

Hydrogen: Its Constitutional Contributions to the Anthropogenic Energy Mix Activating Latent Energy Potentials

by
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Foreword: Hydrogen is not simply the next contribution to the anthropogenic energy mix, which grew over a good two centuries' of time from the renewable energies of the first solar civilization via coal, natural gas, mineral oil, nuclear fission, and electricity to significant higher conversion energy and exergy efficiencies, to the renewable energies now of the second solar civilization², and to hydrogen energy. With four constitutional elements hydrogen completes the mix and helps reduce irreversibilities and, consequently, exergizes energy³ and activates latent energy potentials which—so the definition of “latent”—exist, but are “hidden” and thus so far not utilized:

1. For the time being, all renewable energies are utilized locally, regionally at best, because their secondary energies heat and electricity are not storable and transportable (in macroeconomic terms). A global trade with renewable energies is not in place, since AC transmission is loss-intensive, and high voltage DC transmission is expensive, in cases extraordinarily expensive. — However, the truly big renewable energy potentials of nature are extremely unevenly distributed. Huge solar, wind, or hydro potentials, for instance in Australia, Patagonia or Siberia, lie fallow. If they are to contribute to the global energy trade and meet the also unevenly distributed energy demands, they have to be made storable and transportable over global distances: using the storable and transportable chemical energy carrier hydrogen!
2. Power stations deliver electricity and heat, heat regularly at temperatures, in amounts, and at locations where no user asks for it. The exergetic (= electrical) efficiencies of coal-fired power stations of modern design of nearly 50% are admirable, although the remaining 50% of the energy content of the coal still remains unutilized. If in coal stations combined cycles are utilized instead, which simultaneously deliver hydrogen and electricity, and heat of utilizable temperature regimes and carbon dioxide undergoing carbon capture and storage (CCS), the overall efficiency is raised to more than 60%. Even if 10% are reserved for CCS, the result will be 50% (for comparison, even today's best coal stations with 46% minus 10% will end up at 36%!). Hydrogen exergizes; it reduces the amount of irreversibilities and, thus, activates more technical work from less primary energy raw material.
3. Home heating systems consisting of boilers and burners are energetically extremely efficient, almost 100% of the energy content of natural gas or light fuel oil is converted to heat; exergetically however they are miserable: It is exergo-thermodynamically simply absurd to generate a flame temperature of around 1,000 °C in order to provide a room radiator temperature of 60 to 70°C. — The hydrogen supplied low-to-medium temperature fuel cell, a combined cycle in itself, installed instead, firsthand delivers electricity (= pure exergy) with an efficiency of 35 to 40%, and the remaining heat suffices over most of the year to heat the home (for extreme cold winter nights a small relief boiler will be in place). Here, too: hydrogen exergizes, helps to gain more technical work from less raw material! In addition, a distributed IT-controlled power station will evolve, consisting of millions of small capacity (kilowatts!) “power stations” which easily add up to the equivalent of the gigawatt stations in place and initiating welcome competition. Thermodynamically, in both systems (after 2. and 3.) painfully high irreversibilities are diminished appreciably.
4. In the history of energy trade it so happened that energy selling countries sell energy raw material (coal, oil, gas), simultaneously carrying along the environmental pollutants and the potential greenhouse gases; it is the obligation of the buying countries to remove them in a way that is harmless to environment and climate. — Let's imagine that decarbonization and, thus, hydrogenation and dematerialization take place already at the mine mouth, then clean hydrogen would be shipped, gaseous hydrogen in pipeline grids, liquefied in cryogenic tanker ships, avoiding circulating pollutants and

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² Many of the technologies of the second solar civilization are man-made (e.g., the semiconductor as a prerequisite for the development of photovoltaics) and were inexistent in the first solar civilization.

³ In Gibbs' terminology: exergy = „available energy“ (Josiah Willard Gibbs 1839-1903)

potential greenhouse gases around the globe: hydrogen is free of pollutants , and there is no carbon on board!

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