

OCTOBER 2020

CLEAN SLATE: HOW CANADA CAN SPUR
GROWTH BY PROCURING FROM ITS OWN
CLEANTECH STARTUPS



The Innovation Economy Council

is a coalition of tech-sector leaders dedicated to shaping Canada's industrial innovation policy. Led by MaRS, Ontario Centres of Excellence, Communitech, DMZ, Invest Ottawa, CCRM, Spark Centre, CENGN, NGen, Mitacs and Ontario Genomics, the IEC works with active members of Canada's innovation ecosystem to identify areas for in-depth analysis and offer timely insights to increase Canadian productivity and sustainable growth.

Author: **Shawn McCarthy**

Data and Analytics: **Nigel Biggar**

Editor: **Guy Nicholson**

CLEAN SLATE: HOW CANADA CAN SPUR GROWTH BY PROCURING FROM ITS OWN CLEANTECH STARTUPS

Why innovative startups matter

In the 20th century, countries rich in coal, oil and natural gas prospered. But the 21st century will reward those who lead the race to invent, commercialize and adopt clean technology, particularly zero-carbon energy sources. The future is bright for any innovative cleantech company that can capture a piece of the expanding market for goods and services aimed at reducing environmental degradation caused by human economic activity.

Powered by fossil fuels, the Industrial Revolution brought enormous economic benefits to billions of people. But the deteriorating health of our climate and environment can no longer be treated as the simple cost of doing business. Left unchecked, fossil-fuel emissions will bring catastrophic effects. We must quickly improve energy efficiency and transition to fuels and technologies that produce little to no carbon.

This shift will require a Herculean transformation of nearly every aspect of our modern economy. We need to retool how our computers are kept humming, how our companies produce goods, how we heat and cool our homes and how we travel for work and pleasure. The challenge is even greater given the developing world's legitimate desire for the kind of abundant, affordable energy that has driven modern economies elsewhere.

Canada has joined 72 other countries pledging to achieve net-zero greenhouse gas emissions by 2050. Much of the technology needed to achieve that energy transition will be produced outside our borders.

But for our country to both do its part and prosper, domestic companies need to fortify their presence in the global clean-energy supply chain. Cleantech will be a key source of growth as we move forward, especially after the economic reckoning imposed by COVID-19. In the Speech from the Throne delivered on September 23, the Liberal government promised to create one million new jobs over the next few years, with programs that accelerate a low-carbon transition at the centre of that effort.

Environmental and cleantech products – clean energy, waste management and recycling, goods and services – contributed \$66 billion (three percent) of our country's GDP in 2018.

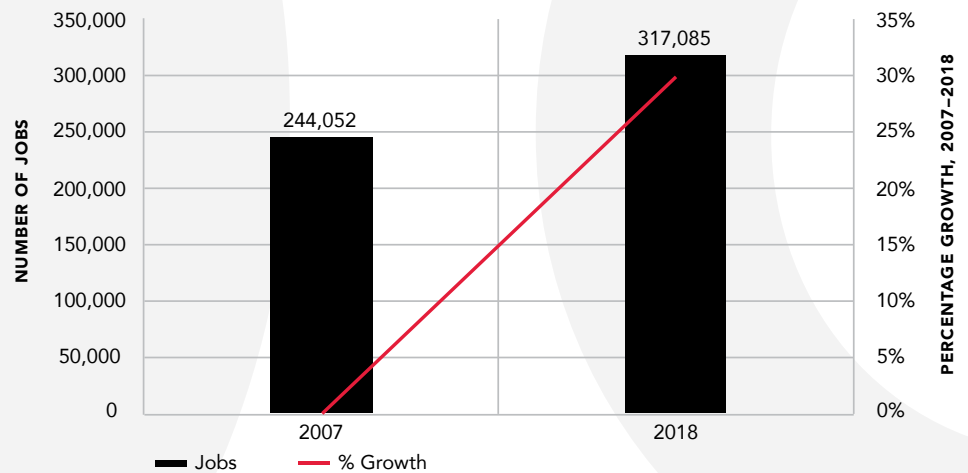
Of the 259 fast-growing startups reviewed by an Innovation Economy Council researcher, seven percent fell in the environmental products category (which includes clean energy and waste management) while 93 percent offered clean technology goods and services.

The startups operate in fields that include energy, advanced materials and advanced manufacturing, transportation and smart cities. This puts most if not all of the startups in advanced industries: industries characterized as doing significantly more research and development than most other businesses (at least \$450 per worker annually) and employing a greater share of Canadian science, technology, engineering and mathematics workers (20 percent more STEM workers than the average for all industries).

Advanced industries are creating jobs and growing at a much faster rate than the overall economy. For example, advanced manufacturing industries have accounted for 30 percent of all new factory jobs created in Canada since the 2008 recession. Similarly, in Ontario, GDP growth has averaged 10 percent in semiconductor and electronic component manufacturing, critical components of clean technology products. That compares to average GDP growth of just 2.3 percent per year across the economy over that period.

Employment in the sector has grown sharply. Between 2007 and 2018, the number of jobs in the environmental and clean technology (ECT) sector increased by 30 percent to 317,085, according to Statistics Canada. Those figures don't include activity in related sectors such as advanced manufacturing and digital controls that often underpin clean technology, noted a paper from the Institute for Climate Choices released in September.

EMPLOYMENT GROWTH, ENVIRONMENT AND CLEANTECH CANADA 2007–2018



In a 2019 survey done by MaRS, 369 cleantech startups reported employment of 17,265 people in 2018, an average of 47 employees per venture. Seventeen of those companies reported more than 100 employees.

Accelerating cleantech growth will require a concerted effort by all levels of government and corporate leaders in virtually every sector of the Canadian economy, says Annette Verschuren, CEO of energy storage company NRSstor Inc.

Canada's startups are key links in the cleantech supply chain because they take the latest research from the labs and develop them into viable commercial products, says Verschuren, who chairs the MaRS Discovery District innovation hub and Sustainable Development Technology Canada, the federal financing agency.

“From startups, you get new businesses that create value, that create employment, that are innovators,” she says. “Innovation is the first step in creating economic value and social value in your country.”

