BERMUDA

REPORT

OF THE

ENERGY CONSERVATION COMMITTEE

NOVEMBER, 1977

GOVERNMENT OF BERMUDA

REPORT OF THE ENERGY CONSERVATION COMMITTEE.

Presented by:

The Hon. Q. L. Edness, J.P., M.P.,
Minister of Works and Agriculture.

November, 1977.

Report of the Energy Conservation Committee.

CONTENTS.

A. PREFACE

On May 10th, 1977, the Cabinet recommended the formation of a special committee to consider all the ramifications of an energy conservation programme. A Committee was set up under the chairmanship of the Director of Public Works, Mr. James Smith, and held its first meeting on May 31st, 1977.

The composition of the Committee follows:

Mr. James Smith, O.B.E., C.Eng., F.I.C.E., F.I.Mun.E., M.I.H.E., Director of Public Works - Chairman
Mr. Erwin P. Adderley, B. Arch., M. Arch., M.A., M.C.I.P., Director of Planning
Mr. G. Fraser Butterworth, Dip.Arch, R.I.B.A., M.I.B.A., President of the Institute of Bermuda Architects
Mr. Stanley A. Oliver, B.Eng., M.P.A., A.A.S.C.E., Director of Transport Control
Mr. Zang Weinacht, B.C.E., M.A.S.C.E., President of The Bermuda Association of Professional Engineers

The following persons were co-opted to serve on the Committee:-

Mr. Edwin S. Mortimer, B.A.(T.C.P.), M.R.T.P.I., A.M.A.I.P., Assistant Director of Planning
Mr. Clifford Rowe, B.Sc.(Eng), C.Eng., M.I.Mech.E., M.I. Chem.E., Immediate Past President Bermuda Association of Professional Engineers.

The Committee reviewed its objectives and agreed on the following terms of reference:

" It is considered desirable to reduce the quantity of imported energy producing fuels into Bermuda and to consider how this objective might best be achieved and to make recommendations accordingly. "

It was decided that since the terms of reference involved several interrelated disciplines, sub-committees would be formed to study and report on the following main headings:

I POWER GENERATION
II BUILDING DESIGN
III LAND USE IMPLICATIONS
IV TRANSPORTATION
V EDUCATION
VI TAXATION
VII LEGISLATION

To achieve its objectives, the assistance of the individuals and organizations listed below (in alphabetical order) was requested and freely given. The Committee wishes to acknowledge its indebtedness not only for the information and assistance provided, but for detailed and critical comments offered.

Mr. Kenneth R. Harding, Collector of Customs (Retd.)
Mr. Geoffrey Melotti, Public Cleansing Officer, Public Works Department.
Mr. Richard Rand, United States Consul General.
Mr. E. T. Sayer, O.B.E.
Mr. F. G. Tite, Divisional Manager, Esso Bermuda.
Mr. C. L. (Jimmy) Vallis, Marketing Manager, Shell Company of Bermuda.
Mr. Llewellyn Vorley, Managing Director, Bermuda Electric Light Company Limited.

Members of the following groups assisted in preparing the sections as noted:

The Bermuda Association of Professional Engineers -

I POWER GENERATION

The Institute of Bermuda Architects -

II BUILDING DESIGN

IV TRANSPORTATION

The Committee has had assistance in this study from sources too numerous to mention. This assistance is gratefully acknowledged. Views expressed by others although considered have not necessarily been included and the Committee accepts responsibility for errors, omissions, conclusions and recommendations.

B. INTRODUCTION

From the outset it was recognized that due to Bermuda's limited size, moderate climate, comparatively small population, and tourist-oriented economy, methods of energy conservation and generation techniques that appear to be practical elsewhere may, in fact, be impractical here.

The following study areas have been considered by the Committee:

I. POWER GENERATION

1.1. (a) the existing facility (Bermuda Electric Light Company)

1.1. (b) Liquid Petroleum Gas.

1.2. Solar Energy.

1.3. Wind Energy.

1.4. Tidal Energy.

1.5. Deep Sea Thermal Energy.

1.6. Nuclear Energy.

1.7. Waste heat (Bermuda Electric Light Company)

1.8. Waste heat (refuse disposal)

1.9. Waste heat (other sources)

II. BUILDING DESIGN

(a) Physical Design.

(b) Insulation.

(c) Programmed Air-Conditioning.

III. LAND USE IMPLICATIONS

To examine possible changes in urban forms and settlement patterns which could lead to energy savings in Bermuda.

IV TRANSPORTATION

(a) Sea Transport.

(b) Land Transport.

(i) private cars
(ii) commercial vehicles
(iii) two wheel vehicles
(iv) mass transportation
(v) parking

V EDUCATION

VI TAXATION

(a) the significance of increased duties on fuel oils.

(b) the possibility of applying rebates on importation of materials used for energy conservation.

VII LEGISLATION

ENERGY SURVEY.

The Committee has, with the co-operation of the oil companies, examined the overall figures for oil and gasoline importation which are illustrated on the accompanying pie graphs. A review of fuel consumption statistics reveals the following interesting factors:

(1) Approximately 65% of all petroleum product imports (other than Liquified Petroleum Gas - L.P.G.) is used for the generation of electricity.

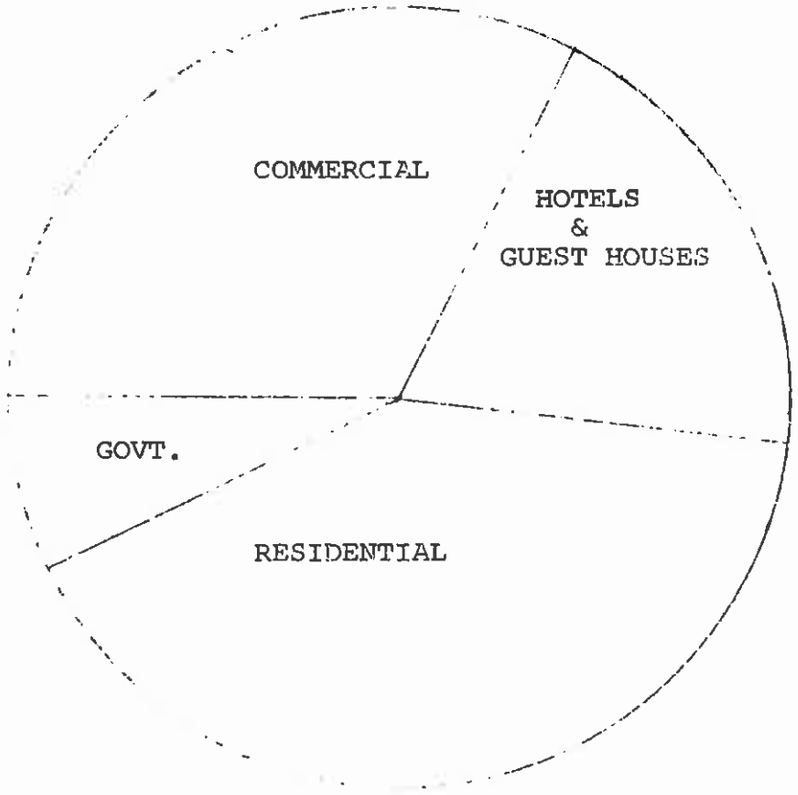
(2) Marine use of fuels amounts to less than 2% of total imports.

(3) The ordinary consumer (e.g. general public) in purchasing gasoline and diesel at retail outlets accounts for less than 15% of total imports.

(4) In addition, if his pro-rata share of electricity consumption (related directly to Bermuda Electric Light Company fuel use) is added to his retail purchases (as in item 3 above) the ordinary consumers impact on total imports amounts to less than 40%.

