THE UNIVERSITY ROLE IN ENERGY STUDIES, MODELLING AND PLANNING POLICY FOR MAURITIUS

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ABSTRACT

The current and projected energy situation in Mauritius, including data on energy sectors, supply, and demand, is presented. The role of the University of Mauritius in energy studies, modelling and planning policy is discussed with respect to identified energy research projects, and the need for a technical resource, the University, to be used by both the government and private sectors in Mauritius.

CURRENT ENERGY PICTURE AND ENERGY SECTOR DEVELOPMENT

With the exception of around 11% of the total energy consumption, which is produced locally by hydro electric power stations and through the use of excess bagasse at the sugar factories, the remaining 89% of primary energy consumed is imported petroleum products ie gasoline, diesel, kerosine, fuel oil and LPG (Baguant and Grimmer). (Excluded from this primary energy consumption is bunkering fuels for ships and aircraft and bagasse utilisation for sugar processing.) Imported petroleum products are in the refined form, since the total consumption is not enough to justify setting up a refinery.

Table 1 gives the estimated current primary energy consumption by fuel types and consuming economic sectors for 1980 (Baguant 1982a). Wood and charcoal consumption in the residential sector has not been considered, due to the difficulty of obtaining good data. But, as much as 40% of families may use wood and charcoal for domestic purposes representing approximately 1786 x 10^9 Btu/yr. If families switched from wood and charcoal use to electricity and fossil fuels for cooking, the increase of fossil fuel importation could be sizeable.

Programmes for developing locally available alternative energy sources have already been initiated. The alternative energy sources, which could have a significant impact on the energy balance of Mauritius in the short term are hydro power and electricity from excess sugar cane bagasse.

In addition to existing hydro power stations (23 MW installed capacity producing an average of 70 GWH of electricity per year), a 30 MW hydro station (Champagne Project) has recently been completed and is expected to produce up to 40 GWH of electricity annually. Thus, the average annual hydroelectricity production is expected to reach 110 GWH representing a fuel oil saving of around 26,000 ton oil equivalent (TOE) computed at 35% thermal conversion efficiency. However, there may yet be difficulties with the availability of water at this new hydro station.

The sugar factories in Mauritius, by making use of excess bagasse and steam, already produce on average 25 GWH of exportable electricity. The fuel oil saving here to the Mauritian Central Electricity Board (C E B) is 6000 TOE.

In the past, bagasse has been viewed as a waste product disposal problem and the bagasse-fired boilers were not designed with high efficiency in mind. It has been shown that, by using steam more efficiently for raw sugar manufacture and by making use of high pressure boilers and condensing turbines as opposed to low pressure boilers and counter pressure turbo alternators, exportable electricity production can be increased 10 fold (Baguant). Such a high pressure steam facility has been installed at the largest of the 21 sugar factories. It is expected in the short term that the total contribution of the sugar industry will be around 80 GWH, representing a fuel oil saving of 19,000 TOE.

FUTURE ENERGY DEMAND AND POTENTIAL ENERGY SECTOR DEVELOPMENT

During the period 1950-80, the total energy consumption in Mauritius, excluding energy in the sugar cane bagasse used by the sugar factories for manufacture of raw sugar, has increased at an average rate of 7-8% per annum. This increase has been in line with increase in GNP (Baguant 1982b).

Based on the results of the analyses of energy/GNP elasticity and assuming that GNP would grow at 3% per annum in real terms, three energy demand levels have been worked out - high, medium and low (Fig. 1). By the year 2010 the energy demand is expected to be in the range 21,000 to 25,000 x 10^9 Btu (518,000 to 622,650 TOE) representing a 2.5 to 3-fold increase compared to the 1980 level of demand.

The completion of the new hydro power and bagasse power stations will almost double the percentage contribution of local, renewable energy resources to the energy needs of Mauritius. However, to further close the gap between energy demand and energy supply from local resources, and to avoid foreign exchange drainage and sustain the economic development process, efforts to develop locally available alternative energy sources must be reinforced.

The biomass, direct solar energy and other alternative energy sources, which could have a significant impact on the energy balance of Mauritius in the short, medium and long term are listed in Figure 2. The energy end uses where those energy sources are already making a substantial input are indicated as are those areas offering potential for further development.

The role of the University of Mauritius as a major research institution in energy sector development, are discussed in the remainder of the paper.

THE UNIVERSITY RESEARCH ROLE

The role of the University of Mauritius in energy research is discussed here in terms of specific University projects.

