Can Hydrogen Power the North?

An exploratory workshop hosted by the GNWT

L'hydrogène, une solution pour le Nord?

Un atelier exploratoire organisé par le GTNO

Government of
Northwest Territories

Gouvernement des
Territoires du Nord-Ouest

If you would like this information in another official language, call us.
English

Si vous voulez ces informations dans une autre langue officielle, contactez-nous.
French

Kīspin ki nitawihtīn ē nīhīyawihk ōma ācimōwin, tipwāsinān.
Cree

Tłı̨chǫ yatı k'ę̀ę̀. Dı wegodı newǫ dè, gots'o gonede.
Tłı̨chǫ

ʔerıhtł'ís Dëne Sųłıné yatı t'a huts'elkër xa beyáyatı theɂą ɂat'e, nuwe ts'ën yółtı.
Chipewyan

Edı gondı dehgáh got'ı̨e zhatıé k'ę̀ę̀ edatł'éh enahddhę nıde naxets'ę́ edahłí.
South Slavey

K'áhshó got'ı̨ne xǝdǝ k'e hederı ɂedı̨htl'é yerınıwę nídé dúle.
North Slavey

Jii gwandak izhii ginjìk vat'atr'ijąhch'uu zhit yinohthan jì', diits'àt ginohkhìi.
Gwich'in

Uvanittuaq ilitchurisukupku Inuvialuktun, ququaqluta.
Inuvialuktun

ᑖᒃᑯᐊ ᑎᑎᕐᒃᑲᐃᑦ ᐱᔪᒪᒍᕕᒋᑦ ᐃᓄᒃᑎᑐᓕᕐᒃᓯᒪᓗᒍ, ᐅᕙᑦᑎᓐᓄᑦ ᐅᖄᓚᔪᓐᓇᖅᑐᑎᑦ.
Inuktitut

Hapkua titiqqat pijumagupkit Inuinnaqtun, uvaptinnut hivajarlutit.
Inuinnaqtun

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Finally, thank you to all the participants for providing their keen insights and thought-provoking questions so crucial to this engaging and productive exercise. Their demonstrated persistence throughout this workshop was much appreciated, especially given the virtual nature of the engagement.

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Foreword

As Canada takes strides toward a net-zero emissions economy, Northerners continue to experience the effects of climate change more acutely than most jurisdictions in the world. It is imperative that we continue to implement the *2030 Energy Strategy (Strategy)* with all the tools at our disposal, while exploring ways to enhance and magnify our current efforts.

However, as with many things in the North, we have a unique set of circumstances, and we must balance the need to reduce our reliance on fossil fuels with competing priorities, such as stabilizing energy costs and maintaining the reliability of our energy systems. This is an approach we committed to in the S*trategy*.

We continue to invest in increasing the use of alternative and renewable energy in the Northwest Territories (NWT), from integrating solar and wind energy into community grids to developing biomass to heat our buildings, from incentivizing electric vehicles to planning for the expansion of the Taltson hydropower system. Hydrogen may offer another opportunity to reduce fossil fuels for end-uses we don't currently have a solution for in the North.

There is much excitement around hydrogen across Canada and globally, as it is increasingly identified as a potential major component of a zero-carbon economy. On January 25, 2022, the GNWT hosted a workshop on hydrogen as part of its commitment to explore emerging technologies and whether they could contribute to the NWT's energy mix and economy. This workshop allowed for advancing this conversation between partners and stakeholders across the territory, including economic development organizations from Indigenous governments, communities, utilities, industry, non-governmental organizations, as well as the GNWT.

As Northerners have shown time and time again, immense challenges can be overcome through resilience, creativity, and a communal spirit. It all begins when we come together to listen, learn, and share ideas.

Avant-propos

Alors que le Canada avance à grands pas vers une économie carboneutre, les Ténois continuent de ressentir les effets du changement climatique plus fortement que dans la plupart des autres régions du monde. Il est donc impératif que nous poursuivions la mise en œuvre de la Stratégie énergétique 2030 (ci-après la « Stratégie ») en utilisant l'ensemble des outils à notre disposition et en explorant tous les moyens d'amplifier nos efforts actuels.

Cependant, comme souvent dans le Nord, nos circonstances sont uniques, et nous devons trouver un équilibre entre la nécessité de réduire notre dépendance aux combustibles fossiles et des priorités concurrentes, comme la stabilisation des coûts énergétiques et le maintien de la fiabilité de nos systèmes énergétiques. C'est une approche que nous nous sommes engagés à adopter dans la Stratégie.

Aux Territoires du Nord-Ouest (TNO), nous continuons d'investir dans les énergies renouvelables et de remplacement, qu'il s'agisse d'intégrer l'énergie solaire et éolienne aux réseaux électriques de nos collectivités, de développer l'utilisation de la biomasse pour chauffer nos bâtiments, d'encourager l'utilisation des véhicules électriques ou de planifier l'expansion du système hydroélectrique Taltson. L'hydrogène pourrait aussi nous permettre de réduire l'utilisation de combustibles fossiles pour les utilisations finales pour lesquelles nous n'avons pas encore de solution dans le Nord.

Cette énergie suscite beaucoup d'enthousiasme au Canada et dans le monde, car elle est de plus en plus considérée comme un élément potentiellement fondamental à l'atteinte de la carboneutralité. Le 25 janvier 2022, le GTNO a organisé un atelier sur l'hydrogène, suivant son engagement à évaluer les technologies émergentes qui pourraient contribuer à l'économie et aux diverses sources d'énergie des TNO. Cet atelier nous a permis de progresser en ce sens, grâce à la participation de partenaires et d'intervenants de tout le territoire, y compris des organismes de développement économique des gouvernements autochtones, des collectivités, des services publics, de l'industrie, des organisations non gouvernementales et du GTNO.

