



## EQUITY RESEARCH

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Blog

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# BLOG: Ballard Is Helping De-Carbon Transport

Read time ~9 Minutes

*One of the goals of our Technology & Innovation Blog is to expose readers to emerging technologies, companies, and their founders and leaders. This week, Ballard Power Systems and its plans for its hydrogen fuel cell technology are the focus.*

Across Europe, banning internal combustion engines (ICEs) by 2030 is on public agendas. Oslo, Madrid and some German cities are now permitted to ban ICEs. This week's blog discusses our recent interview with Ballard Power Systems and its plans to help solve for de-carbonizing initiatives in Europe and China with its hydrogen fuel cell technology.

2020 marks the start of positive trends for Ballard. In 2020, Ballard is expected to make further product deliveries against the more than 3,000 Fuel Cell Electric Vehicles (FCEVs) that have been publicly targeted by its customers and consortium partners. This is significant and why investors should pay attention, as it compares to an installed base of only ~800 Ballard-powered FCEVs.

Technology & Innovation Blog



*All figures in Canadian dollars unless otherwise stated.*

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This document is intended for Kathy BUTLER (CIBC World Markets)

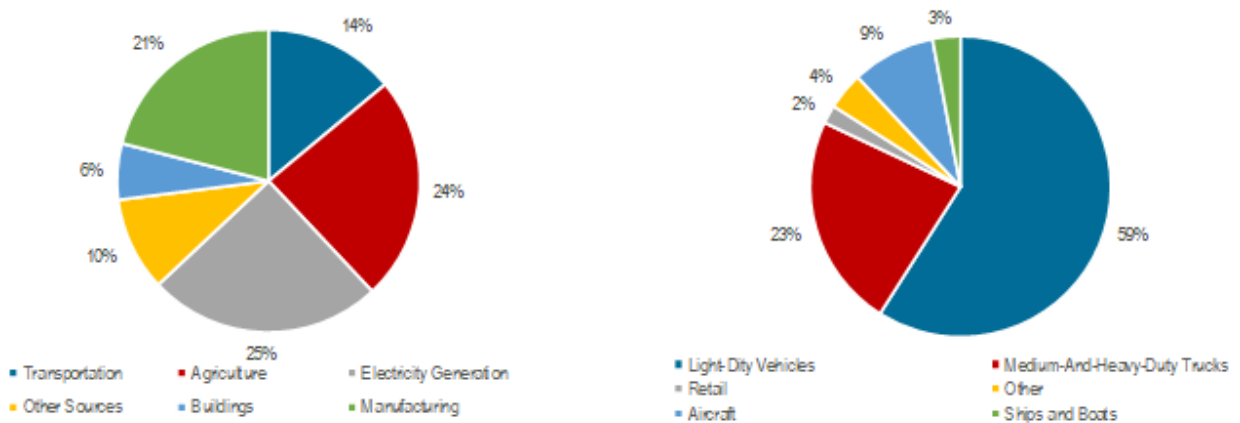
## The Problem: Banning ICE

*“...If we’re going to solve climate change, we need to get to near-zero emission in all the things that drive it – agriculture, electricity, manufacturing, transportation and buildings,” - Bill Gates, GatesNotes 2019 Annual Letter.*

These areas (agriculture, electricity, manufacturing, transportation and buildings) are the five grand challenges to climate change. Each challenge requires breakthrough innovations, according to Bill Gates.

Transportation accounts for ~23% of U.S. greenhouse gases. While U.S. medium and heavy duty vehicles represent only 8% of U.S. vehicles on the road, they contribute about 23% of U.S. green house gas (GHG) emissions (Exhibit 1). In response, many cities are driving towards implementing clean transportation programs. To help achieve this, there is a strong, global desire to move towards zero emission vehicles.

**Exhibit 1: Greenhouse Gas Emissions By Sector (Left) And Share Of U.S. Transportation Sector GHG Emissions By Source (Right)**



Source: EPA.

Those concerned cities and countries are putting policies in place to reduce GHG by banning, or restricting ICEs and diesel engines. Brussels and Oslo have already banned ICEs, while German cities are permitted to ban ICEs. Madrid is expected to ban ICEs by 2020.

