Implementation of Energy Management Systems in the Floreal Group

Final report to the Mauritius Research Council

April 2001

Contents:

1. Synopsis

An Energy Management System (EMS) is an innovative approach applying Engineering and Management techniques to optimise energy efficiency. The benefits for the company as well as for the country are significant. Applying an EMS in the Floreal Group has improved the generation, distribution and utilisation of energy. The methodology used has consisted of the setting up of an Energy Manaqement Framework (EMF), implementing Auditing and Monitoring, Performance Monitoring, Goodhousekeeping as well as optimal use of existing technology. Priority projects have also been identified where investment is worth to be directed. The dyeing and finishing industry, in particular, is the area where priority should be given in the implementation of Energy Management.

2. Acknowledgements

We are grateful to the Mauritius Research Council for sponsoring this project under the Private Sector Collaborative Research Grant Scheme. Our appreciation of the help, support and collaboration of the Management and Staff of the Council should also be put on record, in particular that of Mr K. Heeramun.

We indebted to the University of Mauritius for its collaboration, in particular to Dr R. Beehary-Panray and to Mr Suresh Doman. Trainee students and final-year project students, particularly F. Ruhomally and M. Malecaut are also to be thanked for their positive input in the project,

Our thanks also go to all the Management and Staff of Ferney Spinning Mills, Dyers and Finishers Ltd and Consolidated Dyers Ltd. In particular, the contributions of Messrs Michel Lam, J-F Henri and Bernard Montocchio and Miss R. Chung have been most relevant.

To all employees of the Floreal Group having contributed in the project, we express our deepest gratitude for their interest and active participation.

Last but not least, our tribute goes to Mr Eddy Yeung, Director, Spinning Operations, Floreal Group without whom this project would have never materialized. We are thankful to him for sharing his vision with us, providing his unreserved encouragement and showing his utmost interest in our endeavour.

3. Summary of pervious reports

3.1 Interim report submitted in April 2000

This report introduces the company, discusses its structure and provides details on the energy-consuming activities. In particular, the use of steam and related energy streams is looked into and attitudes towards Energy Management are reported.

The following sub-reports are also included:
Report No. 1 : Setting up an Energy Management Framework (EMF - Activity One)
Report No. 2 : Energy Auditing (Activity 2)

The remainder of the interim report analyses on-going projects and proposes a set of measures for immediate adoption. The expansion of the plant, the possibility of installation of a new boiler as well as the re-assessment of cost and benefits of the project are also reported.

3.2 Second report - July 2000

This report provides feed-back on the progress of the project, presents the constraints observed and identifies the forthcoming tasks to be given priority in the implementation of Energy Management.

The re-definition of the concept of an Energy Management Framework (EMF), the latest results of energy auditing and relevant subsequent analysis, the determination of techniques for optimisation of energy consumption as a function of production, findings on the optimal use of Koenig heat recovery systems and of compressed air and the re-design of the wool-dyehouse are dealt with in depth in the report. The long term vision of the company with respect to Energy Management is also re-visited.

4. Additional reports

Energy Management in dyeing and finishing (Appendix I)

Energy Management : an innovation to follow (Appendix II)

These two additional reports pinpoint the area of priority, namely dyeing and finishing, where Energy Management potential is identified as significant and propose the extrapolation of the implementation of Energy Management to other industries, and in particular, to other dyeing and finishing plants.

5. Conclusions

- Figure 1 shows the specific energy consumption for the dyehouse (CDL & DNF) and for the whole plant including FSM. The effect of the increase in energy prices as from October 2000 is apparent, the specific energy consumption shooting to Rs 15 /kg from an average of Rs 9 /kg (for the whole plant) and to Rs 10/kg from Rs 5/kg (for CDL & DNF). However, this should not mask the fact that the specific energy consumption has been gradually dropping as from March 2001 until the prices increase in October 2001. This fact is confirmed by the trends shown in Figure 2.
- Very early in the course of the current research, a clear relationship between the specific energy consumption and the level of production has been observed. Figures 3, 4 and 5 show this correlation graphically and the equations given may be used for accurate prediction of results. Since the price of energy has changed, Figure 5 may be more relevant, henceforth, as the energy consumption is measured in joules. However, Figure 3 can still be applied as it reflects clearly the decreasing trend in specific electricity consumption (Rs/kg) as production is decreasing (with implications as discussed in previous reports).
- Figure 6 and Figure 7 indicate the total energy consumption for the whole plant in Rs and in joules. Although energy consumption is a factor of the level of production, these figures as well Figures 8 and Figure 9 (also re-inforced by Figure 1 and Figure 2) show clearly that the whole plant has been severely hit by the recent increase in energy prices.
- The energy saving achieved in the dyeing and finishing plant (CDL and DNF) over twelve months in 2000 is estimated as shown in Table I below:

Table I

Months	Production kg	Saving in Rs/kg	Total saving Rs
Jan to Sep 2000	5 000 000	0.2 to 0.5	1.0 to 2.5 million
Oct to Dec 2000	1 800 000	0.4 to 1.0	0.7 to 1.8 million
		Lower estimate Upper estimate	Rs 1.7 million Rs 4.3 million

The energy saving is as a result of the combined effect of the on-going energy management programme initiated by the company and of the introduction of critical measures like the setting up of an Energy Management Framework (EMF), energy auditing, monitoring and targeting, optimisation of Koenig recovery systems, improved recovery of condensate and flash as well as enhanced boiler operation and better energy awareness.

- The energy saving achieved in the FSM over twelve months in 2000 is estimated as shown in Table II below:

Table II

Months	Production kg	Saving in Rs/kg	Total saving Rs
Jan to Jun 2000	850 000	2 to 5	1.7 to 4.3
Jun to Dec 2000		0	0
		Lower estimate Upper estimate	Rs 1.7 million Rs 4.3 million

The energy saving cannot be accurately estimated for the second half of 2000 because of the lack of accurate measurements. If the available data can be relied upon, there is in fact no significant energy saving for the second half of 2000 - a period also marked by the increase in energy prices. The saving in the first six months is principally due to the following:

1. Optimisation of production (as discussed in previous reports).
2. Sustained energy management (through the setting up of an EMF and the conduct of energy audits, supported by all-across awareness).

