TRACKING THE ENERGY TRANSITION 2020

A New Hope

How hydrogen can deliver climate solutions and clean energy competitiveness for Canada

CLEAN ENERGY CANADA

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SFU MORRIS J. WOSK CENTRE FOR DIALOGUE

A race to the top

If there's one thing the energy community can agree on, it's that making the right or wrong long-term bet can lead to investors jumping for joy or burying faces in hands. That's especially true when it comes to the question of whether—and how—Canada's energy sector can evolve and compete in the decades ahead.

Hydrogen has a long, impressive history—it fuelled the first internal combustion engines and launched humankind to the moon—but while the product itself isn't new, how it's both created and used over the coming decades will be. Consequently, the choices we make now as a nation could impact whether Canada's hydrogen sector grows and succeeds or withers and disappears.

Why the renewed interest in hydrogen? **Hydrogen has a number of unique advantages as a climate solution, particularly in sectors that are the most difficult to decarbonize** and where alternatives are limited, often referred to as the "toughest third" of emissions. These include trucking, shipping, and the production of steel, fertilizer, and cement.

Hydrogen thus offers a new hope for combating climate change, but only if its production is cleaned up. While previous estimates found Canada to be a top-10 global hydrogen producer, supplying some three-million tonnes annually for industrial use, most of this hydrogen is made using fossil fuels. In other words, it's part of the climate problem.

But that need not be the case. By capturing and storing this carbon pollution, so-called blue hydrogen can be produced. Given Western Canada's hydrocarbon endowment and experience with carbon capture and storage, blue hydrogen has been described as a lifeline for the struggling oil and gas sector.[1]

Blue hydrogen is indeed a significant improvement over conventional hydrogen from a climate perspective—and can play a role helping build out the hydrogen economy—Canada and the provinces exploring hydrogen must also plan for a future in which "cleaner" hydrogen could be outcompeted by the "cleanest" hydrogen.

Today, that takes the form of green hydrogen, produced using renewable electricity and a process called electrolysis. In the future, green hydrogen could be in competition with hydrogen created via other innovative technologies, like the process being developed by Alberta-based Proton, which separates hydrogen from heavy oil underground, leaving the carbon behind. And it remains to be seen how much cleaner blue hydrogen might become.

What is clear is that **cost and cleanliness will dictate which nations' hydrogen sectors are best positioned to compete in the years and decades to come.**

The good news? According to researchers at Harvard, Canada is among a small group of countries with the highest potential for exporting clean hydrogen, thanks to a clean power system (82% of Canada's electricity grid is already non-emitting) and plenty of access to water (required for electrolysis).[2]

But the time to act is now. **Already, 18 economies comprising more than 75% of global GDP are developing and rolling out hydrogen strategies.**[3] Some, like the EU and South Korea, have dedicated post-pandemic recovery funds to make it happen. Not unlike its contribution to wind power in the '90s and 2000s, Germany's priming of the hydrogen market with a €9-billion ($13.7-billion) strategy could lead to a snowballing competitive market—and increasingly cheaper clean hydrogen.*

A Canadian hydrogen strategy is expected soon. Will it be enough to ensure Canada is not only in the leading pack today but prepared to keep its position in the race? While it is challenging to accurately predict how much or how quickly the hydrogen market will take off, the International Energy Agency cites a "growing international consensus that clean hydrogen will play a key role in the world's transition to a sustainable energy future." BloombergNEF, meanwhile, estimates that **clean hydrogen could meet up to nearly a quarter of the world's energy demand by 2050.**[4]

If Canada is to compete and succeed in the global hydrogen economy, we must harness our competitive advantages and focus on the long-term with a plan to produce, use, and export the world's cleanest hydrogen and its related technologies. A $1-billion federal fund over five years could be invested in strategic regional hubs that leverage local expertise, supporting research and development and, critically, deployment.

Hydrogen offers Canada an opportunity to sustain its role as an energy leader while cementing a role as a climate one. It offers new economic opportunities, both at home and abroad, both as a commodity and a technology play. And critically, hydrogen can help Canada achieve net-zero emissions by 2050. It offers a new hope. But success is not a foregone conclusion, and the race is already afoot. It's time for Canada to get moving.

Merran Smith
Executive Director
Clean Energy Canada

*Foreign currencies have been converted to Canadian dollars using exchange rates provided by the Bank of Canada. For amounts in 2020, we used the average exchange rate of the first eight months. For amounts announced in a previous year, we used the average exchange rate across that year.

"What is new today is both the breadth of possibilities for hydrogen use being discussed and the depth of political enthusiasm for those possibilities around the world. Hydrogen is increasingly a staple of mainstream energy conversations in almost all regions, with a diverse group of countries and companies all seeing hydrogen as having a potentially valuable and wide-ranging part to play in the future of energy."

—International Energy Agency[5]

Photo: Ballard Power Systems

Hydrogen 2.0

In many ways, hydrogen is nothing new. It fuelled the first internal combustion engines more than 200 years ago, lifted early airships to heights never before reached, and a century later launched humankind to the moon in 1969.

Enthusiasm around hydrogen's use in the modern world is also nothing new. Hydrogen's would-be role as a major fuel alternative in transportation was touted in the '70s, '90s, and early 2000s when Canada's largest hydrogen technology company, B.C.-based Ballard Power, saw stock prices soar before taking a dramatic tumble.

But Ballard shares have been climbing upward again in recent years, as has the company's bottom line. **The fuel-cell maker's fourth-quarter revenue increased by 47% in 2019**, while senior executives project annual revenue growth of roughly 30% before really taking off after 2023.[6]

Ontario-based Hydrogenics, another significant hydrogen technology player, has seen similarly successful years.