In Norway, to implement the Oslo ICE ban and reach a car-free city center, the city started by removing 700 parking spots and replacing them with bike lanes, mini parks and benches. The removal of parking spots and bans for cars on certain streets has led to fewer people driving. Parking garages are still available to ease the business impact. The city has also added new trams and metro lines, while reducing the cost of the tickets. Bike shares have also grown to three million trips per year.

By the fall of 2018, Oslo found it had 10% more pedestrians in the center than the year before. Changing habits are a significant barrier, but there is proof it can be done. Other cities are now following including Madrid, Buenos Aires, London, Seoul, Beijing, Paris, Chennai and more.

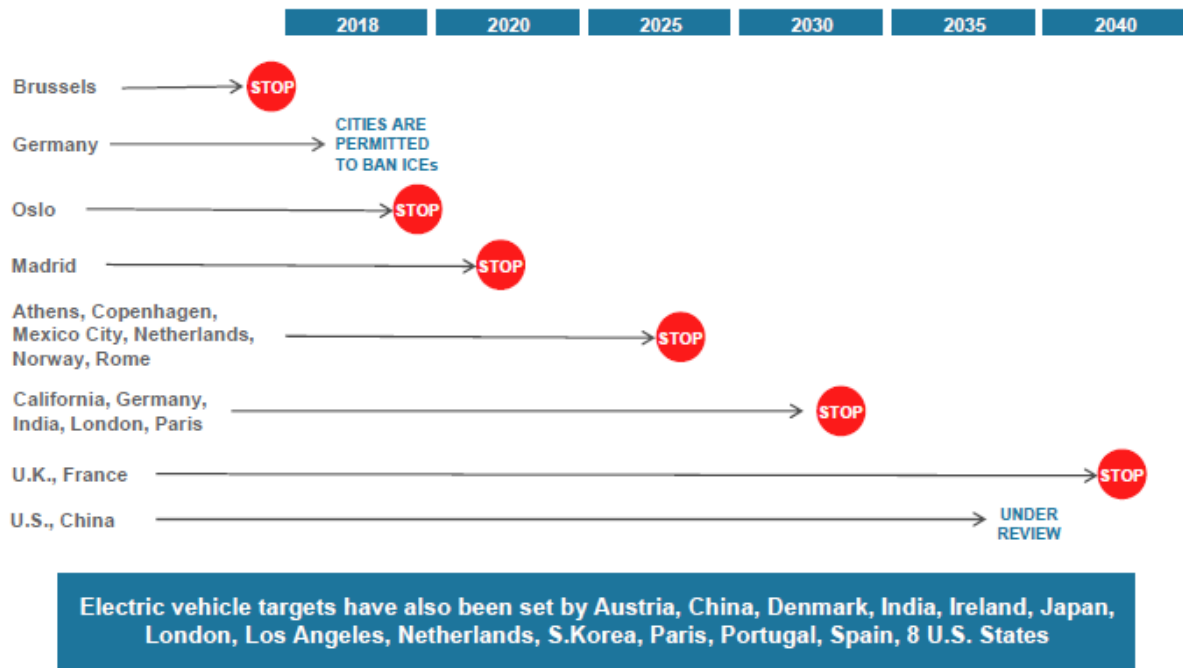
ICE banning highlights from these cities or countries include:

- **Madrid:** created a low emissions zone in its center. Older polluting vehicles are banned but electric cars can use the streets as of November 2018. Electric buses are estimated for 2025.

- **Paris:** By 2024, no diesel cars will be allowed, and by 2030 all ICEs will be banned. Intersections are being redesigned to give people priority over cars.
- **Demark:** ICE ban by 2030 on new vehicle sales. Denmark has urged the EU to ban sales of ICE and diesel cars by 2040.
- **Beijing:** Closed 23 major street to non-resident cars. There is a lottery system to get license plates.
- **Shenzhen:** Has plans for zero emission public transit buses. The Hainan region banned the sale of ICE and diesel cars in 2019.

Each city has its own plan to ease out ICE and diesel vehicles with car-free streets, pedestrian priorities, low speed limits and fees. While the transitions may be bumpy, the goals are clear. To get there, alternative electrification of transportation with enhanced public transit plans must be put place.

**Exhibit 2: Timetable For Banning ICEs**



Source: Ballard

**Technology Options To Replace ICE**

Within transportation, technology options for zero emissions include battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). In March 2019, Bloomberg New Energy Finance (NEF) predicted the number of e-buses in municipal fleets will nearly double by 2025 and equal 6% of the total fleet in Europe. Long term, e-buses are forecast to reach 80% (or 1.3 million e-buses) of the market by 2040.

