# TOWARD A 2030 STRATEGY ON GREEN HYDROGEN AND BIOENERGY

**CONSULTATION DOCUMENT**


Votre gouvernement

Québec

# TABLE OF CONTENTS

# PREAMBLE TO THE CONSULTATION

Québec wishes to assert its role as a North American leader in the environment and renewable energies. It has also committed to reducing its greenhouse gas (GHG) emissions by 37.5% compared to 1990 levels by 2030. In addition, the Gouvernement du Québec is targeting a 40% reduction in the consumption of petroleum products by 2030[1] and carbon neutrality by 2050.

Energy efficiency and direct electrification are at the heart of the solutions to achieve climate and energy objectives, but they will not be enough to replace all fossil fuels due to certain technical or economic obstacles. Other avenues are possible, including the deployment of green hydrogen and bioenergy sectors for which Québec has many advantages. It is in this context that the 2030 Plan for a Green Economy (2030 PGE), published in November 2020, announced the development of the first strategy on green hydrogen and bioenergy.

## A first consultation in spring 2021 which led to the proposal of the outline

In order to clearly identify the specific needs and challenges of the green hydrogen and bioenergy sectors, a virtual consultation exercise was carried out by the Ministère de l'Énergie et des Ressources naturelles (MERN) in spring 2021. These consultations targeted a number of associations, representatives of Indigenous communities and stakeholders from the environment, energy, economic development and research sectors.

Following this first consultation, this consultation document includes and defines a vision proposal, guiding principles and axes of intervention that could guide the development of a green hydrogen and bioenergy economy.

This first proposal was developed in close collaboration with Hydro-Québec, and several other ministries and agencies also participated, including the Ministère de l'Économie et de l'Innovation and Investissement Québec, the Ministère de l'Environnement et de la Lutte contre les changements climatiques, the Ministère des Transports du Québec, the Ministère des Forêts, de la Faune et des Parcs (MFFP) and the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ).

## A new consultation to validate ministerial orientations and propose concrete measures

The enthusiasm for the green hydrogen and bioenergy sectors is being felt here as elsewhere in the world. The opportunity is perfect to position ourselves now as one of the best places in the world to invest in the energy transition and become a hub of the green economy.

This consultation exercise is therefore aimed at our partners in industry, academia and Indigenous communities. The objective is to initiate a constructive dialogue and to hear each of them on the deployment of these sectors of the future, particularly to:

- Understand the needs in each sector;
- Understand the challenges that could be associated with the deployment of these sectors;
- Examine the tools or means that the government could deploy to support this transition.

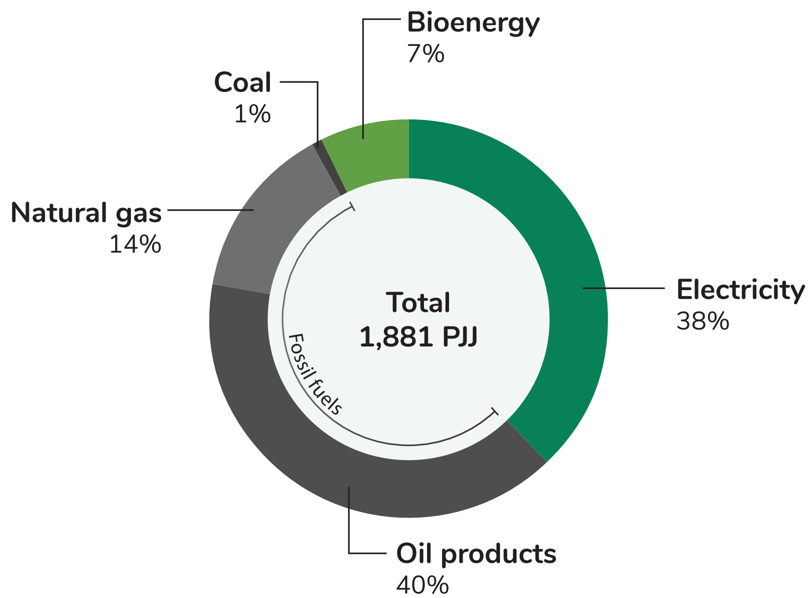
1 *Québec's 2030 Energy Policy, and 2030 Plan for a Green Economy*. This target to be reached constitutes a reduction compared to the 2013 level.

# 1. WHY FOCUS ON GREEN HYDROGEN AND BIOENERGY?

In 2018, 70% of GHG emissions were from energy sources, while nearly 56% of the energy consumed in Québec still came from hydrocarbons (oil, natural gas, coal, natural gas liquids).

We must therefore initiate a real energy transition by using resources more efficiently while replacing fossil fuels with different forms of renewable energy that are more low-carbon.

