

Clearthought

Fuel Cell Technology

Driven by tough emissions regulations the fuel cell market is growing exponentially across the world.

Inside:

- Global view
- Market trends
- M&A activity
- Interview with Luc Wanten, CEO of fuel cell plate manufacturer Borit

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Global view

As the World Energy Council (WEC) recently remarked, hydrogen and fuel cell technologies have experienced “cycles of high expectations followed by impractical realities” going back many years. However, the mix of falling fuel cell prices, stringent climate change requirements, and a strong commitment to the hydrogen sector by many countries – most notably China, South Korea and Japan – is now transforming their potential.

Indeed, the Hydrogen Council, a global CEO-led initiative that brings together leading companies with a united vision and long-term ambition for hydrogen to foster the clean energy transition, is even more bullish.

It says¹ that hydrogen technology has built “unprecedented momentum” on the back of large-scale projects, increasing M&A and investment activity, with governments committing to hydrogen as a part of their climate change strategies. For instance, the EU recently launched a hydrogen strategy, while individual countries such as Germany have unveiled a National Hydrogen Strategy, earmarking €9bn for investment in the technology.

On the corporate front, the past year has also seen a string of notable deals that have put the decarbonisation of transport front and centre. For example, a joint venture between Daimler and Volvo to develop fuel cells for trucks is one of the biggest ever investments into fuel cell technology.

Mobility

As well as mobility, hydrogen can also be used in storage, heat, power and energy use. However, as the WEC say², mobility is now regarded as the most promising sector for hydrogen, and in the form of fuel cells hydrogen is suitable for virtually all means of transport.

But as a mobility option it concedes that these technologies face difficult challenges in terms of cost and required investment, and that the successful adoption and commercialisation of hydrogen as a decarbonisation tool relies on “strategically integrated infrastructure”. Although infrastructure dedicated to hydrogen production and transportation already exists, the vast majority of it is not intended for hydrogen as an energy carrier, but rather as a feedstock.

Batteries vs fuel cells

With fuel cell electric vehicles (FCEVs) now emerging as a complementary technology to battery electric vehicles (BEVs), one of the biggest questions facing the wider sector is how this balance between the two will now evolve in the years ahead. And, more specifically, how the balance is likely to be different depending on the form of transport you are talking about.

Most agree that batteries will be more important in smaller vehicles such as cars, but that fuel cell technologies will have a greater role to play in larger vehicles such as trucks, trains and even planes.

1: Hydrogen Council – Hydrogen decarbonisation pathways – January 2021.
2: World Energy Council – New Hydrogen Economy – hope or hype? 2019



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Advantages and challenges of fuel cell vehicles

Main advantages:

- Fast refuelling, similar to internal combustion engine
- Longer range than batteries
- Long lifespan of fuel cells
- Waste heat from fuel cell system can be used to heat a vehicle
- Better well-to-wheel energy efficiency than internal combustion engine

Main challenges:

- Initial high cost and low volume
- Technology risk and safety perception
- Dedicated infrastructure unavailable
- Cost of vehicles

Source: World Energy Council, Clearwater International



The technology

How a fuel cell vehicle works

A fuel cell generates electricity by forcing a fuel to react with oxygen. The most commonly used fuel today is hydrogen, but fuel cells can use almost any hydrocarbon including gas and alcohol. A constant supply of fuel and oxygen is required to sustain the reaction that produces the electricity.

In essence fuel cell vehicles work by combining the fuel cell's output with existing and proven hybrid battery technology. Electricity is generated in a fuel cell through a chemical reaction between the hydrogen fuel and oxygen. This happens by supplying hydrogen to the anode, or negative electrode, and ambient air to the cathode, or positive electrode.

The fuel cell is made up of individual cells within a membrane electrode assembly (MEA) that are sandwiched

between separators. The MEA consists of a polymer electrolyte membrane with positive and negative catalyst layers on either side. Each cell produces less than one volt of electricity, so hundreds of cells are connected in series to produce the required output voltage. The combined body of cells is called a stack, or the fuel cell unit.

Though a fuel cell can use almost any hydrocarbon as its fuel, hydrogen's advantage is its high energy efficiency. As it can produce electricity without energy-wasting combustion, it is possible to convert 83% of the energy in a hydrogen molecule into electricity – more than double the energy efficiency of a petrol engine.

