Thematic Working Group
Energy and Energy Efficiency

Final Report

August 2001

PREFACE

Energy and Energy Efficiency was one of the nine themes assigned for working groups set up by the Mauritius Research Council with a view to defining priority areas for research to enable sustainable national development of Mauritius. The working group comprised of 10 members who were familiar with the theme assigned and came from various organisations including the private sector.

The objective of the working group was to provide policy guidance to the Council on this theme and establish a list of prioritised topics for research. The group met on four occasions and in addition, a number of informal discussions were held among the members. In this report, a review is presented on the current status of the energy sector in Mauritius with emphasis on the imported energy resources. The report also covered both the actual and projected use of local energy resources paying particular attention to renewable resources like bagasse, solar and solid waste, amongst others.

A number of research proposals have been considered and presented on a priority basis, in details and will serve a basis for eventual consideration for funding.

As Chairman of the Working Group, I wish to place on records my appreciation to all members for their input. My thanks also goes to the Prof. S. Bhoojedhur, Chairman; Dr. A Suddhoo, Executive Director; Mr Heeramun, the Coordinator for this project, and the supporting staff of the MRC for their valuable contribution provided to the Group.

Dr. Kassiap Deepchand
Chairman
Energy and Energy Efficiency Working Group
30th of August, 2001.

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LIST OF ABBREVIATIONS.

CEB	*Central Electricity Board*
CSO	*Central Statistics Office*
GEF	*Global Environment Fund*
GWh	*Giga Watt Hour*
JICA	*Japanese International Cooperation Agency*
KWh	*Kilo Watt Hour*
LRT	*Light Rail Train*
MRC	*Mauritius Research Council*
MCCI	*Mauritius Chamber of Commerce and Industry*
MEPZA	*Mauritius Export Processing Zone Association*
MPU	*Ministry of Public Utilities*
MSA	*Mauritius Sugar Authority*
MSIRI	*Mauritius Sugar Industry Research Institute*
MSPA	*Mauritius Sugar Producers Association*
MW	*Mega Watt*
OTEC	*Ocean Thermal Energy Conversion*
TCH	*Tonnes of Cans per Hour*
TOE	*Tonne Oil Equivalent t*
ULP	*Unleaded Petrol*
UNEP	*United Nations Environment Program*
UOM	*University of Mauritius*
V	*Volts*

1. The Relative Importance of Energy in Mauritius.

Energy is an essential ingredient used by man in his diverse daily activities with the view to contributing to his well being. These can include food production and preparation, transportation, communication, and other leisure related activities. From the past century, industrialisation and the invention of numerous electronic gadgets had immensely increased Man's dependence on energy so much so that the availability of energy has become paramount for sustaining human life. In this respect, it becomes vital that energy be available at all times, in sufficient quantity, at an affordable price and in an environment friendly manner.

As the Republic of Mauritius steps into the Third Millennium, it is crucial that energy resources are identified to allow sustainable development. With the on-going globalisation, the international trade of the country will be dictated by international market forces and prices and inputs. Energy can play a strategic role in the economic development of the island.

In the seventies and eighties the emphasis in the energy sector was laid both on the production of import substitution products, which to reduce import of petroleum products and on the exploitation of renewable sources of energy. To-day, with the advent of new international economic order, the energy sector has to think afresh as to its priorities and research agenda.

The development of the Mauritius into a Newly Industrialised Country is reflected in the extent of energy resource used by the country over the last 15 years.

In Mauritius the main sectors of the economy using energy are the agricultural sector (mainly sugarcane production), the transport sector (mainly vehicles), the manufacturing sector, (sugar, textile and tourism), the commercial sector and households. More than 75% of these energy requirements are met through imported petroleum products. The rest comes from locally available resources like hydro and sugar cane bagasse.

2. The Current Status of the Energy Sector.

In year 2000, the imported petroleum products included gasoline, diesel oil, fuel oil, LPG and coal. The import bill was around Rs 6.1 billion in 2000 compared to Rs 3.8 billion in 1999 and represented 11% of total imports for 2000.

2.1 IMPORTED ENERGY RESOURCES.

Table 1: Import of Energy Sources (1999 – 2000).

Energy source	Physical Unit 1000's Tonnes		Energy Unit (1000's ktoe)		C.I.F. Value (Rs. Million)	
	1999	2000	1999	2000	1999	2000
Gasolene	92.74	89.82	100.16	97.01	475.2	744.3
Diesel Oil	295.55	339.67	298.51	343.07	1,114.0	2,166.7
Dual Purpose Kerosene	231.88	217.37	241.15	226.06	998.5	1,555.4
Kerosene	44.18	27.35	45.95	28.44	178.5	205.8
Aviation Fuel	187.70	190.01	195.20	197.62	820.0	1,349.5
Fuel Oil	246.28	218.76	236.43	210.01	717.7	964.3
LPG	43.57	47.31	47.06	51.10	378.2	510.1
Coal	128.87	222.42	79.90	137.90	112.1	195.0
Total Imports	-	-	**1003.20**	**1065.15**	**3795.71**	**6135.80**

Source: Central Statistic Office

Gasoline:

Some 90,000 tonnes were imported in 2000 that is about twice more than a decade ago to cater mainly for the needs of the land transportation sector. The vehicle population in the corresponding period has also roughly doubled - there are above 90,000 petrol-driven motor vehicles registered to date. The lead content of gasoline is at 0.4 g/l and the introduction of unleaded petrol (ULP) is long awaited. The use of additives is possible to limit environmental damage and increase energy efficiency.

Diesel Oil:

About 340,000 tonnes were imported in 2000, out of which 160,000 tonnes were re-exported as bunkers. The heavy transportation industry with a registered vehicle population of about 30,000 consumed 160,000 tonnes. Industries

required 41,000 tonnes and CEB, 3500 tonnes. Diesel sulphur content will be reduced to 0.2% as from this year.

Kerosene:

Three quarters of the 217,000 tonnes imported in 2000 were used as aviation fuel, the remainder being consumed by the CEB gas turbine in Nicolay and in homes for cooking purposes (subsidised as being "the fuel of the poor").

LPG:

About 47,000 tonnes were imported in 2000 compared to virtually none a decade ago. For safety reasons, it is being promoted to replace kerosene in tonnes as "the new fuel of the poor". Of this amount, 41,000 tonnes were used for residential purposes, 4000 tonnes for the manufacturing sector and 4000 tonnes for the hotels and commercial purposes.

Fuel Oil:

Most of the 220,000 tonnes imported in 2000 was used by the CEB engines (194,000 tonnes) for power generation, although an increasing demand is coming from industry (50,000 tonnes) for it to substitute diesel oil, as it is cheaper. The pollution problems associated with fuel oil should be a matter of concern.

Coal:

Since the nineties the promotion of coal-bagasse power generation has led to an increase in the import of coal - more emphatically when the sugar cane crop suffers from drought or cyclone. In 1999, 130,000 tonnes of coal were imported with only a low share for consumption in industry. This consumption has increased to 222,000 tonnes with the implementation of a new 70 MW firm power plant (coal and bagasse) in the year 2000.

2.2 LOCAL ENERGY RESOURCES.

The major locally available energy resources exploited so far have been hydro, sugar cane bagasse, solar for water heating and woody biomass. The installed capacity for hydro is 60 MW and around 100 GWh of electricity are produced in a normal rainfall year. Major hydro power has been tapped although the availability of this is resource may decrease due to one of its main water supply being diverted to the north of the island for irrigation purposes. There is nevertheless some potential for mini-hydro projects but this will require Government's intervention. Table 2 shows the local production of energy for years 1999 and 2000. 53.3 % of the locally produced energy still generated using diesel and fuel oil. However, the share for both coal and bagasse seem to have increase in 2000.

Table 2: Local Energy Production of Energy (1999 – 2000).

Source of Energy	1999		2000	
	GWh	%	GWh	%
Hydro	29.57	2.1	95.26	6.6
Gas Turbine (Kerosene)	136.64	9.5	42.77	2.7
Diesel and Fuel Oil	930.77	64.6	845.3	53.3
Coal	155.2	10.8	322.72	20.4
Bagasse	188.53	13.1	278.45	17.6
Total	**1,440.71**	**100**	**1584.5**	**100**

Source: CSO

Indeed with respect to sugar cane bagasse, significant development has taken place over the past 10 years or so following clearly defined Government policy on its use for electricity generation for export to the public grid. This was dictated by the crises in the Gulf Area in the years 1971 and 1990 and as a result of Government's strategy to diversify the country's energy base. The installed capacity of power plants in the cane sugar industry rose from around 40 MW in 1995 to around 220 MW in the year 2000. The electricity export to the grid thus increased from around 125 GWh to 600 GWh within that period and is expected to reach around 800 GWh in the year 2001. Of this amount, 360 GWh will be derived from bagasse. Out of the 10 power plants currently in operation, 2 are operating at pressure of 45 bars and one at 82 bars. These units are categorised as firm power plants and operate year round using coal as the complementary fuel. The other 7 plants which use only bagasse are located at factories with low TCH operate at around 25-31 bars and export electricity to the grid during crop time. Their efficiency is low.

