Hydrogen, don’t give up!

For decades, hydrogen has been sold to us as the energy carrier of the future. You might not want to hear it anymore, because the future never seems to start. But times will change as recent developments in Germany indicate, writes Berlin-based renewable energy consultant, Stephan Franz.

APRIL 9, 2018 STEPHAN FRANZ

OPINION & ANALYSIS GERMANY WORLD

The pioneers of the electric energy transition continue to seek new solutions, and eventually the political framework in the energy sector will become more innovation-friendly in Germany again.
Image: Nel Hydrogen

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It doesn't really look good for the hydrogen economy (at the moment). For decades, in numerous research projects and publications, hydrogen has been touted as the energy source of the future. The problem, it is often noted, is that the efficiency of hydrogen production is too low.

Typical efficiencies of electrolyzers lie between 75 and 80%. Further losses of between 5 and 35% result from the compression or cooling of H2, molecular hydrogen, in order to store and transport the gas in a reasonable way.

For on-site use or a direct feed into the gas network, a conversion efficiency of 70% can be assumed. In the case of a reconversion of hydrogen into electricity through fuel cells, another 50% of the energy is lost as heat (energy), resulting in an overall process efficiency of 35%.

In the automotive sector, lead is long gone. We have been promised fuel cell cars by established car manufacturers for decades, and now others are showing us how fast technology can disseminate with battery-powered electric mobility.

According to industry estimates, there are around 60,000 battery-powered e-cars on German roads and, depending on the source, there are 5,000-8,000 publicly accessible charging stations, some with several charging points. By contrast, the roughly 300 hydrogen-powered cars and around 45 hydrogen refueling points in Germany are lagging behind significantly.

This is partially due to the high prices of the cars: The cheapest H2 car costs around €65,000 in Germany, while battery-powered e-cars are available from around €20,000.

Accordingly, the German economic magazine "Wirtschaftswoche" announced the "death of a fuel cell" last year, "invented in 1966, abandoned in 2017".

The important economies of scale stemming from the use of hydrogen technologies in cars will

collapse of lithium batteries of around 20% per year with current storage costs on an industrial scale between €0.05-0.10 per kWh and efficiencies above 90% worsens the outlook for all non-lithium storage technologies.

Further, even the second important competing product for renewable gas is currently too cheap: fossil natural gas. Due to fracking and LNG transport, world market prices for natural gas have fallen rapidly: The average import price in Germany in 2016 was around €0.015 per kWh, i.e. 1.5 eurocents per kWh.

With current costs of water electrolysis around 10 euro cents per kWh without electricity costs, hydrogen in the electricity and heat sector will not be an economic alternative for some time to come.

Even the five cents presented during the last **pv magazine** Future PV roundtable, which can only be achieved under optimal conditions (PV systems in sunny areas with large, continuously running electrolyzers), seem like a joke when compared to low natural gas prices. Thus, the lower-scale use of hydrogen in the energy system remains unprofitable.

This applies to the electricity sector in particular, but in the heat sector, too, it is better to continue heating with efficient CHP systems. In the medium term, only emission taxes or other ways of increasing the price of natural gas might change this.

The missing business case for hydrogen in the energy industry is reflected in the economy of power-to-gas (P2G) projects in Germany. According to the German Energy Agency’s power-to-gas strategy platform, there are 33 pilot projects in the country, of which two-thirds were started between 2011-2014. In 2017, only one new pilot project was started, at the steelworks of Salzgitter Flachstahl in Lower Saxony.

Please stay tuned anyway

But this is just a snapshot, characterized by short-term, well, maybe medium-term considerations. In the long term, the chances are there. After all, hydrogen (H2) is the most common chemical element that occurs only in bound form in nature.

Through the electrolytic process that was invented more than 100 years ago, chemical compounds can be split by means of electric current. Thus, hydrogen can be produced using cheap renewable electricity and, you guessed it, water.

When reconverted into electricity using fuel cells, hydrogen still has the potential to constitute the "missing link" of the energy transition. The focus here is on the seasonal storage of energy for the winter months.

The competing product for offsetting fluctuating RE production is fossil natural gas, whose storage infrastructure can be used at least in part. In the Wesermarsch in North-Western Germany, for example, conventional utility, EWE is testing whether hydrogen can be stored in the huge underground caverns that were built as natural gas storage facilities.

Such applications for hydrogen in the area of power-to-gas (P2G) were discussed during several panels at the recent Energy Storage Europe event, held last month in Düsseldorf. This indicates that hydrogen applications in the energy system tend to be seen as having potential in sector coupling in the medium term.

Thus, this is the time to keep the use of technology open and evolving. The key element here should be the development of attractive segments in which hydrogen can already be used effectively (today): the substitution of conventional hydrogen produced from natural gas for industrial processes, for example, through stricter legislation on the decarbonization of the chemical industry.

This might include the admixture of hydrogen into the natural gas grid up to 9%, by the gradual and regionally differentiated increase of the current admixture limit of 2% (in Germany). And the use of hydrogen in large transport vehicles.