- Thus the total energy saving is between Rs 3.4 million and Rs 8.6 million for year 2000. The latter figures corroborate with the analysis made in earlier reports and with the bottom-up analysis of savings. The corresponding saving in wet processing ranges between 5 and 15 % and between 10 and 30 % in electricity consumption in FSM (the latter being mostly due to optimal production). A more exact estimate is not possible in view of the multiplicity of parameters involved, and in particular, the changes being permanently introduced in the plants. The increase in energy prices in late 2000 implies that the saving will roughly double if all other parameters are unchanged in the future and the Energy Management programme is sustained.
- Assuming as a conservative estimate a saving of 0.5 million litres of diesel achieved during 2000 in D&F and CDL together with an electricity saving of more than 0.5 GWh, the CO2 reduction amounts to about 1700 tonnes and 600 tonnes respectively, that is a total of 2 300 tonnes as a conservative estimate. This is a significant contribution to curbing greenhouse gas emissions, particularly coming from industry in a developing country.
- The impact of Energy Management as a cost-cutting exercise aimed at improving profitability and enhancing competitiveness in the textile industry is evident, more emphatically nowadays with the increase in energy prices. In addition, the pressing need to cut down on CO2 emissions and to protect the local environment have made Energy Management still more important. It is also consistent with the desire of the industry to modernise, improving both quality and productivity.
- It is now more than essential for the company, and the industry in general, to adopt a comprehensive energy policy. In particular, with the help of institutional support, steps should be taken towards the introduction of CHP (cogeneration) in the large textile dyeing and finishing plants. To this effect, along with the setting up of an EMF and regular energy auditing as successfully attempted in the context of the current research, steam flow monitoring for accurate measurement of parameters is necessary. Due to financial constraints, the latter activity has not been undertaken.

- It is remarked that the eventual saving (between 5 and 10 %) in wet processing is less than the initial prediction of 30 to 40 %. The merit goes to the management of the plant, in particular, the maintenance team and the dyehouse team, who have already reached a significant level in the efficient use of energy when the research started. The additional saving was hard-earned, but any slow-down in the Energy Management efforts will provoke not only a lost in the saving of 5 to 10 % achieved thus far, but very important losses, up to 30 to 40 %.
- In the consumption of electricity, the saving achieved (between 10 and 30 %) is beyond the expected 5 % - reckoned earlier as a lower estimate - due to the huge potential of optimisation of production. This has been clearly explained and demonstrated in previous reports.
- Further savings have been identified as up to 20 % in the dyeing and finishing plant as discussed in previous reports. However, sustained efforts around an energy management programme are required. A three-year schedule has been proposed. As far as further saving in electricity consumption is concerned, in the light of the remarks made earlier, estimates are difficult to make. It would be a feat to sustain the achievement arrived at so far, but this is more a matter of equalising production load over several months than anything else. It is recommended that high level management talks are undertaken in order to prevent cases where one month FSM runs on high production and the following one on low production. Since it forms part of a vertically-integrated group, efforts in that direction are more promising than in the case of commission dyers.
- The current concern is that there is no following up of the Energy Management efforts in spite of the extreme interest of top management. Key persons have left the company recently and the recruitment of personnel qualified in Energy Management is strongly recommended. The restoring of the Energy Management Framework and its consolidation as well as the conduct of further studies in the feasibility of such projects like CHP (cogeneration) and heat recovery from finishing are absolute priorities. Above all, efforts must be made to sustain the results achieved so far through good day-to-day maintenance and housekeeping as well as continued education and training.
- The' specific steam consumption per temperature rise per liquor ratio', SSC/TR.LR ratio approach, as recommended by F.Ruhomally in the context of his Final Year Engineering project should be adopted in order to allow proper monitoring of energy consumption of dyehouse activities.
- Last but not least, the recent rise in energy prices is not the first one nor the last one. However, textile companies come and go and what makes some of them survive is indeed the ability to turn threats into opportunities. Energy Management is such an opportunity.

Appendix 1

Implementation of Energy Management in Floreal Group

Energy Management in Dyeing and Finishing

The following report describes the situation in the Dyers and Finishers Ltd (DNF) and the Consolidated Dyers Ltd (CDL) plants of the Floreal Group in relation to the implementation of Energy Management. As shown in the previous interim reports, the dyeing and finishing industry is the area where priority should be given in the implementation of Energy Management in the Floreal Group. ***Part One*** *focuses on the implementation of Energy Management accomplished so far in the context of the MRC project.* ***Part Two*** *provides concrete proposals made in the light of the findings of the applied research work conducted under the Mauritius Research Council's* ***Private Sector Collaborative Research Scheme****.*

Contents

Part One: Current situation at CDL & DNF Ltd.

Steam generation and use

The heat medium used in the company is saturated steam. In the dye-house, steam is used in heat exchangers rather than direct injection. This is generated by means of two boilers namely the Cochrane and the Cradley. These two boilers use diesel as fuel. The fuel consumption may amount to an average of 25000 liters per day. A third coal-fired boiler, the Thomson boiler, is no longer used due to its inability to cope with the steam demand.

The Cochrane boiler has a capacity of producing 13.5 tons per hour and the Cradley, 3 tons per hour. This boiler is mainly used as a spare or a back up in case of large steam demand or breakdown of the Cochrane. The amount of steam produced is at an average of 220 tons per day. Feed-water is passed through a softener plant. This tends to keep the hardness of the feed water very low. Then the water is pre-heated in a flash steam recovery system. The pre-heated water is stored in the hot-well for boiler feeding.

Steam is distributed at different pressures to the different sections of the dye-house; namely the fabric dyeing, the cone dyeing, wool dyeing and the finishing section.

The fabric and Cone and wool dyeing receive steam at an average of 4 bar. Here, steam is used only as a heating medium in the heat exchangers of the dyeing machines. The wool dyeing also use steam for the three dryers in operation.

The finishing section comprises of different machines but the main steam consumers are the two Santex and one Ruckh dryers. The calenders, which are live steam consumers are rated as very low steam consumers.

Steam is distributed through well insulated pipelines equipped with steam traps to minimise loss of steam.

The average production per month amounts to an average of 100,000 Kg of wool, 55,000 Kg of yarn and 360,000 Kg of fabric per month. Figure 1 below shows the variation in the cost of energy over the past years. The cost has been given in Rs/ Kg.

