Net Zero Atlantic
Socioeconomic Impacts of Hydrogen Production in Nova Scotia

Final Report

H370244-0000-100-066-0001

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Abbreviations

The following is the list of abbreviations used in this document:

Acronym / Abbreviation	Description
AACE	Association for the Advancement of Cost Engineering
ASU	Air Separation Unit
BoP	Balance of Plant
CAD $	Canadian Dollars
CAPEX	Capital Expenditure
CHFCA	Canadian Hydrogen Fuel Cell Association
CO_2e	Carbon Dioxide Equivalent
EHS	Emergency Health Services
EUR	Euro
FORCE	Fundy Ocean Research Centre for Energy
FTE	Full-Time Equivalent
g	grams
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GVA	Gross Value Added
GW	Gigawatt
GWh	Gigawatt-hour
H2	Hydrogen
IEA	International Energy Agency
kW	Kilowatt
kWh	Kilowatt-hour
LGC	Large Gas Carriers
LPG	Liquefied Petroleum Gas
LQ	Location Quotient
MM	Million
MoU	Memorandum of Understanding
MT	Megatonne

Acronym / Abbreviation	Description
MW	Megawatt
MWh	Megawatt-hour
NH_3	Ammonia
NS	Nova Scotia
NSAA	Nova Scotia Apprenticeship Agency
NSCC	Nova Scotia Community College
O_2	Oxygen
OoM	Order of Magnitude
OPEX	Operating Expenditure
PEM	Polymer Electrolyte Membrane
SUSEX	Sustaining Expenditure
t	Tonne(s)
TIC	Total Installed Cost
tpd	Tonnes per Day
TWh	Terawatt-hour
USD $	United States Dollars
VLGC	Very Large Gas Carriers

Executive Summary

Under the Economic Goals and Climate Change Reduction Act, Nova Scotia has legislated a net-zero greenhouse gas (GHG) emission economy by 2050. Reaching these GHG emission reduction targets necessitates the decarbonization of all economic sectors. While traditional decarbonization strategies (e.g., decarbonizing electricity generation and the subsequent electrification of end-uses) will help reduce GHG emissions, they will not be sufficient to reach these deep decarbonization goals.

Hydrogen is one of the most promising options in the adoption of low-carbon fuels to meet clean energy goals. Studies facilitated by Net Zero Atlantic found that hydrogen and hydrogen-derived fuels can play an important role in domestic decarbonization and offers a significant export opportunity for the region. One hydrogen-derived fuel, ammonia, has been at the centre of the international discussion around potential decarbonization options for, among other things, marine transportation.

There has been significant interest and growth in green hydrogen production over the past few years as a low-carbon fuel option to reduce GHG emissions. Nova Scotia and the rest of Eastern Canada have been identified as potential hydrogen production hubs due to their high potential for green hydrogen production using renewable wind power and for their access to numerous ports for green hydrogen / ammonia export.

The Federal Government has shown its support for the development of green hydrogen projects with the recent Clean Hydrogen Investment Tax Credit, a refundable tax credit for clean hydrogen production investments mentioned in the 2022 Fall Economic Statement for projects made as of the day of Budget 2023, with the credit being phased out after 2030. The details of this credit will be released in due course, but the lowest carbon intensity tier that meets all eligibility requirements is proposed to receive an investment tax credit of at least 40%. Additionally, Canada and Germany signed an agreement to collaborate in the export of clean Canadian hydrogen to Germany.

The objective of this Study is to provide the Government of Nova Scotia with the information necessary to further understand the socioeconomic impacts of a large-scale, low-carbon hydrogen production facility in Nova Scotia. In order to assess the socioeconomic impacts of large-scale hydrogen production facility in Nova Scotia, a hypothetical project was developed for analysis. This Study first developed a project design and associated CAPEX and OPEX estimates. Using these estimates, the economic impacts were assessed and quantified. Using the outputs of the economic model, a trades and skills assessment and social impact assessment were performed to provide a holistic picture of the potential socioeconomic impacts.

For the hypothetical project, no specific site was selected. Instead, it was assumed that the ‘large-scale hydrogen facility’ would be a Greenfield build in Nova Scotia near an existing port in order to export green ammonia. The project also assumed the necessary utilities (e.g., electricity, water) are available in this area. Any additional power generation requirements for this facility were considered outside the scope of this Study. The overall large-scale hydrogen facility consists of the following main areas:

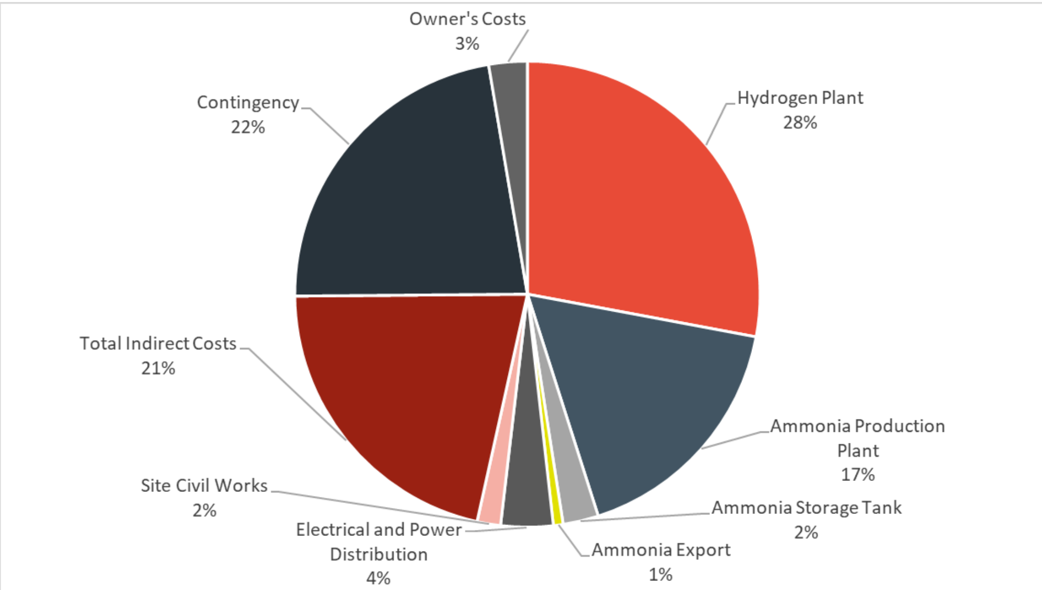
- 500 MW Green Hydrogen Production Plant
- Intermediate Hydrogen Storage
- Ammonia Production Plant
- Liquid Ammonia Storage
- Marine Export Infrastructure

An order-of-magnitude (OoM) cost estimate for this Study was prepared based on limited engineering design, and subsequently has a wide accuracy range. As such, this estimate is not classified in terms of Association for the Advancement of Cost Engineering (AACE) International recommended guidelines. This estimate has been prepared solely to estimate the socioeconomic impacts of a facility of this scale.

A large-scale hydrogen facility requires significant capital expenditure.

The total CAPEX for this project is estimated at CAD $3.15 billion +100 / -50%. Large-scale hydrogen production is still a nascent sector. As the industry grows and the supply chain and technology for large electrolyzers grows, it is expected that the cost of green hydrogen production equipment will reduce over time. However, based on current available data, a facility in the realm of 0.5 GW will require 10-figure magnitude investments. A breakdown of the different costs is provided in the figure below.

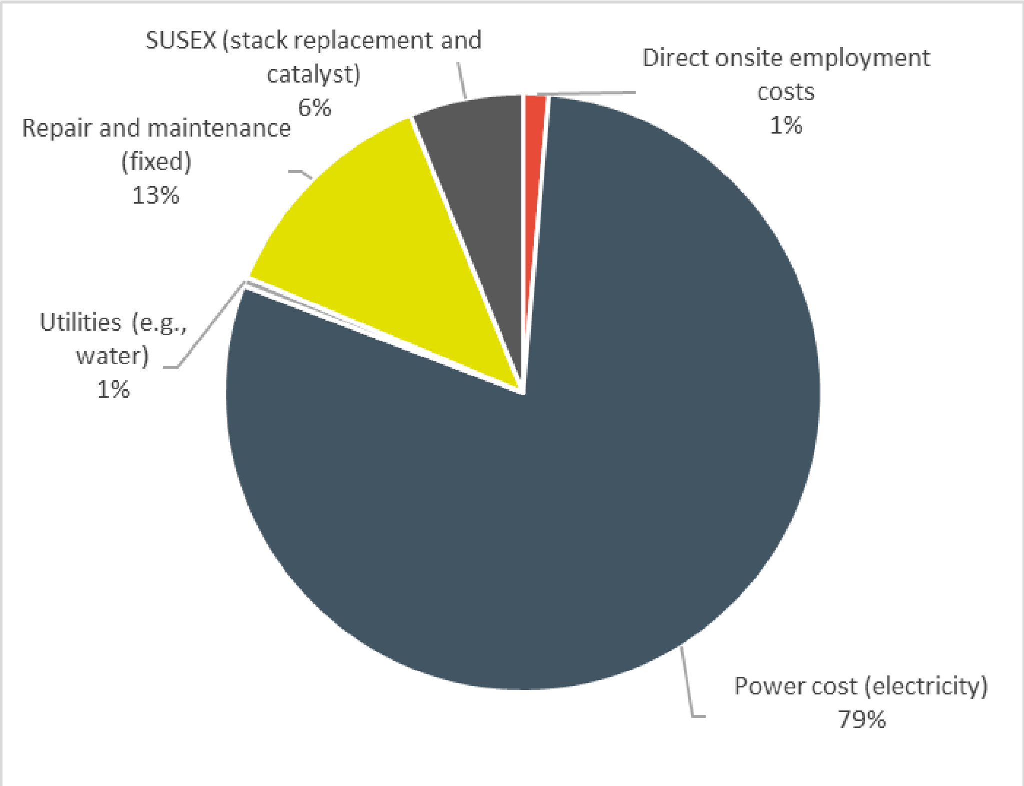
Breakdown of CAPEX Estimate Categories



Large-scale hydrogen production is very energy intensive and requires large sums of consistent renewable energy.

The electrolysis process alone for the selected technology is estimated at 528 MW at the beginning of life (BOL) of the electrolyzers. Over time, electrolyzer efficiency degrades by an estimated 1% per year. However, since the unit operates on a basis of constant hydrogen production, the loss in efficiency results in a higher electrical power demand rather than a decrease in hydrogen production. On top of the electrolyzer electricity consumption is the balance of plant (transformer / rectifier, compressors, auxiliaries, cooling water, etc.) and ammonia production electricity requirements. For this project, it is estimated that electricity costs will make up nearly 80% of the estimated CAD $326 MM per year OPEX. A breakdown of these categories is shown in the figure below.

Breakdown of OPEX Estimate Categories



The extent to which project expenditure is retained in Nova Scotia is a key driver of economic impacts. It is assumed that 27-33% (CAD $655-788 million) of project expenditure is retained in Nova Scotia across the whole of the construction phase and 29-46% (CAD $24-37 million) is retained on average each year during the operational phase.

Different categories of expenditure have different potential for local sourcing. During the construction phase the direct equipment is assumed primarily to be sourced from outside of Nova Scotia, whereas there is significantly more opportunity for local sourcing in other expenditure (indirect costs and construction labour).

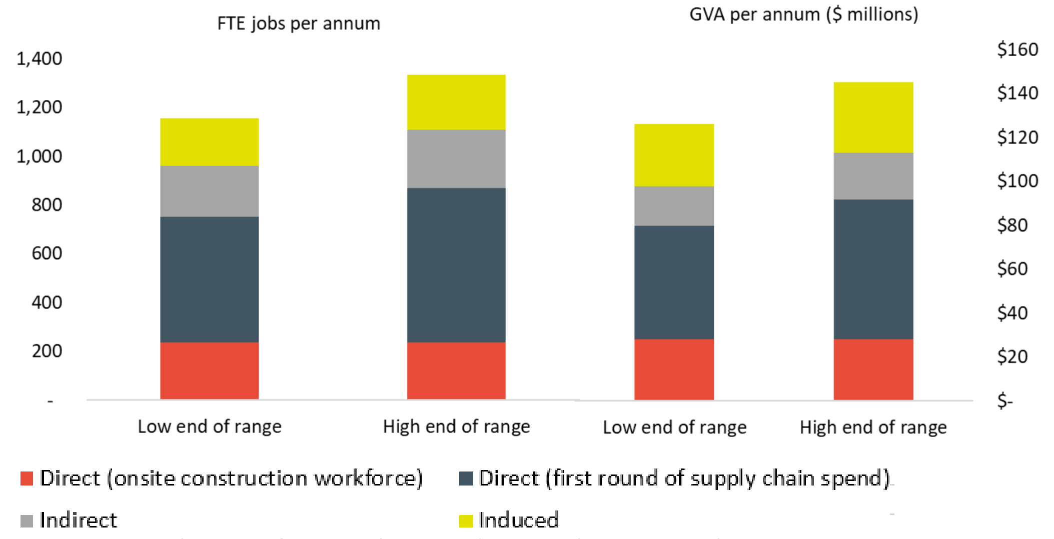
During the operational phase all the expenditure on direct onsite employment costs and other utilities is assumed to be retained in Nova Scotia whereas there is lower potential for local sourcing in the electrolyzer stack replacement and other repair and maintenance expenditures.

Using the estimated CAPEX and OPEX figures and local sourcing levels, a socioeconomic analysis was performed to produce several key findings.

The construction of the large-scale hydrogen project would lead to significant economic impacts during the temporary construction phase. The total annual GVA impact represents an average per annum 0.3% gross increase on Nova Scotian baseline GDP.

There are a significant number of construction jobs along with high-skill jobs related to design and development (i.e., engineering) during the construction phase (including development work undertaken pre-onsite construction commencing) of the large-scale hydrogen facility. All employment and economic value relating to economic activity (such as manufacturing imports) outside of Nova Scotia are not quantified in this assessment. The assessment finds that within Nova Scotia (on average per year) there is potential for a total of around 1,150-1,330 jobs and approximately CAD $126-145 million direct, indirect and induced GVA to be supported by the construction of a 500 MW green hydrogen facility on average over the 6-year construction period.

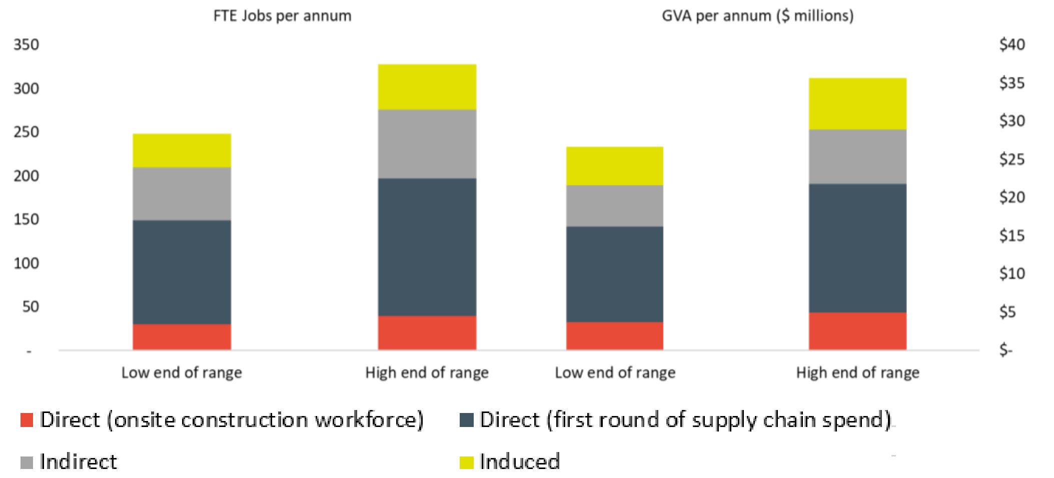
Core Economic Impacts during the Construction phase



The operational phase of a large-scale hydrogen project will support longer-term economic impacts, representing less than a 0.1% gross increase on Nova Scotian baseline GDP. These are highly productive jobs that will be supported over a long-term period.

During the operational phase, the facility would support 30-40 direct on-site FTE jobs, which would be technical positions and have an average cost (salary plus on-costs) of approximately $150,000 per annum. The supply chain (including first round expenditure) will also support a range of jobs. The assessment finds that within Nova Scotia there is potential for a total of around 260-330 direct, indirect and induced FTE jobs and $28-36 million direct, indirect and induced GVA to be supported by the operation of a large-scale hydrogen facility.

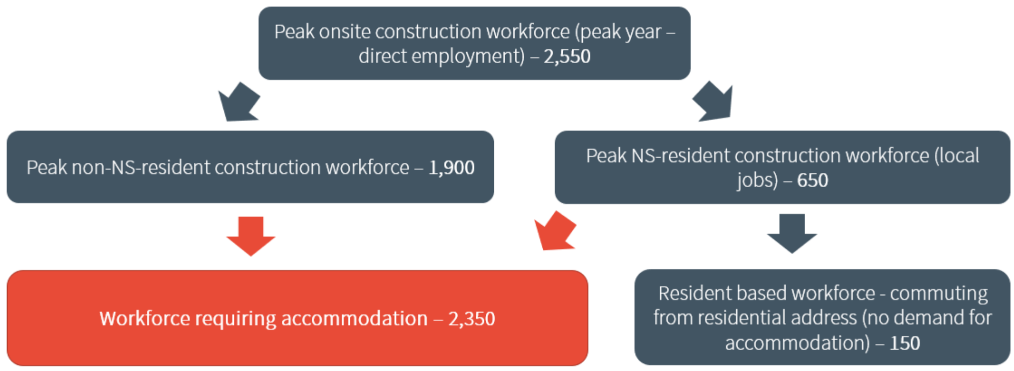
Core Economic Impacts during the Operational phase



The peak direct construction workforce is estimated at 2,550 FTE jobs, of which approximately 2,350 are assumed to require temporary accommodation in the local area. These will place additional demands on a range of social infrastructure.

As a realistic worst-case assumption, a quarter of the construction workforce is assumed to be Nova Scotian and the majority of the Nova Scotian workforce is assumed to reside more than an hour from the hydrogen project.

Peak Construction Workforce Demand



Numbers may not sum due to rounding.

The construction of a 500 MW green hydrogen export facility would also lead to wider economic impacts including tax impacts, skills development opportunities, increased international competitiveness in hydrogen production, increased exports and global decarbonization of downstream sectors.

No additional specific labour market capacity issues have been identified that would put the project at risk from a skills supply standpoint, although there will be large trades and skills implications primarily on the construction sector but also on other supporting sectors (e.g., professional services, transport, warehousing chemicals).

There would be limited implications for the trades involved in raw materials extraction and the manufacture of the equipment used in the hydrogen producing project.

There will be larger trades and skills implications for construction sector workers, including onsite construction labourers, project managers, engineers etc. and professional services. During the early construction phase there will be demand for design, planning, procurement, and professional services. During the later years of construction, there will be an onsite labour requirement primarily in the construction sector. There are also a wide range of trades and skills requirements which will place demand on sectors including construction, transport, warehousing and chemicals.

During the operational phase there will be skills and trades requirements for technical and engineering onsite roles and a variety of maintenance and support roles. The long-term nature of operational roles can provide high skilled roles to the province to attract / retain skilled working age population.

Assessing what specific impacts the project could have on the local community and the supporting social infrastructure will be influenced by a few key factors that are not yet defined. Key to greater levels of precision on the social impact will be the identification of a specific geographical location and more nuance to the workforce profile, such as the length of time that different cohorts of the project workforce will need to be on-site.

This level of detail will allow for more insights and differentiation, such as the categorization levels of impact at the municipal and local levels, the types of impact across rural or urban areas etc. and how the impacts of the project will be change over time and the mitigation choices that could be available.

The demography of the expected workforce will see an inflow of workers to Nova Scotia in the 25-54 age range, who will be predominantly male (approximately 87% of the total workforce) and in the main, will be unlikely to be joined by partners and family members. Whilst the overall peak labour number has the potential for high levels of social impact, mitigating factors such as additional temporary worker housing solutions and the phasing of work activities to complement the area (e.g., peak construction activity coinciding with out of tourist season times) will help and reduce impacts to a medium level.

Nova Scotia has and will continue to experience health challenges post Covid 19, having lost non-urgent provision and seen rural emergency department closures, as well as having existing lower levels of family doctors than the Canadian average. Additional volumes of people will acerbate this, but the profile of younger workers and the lower incidence of those with long-term health issues working on the project, coupled with on-site medical services, should provide degrees of mitigation.

Emergency services have significant levels of voluntary inputs in Nova Scotia, which should be enhanced by having a younger demographic of construction workers, who will be inculcated with safety awareness and behaviours. Forecasting the impacts on the police force will be in line with any population increase and the importance of close coordination with the emergency services from initial project discussions onwards, can contribute greatly to making sure that any additional resources are in place at the right time, that 'fear' of crime is tackled early and that concepts like 'worker's code of conduct' are agreed in advance with any worker representative organisations.

The provision of most municipal services will encounter some form of impact. For example, school provision, which has seen increased demand in Nova Scotia since 20215, will have to cope with the likelihood of some increases in demand but these will be of low or marginal impact for relatively short periods of time. There will need to be adaptations to things like parking arrangements, litter collection and street cleaning, but these can be readily managed.

The size and scale of the project, relative to the location, will be a cause for local concern wherever it is located. However active community engagement from project initiation, underpinned by honesty and integrity in dialogue and subsequent action, will go some way towards mitigating discord. Positioning the project as a net local contributor and economic asset will be key.

If the province is looking to progress a large-scale hydrogen project in Nova Scotia, several activities and studies can be carried out to continue this process including:

- Scoping study for techno-economic viability;
- Seek agreements (memorandums of understanding, letters of intent, contracts, etc.) with off-taker(s), including an understanding of the acceptable carbon footprint of the product, which will help inform the amount of renewable power required for the plant;
- Land / location assessment;
- Establish and carry out permitting pathway; and
- Front-end loading (FEL) stages to final investment decision (FID).

There are a number of enhancement measures that may help to maximize the benefits of the project.

- Ensuring that any dialogue with any scheme or project promoters makes clear that there needs to appropriate consideration and mitigation for the economic and social impacts within their business case.
- Achieving higher levels of local sourcing through supply chain management, and supplier engagement and opportunities for the local community.
- Producing a skills and employment plan with tangible commitments and targets.
- Co-creating Community Engagement Plans, Emergency Service Strategies and Local Traffic Management Plans with key stakeholders.
- Clear and consistent communication with and from the local community, that responds to local challenges and evidences the benefits of the project.

1. Introduction

Under the Economic Goals and Climate Change Reduction Act, Nova Scotia has legislated a net-zero greenhouse gas (GHG) emission economy by 2050. Reaching these GHG emission reduction targets necessitates the decarbonization of all economic sectors. While traditional decarbonization strategies (e.g., decarbonizing electricity generation and the subsequent electrification of end-uses) will help reduce GHG emissions, they will not be sufficient to reach our deep decarbonization goals.

Hydrogen is one of the most promising options in the adoption of low-carbon fuels to meet clean energy goals. Studies facilitated by Net Zero Atlantic found that hydrogen and hydrogen-derived fuels can play an important role in domestic decarbonization and offers a significant export opportunity for the region. One hydrogen-derived fuel, ammonia, has been at the center of the international discussion around potential decarbonization options for, among other things, marine transportation.

In the Maritimes, hydrogen has the potential to deliver up to 22% of the end-use energy demand by 2050 and mitigate 21% of the region's GHG emissions[1]. In addition, hydrogen has the potential to renew Nova Scotia's position as an energy exporter.

1.1 Project Objective

The objective of this Study of the Socioeconomic Impacts of Hydrogen Production in Nova Scotia (the 'Study') is to provide the Government of Nova Scotia with the information necessary to further understand the socioeconomic impacts of a large-scale, low-carbon hydrogen production facility in Nova Scotia. The provincial government is interested in deepening its understanding of the socioeconomic impact that a large-scale hydrogen production facility would bring to the province.

For the purposes of this Study, a 'large-scale hydrogen facility' includes hydrogen production, the process of converting hydrogen to ammonia and storage / transport prior to shipping for global markets. More specifically, the report focuses on infrastructure and services necessary and the socioeconomic impacts of both the construction and operational phases of such a project.

1.2 Scope

In order to assess the socioeconomic impacts of a large-scale hydrogen production facility in Nova Scotia, a hypothetical project was developed for analysis. The scope of the project is broken down into four main tasks and further detailed in this section:

- Project Design
- Economic Impacts
- Trades and Skills Assessment
- Social Impacts

[1] Offshore Energy Research Association, 2021, A Feasibility Study of Hydrogen Production, Storage, Distribution, and Use in the Maritimes.

1.2.1 Project Design

The first task for this project was to define the hypothetical large-scale hydrogen production facility. A Greenfield 500 megawatt (MW) electrolysis plant is assumed for construction in a coastal location in Nova Scotia with the intention of converting the hydrogen to ammonia for international export. A high-level process description, process design basis, and cost estimate were developed for this hypothetical plant for input into the socioeconomic impact assessment.

1.2.2 Phases assessed

The assessment considers the socio-economic effect during the construction phase and the operational phase.

- Construction phase: (including development work): 6 years; It is assumed 2 of the years will be focused on development work (including engineering, studies, and site prep) and the following 4 years will be focused on onsite construction activity. The majority of economic activity in the construction phase will therefore occur to the end of the construction phase.
- Operational phase: Assumed to cover a 30-year period once the construction phase is completed.

1.2.3 Economic Impacts

The economic effects that arise from all phases of the proposed large-scale hydrogen facility were determined by developing a bespoke input-output model using local data. This first task consisted of developing a baseline of the local economy, focusing on its overall scale, shape, and recent performance. The baseline focuses closely on the variables that are most relevant for the economic impact assessment, including population, employment, Gross Value Added (GVA), sectoral composition, earnings, and (un)employment rates.

A proposed economic impact framework was then distributed for discussion and agreement to set out:

- **The sources and drivers of impact:** The capital and operating expenditure incurred in the course of a large-scale hydrogen project, and the portion retained within Nova Scotia – broken down by construction and operational phases.
- **The types of impact:** Direct (including on-site), indirect (supply chain) and induced (wage expenditure) effects.
- **The measures of economic impact:** The core economic effects concentrated on employment (measured as average full-time equivalents per annum) and GVA. Alongside these, wider economic impacts are considered qualitatively.
- **The structure of the economic model:** Hatch have gathered direct, Type 1 and Type 2 jobs, and Gross Domestic Product (GDP) multipliers for Nova Scotia from Statistics Canada[2]. We have created a provincial input-output model which contains

[2] Multipliers available at Statistics Canada: Table 36-10-0594-01 Input-output multipliers, detail level and Table 36-10-0595-01 Input-output multipliers, provincial and territorial, detail level.

direct, Type 1 (direct and indirect) and Type 2 (direct, indirect, and induced) multipliers broken down at a detailed sectoral level at the provincial level. This enables the identification of sectoral patterns to the economic impacts and hence, potential sectoral opportunities.

- **The data inputs into the model:** The expenditure inputs are entered into the model and then sourcing assumptions and sectoral based multipliers are applied to each expenditure item to determine the potential economic impacts (jobs and GVA) for each expenditure item. The project's core economic impacts for each phase can then be determined.
- **The approach to deriving geographical sourcing assumptions:** Based on professional judgement, given the team's prior experience and knowledge in assessing similar facilities and the local knowledge of the baseline conditions.
- **Treatment of additionality and other caveats:** The effects presented in the report are gross impacts. The input-output model is based on purchasing relationships between sectors and households at a detailed sectoral level. It is assumed that these are fixed within and between industries. The input-output model states the total economic impacts associated with that injection, with no effects on prices and capacity constraints.
- **Treatment of uncertainty:** To account for uncertainties in the level of costs and the extent to which goods and services can be sourced locally, impacts are presented using suitable ranges. Maximum impact scenarios (realistic worst case) are considered for the economic modelling outputs used to determine social impacts and therefore the construction labour sourcing is based on a realistic worst-case point-based estimate rather than a range.

In addition, it should be noted that the model functions using 2019 prices as this is the latest available data from Statistics Canada, however the cost estimates are in current prices. The costs are therefore required to be deflated to 2019 prices for the purposes of modelling and then inflated back to current prices for reporting. All financial values are presented in current prices but by the time the project is being constructed / has become operational these values may be significantly higher due to growth in productivity and inflation.

The economic model produces a set of initial estimates to highlight the overall headline results on employment and GVA by phase, as well as the sectoral distribution of these effects, in order to demonstrate potential opportunities for local industry. These effects are put into context by comparing to the size of the overall economy using published data. Importantly, the results also set out high-level estimates of the timing of impacts, given the typical phasing of a project of this nature and scale, especially capturing potential employment by year, and the possible timing of peak employment. This is an important input into the social impact assessment, for which reasonable ranges on the size of the on-site workforce and the likelihood of workers residing in Nova Scotia for an extended period is required.

1.2.4 Trades and Skills Assessment

This scope identifies which trades and skills are required to satisfy the different phases of the hypothetical production plant and assesses these against the existing supply side. There are two key elements to this:

- **Supply assessment:** Drawing on the baseline analysis undertaken as part of the economic impacts, a baseline position on the supply of these skills in Nova Scotia is drawn out, setting out the current skills position of the workforce and recent trends. This includes education and skills data available from Statistics Canada.
- **Demand assessment:** The report provides an overview of the skills and trades that are expected in each phase of the project, focusing on occupations, skill levels and expected earnings levels. This assessment draws on in-house experience from other large energy projects in the region as well as other areas where hydrogen facilities are being progressed.
- The assessment also highlights the potential measures to maximise the trades and skills benefits for Nova Scotia as well as any training needs to consider.

1.2.5 Social Impacts

Working from the Economic Impacts, the Social Impacts review created a range of assessments on the potential impacts and highlights the possible areas where the existing infrastructure capacity may come under strain as a result of the needs of additional workers and their families. This was created through:

- **Supply assessment:** Collected information on the presence and capacity of existing social and community infrastructure in Nova Scotia, taking into account information provided by Net Zero Atlantic (housing, healthcare, emergency response and protection, and other relevant infrastructure e.g., schools). This focuses on a suitable travel to work area from the potential site (e.g., 60-90 minutes), and draws on a range of data sources to provide the most appropriate data indicators of on existing capacity.
- **Demand assessment:** This assessment uses the estimated on-site workforce by year to arrive at an estimate of the likely additional population that may come to live in Nova Scotia, building to a peak labour year. The peak labour year is then used as the highest impact scenario. Using wider demographic data, informed assumptions on the potential wider family members who may accompany a transient workforce, along with the basis for estimating the potential demands for housing (by size and type), health services, schooling, and the typical incidence of emergency services use.

These elements are brought together to make an overall assessment on the potential demands on existing infrastructure, and to highlight any potential pinch points where additional provision may need to be planned for, recognising that there is considerable uncertainty, given that this is an ex-ante assessment of a potential project.

The magnitude of change for each measure has been determined through estimating the deviation from a baseline condition. The criteria used for the assessment of the magnitude of effects are shown below:

- High: The Development will cause a large change to the quality and / or integrity, when compared with existing social conditions;
- Medium: The Development will cause a moderate change to the quality and / or integrity, when compared with existing social conditions;
- Low: The Development will cause slight change to the quality and / or integrity, when compared with existing social conditions; and
- Negligible: No discernible change to the baseline social conditions.

The overall magnitude of impact considers additionality, by reviewing the potential additional population flows arising from the development and the length of time that the additional population will be on the project.

2. Hydrogen Landscape Review

There has been significant interest and growth in green hydrogen production over the past few years as a low-carbon fuel option to reduce greenhouse gas emissions. Nova Scotia and the rest of Eastern Canada have been identified as potential hydrogen production hubs due to its high potential for green hydrogen production using renewable wind power and for its access to numerous ports for green hydrogen / ammonia export.

This section highlights some of the trends in green hydrogen, focusing particularly on policy, industry, and technology highlights that support the growth and interest in this space.

2.1 Policy Highlights

In terms of policies, Canada has released several hydrogen-related policies and incentives in the past three years to push the green hydrogen industry forward. This includes the Hydrogen Strategy for Canada and the Clean Hydrogen Investment Tax Credit.

- **Clean Hydrogen Investment Tax Credit[3] –** A proposed refundable tax credit for clean hydrogen production investments mentioned in the 2022 Fall Economic Statement for projects made as of the day of Budget 2023, with the credit being phased out after 2030. The lowest carbon intensity tier that meets all eligibility requirements is proposed to receive an investment tax credit of at least 40 per cent.
- **The Hydrogen Strategy for Canada[4] –** A framework that was launched in December 2020 to position Canada as a global hydrogen leader and using this low-carbon/zero-emission fuel technology as a key part of our path to net-zero carbon emissions by 2050.
- **Hydrogen Strategy Steering Committee[5] –** The Minister of Natural Resources announced the Hydrogen Strategy Implementation Strategic Steering Committee, which will advance and measure the progress outlined in the Hydrogen Strategy for Canada launched in December 2020.

Many countries have also partnered together to take green hydrogen produced in one country and export it to another country as a low-carbon fuel. Some of the announced partnerships, including the Canada and Germany Hydrogen Alliance have been highlighted below.

