energy Conservation Projects

Utilization of Exhaust Heat

Description. Hot, high moisture laden streams of air are exhausted from some of the equipment in the spinning and weaving and finishing sections of the plant as follows:

- Spinning and weaving section. Steam sizing machines: exhaust temperature = 95°C; fan power = 3 kW; chamber temperature = 100°C; steam usages = 10 percent of the plant total.

- Finishing section. Rotary printing machine dryer: exhaust temperature = 105°C; fan power = 15 kW; duct size = 24 inches. Stenter: exhaust temperature = 100°C; fan power = 7.5 kW.

In all the equipment, heat is provided by means of steam radiators, which are used to heat up incoming air flows. The total amount of heat carried away by these exhaust air streams is quite significant, especially when latent heats of moisture are considered.

It is recommended that recovery of heat in the exhaust air (through a flat plate heat exchanger) and feedback of this heat to the incoming air stream in each case should be considered as an energy conservation measure. Since these air streams are not likely to carry a significant dust load, a modern heat wheel or similar device also capable of absorbing latent heat could be used for these purposes. Since the equipment is widely separated, heat recovery would have to be carried out on an individual basis.

Costs. It is estimated that these suitable heat recovery devices would cost approximately Rs.1,200,000 installed, all together (80 percent foreign).

Savings. It is known that the steam sizing machines takes about 10 percent of the total factory steam consumption. It is conservatively estimated that the printing machine and stenter will absorb another 10 percent of the total factory steam consumption.

It is assumed that installation of heat recovery devices on the exhausts of the equipment mentioned will reduce the steam demand by 25 percent in all cases (i.e., by 5 percent of the total steam demand).

Steam savings = 325 kg/hour. Furnace oil savings = 33,000 gallons/year (at an estimated 78 percent boiler overall efficiency). Cost savings = Rs.700,000 per year. Simple payback = 1.7 years.

Implementation. It is recommended that a technical study of waste heat recovery should be undertaken by the factory engineering staff, together with assistance from local consultancy organizations and manufacturers of waste heat recovery equipment.

Technical feasibility study = 3 months. Procurement, installation, and commissioning = 8 months to 1 year.

Installation of a Capacitor for Power Factor Control

Description. At the present time, the capacitor installed to correct power factor is insufficient to maintain the power factor at around 0.95, which should be easily achievable for a plant of this size. It is recommended that a comprehensive set of automatic power factor correction equipment be installed to increase the power factor from a presently estimated value of about 0.80 to 0.95.

Cost. It is estimated that in improving the power factor to 0.95, the size of capacitor required will be approximately 600 kVAr. The cost of this automatic correction equipment, fully installed, would be Rs.240,000 (90 percent foreign).

Savings. The monthly savings in demand will be 267 kVA, approximately. Cost savings per year = Rs.288,000. Simple payback = 10 months.

Implementation. Since there are a number of local companies supplying power factor correction equipment, it is recommended that the factory engineering staff should proceed on this conservation as soon as possible, without outside help.

Procurement, installation, and commissioning = 8 months.

Reducing Energy Consumption in the Chiller Unit

Description. Temperature and humidity control in the spinning and weaving areas of the factory is carried out by means of air that has been passed through chilled water spray chambers. Chilled water for this purpose is supplied by a single centralized chilling plant consisting of four compressors.

Spent chilled water is returned through unlogged open drains and pipes with partial flow, first to a reservoir and then to the evaporators. At the time of the visit, it was found that the reservoir temperature was lower than the return chilled water temperature. The reason was that one out of two evaporators was always operated on a reservoir bypass, to maintain structural integrity by maintaining fluid pressure. This results in significant energy loss because the bypassed liquid merely cools the ground, through the reservoir walls.

At the present time, the plant engineering staff have managed to reduce the number of operating chillers to one chiller, mainly by raising the chilled water temperature slightly and using steam radiators in air reheat to control the humidity.

The temperature difference between the incoming chilled water and the outgoing chilled water to the plant at the evaporator is only about 3°C. However, the actual temperature of the incoming chilled water before it enters the reservoir is around 24°C, indicating an actual temperature rise in the plant of about 6.5°C to 7.5°C. Since the reservoir is being cooled, the hotter incoming water mixes with the cooler water in the reservoir.

It is estimated that significant savings can be made in chiller electricity consumption if the spent chilled water returns are insulated, reservoir capacity sharply reduced, and recirculation of chilled water is prevented. Tentative costs on associated savings are given below; however, a proper energy audit of the chilled water system is necessary before final judgment is made.

<u>Costs</u>. It is estimated that the cost of effective insulation and a new instrumentation scheme to monitor the plant would be around Rs.800,000 (50 percent foreign).

<u>Savings</u>. It is conservatively estimated that a reduction of 1.5°C in the incoming chilled water temperature to the evaporator would be achieved by proper control and insulation.

Savings in energy = 115 x (1.5/6.5) = 26.5 kW or 185,000 kWh per year. Savings in cost = Rs.370,000 per year. Simple payback = 2.2 years.

Implementation. As mentioned above, it is very important that a complete audit **in and around the chilled water system only** should be carried out as soon as possible by competitive consultants. A plan to improve the energy performance could be set down, based on the results of the audit.

Automatic Control of the Burners

Description. The boilers in this factory are of the water tube type with two burners aligned vertically on the furnace front. Control of air/fuel ratio and burner firing ratio is carried out manually. Flue gas temperature is around 280°C to 300°C, and recent checks by the factory engineering staff showed that the flue gases contain excess O_2 in the range of 4.5 to 5 percent.

It is recommended that conversion of these boilers to fully automatic packaged burners should be carried out. Modern burners will control air/fuel ratio much more precisely and also reduce excess air to around 2 to 3 percent, thereby decreasing furnace oil consumption.

Costs. It is estimated that four packaged burners with automatic controllers will cost around Rs.400,000 each, for a total cost of Rs.1,600,000 (80 percent foreign).

Savings. It is conservatively estimated, based on experience in similar retrofits, that overall savings of 5 percent in furnace oil consumption could be achieved by this measure. Fuel savings = 42,000 gallons/year. Cost savings = Rs.888,000. Simple payback = 1.8 years.

Implementation. The factory engineering staff is fully capable of implementing this conservation effort. However, the original boiler suppliers in the PRC and manufacturers of suitable automatic burners will also have to be consulted, and the resulting technical information evaluated carefully before a decision is made.

Technical feasibility study = 6 to 8 months. Procurement, installation, and commissioning = 1 year.

Improved Caustic Evaporator

Dilute solutions of caustic result from the mills' desizing operations. Currently, 2,200 liters per hour of a 55 gallon/liter solution is charged to a triple effect evaporator. Final concentration is roughly 400 gallons/liter. The caustic evaporator accounts for roughly 30 percent of the mills' total steam demand.

The triple effect evaporator currently operates as if it were three batch distillation units in series. The dilute caustic solution in the first stage is boiled at atmostpheric pressure, with the temperature slightly over 100°C. By the second stage, the concentration of caustic has been increased to over 300 gallons/liter. The third stage is operated under vacuum and results in a final caustic concentration of roughly 400 gallons/liter.

Steam consumption during the caustic concentration operation is roughly 600 kg/hr at 3 bar. A better evaporator design could reduce steam requirements by roughly 40 percent. A mini-energy audit is required on this system to develop the cost/benefit analysis of replacing the current evaporator with a more efficient unit. In the absence of sufficient data, costs cannot be assessed within a reasonable range of confidence.

Automatic Temperature Control in Wash Boxes

Pugoda Textile Mills employs wash boxes in the treatment of their textile products. These wash boxes have the approximate dimensions of 2.5 m by 3.5 m by 2 m. These boxes have no tops. The cloth enters on one end and leaves at the other. The boxes are filled with water at temperatures ranging from 85°C to 95°C, depending on the particular box.

The wash boxes have substantial heat losses due to exposed surface areas and the open tops. Also, the boxes are often kept at temperatures slightly higher than required. Temperature control is currently performed manually.

Installation of automatic temperature control and lagging of the wash box walls would save at least 10 percent of energy input. However, insufficient data exist to estimate resulting savings in monetary units.

4. Terms of Reference

4.1 Energy Audit

A detailed energy audit of the Pugoda textile mills should be conducted, consisting of the following successive steps:

4.1.1 The consultants will conduct a preliminary energy audit (also called survey) or "PEA" to collect historical data on (a) detailed energy use, (b) production, (c) energy-using equipment, and (d) technical personnel available on-site for energy efficiency work. The PEA should not take more than 4 man-days to perform. (See EDMAC's energy auditing manual for more details on conducting a PEA.)

4.1.2 On the basis of the PEA, the consultants will decide, in agreement with plant management, which fixed instrumentation should be installed prior to conducting the detailed energy audit and which areas deserve most attention.

The following areas are likely to be candidates:

- Boilers
- Steam distribution
- Waste heat recovery in the finishing section
- Chiller
- Evaporators
- Wash boxes
- Power factor improvement
- Electric load management.

Mass and energy balances will be prepared, when required, for several representative operating conditions.

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide Pugoda with the following information for each option:

- Description
- Estimated cost in foreign and local currency with sources of information and range of confidence
- Estimated savings in physical units and financial (i.e., at market prices) and economic (i.e., at true cost to the economy) values
- Implementation schedule and recommendations.

The final product will be a practical implementation plan acceptable to Pugoda management and the Ministry of Textiles.

On the basis of the audit results, the consultants will undertake a series of feasibility studies for the projects that are too complex, risky, or capital-intensive to be fully analyzed within the audit.

4.1.3 For each one of the retained projects (likely to include most of the projects identified in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (including demand and market projections)
2. Technical options
3. Cost and performance assumptions
4. Financial analysis
5. Economic and social analysis
6. Implementation

Appendices.