However with the closure of some of the mills in favour of units with higher cane crushing capacities through centralisation, there is additional potential for energy export to the public grid. If such projects are implemented, a total of 660 GWh from bagasse and an additional 1,200 GWh from coal can thus potentially be exported from the sugar industry located power plants. In addition, sugar factories should adopt energy conservation and efficiency measures to reduce their process steam consumption from the current 450 kg per tonne cane to around 300 kg already achieved in the beet sugar industry. These measures would imply additional export of electricity to the grid.

It can thus be said that bagasse energy is at par with other commercial energy resources like fuel oil or coal. The recently approved Sugar Sector Strategic Plan lays emphasis on further bagasse energy development to be linked to cane sugar factory centralisation. Moreover, there is additional potential for energy recovery from the other fractions of the cane biomass, that is the green tops and leaves and the dry trash. This constitutes a significant amount of biomass

resource currently unexploited and which can enhance energy generation from the existing bagasse cum coal power plants.

However, it is felt that bagasse energy development will continue to carry a higher priority in Mauritius, as the present emphasis on maximising sucrose production will gradually shift towards the use of the fibrous fractions (bagasse, CTL and trash). Sugar will probably become a co-product of the sugar industry whereas proceeds from co-generated electricity will constitute an important revenue source for today's traditional sugar factories.

Woody Biomass:

In 1990, it was estimated that as much as 4% of the primary energy consumption in Mauritius was from woody biomass, used largely for cooking purposes. In 2000, this figure had dropped to a negligible 0.4%, thus impacting positively on the ecosystem.

2.3 OTHER RENEWABLE ENERGY RESOURCES.

The relative importance and success of other renewable resources have been limited to some research (for example, on wind energy, biogas, photovoltaic system) and have generally not been accepted commercially. Almost similar results have been registered in a number of countries as well. Those technologies are generally costly and unreliable unless they are backed by a stand-by system and associated with poor public acceptance.

Solar Energy:

It has been reported that only 4% of households are equipped with solar water heaters although the technology is proven to be commercially viable and benefited from Government incentives.

Molasses:

The production of ethanol from molasses as a substitute for gasoline in automobile engines and as an alternative to kerosene should be a matter of future research. This will be a subject to be addressed extensively in the Co-Product Development Programme proposed in the Sugar Sector Strategic Plan.

Bio-diesel:

This is derived from bagasse with the possibility of use in the transportation industry as in Brazil, for example.

Plant Oils:

Coconut oil, for example, from Agalega, can be mixed with diesel in view of optimising the use of a renewable energy resource with the possible bonus of reducing gaseous emissions. More trials are needed to confirm the feasibility of the use of coconut oil.

Solid Waste:

Currently about 800 tonnes of solid waste are produced daily and this may constitute a significant energy source. However, integrated environmental impact assessment of incineration/co-generation plants needs to be done.

Wind Energy:

Prevailing wind is an untapped renewable resource, particularly in the islands – Full feasibility studies still have to be carried out for each specific site. High-speed wind from cyclones is a major constraint. CEB is currently carrying out an in-depth evaluation with emphasis on designs, which can be filted down prior to cyclones.

Ocean Thermal Energy Conversion (OTEC):

Due to the geographic location of Mauritius, temperature differences of more than 20 degree C at depths of 600 to 1,000 metres at coastal distances of 3 to 5 km have been recorded. However, the possibility of converting this potential into electricity should be carefully investigated before any large-scale project can be implemented. MRC has initiated some preliminary studies in collaboration with a team of experts from India.

Geothermal Energy:

The volcanic origin of the island and of its surroundings is a fact - there is speculation that geothermal energy can be exploited. Further investigation is required.

Wave Energy:

The possibility should be scrutinised of using the energy due to the wave motion. Trials were carried out in the past at Riambel but the results still need thorough evaluation.

Biogas:

Research on this resource has been completed and small-scale, family size ($1.5m^3/d$ biogas) designed, tested and demonstrated to be technically and financially feasible. However, it has not gained acceptance in the population due to readily available and cleaner fuel in the form of LPG associated with a general improvement in the standard of living of the population. However, this technology can be of value to the remote islands of Mauritius where farming is practised.

2.4 OTHER ENERGY TECHNOLOGIES.

The use of hydrogen, fuel cells and nuclear energy are not considered here – given that there is little likelihood for these resources to be developed and tested locally. Many waste products such as used motor oil and hot wastewater from

dyehouses can be considered effectively as energy resources. However, since their subsequent recovery requires usually a technological input they have not been considered by the working group.

Moreover, Mauritius is a consumer of energy technologies. We need to make "smart" decisions in the choice and use of energy technologies. Technology transfer that will allow fast track identification, adoption and use of modern and efficient energy technologies should be high on our "energy agenda".

Table 3: Energy Consumption in Mauritius by Sector and Type of Fuel (1999–2000).

Sector	ENERGY UNIT			
	1999		2000	
	1000's Ktoe	(%)	1000's Ktoe	(%)
1. Manufacturing	**325.09**	**35.1**	**354.15**	**33.8**
Fuel Oil	43.34	4.7	50.78	4.8
Diesel Oil	32.98	3.6	42.02	4.0
LPG	3.89	04	3.98	0.4
Coal	15.18	1.6	15.17	1.4
Fuel Wood	0.68	0.1	0.57	0.1
Electricity[2] (GWh)	90.87	9.8	100.6	9.6
Bagasse	138.14	14.9	141.03	13.4
2. Transport	**325.96**	**35.2**	**388.93**	**37.1**
Gasolene	96.66	10.4	114.14	10.9
LPG	0.52	0.1	0.68	0.1
Diesel Oil	127.77	13.8	161.37	15.4
Aviation Fuel	101.01	10.9	112.40	10.7
3. Residential	**147.00**	**15.9**	**164.94**	**15.7**
Kerosene	9.46	1.0	11.87	1.1
LPG	37.48	4.0	44.05	4.2
Fuel Wood[1]	3.04	0.3	2.87	0.3
Charcoal[1]	0.15	0	0.11	0
Electricity[2] (GWh)	96.87	10.5	106.06	10.1
4. Commercial and Distributive	**78.64**	**8.5**	**86.24**	**8.2**
LPG	4.86	0.5	4.48	0.4
Charcoal[1]	0.22	0	0.22	0
Electricity[2] (GWh)	73.37	7.9	81.54	7.8
5. Agriculture	**78.64**	**8.5**	**86.24**	**8.2**
Diesel Oil[1]	2.32	0.3	2.42	0.2
Electricity[2]	4.94	0.5	5.99	0.6
6. Other and Losses	**42.08**	**4.5**	**46.30**	**4.4**
Total	**926.05**	**100.0**	**1.048.97**	**100.0**

Source: CSO

[1] Estimates [2] Island of Mauritius only

2.5 ENERGY IN THE TRANSPORT SECTOR.

The transport sector is one of the heaviest consumers of energy with its consumption representing 37% of total energy consumption on Mauritius in 2001 and needs to be looked into carefully. The means of transport in the country have evolved over the decades from animal-driven carts, horses and palanquins at the beginning of the colonisation era to the massive use of Japanese and European motor-vehicles today. From the natural, non-polluting, but inefficient types used in the earlier days to the non-renewable, highly energetic fossil fuels of our modern times, the transformation of the energy demand and usage in the transport sector has been phenomenal. Today's challenge is to ensure the sustainability of the development of the country by providing everyone with reliable, energy-efficient, environmentally friendly and affordable transport.

2.6 SPECIFIC CONSIDERATIONS.

The energy mix required to attain the above-mentioned challenges should consider the following specificities of Mauritius and Rodrigues.

- Road infrastructure;
- Traffic management, including the incidence of accidents;
- Freight transport to and from the airport/harbour;
- Commuter transport to and from the capital city;
- New vehicle technologies, including alternative modes of transport;
- New fuels, including indigenous derivatives; and
- Links between the airport and major tourist resorts.

