ReTHINK Energy

*Rethink Energy monitors the transition to fully renewable energy markets*

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## Key Issues

# Hydrogen from waste 'could be carbon negative'

We're in the early stages of a race to build-out the production capacity for green hydrogen, with the energy sector starting to come around to the idea that the technology will be key to tackling emissions outside the electricity grid. But with a lack of renewable capacity going spare for electrolysis, finding other sources of clean production will accelerate how quickly the 'hydrogen economy' materializes. Ways2H is among the wave of start-ups that are exploring other technologies, suggesting that municipal solid waste can be processed to extract hydrogen at competitive costs in the near term.

In conversation with Rethink Energy, Ways2H CEO Jean-Louis Kindler was keen to steer away from describing the company's process as 'gasification' – worried about the negative connotations that this has from typically dirty methods of hydrogen production.

While the process is essentially the same – the use of a waste feedstock can, in essence, turn the production of hydrogen into a carbon-negative process. Using a processed feedstock of Municipal Solid Waste, where inert materials such as glass and metal have been removed, particles of between 1 cm and 2 cm are mixed with ceramic beads that have been heated to around 1,000°C. At this heat, the bulk of the waste is converted to methane, hydrogen, carbon monoxide and CO2, while a portion is left as solid char – which can be identified as 'stored carbon.' This char is recovered and burned as the supply of heat for the ceramic beads.

The mixture of gases then undergoes steam reforming, to produce hydrogen and CO2 from the methane – improving hydrogen yield by 50%. Depending on the initial feedstock, Ways2H claims that one ton of dry waste can produce up to 120 kilograms of hydrogen – although typical yields sit between 40 and 50 kilograms. This depends on the water content of the feedstock – which inherently boosts hydrogen content – with the 120 kg figure coming from Ways2H's pilot in South America, which uses sewage sludge as its feedstock.

Through capturing and storing the carbon from the process, Kindler has stated the company's goal to fall into a carbon negative

position – although the initial costs hinge on the elusive development of sequestration and CCUS technology.

**By producing hydrogen from waste, Ways2H hopes to maximize the amount of wind and solar dedicated solely to electricity production**

Municipal solid waste refers to most day-to-day waste from homes, businesses and medical facilities – with around half of it typically coming from food residue. On a global scale, the vast majority of this goes into open dumps (33%) and landfills without gas collection (28.9%). With a high biomass content in this situation, waste can be a major source of methane – with an 84-times greater impact on the climate than CO2, over a 20-year period. By processing waste for green hydrogen, the amount of methane emitted from waste can theoretically be eliminated – bolstering the climate footprint of Ways2H's approach.

The other issue that the technology addresses is the current capacity to source green hydrogen solely from renewables. Using alternative technologies, such as those of Ways2H, wind and solar can be left dedicated to electricity production. To reach suggested targets of 24% of the world's energy mix by 2050, green hydrogen production would demand 31,320 TWh of electricity – more than the 26,000 TWh of global power generation from all sources, and far more than the 3,000 TWh of wind and solar power generation used for electricity today.

We are starting to see momentum gather around renewables dedicated to green hydrogen. Germany's five coastal states and transmission system operators are currently eyeing the country's new 30 GW target for offshore wind as an opportunity for electrolysis. Shell and Eneco are also currently bidding to power green hydrogen production with a Dutch offshore wind farm, while other pilot projects are popping up on a global scale.

In this regard, green hydrogen appears to be in the same place that solar and wind power were 15-years ago, and we anticipate that by 2035 we'll have seen some mammoth growth within the sector. Just as we've seen within renewables, the 'farfetched' ideas of parity in the energy sector will become more and more realistic as costs continue to fall.

Green hydrogen typically costs between $11 and $16 per kg, although we saw prices as low as $2.67 on the open market from Canadian company H2V energies. This is however, still higher than 'grey' or 'brown' hydrogen from fossil fuels, which costs between $1 and $1.8 per kilogram.

For parity to be reached, several things need to happen. Firstly, government support will need to incentivize the early growth in the sector, in the same way we saw feed-in-tariffs facilitate a boom in solar power. This should focus on the current Catch 22 scenario of what's going to come first out of production capacity or distribution infrastructure and allow economies of scale to be reached through the rapid build out of manufacturing facilities. It's also important that carbon pricing puts negative pressure on the cost of existing hydrogen feedstocks – which could squeeze 'grey' hydrogen prices above $2 per kg in the near-term.

But currently, prices aren't that low, and predictions of $1 per kg of green hydrogen are probably on the optimistic side for the next 5 years. This will provide a serious barrier to early investment, especially in lieu of government support. This is where alternative 'greenish' hydrogen from the likes of Ways2H and Proton Technologies can establish an early share of the market.

