Energy Efficiency: The “Made-in-Canada” Resource

Exploring the role of demand-side management in building a more self-reliant and resilient Canada

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Efficiency Canada

Carleton University

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Table of contents

Tables

Figures

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About Efficiency Canada

Efficiency Canada is the national voice for an energy-efficient economy. Our mission is to create a sustainable environment and a better life for all Canadians by making our country a global leader in energy efficiency policy, technology, and jobs. Efficiency Canada is housed at Carleton University's Sustainable Energy Research Centre, which is located on the traditional unceded territories of the Algonquin Nation.

The views expressed, as well as any errors or omissions, are the sole responsibility of the authors.

Executive summary

The Trump administration in the United States is disrupting decades of global economic relationships, and uncertainty abounds. Canada has a new impetus to reduce its economic dependence on the U.S. and increase national resilience by using domestic resources to meet our needs and/or diversify trading relationships. Every Canadian needs to consider the role they play.

Energy efficiency is a primarily "made-in-Canada" resource readily available to strengthen Canada's economic independence. Improving energy efficiency can reduce energy imports and free up domestic energy resources for more productive purposes. Saving energy means more dollars circulate in local economies. It can enhance economic resilience in uncertain times by making the best use of existing energy systems, equipment, and production facilities.

This report examines the supply chains and value chains of various energy efficiency products and services. It finds that energy efficiency solutions are supplied by Canadian companies, are often manufactured in Canada, and apply local expertise. Energy efficiency is also an area where Canadian innovations have created new companies and strengthened Canada's position in global value chains.

Energy efficiency strategies offer benefits in volatile environments because of their adaptability. Unlike power plants, pipelines, etc., with relatively fixed production inputs and processes, there are numerous ways to save energy. Programs can shift between residential, commercial, and industrial sectors and technologies like insulation, heat pumps, and software. Many production inputs are local, and imported components can often be sourced from flexible and competitive global markets. Some strategies, like retrocommissioning and strategic energy management, optimize existing energy systems with little to no material inputs. These strategies can immediately shield against a volatile international trade environment by enabling businesses to extend the life of existing equipment and prevent unplanned equipment replacements.

Different energy efficiency products and sub-categories have their own characteristics. Table 1 outlines different dimensions of Canadian involvement. The first column shows which energy efficiency products or services can be supplied by Canadian-owned companies or companies with significant Canadian senior leadership and offices located in Canada.[1] The second and third columns list products manufactured or assembled in Canada and indicate if key production inputs are sourced within Canada. We also include evidence of Canadian-led innovation and/or ownership of intellectual property, which strengthens Canada's position within global value chains.[2]

[1] An example of the latter is BrainboxAI or Ecobee. Both companies are Canadian start-ups acquired by foreign-owned companies, but maintain senior leadership and offices within Canada. We should note that all categories include an ability to purchase products or services from Canadian-owned companies.

[2] These patterns should be understood as stylized facts that describe the predominant nature of production, and might exclude exceptional cases. For example, the report details discuss examples of residential heat pump assembly within Canada. Given that all industries are continuously involved in forms of innovation, we restricted the table to areas where we found evidence of Canadian owned intellectual property, invention, or Canadian company led commercialization of a product.

Product or solution	Canadian content			
	Canadian companies	Manufacturing or assembly	Production inputs	Innovation / intellectual property
Retrocommissioning and Strategic Energy Management	●	N/A	N/A	●
Cellulose insulation	●	●	●	○
Fibreglass and mineral wool insulation		●	●	
Expanded polystyrene insulation	●	●	●	●
Spray foam insulation	●	●		
Air barriers	◒	◒	◒	○
HRV/ERVs	●	●	◒	●
Windows	●	●		○
Residential heat pumps	●			●
Residential water heating and management	◒	◒		●
Industrial, commercial, and institutional energy efficiency	●	●	◒	●
Smart thermostats	●			●
● Significant ◒ Less common ○ Significant potential				

Table 1. Dimensions of Canadian involvement in sales, production, and innovation

Almost all production processes involve some degree of global trade. Table 2 provides a qualitative description of important trading relationships. This includes international relationships, potential options for trade diversification, and key components or products imported from the U.S. or exported to the U.S. from Canada. Some components for spray foam insulation and windows currently depend on American imports, yet options for trade diversification or local manufacture exist. Canadian companies selling Heat/Energy Recovery Ventilators, windows, and smart thermostats could be negatively impacted by restricted access to U.S. markets.

Areas like residential heat pumps and industrial, commercial, and institutional energy efficiency are part of complex global production networks where components and products are sourced internationally. Yet, they also require the application of Canadian engineering and technical expertise.

Energy efficiency solution or product	International trading relationship/options	U.S. import	U.S. export
Retrocommissioning and strategic energy management	International companies with Canadian offices.		
Insulation	Borate flame retardant imported from Turkey. Options to purchase spray foam insulation MDI feedstock from China and equipment from Europe or Asia.	Spray foam insulation components (MDI & blowing agent) and equipment primarily sourced from the U.S.	
Air barriers	High-performance air and water barriers commonly sourced from Europe.	Common house wrap products manufactured in the U.S. using proprietary process.	
Heat/Energy Recovery Ventilators (HRV/ERV)	Import components, such as polyethylene cores (China) and high-efficiency motors (Germany).		U.S. market is significant for some companies.
Windows	Some high-performance products and processes imported from Europe (e.g. recycled PVC).	No domestic manufacturing of float glass, and 90% of imports from the U.S..	Trade surplus with the U.S. in plastic windows/doors, with almost all exports going to the U.S. Passive House-certified products serve parts of the U.S. market.
Residential heat pumps	A global production system with components sourced internationally. Chinese large-scale	38% of Canadian air-to-air heat pumps were imported from the U.S. in 2023.	

	manufacturing dominant in air-to-air heat pumps vs. a stronger U.S. position in fossil fuel heating.		
Residential water heating and management	Manufacturing of electric and heat pump hot water heaters for the North American market is prominent in Mexico and emerging in China.	AO Smith, Bradford White, and Rheem are major American electric and heat pump hot water heater manufacturers.	
Industrial, Commercial, and Institutional (ICI) energy efficiency	Equipment sourced from diverse global supply chains. Canadian engineering expertise increases the potential to navigate around trade and supply chain disruptions.		ICI scale refrigeration equipment manufacturers, heat pumps and HRVs have significant exports to the U.S. market.
Smart thermostats	Ecobee, Mysa, and others are Canadian-designed smart thermostats that compete with major global players. These products are manufactured in Asia.		91% of Canadian thermostats are exported to the U.S..

Table 2. Trade relationships

Each sub-category explored presented further opportunities to increase Canadian self-reliance and/or economic resilience by expanding local inputs, diversifying trade, promoting innovation, or developing policies that capture more energy savings. Table 3 summarizes some of the suggested strategies outlined in the report.