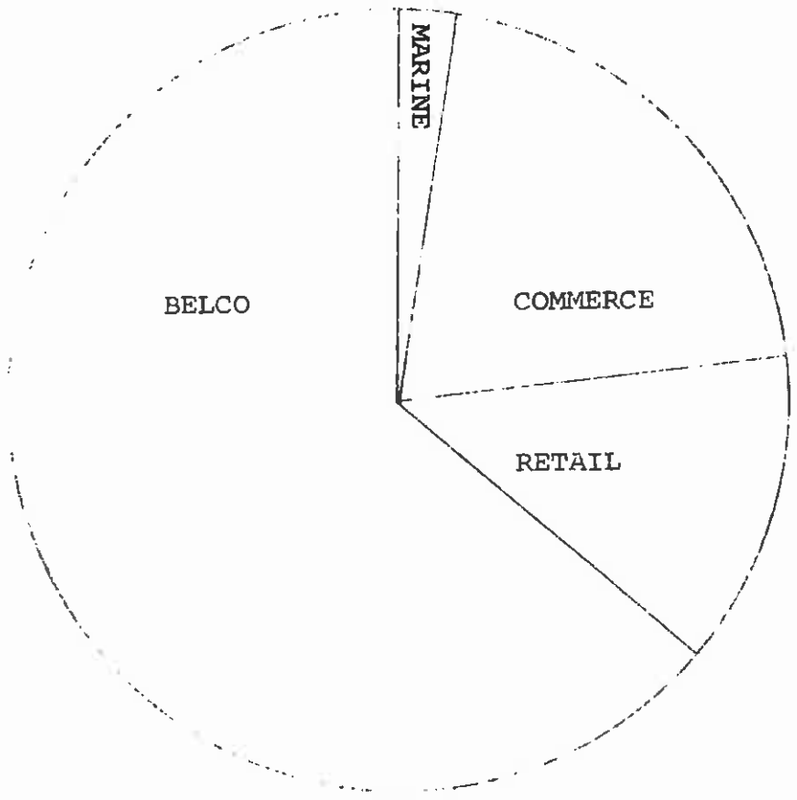
(5) Using the same method of calculation, industry, Government, commercial operations, hotels and guest houses account for approximately 60% of dollar sales.

FIGURE 1.



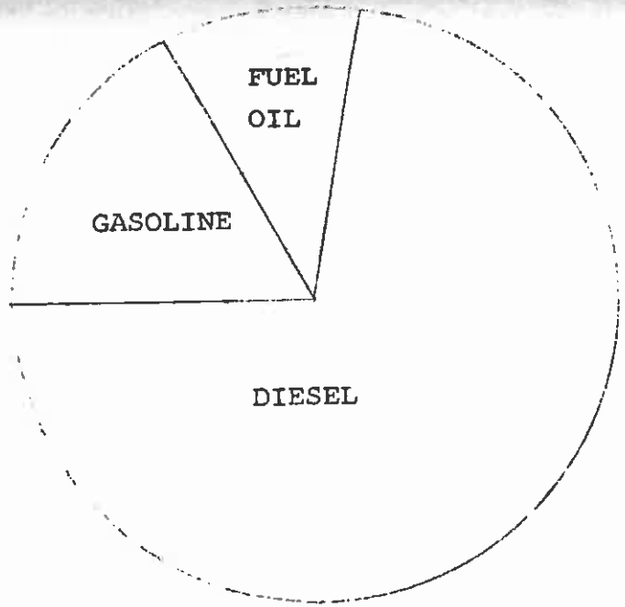
ELECTRICAL DISTRIBUTION BASED ON $ SALES.

FIGURE 2.

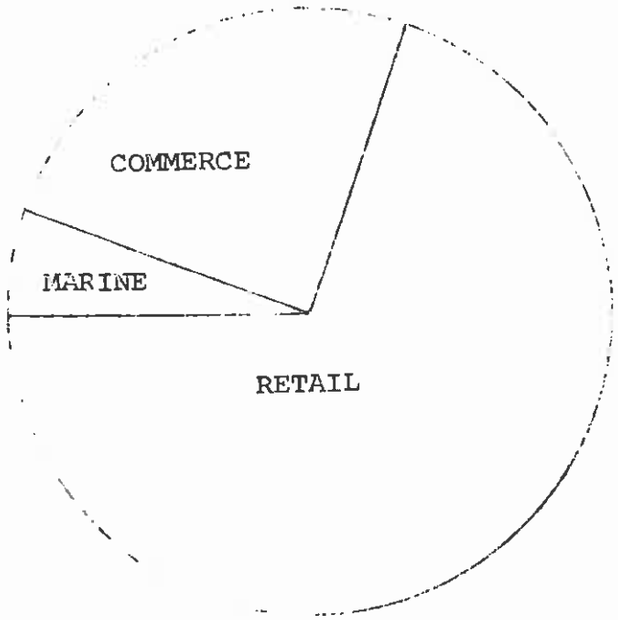


TOTAL OIL AND GASOLINE IMPORT DISTRIBUTION.

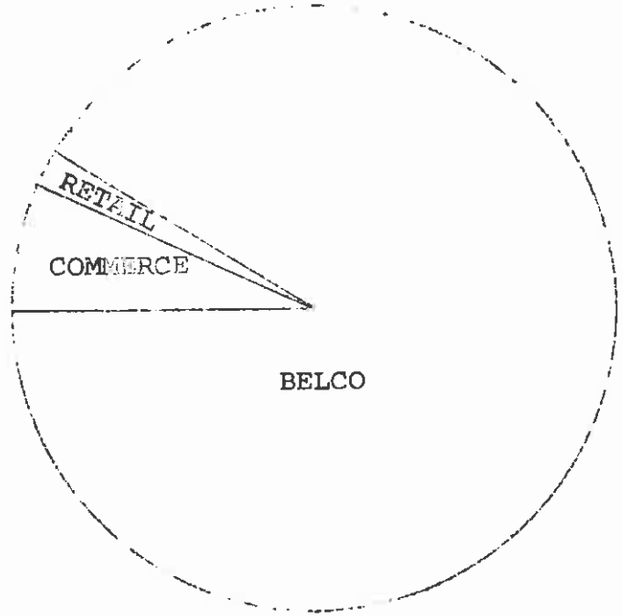
FIGURE 3.



TOTAL PETROLEUM IMPORTS
(Excluding LPG)



GASOLINE DISTRIBUTION.



DIESEL FUEL DISTRIBUTION.

1. POWER GENERATION AND ENERGY SOURCES.

1.1. INTRODUCTION

Much has been said and written about alternative sources of energy. It would appear that, for many years to come, conventional energy sources, e.g., fossil fuels, hydro-electric power and nuclear power will remain the basic means of large-scale power generation. Other methods of providing power for commercial use have not, so far, been proven viable despite considerable scientific research, and as a result cannot be considered for use in Bermuda at present or in the foreseeable future. Unless there is a major scientific breakthrough of some so far impractical source of energy, then the potential use of alternate energy sources is estimated to be a minimum of ten and possibly twenty years away.

Research is vital to the development and commercialisation of alternative sources of energy, not only to reduce the quantity of energy-producing fossil fuels imported, but to utilise other available energy sources efficiently. However, it must be recognised that Bermuda does not have the financial resources nor the technical/scientific facilities available to the major nations and essential to comprehensive research and development programmes. In this context it is significant that Sweden estimates it will have spent some $80 million on intensified energy research and development in the three-year period ending 1977-78; while the U.S. will be spending approximately 2 billion dollars in fiscal 1977 and close to 3 billion dollars in fiscal 1978 on energy research and development. The Committee is of the opinion that Bermuda must await the result of research now being actively undertaken by other Governments before embarking on any alternative energy programme.

1.1. (a) THE EXISTING FACILITY (BERMUDA ELECTRIC LIGHT CO.LTD)

At present Bermuda's major form of commercial energy is electricity. Electric power is generated at a central plant in Pembroke operated by the Bermuda Electric Light Company Limited, and is distributed island-wide through a system that is comparatively problem-free. The value of Plant and equipment costs exceeds $46 million,,(almost $1,000 per head of population) and replacement costs at current market values would, undoubtedly be substantially greater. With the existing system operational and the capital costs expended, it is

logical to look favourably towards the potential of our existing source rather than the numerous and so far unproved, alternatives.

The Bermuda Electric Light Company forecast a maximum annual growth of 5% for the immediate future. This is substantially less than the 9½% experienced prior to 1974. Overall fuel consumption depends upon the mix between diesel and gas turbine generation; the greater the use of the diesel plant the better the efficiency, and the figures quoted for 1976 showed a marked improvement over the years 1973 to 1975. The Company estimate that their efficiency for the years 1977 to 1981 will be slightly better than the year 1976.

