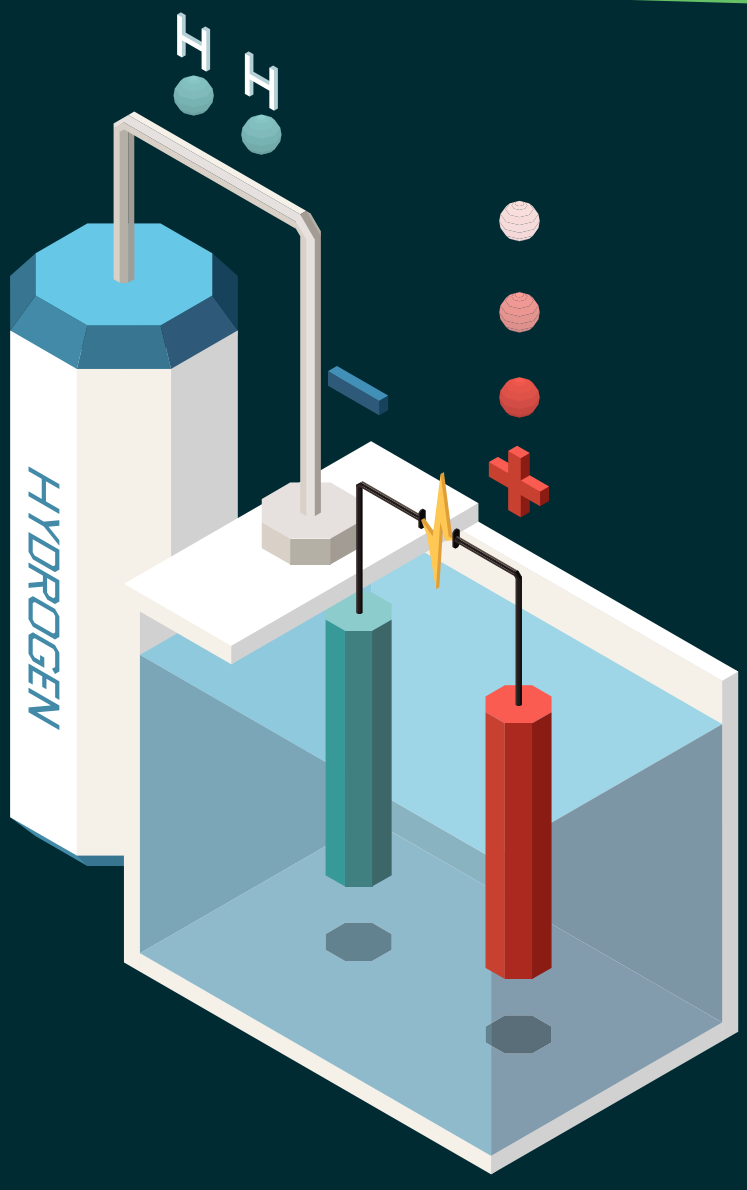
End of last year, BlueTech Research published an Insight Report on the Hydrogen Economy.

Paul O'Callaghan's team was kind enough to share it with me.

I expected it to be straightforward! The World needs to decarbonate, hydrogen is a tool for that, and it's a convenient way to stock excess renewable energy production.



So electrolysis plants will start popping up everywhere, representing a tremendous business opportunity for the Water Industry.

Simple!
Well, simple but...

wrong

That story is much more complex and intricate.

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Equipped with BlueTech's report as a precious translation tool, I went down the Rabbit Hole. In this upcoming trilogy, you will learn:

1. What to think about all the colors of Hydrogen
2. How the "Hydrogen Economy" may or may not impact the Water Industry (and where)
3. How Hydrogen may well have a strong link with wastewater treatment (and why)

So buckle up and embark with me: this journey starts in Vienna in 2018!

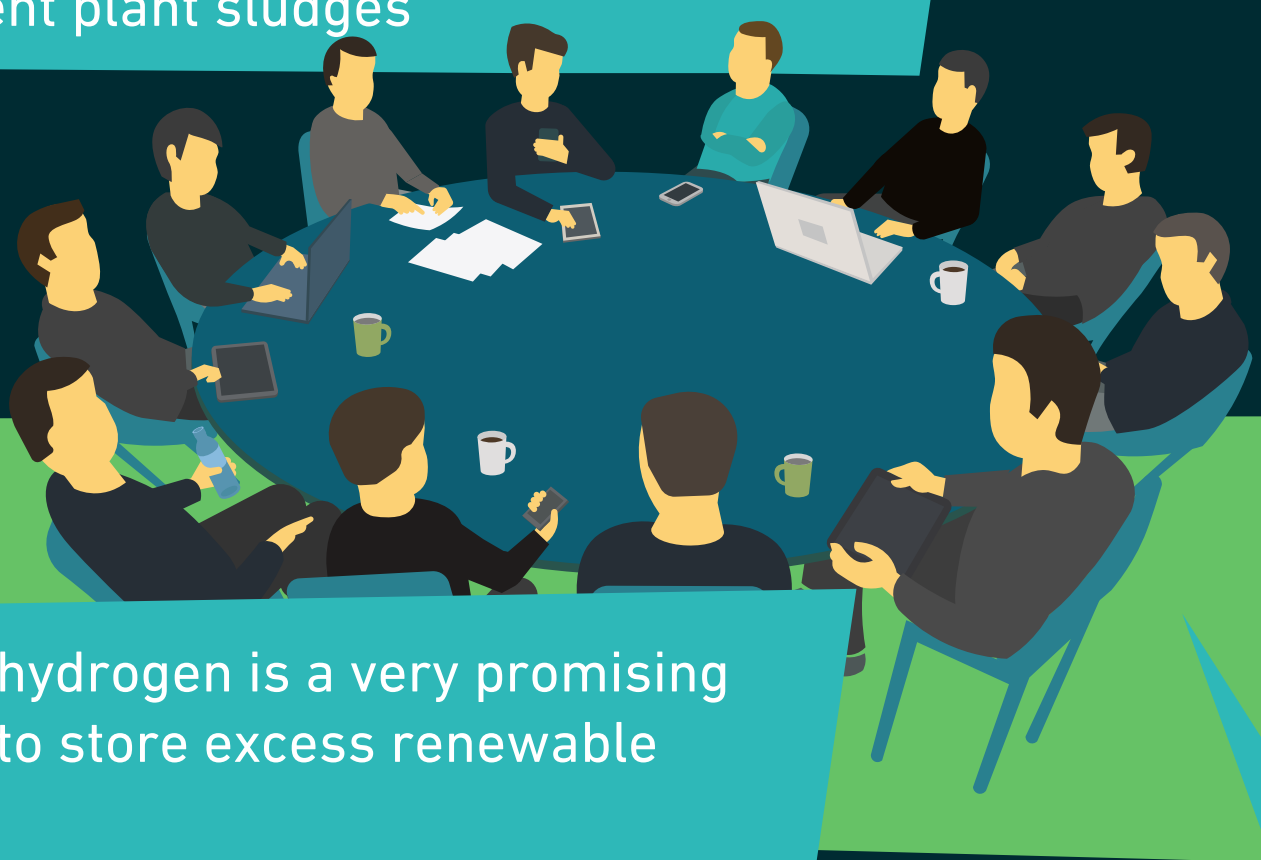
The first time I came across the topic of Hydrogen was indeed during the European Utility Week, and it started from the opening Keynote.

No less than five speakers mentioned it as the future of energy management in a decarbonized world.

Getting ready for the future, you're looking at hydrogen and biomethane...

... there will be "Power to Gas" approaches, like hydrogen for longer-term storage

... we're thinking of clean energy like the production of hydrogen from wastewater treatment plant sludges



... power to hydrogen is a very promising technology to store excess renewable energy

... there will be energy but not in the form of electricity, rather as hydrogen or biogas

The recurring example was, how Germany could solve its negative electricity price issue, thanks to green hydrogen.

The rapid growth of wind farms had triggered a weird effect: during the windy nights, the production of electricity was so much above the demand that power companies had to pay users to take energy out of the network and keep it balanced.

So, storing that energy (Power-to-X) was rapidly becoming the name of the game. And green hydrogen sounded like a good prospect. (it consists of electrolyzing water, to transform it into hydrogen - and oxygen).