Energy efficiency solution or product	Strategies
All products and services	● Use existing policy tools related to new and existing buildings, products, and utilities to amplify and coordinate demand for energy efficiency. ● Expand and nationally coordinate the Deep Retrofit Accelerator Initiative and Greener Neighbourhood Pilot Program to build Canadian supply chains.
Retrocommissioning and strategic energy management	● Support operational energy savings by verifying energy efficiency programs with pay-for-performance and other outcome-based evaluation methods
Insulation	● Increase local inputs by increasing recycling rates of materials used for insulation (paper/cardboard, plastics, glass, styrofoam, industrial wastes) ● Increase local inputs and innovation in natural insulation materials (e.g. agricultural and forestry by-products)
Air barriers	● Diversify trade and use local companies by encouraging the use of high-performance air barriers over standard American-based products
HRVs/ERVs	● Innovate in heat and energy recovery ventilation performance in cold climates, building on a history of Canadian invention.
Windows	● Increase local inputs by recycling PVC window frames ● Increase local inputs by attracting float glass manufacturing powered by renewable energy and energy efficiency ● Innovate by designing window and door performance for Canada's cold climates
Residential heat pumps	● Diversify trading relationships by moving from American-dominated fossil fuel heating systems to heat pumps ● Increase resilience and power in global value chains through coordinated and large-scale bulk purchasing of heat pumps ● Diversify trade and promote Canadian innovation by aligning with international standards in areas like low-carbon refrigerants
Residential water heating and management	● Develop expedited Canadian timelines for minimum efficiency standards that recognize domestic benefits of energy savings and demand flexibility.

Industrial, Commercial, and Institutional energy efficiency	● Support innovation-oriented companies in Canada by aligning with high-efficiency standards in areas like electric motors and pumps ● Continue providing patient capital in support of building retrofits through the Canada Infrastructure Bank
Smart thermostats	● Support Canadian smart thermostat companies threatened with decreased American demand by increasing domestic energy efficiency and peak demand reduction goals

Table 3. Strategies to increase self-reliance and resilience

Consumers who started buying “made-in-Canada” products intuitively understood that increasing domestic demand would support the nation’s strength and independence. As stated above, improving energy efficiency increases Canada’s self-reliance. By better coordinating energy efficiency demands, we can also build stronger domestic supply chains and increase Canada’s strength in global value chains. When energy efficiency solution providers see that a long-term, large-scale market exists, they can coordinate to increase local production and innovation within Canada.

Canada’s existing policies and programs already have structures that can better coordinate energy efficiency demands to build stronger Canadian supply chains. This includes clear demand signals sent by adopting high-performance building codes, energy efficiency product standards, and long-term utility demand-side management programs.

Most prominently are the “market development teams”, created through the Retrofit Accelerator Initiatives and Greener Neighbourhood Pilot Project. The original vision of these initiatives involved aggregating energy efficiency retrofits to spur supply-side transformations, such as process improvements, pre-fabricated construction, and new business models. The coordination of energy efficiency demands can further support Canadian energy efficiency solution providers and facilitate the implementation of the strategies to increase further self-reliance identified in this report. Thus, these market development team programs should be expanded and coordinated nationally to deliver on a mission to use Canadian resources to achieve transformative energy efficiency performance in existing buildings.

Energy efficiency is often called the “first fuel” because it should be the primary focus in energy planning and policy before considering energy supply. It is also a “made-in-

Canada” fuel, readily available to help our nation navigate its new economic environment.

Introduction

In response to the current President of the United States' disruption of trade patterns and threats to Canada's sovereignty, Canadians are looking to buy "made-in-Canada" products. Governments are developing strategies to strengthen the domestic economy, increase resilience, and diversify trade relationships. This report looks at the role of energy efficiency in responding to this national challenge.

Energy efficiency is a strategy for using less energy to achieve the same or better service. Using less energy is a "made-in-Canada" resource because it involves taking actions domestically to reduce the need for energy supply options that could involve importing fuels and materials. It frees up domestic energy resources to be used for better purposes. It is an energy resource that all regions of our country have available to them.

This report explores how energy efficiency can increase Canadian self-reliance and resilience. We start by discussing macro-level impacts of energy efficiency on the economy and the inherent adaptability of energy efficiency program portfolios. These portfolios include several ways to find energy savings that require little to no physical inputs, which increases resilience and protection in the face of economic uncertainty.

We then explore the supply chains and value chains of a subset of products used to improve energy efficiency. We identify if they are already produced in Canada, if there are opportunities to expand local production, diversify trade, or increase Canada's strength within international value chains. Throughout the document, we highlight opportunities and conclude with an overarching policy recommendation to scale up and coordinate energy efficiency demands to build up Canadian supply chains and support a stronger Canadian position within global production networks.

We explored this issue by populating an internal database of energy efficiency companies located in Canada, reviewing relevant industry literature on production processes and business dynamics, and conducting informal interviews with energy efficiency business representatives and sector experts.

This is a preliminary review that we are publishing to contribute to an urgent Canadian discussion. We know there are several more energy efficiency-related products and subsectors we could have explored, and a diversity of energy efficiency-related businesses we have missed. We see value in further research and present this report to share information and spur discussion.

Energy efficiency as a "made-in-Canada" resource

Canada is a major energy exporter, yet we still import to meet our energy needs.[3] Reducing energy demand reduces the need for fuel imports. Efficiency also frees up domestic energy resources that can be more productively used to strengthen the domestic economy. Energy savings also enable us to capture more value from energy exports, which can increase leverage in trade negotiations. For example, a 2018 Energy Efficiency Potential study by the International Energy Agency estimated that improved energy efficiency would increase Canada's oil and gas trade balance by $70 billion USD in 2050 (assuming a constant production baseline). Energy savings would increase the ability to capture more value through exports, without the need to increase production.[4]

Energy efficiency's benefits reverberate across the economy. This upshot was demonstrated in a 2018 economic impact model by Dunsky Energy Consulting. The report showed energy efficiency implementation created an initial boost for the construction, retail and wholesale trade, and professional services sectors. Then, as energy efficiency freed up dollars to reinvest, 75-85 per cent of the total increase in jobs and GDP occurred across the economy in sectors such as manufacturing, food and accommodation, and transportation. There is a drop in energy sales that negatively impacts the utility sector, but the positive impact in all other domestic sectors was far greater, with a net $4 GDP increase for every $1 spent on energy efficiency.[5]

Energy efficiency is called the "first fuel" because it should be the primary focus in energy planning and policy before considering energy generation.[6] These results from scenarios of a more energy-efficient future also suggest it is largely a "made-in-Canada" fuel that uses domestic resources to either reduce energy imports or to enable the

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[3] All of Canada's natural gas and electricity imports, and 80% of refined petroleum product imports came from the US in 2023. 96% of metallurgical coal and 51% of thermal coal imports were from the US in 2022.

[4] Haley, "Study Shows Canada's Efficiency Resource Potential."

[5] Dunsky Energy Consulting. "The Economic Impact of Pan Improved Energy Efficiency in Canada: Employment and Other Outcomes from the Pan-Canadian Framework's Energy Efficiency Measures.," April 3, 2018.

[6] Whiting, "Energy Efficiency Is the World's 'first Fuel' - and the Main Route to Net Zero, Says IEA Chief."

Canadian economy to capture more value from energy production. This policy brief delves further into this “made-in-Canada” characteristic.

A resilient mix of solutions

There are many ways to save energy, and energy efficiency has a very adaptable production process. In contrast, power plants, transmission lines, and pipelines have relatively fixed production inputs and processes.[7]

Energy supply has fixed needs for materials like cement, steel, plastic, copper, etc. Energy efficiency can pivot across programs focused on residential, commercial, or industrial sectors, using different technologies (e.g., heat pumps, insulation, software), and strategies (e.g., system optimization, equipment upgrades).

This adaptability is beneficial in an uncertain market environment, created as the Trump administration disrupts traditional trade relationships. In such an environment, businesses could lose export markets, and people and businesses could witness price increases for some imported goods, or decreases as goods previously bound for the U.S. market are placed on global markets. Supply chain bottlenecks and shortages are also a possibility, and the risk of locking into long-term contracts or fixed supply chain relationships increases. An energy efficiency strategy can adapt to these changing market conditions better than energy production options.