Verschuren has a rare perspective on the sector. She is CEO of NRStor Inc. which develops electricity storage projects, including a partnership with Toronto-based Hydrostor that completed the world’s first compressed-air storage facility in an old salt mine at Goderich, Ont. She is also a director at some of Canada’s biggest corporations, including Air Canada and Calgary-based oil giant Canadian Natural Resources Ltd.

Defining cleantech: Sector or service? Impact or efficiency?

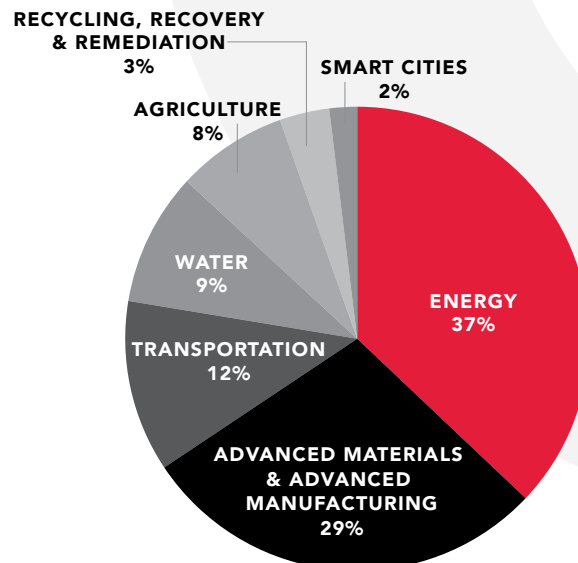
The term “cleantech” is typically applied to a broad array of innovative technologies that provide solutions for pollution, climate-change mitigation and adaptation, and waste management and remediation.

According to Statistics Canada, cleantech is a process, good or service that reduces the environmental footprint of economic activity, either by mitigating the impact of incumbent technology or displacing it with clean alternatives. Often, the innovation also has the effect of improving a company’s financial performance by reducing energy use or waste-management costs.

People often refer to cleantech as a “sector,” but that’s a misnomer. Cleantech isn’t one industry grouping. Rather, it’s an approach to innovation that cuts across sectors.

Cleantech companies operate in the oil-and-gas industry, in advanced manufacturing, in agriculture, in waste management, in energy efficiency, in renewable power, in the electricity grid. Indeed, there are companies developing new materials, digital controls, software and artificial intelligence applications that would not formally be classified as cleantech, but are nevertheless providing essential tools for the energy transition.

CLEANTECH CLUSTERS, 259 VENTURES



Activity ranges widely, from in-house efforts by corporate giants like General Electric, Siemens and Canada's Suncor Energy to well-established startups like Halifax-based CarbonCure Technologies, which provides products to the concrete industry while capturing carbon and recently secured Amazon's climate-change fund as an investor. Cleantech also includes nascent enterprises with little financing and a handful of employees.

Some of these technologies promise game-changing disruption. General Fusion, based in Burnaby, B.C., is developing a fusion reactor that the company expects to become an abundant, inexpensive source of energy. It would cost hundreds of millions of dollars to construct at commercial scale.

Other companies look to prosper one small step at a time – for instance, by reducing waste and inefficiencies in order to cut emissions and reduce operating costs. Toronto's Argentum Electronics, for example, has developed plug-in digital transformers that improve the efficiency of home devices like cellphone chargers and LED lights.

Big-ticket renewable energy, particularly wind and solar, has long dominated the discussion about the future of clean technology. But in truth, the market is far more complex. And Canada has largely picked its lane, leaning in on energy transition solutions such as hydrogen, heat pumps, offshore wind and carbon capture and storage, international consultancy Wood Mackenzie found in a September report, *The Technologies Shaping the Energy Transition*. These technologies are "the game-changers in moving to a low-carbon world," company spokeswoman Anthea Pitt said. Meanwhile, the International Energy Agency advocates for the rapid embrace of energy-efficiency tech as a key element in averting a climate catastrophe. Canadian entrepreneurs are pursuing technological solutions in all these areas.

R&D booms, but Canada's procurement and adoption of cleantech lags

In contrast with all this Canadian research and development activity, the growth of revenue-generating cleantech firms here has been relatively modest, suggesting that these companies face stubborn barriers to market penetration across the economy.

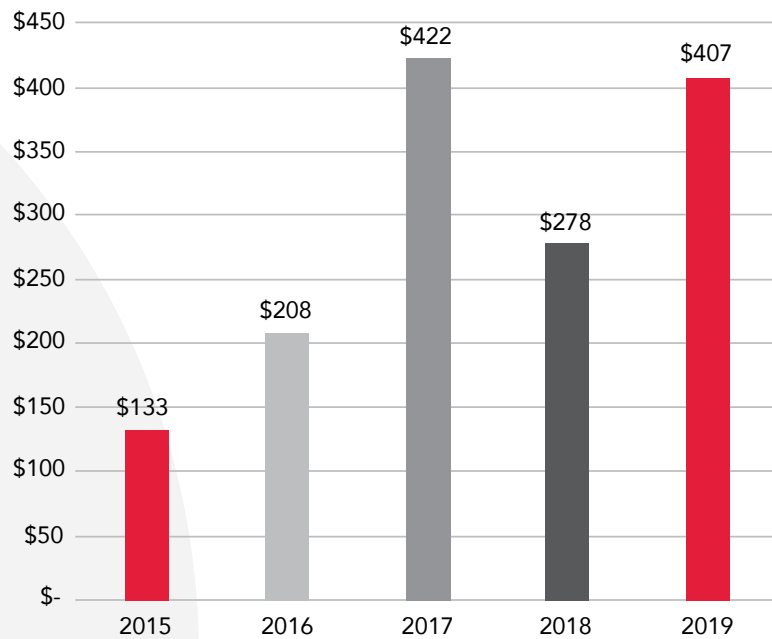
Indeed, Canada ranks among the top spenders on R&D among Group of 20 countries, but it's near the bottom at turning that work into the commercial products companies can be built around.

Between 2013 and 2018, revenues for Canadian clean technology grew 21 percent to \$30 billion, according to Statistics Canada. The broader environmental and clean technology sector, which includes low-carbon electricity and waste management, grew by 25 percent over that five-year period to \$66.3 billion. That's roughly in line with overall GDP growth, a disappointing result for what should be a source of rapid growth.

