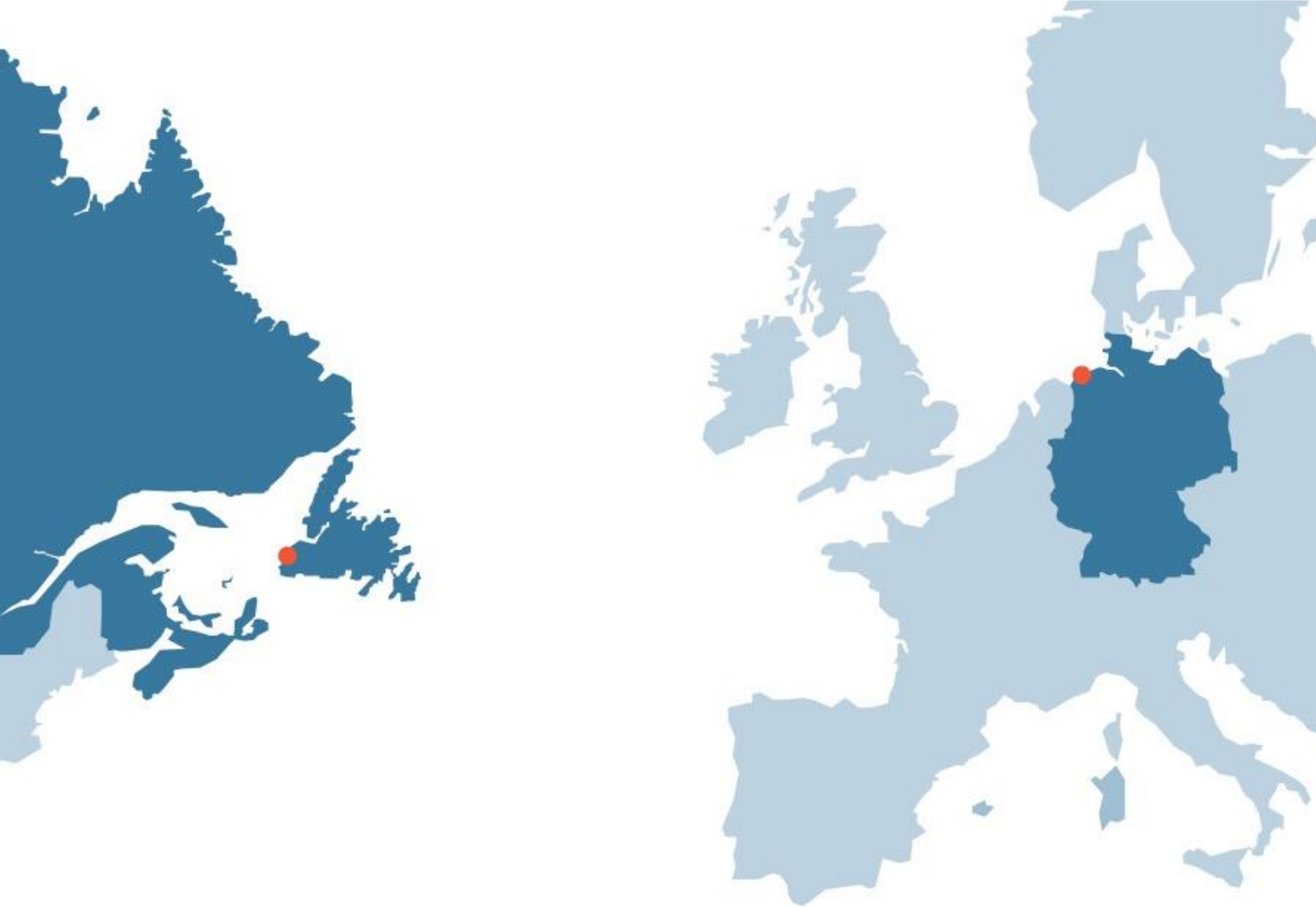

The Canada-Germany Hydrogen Alliance: **Throwing Caution to the Wind**

A report by Canadians for Nuclear Energy
June 2024

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Canadians for Nuclear Energy (C4NE) is a grassroots not-for-profit organization composed of Canadian energy workers, engineers, doctors, tradespeople, scientists, policy experts, and citizens dedicated to pursuing informed, effective energy policy for the betterment of Canada and the planet.

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Letter from the President

As Canada aims to become a major exporter of hydrogen, it seems to have thrown caution to the wind. The federal government has earmarked tens of billions of dollars in subsidies and given hundreds of millions of dollars in loans for hydrogen export projects that have yet to sign firm purchase orders for their product and which face nearly insurmountable economic and thermodynamic hurdles.

Consider that by the time a mixture of wind power, grid electricity, and gas generation at a Canadian hydrogen export project reaches German customers in the form of hydrogen, half of the energy will already have been lost to inefficiencies. And this energy won’t be cheap: capturing it will take overbuilding wind turbines that will be sufficient only to run electrolysers at far-lower-than-ideal capacities. As for economics, both the cost of electrolysis (compared to other ways to make hydrogen) and the difficulties of long-distance transport have independently kept electrolysis and exports at vanishingly small global hydrogen market shares. The Canada-Germany Hydrogen Alliance plans to combine these things.

In doing so, the Alliance risks undermining Canada’s credibility as a climate and energy leader as we head into the middle of the century, and it will stress the pocketbooks of Canadian taxpayers that will see virtually no direct benefit from the projects.

Why does our organization, Canadians for Nuclear Energy, care about hydrogen projects? We became advocates for nuclear power only because the technology fulfills numerous criteria essential for durably combating the threats of climate change and energy insecurity. We are, in fact, technology agnostic. But we aren’t outcome-agnostic.

To make durable progress on climate change and energy security—a goal stated in the founding agreement of the Hydrogen Alliance—we must be willing to critically assess the options put before us. We attempt to do so here.

Sincerely,

Chris Keefer, MD, CCFP-EM
President, Canadians for Nuclear Energy

Executive Summary

Canada has made a heroic effort to keep up with the United States in terms of incentives for low-carbon energy and technology. As we highlight in this report, however, at least one effort to establish Canadian leadership in a new low-carbon industry is unacceptably cavalier: the Canada-Germany Hydrogen Alliance.

The Hydrogen Alliance, entered in the fall of 2022, paves the way for hydrogen export projects in Atlantic Canada that could receive several tens of billions of dollars in subsidies over the next decade. Billed as clean energy projects that promote decarbonization and energy security for our allies, a closer look shows a far more troubling picture.

The Alliance promotes big spending on high-risk, inefficient hydrogen export projects without yet having any firm purchase orders for hydrogen in place. Significant carbon emissions during the production and delivery of the hydrogen risk going uncounted; extraordinary inefficiencies in the hydrogen export process undermine the economics of these projects as **more than half of the energy is lost** before reaching end-users; and subsidy leakage to foreign companies could leave Canadians with little to show for billions of dollars spent.

Moreover, the output of the proposed Canadian hydrogen-ammonia export projects is a small fraction of what Germany could produce domestically with the restart of its nuclear reactor fleet, making the significant financial sacrifice of Canadian taxpayers an avoidable burden as well as a massive liability if Germany reverses its nuclear energy policy.

The Alliance becomes even more questionable when considering the role that these hydrogen exports will play in German energy planning, as they provide a less efficient, less secure, and higher cost alternative to hydrogen that Germany could produce itself but is choosing not to, instead following a policy of dismantling its own clean, nuclear energy supplies.

We are deeply concerned by the scale of the spending on hydrogen export projects given their large economic risks, environmental hazards, and inefficiencies. There is also a lack of transparency around these projects.

Summary of findings

Energy losses: Steep energy losses make the proposed hydrogen exports economically suspect, as most of the energy spent to produce, export, and deliver hydrogen from planned Canadian projects is lost before reaching end-users.

Fugitive emissions: The carbon intensity of these hydrogen exports is much higher than advertised, as inefficiencies and extra energy inputs to transport and deliver the hydrogen raise its estimated minimum carbon intensity to over 2 kg of CO_2 per kg of hydrogen delivered (meriting at most a 15% Hydrogen Investment Tax Credit). However, the current proposed method of counting carbon ignores these emissions, creating significant risk to Canadian taxpayers while failing to incentivize innovation in truly low-carbon solutions.

Avoidable burden: Germany could produce 15 times more hydrogen than the largest proposed Canadian export project using its shuttered fleet of nuclear power reactors, resulting in cheaper, lower-emissions, and more secure supplies of hydrogen without the ecological impact and subsidy spending on Canadian shores.

Local disruption: Local communities remain divided on potentially overstated benefits. Despite the significant ecological impact of these projects, the federal government has refused to offer a federal impact assessment. Moreover, interconnecting major wind-hydrogen-ammonia projects presents risks to the electric grid that are downplayed by project developers.

Subsidy leakage: The primary beneficiaries of subsidy spending on these projects are the subsidiaries of foreign companies and suppliers, while the beneficiary of the end product is Germany (if they decide to buy). Canada stands to capture little if any of the benefit of its generous spending on ammonia exports to Germany, a country that has failed to steward its own low-carbon energy supplies.

Recommendations

Bringing transparency, rigour, and risk mitigation to the proposed megaprojects under the Canada-Germany Hydrogen Alliance should be a priority for Canadian leadership. We recommend that the federal government and provincial governments hosting the proposed hydrogen export projects:

1. Accurately account for all hydrogen exported-related emissions. The 2023 Budget strives to consider the “lifecycle emissions” of Canadian hydrogen exports yet leaves out carbon-intensive processes required to deliver the hydrogen to end customers in Germany. As it stands, the oversight will enable massive quantities of fugitive, uncounted carbon emissions. Accounting for these emissions would:

- Incentivize innovation to meet the 40% tier, rather than inflate the Hydrogen ITC deserved by ignoring major sources of emissions in the export process
- Minimize subsidy leakage to the foreign developers and safeguard against over-awarding subsidies
- Better align the ITC with decarbonization goals
- Improve cost-effectiveness for the government and taxpayers, saving several billion dollars in subsidies

2. Ensure strict oversight of hydrogen export projects. Despite administering potentially billions of dollars in subsidies and granting hundreds of millions of dollars in loans, the federal government has left environmental and other oversight of the hydrogen projects to the provinces. This creates a massive financial risk for Canadian taxpayers, political risk for the federal government, and ecological risk for local communities.

3. Obtain firm hydrogen offtake agreements before offering further financial support. Without firm purchase orders in place, Canada is taking on all the risks of these projects without a guaranteed market for its hydrogen. Given the massive public spending these projects will capture, this is an unacceptable risk for Canadian taxpayers. The Memorandum of Understanding of March 2024 did not go far enough to ensure that Germany will ultimately purchase Canadian hydrogen supplies.

