**BLUE hydrogen and ammonia from hydrocarbons viable with $30-$60 per ton carbon tax**

We can safely and sustainably exploit our natural gas, oil and bitumen resources at huge profits compared to many green energy solutions exempted from carbon and life cycle pollution.

There is no need for a price on carbon and life cycle pollution higher than $30 to $50 per ton with no exemptions for any forms of energy, let alone a $170 per ton price on CO2 with 80-90% industry and 100% green energy exemptions. We need a 'fair' price on all energy pollution.

Lower cost hydrogen and ammonia production from hydrocarbons with less life cycle and carbon pollution than wind, solar, ethanol or biofuels has been already proven to be viable in Canada according to research form the IEA with ONLY a $30 per ton carbon tax on ammonia and $60 per ton for hydrogen.

This level of pollution pricing on all forms of energy would also benefit the production and use of renewable energy even though the life cycle pollution would be priced or taxed, or even if all pollution was exempted, as it the case in much of the USA including in Arizona.

Nikola plans on producing the hydrogen for its vehicles itself and just signed an agreement with the Arizona Public Utilities Commission (APS) for electricity to do it that has dropped for the market price of 3.5 *cents per kilowatt-hour*, to a much lower special contract rate of *2.7 cents per kilowatt-hour*. (Natural gas, nuclear **power**, and coal provided almost all of **Arizona's** net **electricity** generation in 2018. Together they fueled 89% of the state's utility-scale net generation).

**Nikola secures special electricity rate with APS on its way to efficient hydrogen fuel production** | WABC Arizona
https://www.abc15.com/news/business/nikola-secures-special-electricity-rate-with-aps-on-its-way-to-efficient-hydrogen-fuel-production

**The clean hydrogen future has already begun** – Analysis | IEA
*Current estimates put the price of carbon capture, utilization and storage (CCUS) in the range of €50 to €70 per ton of CO2. The price is lower in specific cases like ammonia production.*
https://www.iea.org/commentaries/the-clean-hydrogen-future-has-already-begun

The net cost to eliminate the CO2 in the production and use of hydrogen and ammonia from methane makes it less than half the cost of any renewable form of energy including wind, solar, biofuel, ethanol, hydro or even nuclear power. The total life cycle costs are even lower. The cost of BLUE hydrogen are about one third the cost of GREEN hydrogen.

**Levelised costs will settle the blue-green debate** | Petroleum Economist
*Blue hydrogen will be required to support decarbonisation while green hydrogen matures and its costs decrease.*
https://www.petroleum-economist.com/articles/low-carbon-energy/energy-transition/2020/levelised-costs-will-settle-the-blue-green-debate

The cost of BLUE hydrogen and ammonia from hydrocarbons with ZERO CO2 and lower life cycle emissions are between 25% and 35% of the cost of GREEN hydrogen and ammonia today (both which are exempted from carbon and all life cycle pollution pricing in Canada, even when the electricity used to make it is generated using natural gas, biofuel, ethanol, gasoline, diesel or coal feedstocks).

According to Platts Analytics, SMR gray hydrogen can be produced at a cost under $1/kg, even assuming a natural gas price at $3.50/MMBtu. Adding carbon capture to make blue hydrogen raises the cost to roughly $1.40/kg. Making the fuel green through a PEM (proton exchange membrane) electrolysis production method, though, more than triples that cost to an estimated $4.42/kg – assuming a renewable power cost of $65/MWh. (As you will see from the IEA below, in BLUE ammonia is competitive with GREEN ammonia with electricity at as little as $50/MWh and with oil priced at $40 per barrel, however with natural gas available in Canada at less than half the $3.50/MMBtu cost assumed by Platts Analytics, it is competitive with electricity at as little as $50/MWh assuming the carbon and life cycle pollution costs of GREEN ammonia are excluded).

**Cost, logistics offer 'blue hydrogen' market advantages over 'green' alternative** | S&P Global Platts
https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/031920-cost-logistics-offer-blue-hydrogen-market-advantages-over-green-alternative

There are predictions of GREEN hydrogen at $2/kg by 2030 (which exclude the life cycle production and utilization emissions of the renewable energy used to make it), that its production costs will decrease at a more rapid rate than BLUE hydrogen will, and that it will be competitive with GREY hydrogen within a decade. However either a commodities based low carbon emissions price (global average is $15 to $20/ton of CO2) combined with a life cycle pollution cost (which applies today only to fossil fuels in Canada) and/ or the introduction of lower cost carbon (and life cycle) pollution reduction technologies being commercialized now, or any combination of both may pose a serious challenge to such predictions, however being able to turn stranded, intermittent or off peak electricity into ammonia for multi-commodity uses, including for fuel, grid management and fertilizer reverse the impact of applying pollution pricing without exemptions.

**Green hydrogen to reach price parity with grey hydrogen in 2030** | pv magazine International
https://www.pv-magazine.com/2020/07/16/green-hydrogen-to-reach-price-parity-with-grey-hydrogen-in-2030/

There are multiple existing technologies in use today at grid or world class scale that eliminate the CO2 produced making hydrogen/ammonia from natural gas at low incremental costs.