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[7] For example, there is a global transformer supply bottleneck
Trabish, “Transformer Supply Bottleneck Threatens Power System Stability as Load Grows | Utility Dive.”

Opportunities to benefit from energy efficiency's adaptability

- Policies can support adaptive energy efficiency strategies by supporting programs, or portfolios of programs, that enable administrators to use multiple solutions. For example, a new Canada Greener Homes Affordability Program supports a larger variety of efficiency improvements, such as insulation and air sealing, compared to previous low-income targeted federal efficiency programs.
- Utility regulators that oversee demand-side management programs should recognize the risk-reducing benefits of energy efficiency due to its adaptability in changing market environments. This could include recognizing the risk of becoming locked into supply-side resources that could experience cost increases and/or material shortages. Regulators can value energy efficiency's risk-reducing characteristic by lowering the discount rate used in program cost-effectiveness evaluations[8] and by fully assessing the risks created by more rigid supply-side resource production systems.

Making better use of what we have

One way to increase self-reliance is to make the best use of capital investments already made. Canada has materials and equipment within its borders that might have been previously imported or produced at home. Making the best use of these physical assets can reduce Canada's future dependence on international markets.

In a volatile market environment, an emergency replacement of a piece of equipment or production system creates a significant risk to a business. Imported goods and materials could be tariffed as they cross borders. Decision makers are therefore likely to favour measures that can extend the life and productivity of existing production systems. Given this context, it is important to highlight energy efficiency strategies that focus on optimizing existing systems with little to no material inputs. These strategies often gain insights from data and analyze how to improve the efficiency and extend the life of existing equipment.

[8] A lower discount rate recognizes increased certainty of achieving future benefits.

One example is retrocommissioning. These programs provide a “tune-up” for large equipment and systems in existing buildings through low-cost or no-cost operational changes. It can optimize systems by aligning the operation of equipment with occupancy or actual service needs and prevent wasteful practices like simultaneous heating and cooling. Natural Resources Canada suggests energy savings are typically five to 20 per cent.[9] This service is provided by third-party firms and often involves site visits. Canadian firms owned and/or located in Canada that provide these services include Prism Engineering, WSP Canada, Enerva, Econoler, Ambioner, Nerva Energy, and FRESCo Building Efficiency.

Advanced metering infrastructure and increased computing power now make it possible to optimize and scale data-driven energy savings. For instance, Power TakeOff is a company that started in Waterloo, Ontario that uses patented technology to analyze a utility’s entire network of smart meter data to offer a virtual commissioning service. Brainbox AI is a Montreal-based company that uses patented artificial intelligence technology to continuously optimize HVAC systems.[10]

Another data and operations-focused approach is strategic energy management. This is an ongoing process to achieve energy savings in industrial processes and large buildings through behavioural and operational changes, often through gathering insights from operational data and employee engagement.[11] It is part of a systemic approach to energy management with the potential for certification under standards such as ISO 50001. Savings can range from 10-20 per cent in five years.[12] These services are provided by international companies with Canadian locations (e.g. Schneider Electric, Siemens Energy), Canadian-owned companies (e.g. Edgecom Energy, Akonovia, CGI, BBA, Econoler), or they can be implemented by a company itself with in-house data analytics expertise.

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[9] Government of Canada, “Existing Building Commissioning (EBCx).”

[10] PowerTakeOff is headquartered in the U.S. with senior leadership in Canada and Brainbox AI was acquired by Dublin-based Trane, with Brainbox office headquarters remaining in Montreal.

[11] Gaede and Haley, “A Policy System for Continuous Improvement: Strategies to Bolster Industrial Energy Management Practices and Outcomes in Canada.”

[12] Institute for Industrial Productivity and International Energy Agency, “Energy Management Programmes for Industry: Gaining through Saving.”

Opportunities to optimize existing energy systems

- Federal programs that support energy management include the 50001 Ready Canada Program, ENERGY STAR for Industry, and the Green Industrial Facilities and Manufacturing Program. These could be integrated into a longer-term industrial energy efficiency goal, with sector networks.[13]
- Regulators of demand-side management programs should recognize energy savings from process improvements as much as savings from hard infrastructure or equipment replacements. This could be supported through pay-for-performance approaches and basing performance on gross energy savings.

Intellectual property and Canadian resilience

Tariffs on the trade of physical goods are not the only way nations exert power in international markets. The ownership of intellectual property in the form of patents, copyright, and data can play an important role in the success of Canadian companies and the ability to use products and services within Canada.[14] The U.S. is particularly active in creating and protecting intellectual property and has significant monopoly power over knowledge products and services.[15]

Canadian ownership of IP allows start-ups to compete with larger players. It also enables Canadian companies to negotiate fair business partnerships and can prevent foreign companies from restricting access to services due to IP infringement.

Intellectual property is likely to play a significant role in algorithms used in demand-side energy resources that use large utility-scale data to identify energy-saving opportunities or to support demand response and virtual power plants. These are data-based "intangible" products. In the sections below, we discuss examples of physical products such as air barriers, heat exchangers, heat recovery ventilators, and industrial-scale

[13] International Energy Agency, "Energy Technology Patents Data Explorer – Data Tools."

[14] For a discussion see Balsillie, "Jim Balsillie: An Outdated Myth about Business Investment Is Hurting the Canadian Economy."
Pagano, "The Crisis of Intellectual Monopoly Capitalism."

[15] Hausmann, "Trump's War on the Dark Matter That Powers America."

pumps that are patented. There are also combinations of different technologies or new processes that Canadian companies have patented, as well as situations where foreign ownership of intellectual property obliges Canadians to import from elsewhere.

Canada’s largest number of clean energy patents is in industrial energy efficiency or substitution (19 per cent of total patents), and the 4th largest number of patents is in building energy efficiency (12 per cent of total).[16] Canada’s global rank in the number of patents in these two respective areas is 12th or 11th. Countries with smaller economies and populations that outrank Canada in these areas include Sweden, Finland, Taiwan, and Austria. China, the U.S., and Japan are the top three countries in the total number of patents in these categories.

What role IP plays in Canadian energy efficiency business success and Canada's ability to deploy solutions could be a fruitful topic for further research.

[16] This is the total patent count from 2000-2023 using downloaded data from the International Energy Agency, “Energy Technology Patents Data Explorer – Data Tools.” This includes patents protected by at least two intellectual property offices, with fractional counting when the residence of inventors are from different countries. There are also agriculture energy efficiency and other energy efficiency categories, which make up 2.3% and 0.9% of Canada’s patents. Netherlands, Taiwan, and Spain are countries with smaller populations and GDP than Canada with higher patent counts in the agricultural energy efficiency category.