2.7 ENERGY AND ENVIRONMENT ASPECTS IN TRANSPORT SECTOR.

The current vehicle population exceeds 250,000 with about half consisting of petrol-using auto-cycles and motorcycles owned mostly by low-and medium income-earners. Only 5% of the vehicle population are made up of heavy-duty vehicles, including buses – all running on diesel. The remaining 45% of the vehicle population consist of petrol-driven motor vehicles.

In Mauritius, about 200,000 tonne-oil equivalent (TOE) of petrol with a lead content of up to 0.4 g/l is imported annually. This compares with the import of more than 100,000 TOE of diesel for transport purposes – the sulphur content attaining as much as 0.5% by weight currently in the diesel. LPG has now been introduced as transportation fuel and a rapid growth of the market is expected provided that incentives are adopted to favour such an evolution. New vehicles are fitted with engine and exhaust management systems so that both energy efficiency and pollution control can be improved. Improved sensitisation and enhancement in repair and maintenance technology can significantly help promote the efficient and clean use of energy in the transport sector. It is clear that the face of the future as far as land transport is concerned in Mauritius will be shaped by the decision to be taken in relation to the introduction of an alternative mode of transport on the Port Louis-Curepipe link.

2.8 PROJECT PROPOSALS FOR TRANSPORT SECTOR.

The following areas pertaining to the use of energy in the transport sector should be the focus of applied research work with particular emphasis on the Mauritian context:

- LPG-driven vehicles in Mauritius and Rodrigues: a comparative study of its performance, impacts on the environment, cost feasibility and penetration on the market;
- The potential of using alternative fuels derived from sugar cane by-products for transportation (e.g. bio-diesel and ethanol);
- The impacts of leaded petrol and high sulphur diesel on the health of the population;
- Investigating the relationship between tailpipe emissions and air quality, including modeling of specific situations like the case of busy streets and risky areas;
- A strategic study toward the gradual introduction of unleaded petrol and low-sulphur diesel;
- The potential of using electric vehicles/light tramway in specific areas (like the city centre, the harbour, Grand Baie, outlying islands and Rodrigues);
- The potential to optimise energy usage in transportation through proper traffic management;
- Energy management in the transportation of freight; and
- The Energy-Environment-Economy-Engineering (or E4) implications of introducing an alternative mode of transport between Port Louis and Curepipe.

3. The Constraints and Challenges Facing the Energy Sector.

With the development of the other sectors of the economy (manufacturing, IT and tourism) coupled with the improvement in quality of life, the demand in energy will follow an increasing trend. The imported petroleum products are also associated with uncertainty of price and supply and will continue to be a burden to the economy. It is therefore imperative that measures are taken to utilise the imported and costly energy in a judicious and efficient manner and concurrently to develop and enhance locally available energy resources. Moreover the use of such energy use will imply more greenhouse gas emission, which is posing threat to world climate through global warming. Hence, increasing emphasis should be laid on energy efficiency and substitution of fossil fuels by renewable resources. A number of projects have been identified bearing in mind the above factors.

The challenges and constraints identified are given below:

3.1 CONSTRAINTS.

(i) Increase in demand in energy linked with further development of the manufacturing sector using automated processes, IT sector, tourism, coupled with improvement in quality of life;

(ii) Price uncertainty and fluctuations;

(iii) Supply uncertainty (Major source of petroleum products is from a high political risk area);

(iv) Legal and regulatory framework (Decoupling of generation/transmission/ distribution.);

(v) Demand in electricity (low base load/high peak hours impact on bagasse energy cogeneration projects);

(vi) Emphasis in the manufacturing sector is more on meeting delivery schedule than on energy efficiency or environmental considerations; and

(vii) Rising international competitiveness putting pressure for a decrease in cost of production.

3.2 STRATEGIES.

In order to use energy in a judicious and efficient manner in a country depending so heavily on imported energy, a number of issues of strategic importance have to be addressed. These include:

(i) Energy management measures;

(ii) Efficiency of utilisation of energy in all sector of the economy;

(iii) Benchmarking/standardisation through exchange of information and networking to establish performance indices;

(iv) Renewable energy optimisation and further development to meet Kyoto Protocol commitments and beyond to even enable carbon trading; and

(v) Carbon emission credit.

It is felt that for a country importing more than 80% of its energy products and relying on an export market which is highly competitive, not enough emphasis is being put on efficiency of utilisation of energy resources. There is considerable room for improvement in energy utilisation in the manufacturing sector through adoption of cogeneration (concurrently providing thermal heat for process and electrical energy for driving motors and for lighting). For example, the current efficiency of utilisation of heavy oil in the generation of electricity is around 40%

and its potential is 75%. Use of coal, diesel oil and kerosene are also characterised by low efficiency in the Mauritian industries and appropriate measures are needed for improvement of efficiency.

The most pressing challenge associated with use of energy resources is the one related to climate change resulting from the emission of green houses gases, more particularly carbon dioxide released though the combustion of fossil fuels. There is thus a need to cut down on use of fossil fuel and promote the use of clean energy. More intense use of renewable energy resources is therefore indicated.

The optimal use of energy is largely dependent upon a comprehensive energy policy backed by appropriate strategic initiatives. Such a policy requires not only baseline information regarding resources, consumption patterns and pricing structure, but also the predicted demand and the various options to satisfy this demand. The strategic initiatives include energy planning, environmental issues and energy conservation measures.

3.3 ENERGY PLANNING.

Effective energy planning is based upon the availability of accurate data related to energy consumption in different sectors as well as upon a reliable forecast of energy demand for the future. Moreover, the appropriateness and relative advantage of available energy sources should be carefully assessed and relevant technical and financial feasibility studies for different energy technologies carried out. Thus, whereas solar energy may not be an attractive proposition for the generation of electricity, except in remote areas, the widespread use of solar heating needs enhanced consideration.

With regard to the generation of electricity on a national scale, a comparative study of the different options should be undertaken. These include fuel oil, coal, hydro, bagasse and nuclear energy mainly; but other possibilities should also be considered especially for smaller units, such as wind energy, solar energy and wave energy.

3.4 ENVIRONMENTAL ISSUES.

Addressing the climate change challenge is one of the priorities of the Third Millennium for the whole world. Mauritius will have to cut down on the import of fossil fuel and to promote the use of clean energy. The need to become "self-sufficient in clean energy around year 2020" as underlined in the National Long-Term Perspective Study in 1997 should be the target of clean energy strategies. The University of Mauritius has been very active, particularly in the eighties, in promoting Energy Studies. Currently, the interest in Energy Studies has been renewed as it is also linked with ecological balance. It is vital that further research to investigate the Energy-Economy-Environment-Engineering (E4) interaction be carried out with particular emphasis in the local context. The involvement of industry and of NGOs should be encouraged in such applied

research endeavours. Particular interest should be given to the case of remote islands, including Rodrigues and Agalega.

Apart from financial issues, the choice of appropriate energy options should also be based upon two major considerations, namely (a) self-reliance and (b) the use of pollution-free sources. Both these considerations favour the optimal utilisation of alternative sources of energy, especially wind and solar.

Rodrigues may prove to be an ideal place to promote pilot projects on wind and solar energy. Thus, the possibility to produce electricity from wind energy to be used for the desalination plant under construction should be considered seriously.

The issue of carbon emission bank/carbon trading should be given proper attention. Mauritian strategy of bagasse energy exploitation as a means to mitigate greenhouse gas emission and sugar cane plant as a CO_2 cleaner should be highlighted.

3.5 CONSERVATION MEASURES.

In the industrial sector, considerable energy savings could be effected in two ways, namely through (a) proper auditing and close monitoring and (b) the introduction of more efficient devices. In some cases, especially in the textile industry, heat recovery is also worth investigating.

Similarly, in the transport sector, the use of certain additives could substantially reduce fuel consumption.

In view of the large amount of energy consumed in the industrial sector in Mauritius, the identification and introduction of appropriate energy conservation measures could result in substantial economic benefits.

Benchmarking and standardisation of energy utilisation in the manufacturing sector similar to the one practised in the sugar sector.

Establishing performance indices in energy generation and utilisation is another commendable initiative, which will be beneficial to all the stakeholders.

4. List of Research Topics that Needs to be Undertaken.

The proposals have been prioritised within three broad themes and have been given an ABC priority rating, A having the highest priority.

