Hydrogen:
Good as a chemical, not as an energy source

CONSERVATION COUNCIL OF NEW BRUNSWICK

Canada has pledged to reach **net-zero by 2050** to safeguard communities, landscapes, and wildlife from the ongoing and devastating impacts of climate change. Transitioning to clean electricity—and away from fossil fuels—will be key to making this a reality.

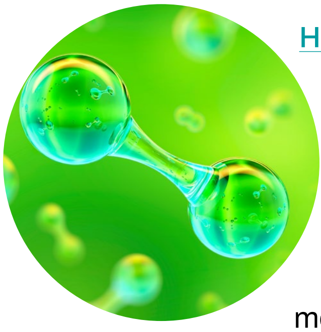
Hydrogen is currently at the center of this net-zero discussion. Hydrogen can be used as a chemical or an energy source, and understanding the opportunities and challenges with both is crucial to fueling the clean energy transition.

Hydrogen is a versatile and valuable chemical in various industries and applications including fertilizers, treating metals, and pharmaceuticals.

Despite its chemical utility, hydrogen faces significant challenges as an energy source.

The production, storage, and transportation of hydrogen require considerable energy inputs, often derived from fossil fuels, thereby limiting its potential as a clean and sustainable energy option. In fact, global production of chemical hydrogen creates more greenhouse gas emissions than the entire aviation industry.

Hydrogen explained



Hydrogen is the most abundant element in the universe and is an energy carrier, meaning it must be created or separated from another substance. Fossil fuels and biomass are currently the most common substance we derive the chemical hydrogen from.

Energy carriers move energy in a usable form between places. Examples of energy carriers are pressurized air, wood, and natural gas.

Energy carriers do not produce energy themselves, but rather hold the energy created by something else. This is the key difference between an energy carrier and an energy source. Carriers can exist in and be converted from various forms, whereas sources are the original resource. Think of electricity; it is an example of an energy carrier as it can be converted into other forms of energy, such as heat. Wind is an example of an energy source.

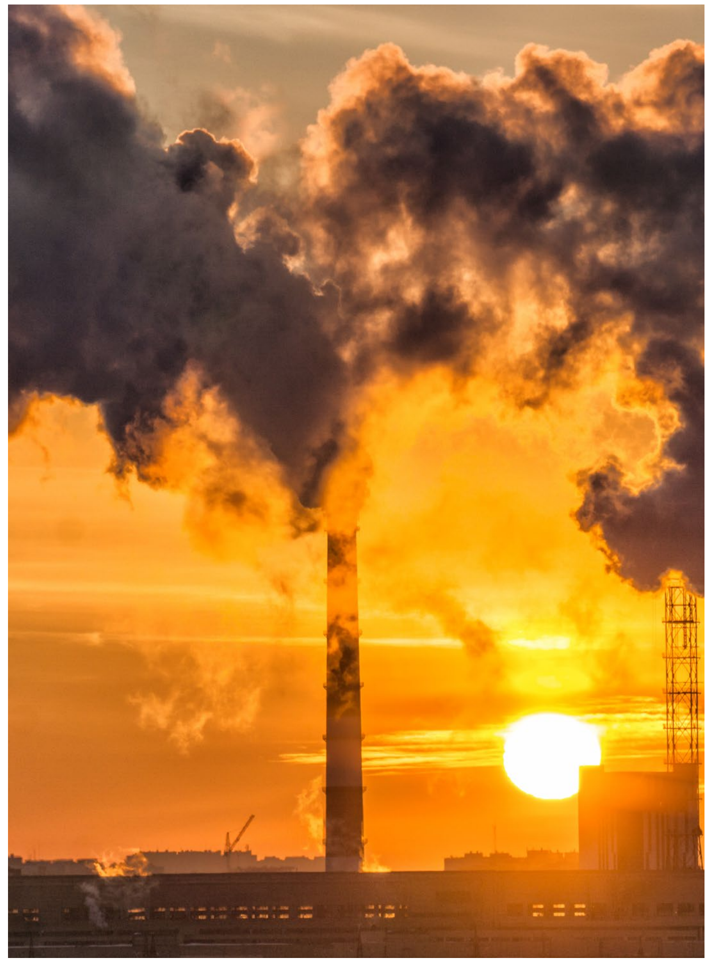
Hydrogen is an energy carrier, and although hydrogen has the highest energy content of common fuels by weight, it also has the lowest by volume as a liquid. For example, by weight its energy content is approximately three times higher than gasoline, but four times less by volume in liquid form.