Source: Toyota UK magazine – how does Toyota's fuel cell vehicle work?

hydrogen-powered heavy-duty vehicles to the market in the second half of the decade.

- Mercedes and Volvo are developing a fuel cell system for trucks with production also scheduled to begin in the second half of the decade.
- German manufacturer MAN is developing hydrogen combustion engines and fuel cell drives. Its parent company Traton is also working with Japanese truck manufacturer Hino on fuel cell drives.



- Toyota and Hino want to test fuel cell trucks with a total weight of 25 tons from spring 2022. The companies are also developing a fuel cell truck for the US market, while in China Toyota is also working with Chinese companies to develop fuel cell trucks.
- US company Nikola recently announced plans to introduce two FCEV trucks. One is an FCEV variant of the Nikola Tre

Cabover for ranges up to 500 miles, and the other is the Nikola Two FCEV Sleeper for ranges up to 900 miles. Nikola and Iveco also want to start production of the Nikola Tre model in 2021.

- Hyundai is producing what it claims is the first heavy-duty truck with fuel cell electric drive-in series, the Xcient Fuel Cell. It plans to use 1,600 of these hydrogen trucks by 2025.
- US company Hyzon Motors, which specialises in fuel cell commercial vehicles, has set up a European headquarters in the Netherlands. The first fuel cell trucks are to be built there this year.

Other transport uses:

Materials handling

The WEC say² one of the most suitable applications for hydrogen-powered vehicles is in warehouse materials handling. Indoor warehouses have stricter requirements on air quality and the speed of hydrogen refuelling and absence of odours make FCEVs attractive in these types of operations for forklifts, narrow aisle lifts trucks, stock pickers and pallet jacks.

Trains

Interest in hydrogen fuelled trains is growing as governments look to phase out diesel-powered trains. For instance, Siemens has partnered with Deutsche Bahn to develop a regional hydrogen train in Germany, and France plans to run its first hydrogen trains from 2023. Manufacturer Alstom says that by 2030 10% of diesel trains will be replaced by hydrogen trains, and that by 2050 it will be 30%.

Aviation

The sector is watching developments elsewhere with interest. The WEC say the sector's decision to choose hydrogen as a decarbonisation pathway depends on hydrogen's safety case and the ability to produce hydrogen at the right cost, at scale and in a carbon neutral manner. Due to the aviation industry's long cycles, if hydrogen became a viable solution, it would still take at least a couple of decades to renew the entire fleet.

Marine

WEC say the use of hydrogen-powered fuel cells for ship propulsion is still at an early design or trial phase with applications in smaller passenger ships, ferries or recreational craft. Ferries which have a 'back to base' operating route could be a suitable early mover market.

1: Spiegel mobility – Die neuen Dampfmaschinen

2: World Energy Council – New Hydrogen Economy – hope or hype? 2019

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Mobility solutions

Although much of the focus on fuel cell technology is around its potential in passenger vehicles, there is also very strong investor interest in other mobility solutions too, especially around heavy goods vehicles.

OEMs are particularly mindful of looming emissions regulations. Under new EU rules manufacturers are required to cut CO₂ emissions from new trucks on average by 15% by 2025 and by 30% by 2030. The EU say CO₂ emissions from heavy-duty vehicles including lorries, buses and coaches, represent around 6% of total

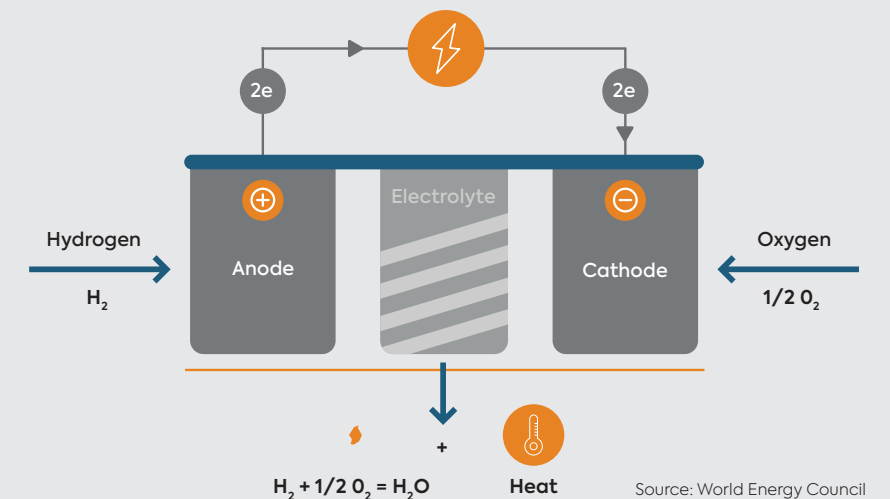
CO₂ emissions in the EU and 27% of total road transport CO₂ emissions.

