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ALTERNATE POLICY AND ENERGY SOURCE ECONOMICS*

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EXTENDED ABSTRACT

A combination of factors has led to a world-wide power dilemma for mankind /1/. These include:

1. Substantially complete utilization of hydraulic potential of rivers close to major load centers.
2. Projected burn-up of existing, recoverable sources of petrofuels and coal, there being no replenishment.
3. Projected burn-up of existing recoverable nuclear fuels processed for use in fission reactors and the high cost of safely disposing of fission products produced.
4. Projected high cost of future breeder reactors and the contingent chemical plants for safely extracting plutonium for use in recycled fuel elements.
5. Lack of knowledge as to when, if ever, the egregious design problems of nuclear fusion will be solved.
6. The rapid approach to practical limits of electrical transmission line high voltage.
7. The extreme complexity, very high cost and impracticality of widespread use of superconductive electrical power transmission lines or storage devices.

Clearly a comprehensive policy that is widely understood, accepted and initiated, both here and abroad, is needed if man is to progress at his favorite breakneck pace using vast amounts of power along the way. Since America is the largest user of energy obtained by combustion of non-replenishible fuels, it makes sense that conversion to energy sources which can be recycled endlessly start here. If it is to be done well, it is important that we in America face up to the task and adopt a comprehensive energy program towards that end. As of now, America does not have such a policy.

Fortunately, there are a number of alternate energy sources which exist in abundance and/or can be recycled endlessly using existing technology. These include:

1. Heat tapped from geothermal sources
2. Velocity of major ocean currents
3. Velocity of winds
4. Solar energy (thermal or photo-voltaic conversion)
5. Combustion of methane recovered from garbage
6. Combustion of methane extracted from kelp
7. Combustion of ethanol from fermented grain
8. Combustion of methanol from destructively distilled wood
9. Combustion of electrolytic hydrogen

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10. Velocity of tidal eagres
11. Power from oceanic wave action
12. Hydro-electric power from large, remote sites
13. Standing temperature gradients in oceans, large lakes and large reservoirs
14. Heat from fusing atoms

This list does not include radiofrequency power received from photo-voltaic satellites, power plants based on standing differences in oceanic salinity or hydrogen dis-sociated from oxygen using non-electrolytic processes which seem to require considerable development and appear to be too expensive. Heat from fusing atoms was included due to the prime importance of solving, if possible, how to obtain unlimited power for millenia and the prevalence of low atomic weight fuel for fusion reactor plants.

Since there is no concise national guide for action, despite the number of available alternate sources of energy, one must attempt to determine the reasons why this is so. National policy makers seem to be confused to the point that the foundation of a national consenses on energy is impeded. Some leaders still believe we must be scared into believing there really is a world-wide energy crisis. Many of these make gloomy prognostications which tend to panic people into making the wrong moves instead of leading them to the right moves, which is tragic. In 1978 half the housing starts in America went for electrical heat due to the feeling that "there won't be any fuel gas starting next year." This was nihilistic and running in the wrong direction at top speed.

The metamorphosis of USAEC to ERDA to the USDOE has contunuously rekindled a dilemma for this large organization. To paraphrase, a promulgator of alternate energy source ideas approaching this metamorphosing group at two-year intervals might encounter: "We are validating the nuclear option, who needs alternate energy sources?"; "We are reorganizing and who knows?"; and, "We are still reorganizing and who are you?" A USAEC Report to President Nixon repeatedly exhorted "Validate the nuclear option." Fission reactor plants would be the source of all of America's energy needs. At WHEC I, paper after paper described production of hydrogen using nuclear fission power. This was early in 1976 and some of us already saw such plants as obsolete and incapable of validation. Since then, the USDOE has discovered solar power and hydro power and converting fossil coal into liquid and gaseous fuels at an accelerated loss of coal reserves. To promote alternate energy sources does not preclude the full practical use of oil, natural gas, coal, coal tars and oily sands. Exploitation of all of these is indicated until alternate energy sources are in full use. After that the remaining fossil fuels can be used for the production of plastics and chemicals.

