FINANCING THE ENERGY TRANSITION:

The Outlook for Cleantech in Canada

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1. WHY FINANCING CLEANTECH IS VITAL FOR THE CANADIAN FINANCIAL SECTOR

Financial institutions play a critical role in the decarbonization journey of the global economy. Realization of emissions reduction targets and net-zero portfolios requires decisive leadership actions of the financial services sector. Activities include engaging with companies, influencing policy and regulation, reducing emissions in directly owned assets, growing carbon-neutral / carbon-negative investments, and reducing exposure to highly emitting assets. Each of these strategies is an inseparable component of the energy transition.

Delayed action will heighten the risks for Canadian financial institutions due to their high exposure to carbon-intensive sectors. This warning is based on a climate scenario study published in January 2022 by the Bank of Canada and OSFI in collaboration with six financial institutions, including RBC, TD, and Manulife. The participants had a total credit exposure of $239.3 billion to the ten most carbon-intensive sectors in the Canadian economy. Notably, each of the oil and gas sector and the electricity sector accounts for close to 30%, followed by 16% in commercial transportation and 13% in energy-intensive industries.[1] In all the analyzed scenarios, significant changes in technologies are expected, stemming from the need to decarbonize the country's economy that is intertwined with heavy-emitting sectors. This significant transition creates risks for lenders and equity holders.

The International Energy Agency (IEA) estimated that the annual investment in clean energy needs to reach $4 trillion by 2030 for the world to be on track toward net-zero emissions by 2050. Defining a pathway to net-zero emissions is a critical strategic undertaking. It will bring a level of certainty for the efficient financing of risk. Developing an effective emissions reduction roadmap is the planning for feasible technology deployment at the 'right' time and in suitable locations. Adequate assessment of risks and opportunities requires knowledge of the energy systems, the cleantech technologies and how they fit together.

This report helps the financial sector leadership develop a rudimentary understanding of cleantech. The knowledge is needed to improve the capacity to assess the risks and opportunities in the energy transition. We achieve this by answering the following questions:

- What cleantech systems are needed?
- How they work?
- What risks and opportunities are there in financing the energy transition in Canada?

2. TARGETING NET-ZERO WITH CLEANTECH

Accelerating the global energy transition to clean energy has become the highest priority in preventing climate change's most dangerous and irreversible effects. Fossil fuels have been the primary energy source ever since the Industrial Revolution. The broader energy sector accounts for 70%-80% of global anthropogenic greenhouse gas (GHG) emissions.[2] To decarbonize this sector, clean energy technology is being adopted at a much higher rate than overall energy demand growth. While global energy demand decreased by 4% in 2020 owing to the pandemic, renewable energy output expanded by 3%. In 2021, demand for renewables is set to grow by a record-setting 8% to 8,300 TWh (terawatt-hour) globally.[3] Despite the growth, current climate policies and pledges fall short in achieving net-zero emissions globally by 2050. The policies and commitments at the COP26 close less than half of the emissions gap by 2030.[4] Therefore, the adoption of clean energy must be further accelerated to meet the 2050 emissions target.

In a net-zero emissions scenario, the global energy market looks drastically different. Starting from the supply, the share of oil, coal, and gas is expected to decline from close to 90% today to around 20% by 2050.[5,6] The trade of fossil fuels will shrink accordingly. In contrast, critical minerals required for manufacturing clean energy systems will account for more than 80% of the international energy-related resource trade.[7] The global energy market shift will significantly impact the Canadian economy, as the oil & gas, mining, and associated manufacturing sectors represent more than 10% of the country's GDP.[8] To transform the sectors that have historically relied on fossil fuels for over a century, close coordination among cleantech, policy, and capital is required.

The cleantech sector in Canada is booming, but much more effort in adoption is needed to secure a leadership position in the long run. Canada's cleantech sector grows faster than the total GDP growth rate (119% faster in 2019).[9] The growth was fueled by the expansion of cleantech in the private sector. Canada ranked second in Global Cleantech Index in 2021 based on Canada's clean technology products and services, such as carbon management and battery recycling technologies. Canada is blessed with natural resources and a strong labor force. We are a major producer of many critical minerals, such as nickel and graphite. Large industrial companies, such as GM, Ford, and Tesla, have invested in or announced cleantech manufacturing facilities in Canada. In addition, the transition to a low-carbon economy continues to receive strong support from the financial services sector and the governments. In 2021, Canada submitted more substantial Nationally Determined Contributions under the Paris Agreement. The country aims to cut the emissions by at least 40%-45% below 2005 levels by 2030, higher than the previous target of 30%.[10] To achieve this ambitious goal, provincial and territorial climate actions have been proposed to scale a wide range of cleantech systems.