Indeed, in late 2020 Europe's largest truck manufacturers said they would stop selling vehicles that produce emissions by 2040. An alliance of Daimler, Scania, MAN, Volvo, Daf, Iveco and Ford signed a pledge to phase out traditional combustion engines and focus on hydrogen, battery technology and clean fuels.

As such most leading truck manufacturers are now forming an array of industry partnerships¹:

- Daimler has established a €1.2bn joint venture with Volvo to develop hydrogen powered trucks. They aim to bring

The science behind fuel cells



Market overview

With increasing demand from a range of transportation segments, fuel cell technology is expected to grow exponentially in coming years.

A report¹ just released by the Hydrogen Council shows a rapid acceleration of hydrogen projects in response to government commitments to deep decarbonisation. As of early 2021, more than 30 countries have released hydrogen roadmaps and 228 large-scale projects have been announced along the value chain, with 85% located in Europe, Asia, and Australia.

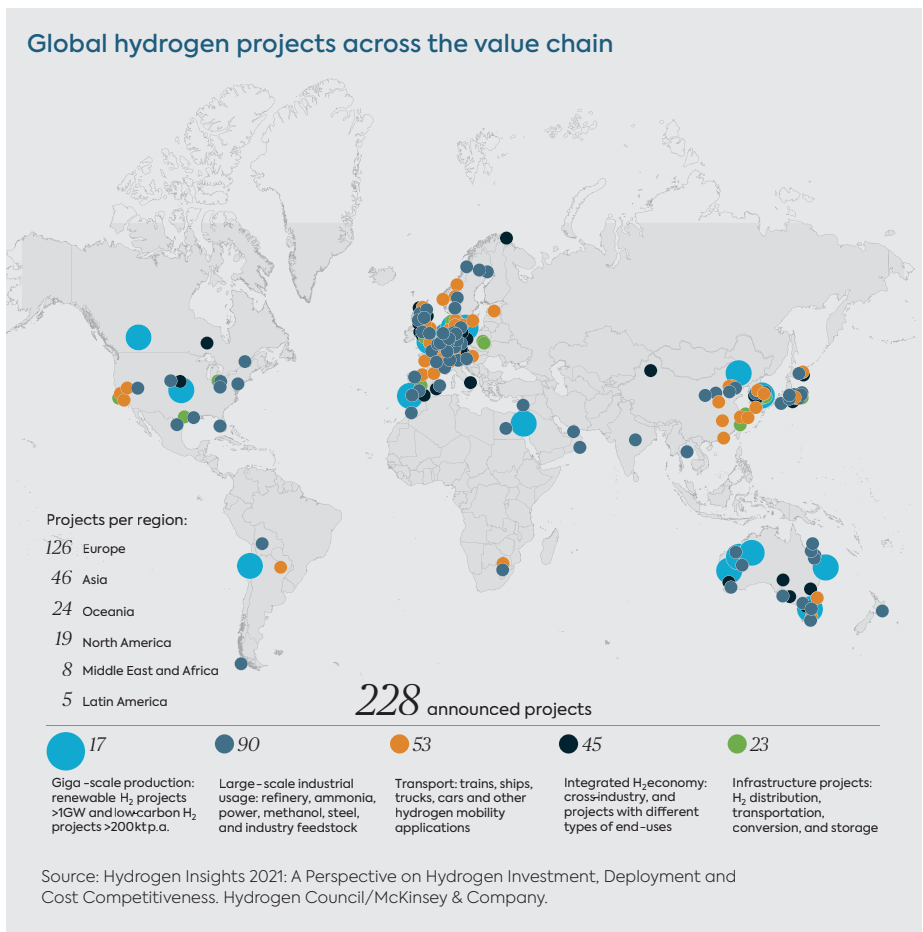
Investment

The Council says that if all announced projects come to fruition, total investments will reach more than \$300bn in spending through 2030. Of this investment \$80bn can be considered ‘mature’, meaning that these projects are in the planning stage, have passed a final investment decision, or are under construction, already commissioned or operational.