Each feasibility study should be discussed with EDMAC prior to submission to Pugoda.

4.2 Team and Project Duration

The energy audit team should comprise:

- A foreign expert specializing in textile finishing processes with more than 5 years' experience in the industry

- One to two additional auditors, possibly including former EDMAC trainees and the Pugoda engineer.

The full audit should take about 1.5 man-months on-site, plus 1-2 months for report preparation (cost: U.S. $20,000-$25,000).

The feasibility studies should be undertaken by the foreign expert in collaboration with the Pugoda personnel, and EDMAC.

The level of effort envisioned for the feasibility studies is between 6 and 9 man-months (cost: U.S. $45,000-$60,000).

ASSOCIATED MOTORWAYS, LTD.

The government has requested that detailed information on Associated Motorways, Ltd. not be published. Donors who are interested in details of energy efficiency investment opportunities in this corporation should contact it directly for information.

CEYLON GLASS COMPANY, LTD. (RATMALANA FACTORY)

Summary

The Ceylon Glass Company's Ratmalana factory produces glass containers. The major energy-using equipment is the melting furnace, which has been recently rebuilt but still consumes 250 kg of oil per tonne of melted glass compared with standard performances of 180-225 kg per tonne of melted glass in other countries.

Based on this comparison and a site visit, fuel oil consumption could be reduced by as much as 23 percent (see Exhibit A). Specialized assistance is required to write the detailed terms of reference for kiln modification, including installation of improved insulation and combustion control.

Exhibit A

Ceylon Glass Company, Ltd. (Ratmalana factory): Summary of Possible Energy Conservation Projects
(1983 energy bill: Rs.23.1 million)

Project	Cost (Rs.000) Total	Cost (Rs.000) Foreign*	Cost (Rs.000) Local	Average Annual financial benefit (Rs.000) Total	Average Annual financial benefit (Rs.000) Foreign[1]	Average Annual financial benefit (Rs.000) Local	Simple payback (years) Financial[2]	Simple payback (years) Economic[3]
Improvements in instrumentation	625	563	62	435	392	43	1.4	1.8
Insulation of furnace	5,000	3,500	1,500	2,890	2,600	290	1.7	2.0
Automatic air/fuel ratio control	800	720	80	580	522	58	1.4	1.7
Burner replacement	1,800	1,440	360	870	783	87	2.1	2.8
Recovery of waste heat from flue gases	1,350	810	540	600	540	60	2.25	2.4
TOTAL	9,575	7,033	2,542	5,375	4,837	538	1.8	2.1

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1]ESMAC estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2]Total cost/average annual financial benefits.

[3]Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using ESMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price
- Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly & Company.

1. Background

Sri Lanka entered the glass industry during World War II, having realized that it had the requisite raw materials for the production of high-quality glass. Two factories were set up: a private factory at Kandana and a government-owned factory at Nattandiya. Their main products were glass tumblers, chimneys (for oil lamps and small bottles). Both operated with a fair measure of success until the end of the war, when they were faced with competition from abroad. Both ceased operations around 1952.

The Ceylon Glass Company (CGC) resumed operations in August 1957, producing 15,000-18,000 bottles per day. In 1960, its output increased to 30,000-35,000 bottles per day, and in February 1965, to 60,000-70,000 bottles per day. Under an expansion plan, another factory was set up at Ratmalana on a 21-acre site in October 1969. The factory's initial average capacity was 72,000 bottles per day; at present, it can produce an average of 110,000 bottles per day. Because the Ratmalana factory can meet current requirements, the Nattandiya factory has been closed.

The Ceylon Glass Company, which is the only manufacturer of glass containers in Sri Lanka, has captured 70 percent of the market share of the glass container market in Sri Lanka. The remaining 30 percent is held by companies in Singapore, India, and Japan, which produce primarily miniature glasses (less than 2 ounces) of sophisticated design. The market share of imports is attributed to the fact that the CGC does not produce miniature glasses and does not accept orders for very small quantities.

Description. The Ratmalana factory uses as its feedstock basic raw material such as silica, dolomite, sodium carbonate, and feldspar, as well as cullet (broken glass). The correct proportions of the various substances are weighed from storage bins and introduced continuously into the furnace.

Glass is melted in the furnace at 1,530°C and fed continuously to two forming machines. Various molds are available for the machines. After formulations are carried out, the glass products are annealed in electrically heated furnaces, inspected, and dispatched to storage.

Financial situation. Through 1982, CGC's financial situation was good. In 1983, however, CGC lost money because kiln rebuilding, which lasted more than 3 months, resulted in production loss and considerable cash drawdown. CGC may suffer a loss in 1984 too, but it should become profitable again in 1985.

Marketing. CGC sales for the 1979-1983 period are given below.

Year (ending March)	Sales (in gross)
1979	192,654
1980	192,817
1981	132,431
1982	146,437
1983	146,229
1984	173,005
1985 (budgeted)	224,884

The company believes that it can produce certain types of sophisticated containers for soft drinks and liquor that are imported at present. The demand for these products could well be over 10,000 gross per annum. In addition, the company is interested in upgrading its current products, producing new products, and engaging in export marketing.

Employment. CGC currently employs 610 people, distributed among the following categories:

Management	22
Supervisory	48
Skilled	87
Semi-skilled	82
Unskilled	261
Clerical and allied	110
Total	**610**

Existing plans for modernization/expansion. The organization is interested in modernization/expansion in the following broad areas:

- Better raw material utilization

- Reduction of energy costs by conservation, better utilization, etc.

- Upgrading the quality control program
- Upgrading the furnace operating program
- Upgrading the mould engineering program
- Upgrading the forehearth, feeder operation program
- Upgrading the present storage, transport, and packaging program
- Upgrading the present maintenance program
- Relating all technology upgrading programs to a substantial increase in pack-to-melt efficiency and an increase in percent pack.

2. Energy Situation

Major energy-using equipment. The major fuel user is by far the melting furnace (see Appendix A), which consumes about 250-300 kg of oil per tonne of glass.

Compressed air is used for fuel oil atomization in the furnace burners and to drive the bottle-forming machines. The significant compressed air requirement is supplied by five compressors with a total power of 575 hp. (See Appendix A for details on plant equipment.)

Fuel and electricity used. Production in 1980 totaled 8,225 tonnes of glass, with furnace oil consumption at 770,936 gallons and electricity consumption at 2,879,110 kWh. Production in 1981 was 10,842 tonnes of glass, with furnace oil consumption at 629,487 gallons and electricity consumption at 3,454,690 kWh. In 1982, production was 10,035 tonnes of glass, with furnace oil consumption at 702,122 gallons and electricity consumption at 4,459,990 kWh. In 1983, production was 12,098 tonnes of glass, with furnace oil consumption at 677,086 gallons and electricity consumption at 4,790,910 kWh.

Over this period, the specific energy consumption of fuel oil fell, while that of electricity rose.

CEYLON GLASS COMPANY, LTD. (RATMALANA FACTORY)

Energy	Fuel oil/ tonnes of glass (gallon)	Electricity/ tonnes of glass (kWh)
1980	0.41	350
1981	0.253	318
1982	0.305	444
1983	0.244	396

Supply Characteristics

Electricity. Breakdowns in the CEB supply are frequent, and represent a major problem. Total installed generator capacity is 1,000 kVA (i.e., 2 x 500 kVA diesel engines), but one alternator is out of operation because of overspeeding.

Fuel oil. CGC has a storage capacity of 33,800 Imperial gallons, which is approximating 2 weeks' supply. The company has no difficulties with supplies from the Ceylon Petroleum Corporation.

Energy management organization. CGC hopes to set up an "energy cell" led by a senior engineer. No energy management organization exists at present.

3. Energy Conservation Potential and Possible Projects

Improvements in Instrumentation

Description. Almost none of the furnace instrumentation is working, and the readings are not reliable because the instruments have not been calibrated for some time. Considering the age of the instrumentation, it is recommended that new instruments be fitted. Furthermore, the instrumentation should be upgraded by fitting air and oil flow meters to each burner to provide information on air/fuel ratios and fuel consumption. An air flow meter should also be installed on the secondary air flow.

Cost. A complete new and upgraded instrument package would cost approximately Rs.625,000 (90 percent foreign).

CEYLON GLASS COMPANY, LTD. (RATMALANA FACTORY)

Savings. The new instrument package would permit much better control of furnace conditions and the reduction of oil consumption.

Savings are estimated at about 3 percent of the total average annual fuel oil bill of Rs.14,500,000 (1983 figure), or Rs.435,000/year.

Payback. The simple payback would be 1.43 years.

Implementation. The technical study and instrument specification would require 6 months, and installation of the total instrument package would also require 6 months.

Insulation of Glass Furnace

Description. At present, the heat loss from the walls at the top and bottom of the glass furnace is considerable. Up to 25 percent of the heat input from the furnace oil is estimated to be lost from the furnace surfaces by radiation and convection.

Installation of the correct type of insulation at an optimum thickness could result in significant savings in furnace oil. Because of the shape of the furnace superstructure, a technical study would be necessary before the insulation could be installed, with a special emphasis on material resistance of the existing kiln elements.

Cost. Inclusive of the technical study, insulation to reduce fuel consumption by 20 percent would cost an estimated Rs.5 million (70 percent foreign).

Savings. A 20-percent reduction in furnace oil use on an annual basis (conservation basis) would equal 135,000 gallons/year. Hence, cost savings would be Rs.2,892,000 per year.

Payback. The simple payback would be 1.72 years before tax, 3.5 years after tax.

Implementation. The technical study and specification would require 2 months, and procurement and installation would require 9 months. Implementation is to be carried out in three stages of 3 months each, to avoid complete shutdown of the furnace and the resultant loss of production.

