

Participants in the Last Clean-Vehicle Segments Emerge

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1. Introduction

I have written enough papers on hydrogen-fueled vehicles to know their potential advantages versus battery-electric vehicles (BEV):

- Fast refueling
- Very long run-time without refueling

There are two segments of vehicles that appear to be unable to easily transition to designs with no greenhouse gas (GHG) emissions:

- Construction vehicles (bulldozers, front loaders, dump trucks, backhoes, etc.)
- Long-range/duration road vehicles (interstate transports, heavy tow trucks, etc.)

There seems to be a match between the above “advantages” and “vehicles” that might suggest the emergence of some hydrogen-fueled vehicles to meet the needs of the two vehicle segments.

I recently completed the paper summarized and linked below. This post describes that my home state (California) is rapidly accelerating the deployment of hydrogen refueling stations. This might accelerate the above emergence.

Hydro-Honda Gets Help from Trains: *I frequently write about transportation. However, it is rarely that I see one flavor of the mobility-industry interact with a completely different flavor. Like, for instance, light road-going electric vehicles interacting with railed vehicles. This is one of those times.*

<https://energycentral.com/c/ec/hydro-honda-gets-help-trains>

Recently, I encountered a couple of articles from overseas that relate to above group of hydrogen-fueled vehicles. I normally am not interested in off-shore articles, but given the other pieces of this puzzle that recently appeared, I couldn't resist writing this paper. Also, one of the largest heavy engine manufacturers in the U.S. has made a major push into hydrogen and other green designs.

2. Construction Vehicles

California is trying to do everything it can to eliminate diesel-powered vehicles by 2045.¹ It appears that this might be possible for on-road vehicles, but this process hasn't even been started for off-road construction vehicles. Given the amount of heavy construction that routinely goes on in California, I would guess that this will be difficult.

The good news is that other countries have started this process (would you believe the U.K.).

¹ Steve Hanley, Clean Technica, “California Contemplates Ban On Diesel Trucks,” Nov 23, 2022, <https://cleantechnica.com/2022/11/23/california-contemplates-ban-on-diesel-trucks/>

Green energy is where the world is headed. Even though hydrogen fueled vehicles are not as popular EVs, hydrogen is booming with potential and seems far more practical than other zero-emission alternatives. While hydrogen is popular in its fuel-cell guise, an internal combustion version is perhaps not as familiar. Although previous hydrogen engine attempts have made headlines, it's JCB that's really pushing the engineering boundaries here.²



JCB's newly-developed hydrogen-powered internal combustion engine is a zero-emission alternative to electric cars and fuel cells. As a manufacturer of heavy-duty machinery, JCB is well aware of the issues with electrifying an excavator or a backhoe loader. Mind you, the company has multiple working electric and fuel-cell machines in their lineup. So it's not like they haven't tried them.

The British heavy equipment manufacturer reckons hydrogen engines can bridge the gap between utilizing existing combustion technology while keeping things simple, inexpensive, and emissions-free. In this latest Harry's Garage video, JCB explains how their hydrogen technology is almost production-ready and that it's the future of all such heavy machinery. Who knows, it might even, one day, trickle down to passenger cars.

As they say, necessity is the mother of invention. JCB was struck with the problem of going zero emissions without sacrificing power and cost of purchase. In a previous Harry's Garage episode, Lord Bamford, Chairman of JCB, mentioned that passenger cars, on average, run about 300 hours per year. In contrast, a regular heavy-duty backhoe would have running hours close to 10 times that amount. He adds that in countries like India, machines of this scale run for at least 5000 hours per year.

So, to have electricity run an industrial equipment for eight hours at the minimum requires significantly more batteries. Not only does it skyrocket the costs involved, but it will add a ton of complexity and increase the overall weight. Therefore, engineers had to think radically.

² Kiran Menon, Hot Cars, via MSN, "This Hydrogen Combustion Engine Is The EV Alternative We've Been Waiting For," March 7, 2023, <https://www.msn.com/en-us/autos/news/this-hydrogen-combustion-engine-is-the-ev-alternative-we-ve-been-waiting-for/ar-AA18kgvW?ocid=msedgntp&cvid=4377b95d884f48b98d3dd11cea5902a3&ei=12>

Lo and behold, the JCB hydrogen engine was born. Currently, JCBs operate using diesel. But by extensively reworking their engine, engineers were able to run it using hydrogen fuel. According to JCB, nothing but steam is emitted from the tailpipe—zero CO₂ at its point of use. What's more, JCB claims that its prototype backhoe loader, fitted with this new hydrogen motor, can do everything its diesel-powered equivalent can do.