The good news is that cleantech investment has quadrupled, and exports have dramatically grown over the past three years.

Last year, Canadian cleantech firms raised \$407 million from domestic venture capital providers, up from just \$133 million in 2015. The leading federal venture-capital provider, Sustainable Development Technology Canada, approved \$156 million for startups in the sector, leveraging another \$233 million from private-sector funders. That's up from SDTC funding of just \$92 million three years ago.

CLEANTECH VENTURE CAPITAL (\$ MILLIONS)



Winning support from SDTC is a major victory for any young startup, as it lends credibility to the enterprise and opens the door to more funding from other government agencies and the private sector.

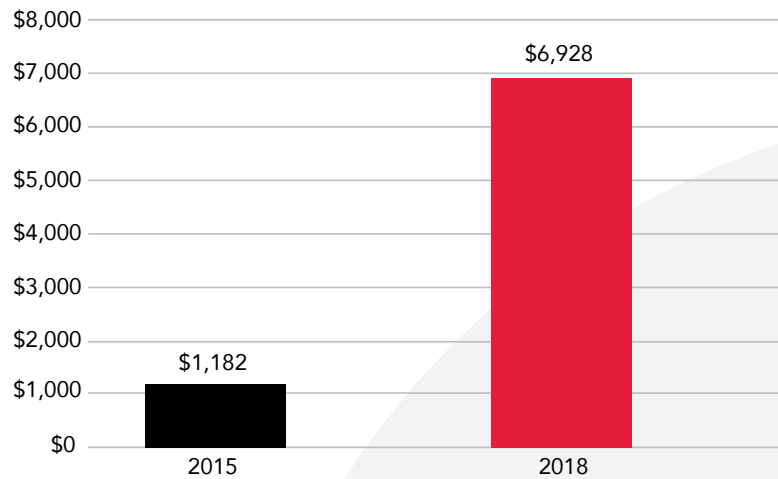
“SDTC is really the cornerstone of Canada’s cleantech ecosystem,” said CarbonCure CEO Robert Niven. “Just about every significant cleantech company has gone through SDTC.”

But while government funding helps, it’s not the same as private-sector confidence and investment. Cleantech financing is dwarfed by the money venture capitalists plow into information and communication technology startups. Compared to cleantech, ITC is “hip, fast and profitable,” says Tom Rand, managing partner at Toronto-based ArcTern Ventures.

ITC and biotech startups typically require far less up-front capital and produce commercial revenue much faster than cleantech, Rand says. Cleantech companies tend to require patient capital, requiring investors to finance pilot projects, then commercial-scale demonstration facilities before revenue is generated.

Cleantech exports rose from \$1.2 billion in 2015 to \$6.9 billion in 2018. But much more is possible. Canadian firms could roughly triple exports to \$20 billion by 2025 if governments enacted the right policies, a federal strategic panel on cleantech found in a 2018 report.

ENVIRONMENTAL AND CLEAN TECHNOLOGY EXPORTS (\$ MILLIONS)



Canadians are elbowing their way onto the world stage. Companies like Ballard Power and Hydrogenics are leading suppliers in a growing hydrogen sector; Halifax-based CarbonCure has customers on four continents for its emissions-reducing technology for concrete, and a host of startups that focus on energy efficiency on the grid and in buildings are making their marks.

But the Canadian scene is still hampered by risk aversion among established players. CarbonCure's Niven argues Canada has to do a better job providing markets for companies commercializing technology, which they can then take into world markets.

Policy instruments such as tax incentives, regulations and pollution pricing will encourage existing companies to invest in cleaner solutions, said Heather Ward, CEO of Tandem Technical, an Ottawa company that is commercializing carbon-capture-and-utilization technology.

"Government procurement is also a key tool that has yet to be applied," Niven said.

According to IEC research on a group of 259 cleantech high-growth startups, total federal procurement over 11 years (2009 to 2020) represents just 3.6 percent of these companies' overall 2019 revenues and just 4.4 percent of their 2019 exports. In other words, these high-growth cleantech companies aren't getting early boosts from government sales. They actually do better outside the Canadian market than they do within it – the opposite of how it works in many other countries, which tend to give local innovators their first sales.

The tendency of business leaders to view the world in short time horizons is particularly challenging for tech-intensive startups, says Michael Tremblay, president and CEO of the Invest Ottawa economic development agency.

“It isn't always the case that the cleantech solutions meet the basic business case and expectation of short-termism that is out there in the marketplace,” Tremblay says. “There have to be incentives from government as an impetus to make these things happen.”

Despite these challenges, Canada has an impressive stable of cleantech startups that are beginning to see commercial success. In its 2020 listing of top green technology companies, the San Francisco-based Cleantech Group consultancy included 12 Canadian firms among its global top 100 innovative firms, more than any other country outside the United States.

The Canadian companies included Vancouver's Axine Water Technologies, which treats industrial waste water; Opus One Solutions, a grid technology firm; Svante Inc., whose technology helps to capture carbon emissions from industrial sources; agricultural technology company SemiosBio Technologies Inc., and Carbon Engineering, whose technology captures CO₂ directly from the air.

Governments and industry need to focus on adoption

Cleantech providers often operate in the business-to-business market, supplying existing companies with new technology to mitigate their environmental impact and improve efficiency. The oil-and-gas sector is a major market for cleantech companies, as producers face regulatory and other pressures to reduce their environmental impacts.

Suncor, for example, is working with advanced manufacturing firm Exergy Solutions Inc. on water-free methods to extract bitumen from the oil sands. At a small lab in Calgary, Exergy provides 3D printing tech that accelerates testing of Suncor's non-aqueous processes.

Oil companies are a crucial market for cleantech firms that offer solutions to environmental and business challenges, according to Suncor strategic advisor Gary Bunio. “These smaller companies will do things in the back of a garage or in their own labs or at a university,” he says, “but they need to have the last step of technology development on the path to deployment, which is a place to put Unit No. 1.”