**Figure 1: Total consumption by energy source in Québec in 2018**



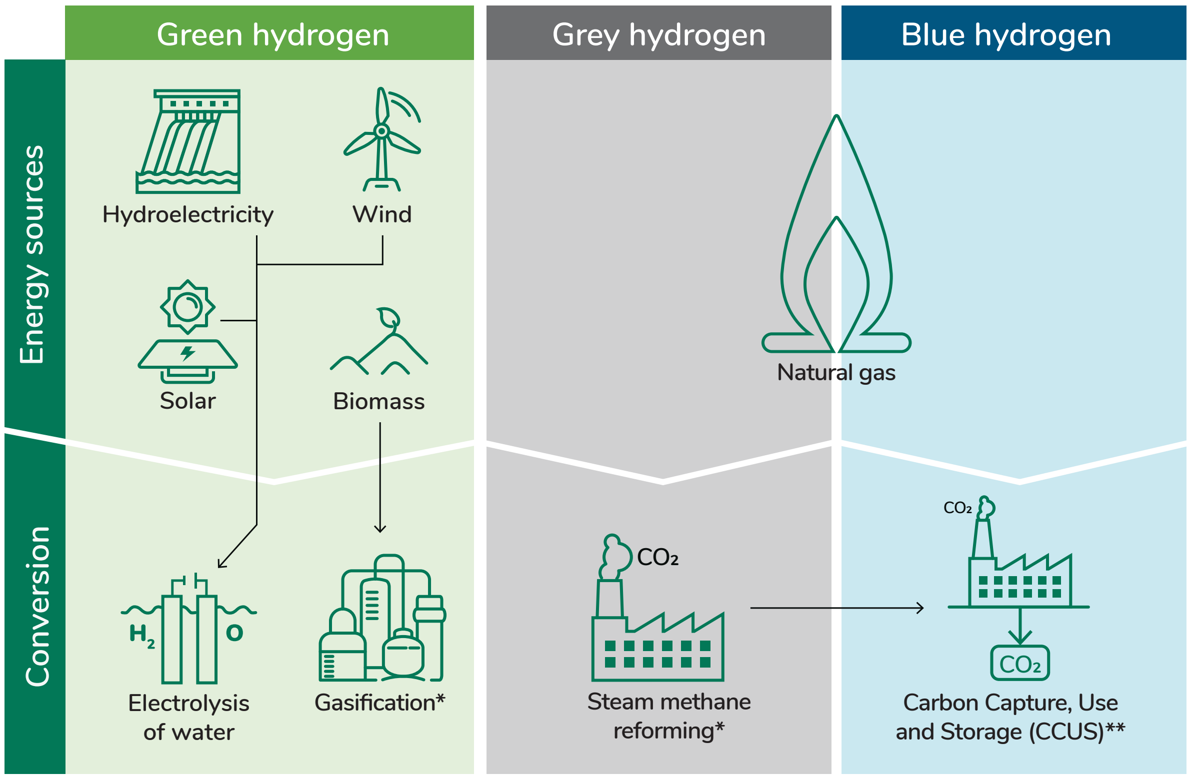

Chair in Energy Sector Management - HEC Montréal, The state of energy in Québec 2021, p.26.

## 1.1 What is green hydrogen and bioenergy?

### Green hydrogen

Green hydrogen can be produced from biomass or by electrolysis of water, therefore with low carbon intensity as opposed to grey hydrogen, obtained from fossil fuels. Québec intends to favour this type of carbon-free hydrogen.

Figure 2: Types of hydrogen




* Most common processes. There could be other processes.
** Carbon capture, use and storage (CCUS) technologies do not guarantee the recovery of all $CO_2$ emissions produced by steam methane reforming.

A distinction is often made between grey hydrogen, blue hydrogen and green hydrogen depending on how they are produced.

Others present the types of hydrogen according to their carbon intensity, that is, the intensity of GHG emissions generated during production. In addition to grey hydrogen, blue hydrogen, and green hydrogen, there is a whole rainbow of hydrogen colours defined according to the method of production and its carbon intensity.

Green hydrogen currently only accounts for a small percentage of global hydrogen production, less than 2%[2]. The largest share of the market remains occupied by hydrogen from fossil sources, often referred to as "grey hydrogen." In Québec, in 2021, the production of green hydrogen was still marginal[3].