From our investigations it is quite clear that the Company are very conscious of the need to develop generating units capable of producing the maximum amount of electricity from a given amount of fuel. In 1972 the Company's consulting engineers made a thorough analysis of all possible alternatives of generating electric power in Bermuda and, as a result, it was concluded that the diesel engine was by far the most viable unit in terms of fuel consumption. Three medium speed diesel generating units were subsequently installed.

The Committee is now advised that the 1972 report is to be updated and the Company have again retained their consulting engineers to study and report on the present stage of development of other forms of energy for power production - particularly insofar as its application to Bermuda is concerned. Not only will they report on renewable forms of energy but also on oil and coal fired steam stations and a nuclear plant. The possibility of completely superseding the existing system is considered highly improbable in the foreseeable future.

1.1. (b) LIQUID PETROLEUM GAS

This source of energy is in general use in Bermuda, the yearly importation approaching 40,000 barrels. It is used mainly for providing heating for domestic and virtually all commercial cooking, space heating, clothes drying etc.

In this role it transforms the original energy bearing raw materials much more efficiently than does electricity as shown in the following table:-

	Generation/ Production Thermal Efficiency		Transportation/ Distribution Thermal Efficiency		Overall Efficiency
Electricity	32.5%	x	86%	=	28%
L.P. Gas	97.%	x	96%	=	93%

However, these figures reflect only the relative efficiencies up to the point of heat emission in the equipment which uses these sources. These results are modified if the efficiency of the using equipment is also taken into account since, in most cases, electrical appliances are more efficient. Taking the appliance into consideration the overall usage efficiencies and the ratios of total energy requirements for electrically heated appliances as compared with gas heated are, for various equipment as follows:-

	Overall Efficiency of supplying Energy to Consumer %		Appliance Energy Utilisation Efficiency %		National Energy Utilisation Efficiency	Ratio of Total Energy Required Elec-Gas
Cooking Range						
Electric	28	x	75	=	21	1.7
Gas	93	x	40	=	37	
Clothes Dryer						
Electric	28	x	65	=	18	3.3
Gas	93	x	65	=	60	
Water Heating						
Electric	28	x	91	=	25	2.4
Gas	93	x	65	=	60	
Space Heating						
Electric	28	x	98	=	27	2.3
Gas	93	x	66	=	61	

*(Source Oak Ridge National Laboratories Report)

Since the efficiencies of conversion from raw materials to both diesel oil and LP Gas are very high, the usage efficiencies given in the above tables can be regarded as applying approximately to the comparative efficiencies of usage within Bermuda of diesel fuel used for power generation as against L.P.Gas.

Although a more efficient source of energy for heating applications the use of L.P. Gas is artificially inhibited by the imposition of import duty a little over 15 times that of diesel oil.

1.1. ALTERNATIVE FORMS OF ENERGY

(c) This section of the report reviews developments elsewhere and comments on their possible use in Bermuda.

1.2. SOLAR ENERGY
1.3. WIND ENERGY
1.4. TIDAL ENERGY
1.5. DEEP SEA THERMAL
1.6. ATOMIC ENERGY
1.7. WASTE HEAT - BELCO
1.8. WASTE HEAT - REFUSE DISPOSAL
1.9. WASTE HEAT - OTHER SOURCES

1.2. SOLAR ENERGY

This form of energy is dilute and intermittent. Three areas must be considered in evaluating solar energy's potential use:

(i) Placing solar collectors on individual houses, hotels and commercial buildings for space heating/cooling and hot water heating.
Solar heating for domestic use has been demonstrated as a practical solution in some areas where the geographical conditions are favourable.

(ii) Constructing solar farms to convert solar energy into electricity using photovoltaic cells.
The key problem in the development of a solar-electric system is the cost of the photovoltaic cells. A cost reduction factor of 100 is required to make the cells competitive. The U.S. Navy, under the sponsorship of Energy Research and Development Administration, is planning to erect a photovoltaic array in Bermuda at Tudor Hill. Construction is planned for the summer of 1978 and the installation will be experimental in nature. At this time there is no indication as to the timing of a conclusive report on the outcome of this undertaking; it will certainly be two or three years hence. The cost of this experimental project is estimated to be $2,000,000 (excluding storage capability). The power output generated at midday will be approximately 60 KW or about one-tenth of 1% of Bermuda's power requirements.

(iii) Building a central station solar collector system to convert the sun's energy to steam and from steam to electricity.
Steam generated by solar energy appears to be the

most practical concept for central solar power stations. Here again the problem is one of cost. High quality equipment must be produced at economically acceptable prices. Demonstration plants are in the planning stages in the U.S., and a plant using this principal is operating in France.

Energy storage is the major problem in considering solar sources and at this stage of development a conventional power generation system must be available as a stand-by to provide the entire power load when called for since adequate storage cannot be technically provided. Large scale, low cost systems for storage of energy generated by solar devices are not available as yet, and there are therefore no savings in capital costs.

Studies carried out in the U.S. indicate that the cost of a generating plant using solar energy will be approximately $2,500 per KW or about five times that of a conventional fossil fuel generating plant. In addition, large land areas will be required to accommodate a massive solar panel installation for commercial use.

Although solar energy is inexhaustible and pollution-free, the cost of the collecting equipment as well as of the storage systems must be reduced very substantially before this source can be considered an economical and practical alternative.

1.3. WIND POWER

Energy available from the wind is enormous and windmills have been used for centuries. However, wind power varies in intensity, with topography, season of the year, time of day. The National Aeronautics and Space Administration is currently conducting a wind power research programme and results will not be available for some time. A site for erection of National Aeronautics and Space Administration's experimental 2,500 KW windmill has recently been selected. However, the cost of this windmill, with blades 300 feet in diameter, is estimated to be 10 million dollars. Bermuda would need a minimum of 20-30 such units to meet its current power requirements.

A Danish windmill, costing $120,000 to construct, has been in operation for some time. This unit is capable of generating 200 KW or approximately one-third of 1% of Bermuda's energy demand. The structure measures 82' to the hub and has a 75' diameter blade, resulting in an overall height of 120' ±. More than 300 windmills of this dimension operating on a continuous basis would be required to meet Bermuda's demand for electricity.

Energy storage is essential for wind power, as it is for solar power, because of the intermittent nature of winds. The cost and size of wind generators and storage systems must be

reduced very substantially before being considered a reasonable alternative. Furthermore, the effect of a series of wind generator towers scattered over Bermuda's landscape and surrounding waters would most certainly raise objections from conservationists.

It is felt that wind power, if used at all, can only be considered as a supplement to other forms of electric power generation. Utilised in this manner, it could save other fuel usage by feeding current into existing systems when wind conditions permit.

1.4. TIDAL ENERGY.

Bermuda is surrounded by the Atlantic Ocean and ocean tides and waves have potential for power generation. However, tidal differentials of approximately 15 feet as well as a narrow inlet are needed. There are comparatively few sites around the world meeting these requirements and Bermuda's tides do not approach the minimum differential.

Tides and wave action, like the winds, are periodic and consequently supplemental energy storage or another source of electricity for continuity of supply is necessary. Studies conducted at a promising site in the U.S. have shown that construction costs would be tremendous and tidal-generated power would not approach a competitive status with other forms of electric power generation.

It would appear that with present technology, tidal power cannot be considered a practical form of energy generation for Bermuda and in all likelihood will at most make only a minor contribution elsewhere. One installation has been built to date in France and this project has not been economically competitive.

1.5. DEEP SEA THERMAL

Ocean thermal gradient power is considered at present to be impractical. Without elaborating on principles involved, studies have shown that the enormous size of heat exchangers required would be prohibitive in cost. A deep sea thermal plant would have to be anchored to avoid storm damage, would be costly to construct and maintain, and generated power would have to be transmitted to the mainland by cable. It is the view of some engineers that this method will have difficulty progressing beyond the "drawing board" even though the cost of fuel is "zero".

1.6. NUCLEAR ENERGY

The amount of electricity generated by nuclear energy is increasing rapidly. It is estimated that the capacity of nuclear plants will increase tenfold within the next fifteen years. Although nuclear capabilities are encouraging.

many problems remain unsolved. Some problems are technical, others are social and/or political.