One country which has already proclaimed fuel cell technology as a priority sector, and which is pouring billions into the sector is China as part of a wider 10-year plan to upgrade its manufacturing industry. The country spent around \$12.4bn on supporting fuel cell powered vehicles in 2018.

Vehicle production

As customer awareness of the advantages of fuel cell technology increases, so the underlying market is expanding and hydrogen vehicles are increasingly being launched into series production.



Toyota’s second-generation Mirai, which is powered by electricity made in its fuel cell stack, went on sale in Japan last year and the company is aiming to make 30,000 vehicles a year. It is also building a new plant to accommodate the expansion of fuel cell stack production.

Hyundai has also announced plans to build its first overseas hydrogen fuel cell factory in Guangzhou, China. The company will initially produce 6,500 fuel cell systems a year at the facility for its Nexo electric SUV.

Hyundai wants to produce 700,000 fuel cells annually by 2030 and has also just manufactured the Xcient fuelcell truck, the world’s first mass-produced hydrogen-powered truck.

1: Hydrogen Insights 2021: A perspective on Hydrogen Investment, Deployment and Cost Competitiveness. Hydrogen Council/McKinsey & Company

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M&A activity

The growing momentum in the fuel cell industry is demonstrated by a series of recent strategic partnerships and M&A transactions, and increased support for accelerating mass-market fuel cell deployment. Over the last couple of years a number of large automotive suppliers and industrial groups have entered into partnerships with specialised fuel cell companies, and as consolidation takes hold the number of independent fuel cell players has been significantly reduced.

Recent deals

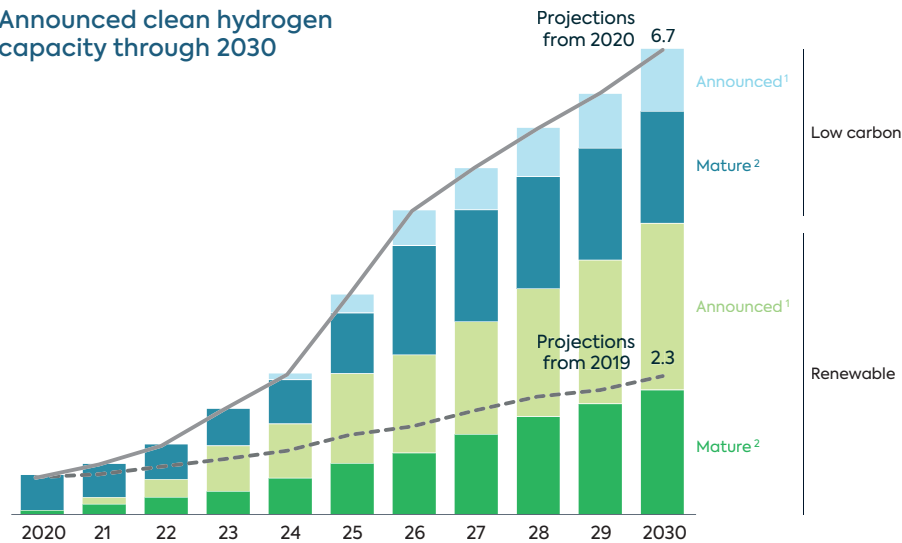
South Korea’s SK Group is investing \$1.5bn in US hydrogen fuel cell maker Plug Power as part of a JV. SK is aiming to produce 30,000 tonnes of hydrogen in 2023, rising to 280,000 tonnes by 2025. Plug Power recently entered the hydrogen-powered

truck market and is also diversifying into drones, aircraft and power plants.

ElringKlinger and Plastic Omnium set up a JV called EKPO Fuel Cell Technologies dedicated to fuel cell stack development, production, and commercialisation. Both companies have been heavily investing in hydrogen technology. By 2030 the JV aims to reach a market share of 10 to 15% in the fuel cell technology business, representing revenues of between €700m and €1bn. Plastic Omnium also recently acquired Swiss Hydrogen and Belgium-based Optimum CPV.