[3] Department of Finance Canada, 'Government consulting on clean hydrogen and labour conditions for clean investment tax credits', *Government of Canada,* 2022 Government consulting on clean hydrogen and labour conditions for clean investment tax credits - Canada.ca
[4] Natural Resources Canada, 'Minister O'Regan Launches Hydrogen Strategy for Canada', *Government of Canada*, 2020 Minister O'Regan Launches Hydrogen Strategy for Canada - Canada.ca
[5] Natural Resources Canada, 'Canada launches hydrogen strategy steering committee', *Government of Canada*, 2021 Canada Launches Hydrogen Strategy Steering Committee - Canada.ca

- **Canada and Germany Hydrogen Alliance[6] –** Canada and Germany signed an agreement to collaborate on the export of clean Canadian hydrogen to Germany.
- **Abu Dhabi to Europe Green Hydrogen Export Agreement[7] –** Masdar, Port of Amsterdam, SkyNRG, Evos Amsterdam and Zenith Energy Terminals have signed a memorandum of understanding (MoU) to explore the development of a green hydrogen supply chain between Abu Dhabi and Amsterdam to support Dutch and European markets.
- **Australia Japan Clean Hydrogen Trade Partnership[8] –** Support projects to develop clean hydrogen and ammonia to export to Japan to deliver on Australia's commitment to reduce emissions by working with other countries to reduce the cost of clean energy technologies.
- **Australia-Germany Hydrogen Export Agreement[9] –** Australia and Germany signed a joint declaration on 13 June 2021 at the G7 Plus meeting, stating the commitment of the two countries to commercialise and purchase green hydrogen.
- **German–Australian Hydrogen Innovation and Technology Incubator initiative[10] –** Announced funding for four new joint projects under an initiative to reduce the cost of green hydrogen production and supports innovative technology in the industry.

2.2 Industry Highlights

Several companies have announced green hydrogen related projects for the upcoming years, some of which includes Yara, EverWind Fuels, Bear Head Energy, and TC Energy. There are also several green hydrogen production developments in Eastern and Atlantic Canada, specifically in Nova Scotia, New Brunswick, and Quebec. This is not an exhaustive list, only a few of the upcoming projects or partnerships are shown below:

- **EverWind Fuels[11] –** Announced that it has acquired the NuStar storage terminal in Point Tupper, Nova Scotia to develop a regional hydrogen hub for Eastern Canada with new green hydrogen and ammonia production facilities ready for as early as 2025.

[6] Natural Resources Canada, 'Canada and Germany Sign Agreement to Enhance German Energy Security with Clean Canadian Hydrogen', *Government of Canada*, 2022 Canada and Germany Sign Agreement to Enhance German Energy Security with Clean Canadian Hydrogen - Canada.ca
[7] Port of Amsterdam, 'Masdar Signs Agreement to Explore Exporting Green Hydrogen from Abu Dhabi to Europe', *Port of Amsterdam*, 2023 Masdar Signs Agreement to Explore Exporting Green Hydrogen from Abu Dhabi to Europe | Port of Amsterdam
[8] 'Australia Japan Clean Hydrogen Trade Partnership', *Ministers for the Department of Industry, Science and Resources,* 2022 Australia Japan Clean Hydrogen Trade Partnership | Ministers for the Department of Industry, Science and Resources
[9] Energy Magazine, 'Australia-Germany hydrogen export agreement signed', *Energy Magazine*, 2021 Australia-Germany hydrogen export agreement signed - Energy Magazine
[10] Minister for Climate Change and Energy, 'Growing Australia's hydrogen supply chain with Germany', *Ministers for the Department of Industry, Science and Resources,* 2023 Growing Australia's hydrogen supply chain with Germany | Ministers (dcceew.gov.au)
[11] EverWind Fuels, 'Everwind Fuels to establish a regional green hub in Nova Scotia', *News Wire,* 2022 EverWind Fuels to establish a regional green hydrogen hub in Nova Scotia reducing carbon emissions and bringing clean energy jobs to Nova Scotia (newswire.ca)

- **Eastward Energy[12] –** Working on a proposed project to produce 5 MW of low-carbon hydrogen in the Halifax Regional Municipality. The project will produce hydrogen through electrolysis using renewable electricity from a local wind project.
- **World Energy GH2[13] –** Proposed a green hydrogen production plant and a wind farm to power the facility near Stephenville, Newfoundland and Labrador. It is expected to go online in 2024 so exports of green hydrogen can start taking place in 2025, as called for in the Canada-Germany energy export agreement.
- **Bear Head Energy[14] –** Buckeye Partners LP has completed a takeover of Bear Head LNG. They have outlined plans to remake the export project into a large-scale green hydrogen and ammonia production facility. The electrolyser capacity is expected to be around 2 GW.
- **Irving Oil[15] –** Irving Oil purchased a 5 MW electrolyser from Plug Power, a leading provider of hydrogen solutions for their facility in Saint John, New Brunswick. The electrolyser is a proton exchange membrane (PEM) system and will be used at the refinery for the production and distribution of hydrogen. The initial phase of the electrolyser will be powered by the local grid and generate 730 tonnes of hydrogen annually for refining and mobility applications.
- **Halifax Port Authority and Hamburg Port Authority MOU[16]** – The Memorandum of Understanding (MOU) between the Halifax and Hamburg Port Authority created a collaboration to focus on the development and economic viability exporting hydrogen from the Port of Halifax to Hamburg.
- **Hydro-Quebec[17] –** Hydro-Quebec awarded an engineering contract to ThyssenKrupp to oversee the construction of an 88 MW water electrolysis plant in Varennes, Quebec. The plant is expected to produce 11,000 tonnes of green hydrogen annually.
- **Yara –** Signed a Letter of Intent with Statkraft and Aker Horizons in February 2021 to electrify and decarbonize Yara's ammonia plant in Porsgrunn to establish Europe's first large-scale green ammonia project in Norway[18]. In May 2021, Yara and ENGIE were awarded an ARENA grant to build (2023) the first industrial green hydrogen

[12] CHFCA, 'Eastward Energy', *CHFCA*, 2022 Eastward Energy - CHFCA
[13] CBC, 'Canada, Germany to sign hydrogen deal in N.L.', *CBC News*, 2022 Canada, Germany to sign hydrogen deal in N.L. | CBC News
[14] Buckeye Partners, 'Buckeye Partners Completes Bear Head Clean Energy Acquisition', *Yahoo News,* 2022 Buckeye Partners Completes Bear Head Clean Energy Acquisition (yahoo.com)
[15] Hydrogen Central, 'Plug Secures 5MW Electrolyzer Sale to Leading Canadian Energy Company Irving Oil', *Hydrogen Central,* 2022 Plug Secures 5 MW Electrolyzer Sale to Leading Canadian Energy Company Irving Oil - Hydrogen Central (hydrogen-central.com)
[16] Port of Halifax, 'Ports of Halifax and Hamburg working to decarbonize shipping corridor', *Port of Halifax*, 2022 Ports of Halifax and Hamburg working to decarbonise shipping corridor | Port of Halifax
[17] Thyssenkrupp, First Green Hydrogen Project becomes reality', *Thyssenkrupp,* 2021 First green hydrogen project becomes reality: thyssenkrupp to install 88 megawatt water electrolysis plant for Hydro-Québec in Canada
[18] Yara, 'Yara partners with Statkraft and Aker Horizons to establish Europe's first large scale green ammonia project in Norway', *Yara,* 2021 Yara partners with Statkraft and Aker Horizons to establish Europe's first large-scale green ammonia project in Norway | Yara International

plant within the existing Yara Pilbara (Australia) ammonia plant to deliver green ammonia[19].

- **TC Energy and Hyzon Hydrogen Agreement[20] –** TC Energy and Hyzon have executed an agreement to explore joint co-developing hydrogen hubs in the U.S. and Canada.

2.3 Technology Highlights

Innovative solutions are required to keep up with the demand for green hydrogen production and deployment. Currently, the largest operational green hydrogen plant has a capacity of 150 MW, where the largest green hydrogen plant under construction has a capacity of 2.2 GW and is expected to be operational by 2025.

- **Ningxia Solar Hydrogen Plant[21] –** It is the world's largest green hydrogen plant that is currently in operation owned by Baofeng Energy Group. It uses electricity from a 200 MW solar power plant located in northwest China's Ningxia Hui Autonomous Region to power a 150 MW of alkaline electrolysers.

- **Helios Green Fuels Project[22] –** It is the world's largest green hydrogen project that is currently under construction in Saudi Arabia. The project is developed by a consortium including Air Products and a Saudi utility called ACWA Power International. It will integrate more than 4 GW of solar and wind energy with storage to deliver around 0.24 million tonnes of green hydrogen or 1.2 million metric tons of green ammonia annually for export, beginning in 2025.

- **TC Energy and Plug Power Hydrogen Liquefaction[23] –** Plug Power has been awarded an order to deliver two 30 tonnes per day (tpd) hydrogen liquefaction systems to TC Energy. The two hydrogen liquefiers are scheduled for delivery in Q2-Q3 2024 and will serve TC Energy facilities in North America that are not yet operational.

- **H2V Energies Quebec[24] –** The facility will use plasma gasification technology to convert raw residual biomass materials such as waste wood and paper into syngas to produce green hydrogen without electrolysis. The estimated production capacity is 49,000 tonnes. The compressed hydrogen will start with a price of CAD $3.50/kg (2022), with taxes, deployment and delivery charges to be estimated on top of that. The facility is set to be constructed in Bécancour Industrial Park and scheduled for production in 2024.

[19] Yara, 'Renewable hydrogen and ammonia production – YARA and Engie welcome a A$42.5 million arena grant', *Yara,* 2021Renewable hydrogen and ammonia production | Yara International
[20] TC Energy, 'Hyzon Hydrogen Agreement', *TC Energy,* 2023 TC Energy — Hyzon Hydrogen Agreement
[21] Recharge News, 'Energy Transition', *Recharge News*, 2022 Record breaker | World's largest green hydrogen project, with 150MW electrolyser, brought on line in China | Recharge (rechargenews.com)
[22] Future Science News, Saudi Arabia starts shift to green fuel production, build $5B hydrogen plant', *Future Science News*, 2022 Saudi Arabia starts shift to green fuel production, builds $5B hydrogen plant (futuresciencenews.com)
[23] TC Energy, 'Plug to deliver two 30-tons-per-day hydrogen liquefaction systems to TC Energy', *TC Energy,* 2023 Plug to deliver two 30-tons-per-day hydrogen liquefaction systems to TC Energy
[24] Renewables Now, H2V Energies to build green hydrogen plants in Quebec, opens order book', *Renewables Now,* 2020 H2V Energies to build green hydrogen plant in Quebec, opens order book (renewablesnow.com)

- **Suiso Frontier Liquid Hydrogen Carrier**[25] – The Suiso Frontier built by Kawasaki Heavy Industries is the world's first liquid hydrogen carrier and its first load was shipping hydrogen from Port of Hastings, Australia to Kobe, Japan in January of 2022. The vessel is capable of carrying up to 1,250 m^3 of liquid hydrogen.

[25] New Atlas, 'Kawasaki launches the world's first liquid hydrogen transport ship', *New Atlas,* 2019 Kawasaki launches the world's first liquid hydrogen transport ship (newatlas.com)

3. Socioeconomic Baseline

3.1 Introduction

The socioeconomic baseline presents the key baseline positions for a variety of indicators relevant to the socioeconomic assessment of a large-scale hydrogen facility. This information has been collected using desk-based research gathering publicly available sources of information. The baseline position is then used in the assessment of socioeconomic impacts to understand the scale of change against existing conditions. The indicators are grouped into demographic, economic, trades and skills, and social indicators. The baseline assessment was completed in December 2022 and reflects the latest publicly available data at the time of collection. The full, detailed baseline analysis is set out in Appendix A. In this section we present the key points for the socioeconomic assessment.

3.1.1 Study Area and Geographies used in the Baseline

Baseline data has been collected and presented for Nova Scotia with Canada used as a national comparator to indicate provincial levels of performance in the different indicators. Where particularly relevant, a more granular level of data is also presented.

3.1.2 Data Sources

Hatch has conducted a baseline assessment of Nova Scotia related to the specific data indicators that are most likely to be impacted by the project. The table below sets out the main data sources considered in the baseline. It should be noted this has been supplemented with additional desk-based research when necessary.

Table 3-1: Baseline Assessment Overview

Subsection of Baseline	Data	Data Source(s)
Demographic	Current population and population trends	• Statistics Canada, 2022, ‘Population estimates on July 1st, by age and sex’.
	Indigenous population	• Statistics Canada, 2021, ‘Census, Nova Scotia Indigenous Population’.
	Population projections	• Statistics Canada, 2022, ‘Projected population, by projection scenario, age and sex’.
Economic	Employment (including sectoral analysis)	• Statistics Canada, 2022, 'Labor Force characteristics by province, monthly, seasonally adjusted, October 2022’.
	Business base (including sectoral analysis)	• Statistics Canada, 2022, ‘Canadian Business Counts, with employees’.
	Commuting	• Statistics Canada, 2022, ‘Commuting destination by main mode of commuting, age and gender’.

Subsection of Baseline	Data	Data Source(s)
	Economic value	• Statistics Canada, 2019, ‘GDP at basic prices, by sector and industry, provincial and territorial’.
	Productivity	• Statistics Canada, 2021, ‘Labor Productivity Data’.
	Hydrogen economy	• Desk-based research including CHFCA reports.
	Energy infrastructure	• Desk-based research from a variety of sources including government websites.
	GHG emissions	• Desk-based research including data from Canadian Energy Regulator.
Trades and Skills	Qualifications	• Varied desk-based research into qualifications and earnings.
	Occupational profile	• Statistics Canada, 2022, ‘Labor force characteristics by occupation, monthly, unadjusted for seasonality’.
	Higher / further education provision	• Varied desk-based research.
Social	Housing and visitor accommodation	• Statistics Canada, 2021, ‘Nova Scotia Housing’. • The Canadian Real Estate Association, 2022, ‘Average House Prices in Canada and Nova Scotia’. • Tourism Nova Scotia, 2022, ‘CBRE Hotels Trends in the Hotel Industry National Market Report: Tourism Accommodations’. • And a variety of desk-based research.
	Healthcare – family doctor patients and workforce	• Canadian Institute for Health Information: Supply, 2021, ‘Distribution and Migration of Physicians in Canada’. • Statistics Canada, 2021, ‘Nova Scotia Age’. • Nova Scotia Health, 2022, ‘Finding a primary care provider in Nova Scotia November, 2022’.
	Hospitals	• Government of Nova Scotia website. • Canadian Institute for Health Information, 2022, ‘Wait Times for Priority Procedures in Canada’. • Nova Scotia Health, 2022, ‘Action for Health – Public Reporting’. • And a variety of desk-based research.
	Emergency Response	• Government of Nova Scotia, 2022, ‘Amendments Support Volunteer Firefighters’. • Government of Nova Scotia, 2022, ‘Directory of Police Agencies in Nova Scotia’.

Subsection of Baseline	Data	Data Source(s)
		• Statistics Canada, 2021, 'Police personnel and selected crime statistics'. • And desk-based research including Government of Nova Scotia websites.
	Education	• Department of Education and Early Childhood Development, 2018, 'Number of Teachers by Region / Board'. • Statistics Canada, 2022, 'Educators in public elementary and secondary schools, by work status, age group and sex, 2020/21'. • Statistics Canada, 2022, 'Number of students in regular programs for youth, public elementary and secondary schools, by grade and sex, 2020/21'. • Department of Education and Early Childhood Development, 2022, 'Enrolments by region and level 2022/23'. • And other desk-based research methodology.

The baseline assessment allows us to provide important context surrounding the effects of the project, thus enabling a more holistic understanding of potential effects.

3.1.3 Baseline Data Limitations

The most up to date information available as of December 2022 has been used in the preparation of the baseline.

Given the conceptual nature of this Study there is no fixed location for the facility. As such it is not possible to narrow down the Study area to below the provincial data. Where appropriate more granular data is presented for the whole of Nova Scotia so that areas with particularly constrained supply can be highlighted.

3.2 Key Points Summary of the Demographic Baseline

The summary below sets out the key demographic baseline findings. The demographic baseline provides useful contextual information that is factored in to the assessment of economic, trades and skills and social effects of the large-scale hydrogen project (see Sections 1, 7 and 8).

Current Population

Nova Scotia had a total population of 1.02 million people in 2022[26].

Around 64% of Nova Scotia's population were of working age (aged 16-64) which is similar to the proportion of working residents in Canada (65%).

Nova Scotia has a higher proportion of residents aged 65+ than Canada and a lower proportion of residents aged 15 and under than Canada. This is reflective of the province's low birth rates.

There are around 52,000 Indigenous people in Nova Scotia, with around 28,000 identifying as First Nation citizens, 21,000 identifying as Métis, 1,000 as Inuit and the remaining identifying as 'other' groups. There are 43 reserves and according to data from 2014, 63% of Indigenous people in Nova Scotia live on a reserve[27].

Population Trends

Historically Nova Scotia has struggled to retain its young working aged population, with significant levels of outmigration (especially to Ontario) due to a relative lack of economic opportunities owing to the collapse of the fisheries industry in Atlantic Canada in the early 90s and the lack of major sized cities compared to other Canadian provinces. This, combined with low birth rates, has meant long periods with stagnant population growth. Recently the province has seen an uplift in population[28] due to increased levels of migration into the province both from international migrants and from the rest of Canada.

Projected Population Growth

Nova Scotia's population is expected to increase by just under 11% (based on a medium growth scenario[29]) between 2021 and 2043, which compares to a 25% increase in Canada[30]. Within this, the working age population is expected to increase by only 4%, compared to 18% in Canada.

3.3 Key Points Summary of the Economic Baseline

The summary below sets out the key economic baseline findings. The economic baseline is used in the assessment of economic and trades and skills effects of the large-scale hydrogen project (see Sections 1 and 7). Importantly this is used to assess the potential change on baseline economic and trades and skills conditions and also the local potential to capture the project expenditure within Nova Scotia.

[26] Statistics Canada: Population estimates on July 1st, by age and sex (2022)
[27] Statistics Canada, 2021, Indigenous identity by Registered or Treaty Indian status and residence by Indigenous geography: Canada, provinces and territories.
[28] Statistics Canada: Population estimates on July 1st, by age and sex (2022)
[29] Based on the medium growth 3 scenario.
[30] Statistics Canada, 2022. Table 17-10-0057-01 Projected population, by projection scenario, age and sex, as of July 1 (x 1,000) https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710005701

Employment and labour market performance

In 2022, there were around 442,000 full-time equivalent (FTE) jobs from a labour force of 516,000 people[31].

The employment rate was 56.7% in Nova Scotia (lower than Canada at 61.6%). The participation rate was 60.8%, (lower than Canada at 64.9%) and the unemployment rate was 6.7% (higher than the average for Canada of 5.2%)[32].

Economic performance can be linked to outmigration of skilled workers and decades of stagnating population (if not actual decline). This had negative implications on the economy in terms of aging population, diminishing labour force, and declining tax revenue[33]. The lower employment rate may also suggest significant capacity in the labour market. Notably apprentice and trades level educated groups in Nova Scotia show higher unemployment rates than average[34].

Business base

There are over 31,650 registered businesses in Nova Scotia. Nova Scotia has a larger proportion of smaller businesses (below 100 employees), and a lower proportion of medium sized businesses, than Canada. The province has just 73 businesses with over 500 employees; however, this is broadly reflective of the proportion of larger businesses seen nationally[35].

Sectoral composition[36 37]

Nova Scotia's largest sectors comprise healthcare (16% of total FTE employees), wholesale and retail trade (15%), and construction (8%). Nova Scotia has a specific specialism in fishing, hunting, and trapping (with a Location Quotient (LQ)[38] of 13.7), with this tied to the province's history and geography.

Nova Scotia has significant economic strengths that could be utilized in the development of a large-scale hydrogen facility to promote local jobs creation and economic growth. The following sectors are highlighted as they are particularly relevant to the development and operation of a large-scale hydrogen facility. The data below shows the relative size of each sector's workforce and employing businesses:

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[31] Estimation based on the proportion of full time and part time workers in Nova Scotia. It is assumed 1 part time worker represents 0.5 FTEs
[32] Labour Force characteristics by province, monthly, seasonally adjusted (October 2022)
[33] Toronto Star, 'Nova Scotia's Long Population Decline Might be Ending, and Immigration Could be Why', *Toronto Star*, 2021 Nova Scotia's Long Population Decline Might be Ending, and Immigration Could be Why | The Star
[34] Nova Scotia, 'Unemployment', *Nova Scotia,* 2023 Unemployment | Careers Nova Scotia
[35] Add/Remove data - Canadian Business Counts, with employees, June 2022 (statcan.gc.ca)
[36] Statistics Canada, Labour Force Characteristics (2021)
[37] Statistics Canada, Canadian business counts, June 2022
[38] The Location Quotient (LQ) is a method of quantifying how concentrated a particular industry, cluster, occupation or demographic group is in a region as compared to the respective national average. The FTE jobs LQ measures the proportion of employment in each given sector relative to the Canadian average whereas the business LQ measures the proportion of businesses in a sector relative to the Canadian average.

- **Construction:** 34,450 FTE employees (8% of the workforce), 3,725 businesses (12% of businesses) and FTE jobs and business LQ of 1.0.
- **Professional, scientific and technical:** 32,350 FTE employees (8% of the workforce) and 2,320 businesses (7% of businesses). FTE jobs LQ of 0.8 and business LQ of 0.6.
- **Manufacturing:** 31,650 FTE employees (8% of the workforce) 1,070 businesses (3% of businesses). FTE jobs LQ of 0.8 and business LQ of 0.9.
- **Transportation and warehousing:** 22,500 FTE employees (5% of the workforce) 1,055 businesses (3% of businesses). FTE jobs LQ of 1.0 and business LQ of 0.6.
- **Utilities:** 4,600 FTE employees (1.1% % of the workforce) 37 businesses (0.1% of businesses). FTE jobs LQ of 1.3 and business LQ of 1.1.
- **Mining, quarrying, and oil and gas extraction:** 2,500 FTE employees (0.6% of the workforce) 62 businesses (0.2% of businesses). FTE jobs LQ of 0.4 and business LQ of 0.3.

Commuting

Commuting statistics show 98% of Nova Scotia commuters commuted within their province. The most common commuting pattern observed is residents commuting from their home in Halifax to their place of work also in Halifax. On the other hand, 2% of Nova Scotia commuters commuted to another province or territory or into Nova Scotia from another province[39]. The rate of cross province commuting in Nova Scotia is generally lower than other larger provinces within Canada. Often in rural areas there are higher rates of people commuting longer distance for jobs in primary sector industries (such as fishing forestry and mining).

Economic value and productivity[40]

In 2019, Nova Scotia contributed almost CAD $43 billion to the Canadian economy in GDP (at basic prices). The most relevant sectors to the Study delivered the following levels of GDP in 2019:

- **The manufacturing sector:** CAD $3.16 billion (7.3% of Nova Scotian GDP).
- **The professional, scientific, and technical services sector:** CAD $1.93 billion (4.5% of Nova Scotian GDP).
- **The transportation and warehousing**: CAD $1.46 billion (3.4% of Nova Scotian GDP).
- **Engineering construction and non-residential building construction sectors:** CAD $1.09 billion (2.5% of Nova Scotian GDP - 1.6% and 0.9%, respectively).
- **The utilities sector:** CAD $0.85 billion (2.0% of Nova Scotian GDP).

[39] Statistics Canada, 2022, Commuting flow from geography of residence to geography of work by main mode of commuting, commuting duration and gender: Census metropolitan areas and census agglomerations (statcan.gc.ca).
[40] Gross domestic product (GDP) at basic prices, by sector and industry, provincial and territorial.

- **The mining, quarrying, and oil and gas extraction sector** CAD $0.34 billion (0.8% of Nova Scotian GDP).

Nova Scotia continues to have the second lowest labour productivity among the 10 provinces in 2021, at CAD $44.0 in real value added per hour. Across most industries, labour productivity in Nova Scotia was lower than the national level. In comparison to Nova Scotia, other higher resource producing provinces like Alberta and Newfoundland and Labrador generate high amounts of real value added relative to the hours worked / size of their workforce. This is because they specialize in capital-intensive industries that require comparatively fewer hours worked to generate high levels of GDP. These provinces tend to create high levels of labour productivity which drives up the national labour productivity average[41].

Hydrogen economy

Hydrogen production in Canada has made significant strides over the last 5 years with hydrogen now forming a key part of the planned transition to net zero. Green hydrogen production plays an important role in decarbonizing energy production within Canada. the province in regard to Canadian The development of the hydrogen economy presents significant opportunities for job creation[42].

Commercial Port Infrastructure

There are numerous commercial ports located across Nova Scotia, with the largest located in Halifax and smaller ports located across the province. In 2017, the Port of Halifax contributed CAD $4.56 billion gross output and 22,400 jobs to Nova Scotia's economy[43], with the direct portion of gross output being CAD $2.5 billion.

Energy infrastructure

Nova Scotia's energy infrastructure is still largely reliant on coal production[44]. The Environmental Goals and Climate Change Reduction Act mandates the phase out of coal generated electricity by 2030.

The province has a history of offshore oil & gas production although this sector has seen no production since the cessation of the Sable Offshore Energy Project and the Deep Panuke Project in 2018.

An array of renewable energy projects has been developed in Nova Scotia with hydroelectricity being the first to be developed and wind now forming an important role in decarbonizing the electricity supply.

[41] Labour productivity is calculated by dividing the real value added by the estimated number of hours worked. The real value added is constructed from the fisher chain index
[42] Chapter 2 - Jobs, Growth, and an Economy That Works for Everyone | FES 2022 (canada.ca)
[43] Port of Halifax operations provides almost $2 billion in economic output each year | AJOT.COM
[44] Clean Energy| Nova Scotia Power (nspower.ca)

Greenhouse gas emissions

Nova Scotia's GHG emissions in 2020 were 14.6 megatonnes (MT) of carbon dioxide equivalent (CO_2e). Emissions have declined 25% since 1990 and 36% since 2005. Per capita emissions are below the Canadian average[45].

The largest emitting sectors include electricity generation (43%), transportation (30%) and commercial and residential buildings (14%)[46]. In 2020, Nova Scotia's power sector emitted 6.3 MT CO_2e emissions, which represents about 11% of Canadian emissions from power generation. Greenhouse gas intensity of Nova Scotia's electricity grid, was 670 grams of CO_2e per kilowatt-hour (g of CO_2e/kWh) electricity generated in 2020.

The table below shows a breakdown of employment and business base data for most relevant sectors and total of all sectors:

45 Canada Energy Regulator, 'Provincial and Territorial Energy Profiles', *Canada Energy Regulator*, 2023 CER – Provincial and Territorial Energy Profiles – Nova Scotia (cer-rec.gc.ca)
46 Canada Energy Regulator, 'Provincial and Territorial Energy Profiles', *Canada Energy Regulator,* 2023. CER – Provincial and Territorial Energy Profiles – Nova Scotia (cer-rec.gc.ca)

Employment and business base data for most relevant sectors and total of all sectors

Sectors	Employment data			Business base data					
				Total employing businesses			Business size breakdown		
	No. of FTE jobs	% of total FTE jobs	FTE jobs LQ	Number of employing businesses	% of total employing businesses	Business LQ	No. of businesses with 1-99 employees	No. of businesses with 100-499 employees	No. of businesses with 500+ employees
Construction	34,450	8%	1.0	3,725	12%	1.0	3,704	20	1
Professional, scientific and technical	32,350	8%	0.8	2,320	7%	0.6	2,289	28	3
Manufacturing	31,650	8%	0.8	1,069	3%	0.9	1,003	59	7
Transportation and warehousing	22,500	5%	1.0	1,055	3%	0.6	1,027	25	3
Utilities	4,600	1.1%	1.3	37	0.1%	1.1	29	6	2
Mining, quarrying, and oil and gas extraction	2,500	0.6%	0.4	62	0.2%	0.3	57	4	1
All sectors	**419,650**	**100%**	**n/a**	**31,660**	**100%**	**n/a**	**31,035**	**550**	**73**

Source: Canadian business counts, June 2022. Note: non employer businesses not included and Statistics Canada: Labour Force Characteristics (2021) and Statistics Canada: Labour Force Characteristics (2021)

Note various degrees of rounding are used.

3.4 Key Points Summary of the Trades and Skills Baseline

The summary below provides additional information to the economic baseline that is specially targeted at gaining a greater understanding of the trades and skills baseline context. The trades and skills baseline is used to assess the potential for change of baseline trades and skills conditions and also the local capacity to maximize trades and skills benefits (see Section 7).

Relevant qualifications

There could be a large overall risk of some shortage of skills (e.g., graduate level engineers) if there is a rapid hydrogen economy expansion.

The qualifications required for operational roles in a hydrogen production facility may range from apprenticeships to high school degrees to on-the-job training to a bachelor's or master's degree qualification. Generally, they will require technical skills.

The earnings and education requirements vary across different parts of the hydrogen economy. For example, a hydrogen lab technician requires an associate degree and earns a salary of approximately CAD $41,000. Whilst a junior hydrogen energy technician may require only a high school degree and earns a salary around CAD $25,000[47].

Occupational profile

The hydrogen economy's skills requirements are varied (varying in skill level from a fuel cell intern to director). Moreover, there will be high demand for technical and engineering occupations roles including hydrogen fuel cell system technician, hydrogen vehicle technician, hydrogen energy system operations engineer and hydrogen energy system installers. Occupations engaging in hydrogen technology research and innovations are also important to the continued advancement of the sector.

Nova Scotia has a significant proportion (14%) of its workforce (138,000 people) engaged in trades, transport and equipment operators and related occupations. Some of these have necessary skills in the building and operation of a hydrogen facility. Other relevant occupations include natural and applied sciences (72,000 workers, or 7% of occupations), manufacturing and utilities (41,000 workers, 4% of occupations) and natural resources; agriculture and related production (22,000 workers, 2% of occupations)[48].

Higher / further education provision

Nova Scotia has several universities that are strong in their reputation for engineering (based on their research performance) including Dalhousie University (Halifax), Acadia University (Wolfville), Saint Mary's University (Halifax), St. Francis Xavier University (Antigonish) and Cape Breton University (Sydney)[49].

The Nova Scotia Apprenticeship Agency (NSAA) offers a wide range of apprenticeships across multiple industries. These include power engineer, mechanical vehicle operator, oil heat

[47] Cavendish Energy, *Emerging occupations and skills in the hydrogen/fuel cell economy and associated education and training requirements*, 2016.
[48] Labour force characteristics by occupation, monthly, unadjusted for seasonality (statcan.gc.ca)
[49] Engineering in Nova Scotia: 5 Best universities Ranked 2022 (edurank.org)

system technician, automotive service technician, communications technician, and powerline technician.

Approximately 2,200 Nova Scotians are enrolled in an apprenticeship each year. Almost all the training is offered through the Nova Scotia Community College (NSCC) system. The college offers more than 120 programs at 13 campuses across the province, with more than 10,000 students[50].

3.5 Key Points Summary of the Social Baseline

The summary below sets out the key social baseline findings. The social baseline is used in the assessment of the potential social effects of the large-scale hydrogen project (see Section 8). Importantly the baseline is used to assess the potential change on social infrastructure supply and thus highlights where demand and supply issues may occur.

Housing and visitor accommodation

The affordability of accommodation in Nova Scotia is comparable to the rest of Canada; however, house prices have risen considerably since 2018. Housing affordability is a particular issue in Halifax[51], where house prices are 1.3 times greater than the Nova Scotia average and 22% of residents spend more than 30% of their income on housing costs.

Health

The provision of family doctors appears to be an issue in Nova Scotia, with over 10% of the population currently on a waiting list to register with a family doctor[52]. Additionally, 15% of family doctors in Nova Scotia are of retiring age or above, which poses future risks surrounding family doctor provision.

Hospital services appear to be operating effectively, with hospitals reporting an average capacity of 87% over the past 18 months[53]. However, average wait times for priority surgeries are longer than the Canadian average indicating that certain services are under strain.

Emergency response

Emergency Health Services (EHS) appear to be under strain with the province experiencing particular challenges surrounding ambulance response times (24.9 minutes on average) and offloading times.

Nova Scotia has 1.9 police officers per 1,000 of the population, which is slightly above the Canadian rate of 1.8, with many municipal police forces across the province exceeding this rate[54].

[50] Post-Secondary Options | Halifax Regional Centre for Education (hrce.ca)
[51] The Nova Scotia Affordable Housing Commission Report, 2021
[52] Statistics Canada, 'Primary Health care providers, 2019',
[53] Nova Scotia Government, 'Action for Health – Public Reporting', *Tableau*, 2023
[54] Statistics Canada: Police personnel and selected crime statistics, 2021

Education

Student-teacher ratios in Nova Scotia are slightly above those in Canada, and Nova Scotia has seen an increase in the number of enrolments into its schools over the past 5 years. The Strait Regional Centre for Education area has a lower student teacher ratio of 11.5 indicating that there may be schools in this district with capacity for additional students[55].

[55] Department of Education and Early Childhood Development, 2018

4. Plant Overview

This section provides an overview of the plant design in terms of electrolysis technology selection, a process description, and the design basis for the proposed plant.

4.1 Process Description

The overall plant will consist of the following main areas:

- 500 MW Green Hydrogen Production Plant
- Intermediate Hydrogen Storage
- Ammonia Production Plant
- Liquid Ammonia Storage Tank
- Marine Export Infrastructure
- This section provides a description of the process. An overview block flow diagram illustrating the scope of the overall plant is provided in Figure 4-1.