Les Ténois l'ont déjà montré à maintes reprises : leur résilience, leur créativité et leur esprit communautaire leur ont permis de surmonter de redoutables épreuves. Tout commence lorsque nous nous rassemblons pour écouter, pour apprendre et pour partager nos idées.

Why the GNWT Organized this Workshop

WHY HYDROGEN?

Hydrogen technology is generating a lot of attention nationally and internationally. Hydrogen represents a good substitute for fossil fuels as it is a good energy carrier, which means it can be used to transport energy from where it is produced to where it is needed, as well as store energy for when it is needed.

If hydrogen is made from renewable or low carbon primary energy sources, it can play a role in replacing fossil fuels, especially in sectors where fewer options are currently available to reduce emissions, such as transportation or heating.

The GNWT is interested in better understanding what role, if any, hydrogen technology might play in the energy future of the NWT.

How hydrogen is produced, transported, converted, stored, and used is called the value chain.

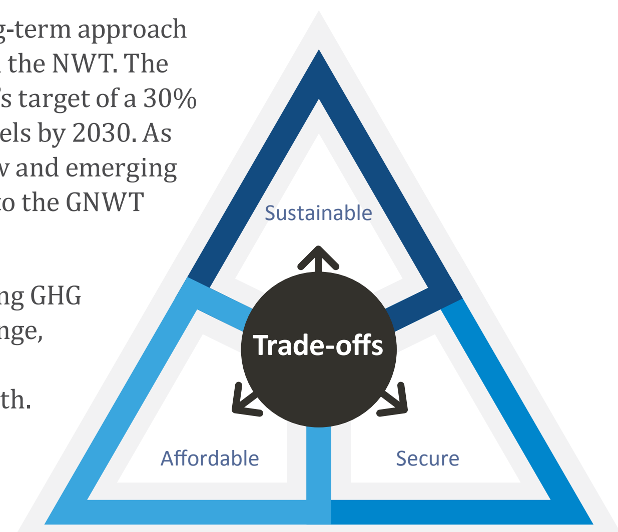
WORKSHOP'S OBJECTIVES

The objectives of this workshop were to share what we know about hydrogen-based technologies, initiate a conversation with our partners and stakeholders about the potential role for hydrogen in the NWT's energy system and economy, and identify the key questions that will need to be answered before next steps are taken.

HOW THE WORKSHOP RELATES TO THE 2030 ENERGY STRATEGY

In 2018, the GNWT released the *2030 Energy Strategy*, a long-term approach to supporting secure, affordable, and sustainable energy in the NWT. The *Strategy* is the GNWT's main vehicle to achieving the NWT's target of a 30% greenhouse gas emissions (GHG) reduction below 2005 levels by 2030. As part of the *Strategy*, the GNWT committed to exploring new and emerging energy technologies. One emerging technology of interest to the GNWT is hydrogen.

While transitioning to a lower carbon economy and reducing GHG emissions is essential to mitigate the effects of climate change, there will be trade-offs that could affect energy costs and reliability, especially in the remote communities of the North. The trade-off triangle—which reminds us that these three components of our energy systems must be balanced—was used to structure the conversation on the possible role for hydrogen in the North.



WHY WE INVITED AN EXPERT FROM THE TRANSITION ACCELERATOR

The GNWT invited Dr. David Layzell from the *Transition Accelerator*, a Canadian non-profit focused on designing and building region-specific, credible energy transition pathways that can develop the local economy, create good jobs, and improve quality of life. At the Transition Accelerator, they recognize that there is not a one-size-fits-all solution in Canada, but there are basic principles and options across all jurisdictions. Their work and experience in hydrogen technologies as a key part of a net-zero economy provided valuable background, context, and guidance for the workshop discussions.

HOW WE STRUCTURED THE CONVERSATION

A week before the workshop, the GNWT held a one-hour webinar to initiate the conversation and help participants prepare for the workshop. The webinar featured brief welcome remarks from Robert Sexton, Director of Energy with the GNWT's Department of Infrastructure, who outlined the premises of the overall engagement, followed by a presentation delivered by Dr. Layzell to provide context on the current state of hydrogen technologies and the NWT energy system.

The day of the workshop started with Dr. Layzell presenting a shorter version of his presentation to remind participants of specificities of the NWT energy systems, as well as going over main hydrogen technologies. Participants were then organized into groups to discuss potential end-uses for hydrogen, as well as possible sources of supply. General discussions were then engaged in to identify common themes, challenges, and possible solutions. The workshop's agenda is included in Appendix A.

HOW THE GNWT WILL USE WHAT WAS HEARD DURING THE WORKSHOP

Outcomes from this workshop will help determine whether there is interest in exploring options for using low-carbon hydrogen as part of the NWT's energy mix. The goal of this workshop was not necessarily to find immediate answers, but rather to formulate and articulate questions that could move us forward.

Energy systems are complex, and hydrogen technology is advancing, and it is crucial to have the data and expertise to make informed decisions on the NWT's energy future. Gathering key partners and stakeholders from throughout the territory to discuss the potential of hydrogen technology is an opportunity to gauge the collective willingness to advance further actions that could make NWT energy systems more affordable, sustainable, and reliable.