Energy systems studies

a. The University proposed to establish a programme in energy modelling and policy planning for Mauritius. A computerised energy database and spreadsheet software will be used to create computer models of energy projections. Present university publications on energy sources and demand will be continuously updated.

b. Assessment of the minimum modular-size unit needed to establish a petroleum refinery in Mauritius should be addressed. The infrastructure for a refinery-based chemical industry would be considered in the economic study, whereby the refinery supplies the by-products of gasoline, diesel, and fuel oil production as chemical feedstocks.

c. Within the local context, it is necessary to identify local industries (eg sheet metal tank fabrication) that can construct energy and conservation devices. Also, the availability of imported materials (eg glass, plastic film, insulation) needs to be documented.

Hydroelectricity

In view of difficulties with the availability of water at hydroelectric plants for release of water for power production, it may be both desirable and necessary to construct a pumped hydropower system at certain sites, using the existing upper reservoir, and a new daily storage reservoir below the power generating station. Such a pumped hydropower system makes sense only if cheap baseload is available, provided by improved steam utilisation efficiency at sugar factories and economic bagasse storage for year-round bagasse burning. The University proposes to investigate possible hydroelectric sites (eg Champagne Project) where pumped hydro may be feasible, depending on the lower reservoir size and soil properties.

Bagasse

a. The University proposed to examine whether reduced income from growing high-fibre content cane is offset by the sale of electricity generated by burning bagasse from that cane. (Of course, to give the proper incentives to the sugar factories to generate excess electricity, credit for bagasse-generated electricity at the marginal or replacement cost of C E B electricity would be required. This is another analysis problem).

b. Methods of bagasse storage during intercrop needs examining. These methods might include baling, pelletising and briquetting. Economically viable strategies need to be developed, and to that effect efforts already initiated at the University must be reinforced and maintained.

c. Regarding the use of bagasse as a substitute for fuel oil and/or diesel in the tobacco and tea industries, preliminary investigations have already been initiated at the University (Baguant and Grimmer) and it is proposed to extend this analysis to other industries.

d. The University proposed to examine the use of bagasse in the residential sector. This will include briquetting, pelletisation, carbonisation of bagasse as a substitute for firewood, and the testing of specially designed stoves, in cooperation with the private sector.

e. In addition to buffering baseload electrical power generated from bagasse through energy storage systems (eg pumped hydro), another way that bagasse could be used for peaking is to transform it into another fuel to be burned in rapid start-up and shut-down engines and turbines. Bagasse could be transformed into methanol, or carbonised into micron-sized particles and mixed with fuel oil, and burned in engines. Fuel transformation tends to be prohibitive both economically and energywise, and the University proposed to study this problem.

Woody biomass

In order to make use of the woody biomass resource available it is essential to undertake or maintain the following investigations:

a. Assess the various quantities and qualities of wood that are being used or could be made available for energy purposes.

b. Identify and assess the techniques which are available for using woody biomass as an energy source in the industrial sector.

c. In the domestic sector, an ongoing project on the design of various models of wood/charcoal/bagasse pellet stoves must be reinforced. (See parallel plans under "Bagasse").

d. Based on the resource data findings, an integrated woody biomass strategy for the island needs to be formulated.

e. International developments on uses and conversion processes of woody biomass need to be continually reviewed.

f. Systematic forestry management must be maintained in order to avoid deforestation.

g. Air pollution problems would need to be identified, particularly in urban areas.

Cane Tops and Leaves

a. A project is in progress at the University to increase the economic value of CTL through production of energy and food. The various aspects being investigated are:

- The extraction of leaf protein
- SCP and ethanol production from CTL juice
- Biogas production through anaerobic digestion of the fibrous residue
- Synthesis gas production using pyrolysis
- Electricity production by burning the fibrous residue and raising steam.

Based on results to date, it has been concluded that CTL is an attractive biomass for co-production of energy and food.

b. More detailed investigations of:

- Electricity generation from the fibrous residue

- Ethanol or SCP production from the juice have been planned. Some of the aspects identified for further investigations are:

  - Cheaper means of CTL handling and preparation

  - Storing of the fibrous residue during intercrop through baling, etc. (see parallel plans under "Bagasse").

  - Possibility of making low grade ethanol for cooking purposes as opposed to high grade ethanol for gasohol production.

c. The long term effects of not directly returning CTL to the sugar cane fields as a soil condition, mulch and anti-erosion practice will be examined. The possibility must be examined that the by-product of energy/food processing could be returned to the fields as a sprayed organic emulsion, similar to the way the residues of molasses production are returned to the cane fields.