Automatic Air/Fuel Ratio Control; Burner Replacement

Description. At present, control of air and fuel to the burners is carried out manually. The oil flow valves and air dampers are opened or closed, depending on visual inspection of the flow and temperature check, using an optical pyrometer. It is recommended that a completely automatic burner air/fuel system be installed.

The control system should be able to maintain furnace temperatures automatically, with operation override and set point changes occurring only when major changes in furnace temperature are required.

Cost. The cost of the control system would be approximately Rs.800,000 (90 percent foreign).

Savings. About 4 percent of the total fuel bill, or Rs.580,000, could be saved annually.

Payback. The simple payback would be 1.4 years.

Other projects may include burner replacement (cost: Rs.1.8 million; savings: Rs.820,000) and additional waste heat recovery (cost: Rs.1.35 million; savings: Rs.600,000).

4. Terms of Reference

4.1 Scope of Work

4.1.1 A detailed energy audit of the Ratmalana factory should be conducted, consisting of the following successive steps:

On the basis of a first identification visit, the consultants will decide, in agreement with plant management, which fixed instrumentation should be installed prior to conducting the detailed energy audit and which areas deserve most attention.

The following areas are likely to be candidates:

- Kilns
- Annealing section
- Compressed air plant
- Other electric systems.

Mass and energy balances will be prepared, when required, for several representative operating conditions.

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide CGC with the following information for each option:

- Description
- Estimated cost in foreign and local currency with sources of information and range of confidence
- Estimated savings in physical units and financial (i.e., at market prices) and economic (i.e., at true cost to the economy) values
- Implementation schedule and recommendations.

On the basis of the audit results, the consultants will undertake a series of feasibility studies for the projects that are too complex, risky, or capital-intensive to be fully analyzed within the audit.

4.1.2 For each one of the retained projects (likely to include most of the projects identified in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (including demand and market projections)
2. Technical options
3. Cost and performance assumptions
4. Financial analysis
5. Economic and social analysis
6. Implementation

Appendices.

Each feasibility study should be discussed with EDMAC prior to submission to CGC.

4.2 Team and Project Duration

The energy audit team should comprise:

- A foreign expert specializing in glass container manufacturing with more than 5 years' experience in the industry, preferable familiar with the type of equipment used at CGC described in Appendix A

- One to two additional auditors, possibly including former EDMAC trainees and CGC engineers.

The full audit should take about 1 man-months on-site, plus 1 month for report preparation (U.S. \$20,000-\$25,000).

The feasibility studies should be undertaken by the foreign expert in collaboration with the CGC management.

The level of effort envisioned for the feasibility studies is between 9 and 16 man-months (U.S. \$75,000-\$100,000).

Appendix A PLANT EQUIPMENT (RATMALANA)

Batch house:

- Avery weighing system with one unit capable of weighing 2,000 pounds and two units capable of weighing 500 pounds each
- Two cullet crushers
- One magnetic separator.

Furnaces (make: Teisen Furnaces Ltd.):

- One 40-ton recuperative end-fired furnace (oil-fired, using 1,000 sec. furnace oil) with 317 square foot melting tank.

Bottle dorming machines:

- One Lynch 10
- One Emhart 5 Section IS machine (single gob)
- One Maul 6 section IS machine (with provisions for double gob).

Forehearth and feeders:

- Two BHF oil-fired feeders, type 60 (one per IS machine)
- One BHF oil-fired feeder, type 50 (for the Lynch 10).

Annealing lehers:

- One Sten Atkinson stordy (SAS), 6 foot, fully automatic, electrically heated
- One Charlton, 5 foot, fully automatic, electrically heated
- One BHF, 5 foot, fully automatic, electrically heated.

PLANT EQUIPMENT (RATMALANA)

Screen printing machines:

- One Duboit, Model D 150, semi-automatic.

Sorting and selection (manual):

- One Lister-Blackstone, 268 kVA generator.

Compressors, receivers, and vacuum pumps:

- Two Kirloskar 150-hp compressors
- One Broom Wade SIB 75-hp compressor
- Two Broom Wade VS 700 125-hp compressors
- One Broom Wade Twin 75-hp compressor
- Six air receivers (42 psi)
- Two Broom Wade 21-hp vacuum pumps.

DUNAGHA COCONUT PRODUCERS COOPERATIVE SOCIETY

Summary

As in the case of the tea estates, major energy efficiency improvement projects lie in the installation of new, improved air heaters and dryers operating on fuel wood.

It is suggested that a joint effort between the tea, rubber, coconut research institutes and local specialized engineering and consulting firms be undertaken to develop an adequate system to be then widely commercialized across industry. Depending on the value of fuel wood (which may vary between U.S. $16 to U.S. $40/ metric tonne, delivered), the payback of such a system would be between 2 and 5 years. In the specific case of Dunagha, up to about 40 percent of fuel costs (Rs.436,000) could be saved at a total investment cost of Rs.875,000, for an overall payback of 2 years (see Exhibit A).

Exhibit A

Dunagha Coconut Producers Cooperative Society: Summary of Possible Energy Conservation Projects
(1983 energy bill: Rs.1.1 million)

Project	Cost (Rs.000)			Average Annual financial benefit (Rs.000)			Simple payback (years)	
	Total	Foreign*	Local	Total	Foreign[1]	Local	Financial[2]	Economic[3]
Installation of power factor correction	40	32	8	48	34	14	0.8	0.4
Improvements to sterilizer								
• Insulation	10	6	4	12	11	1	0.8	0.9
• Replacing burner	175	140	35	168	151	17	1.1	1.3
Waste heat recovery from dryers	150	135	15	100	0	100	1.5	N/A
Efficiency improvements in air heaters	500	0	500	108	0	108	4.6	N/A
TOTAL	875	313	562	436	196	240	2.0	N/A

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

N/A: Not applicable.

*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1]ENMAC estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2]Total cost/average annual financial benefits.

[3]Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using ENMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price

- Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly and Company.

DUNAGHA COCONUT PRODUCERS COOPERATIVE SOCIETY

1. Background

Plant history. This plant was started in 1939 as a co-operative society that would allow coconut plantation owners to obtain a better price for their produce. Initially, the society was a producer of copra. Subsequently, coconut oil milling and desiccated coconut manufacture were added.

The plant is wholly owned by the members of the cooperative. New members must purchase shares and supply the society with a minimum number of coconuts, based on the number of shares purchased. By eliminating the middleman between the final user of coconuts and the coconut producer, it appears that the society has been able to offer the actual producer of coconuts a good price for his produce.

Plant location. The plant is located near Divulapitiya, which is about 10 miles from the main regional town of Negombo. Negombo is located about 25 miles north of Colombo.

Process description. The coconuts purchased from the plantation owner are graded into three categories, depending on factors such as whether they are split or not, the size of nut, etc. Category 1 is always taken for the manufacture of dessicated coconut. Some of category 2 is also taken for this purpose, while the poorer kernels of category 2 and all of category 3 are taken for oil milling. Dried coconut meat or "copra" is the input to the oil milling process. The milling residue is the dessicated coconut.

After being sorted, the nuts are split and the hard outer shells separated from the white kernels. Small pieces of shell adhering to the kernels are sliced away by hand. These sliced strips are also routed to the oil milling plant. The cleaned white kernels are then placed on a conveyor that travels through a bath of hot water kept at a temperature of about 210°F for sterilization. After sterilization, the kernels travel to a cutting machine, where they are chopped into small slices. They then travel through dessicated coconut dryers and are discharged for packing.

The dryers in this particular plant are heated by hot air from wood-fired air heaters. There are a number of trays within each dryer that allow the dessicated coconut to drop through after a specified time of residence

DUNAGHA COCONUT PRODUCERS COOPERATIVE SOCIETY

on each tray. The spent hot air from each dryer is exhausted to the atmosphere through ducts.

In the oil milling section, the kernels to be processed are first dried in special dryers fed by air heaters using firewood. After this stage, the material is finely chopped in a hammermill and fed to screw-type oil expellers, from which the coconut oil is extracted. The raw oil is cleared by passing it through filter presses. It is then graded and packed in drums for export purposes.

Production. Production statistics are shown in the table below (all figures in kilograms):

	Dessicated coconut	Coconut oil	Copra[1]
1980	1,792,845	381,263	274,024
1981	1,451,599	288,347	247,188
1982	1,572,650	391,771	351,070
1983	1,011,131	432,472	292,199

[1]Copra sold as such.

Markets. Dessicated coconut is mainly exported. Copra is purchased by local customers and is also exported. About 90 percent of the coconut oil is sold for use on the local market.

Organization. The cooperative society employs a professional management staff consisting of a plant manager, who has a sales manager and operations manager reporting to him. There are no engineers at the factory. Servicing of machinery, when required, is carried out by the machinery suppliers themselves.

Financial situation. The financial situation of the organization is good in that it has no long-term debt. In fact, it carries considerable cash fixed deposits in banks (see Exhibit 1).

Project evaluation criteria. It was understood that any project would have to be considered by the board of the directors of the cooperative society. Any project with a payback of 2 years or less would be virtually certain to be adopted.

Exhibit 1

Dunagha Coconut Producers Cooperative
Society: Financial Situation
(In rupees)

	1979-1980	1980-1981	1981-1982	1982-1983
Turnover	20,748,045	23,998,362	33,713,817	25,718,633
Profit before tax	738,515	605,347	1,351,029	1,140,187
Total value of assets	2,195,924	2,108,874	2,889,054	3,198,747

SOURCE: Dunagha Coconut Producers Cooperative Society.

DUNAGHA COCONUT PRODUCERS COOPERATIVE SOCIETY

Modifications/expansion. The organization is about to commission a plant expansion for dessicated coconut manufacturers that is newly installed and paid for completely with internal funds. This new factory is virtually identical in design to the earlier factory, but capacity will be increased by 50 percent. There are no further plans for modernization or expansion at the present time.