Prioritize greening current hydrogen production first

Hydrogen is primarily extracted from natural gas via steam methane reforming. This is the process of heating natural gas with steam and a catalyst to produce hydrogen. Coal is the second most common source of hydrogen production, accounting for approximately 23 per cent of global production. Oil and electricity come in third place.

Natural gas, coal, and oil are considered fossil fuels.

When burned, fossil fuels release air pollutants harmful to our health and carbon dioxide, a leading contributor to climate change. Our current dependence on these fossil fuels to create hydrogen as an energy source emits a shocking amount of carbon dioxide: the equivalent of emissions from Indonesia and the United Kingdom combined.



Because of the separation process to remove hydrogen from other elements, more energy is spent producing hydrogen than what is available to then convert into useful energy to fuel New Brunswick's homes, businesses, hospitals, and more.

This is why the only hydrogen New Brunswick should use is that made from excess renewable energy, such as solar and wind power. This is known as green hydrogen.

Green hydrogen should not delay energy efficient solutions

Green hydrogen is a chance to decarbonize sectors without electrification strategies that still rely heavily on fossil fuels or harmful hydrogen options, such as fertilizer and petrochemical processing.

However, green hydrogen is more risky, expensive, and greenhouse gas emissions intensive than what is available to deploy today: renewable energy from solar and wind power. Heating and transport sectors are ready for energy efficient solutions, and the impact of transitioning to clean energies in the near future can help achieve Canada's net-zero commitments.

Producing green hydrogen is also energy intensive and inefficient, which risks slowing the transition to a clean energy economy. In 2019, Canada produced 632 TWh of electricity. Greening Canada's existing hydrogen would require approximately 150 TWh, or 24 per cent of the country's electricity.

This incredible inefficiency is hydrogen's baseline flaw. It would require approximately six times more electricity to heat buildings with green hydrogen fueled boilers than electric heat pumps. A green hydrogen fueled bus needs three times more electricity than one running on a battery.

Storing hydrogen in existing pipeline infrastructure is too expensive for New Brunswick

Pipelines are used to store oil and natural gas to power New Brunswick. Due to the intensive process of producing hydrogen, and how little is then produced, blending hydrogen into existing natural gas pipelines and grids is not a viable solution.

Current natural gas pipelines can hold a maximum of a 20 per cent mix of hydrogen before requiring costly infrastructure upgrades. These pipelines also cannot operate when pure hydrogen is introduced. If green hydrogen was introduced into existing natural gas pipelines at a maximum blend of 20 per cent, it would only reduce carbon emissions by approximately seven per cent while significantly increasing costs for New Brunswick communities.

The cost increase is due to green hydrogen's inefficient nature: blending hydrogen and natural gas cuts down on the available energy stored within a pipeline, so more energy is required to produce the same amount for communities, ultimately increasing costs on New Brunswickers' energy bills.

Approximately one-third of New Brunswickers live in energy poverty, forced to spend an unsustainable portion of their monthly income on energy costs. For many, this means paying more than six per cent of their after-tax income on energy.

Blending green hydrogen into existing natural gas grids means putting the financial burden of a clean energy transition on New Brunswick communities.

The only useful hydrogen is locally produced

Transporting hydrogen over long distances is expensive, inefficient, and will result in significant energy losses across the supply chain.

Hydrogen as an energy source must be liquified for ground transport, which results in a 30 per cent loss of energy in the hydrogen supply. At best, communities are left with merely 23 per cent of the original hydrogen energy once daily losses for boiling off are also accounted for during transport.

Transporting hydrogen also increases the risks of leaks into the atmosphere. New research suggests leaked hydrogen is nearly 12 times stronger than carbon dioxide, making it catastrophic to climate action advancements in recent years.

Transporting hydrogen by ship is also a risky option. Green hydrogen must be converted to ammonia in order to be transported by ship, which increases the chance of ammonia leaking into our oceans and rivers, turning the home for many species at risk into a potentially toxic environment.

Transporting green hydrogen is ineffective and risks setting us back in the fight against climate change. New Brunswick should prioritize **locally produced hydrogen**, though renewable energies and electrification are favourable options.

Ammonia-based options can be 265 times worse than carbon dioxide

Countries are currently exploring options of using ammonia produced from hydrogen as blended alternatives.

Japan's industrial sector is examining the option of ammonia-coal co-firing. This is the process of retrofitting power plants to enable portions of ammonia to burn alongside coal to generate power. However, an ammonia co-firing plant blending at a maximum of 20 per cent would emit 94 per cent more carbon dioxide than the average unabated gas plant in Malaysia, ultimately wasting finite renewable hydrogen.