Four decarbonization strategies, each based on a critical cleantech system, are adopted globally and in Canada. These cleantech systems are:

1. **Electrification** – Electricity replaces fossil fuels in transport, buildings, and industry sectors.
2. **Carbon capture, utilization, and storage (CCUS)** – CCUS technologies reduce emissions from existing fossil fuels-fired power plants and the hard-to-abate industrial processes.
3. **Hydrogen and hydrogen-based fuels** – Low-carbon hydrogen decarbonizes long-distance transport, power and heat generation, and industrial processes, such as chemical production.
4. **Bioenergy** – Biomass, biogas, and liquid biofuels are carbon-neutral energy sources for power generation and transportation. In addition, bioenergy can displace fossil fuels in paper and cement production.

Understanding the cleantech systems is an essential first step of making investment and policy decisions toward science-based emissions targets. The following section presents the cleantech systems. The same structure is followed for each topic. We first introduce the latest trends in technology development – followed by an outlook of technology adoption in Canada.

3. TECHNOLOGY DEEP DIVES

3.1. Electrification

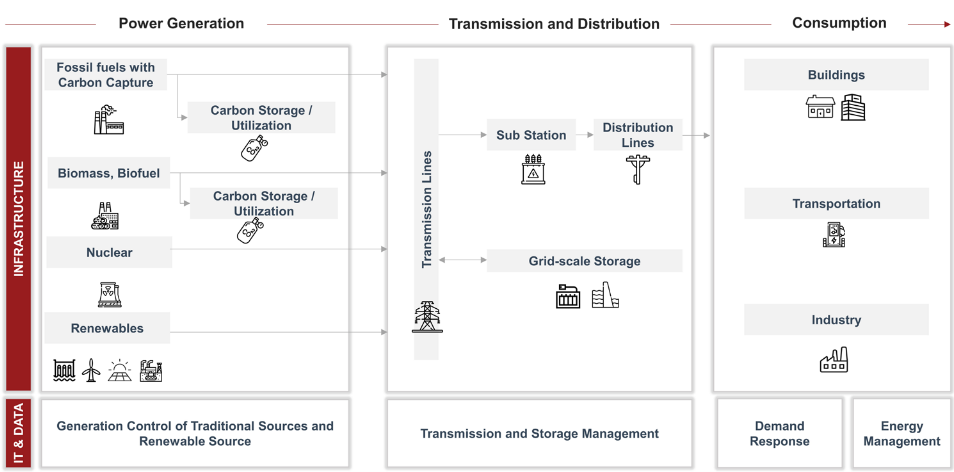
Technology trends

Electrification is the process of switching parts of our economy that currently uses fossil fuels to use electricity instead. Since the Second Industrial Revolution, electrical power has been an important energy source to drive rapid economic growth. Recently, technological advancements in renewable sources and battery technologies have let the science community re-affirm that the electricity system is the core energy system that can power the global economy without heating the planet. The electricity system consists of power generation, transmission and distribution, and consumption (Figure 1).

Electricity is generated from various sources, each with advantages and disadvantages. To select the generation method, evaluation is required on metrics including cost, GHG emissions, and technical requirements such as generation flexibility, fuel supply, and safety:

- The long-term operation of nuclear is the most cost-effective option, with 32 USD/MWh (megawatt-hour) in median levelized cost of electricity (LCOE) at a discount rate of 7%, according to an estimate by IEA.[11] Utility-scale solar PV and onshore wind have a median cost below 60 USD/MWh. By comparison, natural gas-fired plant with highly efficient combined-cycle gas turbines (CCGT) is around 20% more expensive, 71 USD/MWh.
- Coal is the most polluting fuel in life-cycle emissions, emitting over 800 grams of CO_2 for every kilowatt-hour electricity generated (gCO_2eq/kWh). By comparison, natural gas emits around 500 gCO_2eq/kWh; utility-scale solar PV emits 48 gCO_2eq/kWh; nuclear and onshore wind emits 11-12 gCO_2eq/kWh.[12] Even after retrofitting with carbon capture, the emissions of fossil fuels remain high, above 250 gCO_2eq/kWh for coal and 130 gCO_2eq/kWh for natural gas.[13] Nuclear energy's advantages on cost, emissions, and reliable operations, combined with technological advancement in areas such as the small modular reactor (SMR), have revived interest in adoption. Notably, Ontario Power Generation announced in December 2021 the implementation of a 300 MW reactor in Ontario.[14] This project can serve as a substantial precedent of SMR adoption for other provinces and countries, further securing Canada's leadership in nuclear energy.
- Caveats of low-carbon sources must be assessed before deployment. Many renewable sources, such as solar and wind, tend to be intermittent and seasonal. Biomass requires land, so land availability and the impacts on the local ecosystem and food supply need to be researched. Nuclear energy is highly regulated; safety, waste management, and social concerns are top issues to investigate.