4.1 ENERGY PLANNING/POLICY.

Title of Project	Priority
4.1.1 The Energy-Environment-Economy-Engineering (or E^4) implications of introducing an alternative mode of transport between Port Louis and Curepipe.	A
4.1.2 A scientific method of Electricity Costing and tarification.	A
4.1.3 Power Demand Management through a tarification structure.	A
4.1.4 Energy supply and demand analysis with emphasis on the possibilities of fuel substitution.	B
4.1.5 To investigate into the possibility of implementing the use of voltage lower than 240 V in the residential sector.	C

4.2 ENERGY EFFICIENCY.

Title of Project	Priority
4.2.1 Energy efficiency in sugar cane processing.	A
4.2.2 Energy Audits in the Manufacturing sector and the hotels.,	A
4.2.3 Maximisation of co-generation potential in Textile and Process Industry.	A
4.2.4 LPG-driven vehicles in Mauritius and Rodrigues - a comparative study of its performance, impacts on the environment, cost feasibility and penetration on the market.	A
4.2.5 Energy Efficiency & Energy savings in Textile Industry.	A
4.2.6 Enhancing bagasse energy co-generation.	A
4.2.7 Precise Monitoring of energy usage within a process factory.	B
4.2.8 Clean and reliable use of Heavy fuel in small boilers.	B
4.2.9 Survey of appliances used in the household.	C

4.3 ENERGY CONSERVATION/RENEWABLE ENERGY

Title of Project		Priority
4.3.1	The potential of using alternative fuels derived from sugar-cane by-products for transportation (e.g. bio-diesel and ethanol).	A
4.3.2	The feasibility of using solar power, including studies related to Rodrigues and Agalega.	A
4.3.3	The feasibility of using wind power, including studies related to Rodrigues and Agalega.	A
4.3.4	The feasibility of using OTEC power, including studies related to Rodrigues and Agalega.	A
4.3.5	Developing public awareness and requisite capacity in the efficient utilisation of energy resources.	A
4.3.6	Dual-fuel combustion: investigation of possibilities in Mauritius, Rodrigues and the islands.	B
4.3.7	Investigation of the environmental impacts of different energy resources.	B
4.3.8	Investigating the relationship between tailpipe emissions and air quality, including modeling of specific situations like the case of busy streets and risky areas.	B
4.3.9	The feasibility of using wave energy, including studies related to Rodrigues and Agalega.	C

Short write-ups on 23 project proposals identified by the Working Group are attached in Annexure 1.

5. Summary and Recommendations.

Energy is essential to sustain life. It must be available at all times in sufficient quantity and at an affordable price. Major sources of energy world-wide are those derived from fossil fuel. Hydro and biomass are renewable resources. Mauritius is devoid of any fossil fuel and hence 75% of its energy requirements are met through the import of petroleum products derived from fossil fuels and the rest comes from the sugar cane bagasse and hydro.

It was noted that there is room for improvement in the efficiency of utilisation of the various fuel in both generation at power plants and utilisation in the various sectors of the economy – transportation, manufacturing, residential including hotels and commercial. Improvement of energy use in sugar cane processing, adopting energy conservation measures, more extensive use of cogeneration in the textile sector, use of alternative fuel like LPG or ethanol in the transport sector, adoption of an electricity tariff structure to optimise load demand are some of the areas identified to require priority considerations.

Energy generation from bagasse is now a commercial process and will increase over time through centralisation of cane milling activities, which will be tied with bagasse cum coal power plants. Furthermore, more emphasis is required on research and development on renewable energy resources like wind, solar, ethanol from molasses, solid waste and OTEC.

Recommended Readings.

1. Rust, Kennedy and Donkin (1996) Assistance in generation and transmission planning, CEB

2. JICA (1997) Energy study in Mauritius, Ministry of Public Utilities

3. Tractebel (2001) Distribution Study, CEB

4. Deepchand, K. (2001), Bagasse Based Cogeneration in Mauritius – A Model for Eastern and Southern Africa, Occasional Paper No. 2, AFREPEN (African Energy Research Network).

5. Ministry of Agriculture, Food Technology and Natural Resources (2001), Sugar Sector Strategic Plan (2001 – 2005).

ANNEXURE 1:

LIST OF RESEARCH PROPOSALS

Energy Planning/Policy

THE ENERGY- ENVIRONMENT-ECONOMY-ENGINEERING (OR E4) IMPLICATIONS OF INTRODUCING AN ALTERNATIVE MODE OF TRANSPORT BETWEEN PORT LOUIS AND CUREPIPE.

Objectives:

1. To investigate the energy requirements for alternative modes of transport between Port Louis and Curepipe;
2. To compare the environmental impacts associated with energy usage due to the alternative modes; and
3. To perform an integrated E^4 analysis for each of the alternative modes.

Brief Background:

- The need for an alternative mode of mass transport between Port Louis and Curepipe is unanimously agreed upon. The choice is currently between the bus-lane and the LRT.
- Whilst considerations such as overall capital cost, fares and employment have prevailed thus far in the debate over the alternative mode of transport, the use of energy and environmental considerations has been secondary.
- The need for reducing pollution, including CO2 emissions with the additional benefit of cutting down import and reliance of fossil fuel should be considered.
- The use of alternative fuels as transport fuel or of electricity generation for the LRT should be critically analysed.
- This applied research project will focus on the local context and propose ways and means for giving due consideration to E^4 interactions in the selection of an alternative transport mode.

Methodology:

- Analytical investigation on the energy requirements for alternative modes;
- Analytical investigation of engine efficiency and emissions in relation to the alternative modes; and
- Cost benefit analysis for the introduction of alternative mode of transport with particular emphasis on E^4 implications.

Resource requirements:

Financial:	Estimated financial resources of between Rs 0.5 to 1 million.
Manpower:	Research staff: 1 Principal Investigator + 1 Research Assistant.
Equipment:	Computer software.
Institutional support:	Collaboration of the Ministry of Land Transport, the DoE and the University will be essential.
Time Frame:	6 months.
Expected results:	-

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

A SCIENTIFIC METHOD OF ELECTRICITY COSTING AND TARIFICATION.

Objectives:
To develop a systematic method of real costing of energy generated from various sources in a transparent and scientific manner, which will leave little room for unhealthy lobbies eventually penalising all the local consumers.

Brief Background:
Energy decisions, if based on wrong and mistaken assumptions, become burdensome to the population. A pragmatic costing and evaluation of economic implications can help to situate the real merits of various energy options whether these are heavy oil, coal, bagasse, wind, solar or municipal solid wastes.
Shortly after implementation, these issues are very important and their merits should be properly evaluated prior to policy formulation and implementation.

Methodology:
There are rigorous and systematic approaches in evaluating the merits of various energy options. This work will state those methodologies and illustrate them using local known cases and crosscheck figures with statistics available in other countries. It will assess the prevailing and previous pricing situation and determine the implications of such pricing. It will also study the consequences of delayed decisions and their negative impacts on the prosperity of the energy market.

Resource Requirements:

Financial:	Total Research time input - Rs450,000/- One 1-week Bench marking abroad - Rs200,000/-
Manpower:	One Power Engineer, One Economist and one Accountant.
Equipment:	-
Institutional Support:	Collaboration of CEB, Sugar Industry and a of Research Institutions.
Time Frame:	6 months.

Expected Results:
A readily available information structure available publicly to increase transparency in the choice of energy options.

Beneficiaries:
The nation and all consumers

POWER DEMAND MANAGEMENT THROUGH A TARIFICATION STRUCTURE.

Objectives:
To re-assess and determine a realistic and effective tariff structure, which will push in a direction to achieve desired results

Brief Background:
After having been delayed for long, a daytime and nighttime tariff was introduced recently - but it would seem from feedback obtained that this has not generated sufficient interest nor has it given the apparent results.
This is possibly because the proposed tarification has failed to take into account the specific consumption exigencies within major consumer units. This work will start the other way round to address the problem of generating greater incentive to serve the end purpose.

Methodology:
- Study typical load consumption patterns and options available within major;
- electricity consumers;
- Study the typical mix of power generation on the grid;
- Assess the possibilities of shifting demand through the right incentives; and
- which will be beneficial to both the power producers and to the consumers.

Resource Requirements:

Financial:	Research Input	Rs 400,000
	Overseas	Rs 100,000
	Miscellaneous expenses	Rs 60,000
Manpower:	One Main Investigator, One Junior Engineer, and One Economist.	
Equipment:	-	
Institutional Support:	Department of Energy, Mtius Sugar Authority, Central Electricity Board.	
Time frame:	8 Months.	

Expected Results:
A tarification structure which yields desired shift in load demand in order to optimise investment in generation equipment while maintaining industry's production levels.

Beneficiaries:
The Utility and Industry.

ENERGY SUPPLY AND DEMAND ANALYSIS WITH EMPHASIS ON THE POSSIBILITIES OF FUEL SUBSTITUTION.