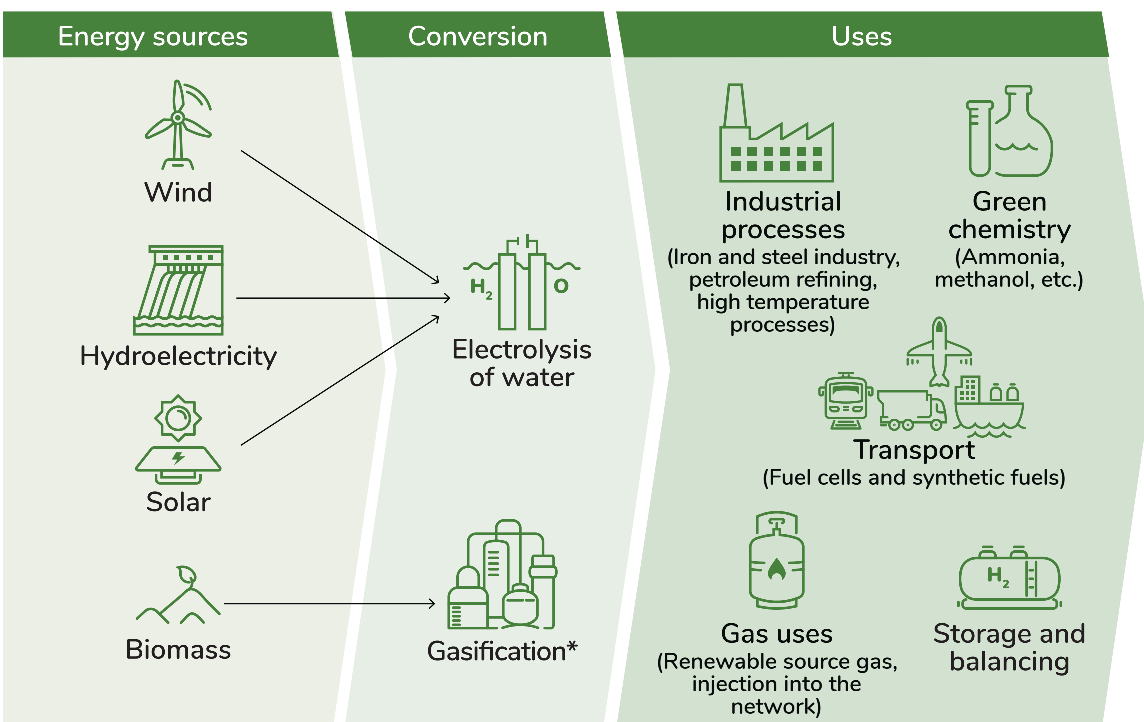
The share of hydrogen from fossil sources is set to decrease over the coming decades because of its incompatibility with the objectives of carbon neutrality and reducing GHG emissions. In this context of energy transition, the development of green hydrogen, the production of which is carbon-free, could constitute an opportunity that may allow to:

- replace hydrogen of fossil origin currently consumed in sectors such as petroleum refining, iron and steel or other industrial processes with green hydrogen;
- replace other sources of fossil energy in applications where hydrogen is currently not or little used, such as heavy and intensive transport.

In addition to the opportunities to substitute fossil fuels in current uses, such as industrial processes and green chemistry, several emerging uses could be developed for green hydrogen in the coming years, for example:

- in land, air or sea mobility applications with the development of fuel cells or synthetic fuels produced from renewable energies;
- in energy uses such as storage;
- in gas applications: production of gas from renewable sources or injection of green hydrogen into the gas network.

Figure 3: Potential applications of hydrogen in Québec




Most common process. There could be other processes.

2 POLYTECHNIQUE MONTRÉAL (2020), *Study on the techno-economic potential of the development of Québec's hydrogen sector and its potential for the energy transition.*

3 Air Liquide has been producing green hydrogen since 2021 at its new Bécancour plant. Additionally, other chemical manufacturers make hydrogen as a by-product of electrolysis.

### Bioenergy

Bioenergy, for its part, is renewable energy produced by living organisms or their by-products, namely biomass.

Québec has been active for several decades in the field of bioenergy, whereas in 2018, bioenergy represented approximately 7% of Québec's primary energy supply[4].

Bioenergy is used to produce heat and electricity and to power thermal engines used in transport. They are renewable energy sources produced by living organisms or their by-products, namely biomass. In Québec, the biomass deposits exploited for bioenergy are divided into three main families:

- **Forestry:** joint products of forestry transformation (chips, bark, etc.), forestry biomass and timber without takers;
- **Agricultural:** vegetable crops and their residues, animal waste (manure, slurry, etc.);
- **Municipal, commercial and industrial:** residues from the residential, municipal, commercial and industrial sectors (from food processing, paper and cardboard from sorting centres, timber for construction, renovation and demolition, from the pulp and paper, biogas produced in landfills, etc.).

In addition, green hydrogen and various biomass deposits can be used together, in particular for the production of synthetic fuels.

Unlike fossil fuels requiring millions of years for their formation, bioenergy is renewable when produced sustainably. It is about prioritizing the right energy in the right place, by enhancing the raw material with appropriate technology.

