

Electrification

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As believers in nuclear energy, and contemplating that it must become the major energy source for the world within the next century, we should be looking at the various consequences of that transition. As nuclear energy becomes available, mainly as electric power, but also as a large scale heat source, it is an enormous change from economies based on oil and gas which produce energy by combustion.¹

The impact will go far beyond supplanting the use of fossil fuels in power generation as we know it today. At present the United States uses about 39 % of its energy as electricity and the world wide level is about 36 %. If nuclear power and coal supplant oil and gas for most uses this percentage will increase, towards 90 % or more, including hydro, geothermal, wind and solar, etc.

The 61 % of the energy use in the U.S. aside from electricity, is to a large extent for heating, industry and transport fuels.

Global Warming

While it might turn out not to be a problem, the world wide opinion seems to be that anthropogenic global warming is a real threat and there are likely to be penalties of one sort or another for emission of carbon dioxide and other green house gases (GHG's) with tightening restrictions in an effort to make a substantial change. The changes set forth in the Kyoto Treaty, which generally will not be met, will have to be increased very substantially to make a significant change in the forecast climate changes.

The United States which initiated concern about global warming and which has done much of the research on it certainly cannot continue to ignore the world wide opinion (right or wrong) and refuse to take some action to support the concerns they have had a major role in creating. The proposed voluntary effort seems unlikely to have much effect without economic incentives.

There will certainly have to be a transition stage, but it will take decades. There will be increasing pressure to accelerate the needed changes if global warming is perceived as a threat even though they will take decades to bring about.

Transport Fuels

Ultimately, autos, trucks, buses, etc. will likely depend on some fuel made by electricity. This is generally thought of today as hydrogen. However, hydrogen has serious problems in storage for extended use. Hydrogen can be produced at the point of use by water electrolysis, to support the transition to more economical pipeline transmission. Perhaps chemicals containing hydrogen will prove a solution since there are some compounds that contain large quantities of hydrogen. There is also a question as to whether hydrogen, as a transport fuel, will produce electric power in fuel cells or simply be burnt as a high efficiency fuel: or perhaps both as current hybrid vehicle technology.

Aircraft are another problem and somewhat different in that weight is a serious problem. Although this would be the last application to be converted from use of aviation fuel it is probably

¹It is worth noting that the same problems would arise with use of Wind Power, Solar PV, Geothermal, Hydro, etc. as major energy sources. They all produce electricity.

feasible to consider liquid hydrogen as a fuel, at least for long range flights and large aircraft. In the absence of shorter range aircraft much more emphasis will be desirable on high speed electric trains. This will, of course, be a very large change for our societies.

Merchant marine shipping, including oil tankers should be transformed to use nuclear propulsion, converting naval nuclear power experience to commercial applications.

Much greater use should be made of local transport by electric power trams, trolleys, regional transportation systems (such as BART) as well as high speed trains for transport over a few hundred miles, etc.

Hybrid cars will be helpful since they act to recover some of the energy lost in braking; they are basically more efficient. Other measures such as speed limits may be useful.

Non-electric, Non-transport Sector

Looking at this issue another way about 1/3 of the world's is used to produce electric power but 2/3 is not. Transport fuels are roughly a quarter of the energy use which will have to be dealt with in a special way, and the balance of roughly 40 % represents the non-electric, non-transport sectors.

As we look forward (far into the future) this 40 % could be the most refractory issue.

A substantial part of this sector is simply space heating of homes, offices, shops, etc. Today the cost of electric heating in most cases is much higher than fossil fuels, mainly natural gas.

There also is a large industry component where fossil fuels are utilized for a wide variety of operations. Some large uses, for example, like cement production, appear difficult to substitute with electric energy at any price.

There will be vast changes needed in our industries. Some, for example the iron and steel industry, and possibly oil refining may be able to use nuclear heat but not small manufacturing, etc.

Alternative Transition Hydrocarbon Fuels

With oil prices in the \$ 45 to 55 per bbl range, hydrocarbons will probably be economically produced from low hydrogen resources such as Athabasca tar sands, shale oils (with the U.S. Having more than 3/4 of the worlds known shale oil resources), heavy oils (such as in the Orinoco Valley in Venezuela or some extra heavy oils in California), bio-mass, or even coal—in addition to production from conventional sources. This will require mining, hydrogenation and extensive processing. From the energy point of view these are low efficiency—they take a lot of energy to produce, sometimes 50 % or more of the final product energy.

The U.S., if it really wanted to, could, in fact, become energy independent by producing oil from oil shales, as well as gas.

These alternate resources for oil all share a serious problems environmentally as well as increased carbon dioxide emissions per unit of energy produced.

It must considered that even in an all-electric economy there is a real need for hydrocarbons for a variety of purposes, lubricants and greases, feed stock for processes producing plastics, medicines, etc.

Energy Demand

It has become the custom both in the U.S. and internationally to consider demand/production with the losses for electric power production as part of the demand/production. With some minor variations the power is considered to be produced with an efficiency of 1/3 or 10,242 Btu/KWH in the case of nuclear, hydro, wind power, solar PV, and sometimes for geothermal. While this is reasonable accurate for light water reactors it would not be the case for higher temperature reactors.

In projections and reviews of past history this seems fairly accurate and convenient. However, in considering a major shift from economies based largely on oil, gas, and hydro to one almost entirely based on electricity, and the transition period extending over many decades, this method may lead to some unintended consequences. It is not that these cannot be taken care of, but that they must be understood and allowed for.

Without ready access to world wide data we might consider the situation in the U.S. It will at least illustrate the point.

In 2000 A.D. the U.S. produced/consumed roughly 100 quads of energy by the usual reckoning. 39.0 quads was used to produce electricity with a presume loss of 2/3 or 26.0 quads. However, 61.0 quads were for non-electric uses with about 7.1 for residential use, 4.2 for commercial use, 22.5 for industrial uses, and 27.2 for transport uses.

We are left with 61.0 quads of non-electric use. If this was converted to electric use (new electric heating, electric power heated or driven processes, etc.) the losses (at 2/3 efficiency) would be twice this or 122.0 quads. The total energy input would, by convention, be 222.0 quads/yr.

This would, of course, be correct if all of the electric power used was generated and then used to replace non-electric uses with one watt replacing a non-electric use which could be replaced by one watt. It is not worth the effort to try to detail this for the present but only to recognize that the overall energy input will be increased by growing demands but also by the transition to electric energy as well.

It seems clear that this is not a trivial consideration when estimating future energy demands especially during a time of transition to an all-electric economy from one based largely on oil and gas.

Conclusion

These are catastrophic changes even though spread over many decades. It certainly is not too soon to start exploring these and developing plans as how to make the necessary changes. This requires the prompt attention of the energy supply industries—oil, gas, coal, electric power, industries using energy (which is most), builders and construction designers, etc.