Even though battery electric cars are currently taking over, other applications in the transport sector are more difficult to develop with batteries. For example, in shipping and rail, the hydrogen economy could reach market maturity faster. Alstom, for instance, is currently developing a H2 regional train for non-electrified routes, which enjoys brisk demand from transportation authorities in Germany.

The pioneers of the electric energy transition continue to seek new solutions. We should not forget: For decades, PV too was considered to be a far too expensive future energy. In other words: hydrogen – please don't give up!

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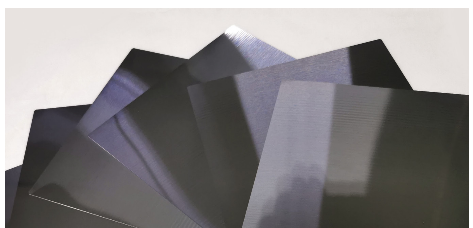

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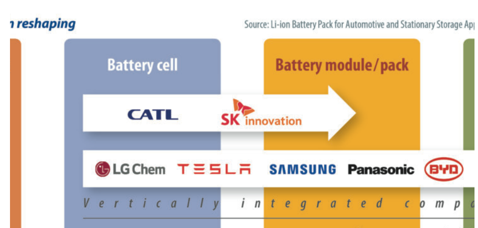

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Pingback: Hydrogen, don't give up! - Renewable Energy Times

James Wimberley

REPLY

April 9, 2018 at 1:31 pm

"With current costs of water electrolysis being/of around 10 cents per kWh without electricity costs .." The only way I can make sense of this is that the designers of electrolysers have been focussing on the wrong performance metric, conversion efficiency. The future in high-renewable countries like Germany will include long periods of weather-driven surplus electricity supply, zero marginal pricing, and forced curtailment. The marginal cost of electricity for electrolysis will at such times be nil at the point of production, the cost of transmission elsewhere. It won't matter if the conversion efficiency is low as long as the capital equipment is really, really cheap. Thought experiment: start with the biggest sealed plastic tank you can buy, seawater, and two fat stainless steel electrodes. On second thoughts, do not try this at home.

James

July 16, 2018 at 4:24 am

Correct. The US DOE is modeling electrolysis in its H2@Scale study at 2 cents/kWH. You can do all sorts of interesting things with H2 at that cost. BY way of additional reference, California now PAYS up to $25/kWH to dump curtailed renewables in to neighboring states. Where it does't displace fossil fuel, it simply displaces other renewables. Various metrics in this article are off by an order of magnitude. The highest electrolysis efficiency is approaching 90% I believe.

When your raw feedstock is unlimited and free, conversion efficiency is not the most critical metric. Seasonal storage and deep decarbonization are. Batteries can't get us to either. H2 can. H2 can decarbonize steel and cement production, biofuel production, heavy duty transit, and home heating. It can also provide seasonal storage of renewables for 100% of grid needs, not just shave off 2-4 hour s for a single day.

Peter Campbell

REPLY

April 10, 2018 at 2:34 am

First of all although it sounds improbable the practical efficiency of electrolysis is 80%; and with a high renewable energy percentage and lots of curtailment its 100%. I'll try and explain how.

Basically with electrolysis, although the voltage efficiency may be lower than 80%, the heat generated by the process is used to generate the steam which is required by the catalyst. So within a closed loop, the electrical efficiency of the electrolyser is increased by 10% or more.

"Very roughly, a new electrolysis plant today delivers energy efficiency of around 80%. That is, the energy value of the hydrogen produced is about 80% of the electricity used to split the water molecule."
carboncommentary .com/blog/2017/7/5/hydrogen-made-by-the-electrolysis-of-water-is-now-cost-competitive-and-gives-us-another-building-block-for-the-low-carbon-economy

The figure used in the wikipedia entry is from 1996 (!) – lots of misinformation being spread:

"Reported working efficiencies were for alkaline in 1996 lying in the 50–60% range for the smaller electrolysers and around 65–70% for the larger plants.[22] Theoretical efficiency for PEM electrolysers are predicted up to 94%.[23] Ranges in 2014 were 43–67% for the alkaline and 40–67% for the PEM, they should progress in 2030 to 53–70% for the alkaline and 62–74% for the PEM."
en .wikipedia.org/wiki/Electrolysis_of_water

So its 80% with modern techniques, electrical efficiency.

The next part now we have 80% electrical efficiency is how do we get up to 100%; and I'll explain.

Going through the maths in detail, we shall consider that depreciation is 100% for all of our infrastructure (man-made salt caverns or NG caverns, and pipes to caverns, PEM electrolyser).

part a:
The electricity from a renewable source is say 100% efficiency; but we can't store much more than a few hours so we reduce the efficiency by the amount of curtailment; maybe 20% or higher when the percentage increases.

So its 80% of the full potential for this renewable energy source.

part b:
The efficiency of a PEM electrolyser is 80%. So you lose 20% of the electricity generated. However, because you can utilise the lost 20% due to curtailment, you are actually back to 100%.