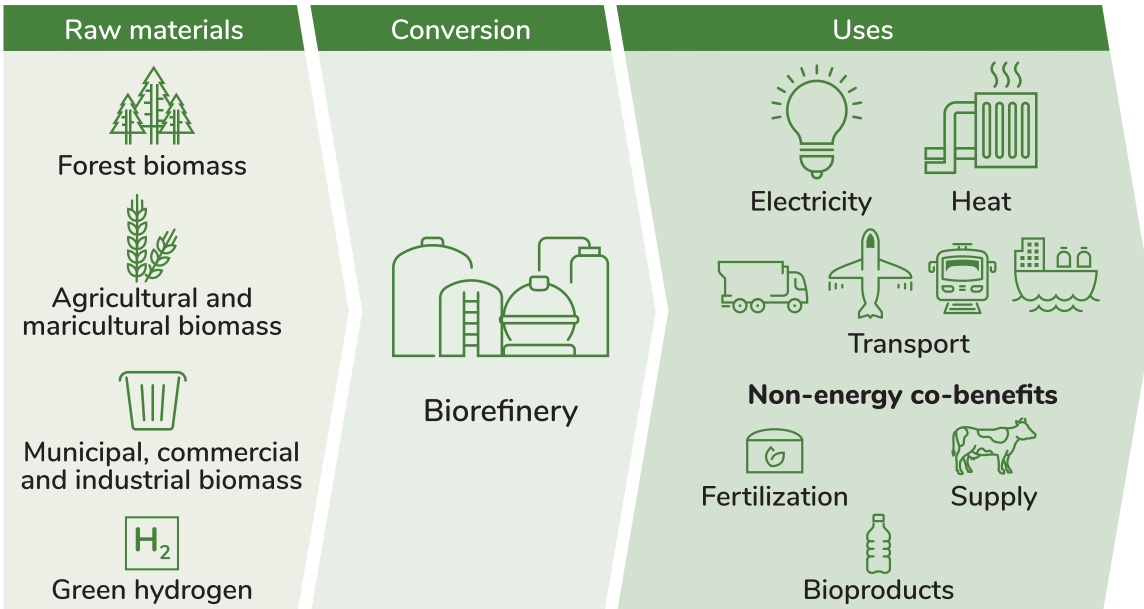
**Multisectoral benefits associated with sustainably produced bioenergy**
Produced sustainably, bioenergy can bring multisectoral benefits:

- **Economic:** value chains must favour the use of raw materials at a price that ensures a certain viability. This use must not compete with other uses. These value chains aim at industrial symbiosis, job creation (direct, indirect and induced) and the revitalization of traditional industrial sectors (e.g., forestry and agrifood industries);
- **Social:** value chains promote the use of raw materials, which is not opposed to the objectives of food autonomy. They contribute to a synergy between communities, municipalities and their territory, thus strengthening the cohesion of the social fabric;
- **Environmental:** the use of raw materials must not be to the detriment of the quality of ecosystems, for example soil fertility. It must follow sustainable agricultural and forestry practices while delivering benefits, such as improving the productivity of forests and their capacity to absorb and capture carbon through tree growth and wood products. Thus, the replacement of fossil fuels by bioenergy favours the reduction of GHG emissions in addition to improving waste management.

4 HEC MONTRÉAL (2021), *The state of energy in Québec*, Chair in Energy Sector Management.

Bioenergy could be of particular interest because of its great versatility in the use and replacement of fossil fuels, especially since the supply and distribution infrastructure already in place can be used without major transformation. All types of solid, liquid and gaseous fossil fuels, like coal, fuel oil, propane and natural gas, can be replaced with bioenergy. Several technologies are mature and could contribute now to the energy transition, while others must be improved, researched and developed.

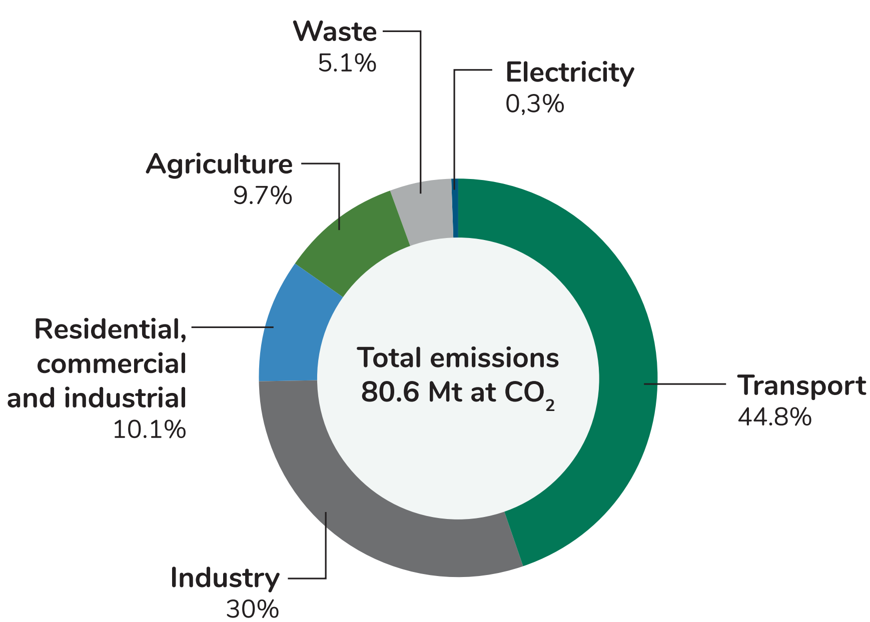
Figure 4: Potential applications of bioenergy in Québec




## 1.2 Accelerate the energy transition and reduce GHG emissions

To accelerate the energy transition, Québec will have to resort to various means to replace fossil fuels in the sectors emitting the most GHGs, more particularly in the sectors of transport, industry and construction, where green hydrogen and bioenergy could already make an active contribution.