It's not all partnerships, though. These innovators also compete with the incumbents to create products capable of displacing older, dirtier technologies. For example, Ottawa-based GBatteries is developing ways to speed up charging for the lithium batteries used by electric vehicles. Widespread adoption of EVs and vehicles powered by hydrogen fuel cells would eat into Suncor's market for gasoline and diesel cars and trucks.

To be sure, cleantech solutions aren't without their own challenges.

Take lithium-ion batteries. A 2019 report by the IVL Swedish Environmental Research Institute estimates that producing batteries for light-duty electric vehicles requires 61 to 106 kilograms of CO₂ equivalent per kilowatt hour of battery capacity. Batteries for the Chevrolet Bolt EV, Nissan Leaf and

Tesla Model 3 are 66 kWh, 40 kWh and 75 kWh respectively, averaging 60.3 kWh. In other words, the lower estimate of the CO₂ equivalent emissions to build a 60.3 kWh battery is 3,678.3 kilograms.

According to the EPA, that amount of emissions is equivalent to 9,127 miles driven by an average passenger vehicle, consuming 414 gallons of gasoline. (The average American driver travels 13,476 miles in a year, according to a 2018 report by the U.S. Federal Highway Administration.) And this doesn't include the social costs of producing lithium-ion batteries: 500,000 gallons of water per tonne of lithium in South America, toxic pollution from Tibetan lithium mines, or child labour used to mine cobalt in the Democratic Republic of the Congo.

The global cleantech market is expected to reach \$2.5 trillion (U.S.) by 2022, a federally appointed cleantech strategy panel concluded in 2018.

What's more, that figure is expected to grow rapidly in the next several decades as the effects of climate change worsen. A 2018 report from the Global Commission on the Economy and Climate calculated that aggressive climate policies would create \$26 trillion (U.S.) in economic activity between 2018 and 2030. And that figure doesn't include the market for pollution abatement and waste management and remediation.

Of course, such bullish forecasts assume that governments around the world adopt the policies needed to drive investment in energy efficiency and non-carbon energy.

The world is currently "far from on track" in embracing the technologies required to meet climate change goals, the Paris-based International Energy Agency said in a June report. The agency, which advises rich countries on energy policy, assessed the status of 46 critical energy technologies and sectors. It found that while progress is being made, we need to accelerate the pace in virtually all areas in order to meet targets laid out under the 2015 Paris Agreement.

Barriers to adoption exist throughout the global economy. They include outdated regulations; incumbent industries that supply cheap, abundant but dirty energy; and a culture of short-term thinking and disposable consumption.

Three years ago, just 10 percent of Canadian firms had adopted clean technology, the Canadian Institute for Climate Choices report said. The COVID-19 pandemic has likely stalled that effort, as businesses focus time and capital on immediate survival and the challenges of navigating a rapidly changing market.

But many governments appear ready to hit the accelerator and spend their way out of the deep economic slump caused by COVID-19. The pandemic has spurred a wave of "green recovery" plans that will increase demand for cleantech solutions – assuming that these lofty pledges become reality.

In the Throne Speech, Canada's minority Liberal federal government pledged to pursue a green recovery with spending programs and tax breaks aimed at accelerating the adoption of clean technology. Assuming it survives in office long enough, the government said it will provide dollar figures for the plan later in the fall, pledging to make Canada "the most competitive jurisdiction in the world for clean technology companies."

The European Union is pledging a green recovery plan worth \$650 billion (U.S.) over seven years. In the United States, Democratic presidential nominee Joe Biden has promised to spend \$2 trillion (U.S.) over four years in a "green new deal" if he wins the White House in November.

"Policy is hugely important" in getting risky, capital-intensive clean technologies to market, said Elyse Allan, former CEO of GE Canada and a director on the board of Brookfield Asset Management.

"It's hard to sell something that is just greener and better if there isn't a respectable and sensible economic proposition," said Allan, who is also a board member at MaRS. "And good policy helps make that economic proposition."

Cleantech markets are expanding to meet environmental demand while improving productivity and driving down operating costs in industry. The Queen's University-based Institute for Sustainable Finance has calculated that the investment needed to meet Canada's 2030 emission reduction targets will total \$128 billion over the next decade. That cost of abatement — including \$26 billion for the oil and gas sector and \$9.4 billion in heavy industry — will require technology that improves competitiveness at the same time as lowering environmental impacts, according to an ISF report released September 29.

The market for nanotechnology, meanwhile, should reach \$90.5 billion (U.S.) by 2021, up from \$39 billion in 2016, according to a study by Research and Markets. The top three applications for nanotechnology are electronics, energy and biomedical, and its adoption by companies in those sectors will improve their competitiveness, that study concludes.

Ensuring rapid and broad-based adoption of clean technology will require more than government subsidies and infrastructure projects. The 2018 federal strategy paper laid out a menu of policy actions to accelerate the development of this strategic sector.

They include regulatory reforms meant to remove barriers and create incentives for technology adoption; greater procurement from governments and large industry to provide markets for small tech companies; efforts to build a dynamic and diverse workforce that results in greater participation by women, people of colour and Indigenous people, and acting to ensure that the financial industry fully accounts for the growing risk of climate change and the opportunities that will arise from addressing it. Based on a review of

490 cleantech startups, the number of companies that have at least one woman as a founding partner is 23 percent – higher than previous years, but still low. A review of a smaller set of cleantech startups revealed that less than two percent of companies have at least one founder who is Indigenous – an issue that needs to be addressed.

Cleantech, or cleanertech?

The Statistics Canada definition of cleantech is a broad category that includes goods and services that only marginally reduce the environmental footprint of a carbon-intensive or highly polluting industry.

Western Canada's oil-and-gas industry counts itself among the largest purchasers of cleantech goods and services as it responds to a variety of environmental challenges, such as reducing methane emissions in the conventional sector, dealing with orphan wells, reclaiming tailings ponds and cutting oil-sands carbon intensity.

While technology can reduce the environmental impact of oil and gas extraction, it doesn't render it completely "clean." The lion's share of its emissions take place when the fuel is burned in a car, truck or airplane engine. "It's the product, not the process" that determines its sustainability, as Harvard University physicist David Keith told webinar listeners this summer.

Still, technology can reduce the emissions released as the resource is being pulled from the ground in natural gas fields or in the oil sands, which has been a big part of Canada's climate-change challenge in recent years.

