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Workshop on Fermentation Alcohol for Use as
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Vienna, Austria, 26 - 30 March 1979

THE INTERACTION BETWEEN ENERGY ACCOUNTING AND COST ACCOUNTING IN THE PRODUCTION OF LIQUID FUELS FROM BIOLOGICAL MATERIALS*

by

P.F. Greenfield**
and
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THE INTERACTION BETWEEN ENERGY ACCOUNTING AND COST ACCOUNTING IN THE PRODUCTION OF LIQUID FUELS FROM BIOLOGICAL MATERIALS*

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The authors discuss briefly the concepts of energy accounting and cost accounting. They argue that in a plant built to produce synthetic fuel, the fuel used as an input in production must be debited against the gross production of the plant. If this is not done, serious errors (several fold) can result in those situations where the cost of producing the synthetic fuel is much greater than the market price; and where the energy needed as an input in producing the synthetic fuel is large relative to the output.

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EVALUATING THE SUCCESS OF A VENTURE

Fairly standard procedures have evolved for evaluating the success of a venture. One simple approach is to estimate the annual return on investment and use this as a measure of the effectiveness with which the capital is employed. For reasons that need not be spelt out here, more complicated techniques involving discounted cash flow are usually preferred. Both techniques give a measure of the annual reward paid for capital, and if this exceeds the so-called opportunity cost of capital, the project is worthwhile. We take opportunity cost to mean the return we might receive from the best of the myriad investment opportunities available to us. There are many variations of this theme, and terms such as pay-off period, profitability index etc. are well known. Sometimes we may wish to determine the minimum cost of providing a partioular need for society - in which case the cost of capital may simply be added to the other costs.

"NET ENERGY ANALYSIS" (NEA)

In the current mood of real concern for the continuity of energy supplies - a second criterion for the suocess of a venture has been floated. This is called the Net Energy Analysis, NEA. It is of particular interest in evaluating the performance of plants to produce synthetic fuel. The idea is to monitor energy flows rather than cash flows - and analogous concepts (e.g. energy pay-off period emerge. Obviously if the justification for a particular plant is to extend our energy supplies, we would regard as suspect any plant whioh in the course of its lifetime consumes more of its product than it produces.

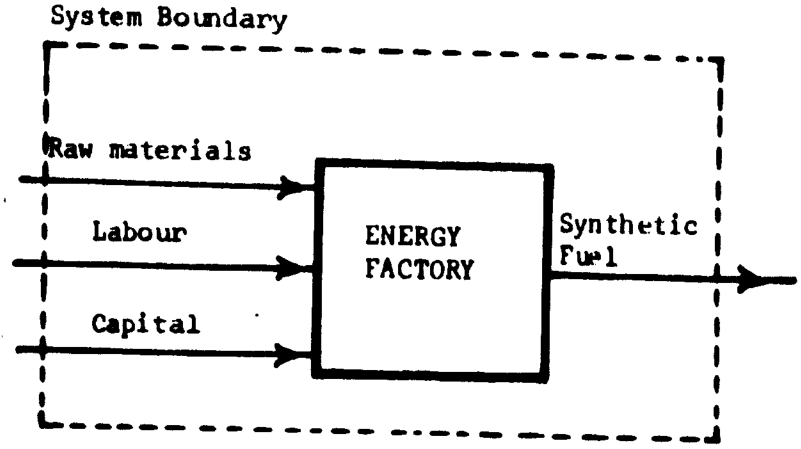
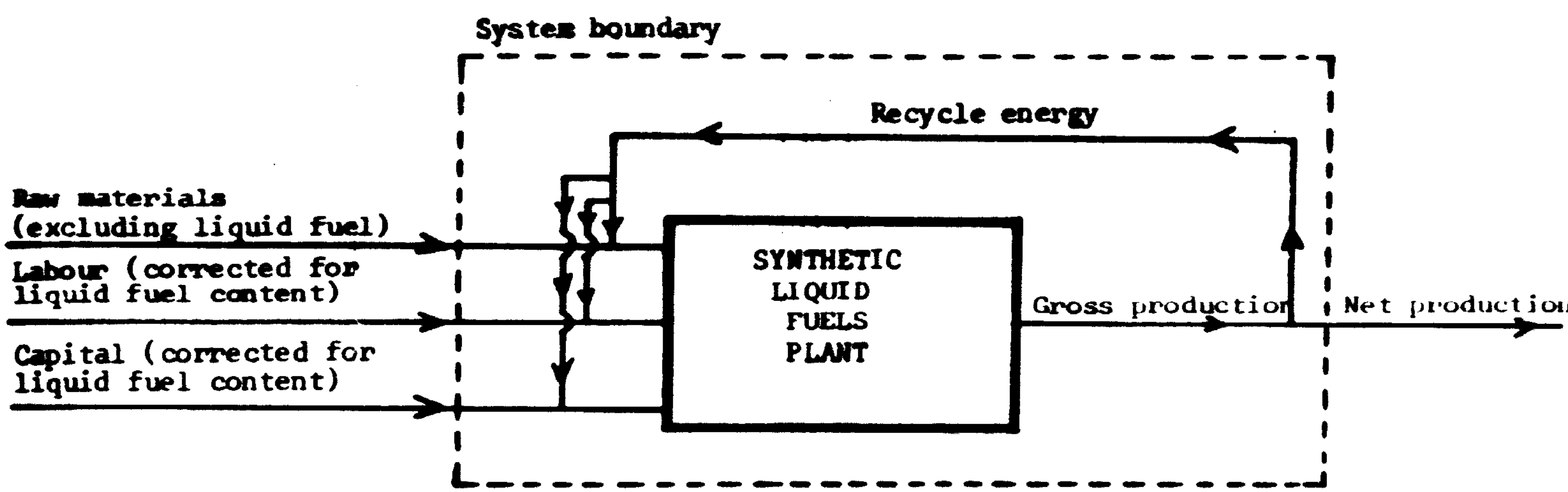