Problems. The only serious problem for the facility is short-term power interruptions. There are no other major problems.

2. Energy Situation

Energy-using equipment. Auto diesel is used to heat water and kernels in a sterilizing tank, as mentioned above. A manually controlled burner is used. Liquid fuel use in the plant is confined to this application.

All heating of dryers for dessicated coconut and coconut slices for milling is by means of hot air from solid fuel-burning air heaters. On inspection, it was apparent that these air heaters were of the same type used in tea drying. All other processing machines, air draft fans, etc., were electrically operated.

Fuel and electricity consumption. Exhibit 2 shows quantities and costs of fuel and electricity at the facility.

Energy management activities. There is no formal energy management organization at this factory. No energy conservation/fuel switching activities appear to have been undertaken at this plant in the past.

3. Energy Conservation Potential and Possible Projects

Installation of Power Factor Correction

Description. At this factory, there is no correction equipment for power factor installed at the present time. With the opening of the new factory for processing dessicated coconuts, the total kVA demand is likely to increase to a maximum of about 250 kVA. Hence, installation of a set of capacitors would be a worthwhile conservation measure.

Exhibit 2

Dunagha Coconut Producers Cooperative Society:
Fuel and Electricity Quantities and Costs

	1980	1981	1982	1983
Quantity				
Electricity (kWh)	N/A	145,855	148,040	155,140
Auto diesel (liters)	83,096	84,474	94,547	74,106
Firewood (yards)	2,376	3,124.5	3,346	1,686
Cost (Rs.)				
Electricity	N/A	195,354	304,906	347,619
Auto diesel	319,335	473,555	548,255	518,115
Firewood	190,527	238,967	323,395	194,235

SOURCE: Dunagha Coconut Producers Cooperative Society.

Costs. It is estimated that total capacitor rating of 85 kVAr would be required, assuming that the present power factor is 0.8 and that it would be corrected to 0.95. The cost of the system would be Rs.40,000 fully installed (80 percent foreign).

Savings. The total saving on maximum monthly demand is likely to be around 40 kVA. Financial savings are thus Rs.4,000 per month, or Rs.48,000 per year, which gives a simple payback of 10 months.

Implementation. The specification and installation of capacitors is now offered as a service by many electrical service companies in Sri Lanka. Implementation can be carried out by one of these specialists in collaboration with the management staff of the cooperative society. Specifications, installation, and commissioning would take 8 months.

Improvements to Sterilizer

Description. At the present time, the sterilizer operates on auto diesel. A standard, manually controlled burner supplies heat to the water tank. Also, it was found that the outside of the tank was uninsulated, and the surface temperature was estimated to be around 70°C-75°C. By converting the burner to furnace oil operation and by insulating the surface of the tank, it should be possible to make significant cost savings. These conservation measures also show a very rapid payback.

Costs. To insulate the outside of the tank with a 1-inch layer of foil-backed insulation, it is estimated that the cost would be Rs.100 per square foot. Since the surface area of the tank is 80 square feet, the total cost of insulation would be Rs.8,000 (75 percent foreign). Installation would be an additional Rs.2,000, for a total project cost of Rs.10,000.

Replacing the existing burner with a modern packaged oil burner capable of burning furnace oil is estimated at a cost of Rs.175,000 (80 percent foreign). This amount includes the preheating unit.

Savings.

Total heat loss from surface of tank = 7.5 x 315
= 2.31 kW

Assuming heat exchanger efficiency to be 60 percent heat value of fuel	= 4 kW
Cost of fuel per hour in terms of heat loss when running on diesel	= Rs.2.60
Cost of fuel lost per year	= Rs.11,714
Simple payback	= 10.2 months.
Total savings possible by converting to furnace oil (i.e., new burner)	= 74,106 x (7 - 4/76)*
	= Rs.167,700/yr
Simple payback	= 12.5 months.

Implementation. These two conservation measures can be easily implemented by the factory staff in collaboration with suppliers of equipment. However, a technical consultant may have to be called in to decide on the size of packaged oil burner required. Specification, procurement, installation, and commissioning would take 1 year.

Waste Heat Recovery From Dryers

Description. In the dessicated coconut plant, there are two dryers that are fed with hot air from wood-fired air heaters. It was found that the external surfaces of the dryers were not insulated, and the surface temperature was about 60°C. Actual exhaust air temperature was found to be 57°C. The exhaust air is discharged directly to the atmosphere.

Despite low temperature level, it would be possible to recover a significant quantity of heat from the dryer exhaust air and use it to preheat incoming air to the air heater. Because of the high moisture content in the outgoing air, it may not be possible to reuse a portion of the same air through recirculation. In this case, it would be necessary to use a suitable heat recovery device such as a heat wheel or heat exchanger.

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*Price difference between diesel oil and furnace oil.

Such a conservation measure would have the effect of reducing the firewood consumption in the air heaters. This measure should also be adopted for the new dessicated coconut factory.

Costs. It is estimated that a heat wheel-type heat recovery device will cost Rs.150,000 installed (90 percent foreign). This figure includes the cost of insulating the dryer surfaces (where possible) and the exhaust ducts.

Savings. From the draft fan horsepower ratings and size, it is estimated that the total outflow from the two dryers is approximately 432,000 kg/hour. Assuming that 30 percent of this heat would be recoverable in waste heat recovery devices, the total savings in firewood would be 54 kg/hour. On the basis of 15 hours of operation per day and 250 days per year, total firewood savings of 202,500 kg could be achieved, or a firewood savings of about 15 percent (comparing the total consumption in the full production year of 1982). Financial savings of Rs.100,000 per year could be achieved, for a simple payback of 1.5 years.

Implementation. For this conservation measure, it would be necessary to obtain consultancy assistance from local or foreign organizations to maximize heat recovery. Technical study and specifications would take 3 months, and procurement, installation, and commissioning would take an additional 8 months.

Efficiency Improvements in Air Heaters

Description. Hot air to the dessicated dryers and the dryers for coconut pieces prior to oil milling are provided by wood-fired heaters of the same design used traditionally in tea estates. The dryers at this particular factory were in fact supplied by a major manufacturer of tea machinery and equipment.

Inspection of the dryer design showed that its overall thermal efficiency is very low, on the order of 25 to 30 percent, as a proportion of wood net calorific value (NHV). The reason for low efficiency is the provision of only a single air pass, lack of external insulation, and insufficient total heat transfer area. A further reason is the operation under conditions of very high excess air. If the efficiency of these air heaters can be improved to around 45 percent overall, there would be a significant reduction in the consumption of firewood.

Costs. It is estimated that a completely new, efficient air heater would cost about Rs.500,000 fully installed (see section on tea estates), all local cost.

Savings. By increasing air heater efficiency to 45 percent, it is estimated that savings in firewood consumption of about 30 percent could be achieved. Financial savings would be about Rs.108,000 per year, which yields a simple payback of 4.62 years.

Implementation. This measure will require backup assistance from the air heater manufacturers, research institutes, and local consultants. A certain amount of R&D work will have to be done. Development, design, and prototype testing will take 1 year; fabrication, installation, and commissioning will take another year.

4. Terms of Reference

4.1 Energy Audit

A detailed energy audit of the Dunagha factory should be conducted to define energy conservation opportunities and potential, consisting of the following successive steps:

4.1.1 The consultants will conduct a preliminary energy audit (also called survey) or "PEA" to collect historical data on (a) detailed energy use, (b) production, (c) energy-using equipment, and (d) technical personnel available on-site for energy efficiency work. The PEA should not take more than 3 man-days to perform. (See EDMAC's energy auditing manual for more details on conducting a PEA.)

4.1.2 On the basis of the PEA, the consultants will decide, in agreement with plant management, which fixed instrumentation should be installed prior to conducting the detailed energy audit and which areas deserve most attention.

The following areas are likely to be candidates:

- Air heaters
- Dryers
- Sterilizer

- Power factor improvement
- Electric load management.

Mass and energy balances will be prepared, when required, for several representative operating conditions.

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide Dunagha with the following information for each option:

- Description

- Estimated cost in foreign and local currency with sources of information and range of confidence

- Estimated savings in physical units and financial (i.e., at market prices) and economic (i.e., at true cost to the economy) values

- Implementation schedule and recommendations.

On the basis of the audit results, the consultants will undertake a series of feasibility studies for the projects that are too complex, risky, or capital-intensive to be fully analyzed within the audit.

4.1.3 For each one of the retained projects (likely to include some of the projects identified in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (including demand and market projections)

2. Technical options

3. Cost and performance assumptions

4. Financial analysis

5. Economic and social analysis

6. Implementation

   Appendices.

Each feasibility study should be discussed with EDMAC prior to submission to Dunagha.

4.2 Team and Project Duration

The energy audit team should comprise one or two local auditors, possibly former EDMAC trainees.

The full audit should take about 2 weeks on-site, plus 1 month for report preparation (U.S. $2,000-$3,000).

The feasibility studies should be undertaken by the auditors in collaboration with Dunagha management and EDMAC.

The level of effort envisioned for the feasibility studies is between 2 and 4 man-months (U.S. $5,000-$10,000).

TEA ESTATES: MATTAKELLE STATE TEA PLANTATION

Summary

The Mattakelle State Tea Plantation is very illustrative of the situation of the other tea estates in Sri Lanka. Based on the visit of this estate and discussions with several plantation superintendents in the Nuwara Eliya region, it appears that between 15 and 50 percent of energy costs could be saved, depending on the type of fuel used (wood or oil) and the type of energy system used (e.g., dryers).