Objectives:

1. To analyse the different supply and demand scenarios for Mauritius, Rodrigues and the islands;
2. To investigate the possibilities of fuel substitution from an E^4 perspective; and
3. To propose measures in order to modify energy demand and supply trends by the relevant fuel substitution in different sectors.

Brief Background:

- Fuel substitution is part of our short history of energy management in the island.
- It is possible to be pro-active and modify the energy demand and supply trends both in quantity and quality by proper fuel substitution.
- The penetration of a given fuel in the local market suffers from major competitive advantages/disadvantages that can be favoured/offset by the provision of relevant incentives/disincentives.
- This applied research project will focus on the local context and propose ways and means for favouring fuel substitution in line with the long-term energy policy of the country with due consideration to E^4 interactions and the specificities of places like Rodrigues, Agalega and the remote areas of Mauritius.

Methodology

- Critical review of the literature on energy forecasts for Mauritius;
- Assessment of the possibilities of fuel substitution from an E^4 perspective;
- Market survey and cost benefit analysis for the introduction of substitution fuels; and
- Review of energy demand and supply scenarios.

Resource requirements

Financial:	Estimated financial resources of between Rs 0.5 to 1 million.
Manpower:	Research staff: 1 Principal Investigator + 1 Research Assistant.
Equipment:	Computer Softwares.
Institutional Support:	The collaboration of the Ministry of Public Utilities as well as that of international co-operation agencies like JICA and UNEP will be required.
Time Frame:	9 to 12 months
Expected Results:	-

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow..

TO INVESTIGATE INTO THE POSSIBILITY OF IMPLEMENTING THE USE OF VOLTAGE LOWER THAN 240 V IN THE RESIDENTIAL SECTOR.

Objectives:
To reduce energy consumption and hence the energy bill of the households in Mauritius.

Brief Background:
(Principle of 240 v/s 40 V) and potential impact on energy generation.

Methodology:
- To carry out a detailed audit of energy consumed for the various activities within a household;
- To identify activities which can utilise a voltage lower than 240 V and propose exact voltage that can be used for the performance of a single (or a group of) activities; and
- To carry out a technical feasibility as well as a cost benefit analysis for the implementation (or otherwise) of a proposal for a typical household.

Resource Requirements:

Financial: Rs 0.5 million

Manpower: 2 man-months

Equipment: -

Institutional support: UOM with the assistance of CEB/MPU/CSO.

Time Frame: 6 months.

Expected Results:
A proposal for implementation of a voltage lower than 240 V for individual activity within a household.

Beneficiaries:
CEB, end users.

Energy Efficiency

ENERGY EFFICIENCY IN SUGAR CANE PROCESSING.

Objectives:

To improve the energy efficiency in cane juice processing for sugar recovery and to increase the amount of electricity exported to the public grid.

Brief Background:

In processing cane for sugar recovery, sugar is separated from the fibrous of cane in the milling department in the form of a juice. This juice is a dilute solution containing most of the sugar and the impurities. The impurities are separated by precipitation through addition of lime to the hot juice. The resulting clarified juice is then concentrated to syrup containing around 75% solids, making use of steam at low pressure. Sucrose is crystallised by boiling the concentrated syrup under vacuum using vapour bled from the evaporators. The crystal sugar is separated from the mother liquor by centrifugation.

The energy efficiency of the evaporation and boiling process is determined by the amount of low-pressure steam used. In an inefficient sugar factory, this value is 550 kg per tonne cane and factories in Mauritius are in general using 450 kg. On the other hand, beet sugar factories use 300 kg of low pressure steam. There is therefore a potential for efficiency of utilisation of steam in sugar cane processing. The lesser process steam consumption implies a higher export of electricity to the public grid. The potential is an additional 30% export. It can be achieved through adopting six or more effect evaporation with intensive use of bled vapour for juice heating and sugar boiling in vacuum pans.

Methodology:

- To carry out a detailed review of the energy utilisation and conservation measures within the boiling house department of a beet sugar processing plant;
- To identify areas in the boiling house department of the cane sugar factory where similar approach can be implemented bearing in mind differences in reducing sugar content of the two types of juices; and
- To propose a design with appropriate modifications to the cane sugar plant taking into consideration the specificities of Mauritian sugar factories.

Resource Requirements:

Financial:	Rs 0.5 to 1.0 million.
Manpower:	A team of 2 local and 2 foreign consultants comprising of chemical process engineers and sugar technologies with experience in cane sugar and beet sugar processing.
Equipment:	Computer and associated logistics.
Institutional Support:	MSPA/MSIRI/UOM/MSA.
Time frame:	A period of 4 months.

Expected Results:

A detailed proposal for implementation of energy efficiency measures in the boiling house department of a cane sugar factory.

Beneficiaries:

Cane sugar factories in Mauritius more particularly those involved in electricity co-generation for export to the public grid.

ENERGY AUDITS IN THE MANUFACTURING SECTOR AND THE HOTELS.

Objectives:
To identify areas in the manufacturing and tourism sectors where energy efficiency can be improved.

Brief Background:
The Mauritian manufacturing sector includes product categories like textile, agro processing, plastic and steel and associated products. This sector consumes 213,000 TOE or 21% of the total energy consumed. It has been observed that management is more concerned with meeting delivery schedule and energy management carries a low priority. The commercial and services activities (including tourism sector), is estimated to consume 86,000 TOE or 8% of total energy consumed in Mauritius. In this sector as well, energy issues carry a low priority.

Methodology:
- To carry out a survey of all the industries in the manufacturing sector and classify them according to components and processing capacity;
- Similar survey of the hotel sector and group them in terms of room capacity and auxiliary facilities;
- To establish a representative sample of the various types of manufacturing industries and hotels and carry out a detailed audit;
- To take stock of any previous studies and on the basis of the present study, propose areas and measures to improve energy management;
- To propose schedule of implementation and quantity benefits over time; and
- To propose a system for monitoring of implementation.

Resource Requirements:

Financial: Rs 2.5 millions.

Manpower: Local Consultants.

Equipment: -

Institutional support: UOM, CEB, MEPZA, and MCCI.

Time Frame: 9 – 12 months

Expected results:
To have a better indication of energy utilisation and efficiency in the industrial section.

Beneficiaries:
Industrial community at larger, planners.

MAXIMISATION OF CO-GENERATION POTENTIAL IN TEXTILE AND PROCESS INDUSTRY.

Objective:
To propose co-generation possibilities for various process factories which clearly demonstrate the vast possibilities of adopting co-generation to improve the overall efficiency and eco-friendliness through proven technology already being used by world competitors.

Brief Background:
Many local process factories (dye-houses, dairies) have simply ignored the vast potential for savings and efficiency gains through the use of co-generation facilities. The paybacks on such projects are such that these factories could have themselves afforded decent installations to reduce environmental pollution

Methodology:

- This project will review the currently exploited co-generation technologies giving the various combinations and ratings, which can find ready application in the local context;
- It will also deal with feasibility aspects of such installations, and also on the operational, maintenance and reliability issues;
- It will also study the economic impact of such alternatives in the local context; and
- Finally, it will focus on successful cases where such technology has contributed enormously to the prosperity of the clients.

Resource requirements:

Financial:	Total Research time input	Rs. 150,000/-
	One 1-week Bench marking abroad	Rs. 50,000/-
	Miscellaneous Monitoring & sample Equipment	Rs. 100,000/-
Manpower:	One Main Investigator and One Engineer.	
Equipment:	-	
Institutional support:	Collaboration of a factory envisaging the use of co-generation technology.	
Time Frame:	6 months.	

Expected results:
A readily available information structure to guide any factory owner to determine the ideal co-generation system most suitable for his scale of operations.

Beneficiaries:
The many textile and process industry facing the need to cut production costs.

LPG-DRIVEN VEHICLES IN MAURITIUS AND RODRIGUES - A COMPARATIVE STUDY OF ITS PERFORMANCE, IMPACTS ON THE ENVIRONMENT, COST FEASIBILITY AND PENETRATION ON THE MARKET.

Objective:

- To compare the energy-efficiency characteristics of LPG-driven vehicles with petrol- and diesel-driven vehicles;
- To compare the polluting emissions characteristics of LPG-driven vehicles with petrol- and diesel-driven vehicles;
- To compare the cost implications of substituting diesel and petrol by LPG in the transport sector in Mauritius and in Rodrigues; and
- To recommend measures towards the promotion of LPG in the transport sector in Mauritius and in Rodrigues, if technically and financially feasible.