Cummins acquired fuel cell and hydrogen production technologies provider Hydrogenics Corporation. Cummins began developing its fuel cell capabilities more than 20 years ago and

Announced clean hydrogen capacity through 2030



1. Includes projects at preliminary studies or at press announcement stage
2. Includes projects that are at the feasibility study or front-end engineering and design stage or where a final investment decision (FID) has been taken, under construction, commissioned or operational

Source: Hydrogen Insights 2021: A Perspective on Hydrogen Investment, Deployment and Cost Competitiveness. Hydrogen Council/McKinsey & Company.





the acquisition accelerates its ability to further innovate and scale hydrogen fuel cell technologies across a range of commercial markets.

Michelin and **Faurecia** formed a JV called **Symbio** combining all their hydrogen fuel cell dedicated activities. The venture is tasked with developing, producing and marketing hydrogen fuel cell systems for light vehicles, commercial vehicles and trucks as well as for other areas of electro-mobility.

Ballard Power Systems entered into a strategic collaboration with **Weichai** to support China’s burgeoning fuel cell EV market. The deal involves a commitment by Weichai to build and supply at least 2,000 fuel cell modules for commercial vehicles in China. Weichai Power is a leading automotive and equipment manufacturer.

Bosch is planning full-scale production of distributed power stations based on solid oxide fuel cell technology developed by **Ceres Power**, a system regarded as ideal for small power stations based in factories and data centres, and for use in EV charging infrastructure.

Bosch and China-based premium commercial vehicle manufacturer **Qingling Motors** have also established a joint venture in China, Bosch Hydrogen Powertrain Systems (Chongqing) Co. Ltd. The new company will develop, assemble and market fuel cell systems for the Chinese market. Later this year a test fleet of 70 Qingling trucks equipped with Bosch’s Fuel Cell Power Module will be launched.

Ceres Power and **Weichai** announced a JV to create a fuel cell manufacturing operation in China. The JV will target