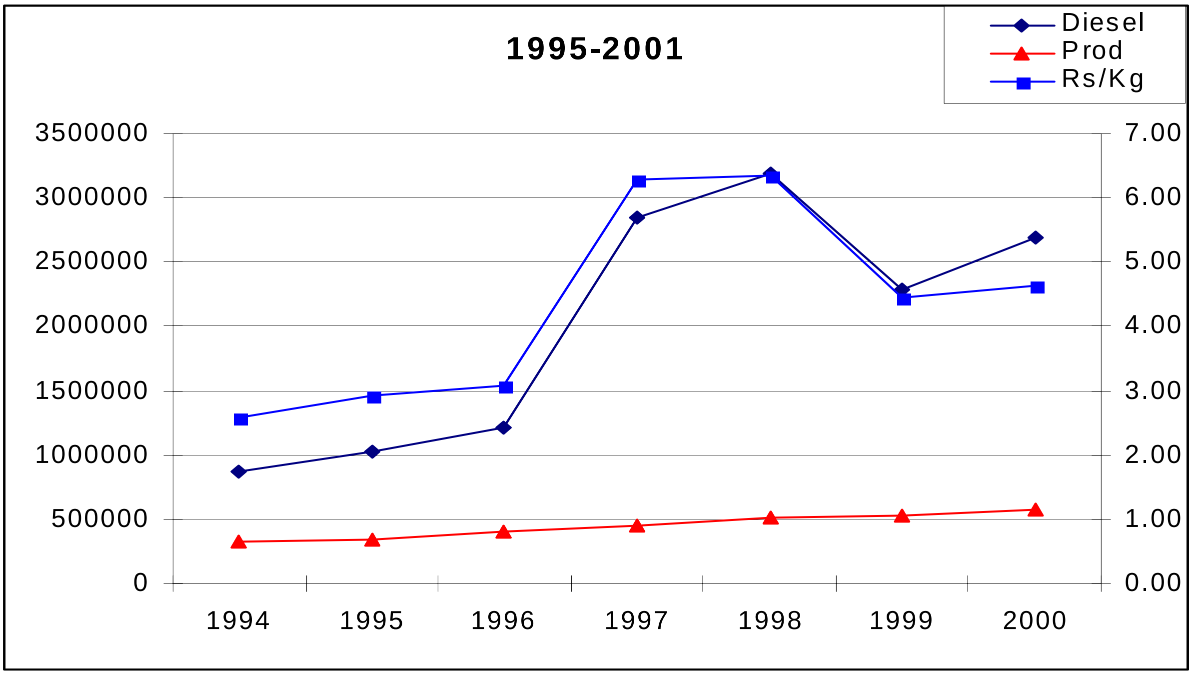

Figure 1 – DNF and CDL (Diesel and production)

Energy recovery systems

Following are descriptions of the energy management techniques existing in the plant implemented in the course of the applied research project funded by the MRC.

Condensate recovery

The condensate recovery consists of collecting the condensate formed after the heating processes, stored for further use in processing. For this, the CDL Ltd. possesses a condensate tank of a capacity of 10 cubic metres. Condensate is the by-product of steam after heating. This is usually hot water at a temperature of about 98 ^{0}C. It consists of a pure liquid of a very high energy content. In the company, hot water is required for processing thus condensate is used. Moreover, it is also used in heat exchangers to pre-heat boiler feed water.

Flash steam recovery

This consists of using condensate to pre-heat boiler feed water. This is done by means of a heat exchanger with the hot fluid being condensate and the cold fluid, feed water. The condensate, after use, is then directed to the condensate tank for storage. Despite of being a high temperature liquid, the condensate is not used directly as boiler feed water. This is due to the contamination problem. This occurs when a coil or tube in a heat exchanger in a dyeing machine is pierced. There the cold fluid is the bath water in which the material is dyed and the hot fluid is steam. If a tube is pierced, mixing of the two fluids can be a consequence. This may result in the condensate returned to be impure and thus said to be ‘contaminated’. This is why it is not used directly as boiler feed water.

Hot effluent segregation

This type of energy management technique consists of retrieving the energy in hot wastewater also referred to as effluent. This should be normally discharged in sewage lines thus a waste in potential recoverable energy.

The Koenig heat recovery plant, used at CDL and D&F Ltd., is the plant responsible to recover the energy in hot effluent. This plant was closely monitored during the whole project duration.

Results

The tables below provides the results for the measurements and calculations of

a) **The specific steam consumption**. This is the ratio of mass of steam used to the mass of fabric processed. it is denoted by s.s.c

b) **The s.s.c per degree temperature rise.** This is obtained by the dividing the s.s.c by the temperature difference by which the bath water was heated. It is denoted by s.s.c / d.t.r.

c) **The s.s.c/d.t.r per liquor ratio**. This is obtained by the dividing the s.s.c/d.t.r by the liquor ratio (l.r). The latter is the ratio of bath water to fabric processed and is already available in the batch information. It is denoted by s.s.c /(d.t.r * l.r).

Table I: Calculated and measure values for machine Scholl 7246 (1200 Kg)

Exp no	Liquor ratio	s.s.c		S.s.c per Degree temp rise x 1E-02		S.s.c per d.t.r per l.r x 1E-03	
		Cal	Mea	Cal	Mea	Cal	Mea
1	7	0.14	0.15	1.28	1.32	1.82	1.89
2	7	0.22	0.24	1.28	1.40	1.82	2.01
3	7	0.14	0.16	1.28	1.44	1.82	2.06
4	8	0.39	0.42	1.44	1.55	1.81	1.94
5	8	0.33	0.36	1.43	1.58	1.79	1.98
6	13	0.24	0.18	2.39	2.55	1.84	1.96

Table II: Calculated and measure values for machine Scholl 7247 (1600 Kg)

Exp no	Liquor ratio	s.s.c		S.s.c per Degree temp rise x 1E-02		S.s.c per d.t.r per l.r x 1E-03	
		Cal	Mea	Cal	Mea	Cal	Mea
1	8	0.25	0.26	1.44	1.52	1.80	1.90
2	10	0.33	0.15	1.83	1.90E-02	1.83	1.90
3	8	0.18	0.22	1.48	1.87E-02	1.85	2.34
4	6	0.17	0.23	1.12	1.37E-02	1.87	2.52
5	6	0.11	0.14	1.12	1.55E-02	1.87	2.29
6	6	0.16	0.22	1.12	1.56E-02	1.87	2.59
7	8	0.31	0.33	1.48	1.64E-02	1.85	1.96
8	8	0.15	0.17	1.48	1.02E+00	1.85	2.16
9	8	0.15	0.16	1.48	2.02E+00	1.85	2.05

Final results finishing machines

The values of steam consumption for the machines in the finishing section were mainly calculated and taken from specifications. They are all given in terms of kilogram of steam per hour, and in some cases kilogram, of steam per kilogram of fabric processed.