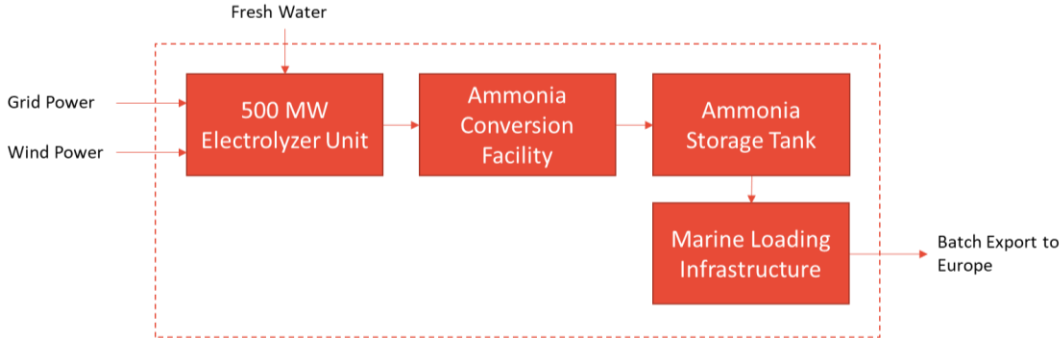


Figure 4-1: Overview Block Flow Diagram of the Overall Plant

4.1.1 Green Hydrogen Production

Two electrolyzer technologies were considered for this Study – alkaline and polymer electrolyte membrane (PEM), which are the two most mature technologies in hydrogen electrolysis. Alkaline electrolysis consists of immersing two electrodes in an aqueous solution of potassium hydroxide (potash, KOH) where the concentration varies between 20 and 30%. The two electrodes are separated by a semi-permeable diaphragm that allows water and charged molecules to pass through but not oxygen and hydrogen under the effect of an electric current. By comparison, PEM electrolysis technology uses a solid polymer to conduct ions. The membrane allows H+ ions to pass from the anode to the cathode while electrons pass through the external circuit when a current is applied between the two electrodes of the system.

Only one technology has been evaluated as part of the design and CAPEX estimate. Alkaline electrolysis has been selected for this Study because it is the most mature electrolysis process, there are no footprint or response time restrictions for this Study, and because it is the least capital-intensive technology of the two prominent options presented. A more detailed comparison of these technologies is included Appendix B.

The hydrogen production plant will consist of alkaline electrolyzers connected in parallel to achieve the overall production capacity for the plant. Each electrolyzer consists of an electro-chemical stack – where hydrogen gas is produced by applying a direct current (DC) through a water-electrolyte solution, splitting the water into oxygen and hydrogen, and balance of stack components such as gas separators, and water / lye circulation loops. An example of an alkaline electrolyzer stack is shown in Figure 4-2.

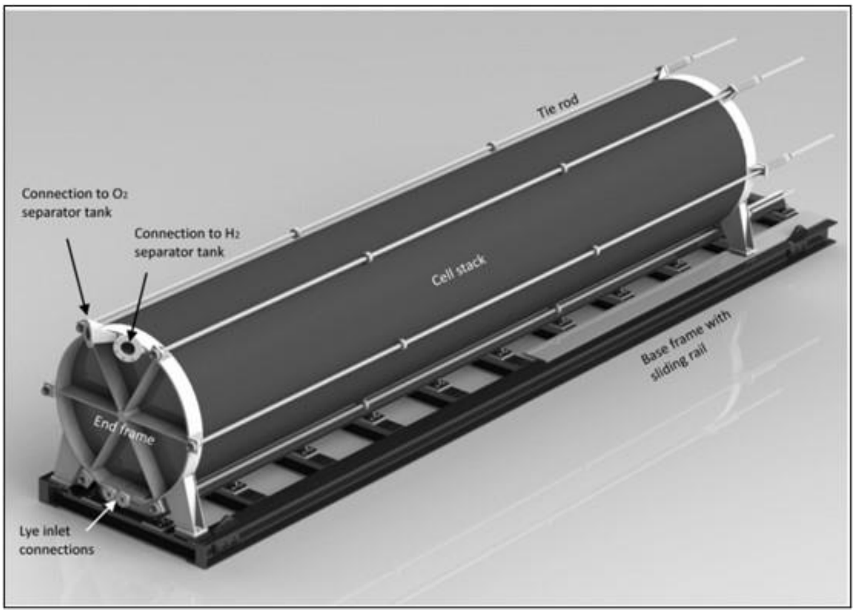


Figure 4-2: A Representative Version of an Alkaline Electrolyzer Stack shown without Balance of Stack / Auxiliary Equipment

Following the generation of saturated hydrogen gas in the electrolyzers, the gas is purified and pressurized to meet the requirements of the ammonia plant via scrubbers, compressors, deoxo units, and dryers.

The Balance of Plant (BoP) to support operation of the electrolyzers includes the following auxiliary systems:

- a demineralized water treatment plant to supply pure and low conductivity water the electrolysis process;
- an electrolyte system, which controls the flow of liquid electrolyte into and out of the electrolyzers and collects / separates the hydrogen and oxygen produced from the electrolyzers into separator vessels;
- an instrument air system to supply dry and compressed air to plant instrumentation; and
- a thermal management (cooling system) to reject heat generated from the electrolyzers.

4.1.2 Hydrogen Storage

A hydrogen storage buffer is required between the hydrogen and ammonia plants to smooth out pressure fluctuations and account for minor discrepancies in the operating loads between the two plants. Bulk hydrogen storage was not considered in this Study but would be necessary if the hydrogen plant is expected to ramp up and down to follow renewable power (wind) production while the ammonia plant has much lower ramping capabilities and prefers a consistent feed to maintain production. Although, the final hydrogen product can be sold separately, this Study assumes that all hydrogen produced is sent to the ammonia production plant via a short pipeline.

4.1.3 Ammonia Production

Ammonia is a form of hydrogen carrier well-suited for long distance transportation. Ammonia can be used to transport hydrogen, but it can also be used directly in many industries, primarily as a raw material for fertilizers and chemical production. Ammonia is currently industrially produced from the Haber-Bosch process via the following reaction:

$$N_2 + 3H_2 \rightarrow 2\ NH_3$$

It is a well-established process in the chemical industry. The process combines hydrogen and nitrogen at high pressure and high temperature to produce ammonia. As part of the process, an Air Separation Unit (ASU) is required to generate nitrogen gas by separating it from ambient air. At high pressures between 150 to 300 bar and temperatures between 350 and 500°C, nitrogen gas and hydrogen gas adsorb onto an iron-based catalyst to react and form ammonia. The reaction generates heat, and the resulting gas is cooled to produce liquid ammonia. Any unreacted synthesis gas is recycled to form ammonia[56]. If the process is powered using renewable electricity and uses green hydrogen as feedstock, the product is referred to as ‘green ammonia’.

4.1.4 Ammonia Storage

Ammonia produced by the ammonia plants will be transferred to ammonia storage tanks in nearby proximity to the jetty via a main ammonia product line.

Liquid ammonia product will be stored in refrigerated ammonia storage tank(s) at near-atmospheric pressure. Ammonia at 1 bar has a saturation temperature of -33.5°C. At 25°C, the saturation pressure of ammonia is 10 bar. As such, large quantities of ammonia are stored in insulated atmospheric tanks with active boil-off management systems to avoid high pressure storage design requirements as would be required for ambient temperature storage.

During normal operation, ammonia vapour generated in the storage tank will be sent back to the ammonia plant refrigeration system to be compressed and condensed before returning to the storage tank. An ammonia storage flare system is also required for a safe incineration of ammonia vapour in the event of boil-off management system failure, power outage, or downtime.

[56] I. I. Cheema and U. Krewer, "Operating envelope of Haber–Bosch process design for power-to-ammonia," *Royal Society of Chemistry: RSC Advances,* vol. 8, pp. 34926-34936, 2018

4.1.5 Ammonia Export

From the ammonia storage tank(s), an ammonia forwarding unit (pumps) will transfer the liquid ammonia to the jetty and marine vessels at the berth through an ammonia loadout pipeline, where ammonia can be loaded out to the shipping vessel.

4.2 Plant Design Basis

This section provides a high-level design basis for the overall plant. A detailed design basis has been included in Appendix B. The key production and storage assumptions for this 500 MW hydrogen production plant are highlighted in Table 4-1.

Table 4-1: Key Design Parameters

Parameter	Value
Design Hydrogen Production Rate	252 tH_2/day
Design Ammonia Production Rate	1,428 tNH_3/day
Design Ammonia Storage Capacity	~50,000 tonnes (~73,000 m^3)

The following assumptions have been made for the overall plant:

- The construction of the overall plant will be built out in a single phase.
- The construction will take place as soon as possible, and therefore only mature technologies are considered.
- The site is Greenfield in Nova Scotia, but no specific location has been identified. As such, there are no layout / footprint constraints.
- The site will have access to the fresh water required for electrolysis. There is a nearby connection to a continuous supply of municipal water.
- Each plant (hydrogen and ammonia) are separate, standalone facilities. No optimization of common utilities was assumed at this stage of the project.
- The overall plant operates continuously at steady state. No operating optimization has been considered (e.g., turning on / off and ramping up / down the hydrogen and ammonia plants).
- The overall plant will be located near an existing port in Nova Scotia. The project is assumed to be located within a 1-hour drive time of populated centres that are large enough to provide accommodation for the limited number of permanent onsite employees and their families.
- Loading infrastructure will be added to an existing port and berth.
- Plant design life is 30 years.

5. Cost Estimate

The order-of-magnitude (OoM) cost estimate for this Study has been prepared based on limited information, and subsequently has a wide accuracy range. As such, this estimate is not classified in terms of AACE International recommended guidelines. This estimate has been prepared to estimate the socioeconomic impacts of a hydrogen production and export facility of this scale – the details of this impact are quantified and discussed further in starting with Section 1 of this report.

The methodology for this estimate incorporates factored cost estimates based on Hatch's in-house data and experience in previous studies. The costs for this estimate are expressed in Canadian dollars (CAD $) 2022.

5.1 Capital Expenditure (CAPEX) Estimate Summary

The total CAPEX for the project is estimated at CAD $3.15 billion. The estimate was prepared to the level of a scoping study with an expected accuracy range of +100/-50%. Figure 5-1 below shows the CAPEX breakdown of the overall plant and Table 5-1 provides the cost breakdown. The basis of estimate is captured in .

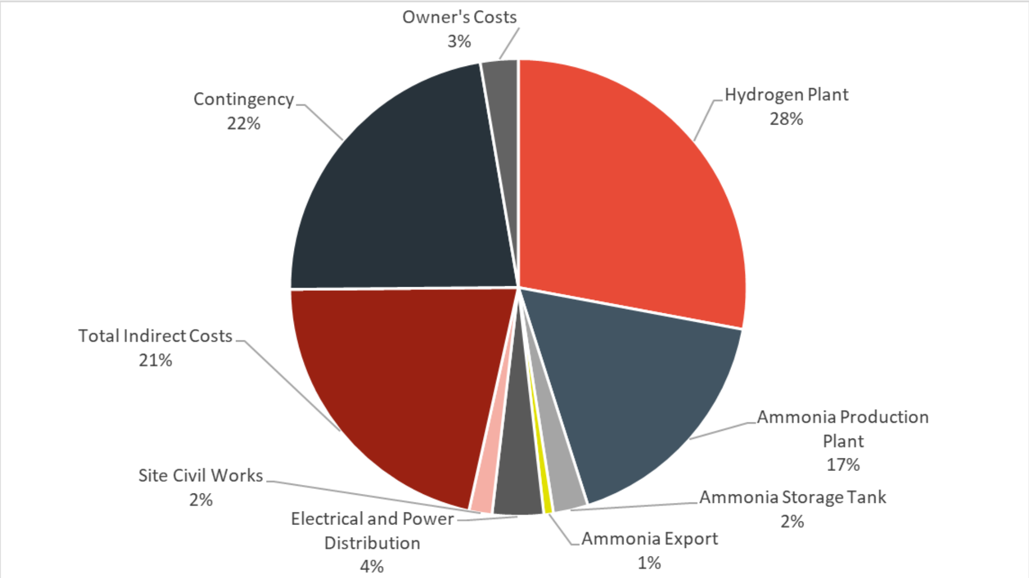


Figure 5-1: Total Hydrogen and Ammonia CAPEX

Table 5-1: Overall Plant CAPEX Breakdown

Area Description	Cost (MM CAD $)
Hydrogen Production Plant	879
Ammonia Production Plant	540
Ammonia Storage Tank	78
Marine Infrastructure	21
Electrical and Power Distribution	114
Site Civil Works	51
Total Direct Costs	**1,683**
Total Indirect Costs (40%)	**673**
Contingency (30%)	**707**
Total Installed Cost (TIC) [Before Owner's Costs]	**3,064**
Owner's Costs (5%)	84
TIC [Including Owner's Costs]	**3,148**

5.2 Operating Expenditure (OPEX) Estimate Summary

The high-level operating cost estimate was prepared based on Hatch's experience in previous projects and publicly available information. A breakdown of the operating costs is provided in Table 5-2 below.

Table 5-2: Overall Plant OPEX Breakdown

Area Description	Cost (MM CAD $/year)
Direct Onsite Employment Costs	5.4
Power Cost [Electricity]	310
Utilities [e.g., Water]	1.9
Repair and Maintenance [Fixed]	49
Sustaining Expenditure (SUSEX) [Stack Replacement and Catalyst]	24

In addition to these costs, the marine terminal handling rates are estimated at approximately CAD $3 million to CAD $4 million. These costs have not been incorporated into the socioeconomic impact assessment because the project assumes it will use an existing port. Port costs have been excluded from this Study but should also be incorporated into future phases of OPEX development. The basis and complete details of these estimates are included in Appendix B.

6. Economic Impacts

The economic impact assessment highlights the overall core impacts on employment and GVA by phase, as well as a high-level indication of the extent to which this is linked to the construction sector compared to other sectors of the local economy (e.g., manufacturing and engineering). These effects are put into context by comparing to the size of the overall economy using the published data presented in Section 1. The results also especially capture the annual peak non-home-based construction employment, since this is a key input into the social impact assessment presented in Section 8.

The potential wider economic impacts that may occur in addition to the core impacts are also considered.

6.1 Modelling Inputs and Key Assumptions

6.1.1 Total Costs

Hatch's engineers conducted an assessment of the estimated costs of developing a 500 MW hydrogen facility in Nova Scotia. The high-level costs are as follows:

- The total CAPEX for this project is estimated at CAD $3.15 billion.
- The total OPEX for the overall plant is assumed to be CAD $391 million per year. However, electricity costs are estimated to make up the majority of the total hydrogen production plant OPEX and these costs are excluded from the economic modelling. When excluding power, the costs are estimated to be CAD $81 million CAD per year[57].

The full report output will provide further information on the split of these costs and the assumptions sitting behind how these costs have been derived. However, as the focus of this note is on the economic outputs these costs are not covered in anymore detail.

6.1.2 Sourcing Levels

Given that hydrogen is a nascent industry, and the 500 MW project is conceptual (with no set location), there are uncertainties and a lack of publicly available information to draw from to inform the sourcing assumptions. This assessment, therefore, presents both base and high sourcing scenarios to account for uncertainties over the sourcing assumptions for the spatial expenditure profile of both the construction and operational phases.

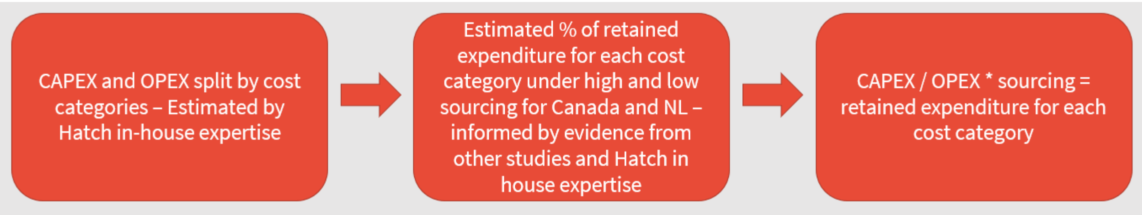


Figure 6-1: Cost and Sourcing

[57] Power costs are excluded as they are very high but are unlikely to result in large scale additional employment. This is due to the fact the input-output derived multipliers give the average effect rather than the marginal effect of additional expenditure.

6.1.3 Construction Phase

It is estimated that between 17% and 21% of non-construction labour expenditure during the construction phase would be retained within Nova Scotia. Our analysis of baseline conditions showed that Nova Scotia is developing some expertise around constructing hydrogen facilities and has relevant existing experience in developing energy infrastructure projects.

It is also estimated that around 25% of construction labour costs are retained within Nova Scotia (by procuring Nova Scotian construction companies) with the majority of expenditure on construction labour leaving the province due to the utilization of non-Nova Scotian construction companies and workforce (as noted in more detail in Section 6.1.4).

Certain expenditure groups have potential to see greater levels of expenditure captured locally than others. The figure below provides an overview of potential sourcing levels across the range of hydrogen project expenditure categories used in the economic model.

For the direct equipment, there are generally assumed to be minimal manufacturing capabilities within Nova Scotia for producing specialized high-value equipment used in hydrogen production with some limited capabilities in sourcing the less specialized equipment from local manufacturers.

For the indirect costs it is assumed that there is a significant opportunity to capture the majority of this expenditure within Nova Scotia. In many instances (such as transportation) it makes commercial sense for the developer to draw on local companies.

For the construction labor involved in installation activity, Nova Scotia has an existing local construction workforce that can be drawn upon to construct the facility but the scale of the construction workforce means that the project is also very likely to draw from construction companies using construction workers who usually reside outside of the local area.

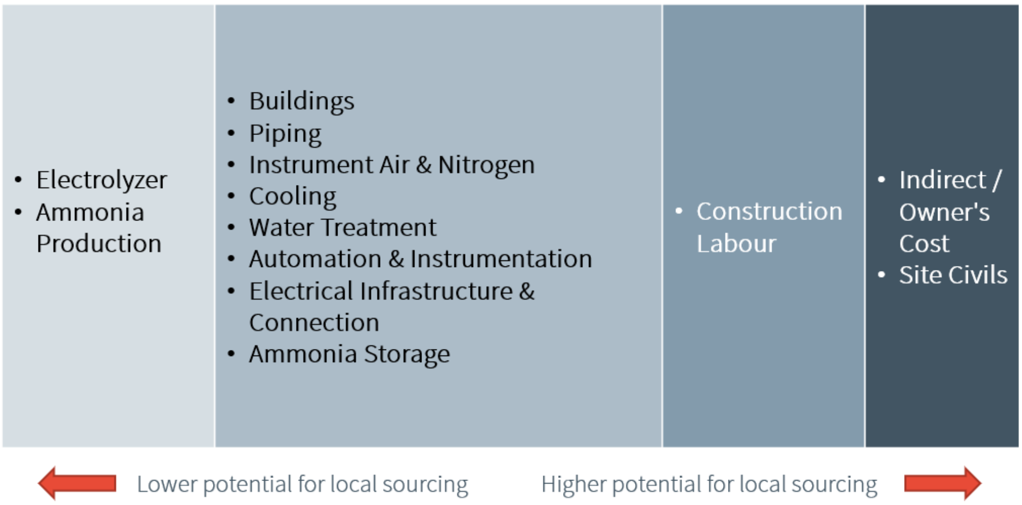


Figure 6-2: Local Sourcing Potential during the Construction Phase

A high-level summary of the sourcing assumptions used in the assessment by expenditure group is outlined below. Overall, it is estimated that 27%-32% of expenditure during the construction phase will be retained within Nova Scotia. The majority of this retained through expenditure on indirect costs (on engineering, procurement, construction management, temporary accommodation, pre-operational commissioning, freight, spare parts, third-party consultation and first fills[58]). In contrast, there is very limited potential to source direct equipment locally due to the specialized equipment required.

Site civils refer to the construction of infrastructure and facilities required to support a building or structure, such as roads, parking lots and drainage systems. Site civils also has a higher local sourcing potential as local companies could be brought in for this activity.

Considering the conditions of the economy it is estimated that 25% of construction labour expenditure will be retained locally (the justification for this assumption is set out in further detail in Section 6.1.4). A point estimate is provided here rather than a range to account for the need to consider a maximum impact scenario (i.e., a scenario with the highest realistic influx of local construction workers). Therefore, the retained level of construction labour should be treated as conservative.

Table 6-1: Overview of Sourcing Assumptions for the Construction Phase

Expenditure group	Expenditure (MM CAD $)	Sourcing (% of retained expenditure within Nova Scotia)	Retained Expenditure (MM CAD $)	Notes
Direct Equipment	1,185	0%-2%	0-19	There is minimal manufacturing capacity within Nova Scotia for producing the specialized high-value equipment used in hydrogen production. There are some limited capabilities in providing less specialized equipment.
Indirect Costs*	758	70%-85%	530-644	Much of this expenditure is likely to be captured within Nova Scotia. In many instances it would be an advantage to utilise local suppliers (e.g., transportation).

[58] Lubricants, lye, water treatment chemicals, etc.

Expenditure group	Expenditure (MM CAD $)	Sourcing (% of retained expenditure within Nova Scotia)	Retained Expenditure (MM CAD $)	Notes
Construction Labour	499	25%	125	This is an upper estimate based on baseline conditions in economy and key sectors. More information on how this is estimated is set out in Section 6.2.
Total*	2,441	27%-33%	655-788	

* Please note contingency is excluded from these costs as contingency costs are not factored into the model due to the risk of overestimating benefits. Owner's costs are included in this total.

6.1.4 *Operational Phase*

The figure below provides an overview of potential sourcing levels across the range of hydrogen project operational expenditure categories. It is assumed that all onsite employees whose main place of work is the hydrogen facility are Nova Scotian residents. The project is assumed to be located within a 1-hour drive time of populated centres that are large enough to provide accommodation for the limited number of permanent onsite employees and their families.

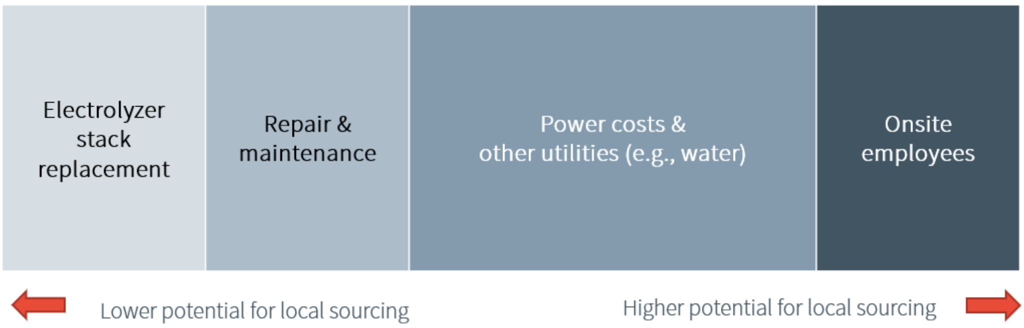


Figure 6-3: Local Sourcing Potential during the Operational Phase

The expenditure has been averaged and annualized; however, there is likely to be variation in expenditure over time (discounting inflation). It is not possible to estimate this variation with any degree of confidence because there is considerable uncertainty over when the electrolyzer stack replacement and other repair and maintenance works will be required. The economic effects therefore have potential to vary in scale over time, especially with regards to support activity required to maintain and operate the facility.

A significant portion of the operational expenditure will be associated with the cost of power. For this expenditure, the marginal effect of expenditure on employment is likely to be significantly lower than the average employment effect. For this reason, the employment impacts related to power purchase are excluded from the costs, sourcing, and economic impact modelling outputs.

It is common to see significantly higher local sourcing levels during the operational phase of energy infrastructure projects including hydrogen projects. Excluding the expenditure on power, it is estimated that 29%-46% of expenditure during the operational phase will be captured within Nova Scotia. This varies considerably by expenditure category. For example, the direct onsite operations and maintenance workers are assumed to be 100% local, whereas 'electrolyzer stack replacement' is assumed to mostly be sourced from outside of Nova Scotia.

When excluding power costs, the level of retained expenditure in Nova Scotia is estimated to be in the region of CAD $24-$37 million per annum.

A breakdown of the cost and sourcing assumptions used for the operational phase is provided in Table 6 below.

Table 6-4: Overview of Sourcing Assumptions Operational Phase

Expenditure group	Expenditure (**MM CAD $**)	Sourcing (% of retained expenditure within Nova Scotia)	Retained Expenditure (**MM CAD $**)	Notes
Direct onsite employment costs	4.5-6	100%	4.5-6	It is assumed that Nova Scotian residents would fill these roles as they are permanent onsite roles. This includes workers who migrate into Nova Scotia to fill the role and subsequently settle in Nova Scotia.
Stack replacement	24	10%-20%	2.4-4.9	This includes labour costs. Approximately 20% of the electrolyzer stack replacement expenditure is anticipated to be on labour. It is assumed that some local labour would be employed to replace the stack but almost all the other non labour inputs would need to be sourced from outside of Nova Scotia.

Expenditure group	Expenditure (**MM CAD $**)	Sourcing (% of retained expenditure within Nova Scotia)	Retained Expenditure (**MM CAD $**)	Notes
Other utilities (not including power)	1.9	100%	1.9	It is assumed that municipal water supply will be available at the selected site. The majority of this water demand is for process use both directly in hydrogen production through electrolysis and as cooling water throughout the plant. for the process and allowance for additional demand at site.
Other repair and maintenance (fixed)	49	30%-50%	15-26	Fixed maintenance costs have been assumed for the hydrogen and ammonia production plants at a rate of 3% of the total direct cost. It is assumed that regular maintenance on common equipment can be performed by local labour, and specialists would be brought in for vendor-specific maintenance for the electrolyzers.
Total	80-82	29%-46%	24-37	

6.2 Non-Resident Based Construction Workforce: Key Assumptions

Using the assumption mentioned above in Section 6.1.2 (25% of construction labour costs are retained within Nova Scotia), it is assumed that 25% of the workforce directly involved in onsite installation and commissioning (i.e., onsite construction workforce) would be Nova Scotian residents.

Given the size and population spread of Nova Scotia and the likely location near a coastal port located away from Halifax it is likely that the majority of these Nova Scotian resident workers would not be located locally (within an hour drive of the site). Therefore, under a worst-case scenario approach, given that 25% of the workforce is estimated to be Nova Scotian and 25% of the Nova Scotian workforce is estimated to be home based, it is anticipated that almost all of the onsite based construction workers (94%) would be **non-home-based** and require accommodation whilst working onsite.

6.2.1 Information used to inform the assumptions

It is noted that the assumption around non-home-based construction workforce is highly uncertain. Therefore, we have used the following information / approach in determining the assumptions laid out above:

- **Worst** case **approach –** Following a worst-case approach we have conducted what is deemed to be a cautious upper estimate of the likelihood of utilizing non-home-based workers.
- **Site location –** The site is assumed to be located near a Nova Scotian port with infrastructure capable of supporting the development. Therefore, the site is both unlikely to be located in close proximity to the main population base in Halifax (and its relatively large workforce) but is also assumed to be located close to existing population centres that help to (among other activities) support the operation of the existing port infrastructure.
- **Labour force and the anticipated scale of the construction workforce demand –** The working aged population and population density, as well as the size of the construction sector (both employment and business base) have been considered. The reason is that all things being equal, the more densely populated an area, and the higher an area's existing presence of construction businesses and employees, the higher the labour capacity to draw workers from the local population. Given that this is a major infrastructure project for the province and the modelling outputs indicates a high requirement for construction workers (see Section 6.3.3), it is unlikely that the local area could support this scale of workforce requirement using only local workers.
- **Travel to work area –** It is assumed that any worker usually residing more than a one-hour drive from the site would need to be accommodated in temporary accommodation close to the site.

6.3 Economic Modelling Outputs

This section sets out the estimated core economic impacts of the hydrogen project. The core economic impacts are also set out in table form in Appendix E.

6.3.1 Construction Phase Employment and GVA Impacts

The diagram below sets out the estimated gross economic benefits that will occur as a result of the construction of a 500 MW hydrogen facility and downstream storage in Nova Scotia. It is estimated that within Nova Scotia, the construction of the large-scale hydrogen facility will generate an average direct impact of CAD $80-92 million GVA and 750-870 Full-Time Equivalent (FTE) jobs per annum over a 6-year period from concept development through to operational readiness and commissioning. This does not include any non-Nova Scotian construction workers who would temporarily move into the province to work onsite.

A number of the local jobs will be located onsite in the construction sector as well as supporting onsite roles such as security staff or cleaning. In addition, the development of the facility will support jobs involved in the development process such as jobs in the engineering sector. However, this employment will only be supported on a short-term basis. Many of the jobs created during the manufacturing process will be supported outside of Nova Scotia and are therefore not quantified in this assessment.

In addition to the direct impact the development will generate further supply chain (indirect) and employee expenditure (induced) impacts within Nova Scotia, which when added to the direct impact will support an estimated total of CAD $126-145 million GVA and 1,150-1,330 FTE jobs per annum during the construction phase.

The total GVA impact represents up to a 0.3% gross increase on Nova Scotian baseline GDP. This therefore represents a significant opportunity for supporting wider economic growth aspirations as well as specifically supporting the local construction sector and the development of local capabilities in sectors such as engineering and manufacturing which have the opportunity to support the project.

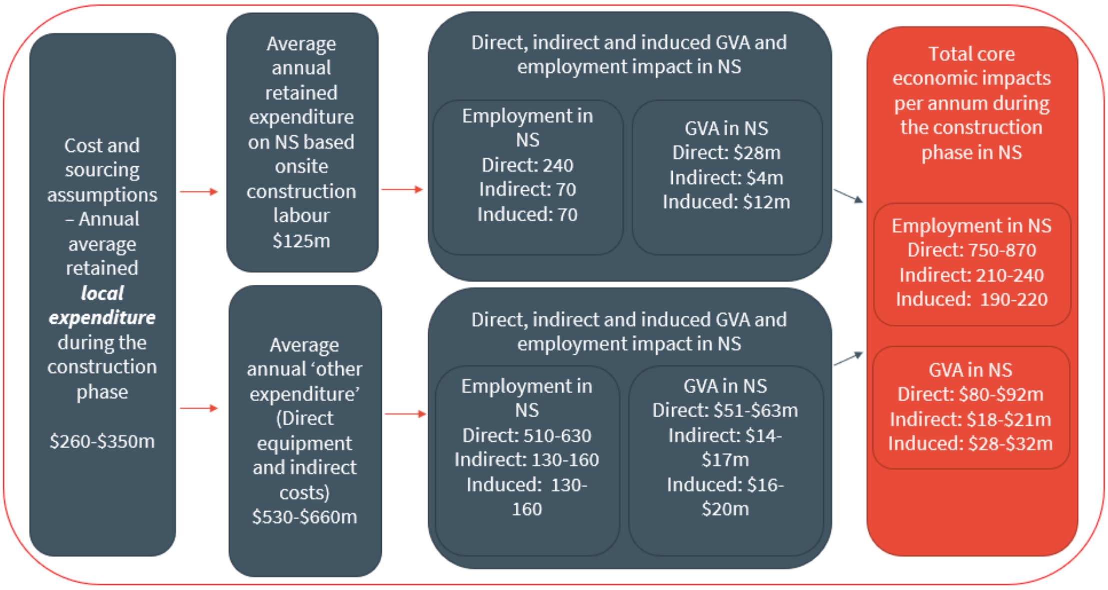


Figure 6-5: Construction Phase Employment and GVA Impacts (Average per Annum)[59]

6.3.2 Operational Phase Employment and GVA Impacts

It is estimated that within Nova Scotia the operation of the large-scale hydrogen facility will generate an average direct onsite employment of 30-40 jobs per annum. Associated with these onsite activities will be an estimated CAD $4.5-6 million of direct GVA per

[59] Please note the ranges in this assessment are driven by the uncertainties around the level of local sourcing. The estimate for construction labour expenditure is point based due to the need to consider the maximum influx of construction workers. Therefore, conservative estimates of the level of local construction worker sourcing are provided.

Numbers may not sum to totals sue to rounding.

annum. It is estimated that these jobs will be a mix of graduate (25%) and technical level jobs (75%). Hydrogen production will place demands for engineering and technical skills in job roles such as 'Hydrogen Fuel Cell System Technician', 'Hydrogen Energy System Operations Engineer', 'Hydrogen Vehicle Electrician', 'Fuel Cell Backup Power System Technician' and 'Hydrogen Energy System Installer'.

Other first round expenditure on supporting the large-scale hydrogen facility operation (e.g., electrolyzer stack replacement, other utilities (e.g. water), and other repair and maintenance) will also generate greater levels of direct FTE employment (120-160 FTE jobs) but will not necessarily be onsite. The supply chain supports a range of jobs related to supporting the operation of the facility, for example engineers who need to be brought in to repair specialized equipment.

In addition to the direct impact the operation of the facility will generate further supply chain (indirect) and employee expenditure (induced) impacts, which when added to the direct impact will generate CAD $28-36 million GVA and support 260-330 FTE jobs per annum within Nova Scotia during the operation phase. The jobs supported through indirect supply chain and induced effects are widely dispersed across many sectors of the Nova Scotian economy. For example, expenditure by onsite workers would help support jobs in a wide range of sectors such as accommodation, hospitality and retail.

In addition to this the development of the facility will support the wider security of local jobs in the electricity production sector, thus aiding in the transition to a cleaner energy production sector in the province. Due to the issues with overestimating the scale of these jobs using input-output multipliers this has not been included within the economic modelling exercise but it is nonetheless important to consider (and will be highlighted in the full report).

The total GVA impact represents less than a 0.1% gross increase on Nova Scotian baseline GDP. However, the operational impact will occur over a long period of time and therefore despite being low in the overall context of the size of Nova Scotian GDP does still represent a significant long-term impact when taken in the context of supporting the transition to cleaner economic growth in the local energy sector. Also, when looked at from the point of view of the local host community rather than the whole of the province, the positive impact can be expected to be more significant.