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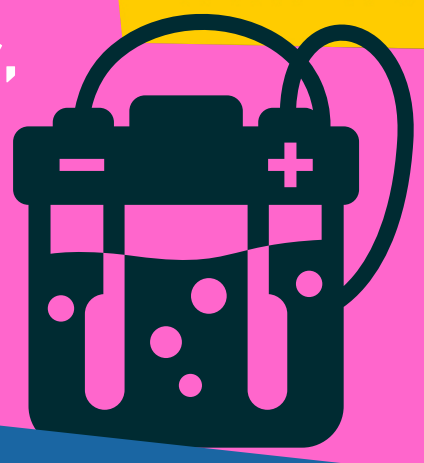


The colors of hydrogen

Green
produced through electrolysis, powered by renewable energy

Blue
produced by steam methane reforming from fossil fuel, but with carbon capture

Turquoise
produced through pyrolysis, from Methane

Purple/Pink
produced through electrolysis and powered by nuclear energy

Brown
gasified from coal

Gray
steam methane reforming from fossil fuel, this time without carbon capture

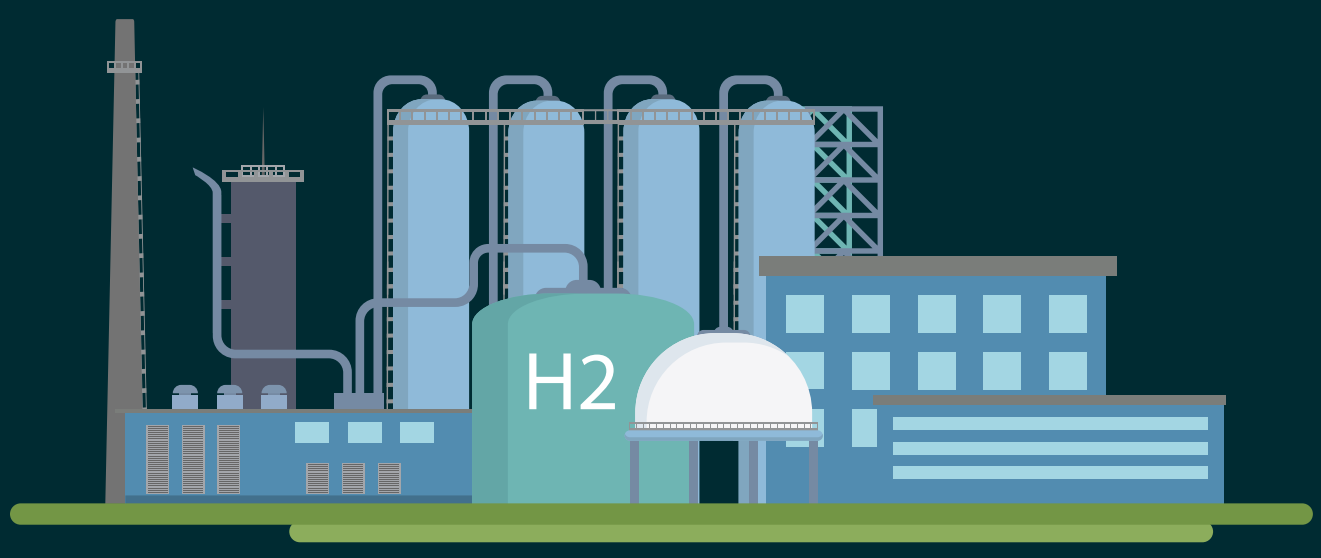
This is not gray, it's black, ultra-black, black hole black, 30% blacker than the fossil fuel that it's made from!

Meet Paul Martin, you'll get to know him better in a jiffy 😉

Now, we may see a colorful panel of Hydrogens and a promising prospect with the Green one.

Yet if we're honest:

98.7% of Hydrogen produced today is created from steam methane reforming from fossil fuel (gray).



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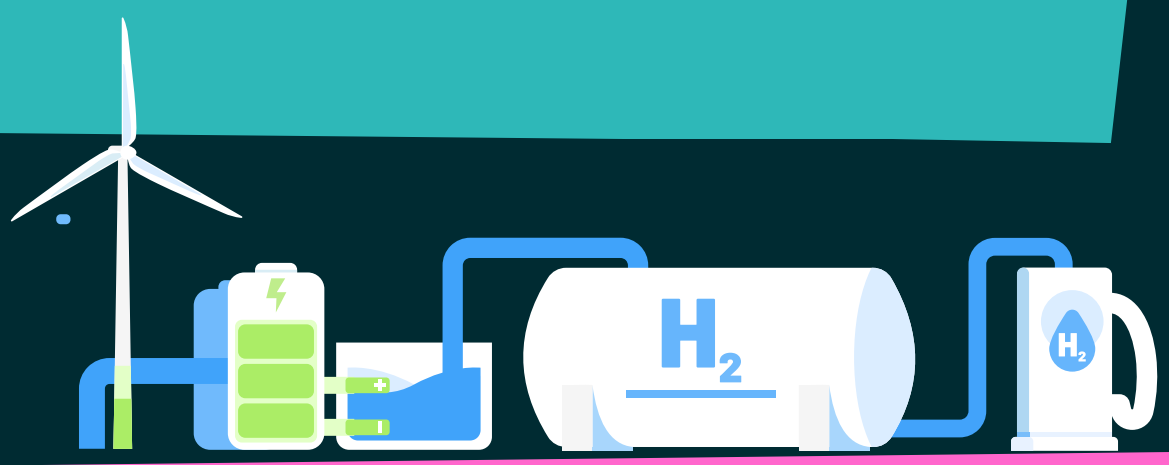
In other words:

There are only two kinds of Hydrogen in the World. The one you can buy (gray) and 1.3% hydrogen that's made as a by-product of electrolysis to make Chlor-Alkali chemicals.



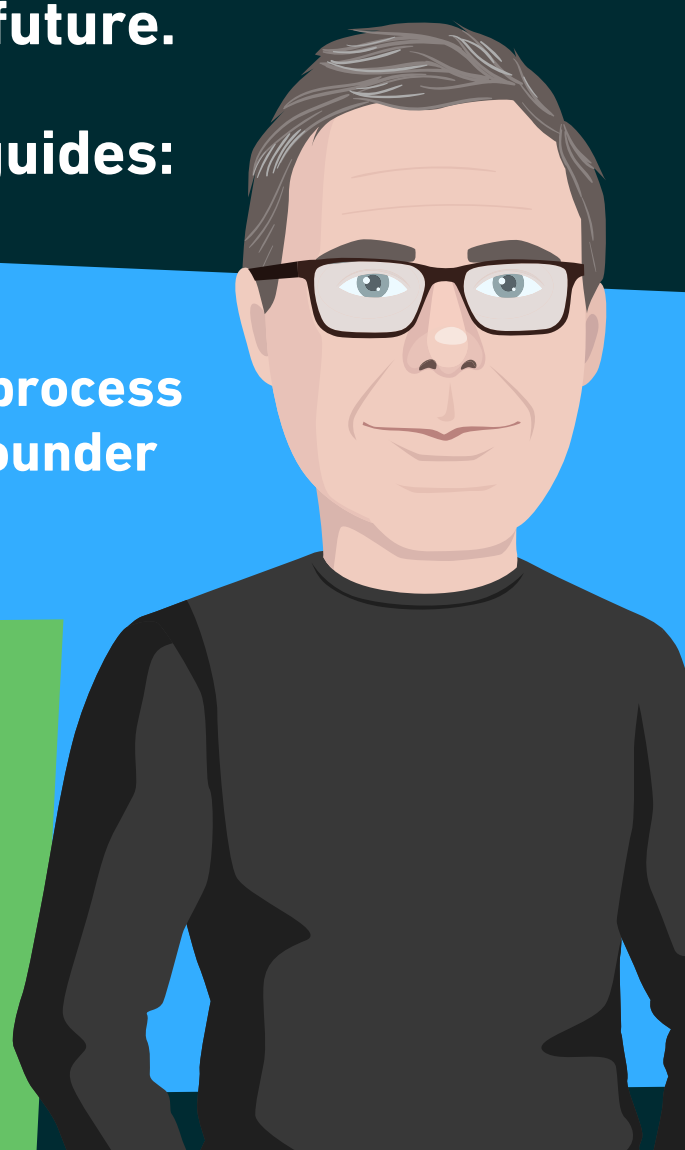
So regardless of the side you'll be picking, there's a common base everybody agrees on.
Long before upscaling (or not) the Power-to-X approaches, there's a lot to build in the wannabe-Hydrogen Economy.

And one thing's for sure: we must find a way to move away from fossil fuels to thrive in a decarbonized future.

Hence let me introduce you to our guides:

Paul Martin is a Chemical process development expert and founder of Spitfire Research.

Alena Fargere is Principal at SWEN Capital Partners and co-founder of the first European investment fund dedicated to renewable gases.



As we've seen, Hydrogen is always addressed as a way to decarbonize our World. Yet:

Hydrogen is more a decarbonization problem we haven't begun to solve and one that we must solve.