Figure 1: The electricity power system consists of complex physical infrastructure and IT & Data.



Utilities-scale energy storage is the latest addition to the grid to improve operational reliability by optimizing the supply from intermittent renewables. The technology stores energy when the supply exceeds the demand and then discharges when insufficient. In technology selection, two requirements are typically assessed: storage capacity (or how much energy needs to be stored) and discharge time (or how long the energy needs to be held). Flywheels, batteries, and compressed air are good candidates for peak-load shifting within a day. For long-term / seasonal storage, pumped hydro, hydrogen, and power-to-methane are preferred.

Buildings, transport, and industry will drive the growth of electricity demand. An average annual growth rate of 1% from now to 2050 in Canada is projected by the Canada Energy Regulator.[15] The maturity of electrical systems in buildings (such as heat pumps) and transportation (such as electric vehicles) is relatively high. The exceptions are long-distance and heavy-duty trucks, ships, and aircraft due to the capacity limitations of Li-ion batteries. Although industrial processes are harder to electrify, adoption in heavy-emitting sectors such as steelmaking has been accelerating recently. For example, in November 2021, the Canada Infrastructure Bank and Algoma Steel finalized the agreement to finance the green steel transformation plan by replacing Algoma's existing basic oxygen furnace (BOF) operations with electric arc furnace (EAF) operations.[16]

Data innovation in utilities creates value by optimizing operations, improving system flexibility, and boosting end-use efficiency. The expanding electricity system creates complexities for managing the devices connected to the grid. All these devices are digitally controlled, and 5G networks enable the era of the internet of things. Tremendous value is unlocked by employing data analytics and artificial intelligence. On the production side, generation outputs need to be optimized based on the demand. On the transmission and distribution side, energy storage systems need to flexibly charge and discharge to balance the supply and demand. On the consumption side, smart energy management systems optimize the consumption pattern, improving energy efficiency and lowering cost.

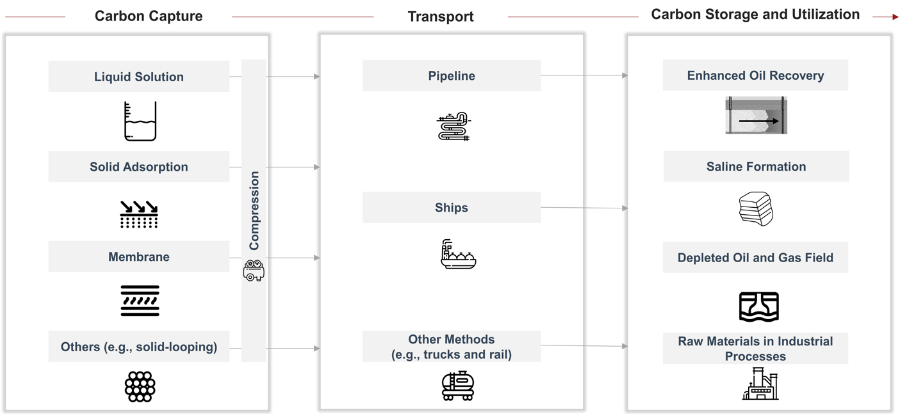
Outlook of electrification in Canada

Electrification is positioned at the central role for Canada to reach net-zero emissions with many 'safe bet' solutions as characterized by the Canadian Institute for Climate Change (CICC).[17] These technologies are commercially available and also consistently required across all transition scenarios. The 'safe bets' are non-emitting electricity and a wide range of end-use adoption, including electric vehicles, electric heat pumps, baseboard heaters, energy efficiency improvement (for electricity use), and all other electrification. Substantial margin improvement ranging from ~30% to ~90% (from the baseline scenario) is projected for batteries, solar panels, and wind turbines companies.[18] The gain will be primarily driven by demand for goods and services required through the energy transition and heightened carbon costs. In contrast, companies in oil and gas, internal combustion engine-powered vehicles, and coal mining will face the threat of bankruptcy in a net-zero emission future due to demand decline and increased environmental costs.

