Chemistry and Alternative Energy Sources

D. C. D. Lecamwasam

Ceylon Tobacco Company, Colombo

In relatively simple terms, energy is the ability to do work. Though probably not widely understood as such, mankind's interest in energy arose from the dawn of civilisation when we first looked for food, clothing and shelter. Muscle power of humans as well as animals was derived from the energy contained in the food that they ate. The energy locked in fossil fuels and in certain physical states of matter, e.g. the potential energy of water at high elevations, the thermal energy contained in naturally occurring geysers, etc, provided the sources of power so very necessary to drive the machinery and provide us the many conveniences of modern living.

According to the laws of thermodynamics and conservation of energy that energy can neither be created nor destroyed and that work, energy and heat bear a fundamental relationship. Under certain conditions, energy is transformed into work with the release of heat. Similarly, chemical reactions could be utilised to transform the energy contained in elements and compounds to provide heat (thermal energy) which in turn could transform the state of a medium, to make it do "work". The motive power of both steam and oil engines as well as the jet engine is basically derived from these fundamental principles and sources.

However, we were not so aware of the economic and social implications of the relationship between chemistry and energy and the impact it has on our daily lives until the energy crisis of the seventies. For us, in the developing "Third World", this is all the more important, for while the developed world is trying to maintain its affluent and high consumption life style, our very survival amidst degrading poverty and deprivation depends upon understanding and using this knowledge.

The natural desire of civilised humans to improve their lot has set us on a course where our progress is dependant on the quantity of fuel available. It is unfortunate that the areas which are short of fuel or cannot afford it are the very areas that need it most. They also have the biggest populations. We therefore have the paradoxical situation where

(*a*) development is proportional to energy resources and.
(*b*) development is inversely proportional to Population Growth. Beggar nations must learn to distinguish between their "wants" and "needs" and carefully husband their resources to initially provide basic needs. The welfare and prosperity of future generations will depend upon the choices we make and the strategies we adopt.

Having made this general preamble to bring into focus our present situation, let us now examine how the relationship between chemistry and energy could be usefully developed to steer us through these difficult times with reasonably acceptable standards of living whilst maintaining and improving the quality of life for future generations. It is by accepting the reality of certain fundamental limitations and making some sacrifices that we shall survive until we reach the next major turning point in our civilization, i.e., the economic and universal harnessing of Solar Energy and its derivatives possibly in the 1990s or more hopefully by the turn of the century.

A little bit of chemistry may not seem out of place here. Most of us are aware that there are chemical reactions between elements and compounds which either require the introduction of heat or yield heat. The former reactions are known as endothermic and the latter exothermic. For example, the combination of carbon and carbonaceous compounds with oxygen yields carbon dioxide, monoxide, other volatiles and incombustibles and a certain quantity of heat is liberated.

Since I have chosen to limit this topic to traditional energy sources, let us consider the common carbonaceous fuels — for example, Coal and Wood Charcoal, Fossil fuel oils, Natural Gas and Biomass, abundantly available in the tropics. To make a proper exposition and have an appreciation of our present predicament of trying to balance energy supply and demand, we should also consider the conventional energy sources we are familiar with in Sri Lanka, viz: hydropower and wind energy as well as the interesting but as yet impractical systems such as OTEC, wave energy and even more questionable nuclear energy.

The Government has at last begun to realise that there are limits to growth and unrestricted use of subsidised power and energy cannot be matched by supplies which are limited by technology, time scales and above all finance. Even with the support of foreign funds and technology some of the alternatives will need deep and serious thought when considered from a point of of integrity of supply, safety of our population, waste disposal, etc. The one single energy resource we have in abundant supply is sunlight. It can outlast all our requirements and is non-polluting. What therefore prevents us from using it? The short answers are technology and finance. There are encouraging signs however that just as in the field of computers, a breakthrough is round the corner. Meanwhile, use of the sun can be made via the photosynthesis/chemical conversion route i.e., use of biomass.

It is quite noticeable that in the past 2 to 3 years an increasing number of knowledgeable and influential persons in our country have begun to realise the benefits of energy plantations, and conversion of agricultural waste materials to provide heat and power. For example, roughly 75% of our total energy requirements are yet met by firewood. This is both wasteful and ecologically harmful, particularly in view of the fact that the reforestation program does not appear to match the required replenishment. What are the other alternatives? There are as yet abundant supplies of agricultural byproducts much of which is going waste. The materials which are very commonly available in our country in large quantities are from the coconut industry, rice husk and straw. Though one may argue that these are used in rural areas, such use is limited and to a large extent wasteful. The problems of transportation, storage, handling and ash disposal and the difficulties and discomfort experienced in burning these materials preclude its general usage.

One such waste material available in large quantities is coir fibre dust. The coconut plantations in Sri Lanka cover about 450,000 hectares and the annual nut yield is about 2500 million nuts. Whilst the fibre industry produces about 150,000 MT of 'Kohubath' annually, there are the existing mounds estimated at about 5 million MT from over 500 fibre mills.