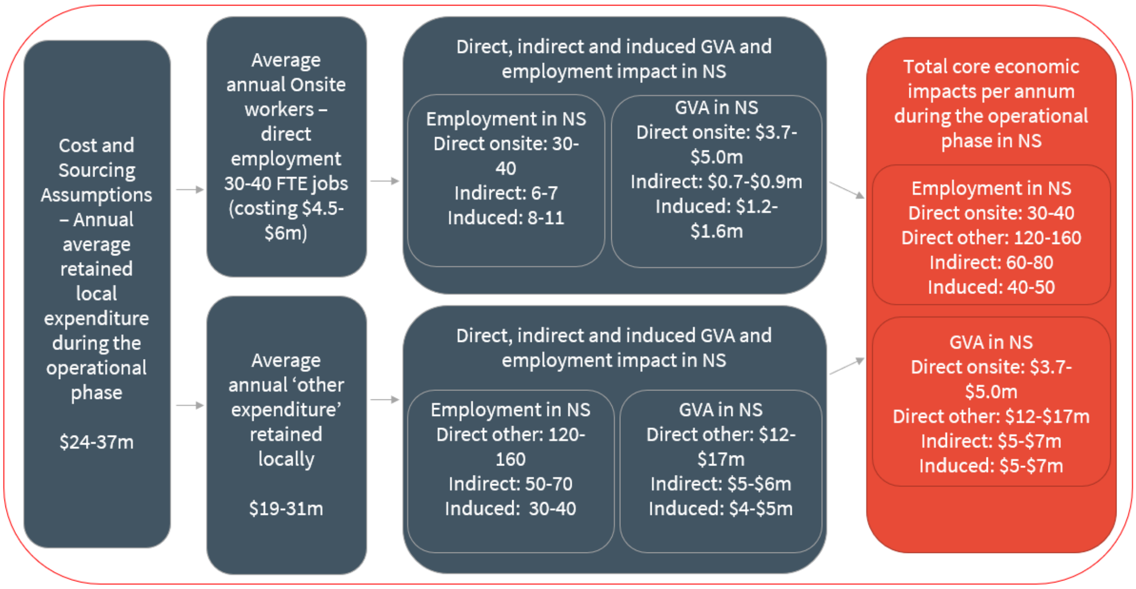


Figure 6-6: Operational Phase Employment and GVA Impacts (Average per Annum)

6.3.3 Peak Construction Workforce Impact – Used to Assess the Realistic Worst Case for Social Impacts

It is estimated that the peak year (penultimate year of the 6-year project) will see 35% of total construction phase expenditure (CAD $1.1 billion). This is an indication of the potential impact to raise considerably higher than the average impact across the construction phase due to the higher requirements for activity during the peak year.

The flow diagram below indicates that CAD $220 million will be spent on onsite construction labour in the peak year. Using Hatch's input-output model, it is estimated that this expenditure will generate an estimated demand for 2,550 FTE construction jobs.

Based on the assumptions laid out in Section 6.2, it is assumed that 500 of these jobs are taken up by Nova Scotian resident workers and the rest are filled by workers whose usual place of residence is outside of Nova Scotia. It is assumed that all 1,900 of the construction FTE jobs usually residing outside of Nova Scotia will require temporary accommodation in Nova Scotia and 500 FTE jobs of the Nova Scotian resident workforce will be located more than an hour drive from the site and therefore will also require temporary accommodation in Nova Scotia. This leads to a **total influx of construction workers into the local area (within a 1-hour drive of the site) of approximately 2,350 FTE jobs** all of which are assumed to require temporary accommodation in the local area and may place additional demands on a range of social infrastructure. This scale of workforce will be used in the worst-case-based assessment of social impact.

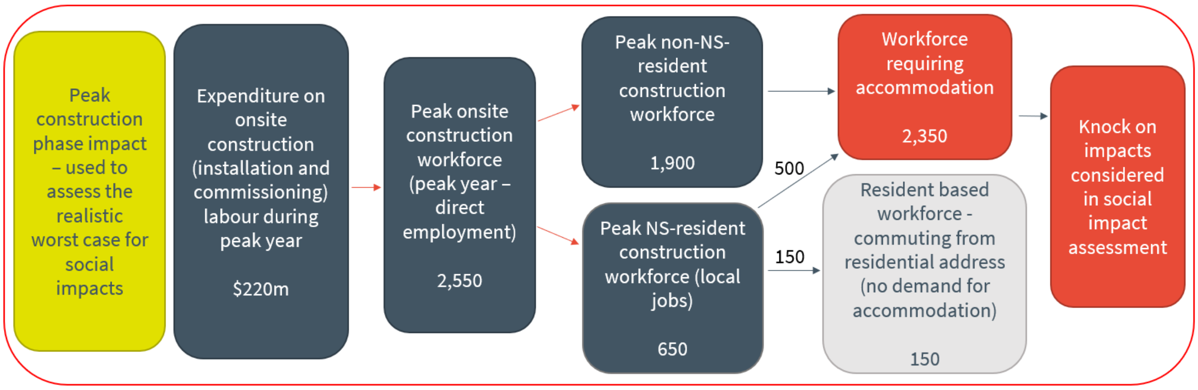


Figure 6-7: Peak Construction Workforce[60]

6.4 Wider Economic Benefits

There are a range of wider socioeconomic benefits that would be delivered by the development of a hydrogen project within Nova Scotia:

6.4.1 Tax Impacts

Expenditure associated with the construction and operation of the facility will generate significant tax income streams to government through direct, indirect, and induced tax effects. This represents an important tax income to government, including provincial government.

6.4.2 Skills

The project will support skills benefits. These are expanded upon in the trades and skills assessment (see Section 7).

The development of a large-scale hydrogen facility would play a role in providing skilled employment locally, helping to **train, retain and attract workers**. If Nova Scotia were to develop other facilities / a hub this impact would be more pronounced.

There may be opportunities to **support apprentices**, which would deliver additional social value benefits to young local people as well as align their training to the skills needs of the future. This is important in the context of high levels of youth unemployment in the province and the social challenges young people face in Nova Scotia.

6.4.3 Boost Economic Activity in the Local Export Port, including Transport Activities

There will be increased activity associated with the export of ammonia products. This may lead to further investment in local port infrastructure and will involve the use of businesses needed to transport the product for export (on both ships and trucks).

6.4.4 International Competitiveness in Hydrogen Production and increased exports

The development can help secure an **early mover advantage** for the local area in which the facility is constructed, helping to develop Nova Scotia's reputation as a place to

60 Please note numbers may not sum up due to rounding.

produce hydrogen within Canada. Building export links with the rest of the world will place Nova Scotia strongly in terms of demand for Canadian green hydrogen exports.

Germany (and indeed the whole of the EU) is potentially a key market that could be served by hydrogen development in Nova Scotia. It is assumed a 500 MW facility would produce 70,000 tonnes of hydrogen per annum, which equates to production of approximately 400,000 tonnes of ammonia per annum. It is assumed all of the ammonia produced would be exported.

The project will also allow Nova Scotia to **boost its export income**, thus helping to reduce the trade deficit.

6.4.5 Decarbonization of downstream sectors

Hydrogen will play an important downstream role to decarbonize various sectors and to help reach GHG emission reduction targets. Some of this could be used for domestic decarbonization, with the scale and scope of this determined by how much of the hydrogen is exported from the province. This will help to reduce GHG emissions for these downstream uses that ultimately will help contribute to reducing the overall negative impacts predicted to occur because of climate change.

7. Trades and Skills Assessment

The baseline assessment presents the position on the supply of relevant trades and skills in Nova Scotia (See Section 1 and more detailed baseline assessment in the Appendix A). This includes employment, education, and skills data available from Statistics Canada. In this section an overview of the skills and trades that are expected during the construction and operational phases of the project is provided, focusing on occupations, skill levels and expected earnings levels. An overview of the potential for mismatches between demand for skills from the project and supply of skills locally is then given along with examples of measures to maximize the impacts on trades and skills.

There will be a requirement for supporting roles such as security and cleaning through operational and construction phases. These roles are less highly skilled and reasonably limited (therefore, they are not discussed further) but nonetheless offer local employment opportunities.

There will also be indirect and induced employment effects (beyond the first round of supply chain expenditure). However, these second order effects are not considered within the trades and skills assessment as they are highly dispersed across the economy and it is, therefore, more spurious to link these effects to specific trades and skills requirements.

7.1 Construction Phase

As noted in Section 1, it is estimated that the construction phase will see a gross impact of 750-870 FTE jobs per annum over a 6-year construction phase created within Nova Scotia.

In addition, it is estimated there will also be a peak requirement for up to (worst case based) 1,900 non-Nova Scotian construction jobs (FTE), which will require temporary migration into the province. These onsite construction requirements will begin following the development work in years 3 to 6 of the hydrogen production project.

This scale of employment effects will have significant implications on trades and skills in Nova Scotia. The commentary below provides an overview of the trades and skills in the different construction phases and across different expenditure categories.

7.1.1 Development Subphase

Based on the economic modelling exercise it is estimated that engineering, procurement, construction management will see a total demand for 1,900 Nova Scotian person years of employment[61] across the 6-year construction phase. It is assumed the majority (70%-85%) of the expenditure in this category is estimated to be retained locally. A significant proportion of the work associated with these jobs will be required to take place in the development subphase (the first 2 years of the 6-year construction phase).

The baseline assessment notes that there are a total of 32,350 FTE jobs in Nova Scotia within the professional, scientific, and technical sector. The sector encompasses many of the professional job roles required during the development phase.

[61] One person year of employment is equivalent to the amount of work one FTE employee does in one year.

The hydrogen production project will require significant preconstruction development work to scope the project and gain permission to commence construction. The work delivered in the development subphase will employ a wide range of skills drawing on professions in sectors including engineering, planning, legal and archaeological. This phase will include the progression of engineering deliverables and project design decisions, which would be confirmed during this phase. As such, a range of high-skilled technical engineering roles are required to design appropriate technology solutions.

During this phase there is an opportunity for a developer to utilize local skills and knowledge. However, developers often bring with them their own established advisory teams, which may limit the scope to source these teams locally. The locations of these teams may be across Canada or in some cases globally, depending on the developer. Developers are likely to search wider (nationally and internationally) where local skills are lacking.

It is therefore assumed that the developer would be able to access the required skills even if the assumed level of local sourcing is not achieved. If needed they can compete for the required skills and broaden the search for these skills to national and global labour markets.

7.1.2 *Onsite Construction Subphase*

Once onsite construction begins there is potential for a wide range of skills and trades requirements mainly covering jobs associated with:

- Labour employed in the extraction and transportation of raw materials;
- Manufacturing sector workers;
- Construction sector workers; and
- Labour employed in a wide range of supporting sectors (e.g., transport and storage).

The table below sets out the anticipated local onsite and other direct employment effects associated with different skills and trades across the construction phase.

Table 7-1: Construction Phase Employment Effects and Relevance To Trades And Skills Assessment

Skills and trades	Scale of employment in Nova Scotia	Notes
Trades engaged in the extraction of raw materials used for construction.	Assumed 0 direct jobs (FTEs).	Raw materials used in the production of the hydrogen facility are assumed to be sourced from the rest of Canada / globally.
Manufacturing sector workers (direct equipment and indirect	Very limited (less than 100 FTE direct person years of	Limited manufacturing capabilities to produce direct equipment locally. It is assumed the developer will go to the

Skills and trades	Scale of employment in Nova Scotia	Notes
costs related to chemicals manufacturing).	employment supported within Nova Scotia).	internationally competitive market to source the optimum manufacturer for each component of direct equipment in terms of the supplier's experience and price.
Wide range of trades captured in other indirect costs.	Indirect cost expenditure will support around 1,800 person years of direct employment (FTEs) or 300 direct FTE jobs per annum across six years.	Costs related to: - Construction indirect costs. - Temporary accommodation. - Pre-operational commissioning. - Freight. - Spare parts. - Owner's costs.
Construction sector employees working onsite.	High demand for onsite construction jobs to be filled primarily by non-Nova Scotian resident workers. 25% of roles (or up to 650 FTE jobs in peak year) filled by Nova Scotian residents.	It is assumed there is a high labour force requirement that exceeds the local labour market capacity in the construction sector. The assessment takes a realistic worst case assessment approach in terms of deriving the highest potential for social impacts.

7.1.3 Raw Materials

The raw materials produced to manufacture the equipment will require roles involved in the extraction and transportation of the materials from source location to the site. However, the majority of these materials will be sourced globally (likely to be from the most commercially optimum location in which the raw material is produced) and therefore the local trades and skills implications are very limited.

7.1.4 Manufacturing Sector Workers

The baseline assessment notes that there are 31,650 FTE jobs employed in the manufacturing sector. This accounts for 8% of the workforce and is less concentrated than nationally (LQ=0.8).

Despite the number of people employed in the manufacturing sector within Nova Scotia there is limited local experience and capacity in the hydrogen production area of the manufacturing sector to have significant implications on the trades and skills assessment. However, there may be measures that can be taken to maximize benefits through appropriate supply chain management, engagement and training and skills measures (see Section 7.3).

7.1.5 *Construction Sector Workers*

As noted in Section 1 over a 6-year period the hydrogen production project is estimated to provide 750 to 870 FTE jobs per annum to Nova Scotia. Early years will require skills for design, planners, procurement and professional services with later years of the construction phase more focused on onsite construction labour requirement primarily in the construction sector. This approach is taken to due to the difficulties in providing a robust and detailed phasing of annual impacts at for a project that is only at a conceptual stage of development.

As set out in Section 6.2 it is assumed that construction workers will be required to work onsite and 75% of the workers are assumed to be non-Nova Scotian residents for the purpose of the economic assessment. In the high / worst case scenario, the requirement of the non-Nova Scotian resident workforce is estimated to be up to 1,900 in the peak construction year but is closer to 1,000 per annum when averaged across the 4 years of onsite construction works.

Construction sector workers include onsite construction labourers, project managers, engineers etc. The baseline assessment notes that Nova Scotia has a significant proportion (14% or 138,000 people) of its workforce are engaged in trades, transport and equipment operators and related occupations. Some of these have necessary skills in the development of a large-scale hydrogen facility.

Construction workers are assumed to have a typical Canadian construction worker salary (in the region of CAD $60,000-70,000); however, there will also be requirements for more specialized high-value roles where high-value construction labour skills or senior roles are required.

The Nova Scotian construction sector employs over 34,000 FTE workers which is 8% of the Nova Scotian workforce. Within Nova Scotia, 3,725 businesses (12% of businesses) are present in the sector.

There is a significant opportunity to utilize companies in the local construction sector and there may be measures that could implemented to maximize local benefits such as providing apprenticeships (see Section 7.3).

7.1.6 *Wide Range of Trades and Skills Captured in other Indirect Costs*

Indirect cost expenditure will support with around 1,800 Nova Scotian person years of direct employment (FTEs) – or 300 direct FTE jobs per annum – across 6 years.

Sectors including construction, transport, warehousing, and chemicals will be supported during the construction phase. The baseline assessment indicates there are 22,500 FTE jobs supported in Nova Scotia in the transportation and warehousing sector. In addition, there over 30,000 FTE jobs supported in both the construction and manufacturing sectors as noted above.

However, these jobs are widely dispersed across a wide range of different trades. Where local capabilities exist in these sectors there may be opportunities to utilize local companies. There may be measures that could implemented to maximize local benefits such as setting out requirements for local souring in supply chain planning (see Section 7.3).

7.2 Operational Phase

There will be demand for technical and engineering occupations roles to operate the site effectively. There will also be demand for roles such as facilities management, security and roles associated with the transport and port operations. Occupations engaging in hydrogen technology research and innovations are also important to the continued advancement of the sector. The project has an estimated demand for 30-40 FTE roles based onsite that will be a mix of graduate and technical roles and it assumed that these workers will be provided to employees residing in Nova Scotia. There is an opportunity to attract and retain highly skilled employees to the province in these roles and provide them with highly valued skills development in an industry which is part of the wider global agenda to decarbonise and therefore growing at a very fast rate. For this reason, skills demand will continue to grow in this area.

The earnings and education requirements will vary across different phases and roles. For example, a hydrogen lab technician requires an associate degree and earns a salary of approximately CAD $65,000. Whilst a junior hydrogen energy technician may require only a high school degree and earns a salary around CAD $40,000. For the assessment it assumed that one onsite FTE employee working onsite would have an average cost of CAD $150,000 and as such would have an average salary in the region of CAD $100,000-120,000. This reflects the relatively high skilled nature of the roles required to operate a hydrogen production facility.

The baseline assessment notes that there are a total of 32,350 FTE jobs in Nova Scotia within the professional, scientific, and technical sectors. This sector will be the primary one from which demand for permanent onsite workers is drawn. Given the size of employment demand in comparison to the scale of relevant employment, it is estimated that there will not be any significant skills shortages when filling the 30-40 onsite jobs (FTEs).

The baseline assessment notes that Nova Scotia has a significant proportion (14% or 138,000 people) of its workforce are engaged in trades, transport and equipment operators and related occupations. The supporting activity associated with operating the facility will provide a significant level of employment for both the supporting roles required for operation and maintenance of the site, transportation of products and increased demands on the port used for exporting. The economic assessment indicates the hydrogen production project would support around 120-160 FTE jobs in Nova Scotia per annum in these ‘other’ direct job roles.

There may be a significant educational and research opportunity to deliver knowledge sharing benefits to both academics and students looking to advance their understanding and research around hydrogen production. Potential ways to maximize this are discussed in Section 7.3.

7.3 Potential Labour Market Capacity Issues

It is estimated the majority of onsite construction workforce will be likely to need to be sourced from outside of Nova Scotia (the modelling assumes that 75% of onsite construction workers will be non-Nova Scotian residents, as noted in Section 1). There is also a limited supply of engineers with the technical knowhow to design the project, and there are a number of areas where local conditions do not allow for local sourcing due to the lack of specialist skills in for example the manufacturing sector.

Based on the assessment outlined above, at this stage no additional specific labour market capacity issues have been identified that would put the project at risk or risk a negative impact on Nova Scotia. That said, this is likely to be an issue that the developer would consider in detail when undertaking investment decisions and project planning. Also, it may be important to consider this project in the province’s wider skills and employment planning.

7.4 Trades and Skills Enhancement Measures

The implementation of a hydrogen production project will be highly aligned with the province’s future aspirations around green skills and green jobs, and as such can be an important aspect of the province’s transition to cleaner forms of development. The following measures are possible steps a developer may take in order to deliver enhanced benefits for the province. The provincial authorities may wish to build requirements and incentives into the consenting process, in order to maximize the trades and skills benefits of a major hydrogen project.

The developer should be encouraged to work with key local stakeholders to discuss the socioeconomic implications of the project including the relevant skills and trades implications. Working with stakeholders such as local educational institutions and local authorities can help ensure that stakeholders are also planning appropriately for the project and that the wider economic development community is cooperating effectively to maximise the project benefits.

7.4.1 High Levels of Local Sourcing through Supply Chain Management and Supplier Engagement

There may be opportunities to maximize local skills and employment benefits through a developer commitment to produce a supply chain plan. This can help achieve higher levels of local supplier use. There may also be opportunities for the developer to run local supplier events, both to advertise tendering opportunities to relevant suppliers locally and to help identify local suppliers with relevant manufacturing skills, capacity, and experience.

7.4.2 Production of a Skills and Employment Plan

Through employment and skills planning it is possible to enhance skills benefits through running apprenticeships, connecting with local education institutions, and maximizing employment benefits.

The baseline assessment notes that Nova Scotia has a number of universities that are strong in their reputation for engineering and the Nova Scotia Apprenticeship Agency (NSAA) offers a wide range of apprenticeships across multiple industries. These include

Power Engineer, Mechanical Vehicle Operator, Oil Heat System Technician, Automotive Service Technician, Communications Technician, and Powerline Technician.

About 2,200 Nova Scotians are enrolled in an apprenticeship each year. NSCC offers more than 120 programs at 13 campuses across the province, with more than 10,000 students. There are 55 apprenticeship programs in designated skilled trades, where 40% of new jobs will be in skilled trades and technologies over the next 20 years in Nova Scotia[62].

The developer may consider fulfilling requests to produce a skills and employment plan, detailing ways in which local skills will be developed and utilized. This may include engagement with local educational institutions to offer apprenticeships and providing training to local employees so that they can upskill whilst working on the project. Through the implementation of an employment and skills plan, the developer should be encouraged to engage with stakeholders on ways to maximize benefits and set out ways in which they will monitor the success of the plan (see Section 7.4.3 below).

7.4.3 Monitoring the Project

Providing insight in respect of the scale and type of trades and skills benefits that the project secures in practice is critical to understanding the success of particular measures employed in skills and employment planning, supply chain planning, supplier engagement and engagement. This will also help to improve the wider evidence base associated with the local economic benefits associated with hydrogen production. Establishing quantified metrics that can be monitored and evaluated is also imperative to being able to continuously improve and learn. It may be recommended that the developer establish appropriate methods and milestones for monitoring their projects key performance metrics.

[62] NSCC, *NSCC 2019 Graduate Survey*, 2019.

8. Social Impacts

8.1 Demographics

The construction phase for the proposed facility takes place over 6 years. The early development and planning (pre-construction phase) will cover years 1 and 2, with construction starting in year 3. Year 4 will see construction increase with it reaching a peak in year 5 with the facility to be completed in year 6 and therefore any impacts will primarily be experienced over a 1-2-year period (primarily in years 4 and 5).

Throughout the 6-year construction phase of the project, the estimated number of workers at peak construction in year 5 will be 2,550, with an estimated 650 of these workers already residing in Nova Scotia.

Of the 650 workers already residing in Nova Scotia, it is estimated that 450 of these will reside more than an hour away from the site and will be required to temporarily relocate during construction. As a result, the population of the local area directly surrounding the new facility will increase by 2,350 at peak construction. This increase in population is likely to oscillate over the 6-year construction phase, with peak construction in year 5.

The majority of Canada's construction workforce are made up of 25-54-year-olds[63] (68%), and therefore the construction of a 500 MW hydrogen facility would likely bring a younger demographic to Nova Scotia over the proposed construction phase. Due to the temporary nature of the employment during this period, the likelihood of the workers relocating permanently with any family members is low.

These temporary increases in population would result in the increased use of infrastructure and facilities in addition to fluctuating demand on service requirements. Due to the variations in construction worker numbers over the 6-year period, impacts on the social infrastructure will vary in magnitude and duration over the course of the construction.

For the operation of the hydrogen facility however, it is assumed that workers will move to the area, likely within an hour's commute, bringing any family members with them. Based on the average Canadian family size of 2.9 persons per family[64], it is assumed that the 30-40 on site operational workers will increase the population of the local area by 87-116 persons if relocating with families. However, with 29% of Canadian households being one person households, an estimated 9-12 of these operational workers would relocate alone. Therefore, there would likely be an additional, permanent increase on the local population within the range of 70-116 people.

8.2 Housing and Accommodation

The population in Nova Scotia has been increasing since 2015, and this increase in population has helped to fuel the growth of the housing market resulting in low vacancy rates across the province. As a result, Nova Scotia has seen an increase in both house

[63] Statistics Canada. Table 14-10-0023-01 Labour force characteristics by industry, annual (x 1,000)
[64] Statistics Canada. Table 98-10-0123-01 Census family structure, presence of children and average number of persons per census family: Canada, provinces and territories, census metropolitan areas and census agglomerations

prices and rental prices, with the government of Nova Scotia implementing a 2% rent cap in 2021 for existing leases in order to protect residents from rising costs.

Of the 2,550 workers that will be employed during construction, 650 of these will already be local to Nova Scotia. However due to the size and population spread of the province, up to 450 of these local workers will also be non-home-based and will require accommodation whilst working on-site, leaving an estimated 200 local workers who could safely commute each day, bearing in mind maximum commuting travel times of 1 hour each way. Therefore, the total workers who require temporary accommodation at peak construction would be 2,350. If there is no provision for housing provided by the project, workers will be required to find accommodation in the surrounding communities.

The location for the 500 MW facility has not yet been determined, however it is assumed that it will be located near a coastal port away from Halifax. The majority of the rental market in Nova Scotia is based in the capital Halifax and therefore alternative housing opportunities will need to be sought out since it is unlikely that the facility will be a commutable distance from the capital.

8.2.1 *Impacts and Opportunities*

There is a popular tourism industry in Nova Scotia with an abundance of short-term, tourist centred properties for rent. If peak construction phases of the development are planned to coincide with the off-peak tourism season, then this would not only provide the temporary accommodation needed to support some of the construction workforce, but it would also provide additional economic opportunities to local businesses in the area. Additionally, homeowners in the local area may rent out bedrooms to temporary workers as a way to receive an additional income.

Due to the existing low vacancy rates, an increased demand on housing will likely lead to further growth and a potential increase in housing related costs for local residents, particularly renters. This impact would likely be short term however, with rental prices stabilizing once peak construction has taken place, and with the facility under operation would likely be restricted to the area directly surrounding the facility.

These impacts on rental prices can also be mitigated through careful planning through a range of mitigations including the provision of temporary housing facilities near the facility, by ensuring peak construction takes place in the tourism off-season, identifying additional housing availability with the local community etc.

8.3 Health Services

8.3.1 *Hospital Services*

In 2020 wait times for priority surgeries began to increase because of the Covid-19 pandemic which led to the cancellation of many non-urgent surgeries. Wait times have not yet reached pre-Covid-19 levels in Nova Scotia, with most wait times for priority surgeries longer than the Canadian average. In 2021/22 there were 19 temporary emergency department closures due to lack of staff, with closures much more common in smaller, rural emergency departments. During the construction phase which will see a younger cohort of workers moving to the province, it may lead to an increase in demand on emergency departments. The new facility may exert pressure on already struggling services, particularly if it is located within a rural area with a smaller emergency department.

8.3.2 Family Doctor Provision

Additionally, the Northern and Eastern Zones of Nova Scotia are experiencing particular struggles regarding the provision of family doctors, with family doctor numbers per 100,000 numbers lower than both Canada and Nova Scotia in the Northern Zone, and high proportions of doctors either meeting or already over the Canadian retirement age in the Eastern Zone. Therefore, a small increase in demand may put extra strain on the public healthcare system if careful approaches to staffing within the healthcare system are not addressed.

8.3.3 Impacts and Opportunities

During the construction phase, the new workforce will likely be made up of a younger demographic due to the average age of Canadian construction workers. Therefore, the demands that this new population will put on health services in Nova Scotia will vary in comparison to older populations of a similar size. There may be an increased pressure on EHS, especially if the facility is in a rural location. However, there will likely be less pressure on long-term health services due to the temporary nature of the workforce, as it is unlikely that the workers would choose to change the location of their family doctor and / or undertake longer-term health care treatments away from their place of residence.

Impacts on health services during this time could be mitigated by the provision of onsite medical services that can help to meet the immediate needs of workers. Therefore, during construction, an influx of new construction workers will likely cause modest increases in the use of local healthcare facilities and any impact will likely be short term. Additionally, the health service provision provided for the project could provide additional capacity to the local health infrastructure.

During operation, the facility will create 30-40 on site jobs, with most workers living within a 1-hour commute of the facility. As previously cited, these on-site workers will increase the population by a range of 70-116 persons most of whom will be using health facilities in the area and will require a family doctor in the local area. As a result, this may have long-term impacts on local health services including priority surgery wait times and family doctor provision.

Therefore, during operation, a permanent relocation of workers will likely cause a mild increase in the use of local healthcare facilities on a long-term basis, which will require some consideration regarding health care staffing to mitigate any additional pressures.

Throughout both the construction and operation periods, the risk of potential pandemics in the wake of Covid-19 will need to be taken into consideration, particularly when dealing with a temporary and transient workforce. Actions should be taken to plan and respond to the spread of infectious diseases including coordinating with the Department of Health and Wellness and the Health Services Emergency Management Department.

8.4 Emergency Services

8.4.1 Fire Services

There are roughly 6,700 firefighters based across 360 fire stations in Nova Scotia with 6,000 firefighters being volunteers. An influx of a younger demographic to the area through the relocation of workers could provide additional volunteers for firefighters and other volunteer-based emergency services and should be regarded as an opportunity.

2,100 firefighters out of the 6,700 firefighting forces are also Medical First Responders which is equivalent to 31% of the force. An increased number of workers that volunteer for the firefighting force could therefore result in more people with medical first aid training and those who would also register as Medical First Responders, recognising the safety culture of the construction sector. Through coordination with EHS, this could provide additional emergency services to local communities, helping to alleviate the strain on the Nova Scotian EHS.

8.4.2 Police Services

A small increase in a younger demographic through the new workforce may create extra pressure on the police force which is already at 1.9 police officers per 1,000 of the population. There is an increased likelihood of crime occurring through the addition of a young working population. This could potentially be associated with travel related crime such as vehicular speeding, and unlawful parking. As part of the wider community management, there should be consideration for how the fear of crime could be managed to help ensure frictionless community integration.

8.4.3 Impacts and Opportunities

During the construction phase, a temporary emergency services facility could be built in coordination with EHS near or on the site to provide additional services to the facility and to local communities to provide medical response. This may help mitigate the increased pressure on the Nova Scotian EHS. In addition, the wider pool of workers will provide additional capacity to draw from in terms of emergency volunteers.

8.5 Education Services

There are 372 schools across Nova Scotia, with the most recent data from 2020-2021 with 9,924 teachers across the province, resulting in a student teacher ratio of 13. Within Nova Scotia there are areas experiencing increased pressures on school services particularly at the elementary level, with enrolments since 2015 increasing by 10,000 at this level.

During construction of the facility due to the temporary nature of the work, the likelihood of workers permanently relocating to Nova Scotia is fairly low. Therefore, any workers who have children requiring education will likely not be relocating to Nova Scotia, and those who do relocate with families will likely be on a short-term basis.

It is assumed that most permanent residents hired for the ongoing operation of the hydrogen facility will move to the area, bringing their family with them (within a 1-hour distance of the site). The youth population (aged 12-17) will likely increase by a range of 27-36 as a result of the operational workers, with a variation in the age of these individuals. Therefore, the additional population who will require access to education over the three education levels will be likely be marginal yet in some communities these increases may still be impactful.

8.5.1 Impacts and Opportunities

During construction, the temporary construction workers are unlikely to bring families which further evidences the low impact the facility would have on the local education services in Nova Scotia.

During operation, the facility would likely have a low impact on local education services due to the rather low predicted number of youth population that would relocate to the area. Additionally, if these children are at junior high or senior high level, the pressure exerted on schools would be less significant due to the decreases in enrolments that Nova Scotia has experienced at these education levels over the past 7 years.

There are also School Districts in Nova Scotia such as Strait, South Shore and Tri-County that have lower than average student-teacher ratios and are therefore likely to be in a slightly better position to manage any added pressures from new students. It may be the case that areas struggling with enrolment numbers would welcome a development that brings additional students to the schools.

8.6 Public Services and Community Impact

Due to the size and scale of the proposed facility it is possible that tensions between construction workers and those employed at the facility during the construction period, and the existing local community may arise.

The construction of a large-scale hydrogen facility will see an increase of vehicles in the area, impacting local traffic volumes and road systems, as well as potentially introducing additional negative quality of life issues (parking, littering, air pollution, etc.). The majority of these additional vehicles will be large trucks delivering materials to the site and depending on the location of the construction workers accommodation, there may also be an increase in cars on the road during commuting times. A project-level Traffic Management Plan for all phase of the project would help mitigate this, setting out potential alternative delivery, set-down and commuting arrangements.

Additionally, there may be strains on services provided by the municipality close to where the facility will be located. For example, additional waste services may be needed as a result of the increased construction workforce and during the winter months, additional snow clearing may be needed if temporary residences are provided in new and previously un-cleared locations. Other public services such as waste collection and recycling, street cleaning and parking provision may be impacted through the increased number of people in the local area and community leisure facilities (swimming pools, playing fields, sports facilities, parks, forests, etc.) may see an increase in usage.

8.6.1 Impacts and Opportunities

Through careful community engagement in the planning phase, any tensions between the existing communities and new residents could be avoided or mitigated on the condition that the community has been actively involved with the development of the project. Any residual impacts on the community, which persist despite active community engagement, can be further mitigated through the implementation of a community relations strategy. This strategy should look to capture how the project will benefit the community and how it is going to support local communities, as well as any enhancements that the project may provide.

The developers of the facility could also provide several targeted services that the local community would benefit from, especially if particular challenges are identified at the planning stage.

Certain traffic related impacts could be mitigated through the provision of buses for workers from accommodation hubs to the construction site, reducing the number of individual cars on the roads at peak commuting times. Additionally, materials required for the construction of the facility could be delivered via the water as the facility is likely to be within close proximity to a port, therefore reducing the number of large trucks on the roads. A traffic impact study could also be conducted to identify any particular concerns in the local area's road systems and to identify if any issues or upgrades that will be needed. Once the extent of the services is determined, any identified impacts could be addressed through a transportation management plan.

Impacts on the services delivered by the municipality will likely be marginal and can be mitigated through additional provision of these services such as waste collections and street cleaning in any temporary residences. The facility can also work in partnership with the municipality to ensure that there is capacity to provide any additional services needed, and where capacity may be limited, working with them to increase capacity or look at alternative delivery arrangements.

Appendix A Baseline Assessment

A.1 Introduction

The baseline appendix presents the baseline position for a variety of indicators relevant to the socioeconomic assessment of a large-scale hydrogen facility. The baseline position is then used as a starting point in the assessment of socioeconomic impacts. The indicators are grouped into demographic, economic, trades and skills and social indicators. The baseline assessment was completed in December 2022 and reflects the latest publicly available data at the time of collection.

A.1.1 Study Area and Geographies used in the Baseline

Baseline data has been collected and presented for Nova Scotia with Canada used as a national comparator to indicate provincial levels of performance in the different indicators. Where particularly relevant a more granular level of data is also presented.

A.1.2 Baseline Data Limitations

The most up to date information available (as of December 2022) has been used in the preparation of the baseline. However, there is often a lag in the publishing of national datasets, meaning there is the possibility that some information may not be up to date.

Given the conceptual nature of this Study there is no fixed location for the facility. As such it is not possible to narrow down the Study area to below the provincial data. Where appropriate more granular data is presented for the whole of Nova Scotia so that areas with particularly constrained supply can be highlighted.