**Hydrogen: grey, blue, and BC green** | Resource Works
*While all three types of hydrogen are equally clean-burning, green hydrogen has by far the least*

*negative effects on the environment. It's also the most expensive: the price today can run as high as US$7.50 per kilogram, compared to US$2.40 per kg for blue hydrogen.*
https://www.resourceworks.com/hydrogen-grey-blue

There are multiple existing technologies in use today at grid or world class scale that eliminate the CO2 produced making hydrogen/ammonia from natural gas at low incremental costs. There are others under development, particularly in Canada where there is a commercial demonstration by Proton Technologies that, as mentioned above, will produce H2 (or NH3) from hydrocarbon resources and abandoned oil and gas wells with low to zero CO2 emissions for as little as 10% of the cost of producing them today. When these technologies reach commercial scale in the near future the cost of BLUE hydrogen and ammonia made from hydrocarbons could be as little as 10% to 20% of the equivalent cost of making it from ANY other form of energy including nuclear power, and still be a fraction of the fraction of the cost of GREEN hydrogen or ammonia made from electricity going forward for decades.

Petroleum-based hydrocarbon resources already exist. The challenge to their continued use is cost-effective clean tech to reduce and eliminate carbon and life-cycle pollution. Most renewable resources are created from cradle to grave and the infrastructure and industrial capacity needed to produce them is many times greater than hydrocarbons. The fastest way to get to large-scale development of green energy is to use hydrocarbon resource sustainably as the bridge.

There will be a stampede to monetize global hydrocarbon energy reserves profitably instead of spending three or more times as much on the short to medium term green or renewable technologies that must mature and be backed up by 100% additional generating capacity primarily from hydrocarbon or nuclear energy (much of which will be wasted to grid manage gating hydro plant water at or blowing nuclear plant steam), or be tripled to provide equivalent stored back up power with 50% net efficiency.

Either way, most renewable energy (excluding a limited amount of hydro electric power) generating capacity must be at least tripled to provide base-load and interruptible electrical power (with round to round generation, storage and regeneration at 50% efficiency) representing 20% of our energy demand, and increased a dozen or more times to provide enough base-load and on-demand renewable energy to replace the 80% of energy we use that is liquid fuels with electricity.

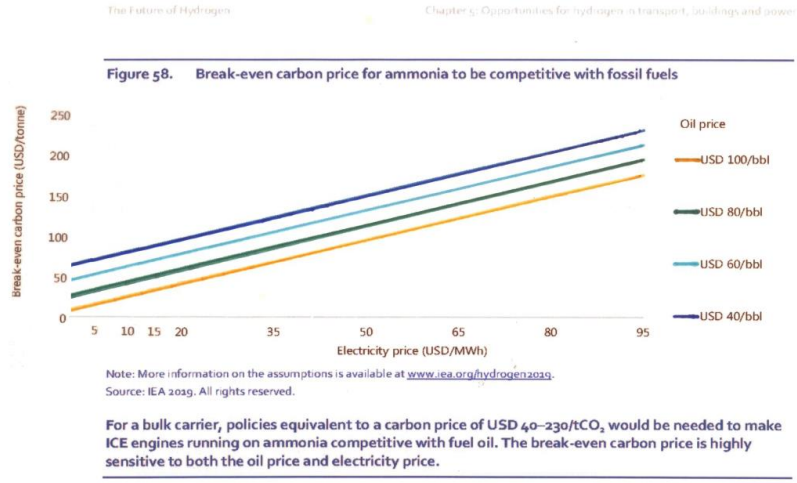
The naked truth few seem to be willing to tell is that the real costs to increase renewable energy production by any measure in Canada is many times the cost of producing cleaner energy from existing gas, oil and bitumen reserves while we wait for the real costs of renewable energy to decrease and catch up.

**Home of the oil sands eyes cleaner future as hydrogen superpower** | BNN Bloomberg
*Proton is testing its zero-emissions technology on a well in Saskatchewan that could reach output of as much as 20 tons of hydrogen a day this fall, Chief Executive Officer Grant Strem said in an interview. A facility the company aims to build in the next two years could produce 500 tons per day at a cost of about 10 Canadian cents (7.6 cents) a kilogram, compared with $1*

*to $3 per kilogram for the currently cheapest method, he said.*
https://www.bnnbloomberg.ca/home-of-the-oil-sands-eyes-cleaner-future-as-hydrogen-superpower-1.1479450

If Trudeau's $30 per ton 2020 carbon tax was applied WITHOUT 80-90% exemptions for large emitters (including ammonia producers) the cost to eliminate the two tons of CO2 generated producing one ton of ammonia would be $40 to $60 per ton, while the carbon tax for emitting the two tons of CO2 would be $60, instead the industry pays $6 today. When the carbon tax reaches $170 per ton in 2030, the real carbon tax cost for the two tons of CO2 emitted should be $340 per ton, more than twice the total production cost for a ton of ammonia made from natural gas, but again under Trudeau's Carbon tax exemptions the actual cost to pollute will only be $34 per ton or 10%, still only about half the cost to eliminate the CO2 entirely in 2020.

ZERO CARBON Green Ammonia from electricity is competitive with ZERO CARBON Fossil based NH3 in Canada with $40 - $60 per ton Carbon Tax with no Industry exemptions. With electricity at 2 cents per kWh and a $40-$60 per ton carbon tax without exemptions it is cost-effective to produce ammonia with zero carbon emitted, same thing with hydrocarbon based ZERO CARBON BLUE Ammonia from lower net cost natural gas in Canada that otherwise emits 2 tons of CO2 for every ton of NH3 (only costing $6 per ton under Justin Trudeau 90% Industry exemption to the $30 per ton 2020 carbon tax).




