CLOSING ADDRESS

INTRODUCE OR DEVELOP FURTHER THE NEW ENERGY TECHNOLOGIES?

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It is a pleasant task as chairman of the Congress Committee to present the closing remarks. Rather than summarize the papers, which has been done very properly by the chairmen of the individual sessions, it is preferable to meditate about the entire congress and some of the conclusions which might be drawn.

Although the need for improved self-sufficiency and increased diversity in energy supply is recognised generally, there does not exist a defined energy policy in the European Community. It is, for example, not universally accepted that nuclear energy will have to make up the energy deficit, or that a massive expansion has to take place in coal production and processing. This is due to differing energy resources, economic targets, historical, sociological and environmental attitudes within the Western European countries and the fact, that the effect of such changes is so fundamental, that they require a consensus in society reflected through each government before they can proceed. Moreover, a great uncertainty exists in view of the wide range of alternatives and interactions with respect to both the technological and logistic aspects. There is a tendency to keep the options open and avoid major and irreversible commitment to any particular coal processing or other oil replacement technology. This recognizes the fact that many of the replacement technologies currently being developed will disappear before the major contenders become established.

How long this can continue before the penalties outweigh the benefits is a matter of individual judgement of enterprises and governments. The penalties, however, will be large for too long a wait-and-see policy. The penalties are:

- no experienced personnel to carry forward the new technological developments and to build and operate the future plants and installations;
- no experienced local (process) equipment industry to provide the new equipment and machinery;
- no infrastructural base for the required change;
- deterioration of the foreign exchange position, because of the necessary import

of plants and energy raw materials for liquid and gaseous fuels and even electricity; and

- loss of employment opportunities.

Because of the major uncertainties which exist in respect to the timing and nature of future oil replacement technologies, industries and countries will find themselves in an exposed position at least throughout the lengthy transition period which will be required to recognise, adjust to, develop and implement the necessary changes on an appropriate scale. It is unfortunate that countries and private industries will be entering this crucial phase of restructuring and technological redevelopment during a period of economic depression. This will probably make it difficult to generate internally the massive new investment money required and this will limit the rate of change.

Certainly there are difficulties and pitfalls in drawing generalised economic conclusions for a situation twenty or more years ahead, involving comparisons between well established processes and plants and those at varying stages of development and credibility. Of great importance is a critical analysis of the enormous number of possibilities and proposals, which are being made for the solution of future problems. Since a process engineer knows that he can not overcome the laws of nature, and that it is not wise to neglect the rules of economics, such an analysis kills a lot of proposals made by inexperienced people. All new energy options should be judged by three criteria:

1. Energy yield. More energy has to come out of a conversion process than has been put into it. (Solar energy of course has to be excluded in these considerations.) This criterion is evident to engineers. One example: A few years ago so much energy was put into the manufacture of a silicon solar cell that the energy pay back time was 50 years.

2. Cost price. This criterion is also evident for engineers. For the energy technologies available today, the economic (or cost price) order of preference is:
 - nuclear, coal + conservation technology
 - gasohol
 - oil and gas
 - all others

3. Specific investment costs or the investment required per unit of output. This criterion is not often used by engineers in their project appraisals, because of being accustomed to abundant capital. However, today economies are depressed and surplus capital is in the hands of OPEC countries.

The importance of specific investment costs can be made clear with an example. As a unit, use investment dollars per unit of energy flow, e.g. \$/kW. Specific investment costs are, in a complex way, related to the pay out time of projects - the higher they are, the longer the pay out time. First consider a comparison between coal and oil.

Within the frame work of the rules of nature, substitution of oil by coal is feasible. A large plant is running commercially South-Africa. Therefore, look at the rules of economics.

Compare a small refinery with a capacity of 25000 bbl/day ($\sim 4000 \text{ m}^3$) and a coal liquefaction plant, as is done in Fig. 1.

Fig.1. Comparison of an oil refinery and coal liquefaction plant (specific investments in \$/kW).

The refinery has a rather simple processing scheme with secondary and cracking capacity; the coal liquefaction plant has the same output in gaseous and liquid fuels. The figures must be used with utmost care; the ratios are important, the absolute values are questionable. Further elaboration of the data in Fig. 1 would lead, if cost prices are the sole basis for our considerations, to the conclusions that coal processing is cheaper (pay back periods will be 2-3 years) and at nowadays oil prices, investment in coal processing should be now.