Figure 5: GHG emissions by sector of activity in Québec in 2018




Ministère de l'Environnement et de la Lutte contre les changements climatiques, Tables of annual greenhouse gas emissions in Québec from 1990 to 2018.

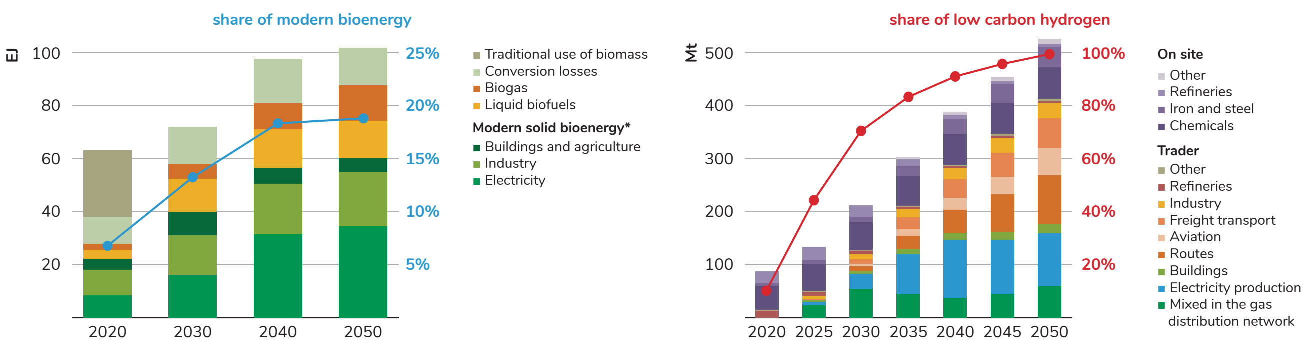
## A major contribution by 2030 and even more by 2050

In reaching the target of reducing GHG emissions by 2030 and carbon neutrality by 2050, fossil fuels will be replaced by a set of potential solutions, including energy efficiency, direct electrification, bioenergy and green hydrogen.

In its report *Net Zero by 2050: A Roadmap for the Global Energy Sector*, published in May 2021, the International Energy Agency (IEA) proposes a roadmap to achieve carbon neutrality in the energy sector on a global scale by 2050 and to limit global temperatures rise to 1.5 °C. According to its estimates, the IEA suggests that global demand for hydrogen should increase five-fold by mid-century to meet carbon neutrality targets[5]. Regarding bioenergy, it estimates that their production should provide nearly 20% of global energy needs in 2050 if global carbon neutrality is targeted.

This report demonstrates the importance that the development of green hydrogen and bioenergy sectors could take, in addition to energy efficiency and electrification, to achieve carbon neutrality in 2050.

**Figure 6: Anticipated growth in demand for hydrogen and bioenergy to achieve carbon neutrality in the global energy sector by 2050**




* Modern bioenergy includes biogas, liquid biofuels, sustainably sourced solid biofuels Adapted from the International Energy Agency's *Net Zero by 2050 A Roadmap for the Global Energy Sector* report.

5 In 2020, global hydrogen production was 90 Mt and could exceed 500 Mt in 2050.

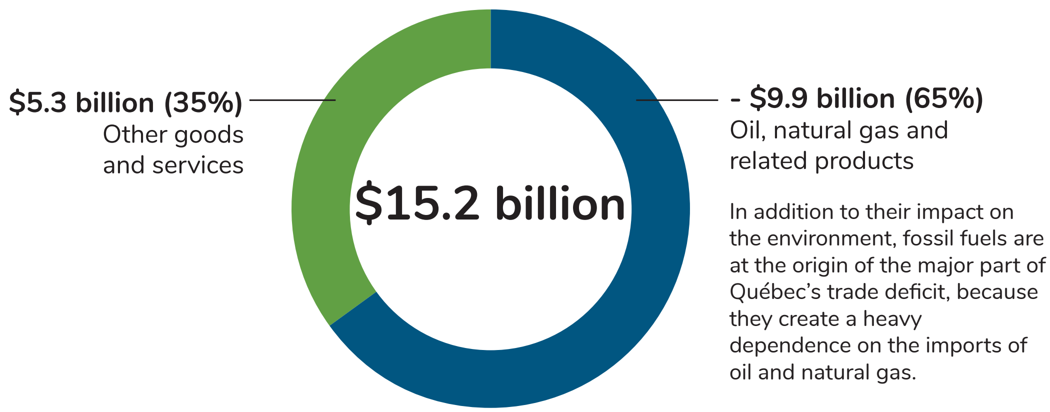
## 1.3 Create wealth and develop global reach

### Economic benefits to build a greener, more resilient and more prosperous economy

The deployment of green hydrogen and bioenergy sectors could contribute to the enrichment of Québec, particularly by replacing imported energy with energy produced on its territory. This deployment will also promote the international influence of Québec know-how as well as Québec's role as a leading North American player in the development of these sectors.