To further the adoption of these technologies, challenges around supply, transmission, and storage need to be addressed in Canada.[19] First, wind and solar can still be less competitive than natural gas-fired power plants with inadequate carbon pricing. In a competitive electricity market, this means less access to financing due to the lack of certainties in profitability and policy. Second, wind and solar energy are intermittent by nature. To account for this issue in Canada, several methods are being explored

- supplementing the intermittent sources with nuclear energy, such as the SMR technology that is studied by four Canadian provinces [20],
- inter-provincial transmission, e.g., connecting the vast hydroelectricity resources in B.C. with Alberta, and
- integration of storage technologies.

Figure 2: An end-to-end view of the CCUS system.



3.2. Carbon Capture, Utilization, and Storage

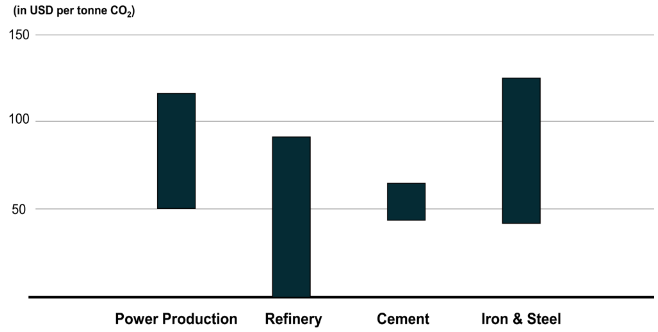
Technology trends

CO_2 can be captured for utilization or permanent storage, from industrial processes, refineries, and power generation. Many CCUS technologies are mature techniques originated from the oil and gas industry. The CCUS system consists of CO_2 capture, CO_2 transport, and utilization or storage (Figure 2).

Scaling CCUS depends on feasible and cost-effective operations. The most cost-effective option is capturing CO_2 from highly concentrated industry and power generation exhaust. Carbon capture relies on high CO_2 concentration in a pressurized gas mixture. When flowing a solvent stream in the opposite direction of an exhaust stream that contains CO_2, the CO_2 will be absorbed by the solvent because of the concentration difference. The higher the CO_2 concentration and the pressure are, the easier and cheaper it is to capture carbon. Comparing the four heavy-emitting industries in Figure 3, some refinery processes such as ethylene oxide production have the lowest capturing cost—around 10 USD per tonne CO_2.[21] The coal-fired power plant has the lowest cost in power generation because burning coal produces exhaust with highly concentrated CO_2. Currently, the unit cost is around 50 USD per tonne. Cement and steel production processes can be in a similar cost range.

Direct carbon capture from the air is in the demonstration stage,[22] but the operations depend on cheap and abundant clean electricity. Considering the low CO_2 concentration in the air, the cost of carbon capture is higher than the conventional absorption method. Direct air capture is only viable where abundant clean electricity is available so that the overall carbon footprint is negative. Because of this requirement, the business competes against end-use electrification for clean electricity supplies.

Figure 3: Cost of carbon capture in selected industries. (Source: Global CCS Institute)



Although Canada is a global leader in CCUS projects, more capacity is needed to meet the net-zero target. It is estimated that one in the six tons of carbon dioxide stored globally has been injected in Canada.[23] There are currently five large-scale carbon capture projects connected to four carbon sinks downstream. Together, Canada has a CO_2 handling throughput of 7 million tonnes. However, multiple studies estimate that at least a 25-million-ton capacity is required by 2035 so that Canada can be on track with the net-zero 2050 target.[24,25]

Scaling transport and storage infrastructure for clustered emitters can be a feasible solution. Infrastructure can accelerate CCUS adoption in new industries and make capture viable for smaller emitters. For example, the U.S. Summit Carbon Solutions network enables capturing projects as small as 90,000 tonnes per year;[26] the Norwegian cement producer Norcem Brevik and Fortum Oslo Varme's waste-to-energy plant are adopting carbon capture as the transport and storage infrastructure is being made available by Northern Lights, a carbon storage company jointly owned by Equinor, Shell, and TotalEnergies.[27]