4. Pursue goals of decarbonization and energy security through more effective means, including holding Germany responsible for its irresponsible energy policy and centering Canadian policy around proven solutions.

The Canada-Germany Hydrogen Alliance: A Costly Proposition

Key Takeaway: The Clean Hydrogen Investment Tax Credit earmarks billions of dollars in subsidies for international companies that plan to build over $80 billion of ammonia export projects on Crown lands and at strategic Canadian ports, supported under the Canada-Germany Hydrogen Alliance. Hydrogen is seen as a low-carbon energy solution, but its international export adds massive complexity, costs, and emissions compared to domestic production.

A new era of incentives

Since the United States passed major incentives for low-carbon technologies in its landmark 2022 Inflation Reduction Act, Canada has scrambled to compete.

In its Fall Economic Statement that year, the Canadian government outlined several new investment tax credits, including, among others, up to a 15% credit for investments in low-carbon electricity generation and up to a 30% credit for investments in clean technology manufacturing.[1] When legislation for these incentives is finalized, Canada will enter a new era of mass subsidies for projects intended to advance decarbonization policy objectives.

Standing out among the tax credits is a **Clean Hydrogen Investment Tax Credit (ITC) of up to an impressive 40%**, accompanied by a 15% credit for hydrogen-to-ammonia conversion facilities to be used for the export of hydrogen. As of spring 2024, official legislation regarding the Hydrogen ITC has yet to be introduced, though the 2024 Budget reaffirmed that it is forthcoming.

The official estimated cost of the Hydrogen ITC is formidable: $17.7 billion over 12 years, with a tax credit awarded based on a project's carbon intensity, measured in kilograms of CO_2 emitted per kg of hydrogen ($kgCO_2/kgH_2$).

Table 1: Clean Hydrogen ITC Tiers

Carbon intensity ($kgCO_2/kgH_2$)	Tax credit rate
Less than 0.75	40%
0.75 to 2	25%
2 to 4	15%
More than 4	None

These subsidies are only one part of an array of incentives, loans, and grants available for hydrogen projects. Considering the generous potential subsidies for hydrogen projects through this ITC, eligible projects deserve adequate scrutiny. In this report, we provide an analysis of a high-profile initiative that plans to make extensive use of the Clean Hydrogen ITC: the Canada-Germany Hydrogen Alliance.

An "Alliance" is formed

In August 2022, Prime Minister Trudeau, German Chancellor Olaf Scholz, and other high-ranking officials signed the "Joint Declaration of Intent" to form the Canada-Germany Hydrogen Alliance.

The Hydrogen Alliance seeks to cooperatively develop hydrogen imports and exports, establishing a maritime trade corridor for hydrogen between Canada and Germany to "address climate change, accelerate the global energy transition and safeguard international energy security."[2] These are objectives with which Canada is proudly familiar, as exemplified by its uranium exports to countries such as Ukraine, supporting energy security while sparing hundreds of millions of tonnes of CO_2 per year by displacing electricity generation from coal, oil, and natural gas.

The Hydrogen Alliance has since been reinforced with further non-binding MOUs between Germany and Canada. An MOU in March 2024 recognized the need for commercial offtake agreements and stated, rather weakly, that "Participants will aim to launch aligned supply and demand side auctions as early as possible, and preferably before the conclusion of 2024, should approvals by relevant authorities be secured in time."[3] As of yet, there are no legally binding agreements in place for the purchase of hydrogen from any Canadian hydrogen export project. Financial support for these projects has, nevertheless, begun to flow.

Big plans in the Maritimes

The gathering place to kick off the Hydrogen Alliance was Stephenville, a small coastal town in Newfoundland near the location of Project Nujio'qonik, a proposed $16 billion (USD 12 billion) wind-hydrogen-ammonia facility from developer World Energy GH2 (a subsidiary of U.S. company World Energy LLC), who claims the project will export 250,000 tonnes of

Stephenville, NL. Photo by Erik Mclean

Near the site of the proposed ammonia export project by EverWind Fuels, Point Tupper, NS

hydrogen per year in the form of ammonia. Another project, only slightly smaller at an estimated $13.7 billion, plans to be located at Point Tupper in Nova Scotia. The developer, EverWind Fuels (a subsidiary of U.S. company TDL Partners), has signed a non-binding agreement with German energy companies Uniper and E.ON to supply each 500,000 tonnes of hydrogen-carrying ammonia per year, expected to start deliveries in 2025.

Newer projects, still in the development stage, have also been given exclusive rights to develop in Crown Lands across Newfoundland and Labrador, New Brunswick, and Nova Scotia. These include a project by EverWind Fuels at Burin Peninsula, NL; a project by American company BAES Infrastructure at Point Tupper, NS; a project by German company ABO Wind near the Avalon Isthmus, NL; and a project near Botwood, NL by the secretive Exploits Valley Renewable Energy Corporation, whose leadership is involved with scattered business dealings in the Maldives, Sri Lanka, South Africa, Romania, and the U.S. southwest.

Unprecedented costs

In all, the combined capital cost of the proposed projects could exceed $66 billion in Newfoundland and Labrador alone, according to the NL Minister of Industry, Energy and Technology.[4] Combined with the Nova Scotia EverWind Fuels project, which is estimated to cost around $14 billion, total capital spending under the Hydrogen Alliance could be well into the $80 billion range.

This figure makes up a large percentage of the total forthcoming investment in hydrogen projects Canada-wide. Including projects still in the feasibility/planning and pre-feasibility stages, and covering all hydrogen-producing technologies including natural gas reforming with carbon capture and biomass gasification, Natural Resources Canada states that it has 80 different projects on its radar totalling over $100 billion in expected capital investment.[5] The vast majority of these projects are smaller and at less advanced stages than the large export-oriented projects on the Atlantic coast. As such, they are not a focus of this report.

The federal government is also making additional financing available through several programs, including the Clean Fuels Fund, the Strategic Innovation Fund, the Canada Growth Fund, and initiatives by the Canada Infrastructure Bank and Export Development Canada. This financing often targets specific projects. For instance, in November 2023, the Federal Minister of Housing, Infrastructure and Communities announced a $125 million loan for the EverWind project at Point Tupper. In the spring of 2024, Export Development Canada announced $128 million in loans for the World Energy GH2 project. An additional $300 million was made available to 10 hydrogen projects through the Clean Fuels Fund.

While the scale and comprehensiveness of the pro-hydrogen policy are impressive, we are concerned that Canada has rushed headlong into a risky situation with major economic, environmental, and energy security questions left unanswered.

Why hydrogen?

A low-carbon battery

Hydrogen is a promising alternative to fossil fuels for hard-to-decarbonize sectors. Unlike carbon-based fuels, which when combusted with oxygen create a carbon-oxygen molecule (CO_2) that contributes to climate change, hydrogen combusts into a hydrogen-oxygen molecule (H_2O), or water. This makes it a potential emissions-free heat source in applications like steel and chemical manufacturing. Or it can be used in fuel cells to generate electricity for mobile or stationary uses.

Hydrogen is often mistakenly considered an energy source, including in Canada's own Budget 2023.[6] However, it is not an energy source but a carrier, akin to a battery. Despite major technical challenges with storing and transporting high-purity hydrogen, Canada and Germany both have large ambitions for the role of hydrogen in their economies to supplant the use of fossil fuels in industry, transportation, and energy production. Both countries have published national hydrogen strategies.[7,8]

The following chart by Liebreich Associates shows a range of potential uses for hydrogen and ammonia, ranked by their competitiveness compared to alternatives.

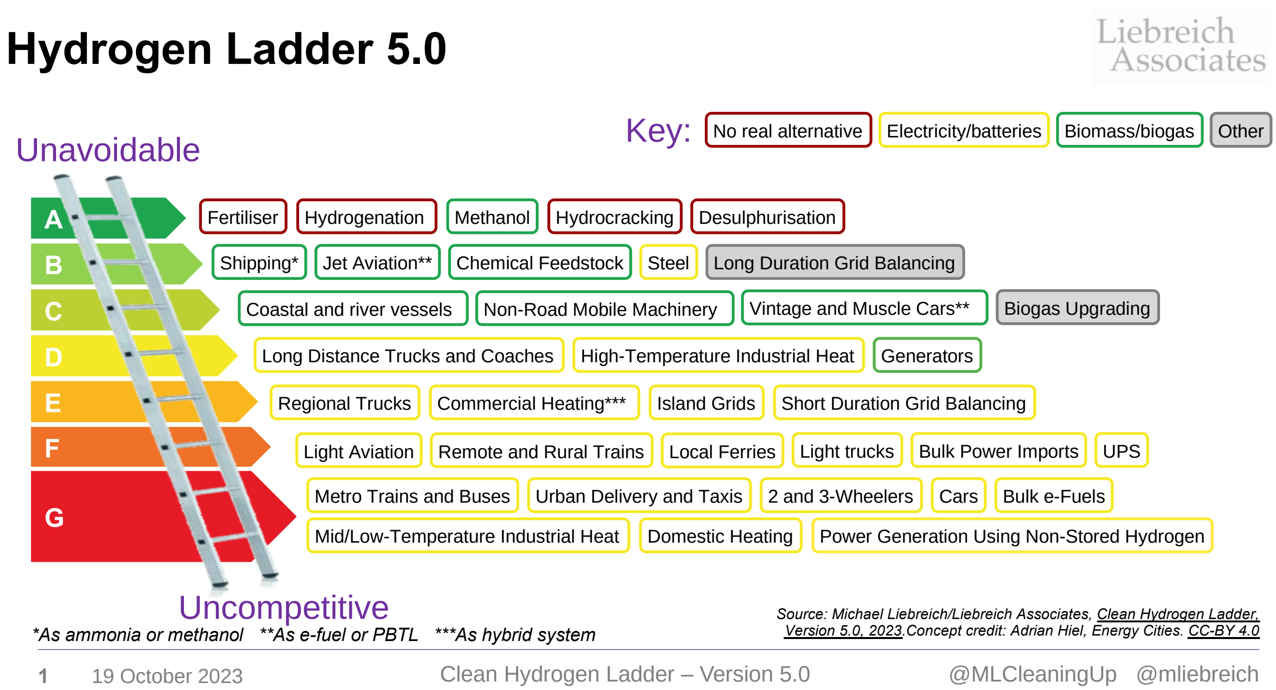


Figure 1: The Clean Hydrogen Ladder. Source: Michael Liebreich/Liebreich Associates, Clean Hydrogen Ladder, Version 5.0, 2023. Concept credit: Adrian Hiel, Energy Cities. CC-BY 4.0

Making it

Since hydrogen gas is rare in nature, we must manufacture it. Virtually all of the world's manufactured hydrogen is produced using a process known as Steam Methane Reforming, which consumes large quantities of fossil fuel feedstocks.[9]

Hydrogen can also be made using electricity with a water feedstock in a process known as electrolysis. Electrolysis uses electricity to break apart molecules of water into separate hydrogen and oxygen molecules. Part of the energy used in this way is later retrievable from the produced hydrogen. In this way, hydrogen functions as a battery.