Currently, batteries have limitations including weight, and recharge times that take hours. The infrastructure to support the ability to charge quickly (at scale) has yet to be implemented. The electrical grid is also not yet designed to support mass electrification, as the current grid can likely handle 20-30% EV penetration. These issues are expected to lead to an array of other “zero emission” drivetrain technologies from fuel cells, to compressed natural gas, to biogas, and bio diesel.



FCEVs are a clean fuel alternative, expected to constitute 20-25% of the transportation sector's energy by 2050, according to the Hydrogen Council and McKinsey's November 2017 *Hydrogen Scaling Up* report. This makes hydrogen a good option, given the limitations of BEV technologies. Fuel cell powered vehicles are also offered in combination with battery electric, known as hybrid configurations.

Fuel cells have zero emissions. Unlike batteries, the carbon intensity is lower. Batteries require mining of many rare earth metals including lithium, nickel, manganese and cobalt. Battery precious metals currently face supply chain risks including high demand for cobalt (due to portable electronics, laptops, energy storage, e-bikes and more) and several supply concerns. Hydrogen fuel cell production uses only platinum, which the industry claims is over 90% recycled, and should enable a significant reduction in cobalt demand.

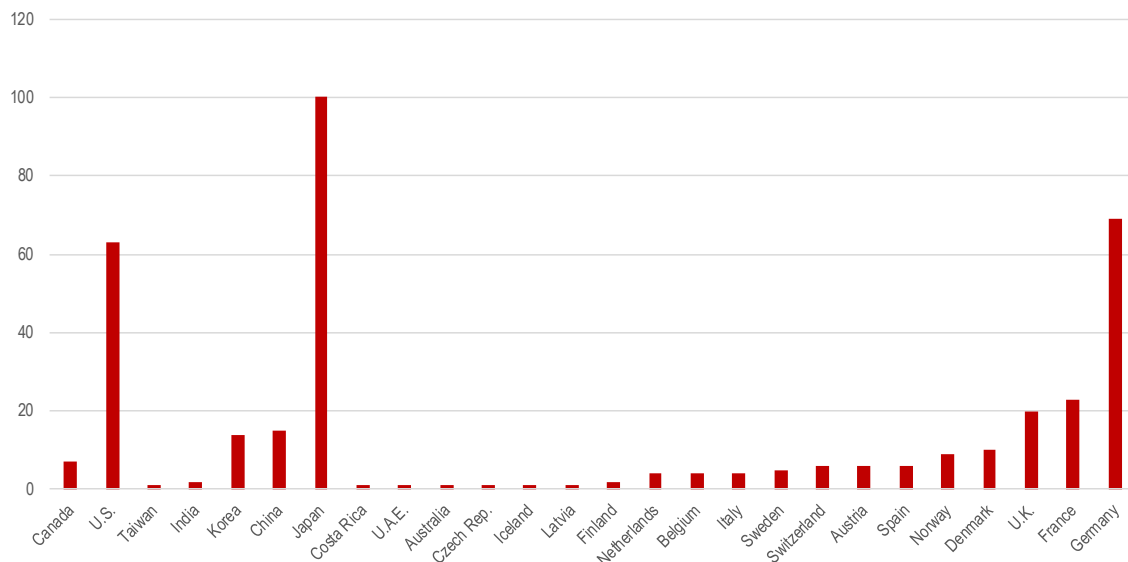
One issue for hydrogen is the limited quantity of fuel stations. Though widespread deployment of hydrogen infrastructure has begun, and is not limiting fleet vehicle applications.

The growth in fuelling stations has been significant to this point in 2019. There are ~31 stations in service in China, and a further 36 are under construction. In addition, China's recent announcement of the "Yangtze River Delta Hydrogen Corridor Project" includes a target of more than 500 hydrogen refueling stations in the Yangtze River Delta region by 2030.

Another issue is that hydrogen is highly flammable under pressure, has a wide explosive range, burns with an invisible flame and cannot be seen or tasted. However, gasoline is more flammable and dangerous than hydrogen fuel. Hydrogen is 14 times lighter than air, its flames emit low radiant energy (are less likely to spread), is non-toxic, and is less combustible. Buses can also be equipped with hydrogen detectors to determine if a leak has occurred.