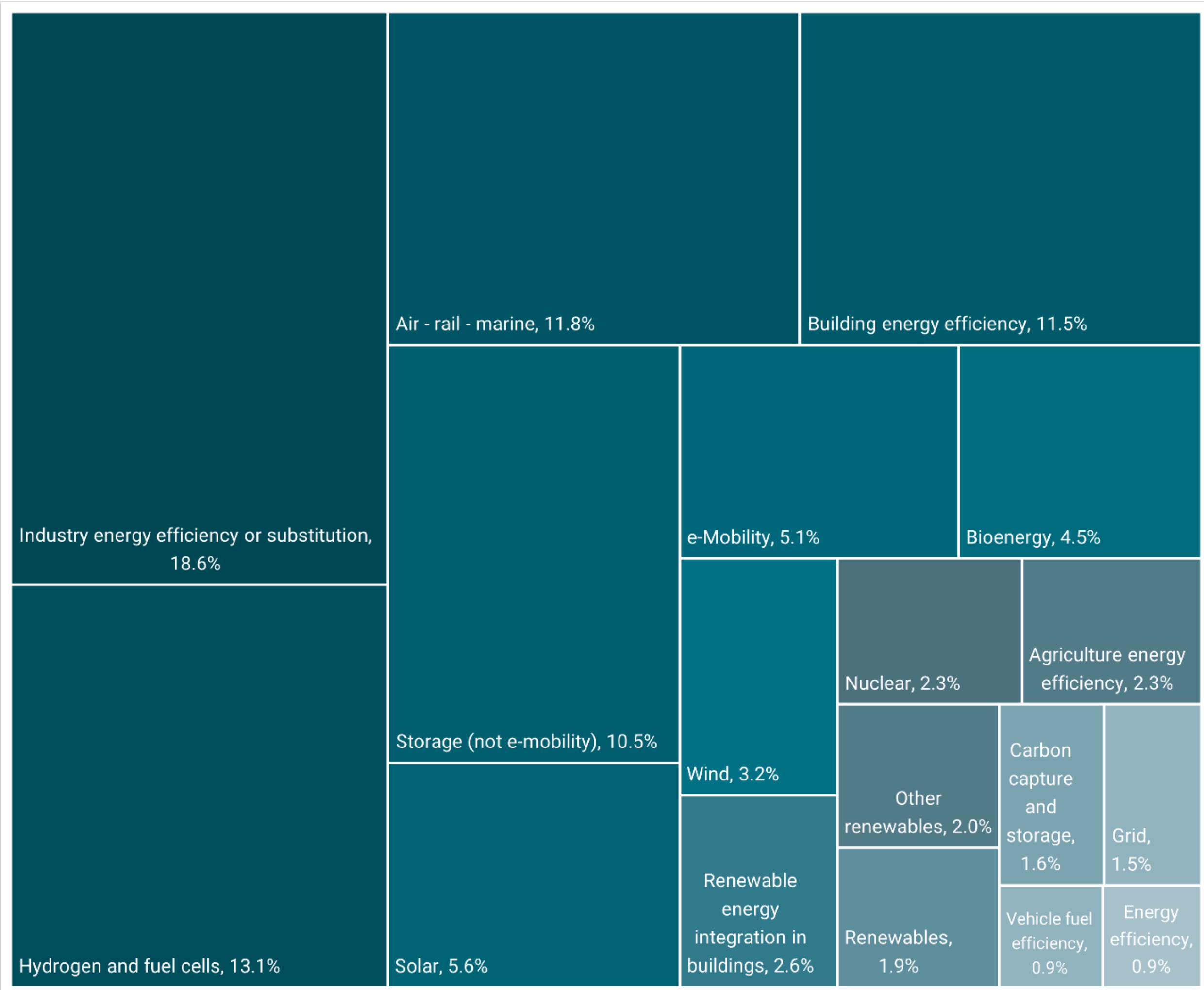

Figure 1. Canadian Clean Energy Patents (2000-2023)

Energy efficiency products and services

As discussed above, several energy efficiency strategies require little to no material inputs and are thus quite resilient to international trade volatility. However, many other energy efficiency improvement strategies use physical materials and equipment. In the following section, we explore some relevant energy efficiency supply chains and value chains of these products. Supply chains refer to the resources used as a product moves from supplier to customer. At times, we discuss “value chains”, which describe how a product or service is made more useful or economically competitive at stages ranging from design, production, marketing, delivery, and support, and how actors capture economic benefits for themselves along these stages.

We selected a few common and representative energy efficiency-related products to explore. We recognize this as a sample. There are many more energy efficiency products we could have explored. The discussion above highlights that energy efficiency strategies are adaptable due to the large number of potential products that efficiency solution providers could use and the continuous growth of energy efficiency-related technologies and products. This makes energy efficiency more adaptive and resilient. Of course, this also means we cannot explore all relevant products in this short report.

Insulation

Insulation resists heat transfer outside buildings, pipes, storage systems, and other places where we want to keep temperatures warmer or cooler than the external environment. Energy efficiency experts can choose from several types of insulation.

A lot of insulation comes from ubiquitous materials sourced from recycling streams. As a cold country, Canada requires a lot of insulation, and it makes sense to manufacture relatively close to demand centres to reduce transportation needs for a low-weight, high-volume product. These characteristics mean that Canada manufactures a lot of insulation within its borders.

Cellulose insulation

Cellulose insulation is mainly made from post-consumer recycled cardboard and newsprint. These materials are treated for fire, pest, and mould resistance, usually with a borate compound, which constitutes about 15 per cent of the weight of the insulation product. Borate combines oxygen with a naturally occurring element called boron. The U.S. (California) and Turkey are the leading global suppliers. In 2023, Turkey supplied 67 per cent of Canada's imports (measured by dollar value), and the U.S. provided 27 per cent.[17]

Canadian manufacturers of cellulose insulation have locations in Québec, Alberta, Manitoba, Nova Scotia, and Ontario (e.g. Soprema, Greenfiber, North Star Fibre, Climatizer Insulation, Igloo Cellulose, and Therm-O-Comfort). In addition, much of the

[17] Observatory of Economic Complexity, "Boron."

equipment used in manufacturing and packaging is developed within Canada by Premier Tech (headquartered in Rivière-du-Loup).

Other bio-based materials are made from agricultural by-products such as stalks, seeds, and straw, along with wood fibre, hemp, seaweed, and mycelia (the root of mushrooms). These forms of insulation sequester carbon over the lifespan of the building and thus help make buildings a form of carbon capture and storage.[18] For example, Natural Fibres is a Val-des-Source, Québec-based company creating hemp and wood-fibre-based insulation. This presents an intriguing opportunity given Canadian expertise in agriculture, forestry, and building science. Integrating dense-pack cellulose insulation within pre-fabricated panels can ensure strong performance by ensuring proper coverage and design for weather resistance and airtightness.

Fibreglass

Fibreglass is a common type of insulation made from fine glass fibres, along with other materials such as silica sand, limestone and the above-mentioned borate. The glass can come from recycled bottles, window panes, etc. The sustainability plans of manufacturers include increasing recycled content and reducing the use of raw materials, e.g., sand, which also reduces the energy intensity of the production process because glass melts at lower temperatures. Owens Corning reported in 2023 that their Canadian-made products include up to 68 per cent recycled content.[19]

This type of insulation is produced by global manufacturers such as Johns Manville, Owens Corning, and CertainTeed. These three U.S.-headquartered companies have at least 12 insulation-related manufacturing facilities in Canada. They are located in Canada due to stronger local demand, cold climates, and building performance requirements.

Mineral wool

This is a type of insulation made from common natural materials like basalt (rock wool) or from a byproduct of steel production or other industrial wastes (slag wool).

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[18] King and Magwood, *Build Beyond Zero: New Ideas for Carbon-Smart Architecture*.
Grazieschi, Asdrubali, and Thomas, “Embodied Energy and Carbon of Building Insulating Materials.”
[19] Owens Corning, “Making the Difference: 2023 Owens Corning Sustainability Report.”

Rockwool is a Danish-headquartered global manufacturer. Its first North American production facility was opened in Milton, Ontario, in 1988, and a regional headquarters opened in 2014.[20] It opened a second manufacturing facility in Grand Fork, British Columbia, in 1999 to service the West Coast.[21] This means two out of three of the company's North American manufacturing facilities are in Canada.

Expanded polystyrene

Expanded polystyrene (EPS) is a fossil-fuel-based styrofoam. It is used in packaging because it is lightweight, rigid, and can be shaped in various forms. Because of its thermal and water resistance, it is also used as an insulator in things like coffee cups and building insulation. In buildings, the lighter weight puts less load on the structure and avoids the need for bigger framing and foundations.