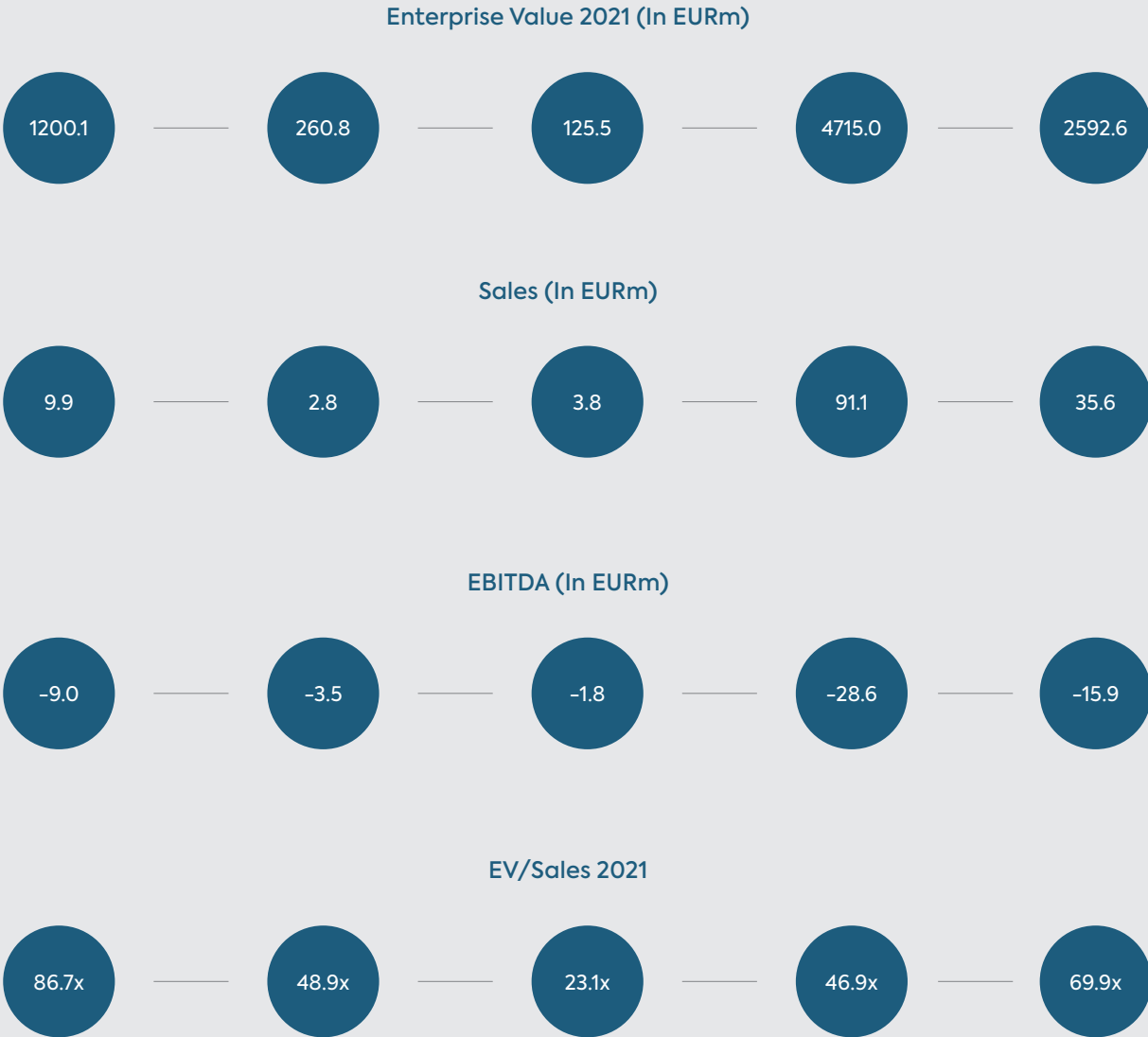
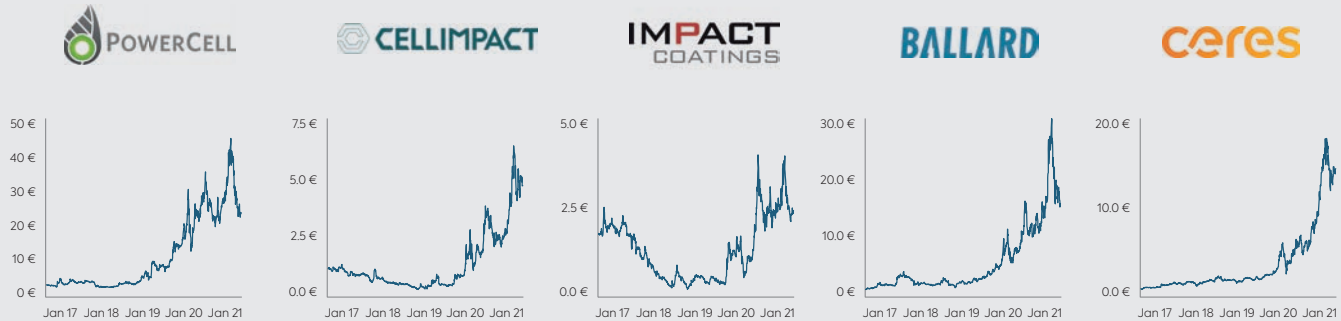
By 2030 the JV aims to reach a market share of
10–15%
in the fuel cell technology business

the rapidly growing Chinese market opportunity for fuel cells.

Hyzon Motors, a fuel cell truck start-up, is going public via a merger with **Decarbonization Plus Acquisition Corporation**. Hyzon has an exclusive focus on hydrogen in the commercial vehicle market and was originally spun out of Singapore-based Horizon Fuel Cell Technologies.

The **Stellantis** automotive group has announced that three electric transporters from **Opel**, **Peugeot** and **Citroën** will be offered with a fuel cell system this year. The fuel cell systems for the mid-sized van range come from **Symbio**, the joint venture between Faurecia and Michelin. The FCEV vans are based on the battery-electric versions of the Opel Vivaro-e, the Peugeot e-Expert, and the Citroën ë-Jumpy.

Fuel Cell valuation



Interview with Luc Wanten

CEO of Borit



The debate around the potential of hydrogen and fuel cell technologies to drive decarbonisation is not new. But with the industry having performed lots of research and limited-scale market introductions, Luc Wanten, CEO of fuel cell plate manufacturer Borit, believes the sector has finally reached a tipping point.

“When it comes to the take-up of these technologies, I really believe there is a big change coming up, and I think it will also be much faster than we expect. What we are clearly seeing now is political, business and investor sentiment across the world firmly supporting the potential of hydrogen as one of the key technologies to help us achieve net zero emission targets. I also think the pandemic has only sharpened the focus on what now needs to happen in terms of responding to the climate challenge.”