Table II1: Calculated and measure values for finishing machines.

Machines	*Steam Consumption, Kg / Hour*	*Specific Steam Consumption Kg Steam /Kg Fabric*
Santex Dryer(4 chambers)	864 [3]	-
Santex Dryer (5 chambers)	1331 [3]	-
Ruckh dryer	500 [1]	-
Calenders (old)	80 [1]	0.4 [2]
Calender (new)	160 [1]	1.4 [2]
Stenter	150 (max) [1]	2.0 [2]

Final results cone dyeing machines

The values for the yarn dyeing machines were provided in the specific steam consumption of the machines.

Table IV Calculated and measure values for cone dyeing machines

Machines	*S.S.C Calculated*	*S.S.C From Reference*
All machines	4.50	6.9 [2]

Final results wool dyeing machines

Table II: Calculated and measure values for wool dyeing machines.

Machines	***Steam Consumption*** ***Kg / Hour***	***Estimated s.s.c*** ***Kg steam/Kg material***
Obermaier	-	6.00
Dryers	550	-

Note: 1- values taken from the specifications of the machines manuals.

2- values taken from Attira, "Heat Economy in Textile Industry", Page XXX.

3- values obtained from calculations.

Part II- Further proposals

The energy (steam) flow is shown in the TableVI below.

Table VI – Current estimate of energy losses

	Status		Energy In J
Boiler house			
Diesel Input with boiler eff 80%			6.384E+11
Blowdown (m3)	not recovered		2.60E+09
Flue gas loss	not recovered		8.42E+10
Distribution losses	not recovered		1.39E+10
Hotwell			1.77E+10
Cone			
Waste water	not recovered		1.05E+10
Return cooling	recovered		2.32E+09
Return condensate (mass)	recovered		1.48E+10
Fabric			
Waste water	recovered		3.81E+10
Return cooling	recovered		2.03E+10
Return condensate (mass)	recovered		9.41E+10
Wool			
Waste water	not recovered		1.05E+10
Waste air	not recovered		4.65E+10
Return cooling	recovered		7.60E+09
Return condensate (mass)	not recovered		1.19E+11
Finishing			
Waste air	not recovered		1.82E+11
Return condensate (mass)	recovered		1.10E+11
Live steam	not recovered		1.50E+10
Koenig out (avg m3)			7.98E+10
Total not recovered			4.84E+11
MAXIMUM Amount possible to be recovered			3.21E+11

.

- For this project many of the optimisation calculations were based on the results obtained in the determination of the specific steam consumption. The new parameter derived, the specific steam consumption per degree temperature rise per liquor ratio (SSC/DTR.LR), was attributed as a constant for all machines. This would need further tests for confirmation. What would be recommended is to perform the same tests on at least two other Scholl dyeing machines to confirm the constant. Moreover, the values for cone and for wool need to be verified.

- The steam balance was made on the basis of average values of steam consumption. These values can be subject to change with the different shades of the dyeing processes for example. To solve this problem, the monitoring and targeting system proposed should be implemented. However, this must be done after the confirmation of the values of the new constant. Implementing this system will enable the managers to know about the variations of the steam demand. In fact, this software based system is one of the best methods to achieve this. Further, the savings associated is quite interesting without big capital investment.
- The implementation of the mixing valve should not only help to reduce the steam production and use but also to help in implementing the monitoring and targeting system. This is because, as a consequence, the mixing valves will promote very little heating in the sub-modules. In fact, only the heating to 95 or 98 ^{0}C would be necessary. Since the number of sub-modules involving steam heating would be decreased, the clash between several machines heating up at the same time can be made easier.
- To cope with the expected increase in the hot water demand due to an eventual implementation of the mixing valves, it would be imperative to look for economical means of producing this water at high temperature. In fact higher, the temperature of the hot water available, higher would be the effectiveness of the mixing valves and higher would also be the steam heating reduction. This decrease in the use of steam for heating would further increase the need to produce more hot water. this is because there would be a decrease in the amount of condensate. In this respect, it would be recommended to implement the energy recovery system from the air in the finishing section of the CDL

Ltd. Also the recovery of condensate in the wool dyeing section is recommended.

- The Koenig heat water recovery has been closely monitored for a period of about seven months during which a very significant increase in savings generated has been observed. This might illustrate the need not just to implement energy saving equipment, but also to ensure that they are running at their peak.

Appendix II

Implementation of Energy Management in Floreal Group

Energy Management : an Innovation to Follow

The following report describes the proposals for the Floreal Group in relation to the implementation of Energy Management in the short and medium term future. It is essential to inscribe Energy Management in the national context of the development of the country and to lay emphasis on the relevance of the example of the Floreal Group for the rest of the textile industry, if not, for all energy consumers. This issue is addressed in ***Part One*** *and* ***Part Two*** *of the report. Then, after a general overview of strategies applicable to the whole of the textile industry, the specific example of Floreal Group is discussed and concrete proposals are made in the light of the findings of the applied research work conducted under the Mauritius Research Council's* ***Private Sector Collaborative Research Scheme****.*

Contents

Part One: The Context and the Relevance of Energy Management

1. Developing Mauritius into the Third Millennium

It is our responsibility to envisage a strategy of development for Mauritius into the Third Millennium. Essentially, we will have to act upon what we have learned from the past, from our successes and our mistakes as well as those of others. The question is about what heritage will we leave to the Third Millennium. Surely, our legacy to the future cannot be similar to the one we benefited from at the beginning of this Millennium. However, we must recognise our achievements and our shortcomings and admit the truth about our experience.

During the 20th century, the world developed as it had never done before. In a similar way, the development of Mauritius over the last decades knows no parallel in the past. However, such development has not been without side-effects and a degradation of the Environment. We have the responsibility to change ourselves and adopt a new way of thinking. Sustainable development is part of such a new paradigm.