There is a widely held view that nuclear plants are unsafe. If strong opposition continues, construction of nuclear facilities elsewhere may be delayed or stopped. At this time, it would be difficult to gauge the public's reaction to the construction of a nuclear energy plant in Bermuda, but we think that it may well be unfavourable.

In addition to possible public opposition and the question of safety, there are some technological problems that remain unsolved. One of the most conspicuous is what to do with the waste from atomic power plants. Some of the most enthusiastic nuclear proponents are not sure of the answer. Burying or dumping waste in the ocean or shooting it into outer space have been suggested, but feasibility or safety have not been proven. However, people in the industry are optimistic that the waste management problem will eventually be solved. It remains to be seen whether the nuclear alternative will be acceptable to Bermuda - politically, socially, environmentally and financially.

WASTE HEAT

In considering the alternatives, it is apparent that further serious investigation is warranted in the utilisation of three limited forms of energy sources available and not at present utilised. In this context, use should be made of the studies already carried out by Belco and others. These forms of energy are:

1.7. Waste heat discharged by the existing power plant's diesel and gas turbine generators;

1.8. Waste heat that may be obtained from processing/incinerating refuse and solid waste;

1.9. Waste heat derived from individual boilers, industrial furnaces, and other heat generating sources at major properties.

1.7. WASTE HEAT - from Electricity Generating Plant.

By far the greatest amount of fuel is used in Bermuda for the generation of electricity by Bermuda Electric Light Company Limited. Taking all factors into consideration, the diesel generator is still the most viable means of converting oil to electricity here. However, approximately 68% of the energy content of the oil is not utilised in this process, the bulk of it carried away in the hot exhaust gases and heat rejected to the cooling water. In fact more heat is rejected from the Bermuda Electric Light Company engines than is used for all of Bermuda's other energy requirements combined.

Unfortunately, substantially higher efficiencies are just not possible in generating equipment appropriate to Bermuda. The gas turbine generator, for instance, is even more inefficient, rejecting 80% of the energy supplied to it. Bermuda Electric Light Company are extremely conscious of these facts and regularly employ consultants in keeping the matter under continual review.

However, the harnessing of this waste heat is another matter and one which, in terms of energy conservation, is deserving of most serious consideration. The problem is to find an economical and practical way of harnessing and putting to work this energy potential which will produce a useful and viable end result. Technically, the task is to collect heat from the exhaust gases before they are discharged to the atmosphere. The most practical way of doing this is to pass these gases through a heat exchanger or boiler in which the heat is transferred to water. The resulting hot water, or more likely, steam will then contain energy in a convenient form for re-use, either to generate power or as a heating medium.

One important obstacle, however, is that the heat exchanger must be sited very close to the engines and it follows that this is also where the hot water or steam will be available. Because it is very costly to convey hot water or steam any appreciable distance, the ideal type of consumer, such as the Hospital or large Hotels is, for practical purposes, out of reach. One alternative is to use the steam to generate electrical power via steam turbines. This possibility has been investigated by B.E.L.Co but found impractical to date. One major problem involves loss of flexibility in the control of power production when using steam turbines whose operation is tied completely to the diesel powered engines.

The other option is to use the hot water or steam for some other process on, or near, the B.E.L.Co. Generating Plant. Bermuda's lack of industry restricts the possibilities available. That most seriously considered was the production of fresh water which although technically feasible has not moved beyond the proposal stage.

Any scheme to use this waste heat will involve a very large capital outlay and, left as a commercial venture, its ultimate fate will be decided by the financial aspects.

1.8. WASTE HEAT - Refuse Disposal

The economically and environmentally sound disposal of refuse, coupled with an energy form produced during the disposal process has, in the past few years, created considerable interest.

Traditionally, the major process that meets the above ideal is direct incineration. Refuse is burnt in an abundant air supply and the resulting hot gases passed through a heat exchanger system to produce steam which can then be put to a variety of uses including electricity generation, heating and cooling systems. High efficiency gas cleaning systems have been in use for a number of years which give levels of chimney emissions well within acceptable standards. Incineration is a complete method of disposal, the only residue being a sterile clinker or ash, clean glass and metals.

In the past few years, considerable progress has been made in the development of processes to produce a refuse derived fuel (RDF).

In these processes, the combustible fraction of the waste (mainly paper and cardboard) is separated and used as a fuel supplement. The loose RDF can be pelletised or briquetted for ease of storage and transportation and can be used in a mix of 15% - 25% with solid fuel-coal and coke, for combustion in conventional solid fuel fired boilers. After extraction of the incombustible and putrescible material still presents a disposal problem.

Mention is made, from time to time, in the news media of Pyrolysis. The theory of Pyrolysis is the slow "cooking" of garbage in a retort in controlled amounts of air or oxygen, and, depending on the process, results in a burnable gas or oil. It has had particular success when used in conjunction with "pure" wastes, i.e., exclusively tyres or exclusively wood, but serious difficulties have been met when the process has been applied to garbage which comprises the whole spectrum of waste matter. The theory has not yet been developed into a reliable and proven process and is unlikely to provide an option for the next 5-10 years.

In general, the evaluation of an energy generating refuse disposal operation would revolve around the following considerations.

(i) Scale: Bermuda produces some 30,000 tons of trade and domestic garbage annually. In the main, such operations as described above, except possibly Pyrolysis, require significantly higher amounts of refuse to justify the likely capital costs.

(ii) Markets: There would seem little point in producing energy in a form that is not readily acceptable in

Bermuda. Consequently, the idea of RDF production would seem to have little or no merit under local circumstances.

(iii) Environment: Any process should satisfy the highest environmental consideration, and the primary objective should be the efficient and complete disposal of garbage with the least possible nuisance. The waste heat operation must always be secondary to the primary objective of efficiently disposing of garbage.

(iv) Levels of Energy Production: Refuse generation rates are seasonal and have peaks and lows, and there are marked fluctuations between the days of the week. If the form of energy produced were not readily storable (e.g.steam) then there may be a conflict between production capabilities and demand. It seems reasonable to assume that a customer for perhaps electricity generated at the disposal site, would expect guarantees as to levels of output, and availability of output between certain hours of the day. There would seem to be an inherent weakness in such a system, on a Bermuda scale at least, in that garbage is not reasonably storable for extended periods of time, steam is not readily storable nor is the end product, electricity.

(v) Economics: The overriding consideration concerning energy production schemes is probably a financial one, and provided the processing cost is reasonable and the level of income reasonable and assured for the long term, then such schemes are viable.

However, there are two points worthy of consideration:-

(a) Energy production schemes are themselves large users of energy.

(b) The results of other methods of disposal can be beneficial to the community and/or the environment, e.g. a marsh that is transformed into a playing field by a landfill operation or the production of compost to enhance barren or substandard areas of land does provide a benefit although not easily converted to dollars. Such improvements do have an intrinsic value, which should be recognised.

(vi) Siting: The siting of a refuse handling plant presents a difficult problem but modern and properly designed installations are not unduly objectionable. It would be naive however to suggest that there would not be any public reaction to a proposal to site such a facility

in any particular locality. It is, of course, obvious that the energy source should be as close to the consumer as possible, except perhaps in the case of electricity generation.

In short it appears that direct incineration with waste heat utilisation holds promise for an energy producing scheme in Bermuda, and that during the next 10 years, pyrolysis might be brought to a stage where it could be considered.

1.9. WASTE HEAT from other sources.

Using waste heat from industrial or other heat producing processes to generate electricity is not a new development. In the 1920's, for example, industry produced 30% of all power generated in the United States by a process known as co-generation. However, cheap energy sources gradually diminished American industry's dependence on waste heat.

"Co-generation" is the term used to define the system where electricity is generated utilizing waste heat and steam from industrial furnances, stacks, gas turbines, diesel engines, and municipal incinerators. Bermuda does not have large industrial complexes capable of generating the volume of waste heat necessary or required to warrant the installation of retro-fit packages (with the possible exception of 1.7 and 1.8 above).

It is quite possible, however, that in the future as co-generation technology develops and minimum size requirements are reduced, application on a small scale may be found here.

Other energy sources, although not at present considered feasible, are briefly mentioned below:

(a) Magneto-Hydrodynamic power. In experimental stages only - joint scientific U.S. - Soviet.

(b) Geothermal Energy - source not available to Bermuda.