Author's comments: How do we get hydrogen to construction sites? Go through the link in “**Hydro-Honda Gets Help from Trains**” in the Introduction, and then to Section 5.

JCB is based in the UK, but appears to have dealers in the U.S. I did a search for dealers near me (Livermore, CA), and the search engine popped up a bunch over in California's Central Valley. Also note that JCB's IC engine is designed for light-to-medium construction vehicles. For heavy vehicles, see the last section of this post.

3. Long-Duration & -Range Road Vehicles

The US at least one major diesel engine manufacturer for trucks and construction equipment is taking a deep dive into both hydrogen fuel-cell and hydrogen-fueled internal combustion engines.

Elon Musk and Tesla executives recently tried to wow investors with ambitious, wide-ranging plans to make vehicles and energy more sustainable. Now Tesla's green energy plans are facing competition from a surprising source: Cummins, a century-old industrial giant best known for making diesel engines and generators.³

The Columbus, Indiana-based company has its own strategy for a multibillion-dollar cleantech business with Accelera, a new brand for batteries, fuel cells, electric truck components and electrolyzers to make “green” hydrogen from water and electricity. Cummins is folding its existing clean power products unit into Accelera after pouring \$900 million into R&D and acquisitions, including the recent purchase of truck parts maker Meritor, to build up the business. Cummins CEO and president, Jennifer Rumsey wants rapid growth for the unit driven by demand for non-polluting trucks—and generous new federal incentives for low- and no-carbon hydrogen production.

“We're well understood as an engine provider, the largest independent engine manufacturer for commercial and industrial equipment, but we're still working to be recognized for the leader that we are in zero-emissions technologies,” Rumsey told Forbes. Her hope is that a new brand more clearly differentiates the company's low- and zero-emissions tech from its longtime business. Cleantech sales were a fraction of Cummins' \$28 billion revenue last year but could double to \$400 million this year and surge through the 2020s, she said. “We've made a commitment to grow that part of our business to \$6 billion to \$13 billion by 2030.”

Much like General Motors CEO Mary Barra, who's pushing the largest U.S. automaker to become a top seller of electric cars and trucks, Rumsey wants to position the big traditional manufacturer she leads to stay competitive in the years ahead as climate worries and regulations from global governments threaten its carbon-fueled core business. And while Musk wants Tesla to be a major player in heavy-duty trucks, he has to convince global fleet operators his new electric Semi is a more reliable, affordable option than Cummins' heavy-duty tech.

³ Alan Ohnsman, Forbes, “Diesel Giant Cummins Has A \$13 Billion Cleantech Goal—Starting With A New Name,” March 8, 2023, <https://www.forbes.com/sites/alanohnsman/2023/03/08/diesel-giant-cummins-hydrogen-accelera/?sh=21faaf2621d7>

The business opportunity—and challenge—for Cummins and other makers of commercial and heavy vehicles is enormous, running to hundreds of billions of dollars in the years ahead to replace traditional truck engines and generators. Transportation is the main source of U.S. carbon emissions, accounting for 27% of the total in 2020, and commercial vehicles spewed more than a quarter of that. New federal CO₂ regulations target a 270 million metric ton reduction for future commercial vehicles, and the European Union is also pushing to ultimately phase out diesel fuel in the 2030s. That creates an existential challenge for Cummins' diesel business but a massive new market opportunity for Accelera.

Accelera is launching with two new contracts that may be worth tens of millions of dollars: batteries and drivetrain components for 1,000 electric school buses that will be produced by manufacturer Blue Bird and a 90-megawatt electrolyzer system for a Varennes Carbon Recycling plant in Quebec, Canada, Cummins' largest such project to date. The aim of the Canadian project, capable of generating 90 tons of hydrogen per day, is to use the green fuel to convert waste into biofuels and reusable chemicals, Cummins said...

Hydrogen is used for steel and metal production, oil refining and in the chemical and food-processing industries, but it's sourced mainly from natural gas in a process known as steam reformation that releases carbon dioxide. The shift to generating the universe's most abundant element from water and renewable energy holds the promise of dramatically cutting industrial CO₂ emissions even before hydrogen becomes a more widely used transportation fuel. Though cars and trucks are a visible source of CO₂ pollution, electric power generation and industrial emissions are close behind, contributing 25% and 24% of U.S. carbon emissions, respectively.

Even Musk, a longtime critic of hydrogen vehicle technology, is moderating his view of the fuel as a way to curb carbon emissions related to manufacturing.