In the United States, nitrous oxide made up six per cent of greenhouse gas emissions from human activities. These include agriculture, wastewater management, and industrial processes. Ammonia produces nitrous oxide. In 2021, it was found the impact of one pound of nitrous oxide on climate change is 265 higher than one pound of carbon dioxide.

Blending ammonia produced from hydrogen with other elements is not effective at reducing greenhouse gas emissions and will result in the transition to a net-zero economy taking far longer than what could be achieved if focus was kept on renewable energies and electrification options.

The 8 colours of hydrogen

Globally, green hydrogen is being applauded as the solution to clean energy and our net-zero future. However, you may have heard of other colours of hydrogen. The colour label depicts how hydrogen was produced. Because hydrogen only emits water when burned, creating it can be carbon intensive, contributing to climate change. By using colour labels, we are able to distinguish between production methods and each type of hydrogen's impact on the environment.

TYPES	HOW IT'S MADE	WHAT YOU NEED TO KNOW
Green hydrogen	**Green hydrogen** converts surplus renewable energy sources (think: solar or wind power) to electrolyze water. This consists of an electrochemical reaction to split water into hydrogen and oxygen, thus creating energy without emitting carbon dioxide.	Green hydrogen is a form of clean electricity which can propel us into the net-zero future. However, producing green hydrogen is incredibly expensive, so it makes up a small portion of available hydrogen energy.
Grey hydrogen	**Grey hydrogen** is produced via steam methane reformation.	In the case of grey hydrogen, it's derived from natural gas without also producing greenhouse gases. It's nearly identical to blue hydrogen.
Blue hydrogen	**Blue hydrogen** is produced via steam reforming, the process of burning natural gas and heated water into steam and capturing carbon emissions.	It is an expensive process by which carbon dioxide is produced, contributing to greenhouse gases. It is also dependent on carbon capture and storage (CCS), a process used for "enhanced oil recovery to facilitate additional oil extraction." This process is expensive (costing up to $200 per tonne), has not yet been proven to scale, is slow to implement, and is energy intensive while failing to decarbonize oil and gas production.
Black and brown hydrogen	This hydrogen is converted from black or brown coal, otherwise known as lignite.	This is the most environmentally destructive form of hydrogen as it releases extensive amounts of carbon dioxide into the air, contributing to pollution, climate change, and environment damage.
Pink hydrogen	**Pink hydrogen** is formed through the unique process of nuclear-powered electrolysis.	Pink hydrogen is incredibly expensive to produce and uses nuclear energy to create hydrogen, creating major environmental concerns.
Turquoise hydrogen	**Turquoise hydrogen** is made via methane pyrolysis, a method of thermal decomposition to produce both hydrogen and carbon.	This hydrogen has the potential to be a low-emission hydrogen, as it relies on thermal processes powered by renewable energies in order to be produced. Turquoise hydrogen is new to the colour chart and has not yet been proven to be effective at a large scale.
Yellow hydrogen	**Yellow hydrogen** uses solar powered electrolysis to be produced.	Yellow hydrogen is also new to the colour chart, and therefore not many details are available yet.
White hydrogen	**White hydrogen** is a geological hydrogen, which means it exists in the Earth's crust.	This form of hydrogen could only be created through fracking, and as such it is not yet being produced due to the environmental damage this would cause.

LEGEND

Expensive — Difficult to scale — Environmentally damaging — Climate action friendly — Inefficient production process

Although green hydrogen has the potential to decarbonize sectors notorious for being difficult to electrify, such as cement production, it's fraught with substantial decarbonization problems neither government nor industry are equipped to solve. **Green hydrogen production is an expensive process, and often produces far too little energy to sustain communities—meaning you spend a lot to get very little in return.** The Intergovernmental Panel on Climate Change (IPCC) echoes this grim outlook: *green hydrogen will represent merely two per cent of total energy consumption by 2050. There are current opportunities to convert chemical hydrogen into green hydrogen.*

This will lower greenhouse gas emissions in industries already using chemical hydrogen. Agriculture and agri-food is one, as farmers rely on fertilizer to feed our growing population.

This has no relation to green hydrogen as an energy source, as it is a different entity from the green hydrogen that would be produced from chemical hydrogen. **Green hydrogen as an energy source is inefficient and expensive.** While research should continue to find ways it can power our communities, we must not get distracted from what is currently available and successful in transitioning to net-zero: **electricity storage, solar power, and wind power**.

Established in 1969, the Conservation Council of New Brunswick is the province's leading public advocate for environmental protection.

A member of the United Nations' Global 500 Roll of Honour, we work to find practical solutions to help families and citizens, educators, governments and businesses protect the air we breathe, the water we drink, the precious marine ecosystem and the land, including the forests, that support us.

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