(c) Hydro-electric Energy - source not available in Bermuda.

(d) High Voltage submarine power cable from East Coast to Bermuda, tying the Island into a U.S. or Canadian power grid.

(e) Photochemical production of hydrogen using photosynthesis or similar process. Small commercial devices may be available in five to ten years. Large hydrogen-producing facilities possibly available in the years beyond. If developed past theoretical status, the production of fuel utilising water, sunlight and green plants may provide the cheapest energy of all.

(f) Use of timber, agricultural waste and bio-mass products to produce alternative fuel sources, materials generally not available in Bermuda to any significant degree.

1.10 CONCLUSION

There seems to be little likelihood in the immediate future of superseding or replacing the existing generating system and its attendant quality of service with an alternative major commercial system.

Nor can we anticipate restrictions being placed on the use of electrical devices, whether they be the small consumer's hairdryer and dishwasher or a major hotel's Heating/Ventilating and Air Conditioning (HVAC) system. We are, for the present at least, dependent on electricity for the amenities and necessities of life as we know it.

And as we look to the future, neither unbridled optimism nor pessimism need prevail. Advances in technology will continue to be made in many areas of power generation and alternative energy sources. It remains to be seen, however, when and how these developments will find practical, efficient and economical application for Bermuda.

1.11 SUMMARY

It is considered that:

(a) Careful observation be kept on developments by other nations, and in the event of a scientific or economic breakthrough, further consideration be given to implementation within the context of Bermuda's special requirements.

(b) Voluntary energy conservation could at the present time be considered the basis for reduction in fuel import requirements.

(c) Alternative individual energy systems and conservation techniques in a domestic and commercial application could effect savings in fuel consumption.

(d) The Bermuda Electric Light Company should be encouraged to continue its policy of keeping abreast of developments in the use of other forms of energy for power generation and use of waste heat.

II. BUILDING DESIGN.

2.1. INTRODUCTION.

Bermuda's use of energy is a reflection of its economic position relative to the Western nations of the world.

Until recent years the cost of energy sources has been relatively low in comparison to personal income, despite the fact that the prime energy source for the Island was being imported in relatively small quantities (in global terms) at comparatively high cost.

Oil was relatively cheap, as was electricity, and no serious consideration was given to conservation of energy.

The energy source used in buildings in Bermuda is derived almost exclusively from oil; either in its refined form to fire the heaters, boilers and desalination plants of the Island's larger enterprises, or in its converted form as electricity to power lights, heaters, electrical appliances, etc., and air conditioners in hotels, commercial buildings, and virtually all private dwellings.

In the area of construction, several points of design (more accurately, non-design) have evolved in this era which are perpetuated, and are the source of considerable energy use.

For the purposes of this study, building types are divided in this section into domestic and commercial classifications.

2.2. DOMESTIC BUILDINGS: BACKGROUND.

According to the Bermuda Electric Light Company Limited sales figures, 41.5% of the electrical energy produced is sold for domestic consumption in the 18,855 (as of 31st December 1976) housing units in Bermuda.

There are several ways to reduce the amount of energy consumed in the home:

(1) by a change of design philosophy (or the application of one);

(2) by a careful consideration of building techniques and buildings; and

(3) by education of the consumer.

A steady degeneration of traditional considerations has taken place over many years in Bermuda. The larger and older houses, with shaded and screened verandahs and porches, have been discarded for the more "romantic" and economical Bermuda Cottage.

Bermudian architecture in its earliest form ignored the exterior. Windows were small, shaded with top-hung shutters; walls were thick and openings were usually carefully placed by the "rule of thumb" of the sailor, to maximise breezes and prevailing winds. Today, too many houses are designed and constructed with few other considerations than an imposing prospect and huge picture windows and sliding glass doors, to maximise the many views available. Unfortunately, the glass areas are frequently unshaded and if they face south or west, create a heat build-up.

2.3. CONSIDERATIONS

All the considerations discussed below can be applied at the lowest cost to a new building if it is thoughtfully designed. However, as there are only 200-250 new houses created each year, more positive results can be expected from consideration of existing structures:-

(a) By selection of the best aspect and fenestration (windows) to take most advantage of cooling winds and breezes. This is only applicable to new buildings where the choice of a good location can reduce the requirement for air conditioning to a minimum. Design of a new house should take into account the siting of large windows and doors, and the layout of rooms, to encourage through ventilation wherever possible.

(b) It is recommended that more consideration be given by all concerned in the building industry to aspect, shade for windows and doors, and the use of verandahs, and porches.
Under present guidelines a verandah, porch or pergola added to an existing house for shade will immediately increase the floor area. Some relaxation by Government of the rules dictating floor area would encourage, rather than discourage, more shade to cool existing walls and windows.

(c) Excessive sunlight entering the house means undesirable heat build-up. To lessen this, more use should be made of top-hung blinds. If the view from a window is all important, a composite top and side-hung blind could be used to advantage.

(d) It is recommended that owners check the reflective

value of the paint they choose. This information is on the side of most paint cans and colour charts. Light, pastel colours will reflect light and heat from buildings; dark colours absorb heat, and this costs money and energy to remove.

(e) It is recommended that existing air conditioners be checked, properly serviced and maintained. New equipment should be designed and installed by experts, and the heat exchange equipment should be shielded from direct sunlight.

(f) In many homes air conditioners are used unnecessarily to provide an air flow. Often a fan is an acceptable and less energy-consuming substitute. Modern versions of the old ceiling fans are now available and can provide an improved living condition at a fraction of the cost of air conditioning.

(g) Virtually all existing air conditioners have a "fan only" mode and this is rarely used.

(h) Rarely are hot water pipes insulated in a Bermuda home. Usually they are buried in a wall, floor or in the ground itself, resulting in unnecessary heat loss to their surroundings. Insulation of pipes is inexpensive and highly recommended.

(i) Hot water heaters all have thermostats; neglect will result in their becoming inoperative, or they may be set too high. A reduction in water temperature requirement could save cost and energy. A simple time switch would cut off the heater at certain periods of the day.

(j) Many homes in Bermuda now have swimming pools that consume energy. Filter systems controlled by time clocks can cut electrical consumption drastically and cause no functional impairment to the pool. Many pools are heated, usually by oil-fired boilers. Perhaps these should be restricted or taxed and/or solar panels substituted to reduce the requirement for fuel oil.

(k) If every effort is made to turn off lights and unwanted appliances, significant, if not huge, benefits would accrue if only in terms of the amount of energy consumed. Savings in small user items do not rest there. A leaking hot water faucet will cost more than just water. A leak of one drop per second is equivalent to 650 gallons per year; a leak that fills a tea-cup in ten minutes can waste

3,280 gallons per year. Oil was used to pump the water and heat the water in its electrical guise. It will also power the truck that delivers more water - all wasted needlessly.

(l) Thermostats are fitted to almost all air conditioners. They usually work, but are often ignored or used improperly. Large energy savings will result from the raising of the desired temperature by a few degrees in summer and/or properly using the thermostat. Doors and windows must remain closed when the A/C system is operating.

2.4. SUMMARY

All the previous points touch on various aspects of the Bermuda home and use or misuse of electrical energy, i.e. oil. All can be adopted simply and cheaply with benefit to the householder and to the Island's economy.

With the exception of points (a) and (b), all are quite minor items, for with careful use the un-airconditioned Bermuda home is quite frugal in its energy requirements. The climate, solid construction, and the proliferation of shade trees, all contribute to a relatively undemanding house. Only large, unshaded glass areas are the real sources of heat problems.

When a householder elects to aircondition his house or a room, there is a considerably different picture. Although, again, traditional Bermuda construction techniques are basically sound, unwanted solar heat inside a house is an enemy of energy conservation. Before air conditioning is used extensively to control an internal environment attention should be paid to how the unwanted heat arrived inside the fabric of the house.

Heat comes from light, cookers, pipes, heaters and people. It also comes in huge quantities from the sun. In Bermuda's climate unwanted heat converted into a useable form can only practically be used for hot water. For most of the year Bermuda houses in general need cooling, not heating. The unwanted heat penetrates into the internal environment by radiation (particularly through unshaded windows), conduction, convection and air infiltration (which is the greatest problem). Air infiltration through gaps round doors and windows accounts for 20-50% of heat flow. Weatherstripping and caulking for an average U.S. house costs $75 to $100, and will save $25 to $50 per year on electricity bills. Costs in Bermuda for the materials and the electricity are higher, but savings are still available. Air infiltration can also be reduced by dampers in chimneys, draught lobbies between air conditioned and untreated areas.