Findings from the workshop will also inform GNWT work on deep decarbonization trajectories for the NWT. The modelling work aims to better understand what low-carbon pathways could look like in the North and to examine the potential for existing and emerging technologies to further reduce emissions in the transportation, buildings, and industrial sectors. This work will in turn inform the five-year review of the *Strategy* planned for 2023–2024.

Background

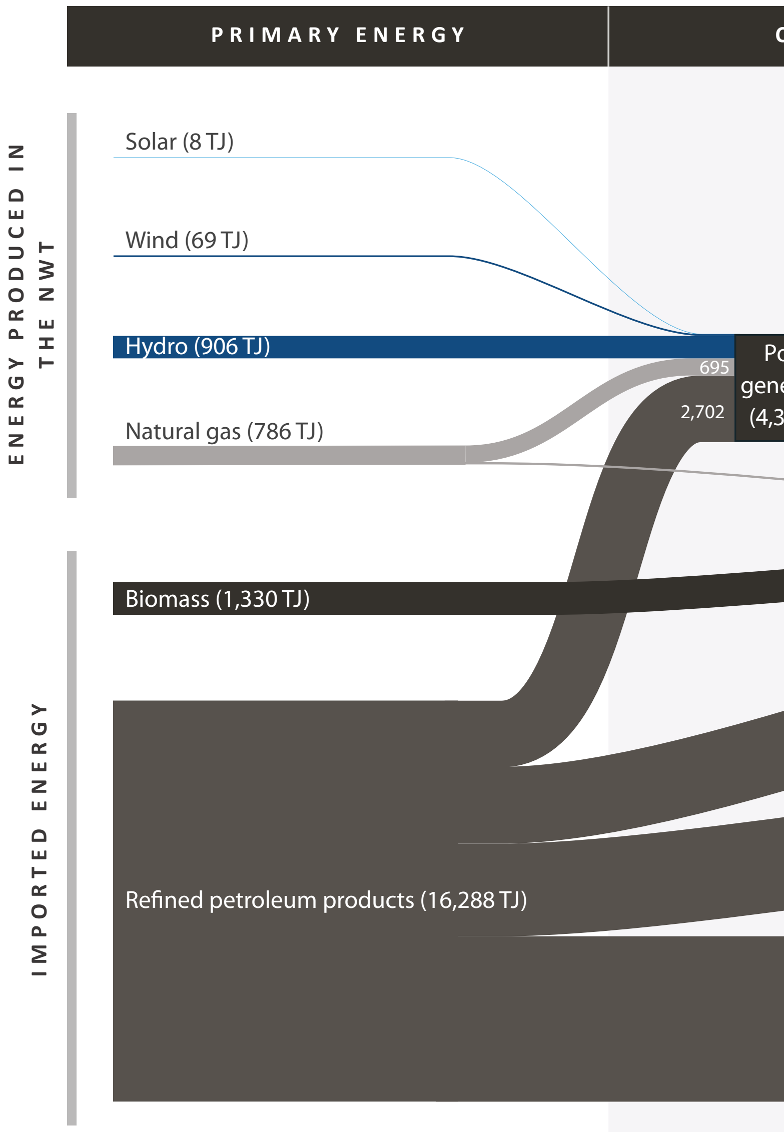
ABOUT NWT ENERGY SYSTEMS

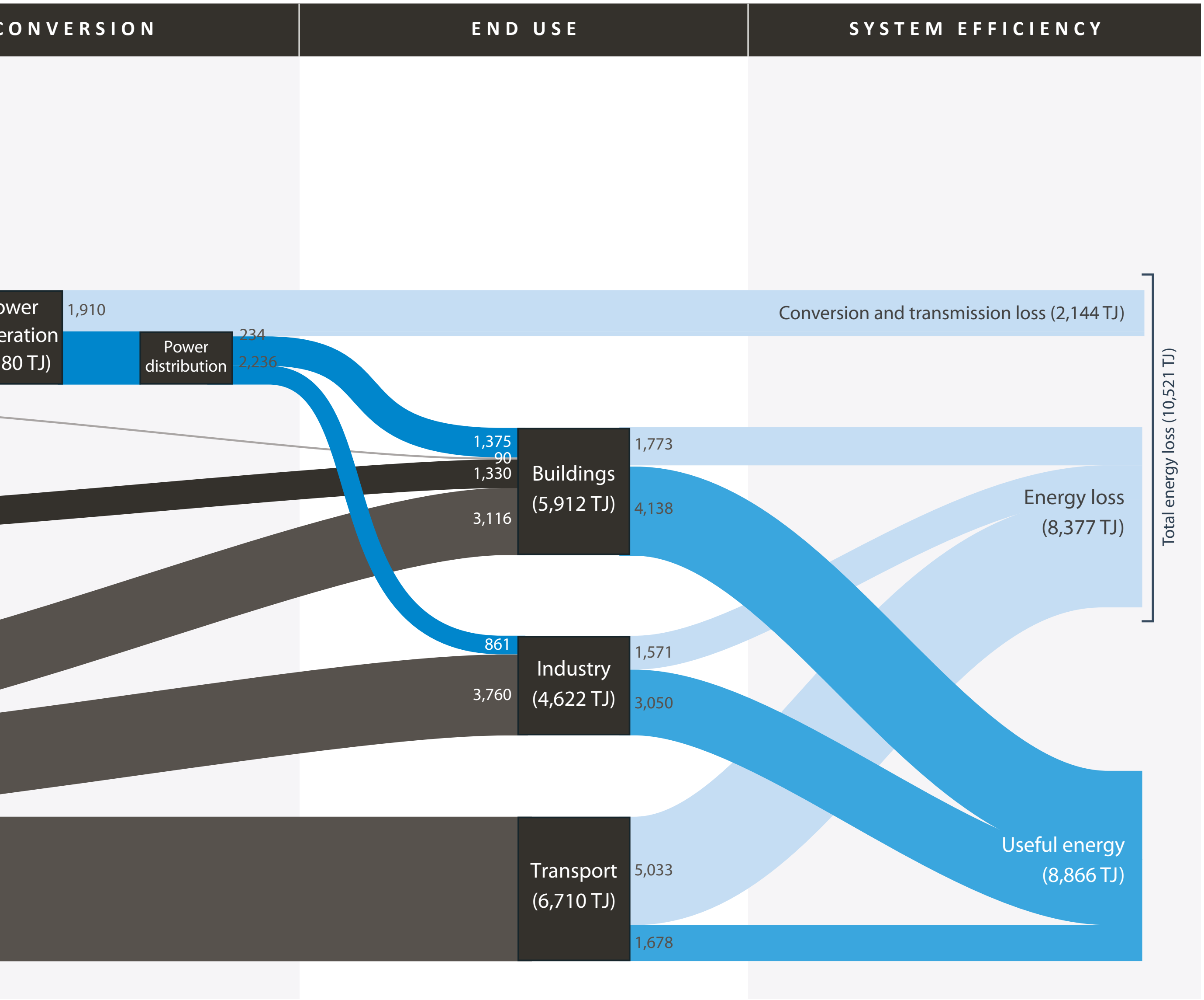
The diagram on this page is called a Sankey diagram. Sankey diagrams are used to show the energy flow from its primary sources to its conversion to fuels and electricity, and how fuel and electricity are used to deliver energy services (e.g., heating, light, transport of people and goods). This diagram shows the NWT's energy sources and uses in 2020, the most recent year for which data is available.