Molasses

a. Problems with gasohol such as modifications of existing storage and distribution points, overall energy balance of the strategy ratio of ethanol to gasoline mixture for gasohol and long term effect on engines have yet to be properly investigated in the local context. Most important of all the tradeoff between a lower gasoline import bill on the one hand and a reduction in molasses revenue on the other needs careful consideration.

b. The use and economics of 94° G L hydrous alcohol needs to be examined. For example, molasses could be diluted with cane juice (containing 5% fermentables) to achieve 10% beer for fermentation, while conserving fresh water. Anhydrous alcohol will operate in engines with only minor modification, and could power irrigation enginers, as well as vehicular engines.

c. Other alternative uses of molasses and/or ethanol need to be investigated:

  - Ethanol as a cooking fuel, to replace kerosene

  - Yeast production as feed for the livestock industry

  - The various ways of using vinasse, an ethanol production by-product, need to be investigated.

Other agricultural and municipal wastes

a. Given the potential of biogas an energy source, the following work already initiated needs to be reinforced:

  - Improve digester performance through stirring the raw material and controlling its temperature.

  - Improve already designed biogas burners.

  - Demonstrate the fertiliser value of slurry.

- Improve performance of a diesel engine already modified to run on biogas.

- Possibility of cutting down capital investment by using other materials for construction of the digester and gas holder.

b. Currently 15% of Port-Louis municipal expense (as an example) is refuse disposal. It would be worthwhile to examine the conversion of municipal wastes into

- Recoverable recyclable materials
- Combustible fuels

Conversion of municipal wastes into fuels would also reduce the use of petroleum fuels to burn the waste.

Plant oils

Possible plants to provide oil would have to be cyclone resistant or grow in non-cyclone seasons. Such plants would hopefully be suitable for marginally arable land. For example, in the US South-West, the jojoba plant has been found to flourish in extremely harsh climatic conditions, while producing a large quantity of oil. Although suitable for dry, wind blown areas, its resistance to cyclones is unknown.

Solar water heaters

Batch solar water heaters would deliver the most energy for the unit cost. Such heaters have been popular in mild climates with no freezing problems. Mauritius might present an ideal place for their use. Several proposed designs will be studies under CSC funding.

Solar dryers

Additional applications of solar dryers eg drying of tobacco leaves, fish and sald, need to be investigated. Subsequently economic analyses of the various models within the local context need to be carried out.

Solar ponds

a. For an economically viable solar salt gradient pond, the following conditions are desirable:

- cheap salt

- impermeable soil

- soil with low thermal conductivity

- fresh water for surface flushing

- minimal rainfall disturbance

- minimal wind disturbance.

The last two conditions would indicate that solar salt gradient ponds may not be feasible in Mauritius, due to its cyclones. If the thermal gradient is destroyed, the entire pond must be drained, losing the stored heat, and the gradient reinitialised. However, solar salt gradient ponds can be very stable against disturbances. Also, alternative pond designs, such as gel ponds, are a possibility, although very much in an experimental stage.

The University proposes to study solar salt gradient ponds with a small scale (perhaps 10 m^2) solar pond to investigate the problems of wind and rain disturbance and the general problems of salt pond stability.

b. Shallow solar ponds (non-salt-gradient) are also a possibility for batch heaters, particularly in the industrial sector.

Photovoltaic (PV)

a. In order to be ready for any development in PVs in Mauritius, it is essential that the University staff should be familiar with such aspects as the PV modules available on the market, their characteristic efficiency, proper installation techniques, etc. Demonstration units are to be set up at the University to identify and investigate the possible applications of PV's for small irrigation projects, domestic water supply, and solar cooling. Economic analysis and comparative cost of this energy source would have to be taken into account.

b. Rodrigues Island is the best site for PV in Mauritius where small scale PV systems could replace the use of diesel generators. (Use of PV on the island of Mauritius does not make much sense at present. There is an extensive utility grid and since peak demands are in the evening and morning solar PV is not a reasonable match to the load peak.)

The University proposes to study the use of PV systems on Rodrigues, paying careful attention to the water-pumping application, problems with salt-infusion to wells, etc. and the general hydrology of Rodrigues, as well as the more straight forward technical aspects of PV water-pumping systems, eg size of array, type of pumps, economics of delivered water, and integration with existing diesel generating systems.

c. The possibility of setting up a PV module assembly industry in the Export Processing Zone (EPZ) in Mauritius is to be explored. Present PV module construction is quite labour intensive. Inexpensive Mauritian labour could significantly lower costs for modules exported to Australia and African Commonwealth nations. The study will be carried out by the Schools of Industrial Technology and Administration in cooperation with the EPZ Association of the private sector.