[PDF] **The Future of Hydrogen** - G20, June 2019, Japan, p. 142 | IEA
https://www.iea.org/reports/the-future-of-hydrogen

**Carbon taxes aren't working any more. Only ramping up policies and infrastructure can accelerate the transition** | Energy Post
*Twenty years ago, scientists agreed on the need to reduce CO2 emissions from the energy sector. Today, there is agreement on the need to eliminate CO2 emissions entirely. Carbon taxes were the policy instrument developed to achieve the first objective effectively and efficiently. However, they are of relatively little use for achieving the second. Carbon taxes raise money from the wrong people, and are vulnerable to politics*
*Carbon taxes' main value may be as a tool to raise revenue for other support instruments. But*

*they are a political choice, and they do disproportionally burden the rural and less wealthy segments of society. The climate doesn't care how governments choose to raise revenue, but as the recent protests in France demonstrate, people do.*
https://energypost.eu/carbon-taxes-arent-working-any-more-only-ramping-up-policies-and-infrastructure-can-accelerate-the-transition/

There are many examples of governments supporting technologies as bad as or even worse than what we use and what we could use, but battery vehicles and ethanol are just two of many examples.

**Subsidizing electric vehicles inefficient way to reduce CO2 emissions: study** | Physics Org
*In subsidizing electric vehicle purchases, Ontario and Quebec end up spending up to 29 times and 16 times, respectively, the carbon market price for each tonne of GHGs eliminated. "Common sense, both economically and ecologically speaking, argues in favor of reducing these subsidies, and even eliminating them," the study concludes.*
https://phys.org/news/2017-06-electric-vehicles-inefficient-co2-emissions.html

**Alternative fuel and Battery vehicles are triggering more--not less--emissions** | Carnegie Mellon University study published in the journal Environmental Science & Technology
*Alternative fuel vehicles (AFVs), such as electric vehicles, can reduce U.S. petroleum consumption and can also potentially reduce emissions. However, a new Carnegie Mellon University study finds that under U.S. federal policy, AFV sales trigger the opposite effect.*
https://phys.org/news/2016-03-federal-policy-reverses-benefits-alternative.html

Exactly the same arguments can be made about false green claims in Ontario's laws, policies and practices, including for ethanol and biofuels that exclude and ignore the science, economics and environmental facts to justify the policies, which are in fact almost entirely designed for partisan the purposes of special interest voter and contributors financial support.

Both Prime Minister Trudeau and Premier Doug Ford are increasing the minimum mandate of ethanol from 5% to 10% (we averaged 9% in Ontario in 2019) to 15%, while exempting it from both carbon pricing and life cycle pollution including 'land use', which when added to the energy economics that ethanol only contains 75% of the energy in the fuel and fertilizer used to produce it, make it worse than gasoline and likely at least as bad as diesel fuel or even coal based energy.
**Ontario hiking ethanol content in gasoline to help fight climate change** - Move to higher ratio of renewable fuels may benefit province's corn farmers
*Ontario plans to raise by half the ethanol content required in gasoline in a move to fight climate change that could also benefit Southwestern Ontario's vast corn belt.*

**Biofuels 'worse than petrol' for the environment, new study finds** |University of Michigan
*The underpinnings of policies used to promote biofuels for reasons of climate have now been proven to be scientifically incorrect Professor John DeCicco, University of Michigan.*
https://www.telegraph.co.uk/science/2016/08/25/biofuels-worse-than-petrol-for-the-environment-new-study-finds/

**Canada lags the United States in climate accounting of biofuels** | International Council on Clean Transportation
*The Clean Fuel Standard (CFS), a major pillar of the Pan-Canadian Framework on Clean Growth and Climate Change, aims to reduce GHG emissions by 30 million tonnes of CO2e annually by 2030 by reducing the GHG intensity of liquid, gaseous, and solid fuels used in transport, buildings, and industry. However, Canada's climate goals are threatened by an accounting error: ignoring emissions from indirect land-use change (ILUC) when quantifying the greenhouse gas (GHG) performance of biofuels. On its current pathway, the CFS could hit its target on paper but will fall far short in real GHG reductions.*
https://www.theicct.org/blog/staff/canada-lags-united-states-climate-accounting-biofuels

**More Ethanol Means Higher Prices, and Not Just for Gasoline** | Daily Signal
*If you like paying less for food, the Renewable Fuel Standard is not great. The mandate diverts food for fuel, boosting crop and feedstock prices. Research from the University of California at Davis finds that increased demand for corn and soybeans due to the Renewable Fuel Standard drove up prices by 30% and 20%, respectively.*
*When it comes to climate policy, the Renewable Fuel Standard is very ineffective. Several studies have shown that land-use conversion and increased emissions from additional farming result in higher levels of carbon dioxide released into the atmosphere compared to regular gasoline.*
https://www.dailysignal.com/2019/10/18/more-ethanol-means-higher-prices-and-not-just-for-gasoline

We need a REAL price on all life cycle pollution from energy production and use with ZERO exemptions, which will lower the overall prices to present levels and eliminate the need for increases. After all the average world price on carbon pollution is $15 to $20 per ton with half of it at $10 per ton, and only about 20% of it globally is covered.