In addition to reducing GHG emissions and increasing Québec's energy autonomy, the use of green hydrogen and bioenergy could help diversify and secure Québec's energy supplies, improve its trade balance and generate jobs in future-oriented fields.

Figure 7: Québec trade deficit




Latest data available (2019), which takes into account international and interprovincial imports and exports.
Source: Preliminary estimates from Québec's Ministère des Finances (2021)

- Other goods and services
- Oil, natural gas and related products

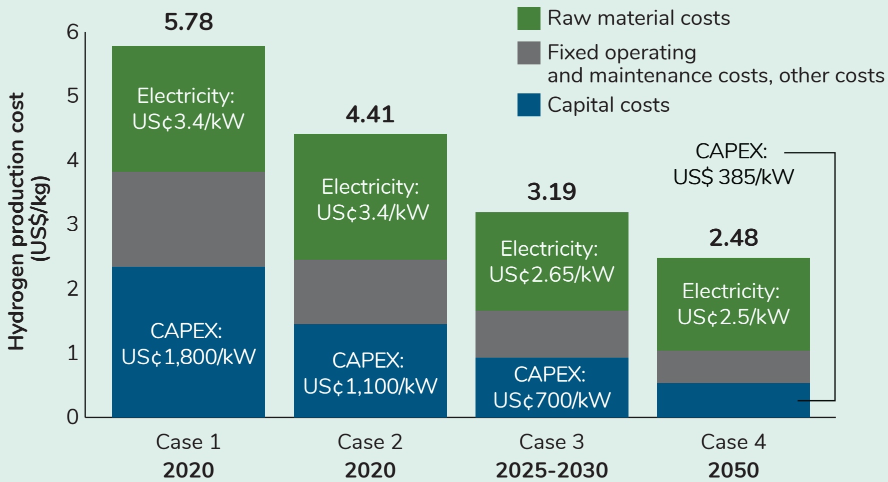
Québec, which enjoys competitively priced renewable electricity production capacities and advantageous biomass availability, is well placed to develop competitive sectors.

The deployment of green hydrogen and bioenergy sectors could also help create and maintain quality jobs and transform current jobs into better paid jobs.

**Profitability for green hydrogen could be possible from 2030**

While currently green hydrogen costs two to five times more than grey hydrogen, mainly because of the investment costs and the cost of the renewable electricity required for the water electrolysis process, several organizations specialists in the field of energy foresee a rapid reduction in the costs linked to the production of green hydrogen[6].

The figure below shows an example of this drop in anticipated costs in Québec, depending on the possible evolution of the cost of raw materials (cost of electricity), costs related to capital (mainly electrolysers) and fixed costs of operation and maintenance.




Cases 1 and 2 give an estimate of the cost of current green hydrogen (2020) in Québec at rate L (4.55¢/kW), case 3 a realistic cost scenario over a 5-10 year horizon. These scenarios take into account the anticipated fall in the cost of electrolysers (a reduction by a factor of 2 from 2025 to 2030 and another factor of 2 thereafter) and the fall in the costs of electricity from wind energy estimated by simulation. These green hydrogen costs should be put into perspective in relation to the cost of manufacturing hydrogen by SMR, which is of the order of $2 to $3/kg without carbon tax or without carbon capture. The long-term economic potential of green hydrogen is therefore very real. Adapted from the Study on the techno-economic potential of the development of Québec's hydrogen sector and its potential for the energy transition (2020).

Compared to hydrogen produced from fossil fuels, the competitiveness of green hydrogen is influenced by the price of carbon, which could be expected to gradually increase by 2030 and beyond.

The profitability of green hydrogen would therefore depend on the evolution of the price of electrolysers, the electricity tariff as well as the price of carbon.

Compared to blue hydrogen, BloombergNEF estimates that green hydrogen would be competitive by 2030 in most markets.

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6 According to the International Renewable Energies Agency (IRENA), which published its report "Green hydrogen cost reduction – Scaling up electrolysers to meet the 1.5°C climate goal" in December 2020, the drop in renewable energy costs and the improvement of electrolyser technologies could make the cost of green hydrogen competitive by 2030.