Outlook of CCUS in Canada

CCUS (from concentrated CO_2 stream) has a promising outlook in transitioning to net-zero emissions. CCUS plays an irreplaceable role in decarbonizing hard-to-abate sectors, blue hydrogen production, and carbon removal technologies such as bioenergy with carbon capture and storage (BECCS). Success adoption of CCUS will create profitable opportunities for the heavy-emitting sectors of steel, cement, fertilizers, chemicals, and refinery. By removing the carbon from the production processes, the companies are protected against increases in carbon pricing. When CCUS is implemented across Canada, Canadian products will become more competitive in the global market due to their low carbon intensity. If this opportunity with CCUS is missed, companies in the heavy-emitting sectors can be threatened by decreasing profitability due to high climate costs and low demand for their products. Given its importance and Canada's CCUS expertise in the oil and gas industry, CCUS presents a strategic opportunity for Canada.

Five categories of challenges need to be overcome for CCUS to be widely implemented in Canada:[28]

- **Financing** – The wide adoption of CCUS largely depends on implementing the carbon capture and storage (CCS) technology. Unlike EOR that produces economic value by using the captured CO_2 to produce oil, CCS stores CO_2 permanently without offsetting value-added. Without certainty on carbon pricing or strong investment from the government, tremendous risks present for private financing options for CCS projects.
- **Technological scope** – CO_2 can be emitted from multiple processes within a firm. In addition, there is a variety of technology for capturing carbon. These complexities may create confusion and limitation for companies to implement carbon capture.
- **Regulatory support** – Canada has numerous positive signals, e.g., a high-level climate framework, various climate pledges in COP 26 and under the Paris Agreement, carbon price increase, clean fuel standard, federal and provincial hydrogen strategies, etc. Yet, concerns are that these policies are not firm enough to support a solid business case for substantial CCUS investments. While firms have been exploring credits and grants from the government, stronger regulatory support will help unlock investments by providing a solid ground for calculating investment returns in CCUS. It is worth noting that the federal policy and fiscal measures outlined in Federal Government's Strengthened Climate Plan will be delivered by March 2022, as stated in the Prime Minister's letter to the Minister of Environment and Climate Change in December 2021.[29]
- **Social and environmental acceptance** – Given CCUS's origin in the oil and gas industry, concerns around greenwashing and funding divergency from deploying renewable energy are commonly heard. Yet, CCUS technology is essential for Canada to reduce indirect emissions. Improved public education, tight monitoring of CO2 leakage, and transparency on the emissions reduction impact and project funding can help to address public concerns.
- **Indigenous support** – Carbon storage sites, carbon pipelines, and blue hydrogen projects are often located around indigenous communities. Therefore, a great collaboration opportunity with indigenous communities is available to ensure prosperity. Meaningful engagement and consultation with indigenous groups are essential.