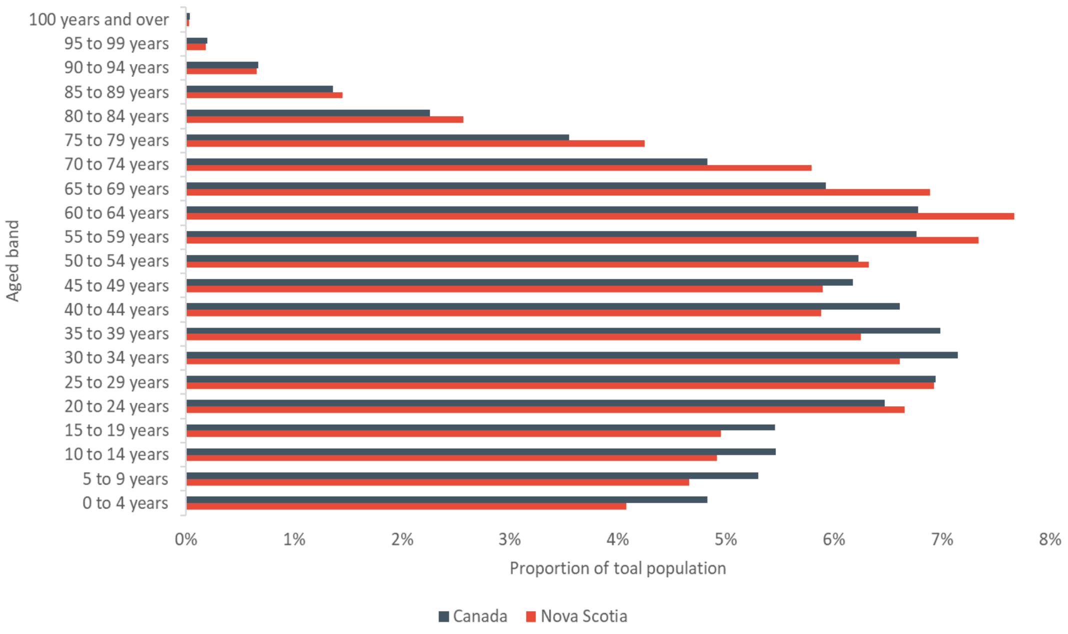
A.2 Demographic Baseline

A.2.1 Current Population

Data available from Statistics Canada shows Nova Scotia had a total population of 1.02 million people in 2022, which is 2.6% of Canada's total population. This has grown from 0.95 million in 2017. It is important that new jobs are provided for this growing population to support the future growth aspirations of the province. The Halifax Regional Municipality contains almost half of the Nova Scotian population (470,000 in 2021)[65]. There are no other comparable large urban areas within the province.

Around 64% of Nova Scotia's population are of a working age (aged 16-64). The proportion of working aged population is 1 percentage point less than in the rest of Canada (65%). Moreover, around 22% of Nova Scotia's population is elderly (aged 65 and above), which is significantly higher than the proportion in Canada (16%). The chart below shows how generally Nova Scotia has lower proportions of residents in each of the 5-year age bands between 0-19 and 30-49 compared to the Canada average.

Demographic Profile, 2022



Source: Statistics Canada: Population estimates on July 1st, by age and sex (2022).

A.2.1.1 Indigenous Population

There are around 52,000 Indigenous people in Nova Scotia, making up 5% of the total population, with around 28,000 identifying as First Nation citizens, 21,000 identifying as

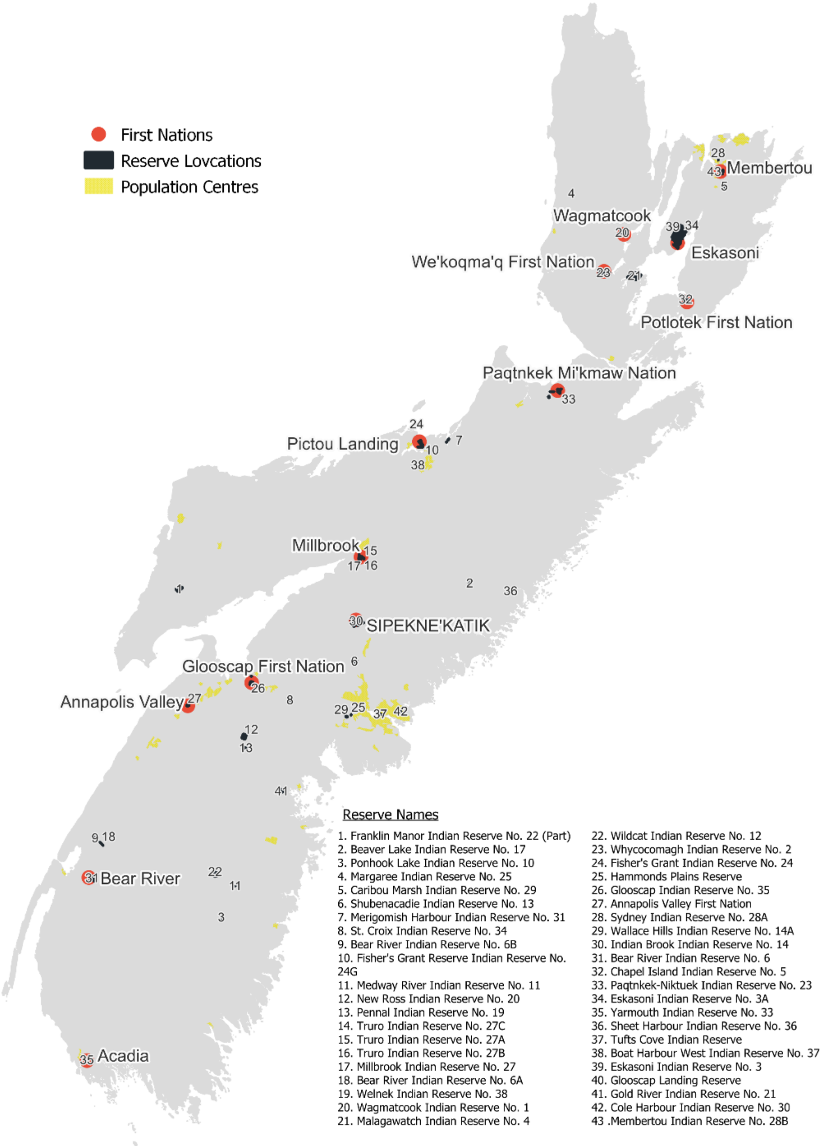
[65] Statistics Canada, 2022. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810001101

Métis, 1,000 as Inuit and the remaining identifying as 'other' groups[66]. There are 13 First Nations in Nova Scotia shown on the map below, with the biggest being Eskasoni and Sipekne'katik[67]. There are 43 reserves and according to data from 2014, 63% of Indigenous people in Nova Scotia live on a reserve.

[66] Statistics Canada, 2021. Indigenous identity by Registered or Treaty Indian status and residence by Indigenous geography: Canada, provinces and territories. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810026401

[67] Nova Scotia Government, Facts Sheets and Additional Information, *Nova Scotia Office of L'nu Affairs*, 2022 Facts Sheets and Additional Information | Government of Nova Scotia

Map of First Nations and First Nation Reserves in Nova Scotia.



Source: Natural Resources Canada, Aboriginal Lands of Canada Legislative Boundaries and Indigenous Services Canada First Nations Location

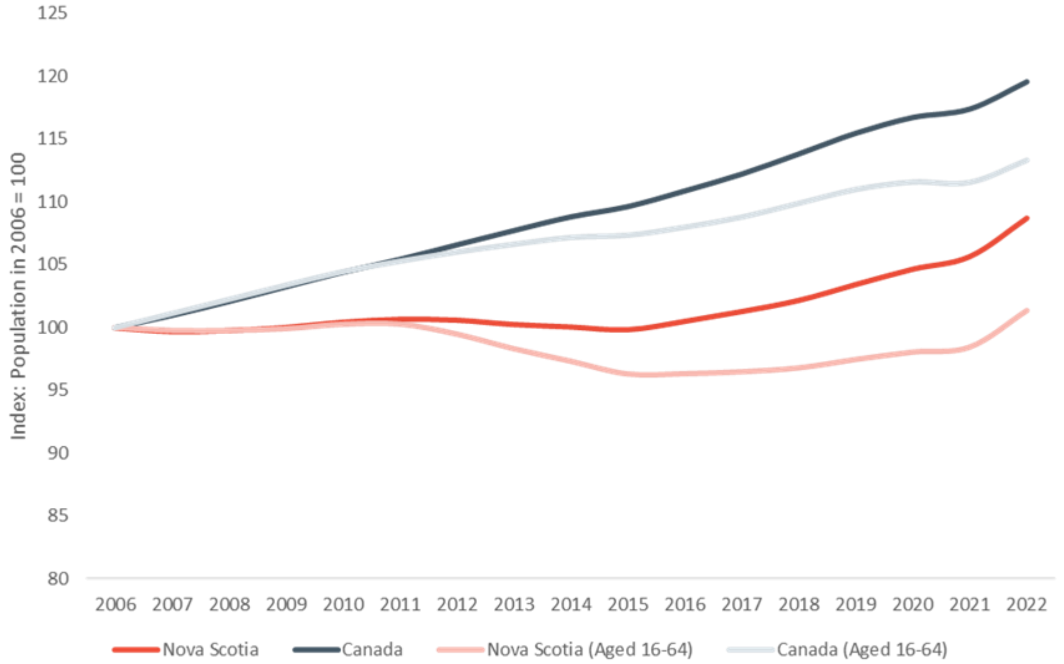
A.2.2 Population Trends

The chart below shows how Nova Scotia's population has changed over the last 15 years. Between 2006 and 2015, Nova Scotia experienced no significant change to its population. After 2015, there was a steady increase in population of 9% between the years 2015 and 2022. In contrast, Canada has seen a significant increase in population growth over the past 15 years with the population growing by just over 16%.

Outmigration in Nova Scotia has been a long-term issue. Ontario has been a pull for Nova Scotians looking for work. As many as 49% of those who leave Nova Scotia are destined for there. The collapse of the fisheries industry in Atlantic Canada in the early 90s increased outmigration from the province, further accelerating the decline when combined with diminishing birth rates. This trend reached a new milestone in the early 2010s when the death rate officially surpassed births[68].

Nova Scotia's working age population significantly decreased from 2011 to 2015 (-4%). But the working age population has since recovered to the levels seen during 2006 to 2010, growing by 5% between 2015 and 2022 (+5%). Nova Scotia's recent increase in population is largely a result of increased immigration numbers and interprovincial migration. In contrast, Canada's working age population has steadily increased over the past 15 years (+13%).

Population Growth Chart 2006-2022: Nova Scotia vs Canada



Source: Statistics Canada: Population estimates on July 1st, by age and sex (2022).

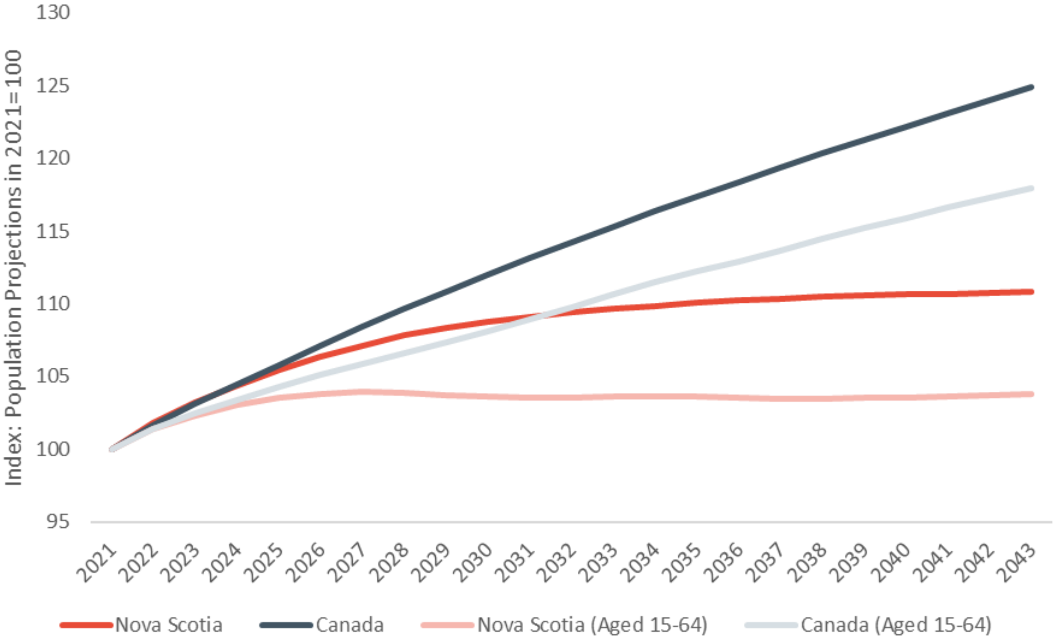
[68] New Canadian Media, 'Immigration', *New Canadian Media, 2021* Nova Scotia's Long Population Decline Might be Ending, and Immigration Could be Why - New Canadian Media

A.2.3 Population Projections

The chart below shows the Statistics Canada 2022 based population projection for the medium growth projection scenario. Overall, it is projected that Nova Scotia's population will increase by just under 11% from 2021 to 2043[69]. Notably, Nova Scotia's working age population is expected to plateau in the 2020s after experiencing a 4% increase from 2022 to 2027.

The province's future population growth is primarily driven by its 65+ aged population. In, contrast to this, Canada's total population is projected to grow by 25% from 2021 to 2043 and the working population is predicted to experience continued growth (of 18%) up to 2043.

Population Projections 2021-2043 – Nova Scotia vs Canada



Source: Statistics Canada: Projected population, by projection scenario, age and sex (2022).

[69] Statistics Canada: Projected population, by projection scenario, age and sex (2022). [69] Based on the medium growth 3 scenario.

A.3 Economic Baseline

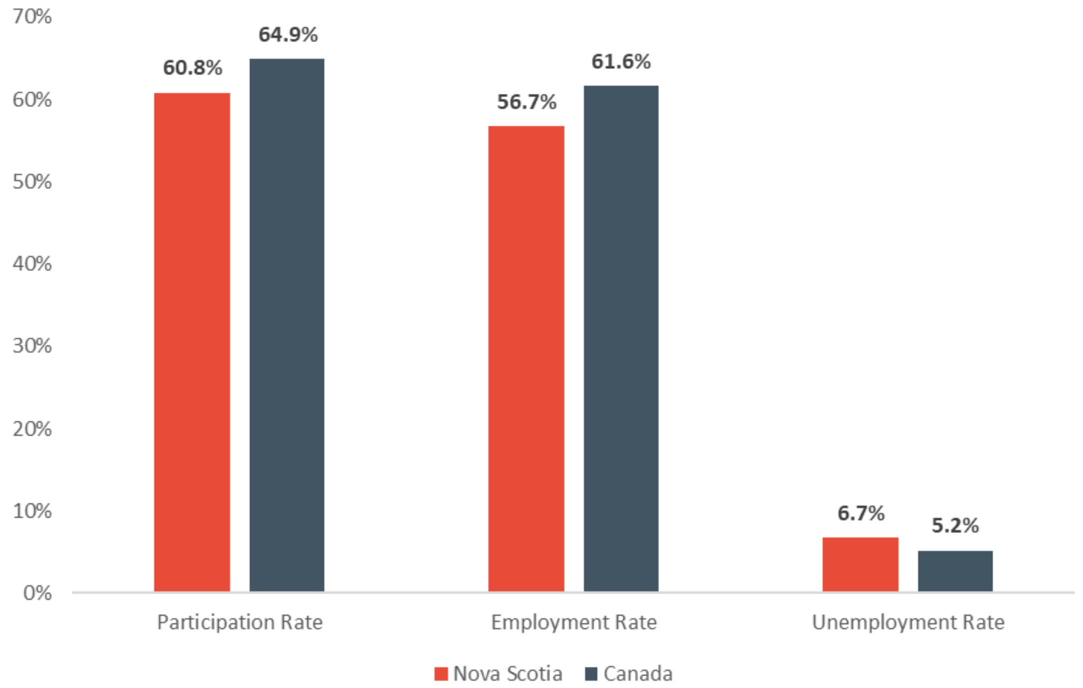
A.3.1 Employment and Labour Market

A.3.1.1 Employment

In 2022 there were around 516,000 people employed in Nova Scotia, which equates to an estimated 442,000 FTE jobs[70].

The employment rate was 56.7% (lower than Canada at 61.6%), the participation rate was 60.8%, (lower than Canada at 64.9%) and the unemployment rate was 6.7% (higher than the average for Canada of 5.2%. These indicators suggest the need for greater employment opportunities in Nova Scotia. This performance can be linked to outmigration of skilled workers, decades of stagnating population change, if not actual decline. This had negative implications on the economy in terms of aging population, diminishing labour force, declining tax revenue. The indicators may also suggest significant capacity in the labour market.

Labour Force Status 2022 in Nova Scotia and Canada



Source: Labour Force characteristics by province, monthly, seasonally adjusted (October 2022). The employment rate is the number of persons employed expressed as a percentage of the population 15 years of age and over. Similarly, the participation rate is the number of labour force participants expressed as a percentage of the population 15 years of age and over. The rate therefore includes retired people. The unemployment rate is the number of unemployed persons expressed as a percentage of the labour force.

[70] Estimation based on the proportion of full time and part time workers in Nova Scotia. It is assumed 1 part time worker represents 0.5 FTEs.

Unemployment rates vary significantly by education level. 'Certified apprentice' level educated individuals in Nova Scotia have 15% unemployment rate when educated in another province and over 12% unemployment rate for apprentice level educated apprentices who obtained their qualifications within Nova Scotia. Those who are educated in 'noncertified trade' also have higher unemployment rates above 10%. This is reflective of the general pattern of those who are educated at university level having unemployment rates below the Nova Scotia average and those who are not educated at university level having higher unemployment rates.

Covid-19 had a particularly significant impact on the Canadian job market. The number of job vacancies in Canada reached an all-time high of 912,600 in the third quarter of 2021, as employers and workers continued to adjust to easing public health restrictions and rapidly evolving economic conditions[71]. The boom in available jobs in Canada has been felt across the country and in almost all sectors of the economy. Restaurants, catering, and hotel businesses more than doubled their vacant positions from Q3 2019 to Q3 2021 with 86,400 job vacancies, a growth of 112.8%. Healthcare and social assistance job vacancies rose by 78.8%, or 52,100 positions. The construction sector's vacant jobs increased by 83.7%, or 34,300 positions, retail by 45.2% or 32,400 job openings, and the manufacturing sector by 62.4% or 31,200 open jobs.

Many Nova Scotian's lost their jobs or saw their hours reduced as a result of public health measures to curb the spread of the virus. The sectors that were affected the most include the hospitality sector. However, other jobs saw an increase in demand. This includes business, finance, and administration jobs, natural and applied sciences and related jobs, health jobs, trades, transport and equipment operators and related jobs, and construction jobs[72]. Nova Scotia now has a shortage of tradespeople and some in the sector say upcoming projects could suffer due to the lack of labour. Estimates show the province will need about 11,000 newly certified tradespeople in the coming years up until 2030[73].

It should be noted that the Indigenous community faces particularly high economic challenges. For example, the unemployment rate for the population living on Nova Scotian reserves was 23%, compared to 10% in the general Nova Scotian population. In addition, the proportion of low-income status amongst Indigenous people in Nova Scotia was 20% in 2021, compared to 15% amongst the general population.

A.3.1.2 Business Base

There are over 31,650 employing businesses registered in Nova Scotia. Nova Scotia has a larger proportion of smaller and a lower proportion of medium sized businesses compared to Canada. It has just 73 businesses with over 500 employees; however, this is reflective of the proportion of larger businesses seen nationally.

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[71] Immigration Canada, 'Labour shortages growing in Canada amid covid-19 recovery', *Immigration Canada,* 2021 Labour Shortages Growing In Canada Amid COVID-19 Recovery - Canada Immigration and Visa Information. Canadian Immigration Services and Free Online Evaluation.
[72] CIC, 'Nova Scotia jobs in-demand because of Covid-19, *CIC News,* 2021 Nova Scotia jobs in-demand because of COVID-19 (cicnews.com)
[73] CBC, 'Nova Scotia in midst of labour shortage in skilled trades, experts say', *CBC News,* 2022 Nova Scotia in midst of labour shortage in skilled trades, experts say | CBC News

Business Counts by employee number

	Nova Scotia		Canada
	No. of businesses	% of total businesses	% of total businesses
Small (0 to 99 employees)	31,035	98.0%	96.0%
Medium (100 to 499 employees)	550	1.7%	3.7%
Large (500 plus employees)	73	0.23%	0.22%
Total	31,658	100%	100%

Source: Statistics Canada, 2022m Canadian Business Counts, with employees, June 2022.

A.3.2 Sectoral Analysis of Employment and Business Base

Nova Scotia has a diversified economy based on both land and sea resources. Traditional industries such as fishing, forestry, and mining are in decline, while tourism and other service industries are becoming much more significant components of the economy.

Historically the most important mineral in Nova Scotia has been coal but this is now being phased out. The rapid increase in coal production and the development of the steel industry were primarily responsible for the province's prosperity in the early 20th century.

Agriculture, fishing, mining, forestry, and natural gas extraction are major resource industries found in the rural areas of Nova Scotia. Halifax has one of the most diverse economies in Canada with strengths in several service sectors including IT, gaming and digital, financial services and ocean technology[74].

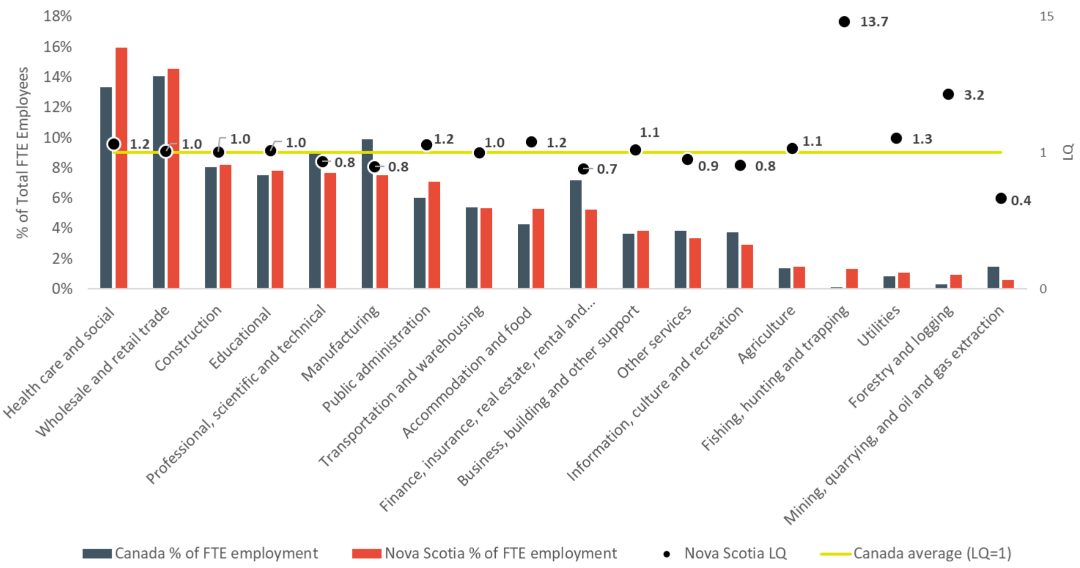
A.3.2.1 Employment – Sectoral Analysis

The graph below shows the sectoral composition of the Nova Scotian labour market in comparison to the national sectoral composition. In 2021 Nova Scotia's four largest sectors by size of labour force were healthcare, (16% of total labour force), wholesale and retail trade (15% of labour force), and construction (8% of labour force). This reflects Nova Scotia's strong wholesale sector, retail trade sector and construction sector. All of these sectors are relatively more concentrated than is seen nationally, (i.e., the LQ is greater than 1[75]).

Nova Scotia has a very high level of specialism in fishing, hunting, and trapping (LQ= 13.7). This can be explained by its historic strength in the fishing industry. In comparison it has relatively low concentrations of employment in mining, quarrying, and oil and gas extraction (LQ=0.4) and finance, insurance, real estate, rental, and leasing (LQ=0.7).

[74] Rugged Thug Life, 'What is the main primary industry in Nova Scotia', *Rugged Thug Life*, 2021 [What is the main primary industry in Nova Scotia? - ruggedthuglife.com]
[75] The location quotient (LQ) is a method of quantifying how concentrated a particular industry, cluster, occupation or demographic group is in a region as compared to the respective national average.

Sectoral Composition of Employment, 2021



Source: Statistics Canada: Labour Force Characteristics (2021)

A.3.2.2 Businesses – Sectoral Analysis

The tables below highlights that a high proportion of Nova Scotian businesses are operating in the retail sector (over 4,000 businesses or 13% of the total number of businesses in the province, which equates to an LQ of 1.2). Then follows construction with over 3,700 businesses operating in Nova Scotia which accounts for 12% of total businesses in Nova Scotia. The Healthcare & social (LQ=1.0) and Agriculture, forestry, fishing & hunting (LQ=2.6) sectors both have over 3,000 businesses in Nova Scotia respectively and comprise of 10% of the total businesses within the province.

Number of Businesses by Sector

Industry	**No. of businesses**	**% of Nova Scotian businesses**	**LQ (vs Canada)**
Retail trade	4,005	13%	1.2
Construction	3,725	12%	1.0
Health care and social	3,150	10%	1.0
Agriculture, forestry, fishing, and hunting	3,035	10%	2.6
Other services	2,975	9%	1.1
Professional, scientific, and technical	2,320	7%	0.6
Accommodation and food	2,170	7%	1.1
Unclassified	1,750	6%	0.8

Industry	No. of businesses	% of Nova Scotian businesses	LQ (vs Canada)
Wholesale trade	1,290	4%	1.0
Real estate and rental and leasing	1,265	4%	0.9
Manufacturing	1,070	3%	0.9
Administrative and support, waste management and remediation	1,065	3%	0.8
Transport and warehousing	1,055	3%	0.6
Finance and insurance	1,010	3%	1.0
Arts, entertainment, and recreation	540	2%	1.2
Information and culture	415	1%	0.9
Education	325	1%	0.9
Public admin	250	1%	1.3
Management of companies and enterprises	150	0.5%	0.9
Mining, quarrying, and oil and gas extraction	60	0.2%	0.3
Utilities	35	0.1%	1.1

Source: Statistics Canada, 2022, Canadian business counts, June 2022. Note: non employer businesses not included. The number of businesses is rounded to the nearest 5.

In terms of the largest businesses (with over 500 employees) these are primarily concentrated in the health care and social (17 businesses with 500+ employees), education (14 businesses with 500+ employees), public administration (9 businesses with 500+ employees) and administrative and support, waste management and remediation sectors (9 businesses with 500+ employees).

Businesses by sectors and employee size band

Industry	No. of businesses in Nova Scotia		
	Small (0 to 99)	Medium (100 to 499)	Large (500 plus)
Retail trade	3,908	95	1
Construction	3,704	20	1
Agriculture, forestry, fishing, and hunting	3,024	12	1
Health care and social	3,024	107	17
Other services	2,961	12	0

Industry	No. of businesses in Nova Scotia		
	Small (0 to 99)	Medium (100 to 499)	Large (500 plus)
Professional, scientific, and technical	2,289	28	3
Accommodation and food	2,151	18	0
Unclassified	1,742	5	1
Wholesale trade	1,271	20	1
Real estate and rental and leasing	1,260	4	0
Transport and warehousing	1,027	25	3
Administrative and support, waste management and remediation	1,023	35	8
Manufacturing	1,003	59	7
Finance and insurance	993	14	1
Arts, entertainment, and recreation	532	7	0
Information and culture	406	10	0
Education	291	22	14
Public admin	205	36	9
Management of companies and enterprises	135	11	3
Mining, quarrying, and oil and gas extraction	57	4	1
Utilities	29	6	2

Source: Statistics Canada, 2022, Canadian business counts, June 2022. Note: non employer businesses not included.

A.3.2.3 Sectors Particularly Relevant to the Development and Operation of a Hydrogen Facility and their Labour Pool and Business Base

Existing development offers evidence of the sectors involved in the development and operations of a hydrogen production facility. The largest hydrogen producer in Canada is Alberta. Alberta has 2 forms of production when generating hydrogen: natural gas-based hydrogen production and renewable-based hydrogen production.

Locally, two major green hydrogen / ammonia facility plants are planned in Point Tupper, Nova Scotia, with the goal to export ammonia overseas. Combined, these projects will produce green hydrogen that will be converted into over 2.2 million tonnes of green ammonia a year[76] [77].

According to the International Energy Agency (IEA) the key sectors for hydrogen production include refining, **chemicals**, **iron and steel**, **freight and long-distance transport, buildings and power generation and storage**.[78] Other sectors include the **technical and construction sector.**

A number of sectors are particularly important when developing, constructing, and operating a hydrogen facility. There may be opportunities to catch greater economic benefits locally where there are relevant local strengths in these sectors, although this will depend on a range of factors including the developer's procurement approach and existing supply chain relationships, and any local sourcing targets placed on them by the local authority:

- **Development phase –** Engineering, planning, legal and other consultancy professions are particularly important in designing and then gaining consent for the facility. Local knowledge and expertise from existing Nova Scotian businesses / business activities may be utilised during this phase. Within Nova Scotia the **professional, scientific, and technical** sector is therefore the most relevant to consider during this phase of the project.
- **Construction phase –** The **construction** sector is particularly relevant during the construction of the facility. In addition, the manufacture of the direct equipment is required (although not necessarily needed to be done locally) may bring opportunities for local supply chain involvement of relevant manufacturing companies. The **manufacturing sector** is therefore important to consider.
- **Operational phase –** Technical jobs are needed to operate the facility. The **professional, scientific, and technical** sector is therefore relevant during the operational phase. The **transportation and warehousing** sector is also important as the transport of the green hydrogen is required for export from an appropriate port. The **mining, quarrying, and oil & gas extraction** is relevant as the knowledge and skills in this sector is potentially transferable to hydrogen development. In addition, the **utilities** sector is important for the supply of utilities to the facility during operation.
- Within Nova Scotia the **professional, scientific, and technical** sector comprising 32,350 FTE employees and 8% of FTEs in the workforce. There are 2,289 employing businesses (7% of businesses) within this sector, 98.7% of which are small businesses. The sector has an FTE jobs LQ of 0.8 and business LQ of 0.6 reflecting the relatively low concentration of business and employment activity within the sector compared to the rest of Canada.

[76] Wind Systems Magazine, 'Everwind to begin green hydrogen production in Nova Scotia', *Wind Systems Magazine*, 2022 EverWind to begin green hydrogen production in Nova Scotia | Wind Systems Magazine
[77] Port Hawkesbury Reporter, 'Community gets first look at Bear Head Energy's project', *Port Hawkesbury Reporter*, 2023 Community gets first look at Bear Head Energy's project - Port Hawkesbury Reporter
[78] International Energy Agency, The future of hydrogen seizing today's opportunities, 2019

- The **construction** sector contains 34,450 FTE jobs within Nova Scotia and accounts for 8% of the workforce. There are 3,725 construction businesses registered within Nova Scotia accounting for 12% of Nova Scotian businesses. Relatively speaking, the sector reflects national employment and businesses concentrations (FTE jobs and employment LQs=1.0).
- The **manufacturing** sector accounts for 31,650 FTE employees within Nova Scotia which equates to 8% of the workforce). There are 1,069 manufacturing businesses registered within Nova Scotia accounting for 3.5% of Nova Scotian businesses. The sector has an FTE jobs LQ of 0.8 and business LQ of 0.9 reflecting the relatively low concentration of business and employment activity within the manufacturing sector compared to the rest of Canada.
- The Nova Scotian **transportation and warehousing** sector compromises of 22,500 FTE employees which is 5% of the workforce. There are 1,055 transportation and warehousing businesses registered within Nova Scotia accounting for 3.3% of Nova Scotian businesses. The sector has an FTE jobs LQ of 1.0 and business LQ of 0.6 reflecting the relatively low concentration of businesses activity within the sector but similar concentration of employment compared to the rest of Canada (which indicates a higher proportion of larger employers).
- Within Nova Scotia the **mining, quarrying, and oil & gas extraction** sector has an FTE jobs LQ of 0.4 comprising FTE 2,500 employees (1% of the total workforce). There are just 62 businesses within the sector (business LQ =0.3).
- The Nova Scotian **utilities** sector compromises of 22,500 FTE employees which is 5% of the workforce. There are 37 utilities businesses registered within Nova Scotia accounting for 3.3% of Nova Scotian businesses, 8 of these businesses employ 100 or more staff. The sector has an FTE jobs LQ of 1.3 and business LQ of 1.2 reflecting the relatively high concentration of business and employment activity within the utilities sector compared to the rest of Canada.

A.3.3 Commuting

Commuting statistics show that the vast majority of Nova Scotian workers place of work is within the province. Data published in 2022, shows that more than 98% of Nova Scotia commuters recorded in the census data (which is limited to census metropolitan / agglomeration areas)[79] commuted within their province and just less than 2% of Nova Scotian commuters commuted to another province (1.2%) or territory or travelled in from another province (0.6%).

The most common commute pattern observed in the province involves people travelling from their residence in Halifax to their workplaces within the same city (71% of

[79] Statistics Canada, 2022, Commuting flow from geography of residence to geography of work by main mode of commuting, commuting duration and gender: Census metropolitan areas and census agglomerations (statcan.gc.ca).

commuters commuting within Nova Scotia recorded in the census metropolitan / agglomeration areas of Nova Scotia).

Generally, the data shows that Nova Scotia in comparison to other larger provinces had higher rates of workers commuting out of the province.

Outside of main urban area, many residents of Nova Scotia commute to work in industries such as fishing, forestry, and mining. These industries are often located in rural areas and require workers to travel significant commuting distances.