What's changed in 2020? Is this just another hydrogen hype cycle?

For its part, the International Energy Agency seems to think this time really is different, citing the "breadth of possibilities for hydrogen use being discussed and the depth of political enthusiasm" as key reasons.[7] After all, the words "climate crisis" were hardly in common parlance even a decade ago. The International Renewable Energy Agency and leading energy analysts from the likes of BloombergNEF, Wood Mackenzie, and Morgan Stanley have also increasingly focused on hydrogen getting cleaner, more cost-competitive, and ultimately playing a pivotal role in decarbonizing future energy systems.[8]

Especially over the last few years, hydrogen has taken a front seat in policy discussions and among decision-makers. In 2017, the global Hydrogen Council was formed and can now count more than 90 members.[9] Even this year, **the energy carrier keeps popping up as jurisdictions across the globe map out their post-COVID-19 economic recovery plans, with many putting clean energy at their centre with explicit plans for hydrogen.**

So, why use clean hydrogen when one could use clean electricity instead? In many cases, electricity will indeed be the preferred option, as we've witnessed so far with passenger cars and the dominance of lithium-battery electric vehicles. But hydrogen has a number of unique advantages, particularly in sectors that are the most difficult to decarbonize and where alternatives are limited—what BloombergNEF calls the "toughest third" of emissions.[10] And therein lies hydrogen's significant potential—and an opportunity for Canada—as we build toward a net-zero 2050.

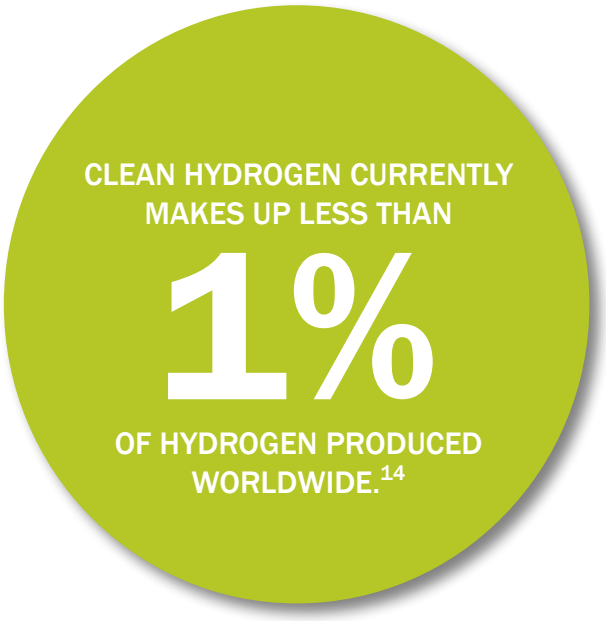
WHAT IS CLEAN HYDROGEN?

Broadly speaking, clean hydrogen is hydrogen produced from zero-emission sources or low-emission sources that could become cleaner over time.

Compared to Canada's current supply, hydrogen from the following sources can be considered clean:

- **Zero-emission electricity from renewables like wind, solar, and hydro.**
- **Natural gas in conjunction with carbon capture and storage, as well as low upstream emissions from natural gas extraction.**
- **Other innovative zero-emission technologies.**

Clean hydrogen thus covers green and best-in-class blue hydrogen, as well as hydrogen produced using other innovative zero-emission technologies. Conversely, hydrogen produced from fossil fuels without carbon capture and storage cannot be considered clean.



COMMON COLOURS

Grey, black, and brown hydrogen is produced from fossil fuels. Most hydrogen around the world is currently created this way; 76% of dedicated hydrogen production uses natural gas (grey hydrogen) and 23% comes from coal (black hydrogen from hard coal, brown hydrogen from lignite).[11]

Blue hydrogen is produced from fossil fuels but in conjunction with carbon capture and storage, meaning that with current technology, up to around 90% of the carbon pollution from production can be captured and sequestered.[12] Once accounting for upstream emissions from the production of natural gas, emissions from blue hydrogen could be around 20% of those from grey hydrogen under optimistic assumptions.[13] Technologies like the one being developed by Proton, which uses hydrocarbons as an in situ feedstock but leaves the carbon behind, do not currently have an established colour designation.

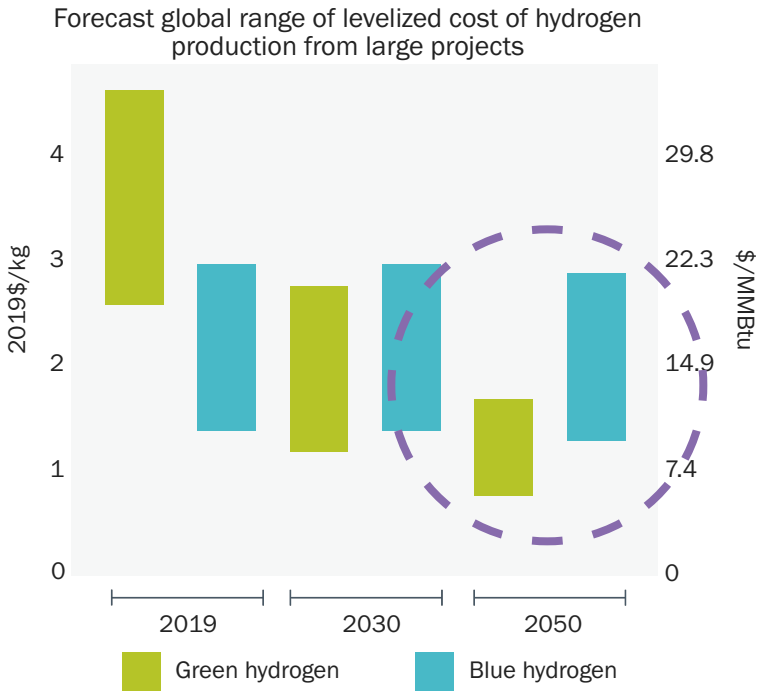
Green hydrogen is produced from renewable electricity such as wind, solar, or hydro using a process called electrolysis. As long as the electricity is generated using non-emitting sources, the emissions intensity of hydrogen from electrolysis is zero.