Despite having no combustion-related carbon emissions, electrolysis remains a highly energy-intensive process with a large carbon footprint when not powered by clean sources of energy.

Of the roughly 94 million tonnes of hydrogen produced globally each year, electrolysis contributes less than one-tenth of one percent (0.1%) owing to relatively high costs.[9]

When charged by clean energy sources, however, hydrogen can serve as a low-emissions energy carrier for use in a range of applications. If these clean energy sources are cheap and abundant, then low-carbon hydrogen would be scalable despite low efficiencies in its production.

By using wind energy to power electrolysis, the proposed hydrogen export projects in Canada bill themselves as "green hydrogen" producers. A far more accurate descriptor of these projects would be to describe them as ammonia export projects. Although project developers tend to refer to their output in terms of hydrogen, **they are actually making and exporting ammonia,** a workaround to address the massive challenges of transporting hydrogen.

Moving it

As the smallest element on the periodic table, hydrogen readily leaks from containers that would be considered “sealed” for the transport of other gases. It embrittles tanks and pipelines as hydrogen diffuses into the metal’s microscopic lattice structure or forms hydrides. And hydrogen takes up an enormous space unless compressed to extreme pressures: for the same energy, about 3 times as much as natural gas and around 3,500 times as much as diesel fuel at atmospheric pressure.

As a result, hydrogen’s economics much favour on-site production and immediate use at industrial facilities. International hydrogen exports in gaseous form are virtually non-existent.

But for countries keen on creating a “hydrogen economy,” the transportation problem must be solved. For regional transport, existing pipeline infrastructure could carry some high-purity hydrogen blended with natural gas, though problems of embrittlement and disruption to carefully calibrated industrial systems arise.[7(p61)] For the long-distance transportation of hydrogen, ammonia has emerged as the favoured chemical carrier.

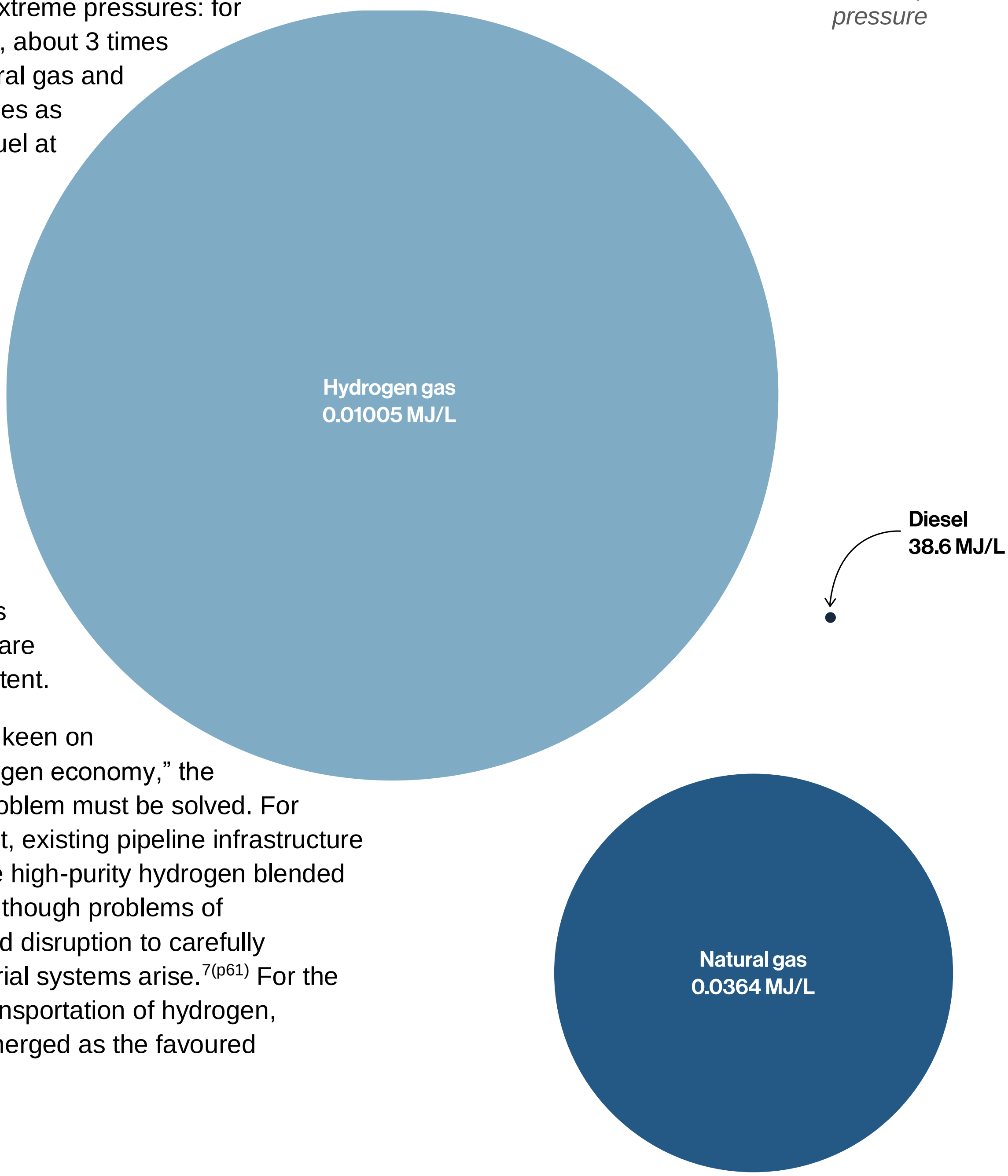


Figure 2: Relative volumes of 1 MJ of fuel at atmospheric pressure

A Very Large Gas Carrier capable of transporting up to 60,000 tonnes of liquid ammonia.

Chemical carrier: Ammonia

Composed of a nitrogen atom and three hydrogen atoms, ammonia is 17.8% hydrogen by weight. Liquid ammonia can be synthesized on-site at an electrolysis facility by feeding hydrogen and compressed nitrogen into a Haber-Bosch reactor. The Haber-Bosch process is widely used to produce a majority of the world's nitrogen-based fertilizers, making hydrogen-to-ammonia conversion technology mature.

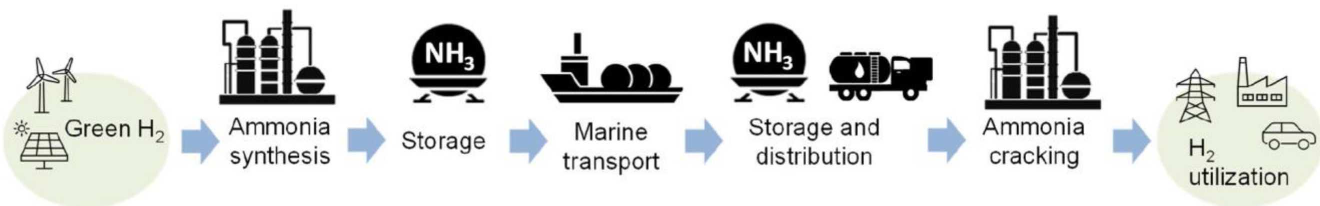
Liquid ammonia is then shipped to its destination, where it can be reconverted into hydrogen via decomposition, or "cracking." The round-trip through ammonia is a steep compromise; it is more economical than alternatives, as the manufacture and transport of ammonia already exist at a large scale to serve the explosives and fertilizer markets. However, it causes significant energy losses during the round-trip conversion.

The proposed hydrogen export projects in Canada exclusively use this mode of transport: shipping liquefied ammonia via large tanker ships. Once at the import terminal, to retrieve hydrogen from the ammonia, the ammonia must be sent through an ammonia cracking plant. At the Wilhelmshaven deep water port in Germany, where Uniper plans to receive Canadian ammonia, an industrial-scale ammonia cracker is being built for this exact purpose.

Unavoidable complexities

The proposed hydrogen projects are understandably quiet about the realities of the export process. If properly counted, the emissions intensity of the export process would disqualify the projects from the highest tier of Hydrogen ITC. As we find in this report, shipping and cracking put Canadian hydrogen exports squarely in the 2 to 4 kgCO2/kgH_2 range, which should make them eligible for a maximum ITC rate of 15%. The inefficiencies in the export process are also highly damaging to the economic competitiveness of hydrogen exports compared to domestic production, which could temper the enthusiasm that has led to such generous financial support for these projects

Figure 3: NH3 value chain as a hydrogen carrier. Source: Spatolisano et al.[10]



A note on units

Hydrogen exports are discussed by project developers with a variety of units. Hydrogen and ammonia both have masses as well as energy contents, and these properties are used somewhat interchangeably.

The retrievable energy content of 1 tonne of hydrogen is 33.33 megawatt-hours (MWh), called its Lower Heating Value. The retrievable energy content of 1 tonne of ammonia, which is 17.8% hydrogen by mass, is 5.18 MWh. This value is 0.73 MWh/tonne *less* than ammonia's percentage mass from hydrogen would suggest. This discrepancy both necessitates the use of additional heat energy to crack the ammonia back into hydrogen and creates an upper theoretical limit of 87% efficiency when converting hydrogen to ammonia.

The efficiency of produced hydrogen, ammonia, or delivered hydrogen is calculated by dividing its maximum retrievable energy content by the total energy that went into producing (and delivering) it. This efficiency changes depending on which stage of the export process the hydrogen/ammonia product is in. For example, prior to its conversion to ammonia, if an electrolyser requires 45 MWh to produce one tonne of hydrogen, its efficiency is 33.33 MWh / 45 MWh = 74%.

The terms "hydrogen export projects" and "ammonia export projects" are used interchangeably.

Findings: A Cautionary Tale

1. Most of the energy is lost in the journey

Key Takeaway: The massive energy losses associated with the international export of electrolysis-produced hydrogen make the economics of the proposed projects extremely dubious compared to domestic production of hydrogen and alternate uses of the energy inputs. This physical reality threatens to undermine the long-term viability of the planned hydrogen export projects.