Ways2H currently operates at a cost of around $5 per kg – although this depends on the feedstock – with Kindler suggesting that costs will fall to around $3 per kg in the next 5 years. With renewable capacity neither sufficient, nor cheap enough to produce green hydrogen at scale in current markets, "Each and every solution that we can use to produce hydrogen in a clean manner is extremely welcome," says Kindler. This will also be needed to meet the promises made in the trucking, steel, and cement industries, for 30% green hydrogen by 2030. Analysts have indicated that the cost of these subsidies will be around $150 billion.

**The first role of green hydrogen will be to replace existing hydrogen feedstocks produced by fossil-fuels**

The adoption of clean hydrogen will probably first replace existing hydrogen feedstocks, where brown or grey hydrogen have previously been used, before making its way into industries such as steelmaking, cement and heavy trucking. The purpose of promotion policies from governments should be to instigate and maintain a virtuous cycle of rising demand and falling prices for green hydrogen – allowing entrance into markets such as ammonia production, shipping and electricity storage.

The technology – and the birth of Ways2H – comes as part of a joint venture between Clean Energy Enterprises in the US and Japan Blue Energy Corporation, with the latter more focused on the technical aspect of the technology which it has been developing for over 20 years. Clean Energy Enterprises has a greater role in commercializing the technology.

The first pilot of the technology was operational in Japan between 2002 and 2005. Since, four demonstrator projects have been installed, including a 50 kg-per-day system in Japan, as well as others in California and South America. This has allowed Ways2H to overcome the unstable equilibrium issue that gasification projects have faced in the past. The company currently claims to be in "serious discussions" around 2 commercial projects, with dozens of prospects in countries including India, the Philippines, the US and throughout Europe.

Finance, so far, has come largely from private investors in the US, although the company plans to enter a second round of funding in coming months to boost its commercialization.

**"There has been a deafening silence from the oil and gas sector in the hydrogen economy" says Kindler**

Interest in commercial projects has been more focused on the waste management side of things, rather than on the production of green hydrogen. While we would have expected fossil fuel players to be keeping a keen eye on different approaches to green hydrogen, Kindler stated that "There has been a deafening silence from the oil and gas sector in the hydrogen economy," – casting further suspicion over net-zero promises.

This has favored the company's smaller system, which can process around 1 ton of waste per day and aims to provide a decentralized and transportable approach to waste management. Early interest has been shown from medical companies for immediate waste processing. The demand from these sectors has come from companies facing a more difficult scenario for waste than they have in recent years, after losing the outlet for plastic disposal in Asia since EU regulations came into play in 2017.

This can also tackle tipping fee costs. In California, for example, municipalities have to pay in excess of $100 per ton to have their waste processed.

These smaller products can help provide key demonstrations of Ways2H's technology, but to make a dent in the possible demand for hydrogen, the company will hope to scale the production of its larger, 20 to 30 ton per day model, while also aiming to produce 200 ton per day systems.

In demonstrating the scalability of gasification for green hydrogen, Kindler cited the 1 billion tons of biomass waste in the US

each year. If all the hydrogen were extracted out of these systems, it would be enough to completely displace the energy produced to power vehicles with gasoline in the country. While acknowledging this as a demonstration of the scale, Kindler stated his belief that waste can provide a third of the world's hydrogen needs in the long run.

## Energy Storage

### Fuss over Form Energy could be applied to any one of 200 start ups

When we last looked at Form Energy, the aqueous battery specialist part-funded by cash from Bill Gates' Breakthrough Energy Ventures fund, we were annoyed at the huge amount of publicity it received primarily because Gates was among the investors. Now as it moves within a few years of its first installation, we find ourselves annoyed at how it alone has sparked a debate about whether Lithium Ion is the right battery technology to store renewables grid energy.

There are hundreds of other companies that should have sparked that debate – and there are hundreds of worthy investments which have a chance at becoming either long duration storage or simply a rival to Lithium Ion.

We talked this week to half a dozen energy storage specialists and each of them have placed their confidence in another form of storage, be it, compressed air, thermal storage, redox batteries of various kinds, mechanical (using gravity or momentum) or other forms of chemical batteries and we will hear from each of them in our forth-coming tracking service for energy storage.

But their collective view is that each type of energy storage had a benefit but most have at least one drawback and that Form Energy would be no different. Gravity based systems need something very heavy and very large to be built, or they require an existing 2 kilometer shaft, which often means putting it on the site of an old mine. The closer you get to town to build one, the higher the price of the land you build it on, and the more tricky the build if you want to dig deep. For compressed air storage, most systems rely on gas turbines to reheat the compressed air, so have a residual CO2 footprint. Thermal energy storage is bulky and requires huge areas in cities to be set aside for insulation of ducting for the heat, and are of course only efficient at supplying heat to thermal ap-

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