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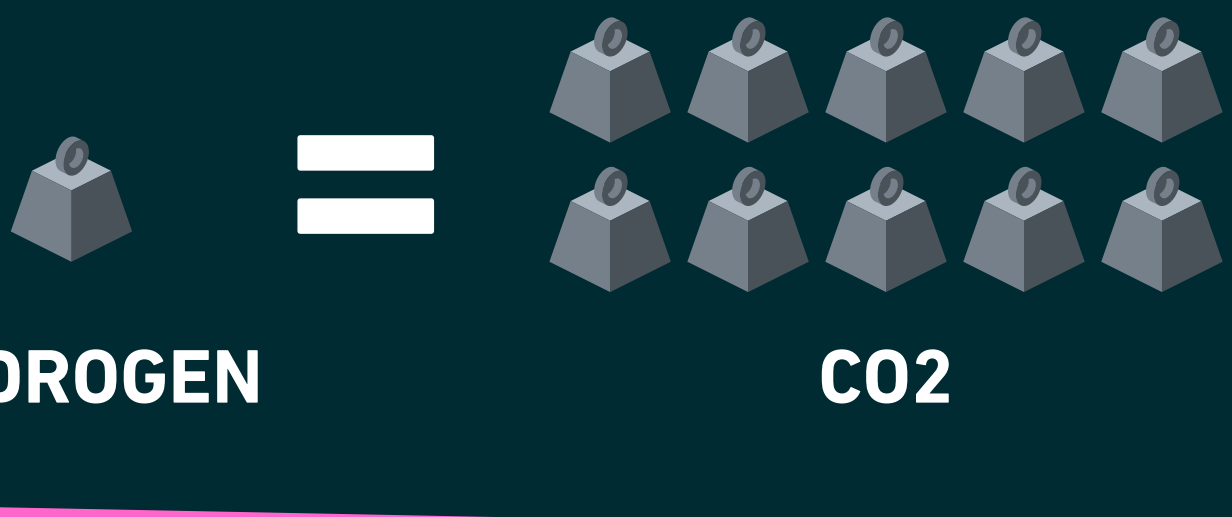
Why?

Today, the World is using 120 million tons of Hydrogen a year, and as 98.7% of it is being produced from fossil fuels, it is, in turn, a carbon-intensive good.

In a decarbonized future, the Hydrogen needs will fall to 90 million tons, as we no longer will have to desulphurize fossil fuels. Yet:

For one ton of gray Hydrogen, you're producing 10 tons of CO2



So, even in a decarbonized future, the hydrogen economy will be producing 900 million tons of CO2 a year if it doesn't move away from gray Hydrogen.

(And BlueTech's report shows how this is even twice worse when you're using coal as a feedstock, aka brown Hydrogen!)

Blue Hydrogen would enable us to capture 60% of this CO2 with the current market standards (and 90% with more advanced technologies)

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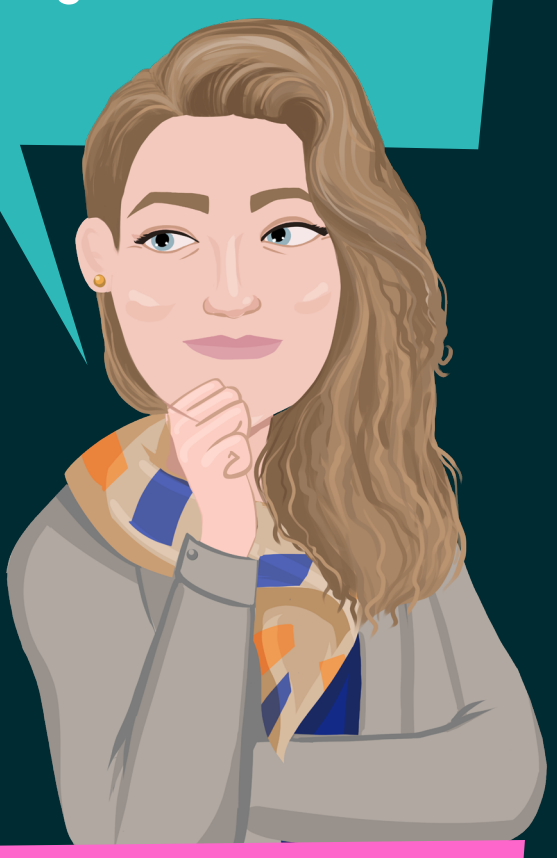
CO2
CO2
CO2
CO2
CO2

This adds 1-3€ per kilogram to your hydrogen production costs, knowing that today's gray Hydrogen costs 1.5-3€ per kilogram.



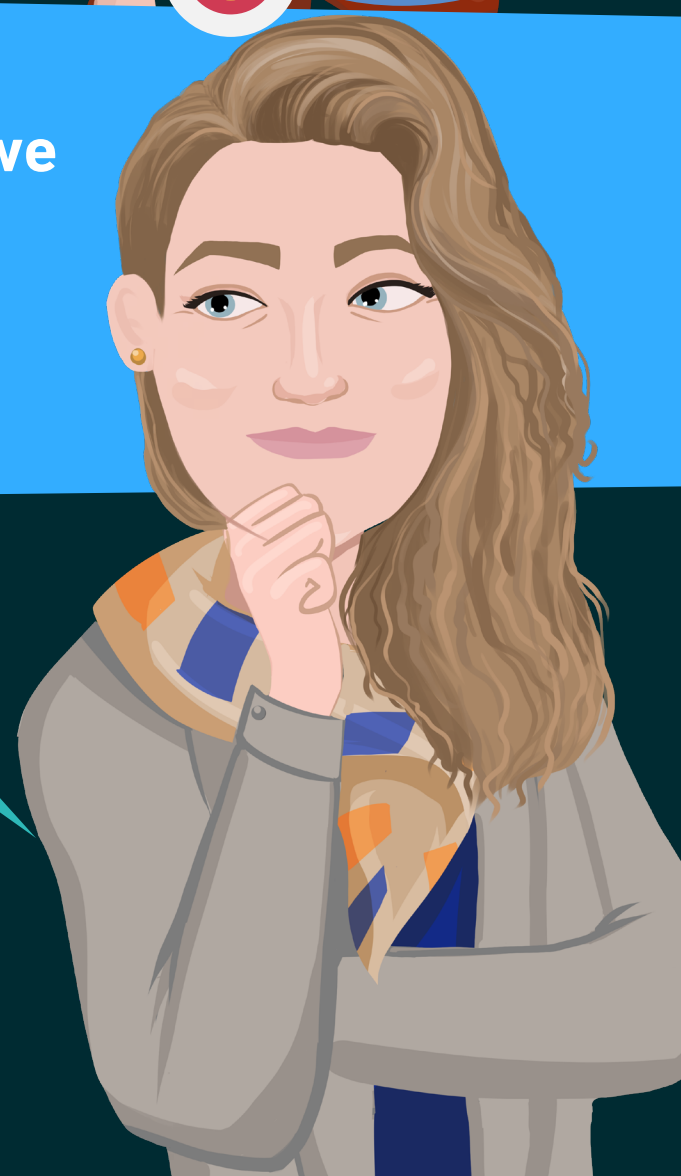
So, switching from Gray to Blue would double the price tag.

And that's not the only issue:

Today's carbon capture processes involve methane leakages, and Methane on a 20-year time horizon has 86 times the global warming potential CO2! So this Blue Hydrogen is Blackish.

Hence, if Blue isn't really a solution, what color shall we turn to?

Zero emissions can be done by replacing natural gas with biomethane, which has a zero carbon footprint...



That's, for instance, the case with Turquoise, (as we'll see in-depth next week)

... alternatively, you can leverage renewable electricity to run electrolysis of Water and produce green Hydrogen!

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Remember? That's the Hydrogen I was referring to, talking of Germany's excess wind power during nights.

... and that's also the Hydrogen we're mostly looking at, as water professionals, as it requires large amounts of very clean Water.

How much Water, exactly?

For one kilogram of Hydrogen, you need nine kilograms of Water, and the Water has to be pure.

So to decarbonize 90 million tons of gray Hydrogen, we'll need

810 million tons of Water

(aka, cubic meters).

If we factor in the water needs of the cooling process, that roughly multiplies the figure by ten, reaching

9,180 million cubic meters.

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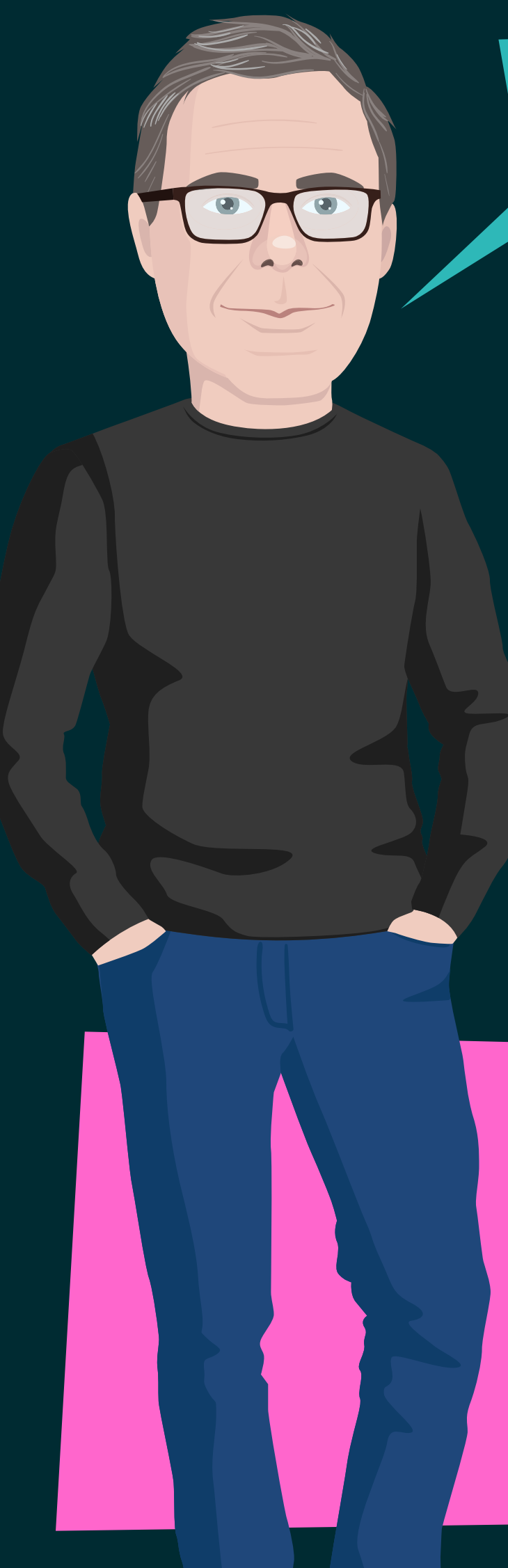
That may sound huge, but compared to the World's projected 6,900 billion m^3 water abstractions in 2030, this isn't very important: we're talking of 0.13% of the World's water use.