Energy losses in the production of hydrogen are inevitable. Typical electrolysis efficiencies average around 72%, with some emerging technologies claiming efficiencies near 88%. However, for export projects, electrolysis is only one stage at which energy losses are possible, with the Haber-Bosch ammonia conversion, transport, and ammonia cracking being others. With current technology, electrolysis + the Haber-Bosch process to make ammonia is at most about 66% efficient before loading the product onto a tanker ship.[11] Then, re-converting it to hydrogen using ammonia decomposition, or "cracking," requires extra fuel inputs and creates further inefficiencies that drive the energy losses throughout the process to over 50%.[12–14] In all, more than half of the energy that would be used to bring Canadian hydrogen to German shores would be lost *before* it could be used.

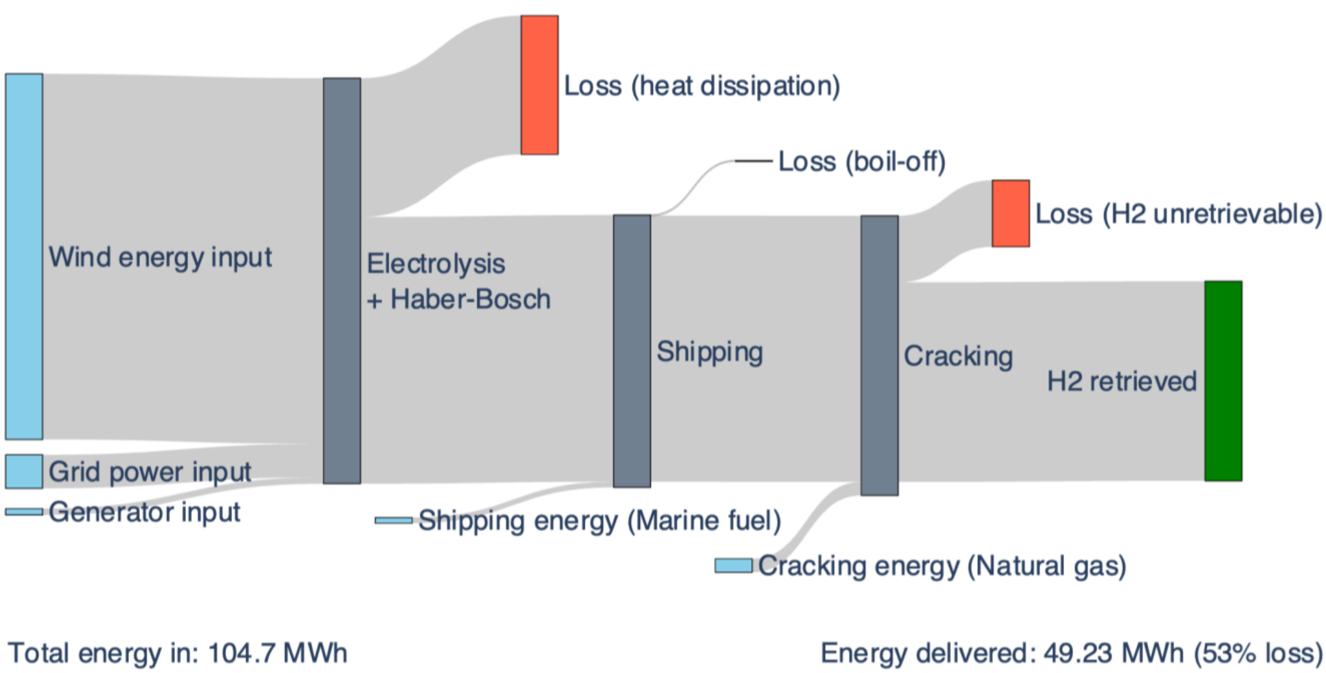


Figure 4: Energy losses during the hydrogen production and export process

Compared to domestically produced German hydrogen that avoids the conversion to ammonia and back, the low efficiency of exported Canadian hydrogen multiplies its carbon intensity, ecological impact, end-user price, and subsidy cost for each unit delivered. This constitutes a major competitive disadvantage.

Subsidizing waste heat

Given the added inefficiencies from the export process, for every 1 kg of Canadian hydrogen delivered to Germany, Germany could have produced 1.5 kg of hydrogen using the same amount of energy and, in doing so, avoided the extra cost and emissions from shipping and cracking ammonia. In this sense, hydrogen exports carry a 50% "inefficiency tax" just to overcome energy losses during export. By using subsidies to make these hydrogen exports competitive with those of other sellers, it will be the Canadian taxpayer who is on the hook for this inefficiency tax.

Considering that current planned projects total over $80 billion and will lobby for the highest Hydrogen ITC bracket of 40%, this "inefficiency tax" could total over $10 billion essentially to **subsidize the production of waste heat.**

Use case: low-carbon steel

How does imported hydrogen look from an end-user perspective? Take low-carbon steel, which Germany cites as a large potential use case for hydrogen.[15] One method of producing low-carbon steel uses hydrogen to make direct reduced iron, which is then fed to an electric arc furnace. Each tonne of steel produced this way requires around 3.5 MWh of electricity, two-thirds of which is used to power electrolysis to make the required hydrogen.[16] If, instead of the 72% efficiency achievable with on-site electrolysers, 50% efficient imported hydrogen were used, it would drive up the total electricity requirements for each tonne of steel to 4.7 MWh — a 35% increase.

Considering that "green steel" already carries around a 40% premium compared to regular steel, an *additional* 35% increase in the required electricity input could make steel produced this way utterly uneconomic if the extra energy inputs are reflected in the cost of the imported hydrogen.[17] Subsidies could temporarily hide the extra costs from German steel producers. Still, somebody must pay for the extra inefficiencies, whether the producer, customer, the planet, or all the above. As a whole system, lower efficiencies dramatically increase total energy use, mining, and consumption of materials for the same amount of steel, making the process less affordable and less sustainable.

Moreover, the higher carbon intensity of the imported hydrogen effectively triples the electricity-related emissions of steel produced with hydrogen imports versus on-site electrolysis using low-carbon sources. This raises doubts about whether steel produced this way could even be considered "green."

Economic delusions

Close to 100% of current global hydrogen production occurs on-site where it is needed.[18] And of this on-site production, the higher cost of electricity-powered electrolysis compared to Steam Methane Reformation of fossil fuels has held electrolysis at a mere 0.1% global market share.[9(p64)] **The combination of electrolysis *and* inefficient international hydrogen exports is therefore, on economic grounds alone, an extremely dubious proposition.**

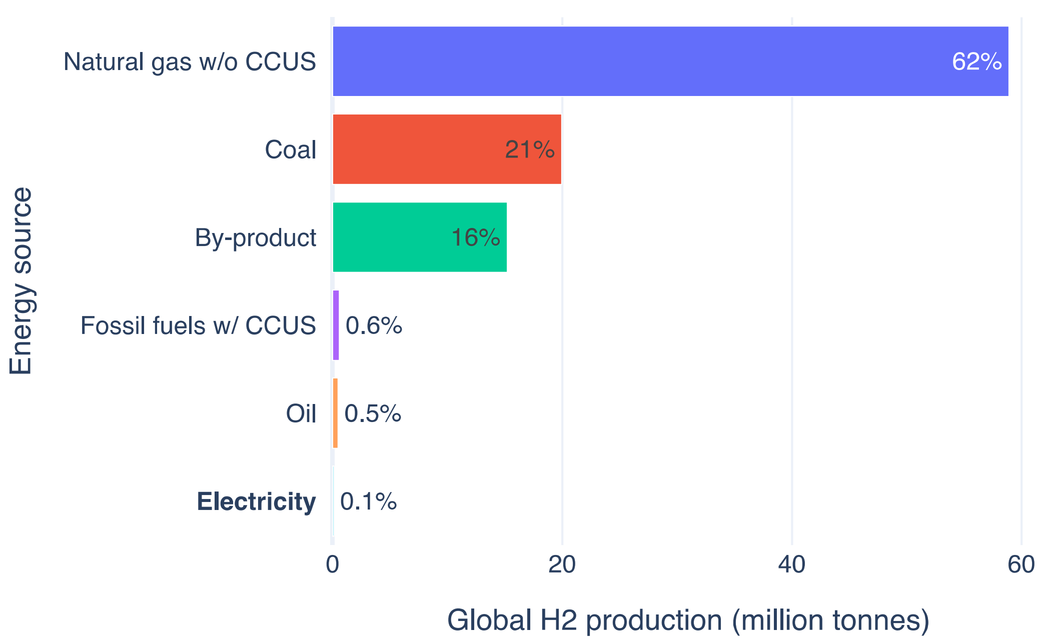
Yet Canada is moving forth on tens of billions of dollars in subsidies for hydrogen export projects *without binding purchase agreements* from Germany or elsewhere. This constitutes a major risk for the taxpayers supporting these projects, as well as for the communities that are banking on the success of these projects for jobs and local economic activity.

At-risk projects

These dubious economics do not even factor in the major challenges sweeping across the wind sector. Increasing costs have forced the cancellation of far less ambitious projects by far more credible developers than those proposing Canadian wind-hydrogen-ammonia export projects. In Europe, the largest onshore wind project is facing bankruptcy after being unable to fulfill contractual obligations for baseload power.[19] And Siemens, the provider of the PEMEC electrolysers for the Canadian hydrogen projects and a leading wind turbine manufacturer, recently had a subsidiary bailed out by the German government for financial troubles in its wind division.[20]

Even with substantial subsidies to attempt to overcome the wasted energy and questionable economics of hydrogen exports, the proposed projects pose an alarming risk of failure, making it essential that the government preserve project offramps and apply independent oversight.

Figure 5: Global hydrogen production by technology, 2022. Source: IEA[9(p64)]



2. Carbon emissions are higher than “wind-powered” hydrogen would suggest

Key Takeaway: Only counting on-shore Canadian carbon emissions woefully underestimates the carbon intensity of the final hydrogen deliveries from the proposed projects, and even the on-site emissions are higher than project developers are advertising. We find major shortcomings in the current method of evaluating the carbon intensity of these projects. When true lifecycle emissions are assessed, we find the maximum achievable ITC for hydrogen export projects to be 15%.

Projects being developed under the Canada-Germany Hydrogen Alliance are billed as high-efficiency, renewable energy projects. Even if the economics are questionable, one might argue that they at least provide clean energy.

World Energy describes its Nujio’qonik project, for example, as a producer of green hydrogen, which it defines as hydrogen “produced from only water and renewable electric power.”[21] It also once touted that its electrolysers would be procured in part from Bloom Energy, which claims to have achieved an impressive 88% efficiency with their solid-oxide electrolysers, though plans for this higher-efficiency electrolysis were quietly dropped in the project’s revised Environmental Impact Statement (EIS) in 2024.[22] Based on this description, it would seem there is no reason for the project should fail to qualify for the 40% Hydrogen ITC. However, this characterization is misleading.