Insulation is rarely applied in Bermuda, but can reduce heat flow considerably. In the U.S.A. it is mostly used to prevent the heat energy getting out. It is just as valid to prevent it getting in. In a region of the States with mild winters (45^{o} lowest average). and hot summers, an investment in roof insulation can be returned within a year.

A large U.S. manufacturer of insulation material has indicated that hot climate areas can effect considerable savings in electricity consumed for air conditioning homes by roof space insulation.

Roof insulation of air conditioned houses using approved materials is a strong recommendation.

Window insulation plays a part. A single pane of glass passes heat twenty times more quickly than a well-insulated two-pane unit. Conservatively, and again using U.S. sources of information, a double glazed window will certainly pay for itself within ten years. When applied to a new structure, this figure is considerably less.

2.5.COMMERCIAL BUILDINGS : BACKGROUND

An estimate has been made that approximately 20,000 - 25,000 square feet of office space has been created in Bermuda each year for the last five or six years. No figures are available that show the amount of commercial buildings as a total, but all offices, shops and other commercial enterprises, other than hotels and guest houses, use 32.5% of the Island's electrical energy.

Most commercial buildings are air conditioned to maintain required personal comfort conditions, and because of this and their extensive use of artificial illumination, they probably will show the biggest benefit from an energy-saving programme.

Building standards vary more in the commercial world than in the domestic. There are no existing code requirements that require a building to have an insulated roof, double glazing, or other energy-saving construction. Some buildings do have these and other features, but many do not. Higher capital cost is the usual plea by the developer when insulation, double glazing, or solar shielding are proposed. Expressed as a percentage of the total project cost these items are usually very small, but they are the first to go when costs are pared.

2.6.CONSIDERATIONS

Most of the principles discussed in domestic design apply to a commercial building, but with greater emphasis. Heat gain and heat flow should be minimised and not disregarded.

(a) As much electrical energy is consumed by lights, careful use of natural illumination should be encouraged. The "glass box" does have advantages here, but unshielded windows will gain heat and thus increase the cooling load.

(b) To counteract this, a greater emphasis should be made in commercial structures to provide correct sun control at all south and west facing windows. The easiest way to do this is to provide permanent sun shades in front of the glass line. Unfortunately, space on a commercial building usually prevents this happening, as city lots are small. A relaxation of ordinances, to allow sun control shields to project over the building line, could overcome this problem.

(c) As an alternative, double glazing, is recommended to control sun penetration, perhaps in conjunction with Venetian blinds or drapes. Similarly, the properties of LHR glass (light and heat reflecting) could be employed.

(d) Roof insulation is seldom used and its effects in the space below can be significant. A thick, reflective roof with good insulation can cause an effective time lag before the space below becomes heated, perhaps until the end of a normal working day.

(e) Commercial buildings require more energy for cooling than a house. The effect of raising the thermostat settings is thus more beneficial. The building inhabitants are rarely responsible for, and are not consciously aware of, thermostat settings, open windows and doors. Education of the occupants could benefit the community's oil consumption bill considerably. A simple time clock can effect savings, but these are often overlooked or incorrectly set in a commercial premises.

2.7. SUMMARY

Major control equipment manufacturers and computer manufacturers in the U.S.A. have recently developed building climate control systems which, when correctly installed in a well-designed, well-maintained commercial project, can monitor via sensors inside and outside the building the functions of the air-conditioning, and lighting systems of a complex organisation.

Through the use of a central computer, energy consumption in a building can be programmed so that the building's equipment can be used in the most effective and efficient manner to meet demand. Thus a space used twice per day is cooled twice per day, not all day. The equipment is switched on at the correct time, controlled by temperature controls which can sense the outside weather conditions. Systems as sophisticated as this may soon be available, and operational in Bermuda. The costs are an unknown variable at this stage, but the results in the U.S.A. have been significant, and there may be potential savings in the Island's fuel consumption if all large commercial enterprises were to utilise such a system. However, the volume of electrical energy must be of considerable size for these economics to apply.

Hotels and guest houses use 19.5% of the Island's electrical power, and also considerable quantities of fuel oil, (for their heating and desalination requirements). Experiments in reducing the energy costs by employing solar heaters at one of the major hotels are reported by their engineer to be very successful.

The same hotel has employed a system management programme of its own that has shown reductions of over $18,000 per annum in electrical costs, despite increased demand and increased unit costs in the same period.

The Bermuda Electric Light Company has reported that the hotel industry has reacted realistically to the increased unit cost of electricity and efficiency has increased markedly.

As unit costs rise, the commercial and hotel sectors of the Bermuda consumer market will undoubtedly invest in more sophisticated and efficient equipment, so that volume demand for electrical and fuel oil energy may well decline. The anticipated increase in demand has declined from 9.4% per annum before 1974 to an assumed 5% per annum now. It may well be that demand could reduce further, if the complex control systems are employed and the community of Bermuda becomes as energy conscious as the U.S. Government, who are spending millions of dollars per annum on energy research.

III. LAND USE IMPLICATIONS.

3.1. INTRODUCTION

The development of urban forms which will lead to reduction in distance and travel times to work, and the use of individual means of transportation is the objective uppermost in the examination of this study area.

That "traffic is a function of land use" is a well worn planning cliche. In theory, and in practice too, a redesign of urban form based on pedestrian links or mass transit systems of one sort or another can have significant effects on energy consumption as far as modes of transportation are concerned. In many new communities throughout the world this has been a part of the basic design criteria (although usually expressed in terms of trying to reduce travel-to-work time, or traffic congestion and parking problems).

Examples can be found in the Swedish satellite settlement system around Stockholm based on linear transport corridors; the southward expansion of Paris into new suburbs centred on the metro lines; and several of the Mark II new towns of Britain such as Skelmersdale and Cumbernauld, where design is based on pedestrian linkage with high density housing within close proximity of the central business area.

Linear city development has had many proponents, although where the cost of mass transit systems rise (for example Bay Area Rapid Transit System in San Francisco, and the high cost overruns on the newly opened Washington D.C. subway) and there is increasing incentive to use private cars, the disadvantages of linear development become apparent.

In the design of new settlements, regardless of whether the form is nucleated, linear, stellar or gridiron, a basic premise is usually the reduction in travel time, in journey to work and play, in order to reduce congestion, economise on land resources and reduce public and private costs.

3.2. BACKGROUND

Settlement form cannot be separated from modes of transport. In Bermuda the present day settlement pattern is a result of two factors: land ownership (and subdivision) and the use of motor vehicles since 1947. From a fairly concentrated settlement pattern which is discernible from the 6-inch Ordnance Survey map's 1897 edition, the Island's developed areas which prior to the 1940's had been served by pedestrian links, by horse drawn transport, by boat and by train exploded outwards as a result of the new mobility provided by the motor car. Settlement took place on virgin

land, sub-divisions proliferated in the 1950's and 1960's, characterised by the construction of individual houses on medium size (¼ acre) lots. As a result, over 52% of the Island is urbanised, much of it with medium and low density housing estate development. Given the necessary environmental constraints, apart from infill development there are no large areas left for development and the settlement pattern for the future will be therefore heavily dictated by the existing development pattern. There is virtually no opportunity for innovative settlement patterns predicated on transport systems which are not based on the use of private motor vehicles. Even if radically new forms of development were to take place at Dockyard - which is the last major area available for development - the small scale of the area affected and the need to integrate communication systems with the Island's present communications network makes it extremely unlikely that new urban forms would result in significant savings in energy consumption.