Increasing momentum in the fuel cell space has been confirmed by recent deals along the transportation value chain. Related transactions include Cummins \$290MM acquisition of Hydrogenics, Bosch's Licensing agreement with Powercell, CNH Industrial's partnership and planned \$250MM investment in Nikola, and Weichai Power's \$164MM investment in Ballard.

**Exhibit 3: Number Of Hydrogen Refueling Stations At The End of 2018**



Source: IEA



## Buses And Trucks Powered By Hydrogen Fuel Cells Are A Good Option

*“Hydrogen powered fuel cell vehicles could constitute up to 20% of the global fleet”,*

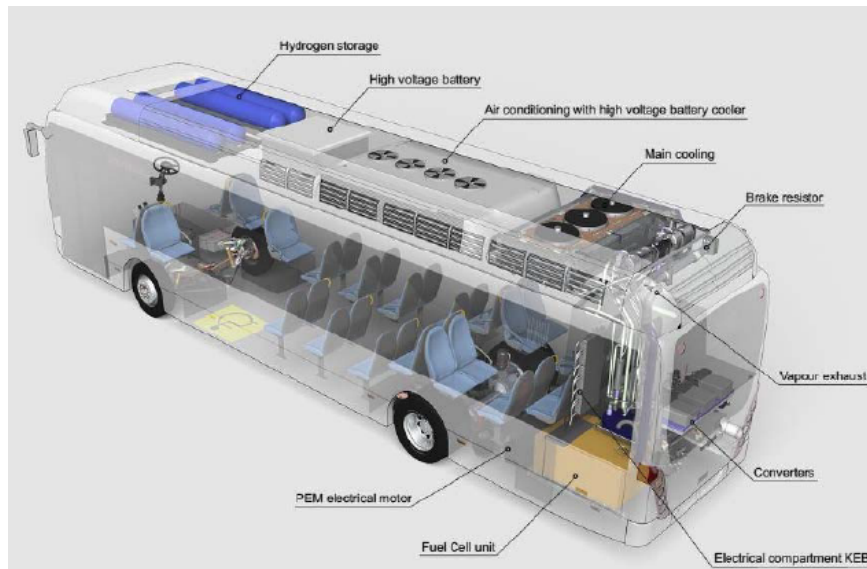
*-Hydrogen Council*

Hydrogen fuel cell systems are achieving market traction today, particularly in Medium and Heavy Duty (M/HD) Motive applications, where they are an accepted clean energy option. They also meet key requirements: from extended range in excess of 100km; heavy payloads of greater than ten tons; rapid refueling (typically no more than ten minutes); and route flexibility. M/HD applications include transit buses, commercial trucks, trains and marine vessels.

All FCEV configurations are, strictly speaking, hybrids – in some instances fuel cell power is dominant (with small batteries or ultracaps), while in other instances battery power is dominant (with the fuel cell acting as an onboard battery charger to extend vehicle range).

Typical transit buses are on the road for 15- 20 hours per day, so replacement with zero-emission fuel cells solves for heavy GHG emissions. And, with a single hydrogen station at the bus depot, the fleet can be refueled efficiently at night and be ready for all-day operation the next morning. These characteristics make FCEVs well suited for vehicle fleets where common centralized refueling infrastructure is appropriate.

### Exhibit 4: A Fuel Cell Electric Bus And Its Components



Source: Ballard.

Ballard estimates that the total market for heavy duty electric and trucks will reach \$20 billion by ~2025. It further expects that there will be 20,000 fuel cell commercial vehicles (buses and trucks) by 2023. If achieved, this is significant as there were only 2,500 e-buses in Europe, and 300 in the United States at the end of 2018. China made up 99% of the entire e-bus market or 425,000.

Longer term, McKinsey has predicted that the total hydrogen fleet could be 20-25% of the global fleet that includes 400 million cars, 15–20 million trucks and 5 million buses of the global fleet by 2050.

## Ballard's 2020 Deliveries For Europe And China Are Rising

Ballard's fuel cells have had 16 million miles of on-road experience, used primarily in trucks and buses. Its FCmove™ fuel cell module is an eighth generation product. Significant performance data has been collected. This data is helping customers make decisions that include fuel cell systems. To help with decision making, Ballard estimates that compared to 2009, total cost savings could be up to 80% by 2023.