Figure 1 Schematic of Synthetic Fuels Plant

Figure 2 <u>**Schematic of Synthetic Liquid Fuels Plant, showing Recycle Energy**</u>



The picture begins to look more complicated: We know energy is conserved (First Law of Termo-dynamics). We know there are limitations in converting one form of energy to another (Second Law of Thermodynamics). We know that every spontaneous process reduces the total store of available energy. Aside from thermodynamics - we concede that the value of energy is very much a function of how it is presented - place, time, convenience, cleanliness, continuity of supply etc.

In a free enterprise system we would normally rely on the price system to sort out our priorities. Thus although sunlight and coal are cheap the extent of their use is limited because of their relative inconvenience. We may well be prepared to "buy" convenience in a plant converting coal to gasoline, fully aware of the energy sacrifices we make.

The market system certainly seems to bring thermodynamics and taste together in a very convenient way. It is difficult, ex ante, to see why this approach should be any less effective than it is for example, for food marketing. Nevertheless our purpose in this paper is not to contrast and inter-relate these two approaches - although we must report in passing that some recent papers have been fairly critical of the NEA concept. (Hill et al., 1977; Leach, 1977).

Our purpose, rather, is to show that in one particular set of circumstances the conventional cost accounting does indeed fail - and under these circumstances there is a very real need to examine the joules as well as the dollars. Surprisingly large errors (several fold even) can result if due care is not taken.

TABLE I

SHOWING THE TRUE COSTS AND PRODUCTION RATES FOR A SYNTHETIC LIQUID FUELS PLANT
(Basis: 1000 litres gross production; Cost of gasoline: 15¢ per litre)

A	Total cost of operating plant (assumed) $		150			300			600	
B	Apparent cost per litre synthetic fuel (A$1000) ¢		15			30			60	
C	Amount of synthetic fuel recycled - litres (assumed)	200	500	800	200	500	800	200	500	800
D	Net production - litres (1000-C)	800	500	200	800	500	200	800	500	200
E	Credit for recycle stream in $ (0.15 C)	30	75	120	30	75	120	30	75	120
F	Net cost of operations of plant - $ (A-E)	120	75	30	270	225	180	570	525	480
G	Cost per litre of net production - cents (F/D)	15	15	15	34	45	90	71	105	240
H	Ratio true cost to apparent cost (G/B)	1.0	1.0	1.0	1.1	1.5	3.0	1.2	1.8	4.0

SECURING LIQUID FUEL SUPPLIES

Australia's most serious energy problem in the short and medium term is the continuity of supplies of liquid fuel for transportation. As a nation we are 65% self sufficient, but we are uncomfortable in the knowledge that we are dependent on the OPEC countries for our remaining supplies. The situation appears to be getting worse rather than better. (Note that a similar situation effectively exists in most countries. The problem centres around liquid fuel because only in the case of crude oil is the market controlled by a cartel. Coal, LNG, uranium etc. are all traded much more freely).