There is certainly a lot of cleantech R&D activity in Alberta, but progress in commercializing it and deploying it in the field has been slow. Meanwhile, the province receives regular warnings that its oil-and-gas industry has little potential for further growth and is likely to shrink as the world makes the transition away from fossil fuels in coming decades.

In fact, Western Canadian producers face a triple whammy: abundant global supply; constrained demand due to new technology, climate change and the pandemic; and a global perception that the Canadian industry is simply too high-cost and too carbon-intensive for future investment.

"Western Canada has to find new ways to compete," says Grant Strem, CEO and chair of Calgary-based Proton Technologies. His startup firm is launching a pilot project to test its process for extracting clean-burning hydrogen, rather than oil or gas from underground formations.

"There is a tremendous opportunity. It's going to look different and change is hard," he says. "But change is going to come whether we want it to or not."

Industry proponents, however, say they can stave off their demise by investing in technology that reduces operating and capital costs while lowering production's environmental footprint.

Such improvements have already seen the industry reduce its GHG emission per barrel of crude produced by roughly 22 percent, according to research by Bank of Montreal analysts. But that's still a long way from achieving a goal of net-zero emissions in the extraction phase, as companies like Cenovus aspire to.

It's been a big shift for many industry executives, says Jason Switzer, executive director of the Alberta Clean Technology Industry Alliance. "Until recently, cleantech was a swear word in Alberta."

Market opportunities differ dramatically across the country. Alberta accounted for 15 percent of Canada's ECT output in 2018, but skewed heavily toward environmental services supporting the resource sector. Ontario generated 40 percent of ECT activity, but accounted for 62 percent of clean energy equipment.

Still, Alberta has a growing startup sector, and Calgary was rated one of the world's top 15 cleantech ecosystems in 2019 by San Francisco's Startup Genome. Of 69 venture companies that responded to a 2018 survey, half were servicing markets in oil, gas and mining, while the rest were in areas such as agriculture and the power sector, according to a 2019 report from MaRS and the Alberta Clean Technology Industry Alliance.

One area of focus for the future is carbon capture, use and storage. Companies like Tandem Technical, Carbon Upcycling Technologies and SeeO2 Energy are developing industrial uses for CO₂ that can be captured from oil and gas and other industrial operations. Wood Mackenzie and the International Energy Agency have both touted carbon capture as a critical technology that must be deployed to clean up existing coal-fired power plants and other fossil-fuel facilities.

Producers are now betting that they can gain competitive advantage by producing the lowest-carbon oil in the world, appealing to investors who are starting to take climate-change portfolio risks seriously.

They may have left it too late. In order to deploy these technologies, the companies need to attract capital. But major institutional investors are leery given poor industry economics and climate-related risks, says Allan, the former GE Canada executive.

Meanwhile, startup companies across the country are having commercial success and providing the foundation of Canada's economy of the future.

Argentum Electronics is on a mission to reduce wasted power

Technologies that improve energy efficiency are often the cheapest way to meet future energy needs and reduce emissions.

About \$150 billion (U.S.) was spent in 2019 on improving energy efficiency in buildings, including the plug-in devices and lighting, according to the International Energy Agency. The IEA is encouraging governments to ramp

up incentives to increase that figure dramatically as a key element in the plan to meet GHG reduction targets.

And the market for efficient consumer electronics and appliances is expected to hit \$455 billion (U.S.) by 2022, according to California-based BIS Research.

In the United States, nearly five percent of the electricity generated by utilities is lost through the transmission and distribution system, according to U.S. Energy Information Administration data reviewed by MaRS analyst Nigel Biggar.

The cost of these power losses make them a golden opportunity for innovators.

Argentum Electronics' patented technology came from a collaboration of friends led by Bolis Ibrahim and Sagar Jaiswal, who were studying electrical and mechanical engineering at Ryerson University and the University of Toronto.

Working in university labs, the pair engineered the Digital DC Isolation Transformer, which reduces the electricity loss that occurs when the alternating current entering the home is converted to the direct current used in most electronic devices and LED lighting.

Transforming AC into usable home DC means an additional loss of up to 30 percent, usually in the form of heat, Ibrahim says.

"We're basically on a mission to eliminate all this nonsense by converting the power distribution [in a building] from AC to DC and ensure businesses take back control of these losses," Ibrahim says. "That's money in their pockets at the end of the day." He says building owners will be able to recoup the cost of Argentum's more efficient transformer in a year.

Such efficiency gains will be increasingly important as governments implement policies to increase clean electricity as a source for buildings and transportation, part of a broader effort to decarbonize the economy.

In its recent Throne Speech, Canada's federal government pledged programs to target energy use in buildings and boost EV purchases across the country. Argentum also is marketing a transformer that provides more efficient power conversion for electric-vehicle charging.

Ibrahim and Jaiswal have kept things lean, surviving on prize money from engineering awards and grants from innovation hubs such as the Northumberland Community Futures Development Corp. in Cobourg, Ont., where they now maintain an office. They're now planning for a seed round of venture financing.

While it is still in pre-commercial phase, Argentum has pilot projects that are being financed by its partners, including WZMH Architects, the Toronto-based firm that designed the CN Tower, and Ottawa-based property developer Minto Group.



Evelyn Allen
Co-founder and CEO of Evercloak

Evercloak uses nanomaterials to unlock energy efficiency

Advanced materials are driving innovations in clean technology that improve performance in energy production and consumption. Kitchener, Ont.-based Evercloak is using a unique process for applying nano-materials to reduce energy use in heating and air conditioning.

The development and use of such materials are the key both to the high-efficiency conversion of clean energy into electrical energy, and to commercialization of electrical storage units.

Evercloak pledges to make it economically feasible to apply nanomaterial coatings over a large area. It's pursuing a number of demonstration projects, including one paid for by Next Generation Manufacturing Canada (NGen), the federally funded advanced manufacturing supercluster.

Evercloak is working on that project to produce graphene membranes with another Ontario startup, ZEN Graphene Solutions. In July, NGen awarded Evercloak and ZEN \$125,000 each for a joint project that will lower the cost of graphene coatings.