The key to interpreting a Sankey diagram is to remember that the width of each line shows the quantity of energy. Also, the left side of this diagram highlights the difference between local and imported energy in the NWT. The right side of this diagram (under System Efficiency) shows where energy is most efficiently used (buildings and industry) and where it is lost (power generation and transportation).

In 2020, NWT primary energy supply represented 20,020 terajoules (TJ). Fossil fuels were the dominant source of energy in the NWT, accounting for 85% of the overall territorial energy supply. Transportation accounts for most of the energy used in the NWT, with industry driving demand. Transportation relies on gasoline for light-duty vehicles and diesel for heavy-duty vehicles. Refined petroleum products are the industry's primary source of energy to operate its facilities. Buildings primarily use a mix of electricity and petroleum products (e.g., heating oil and propane), with biomass becoming an emerging alternative for heating.

Figure 1. Energy flows in the NWT in 2020 (in terajoules)





Source: *Statistics Canada, GNWT, NTPC, Northland Utilities*

Notes: *Power generation in the industrial sector is estimated using data from Statistics Canada. Energy loss from the end use is estimated using the average conversion efficiency of technologies for a given sector in North America. Buildings demand for natural gas uses 2019 data since 2020 data was deemed unreliable. 1 terajoule (TJ) equals 1,000 gigajoules (GJ).*

LOCALLY PRODUCED ENERGY

The upper left side of the diagram shows locally produced energy. Despite recent progress with solar, it only provides a tiny portion of NWT's overall energy requirement in 2020. All the wind energy in the NWT—again, a tiny portion of the overall mix—is currently produced at the Diavik Mine wind farm. Hydro power is entirely produced and used in the North and South Slave regions. Natural gas is only used in two communities—Inuvik and Norman Wells—for power generation and space heating.

IMPORTED ENERGY

The lower left half of the diagram shows imported energy. Wood pellets provide some energy for heating, as does cordwood sourced locally across the NWT. Imported refined petroleum products make up the bulk of energy supply in the NWT, and are used to provide heat and power to buildings and industry, as well as fuel for transportation.

Refined petroleum products are supplied to communities in various ways. Some communities with year-round road access have it delivered by truck. Harder-to-access communities are generally re-supplied through a combination of rail to Hay River and barge on the Mackenzie River, with an extra step for communities only accessible by winter road. Some communities in the High Arctic are sometimes supplied through tankers coming from overseas. Being remote—with an extreme cold climate and lack of economies of scale—makes the NWT a very challenging logistical and operating environment for energy security and affordability.

A FRAGMENTED POWER SYSTEM

The NWT electricity grid is not connected to the North American electricity grid. In fact, there are 27 separate electricity microgrids in the NWT. Two isolated hydro systems power the North and South Slave regions, where about 69% of the NWT population lives. In the remaining 25 communities, electricity is provided by thermal generators running on fossil fuels—diesel in most communities—with Inuvik and Norman Wells relying primarily on natural gas-generated electricity.

A PRIMER ON HYDROGEN

WHAT HYDROGEN IS

Hydrogen gas (H_2) is a colourless, odourless, tasteless, non-toxic gas, and is the most abundant element found in the universe. That said, it is not found in large quantities on Earth in its molecular form of H_2 but rather in other molecular forms such as water (H_2O), methane (CH_4—the major component of natural gas) or other heavier hydrocarbons.

For more than a century, hydrogen has been used in Canada in industry to produce fertilizers for agriculture, refine hydrocarbons, and make a range of chemicals and materials.