3.3. Hydrogen

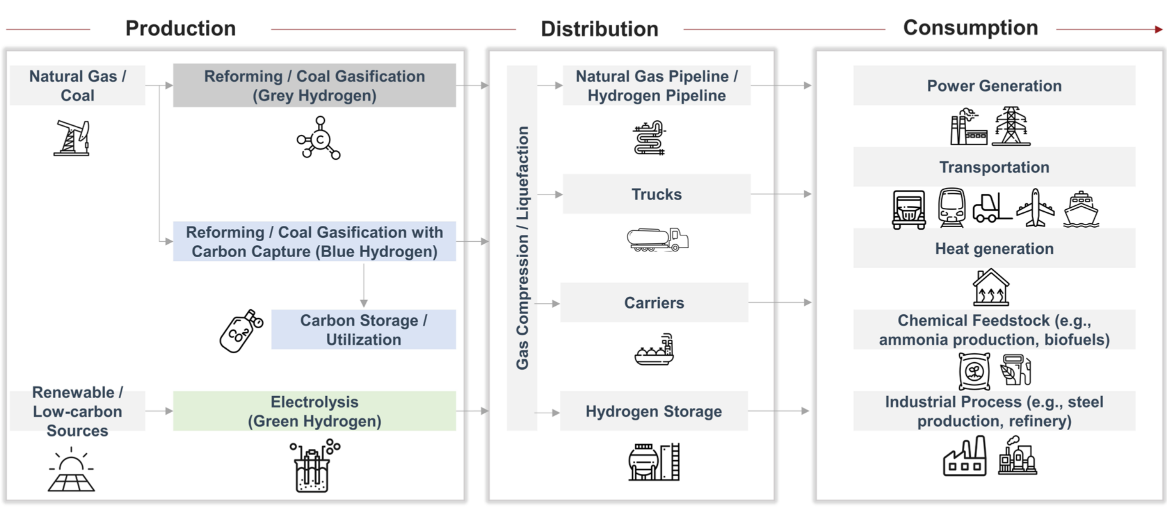
Technology trends

Hydrogen (H_2) can decarbonize sectors where few alternative low carbon solutions exist, such as long-distance transport, long-term energy storage, and iron & steel production. Hydrogen and hydrogen-based fuels can be transported and traded across regions in large quantities. They have zero GHG emissions at the point of use. The hydrogen energy system consists of production, distribution, and consumption (Figure 4).

Hydrogen's crucial role in decarbonizing hard-to-abate sectors is increasingly clear. Up to September 2021, 12 countries, including Canada, have published their national hydrogen strategies.[30] In the past November, Alberta unveiled its hydrogen roadmap, aiming at a long-term leadership position in the global hydrogen economy by leveraging the province's abundant blue hydrogen resources and extensive production experience.[31] To reach net-zero by 2050, the global hydrogen demand will need to increase from the current 90 MT to 660 MT. Moreover, the growth will need to be driven by low-carbon hydrogen.[32,33] To align with that long-term target, by 2030, a capacity of at least 50 MT low-carbon hydrogen should be added. If we miss this milestone, the net-zero 2050 target may become unrealistic because emissions reduction of the hard-to-abate sectors would likely fall behind.

Expansion of hydrogen infrastructure is a good indicator to monitor the growth of the hydrogen market. To distribute hydrogen, the gas is first compressed, liquified (LH2), or converted into ammonia (NH_3). Yet, hydrogen liquefaction can be costly because the process requires a low temperature. The boiling temperature of hydrogen is -253°C, compared to -162°C of natural gas. Hydrogen can be blended into natural gas pipelines, and a blend level of less than 20% is generally considered acceptable.[34] Blending low-carbon hydrogen decarbonizes the natural gas network. An example of such a project in Canada is Enbridge Gas's power-to-gas operations in Ontario.[35] If hydrogen adoption accelerates, existing natural gas pipelines can be modified to dedicated hydrogen pipelines. This requires re-engineering of the pipeline design to prevent hydrogen leakage. Hydrogen carriers will be used for international trade, such as Australia-to-East Asia and Middle East-to-Europe. Tracking the growth of the fleet indicates how fast the hydrogen trade grows. Trucking is essential for the last-mile distribution of hydrogen. For distances longer than 300 km, trucking of liquefied hydrogen is most economical, and for shorter distances, trucking of compressed gas can offer a more attractive cost.[36]

Figure 4: An end-to-end view of the hydrogen energy system.



Based on the break-even cost of hydrogen, early-adopting industries are mobility, industry feedstock, and power. In mobility, hydrogen fuel cells compete mainly with diesel internal combustion engines such as trucks, buses, and rails. The industry targets a market share of 11% of heavy-duty truck sales in 2030.[37] In addition to cost reduction, hydrogen fueling stations need to mature to overcome the range anxiety issue. The steel industry could account for about 4% of hydrogen demand in 2030.[38] Early adopters of green steel are seen in the automotive industry, which climate-minded customers have significantly impacted. Almost two tonnes of CO_2 are emitted to make one tonne of steel using the traditional method with coking coal, and steel accounts for around half the weight of a passenger vehicle. In November 2021, Volvo launched the world's first vehicle using fossil-free steel, supplied by the Swedish steelmaker SSAB. In October 2021, BMW announced that they will start sourcing green steel from 2025. Power with hydrogen is commercially available. Hydrogen and hydrogen-based fuels can be used as base-load generation sources to supplement the intermittent renewables. In October 2021, the French energy company HDF Energy and Canada's Ballard Power announced the world's first multi-megawatt and baseload hydrogen power plant; this design will increase the utilization of a solar park connected to the plant by allowing the intermittent source to produce hydrogen.