ZEN's graphene coatings can be used to enhance the antiviral and antibacterial properties in personal protective equipment, as well as improve water filtration and strengthening composite materials that are used in a host of end products.

In a separate project, Evercloak also has funding from Natural Resources Canada to accelerate a demonstration project using the company's nanotech to dramatically improve the efficiency of dehumidifiers in building heating, ventilation and air conditioning systems.

It's a crucial challenge. Average global temperatures are rising due to climate change, and that change will likely accelerate in the coming decades. North Americans are already seeing hotter summers, but people who live in hotter Middle Eastern, North African and Indian climates now face dangerous levels of heat.

BIS Research forecasts a market for efficient HVAC at \$345 billion (U.S.) by 2022, up from \$153 billion in 2015.

More people will want air conditioning, which will in turn exacerbate the emissions problem unless power grids are decarbonized and HVAC units are made more efficient. Dehumidifier units represent a substantial portion of the up-front cost and operating expenses for air-conditioning units.

Evercloak co-founder and CEO Evelyn Allen is one of a growing number of women in the cleantech field. She got a major boost from the MaRS Women in Cleantech Challenge, which offers financial support and more for female-led startups.

Armed with a master's degree in environmental engineering, Allen had been working in innovation for more than a decade. She was in the technology commercialization office at the University of Waterloo, one of Canada's top engineering schools, but had not developed her own tech.

Evercloak now has 17 full- and part-time employees. It's planning commercial pilot projects and is in talks with four potential partners.

With the university's support, she surveyed opportunities in the school's own laboratories and found a partner in Professor Michael Pope, who had developed a process for continuous coating of single-layer nanomaterials such as graphene. In a 2019 survey of purely cleantech companies conducted by MaRS, 112 of the 490 respondents – 23 percent – had a female founder.

Boosting the number of women in the cleantech space is critical. Although the numbers are growing – some exciting upstarts to watch include:

Julie Angus, co-founder and CEO of Open Ocean Robotics, which develops autonomous energy-harvesting boats to collect information from oceans and instantly relay it;

Nivatha Balendra, founder and CEO of Dispersa, a company dedicated to providing natural microbe-derived alternatives to synthetic chemicals;

Amanda Hall, founder and CEO of Summit Nanotech, whose efficient extraction process improves lithium mining to make it more sustainable;

Alexandra Tavasoli, CEO at Solistra Corp., which uses patented photocatalysts that drive the conversion of carbon dioxide into value-added liquid fuels; and

Luna Yu, founder and CEO at Genecis Bioindustries, which converts food waste into biodegradable plastics and other high-value materials.

Proton Technologies supplies the emerging hydrogen economy

Companies aiming to bring new energy sources to market aren't just competing with incumbent power sources. The emerging hydrogen sector is also vying to become an energy cornerstone, and it has powerful public backers, including the federal government in Ottawa and the provincial government in Alberta.

Hydrogen is not an energy source; it's more like a storage medium. It can be produced from natural gas, a process that is cheap but produces significant GHG emissions. More climate-friendly sources include so-called "blue hydrogen," which uses natural gas but captures and sequesters the CO₂, and "green hydrogen," which involves an expensive electrolysis process using surplus power.

Several countries around the world have produced strategic plans to boost the deployment of hydrogen tech, including the United States, China, Britain, Japan, South Korea and Australia. Canadian governments are now joining them.

The market for hydrogen-based technologies has been slow to take off. Because demand is weak, costs remain high, precluding widespread adoption – a “self-reinforcing vicious cycle,” the Alberta-based non-profit Transition Accelerator says in a September report.

Canada has a number of leading players in the hydrogen supply chain. B.C.’s Ballard Power Inc. and Ontario-based Hydrogenics Corp. are leading fuel-cell manufacturers with strong commercial presence in niche markets.

Several Canadian startups are also pioneering new methods for producing hydrogen or improving existing tech.

Planetary Hydrogen, based in Gatineau, Que., is pursuing technology that uses electrolysis to produce hydrogen while adding a mineral that allows CO₂ to be captured from the air.

Vancouver-based Ekona Power is engineering a novel approach that uses natural gas to produce hydrogen and pure CO₂, which can be sold as an industrial product or sequestered underground. The company is 50-percent owned by Evok Innovations, a cleantech funder and a partnership of the B.C. Cleantech CEO Alliance, Suncor and Census Energy.

Canada can produce low-carbon hydrogen that is competitive with the cost of diesel fuel, the Transition Accelerator report concludes. Western Canadian companies could use their vast reserves of natural gas combined with ample opportunity for sequestering CO₂, while Central Canada could produce green hydrogen with its surplus supply of wind, solar and nuclear power.

Calgary-based Proton Technologies has a particularly ambitious vision: producing hydrogen from oil and gas deposits by using oxygen to break up the hydrocarbon molecules in the formations. It would then recover the hydrogen – while leaving the carbonates in the ground.

The company is planning a commercial-scale demonstration project in Saskatchewan, Proton CEO Grant Strem says, and it has a major oil company willing to finance it. Strem says the company’s initial estimates suggest the hydrogen can be extracted at competitive costs. An abundance of low-cost hydrogen could facilitate the transition of North America’s truck fleets from diesel to hydrogen fuel cells, and it would be a boon to Canada’s oil-and-gas producing provinces, which likely face declining demand for fossil fuels in coming decades.

BluWave-ai harnesses AI and immigration to lead the smart-grid transition

BluWave-ai is an example of the deeply technical innovation work where companies are using cutting-edge digital controls, advanced manufacturing techniques, supercomputing and artificial intelligence to achieve efficiency gains and create value on the grid.

The smart grid describes a power system that allows greater control and precision in electricity generation, transmission and end use than the traditional model. The market for smart grid technology was \$32 billion (U.S.) in 2017, and is expected to grow to \$70 billion in 2024, according to Delaware-based market research firm Global Markets Insight.

Other Canadian firms leading the smart grid transitions include Clir Renewables, a Vancouver-based software startup developing a cloud-based renewable energy asset management application, and Opus One Solutions, which helps grid operators analyze and manage supply and demand.