Wind energy

a. There is a need to expand wind resource prospecting with a large number of inexpensive anemometer data loggers. Wind resources are quite site-specific. The University propose to use wind data accumulators with the cooperation of the Meteorological Department, to improve the wind data grid for both Mauritius and Rodrigues.

b. The mechanism for collaboration that already exists between the Meteorological Department and the University should be reinforced for the benefit of the wind energy programme development.

c. Underground water pumping and electricity generation for the national grid appear to be an attractive proposition at this stage. However, the effects of underground water removal on ocean salt water infusion needs to be examined carefully.

d. Problems posed by risk of cyclones, corrosion due to high salt content of the atmosphere, especially in the coastal areas, need to be given careful consideration when designing or selecting wind generators. The University proposes to conduct research on these above problems.

Wave energy

Several problems associated with the wave project have been identified:

- Proper siting of the turbines

- Permeability and strength of the reef

- Ecological impacts of the wave-ramp on the reef and coastal areas (salt water infusion)

- The effect of seasonal variation on the electrical output.

Though it is recognised that wave power will most probably not have an impact on the energy balance of Mauritius during this century, continual monitoring and reviewing of development elsewhere must be maintained.

O T E C

At this stage it is proposed that the University, in collaboration with the Meteorological Department collect appropriate data to evaluate the potential of OTEC systems in Mauritius. Future developments elsewhere need to be properly documented and systematically updated. Eventually, such work will be used in feasibility studies at the appropriate time.

Geothermal energy

The possibility of obtaining assistance from international institutions would appear to be the appropriate strategy for completing the technical work necessary before actually getting into the drilling stage. An academic institution such as the University is in a good position to obtain such assistance and to analyse the geothermal energy potential, for the public and private sectors.

Energy conservation

a. Conservation efforts should be complemented and reinforced by the development of a more active and systematic conservation programme. Within such a programme, energy consuming sectors need to be identified where conservation could have significant impact in the immediate and long term.

b. For example, conservation in the transportation sector, which consumes almost 50% of the total primary energy, would have a significant impact on energy savings. One third of the population consumes four-fifths of the fuel, while two thirds consumes one-fifth of it. Approaches to increasing the use of public transport, in particular buses, and away from use of private cars are to be investigated.

c. In the industrial sector, introduction of systematic energy auditing schemes would help to identify the potential for substantial energy savings. Even at the sugar factories, such schemes would help in saving process steam.

d. In the residential sector, introduction of new cooking fuels and stoves will reduce the demand for imported kerosine for cooking. Also, the introduction of new housing design based on possible heating/cooling concepts could increase the comfort factor of housing on Mauritius.

e. Substitution in energy carriers also leads to energy and foreign exchange savings; eg it has been shown that shifting from kerosine to LPG would lead to a decrease in total BTU importation. Policies should therefore be geared towards encouraging such substitution. The University proposes to study these effects, in collaboration with other public and private sector organisations.

f. The University will continue to participate in energy conservation programmes mounting seminars, workshops, and energy conservation campaigns in close collaboration with the private and government sectors. Training courses in energy management could also be conducted at the University to upgrade the skill of policy makers, planners and plant managers.

CONCLUSION

We have examined various energy sources and uses. Figure 2 shows a matrix diagram linking alternative energy sources (including energy conservation) and energy end uses in the Mauritian energy sectors. The dots indicate possible areas of contribution of the various alternative energy/conservation technologies to the identified energy end uses. (Check marks indicate areas where substantial contribution are already being made). It should be noted that in many areas, the total amount of a given energy source cannot provide enough energy for all the end uses identified. In such cases, the use of an energy source will be dictated by the economics of the situation. Also, it is important not to double-count fuel energy inputs to the electrical generation sector and electrical energy inputs into the remaining sectors.

It is only by overall systems analysis of the energy situation, in a comprehensive Energy studies programme, that the proper development and use of Mauritian energy resources can be undertaken. The University of Mauritius, as the leading technical resource on the island, would be the ideal focus for such energy studies conducted in an apolitical atmosphere for the benefit of both private and government sectors.