HOW HYDROGEN IS PRODUCED

Although hydrogen is emission-free at the point of end-use, not all hydrogen is generated equal and how it is produced matters from a climate perspective. In fact, the large share of hydrogen produced today is made from natural gas and is associated with upstream GHG emissions in the same order of magnitude as natural gas. Some hydrogen produced from natural gas employs Carbon Capture and Sequestration (CCS) technologies to abate the bulk of these GHG emissions and produce low-carbon hydrogen. A very different production method relies on an electrolyzer to split water molecules into hydrogen and oxygen. When fed with zero-carbon electricity such as hydropower, this process generates virtually zero-carbon hydrogen.

Currently, Canada produces 8,200 tonnes of hydrogen per day—equivalent to 34 million litres of gasoline—primarily from natural gas and without the use of CCS technologies.

Hydrogen can also be converted to ammonia, which is easier to transport and can be used as-is in certain energy applications or can be transported to where it is needed and then converted back to hydrogen for end-use.

HYDROGEN PRODUCTION COSTS

Large-scale production of hydrogen from natural gas (without the use of CCS) is associated with costs per unit of energy in the same range as traditional sources of energy. In comparison, low- and zero-carbon hydrogen is generally more expensive to generate, primarily due to the cost of CCS technologies (when produced from natural gas) and renewable electricity (when employing an electrolyzer) as well as conversion efficiency.

TRANSPORTING AND STORING HYDROGEN

Gaseous hydrogen has low energy content by volume, so it must be compressed or liquefied to be stored and transported. Hydrogen is currently technologically challenging and economically costly to transport and store. However, breakthroughs in storage and transportation technology could be found by producing and using hydrogen at a large scale.

HYDROGEN AS AN ENERGY CARRIER

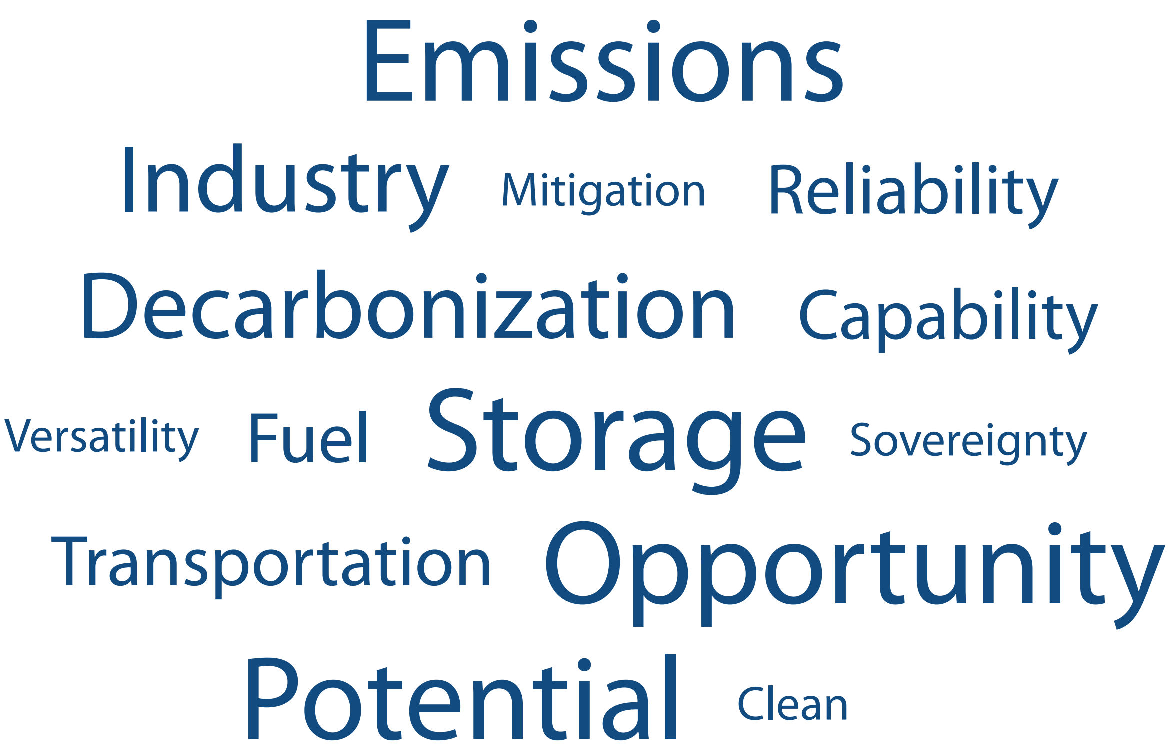
Because hydrogen is emissions-free at the point of use—only producing water and heat when you use it—global interest in producing and using hydrogen as a versatile energy carrier that can help reduce GHG emissions in sectors where few or no decarbonization options are currently available has been fast increasing. In fact, hydrogen can be either combusted (in an engine or a turbine), fed into a fuel cell to produce electricity, or also be blended—with natural gas or diesel, for example—to reduce the carbon intensity of traditional fossil fuels. This makes hydrogen a potential candidate to displace diesel, heating oil or natural gas in sectors such as heavy-duty transportation, space heating in buildings, heavy industry, as well as power generation, although there are some technical barriers to doing this.

What We Heard Throughout the Day

This section provides an overview of what we heard throughout the January 2022 workshop, session by session.

CHAT BLAST

To start the conversation, participants were invited to complete the sentence "What I find most exciting/interesting about hydrogen technologies is . . ." The word cloud below reflects the occurrence of themes and issues mentioned during the chat blast.