A TALE OF TWO PATHWAYS

Between 2000 and 2018, roughly 230 green and blue hydrogen projects went into operation globally, though the capacity of blue hydrogen projects currently dwarfs the former. This trajectory is likely to change.

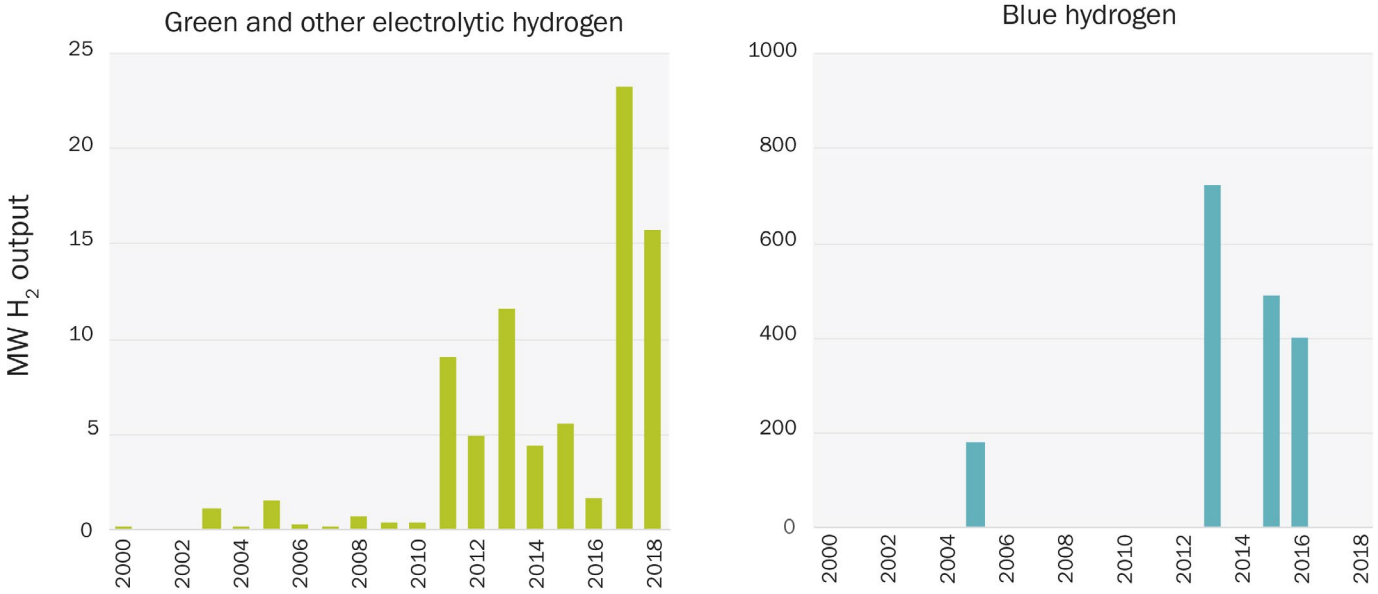
According to analysts at Wood Mackenzie, the cost of green hydrogen will drop by up to 64% until 2040, while the cost of blue hydrogen will see a rise of 59% over the same period, mostly due to natural gas prices.[15] A 2019 study in Nature Energy concluded that if market trends continue, **green hydrogen could be cost-competitive within a decade.**[16] Some analysts are even more bullish, with Morgan Stanley projecting that cheap wind power in some states could enable green hydrogen to compete on cost with grey hydrogen as soon as 2023.[17]

The cost of producing green hydrogen is projected to be on par with blue by 2030 and cheaper thereafter



Source: BloombergNEF, 2020[19]

The capacity of new green/electrolytic and blue hydrogen projects completed since 2000. While blue is well ahead (note the Y-axis), green is quickly accelerating.



Source: International Energy Agency, 2020[18]

> **"It is increasingly clear that the goals of the Paris Agreement cannot be met without a substantial scale-up of clean gas technologies—such as hydrogen."**
>
> *—Jon Moore, BloombergNEF CEO*[27]