Not just renewable energy

Far from relying solely on renewable energy, the project has requested an interconnection to the Newfoundland grid (to secure energy equal to one-fifth of the output of Muskrat Falls) as well as three to four gas-fired General Electric LM6000 turbines of 53 MW each.[23,24] The reason for these extra energy sources is to cope with the variability of wind generation. Although electrolysis has some ability to flex up and down to match wind power, it nonetheless needs to maintain a minimum load to avoid damaging equipment and to pay off its installation and operating costs. In Newfoundland, electricity sourced from the grid is primarily low-carbon hydropower. In Nova Scotia, however, where EverWind Fuels is planning a nearly $14 billion ammonia export project, roughly half of the grid electricity that will be used to support its electrolysers comes from burning coal.

Fossil fuel Trojan horse

Likely to avoid the public perception risk of building gas-fired turbines at its site, World Energy claims its gas turbines will run on hydrogen or ammonia, which makes virtually no carbon emissions. In reality, the original EIS stated that the project would use three to four of the fuel-flexible GE LM6000 turbine. This model of turbine supports burning hydrogen, but only when blended with natural gas to a maximum of 35% by volume.[25] In tests by the Electric Power Research Institute, this reduced emissions by just 14% compared to fully natural gas fuel.[26] Stating that these are “hydrogen fired” turbines that only need fossil fuels to start up and that “switchover to hydrogen occurs once up and running” obscures the fact that their emissions profile is only slightly different from ordinary natural gas turbines. To operate these turbines, World Energy has been in discussions with ProEnergy, a U.S. oil and gas firm.[24]

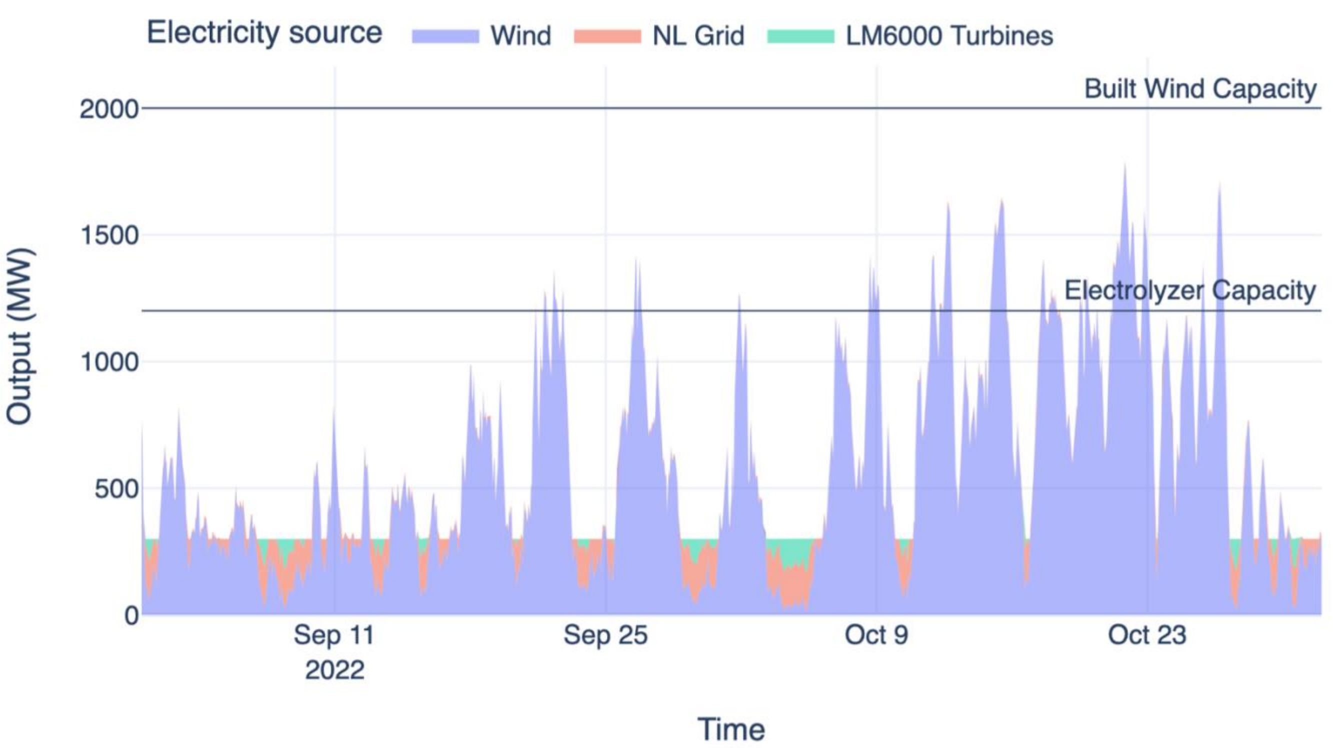
Modelling energy consumption

Using seven years of wind data from Ontario, we modelled the hourly energy mix of the Nujio'qonik project necessary to maintain a minimum load factor of 25% on the electrolysers. Doing so produced almost exactly the 50% average electrolyser utilization that World Energy anticipated in its EIS.[11(pES.2)]

We used Ontario wind data due to the availability of hourly measurements. Similar data for Nova Scotia, Newfoundland and Labrador is of limited public availability as of this modelling. While using Ontario data might intuitively yield "worse" results compared to better coastal wind resources, we find the opposite might be true. Ontario possesses around 5 GW of installed wind capacity, whose larger geographical distribution "smooths" its generation curve compared to the wind farms proposed for any one hydrogen project. This smoothed generation is more favourable for electrolysis, which is vulnerable to major spikes or lulls in generation. Furthermore, in 2022, 603 megawatts of installed wind turbines in Nova Scotia produced 1.3 TWh of electricity, representing a capacity factor of just 25%. That same year, the 4,883 MW of installed wind turbines in Ontario produced 13.8 TWh, a higher capacity factor of 32%. Therefore, using Ontario wind data could potentially *advantage* the model, yielding conservative results for the quantity of both grid and gas-fired electricity required.

The dispatch order of generating sources is first wind, followed by NL grid energy capped at 155 MW as requested by World Energy, and finally followed by the gas-fired turbines capped at an installed 159 MW (3 generators of 53 MW each) capacity. Backup resources (NL grid power and gas turbines) are only dispatched when needed to maintain the 25% load factor on the electrolysers. A two-month sample of the results is shown below.

Figure 6: Two-month visualization of modelled electricity use of Project Nujio'qonik by Phase 2



Based on this model, we can expect that electrolysers will get on average about 90% of their electricity supply from wind, 8% from the NL grid, and the remaining 2% from gas-fired turbines. We find this breakdown of energy sources to be realistic if not optimistic from an emissions perspective. The high utilization of wind is achievable only with a low overall utilization of the electrolysers and a large overbuild of wind capacity. The use of gas-fired turbines below 2% is unlikely, as such infrequent use is already hard to justify given the cost of building and maintaining the turbines. To increase its electrolyser utilization, World Energy would need to run its gas turbines more frequently or increase the amount of power it draws from the NL electric grid. Both have significant downsides. Running the gas turbines more often would dramatically increase the carbon intensity of the on-site electricity, while expanding the requested interconnection capacity to the Newfoundland grid exposes the request to additional barriers, as it poses a greater challenge to grid operation and makes such a request more likely to be rejected.

The best-case scenario misses the 40% ITC

The weighted average carbon intensity of the modelled energy mix is 26 gCO_2/kWh (under the optimistic assumption that the NL grid is entirely hydropower). Even if it were to run on 100% wind power, the project would need to produce hydrogen at an 80% efficiency or above to achieve the 40% ITC. At 26 gCO_2/kWh, the 40% ITC tier is entirely off the table, since even with the highest possible electrolyser efficiency of 88%, the carbon intensity of the resulting hydrogen would still be approximately 1 $kgCO_2/kgH_2$, qualifying only for the 25% ITC.

Lower-than-advertised efficiencies

The actual efficiency achievable by the project is far below 88%. In its revised EIS, World Energy GH2 stated that it was dropping its plans to use higher-efficiency solid-oxide electrolysers (SOEC) in favour of the more-flexible but lower-efficiency proton-exchange membrane (PEM) electrolysis, provided by German company Siemens.[27,28] The efficiency of PEM electrolysers peaks around 72%. Moreover, the output of all of Canada's proposed hydrogen export projects is not in fact hydrogen, but ammonia. The hydrogen made from the electrolysis, in order to ship it, is converted to ammonia using a Haber-Bosch reactor which combines the hydrogen with compressed nitrogen. This ultimately yields an efficiency of at most 66% by the time the product is in an export-ready ammonia form.

This aligns with numbers provided by World Energy in its original EIS, which pinned the maximum yearly ammonia production from a 1,200 MW hydrogen/ammonia plant at 1.17 million tonnes.[11] Over a year, at full bore the electrolysers would consume around 10.5 million MWh of electricity to produce the 1.17 million tonnes of ammonia. The total energy content of this ammonia (at 5.91 MWh/tonne) would be 6.9 million MWh. This corresponds to an efficiency of:

$$6.9\ million\ MWh \div 10.5\ million\ MWh = 66\%$$

This efficiency means that 9 MWh of electricity is required per tonne of ammonia produced, or 50 MWh per tonne of hydrogen produced. This claim is at the optimistic end, but in the range, of best estimates for this production pathway of 9-12 MWh per tonne of ammonia.[12(p10235),29,30(p13)]

Fugitive emissions by design

The production of ammonia is the point at which the "cradle-to-gate" analysis of carbon emissions stops. Let us take inventory: At a 66% efficiency, the carbon intensity of 100% wind-powered ammonia production would be:

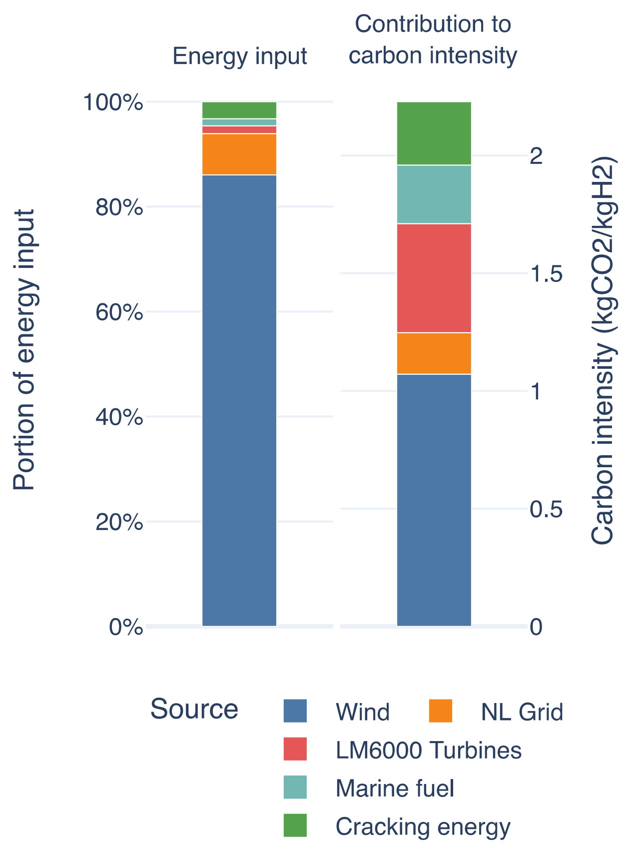
$$0.018\ kgCO2/kWh \times \frac{33.33\ kWh/kgH2}{66\%} = 0.9\ kgCO2/kgH2$$

Already, this qualifies for a maximum Hydrogen ITC of 25%. However, we showed that the actual carbon intensity of the electricity input is closer to 0.026 kg (26 g) of CO2 per kWh, corresponding to a carbon intensity of 1.3 kgCO2/kWh. *Even now, we have not fully accounted for the per-unit carbon intensity of the delivered hydrogen.*

At this point, the Canadian hydrogen projects have not yet delivered hydrogen to their customers in Germany. The product is not even in its intended hydrogen form — it is still ammonia. The Canada Budget 2023 states that "since hydrogen is a clean source of energy, downstream emissions after the hydrogen is produced would not be considered."[6] While it's true that the combustion of hydrogen does not result in carbon emissions, there is a lot more downstream activity than merely its end-use: there remains heavy shipping across the Atlantic and an energy-intensive ammonia cracking process, both of which are mandatory parts of delivering the hydrogen product. These unavoidable processes must be considered part of the "life-cycle emissions" of hydrogen exports. Excluding them from consideration would constitute a major lapse of scrutiny when distributing tens of billions of dollars of taxpayer money.

The Budget 2023 proposed a one-time assessment of a project's carbon intensity every 5 years with independent verification and the opportunity for reclaiming ITC spending if the results differ from what was expected. However, the government still sets the scope of the emissions counting, and in its current form this scope is severely inadequate. To its credit, Environmental and Climate Change Canada is continually revising its Fuel LCA Model to account for new variables in the quickly developing hydrogen sector. And legislation on the specifics of carbon intensity calculations have not been finalized. Still, we are highly concerned that downstream operations will not be properly factored into the carbon intensity calculations for Canadian hydrogen exports.

Figure 7: Breakdown of modelled energy inputs and their respective contribution to the carbon intensity of delivered hydrogen from a Canadian hydrogen export project



Shipping and cracking: downstream emissions that matter

How does the ammonia shipping and cracking process affect the carbon intensity of the delivered hydrogen? Once produced, the ammonia must be shipped across the Atlantic. The most efficient option is to use Very Large Gas Carrier ships, known as VLGCs, with capacities of up to 60,000 tonnes. By the time the ship arrives back at Stephenville after having delivered its latest ammonia cargo to the German port of Wilhelmshaven, it will have travelled close to 6,000 nautical miles round trip.

Despite much lower boil-off rates for liquefied ammonia than for liquefied natural gas, and the low fuel consumption relative to land or air transportation, the shipping process nonetheless will require over 600 tonnes of marine fuel per round trip based on figures from BW LPG, releasing an estimated 23,000 tonnes of CO2.[31] Some of these emissions could be avoided by using the ammonia cargo as fuel in a fuel-flexible cargo ship. However, this is not yet a widely used practice and would result in the delivery of less ammonia, which further increases the per-unit carbon intensity of the delivered product.

Once delivered to Germany, if Germany wishes to have hydrogen, the ammonia must be "cracked" back into high-purity hydrogen. This is another heavy blow to the efficiency of hydrogen exports. Not only does this cracking process require high temperatures, likely to be achieved by the combustion of natural gas (to the tune of around 0.3 MWh per tonne of ammonia), but announced ammonia cracking projects anticipate losing as much as 25% of the hydrogen by weight during the process.[10,12]

When properly accounted for, this hydrogen loss, along with the extra energy inputs to ship and crack the ammonia, **drops the overall efficiency of the process to less than 50%.**

With this low efficiency, the carbon emitted through the whole process becomes concentrated on a per-unit basis in the delivered hydrogen.

Using best estimates for the energy requirements of shipping and ammonia cracking and the data-driven results of our model of Nujio'qonik on-site energy consumption, combined with the lifecycle carbon intensity of each energy source, **we calculate the carbon intensity of the delivered hydrogen to be at least 2.2 $kgCO_2/kgH_2$.** This would qualify only for the 15% Hydrogen ITC and actually overlaps with the carbon intensity range achievable by "blue hydrogen," produced from natural gas with varying degrees of carbon capture.[32]

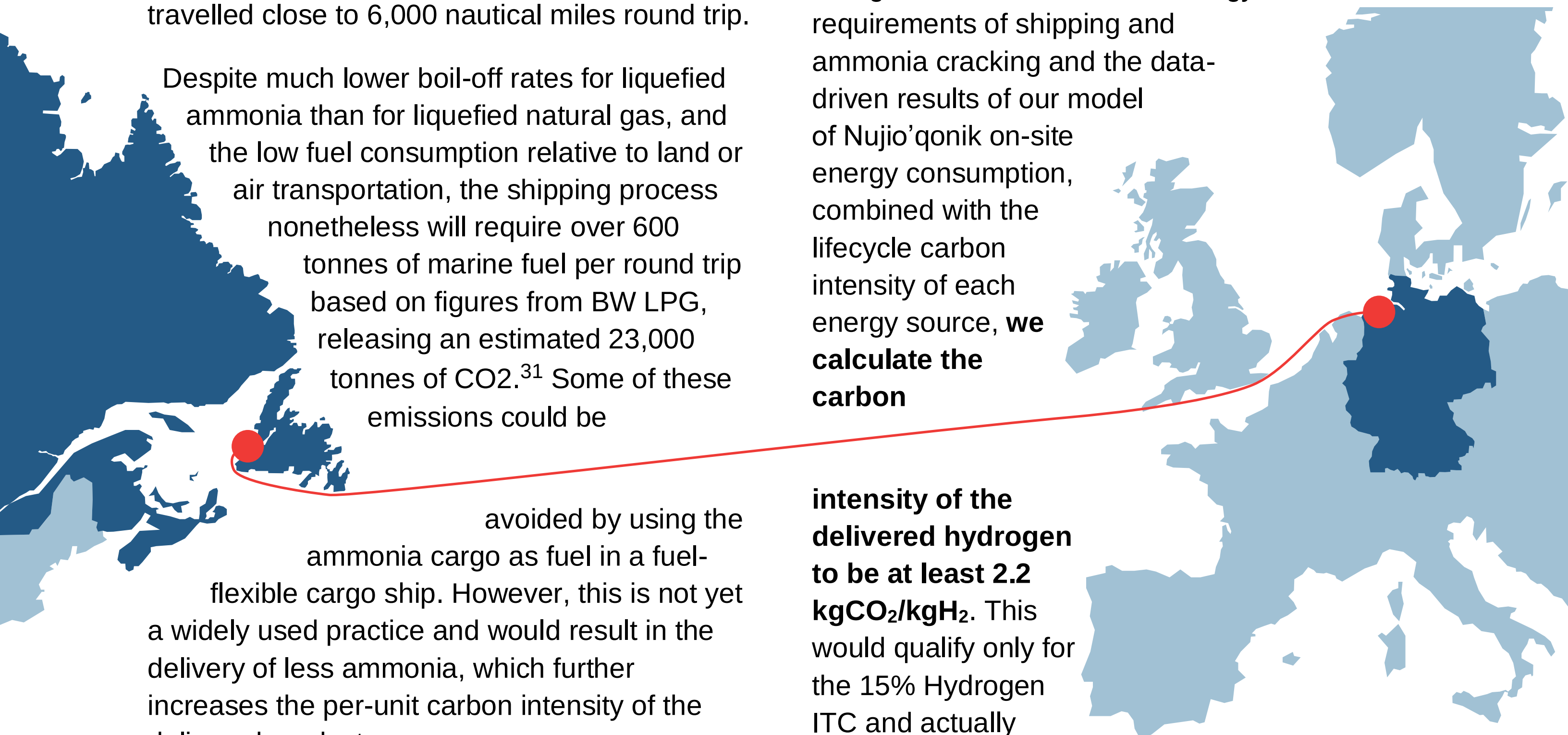


Figure 8: Shipping route from Stephenville to Wilhelmshaven. Approximately 3,000 nautical miles.

3. Canadian hydrogen exports are redundant to Germany's capabilities

Key Takeaway: Major Canadian subsidy spending and ecological disruption to produce hydrogen would be entirely redundant to Germany's own capabilities if the European country made use of its nuclear reactor fleet to power electrolysis domestically. Doing so would ensure lower prices, cleaner hydrogen, and more secure supplies than those offered by Canadian export projects. By indulging in an unscalable energy strategy, Canada and Germany undermine the Hydrogen Alliance's stated objective of promoting energy security and decarbonization.

Self-inflicted energy shortages

Despite the added inefficiencies, costs, and environmental impact of H_2 imports, Germany claims to have few other options. It projects local demand for hydrogen to reach 95–130 TWh per year by 2030.[33] Of this, 70 percent will need to be imported. To meet these needs, Germany is looking far beyond Canada and has already signed additional non-binding agreements for hydrogen supplies with Saudi Arabia, Australia, Chile, Namibia, Ukraine, and Morocco.[34]

This is largely the result of systematically dismantling their own energy supplies. Since 2021, during the worst energy crisis since the 1970s, Germany prematurely shuttered over 8,000 MW of safely operating, zero-carbon nuclear energy, a result of its politically-driven nuclear phaseout policy.[35] Hypothetically ranging from 72% to 88% efficiency, electrolysers powered by these nuclear reactors could produce 51–62 TWh of hydrogen per year, fulfilling a majority of their domestic needs with no additional land use.