2. Sustainable use of energy

Devoid of natural resources, Mauritius has to import almost all of the raw materials needed for its development. Most important among all these raw-materials is energy. Development in its various forms, including the increased use of fossil fuel, has inevitably left some scars on the once-immaculate green island surrounded by blue lagoons. Air pollution, waste water disposal, solid waste, noise pollution are some of the problems frequently reported in the media. However, the damage is nothing yet compared to the situation in the major cities or sea resorts of the Third World. The country should not wait until the latter state is reached. Hence, a strategy of sustainable development has to be adopted so that Mauritius can continue its development, including the modernisation of its textile industry, with minimum harm to the Environment. Sustainable development is of particular significance for Mauritius as it is a small island country with a fragile ecological balance and a high population density of more than 500 per km^2. The protection of the health of the people and of the physical surrroundings are not the only concerns. The world is a global village and any long term strategy will have to consider the intricate relationship which links Mauritius to the outer world. Such a strategy will have widespread political, economic, social and environmental ramifications centred around the concept of sustainable development.

One inevitable issue to be addressed within any strategy for sustainable development is energy. Energy is essential for development and its use is linked to major environmental problems. For most countries, including Mauritius, energy is mainly an imported input. For a sustainable development, such countries should find ways of guaranteeing their supply of energy for the future at an affordable cost. Addressing the climate change threat is one of the great challenges the world is to face at the beginning of the next Millennium. Developing countries should do their utmost to cut down on their consumption of fossil fuel if the global rate of carbon dioxide emissions in the atmosphere is to be significantly reduced. Hence, the National Long-Term Perspective Study is right to propose that efforts should be made such that Mauritius is self-sufficient in clean energy around year 2020.

3. Energy Management in the Textile Industry

However, the current trend points more towards a persistent reliance on fossil fuel, most particularly for the textile industry. The striking socio-economic phenomenon that marked the development of the island over the recent decades was unquestionably the emergence of the textile industry. Although official statistics are not available, it is realistic to relate the growth in demand for fuel oil and coal to the spread of textile dyeing and finishing activity over the island.

Of the four ‘cylinders of the engine of growth’, the textile industry is the most energy intensive; it is also an area where ‘sensible conservation measures’ can be applied, if not where renewable energy can also be utilised. The management of energy – Energy Management – is the tool *par excellence* to achieve a sustainable use of energy in the textile industry in Mauritius .

4. Reasons for Energy Management in the Textile Industry

<u>Reliance on the import of fossil fuel: Mauritius and its textile industry</u>

The textile industry in Mauritius will continue to be one of major importance. Its modernisation must integrate the vital issue of Energy Management. The reliance on fossil fuel is a liability that can be countered only by Energy Management. It must be remembered that the *boom* of the textile industry happened at a time when the price of oil in real terms was decreasing (1983 to 1990). Had it been otherwise or had the

Iraqi invasion in 1990 had a long term repercussion on the oil market, the textile industry and the economy of Mauritius would have been in difficulty due to the strong reliance on fossil fuel. It should be a fundamental policy to reduce the reliance on fossil fuel in order to lessen the risks on the economy in the case of a sharp rise in prices and to face any possible disruption in the supply of fuel. Mauritius is over 5000 km away from the Gulf, off the major trade routes and is situated in a region with risks of climatic instability. As an example, a reserve of fuel oil equivalent to 10-day normal consumption in a textile dyeing and finishing plant will last for more than 12 days if Energy Management is applied to reduce the demand by 20 %. Given the highly competitive nature of the textile market where quick response is crucial, this 2-day extension should prove to be a life-line in the event of a supply disruption.

Increased profitability

Energy Management also offers direct economic advantages. In the early 1980s, abundant cheap labour favoured a rapid growth of the textile industry. Today, labour is neither abundant nor cheap. More generally, the cost of production has increased such that in that respect Mauritius has lost much of its competitive advantage to emerging producers in China, India, Vietnam or Madagascar. If not by cutting down labour costs, reducing the cost of production is possible by Energy Management. Reduced consumption of fuel and reduced cost of production have an immediate impact on profitability. As far as the investment required is concerned, it is paid back within less than one year in a number of cases. Energy Management has indeed a proven track record. Compared to efforts to increase profits by increasing sales, for example, Energy Management is less demanding. The former need sustained management and marketing attention and are often accompanied by high risk investments.

Increased competitiveness

With the globalisation of world trade, the Lome preferences from which the Mauritian textile industry has been benefiting will come to an end. Competition will come not only from countries like China, India, Vietnam and others in Africa and Asia but also from competitors within Europe and within the USA. The attempt of Mauritius to seize a share of the high value-added textiles market may suffer considerable opposition in case of a successful restructuring of the EU market – enlarged or with links with East Europe – and of the North American market. When it is important to be competitive on a long term basis rather than to guarantee short term profitability, cutting down production costs through Energy Management is a solution not to be neglected. In such cases, savings in terms of energy will not be used to increase the end-of-year profits but will help bring down the cost of the product with a view to increase the market share. It is important to note that some countries, particularly in the West, have the advantage of more advanced and energy-efficient technology than the one in Mauritius. Energy Management will also boost the competitiveness of the textile industry in Mauritius by enhancing quality and promoting quick response – these benefits naturally add to most improvements in energy efficiency.

<u>Reduced trade deficit</u>

In 1984 the import of fuel reached 18 % of the total value of our imports. A series of investigations into energy use was launched by the Government with emphasis on the domestic and industrial sectors. However, as the share of the energy item in the import bill decreased in the subsequent years, less and less attention was addressed to the issue. It is true that in 1996, for example, the import of fuel represented only about 7 % of total imports. However, in 1996, Mauritius was using at least three times more imported energy than in 1984. The level of total import increased at a faster rate such that a fall in the ratio of fuel import to total import was to be expected (in 1996, total import amounted to six times more than in 1984). Thus, Energy Management is at least as important now as it was in 1984 when the Government thought it worthwhile to emphasise on energy conservation in its Development Plan. Even if today, oil import does not weigh heavily in the trade deficit, it is to be feared that an increase in world oil prices will be a severe blow to the economy.

5. Environmental importance

<u>Less energy implies less pollution</u>

A simple relationship that is often forgotten is that *less energy implies less pollution*. Regulations in some countries reckon the importance of the latter relationship and set different norms for different levels of energy use. Industrial plants can often avoid the more strict rules applicable to high-consumption plants by promoting Energy Management in order to be included in the low-consumption level where the regulations are easily satisfied.