According to the Hydrogen Council, the main criteria that will allow to reduce the costs of hydrogen in the future are, in particular, the industrialization of the electrolyser manufacturing, the improvement of electrolyser efficiency, electrolyser operation and maintenance, and the use of low-cost electricity.

# 2. THE PROPOSED OUTLINE

The green hydrogen and bioenergy sectors seem to present common challenges. They could call for a global and concerted action to, for example:

- ensure optimum use of Québec's natural and energy resources;
- eventually close the current price differences and thus promote their competitiveness in relation to the cost of fossil fuels;
- increase networking among industry, government and research actors;
- accelerate development and the technology transfer to the industrial environment.

## 2.1 One vision and five guiding principles

A 2030 strategy on green hydrogen and bioenergy would aim to put in place favourable conditions to meet current challenges and remove obstacles to the development of green hydrogen and bioenergy sectors.

One vision, five guiding principles and three axes of intervention could be proposed, depending on the information currently available and collected during the first consultation in spring 2021.

### Proposed vision

With its natural resources and the dynamism of players in the field of renewable energies, Québec intends to innovate, promote its expertise and strengthen the role of green hydrogen and bioenergy in its energy portfolio to decarbonize its economy and improve its position advantageously on the international scene.

### Five guiding principles

The 2030 strategy on green hydrogen and bioenergy would be structured around five guiding principles:

- Act in complementarity with energy efficiency and direct electrification of the economy by using green hydrogen and bioenergy, depending on the sector, so as to contribute to the achievement of the GHG emission reduction target for 2030 and carbon neutrality in 2050;
- Contribute to Québec's energy autonomy by substituting renewable energies produced in Québec for imported fossil fuels;
- Foster the collaboration and participation of regional, local and Indigenous communities in the deployment of green hydrogen and bioenergy sectors, respecting best practices in terms of sustainable development and social acceptability;
- Maximize the socioeconomic benefits of these sectors in Québec and develop global reach by focusing on the export of Québec know-how;
- Put the principles of the circular economy and life cycle analysis at the heart green hydrogen and bioenergy projects with the aim of ensuring optimal and sustainable use of natural resources and residual materials.

## 2.2 Three axes to decarbonize, innovate and excel

The objectives of the strategy could be broken down into three axes, namely the business environment, knowledge and innovation and, finally, collaboration, information and promotion measures.

Social acceptability, which is one of the essential conditions for the success of the strategy, would translate into different measures and ways of working together, according to the needs and priorities of each community.

### Axis 1
### Business environment

**Objective 1: Develop production and distribution infrastructure**

- **Promote** the deployment of green hydrogen and bioenergy production and distribution infrastructure in prioritized market segments, particularly in strategic locations

**Objective 2: Increase green hydrogen and bioenergy use**

- **Adopt** economic, fiscal and regulatory levers for the deployment of sectors
- **Make** regulatory and administrative changes allowing the safe and sustainable use of green hydrogen and bioenergy as well as the harmonization of standards
- **Promote** the industrial deployment of technologies to accelerate the energy transition

### Axis 2
### Knowledge and innovation

**Objective 3: Improve knowledge and its dissemination**

- **Increase and update** knowledge and expertise in the fields of green hydrogen and bioenergy
- **Use** optimum and sustainable resources
- **Support** collaborative innovation by bringing together research and industry circles
- **Support** the training of a qualified workforce

**Objective 4: Develop innovative solutions and processes**

- **Continue** funding research and development (R&D) and carrying out demonstration projects
- **Foster** the establishment and emergence of companies with specialized knowledge and know-how

### Axis 3
### Collaboration, information and promotion

**Objective 5: Increase the commitment of public and private actors in favour of the development of green hydrogen and bioenergy sectors**

- **Promote** the networking of various local, national and international actors
- **Promote** Québec's expertise and business opportunities in green hydrogen and bioenergy on the international scene
- **Attract** investments or capital to finance projects in Québec

**Objective 6: Encourage the support of local and Indigenous communities in the development of value chains**

- **Inform** the population about the sectors and their role in the fight against climate change
- **Promote** the participation of stakeholders and Indigenous communities in the development of value chains

# 3. WE WANT TO HEAR FROM YOU

## Questions for discussion

Please consider the questions below in your comments.

### Vision, guiding principles and axes of intervention

1. How would you improve the proposed vision statement and guiding principles?
2. How would you improve the axes of intervention and the proposed objectives?
3. What do you think should be the key results of the strategy?

### Reducing greenhouse gas emissions

1. What do you think could be the contribution of the green hydrogen and bioenergy sectors to Québec's greenhouse gas emissions reduction target for 2030?
2. What do you think could be the contribution of the green hydrogen and bioenergy sectors to the goal of carbon neutrality by 2050?
3. What other environmental benefits should be taken into account in developing the strategy?

### Stimulating economic development

1. What role could green hydrogen and bioenergy play in various regions and economic sectors?
2. What would be the needs, for example in workforce training, to stimulate the economy throughout Québec?

