The Oil Drum
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The Hydrogen Dream

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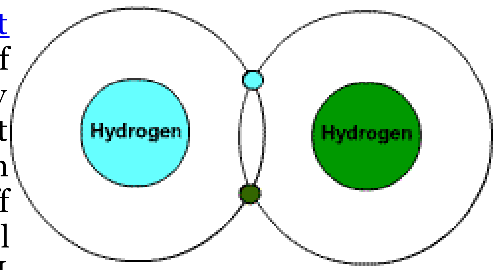

Last week I went to Longwy's university campus, the Institut Universitaire de Technologie (part of the University of Lorraine), for a conference on renewable energies and energy efficiency. It was an event integrated in an InterReg project for innovation, called Tigre, gathering institutions from Lorraine, Saarland, Luxembourg, and Wallonie. It kicked off with a session on tri-generation, and went on with parallel sessions on waste biomass, and on hydrogen and fuel cells. I opted for the latter, feeling really curious about the present state of research on this field.

Cesare Marchetti proposed hydrogen (H_2) as a large-scale energy vector almost fifty years ago. The main concern then was to find a simple way to feed transport systems with what seemed to be a fountain of energy about to come from the expanding nuclear park. The nuclear dream is largely gone, but hydrogen lives on. Is this dream about to come true as a piece in the transition puzzle to a post-fossil fuel world? That's what I was expecting to find out.

Home concept

Today the hydrogen dream is very different from Marchetti's. It starts with a home, self-reliant and grid-disconnected, housing a micro-generation system, mostly solar and wind, that primarily feeds the electrical system. Then surplus energy is converted into hydrogen and stored in a container in a special division of the house. This hydrogen can later be used to generate electricity through a fuel cell when the micro-systems do not match the instantaneous power needs; the waste heat generated by the fuel cell can also be used to heat the house. Finally, this hydrogen can be used to feed one or more vehicles powered by fuel cells. A general presentation along these lines opened the session by Sophie Didierjean from the University of Lorraine.

There is an obvious philosophical dimension to this dream that I won't explore here because tje technical aspects are enough to question it. This dream is, in a way, an attempt to save suburbia in the US, that has been successfully exported to Europe. It happens that suburbia here is the exception rather than the norm, as European suburbs are synonymous with cheap vertical housing, where most folk park their vehicles in the streets and commute by mass transit.

There is then another important issue - financing. For a new house, this technology pipeline can easily increase costs by 50% on a rough estimate, added to which is the increased cost of vehicles. These cost increases translate themselves into higher debt levels, that combined with present-day interest rates can be a killer. For grid connected solutions we have feed-in tariffs that anticipate financial returns and offload investor risk, but for disconnected solutions, this isn't the case. The case can be posed for directed subsidies for the acquisition of disconnected technologies, but it misses the social contract that feed-in tariffs force, guaranteeing that micro-producers are the most effective possible, favouring higher net energy; this is something much harder to accomplish with disconnected solutions. Once again this can easily become a philosophical discussion - should society finance a system that translates into detachment from it?

Hydrolysis

Going straight to the crux of the matter, I'll jump to Volker Loos, from the Fachhochschule of Trier, who gave a general presentation on the possibilities of H2 as an energy vector. I'll have to start from the finish, since it was during the Q&A session of this talk that the critical question came from the audience regarding the efficiency of hydrolysis today. At best this figure can approach 80% for a water temperature between 70 ºC and 80 ºC. Not bad, but the problem is that the process of H2 usage has just begun; after that comes compression, storage in a container, decompression and electrochemical processing through a fuel cell or by combustion. In all these steps there are mass and energy losses that further cut efficiency; the end result is far from mature electrical storage technologies like back pumping in dams or magnetic flywheels, and also far from other emerging technologies like large scale compressed air storage.