EPS is a plastics product, produced with by-products from oil refining and ethylene production. Polystyrene beads are expanded to trap air inside the material, usually by using pentane as a blowing agent (also an oil refining by-product).[22]

This product is manufactured in numerous locations in Canada by businesses like AMC Foam (Manitoba), Forte EPS Solutions (Alberta), and NexKemia (Québec). The petrochemical by-products used in production are all produced in Canada.

The materials needed could increasingly come from recycling, improving sustainability and the use of local resources. For example, NexKemia markets a product with 30 per cent recycled content,[23] and Polystyvert in Montreal developed a dissolution process to recycle several types of polystyrene.[24]

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[20] ROCKWOOL, "ROCKWOOL Milton - Community Page."

[21] ROCKWOOL, "ROCKWOOL Grand Forks, BC - Community Page."

[22] Closely related is Extruded Polystyrene (XPS), which is made by extruding molten polystyrene. XPS has higher moisture resistance and R-value, is available in standard panel sizes and less simple to mold into different shapes, and tends to have higher carbon emissions in its production.

[23] NexKemia, "Sustainable Expandable Polystyrene Foam (EPS) Resins with Recycled Content."

[24] Polystyvert, "Technology: Polystyren Recycling."

Spray foam

Spray foam is a mixture of two chemicals (an isocyanate and polyol resin) that react by expanding and solidifying when applied together. It is applied using proportioners, spray guns, and transfer pumps.

Methylene diphenyl diisocyanate (MDI) is the isocyanate used for spray foam and various polyurethane products. It is derived from petroleum and natural gas processing, with production dominated by global companies: Huntsman Corporation (U.S.), BASF (Germany), and Wanhua Chemical (China). Most Canadian feedstock likely comes from Texas oil and gas refining operations.

The industry is working to reduce this product's embodied carbon. It is possible to use blowing agents in the resin with a lower global warming potential (GWP), and Canadian regulations are phasing down the use of high-GWP options. Most blenders in Canada use Honeywell's Solstice® Liquid Blowing Agent technology because it meets evolving Canadian standards for GWP. It is only made in the U.S..

The resin can be made from recycled plastic bottles. Elastochem is a Canadian company that reports diverting over 200 million plastic bottles a year.[25] Soprema, a French multinational company with its North American headquarters in Drummondville, Québec, is building a plant to produce resin from recycled materials.[26]

The equipment used to apply spray foam is dominated by two U.S. manufacturers (Graco and PMC brands). Equipment is also made in Europe and China. To sell in Canada, they would need to be certified by Canadian safety standards.

The blending of resin, final manufacturing, and sale of spray foam (and related equipment) occurs in Canada, due to high demand for the product in northern climates. Companies include Elastochem (Brantford, Ontario), Soprema (French-owned, with North American head office in Drummondville, Québec), Grizzly Gold (Waterloo, Ontario), Genyk (Shawinigan, Québec), and BASF Canada (A German multinational with Canadian headquarters in Mississauga with 1,200 employees across Canada). Equipment suppliers are located across Canada, for example, Bolair Fluid Handling

[25] Elastochem Specialty Chemicals, "Insulthane® Extreme Turns Plastic Waste into Energy Efficient Insulation."

[26] Government of Canada, "Government of Canada Supports SOPREMA in Opening New Ecofriendly Plant in Drummondville."

Systems and Canadian Urethane Spray Equipment in Ontario, Polysource and Pinnacle West in British Columbia, and MultiFIX in Québec.

Insulation opportunities

- Facilitating higher recycling rates would increase insulation's environmental performance while further localizing the production process. Recycling paper/cardboard, plastics, glass, styrofoam, and industrial waste creates circular economy opportunities.

- Explore the potential for a Canadian industrial strategy to produce natural building products that have low-embodied carbon or sequester carbon, including insulation from agricultural and forestry by-products. This could be combined with the prefabrication of walls and roofs and modular building techniques to achieve high-performance building envelopes.

Air sealing

Energy-efficient buildings minimize air leakage, which prevents heat loss in the winter and heat gain in the summer. When combined with ventilation (see below), airtightness improves indoor air quality by controlling moisture and blocking pollutants and allergens from entering buildings.

Airtightness is typically measured with a blower door, which pressurizes and depressurizes buildings. The invention of this technology can be traced back to National Research Council experiments in the late 1960s and the construction of the Saskatchewan Conservation House in 1977.[27]

Synthetic membranes wrapped around a building can create an air barrier layer. This layer can be mechanically fastened (with staples and tape) or self-adhering (such as peel and stick or liquid rolled on). Builders aiming to achieve high levels of airtightness and durability may prefer products sold as a complete system (membrane + fastening) with system warranties. Tyvek is a commonly used mechanically fastened house wrap made by U.S.-based DuPont through a proprietary process that heats and compresses

[27] See Tamura, "Measurement of Air Leakage Characteristics of House Enclosures."
Orr and Figley, "An Exhaust Fan Apparatus for Assessing the Air Leakage Characteristics of Houses."

high-density spun polyethylene fibres. They have two large factories located in Virginia and Luxembourg, ship globally, and often sell under other proprietary names, such as Home Hardware or Rona. Typar is another common brand that is also made in the U.S. Housewraps made in Canada include BP Air-Lock and Air-Gard, made by Fabrene Inc. (North Bay, Ontario) and distributed by Building Products of Canada (Québec)[28] and Novawrap by Tuck/Intertape Polymer Group (Truro, Nova Scotia). EPAK HouseGuard is a Canadian company that manufactures its product in Korea and/or Canada.

Self-adhering wraps may be used on commercial-scale buildings that require a more durable product due to prolonged exposure to the elements before cladding, retrofits where taping may be challenging, and/or applications where high levels of airtightness are required. Self-adhering products can cost more, but are more resistant to tearing and damage, and they have the ability to self-seal punctures from nails, all contributing to greater ease in achieving airtightness. Bitumen peel and stick, vapour impermeable air barrier systems are made in Canada by Henry Company (U.S. owned, made in Petrolia, Ontario) and Soprema (made in Drummondville, Québec or Woodstock, Ontario). Acrylic and butyl adhesive, as well as vapour permeable wraps, are more costly than bitumen but can be easier to work with, are more UV resistant, and tolerate a wider temperature range for installation. These high-performance air and water barriers are primarily sourced internationally from companies such as Dorken/Delta and Proclima in Germany or SIGA in Switzerland, with proprietary technology, capital investment in advanced production processes and a reputation for making high-quality, durable, highly air-tight products.

Many of these manufacturers also produce complementary adhesive tapes to seal mechanical house wrap. Tuck brand is made in Nova Scotia, a generic sheathing tape that is well known by most builders for taping indoor air/vapour barriers and outdoor housing wraps. Air barriers can also be achieved indoors through polyethylene vapour barriers, smart vapour barriers, pressurized aerosols (Aerobarrier) and even drywall with paint. Sheathing-type, rigid air barriers, such as a membrane or coating applied to gypsum board, and fluid-applied air barriers, are further variations. Unfortunately, the investigation of the full suite of air barriers was beyond the capacity of this project.

Our initial look finds that there are both Canadian and international options for achieving airtightness performance in buildings. Moving from standardized “house

[28] Government of Canada, “[CCMC 13294-R] CCMC Canadian Code Compliance Evaluation.”

wrap" towards higher-performance air and water barriers could present an opportunity for trade diversification and/or increased use of Canadian-made products.