### International promotion

1. What do you think of the business opportunities that green hydrogen and bioenergy could bring in promoting Québec internationally?

### Concrete measures to take action

1. Where and when is it appropriate to use green hydrogen and bioenergy?
2. With regard to green hydrogen, at what potential stages of the value chain (production, storage and distribution as well as end use) is Québec best placed to become the leader in their development?
   2.1 Which uses offer the greatest potential for cost reduction?
3. How can you help implement the strategy?
   3.1 What do you think is missing to make projects a reality?

# APPENDIX

## Glossary

**Bioenergy:** Renewable energy sources produced by living organisms or their by-products, namely biomass.

**Note:** The various forms of bioenergy, solid, liquid or gas, are produced mechanically, biologically or chemically from biomass.

**Biofuel:** Fuel produced from organic matter, intended to fuel a vehicle.

**Note:** Bioethanol and biodiesel are examples of biofuels, which can be incorporated into fossil fuels to reduce the consumption of fossil fuels. A distinction is made between first generation biofuels (obtained from raw materials traditionally intended for food, such as sugar beet, soybeans, canola, corn or wheat) and second and third generation biofuels (obtained from biomass not intended for food).

**Biomass:** All organic matter, of animal or plant origin, present in a given terrestrial or aquatic environment, which can be used for the production of energy or for other purposes, such as the production of insulation, fertilizers or materials.

**Note:** In Québec, the biomass deposits exploited for bioenergy can be divided into three main families: forest, agricultural and urban; urban includes the organic matter portion of industrial and municipal residual materials.

**Carbon intensity:** Ratio of $CO_2$ emissions to the amount of energy used for a given activity.

**Note:** Carbon intensity allows comparisons to be made, especially between countries or economic sectors.

**Carbon neutrality:** State of an organization or individual that has reduced its carbon dioxide ($CO_2$) emissions to zero or offset those that could not be reduced.

**Circular economy:** Production, exchange and consumption system intended to optimize the utilization of resources at every stage of the lifecycle of goods or services, in a circular logic, while reducing the environmental footprint and contributing to the welfare of individuals and communities.

**Note:** The circular economy is based on practices such as eco-design, repair, reuse, recovery and recycling.

**Combustible:** Material that has the property of burning on contact with an oxidizer (such as oxygen) and of producing usable heat.

**Decarbonize:** Reduce carbon dioxide and other greenhouse gas (GHG) emissions in an industry or sector of activity, in particular by replacing hydrocarbons with renewable electricity and improving energy efficiency.

**Electrolysis of water:** The process of breaking down water ($H_2O$) into hydrogen ($H_2$) and oxygen ($O_2$) atoms using an electric current.

**Note:** An electrolyser uses electrochemical reactions to break down water.

**Energy portfolio:** Distribution of the different primary energy sources used to meet the energy needs in a given territory.

**Fossil energy:** Energy produced from matter resulting from the decomposition and fossilization of organic matter deep within the Earth.

**Note:** Coal, oil and natural gas are fossil fuels. They are not considered renewable since they take tens of millions of years to form.

**Fuel:** Combustible that is intended to supply a heat engine.

**Note:** The heat engine transforms chemical energy into mechanical energy.

**Fuel cell:** Device that produces electricity by converting the energy that comes from the chemical reaction between a combustible and an oxidizer, such as hydrogen and oxygen.

**Green chemistry:** Field related to chemistry that aims to reduce or eliminate any use and creation of dangerous products for living beings and the environment and to design non-polluting products and processes.

**Greenhouse gases (GHG):** Gas that retains, in the atmosphere, part of the infrared radiation (of solar origin) emitted toward space by the surface of the Earth, thus contributing to its warming.

**Note:** Carbon dioxide, methane and ozone are among the main GHGs produced by human activities. Human activities resulting from the industrial revolution dramatically increased the amount of GHGs in the atmosphere, which are responsible for climate change.

**Hydrogen (symbol H):** Very light, colourless and odourless gaseous chemical element, the atom of which is made up of a single proton and a single electron.

**Note:** Hydrogen (H) is one atom, while dihydrogen is a molecule containing two atoms of hydrogen (H2). In the strategy, we speak of dihydrogen, commonly called "hydrogen."

**Lifecycle analysis:** Method used to assess the environmental impacts associated with all stages of a product's life, i.e. from the extraction of raw materials to disposal or recycling, including the treatment of materials, manufacture, distribution, use, repair and maintenance.

**Natural gas:** A mixture of gaseous hydrocarbons consisting mainly of methane, which can be used as a fuel.

**Oxidizer:** Substance that, by combining with a combustible and a supply of energy, allows the combustion of the combustible.

**Renewable energy:** Energy that renews itself naturally and quickly enough to be considered inexhaustible on the human time scale.

**Note:** Examples of renewable energy are wind power, solar power, hydropower and bioenergy.

Énergie et Ressources naturelles
Québec