**Carbon Pricing** | The World Bank
*According to the World Bank's State and Trends of Carbon Pricing 2018, 80 percent of emissions are still not covered by carbon pricing. And half of current emissions covered by carbon pricing initiatives are priced at less than $10 per ton CO2e. This is far short of the level needed to drive transformational change: estimated at $40-80 per ton by 2020 and $50-100 per ton by 2030 according to the High-Level Commission on Carbon Prices, co-chaired by Joseph Stiglitz and Lord Nicholas Stern and supported by the World Bank.*
https://www.worldbank.org/en/results/2017/12/01/carbon-pricing

According to independently verified research there are 400% to 500% greater profits available from converting natural gas to ammonia for transport to markets in North America and overseas than is possible with LNG using the same natural gas and there are even higher profits for jurisdictions that have no gas to import it and export ammonia. The life cycle and carbon emissions of ammonia verses LNG are much lower even when the CO2 is emitted where the NH3 is produced because the carbon in the gas is not transported to be emitted by the end user.

The CO2 from the production of ammonia from natural gas can be totally eliminated for $30 to $60 per ton maintaining 80% of the increased profits while producing the greenest and cleanest

energy possible from either hydrocarbons, and clean ammonia made from electricity generated from renewable energy at as low as $0.02/kWh.

**MITACS PHASE 3 - Comprehensive Evaluation of NH3 Production and Utilization Options for Clean Energy Applications**
https://www.nh3fuel.com/images/documents/2017-03-25 - MITACS-Final-Report-P3-IT08015.pdf



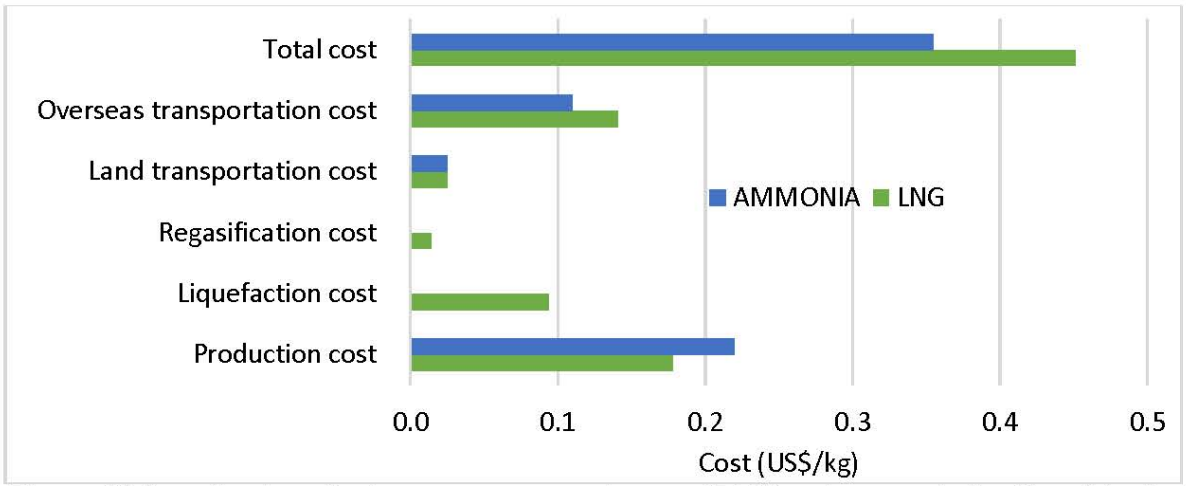



Figure 46 Contribution of sub-processes to total cost of LNG and ammonia for Case 2 in the U.S

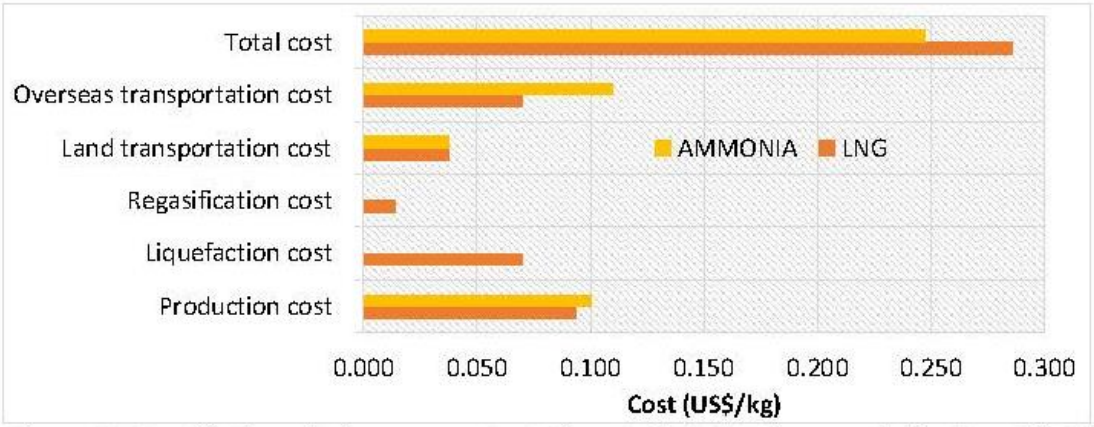



Figure 48 Contribution of sub-processes to total cost of LNG and ammonia for Case 3 in Middle East

