

The Hydrogen Energy Economy

# An Industry Tycoon in Sight?

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**D**o we see any *Friedrich Krupp, Henry Ford, Werner von Siemens, Cornelius Vanderbilt, Bill Gates* of hydrogen and hydrogen technologies? Do we already see entrepreneurial matadors somewhere in the world who are devoting their thinking and acting, their skills, their financial capital, and their organizational talent to evolving hydrogen technology markets? To clean hydrogen production, to its different types of storage, to hydrogen transport and trade, to hydrogen utilization technologies? Are we expecting well-known companies to start or be on the verge of starting to become matadors in hydrogen energy businesses?

Yes we do, and no we do not (yet), both answers have some truth. Of course, there are the space rockets' launching companies which would not even exist without hydrogen, in this case liquefied, stored, transported, and combusted hydrogen; and there are the industrial chemistry companies utilizing hydrogen as a commodity, and of course, there are the Seven Sisters running their refineries, and there are the methanol or ammonia manufacturers producing their needed hydrogen captively.

All aforementioned hydrogen businesses have something in common: they belong to »old« well established markets: hydrogen as space launching propellant began more than half a century ago, and hydrogen chemistry and trade in technical gases are still much older.

No, what is meant with our question about the hydrogen matadors refers to those who take care of the novel markets-to-come of the forthcoming hydrogen energy economy and here the answer is rather modest.

If we look onto summaries of hydrogen energy technologies already marketed in small quantities, or in a waiting position, or still in R&D labs and development shops, is there a matador visible? One whose key technology is the basis for the up-and-coming economically viable hydrogen energy market? One like *H. Ford*, who started the mass production of reasonably priced autos (the legendary »Tin Lizzy«) and gained a world industrial empire; as did *W. von Siemens*, whose electrical generator provided the core solution of generating power at one place and using it somewhere else, the still valid solution of geographically disconnected energy production and utilization.

In our times we had *Geoffrey Ballard* who, with a number of colleagues, founded Ballard Power Systems in Burnaby, British Columbia/Canada; and we have almost all big world auto makers who are developing fuel-cell (FC) vehicles – a little hesitantly, though, since they are in parallel developing other electric vehicles that get their electricity not on board but from outside, like the plug-ins, the hybrids, the pure electric battery vehicles, and combinations. For the industry's policy makers' market developments are still not too clearly foreseeable; perhaps here we get a feeling of the frequent change of FC vehicle market entrance dates which automobile companies used to announce.

For stationary or portable FCs, a wealth of small to very small companies have developed worldwide that are still in their research, development and demonstration phases delivering small lots of products to a limited number of clients. Normally these companies' financial situation is modest, to say the least, if not risky, since they live of risk capital with interest rates of 30 % or even higher. Similar things are true for mobile storage developers.

An exception to this general observation are perhaps the big players in electronic devices, who have clearly devoted themselves to portable micro-to-mini FCs for all sorts of portables like cellular phones, camcorders, television cameras, and the like. However, how about the major electricity utilities and the coal industry and their inclination to build efficient combined cycle power plants delivering simultaneously both electricity and

hydrogen? No, they are still on their usual pathway constructing energetically excellent efficient coal fired electricity plants with nearly 50 % efficiency or even a little higher. The engineer and the energy economist admire that, no doubt, but let's be realistic, the remaining 50 % of the coal's energy content is still being converted to high temperature exhaust heat with no industrial user around; only in the very rare situations when, say, a cement factory or a steel mill is located in the vicinity does the high temperature exhaust heat perhaps find a market.

Electrolytic wind-hydrogen or solar-hydrogen is even farther away from the market. Still, wind energy converters and solar generators »only« deliver electricity, and when, say, an off-shore wind park needs efficient and reliable electricity transport in order to be connected to its far away on-shore users, HVDC solutions enjoy priority (if the distance and nasty sea floor conditions allow for). The situation changes when very large amounts of wind or solar electricity are planned to contribute to the world energy scene, for example, wind from Patagonia in the far away South of Argentina, or solar from Australia, both commissioned to supply Europe or Japan or the United States. In such cases hydrogen as the transportation means is unavoidable. But, far and wide, no major energy company in the world is following that idea as yet, not to speak of a matador.