HYDROGEN END-USES IN THE NWT

WHAT WE ASKED PARTICIPANTS

During the workshop, participants were asked to answer the following questions:

- *What do you find most interesting or exciting about the possible applications of hydrogen technology in the NWT?*
- *Where do you see the greatest opportunities and why?*
- *What are the key questions, considerations, or barriers we need to explore or think through?*

WHAT WE HEARD

“Despite a lot of interest in potential end-use, is hydrogen a five-year opportunity or a 25-year opportunity?”

“We see a decarbonization opportunity in small communities, where you could use renewable energy produced locally to produce hydrogen or transform it into ammonia. However, not much is known about the costs, the technical limitations, the safety issues.”

“We are excited about using existing surplus electricity for hydrogen production, with the potential for use in the transportation sector.”

“The most likely end-uses for hydrogen in the NWT would be transportation and heating. Those are our biggest sectors and the most difficult to target.”

“We are interested in hydrogen’s potential for energy storage from renewable energy, the versatility of hydrogen and how you can transform it into other commodities and back. It may be a way of diversifying the energy system in the North, particularly around power generation and transportation.”

WHAT WE HEARD: END-USES BY ISSUE

This section summarizes some of the questions, comments and concerns we heard at the workshop during this breakout session.

POTENTIAL ROLES IN THE NWT ENERGY SYSTEM

Participants from the workshop identified four sectors where hydrogen could potentially make a positive impact on the territory's energy systems in the short term:

- The importance of **heavy-duty transportation** in the NWT makes it a prime candidate for the integration of hydrogen as an energy carrier to replace diesel.
- Hydrogen could potentially fill the energy needs of **remote industry** (mining), which currently relies primarily on diesel generators for its power needs.
- Hydrogen could also play a role in the **power sector**, where it could be used to store energy and generate power on demand, especially when combined with renewable generation.
- **Space-heating** is another sector where hydrogen could possibly displace heating oil and propane.

Building Knowledge

We need more concrete information on how hydrogen and ammonia could be used in the North. For example, at what scale is hydrogen production feasible or economic for us? What are the risks for land and water in case of an ammonia spill? When does trucking become less effective than a pipeline? What's the lifecycle efficiency of producing, storing, and using hydrogen? What is the value chain efficiency and the cost? How could hydrogen help stabilize the electric grids? For people working on community energy plans, this information needs to be presented in plain language.

Technology's Fit-for-the-North

What technologies are going to work in our cold climate? The NWT has tried new technologies in the past that turned into dead ends. We want to avoid that when implementing new technologies.

Prudent Use of Resources

Should we use surplus power to produce hydrogen or to increase electrification of existing end uses? It might make more sense to use surplus hydropower to displace diesel generation for end uses such as mining operations.

Energy Independence

Could encouraging local production of hydrogen as opposed to importing refined products contribute to energy independence? This could be a good news story for the NWT. With the growing global demand for hydrogen, there might be future potential to export—maybe from the Arctic Ocean.

Benefiting All

We will also need to train people and provide them with additional skills if we decide to produce locally. There might be an opportunity to be a leader and provide local jobs, like what was done with biomass heating in buildings.

Economic Viability

More work needs to be done to examine the economics of various clean technology options and compare them against each other. To build a better business case, industry needs to be better engaged, and we must understand how residential users and smaller commercial users would affect the value chain. Are there local business opportunities and broader economic opportunities for the North in pursuing this technology? Since so much study is being conducted worldwide on the technology, perhaps we should focus on the economics in the NWT?

Reaching Scale

To make hydrogen technologies cost effective, we need to reach scale. Terawatt hours and gigawatt hours are different orders of magnitude. Green hydrogen will require a lot of renewable energy to be developed, and this will take time and money.

Recognizing Sunk Costs

We must keep in mind the sunk costs already invested in diesel generation, especially at the mines and the regulated electricity system. Those investments must be paid for, even if we switch to a different technology.

Identifying Testing and De-risking Opportunities

Where are the potential areas the government can fund pilot projects and de-risk the technology in the NWT? Perhaps the NWT could use some of our excess hydropower that is not being used right now to test small scale hydrogen production and local end use.

HYDROGEN SUPPLY IN THE NWT

WHAT WE ASKED PARTICIPANTS

Would it better for the NWT to import hydrogen, produce it locally, or to have a mix of both?

WHAT WE HEARD

" The NWT typically copies other jurisdictions. When it comes to hydrogen technologies, maybe there is an opportunity to explore new, breakthrough models, such as combined heat and power in the residential sector. "

" Under any supply option, robust supply chains are needed given the North's realities. Whichever option we look at, we must be sure we know what we're doing. "

" We need a regional roadmap. Figuring out what the steps would be, who would be involved, etc. in developing hydrogen in the Northwest Territories. "

" There is lots of talk right now about whether it's technically feasible, but many of the unknowns are at the economic level. "

" What is the lifecycle efficiency from a wind turbine to electrolysis to fuel cell? How much energy do you have to put in compared to how much you get out? And what are the economic implications of that? "

" Getting it to a commercial level is only possible when you get industry support. Governments need to communicate directly to industry to understand completely what these technologies have to offer and get behind companies taking the leap. "

WHAT WE HEARD: HYDROGEN SUPPLY BY ISSUE

This section summarizes some of the questions, comments and concerns we heard at the workshop during this breakout session.

