

18WHEC Villa Hügel ew

Hydrogen Energy — Completing Human's Energy Mix¹
by
Carl-Jochen Winter, Ueberlingen, Germany²

**Minister for Economic Affairs and Energy, Christa Thoben,
Dr T. Nejat Veziroglu, President of the International Association for
Hydrogen Energy,
Ladies and Gentlemen!**

**This a great event! This is a great event for energy, in particular for
hydrogen energy!**

¹ Invited paper given at the Krupp Foundation's evening invitation in the Villa Huegel on the occasion of the 18th World Hydrogen Energy Conference (www.WHEC2010.com), 17 May, 2010 in Essen, Germany

² Professor Dr.-Ing. C.-J. Winter, IAHE Fellow and Vice President-The International Association for Hydrogen Energy (IAHE), Obere St.-Leonhardstr. 9, 88662 Ueberlingen, Germany, Tel. ++49 7551 944 5940

With gratitude we acknowledge the invitation of the Krupp Foundation for this evening's reception of the hydrogen community which gathered in Essen, Germany in order to run the 18th World Hydrogen Energy Conference (www.WHEC2010.com). Since 36 years these conferences have been held every two years on a different continent, and with an increasing number of attendees – truly a powerful sign of continuity: Thank you, Dr Veziroglu, the merit is yours!

Essen as the host city of the conference was selected for good reason: it is the capital of the Ruhr, Germany's industrial centre for more than 200 years. In our times, Essen has developed into the heart of one of Europe's most important energy regions. Companies of world reputation are headquartered in Essen and North Rhine-Westphalia. The primary energies coal, oil and natural gas are entrepreneurially governed from here, and so is the secondary energy electricity. And not least, Essen has been selected the "European City of Culture 2010": hydrogen energy is part of that culture!

Energy, ladies and gentlemen, was never something static: The centuries did and still do alter the playground. Not too long ago, in the late 18th century coal started to replace the renewable energies of the first solar civilisation, the only forms of utilized energy since the advent of humans on earth. The 19th century was coal's century, beginning at its end piece by piece replaced by oil and gas. After the market advent of Siemens' electrical generator and Edison's light bulb around the turn of the 19th to the 20th century, electricity began its triumphal procession which — after more than 100 years now — has by no means come to an end. The middle of the 20th century saw nuclear fission, and first timid, apologetic renewable energies, now of the second solar civilisation, which is characterized by human-made inventions that did not exist in the first civilisation such as the photovoltaic cell, the fuel cell, the modern wind generator, among others. Never did humans utilize only one form of energy, never did an incoming one completely replace the "old" ones; humans' ever increasing thirst for energy needed them all: heterogeneity grew! Truly: Not in vain, we may wait "until something better comes along" (David S. Scott).

What will that be? What does the energetic 21st century hold in hidden stock? – No one really already knows. It may be fusion, may be solar from space, may be thermal ocean layers' enthalpy differences, may be methane hydrates from deep sea floors. All

these ideas (and many more) may or may not materialize. What, however, is clearly seen and urgent already now is three things:

- 1) As an indisputable policy obligation, nations have to get rid of their energy dependence; for instance energy-short Germany suffers under an almost life risking energy import dependency of some 75%!
- 2) The second factor of two in the energy equation besides primary energies, i.e., energy technologies and engineering skills, urgently needs to take over the dominating role! The importance of primary energy raw materials will be taking a downward slope, the importance of efficiency-raising technology skills an upward trend: Making more energy services from less primary feedstock is the creed! The name of the game is education, education, education! It is the “railroads” of the 19th century or the “information technology” of the 20th!
- 3) Energy needs to be cleaned up in order to meet the rigorous obligations vis-à-vis the environment and climate change.

At this point of my talk - well, did you really expect anything else from me? – hydrogen energy comes into play: Like electricity, its “running mate” in the secondary energy regime, hydrogen energy is exclusively technology-driven. There is no primary energy from which it can not be produced — coal, oil, gas, uranium, all sorts of renewables. Hydrogen energy policy is technology politics – truly a centrepiece of energy poor, but technology rich countries (like mine). Engineering skills are “energy”, “national energy” you are inclined to say! Hydrogen is environmentally and climatically clean, and, if generated from renewable energies, it is absolutely clean along its entire energy conversion chain.