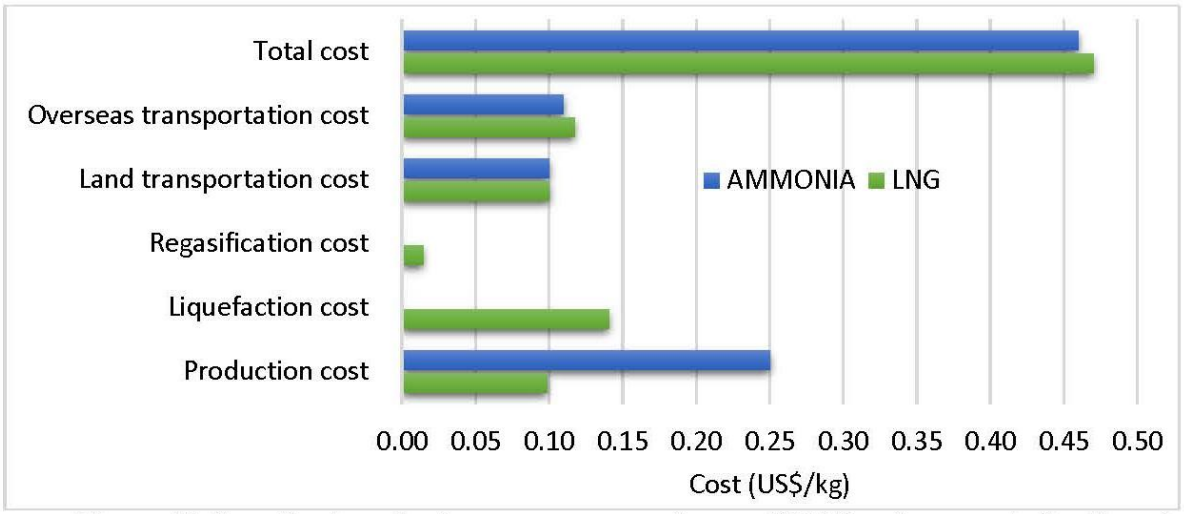



Figure 50 Contribution of sub-processes to total cost of LNG and ammonia for Case 4

All Canada needs to lead the world in low cost clean energy production and utilization technologies are energy and environmental policies based on science and economics instead of the nonsense and nonscience many of them are based upon now.

Today 40% of the CO2 generated producing ammonia in Alberta is sequestered using their $1.2 billion dollar CO2 pipeline, and interestingly the rest of it could be eliminated at a lower total cost using other proven technologies today as could all of it anywhere in the world now.

Canada produces the lowest carbon emitting ammonia produced by any country on earth using the lowest carbon content natural gas feed stock available. Whereas the average of two tons of CO2 is produced making one ton of NH3, in Alberta their net is 1.8 tons BEFORE their additional 40% reduction using CCS technologies reducing the total to 1.08 tons of CO2 per ton

of NH3, or almost half the global average already today.

What is a better bet? That green energy technologies that need to be manufactured and deployed and primarily initially used for electrical power will be used to produce the four to five times as much cleaner fuels we need to use, OR that the conventional grey and brown energy industries 'GREEN energy' pivot will actually mostly be to 'BLUE energy' made from their massive reserves of hydrocarbons that have been created already and only need to be refined using clean tech or carbon capture, storage and /or conversion into urea, char or carbon black at a fraction of the cost of any green technologies including green ammonia?

What are the competing infrastructure costs to increase the grid ten to twenty times the size to manage renewable mainly interruptible electricity to replace liquid fuels verses being able to use the existing natural gas infrastructure to deliver 1.5 items the hydrogen contained in gas to ammonia with few modifications, at lower pressures, much safer than gas or hydrogen ever could be, using the existing infrastructure, without the need to build a single new pipeline?

**An Alternate View on Pipelines — Transport Ammonia not Crude** | Ottawa Life Magazine
https://www.ottawalife.com/article/an-alternate-view-on-pipelines-transport-ammonia-not-crude?c=9

What about the cost for new energy infrastructure, is increased pipeline or grid use better? Should we add hydrogen to natural gas to extend the use of methane and related emissions or should we transport 1.5 times the energy stored in ammonia than we can in natural gas or the equivalent energy in electricity over the grid?

**Alternatives to Electricity for Transmission, Firming Storage, and Supply Integration for Diverse, Stranded, Renewable Energy Resources: Gaseous Hydrogen and Anhydrous Ammonia Fuels via Underground Pipelines** | ScienceDirect
https://www.sciencedirect.com/science/article/pii/S1876610212014609

While most of the industrialized whole world has plans to start throwing $billions today and $trillions of dollars in the next few decades at emerging hydrogen technologies few of them are economically viable without life cycle and carbon pollution exemptions, subsidies and minimum mandated use laws, which will end sooner than later one way or another due to emerging global fiscal, scientific and political influences post COVID-19.