It's worth noting that commute patterns in Nova Scotia, like many places, have likely been affected by the COVID-19 pandemic. With more people working from home or adopting flexible work arrangements, commute patterns may have shifted in recent years.

A.3.4 Economic Value and Productivity

In 2021, Canada generated a GDP (at basic prices[80]) of CAD $2.5 trillion. Nova Scotia accounts for a small proportion of this value and contributed almost CAD $43 billion to the Canadian economy in GDP. A sectoral breakdown of GDP is available for 2019 and presented in the table below[81]. Notably, of the most relevant sectors to the Study:

- The manufacturing sector delivered 7.3% of Nova Scotian GDP.
- The professional, scientific, and technical services sector delivered 4.5% of Nova Scotian GDP.
- The transportation and warehousing sector delivered 3.4% of Nova Scotian GDP.
- Engineering construction and non-residential building construction sectors delivered 1.6% and 0.9% of Nova Scotian GDP respectively.
- The utilities sector delivered 2% of Nova Scotian GDP.
- The mining, quarrying, and oil and gas extraction sector delivered 0.8% of Nova Scotian GDP.

Breakdown of GDP by Sector, 2019

Sector	Nova Scotia GDP by Sector (MM CAD $)	% of total GDP	Canada % of total GDP comparison
Owner occupied dwellings	4,937	11.6%	8.3%
Finance, insurance, real estate, rental, and leasing and holding companies	4,264	10.0%	11.5%
Manufacturing	3,164	7.4%	9.9%

[80] Basic prices refer to the prices of goods and services produced by a firm, excluding any taxes or subsidies on those goods and services. Basic prices are used in national accounts and economic statistics to measure the total output and value added of the different sectors of an economy.
[81] Statistics Canada.

Sector	Nova Scotia GDP by Sector (MM CAD $)	% of total GDP	Canada % of total GDP comparison
Other federal government services	3,014	7.1%	2.7%
Retail trade	2,796	6.5%	5.0%
Government education services	2,727	6.4%	4.9%
Government health services	2,686	6.3%	3.9%
Professional, scientific, and technical services	1,931	4.5%	6.2%
Health care and social assistance	1,602	3.8%	2.9%
Other provincial and territorial government services	1,534	3.6%	2.4%
Transportation and warehousing	1,463	3.4%	4.8%
Information and cultural industries	1,367	3.2%	3.0%
Wholesale trade	1,278	3.0%	5.1%
Accommodation and food services	1,109	2.6%	2.3%
Other municipal government services	974	2.3%	3.0%
Residential building construction	959	2.2%	2.6%
Administrative and support, waste management and remediation services	919	2.2%	2.8%
Fishing, hunting, and trapping	896	2.1%	0.1%
Utilities	846	2.0%	2.2%
Engineering construction	695	1.6%	2.2%
Non-profit institutions serving households	674	1.6%	1.4%
Other services (except public administration)	641	1.5%	1.5%
Repair construction	505	1.2%	1.4%
Non-residential building construction	403	0.9%	1.2%
Crop and animal production	361	0.8%	1.4%
Mining, quarrying, and oil and gas extraction	337	0.8%	5.7%
Arts, entertainment, and recreation	183	0.4%	0.7%
Other Aboriginal government services	174	0.4%	0.2%
Educational services	88	0.2%	0.2%

Sector	Nova Scotia GDP by Sector (MM CAD $)	% of total GDP	Canada % of total GDP comparison
Forestry and logging	71	0.2%	0.2%
Support activities for agriculture and forestry	61	0.1%	0.1%
Other activities of the construction industry	46	0.1%	0.1%

Source: Source: Statistics Canada, 2019, Gross domestic product (GDP) at basic prices, by sector and industry, provincial and territorial.

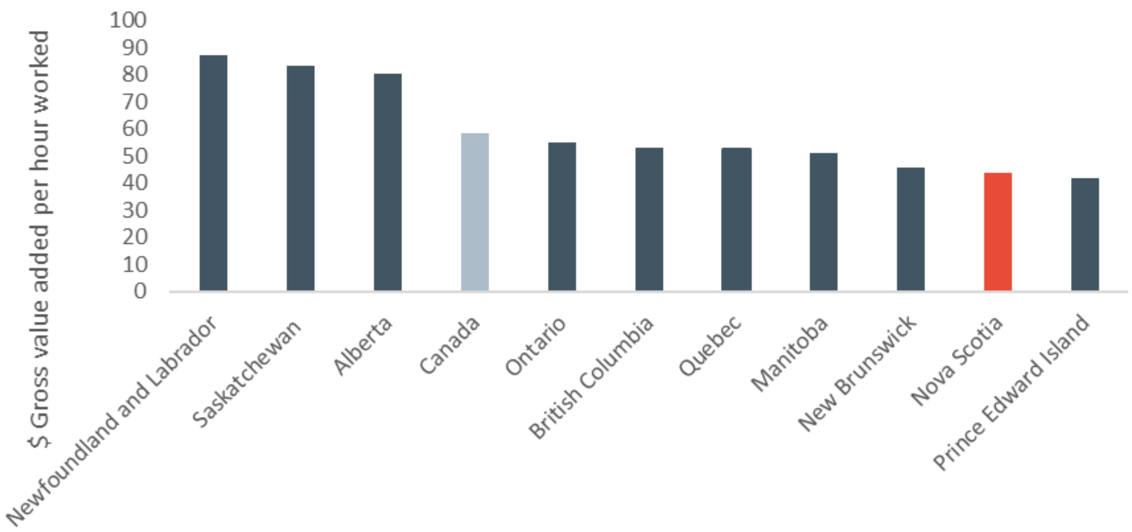
In comparison to Nova Scotia other higher resource producing provinces like Alberta and Newfoundland and Labrador generate high amounts of real value added[82] relative to the hours worked / size of their workforce. This is because they specialize in capital-intensive industries that require comparatively fewer hours worked to generate high levels of GDP. These provinces tend to create high levels of labour productivity which drives up the national labour productivity average[83].

Nova Scotia continued to have the second lowest labour productivity among the 10 provinces in 2021, at CAD $44.0 in real value added per hour. Across most industries labour productivity in Nova Scotia was lower than the national level. The industries that were an exception to this were:

- Information and cultural industries.
- Holding companies.
- Educational Services (private institutions).
- Finance and Insurance.
- Real estate, rental, and leasing.

[82] Labour productivity is calculated by dividing the real value added by the estimated number of hours worked. The real value added is constructed from the fisher chain index.

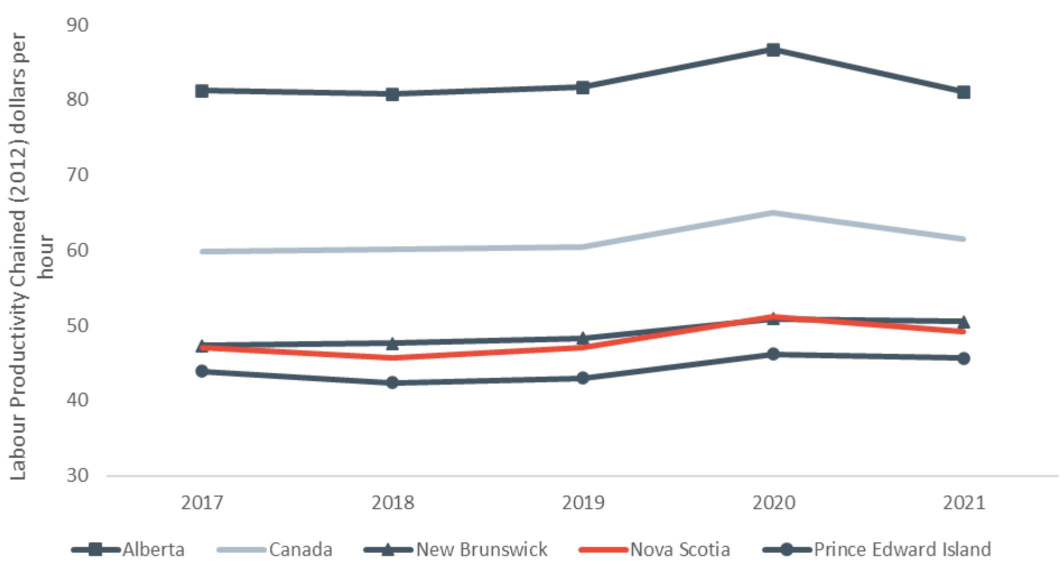
Labour Productivity by Province (GVA per hour Worked)



Source: Statistics Canada Labour Productivity by Province, Business Sector Industries, Adjusted for Inflation 2012 base year (2021)

Labour Productivity over time has been relatively low in Nova Scotia averaging around CAD $48 per hour between 2017 and 2021 as shown in the figure below.

Labour Productivity over time (Chained 2012 dollars per hour)



Source: Statistics Canada. 2022. Labour Productivity and related measures by business sector industry and by non-commercial activity consistent with the industry accounts.

A.3.5 Hydrogen Economy

Although it is still a fairly nascent sector with regards to deployment of clean energy, Canada is a global leader in the hydrogen and fuel cell sector. Hydrogen demand has risen internationally, with countries and organisations striving for clean energy commodities and solutions.

The 2022 Fall Economic Statement highlighted Canada's determination to scale up the hydrogen sector. The Investment Tax Credit for Clean Hydrogen will help incentivize domestic hydrogen production and demand, will help advance innovation, and will support high-quality jobs[84], while helping Canada meet its domestic GHG reduction targets and support global clean energy needs. The statement, which highlights clean hydrogen as an essential part of Canada's net-zero future, outlines the government's commitment to accelerate hydrogen energy adoption through the new Canada Growth Fund and investment tax credits for hydrogen fuel cell electric vehicles and refuelling infrastructure[85].

The CHFCA (Canadian Hydrogen and Fuel Cell Association) notes that hydrogen gas has been utilized and developed into multiple forms of global solutions to the climate emergency. Hydrogen:

- is the leading candidate to replace coal in steelmaking and other fuels for industrial heating.
- has been recognized as the leading candidate for seasonal storage of renewable energy and can be used to replace liquid fuels for industrial heating.
- has transportation uses which includes for passenger vehicles, buses, trucks, trains, trams, ships and planes, stationary and back-up power and material handling.
- paired with carbon capture and sequestration, can also help the traditional energy sector transition into low emissions energy.[86]

The CHFCA sector profile report offers insights into the Canadian hydrogen and fuel cell sector. The information presented in the report was collected through a survey of companies, educational institutions and government agencies that are directly involved in hydrogen and fuel cell activities in 2019, 2020 or 2021 in Canada. A total of 305 organizations were invited to participate in the survey, of these 105 organizations provided information.

The main findings from the CHFCA 2022 report were:

- The survey respondents' main focus areas were hydrogen production (31%)[87].

[84] Government of Canada, 2022, Chapter 2 - Jobs, Growth, and an Economy That Works for Everyone | FES 2022 (canada.ca)
[85] CHFCA, 2022, Canada's hydrogen sector applauds fall economic update, *CHFCA*, Canada's hydrogen sector applauds fall economic update - CHFCA
[86] CHFCA. 2022. Canadian Hydrogen and Fuel Cell Sector Profile Final Report H370244 - NZA - Hydrogen Production in Nova Scotia - CHFCA-Sector-Profile-2022-Final.pdf - All Documents (sharepoint.com)
[87] CHFCA. 2022. Canadian Hydrogen and Fuel Cell Sector Profile Final Report CHFCA Sector Profile 2022

- The survey respondents' main market focus areas were hydrogen production (59% listed this as a focus area).
- Relevant technological focus areas for survey respondents included hydrogen production through electrolysis (53% of respondents listed this as a priority) and hydrogen storage (41% of respondents listed this as a priority), and hydrogen infrastructure (39% of respondents listed this as a priority).
- Hydrogen demand has risen internationally, with countries and organizations striving for clean energy commodities and solutions.
- Additional opportunity has been created by the hydrogen and fuel cell sector in research, development, and demonstration where the sector has generated an expenditure of CAD $125 million[88].

The table below demonstrates the evolution of the hydrogen and fuel cell sector across Canada between 2016 and 2021. The data shown represents survey respondents to the annual Canadian Hydrogen and Fuel Cell Sector profile. The popularity and demand for hydrogen and fuel cells is rapidly growing with revenues increasing considerably over the past 5 years. The growth of the sector is particularly apparent in the labour market in the hydrogen and fuel cell sector with 1,785 jobs reported in the survey in 2016 compared to 4,291 jobs in reported in the survey in 2021.

Survey Respondents for the annual Canadian Hydrogen and Fuel Cell Sector 2016 vs 2021

Hydrogen and fuel cell sector survey respondent	CHFCA (2016)	CHFCA (2021)
No. of survey respondents	65	105
Revenue from product sales	CAD $125 million	CAD $412 million
Revenue from the provision of services	CAD $84 million	CAD $115 million
Employment (jobs)	1,785	4,291
R&D expenditure	CAD $173 million	CAD $125 million

Sources: CHFCA Sector Profile 2022 and CHFCA Sector Profile 2016

A.3.6 Commercial Port Infrastructure

There are a number of ports located within Nova Scotia with the largest commercial port located in Halifax. The Port of Halifax employs over 22,400 people[89] through the operations of the port and Nova Scotia exporters, and in 2022 the port handled 446,026 TEU (Twenty Foot Equivalent Units) of cargo[90].

[88] CHFCA. 2018. Canadian Hydrogen and Fuel Cell Sector Profile Microsoft Word - CHFC Sector Profile 2018 - Final Report v2.docx (chfca.ca).
[89] Port of Halifax, 'Fact Sheet', *Port of Halifax*, 2022 Fact Sheet | Port of Halifax
[90] Port of Halifax, 'Cargo Statistics, *Port of Halifax*, 2022 Cargo Statistics | Port of Halifax

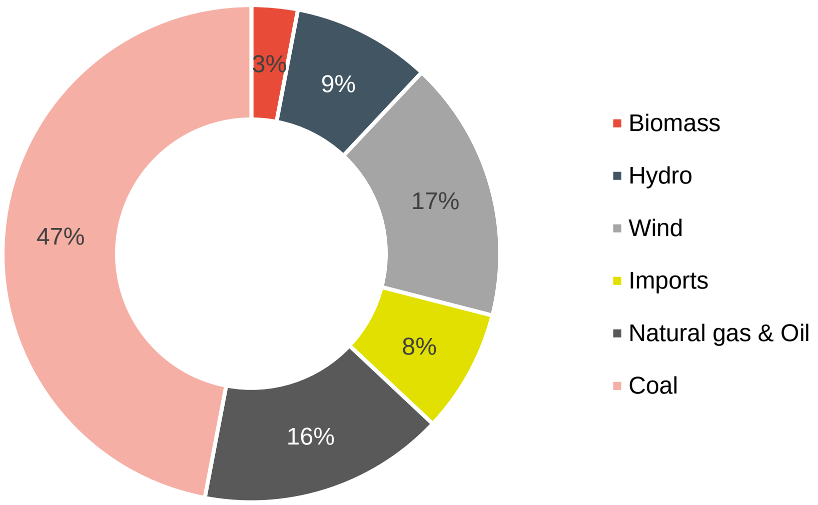
The most recent economic impact report, produced by Chris Lowe Planning and Management Group, found the Port of Halifax's economic output in 2017/18 from operations to be CAD $1.97 billion[91]. Through the port in 2017, Nova Scotia container exporters contributed over $2.58 billion to the province's gross output. When combined with port operations the total impact of the Port of Halifax on Nova Scotia's gross output is CAD $4.56 billion[92].

Smaller ports that can also accommodate commercial ships are located across the province including Pictou, Digby, Mulgrave, Port Hawkesbury, Yarmouth, Shelburne, Parrsboro, Sydney and Hantsport.

A.3.7 *Energy Infrastructure*

Nova Scotia's share of electricity generation from renewable sources has grown from 11% in 2005 to 32% in 2021[93]. In 2021 Nova Scotia generated 7.4 terawatt-hours (TWh) of electricity comprised of multiple generation sources including coal, hydro and tidal, natural gas, wind, biomass, and fuel oil. The figure below shows the electricity generation by source type.

Electricity Generation by Type in Nova Scotia (2021)[94]



A.3.7.1 Hydroelectricity

The Nova Scotian geography and lack of a major river system keeps hydro electricity from being a major source of electricity in Nova Scotia. Currently, there is approximately 510 MW of renewable hydroelectricity capacity generation in Nova Scotia[95]. Nova Scotia

[91] AJOT, 'Port of Halifax operations provides almost $2 billion in economic output each year', *AJOT,* 2022 Port of Halifax operations provides almost $2 billion in economic output each year | AJOT.COM
[92] AJOT, 'Port of Halifax operations provides almost $2 billion in economic output each year', *AJOT,* 2022 Port of Halifax operations provides almost $2 billion in economic output each year | AJOT.COM
[93] Canada Energy Regulator, Canada's Energy Future Data Appendices, 2021, Electricity Generation - Canada.ca (rec-cer.gc.ca)
[94] NS Power, 'Powering a green Nova Scotia, together', *NS Power*, 2023 Clean Energy| Nova Scotia Power (nspower.ca)
[95] NS Power, 2022. 'Nova Scotia Utility and Review Board 2022, 10-Year System Outlook' 2022 10YSO (nspower.ca)

Power a subsidiary of Emera (a multinational energy holding company), operates 33 hydroelectric plants on 17 hydro river systems across Nova Scotia[96].

A.3.7.2 Biomass

Nova Scotia Power operate a 60 MW biomass plant in Port Hawkesbury that provides around 3% of the province's electricity.

A.3.7.3 Wind

There are currently more than 300 commercial wind turbines generating electricity in Nova Scotia.

In 2022, the provincial government of Nova Scotia has selected 5 onshore wind projects estimated to generate 1,373 GWh per year, which is approximately 12% of Nova Scotia's total energy consumption. The projects are expected to be operational by 2025 and it will enable Nova Scotia to create 70% of its electricity from renewable sources[97].

The average cost of energy produced by the 5 wind projects is predicted to be CAD $53.17 per MWh, which is lower than the current average cost of electricity in Nova Scotia. The province expects to save ratepayers CAD $120 million annually[98].

Nova Scotia does not have any offshore wind generation currently; however, the province recently announced offshore wind generation targets. In September 2022, Nova Scotia Premier Tim Houston announced the goal to produce 5 GW of offshore wind energy to support green hydrogen production by 2030 with the first call for bids in 2025[99].

Offshore wind energy can be used to generate renewable electricity to produce green hydrogen for use in the province and for export. The electricity can also be another option to help Nova Scotia and Canada meet future clean electricity needs. Nova Scotia's offshore wind industry will be developed in consultation with Fishers, First Nations, and other stakeholders.

A.3.7.4 Tidal

The Annapolis Tidal Station is the only tidal power generating station in North America with a 20 MW generating capacity. However, after an equipment failure in 2019, the station has been idle for two years and is expected to be decommissioned over the next 10 years[100].

Soluna Energy partnering with the town of Annapolis Royal where the Tidal station is located to develop a small-scale tidal power pilot project in nearby Digby Gut. The pilot

[96] NS Power, 'Electricity', *NS Power,* 2023 Electricity| Nova Scotia Power (nspower.ca)
[97] CBC, 'NS selects five wind projects to produce electricity from renewable sources', *CBC News,* 2022 N.S. selects five wind projects to produce electricity from renewable sources | CBC News
[98] CBC, 'NS selects five wind projects to produce electricity from renewable sources', *CBC News,* 2022 N.S. selects five wind projects to produce electricity from renewable sources | CBC News
[99] Nova Scotia Government, 'Province sets offshore wind target', *Nova Scotia Government,* 2022 Province Sets Offshore Wind Target - Government of Nova Scotia, Canada
[100] CBC, 'Nova Scotia Power to pull plug on tidal station seeks $25M from taxpayers', *CBC News,* 2021 Nova Scotia Power to pull plug on tidal station, seeks $25M from ratepayers | CBC News

requires access to the grid for two megawatts of capacity and is expected to cost CAD $400,000[101].

The Fundy Ocean Research Centre for Energy (FORCE) also sites projects that continually tests tidal turbines. Nova Scotia's Bay of Fundy has been identified as one of the best potential sites in North America for tidal power generation[102].

A.3.7.5 Offshore Oil & Gas

The oil & gas extraction sector in Nova Scotia which includes both onshore and offshore petroleum reserves has played a significant role in Nova Scotia's economy since the turn of the century, generating nearly CAD $2 billion in provincial revenue from petroleum royalties[103].

The Sable Offshore Energy Project, which was co-owned by ExxonMobil Canada, Shell Canada, Imperial Oil Resources, Pengrowth Corporation, and Mosbacher Operating Ltd. was the first offshore natural gas project in Atlantic Canada to deliver gas to the Maritimes and the northeastern United States. The first 12 years of the Sable offshore energy project created an average of 3,200 jobs and significant revenue for Nova Scotia.

Despite this, Nova Scotia has lagged behind in oil production compared to other provinces such as Alberta or Newfoundland & Labrador and has seen a significant fall in hydrocarbon production over the past decade.

2020 marked the first year in at least 25 years where the province derived no revenue from petroleum royalties. In 2019, all production from the Sable Offshore Energy Project has been permanently shut down, with decommissioning activities to continue throughout the year[104]. Since the shutdown, Nova Scotia now relies on natural gas imported from the U.S., as well as liquefied natural gas (LNG) delivered from Saint John, New Brunswick[105].

A.3.7.6 Natural Gas

In 2021, about 16% of Nova Scotia's electricity generation comes from natural gas and oil. The Burnside Combustion Turbine (132 MW), the Victoria Junction Combustion Turbine (66 MW), and the Tusket Combustion Turbine (24 MW) mainly use fuel oil. The Tufts Cove Generating Station was re-fitted in 2000 to burn either fuel oil or natural gas, however, due to low natural gas prices in recent years, the entire plant has been running largely on natural gas instead[106].

[101] CBC, 'Annapolis Royal makes power play to deal with big revenue drop', *CBC News,* 2021 Annapolis Royal makes power play to deal with big revenue drop | CBC News
[102] Canada Energy Regulator, Market Snapshot, *Canada Energy Regulator,* 2016 CER – Market Snapshot: Canadian tidal power capacity fourth in the world, with potential to add up to 7 000 MW more (cer-rec.gc.ca)
[103] Fraser Institute, 'Investors souring on Nova Scotia's oil and gas sector', *Fraser Institute,* 2021 Investors souring on Nova Scotia's oil and gas sector | Fraser Institute
[104] CTV News, 'Sable Offshore Energy Project permanently shuts down after nearly 20 years', *CTV News,* 2019 Sable Offshore Energy Project permanently shuts down after nearly 20 years | CTV News
[105] Canada Energy Regulator, 'Provincial and Territorial Energy Profiles – Nova Scotia', *Canada Energy Regulator,* 2023 CER – Provincial and Territorial Energy Profiles – Nova Scotia (cer-rec.gc.ca)
[106] NS Power, 'Tufts Cove: Over five decades of power generation', *NS Power,* 2021Tufts Cove: Over five decades of power generation| Nova Scotia Power (nspower.ca)

A.3.7.7 Coal

Nova Scotia has a long association with coal with over 250 consecutive years of mining. Nova Scotia is the most coal-dependent province in the country and the province imports coal from abroad. In 2019, over half of electricity (51%) generated by Nova Scotia Power comes from burning coal[107]. Nova Scotia's coal and coke generating stations include Lingan (600 MW), Point Aconi (171 MW), Point Tupper (154 MW), and Trenton (307 MW).

In 2021, the province passed the Environmental Goals and Climate Change Reduction Act which outlined numerous climate change objectives over the next decade, one of which includes phasing-out coal-fired electricity generation by 2030[108].

A.3.7.8 Jurisdiction Connection

Nova Scotia's electricity grid is connected to a few provinces nearby in the Atlantic region. It is connected to New Brunswick through a 350 MW transmission line which enables the trade of electricity between the two provinces. The Maritime Link Project also connects Nova Scotia's electrical gird with the Muskrat Falls hydro facility in Labrador through the Labrador-Island Transmission Link, where the power was first received by Nova Scotia in August 2021. Hydro power delivered through the Maritime Link will displace some of Nova Scotia's thermal generation. The Atlantic Loop, which is to be implemented, would further expand the electrical grid connections between Nova Scotia and nearby jurisdictions to provide greater access to renewable electricity, like hydro from Quebec[109].

A.3.8 Greenhouse Gas Emissions

- Nova Scotia's GHG emissions in 2020 were 14.6 megatonnes (MT) of carbon dioxide equivalent (CO_2e), with the largest emitting sectors being electricity generation (43%), transportation (30%), and residential and commercial buildings (13%)[110]. Nova Scotia's emissions per capita is 14.9 tonnes CO_2e which is 16% below the Canadian average of 17.7 tonnes per capita. In 2020, Nova Scotia's electricity / power sector represented about 11% of Canadian emissions from power generation.
- The GHG intensity of Nova Scotia's electricity grid was 670 g of CO_2e/kWh (2020), which is a 24% reduction from the province's 2005 level of 880 g of CO_2e/kWh but still higher than the national average of 110 g of CO_2e/kWh in 2020.

[107] Canada Energy Regulator, 'Provincial and Territorial Energy Profiles – Nova Scotia', *Canada Energy Regulator*, 2023 CER – Provincial and Territorial Energy Profiles – Nova Scotia (cer-rec.gc.ca)
[108] Global News, Nova Scotia bill sets climate change targets, aims to end coal fired power by 2030, *Global News,* 2021 Nova Scotia bill sets climate change targets, aims to end coal fired power by 2030 - Halifax | Globalnews.ca
[109] Ottawa 'very committed' to Atlantic Loop electricity mega project despite pause | CBC News
[110] CBC News, 'Ottawa very committed to Atlantic Loop electricity mega project despite pause', *CBC News,* 2022 Ottawa 'very committed' to Atlantic Loop electricity mega project despite pause | CBC News

Nova Scotia Power is working towards 80% renewable energy by 2030 and phasing out coal as per the Environmental Goals and Climate Change Reduction Act. They have planned to[111]:

- Increase solar and wind generation in Nova Scotia's electricity grid mix;
- Work with Bridgewater, Onslow, and HRM to add new energy storage which includes grid-scale and residential battery storage;
- Convert a small number of coal facilities to natural gas as an interim solution while planning for potential future use of green hydrogen; and
- Connect to clean energy sources in other parts of Canada like Quebec by strengthening the transmission line to New Brunswick.

The government has also released a plan to reduce GHG emissions from electricity by 90% by 2035, some of which include[112]:

- A call to increase the amount of renewable energy by building at least 500 MW of new local renewable energy by 2026 and additional 50 MW of community solar; and
- A commitment to continue to work with neighbouring provinces to transfer more electricity across Atlantic Canada through projects like the Atlantic Loop.

[111] NS Power, 'Powering a green Nova Scotia, together', *NS Power*, 2023 Clean Energy| Nova Scotia Power (nspower.ca)
[112] CBC News, 'NS releases sweeping plan aimed at cutting emissions, reaching climate goals', *CBC News,* 2022 N.S. releases sweeping plan aimed at cutting emissions, reaching climate goals | CBC News

A.4 Trades and Skills Baseline

A.4.1 Relevant Qualifications

Undergraduate engineering programmes are liable to adapt as industrial needs evolve. It takes approximately 4 to 8 years for engineers to complete their professional qualifications. Hence, there is an overall risk of some shortage of graduate level engineers if there is a rapid hydrogen economy expansion.

The qualifications required for roles in a hydrogen production facility may range from apprenticeships to high school degrees to on-the-job training to a bachelor's or master's degree qualification. The earnings and education requirements vary across different parts of the hydrogen industry. For example, a hydrogen lab technician requires an associate degree and earns a salary of approximately CAD $41,000. Whilst a junior hydrogen energy technician may require only a high school degree and earns a salary around CAD $25,000[113].

A.4.2 Occupational Profile

The table below sets up the occupational profile of Nova Scotia compared to Canada. Nova Scotia has a significant proportion (14%) of its workforce engaged in trades, transport and equipment operators and related occupations. Some of these occupations contains the necessary skills in the building and operation of a hydrogen facility. Other relevant occupations include natural and applied sciences (7% of occupations), manufacturing and utilities (4% of occupations) and natural resources; agriculture and related production (2% of occupations).

Occupations by Sector

Occupation	Nova Scotia Occupations	Nova Scotia (% of total)	Canada (% of total)
Sales and service	228,000	24%	22%
Business, finance, and administration	151,000	16%	16%
Trades; transport and equipment operators and related	138,000	14%	14%
Law and social; community and government services	102,000	11%	10%
Health	92,000	10%	8%
Management	74,000	8%	10%
Natural and applied sciences and related	72,000	7%	9%

[113] Bezdek, R.H., 2018. The hydrogen economy and jobs of the future. The hydrogen economy and jobs of the future | Renewable Energy and Environmental Sustainability (rees-journal.org)
Note: The salaries stated here have been converted to Canadian dollars and inflated to 2022 prices. This has been estimated using Stats Can GDP deflators and December 2022 exchange rate data.

Occupation	Nova Scotia Occupations	Nova Scotia (% of total)	Canada (% of total)
Art; culture; recreation and sport	23,000	2%	3%
Manufacturing and utilities	41,000	4%	4%
Natural resources; agriculture and related production	22,000	2%	2%
Education	21,000	2%	2%

Source: Statistics Canada, 2022, Labour force characteristics by occupation, monthly, unadjusted for seasonality.

The hydrogen economy's skills requirements are varied. As the scale-up and expansion of the hydrogen economy occurs a wide range of jobs will be created and required to support the operations and development of hydrogen facilities, including hydrogen production facilities. Hydrogen related occupations range in skill level from a Fuel Cell Intern to Director. Moreover, there will be high demand for technical and engineering occupations roles including hydrogen fuel cell system technician, hydrogen vehicle technician, hydrogen energy system operations engineer and hydrogen energy system installers. Occupations engaging in hydrogen technology research and innovations are also important to the continued advancement of the sector.

Other occupations required to build and operate a hydrogen facility outside the realm of the hydrogen economy include occupations associated with the development, deployment, building and maintenance of hydrogen infrastructure as well the transportation of hydrogen.

A.4.3 Higher / Further Education Provision

The top 5 universities for engineering (based on their research performance in engineering[114]) in Nova Scotia are:

- Dalhousie University (Halifax)
- Acadia University (Wolfville)
- Saint Mary's University (Halifax)
- St. Francis Xavier University (Antigonish)
- Cape Breton University (Sydney)

The Nova Scotia Apprenticeship Agency (NSAA) offers a wide range of apprenticeships across multiple industries. The engineering / technical apprenticeships they offer are in occupations such as Power Engineer, Mechanical Vehicle Operator, Oil Heat System

[114] Edu Rank, '5 Best Universities for Engineering in Nova Scotia', *Edu Rank,* 2023 [Engineering in Nova Scotia: 5 Best universities Ranked 2022 (edurank.org)]

Technician, Automotive Service Technician, Communications Technician, and Powerline Technician.

The provincial government is committed to spending in order to encourage more young people into apprenticeship training. There are approximately 2,200 Nova Scotians enrolled in an apprenticeship each year. Almost all the training is offered through the Nova Scotia Community College (NSCC) system. The college offers more than 120 programs at 13 campuses across the province, with more than 10,000 students. Students can earn certifications, diplomas, and advanced diplomas. An NSCC annual survey found that 88% of graduates are employed in their field of choice, with 90% of those employed living and working in Nova Scotia. There are 55 apprenticeship programs in designated skilled trades, where 40% of new jobs will be in skilled trades and technologies over the next 20 years in Nova Scotia.

Three other notable associations involved with apprenticeships in Nova Scotia are the United Association of Journeyman and Apprentices of the Plumbing and Pipe Fitting Industry, the International Association of Heat and Frost Insulators and the Nova Scotia Boatbuilders Association[115].

[115] Halifax Regional Centre for Education, ‘Post Secondary Options’, *Halifax Regional Centre for Education,* 2023 [Post-Secondary Options | Halifax Regional Centre for Education (hrce.ca)]

A.5 Social Baseline

A.5.1 Housing and Visitor Accommodation

In Nova Scotia there are 428,230 dwellings, 285,995 of which are privately owned, 139,415 are rented and 2,820 are provided by the local government[66]. According to the Canadian Housing survey, 11.4% (45,100) of Nova Scotian households in 2018 were in core housing need, which is a metric which considers housing suitability and affordability, with over half of those identified residing in Halifax[116]. The most recent 2021 census data indicates that currently, 18% of Nova Scotians spend 30% or more of their income on housing costs, compared with 21% of Canada, yet in Halifax this figure rises to 22%[116].

The average house price in Nova Scotia is CAD $368,600 which is 42% lower than the Canadian average of CAD $632,802[117]. However, in Halifax the average house price is CAD $479,600 (30% greater than the Nova Scotia average[117]). Since 2016, there has been an upward trend in new housing construction in the province however the overall rate remains below historic construction trends and vacancy rates remain low, particularly in Halifax[122].

The private rental market in Nova Scotia is concentrated in Halifax, with 86% of the provincial rental market located there[116]. The median monthly rental price in Nova Scotia in October 2022 was CAD $1,200, which was 7% greater than the Canadian median rental price of CAD $1,120[118]. Since 2016, the median rental price in Nova Scotia has increased by 71% from CAD $650 to CAD $1,110, with this increase primarily driven by Halifax and East Hants[119].

Due to the high rates of increase seen in rents in recent years, the government of Nova Scotia has implemented a 2% rent cap for existing leases to protect residents whilst housing stock issues are addressed[120]. However, this does not apply to new tenants and new leases, therefore only those in existing leases are protected.

Nova Scotia has recently announced that it is investing an additional CAD $19.5 million to their initial CAD $12.5 million investment, to preserve, improve and modernise existing affordable housing and create more community housing that is provided by the Government[121].