Key general projects to be undertaken include design of new wood-fired fluidized bed air heater for tea drying, use of dryer waste heat to dry firewood, use of biogas to supply cooking fuel for workers, and rehabilitation/construction of new, small hydrosystems to produce factory power. (See Exhibit A for some estimates of costs and benefits at Mattakelle Tea Estate.)

Exhibit A

Tea Estates: Mattakelle State Tea Plantation: Summary of Possible Energy Conservation Projects
(1983 energy bill: Rs.2.9 million)

Project	Cost (Rs.000)			Average Annual financial benefit (Rs.000)			Simple payback (years)	
	Total	Foreign*	Local	Total	Foreign[1]	Local	Financial[2]	Economic[3]
Design of new wood-fired air heaters (2 numbers)	600	0	600	472	118	354	1.3	0.8
Use of dryer waste heat for drying firewood	60	0	60	24	0	24	2.5	N/A
Use of biogas	200	50	150	85	0	85	2.4	N/A
Use of mini and micro hydropower systems to serve four estates	(30,000)	(18,000)	(12,000)	(4,800)	(3,360)	(1,440)	(6.25)	(2.8)
TOTAL	860	50	810	581	118	463	1.5	N/A

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

N/A: Not applicable.

*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1]EDMAC estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2]Total cost/average annual financial benefits.

[3]Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using EDMAC guidelines; i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price
- Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly and Company.

TEA ESTATES: MATTAKELLE STATE TEA PLANTATION

1. Background

History. This plantation was established as a coffee plantation over 100 years ago. After the coffee blight of the late nineteenth century, tea was planted. The plantation now covers approximately 600 acres. It has a completely self-contained factory for the manufacture of tea and also processes tea from adjacent plantations, as well as some purchased green leaf. The manufactured tea is found in six to eight different grades, and is sold at auction in Colombo through brokers. The plantation is located in a prime tea-growing area about 18 miles from Nurawa Eliya on the Talawakelle Road.

Process description. The green leaf from the field is first "withered" (or dried) in large trough-tvpe dryers by means of a current of air blown upward through a bed of leaves. Approximately 3.5 kilos of leaves are loaded per foot of trough. At Mattakelle, there are 18 troughs, each measuring 90 feet long by 6 feet wide. Each trough has an axial fan installed to blow air through the leaf. Withering troughs are usually installed on the highest floor of a factory to make partial use of hot air from the exhausts of the tea dryers mounted on the lower floors.

The withered leaf is sent down for "rolling" through chutes in the floor. The leaf is then rolled in specially built tea rolling machines for a period of 20 to 30 minutes. The rolled tea is sent through a sifter for grading purposes and then put aside in beds to ferment. The humidity of the ambient air during fermentation is carefully maintained at high levels by means of water sprinkler systems.

After fermentation, the tea is sent through a rotary screen-type device called a "Rotovane" for further crushing and rolling, after which it is dried in specially built dryers. Mattakelle has two dryers: a conventional hot air dryer in which hot air is blown through a bed, and a fluidized bed-type dryer in which the bed of tea is actually fluidized by the hot air. In these dryers, the tea reaches its familiar form and texture. The final stages -- sorting, grading, and packing -- are then carried out in a separate room.

The drying medium for tea is clean hot air. In the fluidized bed dryer, an oil-fired heat exchanger produces the air. Heavy diesel is used in a fully automatic packaged oil burner, and heat exchange takes place between the resulting hot flue gases and clean air drawn into the heat exchanger. A two-pass system is used, with the air in the first (outer) pass in counterflow and the air in the second (inner) pass in parallel flow. An induced draft fan draws air through the heat exchanger and is also responsible for generating sufficient pressure for fluidization.

In the other, more traditional dryer, the hot air is generated by means of a wood-burning air heater. An induced draft fan draws air through a single-pass heat exchanger that heats fresh air. In both dryers, the maximum air temperature is about 210°F. Hot air discharged from the dryer exhausts is drawn up by the fans on the withering trough floor and used in the initial withering of the tea. Since withering is carried out at a very low temperature, ambient air is intermixed with hot exhaust air from the dryers if the temperature of the latter is too high.

Thus, it is apparent that some cascaded use of hot air is carried out. However, it was found that there was a gap of several feet between the dryer exhaust outlets and withering trough fan inlets. Thus, a great deal of ambient air is mixed with hot exhaust air from the dryers even before entry to the fans.

It should be mentioned that 95 percent of the machinery, including all motors below 15 hp, are of Sri Lankan manufacture.

Production. The production of made tea at this factory is approximately 450 tonnes per year from the crop of the Mattakelle Estate. In addition, they process a further 225 tonnes from the neighboring Palmerston Estate (in which the factory has been closed down) and also from bought green leaf. The throughput is about 1,500-2,500 kilos per day for 300 days of the year, operating on one 8-hour shift.

Production costs per kilo of tea vary slightly from month to month. Costs for the current year (1984) are as follows:

	January	February	March	April
Cost per kilo of made tea (Rs.)	21/24	20 79	22/33	22/39

TEA ESTATES: MATTAKELLE STATE TEA PLANTATION

At the present time, the selling price of tea is very high, at Rs.45-50/kg; therefore, the estate will make a very good profit this year. However, this happy situation will probably not last because sharp price fluctuations are a feature of the tea market worldwide.

Markets. About 90 percent of the tea grown in Sri Lanka has an export market. This is especially true of the higher grades produced in the factories at elevations 2,500 feet above sea level, which are mainly used for blending purposes.

Employment. Total employment, including field hands, is currently about 900. Of this number, about 500 are employed for leaf plucking. The management organization is shown in Exhibit 1.

There are no qualified engineers on the estate staff. Simple maintenance is carried out by the factory officer, who is responsbile for operation of the machinery. Major repairs and maintenance are carried out by the machinery suppliers, who maintain regional offices in most of the plantation districts.

Financial situation. In 1983 and early 1984, total production cost at the factory gates had remained at around Rs.20 to Rs.24 per kilogram. The selling price of tea has increased from around Rs.39 per kg in 1983 to around Rs.45-50 per kg at the present time. Thus, there would be net margins of nearly 35-40 percent as a percentage of turnover at the moment.

However, because the estate is publicly owned through a corporate body called the State Plantations Corporation, revenues are credited not to the estate but to the Corporation head office in Colombo. The head office then disburses funds as required to the estate.

All major capital expenditures are controlled by the corporation head office. Similarly, it was understood that energy conservation projects would be subject to corporate control and approval. However, given the present highly profitable state of the tea in industry, it is quite likely that approval would be forthcoming for such projects. 1/

Modernization/expansion. There is a major World Bank-funded rehabilitation program for the plantation industry in Sri Lanka. As part of this program, purchase of energy-saving equipment is possible. For example, it

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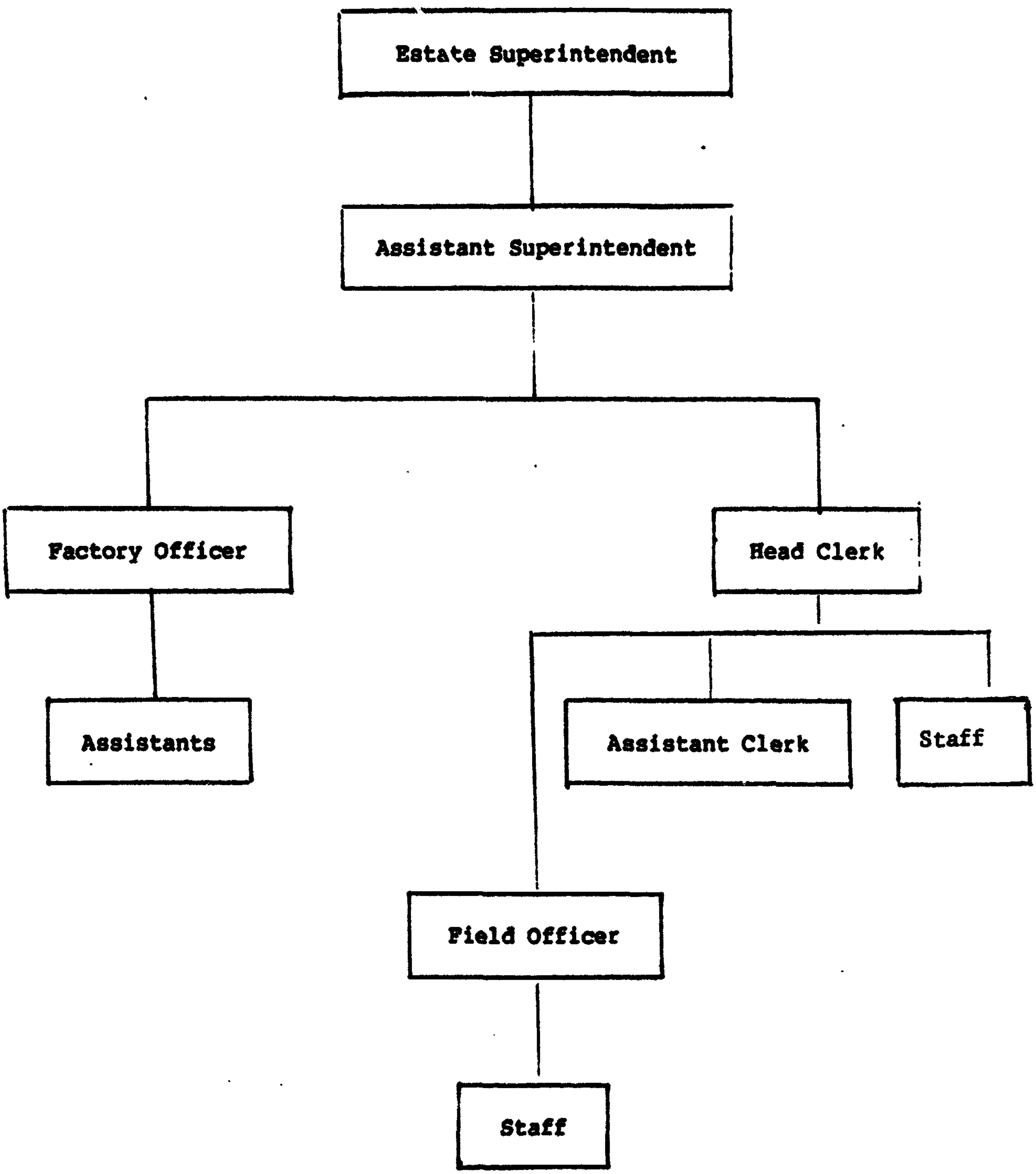
1/ This reflects the situation in the tea industry as of mid-1984. The approval of conservation projects would obviously depend more on the profitability of tea at the time such projects are presented to the head office.