The fully-completed Nujio'qonik project (with around 1.8 GW of electrolysers) will cost an estimated CAD 16 billion and occupy over 1,000 square kilometres.[36] At the expected 50% overall utilization of its electrolysers and roughly half of its inputted energy irretrievable from the delivered hydrogen, the project will deliver around 4 TWh of hydrogen per year. This is about 1/15th of what Germany could produce from its half-dozen nuclear plants while requiring little more than the capital cost of new electrolysers. At a capital cost of USD 1,100–1,800 per kilowatt for PEM electrolysis, the cost for electrolysers to make use of the full output of the otherwise unused, recently shuttered German nuclear fleet would range between 9 and 15 billion USD.[37]

Isar nuclear power plant in Essenbach, Germany, powered down in 2023. Photo by E.ON Kernkraft GmbH, CC BY-SA 3.0

Using the figures from Nujio'qonik, for Canada to match the hypothetical H_2 production capacity of electrolysers powered by already-built German nuclear plants **would require astronomical expenditure**, including**:**

- **240 billion CAD** in capital investment for wind turbines, electrolysers, and ammonia conversion facilities
- **60,000 MW of new wind capacity** (equal to Germany's entire installed wind fleet)
- **3,000 MW of new gas-fired generators**
- **2,000 MW of additional balancing power** from the grid, the equivalent of three large CANDU nuclear units
- **15,000 square kilometres of land** (twice the land area of the Greater Toronto Area)
- **30,000 MW of electrolysers** (3x the electrolysers needed if they were instead coupled with the German nuclear plants) coupled with sufficient ammonia conversion capacity
- **Over 200 round trips across the Atlantic** Ocean each year by the largest gas carrier ships in the world

The reason for these enormous numbers is that the relatively low capacity factor of wind generation translates into low utilization of electrolysers despite the dramatic overbuilds of wind turbines and backup energy sources needed to maintain a minimum "load factor" of the electrolysers. Run all of that through the efficiency-killing round trip through the chemical carrier of ammonia, and the requirements to match the domestic H2 production from a nuclear-powered electrolyser fleet running at near 100% capacity factor are nearly unfathomable.

Using the German nuclear fleet would permit electrolysers to run at their maximum output most of the time, with no need for capacity overbuilds. And by skipping the ammonia synthesis, shipping, and cracking process, it would benefit from much better overall efficiency, cost, carbon intensity, and security of supply.

Although the German nuclear reactors are in shutdown mode, a study in July 2023 by Radiant Energy Group, which interviewed leaders at nuclear-operating utilities, found "no insurmountable hurdles" to the restart of the reactors.[38] Five of the reactors, it says, could be restarted within 9 to 12 months following a withdrawal of their decommissioning license applications. The largest hurdles, according to the report authors, are political. Nevertheless, it is beyond the scope of this report to assess whether the German nuclear fleet can or will be restarted.

A lose-lose game

Canada and Germany both lose in the Hydrogen Alliance. Canada must industrialize vast tracts of land and shell out billions of dollars in subsidies to provide Germany with an almost negligible quantity of hydrogen compared to what the European country could produce itself. Meanwhile, Germans pay a higher price for an inherently less secure, less environmentally friendly supply of hydrogen.

Canada would much more effectively advance its goals of energy security and decarbonization if it took a firm stance against Germany's self-sabotage of its low-carbon energy supplies and its attempts to shift the resulting avoidable burden to other countries, where Germany depends on excessive local subsidies to overcome steep economic and thermodynamic obstacles. It is especially important to take a strong stance on Germany considering its hesitancy to commit to binding purchase orders even as it entices various countries with non-binding MOUs to take big bets on hydrogen, growing its eventual option pool without taking on risk itself.

4. The projects court local disruption

Key Takeaway: Large wind farms and hydrogen-ammonia facilities create significant ecological impacts and hazards. Despite this, the federal government has left the environmental assessment process entirely to the provinces. Moreover, the connection of these projects to provincial electric grids is a potential threat to the stability of electricity systems despite claims by project developers of "mutual benefit." Local economic benefits remain as uncertain as the prospects for the success of these projects, with significant divides in the local community regarding potentially overstated benefits and a lack of transparent consultation.

Risk to the power grid

Beyond economics and carbon emissions, the proposed ammonia export projects are also questionable from a grid safety and environmental perspective. As World Energy's Nujio'qonik project has more publicly available information and is farther along than other projects, we use it as an example to illustrate local impacts. **We do not intend to take particular aim at World Energy—the broad conclusions apply equally, if not more so, to other proposed projects that are not as far along.**

To cope with the intermittency of the wind generation, World Energy not only plans to build on-site gas-fired generators but has also requested access to the Newfoundland grid, asking that N.L Hydro make available 155 MW of generating capacity for the Nujio'qonik project, available round-the-clock during the summer months.[23] It is unclear whether this would be the maximum capacity of the physical grid interconnection.

Connecting several gigawatts of electrolysers and wind turbines to the Newfoundland grid is not a trivial task. To protect the delicate electric system, Newfoundland's grid standards require that:

> All power producer facilities connecting a power plant with an installed capacity exceeding 155 MW on the Island of Newfoundland must be designed, built and operated such that no single element contingency in those facilities can result in loss of generation in excess of 155 MW.[39(p24)]

The purpose of this rule is to avoid a sudden voltage drop too large for the relatively small island grid (less than 2,000 MW) to handle.[40] To meet this requirement, World Energy stated in its initial EIS that it will install extra transformers to create redundancy and to connect no more than 25 turbines of 6.1 MW each to a single 66-kilovolt energy collector system (keeping the sudden losses below 155 MW if one happens to fail). However, they ignore the common mode failure inherent to wind generation: **a wind lull.**

In our modelling, even with the on-site generators idle and the electrolysers running at full bore, there were 120 times when the excess wind power from Nujio'qonik dropped from 155 MW or higher to zero within less than one hour. The amount of wind power exceeding what the electrolysers can use at times fluctuated from 500 MW to zero in a matter of hours. What the project can't send back to the grid or use, it will have to curtail or ground. Because the wind varies so much, the solution of building more electrolysers to capture that excess wind power would be hard to justify economically, as their overall capacity factor would be quite low.

It is striking that a project with a nearly 2-to-1 ratio of wind capacity to electrolyser capacity still needs both gas-fired generators and substantial grid tie-ins to operate. A project like Nujio'qonik, with over 3 GW of wind and 1.8 GW of electrolysers in its final planned stages, could be a major destabilizing force on the 2 GW Newfoundland grid. The risks deserve close consideration.

World Energy claims that the grid connection will be "mutually beneficial," a statement that has not been reciprocated by NL Hydro.[21] A long-standing moratorium on wind generation from private developers was lifted in anticipation of hydrogen export projects, not because the province desired to put more wind capacity on the electric grid.[41,42]

Environmental Impact

The land area that World Energy intends to occupy with wind turbines totals over 1,000 square kilometres. EverWind Fuels, which filed its environmental assessment in October 2023, has applied for leases on over 500 square kilometres of land. Combined, the various proposed hydrogen export projects occupy several thousands of square kilometres of Crown land situated at strategic ports.

Developers plan to use some of the largest onshore wind turbines ever made, such as the GE Cypress wind turbine, with a power rating of up to 6.3 MW. Building these will require extensive blasting for super-wide access roads through rare and endangered species habitats,[43] large steel and concrete foundations, underwater construction for laying transmission, and other ecological disruptions.

The 6.3 MW GE Cypress wind turbines reach nearly 250 meters tall at the tip, four times the height of the Statue of Liberty. Each blade is the length of a Boeing 747 jumbo jet.

Codroy Valley, Newfoundland, the site of one of the two wind farms proposed during Phase 1 of the World Energy Nujio'qonik project. Photo by Erik Mclean.

A looming hazard

The ammonia production facilities pose a human health risk in the case of an accident. Liquid ammonia is a hazardous chemical, corrosive to human skin, eyes, and lungs, and it readily absorbs into water with resulting toxic properties. In the vast quantities to be generated along the Canadian coast, ammonia poses a significant chemical hazard that will require extensive buffer zones around the shipping facilities. In 2007, a hose burst at an Illinois ammonia facility, creating a toxic vapour cloud that required three towns to temporarily evacuate, killing livestock. Firefighters and police officers were treated for fume inhalation.[44]

Feds offer little oversight

Aware of the significant environmental impact, the Miawpukek First Nation requested a federal assessment of the World Energy project. In response, the federal Minister of Climate Change and Environment, Steven Guilbeault, called such an assessment unnecessary.[45] Wind energy projects are not legally subject to federal environmental assessment. This is due to major deficiencies in the Impact Assessment Act, which gives a categorical free pass to all wind and solar development, even for megaprojects such as those proposed under the Canada-Germany Hydrogen Alliance.[46]

“Deficient” environmental assessment

With federal aloofness, the environmental review process has been entirely local. World Energy submitted its initial EIS for Project Nujio’qonik in August 2023. After two months of review by the Newfoundland Minister of Environment and Climate Change, the EIS was deemed “deficient” in a decision letter in late October. The Minister returned the 4,000-page document to World Energy, asking for improvements to its baseline data and information, assessment of potential environmental and cumulative effects, mitigation and monitoring plans, and more.[47] World Energy GH2 has since revised, amended, and submitted a new EIS which was accepted by the province in the spring of 2024.

Local reception

Sentiment toward the project in the Port au Port/Stephenville area is divided. Although polling by World Energy showed “very high support for green energy development and for onshore wind development,” local group Environmental Transparency Committee says that 84 percent of residents on the peninsula are against the project.[48] One resident described feeling that the project is a “forgone conclusion” given the rushed public consultation process.

World Energy claims it will have a beneficial impact on the local economy, as their project offers a double-digit billion-dollar opportunity. This line of reasoning has garnered support from local and provincial governments that stand to benefit from significant federal investment in these projects. However, the longevity of the local economic benefit is in serious question. Most of the jobs will be in the construction of wind turbines and other facilities, which will create a spike of employment in construction followed by a much smaller number of operation and maintenance jobs. With deliveries of hydrogen from Canadian export projects unlikely to be cost-competitive on the international market with alternative and domestic hydrogen sources, longer-term jobs created by these projects will be at continual risk, particularly when subsidies meant to improve their competitiveness dry up.

5. Subsidies are at high risk of leakage

Key Takeaway: The benefit of these projects to Canadians is vanishingly small compared to the large subsidy spending they may consume. Project developers and equipment suppliers consist almost entirely of subsidiaries of foreign companies eyeing Canadian subsidies, appealing to provincial governments by promising economic development while industrializing vast tracts of federal Crown Lands with strategic access to shipping ports. The end product provides little direct benefit to Canadians, nor do these projects substantially progress Canada's national hydrogen strategy.

Subsidy leakage refers to domestic subsidy spending that escapes from the Canadian economy to foreign companies. Project developers stand to benefit massively from subsidies under the Hydrogen Investment Tax Credit. But do the project developers in turn benefit Canadian interests? Hardly. Despite attempts to limit the Hydrogen ITC for use by Canadian corporations, the international nature of these projects and their developers creates a high risk for subsidy leakage.