Still, that's only true if we're making this Green Hydrogen out of renewable energy.



To make a kilogram of green Hydrogen requires 50-65 kWh of energy. Producing this through a thermal power plant would require orders of magnitude more Water than nine kilograms!

Actually, a study by Michael Webber estimates that order of magnitude at 4,200 kilogram of Water per kilogram of Hydrogen.

1 kg Hydrogen

4,200 kg Water

That would now represent 5.5% of the World's water abstractions, which would hardly be sustainable.

So, if green Hydrogen has to be done from renewables, how much of the World's capacity would that gobble?

To make 90 million per year using the best electrolyzer in the World, you would need 4,500 terawatt-hours of electricity. In 2019, all the wind and solar in the whole World added up to only 2,100 TWh!

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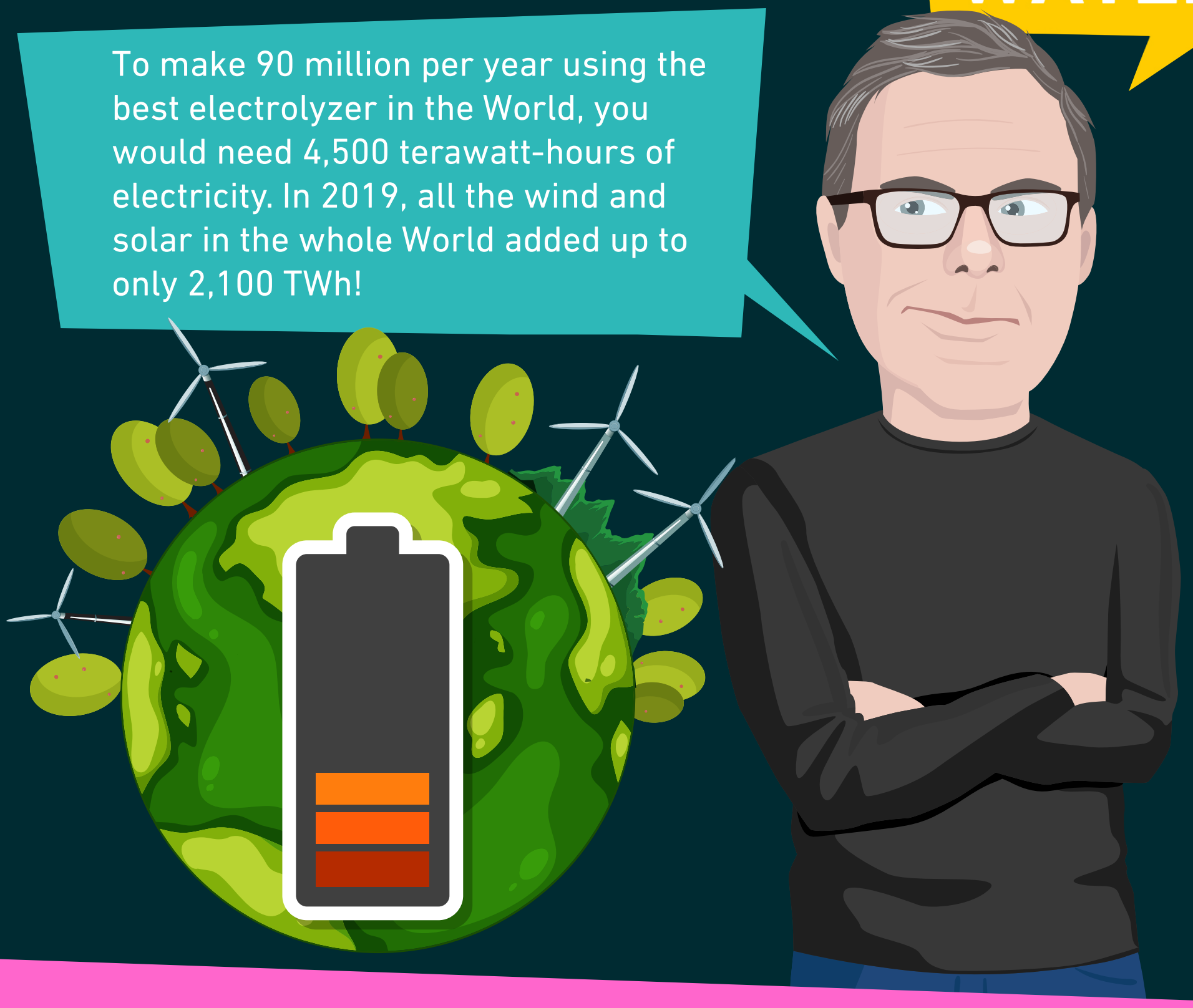

That may still not be the strongest limiting factor. As BlueTech Research underlines in their hydrogen economy insider report, Green Hydrogen costs 5-7 times more than Gray Hydrogen.

So, on the flip side, it's carbon neutral.

But on the downside, it may be costly in Water if not done from renewables; the renewables installed base is far from being sufficient, and it's expensive.

End of the story?

When you double the cumulated production capacity, the price drops by a percentage. For wind and solar, it was around 30%, for Hydrogen, it is supposed to be between 10 and 17%.

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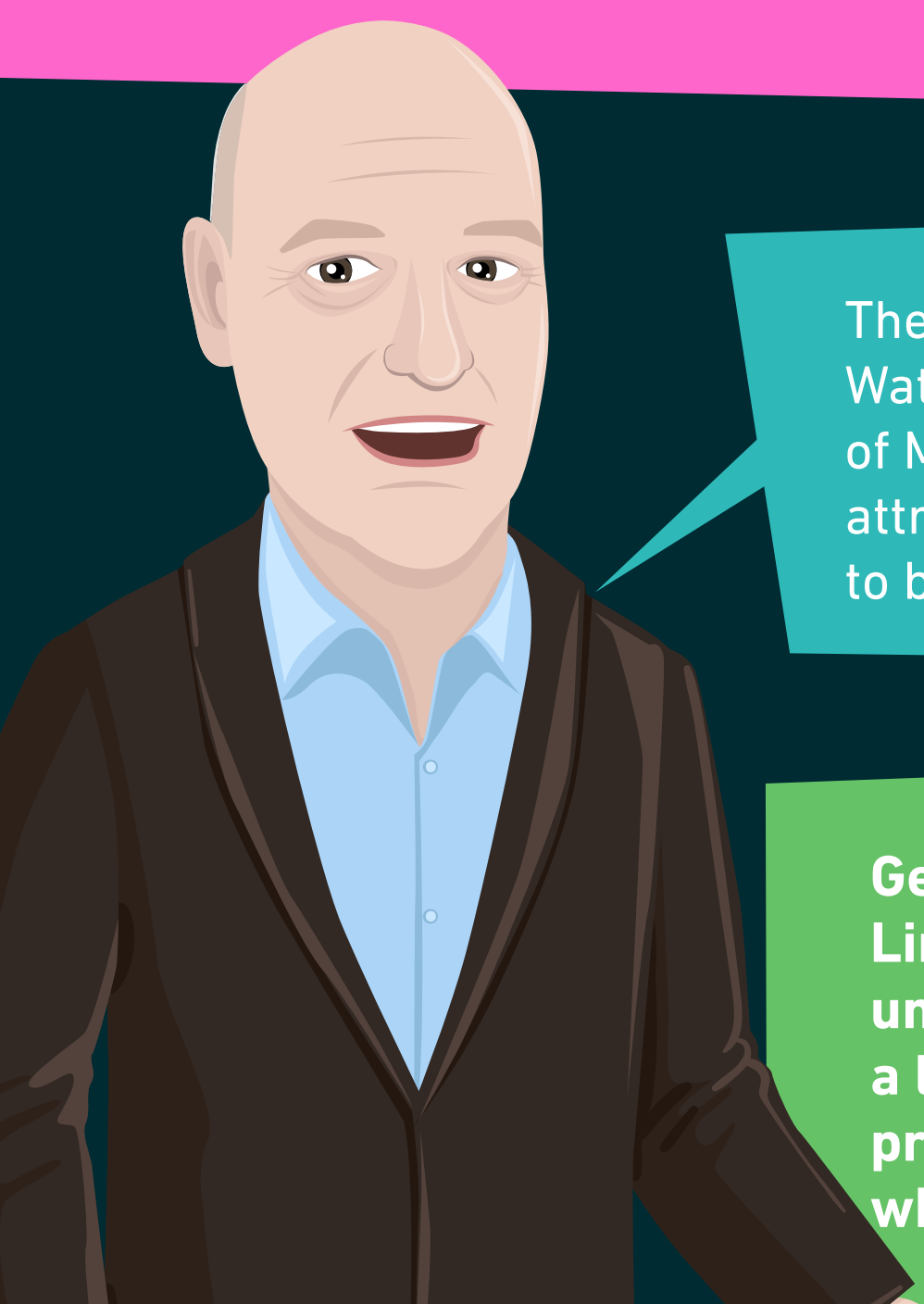
So there are scale effects to expect! However:

We're more earnest in desiring decarbonization, and renewable electricity is getting cheaper and cheaper. Yet, in terms of thermodynamics, nothing's changed!

Hence, there's a limit as to how low the price can go, and that limit has much to do with the nature of the electrolysis process itself.



The hydrogen-oxygen double bond of Water, as opposed to the single bond of Methane, has an incredibly strong attraction and takes a lot more energy to break.

Geoff Ward is the CEO of Hazer Group Limited, a pioneering company undertaking the commercialization of a low-emission hydrogen and graphite production process - more to that when we tackle Turquoise Hydrogen.

But back to my question:

Is that the end of the story for Green Hydrogen?

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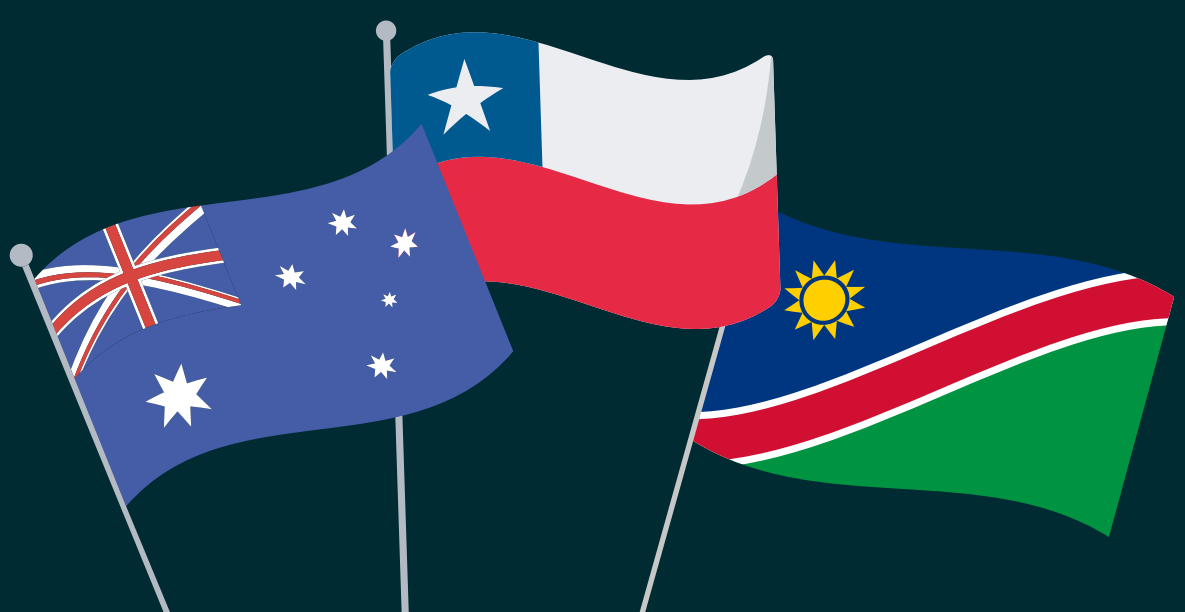
That's where our Hydrogen guides disagree the most.

For Paul Martin, to minimize the extra cost associated with Green Hydrogen as a necessary evil to wipe out gray Hydrogen, some areas shall specialize in producing it.

You need a desert with an ocean to the west. So you get a high capacity solar factor, and every night the land cools down and triggers strong winds.

This provides you with a good potential for renewable energy, while the ocean also serves as a water source through desalination.



This is a major opportunity for places like Western Australia, Chile, or maybe Namibia!

But whenever we start thinking of using that green Hydrogen for anything else than replacement of the gray one, Paul is adamant:

Hydrogen is amazing, but it's just a tool that needs to be used for the right purposes, and burning it as fuel is not the right purpose for it.

An opinion he supports with hard facts, ranging from the low power density of Hydrogen to the cost we already discussed through the narrow path to scale.

That's where Alena Fargere disagrees:

You can make a lot of things with Hydrogen! You can power cars, buses, trucks, trains, planes, boats...

There's even a section of that market where Hydrogen is cost-competitive:

the Forklifts.

The Idea in the mobility scenario is to cover the long distances that may be problematic for batteries.

But that's not the only perk:

With two technologies (electricity and Hydrogen), you can do more than with only one. You become more cost-efficient if you decrease the 100% electric vehicles scenario and add 10% of hydrogen fuel cells!

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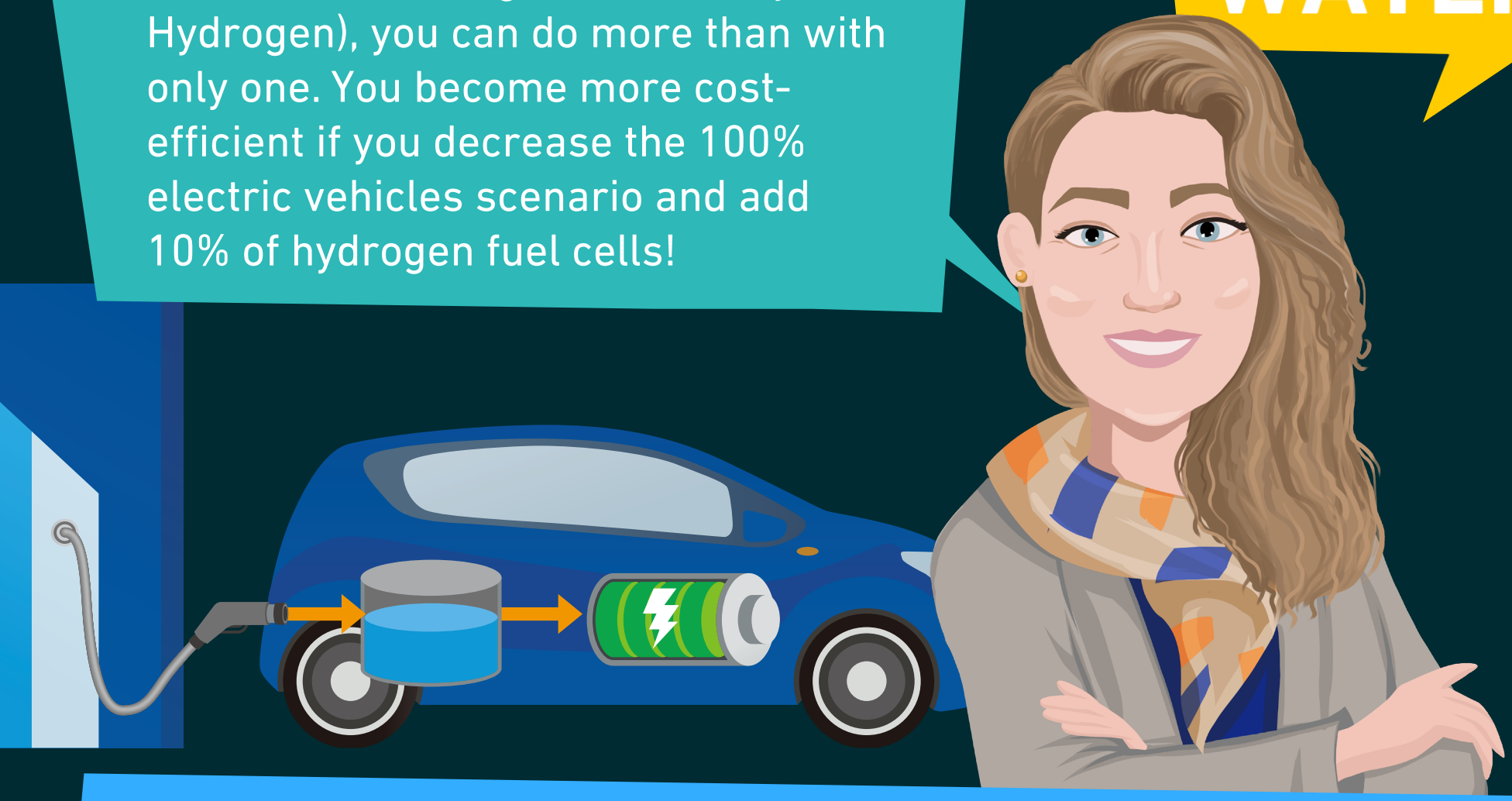