Hydrogen's role in a net-zero Canada

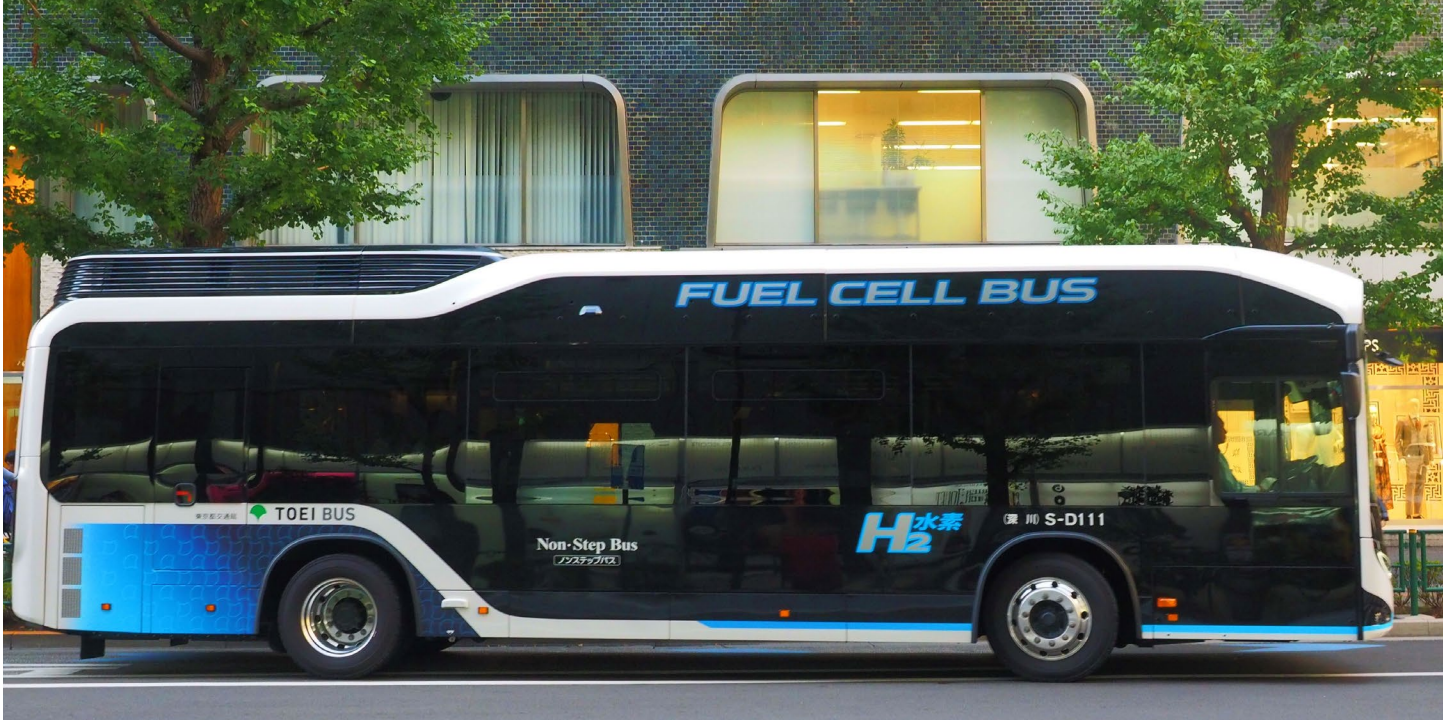
As Canada has pledged to reach net-zero emissions by 2050—doing its part to restrict climate change to 2°C or even 1.5°C—we must not only find short-term carbon pollution reductions but put our economy on a long-term trajectory to net zero. In short, some reductions are harder than others, and in these areas hydrogen could play a critical role. In fact, **BloombergNEF estimates that hydrogen could abate up to 37% of the world's energy-related emissions with strong policy support.**[21] (In Canada, 82% of emissions came from energy in 2018.[22]) Broadly speaking, hydrogen can help decarbonize our economy by:

1. **Replacing fossil fuels with new hydrogen-based applications**, particularly in sectors that are the most difficult to decarbonize and where alternatives are limited (the aforementioned "toughest third" of emissions).

2. **Decarbonizing natural gas utilities**, which are increasingly setting targets or facing regulations requiring they blend in increasing amounts of renewable gases, including biomethane and hydrogen.[23] Up to 15% of the blend can be hydrogen with little modification to existing pipeline systems and appliances.[24]

3. **Reducing the emissions intensity of grey hydrogen production by making it blue or replacing it with green.** Current emissions from global industrial hydrogen production (used in refineries and the fertilizer industry) amount to 830 million tonnes of CO_2 per year.[25] For comparison, Canada's entire economy emits just over 700 million tonnes annually.[26]

4. **Using hydrogen to store energy.** As we decarbonize our energy systems using variable sources of electricity (the wind doesn't always blow and the sun doesn't always shine), there is a growing need to store this clean energy for use during all hours of the day—something hydrogen can be used for.



OPPORTUNITIES FOR DEEP DECARBONIZATION

Industrial heat

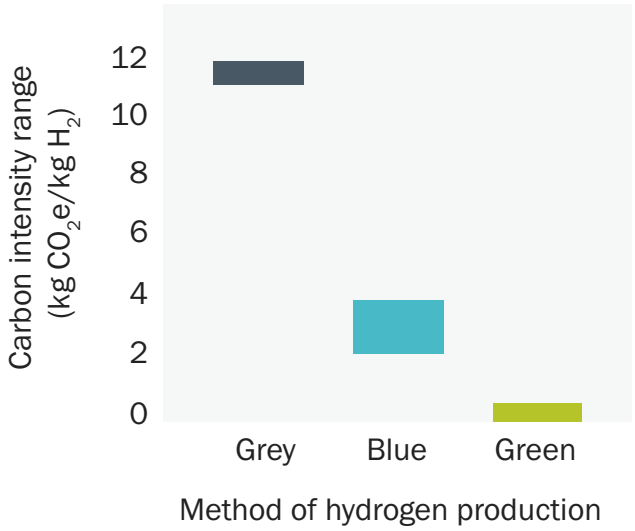
When it comes to producing steel and cement, high temperatures of up to around 1,500°C are often needed to get the job done. Creating temperatures that hot usually requires burning something: generally coal or natural gas. The answer? Successful demonstrations have shown hydrogen can stand in for fossil fuels.[28] Steelmakers in Sweden and Germany are already making plans to transition their furnaces,[29] while hydrogen could be paired with other combustibles to fire cement kilns.[30] There is also an opportunity to clean up the emissions intensity of existing hydrogen use in refineries and the fertilizer industry, which both currently draw on grey hydrogen as a feedstock. **In Canada, energy-related carbon pollution from refining, chemicals, steel, and cement accounts for roughly 6% of all emissions.**[31]