However, further analysis leads to the following. Specific investment in coal processing is around five times higher than in oil processing. The refinery operations will give -depending on the profitability- an annual cash flow of \$10-30 million. If all the money generated in today's oil processing would be used for reinvestment in coal processing, it would take at least 20-30 years be-

fore sufficient money is available to build a coal liquefaction plant. This is far too long. So specific investment costs, and especially the ratio of it for new technology to the existing technology, is dominant for the renewal rate of technology. That is, today's energy industry based on oil and gas by itself cannot generate the funds required for the future energy industry. Huge additional funds have to be generated to provide the required investment money, either by the industry itself, governments or individual investors. And, much development work, especially in demonstration plants, is still required to reduce the investment costs per unit output.

In the many lectures in this congress many specific investment costs have been mentioned. As a summary of the congress a table of specific investment costs, and some others, is given in Table 1.

Table 1
Specific investment costs

PROVEN TECHNOLOGY		
Oil/gas, production + transport	20 - 300	\$/kW
Oil refining	100	
Liquefied natural gas (LNG)	400	
Energy saving	10 - 500	
Nuclear	1500	
NEW TECHNOLOGY (Lead time 10-20 years)		
Coal, mining + transport	75 - 250	
Coal, gasification-liquefaction	400 - 600	
Coal power station, direct combustion	600	

These figures must be used with great reservations. In Table 2 are the specific investment costs for other technologies without a distinction between thermal and electrical energy. Because on the large penetration of cogeneration, no distinction can be made anymore between thermal and electrical energy. Also, kW of oil or gas fuel replaced is, therefore, not a good basis for comparison. This second oversimplification is presented with apologies but should not affect the conclusions.

Table 2
Specific investment costs - Direct energy sources

<u>SOLAR</u>		
Hot water space heating	~5000	\$/kW
Silicon cells	~25000	
	(+5000)	
Thermal power	~2000	
<u>Wind</u>		
Mills	5000	
	(+1200)	
<u>SEA</u>		
Tidal	3000	
OTEC	4500	
<u>BIOMASS</u>		
Alcohol	400 - 600	
Wood	~30	

All figures in the table are averages, of course. The specific investment costs in the local marketing and distribution systems haven been excluded. For oil or gas production, and transport, the highest figures refer to off-shore production as in the North Sea. The figures on production, transport and refining should be added, the same as for coal. Coal technology is more costly than the present oil and gas technology. However, at the present state of development the exploitation of all direct energy sources is more than ten times as costly as all proven or new technologies. For silicon cells and wind energy, future potentials of \$ 5000/kW and \$ 1200/kW respectively are stated. Only the conversion of biomass into alcohol fuels is within the reach of societies, but they require a favourable climate and a sound agricultural economy. Wood is unfavourable for ecological reasons. Much development work is still required for direct energy sources and many inventions still have to be made. Comparing the figures in the table leads to the following conclusions:

1. The first task is efficient energy management, that is conservation.
2. The best alternatives -after efficient energy management- for oil and gas are coal and nuclear energy. Coal conversion technology is not yet proven but on the threshold of commercialisation. Development work is also required to reduce specific investment costs.

3. The use of direct energy sources still requires much development to reduce specific investment costs. A rather considerable penetration can be expected by mid of the 21st century because of the renewable character and the absence of energy raw material costs. The only exception is alcohol fuels from biomass, which can be introduced now.

If this has become clear as a result of this congress on Advanced Energy Conversion, and if industry and research institutes accept the challenges, this congress has served its purposes.

This brings me to the end of my address and the pleasant duty to express the thanks of all of us to all the people who worked very hard in the preparation of this congress:

- The crew behind the scene, the congress office.
- The congress committee and its executive committee.
- Mr. Govert Verheul, the secretary of our Executive Committee. He retires this month. I feel this successful congress is a beautiful and rewarding conclusion of his professional career. We are very grateful to him.
- An enormous effort has been spent by the speakers, who presented data and ideas, which are the real results of the congress.
- The people who contributed to the discussions and participated in the various sessions. The resonance of the audience was very pleasing and this is the best indication of a successful congress.