toyaktuk Peninsula area. The temperatures of the Yukon Coastal Plain are probably also in the same temperature range. Consequently, the mean annual ground temperature has not risen, for any prolonged period, by more than 7° to 10°C above that of the present, for a period greater than 40,000 years, otherwise melting and collapse of the icy structures would have occurred.

J. ROSS MACKAY
Department of Geography, University of British Columbia, Vancouver
V. N. RAMPTON
J. G. FYLES
Geological Survey of Canada, Ottawa, Ontario

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A Hydrogen Economy

The medium of energy transport from an atomic reactor to sites at which energy is required should not be electricity, but hydrogen. The term "hydrogen economy" applies to the energetic, ecological, and economic aspects of this concept.

The concept envisages atomic reactors held on platforms floating on water. They are in water sufficiently deep to make heat dissipation easy. The electricity they make would be converted on site to hydrogen and oxygen by electrolysis. The hydrogen would be piped to distribution stations and thereafter sent to factory and home. Reconversion to electricity would take place in on-site fuel cells, the only side product being pure water. Some advantages of the concept are:

1) A considerable increase in our energy supply will be needed in coming decades, and we must avoid air and heat pollution in its creation. This method avoids both. It does not imply a pollutional limit on growth. Its efficiency would be about 36 percent (if one assumes conservatively a 60 percent efficiency in both the use of energy to produce hydrogen and its reconversion at the fuel cell). Conversely, direct current would be generated. (In a transition period, alternators would consume another 1 to 2 percent of energy.)

2) The electricity supplied thus would be cheaper than that sent by overhead cables at distances greater than about 400 km from the reactor source (*1*). At 1600 km, the cost would thereby be halved.

3) The hydrogen economy would produce about 14 liters of pure fresh water per household per day, at the present level of the use of electricity. By A.D. 2000, the average household in the United States is likely (*2*) to consume ten times more electrical energy than at present. In this situation, the drinking water needed for a household would be a by-product of its electrical energy source.

4) Energy needs are cyclical; atomic reactors work continuously. Cryogenic hydrogen storage would be possible.

5) The hydrogen would run trucks, cars, ships, and trains, by means of fuel cell–battery combinations and electric motors. Transportation would be not only nonpolluting but also silent and cheaper in running costs (because of the greater efficiency of energy conversion). The performance of vehicles thus powered (without further research) would be comparable with that of present ones.

6) Aircraft could run on liquid hydrogen by using jet transducers similar to the present ones. Their range would be increased two to three times for the same weight of fuel. The emission into the atmosphere of CO_2, NO, and unsaturated hydrocarbons would be avoided. One-man jet helicopters might become feasible because the use of liquid hydrogen would give a 300 percent reduction in weight of fuel per unit of energy compared with gasoline.

7) Chemistry and metallurgy: Iron ore could be economically reduced by hydrogen directly to iron, the airborne excess product being steam. At plasma temperatures, aluminum could be produced more cheaply by thermal reduction of Al_2O_3 with H_2 than by the present method, even if cheapened electricity were used. Ammonia could be produced at about half the present price. Hydrogenation of fats would be cheaper. Those processes in chemical technology which involve continued emissions could be converted to fumeless electrochemical processes.

8) Fusion reactors will need deuterium. Deuterium is a by-product of water electrolysis.

The main difficulties which we would face in getting started toward a hydrogen economy are (i) conservatism; (ii) the absence of education or training in electrochemical engineering; and (iii) the public's fear of hydrogen. This is outmoded; railway cars containing liquid hydrogen pass casually through our cities and tunnels.

The prospect is for abundant energy and as affluent an economy (if the population growth can be limited) as we want in the future without the ecological difficulties which we now foresee in obtaining the first and maintaining and spreading the other.

J. O'M. BOCKRIS
School of Physical Sciences, Flinders University, Bedford Park, South Australia 5042, Australia

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