Building Brand New Value Chains

Unlike electricity and biomass energy, robust value chains for hydrogen don't exist anywhere today. Hydrogen is typically produced on an industrial scale right beside the plants that use it. It is not moved around or used as an energy carrier, but rather as an industrial feedstock to change the chemistry of other chemical processes. To shift to a net-zero energy system, new hydrogen value chains must be created and integrated with our electricity energy systems. Value chains for energy are dependent on energy demand, so that's where the focus should be. Heavy-duty vehicle operators, companies that need fuel for industrial processes, people who want space-heating and hot water, and even power-generation facilities looking for energy to make electricity are all critical to establish and pay for the entire value chain.

Importing vs. Exporting

If the NWT imports hydrogen, supply will most likely come from Alberta. Local production for export may be feasible down the road, through electrolysis using surplus hydropower from the South Slave or through reforming of natural gas in the Beaufort Delta, but only done at large enough scale to be competitive. We could import while catching up with the commodities and distribution means. Perhaps the NWT could be a proving ground, and in the process create some local economic benefits. However, we need more information to make informed decisions.

Regional Approach

The most likely path forward for hydrogen in the NWT would be a regional approach. In such a large territory, each region will have different needs, including different potential supply and demand options. Some regions currently don't have the option to generate hydrogen, so the priority would be to get more renewable capacity in those regions first. Once that is achieved, we could consider adding hydrogen into the energy mix. An NWT hydrogen strategy would need to be driven regionally and by an identified market, or an identified regional anchor client, such as mining, marine transportation, or heating fuel.

If there is a regional market, then maybe production for local use makes sense. If there is an exporting business opportunity—for example, producing hydrogen and/or ammonia in the South Slave and connecting to the existing value chain via northern Alberta—then perhaps that should be considered.

Scaling Up Successes

The NWT leads the way in biomass heating and natural gas power generation, creating natural gas and biomass supply chains that allowed us to adopt new technologies. There might be an opportunity to repeat this feat, perhaps by leveraging operations like the GNWT's Marine Transportation Services or private sector companies. The NWT started from scratch with biomass only 15 years ago, and liquefied natural gas (LNG) less than a decade ago. However, we learned that in terms of robust supply chains and good end-use markets, biomass and LNG are still imported. The NWT does not produce those commodities in significant quantities yet. Hydrogen will likely present the same challenge.

Innovative Models

There may be unique opportunities in the NWT to be in the vanguard of how hydrogen is incorporated into energy systems. Some breakthrough models may include creative ways to use hydrogen in combined heat and power systems, especially for the residential sector. It could be worth doing a study to define use in different residential sectors to see if it would make sense. There could be a lot of value in exploring other sectors to identify breakthrough models in the applications of hydrogen in the NWT, and not always waiting to see what other jurisdictions have tried.

Bringing it all Together

THE EXPERT'S VIEW

Dr. Layzell suggested three areas in the NWT with potential to leverage local resources to produce and integrate hydrogen into their energy systems:

- **The North Slave and South Slave regions –** These regions currently have near year-round access to hydropower, which combined with water from Great Slave Lake could be used to generate zero-carbon hydrogen. Since 69% of the NWT's population live in these two regions, there may be potential for concentrated demand, which could support some initial trials. The proximity to Alberta could also lead to exploring the option of delivering hydrogen or ammonia to Edmonton.
- **The Mackenzie Valley and Beaufort-Delta Region –** These regions benefit from oil and gas resources, which could be combined with CCS technologies to produce low-carbon hydrogen. Access to tidewater could support significant economic development, and communities could generate some local demand.
- **Remote communities (including industrial sites) –** In remote communities, hydrogen could offer a local, versatile source of energy able to displace imported refined petroleum products.

KEY ISSUES RAISED BY PARTICIPANTS

Throughout the workshop, we heard a clear call for more research on the potential and applicability of hydrogen in the NWT. This section summarizes some of the common questions, comments and concerns we heard at the workshop discussions.

REGIONAL ROADMAP

To understand what steps must be taken to develop hydrogen in the NWT and who would be involved, we need to use potential scenarios created on a regional basis. For example, what does this look like for a residential house, for a small community, a large community, or a sector like transportation or industry?

TECHNICAL FEASIBILITY

We need to compare hydrogen to other available technologies, like increased electrification or increased penetration of renewables. Can we do something here that hasn't been done anywhere else (e.g., combined heat and power, solid state storage technology, replacing gensets in remote communities) to address our specific needs? Would we be willing to take that risk?

ECONOMIC FEASIBILITY

The economic unknowns regarding hydrogen energy must be addressed. We need to understand the capital costs, operation costs and process efficiencies of all options. We must have a clear vision of what the transition path looks like. If we build it, will they come? Is it wiser to transition in small increments? What's the timeframe for transitioning to using hydrogen?

REALISTIC OPTIONS

What is the broader suite of options that we have at our disposal to locally produce the energy we need while reducing GHG emissions? Could we import, export, and/or produce hydrogen? Could we use hydrogen in a gas form or liquid form, or with ammonia or other carriers and at what scale?

LIFECYCLE ANALYSIS

We need to conduct a lifecycle analysis of all our options. How much energy do you have to put in and how much do you get out at the end? What are the lifecycle costs, the economic benefits, jobs, and training opportunities? What are the various risks and how can you manage them? How reliable and robust would that risk mitigation be?

RELIABLE DATA

To assess the need for refueling stations and/or new infrastructure, we must accurately identify the number of heavy-duty vehicles on NWT roads and how many transport trucks are coming from Alberta.