To name some of the main companies involved:

- **U.S. company World Energy LLC**, which fully owns World Energy GH2, developing a project in Newfoundland
- **U.S. company** TDL Partners, which fully owns EverWind Fuels, developing projects in Nova Scotia and Newfoundland and Labrador
- **U.S. company** Cross River Infrastructure Partners LLC, developing a project with the Belledune Port Authority in New Brunswick
- **U.S. company** BAES Infrastructure, which fully owns Bear Head Energy, developing a project in Nova Scotia
- **German company** ABO Wind, developing a project in NL
- Exploits Valley Renewable Energy Corporation, a company with little public information but business ties with **the Maldives, Sri Lanka, South Africa, Romania, and the United States**, developing a project in NL
- **U.S. company** Pattern Energy, seeking to build an H2 project at Port of Argentia, NL

As subcontractors:

- **German company** Siemens, for PEMEC electrolysis
- **U.S. company** Bloom Energy, for SOEC electrolysis
- **U.S. company** GE, for gas-fired turbines and the large wind turbines (GE's manufacturing takes place in **Germany, China, India, Brazil, and the U.S**.)
- **U.S. company** ProEnergy, for gas-fired turbine operation
- **South Korean company** SK Ecoplant, for heat recycling facility to assist with electrolysis; SK Ecoplant subsidiary, SK Ecoengineering, for EPC services for the World Energy Haber-Bosch facility
- **Danish company** Topsoe, for Haber-Bosch ammonia synthesis loop

Virtually none of these companies have Canadian roots, and yet they are the potential recipients of billions of dollars in tax credits, grants, and low-interest loans from the federal government and are acquiring strategic ports on the Canadian coast. Even their products are destined entirely for foreign buyers.

It is reasonable at this point to ask: what are Canadians getting for their money?

Misalignment with the Canada Hydrogen Strategy

In a broader appeal to Canadian national interests, World Energy argues that:

> …not developing the Project could move the region and Canada further from the Government of Canada's goals outlined in the Hydrogen Strategy for Canada…[11]

This is questionable. Canada's National Hydrogen Strategy is largely concerned with domestic applications. The 100-plus page document outlines a vision for a Canadian economy that uses hydrogen for fully 30% of its end-use energy by 2030. Observe where "Hydrogen for Export" is placed in the chart illustrating how Canada might integrate hydrogen into its economy.

The Strategy specifically states that "Canada is uniquely positioned to become a large-scale exporter of hydrogen to serve this growing market, but **domestic deployments must lead**" (emphasis added).[7(pIX)] This statement hardly squares with the current prioritization of hydrogen export projects, which are on track to dominate total government spending under the Hydrogen ITC.

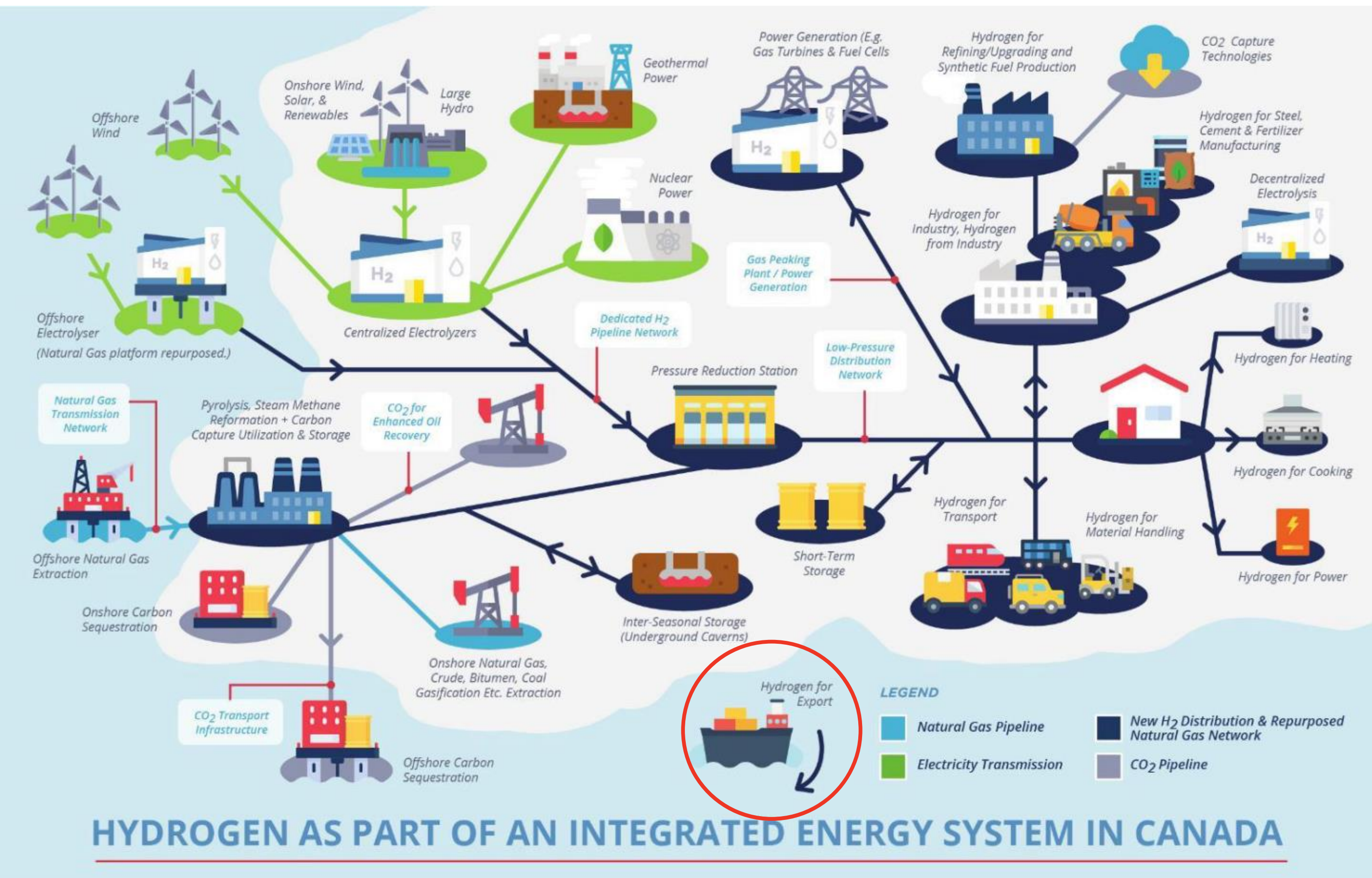


Figure 9: Hydrogen as part of an integrated energy system in Canada. Source: Hydrogen Strategy for Canada, 2020 [7] (red circle around "Hydrogen for Export" added).

Decarbonization and energy security: what success looks like

The Canada-Germany Hydrogen Alliance falls short of achieving its stated goals of providing energy security and decarbonization for our allies and bolstering Canada's position as a low-carbon energy leader. These goals, though noble, are difficult to achieve. Indeed, to many countries, they are defining challenges of this century.

But Canada already contributes to the energy security and decarbonization of its allies through an export that has received much less attention than hydrogen: uranium and nuclear energy.

In early 2023, it was announced that Canadian uranium facilities would supply all of the uranium needed to manufacture the fuel for Ukraine's nuclear fleet through 2035.[49] Amid Russian aggression and attempts to move away from Russian fuel exports, Canadian uranium is actively keeping the lights on for millions of people across Europe.

By fueling zero-carbon nuclear power plants that displace polluting sources of electricity, Canada's uranium exports offset around one-third of the country's total all-sector emissions each year, making it by far our most important clean energy export. Canada's direct exports of its homegrown CANDU nuclear technology also provide reliable, low-carbon electricity in Argentina, South Korea, China, and Romania. In Romania, the planned construction of two new CANDU units will bring the share of energy generation from Canadian nuclear technology in the country to nearly 50%.

We present the case of uranium for the sake of comparison — an example that proves that the noble goals of decarbonization and energy security are not purely elusive and can be achieved by proven means.

If even a fraction of the funding earmarked for these hydrogen projects were spent on nuclear power to modernize our homegrown CANDU reactor technology or risk-share on new nuclear projects, it would be transformational for Canada's ability to achieve energy security and decarbonization while helping our allies to do the same.

Recommendations

The assessment in this report reveals the immense hurdles to overcome to compete with domestic hydrogen production. Massive investment in green hydrogen export projects has a high risk of becoming a boondoggle—ecological destruction and burdensome subsidies for a product few, if any, countries will be able to justify buying. Undeterred by the lack of firm purchase orders, Canada has moved ahead with massive loans and forthcoming subsidies for ambitious projects.

With draft legislation for the Clean Hydrogen ITC not yet released, now is the opportunity to incorporate crucial provisions to ensure that the Canada-Germany Hydrogen Alliance better aligns with its goals.

We recommend that the federal government, as well as the provincial governments hosting the proposed hydrogen export projects, adopt the following policies:

1. Accurately account for all hydrogen exported-related emissions. The 2023 Budget strives to consider the "lifecycle emissions" of Canadian hydrogen exports yet leaves out carbon-intensive processes required to deliver the hydrogen to end customers in Germany. As it stands, the oversight will enable massive quantities of fugitive, uncounted carbon emissions. Accounting for these emissions would:

- Incentivize innovation to meet the 40% tier, rather than inflate the Hydrogen ITC deserved by ignoring major sources of emissions in the export process
- Minimize subsidy leakage to the foreign developers and safeguard against over-awarding subsidies
- Better align the ITC with decarbonization goals
- Improve cost-effectiveness for the government and taxpayers, saving several billion dollars in subsidies

2. Ensure strict oversight of hydrogen export projects. Despite administering potentially billions of dollars in subsidies and extending hundreds of millions of dollars in loans, the federal government has left environmental and other oversight of the hydrogen projects to the provinces. This creates a massive financial risk for Canadian taxpayers, political risk for the federal government, and ecological risk for local communities.

3. Obtain firm hydrogen offtake agreements before offering further financial support. Without firm purchase orders in place, Canada is taking on all the risks of these projects without a guaranteed market for its hydrogen. Given the massive public spending these projects will capture, this is an unacceptable risk for Canadian taxpayers. The Memorandum of Understanding of March 2024 did not go far enough to ensure that Germany will purchase Canadian hydrogen supplies once production is underway.

4. Pursue goals of decarbonization and energy security through more effective means, including holding Germany responsible for energy irresponsibility and centering policy around proven solutions such as the domestic use and export of nuclear energy and uranium.

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