Residential and commercial heat

When it comes to heating homes and businesses, the case for hydrogen is a little less clear, given clean electricity is already commonplace. Where clean electricity is not a viable option, hydrogen can be blended into existing natural gas heating networks (at safe levels of up to 15% by volume in some cases) to reduce the carbon intensity of this heat supply.[32] Calgary-based gas and electricity company ATCO is behind a $5.7-million pilot project in Fort Saskatchewan, Alberta, that will see hydrogen blended with natural gas for home heating starting next year,[33] while in British Columbia, utility FortisBC is looking to blend hydrogen into its natural gas grid and has partnered on a proposed $200-million-plus green hydrogen plant in northern B.C.[34] The U.K. and Italy have already begun hydrogen blending tests, while in the Netherlands a plan is underway to trial heating homes with 100% hydrogen.[35] **In Canada, energy-related carbon pollution from buildings accounts for roughly 11% of all emissions.**[36]

Heavy-duty transport and rail

Comparing the carbon intensity of hydrogen production in Canada



Source: Pembina Institute, 2020[20]

Longer driving distances require larger batteries, but this comes at the expense of payload capacity. Cold climates can further limit the range of electric buses given space heating requirements for passengers. Hydrogen may therefore represent an advantage for some heavy-duty vehicles. BloombergNEF and others estimate that long-haul, heavy-payload trucks could be more cost-effective running on hydrogen than diesel by 2031.[37] Early examples include two fuel-cell hybrid trucks that are currently being tested between Edmonton and Calgary,[38] and up to 400 diesel-powered mining haulers that Anglo is converting to hydrogen at a South African mine.[39] Rail is another area of potential, particularly where electrification is not possible. The world's first hydrogen-powered train in Germany and Ontario's hydrogen feasibility study for its GO Transit network show promise—while creating business for Canada-based companies like Ballard and Hydrogenics.[40] **Nationally, energy-related carbon pollution from heavy-duty transport and rail accounts for roughly 10% of all emissions.**[41]

Marine and aviation

Liquid hydrogen could power roughly 99% of container vessels that cross the Pacific Ocean, according to a study from the International Council on Clean Transportation,[42] though that dream is still some way off. Demonstration vessels are in the works in France and Norway: a push-boat and a high-speed ferry, both of which will run on hydrogen starting in 2022.[43] In April 2019, Ballard announced a Marine Center of Excellence in Denmark to explore how fuel-cell technology could be used in boats.[44] And farther down (and higher up on) the horizon is the prospect of hydrogen-powered aircraft. While commercial planes aren't for sale yet, California/U.K.-based startup **ZeroAvia carried out the world's first test flight of a commercial-grade aircraft powered by hydrogen in September** and is looking to put a 20-seater into the air by 2023.[45] It's not without competition: another startup in California aims to bring hydrogen technology to regional airliners as soon as 2024, and European manufacturer Airbus has revealed concepts for three hydrogen-powered planes that could be flying by 2035.[46]

Synthetic fuels

While still early days for this application, hydrogen can be combined with carbon to create synthetic fuels. The process itself isn't new. It's one that's been used by nations in the past that have found themselves short on oil. **B.C.-based Carbon Engineering—a carbon removal technology company—has plans to combine the carbon dioxide it captures with clean hydrogen to make synthetic fuels.** Because the fuel is made with carbon captured from the atmosphere, its subsequent use is essentially carbon-neutral.[47]

The global hydrogen landscape

A number of governments around the world have adopted hydrogen strategies and put forward significant funding for the technology.

The EU's and several of its member states'—especially Germany's—plans to push the use of hydrogen will likely trigger a competitive race with China, according to BloombergNEF's global head of industry and building decarbonization.

These recent commitments "completely change the outlook" for hydrogen as competition could help drive down costs and scale up production, he says. "That really sends a strong signal to everybody else—to China, to Japan, to South Korea, perhaps to parts of the United States—to say: 'Ok, we can't be left behind here.'"[48] With our geographical advantages, Canada could easily add itself to that list.

Who has a hydrogen plan?

Jurisdiction	Has a plan	Funds committed*
European Union	✓	*Backed by COVID-19 stimulus package that earmarked at least €547.2 billion ($830.3 billion) for climate action*
South Korea	✓	*Included in clean stimulus plan worth ₩114-trillion ($128.6-billion)*
Germany	✓	€9 billion ($13.7 billion)
France	✓	€7.2 billion ($10.9 billion)
Portugal	✓	€7 billion ($10.6 billion)
United Kingdom		*Highlighted in £350-million ($602.2-million) clean stimulus package and Scotland's £62-million ($106.7-million) energy recovery fund*
Norway	✓	*Included in clean stimulus plan worth 3.6 billion kroner ($510.5 million)*
Austrailia	✓	A$300 million ($273.2 million)
Denmark		€100 million ($151.7 million)
Netherlands	✓	€35 million ($53.1 million)
Spain	DRAFT	€25 million ($37.9 million)
Lithuania		€22 million ($33.4 million)
New Zealand	✓	NZ$20 million ($17.2 million)
Canada	DRAFT	?

*Italics indicates that funds are part of a COVID-19 stimulus and recovery package that also covers other funding areas.

Previous estimates found Canada to be a top-10 global hydrogen producer, producing some three-million tonnes of hydrogen annually for industrial use. However, most of this hydrogen is produced from fossil fuels and is therefore not clean.[56]

Canada

As of 2017, hydrogen technology and services companies in Canada had revenues of at least $207 million and employed over 1,600 people in the country.[49] **It's on this technology side of hydrogen, particularly in fuel cells, where Canada has been a global leader and exporter.** These companies are explored in the next section. On the production side, for which public revenue and job numbers are not available, Canada is a major producer of grey hydrogen, but clean hydrogen remains a largely unrealized opportunity.