For green hydrogen to be competitive, the capital cost of hydrogen electrolyzers needs to be halved. The per kW cost of electrolyzers (for green hydrogen production) is currently above $560.[39] Green hydrogen can become cost-competitive if the electrolyzers cost drops below $250 per kW.[40] This cost target will likely be reached with the scaling of the hydrogen market. If the market can reach 1,000 MW p.a., economies of scale and R&D efforts such as power density improvement are projected to reduce the cost by $201 per kW and $94 per kW, respectively.[41] This market size can be achieved in the near future based on the historical capacity addition and growth data. In 2020, close to 70 MW capacity was installed worldwide with a year-over-year growth rate of around 100%.[42]

Hydrogen-powered maritime transport and air travel are good examples of hydrogen R&D pipeline projects. According to marine technology company Wartsila, fully ammonia-fueled marine engines will be available as early as 2023. Ammonia retrofit packages for existing vessels are expected two years after that.[43] Airbus aims to commercialize the world's first hydrogen-powered zero-emission aircraft by 2035.[44]

Outlook of Hydrogen in Canada

Characterized as a 'wild card' (i.e., high risk and high return) solution by CICC, the adoption of clean hydrogen depends on the de-risking of financing and investment. On the demand side, both domestic and export opportunities need to be assessed for low-carbon hydrogen producers to have a clear go-to-market strategy to secure revenue. Like all resource trade, moving large volumes of hydrogen depends on a functioning supply chain and reliable infrastructure, which can be costly to build from scratch. To overcome this barrier in the near term, clean hydrogen that can be produced and consumed locally is a low-risk play. Opportunities include blending hydrogen in the existing natural gas lines and blue hydrogen production paired with adjacent industries that consume hydrogen as a feedstock in Alberta. Exporting fuel cells and electrolyzers continue to have a positive outlook as the European and Asia markets see increasing demand. Confident with a sustained demand over the long-term, CICC projected that fuel cell companies present clear opportunities through the transition to 2050, with a profitability improvement ranging from ~55% to ~80%.[45]

Natural Resources Canada has outlined numerous challenges to overcome in Canada's national hydrogen strategy.[46] Economically, clean hydrogen is still more expensive than fossil fuels (such as natural gas) partly because the market's climate cost is not adequately reflected. Looking ahead, progress in carbon pricing and the clean fuel standard will likely change the economics of hydrogen investment. On the end-user side, scaling hydrogen depends on the increased availability of fueling infrastructure and the reduced cost of fuel cell technologies. Learnings from the adoption journey of li-ion batteries are valuable for hydrogen adoption; firm government policy and regulatory support, updated codes and standards, and improved public awareness are critical to stimulating demand at the early stage of hydrogen adoption.

3.4 Bioenergy

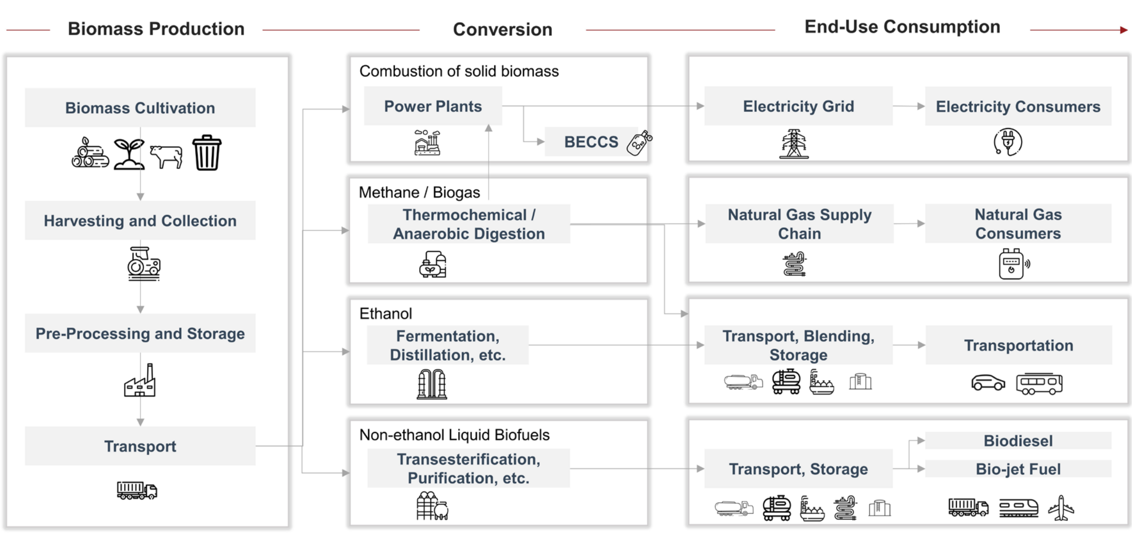
Technology trends

Bioenergy is a renewable form of energy, releasing chemical energy stored within organic material. Bioenergy can be compatible with existing fossil fuels engines. The combination of bioenergy with CCUS can lead to negative emissions. The bioenergy system consists of biomass production, conversion, and consumption (Figure 5).

