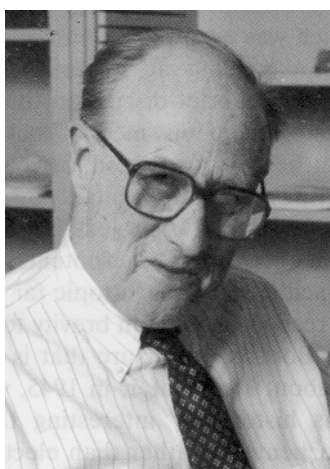


## THE HYDROGEN ECONOMY AND THE EXHAUSTION OF OIL



John O' M. Bockris  
Molecular Green Technology  
College Station, TX 77845

Readers will be familiar with the ideas of the Hydrogen Economy which were first suggested in 1971. The basic energy source would be renewables, solar, etc., and also, if it cannot be avoided, a much altered series of nuclear reactors which would be safe from terrorist attack (for example buried underground).

The idea of hydrogen as a storage and transmission medium, coupled to fuel cells in respect to the production of electricity and used directly in a way similar to that in which natural gas is now used, – would be helpful to sporadic resources. Most of the renewables are sporadic, however, one can produce the hydrogen from the splitting water during times at which energy is available and store it so that the actual out flow of the hydrogen meets the market needs while the inflow can be carried on whenever the energy is available.

In the nuclear alternative, there is a need for hydrogen because nuclear reactors are difficult to turn on and off but the need for energy is cyclical and therefore it is desirable to let the reactors run steadily at

all times and use hydrogen as the storage and transmission medium.

The Hydrogen Economy is doing well, – and one of the major reasons for this is the advances in fuel cell technology made by a Canadian company, Ballard, who has shown that it is possible to make fuel cells with suitable economics so that they can be made to give the electricity for electric cars, utilizing either stored hydrogen (as with the BMW Company) or with reforming of fossil fuels such as methanol (as with the Daimler company).

The question is a matter of timing. We depend on natural gas, oil and coal. Now, oil, which is the most important of the energy economy of the moment, has a short life time. Oil has often in the past said to be "have only 20 years to go" and these predictions have proved inadequate because of the advance of extraction technology.

This time there are serious signs that the combustion of oil, as a major source of our economy, has a limited life. The predicted dates of geologists now are such that the maximum rate of the delivery of energy from oil will be past sometime between 2004 and 2020. Hence, we are already in a bad situation because the time it will take to create renewable energy plants is measured in decades, not years. Of course, the predicted date of the oil supply maximum does not mean that oil will cease to be used. There is a bell shaped curve and there will be the down side of the bell shaped curve during which we can still use oil, – but decreasingly.

There is another view, though it comes from the oil companies. This is that new methods of extraction will be able to obtain from the ground more oil than we think is at the moment available. This view may be sustainable, particularly in the technique known as "lateral extraction" in which shafts are driven in the ground to reach the oil but also lateral shafts between the vertical shafts increase the amount of oil which may

be tapped. The use of steam to reduce the viscosity of the oil which is found at lower depths is also helpful.

But, these methods must have a limit and for the following reason. Of course, they, themselves, take energy and the deeper one goes, and the more energy one has to use to coax the oil out of the ground, the more energy per unit of the oil obtained is spent. Eventually, one reaches a situation in which one has to put into the extraction of oil the same amount of energy as one gets from the oil extracted, whereupon further extraction of oil is, of course, pointless.

I would like here to outline the renewable sources which we can develop, – at present only solar has been developed.

The most important is solar and there are several ways of extracting it. For example, not only the well known ways of photovoltaics but also such methods as the ocean thermal energy conversion in which a probe is sunk to depths where the water is near to 4°C and then this cold water is pumped up to condense some working fluids such as liquid ammonia in a heat engine driven by the warmth of the sea on the surface (particularly in tropical regions).

It is lamentable that only photovoltaics is being developed at this time. However, there have been advances there and the estimated cost are 2010 for photovoltaic electricity is about \$.11 per kWh. Conversion of this to the price of hydrogen shows that it would be significantly more expensive than the present costs of gasoline, but only if one neglects the cost of pollution and if one takes that into account (and it has been quantified), then there is no doubt that one would not have to sacrifice much to live in a clean world, largely on solar light.

Wind energy is the leading alternative energy resource at the moment, especially in respect to price because there are numerous parts of the world where the average velocity of wind is more than 25 kph at which speed one can produce energy economically.

A novel idea is to extract wind energy in the Antarctic where one can rely for 9 months of the year on winds as much as 60 kph. This would give electricity at less than \$.01 per kWh, and then one would be able to electrolyze sea water and condense the resulting hydrogen to liquid hydrogen to be removed in tankers.

Then, there is the geothermal energy and apart from the sources which are well known, – surface sources, – there are systems analyses of what is called "hot rock geothermal". Looking at the good side of this, it would allow one to obtain as much energy as one wanted, by drilling appropriate caverns in the earth at depth where the temperature is above the boiling point of water. The caverns would be partly self producing because there would be a split in the rocks at the bottom of the first artificially made cavern which will give greater area available to cold water at temperatures which would send it up as steam. Everything would have to be done twice in this method because, after about 10

years, the sides of the caverns would have cooled down so that one would have to start up a parallel cavern while the one which had cooled down heated up again.

The greatest unused source at the present time is gravity. This can be used in various ways wherever the tide is more than about 10 m, and there are many places in the world where this is the case.

There are a few places in the world where there is already an ideal geographic distribution of land. One needs a kind of brief inlet to a large lake. At high tide the water comes in, fills the lake and at lower tides the lake empties out again. In both cases there are turbines in the narrow inlet, working and giving electricity. One such plant already exists in France.

Such concepts might be extended artificially, particularly in places in the world where there is barren land and at the same time high tides as in northwestern Australia. There is the possibility of making artificial inlets, each of which would provide a certain number of megawatts of tidal electricity.

There is another idea in respect to the use of gravity is to weigh down a buoy with waste materials which have been salted out with suitable bacteria, tip the wastes out at the bottom of the sea floor and let the buoy ascend. Going down and going up there is gravitational energy available and it is easy to draw mechanical devices whereby this energy can be transduced to electricity.\* As to the wastes left on the floor bottom, this needs research but it seems likely that there can be bacterial decomposition.

Last of all, I mention free energy. This does not mean the free energy of the physical chemist or physicist, but the idea here is that one might be able to tap into the electromagnetic atmosphere which exists even in vacuo and comes from the surrounding universe.

Finally, it is reasonable to assert the development of renewable energies is one of the more important political objectives of any country for it would solve the exhaustion of energy which will come to all countries because we have been using nonrenewable energies for about 200 years; and also because of the growing anxiety in respect to the world temperatures increase because of the increase of (fossil fuel based) CO<sub>2</sub> in the atmosphere.

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\*One way of using gravity is to tap into the streams of the world which work because the moon pulls the sea up a little bit where the earth bulges near the equator and the water then flows down, – and creates very long streams which may go a substantial distance around the world. The most well known is the Gulf Stream which flows at about 6 kph, but there are several other streams in the world where one could insert turbines and draw out electricity.