INCENTIVES

We need to explore possible pilot programs, grants or rebates that could be initiated to affect uptake and acceptance of hydrogen energy in the NWT.

SOCIO-ECONOMIC EFFECTS

We need to study the potential consequences of pushing a transition to hydrogen energy. How would this affect different communities? Would there be winners and losers?

NEXT STEPS

Regardless of the technological, economic, or social benefits or ramifications of pursuing hydrogen as an energy carrier for the NWT, the consensus is that much more study is required. These studies must also be explained in plain language to community representatives, industry, and the general public if there is to be a social licence to use hydrogen and business investment in this energy source.

Appendix A: Workshop Agenda

TIME	TOPIC
8:50 am	Opening of the virtual room
8:55 am	**Zoom technical overview** 15 min
9:10 am	**Introductions and setting the stage for the day** 20 min
9:30 am	**Presentation:** **NWT's energy context** (Robert Sexton - GNWT) 15 min
9:45 am	**Presentation: Hydrogen 101** (Dr. David Layzell - Transition Accelerator) 45 min
10:30 am	Break
10:40 am	**Breakout session: End-uses** ***How/where could hydrogen play a role in NWT energy systems?*** 50 min
11:30 am	**Debrief and discussion** 30 min
Noon	Mid-day break
12:45 pm	**Breakout session: Supply** ***How could hydrogen be sourced for use in the NWT?*** 50 min
1:35 pm	**Debrief and discussion from the second breakout** 35 min
2:10 pm	Break
2:30 pm	**Bringing it all together** 30 minutes
3 pm	**Closing remarks (GNWT)**
3:15 pm	**Adjourn**

Appendix B: List of Participants

NAME	ORGANIZATION	JOB TITLE
Alex James	Town of Fort Smith	Community Climate Change and Energy Champion
Bill Gourley	Superior Propane	Director, Indigenous & Government Affairs
Bruno Pereira	NT Energy	Director
Chad Bonnetrouge	Catalyst 2020	Fort Providence
Cheri-Ann MacKinlay	Natural Resources Canada	Science and Technology Advisor
Cory Doll	GNWT, ENR	Manager, Climate Change and Air Quality
Darbie Desrosiers	Inuvialuit Regional Corporation	Clean Energy Coordinator
Dave Lovekin	Pembina Institute	Director, Renewables in Northern Communities
David Mahon	GNWT, INF, Strategic Infrastructure	Senior Engineer, Energy Initiatives
Dennis Bevington	President	Stand Alone Energy Systems Ltd.
Eric McNair-Landry	Ecology North	Chair of the Board
Felix Mercure	CIRNAC	Environmental Policy Analyst
Grant Sullivan	Nihtat Energy Ltd.	President
Iqbal Bhatti	Denesoline Corporation (Lutselke Dene First Nation's economic development agency)	Sustainability & Technical Applications
Jack VanCamp	Vice-President and Principal	Stand Alone Energy Systems Ltd.
Jennifer Phillips	NWT Chamber of Commerce	Executive Director
John Henderson	Deton'Cho Corporation	COO
Karen Horassi	Hamlet of Tulita	Community Energy Champion
Kevin O'Reilly	SCEDE	MLA, Member of the Standing Committee on Economic Development and Environment
Lachlan MacLean	City of Yellowknife	Manager, Asset Management
Margaret Gorman	Denendeh Investments Incorporated	Chief Operating Officer
Margaret Mahon	Arctic Energy Alliance	Operations Manager
Michael Ross	YukonU Research Centre, Yukon University	NSERC Industrial Research Chair in Northern Energy Innovation
Motwakil Eldoma	Government of Nunavut	Senior Advisor, Petroleum Resources, Department of Economic Development and Transportation
Patrick Gall	Aurora Research Institute	Manager of Technology and Development
Paul Clyne	GNWT, INF, Strategic Infrastructure	Senior Engineer, Energy Initiatives
Ryan Makela	ATCO	Manager, Northern Development
Sara Brown	NWTAC	Chief Executive Officer
Tim Tutcho	Catalyst 2020	
Tom Hoefer	Executive Director	NWT & Nunavut Chamber of Mines
Mike Harlow	GNWT, ITI	Manager of Petroleum Resources Planning
William Gagnon	GNWT, INF	Climate Change Strategic Lead

The following individuals supported the workshop throughout the day:

NAME	ORGANIZATION	JOB TITLE
Benjamin Israel	GNWT, INF, Energy	Senior Coordinator
David Layzell	Transition Accelerator	Energy Systems Architect
Daya Nhuchhen	GNWT, INF, Energy	Senior Coordinator Low Carbon Economy Fund
Eric Chalker	GNWT, INF, Energy	Senior Coordinator Low Carbon Economy Fund
Gabrielle Moser	GNWT, INF, Energy	Advisor, Energy Policy and Programs
John Williams	GNWT, INF, Energy	Senior Engineer
Loretta Ransom	GNWT, INF, Energy	Advisor, Energy Funding, Research and Development
Naeim Roudehchi	GNWT, INF, Energy	Energy Engineer
Patrick Smith	GNWT, INF, Energy	Intern, Environmental Analyst
Patrick Wrigglesworth	GNWT, INF, Energy	Advisor, Energy Analytics & Regulatory Affairs
Remi Gervais	GNWT, INF, Energy	Manager, Energy Policy and Programs
Rob Marshall	GNWT, INF, Energy	Manager, Energy Policy and Programs
Robert Sexton	GNWT, INF, Energy	Director
Roxane Poulin		Facilitator