The major problems which have prevented the large scale use of coir dust as a fuel have been its very high moisture content, basically due to the method adopted locally in processing for fibre, i.e. "retting" and its low density. At the moment, work is underway to overcome both these disadvantages, i.e. a means of economically drying large quantities of kohubath and compacting the mass into fuel logs. Thus a convenient form of firewood will be available for domestic and industrial use.

The composition of kohubath found in literature is as follows:

Table 1. **Composition of Kohubath**

Proximate Analysis (Dry)		**Ultimate Analysis (Dry Ash free)**	
Fixed Carbon	26%	Carbon	46%
Volatiles	62%	Hydrogen	7%
Ash	12%	Oxygen	46%
		Nitrogen	1%

Chemical Analysis

Holo Cellulose	30%
Lignin	60%
Ash	10%

High Calorific value on ash free basis about 20,000 KJ/Kg.

(Ref. J. D. Mannapperuma—paper presented at SLAAS 15.12.81)

It will therefore be seen that densely compacted dry briquette logs of density approximately 1000 Kg/m^3 offer good heating value and economical short haul transport together with easy storage and handling.

It will be useful here to consider the comparative costs of these coir dust briquettes with other traditional fuels (1981 prices).

Table 2. **Comparative costs of coir dust briquettes**

	Firewood	*Coir Dust Briquettes*	*Furnace Oil*	*Heavy Diesel*
Unit	Kg.	Kg.	Kg.	Kg.
Price (Rs.)	-/40	1/50	4/60	6/60
Ash %	2.0	5.0	0.2	0.02
Moisture %	35.0	10.0	1.0	-----
Heat Value KJ	11,700	19,200	42,500	44 000
Combustion Efficiency %	72	79	81	81
Useful Heat	8,400	15,200	34,400	35,000
Cost of Useful Heat Rs/GJ	47/60	98/70	133/70	185/40

Thus in actual use, whilst coir fibre dust briquettes are about twice as expensive as firewood they are about half the cost of fuel oil used for heating purposes. In integrated systems using combined heat and power there will be several advantages of introducing solid fuel firing direct in furnaces or via the gasification route. The technology for conversion of solid fuels in block form or as particulate matter using boilers, steam turbines coupled to generators and exhaust heat exchangers, condensing open or closed loop feed systems is very sound and well known. Gasification gas engines coupled generators using waste heat recovery systems, are technically reliable and a viable source of power for us, even though gasification did fall out of favour after the World War II mainly due to low fuel oil prices. Both systems are currently returning to the European and Japanese markets, economic units for steam/turbo generation being in the 2 — 50 MW range and gasification 1/2 — 2 MW range. Therefore, a programme for using kohubath as an alternative fuel to replace imported fuel oil and to an extent as a substitute for firewood, is very feasible. It is estimated that if suitable incentives are provided for the necessary conversions about 25% of our fuel oil import for heating purposes could be replaced with these briquettes. However, as long as it is possible to obtain firewood by illicit means without much risk or grave consequences, it will not replace the use of firewood on any significant scale.

On an islandwide scale and considering major usage only about 70% of our total energy requirements are for cooking purposes. The balance 30% is roughly divided equally between transport and power generation. Of course this is in quantitative terms but it is very necessary that we view this in terms of rising costs of imported fuel and the saturation levels being reached in adding to our hydropower generation within acceptable cost/time targets. From this aspect alone, "fuel farming" seems to be a very appropriate answer to our needs.

If we could only overcome our conservative fears and be more open minded about the changes being wrought around us we should see the obvious advantages and the opportunities before us to convert solar energy to useful power and energy using fuel farms.

1. Viable, self-renewing energy plantations can be grown very advantageously in small allotments.

2. Plantation requirements for 10 MW power plants would be about 1000 hectares.

3. It is the most compact form of naturally available biomass.

4. Use of biomass will have the least interference with the ecological balance.

5. The exhaust emissions are almost sulphur free and the ash is re-usable for plant growth.

6. No serious environmental dangers.

7. An economic means of converting solar energy to produce electricity.

8. Storage, transportation and handling are manageable and within the means of a production unit.

9. The growth of wood fuel reserves has many additional benefits in soil and water conservation, foliage, shade plants and wind breaks, etc.

The village reawakening movement and the rural electrification programmes have brought in their wake increased demand for supply and distribution of electrical power in widely separated areas albeit in limited quantities. Central generation and distribution of electrical energy is both uneconomic and wasteful particularly considering that most of the demand will be for household lighting. Biogas generation using animal dung and agricultural waste can be considered for small localised units.

The conversion of Solar Energy to heat and electricity can be through several paths but as yet these require expensive and sophisticated technologies for wide usage. On the other hand biomass is essentially stored chemical energy produced by photosynthesis. The biomass itself can be converted into energy by several methods, the commonest of course being by burning. Though other energy sources such as wind, mini-hydro and solar are being considered, it is abundantly clear that in our own situation the greatest potential for alternative energy lies in the use of energy from biomass.

References

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