**The Hydrogen Boom Is On Track To Hit $11 Trillion** | OilPrice.com
https://oilprice.com/Energy/Energy-General/The-Hydrogen-Boom-Is-On-Track-To-Hit-11-Trillion.html

**Green Hydrogen Catapult - World's green hydrogen leaders unite to drive 50-fold scale-up in six years** | Race to Zero
https://racetozero.unfccc.int/green-hydrogen-catapult/

**World Goes Nuts Over Green Ammonia, Now That Green H2 Is Old Hat** | Cleantecnica
https://cleantechnica-com.cdn.ampproject.org/c/s/cleantechnica.com/2020/11/26/world-suddenly-goes-nuts-over-green-ammonia-now-that-green-hydrogen-is-old-hat/amp/

While some tech companies and green energy promoters will continue to justify the public relations and marketing benefits of paying many times the market price for so-called greener solutions, public and consumer backlash to green-washing and the waste of hundreds of $billions if not $trillions in public funds and higher energy costs will very quickly level the global energy marketplace for all technologies. As a result all subsidies and incentives skewing the energy marketplace will be gone much sooner than most people expect.

**Microsoft tests hydrogen fuel cells for backup power at datacenters** | MICROSOFT Innovation Stories
https://news.microsoft.com/innovation-stories/hydrogen-datacenters/

Ammonia energy and fuel applications have been proven to be safer, lower cost and more readily deployable than using hydrogen itself in most applications due to energy density, temperature and pressure issues for storage and transport, including for use in passenger vehicles.

As noted above, the "MITACS PHASE 3 - Comprehensive Evaluation of NH3 Production and Utilization Options for Clean Energy Applications" and several other research projects we did with **Ontario Tech University** (OTU) published by the AIChE and in several journals, and other ammonia energy and fuel research they have done in the last 20 years, combined with other research noted in the 5,540 page, $4,200 USD "Comprehensive Energy Systems" concluded that using ammonia energy or fuel production or utilization technologies improved every industrial, power generation, agricultural and transportation application, except transoceanic air flight.

**Comprehensive Energy Systems** | Elsvier
*Provides a unified source of information covering the entire spectrum of energy, one of the most significant issues humanity has to face. This comprehensive book describes traditional and novel energy systems, from single generation to multi-generation, also covering theory and applications. In addition, it also presents high-level coverage on energy policies, strategies, environmental impacts and sustainable development. No other published work covers such breadth of topics in similar depth. High-level sections include Energy Fundamentals, Energy Materials, Energy Production, Energy Conversion, and Energy Management.*
https://www.elsevier.com/books/comprehensive-energy-systems/dincer/978-0-12-809597-3

**Hydrofuel and UOIT submissions** | AIChE Conference 2017-11-01
https://www.nh3fuel.com/index.php/news/12-latest-news/49-aiche-conference-2017-11-01

There is an **Ammonia Energy** industry association.
https://www.ammoniaenergy.org

There have been **17 annual conferences** between 2003 and 2020, with joint AIChE annual conferences since 2017.

https://nh3fuelassociation.org/events-conferences

The **Association members** include the largest and leading companies in the world in their sectors, including fertilizer, marine shipping, oil and gas, engine and power generation manufacturing, industrial and refinery plant and equipment, and conventional and renewable energy companies.
https://www.ammoniaenergy.org/members

**Energy Comparisons** | NH3 Fuel Association
https://nh3fuelassociation.org/comparisons/

In 2018 both Toyota and Hyundai ran their hydrogen fuel cell vehicles with on-board ammonia fuel, from which the hydrogen was separated on demand using an Austrailian technology. Hyundai recently announced that it has signed a memorandum of understanding (MOU) with CSIRO for the "development and future commercialisation" of its metal membrane technology.

**CSIRO extracts pure H2 from ammonia in live driving test** | electrive.com
https://www.electrive.com/2018/08/09/csiro-extracts-pure-h2-from-ammonia-in-live-driving-test/

It has been clearly demonstrated to be greatly superior to transport hydrogen for fueling stations stored in ammonia (NH3) than to transport hydrogen (H2) itself. In addition the technology to separate carbon from hydrogen in natural gas (methane) at fuel pumps has also been proven, as has been producing hydrogen on-demand via electrolysis for fuelling on demand at stations as well. There are still many issues regarding the use of hydrogen, especially in large numbers on board passenger vehicles in urban centres that need to be resolved.

**Hydrogen Fueling Station Archives** | Ammonia Energy Association
https://www.ammoniaenergy.org/topics/hydrogen-fueling-station

There is also a mountain of work being done looking at using ammonia fuel and energy:

**Aircraft**
https://www.ammoniaenergy.org/articles/zero-emission-aircraft-ammonia-for-aviation

**Marine applications - Man Energy Solutions** (who will have an ammonia engine by 2024 and retrofits by 2025)
https://shippingwatch.com/suppliers/article12336077.ece
**Wärtsilä**
https://dieselgasturbine.com/wartsila-using-ammonia-in-combustion-trials

**Power generation in Japan**
https://www.ammoniaenergy.org/organization/tohoku-university

**China**
https://www.ammoniaenergy.org/articles/ammonia-in-china-change-is-coming

**Use of NH3 fuel to achieve deep greenhouse gas reductions from US transportation** | ScienceDirect
*Aggressive implementation of NH3-fueled light duty vehicles replacing gasoline vehicles by 2040, produces a 96% reduction equivalent to a reduction of approximately 718 million metric tons CO2 equivalent in that year's emissions.*
https://www.sciencedirect.com/science/article/pii/S235248471500027X