Air sealing opportunities

- Building codes and existing building performance standards that include mandatory airtightness testing and high air sealing performance requirements may increase the use of high-performance air barriers that are either made in Canada or frequently sourced from Europe. If projects use standard American-sourced air and weather barriers, improved performance requirements may require the use of Canadian-manufactured tape and trained Canadian labour for detailed taping or assembly of pre-fabricated wall systems.
- Programs like the Local Energy Efficiency Partnerships, which link builders and renovators with manufacturers through technology forums and technology trials, could be leveraged to support the Canadian development of high-performance air barriers.

Heat/Energy Recovery Ventilation

Heat Recovery Ventilators (HRVs) and Energy Recovery Ventilators (ERVs) are mechanical systems that bring fresh air into a building and preheat it with heat extracted from the stale air being exhausted. An HRV transfers heat between air streams, while an ERV also maintains interior humidity. These systems enable constant ventilation and air filtration in airtight buildings while wasting less energy.

The technology consists of a heat or energy exchange core made from aluminum, plastic, or paper housed within a cabinet, with filters, motors, and dampers. Units can also include defrosting systems and specialized control systems. In northern climates, it is important that the core can avoid frost build-up, which can be accomplished with larger channels, special membranes,[29] and pre-heaters. The National Research Council tested a dual-core technology for arctic performance.[30] Specific designs may include variable speed, energy-efficient motors, controls, and motorized dampers that can

[29] Rafatinasr, "Frosting in Membrane Energy Exchangers."
[30] National Research Council, "Air Ventilation Systems for Arctic Housing."

optimize the fan use for ventilation needs and adjust to changes in occupancy and humidity.

Canadian companies can have proprietary technologies for core design and system controls. They include Oxygen8 in Vancouver, British Columbia; Reversomatic, with facilities in the Greater Toronto Area; and Nu-Air in Windsor, Nova Scotia. There are several more residential/commercial HRV and ERV companies that assemble in Canada (refer to ICI section for larger units). These include Aldes (a subsidiary of Aldes Group in France) assembling in Saint-Léonard-d'Aston, Québec. Broan-Nu Tone / Venmar (U.S. owned) assembles Drummondville, Québec ; LifeBreath in London, Ontario (acquired by Swiss owned Zehnder); Fantech in Bouctouche, New Brunswick (acquired by Swedish owned System Air).

A significant amount of design and assembly is domestically based due to the history of their invention and requirements for the product in Canadian building codes designed for cold climates. The technology behind HRVs/ERVs has roots in Canada.[31] For example, the vänEE product evolved from Dirk vänEE and Rick Olmstead's involvement in the 1970s Conservation House project in Saskatchewan.[32] Heat exchange cores are likely being designed in Canada, with potential use of offshore manufacturing for polyethylene cores, and supply of high-efficiency motors from high-quality engineering locations like Germany. The final assembly of the HRV/ERV units is likely to occur in Canada due to the need for commercial customization or the diseconomies involved in shipping a product with a lot of empty space.

[31] Huck, "'Passive Home' Movement a Success in Germany, but Not in Saskatchewan Where It Started."
[32] Broan-NuTone, "About Broan-NuTone Venmar."

Ventilation opportunities

- Canada should continue developing and claiming intellectual property on high-performance ventilation technology, given increasing concerns with indoor air quality, the construction and renovation of buildings for airtightness, and ventilation technologies tailored to Canada's arctic and cold climates.

Windows

Windows and doors are part of the building envelope. Energy-efficient windows can be constructed through different configurations of the glass layers and coatings, the gas or vacuum created in between, and the window frame design using non-conductive materials. The integration with the critical layers of the building envelope and the quality of installation also impact window performance.

There is a high amount of local manufacturing in fenestration products. Canada has about 2,000 businesses classified as metal, plastic, or wood window and door manufacturers.[33] Final assembly and manufacturing steps occur close to demand centres because this is a highly customized, heavy, and fragile product that is required within short turnaround times. Local expertise is needed to service warranties, and quality control is paramount. Customization is also often required to meet architectural specifications, and local manufacturers are best able to demonstrate compliance with local building codes and standards. Several Canadian manufacturers are small-to-medium businesses, while the U.S. has larger manufacturers. Canada exports more plastic windows and doors than it imports, with almost all exports going to the U.S..[34] Increased domestic sales could offset the potential loss of this export market.

Energy efficiency building codes and standards in British Columbia and the demand for highly airtight, watertight, and durable products for large buildings in our climate with temperature extremes spurred the manufacturing of high-performance windows.

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[33] Statistics Canada, "Table 33-10-0661-01: Canadian Business Counts, with Employees, December 2022." Data from July 2022. While businesses are generally assigned a single NAICS code based on the primary product produced, it is possible that some businesses could be double counted across the three relevant codes added here.

[34] Observatory of Economic Complexity, "Plastic Doors, Windows and Window Frames (HS: 392520)."

Companies developing highly efficient windows focus on research and development on the frame and glass design, and undertake regular performance testing.

Several distinct manufacturing processes are involved, relating to the frame and sash, door slab, the insulated glass units, hardware, spacers and final window and door assembly. Companies following different business strategies will source components globally or locally. Some Canadian fenestration manufacturers invest in manufacturing machinery for these components to achieve high levels of quality control to reduce warranty costs and/or supply chain risk. Others choose to outsource the manufacture of these components. Some specialized products have only one or a few relevant suppliers. For example, Oxy Vinyls is the leading Canadian manufacturer of vinyl resins for PVC windows.

Float glass is the primary product without a Canadian manufacturing option. Canada is the second largest importer of this product in the world, with almost 90 per cent of its imports coming from the U.S. in 2023.[35] The manufacturing process involves heating silica sand or other materials to produce molten glass, which is then floated on a molten metal to create a flat surface and cooled. It requires significant, consistent energy inputs. Canada used to manufacture float glass in Ontario, with linkages to the automobile sector, yet the foremost manufacturer shut down in 2009.[36] There is potential to attract manufacturing within Canada, with reported interest in developing a silica sand deposit in Manitoba.[37] The business case would likely rely on valuing a reduced environmental footprint because of Canadian hydroelectricity, other forms of renewable energy, and modern high-efficiency manufacturing processes (e.g., waste heat recovery).

There is potential for further innovation in fenestration products, and a reason for Canada to advance these frontiers due to its climate, which varies between extreme temperatures and moisture levels. For example, increasing the durability of window profiles and insulated glass would enable longer-term warranties and reduce risks for condos, community buildings, etc. Further energy efficiencies could be achieved through vacuum-insulated sealed glass units.[38] There is also potential to increase the

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[35] Observatory of Economic Complexity, "Float Glass (HS: 7005)."

[36] Toronto Star, "Oshawa Glass Works to Close next Year - Glass Canada."

[37] Canadian Premium Sands, "Canadian Premium Sand Plans Float Glass Facility in Manitoba."

[38] Jung, Kim, and Ko, "Recent Progress in High-Efficiency Transparent Vacuum Insulation Technologies for Carbon Neutrality."

use of local resources through recycling. For instance, in Germany, recycling of discarded PVC windows and doors is common practice.[39] The PVC frame is actually strengthened the more it is recycled. Developing a PVC recycling stream within Canada could increase the independence of Canadian window supply chains by enabling the use of local resources and increasing the durability and environmental performance of Canadian-made windows.

Films and membranes can also be added to existing windows to improve energy efficiency. Canadian companies include Ecolo Synergy and Window Film Systems. The area around the window is also an important component of energy savings. It requires qualified window installation and designing things like solar shading solutions that enable passive solar heating in the winter while blocking it in the summer.