There are early indicators this is changing. The governments of Canada, B.C., and Alberta are currently working on hydrogen strategies,[50] while Quebec has shown interest in hydrogen.[51] Last year, Natural Resources Canada released a report on hydrogen pathways,[52] while a new Alberta task force with stakeholders across industry and government is developing "a framework to implement a hydrogen economy in the region."[53] The province of B.C. similarly sponsored a provincial hydrogen study in 2019,[54] while the Ontario government has seriously explored using hydrogen fuel-cell-powered trains on its GO Transit network.[55] But other nations have already put forward their hydrogen plans and the investment dollars to realize them. **If Canada is to seize the hydrogen opportunity, now is the time to capitalize on our potential.**

European Union

As of 2020, it's clear which continent is most seriously positioning itself to win a competitive hydrogen race. Unveiled in July, the EU's hydrogen strategy prioritizes green hydrogen while allowing blue hydrogen in a transition phase. The EU envisions installing at least six gigawatts of green hydrogen by 2024 and at least 40 gigawatts by 2030. This would be followed by the large-scale deployment of new hydrogen technology out to 2050.[57] **The strategy is backed by the EU's COVID-19 stimulus package, which earmarked at least 30% of its €1.8-trillion ($2.7-trillion) total for climate action over the next seven years.**[58]

Germany

Not unlike its contribution to wind power in the '90s and 2000s, Germany's early leadership in the hydrogen market could create a snowball effect around the world. **With a national €9-billion ($13.7-billion) hydrogen strategy—a significant slice of its €130-billion ($197.2-billion) COVID-19 stimulus package—Germany aims to create a market for competitively priced clean hydrogen.**[59] The country is also an eager adopter of hydrogen technology. Canadian-made fuel cells from Hydrogenics can be found in the world's first hydrogen-powered trains in Germany,[60] while last year steel manufacturer Thyssenkrupp successfully ran a furnace entirely on hydrogen, also a world first.[61]

United Kingdom

Hydrogen was highlighted in the U.K.'s £350-million ($602.2-million) clean stimulus package and in Scotland's £62-million ($106.7-million) energy recovery fund, both unveiled over the summer.[62] **National Grid, one of the world's largest investor-owned utility companies, has said hydrogen will be "necessary" for the U.K. to meet its net-zero emissions goal.**[63] Earlier this year, green hydrogen was also injected into a U.K. gas network—one way that natural gas heating can be made cleaner—while Norwegian oil and gas giant Equinor has plans to build a blue hydrogen facility in the country.[64]

Scandinavia

Climate hawks won't be surprised that Europe's northernmost countries are also leading the charge on hydrogen. **Denmark** is spending €100 million ($151.7 million) on roughly 100-megawatts of green hydrogen capacity,[65] while in the private sector, oil-and-gas-turned-renewable-energy company (and stock market star) Ørsted is teaming up with Copenhagen Airport and others on a green hydrogen fuel facility.[66] In **Sweden**, two steel companies are transitioning their furnaces to eventually run on hydrogen.[67] And **Norway**, like many other European countries, highlights hydrogen in a 3.6-billion-kroner ($510.5-million) clean stimulus package, while state-owned Equinor aims to be a player in hydrogen at home and abroad.[68] Norway unveiled its clean hydrogen strategy in June.[69]