Exhibit 1

Management Organization



SOURCE: Mattakelle Tea Estate.

is understood that the World Bank is funding only the purchase of wood-fired dryers and not those fired with oil.

Regarding Mattakelle Estate, there would appear to be no plan for expansion at the moment.

2. Energy Situation

As indicated earlier, most of the machinery is operated on induction motors of three- phase, 415-V rating, with the largest motor being about 25 hp. The total installed electrical capacity is about 250 kVA. The Ceylon Electricity Board supplies electrical power through a stepdown transformer.

Liquid fuel is used only in the air heater that feeds the fluidized bed dryer. Heavy diesel is used for this purpose in an automatic packaged boiler. Firewood is used in an air heater that supplies hot air to the older (traditional) dryer.

Fuel and electricity consumption. The monthly statistics from the beginning of 1984 are shown in Exhibit 2. The average price of electricity during this period was more than Rs.2/kWh, indicating a high maximum demand in relation to average demand. A problem with the electricity supply is the high frequency of power failures, which causes tea production to come to a standstill. The problem is so severe that the estate is currently considering the possibility of installing standby generators.

Supplies of fuel oil are kept in storage tanks. Oil is supplied by road tanker, and sale price averages Rs.8.1/liter. Firewood is delivered by private firewood suppliers at a price of Rs. 115-150/yard. Payment for firewood is made according to cubic yards delivered (measured as a 3' x 3' x 3' stack of firewood). Thus, the actual weight of wood purchased is highly variable.

Specific energy consumption. The specific consumption of electricity drops with increasing throughput of made tea in the factory. This is probably because motors operate at full load even when withering troughs and dryers are not fully loaded, and also because of longer idle running times. The specific liquid fuel consumption of fluidized bed dryers (estimated from figures at Mattakelle and other estates) is about 50 liters of

Exhibit 2

Fuel and Electricity Consumption, 1984

Month	Fuel	Quantity	Total cost (Rs.)	Production (made tea, kg)	Total energy cost per kg of made tea (Rs.)
January	Electricity	52,020 kWh	105,454	56,372	4.48
	Fuel oil	14,400 liters	116,495		
	Firewood	178 yards	29,137		
February	Electricity	51,280 kWh	104,188	45,547	5.18
	Fuel oil	13,450 liters	108,810		
	Firewood	142 yards	23,063		
March	Electricity	45,020 kWh	93,484	60,477	4.18
	Fuel oil	16,750 liters	135,842		
	Firewood	139.6 yards	22,182		
April	Electricity	53,970 kWh	108,788	71,946	4.08
	Fuel oil	18,225 liters	148,048		
	Firewood	222 yards	36,312		

SOURCE: Mattakelle State Tea Plantation.

fuel per 300 kg of made tea (i.e., about 0.16 kg of oil per kg of tea). In cost figures, this corresponds to about Rs.1.35 per kg of made tea. The older dryer uses about 1 gallon of fuel per 40 pounds of made tea (i.e., about 0.24 kg of oil per kg of tea, or about Rs.2/05 per kg).

When the oil heaters in the fluidized bed dryers are replaced by wood-burning air heaters, production is about 350 kg of tea per cubic meter of wood, or about 267 kg of tea per cubic yard. At a price of about Rs.150 per yard, specific consumption is about 0.0037 cubic yard per kg of tea, or about Rs.0/56 cts. per kg made tea. Older wood-fired dryers produce approximately 230 kg of tea per cubic yard, or about Rs.65.2 per kg of made tea. Thus, the fluidized bed dryers, whether fired on liquid fuel or wood, are about 15 percent more efficient than the older dryers.

Energy conservation activities. At Mattakelle, the only activity in this area has been the planting of fuelwood/shade trees in areas such as ravines that are unsuitable for tea. The species planted include eucalyptus and acacia; the eucalyptus reach harvesting age in 6 to 8 years.

3. Energy Conservation Potential and Possible Projects

Based on the above analysis and discussions with state management, as well as specialized engineering firms, such as Ceylon Commerce Company Ltd., it appears that there is a large scope for energy cost savings in tea estates. Several possible projects to lower energy consumption are presented below with preliminary costs and benefits.

Design of a New Wood-Fired Air Heater

Description. As mentioned above, some of the older tea dryers use wood-fired air heaters of a single-pass design. On inspecting the internals, it was apparent that the efficiency of heat transfer could be further increased, essentially by improving the required surface areas.

The most efficient form of dryer at the present time is the oil-fired fluidized bed type, which requires about

0.16 kg of oil per kg of made tea. This is equivalent to using about 0.67 kg of wood (assuming the same efficiency) with a moisture content of 45 percent, or -- in monetary terms (at 600 Rs./tons cost of wood) -- a cost of Rs.0.40 per kg of made tea. This is about 30 percent lower than the figure for a wood-fired fluidized bed dryer and 40 percent lower than the figure for a traditional (non-fluidized) dryer.

Scrutiny of the design of air heater that is currently being used with fluidized bed dryers shows further scope for improvement. It is estimated that ultimately it would be possible to reduce the consumption of fuel by 50 percent in wood-fired air heaters.

Costs. It is estimated that the actual cost of an energy-efficient heater would be approximately Rs.300,000 fully installed. Two new heaters would cost Rs.600,000 (mostly local costs).

Savings. At Mattakelle Estate, it is estimated that using energy-efficient air heaters for both the fluidized bed dryer and the older dryer would result in a cost per kg of made tea of about 45 cts., based on the price of firewood. Assuming that two-thirds of the tea is dried in the fluidized bed dryer and one-third in the traditional dryer:

Average savings of fuel oil per month in financial terms	Rs.46,800
Total savings of firewood in the older dryer	Rs.20,000
(Assuming an average production of 52,000 kg per month)	
Total cost of firewood used in new energy-efficient heaters attached to both dryers	Rs.21,000
Monthly energy savings	Rs.39,300
Yearly energy savings	Rs.471,600
Simple payback	1.27 years.

In this particular case, there is a very quick payback because one of the dryers is being operated on heavy diesel. It is also instructive to consider the case where two solid fuel-fired heaters are already installed. It is estimated that the savings resulting from the replacement of an existing, inefficient air heater with an efficient air heater would be about 25 cts. per kg of made tea (i.e., an efficiency improvement of about 40 percent), yielding annual financial savings of Rs.156,000 and a simple payback of 3.85 years. Therefore, even in estates with already existing wood-fired air heaters, replacement with new, highly efficient heaters would be a viable proposition.

Implementation. Because improvements in efficiency of wood-fired air heaters would have such a significant impact on the tea sector, a donor should play a major role in the design and development phase. Since the technology of air heaters is very well known, the time period to produce a viable design should not be more than 2 years.

Costs. Prototypes could be tested on estates within a period of 1 year to 18 months. Thereafter, fabrication, supply, and installation would be carried out by the traditional suppliers of tea estate machinery, within a period of 6 months per unit.

Use of Dryer Waste Heat for Drying Firewood

Description. The new air heater design recommended above must still release its flue gases at temperatures above 150°C to prevent condensation of sulfur compounds and corrosion of metal parts. However, it should be possible to go below this figure if the flue gases are used in some simple covered shed or similar arrangements to dry firewood prior to feeding into the air heaters. This would result in a further increase in efficiency for very little capital expenditure.

Costs. It is estimated that an arrangement to dry firewood using flue gases would cost around Rs.60,000 (all local).

Savings. Assuming that moisture content is reduced from 45 percent to 25 percent (that is, from average natural moisture content to typical moisture content of dried wood) by this arrangement, calorific value would improve from 2,300 kcal/kg NHV to around 3,370 kcal/kg NHV. Hence, per original kg of purchased wood, the amount remaining after drying would be about 0.734 kg. The NHV of this quantity of wood will be about 2,470 kcal. Hence, by drying the wood, an improvement in usable heat of about 7.5 percent per kg of purchased wood will result, and annual wood purchases could be reduced by the same figure. Therefore, based on wood purchases of 27,000 per month for two dryers, the annual financial savings would be about Rs.24,300 and yield a simple payback of 2.47 years.

Implementation. In this case as well, some development work is necessary and could be funded by donors. The Tea Research Institute could be the main participant in development work. Actual implementation of a simple design of dryer could be carried out by estate staff in about 3 months.

Use of Biogas

Description. All estates have a significant population of farm animals as well as human beings. In the case of Mattakelle Estate, there are 1,200 persons and 156 cattle. One cow is equivalent to about 8-10 human beings in terms of fermentable waste. The total population will produce waste matter equivalent to that of a herd of about 250 cattle. It has been estimated by the Tea Research Institute (TRI) that this would be sufficient to produce enough biogas for the cooking needs of 80-85 medium-size (i.e., 5 people) families (i.e., 425-450 people). Hence, by using a biogas digester, it may be possible to supply the entire cooking needs of about one-third of the entire estate population.