3.3.CONSIDERATIONS

What energy savings are possible through planning policies given the existing diffuse settlement pattern? Development Plan policies based on reducing travel time and maximising convenience will effectively help meet the goal of reducing energy consumption. Development Plan 1974 policy seeks to encourage the growth of local service centres in which a concentration of housing, shops and services will occur. The Development Plan 1974 introduced higher densities in and around service centres, lowered the minimum size of building lots and encouraged the development of relatively high density housing. All the service centres are located along a major spine route, capable of service by the public transportation system. The effect should be to prevent the overwhelming dominance of Hamilton as a service centre increasing, and to ensure the provision of an adequate level of services in each locality, thus reducing travel time (and fuel consumption) required for journey to shops, schools and services. This policy is reinforced by policies aimed at curbing the outward expansion of the City of Hamilton and by limits on parking within the City. Apart from the possibility of changes in transport modes brought about as a result of deliberate decisions by Government, there appears to be little potential for additional energy saving through radical new settlement forms - given present economic and environmental constraints. The use of express buses, mini-buses serving outlying estates, and a special school bus system are all possibilities.

Given present environmental constraints and personal preferences, and the scale of Bermuda, the development of multi-storey housing or substantially higher density complexes of housing, shops and offices is unacceptable. Perhaps the nearest Bermuda has come to in such terms is the shopping plazas, and the malls in the City of Hamilton where a concentration of facilities is available and where the pedestrian predominates.

Parking policy is an integral part of Planning policy and is especially important within highly urbanised areas where deliberate decisions about the amount of parking space which is required to be provided and its location have a significant affect on the attractiveness of various modes of transport. Parking policy can be used as a means of energy conservation by discouraging the use of private cars, either by restricting them completely or by limiting the number of parking spaces available or by various policies aimed at discouraging all day parking. In Bermuda the basic parking philosophy has been to cater to the car user by providing peripheral parking around the City of Hamilton for all day parking and to provide space for short term parking in the city centre. In view of the need to encourage more energy economic modes of transport and having regard to improvements which are now being made to the bus service it may well be that further provision of car parking spaces within the City of Hamilton should not be made. This, coupled with planning policies aimed at improving the level of services available in a small number of shopping centres and the provision of ample parking space in these locations would appear likely to result in reductions in car journeys and therefore result in some energy savings. Whether these actual savings would be justified when weighted against lack of convenience, additional costs of running an extended bus service, and other factors remains to be seen.

3.4. CONCLUSIONS

Apart from a refinement of development policies at present in existence, combined with a deliberate decision to curb the use of cars and increase public transportation facilities - and given the need to preserve the essence of Bermuda's built and natural environment - there would appear to be virtually nothing further that can be done from a physical planning point of view to aid savings in energy consumption.

IV. TRANSPORTATION.

4.1. INTRODUCTION

Energy consumed by the motor vehicle forms a significant percentage of Bermuda's total fuel imports, and any savings which can be made in this area must be of consequence. Public or private transportation are everyday involvements by the average citizen and habits in this area become very personalised. To the majority the ownership of a private car is a treasured social asset and one must therefore be very careful when evaluating recommendations for change.

The introduction of the private car into Bermuda in the 1940's, albeit with some restrictions, established a trend which cannot now be reversed. Suggestions that this be done, e.g. the Tressider Report, have been set aside, as have less dramatic proposals such as that suggesting a reduction in the permissible size of cars which can be licensed.

4.2. CONSIDERATIONS

4.2. (a) Sea Transport

One of the largest fleet operators is the Department of Marine and Ports Service. This entire fleet is diesel powered. Any increase in operation and consequent increase in consumption will be a result of:

1. More frequent passengers service.
2. Combination and co-ordination with the land public transportation system providing greater efficiency and increased use of both systems, and
3. Additional freighters or luxury liners having to be manoeuvred into place by tug boats.

Any increases in these areas requiring additional fuel would have as a counterpart additional revenue which may help to offset the expense and presumably savings in fuel consumption by other modes of transport.

It is difficult to expect that even the most dilligent promotion of the ferry service as a mode of transport will have any significant effect on less economical modes of travel and thus the energy savings factor of an increased service would be minimal. In any event expansion of the ferry service is limited by the lack of parking spaces in the vicinity of the ferry stops and the small population of the catchment areas served by this mode of transport.

The Committee is of the opinion that if one is to consider energy savings as the essential criteria, then funds and management effort would be better spent on further improvements to the bus service in preference to the ferry service.

The fleet of craft used in Bermuda primarily for commercial fishing is, in the main, a user of diesel fuel. There appears to be a steady change-over from gasoline to diesel engines even in the privately owned cabin cruisers, and it is felt that this change-over is due to economics. The smaller boats used for sking, racing, and other pleasure purposes are basically premium gasoline users. The amount of fuel consumed by this segment of the community is relatively small and is controlled only by the desire of the user, taking into consideration the prevailing cost.

4.2.(b) Land Transport

(i) Private Car

A close look at the models of vehicles having larger engines shows that some of them have better fuel consumption ratings than others with smaller engines. Consequently, it does not follow that a greater tax on large cars, or even cars with large engines, will have the desired effect of saving fuel.

While it is recognised that a slightly higher speed limit would allow cars to run more efficiently, the Committee cannot endorse this idea because resulting effects would be detrimental to life in Bermuda as we know and enjoy it.

There is a move towards diesel engined private cars. However, in view of Bermuda's restrictions the range of vehicles available is severly limited. Because of stringent environmental standards the diesel engine has not become the automatic choice, and international research is aimed at other alternatives. Naturally, whatever becomes the trend, Bermuda will benefit from these developments.

There is only a slight difference in cost between regular and premium gasoline. A greater variance in price would encourage the public to use only that type of fuel which they require. The use of premium gasoline in an engine designed for regular gasoline is an obvious wastage.

It is very important that the motoring public be made aware of the fuel economies to be derived from having properly maintained engines, as well as being educated not to waste fuel by extravagant driving styles.

Further restricting the number of cars permitted in Bermuda would lead to fuel savings. However, attempts to amend legislation to this end, but for other reasons, have not received support in the past. An alternative, and probably more positive means of effecting fuel economy, would be to encourage by tax concessions, the importation of those models having a superior fuel consumption record, e.g. say better than 35 m.p.g. - 13 km per litre. Such a move would have a significant effect on gasoline consumption once the older car models had completed their useful lives.

It was agreed that car usage by young persons was largely for pleasure rather than need. The possibility of raising the minimum age, to say 21, at which a person can hold a car driver's licence appears at first sight to have considerable merit for reducing fuel consumption. However, we appreciate that there would be real difficulties in any attempt to implement such a proposal.

(ii) Commercial Vehicles.

To achieve a degree of fuel savings in the commercial area the possibility of replacing all petrol engined vehicles by those powered by diesel over a period of time was examined. However, considering the relatively small number of vehicles in this category there is insufficient justification to pursue this line of thought.

(iii) Two-Wheel Vehicles.

Bermuda is fortunate from a fuel economy point of view that a large proportion of the Island's vehicles comprise auxiliary cycles, motor cycles and scooters (19,000 out of 34,000) which are used by residents and tourists alike, and which are extremely economical in their consumption of fuel. Also the small size of the Island and comparatively short journeys required are factors which work together to reduce the Island's overall energy requirements in terms of vehicle fuels.

The encouragement of the use of pedal bicycles, through the provision of cycle paths, using parts of the railway-right-of-way and tribe roads, would seem to have potential for effecting some energy savings as well as being of benefit by providing healthy exercise, and enabling youngsters to learn road safety at an early age.

(iv) Mass Transportation.

The idea of car pooling always appears to be a panacea to achieve greater efficiency of individual vehicle usage. In practice however it is often inconvenient and, unless there were other restrictions, a vehicle not used by a member of a car pool would most likely to be used by someone else in that household.

Excluding any technological advances made in the future, it is felt that more people must be attracted to the existing public transportation system in order to save fuel. Ideas recommended to promote this mode of transport are cheap single fares regardless of distance or time and more frequent service. It is recognised that in recent years the Bus Service has improved and the resulting increase in passenger load must have achieved some fuel economy. This must attract more people as it is definitely

a saving to use the same amount of fuel to move as many as 50 people in a bus as compared to five or less people in a private motor car. Many Bermudians are not aware of how efficient the bus service is and an effort should be made, either by an advertising campaign or some similar promotional efforts, to try to win them over to mass transportation. The population of Bermuda in terms of size and distribution is such that any alternative mass-transport system would probably not be a viable proposition.

V. EDUCATION.

All sections of the public should be educated in the benefits, both personal and national, which can result from the more economical use of energy. Once the facts are understood, the potential savings will, in most cases, provide sufficient incentive to secure the desired results.