Elsewhere in Europe

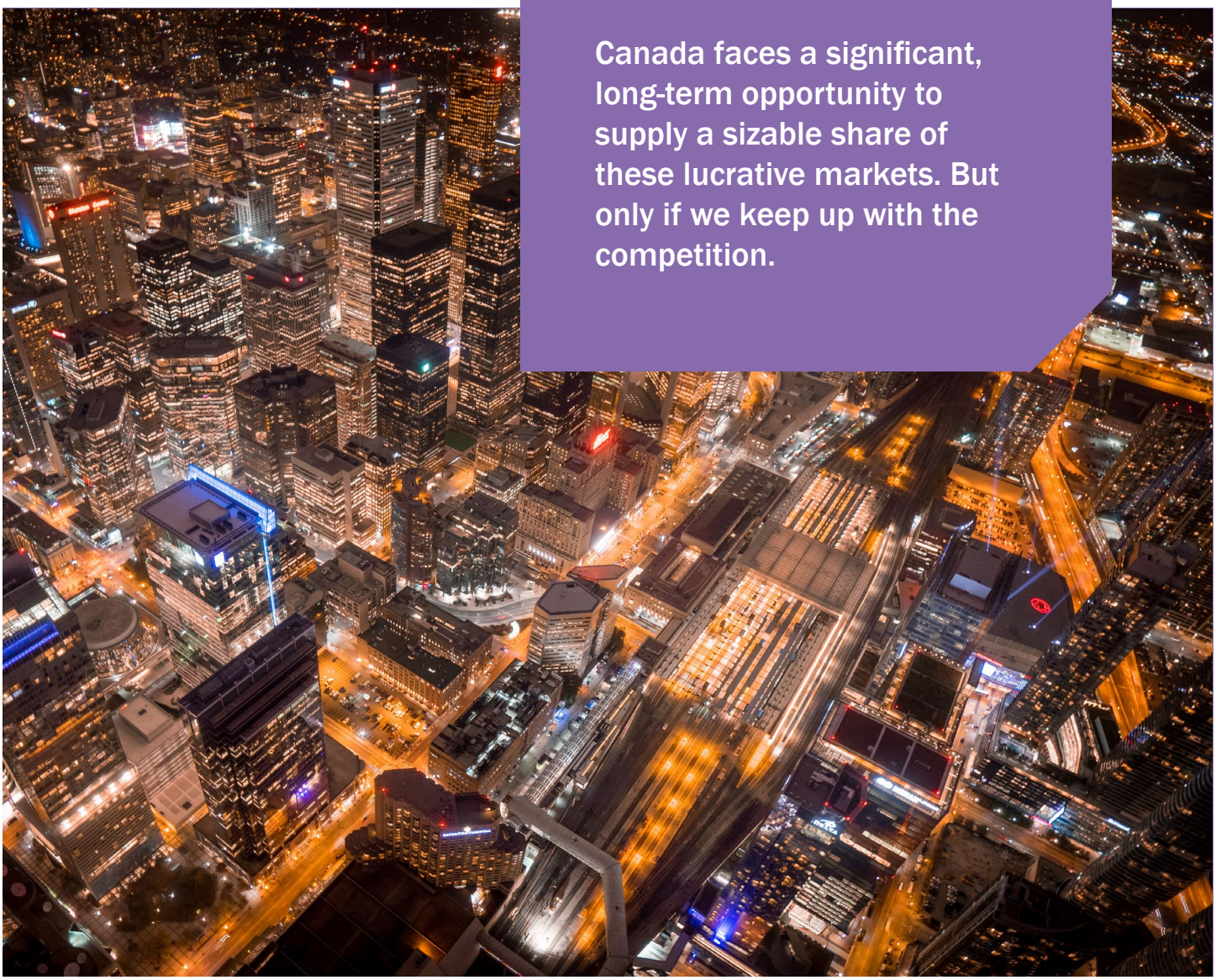
Europe's largest utility, **Italy**'s Enel, is launching a green hydrogen business next year, eyeing markets in the U.S., Spain, and Chile.[70] And speaking of **Spain**, the country's auto sector bailout came with green strings attached, with €25 million ($37.9 million) earmarked for research into hydrogen's use in transit and commercial vehicles.[71] Next door, **Portugal** has its own €7-billion ($10.6-billion) national hydrogen strategy and plans for a solar-powered hydrogen plant that could be up and running as soon as 2023.[72] **France** announced €2 billion ($3 billion) over two years for green hydrogen as part of a stimulus package, with a further €5.2 billion ($7.9 billion) to be invested by 2030.[73] Two French companies want to build massive solar farms whose excess energy would be used to produce hydrogen, while researchers in **Austria** are exploring ways to integrate hydrogen into existing natural gas infrastructure.[74] And in the **Netherlands**, whose hydrogen strategy was unveiled in March, Shell and Dutch gas company Gasunie are teaming up to build a massive hydrogen plant in the country's north.[75] Even the small Baltic nation of **Lithuania** is investing stimulus dollars in hydrogen.[76]

Asia

China, Japan, and South Korea all have ambitious hydrogen targets and are looking to meet demand through imports (an opportunity for Canada explored in the next section).[77] **China** is already a major buyer of B.C.-based Ballard's fuel-cell technology, which currently powers more than 650 electric buses and 2,200 electric trucks in the country.[78] In **South Korea**, there is also a large focus on transportation. The country's ₩114-trillion ($128.6-billion) clean stimulus plan includes support for hydrogen vehicles. Hyundai, meanwhile, aims to export 1,600 hydrogen-powered trucks to Europe by 2025, while Seoul will convert 4,000 buses to electric or hydrogen power by 2025.[79]

Other countries

In the **U.S.**, California is out in front (as usual in matters of climate action). Los Angeles plans to be the first American city to use green hydrogen for electricity, eventually phasing out natural gas entirely,[80] while two companies are planning to build facilities in California that would turn waste into hydrogen.[81] **Saudi Arabia**, no stranger to big projects, has plans to host the "world's largest" green hydrogen plant,[82] while mining company Anglo is looking to convert 400 diesel-powered haulers to hydrogen at an open-pit mine in **South Africa**.[83] But the place to watch may be **Australia**, with an economy similar to Canada's. The land down under has had a national hydrogen strategy since November of last year,[84] with up to A$300 million ($273.2 million) set aside for its Advancing Hydrogen Fund. The fund identifies green hydrogen projects as an early priority and will consider further investments that advance hydrogen production, export and domestic supply chains, regional hubs, and projects that build local hydrogen demand. Australia has also proposed A$18 billion ($16.4 billion) over the next decade for hydrogen and four other low-emission technologies as part of a technology investment roadmap.[85] Last but not least, in September 2019, **New Zealand** laid out its vision to harness the hydrogen opportunity with a focus on green hydrogen.[86] The country is planning a nationwide network of hydrogen stations to supply zero-emission fuel to trucks, buses, and commercial fleets from 2021 and aims to bring in 1,500 hydrogen-powered trucks by 2026.[87]



Canada faces a significant, long-term opportunity to supply a sizable share of these lucrative markets. But only if we keep up with the competition.

Size of the prize

It's clear hydrogen is taking off. As for how high it could soar this time, **BloombergNEF estimates that clean hydrogen could meet up to nearly a quarter of the world's energy demand by 2050** (using roughly 700-million tonnes of hydrogen), with annual sales of US$700 billion and billions more spent on equipment.[88] Deloitte, meanwhile, projects that global demand for hydrogen could reach up to a more modest but still significant 300-million tonnes by 2050, up from 70 million today.[89] While projections vary significantly—as the level of future hydrogen uptake depends on public policy and the development of various technologies—all estimates see some level of growth.

By investing in domestic clean hydrogen production and innovation, **Canada's federal government could bolster national prospects of exporting made-in-Canada hydrogen and the technology that utilizes it.** With hydrogen set to become increasingly important in decarbonizing global energy systems and improving air quality, Canada faces a significant, long-term opportunity to supply a sizable share of these lucrative markets. But only if we keep up with the competition.