### No champion has evolved yet

The technical gases industry is well prepared to play an important role in the hydrogen energy field. The major companies – Linde, Air Products, Air Liquide, Praxair, and perhaps a few others – are experts in electrolyzers, steam methane reformers (SMRs), liquefiers, hydrogen dispensers, and filling stations. None of them, however, has developed into a champion's role, leaving all the others behind, so far. Similarly, »Big Oil« is absolutely knowledgeable and experienced in hydrogen and its technologies. Large amounts of captive hydrogen are in use in crude oil refining, for the production of reformulated gasoline or de-sulfurized diesel. But again, no champion has evolved yet.

Having said all this, can a hydrogen energy tycoon realistically be expected? Most probably not. Let's see: Most of the hydrogen energy technologies along their complete conversion chain from production of hydrogen via storage and transport to dissemination and finally utilization go back to inventors who have lived and researched over the past two centuries and a half starting in the later eighteenth century. Mostly as late as in the second half of the twentieth century, their inventions were taken over by developers in national labs or universities, and their results are now under the control of the appropriate industries who simply buy what has left the labs, approaches market readiness, and promises profitable return. The coal, oil, and gas industries are familiar with all aspects of hydrogen production in gasifiers, reformers, partial oxidizers, and other approaches. The electrochemical industry builds and operates electrolyzers. Pipelines hundreds of kilometres long for  $\text{GH}_2$  and  $\text{LH}_2$  (much shorter) are day-to-day practice. Storage on the ground and underneath are fully operable, taken care of by the technical gases or industrial chemistry industries, or by space launching companies.

In the final link of the hydrogen conversion chain, the utilization link, we see a different picture: The hydrogen fuelled portable mini-to-micro FCs are clearly in the domain of the electronics' industries. Small to medium size companies have specialized on portable FCs in the kilowatt range for military applications or leisure activities. Deliverers of central heating systems for residential homes or office buildings are active in low-to-medium temperature FC replacements of the traditional boiler/burner combinations. Here a challenging controversy is to be expected between central heating system companies and electricity utilities. Because with their FCs the system companies no longer deliver only heat devices, but devices which simultaneously generate heat and electricity. In a country like Germany, to take that example, with some 15 million boilers/burners replaced by FCs à 5 to 10 kW electric, the distributed power easily sums up to today's full electric power on line! Since this newly evolving competition in the electric power market competes with the

traditional power business of the electricity utility companies on line, the matter will become rather touchy. An exciting development is foreseen and as its result one or two matadors may evolve.

The auto manufacturers deserve special attention: It may be that the present major challenges – cost reduction, fuel consumption reduction, change of fuel to carbon poor/hydrogen richer compounds – will be mastered by further-developed ICE vehicles, natural gas or biofuels, and hybridized electric vehicles of various designs. In the longer run when the traditional fossil fuels get scarcer and scarcer (and ever more expensive), the ICE's development potential approaches its limit, and the land surface area dedicated to the production of biofuels is completely exploited; then hydrogen energy, in particular renewable hydrogen, gets to its tipping point.

Let's return to our question: Will we see »An Hydrogen Energy Industry Tycoon?« It seems not too realistic to expect one, at least not in an early period of time. The energy-related industry branches appear to be well prepared to add to their portfolio hydrogen energy and all sorts of hydrogen technologies, as soon as indications of forthcoming profitability favour investments. One thing, however, should not be forgotten: energy is a highly political matter, and so will be hydrogen energy! We said it earlier: »The laws of parliaments and the laws of nature have developed increasingly divergent, and it is unreasonable to expect that the laws of nature will yield!«

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