Less energy also implies less material. An example is the use of steam in the textile industry. A reduction in steam demand leads not only to a reduction in the fuel input and in associated emissions but also to a lower requirement of water – an extremely valuable resource . Other advantages of a more efficient use of steam occur as lower pumping costs, less chemicals used in water treatment, and less water pollution since steam often finishes as high temperature waste water at the end of the cycle of textile processing. In the case of solid fuels, the problems of ash disposal, smoke and grit are minimised by Energy Management.

<u>Coupling of Energy Management and environmental protection</u>

Industry may be required by the authorities to install pollution control equipment. The installation of the latter invariably brings no direct return on investment. On the other hand, the introduction of pollution control technology increases operation and maintenance costs. However, coupling an appropriate high pay-back Energy Management investment with the stipulated pollution control investment generates funds to help pay for the latter. One example is the conversion from fuel oil to LPG (liquefied petroleum gas). This conversion permits the use of an economiser to recover energy from the flue gas to preheat boiler water. The reduction in fuel consumption due to the economiser at least partially pays for the fuel conversion and for the investment in the economiser. Another example is the use of hot textile waste water in a heat exchanger to warm process water. The temperature of the waste water is thus suitably lowered to make bacteriological treatment possible. The cost of the treatment plant is partially offset by the saving from to the heat recovery system.

<u>Environmental competitiveness</u>

The advent of *Eco-label* for textile products, the spread of the ISO 14 000 standards, the attempt to include environmental issues on the agenda of the World Trade Organisation (WTO), the growing number of conventions on energy and environment are issues to which Mauritius cannot remain insensitive. It is sufficient that a few pictures of pollution in Mauritius are circulated in the media in Europe or in the U. S for the *Made in Mauritius* label to take a severe blow in the competitive textile market. Textile companies are increasingly concerned about their public image specially at a time when customers and investors are sympathetic to environmental issues. Thus, Energy Management is important as it is part of the wider domain of Environmental Management.

Conquering the climate change challenge

The evolution of the European and U.S legislation on pollution shows that the concern of environmental degradation has changed over the last centuries. The creation of the Environmental Protection Agency (EPA) in the U.S in 1970 was a turning point; it happened at a time when the environmental movement was emerging as a power to reckon with and when a transition in the concept of pollution was occurring. Before, pollution was short-living, localised and limited mostly to large cities. After the 1970s, pollution became associated with irreversible, long-term and possibly catastrophic consequences on a planetary scale. Industrialised countries are adopting targets to curb carbon dioxide emissions in view of countering the threat of global climate change. A commitment was taken by President Clinton in 1997 to reduce carbon dioxide emissions in the U.S down to 1990 levels between years 2008 and 2012 with further cuts in the following five years. President Clinton also called for developing countries to reduce their emissions but stopped short of demanding they meet specific targets.

Although there is no certainty that carbon dioxide emissions – originating mostly from fossil fuel combustion – will lead to a global climate change, the risk is sufficient justification for adopting preventive measures. However, it is relevant to question the extent to which resources should be devoted to such a preventive strategy in view of the growing scarcity of means and of the need for development, particularly in the developing world. A *minimum regret* approach is to be favoured by developing nations like Mauritius: actions taken to curb carbon dioxide emissions should yield primary benefits such as cost savings. In the unlikely event that the world got it all wrong concerning the threat of global climate change due to carbon dioxide emissions, there should be *minimum* r*egret* for the actions taken.

Energy Management actions are *minimum regret* actions. The importance of Energy Management irrespective of the climate change implication has already been discussed. Energy efficiency and conservation measures – optimised through Energy Management – have long been recognised as beneficial. The Green Energy Conference held in Montreal in September 1989 concluded in colourful terms that

‘Energy conservation is the most abundant, least expensive, safest, cleanest and most reliable form of energy in the world today.’[i] The United States Energy Association (USEA) has proposed a five-point plan to adopt energy efficiency measures calling for ‘ the United States and other nations in a spirit of common interest and common sense to get down to business in fully realising the potential of energy efficiency.’[ii] The various scenarios that have been proposed for sustainable energy use all underline the importance of energy efficiency.[iii] The World Energy Council acknowledges that there is a general agreement to give priority to energy efficiency even in countries of the South with low consumption levels[iv] (like Mauritius). In its programme for the last decade of this century, the Government of Mauritius included the objective of promoting energy conservation measures at consumer level as well as at production and distribution levels. Several publications have underlined such a commitment of the Government.[v] The National Long-Term Perspective Study specifically refers to the objective of ‘sensible conservation’ as a means of achieving self-sufficiency in energy.

Part Two: Voluntary initiatives: Floreal Group, MRC and UoM

In the past, successful energy conservation programmes in Canada were triggered by voluntary industrial task forces. A similar initiative by the American Textile Manufacturers Institute proved to be effective to such a point that the Department of Commerce used it as a model for its voluntary trade association programme. More recently, the United States Energy Association has acknowledged that true innovation in energy policies and Energy Management programmes has been coming from individual states, from communities and from the private sector.

Promoting voluntary initiatives towards Energy Management in Mauritius should be the target of all institutional support instruments. The main reasons for favouring voluntary actions instead of interventionism are given in Figure 1.

Investment -friendliness	
Statutory regulations are costly and complex to implement	**Different plants have different needs and different capacities**
Liberalisation and deregulation of the economy	**Freedom and democracy : a long-living tradition in Mauritius**

Figure 1. Reasons for promoting voluntary actions.

There is no compulsion in Energy Management. Its success relies on people with a voluntary and natural interest in sustainable development and showing a strong will power to promote sustainable use of energy and reap its benefits. Their consciousness of the importance of Energy Management is not restricted to their work or their business – Energy Management is their way of living. The purpose of institutional support is to allow them to overcome the obstacles against Energy Management that they face in different fields. Institutional support instruments come to help these men and women – engineers, managers, machine operators, business people, fuel suppliers, energy consultants, academics, researchers, policy makers, environmentalists.

It is in this perspective that must be viewed the initiative of the Floreal Group to approach the Mauritius Research Council (MRC) and the University of Mauritius

(UoM) to collaborate in this current project. Apart from being an example of private sector - university partnership, this project is also an example of the type of facilitation and support that should come from the Government (through the MRC) to promote applied industrial research. It is expected that the findings and recommendations will serve other parties in industry and in the private sector more generally. The findings and recommendations will also be of interest to the Governement as well as other policy-makers. The UoM is also called upon to pursue its role in the service of the development of the country both by following up the practical implementation of the findings and recommendations and by prolonging the research on Energy-related issues, and on Energy Management in particular.

