Key Features:

- **Company Focus:** Advisory & Consultancy Services
- **Stephen B. Harrison:** Founder & Managing Director
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FEATURE

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Could Turquoise Hydrogen Make Hydrogen Greener?

The emerging hydrogen economy and decarbonisation are diverse topics moving extremely fast. sbh4 offers hydrogen utilization and carbon capture training for investors, strategy teams, and operators in the energy, infrastructure, and industrial sectors. We talk with the founder of sbh4, Stephen B. Harrison, about the decarbonisation of methane using turquoise hydrogen, an emerging technology which encourages us to think of new possibilities for our long-term future.

There's been a lot of discussion lately about hydrogen and its role in decarbonisation and limiting global warming. Scaling up decarbonisation is enormously costly, and not all consumers can afford greener but more expensive electricity. Meanwhile, only a minority of technologies will be successful from the laboratory to the pilot plant to commercialization. sbh4, a company offering a range of consultancy and advisory services in hydrogen utilization and storage for investors, operators, and strategists, encourages companies and governments to consider the long-term ramifications of successful decarbonisation.

sbh4 offers a unique perspective on the different ways to produce hydrogen, and on the most affordable and potentially most promising approaches on a large scale. While green hydrogen from renewable sources emits no carbon emissions at all, it is currently expensive. A lot of hydrogen production technologies, such as blue, brown, grey, and black hydrogen – emit some sort of greenhouse gas emissions of carbon dioxide and need carbon capture technology downstream.

Another form of hydrogen technology is turquoise hydrogen, or methane cracking, a process which converts methane into hydrogen and solid carbon using pyrolysis (heat energy at high temperatures). This solid carbon comes in different forms, depending on the turquoise hydrogen technology (ten different turquoise hydrogen processes currently exist). Some produce higher quality carbon, such as graphite, through to high-value functional carbon black.

"If put to good use, carbon could be more of an opportunity than a problem"

While carbon is a dirty word in the energy sector, Stephen and sbh4 want us to think about this differently. A more important question, Stephen suggests, could be "what can we do with this carbon?" Turquoise hydrogen produces one ton of hydrogen and 3 tons of carbon. If put to good use, this carbon could be more of an opportunity than a problem.

Graphite is useful in lithium-ion batteries, and each electric car needs at least 25 kg of graphite. If we are going full electric, we need serious quantities of graphite.

Meanwhile, carbon black is also useful for tire making, so this graphite and carbon black could be useful for the clean automotive industry in general. Carbon can also be used for iron ore by reducing iron oxide and create high-value iron. However, this technology creates CO2. For every possible use of the carbon by-product, it would be necessary to work out if we are decarbonising an entire supply chain, or only moving the carbon emissions downstream. We need to be careful in our choices and consider the full lifecycle analysis as any decision will impact our future.

Chart 1: Example of Mythane Pyrolysis for Turquoise Hydrogen Production

Methane pyrolysis (cracking/splitting) for turquoise hydrogen production

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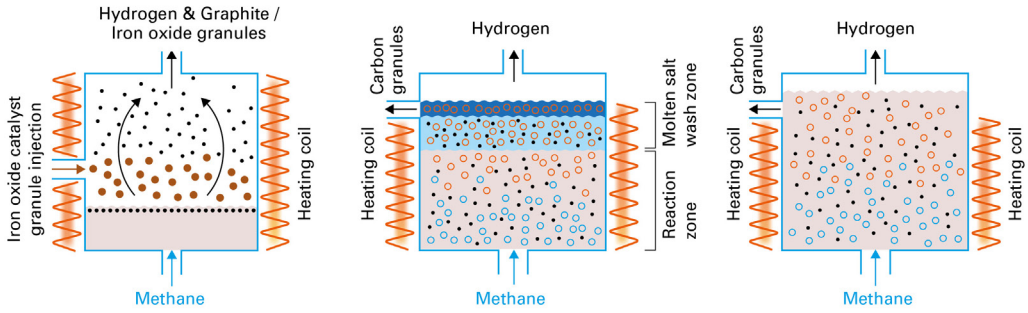
Notes:
- Unreacted methane can be separated from the hydrogen using PSA and recycled to the reactor
- The size of the carbon granules is influenced by operating conditions and the residence time of the carbon in the reactor
- Heat may be from renewable electricity
- Methane can be from natural gas or biogas



	Fluidised Bed Methane Pyrolysis	Molten Metal Methane Pyrolysis	Molten Salt Methane Pyrolysis
Process shown	Hazer	TNO EMBER	C-Zero
Hydrogen content as reactor outlet	~92%	~95%	~95%
Carbon production	80 to 95% graphite encapsulating iron particles	Carbon granules	Carbon granules
Catalyst required	Iron oxide granules	Molten 27% Nickel - 73% Bismuth	Molten Manganese Chloride
Heating mechanism	Indirect heat applied around the reactor	Indirect heat applied around the reactor	Indirect heat applied around the reactor
Reactor temperature	900 °C	1100 °C	650 °C
Reactor pressure	Close to atmospheric pressure	Up to 5 bar	Up to 5 bar

If turquoise hydrogen is going to be adopted and if we are to convert all the methane we have into hydrogen, we will have so much solid carbon on our hands that the solutions we propose right now and seem big to us will seem insignificant by 2050. As Stephen puts it, "Just pause for a moment and imagine hydrogen flowing in pipelines instead of natural gas, and enormous mountains of carbon".

sbh4 proposes radically different ways to use these massive quantities of solid carbon, looking to the past for inspiration. For instance, the Mayans and Incas used to fertilize soils using bio-char. We could do this too with our turquoise hydrogen coarse carbon. Instead of pursuing deforestation to create agricultural land to grow food, we could potentially use the enormous quantities of carbon created by turquoise hydrogen to improve fertilize soils and grow crops in the desert. This would end deforestation and world hunger at the same time. Solutions like this require a tremendously large-scale vision that considers the full variety of global issues.

This is the mindset we need to make decarbonisation and electrification a reality. We need deeply transformative solutions that can solve real-world issues. We need to actively research what to do with unimaginably large quantities of carbon, or of captured CO2, or any other fuels generated by any form of decarbonisation technology in any form. This is what our scientists, governments, and organizations need to focus on solving, and it needs to happen right now. HS

Image 1: Graphite Structure