**"Levelized cost of energy storage" Ammonia is the only grid scale option** | US-DOE Advanced Research Projects Agency - Energy (ARPA-E)
*The US Department of Energy, which is funding a portfolio of renewable ammonia synthesis technologies through its Advanced Research Project Agency (ARPA-E), has demonstrated that ammonia is already the lowest-cost, proven technology for long-term, large-scale energy storage, where "long-term" refers to any time period greater than one day.*
https://nh3fuelassociation.org/2016/07/06/ammonia-for-energy-storage-and-delivery/
https://i0.wp.com/ammoniaindustry.com/wp-content/uploads/2016/10/ARPA-E-ammonia-LCOES.png?ssl=1

**Feasibility Study on the Supply Chain of CO2-Free Ammonia with CCS and EOR** | Institute of Energy Economics, Japan - IEEJ
Japan to use ammonia fuel to reduce total CO2 emissions by 80% in 2050 for electrical power generating. The cost of clean NH3 fuel and energy is half the cost of hydrogen and all hydrocarbons including natural gas even when it is made from it. Profits from converting natural gas to ammonia are many times higher than from transporting LNG.
https://eneken.ieej.or.jp/en/genre/economy_list.php?l1_s=0
https://eneken.ieej.or.jp/data/8371.pdf

**Plastic fantastic: How does Tokyo recycle its waste?** (Making Ammonia) | The Japan Times
1,000+ workers process 195 tons of waste plastic a day, making 175 tons of ammonia.
https://www.japantimes.co.jp/life/2017/06/10/environment/plastic-fantastic-tokyo-recycle-waste/#.XLo4U9jaskI

**Diesel fuel generators and trucks to be powered by cleaner NH3 fuel** | Hydrogen Fuel News
*TFX International will provide two diesel fuelled generators and transport trucks to use Hydrofuel® ammonia fuel and Ammonia Solutions© multi-fuels systems.*
http://www.hydrogenfuelnews.com/diesel-fuel-generators-and-trucks-to-be-powered-by-cleaner-nh3-fuel/8537705/

The Ammonia Energy Association cites Hydrofuel Inc.'s and OTU's work in several sections on their website including:

**NH3 Fuel Cells**
https://www.ammoniaenergy.org/topics/nh3-fuel-cell

**Fuel Cells**
https://www.ammoniaenergy.org/topics/fuel-cells

**NH3 Internal Combustion Engine**
https://ammoniaenergy.org/topics/nh3-internal-combustion-engine

**OTU's Fuel Cell developed by Dr. Dincer**.
https://www.ammoniaenergy.org/articles/uoit-develops-its-own-flavor-of-direct-ammonia-fuel-cell

**Ontario Tech University** (aka. University of Ontario) | Ammonia Energy Association
https://www.ammoniaenergy.org/?s=University+of+Ontario

**University of Ontario Institute of Technology** | Ammonia Energy Association
https://www.ammoniaenergy.org/organization/university-of-ontario-institute-of-technology/

**Hydrofuel Inc.** | Ammonia Energy Association
https://www.ammoniaenergy.org/organization/hydrofuel-inc/

OTU has a patent on a low cost high efficiency ZERO emission ammonia engine that uses the hydrogen (H2) for fuel, and the nitrogen (N2) split from ammonia (NH3) by providing the cooling (and heating using a heat ex-changer) to reduce fuel consumption by an additional 20%. It is more efficient, robust, cleaner, and lower operating cost and total cost of ownership than anything available today running on any fuel.

**US8272353B2 - Apparatus for using ammonia as a sustainable fuel, refrigerant and NOx reduction agent** | Google Patents
https://patents.google.com/patent/US8272353B2/en

OTU also has a patent on a high efficient waste heat recovery engine.

**US7080512B2 - Heat regenerative engine** | Google Patents
https://patents.google.com/patent/US7080512B2/en

OTU has developed world leading ammonia fuel cell technology.
**Ontario Tech Develops Its Own Flavor of Direct Ammonia Fuel Cell** | Ammonia Energy Association
https://www.ammoniaenergy.org/articles/uoit-develops-its-own-flavor-of-direct-ammonia-fuel-cell/

Although established 18 years ago in 2002, OTU has published the most extensive research in the last 50 years in Canada on "Ammonia Energy", with 214 out of 1,421 documents, according to a recent report in the International Journal of Energy Research.

**Ammonia-based energy solutions and research and development efforts in Canada: A perspective** - 50 Years, 1970 to 2020 | International Journal of Energy Research
https://onlinelibrary.wiley.com/doi/full/10.1002/er.5931