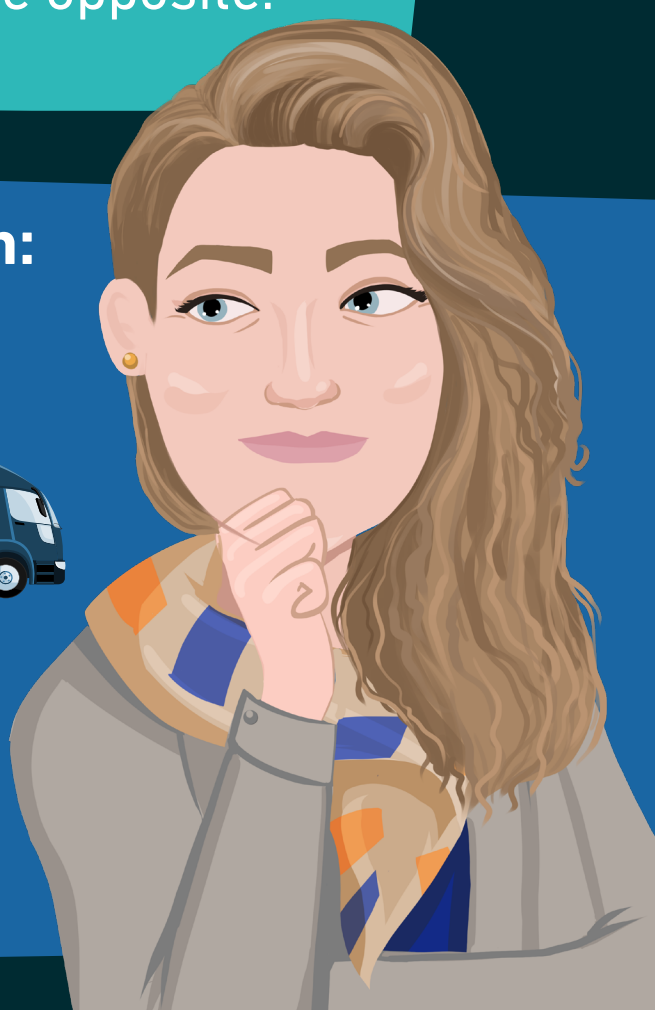
The Idea is that the last percentages (from 90 to 100% electric vehicles) involve expensive investments and grid reinforcements to cover the peaks - something hydrogen fuel cells would flatten out.

Yet, as BlueTech reports, large-scale Hydrogen mobility programs such as Scania's one have recently been stopped.

There is a path to scale for batteries, for Hydrogen it's quite the opposite.

Alena sees further uses of Hydrogen, though:

Green Hydrogen can replace the Gray one in the industry and replace some other carbon-based fuels.



To achieve this, both our guides agree:

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We need decarbonization policies, carbon taxes, and emission bans that signal to people you shouldn't use fossil fuels unless you don't really have an alternative.

States need to implement support mechanisms to accompany the roll-out of the hydrogen economy

The role of Hydrogen in that story may start with the most pressing issue of replacing the "blackish" gray one.

... and future will tell if the

EU 470Bn€ investment

expected in BlueTech's report by 2050, or SWEN Capital's

475 M€ green gas funds

can unleash a Hydrogen opportunity beyond this "lowest hanging fruit."

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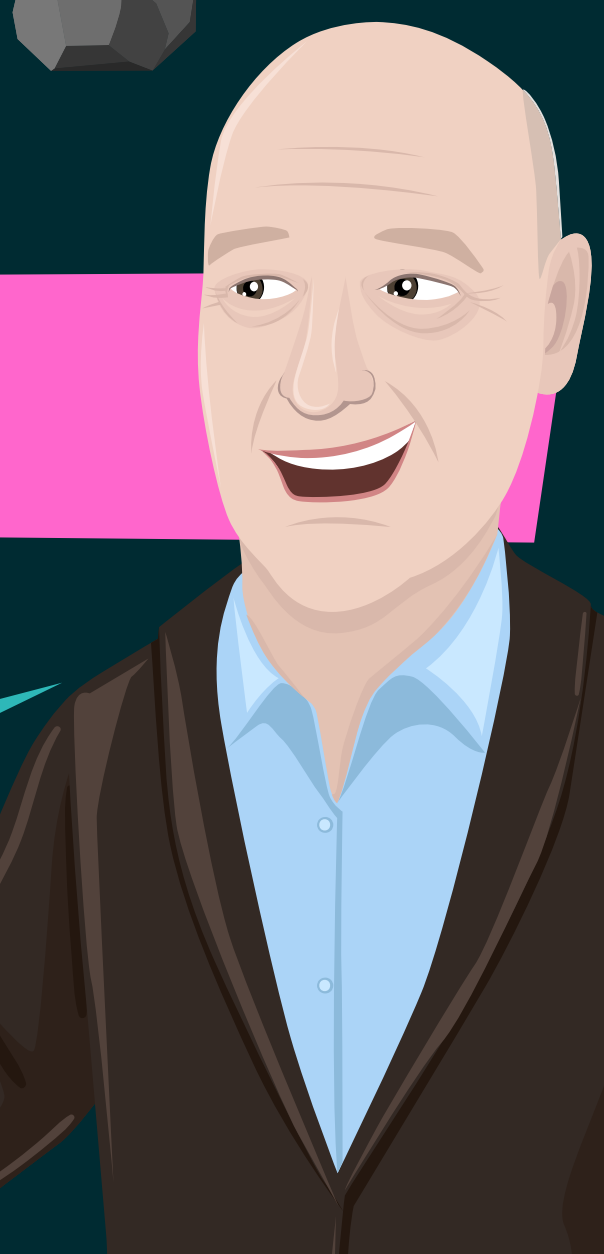
Towards Carbon-Negative Hydrogen?

Let's make a quick color recap: we want to move away from blackish gray and brown; blue might be as much a problem as a solution; Paul qualified purple as a "waste of nuclear electricity," and green divided our guides.

Yet, there's a color that can be greener than green: Turquoise.

Imagine you would be producing biomethane, which is, by definition, carbon neutral.

If you then use this biogas in a pyrolysis process to form Hydrogen and capture the carbon as graphite, your entire process now becomes carbon negative!



Is this science-fiction? Not at all!

We're building our first demonstration project at Woodman Point, in Perth, Australia. It will be a 100 ton/annum Hydrogen production facility and co-produce about 375 tons of graphite.