BlueWave-ai has customers across the world, including Hydro Ottawa; Dubai's electric utility; the city of Summerside, PEI; and Tata Power, which serves Mumbai.

The Ottawa-based startup brings together a variety of disciplines to produce its patent-pending software: power systems, networking, cloud computing, data storage, artificial intelligence and real-time optimization and controls.

The company closed a seed round of financing for \$3.4 million last year. BluWave-ai founder and CEO Devashish Paul expects to go back to the market for more financing in 2021 and to reach positive cash flow in about 18 months. The firm has grown consistently since its inception in 2017, even during the pandemic.

Immigrants play an important role in Canada's startup ecosystem, Paul said. The country's diverse and welcoming culture is a key advantage in the global competition for tech talent. MaRS surveyed 490 pure-play cleantech companies and 49 percent of them had at least one foreign-born founder.

Paul was born in Canada but spent several years in his parents' native India before returning to attend the Royal Military College of Canada and the University of Ottawa. After a 20-year international career in networking and supercomputing, he started BluWave-ai.

Of the 25 employees now working out of the company's Ottawa headquarters, Paul estimates that half are immigrants, including several recent arrivals. His foreign-born staff hail from China, Vietnam, India, Iran, the United Arab Emirates, France, Germany, Ukraine and Israel.

Immigrants from the developing world bring a particular sense of urgency to the cleantech imperative, according to Paul. They have often seen first-hand what happens when the environment takes a back seat to other priorities, and they know the value of creating wealth more sustainably.

"People who've lived in Canada their entire lives don't actually get how pristine our place is, and that more has to be done for the rest of the world," he says.



General Fusion

General Fusion's moonshot would turn energy on its head

Much of the cleantech sector revolves around improvements to existing energy technology production or consumption. Even the innovations directly threatening to displace fossil fuels – wind, solar, electric vehicles – mostly involve evolutionary transformation.

Commercial-scale fusion energy is one of the moonshots. Nuclear fusion has long been the dream of the technology world. Unlike nuclear fission reactors, where atoms are split, fusion welds atomic nuclei together. It produces no radioactive waste and is completely safe. And, like fission, it's carbon-free.

General Fusion, based in Burnaby, B.C., is in a race to prove commercial viability. Successful production at a competitive cost would result in massive disruption of the energy industry, for both electricity generators and fossil-fuel producers.

Fusion technology would be particularly attractive for use in the developing world, where governments are planning to dramatically expand energy production to meet the needs of their populations that aspire to middle-class lifestyles. In India, for example, energy consumption could grow 400 percent over the next 30 years, according to the IEA.

General Fusion believes it can be first to the finish line, although it faces competition from a host of private firms and a well-funded consortium known as ITER, which plans to build the first fusion research reactor in France.

Advances in superconductivity materials, digital controls and advanced manufacturing will make the fusion dream a 21st-century reality, General Fusion CEO Christofer Mowry says.

"The things that we need didn't exist" decades ago, when scientists first began experimenting with fusion technology, he says. "General Fusion is leading the race to commercialization. We have the most elegant solution out there and have been working on it the longest."

The firm is proceeding with construction of its first commercial-scale demonstration plant, which will take five years and \$135 million.

The company has already raised approximately \$200 million, including \$80 million from the federal government in Ottawa. The rest is from private investors, such as Amazon CEO Jeff Bezos and Microsoft Corp., and the sovereign wealth funds of countries such as Singapore and Malaysia.

Mowry says Ottawa has to be prepared to take a chance in providing major financing for such technologies. These investments come with a high degree of risk, but also giant rewards. That's especially true where the tech has the potential to solve urgent problems like climate change.

"Government has to be making bets on frontier firms that have a really good shot at bringing a disruptive technology to the market and changing the game. And that's where the heavy lift is required. It's not entirely up to government, but the continued partnership helps attract the private capital," he says.



Jennifer Wagner
President of CarbonCure

CarbonCure Technologies buries GHGs in stronger concrete

While many of Canada's cleantech companies aim to displace traditional technologies, others target industrial customers with products and services that reduce their environmental footprint.

Halifax-based CarbonCure Technologies supplies the concrete industry with technology that can cut costs, improve product strength and lower GHGs. It's a critical mission, as economists project that the total floor space of buildings worldwide will double over the next 40 years, with a resulting boom in demand for construction materials.

The market opportunity is massive. The top 10 cement and concrete companies around the world generated nearly \$120 billion (U.S.) in revenue in 2017, while the industry in Canada estimates that it contributes \$76 billion in direct and indirect activity.

Meanwhile, the built environment – that is, the floor space of buildings – is expected to double over the next 20 years, CarbonCure CEO Robert Niven said.

CarbonCure essentially injects carbon dioxide into the process of making concrete from cement. The CO₂ allows more cement to bind to other compounds, making stronger concrete while requiring less feedstock.

The company has seen its volumes double every year and now employs 55 people in Halifax and Vancouver. CEO Robert Niven says growth has accelerated even during the pandemic. CarbonCure now serves nearly 300 concrete plants across the world, a majority of which are in the United States.

Niven's goal is to divert 500 megatonnes of CO₂ over the next 10 years. That's an amount roughly equivalent to Britain's yearly emissions.

The company landed its largest investment yet in September, an undisclosed amount from Amazon's \$2-billion climate pledge fund. But Niven says there are two factors holding back his company from even greater growth: conservative procurement policies and regulatory inertia.

Construction industry standards are "slanted far too much toward regulating technology that was developed 50 years ago. And they're restricting anything new from happening," he says.

Climate-friendly procurement policies are crucial because government, with all its public works, is the largest single buyer of concrete. Some American states are implementing green procurement practices that award preference to low-carbon suppliers of concrete, steel and other materials. Ottawa is also working with the provinces to introduce better practices. But there is a long way to go.

Travis Butler, President of Butler Concrete & Aggregate Ltd., based in Victoria, B.C., was one of CarbonCure's first Canadian customers. The technology is now in use in three of the company's four plants on Vancouver Island.

Butler Concrete was recently judged to have the lowest GHG intensity of any concrete maker in North America, an award the CEO is proud of, but it hasn't translated into more sales yet. "We'd like to see that, but it's not often a big issue for developers or governments," he says. He hopes to capitalize if Ottawa and the provinces do introduce new procurement standards that provide incentives for lower-carbon suppliers.