Window and door opportunities

- Encourage window and door innovations made for the Canadian cold climate through R&D, efficiency standards, and the development of Canadian-specific testing and certification policies that encourage continuous innovation and high performance.
- Explore the potential to develop high-efficiency and clean energy-powered float glass manufacturing in Canada.
- Explore the potential to recycle Canadian PVC window frames to reduce reliance on American imports and develop international partnerships (e.g. circular economy initiatives in Germany).

Residential heat pumps

Heat pumps are highly energy-efficient heating systems because they move heat between the exterior and indoor environments instead of converting energy to heat, a process that has inherent losses. There are several types of residential heat pumps, including air-to-air, air-to-water, and ground-source heat pumps. The technology is based on the vapour-compression process used in air conditioning and refrigeration

[39] Bendix et al., “Circular Economy for Durable Products and Materials.”

systems, and thus, the production of heat pumps has commonalities with these products.

What is often termed heat pump manufacturing consists of assembling the various components, which include compressors, heat exchangers (coils), refrigerants, a reversing and expansion valve, motors and fans, refrigerant lines, and electronics in the control panels that connect with a thermostat. The underlying technology and the components involved are mature, and thus tend to be produced by large multinational companies with established networks to source materials, ensure quality control, and achieve economies of scale. China's capacity for high-volume manufacturing includes heat pumps. In 2023, China held 42 per cent of the global manufacturing capacity for heat pumps, with stronger positions in components like compressors and refrigerants.[40]

Heating systems have distinct regional characteristics. There are regional patterns to heating distribution systems (e.g., ducted, hydronic) and standards for voltage, frequency, refrigerants, and energy efficiency. For example, the European Union has regulations to reduce the global warming potential of refrigerants that differ from those in North America. They allow propane (R290) to be used as a refrigerant, which requires the use of different components in heat pumps for safety reasons. Procurement of heating systems by final consumers can have short lead times, and the final equipment's bulkiness makes it challenging to transport. These factors favour the final assembly of heat pump components in relatively close geographic proximity to final demand on a continental basis. Canada is not a large market from a global perspective, so these factors that create geographic "stickiness" tend to pull Canada towards American supply chains for space heating and cooling equipment.

Canada is a net importer of most types of space heating and cooling equipment. A significant amount of fossil fuel heating equipment is imported from the U.S..[41] Companies like Carrier, Lennox, Bryant, and Goodman are prominent American manufacturers.

Asian manufacturers are more prominent in air-to-air heat pumps (particularly side-discharge units and mini-splits), leading to Canada's more diverse trade pattern. In

[40] Martinez-Gordon, Delmastro, and Dou, "Is a Turnaround in Sight for Heat Pump Markets?"

[41] In 2023, 73% of Canadian of the dollar value of imports were from the US for non-electric air heaters and hot air distributors made out of iron and steel (HS Code 732290), 59% of liquid fuel furnaces (HS Code 8416), and 44% of central heating boilers (HS Code 840310). From observatory economic complexity and ISED Trade Data Online.

2023, 42 per cent of Canadian reversible air-to-air heat pumps imports were from China, and 38 per cent from the U.S.[42] Global manufacturers include Gree and Midea, headquartered in China; Mitsubishi Electric, Daikin, Fujitsu, Panasonic, Hitachi, headquartered in Japan; Carrier, Trane and Lennox, headquartered in the U.S.; and Samsung and LG Electronics in Korea.

Europe also manufactures heat pumps, with a stronger specialization in hydronic systems and large-scale applications (e.g., district heating) and industry. Manufacturers include Vaillant, Bosch, and NIBE. Because Canada has historically had fewer water-based heating systems and the administrative costs required to comply with North American standards, these companies do not play a prominent role in the Canadian market.

The International Energy Agency finds a relatively lower amount of corporate concentration in the production of heat pumps compared to other clean energy technologies. The top suppliers of wind turbines, fuel cells, and batteries have a larger market share than the top global suppliers of heat pumps.[43] This means Canada has more options as a global consumer.

There is not a significant amount of manufacturing or assembly of residential heat pumps in Canada.[44] As stated above, the production of the final product involves several components that are sourced globally, and thus, there might not be a significant advantage from locating the final assembly within Canada. Thus, an assessment of Canadian self-reliance and resilience should consider the extent of Canadian economic activity occurring along the value chain, the diversity of trading relationships, and the ability for Canadian actors to find points of leverage and advantage within value chains to benefit consumers and/or Canadian economic development. From this perspective, there are several examples of Canadian involvement in heat pumps.

Some globally sourced heat pumps are sold under Canadian-specific brands by Canadian wholesalers and distributors. This includes Moovair by Master Group, Mits

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[42] HS Code 841581. Another relevant trading category is 841861 for refrigeration equipment with heat exchange, where Canada imported 51% from the U.S. and 28% from China. Observatory of Economic Complexity.

[43] International Energy Agency, "Energy Technology Perspectives, 2023."

[44] Two examples of assembly of air-to-air heat pumps in Canada include Turcotte's (part of TTI Climatisation Chauffage) "Turbofin" heat pumps in Québec; and Maritime Geothermal's Nordic heat pumps in New Brunswick.

Air, Direct Air, Napoleon, Novair and Dettson (owned by Innovair Solutions). The brands can negotiate lower prices and spare parts from suppliers through high-volume purchasing and warehousing and by exercising their ability to form partnerships with different suppliers. They can also provide information and expertise to suppliers to customize products for cold climates (e.g. better defrost algorithms and sensors).

Although heat pumps are generally made outside of Canada, Canadian companies have developed novel technology configurations that incorporate heat pumps. Minotair is a Québec-based company that combines a heat pump with an energy recovery ventilation system, marketed to passive house designers.[45] Stash Energy is a New Brunswick start-up that combines an air-source heat pump with thermal energy storage using phase change material to manage electricity system peaks.[46]

Canadian companies are involved in residential and light commercial air-to-water and ground source heat pumps that have applications in more specialized markets. Maritime Geothermal has designed and manufactured the Nordic brand of air-source and geothermal heat pumps since 1983, Geoflex Energy Transfer Systems manufactures geothermal heat pumps in London, Ontario and Arctic Air in Winnipeg markets air-to-water heat pumps. TTI Fab in Québec has innovated and produced pool heat pumps for cold climate applications for over 30 years.[47] Eden Energy is a Canadian distributor that traces its history to the Canadian innovation of the "waterfurnace" water-source heat pump (Waterfurnace is now an American-based company).[48]

Canadians are also involved in innovations in the traditional refrigeration process. Enersion is a company spun off from University of Toronto research, using nano-porous materials instead of refrigerants for heat pump systems. They market to large-scale commercial buildings, yet the technology could also be applied to residential homes.[49]

To conclude, heat pumps are made up of multiple components delivered by a complex global supply chain. Canada has domestic expertise in the relevant technology, which means it has the ability to manufacture and assemble heat pumps. However, this might not be the most advantageous role in globally produced technologies like air-to-air heat

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[45] Alter, "Minotair 'Magic Box' Heats, Cools, Ventilates and Dehumidifies."

[46] Underwood, "Getting to Net Zero: How Stash Energy Is Transforming the Way We Heat Our Homes."

[47] TTI Fab, "TTI Fabrication | Our History | How TTI Fabrication Came to Be..."

[48] Egg and Egg, "Geothermal Coming of Age: A Short History."