Another thing worth retaining from this presentation is the idea of injecting H2 generated at renewable energy parks into the natural gas supply grid. If there is a way I can see H2 working out, it is that there are only two conversion steps in the process, hydrolysis and combustion. Apart from that it is also important that most of the infrastructure is already in place. The idea is quite simple: using the natural gas grid as a large buffer when demand isn't there for the electricity generated by renewables. The obstacles I see to this scheme are that in the first place, the suitability of the grid, designed to transport a considerably heavier molecule (methane) thus perhaps permeable to H2, thus raising security and efficiency questions. And finally, the entire efficiency of the process: assuming a best case 80% for hydrolysis, no mass losses and 60% for a combined cycle combustion, the end result is below 50%.

Finally, Volker Loos mentioned that several automakers have plans to introduce fuel cell powered cars in the following years: Mercedes in 2014, Toyota and General Motors in 2015, and Volkswagen in 2020. The price of these cars is at this time estimated to be 20% over that of present day hybrids. It remains to be seen what the impact of the increased demand for platinum will be on these estimates.

Platinum

And then to talk about platinum was Nathalie Job from the Universiy of Liège, an institution presently researching synthetic carbons to produce electron conductors for fuel cells. These conductors should both reduce the rate of platinum used per fuel cell and increase the life time. The details of this work can easily go into electrochemical aspects that are well outside my realm of knowledge. A read of this article may help you get a better idea of what this research is about.

Nevertheless, one can have an idea how important this issue is by using basic algebra. Platinum is one of a handful of metals known to man that are denser than gold, found in the crust in about the same abundance as the latter. But platinum is much harder to find and mine, thus its annual production is about 10% of that of gold, in the order of 200 tonnes. Every year close to 60 million cars are produced in the world - if all of them required the usage of platinum, those 200 tonnes would translate into little over 3 grams (about 0.15 cm^3) per car; fuels cells require in the order of 0.5 grams of platinum per W of power output. Any massification of fuel cells shall require totally platinum-free technology.

Chemical storage

Then, on the chemical side of things was Yaroslav Filinchuk from the Catholic University of Louvain. He came to present a theoretical concept for the storage of H_2 using borohydrides, an highly reactive, porous material that can store light gases. The basic idea is to use the hollow spaces that the molecular structures of these materials create to “lock” inside smaller molecules. The main advantage is the possibility of storing H_2 at ambient temperatures, thus avoiding energy losses in compression/decompression or liquefaction/gasification processes. They may also reduce mass losses during storage, but once again my knowledge is thin on the field, so I recommend again a closer reading of a recent article on the subject.

Continuous electrical generation

Ending the session was a host speaker, Angel Scipioni from the IUT, presenting the energy mix of France. This was mostly a generalist address with lots of interesting numbers cast here and there, clearly showing that the largest state of the EU has lagged somewhat behind on the build-up of renewable infrastructure, because it has a huge nuclear park. What struck me was a direct reference to Peak Oil, but in the past tense, as an additional reason for a transition to renewables and H_2. Even though acknowledging it, Angel Scipioni seemed not give much importance to it, stating that France had so far coped well with higher petrol and diesel prices. I wonder how widespread this sort of view is; in any case it is a reminder of how far the awareness raising process still has to go.

Angel Scipioni finished his talk quickly, explaining a research project presently in place at the IUT. The idea is to combine different renewable energy technologies with H_2 generation and storage to build a system capable of continuous electrical generation. The concept uses, for instance, technologies that generate electricity from low-speed winds. One day I'd like to see an net energy assessment of such system.

Conclusion

So the hydrogen dream lives on. Where will these research projects lead? Are all of them in vain? Perhaps not, but hydrogen continuously appears somewhat behind alternative technologies; for a massification of it to use as an energy carrier, nothing short of a revolution will do. In many regards, huge steps forward will have to be made in order to bring efficiency into a comfortable zone. With several other technologies closing in on maturity, there doesn't seem to be much time left. And finally, whenever I reflect upon hydrogen, I'm always somewhat baffled as to why molecules like ammonia (heavier) or methanol (heavier and less hazardous) aren't preferred as energy carriers.

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