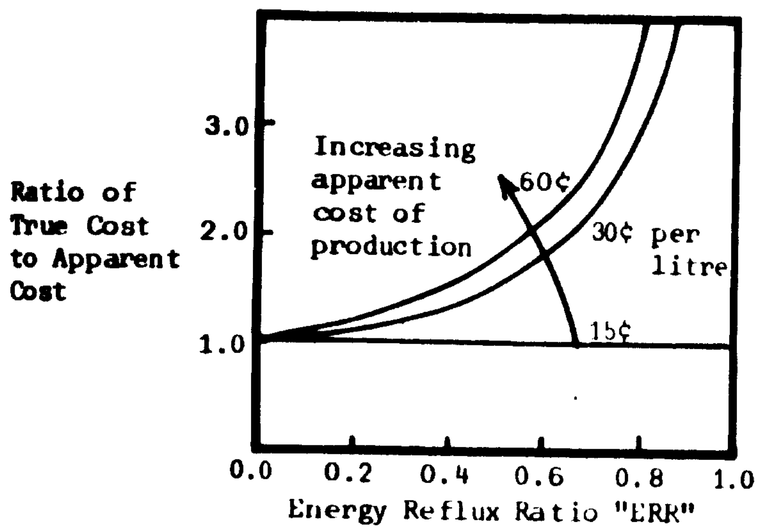


Figure 3 Showing how True Cost increases with Plant Costs and Energy Reflux

It has been argued quite strongly here in Australia that we should increase our self sufficiency by building plants to synthesise liquid fuels. Many such options are open to us (Nicklin, 1978) but all crude oil. Proponents of the idea argue that the increased security is worth the high price. Brasil, for example, has undertaken a major programme of energy independence via ethanol. The ethanol route to independence has nevertheless been challenged on the grounds that the net energy gain is small (Gartside, 1975)

Increased self sufficiency can be achieved by a variety of processes in a plant shown schematically in Figure 1. A characteristic of such a plant is that it will almost certainly not be competitive - it is justified on the grounds of increasing the national security. A two-tiered system of energy pricing emerges. The cost of the synthetic product can be calculated by conventional procedures, but a method of subsidization must be developed if it is to be marketed.

A POSSIBLE PITFALL

The sole raison d'être of the synthetic liquid fuel plant is to increase the supply of energy in the convenient liquid form. The capacity of performance of the plant must therefore be measured by the net liquid fuel production as shown in Figure 2 and not by the gross production shown in Figure 1. Note the importance of defining our system clearly. (The dotted lines in Figures 1 and 2). Note that part of the gross product must be recycled (at least notionally) to compensate for the liquid fuel used as an input. This classic "feed back" effect will certainly influence the economics of synthetic fuel production.

Chemical engineers will see an analogy between the flow of this energy back into the system and the concept of reflux in distillation columns. For this reason we call the return energy stream the "energy reflux" and the "energy reflux ratio" (ERR) we define as the fraction of the gross energy production which is returned to the system. The acronym would appear to be fitting.

QUANTIFYING THE FEED-BAG EFFECT

Table 1 is largely self explanatory and shows the importance of the effect under various conditions. The results are graphed on Figure 3. Note that for plants which produce synthetic fuel at a significantly higher price than OPEC-based fuel; and for plants in which the net energy produced is small in relation to the inputs (high reflux ratio) - the error can be large indeed. Not just a few per cent, but several fold. This is precisely the situation which exists for many of the suggested synthetic fuel plants. Certainly ethanol production from crops is often quoted as a case where the net energy gain is relatively small.

Despite this, in virtually every paper we have seen, the effect of this feed-back loop has not been considered, and we believe the cost of inputs have always been evaluated at "current market prices" rather than at the higher prices associated with the high cost energy produced by the plant. Nor has the capacity of the plant been corrected.

We wonder in the evaluation of the Brazilian programme, whether this feed-back effect was considered. If not, the true cost of energy independence in Brazil will become increasingly clear as the ethanol supplies an increasing fraction of the liquid fuel needs. Energy costs would rise at an unexpectedly high rate. The effect would became clear, but by then it would be too late to reverse the decision.

Quantifying the effect accurately is not easy because there will also be an effect on the capital and labour inputs (Figure 2). It seems reasonable that any liquid fuel attributable to the manufacture of the plant itself should be debited against the production. Similarly if the plant is located some distance from its infrastructure, there will be an effective loss of production attributable to the labour input (Figure 2). This would be the liquid fuel needed to take the employers to work. An energy input-output analysis (energy Leontieff functions) would appear to be very useful

This effect would apply to all synthetic energy plants, and its evaluation for such processes as energy from shale, crops, kelp, etc. would be of interest.

CONCLUSIONS

In calculating the capacity of a synthetic fuels plant, and in calculating the costs, care must be taken to debit against production the energy required in the operation of the plant. If this is not done, in those situations where the cost of synthetic fuel is high relative to the market price, and where the net energy gain is small, massive errors can arise in estimating the cost of synthetic fuel.

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