Visitor accommodation in Nova Scotia had a 56% occupancy rate in 2022, which is a 13%-point increase from 2019[122], indicating that tourism in the area has recovered well post Covid-19. Halifax had the highest occupancy rate, at 65%, which is 1% less than the

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[116] The Nova Scotia Affordable Housing Commission Report, 2021.
[117] The Canadian Real Estate Association, 2022
[118] CMHC Rental Market Survey, 2022. Please note these figures are for the primary rental market.
[119] Housing Market Information Portal, Canada Mortgage and Housing Corporation, 2021
[120] Government of Nova Scotia, 'Legislation supports housing plan, capping rent increases, addressing supply', *Government of Nova Scotia,* 2021 Legislation Supports Housing Plan, Capping Rent Increases, Addressing Supply - Government of Nova Scotia, Canada
[121] Government of Nova Scotia, 'More funding for affordable housing, modular homes', *Government of Nova Scotia,* 2021 More Funding for Affordable Housing, Modular Homes - Government of Nova Scotia, Canada
[122] Tourism Nova Scotia: Tourism Nova Scotia Accommodations, 2022

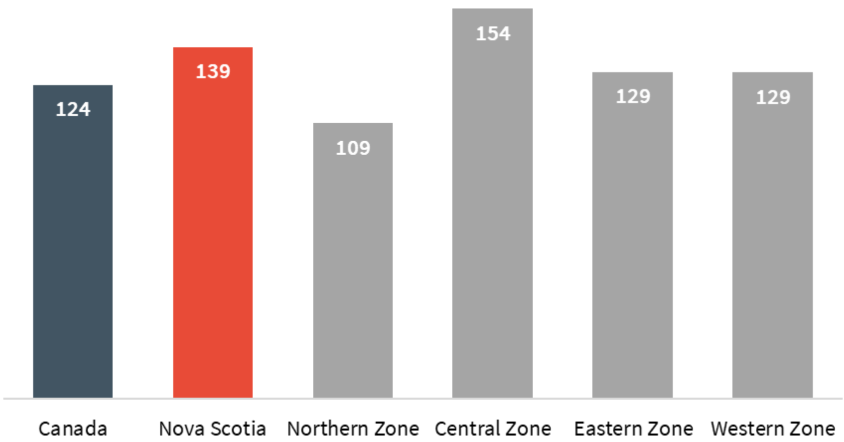
rate in 2019[122]. The average room rate across Nova Scotia is CAD $162, with Halifax's average at CAD $171[122].

A.5.2 Healthcare – GPs Patients and GP Workforce

As of 2021, there were around 1,370 family doctors in Nova Scotia and 47,340 in Canada[123]. In recent years the number of family doctors has been increasing; however, there still appears to be a family doctor shortage across Canada which is likely linked to the 20% increase in population aged 65 and above since 2016[66]. In 2019 data showed that 14.5% of Canadians did not have a regular health care provider, with Nova Scotia only slightly below with 14.4% of residents reporting they had no access to a regular health care provider[124]. However, more recent research conducted by the Angus Reid Institute has found that around 17% want a family doctor yet does not have access to one[125].

Currently in Nova Scotia, approximately 125,278 residents (13% of the total population) were on the 'Need a Family Practice' Registry as of December 2022 suggesting that Nova Scotia is performing slightly better than Canada as a whole[126]. When looking at the age of family doctors, around 15% in Nova Scotia are meeting, or are already over, the Canadian retirement age of 65, with the Eastern zone having 20% of their family doctors in this age bracket[123]. This poses future risks surrounding family doctor provision if careful action is not taken to not only replace currently practising family doctors that are of retiring age, but to also recruit additional doctors to meet increased demands.

Number of family doctors per 100,000 people 2021



Source: Canadian Institute for Health Information (CIHI), Supply, Distribution and Migration of Physicians in Canada, 2021

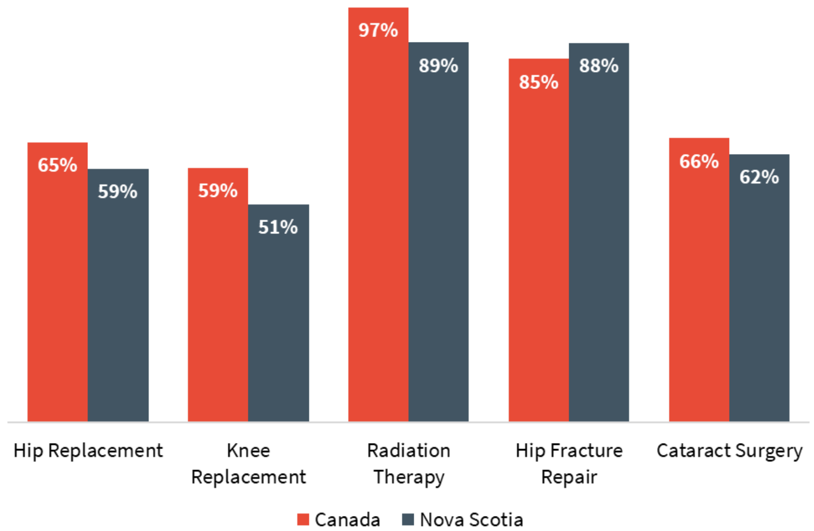
[123] CIHI, 'Supply, Distribution and Migration of Physicians in Canada – Data Tables', 2021
[124] Statistics Canada, 'Primary Health care providers, 2019', 2020 Primary health care providers, 2019 (statcan.gc.ca)
[125] Angus Reid Institute, 'Doc Deficits: Half of Canadians either can't find a doctor or can't get a timely appointment with the one they have', *Angus Reid Institute,* 2022 Doc Deficits: Half of Canadians either can't find a doctor or can't get a timely appointment with the one they have - Angus Reid Institute
[126] Nova Scotia Health, 'Finding a primary care provider in Nova Scotia December', 2022

A.5.3 Hospitals

There are 43 hospitals across Nova Scotia, 8 of which are located in Halifax[127]. From April 2021 to December 2022, the average total occupancy rate in hospitals across Nova Scotia was 86.7%[128]. In 2021, wait times for most priority procedures in Nova Scotian hospitals exceeded those in Canada, with Nova Scotia hospitals having a smaller percentage of procedures that met national benchmarks[129].

Wait times began increasing in 2020 due to the Covid-19 pandemic impacting hospital capacity which resulted in hospitals postponing non urgent surgeries and treatments[130]. Wait times across most priority surgeries have yet to reach pre pandemic levels, with radiation therapy, hip fracture surgery and cataract surgery the worst impacted[129].

Percentage of patients receiving care within established benchmark time frames* in Canada and Nova Scotia, 2021



Source: Wait Times for Priority Procedures in Canada, Canadian Institute for Health Information 2022.
*Benchmarks are as follows: hip replacement (26 weeks), knee replacement (26 weeks), radiation therapy (4 weeks), hip fracture repair (48 hours) and cataract surgery (16 weeks).

A.5.4 Emergency Response

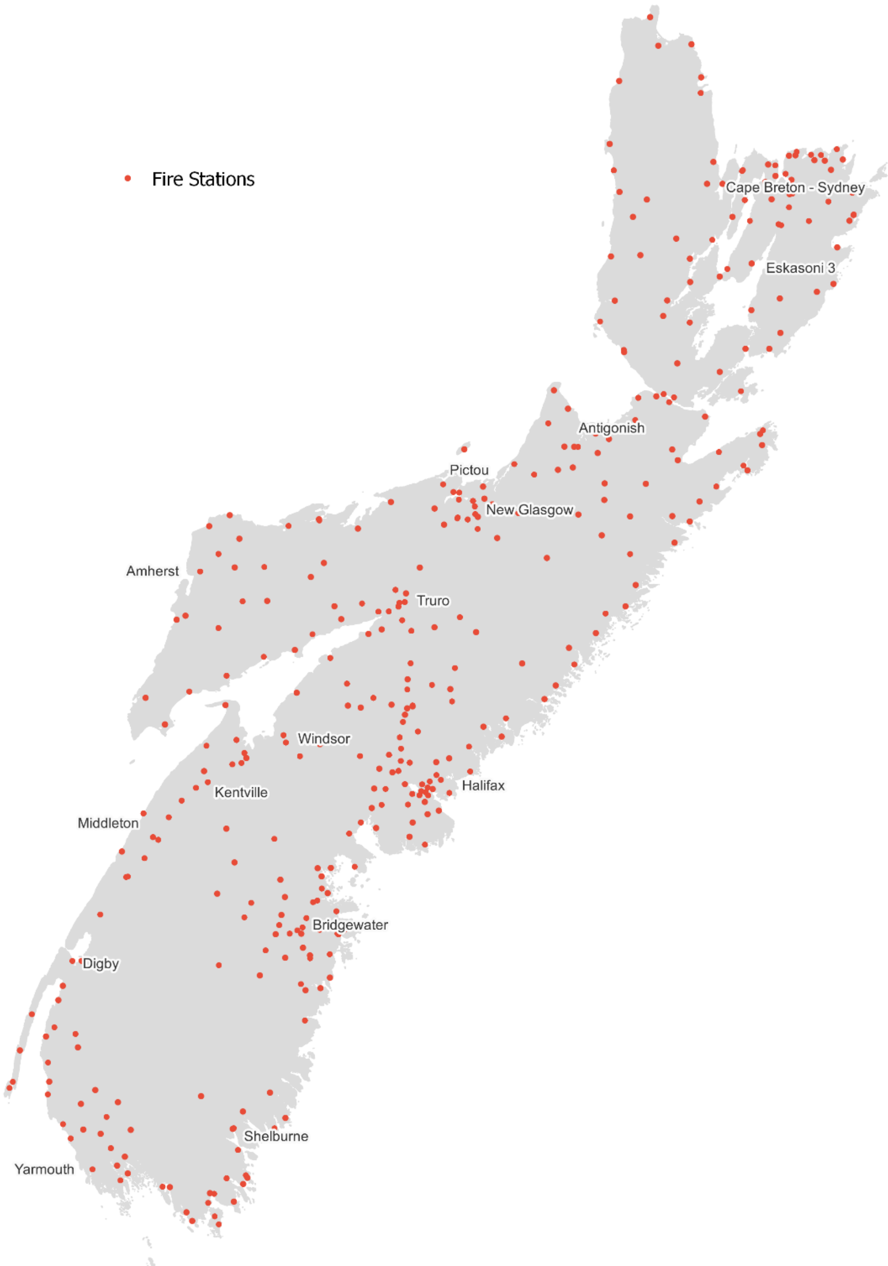
A.5.4.1 Fire and Rescue

There are 360 fire stations across Nova Scotia, shown on the map below, with 6,000 volunteer and 700 paid firefighters[131]. The Fire Departments in Nova Scotia are primarily

[127] Nova Scotia Government, 'Nova Scotia Hospitals', 2023 https://novascotia.ca/dhw/about/hospitals.asp
[128] Nova Scotia Government, 'Action for Health – Public Reporting', *Tableau*, 2023 Action for Health - Public Reporting | Tableau Public
[129] CIHI, Wait Times for Priority Procedures in Canada – Data Tables, 2022
[130] CTV News, 'Staffing shortages, more complex disease pushing up surgery wait times in Nova Scotia', *CTV News,* 2022 Surgery wait times in N.S. pushed up by lingering pandemic problems | CTV News
[131] Nova Scotia Government, 'Amendments Support Volunteer Firefighters', *Nova Scotia Government*, 2019 Amendments Support Volunteer Firefighters - Government of Nova Scotia, Canada

served by volunteer firefighters, particularly in rural regions, with paid firefighters in larger towns and cities[132]. It is estimated that around 2,100 firefighters are also registered Medical First Responders who are able to provide additional services to their communities through medical response in coordination with EHS[132].

Fire Station locations across Nova Scotia



Source: Nova Scotia Topographic DataBase, 2022

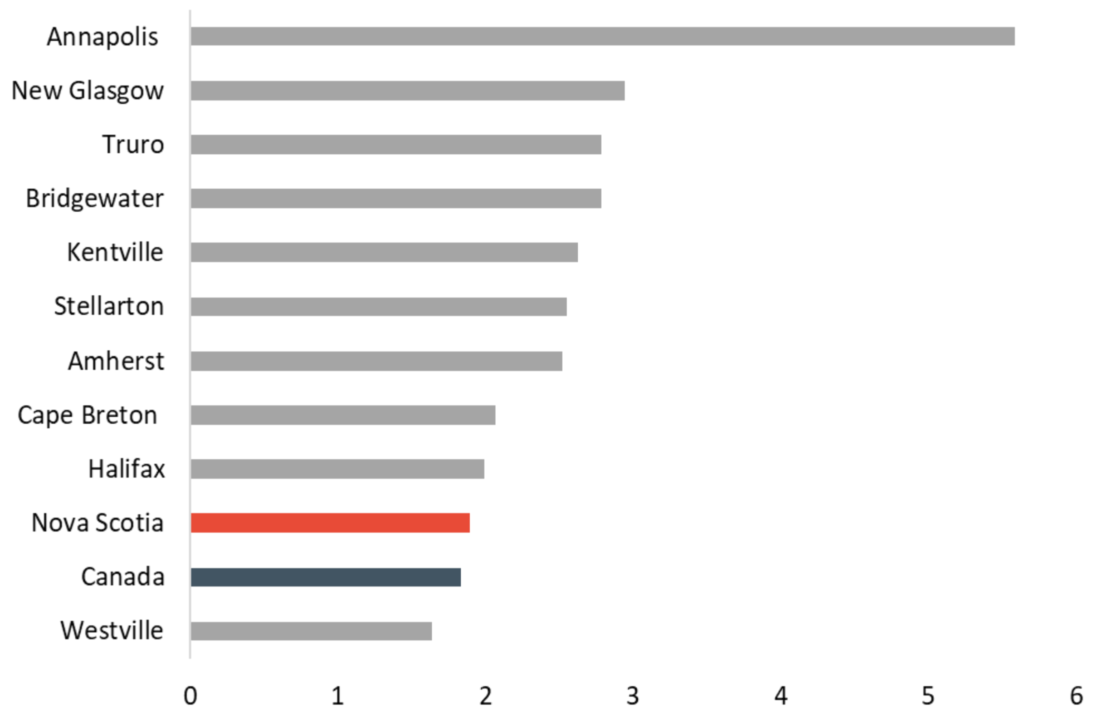
[132] Canadian Volunteer Fire Services Association, 'Nova Scotia Annual Report', 2018, [Nova Scotia Annual Report | Canadian Volunteer Fire Services Association (cvfsa.ca)]

A.5.4.2 Police

The Royal Canadian Mounted Police has 53 detachments across the province of Nova Scotia[133]. Many of the cities and large towns also have their own municipal police forces (10 exist across Nova Scotia)[134].

In Nova Scotia there are 1.9 police officers per 1,000 of the population, which is on par with the Canadian average of 1.8 per 1,000[135]. Annapolis in Nova Scotia greatly exceeds both averages, with 5.6 police officers per 1,000 people (Annapolis has a very small population). An area for slight concern in Nova Scotia is Westville which falls below 1.7 per 1,000.

Municipal police officers per 1,000 of the population



Source: Statistics Canada, Police personnel and selected crime statistics, 2021. Due to data availability only the 10 main police municipal areas have been selected. The data for the missing areas may explain the lower rate of police per 100,000 of the population in Nova Scotia.

A.5.4.3 Emergency Health Services

There are 38 emergency departments across Nova Scotia, with most operating on a 24/7 basis apart from 7 that have established alternative operating hours. In 2021/22, there

[133] RMCP, 'About the RCMP in Nova Scotia', *RCMP,* 2023 About the RCMP in Nova Scotia | Royal Canadian Mounted Police (rcmp-grc.gc.ca)
[134] Nova Scotia Government, 'Directory of Police Agencies in Nova Scotia', *Government of Nova Scotia,* 2022 Directory of Police Agencies in Nova Scotia | novascotia.ca
[135] Statistics Canada, 2021. Table 35-10-0077-01 Police personnel and selected crime statistics, municipal police services https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3510007701

were 19 temporary emergency department closures due to lack of staff and these were more commonly in smaller, more rural areas[136].

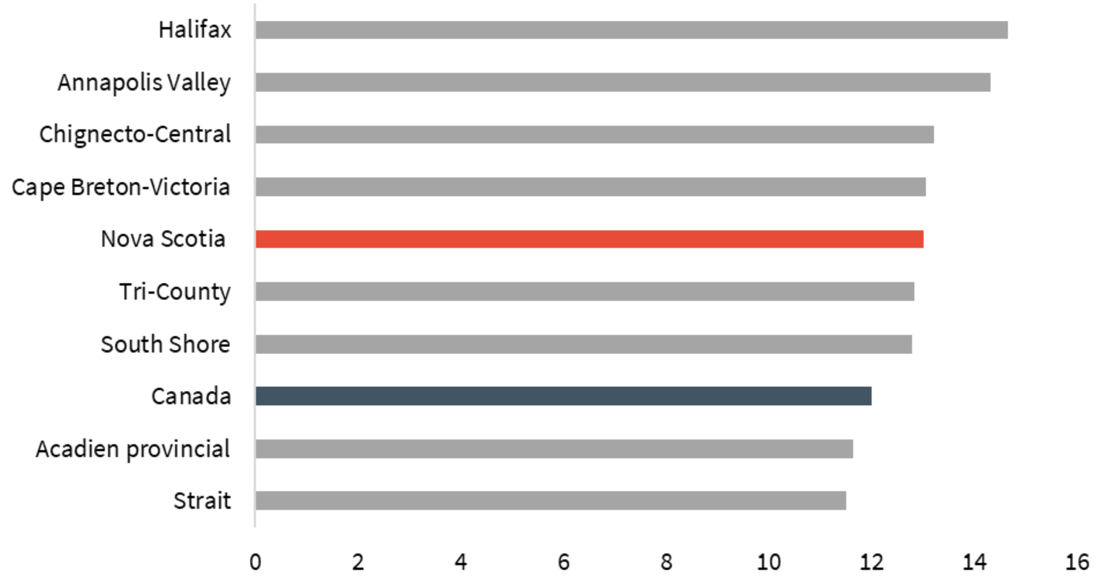
There are around 160 ambulances in Nova Scotia and around 1,200 paramedics registered in the province[137]. The average wait time for an ambulance in Nova Scotia from May 2022 to November 2022 was 24.9 minutes[128] which is significantly higher than New Brunswick's benchmarks for emergency response times of 9 minutes or less than 90% of the time for urban areas and 22 minutes or less than 90% of the time for rural areas[138]. The EHS department acknowledges issues surrounding long off-loading times of patients from ambulances to the relevant emergency services department which for the same six-month period was 79 minutes[139].

A.5.5 Education

There are 372 schools across Nova Scotia with a total of 129,121 students enrolled[140]. The most recent data from 2020-2021[141] indicates that there are 9,924 teachers in the province, giving a student-teacher ratio of 13. This is a little higher than the Canadian average, which currently stands at 12[142].

[136] Department of Health and Wellness Annual Accountability Report on Emergency Departments, 2021-2022.
[137] Government of Nova Scotia, 'New EHS Contract Addresses Recommendations in Fitch Report', 2021 New EHS Contract Addresses Recommendations in Fitch Report - Government of Nova Scotia, Canada
[138] Response Times | Ambulance New Brunswick (ambulancenb.ca)
[139] Fitch & Associates, 'Current State & Best Practices Review', 2019 FITCH-EHS-Report-Redacted.pdf (novascotia.ca)ca)
[140] Department of Education and Early Childhood Development. 'Enrolments by Region & School per School Year: 2022-2023', Enrolments by Region & Level: 2022-2023 | Statistical Summary (ednet.ns.ca)
[141] Statistics Canada, 2022. 'Educators in public elementary and secondary schools, by work status, age group and sex' https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3710015301
[142] Statistics Canada, 2022. 'Number of students in regular programs for youth, public elementary and secondary schools, by grade and sex' https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3710000701

Student to teacher ratios in Nova Scotia and Canada

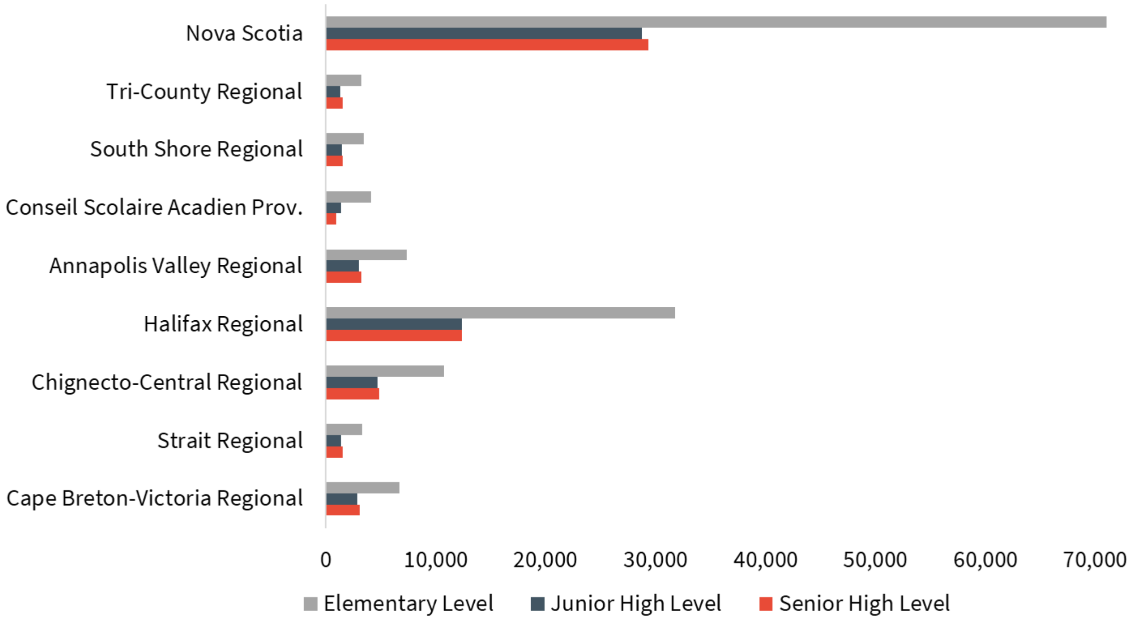


Source: Department of Education and Early Childhood Development, 2018. Statistics Canada, 2022. Due to data availability the Nova Scotia regions were calculated using 2018 teacher numbers, and Nova Scotia and Canada ratios were calculated using 2021 teacher numbers.

Since 2015-16, student enrolment numbers have been increasing in Nova Scotia across all education levels apart from senior high level, with the largest increase seen at the elementary level with 10, 615 more enrolments in 2022-23 than 2015-1664. From the same period, senior high-level enrolments have decreased by 782 and junior high-level enrolments have increased by 1,136[140].

The figure below shows that over half of all elementary to senior high-level pupils are enrolled at elementary level (2022/23).

Number of pupils per educational level across Nova Scotia's school districts



Source: Enrolments by region and level. Department of Education and Early Childhood Development, 2022

There are 10 universities across Nova Scotia that saw 50,000[143] student enrolments in 2022, including 4,000 international students[144]. Out of these 10 universities, 7 are in the Halifax Regional Municipality, accounting for 34,000 students, with almost two thirds of these attending Dalhousie University.

The Indigenous communities face particular challenges through their education. According to 2021 Census data[145] relating to educational attainment, 28% of Indigenous people have a high school diploma or below, compared with 27% of the general population. However, in 2021, 49% of Indigenous people had a post-secondary certificate, diploma or degree compared to 56% of the wider population. This suggests that there are barriers faced by Indigenous people in Nova Scotia in either accessing or completing post-secondary education.

143 Association of Atlantic Universities, '2022-2023 Preliminary Survey of Enrolment', *Association of Atlantic Universities*, 2022 Statistics: Surveys of Preliminary Enrolments - Association of Atlantic Universities
144 Study Nova Scotia, 'Our Diverse Student Population', *Study Nova Scotia, 2023* Our Diverse Student Population – Study Nova Scotia
145 Statistics Canada, 2022. 'Highest level of education by major field of study and Indigenous identity: Canada, provinces and territories, census metropolitan areas and census agglomerations with parts' https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810041401

Appendix B Project Design Basis

B.1 Overall design assumptions

- The construction of the overall plant will be built out in a single phase.
- The construction will take place as soon as possible, and therefore only mature technologies are considered.
- The site is Greenfield in Nova Scotia, but no specific location has been identified. As such, there are no layout / footprint constraints.
- The site will have access to the fresh water required for electrolysis. There is a nearby connection to municipal water.
- Each plant (hydrogen and ammonia) are separate, stand-alone facilities. No optimization of common utilities was assumed at this stage of the project.
- The overall plant operates continuously at steady state. No operating optimization has been considered (e.g., turning on / off and ramping up / down the hydrogen and ammonia plants)
- The overall plant will be located near an existing port in Nova Scotia.
- Loading infrastructure will be added to an existing port and berth.
- Plant design life is 30 years.

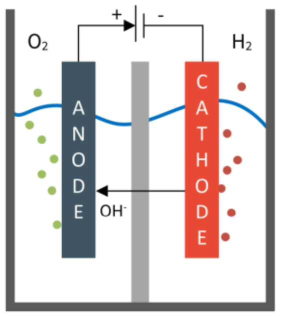
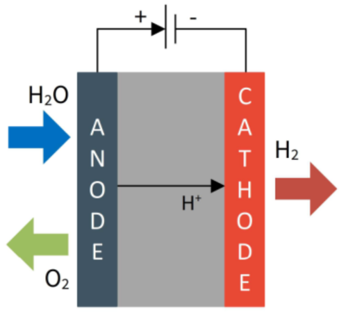
B.2 Hydrogen Production Plant

B.2.1 Electrolysis Technology Selection

Two (2) electrolyzer technologies were considered for this Study – alkaline and PEM, which are the two most mature technologies in hydrogen electrolysis. Alkaline electrolysis consists of immersing two electrodes in an aqueous solution of potassium hydroxide (potash, KOH) where the concentration varies between 20 and 30%. The two electrodes are separated by a semi-permeable diaphragm that allows water and charged molecules to pass through but not oxygen and hydrogen under the effect of an electric current. By comparison, PEM electrolysis technology uses a solid polymer to conduct ions. The membrane allows H+ ions to pass from the anode to the cathode while electrons pass through the external circuit when a current is applied between the two electrodes of the system.

A high-level comparison of the two technology types has been provided in Table B-1. The comparison is based on typical data for each technology but does not cover all scenarios and configurations. BoP systems are not included in this comparison and the information presented is not exhaustive. Colours have been used to represent relative comparisons between the technologies with green as the most favourable, orange as neutral, and red as least favourable.

Table B-1: Electrolyzer Technology Comparison

Technology	Alkaline	PEM
Overview		
Schematic		
Electrolyzer Inputs	Demineralized Water MV Electricity	Demineralized Water MV Electricity
Electrolyzer Outputs	H_2 Gas O_2 Gas	H_2 Gas O_2 Gas
Electrolyzer Components (Vendor Supplied Equipment Package)	Cell Stack(s) Gas Separation Gas Cooling Water Circulation	Cell Stack(s) Gas Separation Gas Cooling Water Circulation

Technology	Alkaline	PEM
	Electrolyte Circulation	
Optional Components (Vendor Supplied Equipment Package)	Rectifier(s) Gas Purification	Rectifier(s) Gas Purification
Cell Stack Size	Up to 6.5 MW	Up to 2.5 MW
Electrolyzer TRL	9	8-9
Operational Plant Size >100 MW	Yes	No
Operational Plant Size >10 MW	Yes	Yes
Cell Stack Materials		
Electrolyte	Liquid KOH or NaOH	Solid Polymer
Catalyst	Nickel-based	Platinum/Iridium-based
Electrolyzer Key Parameters		
Efficiency	50-55 kWh/kg	53-60 kWh/kg
Degradation Rate (Stack Lifespan)	🟢	🟡
Start-Up Time	🟡	🟢
Response Time	🟡	🟢
Turndown Ratio	🔴	🟢
H_2 Delivery Pressure	🟡	🟢
H_2 Gas Quality	🟡	🟢
Footprint	🔴	🟢

Only one (1) technology has been evaluated as part of the design and CAPEX estimate. Alkaline electrolysis has been selected for this Study because it is the most mature electrolysis process, there are no footprint or response time restrictions for this Study, and because it is the least capital-intensive technology of the two prominent options presented.

B.2.2 *Design Assumptions*

- The hydrogen plant will use alkaline electrolysis to generate hydrogen gas. Nel's flagship alkaline electrolyzer (A485) was assumed for this Study but alternative technologies and vendors can be considered in future project phases.

- Normal operation is defined as 500 MW of electrolysis at beginning of life conditions. Note: the total power required for the hydrogen plant will be greater than 500 MW to account for BoP loads and stack degradation (over time).
- The hydrogen plant will operate continuously at normal operating conditions i.e., it will not turn on / off or ramp up or down with the wind supply. Note: the total production of alkaline electrolyzers output can be adjusted (ramped up or down) by approximately ± 10% per minute, to a minimum load of ~15% of full capacity. Therefore, load following can be considered in a future project phase.
- Oxygen gas generated as a co-product in electrolysis will be vented to the atmosphere.

B.2.3 Design Parameters

Table B-2: Hydrogen Production Plant Design Basis Parameters

Parameter	Value
Design Production Rate	252 tH_2/day at 100% load
Operating Production Rate	214 tH_2/day at 85% load (1)
Plant Availability	90%
Degradation Rate	1% (1)
Stack Replacement Interval	10 years
Response Time	10% per minute
Turndown Ratio	15-100%
Product	Hydrogen (H_2)
Product Purity[1] to Ammonia Plant	99.99 %vol 5 ppm(v) H_2O 5 ppm(v) O_2 Remainder N_2
Delivery Pressure to Ammonia Plant	7.0-7.5 bar(g)
Delivery Temperature to Ammonia Plant	25-30°C
[1] Hydrogen product purity shown is current design basis from in-house data. Additional hydrogen purification (deoxidation and drying) may be required to satisfy ammonia plant feedstock purity requirements to suit ammonia product purity requirements defined by off-taker agreements. Hydrogen purity requirements should be refined during future project phases.	

(1) Previous vendor discussion has indicated that operating the electrolyzers at 100% capacity factor increases the rate of degradation. The basis of this Study therefore considers an 85% capacity factor for electrolyzer operation and assumes stack

replacement to be every 10 years. The electrolyzers and hydrogen plant will, however, be designed to support plant operation up to 100% capacity factor.

(2) Each Nel A485 electrolyzer consumes approximately 2.2 MWe at beginning of its operating life. Over time, electrolyzer efficiency degrades by an estimated 1% per year. However, since the unit operates on a basis of constant hydrogen production, the loss in efficiency results in a higher electrical power demand rather than a decrease in hydrogen production. For example, after 10 years of operation, an electrolyzer that has been operating at 100% capacity factor would be estimated to consume approximately 2.42 MWe. Due to this loss in efficiency over time, vendors recommend that the electrolyzer stacks should be replaced on approximately 10-year intervals.

B.2.4 Plant Layout

The project's hydrogen plant is configured as six (6) process buildings. Each building consists of:

- 40 electrolyzer stacks. The stacks are arranged / grouped based on the transformer and rectifier combination used to supply the unit. One (1) 34.5 kV / 0.9 kV transformer will power four (4) 0.9 kV / 414 VDC rectifiers which will supply power to eight (8) electrolyzers.
- One (1) hydrogen vent stack.
- One (1) oxygen vent stack.
- One (1) compressor per 20 stacks. Hydrogen compression will be in its own building.

B.3 Hydrogen Storage

B.3.1 Design Assumptions

- Buffer storage will smooth out pressure fluctuations between the hydrogen and ammonia plants.
- Hydrogen will be stored above ground in gaseous form.

B.3.2 Design Parameters

Table B-3: Hydrogen Storage Properties

Parameter	Value
Storage Temperature	Ambient (Outdoors)
Storage Pressure	7 bar(g)
Product	Hydrogen
Storage Capacity	1.3 tonnes
Storage Duration	7 minutes

B.4 Ammonia Production Plant

B.4.1 Design Assumptions

- The ammonia plant will use the Haber-Bosch process.
- The ammonia plant will operate continuously.
- The ammonia plant will be sized based on hydrogen generated and taking into consideration 'standard' ammonia plant capacities.

B.4.2 Design Parameters

Table B-4: Ammonia Plant Production Properties

Parameter	Value
Plant Design Production Rate	1,428 tNH_3/day
Nominal Production Rate[1]	1,214 tNH_3/day
Plant Availability	90%
Product	Ammonia (NH_3)
Product Quality	99.9 %wt Ammonia 0.1 %wt Water 5 ppmw Oil
Delivery Pressure to ammonia Storage	5 bar(g)
Delivery Temperature to Ammonia Storage	-33.5°C
Note: 1. Limited by nominal hydrogen production rate (85% efficiency).	

B.5 Ammonia Storage

B.5.1 Design Assumptions

The ammonia storage tank(s) will be sized to provide adequate buffer capacity between shipments. As a result, the storage capacity required is directly dependent on the cargo capacity of the shipping vessel.

Liquid ammonia is expected to be stored in refrigerated ammonia storage tanks at near-atmospheric pressure at the site in between shipments.

Currently, industrial atmospheric / low-pressure ammonia storage tanks have capacities from 15,000 to 50,000 tonnes (~24,000 to 80,000 m^3) of ammonia[146] [147]. With a nominal production of 1,214 tNH_3/day, the ammonia production facility is expected to produce ~49,000 m^3/month. To account for potential shipment variance, the storage tank is designed to be 1.5 times the monthly production capacity. This is a good rule of thumb buffer capacity based on Hatch's experience and has been allowed for to account for potential ship delays that could impact production.