"It is needed for industrial processes and can be produced just by splitting water essentially," he told investors last week. Still, the billionaire entrepreneur who built Tesla on the premise that lithium-ion batteries are the best option for both cars and large-scale energy storage reiterated his general disdain for a technology that could be a competitor to his long-term plans.

"My personal opinion is that hydrogen will not be used meaningfully in transport . . . it shouldn't be," he said.

Given that Tesla has been quick to take advantage of billions of dollars of cleantech incentives for more than a decade, Musk's sudden interest in hydrogen may result from a new federal program in the Inflation Reduction Act signed into law last year. It provides a tax credit of up to \$3 per kilogram of clean hydrogen—produced without carbon emissions—and is intensifying interest in the fuel.

"The hydrogen economy—honestly, everybody's seeing the potential of it and trying to look at interesting ways to get in there," said Amy Davis, president of the Accelera unit, citing conversations she's having with a range of manufacturers and energy companies about electrolyzers. "It's going to take the oil and gas companies making moves. Then you'll start to see a tidal shift once you get some big projects in the mobility space," she said, declining to name specific companies.

Accelera is positioned to be a top supplier of green hydrogen tech, Davis said. “We already have a 20-megawatt electrolyzer in service today—we’re learning from it—and over 600 electrolyzer applications out in the field,” she told Forbes. “We’re a bit ahead.”

Prior to the Varennes Caron Recycling plant deal, Cummins said in December it will supply a 35-megawatt electrolyzer system to Linde, the world’s largest producer of hydrogen, to make zero-carbon hydrogen with water and electric power from Niagara Falls.

Though companies including Nikola, Daimler, Volvo, Hyundai and Toyota have plans to build a market for heavy-duty hydrogen vehicles, Cummins sees that market as taking a bit longer to develop, given the need to create a hydrogen-fueling infrastructure. Instead, Davis said that major shipping ports and more enclosed environments look like better early potential for Accelera.

3.1. The Biomethane Bridge

PACCAR will work with Cummins Inc. (NYSE:CMI) to offer the new Cummins X15N natural gas engine in Kenworth and Peterbilt trucks. The X15N is the first natural gas engine to be specifically designed for heavy-duty truck applications with up to 500 horsepower output. The engine will include the integration of the Cummins Clean Fuel Technologies fuel delivery system.

“PACCAR can help customers achieve their business goals by offering sustainable, affordable power solutions that use proven engine technology and existing infrastructure,” said John Rich, PACCAR chief technology officer.

PACCAR, Cummins and several customers including FedEx Freight and Knight-Swift will demonstrate the ability to achieve lower carbon emissions for long-haul transport using internal combustion engine technology.

“The X15N is essential to our commitment to help customers reach net-zero greenhouse gas emissions and to improve NOx. Importantly for the customer, the X15N will reduce the cost of adopting low emissions technologies for their fleet, and gives them the confidence to do so, built on the strong foundation of more than 30 years of experience with natural gas,”

When operating on renewable natural gas, also known as RNG or biomethane, the X15N engine will be able to achieve major reductions in the lifecycle greenhouse gas emissions of Peterbilt and Kenworth trucks. This can range from a 90 percent reduction to carbon neutral, or even carbon negative, depending on the bio-source and waste feedstock used to produce the fuel.

The new X15N is capable of lower NOx levels than the 2024 EPA and CARB standards. Equally impressive is the 1,850 ft-lbs. of peak torque output provided by the X15N, which will provide optimum performance when paired with Eaton Cummins Automated Transmission Technologies HD and XD Transmission.

3.2. Other Long Duration Road Vehicles

In the U.S. there are many delivery trucks and service trucks that travel the Interstates. In sparsely populated areas, these vehicles travel many miles each day, and charging every few hundred miles becomes problematic. The extreme use case for this is in the Australian Outback, so one might expect to find some early adapters for hydrogen technology here. Even better is if they use U.S.-based hydrogen technology.

Hyzon, a US-based startup with executives from Australia, drove its first Australian-built hydrogen fuel cell electric truck out of its Noble Park headquarters in Melbourne's south-east on Monday, March 6.⁴

The company has been active in Australia for a few years now and is beginning to deliver on its pre-orders, including with RACV's towing subsidiary, Nationwide. Speaking at the launch, RACV CEO Neil Taylor noted that Nationwide owns 1,000 towing trucks – three of which are now powered by hydrogen, with the commercial trials potentially promising a new zero-emissions future for the fleet.

"We're making it very clear that we've got a product now, the first product that's been designed locally, that's ready to go into market," John Edgley, Hyzon's Melbourne-based international president, told The Age newspaper. "That will give more confidence that actually we can start transitioning these big fleets in companies that have thousands and thousands of these trucks."