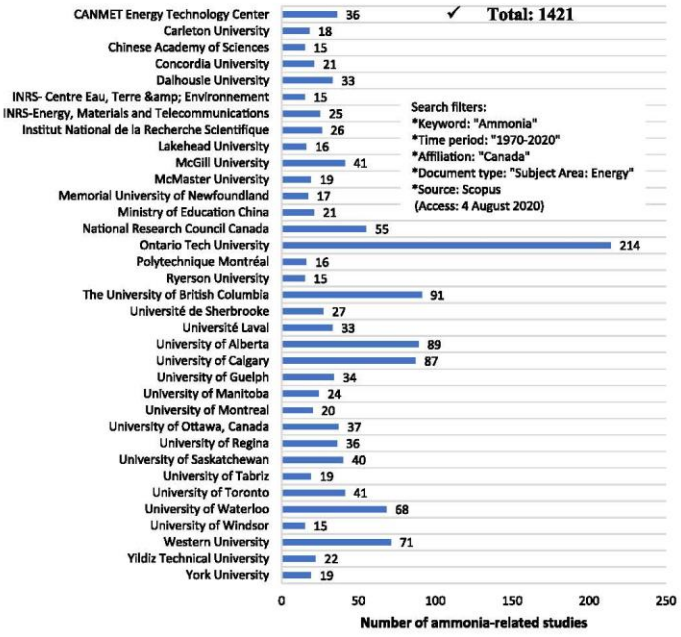



**FIGURE 8** Canadian institutes that have published more than 15 ammonia-related publications in the subject area of energy (data from Reference 8) [Colour figure can be viewed at wileyonlinelibrary.com]

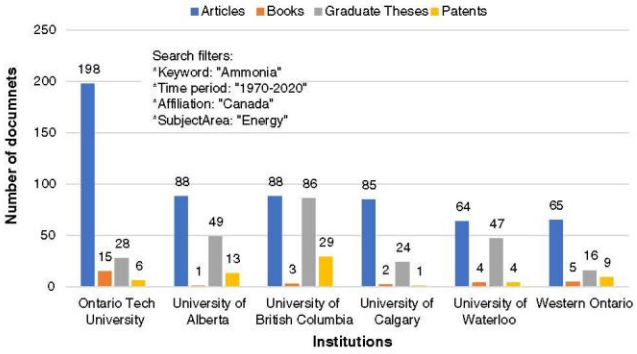



**FIGURE 9** Top six Canadian institutes making the highest contribution to ammonia research in the subject area of energy (data from References 8–10) [Colour figure can be viewed at wileyonlinelibrary.com]

As a nature-friendly energy carrier and an appropriate medium for the storage of hydrogen, ammonia attracts the attention of researchers working on clean energy and energy technologies. Figure 8 shows Canadian institutes and the number of their ammonia-related studies in the subject area of energy. Data and information retrieved from Scopus indicate that there have been 1421 research studies approaching ammonia energetically. Ontario Tech University, which has been founded in 2002, appears as the pioneering institution of Canada in ammonia-based energy research by conducting 214 studies. The affiliation of the studies shows that Researchers working at Clean Energy Research Laboratories (CERL) located in Ontario Tech University play a major role in this success. Furthermore, the top six Canadian institutes that consider ammonia in

OTU also has world leading I.P. for the production of hydrogen and ammonia including; Solar and Electrochemical ammonia synthesis; Hydrocarbon ammonia synthesis without emitting the carbon or CO2; Solid, biomass, plastic and liquid waste, and waste water conversion to hydrogen and ammonia; and Direct sequester of CO2 into elemental carbon.

We are the commercialization partner for OTU for multiple hydrogen and ammonia energy and

fuel production or utilization technologies under an option to an exclusive licence.

- Solar ammonia synthesis
- Electrochemical ammonia synthesis
- Hydrocarbon ammonia synthesis without emitting the carbon or CO2
- Ammonia Heating and Cooling Engine
- Ammonia Fuel Cell
- Waste water to hydrogen
- Waste plastic to ammonia
- Direct sequester of CO2 into elemental carbon

We presently have three additional MITACS co-funded projects underway with OTU with a total budget of over $100,000 including HST. We have committed to spend a minimum of $500,000 to $1 million (assuming at least 50% in matching grants) in research and development and commercial demonstration costs of OTU's and Hydrofuel Inc.'s technologies over the next several years with OTU.

Finally, even if the Supreme Court of Canada finds that the Trudeau Government's Greenhouse Gas Pollution Pricing Act (GGPPA) is constitutional it doesn't mean the ways it is being implemented are.

Just as there have been multiple court decisions in Canada and the USA reviewing many environmental and economic policies that concluded they were unconstitutional, a review of Canada's present policies is very likely to succeed.

It can be clearly proven that in many cases that doing nothing at all gets similar results to those 'chosen' to be superior with incentives and special treatment by this policy, because the total pollution from the 'chosen' technologies is a great as or greater than existing forms of energy production and use.

More importantly, the life cycle pollution from most so-called green energy technologies 'chosen' for minimum mandated use, subsidies and carbon and life cycle pollution emission exemptions are many times greater and more costly than dozens, if not hundreds, of alternatives prevented from market entry by these same policies.

The political rhetoric cannot continue to avoid and ignore the real the science and economics of global energy production and use. We are going to have to pay the piper and the best way to do it is by building an ammonia economy based on fully costed user-pay energy, environmental and economic policy.

The user pay policies we propose will level the playing-field for consumers and the public and private sectors to be able to use energy produced using the environmental and economic practices, and encourage and reward investments in innovation sooner than later. Such a policy can be applied to exports and import based upon the level or corresponding policies in other countries.

The one technology we now know will be a huge part of our energy mix going forward is ammonia energy and Canada is positioned to lead the world notwithstanding the head start other countries appear to be have already.

Regards,

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