That plant will feature the

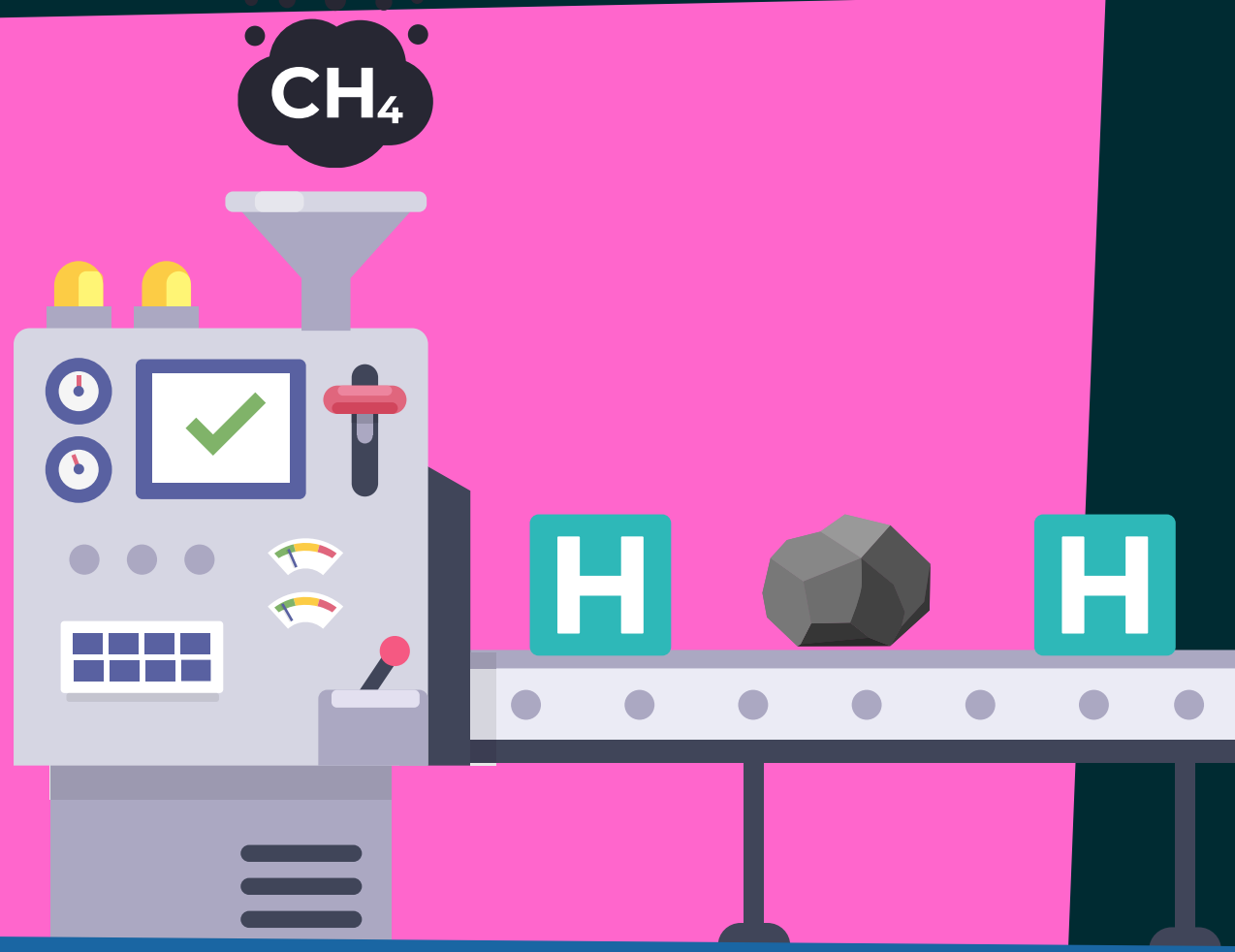
HAZER process

- an acronym for Hydrogen And Zero Emissions Research.

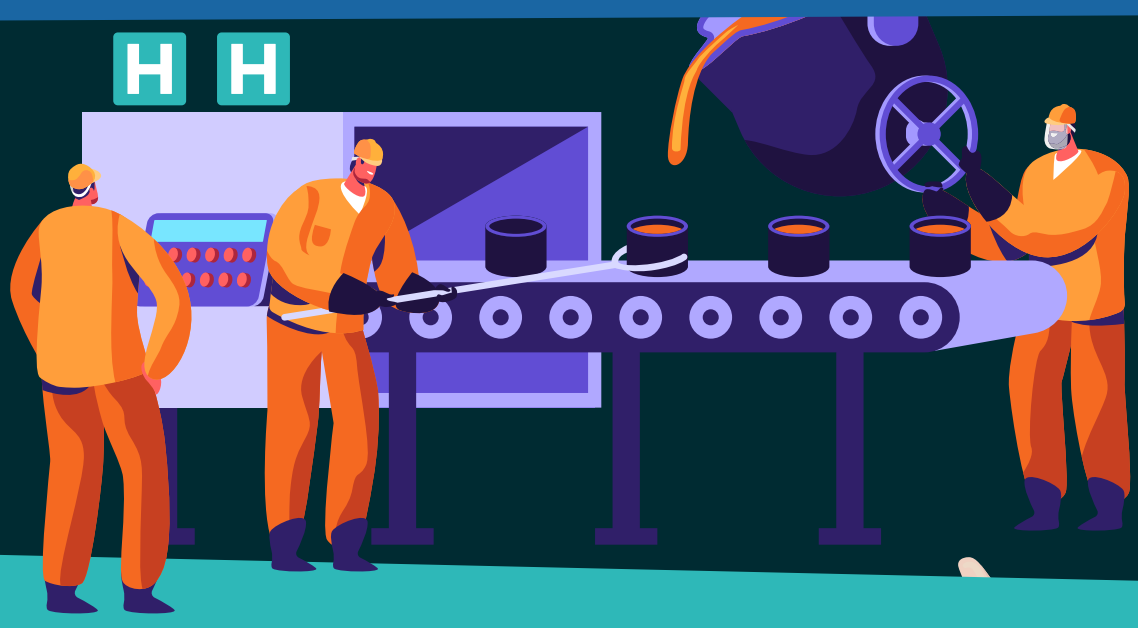
And Woodman Point isn't actually any industrial location: it is... a wastewater treatment plant!

We thought it would be a very good opportunity for both the wastewater and the clean energy industries to collaborate! It showcases the lowest emission, most sustainable and most circular economy application of the technology.

Indeed, biomethane produced out of wastewater sludge digestion will be taken through HAZER's reactor and split to create two high-value products: (Turquoise) Hydrogen and Graphite.



Hydrogen could be used in heavy vehicle transport, or actually even closer to the point where it's produced:



The city of Perth has metal processing and other industries; a number of them use Hydrogen. With our process, we could supply Hydrogen into these heavy industrial applications.

A key feature of this approach is that it turns carbon into a valuable feedstock, 90% pure at the outlet of the reactor.