For each particular application the public should be made aware of how, in the first instance, the energy requirement can be reduced to a minimum, and then of the relative advantage of the types of energy available and the selection and efficient use of the equipment involved.

While the companies selling energy forms give excellent advice on the economical use of their own products they can hardly be expected to recommend the use of an alternative, except in extreme cases.

This points the need for an independent body to actively develop an information programme for the public and to help answer queries which arise on this subject.

It is suggested that this body be a Government appointed Standing Committee supported by sufficient funds to sustain an educational programme of sufficient impact. An understanding of the basic principles involved will prove the most effective and durable method of implementing energy conservation since it will not only enable the public to judge and use what are currently the best of the alternatives, but will allow them to reaccess their decisions as new products and techniques become available.

VI. TAXATION.

Prices of fuels as they arrive in Bermuda have been set by the World Market and are likely to reflect their intrinsic values. The lack of uniformity in the method of applying import duty creates a price differential to the consumer which may well lead to a wasteful energy pattern, and so adversely affect the use of a more efficient energy source.

From the point of view of energy conservation there is a strong case to be made for equalising import duties on fuels used in Bermuda for similar purposes e.g. B.E.L.Co. fuel requirements, L.P. Gas and oil used for heating would bear one rate of taxation.

While the Committee is not in favour of increasing petrol taxes as a deterrent to excess fuel usage, it does recognise that present tax levels encourage energy conservation. Those users who avoid unnecessary journeys, select vehicles with good fuel economy features, maintain the efficiency of their engines, drive sensibly and use the correct grade of fuel, etc., all play their part in reducing energy consumption.

The present import duties and annual taxation scale for cars based on physical dimensions, support energy conservation but fail to penalise models that have excessive fuel consumptions.

The Committee recommends re-adjusting taxes to create a climate in which competition is based on fuel usage efficiency.

While tax relief on selected energy saving imports, e.g., solar panels, should be considered individually on their merits they must, to be viable, be sufficiently attractive without this assistance. However, in order to encourage potentially effective experimentation and field trials, there is a case for giving tax relief in such cases for a limited 'pioneer' period.

Although not a direct taxation matter, Government subsidies to the Public Transportation system have an important bearing on the service it can provide and what it has to charge its passengers. An inefficient or expensive service will cause an upswing in the ownership and use of private vehicles and hence to the less efficient use of energy. The converse also applies.

Appropriately applied taxation or subsidies can guide the public to good fuel conservation habits while allowing a degree of freedom to those who wish to use fuel extravagantly and are prepared to pay for the privilege.

VII. LEGISLATION.

The opportunity for creating appropriate legislation will probably be of the greatest significance in the establishment of Energy Conservation Codes, e.g., for new buildings. Legislation could be drafted not only to impose stricter controls but also to relax existing regulations such as might apply to fresh air requirements, lighting levels, etc. Existing standards were developed in an era of comparatively plentiful and cheap energy and design margins were often more than generous.

The American Society of Heating, Refrigeration, and Air Conditioning Engineers has recently completed work on a model Energy Conservation Standard for New Buildings and is currently nearing completion on a companion Standard for Existing Structures. These and similar developments should be kept under continuous review and introduced, as appropriate, into our own legislation.

The Committee realises that should stringent restrictions in energy consumption be needed at any time, as in conditions of national emergency, these could be achieved by legislation devised to curtail the importation and use of certain types of non-essential equipment such as high powered boat engines, pool heaters, etc. However, since proportionate to the whole field of energy use, consumption in these areas is relatively small, the Committee has no recommendations to make of this nature to be applied under the normal conditions which now exist.

VIII RECOMMENDATIONS

8.1(a) POWER GENERATION

The Committee is satisfied that the Bermuda Electric Light Company is acting in a responsible and active manner with regard to the economies of power generation and because of this, there is no need at this time for Government to seek outside expertise in this field. The Committee has received an assurance that the findings of the consultant study presently being undertaken by the Company into the present state of development of other forms of energy for power production can be made available to Government on request, and the Committee recommends that this offer be accepted.

8.1(b) WASTE HEAT

The Committee recommends that the Bermuda Electric Light Company study currently underway should lay particular emphasis on the feasibility of putting to work the waste heat discharge from the Company's existing power generating plants.

8.1(c) ENERGY FROM REFUSE

The Committee is aware that the Public Works Department presently has under consideration various schemes for further refining the method of refuse waste disposal. The Committee recommends that Government should look with favour on any scheme which takes advantage of the energy producing properties of industrial and domestic waste.

8.2(a) BUILDING DESIGN

There is a temptation to design exotic but not necessarily energy conscious domestic and commercial building units in Bermuda.

It is recommended that the Department of Planning, in their examination of development applications, should play the role of educationalist and attempt to persuade applicants to amend extravagent energy consuming designs to a more conservative and economical form.

8.2(b) ENERGY SYSTEMS MANAGEMENT

Programmed air conditioning and lighting controls may show some energy (and recurrent cost) savings when applied to hotel and commercial complexes. Progress has already been made in Bermuda in this field and Management should be made more aware of the energy saving possibilities available. It is recommended that the educational programme outlined at

recommendation 8.4. include provisions for the promotion of this potential energy saving.

8.3. PUBLIC TRANSPORTATION

The promotion of the bus and ferry service at the expense of the private car is a real and practical means of reducing overall fuel consumption. The Committee notes with satisfaction the very significant improvements made in the bus service in recent years and recommends that Government continue to make use of every opportunity to encourage the use of public transportation.

8.4. EDUCATION

We recommend that a Standing Committee be appointed to promote Energy Conservation by education. The Committee should have the services of a professional in the field of advertising available to it as publicity adviser. Funds to service the Committee and to cover the cost of publications, advertising, etc., should be provided.

8.5. TAXATION

The Committee recognises the affect of taxation as a means of implementing fuel conservation and therefore feels that the implications of the following proposals should be considered.

8.5.a. TAXATION - L.P. GAS

The Committee recommends that consideration be given to adjusting the import duty on Liquid Petroleum Gas to be the same as that applied to diesel oil from which the substantially less efficient electrical heating is derived.

8.5.b. TAXATION - VEHICLES

That consideration be given to the encouragement, by appropriate tax concessions, of the importation of cars having a superior fuel consumption record, e.g., say better than 35 m.p.g. - 13 km. per litre.

8.5.c. TAXATION - RELIEF FOR ENERGY SAVING PRODUCTS

In order to encourage potentially effective experimentation of energy conserving products e.g. solar panels, there is merit in giving tax relief in such cases for a limited 'pioneer' period.

8.6.a. LEGISLATION - BUILDING STANDARDS

It is recommended that the model Energy Conservation codes and regulations being formulated abroad, especially in the U.S.A. be kept under constant review. In particular those emanating from the American Society of Heating, Refrigeration and Air Conditioning Engineers, are receiving the widest acceptance, fifteen States having adopted their Standard 90-75 (Energy Conservation in New Building Design). The companion recommendation 100P (Existing Buildings), when published, should receive particular attention. The most appropriate parts of these proposed codes should be considered for incorporation into Bermuda's own regulations.

8.6.b. LEGISLATION - EQUIPMENT STANDARDS

Parallel regulations to those concerning buildings are being introduced in the U.S.A. to demand high efficiencies from energy consuming equipment e.g. air conditioners. Once these standards have been firmly established and the resulting products become generally available then consideration should be given to the introduction of local legislation to ban the lower performance models.

8.7. RESEARCH PROGRAMME

The expenditure of funds by the Bermuda Government on any form of energy research programme is not recommended. The larger developed nations are spending vast sums on energy conservation and generation research and the outcome of these efforts will be well documented in the Technical Press, and thus available to Bermuda.

8.8. PUBLIC UTILITIES COMMISSION

Concentrated community efforts to economise on the amounts of energy consumed could easily be discouraged if the consumer were presented with rate increases introduced to offset reduced sales.

To control such increases, The Public Utilities Commission should remain in being and be a constant observer over costs, services rendered and internal company efficiencies.

8.9. REVIEW COMMITTEE

We recommend that a Committee similar in make up to the one presently reporting be appointed three years hence to review developments.