Brief Background:

- The use of LPG is favourable both for attaining higher energy efficiency and for reducing pollution, including CO_2 emissions;
- The penetration of LPG as transport fuel in the local market suffers from major competitive disadvantages that can be offset by the provision of relevant incentives; and
- This applied research project will focus on the local context and propose ways and means for favouring the introduction of LPG in key areas of the transportation industry with due consideration to E^4 interactions.

Methodology:

- Experimental investigation both on test-bench and on road-vehicles in relation to engine efficiency and tail pipe emission; and
- Market survey and cost benefit analysis for the introduction of LPG-driven vehicles.

Resource requirements:

Financial: Estimated financial resources of between Rs 1 to 2 million.

Manpower: Research staff: 1 Principal Investigator + 1 Research Assistant.

Equipment: Gas analysers + dynamometer test bench.

Institutional support: -

Time Frame: 9 to 12 months.

Expected results: -

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

ENERGY EFFICIENCY & ENERGY SAVINGS IN TEXTILE INDUSTRY.

Objectives:
To thoroughly investigate all the pertinent areas in textile industry where energy in the form of electricity, fuel and heat is lost without any attempt to save. This work will give the technical solutions as well as the investment and other implications so that eventual factory owners will have an information base to decide upon investment options

Brief Background:
Most of the local process factories (dye-houses, washhouses, and dairies) are simply wasting enormous amounts of energy without fully having analysed the immense advantages they could have derived. Discerning buyers (Americans, Germans) are now focussing on Energy efficiency and energy savings issues to assess the commitment of manufacturing companies towards environmental protection.
Vast progress has been achieved in the energy recuperation technology (some being used locally), and this work will vulgarise this technology to convince owners to envisage adoption of measures to improve efficiency, save energy and reduce pollution loads.

Methodology:
This project will review the currently prevailing practices and situations, which lead to energy inefficiency and to energy wastages. It will study the comprehensive list of various possibilities of improvement and will highlight the currently available technologies to reduce wastages and the feasibility aspects of each of the alternatives.

Finally, it will focus on successful cases where such technology has contributed enormously to the financial prosperity of the clients.

Resource Requirements:

Financial:	Total Researcher time input - Rs150,000/- One 1-week Bench marking abroad - Rs50,000/- Miscellaneous Monitoring & sample Equipment - Rs75,000/-
Manpower:	One Main Investigator and One Engineer.
Equipment:	-
Institutional support:	Collaboration of a factory currently using recuperation and savings technologies.
Time Frame:	6 months.

Expected Results:
A readily available information structure to guide any factory owner to determine the ideal energy savings system most suitable for his scale of operations.

Beneficiaries:
The many textile and process industry facing the need to cut production costs.

ENHANCING BAGASSE ENERGY CO-GENERATION.

Objectives:
To investigate into the benefits of adapting higher-pressure boiler and turbo alternator in energy export to the public grid.

Brief Background:
The cane delivered to the sugar factories for processing into sugar comprises of two fractions – a juice fraction containing most of the sugars and a fibrous fraction known as bagasse consisting of the original fibre of the cane and around 50% moisture. All the energy requirement of the cane to sugar process is met through the combustion of the bagasse to generate live steam which in turn is used to drive the prime movers of turbo alternators (to generate electricity) and heavy roller mills, the exhaust steam from these two major sources are used for juice heating and evaporation and subsequently sugar boiling in the process of recovery of sugar from the juice.

The live steam pressure was until recently, generally in the range of 20 to 30 bars. With the growing emphasis on co-generation of electricity to the public grid, the pressure of the live steam being adapted has increased up to 82 bars with the result that electrical energy export to the grid has been on the increase. For example, with live steam at 20 bars pressure, the energy export is 20 kWh per tonne of cane and this figure rises to more than 100 kWh/tonne with adoption of a pressure of 82 bars.

Methodology:
- To carry out a survey of existing boilers in use in the Mauritian cane sugar factories.
- To conduct a feasibility of implementing high pressure boilers in replacement of the existing ones bearing in mind sugar factories centralisation programme implying higher cane crushing capacity and relatively higher number of crop duration.

Resource Requirements:

Financial:	0.5 – 1.0 million.
Manpower:	A team of 2 local and 2 foreign consultants including sugar technologist, mechanical engineer, electrical engineer and financial analyst.
Equipment:	Computer & Logistics.
Institutional Support:	MSPA/MSA/MSIRI/UOM/MPU.
Time frame:	6 months.

Expected Results:
A feasibility report which will enable sugar factories to make appropriate investments and Government to facilitate such investments given that boilers and turbo alternators represent more than 40% of the total mill investments and such equipment have a long life (40 years or more).

Beneficiaries:
The cane milling companies and the energy sector of Mauritius.

PRECISE MONITORING OF ENERGY USAGE WITHIN A PROCESS FACTORY.

Objectives:
You can manage only what you measure (Lord Kelvin). This applied research work will focus on the strategy which will enable factory owner to embark an energy usage monitoring programmes at much affordable (RS 300,000) cost than what is presently chargeable (RS 1 Million to RS 1.5 Millions).

Brief Background:
A Measurement program, for monitoring energy usage in a factory is presently quite prohibitive, the costs being broken down as follows: -

Development and use of software:	RS 400,000 – RS 500,000
Use of meters and metering Devices:	RS 400,000
Related Hardwares:	RS 100,000
Installation and supervision:	RS 250,000

Such an amount charge to each client deters factory owners, and as a result there is no effective management of these high cost items within factories. To win this competitive race, it is, however, essential for all our manufacturing units to adopt the measurement culture. This research work will address this particular issue.

Methodology:
- Assess the currently available software and develop a customised package;
- Selection of the most appropriate types of metering devices and hardwares;
- Selection of the most appropriate and convenient methods of fitting and removing the metering device;.
- Determining the most affordable schemes to encourage industry to avail themselves of this indispensable tool and
- Trial of the package in one major textile unit.

Resource Requirements:

Financial:	A software Development customisation	Rs 600,000
	Overseas	Rs 100,000
	Metering Devices	Rs 400,000
	Hardware Installation Kits	Rs 250,000
	Supervision and Installation expenses	Rs 150,000
	TOTAL	Rs1.5 Millions

Manpower: One industrial Engineer and one Software Engineer
Equipment: -
Institutional Support: MRC, One textile factory serving candidate site

Time frame: 9 Months

Expected Results:
A proven and simplified method of monitoring energy costs in industry vendors affordable.

Beneficiaries:
The Whole Industry.

CLEAN AND RELIABLE USE OF HEAVY FUEL OIL IN SMALL BOILERS.

Objective:
To set out a systematic approach for users envisaging the utilisation of heavy fuel to ensure proper design and installation of their fuel system and exhaust chimney to obtain clean, reliable and economic performance.

Brief Background:
Many local process factories (dye-houses, dairies) previously using heavy fuel have been forced to shift to more expensive fuels (diesel, LPG) in an attempt to reduce pollution apparently generated by their factories.
These same factories could have operated on heavy fuel with considerable savings if they had properly designed fuel treatment, fuel burning system and emissions disposal system.
As a result of recent price increases in diesel oil, many factories have reverted back to the use of heavy fuel and in their effort to abate the risk of pollution, they are resorting to the use of new burners, or ineffective fuel additives, etc whist still disregarding the basic precautions and design considerations.

Methodology:
This project will start with the basic design considerations which lead to clean combustion of fuel oil in a combustion chamber, and then give the specific requirements to satisfactorily burn heavy fuel oil of any given viscosity.
After describing relevant features of various sources of heavy oil, and how they are supplied to process industry (along with shortcomings in the supply system), consideration shall be given to the design of a proper fuel treatment installation (water separation by drainage and decantation, centrifugation, appropriate filtration, precise heating, and monitoring of fuel quality at relevant stages.
Finally, it will emphasise the salient features of Combustion process monitoring and chimney design and maintenance, which are most often ignored.

Resource requirements:

Financial:	Total Research time input	Rs 160,000/-
	One 1-week Bench marking abroad	Rs 50,000/-
	Miscellaneous Monitoring & sample Equipment	Rs 300,000/-
Manpower:	One Main Investigator and One Engineer	
Equipment:	-	
Institutional support:	Collaboration of a factory facing the pressure of "causing" pollution.	

Time Frame: 8 months.

Expected results:
A readily available information structure to guide any potential boiler user to choose the appropriate facilities to burn the cheapest fuel without causing any pollution.

Beneficiaries:
The many textile and process industry facing the need to cut production costs.

SURVEY OF APPLIANCES USED IN THE HOUSEHOLD.

Objectives:
To come up with a statistics on household appliances and propose the best mix of appliances for an energy efficient household.