So its 100% efficient, not 35% efficient. And no, its not a round trip energy value; its the energy value of electricity converted into gas which can be stored in volume and utilised in all the sectors where natural gas is utilised today.

Tarkovacs Stefan

May 31, 2018 at 2:13 pm

Could we be in touch ? Stefan Tarkovacs

Emil Mikhailoff - CTO, Grainis ltd. Hydrogen Bulgaria

REPLY

April 10, 2018 at 3:37 am

I suppose, based on my 12-year experience, that the Electrolyzer design, shown on the picture, perform a very high H2-leakage rate. No sealant could stop that leakage. Also, there is a significant congestion of gas bubbles between the electrode plates, which slows down the electrolysis process and decreases its efficiency.

Jonathan Stokes

REPLY

April 16, 2018 at 4:53 pm

Electrolyser systems typically require the over-sizing of subsystems, such as the power supply and thermal management, which is a setback. They are composed of a varying number of cell stacks which affects the cost, rate of production and efficiency. New researches in membrane technologies by engineers might increase conductivity, and reduce the amount of precious metals required in the process.

kafantaris

REPLY

April 26, 2018 at 11:13 pm

There’s no need to choose between hydrogen or battery when you can have both in the same car — giving you advantages of two technologies — and a combined range of over 1000 miles. But you won’t want to drive this car that far, preferring instead to have it parked in the driveway and watch it from the kitchen window. That’s how breathtaking and original it is — designed by a young man who grew up two blocks from the Packard Brothers. That’s right, an Ohio company is building a long range hydrogen/battery car in California that’s about to steal your heart away.

Claus-Rüdiger Martin REPLY

May 7, 2018 at 6:55 am

I want to make it short:
1. H2 is linking mobility with heating, cooling and producing own electricity.
2. H2 is locally cause of local storage for a certain time enabling autarky concerning mobility, heating, cooling, electricity.
3. So its use makes independend from an instantly working net central regulated electricity net. So a sudden blackout dependend on a working software is ruled out.
4. Its storage concerning day-night and summer-winter is cheaper, and local.
5. Most important: H2 use can be used quickier by Third World Countries, even at all, because it’s affordable. Cable infrastructure and batteries aren’t affordable to them.
6. In addition sunny states can produce their own h2 fuel and will be politically and concerning energy independend and autark.

Bob Wallace REPLY

May 26, 2018 at 6:07 am

Hydrogen generated by reforming methane is an energy source. But it's an energy source we must avoid using unless we can find an affordable and guaranteed way to sequester the released carbon from the methane.

Hydrogen from electrolysis is an energy storage method.

Hydrogen might be a usable energy storage method in some cases. And it might be a good way to provide industrial heat that is now supplied with fossil fuels.

Hydrogen is not likely to be a fuel for shipping, as in transoceanic shipping. Energy per volume problems.

And it's unlikely that there's a role for hydrogen for road-traveling vehicles. At 35% electricity -> kinetic energy efficiency the electricity per mile would cost well over 2x that for an EV.

Then one has to add in the cost of infrastructure for electrolysis, compression, storage and distribution. EVs will simply kill H2 FCEVs based on cost of operation.

Plus plugging in is a lot more convenient that driving to a filling station.

Bob Wallace REPLY

May 26, 2018 at 6:10 am

Hello mod,

How does one follow comments on this site?

Max Hall

May 28, 2018 at 9:22 am

Hi Bob,
Thanks for the interest, I'm afraid you will have to log on to each article and read the comments to stay abreast of what our readers are discussing,
Max

K. H. Flottorp

REPLY

May 30, 2018 at 9:48 pm

You address two issues in the same article:
1.Production of Hydrogen – the simplest is through methane/hydrite – needs waste and will generate cheap hydrogen in free form.
2. Storage and pressure. Above 350bars, hydrogen becomes a liquid and then solid and need special valves. Just like water. It is not that simple to hold solid / liquid as gas that most believe hydrogen is.
3. You assume fuel cells to generate electricity. There is a variant of the rotary Wankel engine that has a better efficiency than fuel cells – unmodified without feedback they are at 0.60 but with modifications, above 0.8. A large scale generators has been made with this efficiency. And beware: this does not need any gearbox so it can drive a propeller with the engine where the gear is located on an outboard z-drive. The rest: engine room and fuel tanks can be used to hold hydrogen tanks. What if you can fill a cruiser up for the entire summer cruising in one shot?

Pingback: Científicos japoneses buscan reducir los costos de hidrógeno producido por la FV – pv magazine Latin America

shady

REPLY

April 19, 2019 at 2:50 am

Water electrolysis cell driver circuit new idea.
Dear,i have new idea for production hydrogen by electrolysis method this idea is[driver circuit for electrolysis cell working by new concept] very high production rate by using this driver circuit. can me display my idea to your company?thanks

Talis

REPLY

May 10, 2020 at 1:08 am

Good article, thanks Stephan Franz.

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