The opportunity for hydrogen tech companies

Ballard Power in Burnaby, B.C., is a developer and manufacturer of fuel-cell products with US$106.3 million ($141 million) in revenue last year and around 700 employees as of 2020.[90] It is Canada's largest hydrogen technology company. Ballard's fuel cells currently power more than 650 electric buses and 2,200 electric trucks in China, and the contracts keep coming.[91] Last year, China-based Weichai Power, a major diesel-engine maker, bought a 20% stake in Ballard for US$163 million ($216.3 million).[92]

Proton Technologies in Calgary is developing a low-cost method for producing hydrogen that involves the underground combustion of remnant oil in abandoned reservoirs, keeping the emissions released during this process below the surface.[94] Proton is currently piloting its technology in Saskatchewan.[95]

Hydrogenics in Mississauga, Ontario, is a developer and manufacturer of hydrogen generation and fuel-cell products with US$34 million ($44 million) in revenue in 2018 and around 160 employees as of 2017. The company's fuel cells were used in the world's first hydrogen-powered trains in Germany. Hydrogenics was acquired by major U.S. diesel engine manufacturer Cummins last fall.[93]

Ekona Power in Vancouver is developing a novel method of producing hydrogen from natural gas that reduces emissions by up to 90% compared to conventional natural-gas-based hydrogen production—it even generates some electricity at the same time.[96]

The opportunity for oil and gas companies

Shell has been capturing CO_2 from natural-gas-based hydrogen production at its Quest carbon capture and storage facility near Edmonton, an example of a blue hydrogen project in Canada. According to Shell, the project has captured some four million tonnes of CO_2 since launching in 2015.[97] In Germany, Shell and ITM Power (whose share price increased 290% in the first five months of 2020[98]) are building the world's largest hydrogen electrolysis plant at a refinery. The hydrogen will be sold to the refinery for use in processing and upgrading its products.[99]

Calgary's **Enbridge Gas** is working with Mississauga's Hydrogenics on a power-to-gas project in Markham, Ontario, using surplus renewable electricity to produce hydrogen for storage and, possibly at a later stage, blending into the province's natural gas distribution grid.[100]

Calgary-based gas and electricity company **ATCO** is behind a $5.7-million pilot project in Fort Saskatchewan, Alberta, that will see hydrogen blended with natural gas for home heating starting next year. It will be Canada's largest hydrogen-blending project to date.[101]

Launched in 2019, a three-year, $15-million project—the **Alberta Zero-Emissions Truck Electrification Collaboration**—will test run two fuel-cell electric hybrid trucks between Edmonton and Calgary, fuelled by hydrogen produced in Alberta.[102]

Photo: Suiso Frontier Source / Kawasaki Heavy Industries

The production opportunity

China, Japan, and South Korea all have ambitious hydrogen targets and are looking to help meet domestic demand through imports. Canada is strategically located with potential access to these and other key markets. What's more, the International Energy Agency has identified establishing the first shipping routes to kickstart global hydrogen trade as a near-term opportunity, leveraging lessons learned from the growth of the LNG market.[103]

Real-world examples of hydrogen trade are beginning to emerge, in fact. As a densely populated, mountainous country, Japan's ability to produce clean energy is limited, and thus the Asian nation is and will continue to be a major energy importer. In January, an agreement was signed for Australia to supply hydrogen to Japan.[104] The world's first liquefied hydrogen carrier will begin transporting hydrogen from Australia in late 2020, if COVID-19 does not delay that timeline.[105] And just this September, Saudi Arabia shipped ammonia, a compound of hydrogen and nitrogen, made from blue hydrogen to Japan for emissions-free power generation.[106] According to the International Energy Agency, despite transportation and conversion costs, importing hydrogen from Australia could soon be cheaper for Japan than it would be for the country to create its own.[107]

Harvard researchers recently listed Canada among a small group of countries with the highest potential for exporting clean hydrogen, thanks to a clean power system (82% of Canada's electricity grid is already non-emitting) and plenty of access to water (required for electrolysis).[108]

Capitalizing on the world's cleanest hydrogen

Canada has an opportunity to lead in and benefit from the global push toward clean hydrogen. So, how do we seize it?

First and foremost, **Canada's hydrogen strategy needs to focus on both supply and demand.** Production must ramp up quickly, and it needs to be clean with a timeline and a regulatory framework to make it cleaner over time. This means not only supporting blue hydrogen production but the development of green hydrogen production and innovative technologies such as the one Proton is piloting in Saskatchewan, which bears no colour but supports the drive to cleaner hydrogen just the same. Investment in clean hydrogen supply will only happen if there is clear and growing demand alongside infrastructure that links production with end use.

Second, **Canada's hydrogen strategy needs to be adequately funded**, with dedicated investment tied to implementing it. The Task Force for a Resilient Recovery recommends an allocation of $1 billion to support Canadian leadership in clean hydrogen.[109]

Third, **we must leverage regional strengths. Canada is a vast country with diverse opportunities** for both hydrogen production and use. An effective hydrogen strategy for Canada must complement provincial efforts and seek to develop "regional nodes" that leverage local expertise and partnerships where hydrogen use is most optimal.[110] This will require regional collaboration among hydrogen suppliers and end users from different sectors (such as transport, gas utilities, and industry).

Finally, **the drive toward clean hydrogen requires the development and deployment of clean technologies.** Whether it's in fuel cells to power trucks and trains, or in storage technologies to help reduce emissions in hydrogen production, policies and programs that spur cleantech innovation will benefit Canada's hydrogen sector.

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