Brief Background:
Energy carriers used in the majority of Mauritian households comprise of electricity (used mainly for lighting and running appliances like TV, radio, microwave ovens) and gas (LPG). The mix of there energy carriers utilised in households depends on the household income. It is thus desirable to establish this mix for the various income groups. The statistics generated will enable one to determine the change in energy consumption pattern with an eventual rise in household income. It will thus help energy planners in working the energy strategy of the country.

Methodology:
- On the basis of household survey statistics available at the Central Statistical Office, to establish a representative sample of households on the basis of income groups;
- To carry out a detailed survey of appliances used in these households, for its various activities – working, lighting and running electrical or gas operated appliances; and
- To come out with typical households specifying income and mix of appliances.

Resource Requirements:

Financial: Rs 0.5 million.

Manpower: One UOM academic + A group of final year students.

Equipment: -

Institutional support: UOM/MRC.

Time Frame: 6 months.

Expected results:
A databank on energy mix in households with different income.

Beneficiaries:
Energy planners and policy makers in developing household energy strategies.

Energy Conservation/Renewable Energy

THE POTENTIAL OF USING ALTERNATIVE FUELS DERIVED FROM SUGAR-CANE BY-PRODUCTS FOR TRANSPORTATION (E.G. BIO-DIESEL AND ETHANOL).

Objective:

- To investigate the processes of producing alternative fuels from sugar-cane by-products;
- To compare the combustion and emission characteristics of alternative fuels in vehicle engines; and
- To recommend measures towards the promotion of alternative fuels derived from sugar-cane by-products in transport sector.

Brief Background:

- The use of alternative fuels derived from sugar-cane by-products is favourable for reducing pollution, including CO2 emissions with the additional benefit of cutting down import and reliance of fossil fuel. The penetration of such alternative fuels as transport fuel in the local market suffers from major technological and competitive disadvantages that can be offset by the provision of relevant incentives.This applied research project will focus on the local context and propose ways and means for favouring the introduction of fuel alternatives derived from sugar-cane by-products in key areas of the transportation industry with due consideration to E^4 interactions.

Methodology:

- Experimental investigation on the conversion of sugar-cane by-products to alternative fuels;
- Experimental investigation both on test-bench and on road-vehicles in relation to engine efficiency and tail pipe emissions; and
- Market survey and cost benefit analysis for the introduction of alternative fuel-driven vehicles. Relevant recommendations to favour such an introduction.

Resource requirements:

Financial:	Estimated financial resources of between Rs 1.5 to 2 million.
Manpower:	Research staff: 1 Principal Investigator + 2 Research Assistants.
Equipment:	Gas analysers + dynamometer test bench as well as experimental set up in lab and in the sugar industry to investigate chemical processes involved.
Institutional support:	Collaboration of the sugar industry, the MSA, the MSIRI and the University will be essential.
Time Frame:	12 to 18 months
Expected results:	-

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The sugar industry by the diversification of its activities;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

THE FEASIBILITY OF USING SOLAR POWER, INCLUDING STUDIES RELATED TO RODRIGUES AND AGALEGA.

Objectives:

- To analyse the different insolarity regimes in Mauritius, Rodrigues and the islands;
- To investigate the possibilities offered by new developments in solar energy technology; and
- To investigate the exploitation of solar energy from an E^4 perspective in specific cases in different sectors in Mauritius, Rodrigues and Agalega and to recommend measures to favour such an exploitation.

Brief Background:

- A lot of information is currently available from diverse sources on the potential of using solar power in Mauritius, Rodrigues and the islands. Several projects have been carried out on a pilot-scale in the past with mixed results. It is essential to review the situation critically and to highlight the real potential of solar-power.
- Fuel substitution is part of our short history of energy management in the island.
- It is possible to be pro-active and modify the energy demand and supply trends both in quantity and quality by proper fuel substitution.
- This applied research project will focus on the local context and propose ways and means for favouring the introduction of solar power in line with the long-term energy policy of the country with due consideration to E^4 interactions and the specificities of places like Rodrigues, Agalega and the remote areas of Mauritius.

Methodology:

- Critical review of the literature the use of solar energy regimes for Mauritius, Agalega and the islands. Review of the recent history of pilot-projects in view of identifying constraints and finding remedial solutions.
- Assessment of the innovations in solar energy technology to respond to local constraints.
- Market survey and cost benefit analysis with recommendations to favour the penetration of solar power for specific cases.
- Possibly, a pilot-project to provide data for applied R&D purposes.

Resource requirements (excluding the pilot project):

Financial:	Estimated financial resources of between Rs 0.5 to 1 million.
Manpower:	Research staff: 1 Principal Investigator + 1 Research Assistant.
Equipment:	Computer Softwares.
Institutional support	The collaboration of the Ministry of Public Utilities as well as that of international co-operation agencies like JICA and UNEP will be required.
Time Frame:	9 to 12 months

Expected results: -

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

THE FEASIBILITY OF USING WIND POWER, INCLUDING STUDIES RELATED TO RODRIGUES AND AGALEGA.

Objectives:

- To analyse the different wind regimes in Mauritius, Rodrigues and the islands;
- To investigate the possibilities offered by new developments in wind energy technology; and
- To investigate the exploitation of wind energy from an E^4 perspective in specific cases in different sectors in Mauritius, Rodrigues and Agalega and to recommend measures to favour such an exploitation.

Brief Background:

- Information is currently available from diverse sources on the potential of using wind power in Mauritius, Rodrigues and the islands. Several projects have been carried out on a pilot-scale in the past with mixed results. It is essential to review the situation critically and to highlight the real potential of wind-power. This applied research project will focus on the local context and propose ways and means for favouring the introduction of wind power in line with the long-term energy policy of the country with due consideration to E^4 interactions and the specificities of places like Rodrigues, Agalega and the remote areas of Mauritius.

Methodology:

- Critical review of the literature on wind energy regimes for Mauritius, Agalega and the islands. Review of the recent history of pilot-projects in view of identifying constraints and finding remedial solutions.
- Assessment of the innovations in wind energy technology to respond to local constraints such as cyclonic winds.
- Market survey and cost benefit analysis with recommendations to favour the penetration of wind power for specific cases.
- Possibly, a pilot-project to provide data for applied R&D purposes.

Resource requirements (excluding the pilot project)

Financial:	Estimated financial resources of between Rs 0.5 to 1 million.
Manpower:	Research staff: 1 Principal Investigator + 1 Research Assistant
Equipment:	Computer Softwares.
Institutional support:	The collaboration of the Ministry of Public Utilities as well as that of international co-operation agencies like JICA and UNEP will be required.
Time Frame:	9 to 12 months
Expected Results:	-

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

THE FEASIBILITY OF USING OTEC POWER, INCLUDING STUDIES RELATED TO RODRIGUES AND AGALEGA.

Objectives:

- To analyse the different potential of using OTEC in Mauritius, Rodrigues and the islands;
- To investigate the possibilities offered by new developments in OTEC technology; and
- To investigate the exploitation of OTEC energy from an E^4 perspective in specific cases in different sectors in Mauritius, Rodrigues and Agalega and to recommend measures to favour such an exploitation.

Brief Background:

This applied research project will focus on the local context and propose ways and means for favouring the introduction of OTEC power in line with the long-term energy policy of the country with due consideration to E^4 interactions and the specificities of places like Rodrigues, Agalega and the remote areas of Mauritius.

Methodology:

- Critical review of the literature on OTEC with particular reference to its relevance for Mauritius, Agalega and the islands. Review of the recent history of pilot-projects in view of identifying constraints and finding remedial solutions.
- Market survey and cost benefit analysis with recommendations to favour the penetration of OTEC for specific cases.
- Possibly, a pilot-project to provide data for applied R&D purposes.

Resource requirements (excluding the pilot project):

Financial:	Estimated financial resources of between Rs 1 to 2 million.
Manpower:	Research staff: 1 Principal Investigator + 1 Research Assistant.
Equipment:	Computer Softwares.
Institutional support:	The collaboration of the Ministry of Public Utilities as well as that of international co-operation agencies like JICA and UNEP will be required.
Time Frame:	9 to 12 months.
Expected results:	-

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

DEVELOPING PUBLIC AWARENESS AND REQUISITE CAPACITY IN THE EFFICIENT UTILISATION OF ENERGY RESOURCES

Objectives:
To develop public awareness on the need to conserve energy in households, use available alternative energy resources and promote capacity building in this sector.