Costs. It is estimated that the installed cost of a biogas digester for this volume of gas would be about Rs.200,000 including the collection system (75 percent local).

Savings. It is estimated that a medium-sized family would use about 10 lbs. of firewood per day. Annual savings in firewood at Rs.600/form = Rs.85,000. Simple payback = 2.35 years.

Implementation. Since biogas digesters are being popularized and installed by a number of organizations in Sri Lanka, this conservation measure could be easily implemented by the estate management, with consultancy assistance from the TRI. The total implementation period would be about 1 year.

Use of Mini and Micro Hydropower Systems

Description. In the past, many tea estates had their own power generation capability by using small Pelton wheels connected to generators. With the advent of cheap fuel in the 1950s and electrification programs, these units were allowed to fall into disrepair. Since individual estate units were only in the 50- to 80-kW range, and since estate power requirements are not much greater, present-day implementation could be carried out by cooperative ventures between several estates. In this method, one or two estates with significant hydro potential will exploit this to the fullest and then distribute the power to the others.

Costs. It is estimated that a group of four estates will require about 1 MW in power, and the cost (at Rs.30,000/kW) would be around Rs.30 million (60 percent foreign).

Savings. The total annual savings would be around Rs.4.8 million, yielding a payback of about 6.25 years.

Implementation. This measure would have to be implemented in collaboration with a number of organizations (e.g., CEB). However, no technical difficulties are foreseen for these measures. Implementation would take a total of 2 to 3 years.

4. Terms of Reference

Detailed energy audits of 2-3 representative tea estates should be conducted in collaboration with the Tea Research Institute to obtain sufficient data to allow detailed feasibility studies of the four projects described in Section 3.

The energy audit can be conducted by local specialized teams, such as those sponsored by EDMAC, including CTC Services. TRI researchers and perhaps engineers from the Ceylon Company of Commerce should be associated with this effort. Each factory audit should require about 8 man-weeks to perform, including report preparation. Associated costs should be around Rs.20,000 to Rs.25,000. More general guidelines for the consultants are provided below.

Payback. The simple payback would be 1.8 years.

Implementation. Factory personnel should be able to implement this measure with assistance from local consulting organizations and manufacturers at the plant. The technical study would take 5 months, and the procurement, installation, and commissioning of the boiler would take 8 months.

4. Terms of Reference

4.1 Energy Audit

A detailed energy audit of selected tea estates should be conducted, consisting of the following successive steps:

4.1.1 The consultants will conduct a preliminary energy audit (also called survey) or "PEA" to collect historical data on (a) detailed energy use, (b) production, (c) energy-using equipment, and (d) technical personnel available on-site for energy efficiency work. The PEA should not take more than 3 man-days to perform for each estate.

4.1.2 On the basis of the PEA, the consultants will expeditiously decide, in agreement with factory management, which fixed instrumentation should be installed prior to conducting the detailed energy audit and which areas deserve most attention.

The following areas are likely to be candidates:

- Dryers
- Hot air generators/heaters
- Electric generation and utilization.

Mass and energy balances will be prepared, when required, for several representative operating conditions.

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide the tea estates with the following information for each option:

- Description
- Estimated cost in foreign and local currency with sources of information and range of confidence
- Estimated savings in physical units and financial (i.e., at market prices) and economic (i.e., at true cost to the economy) values
- Implementation schedule and recommendations.

On the basis of the audit results, the consultants will undertake a series of feasibility studies for the projects that are too complex, risky, or capital-intensive to be fully analyzed within the audit.

4.1.3 For each one of the retained projects (likely to include most of the projects identified in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (including demand and market projections)
2. Technical options
3. Cost and performance assumptions
4. Financial analysis
5. Economic and social analysis
6. Implementation

Appendices.

Each feasibility study should be discussed with EDMAC and TRI prior to submission to the tea estates.

4.2 Team and Project Duration

The energy audit team should comprise:

TEA ESTATES: MATTAKELLE STATE TEA PLANTATION

- One/two TRI specialists
- One to two additional auditors, possibly including former EDMAC trainees and tea estate engineers.

The full audit should take about 1 man-month on-site per tea estate, plus 1-2 months for report preparation (U.S. $2,000-$3,000).

The feasibility studies should be undertaken by the consultants in collaboration with TRI representatives from tea estate management and EDMAC.

The level of effort envisioned for the feasibility studies is between 9 and 16 man-months (U.S. $15,000-$20,000).

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Summary

Energy savings at the Mawanella rubber factory could be achieved through the conventional use of electric power factor correction devices and appropriate combustion practices, but mostly through fuel diversification. It has been estimated that, taken together, these various measures could reduce the factory's energy costs by about half, with an average payback for the projects of less than two years (see Exhibit A).

The fuel diversification would involve substituting wood for diesel oil through the installation of a multifuel (i.e., wood and oil) heater with a crumb dryer. As many rubber estates have access to their own source of wood in the form of old rubber trees, it could be to their advantage to consider substituting wood for petroleum products. Mawanella is a central processing factory, and the Sri Lanka Rubber Co. does not own planations to extract wood from. Even in its case, however, fuel cost reduction through the use of wood has been estimated at 40% for a financial payback of about two years. In considering any substitution of rubber trees for petroleum, the economic value of the trees as fuel should be weighed against their value as industrial wood.

It should also be pointed out that, while a wood-fired (or multifuel) air heater seems technically feasible, it has not yet been tried in Sri Lanka. As part of the feasibility study, a suitable air heater would therefore have to be designed and installed. This testing of the heater's technical, economic and financial viability should be done in conjunction with the Rubber Research Institute.

Exhibit A

Sri Lanka (Ceylon) Rubber Manufacturing Company Ltd.: Summary of Possible Energy Conservation Projects
(Total 1983 energy bill: Rs.640,000)

Project	Cost (Rs.000) Total	Cost (Rs.000) Foreign*	Cost (Rs.000) Local	Average Annual financial benefit (Rs.000) Total	Average Annual financial benefit (Rs.000) Foreign[1]	Average Annual financial benefit (Rs.000) Local	Simple payback (years) Financial[2]	Simple payback (years) Economic[3]
Power factor correction	50	40	10	76	53	23	0.6	0.3
Use of a multifuel air heater with crumb rubber dryer	600	0	600	313	272	31	1.8	1.3
TOTAL	650	40	610	389	325	54	1.7	0.9

Mid-1984 exchange rate: 1 U.S. dollar = Rs.25.

*Foreign costs include engineering and design costs (roughly 10 to 15 percent of total project foreign costs).

[1]EMWAC estimates that the foreign content of electricity is 70 percent of market price and that the foreign content of oil is 90 percent of market price.

[2]Total cost/average annual financial benefits.

[3]Estimate taken as project foreign CIF cost and half project local cost (to reflect duties, which average 7.5 percent of CIF value for this type of equipment, unused labor force, etc.)/economic value of annual benefits. The economic value of annual benefits has been estimated using EMWAC guidelines, i.e.:

- Opportunity cost of electricity = 1.75 market price to reflect long-term development marginal cost of Rs.3.5 (U.S. $0.14)/kWh vs. Rs.2.0 (U.S. $0.08)/kWh for market price
- Opportunity cost of fuel oil = 75 percent of market price, or U.S. $144/tonne to reflect current and future re-export of excess refinery supply of fuel oil.

SOURCE: Hagler, Bailly & Company.

SRI LANKA (CEYLON) RUBBER MANUFACTURING COMPANY LTD.

1. Background

This plant uses natural rubber latex as a raw material and produces technically-specified grades of rubber in block form for export and also centrifuged latex for local use. The factory was set up in the early 1970s. Originally, it was operated under a publicly-owned corporation called the State Rubber Manufacturing Corporation. With the advent of liberalization policies under the present government, the corporation was partially privatized with some of the factories being desolved under a private company with the name Sri Lanka (Ceylon) Rubber Manufacturing Company Ltd.

Plant location. The plant is located at Mawanella on the main Colombo-Kandy Road about 50 miles from Colombo.

Process description. Latex is received in road tankers and unloaded into one of two large settling tanks. From here, it is taken to a series of ceramic tile-lined coagulation tanks, where the correct chemicals are added and coagulation is allowed to take place.

The coagulated latex is dried in custom-made, oil-fired, through-pass type drying chambers. After drying, the crumb rubber is baled in hydraulic presses and packed for export in wooden open crates.

Centrifuged latex is produced in an electric centrifuge, which takes latex direct from the main storage tank. It is then stabilized and stored in tanks, for collection by local customers. Latex production was only started in 1982.

Production. Technically specified rubber production in 1980-1981 was 1,971,200 kg; 1981-1982: 1,530,488 kg; 1982-1983: 507,910 kg; 1983-1984: 769,800 kg. Concentrated latex production in 1982-1983 was 101,557 kg; in 1983-1984: 69,044 kg.

Markets. As mentioned above, all the technically specified rubber produced is exported to customers.

Organization. The plant consists of one factory manager and three executives who look after day-to-day operations. There is no energy management organization at the present time or envisaged for the future.

Project evaluation criteria. It is understood that all projects would be evaluated by personnel at the head office in Colombo. Furthermore, any project with a payback period of 2 years or less would receive favorable attention.

SRI LANKA (CEYLON) RUBBER MANUFACTURING COMPANY LTD.

Existing plans for modernization/expansion. At the present time, the factory has installed and commissioned another process line for recovering skim rubber from the skim latex of the concentrate line. There are no plans to expand the factory any further, at the present time.

Financial situation. The actual balance sheet was not obtainable at the factory. However, the profit and loss situation would be as follows: 1982-1983 profit was Rs.2.1 million; 1983-1984 profit was Rs.1.4 million.

Problems facing facility. A major problem for this facility is the frequent electric power interruptions of short duration, which cause problems with the process machinery. While purchase of a standby generator is contemplated, the large cash requirement has stopped them from doing so.