Growth

Borit is particularly well positioned to capitalise on the growth of the hydrogen economy which, as Wanten says, is increasingly championed by governments and companies across the world. However, when the Belgian company was originally founded in 2010 it was looking to use its proprietary technology across a wide range of market segments, such as medical technologies and high strength structural components, as well as fuel cells.

But Wanten, who says he moved from “intrapreneuring” in a corporate environment to “entrepreneuring” with technology start-ups and scale-ups, says it quickly became apparent that there was a very natural fit between

the technologies Borit was developing around very thin metal foils, and the fuel cell requirements.

“It became an obvious match for the company and we really believed we could excel in it. On a personal level I was curious about the potential of the technology and was excited about how we could build a whole strategy for the long-term.”

Technology development

Having decided to focus on the fuel cell market the company spent the next few years both enhancing its technology development and staking its place in the wider hydrogen ecosystem.

As he adds: “In those early days the whole fuel cell sector was still emerging so it was really important for us to be as close as possible to both manufacturers who might employ the technology, especially across the automotive industry, and also to other start-ups. From the outset it was crucial to create loyal partnerships with OEMs and other emerging players.”

Fast forward to 2021 and the strategy has paid off in spades. Borit has grown to become the world’s largest independent one-stop-shop supplier of metal bipolar plates and has a strong and diverse international customer portfolio consisting of OEMs, Tier 1 suppliers, and fuel cell and electrolyser technology companies active in both automotive and non-automotive segments.

Today the automotive industry accounts for more than 50% of turnover at the business and Wanten expects production volumes to grow significantly in the years ahead.

“This is potentially a huge market for us as we scale up the business further. We are talking about literally making millions of plates a year.”

But he stresses that the business is not putting all its eggs in one basket. “There is considerable growth potential in sectors such as electrolyser systems, stationary systems for back-up power, or combined heat and power systems for housing, while one mustn’t forget the opportunity around other forms of transport too such as trains and planes.”

Transport mix

Indeed, Wanten insists the hydrogen ecosystem extends far wider than cars, epitomised by Daimler Truck joining forces with Volvo Group to develop fuel cells for trucks, and that a number of train-makers are already experimenting with fuel cell technology.

“One of the biggest debates in the industry is the extent to which fuel cell and battery technologies will work together. Our view is that we will end up with a number of hybrid offerings whereby fuel cells help energise a car battery. In small vehicles the fuel cells won’t be that big, but in planes and trains it will be the other way round.”

Complementary with all other players, he says governments now have a huge role to play in further driving the

growth of the ecosystem and welcomes the recent EU hydrogen strategy in this regard. “The future availability of hydrogen is a potential barrier to growth and the infrastructure needs to be there to drive it. The likes of South Korea, Japan, and especially China, have also developed long-term plans around the use of fuel cells in electric vehicles.”

Chinese investment

China is expected to become the world’s largest market for electric vehicles powered by fuel cells, with the country aiming to build a million vehicles by 2030. It is also a major reason why Borit, advised by Clearwater International, has created a strategic partnership with the Chinese publicly listed automotive components manufacturer Weifu.

Wanten says Borit will naturally benefit from Weifu’s footprint in the Far East, but stresses that Borit will also be able to support an overall global strategy in new electrification technologies. “The European and North American market remain very important to us and this deal is all about us scaling up production further, value chain integration, and using this partnership to take us to the next level. It will also help us face up to ever increasing competition, especially from new entrants in this industry.”

Borit also shares a number of synergies with Weifu’s Denmark-based subsidiary IRD, a leading specialist in fuel cell membrane and graphite bi-polar plate products. Indeed the combination of Borit, IRD and Weifu’s fuel cell activities now creates one of the world’s leading players of single cell components.

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Our recent automotive transactions


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on the sale to




Sell-side
Undisclosed




sold




to




Sell-Side
€42.7m




sold




to




Sell-side
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sold




to




Sell-side
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acquired a majority stake in



Buy-side
Undisclosed




sold




to

Zhejiang Tieliu Clutch Co. Ltd


Sell-side
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sold




to




Sell-side
Undisclosed




acquired



Buy-side
€180m



sold to




Sell-side
Undisclosed




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