Many types of bioenergy are commercially available, such as solid biomass, biomethane, and liquid biofuels. Biomass-fired power plants and heaters are alternatives to burning coal. Thus, banning coal can drive growth. After Ontario committed to ending coal use, Ontario Power Generation's Atikokan generation station was converted from burning coal to burning biomass in 2014.[47] Adopting biomethane (also known as biogas or renewable natural gas) is key to reducing methane emissions from landfills and wastewater treatment facilities. Biomethane can be injected into natural gas pipelines, thereby decarbonizing the natural gas supply. Bioethanol and biodiesel can be blended into gasoline and diesel, respectively. Low carbon fuel standards usually regulate the blend rate. In Canada, the biofuel contents in gasoline and diesel increased significantly over the last ten years due to federal and provincial regulations.[48] While further increasing the blend rate can effectively decarbonize the transportation sector, the fuel's compatibility with engine materials must be carefully studied. Engines can get damaged if the fuel is incompatible or the blending rate is too high. Although some bio aviation fuels and regular fuel can be blended with a 50:50 ratio,[49] the cost of bio aviation fuels is up to 8 times higher.[50] Despite the high price, many countries plan to mandate the renewable content in aviation fuel to transition the aviation industry; Sweden and Norway aim at a blending rate of 27% and 30%, respectively, by 2030.[51]

Bioenergy with carbon capture and storage (BECCS) is a highly anticipated technology. To reach net-zero, bioenergy needs to be paired with carbon capture to produce energy with negative emissions. Yet wide adoption of BECCS depends on the availabilities of biomass and CO_2 infrastructure. Without firm policy and pricing on carbon, it is challenging to justify BECCS projects financially.

Figure 5: An end-to-end view of the bioenergy system.



Outlook of bioenergy in Canada

Bioenergy is a 'safe bet' clean energy source through the energy transition.[52] The demand is from liquid fuels for transportation, renewable natural gas, solid biofuel for power generation, and BECCS technology. Domestic policy and regulations, such as the clean fuel standard and carbon pricing, can drastically influence the demand and the competitiveness of bioenergy. Thus, financiers must pay close attention to policy changes, such as mandated blending rates and carbon intensity in fuels, to accurately model the return on investment for bioenergy projects. Regulatory measures from other countries may spark demand as well. For example, mandating low-carbon content in aviation by regulators in Europe would push Canadian airlines that have a presence in the market to procure more bio aviation fuels. The scaling of bioenergy demand creates opportunities for midstream and downstream oil and gas companies by leveraging their knowledge, expertise, and assets.

4. POWERING AHEAD

To de-risk the complex energy transition, we recommend five actions to Canadian financial institutions:

- **Build up a cleantech-centered culture and talent pool** – Infrastructure and technology transformation will need to accelerate across all sectors. The IEA estimated that the renewable deployment rate must quadruple by 2030 in a net-zero 2050 scenario. To meet the demand, a sustained, cleantech-centered culture and a skilled labor force are required.

- **Electrify everything** – Clean electricity takes the leading and central role in decarbonizing energy use. Increasing the supply depends on the deployment of low-carbon sources and increasing the power grid's capacity and capability. The critical issue of intermittent supply stemming from solar and wind needs urgent solutions, such as interprovince connections and the addition of energy storage.

- **Establish leadership in hard-to-abate sectors** – Companies have already started to buy in the green procurement movement aiming at a long-term competitive edge by curbing the scope 3 emission. This disrupts companies across the supply chain, especially those in the hard-to-abate sectors such as iron & steel, cement, and chemicals. Suppliers with low-emissions production methods will stand out from the competition.

- **Leverage synergies to scale critical infrastructure** – Many cleantech energy systems are interdependent. For example, carbon capture technology and CO_2 infrastructure are needed for blue hydrogen to be viable. Scaling one type of infrastructure can be valuable for adopting a broad range of technologies.

- **Lead, not just follow, the carbon price evolution** – Businesses have already started to factor carbon price into their operations to manage and mitigate risks associated with climate costs. Voluntary carbon markets are available for trading carbon credits. To lead this evolution, it is critically important to tailor a feasible reduction roadmap by analyzing the carbon footprint across business operations.

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