On the Way to a Sustainable Energy Future

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1. Summary

The establishment of a sustainable energy future is one of the most pressing tasks of mankind. With the exhaustion of fossil resources the energy economy will change from a chemical to an electrical base. This transition is one of physics, not one of politics. However, proven technolog

the heritage of James Watt and Carnot. Certainly, the energy end use technologies and consumer habits need to be adapted to electricity, the base energy of a sustainable future.

4. Inversion of the Energy System

Because of the dominance of electrical energy and the relatively weak position of chemical energy in as sustainable future, our energy supply system will undergo significant changes.

Today's energy system is dominated by chemical carriers like coal, oil and gas. Electricity and transportation energy are derived from chemical energy by thermal power plants, heat engines, or fuel cells. During the last two centuries scientists and engineers have developed fascinating thermal energy conversion devices and related theories. From oil wells to driving on highways, much of today's economy is directly related to the conversion of chem

while the electric power grid only needs a modest extension in most parts of the world. In fact, the electron option may be much closer to today's energy technology and, therefore, much easier implemented than the hydrogen option.

In simple terms, a "hydrogen economy" has to compete with an "electron economy". Both options deliver renewable electricity to the people, but by use of different energy carriers. Winner will be the option with the lower energy losses between energy source and energy services. The situation is illustrated in Figure 1. The competition between hydrogen and electricity is determined by the respective overall energy efficiency between renewable source and end use.

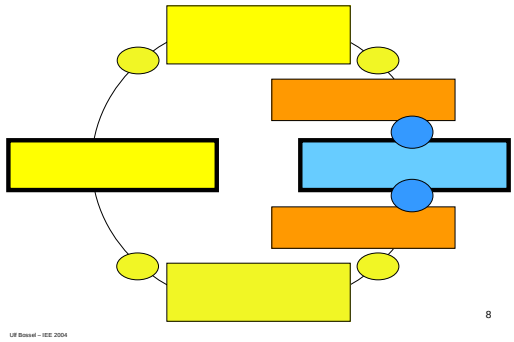

Figure 1 Energy distribution options in a sustainable energy future

6. The Myth of "Hydrogen Energy"

Hydrogen is promoted (e.g. [1]) as a new source of energy. This is certainly nonsense, to be clear. It is true that hydrogen is the most abundant element of our universe, but it exists only in chemical compounds like water, fTf10.0521.12 rca

electricity with fuel cells and the subsequent DC/AC conversion are associated with heavy energy losses. These processes cannot be made much more efficient by additional research and development. The main losses reflect the physics of hydrogen. Only a small fraction of the original renewable electricity can be recovered by consumers with efficient hydrogen fuel cells.

The results of the cited report [2] are presented for six significant stages. The energy losses or the parasitic energy consumption is presented in percent of the Higher Heating Value HHV of the delivered hydrogen. Furthermore, the results of this engineering analysis are presented as curves to allow readers to find answers for parameters of choice. As assumptions and equations are contained in the original study, only the most essential graphs are presented here.

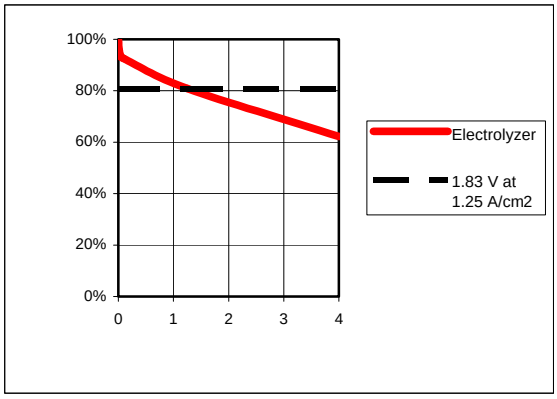

Figure 3 Energy losses of hydrogen production by electrolysis.

The energy losses are directly related to the operational parameters of an electrolyzer. Internal Ohmic ("IR") losses are proportional to the electric current. Current densities between one and two Amperes per cm^2 are standard resulting in power losses in the range of 30%. Higher efficiencies can be obtained for lower current densities and lower output. Electrolyzer optimization is a matter of economics, not physics.

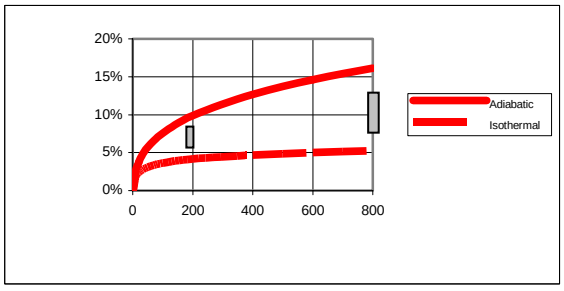

Figure 4 Compression of hydrogen gas

Because of its low molecular weight, the compression of hydrogen requires eight times more energy than the compression of natural gas and 15 times more than the compression of air. Multistage compressors with intercoolers are needed to compress hydrogen close to the ideal isothermal