Part Three : General Recommendations for Floreal Group

1. Introduction

This Part first identifies strategies applicable to the dyeing and finishing industry in Mauritius to facilitate the implementation of Energy Management techniques and technologies. The strategies for optimising the use of steam dyeing and finishing plants centre around the following key points:

- The strategies should relate to the political, economic and environmental importance of Energy Management for the textile industry in Mauritius.
- The strategies should contribute to overcome the obstacles to Energy Management in dyeing and finishing plants.
- The strategies should allow an optimum exploitation of the potential of Energy Management in the following ways:
    a) The implementation of low cost, short payback available techniques and technologies.
    b) The development of relevant indigenous techniques and technologies, including, a heat recovery method for waste water.
    c) The implementation of selective Third Age technology.
- The strategies should reckon the differences between small and large textile dyeing and finishing plants.
- The strategies should, finally, lead towards the modernisation of the textile industry making Mauritius a centre of excellence in dyeing and finishing activity.

2. Components of Energy Management

In order to organise Energy Management effectively, an Energy Management Framework (EMF) is necessary. The EMF is one of the three components of Energy Management in the context of the dyeing and finishing industry in Mauritius, as shown in Figure 2. Each component refers to an area of application of the various Energy Management techniques and technologies identified earlier. The EMF relates essentially to management techniques although the support of engineering tools like steam monitoring and new developments like computerisation are also part of the EMF.

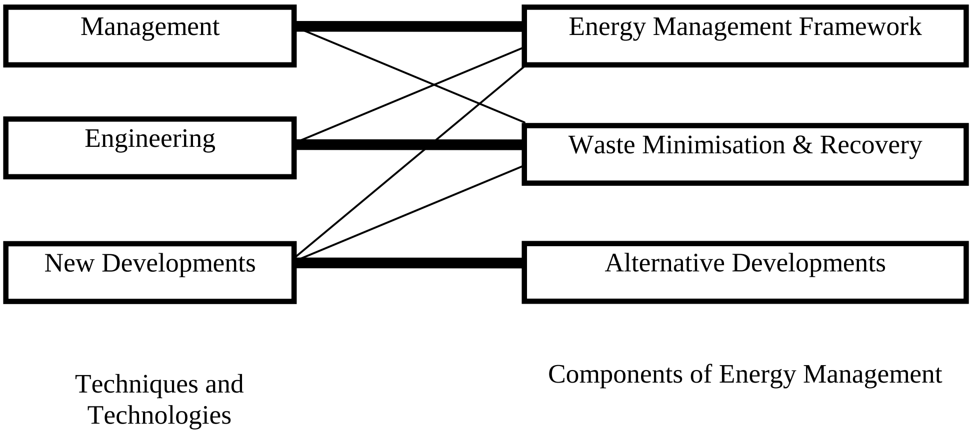

Figure 2. Components of Energy Management

Most of the engineering techniques and technologies discussed pertain to the domain of Waste Minimisation & Recovery. A third area of Energy Management is Alternative Developments englobing innovations in Information Technology, in the use of steam and in alternative technologies, that is, in Third Age technology. This third area is not generally applicable to small dyeing and finishing plants in Mauritius.

Functions of the EMF

The functions of the EMF are illustrated in Figure 3. Monitoring & Targeting and Auditing are central EMF functions. The setting up of the EMF is necessary before the textile dyeing and finishing plant can take measures in the areas of Waste Minimisation & Recovery and Alternative Developments.

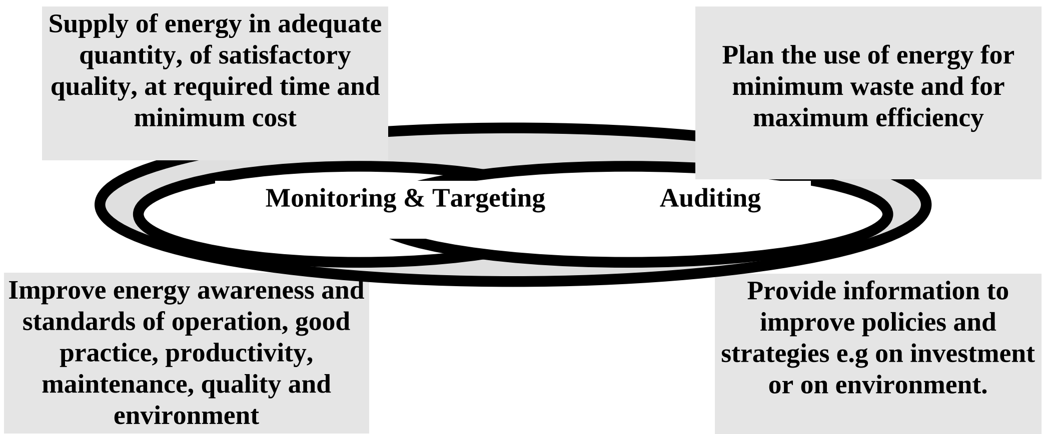

Figure 3. Functions of the EMF

The Troika

The EMF is managed through a 'troika' consisting of three persons with respective responsibilities as defined in Table II. The function of the troika is to develop and apply Energy Management strategies based on the company policies. It is recommended that the person responsible for Engineering in the plant assumes the role of Energy Manager. Important decisions are taken by consensus by the troika. The Energy Manager is afterwards given full authority to implement specific actions. The involvement of the Production Manager in the troika should ensure a participative dimension to Energy Management.

Table II. The Energy Management Troika

The Top Manager is the Head of the troika, but decision-making is through consensus. The troika develops and applies strategies relative to Energy Management based on the company policies.		
Troika	Authority	Responsibility
Top Manager	In small plants, this person can be the Managing Director or the owner. In large plants, the Top Manager is a Senior Executive above the two other members of the troika in the company hierarchy.	Implementation of energy-related policies Reports to Directors
Energy Manager	In the small plant, this person is the Works Engineer, the Maintenance Manager or the Chief Technician. In large ones, this role is filled by the Technical Manager, the Maintenance Manager, the Chief Engineer or the Engineering Manager.	Coordination of EMF Implementation of all Energy Management techniques and technologies Reports to Top Manager
Production Manager	Production manager, factory manager or dyehouse manager as appropriate.	Efficient use of energy Facilitation of Energy Management Reports to Top Manager

The EMF is the driving force of the other components of Energy Management, that is, Waste Minimisation and Recovery and Alternative Developments. For the dyeing and finishing industry in Mauritius, the EMF is also a step towards modernisation in terms of improving efficiency and productivity, water management, waste management, enhancing health and safety standards, implementing environmental protection, using cleaner and more sophisticated technology as well as involving and motivating employees and management at all levels. Currently, Total Quality Management (TQM) is not applied in dyeing and finishing plants in Mauritius. The EMF can serve as an instrument towards achieving TQM wherever this is appropriate. The impact of the EMF is shown diagramatically in Figure 4.