The "last vast sites for 60 Hz hydro power and what to do with it" syndrome is of interest. In Greenland there is a bowl with a bottom almost 400 meters below sea level. This bowl is filled with almost 3 KM of freshwater ice. The interior is dry and receives snow in winter. Surprisingly the east and west coasts are largely ice-free, and water run-off over nine months of each year is enormous and often exceeds the winter input /27. There are few electric loads in Greenland, but its coasts could be lined with hydro-electric

plants accompanied by electrolyzers for dis-sociating water into its constituent gasses. The 99.5% electrolytically pure hydrogen and oxygen could be piped to a central terminal on each coast. The hydrogen could be combined with nitrogen (obtained cryogenically from air) at 1,000 atma pressure and 1000°K to form ammonia (NH_3) which could be shipped as a liquid. The oxygen could be liquefied for shipment. Hydrogen could be piped from the eastern terminal to Europe via Iceland, Scotland and England. Likewise it could be piped from the western terminal to Canada and the U.S.A. via Baffin Island /1/. At remote sites 60 Hz frequency is unnecessary. Inexpensive 2- and 4-pole generators would have AC output of varying frequency, voltage and amperage. Solid state rectifiers with controlled DC voltage output would power the electrolyzers, and hydrogen (oxygen) production would vary with electrical energy consumed. The average available head is 555m and estimated available power is 116,000 MW /2/. Similar, if lesser, remote sources of hydro power exist in Alaska, Central Africa and southeast Asia.

Alternate policies are needed to assure ourselves and our successors complete success in meeting future energy requirements. These include:

1. The main thrust of our efforts should be to encourage and develop alternate energy sources to slow depletion of irreplaceable fossil fuels, rather than the reverse.
2. We should continue to press for maximum funds and effort to develop fusion reactor plants if this be possible.
3. We should accept the fact that nuclear fission power plants are outmoded and concentrate on what to do with the cores when they are depleted to the point of no return.
4. We should limit our manufacture of synthetic fuels from coal to military needs rather than intensify the depletion of our coal reserves.
5. We should adopt the premise that fuel gas will continue to be distributed to homes and businesses for the indefinite future, irrespective of its makeup or source.
6. We should greatly intensify plans for using electrolytic hydrogen which can be fired in air at normal thermal efficiencies or can be recombined with electrolytic oxygen at higher efficiencies in fuel cells without fuel preparation sections, boilerless steam turbines and compressorless gas turbines.

Many alternate energy sources are variable. This particularly applies to solar energy which at best is a less than 50% proposition. This also applies to tidal power, river velocity power, wind velocity power and wave power. To operate such variable or remote sources on a firm basis requires storage of some or all of the electrical energy generated. Electrical energy can be converted into chemical energy on a one-to-one basis at low temperature by electrolytic dis-sociation of water. Both hydrogen and oxygen can be collected and stored. Hydrogen is a fuel. When recombined with oxygen, it burns to water vapor. Hydrogen has three times the specific heat content of petrofuels and four to five times that of the better grades of coal. It is naturally fluffy and must be used under high pressure, low temperature, or both, to equal natural gas heating value throughput in the same pipe. Also, it must be contaminated in the order of 1% to create an odor

for detecting leaks, luminosity to check burner performance, and prevent hydrogen embrittlement.

One of the driving reasons for our energy dilemma is the interlocking of price between various non-replenishable fossil and fissionable nuclear fuels. When OPEC oil prices rose from $2 to $30 per barrel during the 1970s, the price of other fuels also rose. Nuclear fuel rose by a factor of 7 in the form U_3O_8 and might have risen more in the absence of the need for expensive enrichment and cladding. After 1973 a major supplier of fuel elements cancelled its long-term contracts. If coal could be sold for the same cost per MBTU as oil, it would cost $110 per ton delivered. Western USA coal presently costs $50 per ton delivered, and might have risen more in the absence of the need for expensive equipment for handling, storing, pulverizing, soot blowing, ash collection and removal of objectionable flue gas ingredients. Present costs for thermal-electric plants are close to $1250/KW (nuclear), $750/KW (coal-fired) and $350/KW (oil-fired). Oceanic hydro power and weightless solar energy collection should be pushed for the near term and fusion power for the long term, in addition to other smaller scale alternate energy sources listed earlier. At $7.50/MBTU (present cost of fuel oil), an oil-fired thermal-electric plant is saddled with a fuel cost of 2.6¢/KW-HR which alternate energy plants using free sources of energy avoid altogether. This is quite an edge when costs of the necessary equipment are considered.

REFERENCES

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