Brief Background:
While available energy is not being utilised optimally, a host of alternative energy resources are ignored, and Mauritians generally stick to utilising conventional energy like petrol, gas and electricity. There is plenty of sunshine and yet the number of houses utilising solar water heaters is very small. Mauritius has a regular wind current and still there are no windmills to tap the wind energy potential. The possibility of developing biogas has been demonstrated successfully, and yet farmers and breeders hardly have biogas digesters to generate alternative energy. In the interim the bills for importing conventional energy are increasing with higher and higher demand. The feasibility and viability of solar heaters and coolers, biogas digesters, wind generators and other non conventional energy resources, need to be reviewed in the light of improved technologies, with a view to popularising and commercialising them. In the process human resource capacity can be enhanced through adapting improved technologies for the market.

Methodology:
Public awareness will be created through seminars and media coverage, including programs on the local radio and television. Financial, fiscal and institutional incentives will be given to potential entrepreneurs who are capable of bringing most of these technologies to the consumers. Major producers of poultry, pork, fish and vegetables will be encouraged to produce biogas by giving them the necessary tools. And the government can set up wind farms on the coastal land and high ground. Foreign partners, who have developed wind farms in Caribbean islands, can be invited to develop this renewable alternative energy resource.

Resource Requirements

Financial:	Rs 100,000/ for developing public awareness through seminars, radio and television presentations. Rs 400,000/ as seed money to select entrepreneurs for marketing available energy technologies on a small scale.
Manpower:	One Main Investigator, One Junior Engineer, and One Economist
Equipment:	-
Institutional Support:	UoM, CEB, Ministry of Public Utilities, GEF.
Time frame:	2 years
Expected Results:	-

Beneficiaries:
- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- Other developing countries by the example we set for them to follow.

DUAL-FUEL COMBUSTION: INVESTIGATION OF POSSIBILITIES IN MAURITIUS, RODRIGUES AND THE ISLANDS.

Objectives:

- To analyse the availability of wastes and by-products for recycling and recovery of energy;
- To investigate the possibilities of dual-fuel combustion in different sectors in Mauritius, Rodrigues and in the islands; and
- To investigate the consequent possibilities of fuel substitution from an E^4 perspective.

Brief Background:

- Wastes and by-products are available in different forms and in large quantities in different sectors. Possibilities exist of dual fuel combustion e.g. coal/bagasse, plant oil/ diesel, solid waste/coal, used oil/diesel, cane-top/bagasse.
- Fuel substitution is possible if the technological barriers are overcome and the use of wastes/by-products is vulgarised.
- This applied research project will focus on the local context and propose ways and means for favouring fuel substitution in line with the long-term energy policy of the country with due consideration to E^4 interactions and the specificities of places like Rodrigues, Agalega and the remote areas of Mauritius.

Methodology:

- Critical review of the literature on the availability and use of wastes/by-products in dual fuel combustion.
- Experimental work on dual fuel combustion, including assessment of proper dosage for efficient combustion and minimal polluting emissions.
- Assessment of the possibilities of fuel substitution from an E^4 perspective.
- Market survey and cost benefit analysis for the introduction of substitution fuels.

Resource requirements:

Financial:	Estimated financial resources of between Rs 1 to 2 million.
Manpower:	Research staff: 1 Principal Investigator + 2 Research Assistants
Equipment:	Experimental burner set-up and combustion analysis equipment.
Institutional support:	The collaboration of the different industries, Ministries and of the University will be required.
Time Frame:	18 to 24 months

Beneficiaries:

Beneficiaries:

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- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

INVESTIGATION OF THE ENVIRONMENTAL IMPACTS OF DIFFERENT ENERGY RESOURCES.

Objectives:

- To analyse the impacts on the local environment, including the population, of the use of different energy resources;
- To analyse the impacts on the global environment of the same; and
- To propose measures in order to modify energy demand and supply trends, including the efficient use of energy, in different sectors in order to minimise impacts on the environment with due consideration to E^4 interactions.

Brief Background:

- Fuel substitution is part of our short history of energy management in the island.
- It is possible to be pro-active and modify the energy demand and supply trends both in quantity and quality by proper fuel substitution.
- The penetration of a given fuel in the local market suffers from major competitive advantages/disadvantages that can be favoured/offset by the provision of relevant incentives/disincentives.
- This applied research project will focus on the local context and propose ways and means for favouring fuel substitution in line with the long-term energy policy of the country with due consideration to E^4 interactions and the specificities of places like Rodrigues, Agalega and the remote areas of Mauritius.

Methodology:

- Critical review of the literature on energy forecasts for Mauritius;
- Assessment of the possibilities of fuel substitution from an E^4 perspective;
- Market survey and cost benefit analysis for the introduction of substitution fuels; and
- Review of energy demand and supply scenarios.

Resource requirements:

Financial:	Estimated financial resources of between Rs 0.5 to 1 million.
Manpower:	Research staff: 1 Principal Investigator + 1 Research Assistant.
Equipment:	Computer Softwares.
Institutional support:	The collaboration of the Ministry of Public Utilities as well as that of international co-operation agencies like JICA and UNEP will be required.
Time Frame:	9 to 12 months.
Expected results:	-

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

INVESTIGATING THE RELATIONSHIP BETWEEN TAILPIPE EMISSIONS AND AIR QUALITY, INCLUDING MODELING OF SPECIFIC SITUATIONS LIKE THE CASE OF BUSY STREETS AND RISKY AREAS.

Objective:

- To correlate the results of two research investigations that have been carried out (1) on the tail pipe emissions from vehicles and (2) on the ambient air quality;
- To perform further tests to verify any correlation observed; and
- To develop analytical models to investigate pollution dispersion scenarios along busy streets and risky areas.

Brief Background:

- Two research projects sponsored by the MRC and by the MSA have provided important data and information on tail-pipe emissions and on ambient air pollution respectively. Correlation of the data and analytical modeling will enable the prediction of pollution dispersion scenarios along busy streets and risky areas.
- This applied research project will focus on the local context and propose ways and means for promoting a clean environment and of avoiding possible catastrophes.

Methodology:

- Analytical investigation of the results of the two studies;
- Experimental investigation both on test-bench and on road-vehicles for tail-pipe emissions as well as ambient air measurements; and
- Mathematical modelling of air pollution scenarios.

Resource requirements:

Financial:	Estimated financial resources of between Rs 1 to 2 million.
Manpower:	Research staff: 1 Principal Investigator + 1 Research Assistant.
Equipment:	Gas analysers, including already available technology such as used by the Air Pollution Monitoring Unit at the University. A software for air pollution modeling will be required.
Institutional support:	Collaboration of the Air Pollution Monitoring Unit, the MSA and the MSIRI together with the UoM.
Time Frame:	12 to 18 months.
Expected results:	-

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.

THE FEASIBILITY OF USING WAVE ENERGY, INCLUDING STUDIES RELATED TO RODRIGUES AND AGALEGA.

Objectives:

- To analyse the different waves in Mauritius, Rodrigues and the islands;
- To investigate the possibilities offered by new developments in wave energy technology; and
- To investigate the exploitation of wave energy from an E^4 perspective in specific cases in different sectors in Mauritius, Rodrigues and Agalega and to recommend measures to favour such an exploitation.

Brief Background:

- A lot of information is currently available from diverse sources on the potential of using wave power in Mauritius, Rodrigues and the islands. It is essential to review the situation critically and to highlight the real potential of wave-power.
- This applied research project will focus on the local context and propose ways and means for favouring the introduction of wave power in line with the long-term energy policy of the country with due consideration to E^4 interactions and the specificities of places like Rodrigues, Agalega and the remote areas of Mauritius.

Methodology:

- Critical review of the literature on wave energy regimes for Mauritius, Agalega and the islands. Review of the recent history of pilot-projects in view of identifying constraints and finding remedial solutions.
- Assessment of the innovations in wave energy technology to respond to local constraints such as cyclonic winds.
- Market survey and cost benefit analysis with recommendations to favour the penetration of wind power for specific cases.
- Possibly, a pilot-project to provide data for applied R&D purposes.

Resource requirements (excluding the pilot project):

Financial:	Estimated financial resources of between Rs 0.5 to 1 million.
Manpower:	Research staff: 1 Principal Investigator + 1 Research Assistant.
Equipment:	Computer Softwares.
Institutional support:	The collaboration of the Ministry of Public Utilities as well as that of international co-operation agencies like JICA and UNEP will be required.
Time Frame:	9 to 12 months.
Expected results:	-

Beneficiaries:

- Government will have vital information for decision-making;
- The Mauritian Economy with possibility of reduced trade deficit and job creation;
- The public, particularly our children, by benefiting from a better environment; and
- Other developing countries by the example we set for them to follow.