Today, electricity and steel keep coal alive, tomorrow clean hydrogen will be keeping clean coal alive, which, for sure, will be utilized for many more decades to come. Coal-derived hydrogen even offers coal a renaissance in the transportation and home heating sectors, which account for some two thirds of the end energy demand of Germany! Hydrogen fuelled low temperature fuel cells aboard vehicles or in basements of residential homes support decentralized electricity generation, which, for the time being, lies fallow. From a multitude of excellently IT-controllable hydrogen fuelled rolling or stationary fuel cells a powerful and efficient clean virtual power plant will evolve as a competitor of the centralized power plants on line. Decentralised electricity is hydrogen-by-wire!

But again: Novel energy technologies need well thought through transition periods and plentiful time, many decades up to half centuries until their irrevocability. Wishful thinking of the public and – here and there – of the political class seldom meet the realistic, down-to-earth assessments of engineers and economists. We observe that the laws of parliaments and the laws of physics increasingly drift apart, and it is unlikely to expect that the laws of physics will yield!

Hydrogen energy enjoys a stable historic fundament, since up to date two thirds of all atoms of fossil fuels burnt are already hydrogen atoms, with an ongoing upward trend. Hydrogen exergizes energy (something for exergo-thermodynamicists among us); it makes more technical work from energy. For the engineer the nearly 50% efficiency of modern coal fired power plants is admirable, no doubt. But there is more in it, if we return ad fontes: hydrogen inextricably helps reduce the painful irreversibilities in combustion, energy transfer and exhaust of energy conversion chains.

In a nutshell: “We are bad farmers, because we have too much land” (Benjamin Franklin); paraphrased we read: we are bad energy engineers, because we have too much energy (raw materials). Consequently, thinking and acting in primary energy raw materials was yesterday, thinking and acting in clean and efficient energy technologies is today’s challenge, and is to becoming tomorrow’s. “No-energy (raw materials) energy supply” is perhaps a little too far fetched, but not at all a pie in the sky. Only three examples of many more: The solar-hydrogen home needs (almost) no energy from the market; auto makers trim their gas guzzling vehicles to admirable 3 litres per 100 kilometre or less, cutting down in parallel on cost, noise, fuel burnt, and emissions; German industry’s energy productivity regularly comes down by 1 to 2 percent per annum! — Already in the early 1990s the Enquête-Commission of the German Bundestag “Protection of the Earth’s Atmosphere” recommended to the Federal Parliament, unanimously with the votes from both sides of the aisle, to run the country with 60% national energy efficiency instead of today’s meagre 30% (btw, the world’s figure is some 10% — bitter to say!). With the technologies at hand, what is lacking is the political will and economic viability: The price of oil is still too low. But let’s be patient here, time will tell, it works in our way!

Bluntly said, with or without hydrogen ...

- ... decarbonization of fossil fuels is climatically mandatory, with hydrogen, however, less irreversibilities make the process much more efficient.
- ... utilization of renewable energy is due, but with hydrogen so far fallow lying huge far away sources will becoming storable and transportable, and get entry to the global energy trade market — such as Patagonian wind, Australian solar, African solar.
- ... exergetically highly efficient low temperature fuel cells in transportation and buildings at the back end of national energy conversion chains are in a dormant position waiting for their fuel, with hydrogen the so far hidden great potential of decentralised electricity will be opened up.
- ... environmental and climatic cleanness urge energy raw materials' transport around the globe getting rid of trafficking in pollutants and potential greenhouse gases, with decarbonization already at the mines' outlet trafficking in clean hydrogen becomes obvious.

I am now going to close my talk with seven recommendations for action in erecting the up and coming hydrogen energy economy: actions speak much louder than words!

I For the power plant engineer:

- Stop burning coal, gasify it instead, produce hydrogen (H₂) and carbon dioxide (CO₂), sequester CO₂, and utilize the H₂ cleanly and extremely efficiently in gas turbine/ high temperature fuel cell combined cycles or sell it on the hydrogen market

II For the exporter of fossil energy raw materials:

- Decarbonize fossil fuels and sequester CO₂ already at the mine's outlet and ship value-added clean hydrogen as a gas via natural gas/hydrogen pipeline networks or liquefied via cryotankers to global hydrogen markets, thus avoiding trafficking in environmental pollutants and potential greenhouse gases around the globe. Thereby, transfer the obligation to remove environmental pollutants and potential greenhouse gases from the raw materials' buyer to the raw materials' seller!