B.5.2 Design parameters:

Table B-5: Ammonia Storage Properties

Parameter	Value
Storage Temperature	-33°C
Storage Pressure	1 bar(g)
Product	Ammonia (NH_3)
Number of Tanks	1
Storage Capacity per Tank	~50,000 tonnes
Storage Volume per Tank	~73,000 m^3
Storage Duration Total	1.5x monthly production capacity

[146] Exploring Canada's Energy Future - Canada.ca (cer-rec.gc.ca)
[147] CER – Market Snapshot: Canadian tidal power capacity fourth in the world, with potential to add up to 7 000 MW more (cer-rec.gc.ca)

B.6 Marine Infrastructure

B.6.1 Design Assumptions

The converted hydrogen will be exported as ammonia on marine vessels in a batch operation. Assuming all hydrogen production will be shipped overseas, the port shall handle an annual throughput of approximately 400,000 tonnes (585,000 m^3) of ammonia.

A single (1) vessel will be used to transport the ammonia to Europe.

Liquid ammonia is typically transported in gas carriers designed for liquefied petroleum gas (LPG). Amongst the LPG carriers, there are three different types used to transport liquid ammonia:

1. **Fully refrigerated –** Cargo tanks set at ambient pressure and -50°C achievable refrigeration;
2. **Semi refrigerated –** Cargo tanks set at a pressure range of 4.08-8.16 kg/cm^2 (4-8 bar) and a temperature of -10°C; and
3. **Fully pressurized –** Cargo tanks set at a pressure of 17.34 kg/cm^2 (17 bar) and 45°C.

Fully refrigerated vessels typically have the largest cargo capacity and can be designed as Very Large Gas Carriers (VLGCs) with a capacity of 80,000 m^3. Currently ammonia can be exported in gas carrier vessels ranging from very small gas carriers with volume capacities between 10,000-30,000 m^3, large gas carriers (LGCs) with volume capacities between 50,000-60,000 m^3 through to VLGCs with volume capacities up to approximately 85,000 m^3.

The preliminary assumption is that the vessel calling at the selected port to load refrigerated ammonia for export will arrive and berth using tug assist and pilots, in ballast condition with a displacement equivalent to up to the maximum bunker load.

It is assumed that the voyage to Europe will take 10-11 days one way. Assuming one (1) vessel will leave each month for a total of 11 trips per year, an LGC was assumed with volumes between 50,000-60,000 m^3. For this Study, an LGC vessel with a volume capacity of 55,000 m^3 or an equivalent of 37,500 tonnes ammonia capacity has been assumed as the vessel calling to port.

Liquid ammonia forwarding pumps will be used to transport the liquid ammonia through a pipeline to the jetty, where the ammonia can be loaded out to the shipping vessel. From the storage tank the pumps will transfer the ammonia to the jetty through an ammonia loadout pipeline. This line will be designed to transfer up to 3,000 m^3/hr to provide the ability to fill a vessel with 55,000 m^3 cargo tank capacity in 20 hours of active flow time, 30 hours of total docking time (10 hours of buffer for pre-cooling, mooring, etc.) which should be sufficient for an LGC.

It is assumed that 2 loadout arms will be installed for the project to accommodate the liquid design flow rate.

B.6.2 Design Parameters:

Table B-6: Vessel Particulars

Vessel Particulars	Design Vessel
Vessel Type	Generic Refrigerated LGC (Ammonia Compatible)
Geometric Size (m^3)	55,000
Ammonia Capacity (tonnes)	37,500
Length Overall – LOA (m)	± 200
Beam (m)	32-33
Moulded Depth (m)	20-21
Ballasted + Bunker Draft (m)	± 7.0
Fully Laden (Summer) Draft (m)	11-11.5

B.7 Electricity Generation

While the design, construction and operation of the facility's electricity generation have been excluded from the scope of this Study, the following assumptions have been made:

- A combination of grid and onshore wind power will supply the required power to the plant during normal operation.
- The power supply will be sized to provide the total power requirements of the overall plant (hydrogen electrolysis, ammonia conversion, BoP systems, etc.).

Appendix C Basis of Estimate

C.1 Introduction

The order-of-magnitude (OoM) cost estimate for this Study has been prepared based on limited information, and subsequently has a wide accuracy range. As such, this estimate is not classified in terms of AACE International recommended guidelines.

This estimate has been prepared to estimate the socioeconomic impacts of a hydrogen production and export facility of this scale – the details of this impact are quantified and discussed further in starting with Section 6 of this report.

The methodology for this estimate incorporates factored cost estimates based on Hatch's in-house data and experience in previous studies. The costs for this estimate are expressed in Canadian dollars (CAD $) 2022.

C.2 CAPEX Estimate

The total CAPEX for this project is estimated at CAD $3.15 billion. The estimate was prepared to the level of a scoping study with an expected accuracy of +100 / -50%. Figure 5-1 below shows the CAPEX breakdown of the overall plant and Table 5-1 provides the cost breakdown.

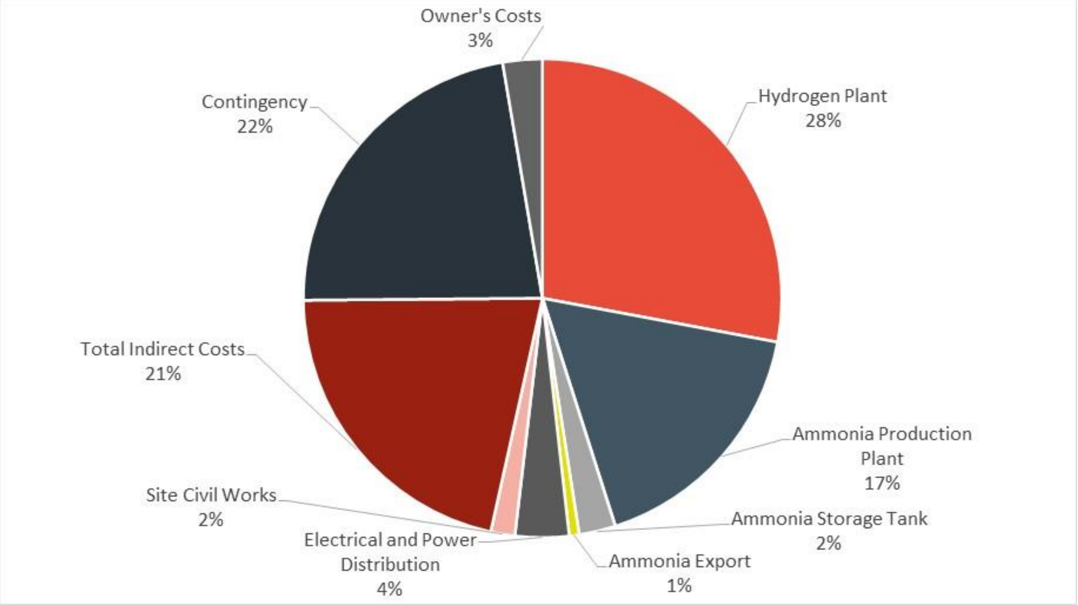


Figure C-1: Total Hydrogen and Ammonia CAPEX

Table C-7: Overall Plant CAPEX Breakdown

Area Description	Cost (MM CAD $)
Hydrogen Production Plant	879
Ammonia Production Plant	540
Ammonia Storage Tank	78
Marine Infrastructure	21
Electrical and Power Distribution	114
Site Civil Works	51
Total Direct Costs	**1,683**
Total Indirect Costs (40% of direct costs)	**673**
Contingency (30% of direct + indirect costs)	**707**
TIC (Before Owner's Costs)	**3,064**
Owner's Costs (5% of direct costs)	84
TIC (Including Owner's Costs)	**3,148**

Numbers may not sum up due to rounding.

C.2.1 Foreign Currency Rates

The table below shows the currency conversions used for the cost estimate.

Table C-8: Currency Conversions

CAD $ to USD $	1.36
CAD $ to AUD $	0.92
CAD $ to EUR	1.43

C.2.2 Estimate Methodology

The Hatch estimate was prepared using the following methodology:

- In-house budgetary pricing from technology vendors for core processes. Cost scaling is assumed to be linear at this stage (highly modularized equipment, no economy of scale assumed) and no optimization of common BoP systems was considered.
- Historical pricing for secondary equipment.
- Related infrastructure such as civil, electrical, piping, etc. based on Hatch historical projects.
- Site construction and subcontract costs, and direct labour hours were factored using Hatch historical data.
- Indirect costs based on historical benchmark percentages of direct costs.
- Contingency based on percentage of direct and indirect costs per best practice for the given accuracy of the estimate.
- All in-house prices in currencies other than Canadian dollars were converted to project costs using project currency exchange rates listed in this document.
- An estimate base date of Q4 2022.

C.2.3 Exclusions

The following have been excluded from the estimate:

- Costs associated with accelerations or delays of the project schedule.
- Project financing and working capital.
- Development fees and approval costs.
- Land purchase fees.
- Insurance fees.
- Economy factors / pressure on labour productivity (less skilled workforce).
- Escalation past the estimate base date.

- Taxes or duties.
- Force majeure.

C.2.4 Hydrogen Production Plant and Storage

The estimated direct cost for the hydrogen production plant is CAD $879 million. This includes:

- Process area:
  - Electrolyzers and BoP (rectifiers and transformers, gas separation, compression, purification, piping costs, electrical connections, instrumentation and controls, buffer storage, busbar allowances);
- Area services and utilities (water treatment, instrument air & nitrogen, cooling);
- Integration of equipment (piping, electrical, instrumentation and control); and
- Buildings.

The electrolyzers and BoP are responsible for nearly 50% of the hydrogen direct CAPEX. Table C-9 below shows the breakdown of the hydrogen plant direct cost.

Table C-9: Hydrogen Plant Direct CAPEX Breakdown

Area Description	Cost (MM CAD $)
Electrolyzer + BoP	488
Water Treatment	21
Instrument Air & Nitrogen	0.9
Cooling	8.6
Integration of Equipment	89
Buildings	273
Total Direct Cost	**879**

Numbers may not sum up due to rounding.

C.2.5 Ammonia Production Plant and Storage

The direct CAPEX for the ammonia plant and storage is CAD $617 million. This includes:

- The ammonia production plant, including Haber-Bosch process equipment, utilities (e.g., ASU, instrument and plant air, etc.), electrical and power distribution, and piping, electrical, instrumentation and process control systems; and
- The storage tank, including the associated piping, electrical, instrumentation and process controls systems required between the ammonia plant and the storage tank.

The table below shows the breakdown of the ammonia plant and storage direct costs.

Table C-10: Ammonia Plant and Storage Direct CAPEX Breakdown

Area Description	Cost (MM CAD $)
Ammonia Production Plant	540
Ammonia Storage	78
Total Direct Cost	**617**

Numbers may not sum up due to rounding.

C.2.6 Marine Infrastructure

Marine infrastructure direct costs are estimated at approximately CAD $21.3 million. This includes:

- Marine loading arms;
- Inert gas system;
- Piping from storage to jetty;
- Loading pumps;
- Allowance for pipe rack modifications, assuming the use of an existing jetty; and
- Allowance for civil, structural, electrical, and instrumentation costs for marine infrastructure (28% of direct costs above)

C.2.7 Electrical and Power Distribution

Electrical and power distribution systems are estimated to cost approximately CAD $114 million for a project of this scale based on experience with other Greenfield hydrogen production projects. The electrical and power distribution costs include transmission lines, main substation, site power distribution system, and emergency back-up power generator. The back-up generators will be used to power the BoP and necessary utilities in the event of a power failure.

C.2.8 Site Civil Works

Site civil works is assumed to be 3.5% of the total direct cost, which includes earthworks, roads / parking, common buildings / facilities, and site draining and ponds. This cost is estimated as CAD $58.1 million.

C.2.9 Indirect Costs

Indirect costs include all items that are necessary for the development and completion of the site but are not directly attributable to direct construction costs. Indirect costs were benchmarked against similar projects and estimated as a percentage of the total direct costs. The total indirect cost is calculated to be 40% of the direct costs. A breakdown of the 40% indirect factors is detailed in the table below.

Table C-11: Indirect Cost Percentage Breakdown

Indirect Cost Factors	% Direct Costs
Engineering, Procurement, Construction Management	20%
Construction Indirects	6%
Temporary Accommodations	3%
Pre-Operational Commissioning	2%
Freight	5%
Spare Parts	2%
Third-party Consultation	1%
First Fills (Lubricants, lye, water treatment chemicals, etc.)	1%
Total	**40%**

Numbers may not sum up due to rounding.

C.2.10 Contingency

The estimated contingency is incidental expense for unknown project costs that may be incurred, but which cannot be identified due to the lack of complete, accurate, and detailed information. Contingencies should be expected to be expended. These include items and / or conditions that may be required to complete the project, for which the state and effect are uncertain, and are associated with project risk. The contingency is assumed to be 30% of the direct cost + indirect costs. This is typical and recommended for order of magnitude estimates.

C.3 OPEX Estimate

The high-level operating cost estimate was prepared based on Hatch's experience in previous projects as well as publicly available information.

The annual operating cost for the hydrogen and ammonia plant has been divided into the following areas:

- Hydrogen Production Plant and Storage
- Ammonia Plant Production and Storage
- Marine Terminal Handling Rates
- Port costs have been excluded from this Study but should also be incorporated into future phases of OPEX development.

C.3.1 Hydrogen Production Plant and Storage

The total OPEX for the hydrogen production plant is estimated to be CAD $326 million per year. Figure C-2 below shows the breakdown of the OPEX. Electricity costs are estimated to make up 89% of the total hydrogen production plant OPEX.

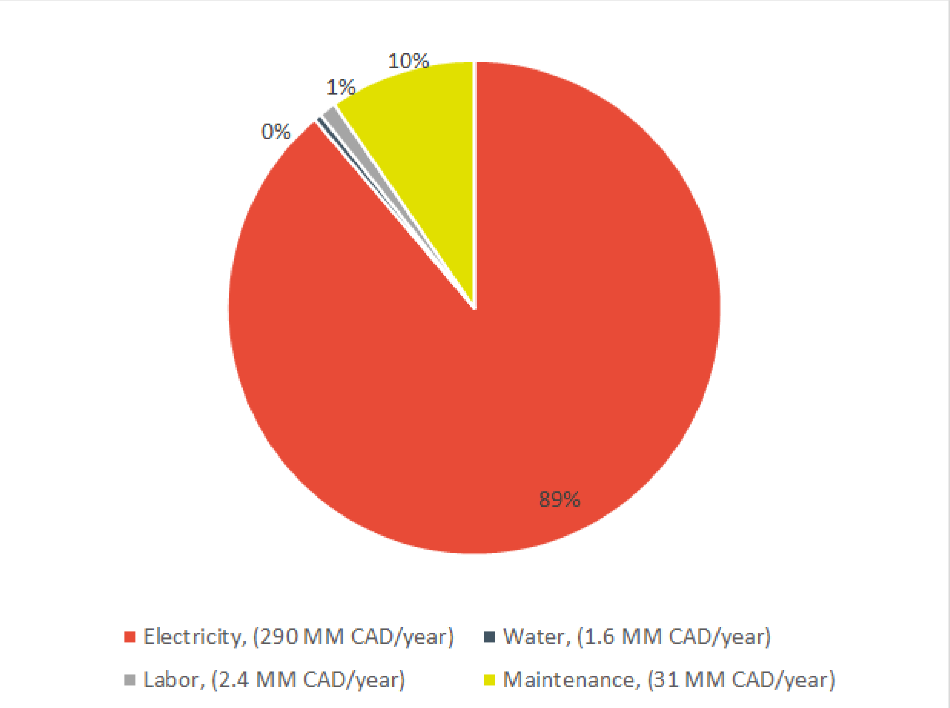


Figure C-2: Hydrogen Production Plant OPEX Breakdown

The cost estimate for the hydrogen production plant was developed based on the following assumptions / parameters:

- The electricity consumption is based on electrolyzer loads (i.e., electrolyzer efficiency) and BoP loads. An electricity cost of CAD $70/MWh is assumed based on recent Hatch studies in similar areas. Results are for beginning of life conditions.

- Water consumption is per vendor information and water cost is assumed at CAD $0.5/m³ based on recent Hatch studies in similar areas.
- Maintenance costs are assumed to be 3% of directs.
- Labour is assumed to be 24 employees over 3 shifts with an assumed average cost per employee of CAD $150,000/year.
- Note: SUSEX costs have been excluded from the OPEX breakdown above. This is the sustaining expenditure required to replace electrolyzer stacks and deoxo catalyst. For example, electrolyzer stacks must be replaced on average every 10 years. On an annualized basis, this is approximately CAD $24.5 million per year.

C.3.2 *Ammonia Production Plant and Storage*

The total OPEX for the ammonia plant and storage facilities is assumed to be CAD $40 million per year. The figure below shows the breakdown of the OPEX, where the electricity costs are responsible for nearly half of the total.

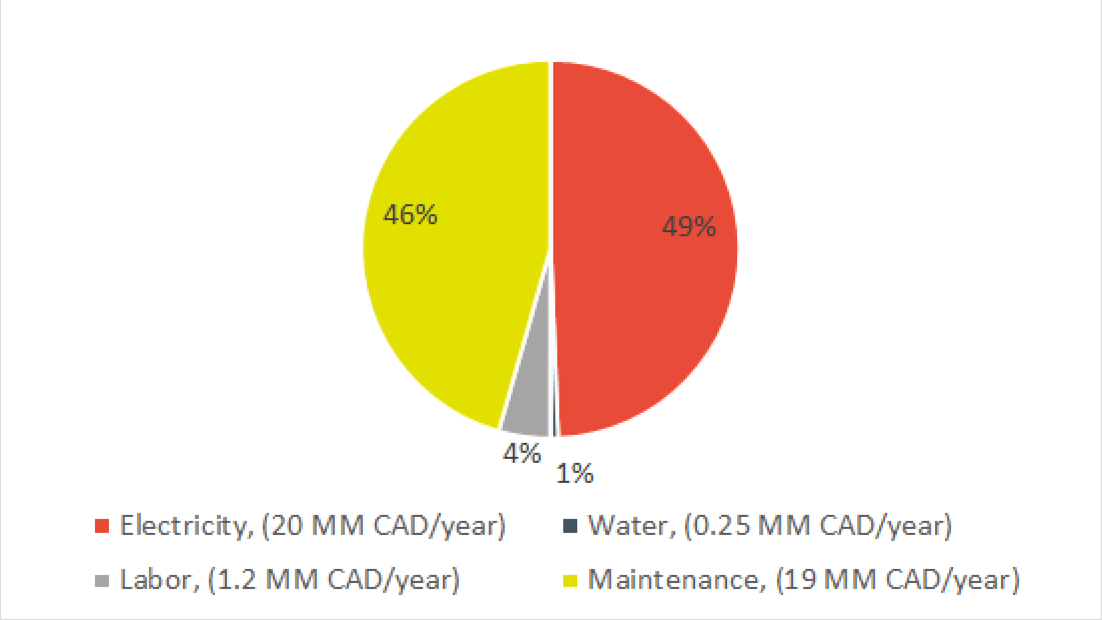


Figure C-3: Ammonia Production Plant and Storage OPEX Cost Breakdown

The cost estimate for the ammonia production plant and storage was developed based on the following assumptions / parameters:

- The electricity cost of $70 CAD/MWh is based on recent Hatch studies in similar areas.
- The cooling water requirement is based on previous Hatch studies. Water cost is assumed at CAD $0.5/m³ based on recent Hatch studies in similar areas.
- Maintenance costs are assumed to be 3% of directs.

- Labour is assumed to be 12 employees over 3 shifts with an assumed average cost per employee of CAD $150,000/year

C.3.3 Marine Handling

Marine terminal handling rates will apply for the loading of the ammonia product on to ocean going vessels. This rate includes marine terminal related costs such as:

- Annual maintenance costs;
- Electrical energy costs for power demand / load;
- Manpower costs (management, labour, security);
- Facility / equipment lease costs; and
- Terminal owner's / operator's profit.

Handling rates are highly variable and depend on several aspects, many of which are at the discretion of the terminal owner / operator – such as approach to maintenance, land / water lot / equipment lease costs vs. ownership, recovery of capital investments and financing, and corporate tax structure.

The approach regarding maintenance, the level of performance of the electrical and mechanical components, and the level of automation are key considerations. It is therefore important to note the following:

- Maintenance costs are related to the design and quality of the mechanical and electrical components (and to a lesser degree other infrastructure elements) incorporated into the operation.
- The philosophy of the owner and / or terminal operator regarding maintenance can impact maintenance costs, and often depend on non-technical considerations such as depreciation rules for taxation, corporate tax structure, cost of capital, projected throughput trends, etc.
- The more efficient electrical components, the less power load / demand and associated electrical energy costs.
- The higher the level of automation of the operation, (including mechanical, electrical, controls components and equipment) the lesser the labour and associated costs.

Based on a marine terminal handling costs of CAD $7.5/tonne – CAD $10/tonne of product, a 400,000 tonnes of annual ammonia product export can cost between CAD $3 million and CAD $4 million.

The following elements are excluded from the marine terminal operating cost estimates in this Study, and need to be considered in future phases of the project:

- Vessel demurrage;
- Training;
- Insurance;

- Taxes;
- Recovery of capital investments and financing;
- Facility lease cost and property taxes; and
- Terminal owner's / operator's profit.

As noted above, the estimated marine terminal handling rates are exclusive of any recovery of capital investments and financing associated with upgrading and / or repairing the existing infrastructure to support the operation. Depending upon the commercial arrangement between the port and the hydrogen / ammonia plant owner for using the existing marine terminal assets, fees associated with capital recovery could be added to the handling rate or treated as a separate payment item.

C.3.4 Exclusions

C.3.4.1 Port costs

Port costs include port service / use and harbour transit costs. Harbour transit costs are the costs that can be attributed to transiting from the open ocean to the terminal facility. Port service / use costs may include such things as:

- Pilotage, pilot boats and transfers;
- Tug support;
- Port/harbour, anchorage, tariffs, tonnage, and other dues;
- Mooring line services;
- Wharfage;
- Agent fees;
- Security;
- Pollution insurance; and
- Draft surveys.

Some of these costs may or may not apply to specific marine terminals depending on terminal ownership structure, commercial arrangements between terminal owners and service providers and the Authority having jurisdiction over the terminal operations. Port costs are excluded from this Study, however, should be considered in future phases of the Project.

Appendix D Economic Impact Assessment Methodology

D.1 Methodology of Quantitative Economic Impact Assessment

This Appendix sets out the method used for the quantitative assessment of economic impacts of the project.

D.1.1 Quantitative Assessment Overview

An overview of the quantitative assessment approach is set out in Figure D-4 below. The assessment is broadly divided in to three key elements:

1. The assessment of average annual core economic impact during the construction phase.
2. The assessment of average annual core economic impact during the operation phase.
3. The assessment of the scale of the peak construction workforce and the associated influx of construction workers to Nova Scotia (which is key to the social impact assessment).

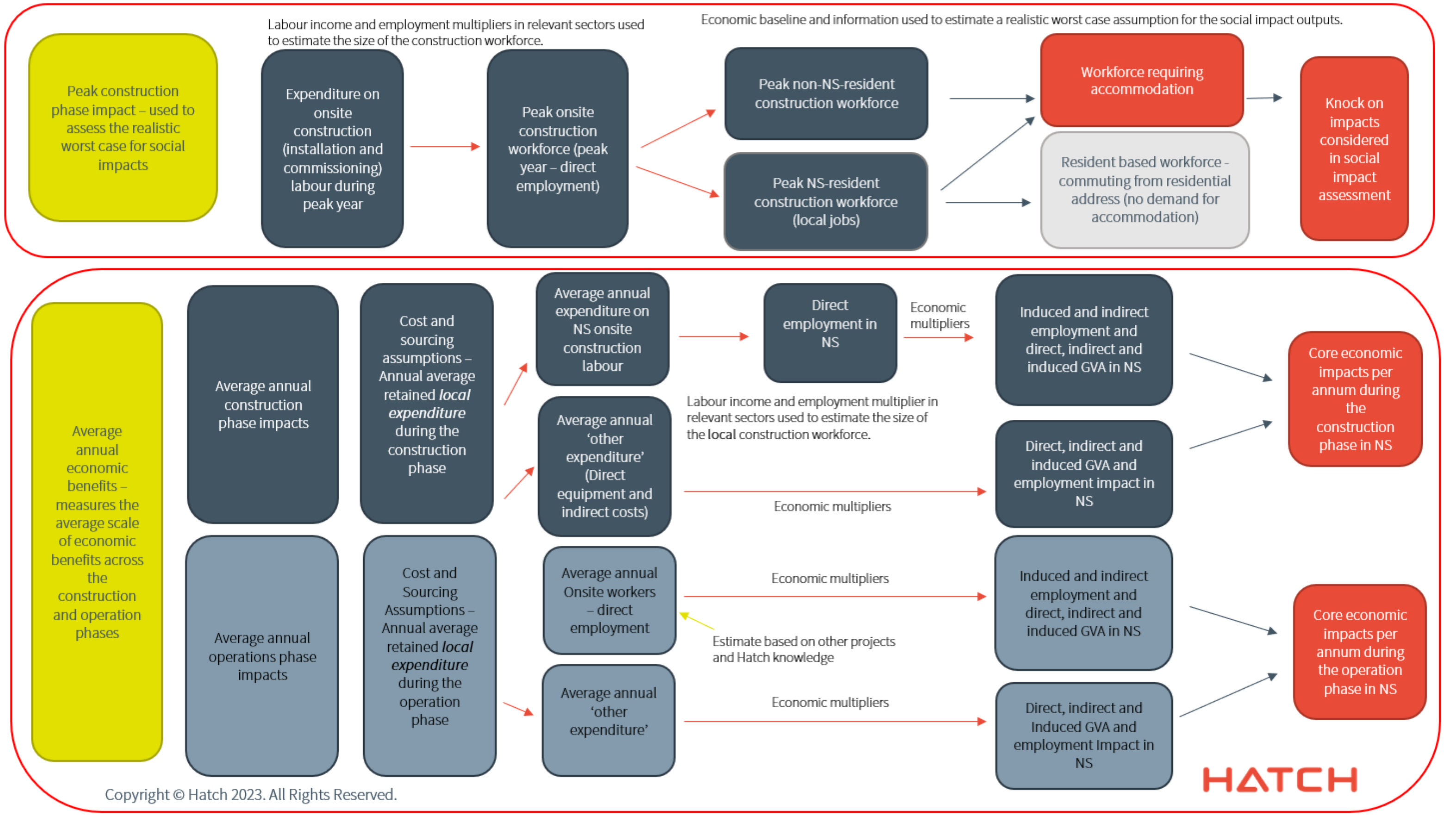


Figure D-4: Quantitative Assessment Approach

D.1.2 The Sources and Drivers of Impact

The capital and operating expenditure incurred during the development and operation of the hydrogen production project, and the portion retained within Nova Scotia, are the key drivers of the scale of economic effects. In addition, the non-local construction workforce is also considered even though this does not represent expenditure retained within Nova Scotia in the model (as this is relevant to determining the social impacts).

The cost estimates have been generated from the project design work, whilst the sourcing estimates are based on professional judgement, given the team's prior experience and knowledge in assessing similar facilities and the local knowledge of the baseline conditions.

These costs are broken down into some key headings below.

D.1.2.1 Construction Phase

- Direct equipment costs: electrolyzer and BoP, utilities (water treatment, instrument air, nitrogen, cooling), electrical infrastructure (substation and power distribution), integration of plant (piping, electrical, and instrumentation and control (I&C)), buildings, ammonia production equipment (mechanical), liquid ammonia tank, port infrastructure equipment.
- Construction labour costs: civil, steel, structural, mechanical equipment, piping, HVAC, electrical, I&C.
- Indirect costs. Including general development and project management (engineering and third-party consultation).

D.1.2.2 Operational phase

- Direct onsite employees, stack replacement, repair, and maintenance, etc.[148].

The level of expenditure will be estimated for the phases above, and the level of sourcing will be presented as a range for each phase, given the high levels of uncertainty. Each expenditure item will have an associated local sourcing estimate.

D.1.3 Types of Impact Assessed Quantitatively

1. Direct (including on-site and first round of supply chain);
2. Indirect (additional rounds of supply chain impact not including first round impacts); and
3. Induced (wage expenditure).

[148] Power costs are excluded as they are very high but are unlikely to result in large scale additional employment. This is due to the fact the input-output derived multipliers give the average effect rather than the marginal effect of additional expenditure.

D.1.4 The Quantitatively Assessed Measures of Economic Impact

The core economic effects are concentrated on employment, which is measured by FTE jobs and GVA per annum.

D.1.5 Structure of the Economic Model

Hatch has gathered direct, Type 1 and Type 2 jobs, and GDP multipliers for Nova Scotia and Canada from Statistics Canada[149]. We have created a provincial input-output model which contains direct, Type 1 (direct and indirect) and Type 2 (direct, indirect, and induced) multipliers broken down at a detailed sectoral level at the provincial level. This enables the identification of sectoral patterns to the economic impacts and hence, potential sectoral opportunities.

D.1.6 The Data Inputs into the Model

The expenditure inputs are entered into the model and then sourcing assumptions and sectoral based multipliers are applied to each expenditure item to determine the potential economic impacts (jobs and GVA) for each expenditure item. By summing the economic impacts, the project's core economic impacts for each phase can be determined.

D.1.7 Assumed Time Periods by Phase

We will apply the following time periods for the construction and operational periods:

- Construction phase (including development work): 6 years; and
- Operations phase: 30 years.

To understand the (realistic worst case) maximum social impacts associated with an influx of construction workforce we consider the peak construction workforce impact for the peak year of the construction phase. This is assumed to be the penultimate year of the project. Hatch have profiled the project expenditure across the construction phase per annum. The penultimate year of the construction phase is estimated to have the highest annual level of expenditure (therefore the highest level of economic activity is predicted to occur in this year). The profiling of expenditure is based on Hatch's in-house experience of hydrogen and other major capital project expenditure profiles. It should be noted that given the highly conceptual nature of this project the expenditure profile is indicative and should be treated with a high degree of uncertainty.

D.1.8 Prices and Inflation

The model functions using 2019 prices as this is the latest available data from Statistics Canada; however, the cost estimates are in current (2023) prices. The costs are therefore required to be deflated to 2019 prices for the purposes of modelling and then inflated back to current prices for reporting. All financial values are presented in current prices but by the time the project is being constructed / has become operational these values may be significantly higher due to growth in productivity and inflation.

[149] Multipliers available at Statistics Canada: Table 36-10-0594-01 Input-output multipliers, detail level and Table 36-10-0595-01 Input-output multipliers, provincial and territorial, detail level.

D.1.9 Additionality and Additional Economic Modelling Caveats

The economic outputs are based on a gross assessment of the GVA and employment impacts of a Nova Scotian 500 MW hydrogen production project. The assessment is primarily based on the potential scale of expenditure injection into Nova Scotia and should be treated with the following caveats:

- The input-output model is based on purchasing relationships between sectors and households at a detailed sectoral level. It is assumed that these are fixed within and between industries.
- The input-output model states the total economic impacts associated with that injection, with no effects on prices and capacity constraints.

D.1.10 Uncertainty

To account for uncertainties in the level of costs and the extent to which goods and services can be sourced locally, impacts are presented using suitable ranges. Maximum impact scenarios (realistic worst case) are considered for the economic modelling outputs used to determine social impacts and therefore the construction labour sourcing is based on a realistic worst-case point-based estimate rather than a range.

Appendix E Economic Impact Tables

Table E-1: Estimated Gross Direct, Indirect and Induced GVA and Employment Impacts within Nova Scotia – Construction Phase

		Average per annum		Person years of employment / total GVA impact across 6 year construction phase	
		Base sourcing	High sourcing	Base sourcing	High sourcing
GVA (CAD $ MM)	Direct / first round benefits	80	$92	480	550
	Indirect benefits	18	21	110	130
	Induced benefits	28	32	170	190
	Total benefits	**126**	**145**	**760**	**870**
Jobs (FTEs)	Direct / first round benefits	750	870	4,500	5,250
	Indirect benefits	210	240	1,250	1,450
	Induced benefits	190	220	1,150	1,350
	Total benefits	**1,150**	**1,330**	**6,900**	**8,000**

Numbers may not sum up due to rounding.

Table E-2: Estimated Gross Direct, Indirect and Induced GVA and Employment Impacts within Nova Scotia – Operational Phase

		Base sourcing	High sourcing
GVA (CAD $ MM)	Direct other	3.7	5
	Direct / first round benefits	12	17
	Indirect benefits	5	7
	Induced benefits	5	7
	Total benefits	**$28**	**$36**
Jobs (FTEs)	Direct onsite	30	40
	Direct other	120	160
	Indirect benefits	60	80
	Induced benefits	40	50
	Total benefits	**260**	**330**

Numbers may not sum due to rounding.

Table E-3: Peak Construction Workforce Demand used to assess the Realistic Worst Case for Social Impacts

<table>
<tr><th colspan="3">Peak onsite construction workforce (peak year – direct employment)</th></tr>
<tr><td colspan="3">2,550</td></tr>
<tr><th>Peak non-NS-resident construction workforce</th><th colspan="2">Peak NS-resident construction workforce (local jobs)</th></tr>
<tr><td>1,900</td><td colspan="2">650</td></tr>
<tr><th>Workforce requiring accommodation</th><th>Workforce requiring accommodation</th><th>Resident based workforce – commuting from residential address (no demand for accommodation)</th></tr>
<tr><td></td><td>500</td><td>150</td></tr>
<tr><th colspan="2">Workforce requiring accommodation (used for social impact assessment)</th><th>Resident based workforce – commuting from residential address (no demand for accommodation)</th></tr>
<tr><td colspan="2">2,350</td><td>150</td></tr>
</table>

Numbers may not sum up due to rounding.