2. Energy Situation

Energy-using equipment. The process line for technically specified rubber consists of three roller-type mills (i.e., a crusher, a macerator and a creper) and a creper/hammermill. These mills are driven by electric motors, and require no heating sources.

The other major energy-using plant is the crumb rubber dryer mentioned above, which uses heat generated by an oil-fired automatic packaged burner, running on heavy diesel. Hot air and gases are circulated through a long pass-type drying chamber in which trolleys carrying crumb rubber are sent through.

Electrical energy is also used to provide hydraulic pressure for the main baling process.

Fuel and electricity usage

	1980/81	1981/82	1982/83	1983/84
Electricity (kWh)	239,960	188,390	152,170	122,510
Cost (Rs.)	133,560	239,621	300,561	303,737
Fuel				
Cost (Rs.)	571,648	734,634	470,000	338,717

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Specific energy consumption (in Rs. per kg of product) (see Exhibit 1).

The management organization was not made available to the in-country team.

With regard to energy conservation activities, the factory manager has measured the power factor, which was found to be very low, at around 0.75. The factory has considered the installation of power factor connection equipment. No other energy conservation measures have been contemplated or carried out.

3. Energy Conservation Projects

Both fuel and electricity consumption can be reduced by 10-15 percent. Two candidate projects are presented below.

Power Factor Correction

Description. As mentioned earlier, a measurement of power factor has been carried out by the factory manager and found to be very low. A significant conservation measure would be the installation of capacitors for the correction of power factor.

Costs. It is estimated that the cost of power factor correction equipment would be Rs.50,000 installed (80 percent foreign).

Savings. Once the scrap milling section is in operation, it is estimated that maximum demand would be around 300 kVA.

Hence, the new maximum demand of power factor is increased to 0.95 and would be = (300 x 0.75)/0.95. Saving in maximum demand = 63 kVA. Reduction in cost = Rs.6,300 per month = Rs.75,600 per year. Simple payback = 8 months.

Implementation. This measure can be easily implemented by the factory staff in collaboration with equipment suppliers.

Exhibit 1

Specific Energy Consumption
(In Rs. per kg of product)

TSR	1980/81	1981/82	1982/83	1983/84
Total production cost	10.92	9.85	10.35	15.74
Electricity cost	0.07	0.16	0.32	0.32
Fuel cost	0.29	0.48	0.53	0.44
Total energy cost as a percent of total production cost	3.00	6.50	8.10	4.80

SOURCE: Sri Lanka (Ceylon) Rubber Manufacturing Company Ltd.

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Use of a Multifuel Air Heater with Crumb Rubber Dryer

Description. At the present time, hot air for crumb rubber drying is provided from automatic packaged burners operating on auto diesel. Gases from burners and excess air are mixed together and act directly on the crumb rubber in trays within the dryer. Because of direct use, it is not possible to consider the use of heavy residual oils as they may lead to contamination of the crumb rubber.

An option that can be considered is to use an air heater, which utilizes a solid fuel such as firewood. This would be a separate piece of equipment whose outlet could be directly coupled to the existing dryer air inlets. The burners would remain to act as standby and to provide a peaking temperature rise, if necessary.

Costs. It is estimated that purpose built air heaters, fully installed, would cost around Rs.600,000.

Savings. Considering the typical high production level year of 1981/1982, the total amount of wood required to replace 85 percent of the diesel would be 520 tons of wood for a total cost of Rs.312,000 per year. Cost of additional oil (15 percent) would be Rs.110,000 per year, for a total cost of fuel of Rs.422,000 per year. Cost savings would then reach Rs.312,634 per year. Simple payback = 1.9 years.

Implementation. The feasibility study must evaluate the availability and cost of wood to the Mawanella factory over the life of the heater. In an area of existing or impending shortage of wood, the cost and benefits of this measure to the economy should be examined more closely. In any case, the value of the rubber trees as fuel must be weighed against their value as industrial wood. It should also be emphasized that, while such a heater seems technically feasible, it has not yet been tried in Sri Lanka. As part of the feasibility study, the Rubber Research Institue should therefore be involved in designing and installing such a heater on a test basis to evaluate its technical, economic and financial viability. The design, fabrication, installation and commissioning of such a heater should take under two years.

It should be pointed out that the recommended analysis of the economics of substituting wood for oil in a multifuel air heater and of the availability and cost of wood to the Manwella factory may indicate that it makes better economic and financial sense to test such a heater elsewhere. As many rubber estates have access to their own old rubber trees, they may make better candidates for this type of work. Because it is a central processing factory, Manwella does not own plantations to extract wood from.

SRI LANKA (CEYLON) RUBBER MANUFACTURING COMPANY LTD.

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4. Terms of Reference

4.1 Energy Audit

A detailed energy audit of the Sri Lanka (Ceylon) Rubber Manufacturing Company Ltd. should be conducted, consisting of the following successive steps:

4.1.1 The consultants will conduct a preliminary energy audit (also called survey) or "PEA" to collect historical data on (a) detailed energy use, (b) production, (c) energy-using equipment, and (d) technical personnel available on-site for energy efficiency work. The PEA should not take more than 3 man-days to perform.

4.1.2 On the basis of the PEA and immediately after, the consultants will decide, in agreement with factory management, which fixed instrumentation should be installed prior to conducting the detailed energy audit and which areas deserve most attention.

The following areas are likely to be candidates:

- o Dryers
- o Hot air generators/heaters
- o Electric utilization (mills).

Mass and energy balances will be prepared, when required, for several representative operating conditions.

For each audit area selected, the consultants will perform an instrumented analysis of the energy-related flows to identify areas of improvements. Energy balances should be developed and potential savings estimated. When several options are possible, the consultants will provide the following information for each option:

- o Description

- o Estimated cost in foreign and local currency with sources of information and range of confidence

- o Estimated savings in physical units and financial (i.e., at market prices) and economic (i.e., at true cost to the economy) values

- o Implementation schedule and recommendations.

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On the basis of the audit results and immediately after, the consultants will undertake a series of feasibility studies for the projects that are too complex, risky, or capital-intensive to be fully analyzed within the audit.

4.1.3 For each one of the retained projects (likely to include most of the projects identified in Section 3), the consultants will prepare a detailed feasibility study according to the following format:

Executive Summary

1. Introduction (with market and demand projections)

2. Technical options

3. Cost and performance assumptions

4. Financial analysis

5. Economic and social analysis

6. Implementation

Appendices.

Each feasibility study should be discussed with EDMAC and RRI prior to submission to the Sri Lanka Rubber Company.

4.2 Team and Project Duration

The energy audit team should comprise:

- One/two RRI specialists
- One to two additional auditors, possibly including former EDMAC trainees and engineers from the company.

The full audit should take about 1 man-month on-site, plus 1-2 months for report preparation.

The feasibility studies should be undertaken by the company consultants in collaboration with RRI representatives and EDMAC.

The level of effort envisioned for the feasibility studies is between 6 and 12 man-months.

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

Activities Completed

Energy Assessment Status Report	Date Completed
Papua New Guinea	July, 1983
Mauritius	October, 1983
Sri Lanka	January, 1984
Malawi	January, 1984
Burundi	February, 1984
Bangladesh	April, 1984
Kenya	May, 1984
Rwanda	May, 1984
Zimbabwe	August, 1984
Uganda	August, 1984
Indonesia	September, 1984
Senegal	October, 1984
Sudan	November, 1984
Nepal	January, 1985
Zambia	August, 1985
Peru	August, 1985
Haiti	August, 1985
Paraguay	September, 1985
Morocco	January, 1986
Niger	February, 1986

Project Formulation and Justification

Panama	Power Loss Reduction Study	June, 1983
Zimbabwe	Power Loss Reduction Study	June, 1983
Sri Lanka	Power Loss Reduction Study	July, 1983
Malawi	Technical Assistance to Improve the Efficiency of Fuelwood Use in Tobacco Industry	November, 1983
Kenya	Power Loss Reduction Study	March, 1984
Sudan	Power Loss Reduction Study	June, 1984
Seychelles	Power Loss Reduction Study	August, 1984
The Gambia	Solar Water Heating Retrofit Project	February, 1985
Bangladesh	Power System Efficiency Study	February, 1985
The Gambia	Solar Photovoltaic Applications	March, 1985
Senegal	Industrial Energy Conservation	June, 1985
Burundi	Improved Charcoal Cookstove Strategy	September, 1985
Thailand	Rural Energy Issues and Options	September, 1985
Ethiopia	Power Sector Efficiency Study	October, 1985
Burundi	Peat Utilization Project	November, 1985
Botswana	Pump Electrification Prefeasibility Study	January, 1986
Uganda	Energy Efficiency in Tobacco Curing Industry	February, 1986
Indonesia	Power Generation Efficiency Study	February, 1986
Uganda	Fuelwood/Forestry Feasibility Study	March, 1986

Institutional and Policy Support

Sudan	Management Assistance to the Ministry of Energy & Mining	May, 1983
Burundi	Petroleum Supply Management Study	December, 1983
Papua New Guinea	Proposals for Strengthening the Department of Minerals and Energy	October, 1984
Papua New Guinea	Power Tariff Study	October, 1984
Costa Rica	Recommended Tech. Asst. Projects	November, 1984
Uganda	Institutional Strengthening in the Energy Sector	January, 1985
Guinea-Bissau	Recommended Technical Assistance Projects	April, 1985
Zimbabwe	Power Sector Management	April, 1985
The Gambia	Petroleum Supply Management Assistance	April, 1985
Burundi	Presentation of Energy Projects for the Fourth Five Year Plan	May, 1985
Liberia	Recommended Technical Assistance Proj.	June, 1985