III For the developer of giant wind parks:

- Electrolize water with wind-generated electricity, liquefy hydrogen and ship it to the usually far away heavy energy user countries,

thus allowing the so-far fallow-lying huge wind resources of the world to participate in the global energy trade

IV For the supplier of home heating systems:

- Exergize energy, i.e., make more technical work from energy with highly efficient hydrogen fuelled low temperature fuel cells simultaneously providing electricity and heat, and put together from a multitude of fuel cells a decentralized, environmentally and climatically clean IT-controlled power plant as a powerful competitor to the centralized plants on line — truly, a “hydricity” (Geoffrey Ballard) example of the two mutually interactive secondary energy carriers hydrogen and electricity! The highly efficient back end of the hydrogen energy conversion chain compensates for the moderately efficient front end of the chain.

V For the auto maker:

- Store hydrogen on board fuel cell vehicles and thus create a completely environmentally and climatically clean electrical transport system with vehicles of elevated efficiency, and the same weight, the same volume, and the same range as now customary.

VI For the aircraft engineer:

- Before supplying the jet engines with hydrogen fuel, take liquid hydrogen on board, re-gasify it by cooling the wing surfaces and, thereby, laminarizing the lower drag airflow, and then utilize the gaseous hydrogen in an efficient fuel cell for onboard electricity supply while parking at the airport-ramp or taxiing on the port's apron. Replace the noisy, polluting and inefficient kerosene fuelled auxiliary gas turbine power unit.

VII For the infrastructure technology developer:

- Bring stationary pressurized fuel cells and electrolyzers to market
- Excavate or leach out underground hydrogen storage capacities
- Install and operate liquefiers
- Install filling stations
- Run natural gas/hydrogen “NaturalHY” combined pipeline networks
- Develop LH₂ cryotankers and on-shore and on board re-gasification technology

I close quoting Max Planck: “The usual way a scientific truth becomes generally accepted is not that its opponents are

persuaded and stand corrected, but that its opponents gradually die out and the next generation grows up with that truth just from its start". — Don't we really shame ourselves leaving it to the generation of our sons and daughters to erect the hydrogen energy economy? What hydrogen needs now is vigour, not fickleness; major capital, not petty cash; continuity, not ups and downs; and, perhaps the most important of all, conviction, not ambivalence!

And finally, a few words on my own behalf:

At the end of this conference, after 10 years my collaboration with the North Rhine – Westphalian energy ministry will come to an end for good.

After 10 challenging years, busy years, and, not at all least, fascinating and successful years.

It was my pleasure and privilege to meet with colleagues and play professionally the game of energy consultancy, and in particular hydrogen energy consultancy: I brought forward ideas, proposals, suggestions. My colleagues in the administration took them (or left them out) and converted those taken into novel energy technologies.

Thank you, Dr Grossmann, for your valuable and appreciated support: I am convinced that your excellently performing company with electricity and hydrogen will, truly, be controlling the energy to lead!

Thank you Minister Thoben, and thank you Dr Baues and team! You do count on hydrogen and its technologies — truly, you didn't count them out at all!

I bid farewell to North Rhine – Westphalia, Germany's hydrogen energy state number one in being, and beat a retreat to my south-westerly province.

Thank you for listening.

And be reminded: Beware of old men, they have nothing to lose (George Bernhard Shaw).

More to read:

Carl-Jochen Winter, Joachim Nitsch (Eds.), Hydrogen as an Energy Carrier, Technologies-Systems-Economy, Springer 1988, ISBN 3-540-18896-7, ISBN 0-387-18896-7

Carl-Jochen Winter, Hydrogen Energy – Abundant, Efficient, Clean; A Debate over the Energy System-of-Change, ew-special 1/2009, www.vwew.de; www.itsHYtime.de

Carl-Jochen Winter, Hydrogen Energy – Abundant, Efficient, Clean; A Debate over the Energy-System-of-Change, Elsevier, International Journal of Hydrogen Energy 34 (2009), S1-S52, <http://dx.doi.org/10.1016/j.ijhydene.2009.05.063>; <http://energylocate.com/home/articles/news/169-hydrogen-energy-abundant-efficient-clean>