Hyzon also has orders in from Coregas in New South Wales, Ark Energy in Queensland, and garbage truck company Superior Pak, part of an agreement which sprouted from a hydrogen innovation hub in Bundaberg.

As part of its partnership with RACV, Hyzon is turning its Australian Noble Park headquarters into purpose-built facility to include corporate offices, a showroom, assembly warehousing and workshops. The company is now preparing to break ground on the 10,000-square-metre manufacturing facility, with the early stages of construction having begun.

Hyzon says the facility is expected to generate over a 100 localized engineering and manufacturing jobs by 2025, with "hundreds more indirect jobs expected through the supply chain."

Hyzon is headquartered in Rochester, New York, but its former CEO and co-founder Craig Knight is Australian, which has presumably led the company to pay attention to Australia's often overlooked hydrogen fuel cell electric vehicle (FCEV) market. The company established its Australian outpost in 2020, and, according to The Age, has now grown its teams to just over 50 engineers, fabricators, welders and designers.

⁴ Bella Peacock, PV Magazine Australia, "Locally built hydrogen tow trucks to be hauling in Victoria from this year," March 8, 2023, https://www.pv-magazine-australia.com/2023/03/08/locally-built-hydrogen-tow-trucks-to-be-hauling-in-victoria-from-this-year/?utm_source=USA+%7C+Newsletter&utm_campaign=74182842a8-RSS_EMAIL_CAMPAIGN&utm_medium=email&utm_term=0_80e0d17bb8-74182842a8-159946110

4. Heavy Construction Equipment

Cummins also offers engines here, and some pretty large ones. They also offer bio-methane and hydrogen versions.

Cummins diesel engines power construction machinery around the globe. Through proven partnerships with some of the world's finest brands, Cummins engines are available in equipment ranging from bulldozers and excavators to grinders and air compressors.⁵

To accommodate the vast needs of the worldwide construction industry, Cummins offers a diverse engine lineup, with ratings from 50-1200 hp. Every Cummins construction engine is engineered to deliver outstanding productivity, built for reliable performance in the harshest environments and designed to give you every advantage for your next job...

Using hydrogen to power an engine or motor is more straight-forward than you might think. There are two ways to do this.⁶

The first way involves a device known as a fuel cell. The fuel cell converts hydrogen to electricity, which then powers the vehicle's electric motors, just like in any electric vehicle.

The other way is hydrogen engines; internal combustion engines that burn hydrogen as the fuel. Either method has its advantages and applications where they are best suited. However, the latter, using internal combustion engines is a more familiar technology.

Today, if you saw a modern internal combustion engine designed to run on hydrogen, you might not know that it's not meant for natural gas. Four-stroke hydrogen internal combustion engines (Hydrogen ICE) operate on the same cycle as regular natural gas engines and have almost the same components—engine block, crank, cylinder heads, ignition system, installation parts, and so on.

Diesel engines and hydrogen engines also share similar components. These include an engine block, crank, and installation parts such as mounts and flywheel housings.

At Cummins Inc., we are leveraging our existing platforms and expertise in spark ignited technology to build hydrogen engines. Our hydrogen engine is a spark ignited engine variant with similar engine hardware to natural gas and gasoline engines.

This high commonality among engine components introduces scale advantages. This economies of scale is critical in the transportation sector's journey to lower emissions. It reduces costs and delivers the needed reliability.



⁵ Cummins, "Construction Equipment Manufacturers that Offer Cummins Engines," <https://www.cummins.com/engines/construction/construction-oems-offer-cummins-engines#:~:text=Through%20proven%20partnerships%20with%20some%20of%20the%20world%E2%80%99s,diverse%20engine%20lineup%2C%20with%20ratings%20from%2050-1200%20hp>

⁶ Jim Nebergall, Cummins Newsroom, "How Do Hydrogen Engines Work?" <https://www.cummins.com/news/2022/01/26/how-do-hydrogen-engines-work>

Hydrogen internal combustion engines are appealing to vehicle makers for two primary reasons: first, their similarity with traditional internal combustion engines; second, hydrogen's ability to power vehicles as a zero-carbon fuel.

An original equipment manufacturer (OEM) can build vehicles with hydrogen engines that are very similar to existing internal combustion engines. Most of the vehicle's other components and software remain the same.

Hydrogen engines are also attractive to end users. Hydrogen engines look, sound and work like the internal combustion engines that every mechanic in the world is used to. Their reliability and durability are equal to that of diesel engines...

Examples of hydrogen engines in the mobility and transportation sectors also go beyond medium and heavy-duty trucking. You can find users evaluating hydrogen engines in marine, construction, and beyond.