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TABLE 1: Sectoral Energy Consumption, Mauritius - 1980

Consuming Sector	FUEL TYPES								Total	Per cent
	Gasoline Regular	Gasoline Premium	Diesel	Kerosene	Fuel Oil	LPG	Electricity			
Transportation	119	1516	2481	-	-	-	-		4116	47.4
Residential	-	-	-	877	-	76	447	(131)	1400	16.1
Commercial	-	-	-	-	-	-	225	(66)	225	2.6
Industrial	-	-	-	-	514	-	300	(88)	814	9.4
CEB - Internal Uses	-	-	-	-	-	-	14	(4)	14	0.2
Line and Other Losses	-	-	-	-	-	-	225	(66)	225	2.6
TOTAL CONSUMPTION	119	1516	2481	877	514	76	1211	(355)	6794	78.3
CONVERSION LOSSES - CEB									1892	21.7
TOTAL PRIMARY ENERGY INPUT									8686	100.0

NOTE:

(i) With the exception of figures in ( ) which are in million KWH, all the other figures are in 10^9 BTU.

(ii) The electricity consumed by the individual sectors do not include the portion of energy lost during the electricity generation process. All such conersion losses are indicated separately.

(iii) Percentages are based on the total primary energy consumed.

(iv) The blanks "____" indicate that the fuel type is not consumed directly by the economic sector concerned.

FIGURE 1: Total Energy Demand (1950-2010)

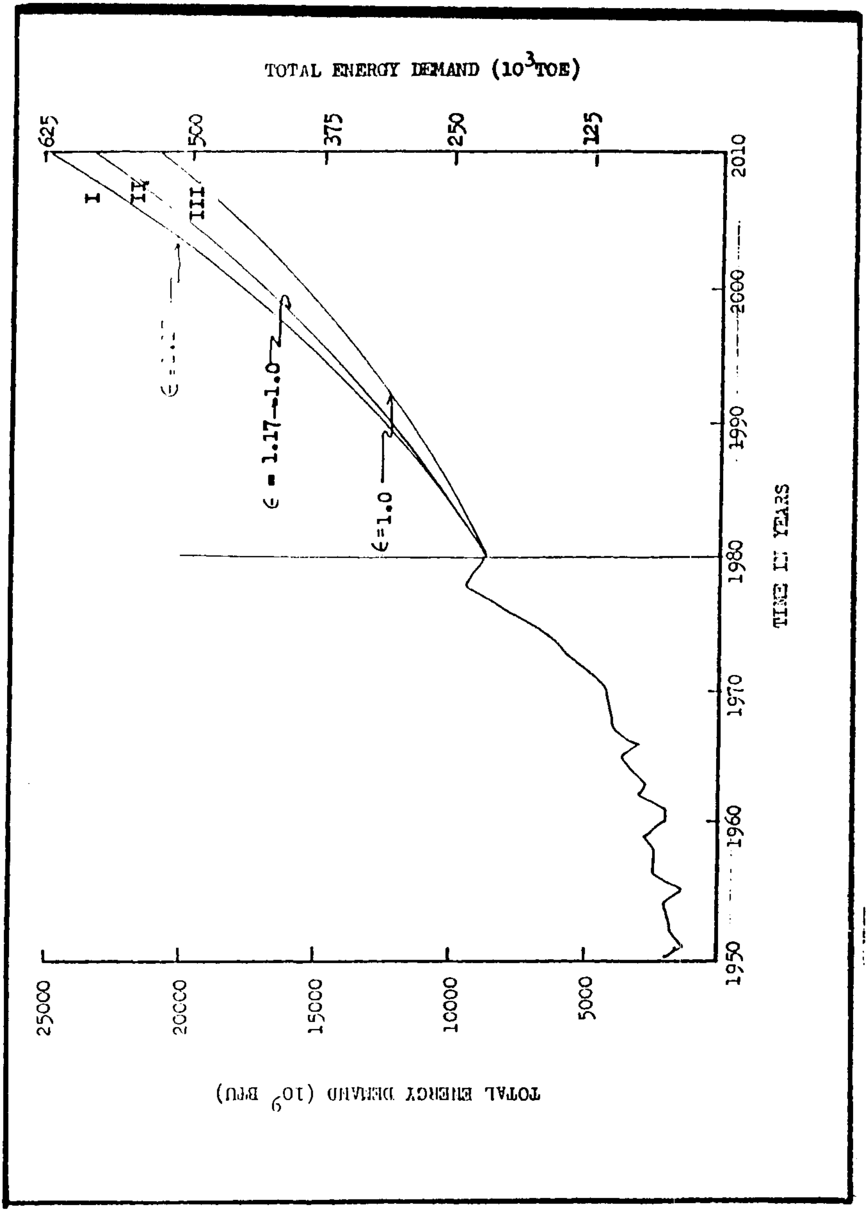

FIGURE 2: Matrix of Energy Sources versus Energy End uses