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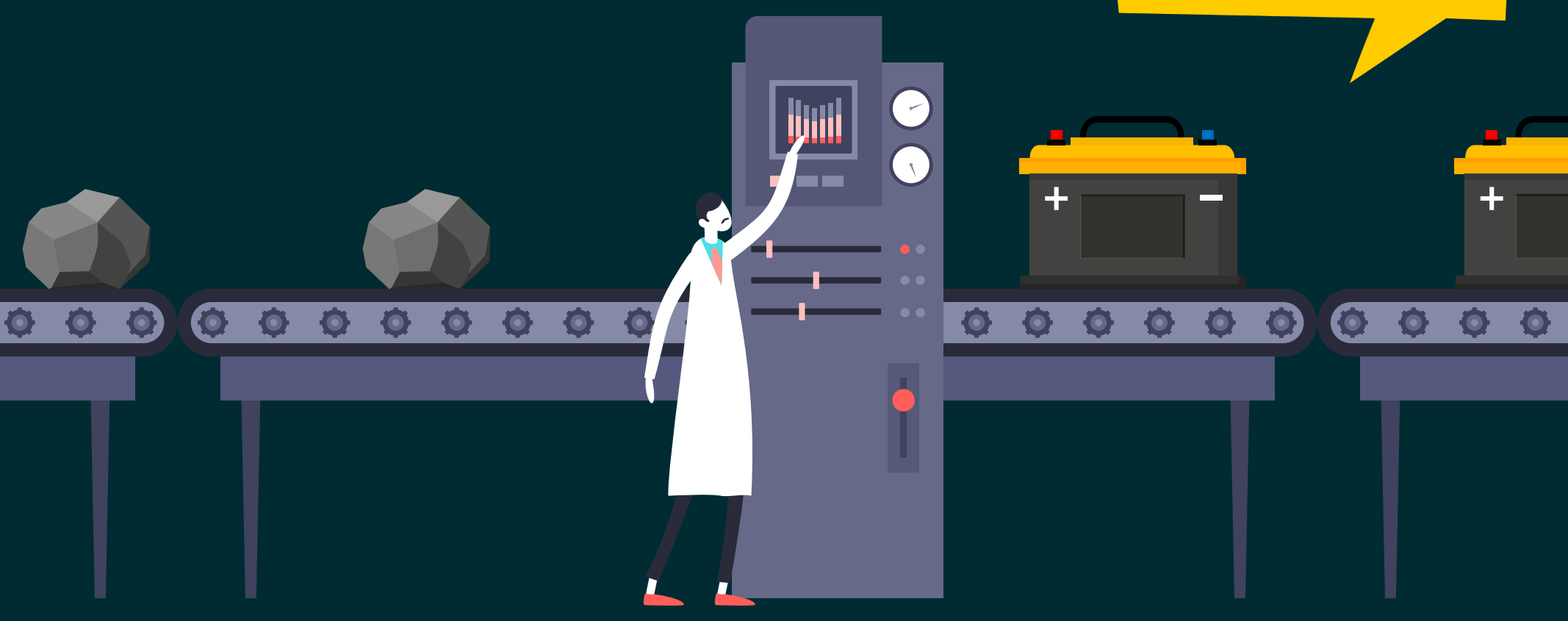
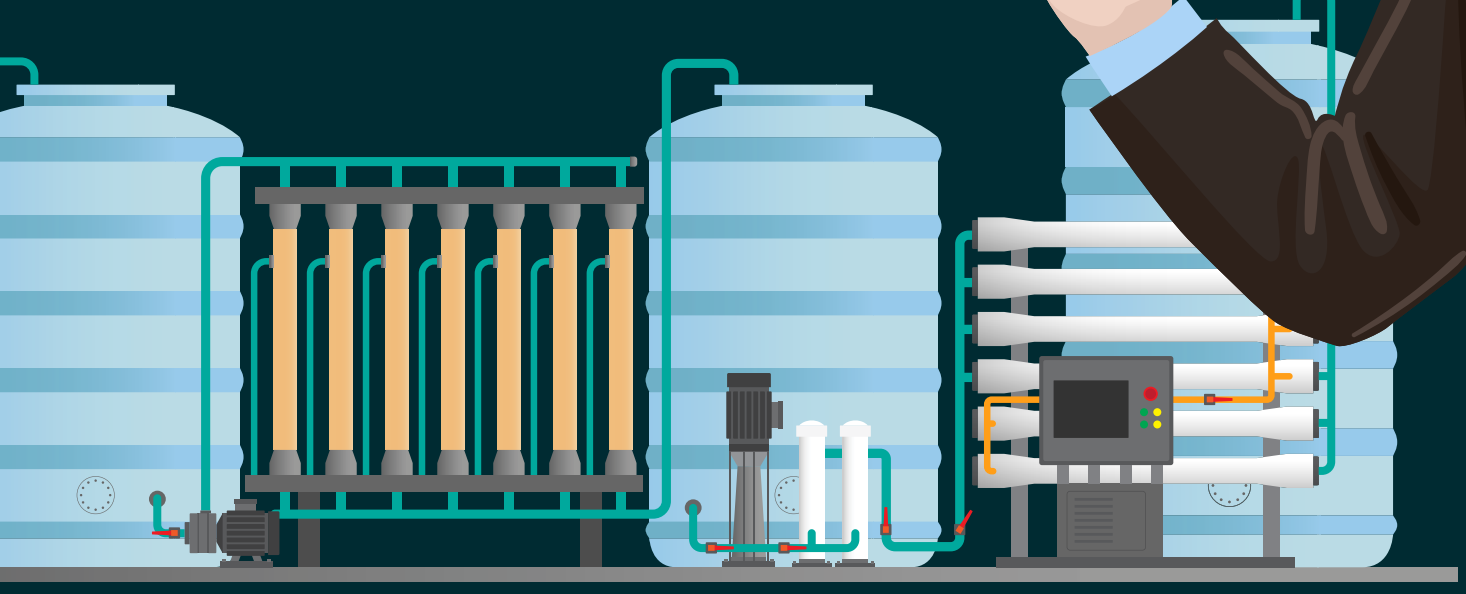
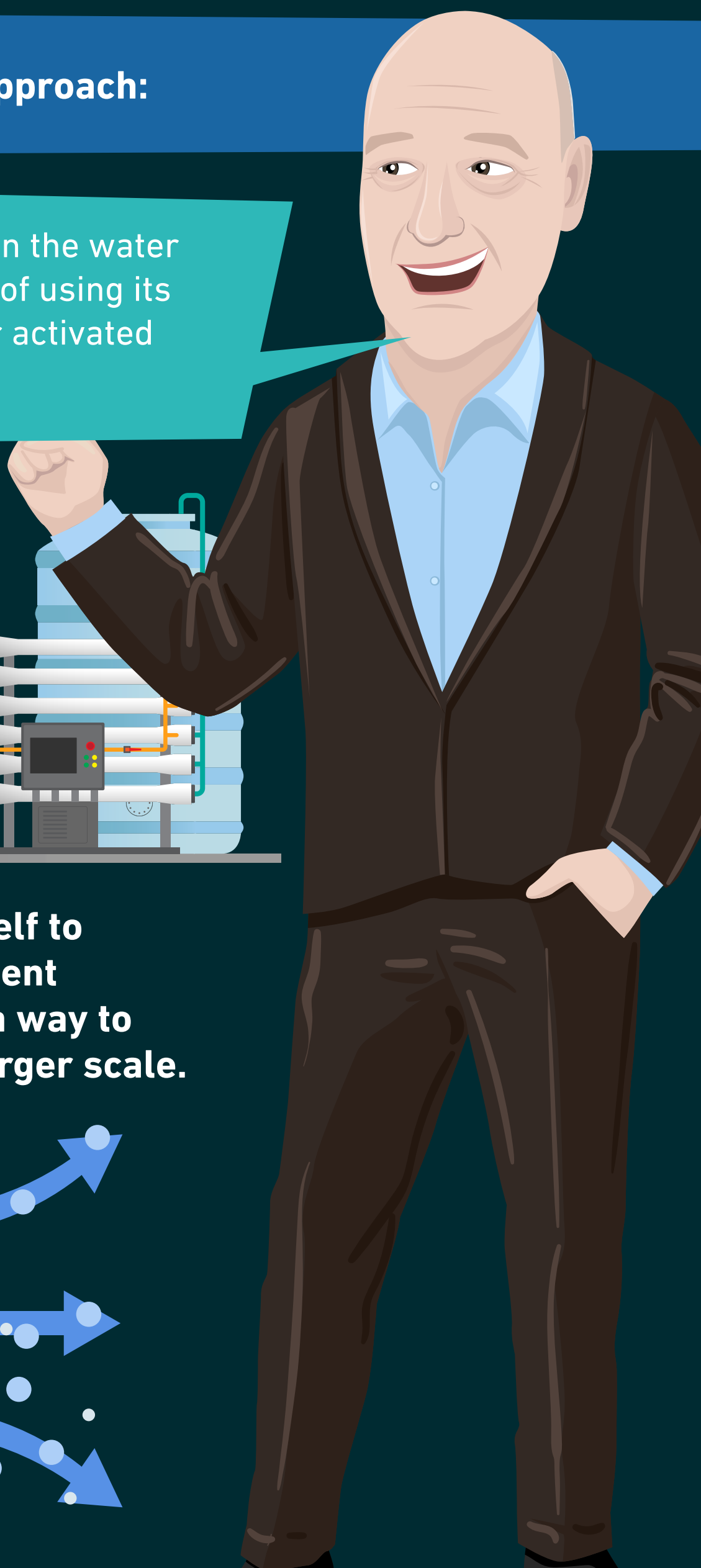


It could have several applications, ranging from low-value options (e.g., road-making, building materials) to high-end ones (e.g., battery anode materials).

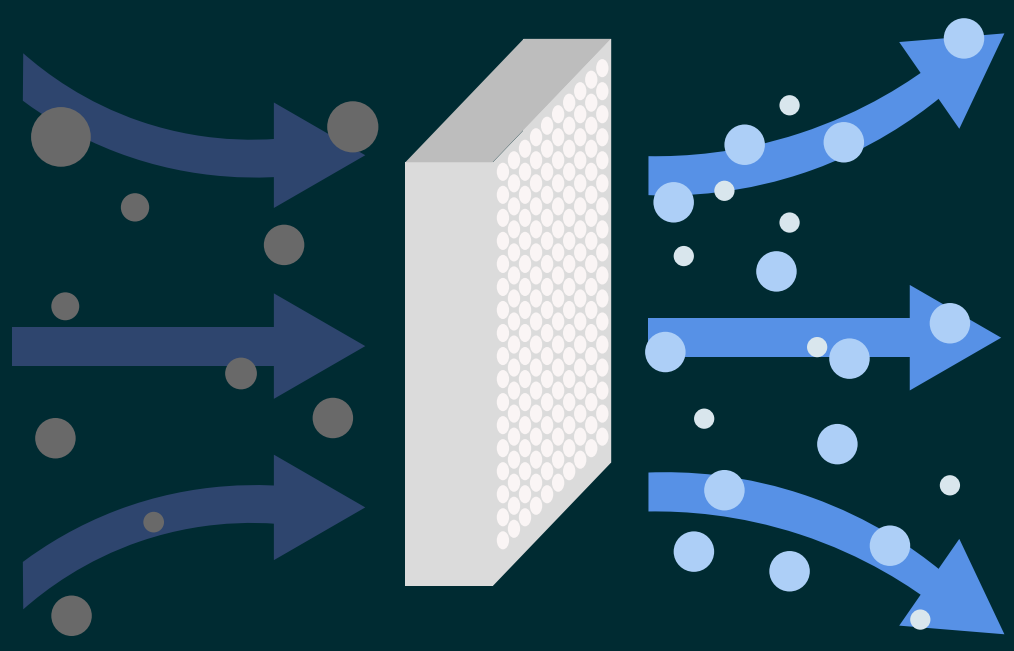
And in an even more circular approach:

We're evaluating ways to reuse it in the water treatment industry itself, as ways of using its unique properties to substitute for activated carbons





Hazer doesn't intend to limit itself to the scale of Wastewater Treatment Plants, and sees in its process a way to decarbonate natural gas on a larger scale.



Yet from a Water Industry perspective, isn't that an exciting prospect to contribute to the energy transition, leverage synergy effects (e.g., heat exchangers), and decarbonize the sector itself?

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I bet many will be closely monitoring whatever happens in Perth in the next years!

So, what did we learn on that journey?

Maybe that, as water professionals, we shall keep an eye on the development of Green and Turquoise hydrogens - yet without stopping everything to focus just on that, as BlueTech's report wisely advises.

Maybe also, that there are many sides to a single story!

But above all, this entire investigation proves how central carbon topics will be in the next years - in case anyone still doubted it.

It was a blast to conduce this (huge😅) piece of work; I'd like to thank BlueTech's team, Paul Martin, Alena Fargere, Geoff Ward, and all the ones that pointed me in the right direction along the way.

If you like this kind of deep-dive, consider subscribing to the "(don't) Waste Water" podcast, and please: Share it around you!