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### Exhibit 5: FCmove™: Ballard's 8<sup>th</sup> Generation Fuel Cell Module



Source: Ballard.

Founded in 1979, Ballard has taken a long time to reach its installed base. That rate of growth is about to change. Today, Ballard is powering about 40 fuel cell electric buses (FCEB) in Europe, 170 FCEBs in China and 30 FCEBs in the U.S., along with almost 600 commercial trucks in China.

With a ramp up expected to start in 2020, over 3,000 FCEBs are publicly targeted by customers and partners to be delivered through 2023. This is the start of what Ballard expects to be a multi-year trend of growth for FCEBs.

In Europe, the JIVE funding program ("Joint Initiative for hydrogen Vehicles across Europe") will support the ultimate deployment of 294 FCEBs of which a proportion have been identified. To date, Ballard has orders for modules to power the following 92 buses under JIVE (with the large majority expected to ship in 2020):

- 5 modules for buses in Pau, France
- 20 modules for buses in London, U.K.
- 30 modules for buses in Cologne, Germany
- 10 modules for buses in Wuppertal, Germany
- 12 modules for buses in Bolzano, Italy
- 15 modules buses in Aberdeen, Scotland

In Europe, Ballard is also a member of the H2Bus Consortium with a program for FCEB deployments. The consortium members – including Ballard – are targeting the delivery of 1,000 FCEBs throughout Europe by 2023 at competitive prices. The consortium members are forward-pricing the buses and hydrogen supply based on the 1,000-unit volume target to help accelerate momentum in the European market. Under this program, an initial 200 buses will be deployed in each of the U.K., Denmark and Latvia. With these buses comes hydrogen fuel which will be delivered by a large scale production plant in Herring, Denmark.

In China, Ballard anticipates commissioning of its joint venture facility with Weichai Power in the next several months. Weichai is stated owned, and the largest diesel engine OEM in China. In the interim, since May 2019, the joint venture issued a purchase order to Ballard valued at \$44M to enable partial fulfillment of Weichai Power's commitment to power 2,000 FCEVs (buses & trucks) by 2021.

Ballard is in the process of shipping components and module kits from its Vancouver facility against the Weichai order, which will be sufficient to fulfill roughly one-third of Weichai's 2,000 module commitment. The remainder of the 2,000 modules needed to power FCEVs will come from the JV operation - with Ballard exclusively supplying its patented propriety membrane electrode assemblies (MEAs) required for these modules also from its Vancouver facility. Its positive to see Ballard's ability to sell and ship its technology to China while protecting its IP.

Beyond 2020, this JV will have capacity to supply modules for up to 20,000 vehicles per year. Weichai has taken a 19.9% interest in Ballard. For context, approximately 400,000 buses are manufactured in China per year, considerably more than the ~20,000 manufactured in Europe and North America combined.

Ballard is also working in other M/HD Motive verticals, including trains/trams and marine vessels, along with light-duty vehicles including forklift trucks, UAVs and passenger cars. Ballard is working with Audi, which has announced plans to bring its h-tron hydrogen car to market in the 2022-23 timeframe.

Ballard's competitive edge is its technology with 1,500 patents and patent applications, and strong product performance, including modules with more than 35,000 hours of operation with minimal maintenance. It also has unsurpassed field experience, including 25MM kilometers of vehicle operation, production of 5MM MEA's and delivery of over 850 MW's of product. Its customers and partners include VW/Audi, Weichai Power, CRRC, ABB, Siemens, BAE Systems, New Flyer and Van Hool.

There are only a handful of public competitors in the fuel cells space. Plug Power is a Ballard customer and is headquartered in New York where it designs and manufacturers fuel cells. It has a market cap of \$1.4B, and the stock is up ~85% this year as Plug executes on its goal of reaching \$1B in sales within four years. Plug Power's customers include Amazon and Walmart which use its fuel cell technology with forklifts for commercial operations. It is used in more than 25,000 fuel cell-powered forklifts in the U.S., and is expanding with DHL to power its StreetScooter vans, and with FM Logistics to supply its hydrogen capacity for the next five years for its fleet vehicles. Other competitors include Intelligent Energy and PowerCell Sweden.

## Conclusion

We expect the next few years to be the start of favourable trends for Ballard, as it ramps up product shipments to customers in the key geographies of Europe, China and California. Aided by favourable industry trends, we will continue to track its progress and recommend investors also pay attention.

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