Brandon Moffatt
Co-founder of StormFisher

StormFisher diverts landfill waste to generate renewables

StormFisher has no proprietary technology of its own, but it uses tech to develop and operate facilities that recycle food, waste and water in an environmentally benign, economically sustainable manner.

Its facility in London, Ont., is an anaerobic digester that takes in organic waste from municipal green-bin programs, restaurants and food processors. It uses the waste to generate electricity and renewable natural gas, as well as organic fertilizer.

The market is enormous as municipalities across Canada and indeed throughout the world look for ways to divert waste from landfills. The energy from organic waste generated in Toronto, for example, would be sufficient to provide heat and power for all city-owned buildings.

The waste-generating companies save money by delivering the organic material to StormFisher's plant, rather than paying tipping fees at a landfill site, says Brandon Moffatt, who is vice president for business development and a company founder.

While electricity has been the primary energy product, StormFisher is increasingly looking to sell renewable natural gas into the province's regulated distribution system in partnership with Enbridge Gas Distribution.

The methane emitted from aging landfills is 84 times more potent than CO₂ as a greenhouse gas, according to the U.S.-based Environmental Defense Fund. So Quebec, British Columbia and several American states have introduced mandates that force local utilities to purchase renewable gas from landfills and digesters. Ontario is developing a voluntary system.

Renewable gas is considerably more expensive than natural gas. But government mandates, carbon pricing and the looming federal Clean Fuel Standard will all drive utilities to demand more renewable natural gas, which in turn will create a market for additional projects, Moffatt says.

Enbridge sees StormFisher and other startups as important partners as it pursues its own renewable natural-gas opportunities. The company is taking a long view that aims to protect its investment in transmission and distribution pipelines that have many more decades of useful life.

"The more fossil fuel we can displace with renewable sources like renewable natural gas and hydrogen, the better we can manage our assets in the ground," says Rob Dysiewicz, Enbridge's manager for RNG business development.

A call to action

Cleantech entrepreneurs have identified key roadblocks for commercial success, but even in the most welcoming markets, some companies will fail. We need to increase the odds that Canadian startups with innovative technology and sound business plans make it across the “valley of death” between demonstration mode and commercial scale-up. Direct government support in the form of tax incentives, grants and loans is crucial, especially for the large “frontier” bets that come with high capital costs and long development timelines.

Governments at all levels should review regulations to ensure they don’t inhibit innovation. They can update procurement policies to give preference to environmentally responsible suppliers and to encourage small- and medium-sized businesses.

Banks and institutions can adhere to sustainable finance principles to ensure investors take full account of climate and other environmental risks and opportunities. And the corporate sector can be more nimble in seeking out innovative startups that offer solutions to their environmental challenges.

Executive summary

Canada's success in transitioning to a low-carbon future will depend on two related factors: the degree to which governments, businesses and households adopt clean technology, and the degree to which those cleantech goods and services are provided by Canadian companies.

Across the country, tech entrepreneurs are striving to bring innovative solutions from the laboratory and prototype stage to commercial reality, both at home and in export markets. With the right support, these companies will grow into economic powerhouses, generating good jobs and tax revenue for decades to come in Canada.

Employment in the environmental and clean technology sectors was 317,085 jobs in 2018, up 30 percent in a little over a decade, according to Statistics Canada. Tens of thousands more jobs were created by clean technology startups that are just moving into commercial operation. Responding to a MaRS survey, 369 cleantech venture firms reported employment of 17,265, an average of 47 people per firm.

The combination of the COVID-19 pandemic and ongoing concerns about the growing climate crisis makes 2020 a pivotal time for the cleantech sector. Governments around the world are ramping up stimulus packages to rescue their battered economies and collectively allocating trillions of dollars toward the low-carbon transition.

Canada is one of 72 countries that has committed to achieving net-zero greenhouse gas emissions by 2050. That effort will require a massive deployment of new technology to reduce the carbon footprint of existing activities and displace old industries with new low-carbon ones.

The sector is also export-oriented, as the global market for climate-change-related goods and services continues to grow. The global cleantech market is expected to hit \$2.5 trillion (U.S.) by 2022. Canadian exports for cleantech goods and services hit \$7 billion in 2018 and could nearly triple to \$20 billion by 2025, according to a 2018 report by a government advisory group.

The cleantech sector includes companies that work across the economy, providing goods and services that lower the environmental footprint of an existing activity or supplanting a more polluting process with a cleaner alternative. They deploy nanochemistry, advanced manufacturing, digital controls, artificial intelligence and more to enhance the productivity and lower the environmental footprint of energy and industrial systems.

We've already seen some remarkable successes as Canadian startup ventures move into the big leagues. They supply hydrogen-powered vehicles; they commercialize applications for modern power grids and electric vehicles; and they market technologies that allow companies to capture carbon dioxide and either sequester it or turn it into valuable products.

Still, the deployment of that technology could be dramatically accelerated with more supportive policy. Many cleantech companies rely on new processes or facilities that are capital intensive but create value by increasing efficiency, reducing environmental impact or reducing energy or water use. Those companies can face significant financial hurdles in finding their first customers and translating their innovations into profitability.

Venture capital investment, which funds earlier-stage cleantech development, has risen sharply, with Canadian venture investors allocating \$407 million to cleantech startups, compared to \$133 million five years ago. But that in turn is dwarfed by the venture capital invested in information, communications and telecommunications startups, which typically reach the market faster with lower capital costs.

Companies need government assistance to get across what is often described as the “valley of death” – the gap between pre-commercial product development and commercial sales.

One common theme that most cleantech entrepreneurs agree on is that governments could boost commercialization efforts through procurement programs. Innovation Economy Council research on fast-growing cleantech firms found that just three percent of their revenues came from procurement.

Ventures also need partners in incumbent industries to provide markets for their technology, while guiding them over real-world hurdles that may not appear in laboratory-based pilot projects.

Technology hubs can also provide important resources for these startups, including market analysis, connections to peers and industry mentors and, in some cases, financial support.



**INNOVATION
ECONOMY
COUNCIL**

innovationeconomyCouncil.com