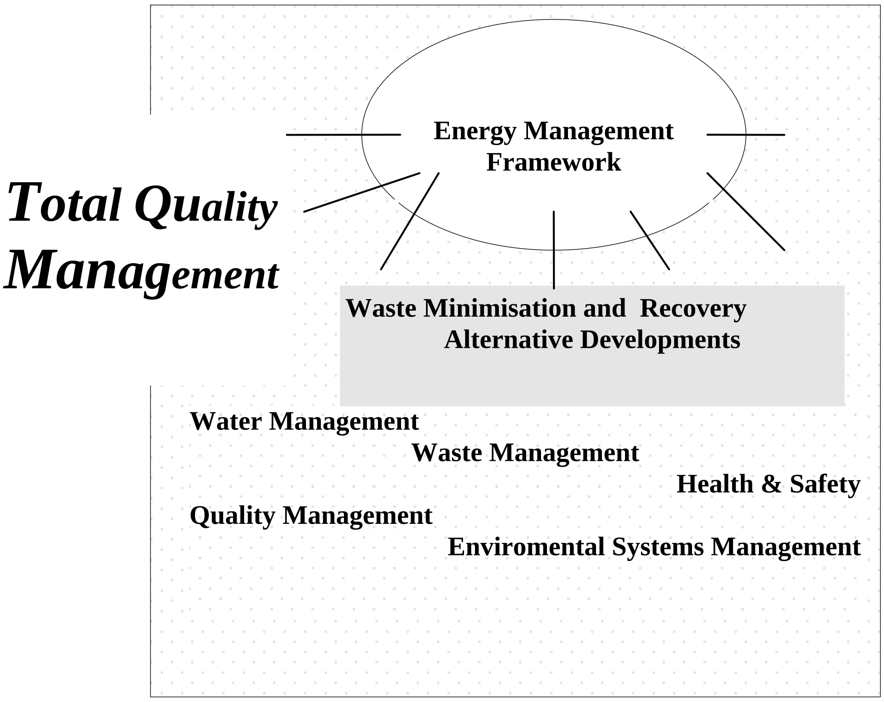

Figure 4. Impact of EMF

3. Recommendations for The Floreal Group Specifically

The vision of the company is to make its plant a centre of excellence in dyeing and finishing .

The company commits itself to energy management as a means of attaining modernisation and sustainable energy use in its dyeing and finishing plant.

The following policies are adopted in the context of a new energy management programme:

- An Energy Management Framework is to be set up to implement energy management.
- Low-cost, high payback measures are to be considered in priority during the first year of the energy management programme.
- The implementation of Third Age technology to bring energy savings as well as benefits in terms of productivity, quick response, quality and environment protection is to be promoted as from the second year of the programme. Exceptionally, for these projects pay-back periods of up to 3 years are acceptable.
- A target reduction of 10 % of the fuel consumption within 12 months and a further reduction of 10 % within the next two years should be achieved with all investments paid back within 2 years.
- If coal is utilised, its consumption is first reduced by the above measures and in the second year of the programme, a feasibility study is carried on fuel substitution.
- Research, development and demonstration projects are to be considered as from the second year of the energy management programme.
- Education and training should be a permanent feature of the energy management programme.
- Energy management should serve as a vehicle to facilitate the introduction of Total Quality Management.
- Targets should be reviewed every year.

- Regular reports of the progress of the energy management programme should be made to the employees as well as to the directors.

Details of the energy management programme are shown in Table III.

Table III.Energy management programme for Floreal Group

Time Scale	Main sources of funding	Principal Measures	Costs (discounted[1]) within 10 % accuracy at 1997 prices	Benefits within 5 % accuracy
-12 months				
	Sponsored training	Setting up of energy management framework	Rs 50 000 for Monitoring and Targeting	Overall energy savings of 10 % over the first year
		Reduce flash steam loss	Rs 10 000	
		Reduce boiler loss		Unquantified benefits in terms of water saving, less pollution, improved health and safety, quality enhancement, reduction in process time and productivity gain.
		Reduce steam trap loss and distribution loss	Rs 10 000	
6 months		Re-use of hot waste water and cooling water recovery	Rs 200 000 Rs 100 000	
		(other possibilities: use of economiser, reduce live steam usage, pressure reducers and use of fuel additives)	plus hidden costs such as management time, maintenance and education.	
12 months				
		feasibility studies and audits		
18 months				
		direct gas-fired heating		
24 months		localised waste water heat recovery	Rs 2m	Overall, an extra 10 % energy saving over the second and third years along with improvements in terms of productivity, quality, quick response and environment-friendliness. A step further towards Total Quality
		low liquor ratio technology	Rs 0.5m	
		(other possibilities:further minimise live steam use, automation and control systems and centralised waste water heat recovery)	Rs 2m	
		More direct gas- heating and better control and automation	Rs 2m	
		Solar heating		
		small scale CHP unit R, D & D project		
36 months				

[1] 'discounted' implies that financial incentives are considered

[i] F. Elkami, Towards rational use of energy and...,*OPEC Bulletin*, March 1994,p7.
[ii]USEA energy Efficiency Committee, Getting Down to Business: Foundations of an Energy Efficiecy Strategy,*Strategic Planning for Energy and Environment*, Vol 12, No 1, 1992,p8.
[iii] for example refer to *UNEP Greenhouse Gas Abatement Costing Studies*:Phase Two Report, UNEP Collaborating Centre on Energy and Environment,Risϕ National Laboratory, Denmark,May1994 and to John Baker, Conclusions et recommandations du Xve Congres du CME, *Revue de l' Energie*,February 1993, No. 446,p128 and also to *op cit*, Ref.12, p111.
[iv] Jean-Romain Frisch, L'Energie pour le Monde de Demain, *Revue de l'Energie*, March / April 1994, No. 457, p180.
[v]e.g refer to *Energy Sector Report No. 1*, July 1986, Ministry of Energy.