[49] Government of Canada, "Cool Customer."

pumps, given the dominance of global manufacturers. Business relationships are international and could be further diversified, despite factors that gravitate the Canadian sector towards North American production systems. Canada can capture value and increase its strength in global value chains by scaling and coordinating demand so our nation can act as a sophisticated and meaningful consumer of the technology. Canada can also gain resilience and strength by finding strategic areas for innovation along the value chain, such as the mass marketing and deployment of heat pumps, sophisticated control and defrost systems for cold climates, low global warming potential refrigerants or the elimination of refrigerants, and the use of heat pumps in specialty applications.

Heat pump opportunities

- Recognize heat pumps as an opportunity to diversify trading relationships away from American-dominated fossil fuel heating technologies.
- Increase and coordinate heat pump demand. Predictable and large-scale demand gives Canadians increased power to negotiate with global suppliers, and could result in on-shoring more assembly within Canada.
- Coordinate demand for specialized markets for less internationally commodified air-to-water, ground source, water-to-water heat pumps.
- Consider developing Canadian-specific standards to enable more diverse trading relationships, support Canadian companies in marketing innovations, and prepare for forthcoming international standards. This could include working with the European Union to enable the use of lower "global warming potential" refrigerants in Canada.

Residential water heating and management

Water heating requires 17 per cent of the energy used in an average Canadian home. In addition, water can act as a thermal battery, making it a good candidate for consuming electricity during off-peak times to alleviate grid constraints.

We are unaware of any residential electric heat pump water heaters manufactured in Canada. AO Smith, Bradford White, and Rheem are major American manufacturers of electric water heaters, including heat pump options, though products are reportedly often made in Mexico. Midea, a major Chinese manufacturer, has a heat pump hot water heater. Giant Factories (a subsidiary of AO Smith) manufactures electric resistance water heaters in Québec.

U.S. standards under the Biden Administration required almost all electric storage water heaters to be heat pumps by 2029. The “no backtrack” provision does not allow President Trump to change these regulations without Congressional approval. However, the President has threatened not to enforce regulations.[50] While the federal government has traditionally harmonized with U.S. efficiency standards, this is an area where Canada has recently opted for weaker efficiency standards.[51] Yet, even the modest improvements in water heating efficiency will not come into effect until the same date as the stronger U.S. standards (2029). Thus, Canada appears to be harmonizing with a delayed timeline without harmonizing with a stronger efficiency standard. Canada’s linkage with the American testing and standard-setting systems appears to produce constrained choices when a Canadian-specific standard might be appropriate.

There are Canadian companies that use technology to schedule water heating at a lower cost and lower emissions during off-peak times. This includes EcoPeak, a hot water tank that uses three elements to smooth the timing of hot water consumption, developed by Giant (the above-mentioned Canadian-based manufacturer) with Hydro-Québec.[52] Québec-based Sinopé technologies has a controller that shifts the time of use of existing hot water tanks, with a sensor that will override the shut-off if the tank temperature drops below acceptable health standards.

Canada has a history of using drain water heat recovery more than other countries in residential homes, after this technology was supported through building codes in Manitoba and Ontario.[53] There are small-scale companies offering this technology (e.g., RenewAbility Energy, EcoInnovation Technologies).

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[50] deLaski, “Stopping Enforcement of Appliance Standards Would Bring Inferior Products with Big Costs | ACEEE.”

[51] Government of Canada, “Canada Gazette, Part 2, Volume 159, Number 8.”

[52] Giant Inc., “About Us.”

Sinopé, “Calypso - Smart Water Heater Controller.”

[53] California Energy Codes & Standards, “Drain Water Heat Recovery – Final Report.”

Residential water heating opportunities

- Develop Canadian timelines for water heating efficiency standards rather than following U.S. schedules. If opting against adhering to the higher U.S. efficiency standard for electric storage water heaters, explore a “made-in-Canada” approach that encourages efficiency, demand flexibility, or peak demand reduction.

Industrial, Commercial, and Institutional (ICI) energy efficiency

Industrial, Commercial, and Institutional (ICI) buildings and operations have varied heating and cooling applications, unique energy use cases, and site-specific conditions. This sector can use a range of different equipment types and technology configurations. Equipment can be sourced from diverse global supply chains. These complex characteristics mean that improving energy efficiency often requires local expertise, whether the equipment is manufactured in Canada or imported. A Canadian agenda for increased self-reliance and resilience in industrial, commercial, and institutional operations should consider how Canadian expertise can be used to navigate around potential trade and supply chain disruptions, as well as opportunities to support Canadian business innovation in specific points along complex value chains.

To outline the variety of possible technical configurations, consider that commercial, institutional and industrial operations have different energy use profiles. An office building’s energy use might include lighting, computer equipment and heating and cooling rooms to different temperatures. A restaurant uses energy-intensive kitchen equipment. A hospital requires high-quality ventilation and air filtration and must operate specialized medical equipment around the clock. Manufacturing and food processing can use heat for drying, melting, sterilizing, etc. A complete system to heat, cool and move fluids (air, water, materials) can range from a single packaged unit to a complex combination of equipment, tanks, piping, pumps/blowers, valves and controls, with each component requiring equipment selection and sizing. The assembly of such a system could occur in a factory, or by specialists on a roof or in the mechanical room of a building. Opportunities for energy efficiency are therefore plentiful in this sector, including retrocommissioning and energy management (discussed previously), energy-saving heating and cooling equipment wherever a temperature change is required, and equipment that moves fluids more efficiently.

Highly qualified personnel are needed, even in cases where equipment is less site-specific and imported from outside of Canada. For instance, most ICI equipment manufacturers and distributors employ sales or application engineers to communicate technical details on their range of products to potential clients. Designing a complete solution for a complex application can require sizing and selection of multiple pieces of equipment, and the appropriate interconnecting piping, valves and controls. This “process engineering” requires knowledge of fluid and thermal dynamics and typically involves an engineer or designer with the requisite training and experience. Installation of systems requires licensed refrigeration mechanics, electricians, plumbers, welders and/or steamfitters, depending on the fluids (e.g. air, water, steam) and may be employed by mechanical contractors or equipment distributors. Thus, Canadians are involved whether a project involves a single piece of imported equipment or a more highly engineered, locally fabricated solution. Canada’s education system produces people with the required expertise, and locating this expertise close to demand assists sales processes, commissioning ongoing maintenance, and quality assurance. The diversity of manufacturers, technology types, use cases and innovations for energy cost savings creates a knowledge ecosystem, which readies Canada to be more resilient and adaptable in managing demand in these energy systems.

Energy-saving opportunities for space and water heating and cooling within ICI buildings can be achieved through off-the-shelf modular units (e.g. heat pumps) or pre-engineered packaged systems. For example, Trane is an Irish-headquartered company with a complete line of energy-saving ICI equipment, which employs an estimated 700 people within Canada. Master Group is a Canadian-owned distributor with 50 branches across Canada and training centers/labs in British Columbia, Alberta, Québec and Ontario. Mitsubishi Electric has a training centre in Markham, Ontario and distributors nationwide for their commercial heat pumps. Viessman has large training facilities in Ontario and British Columbia and offers hydronic heat pumps. Examples of Canadian distributors and/or custom manufacturers of ICI equipment that typically also house engineering expertise include: E.H. Price with offices across Canada; Riada, Refrigerative Supply and Olympic International serving British Columbia and Yukon; Heat Transfer Solutions Engineering, O’Dell HVAC Group and Mits Air with Ontario offices; Midwest Engineering in Manitoba; and ITC Technologies serving Québec and the Maritimes. Numerous others are likely to exist across the country.

Some heating and cooling applications require more customized engineering, necessitating chemical, mechanical and/or electrical engineering expertise. Facilities requiring large amounts of cooling, like cold storage, warehousing, dairy, brewing, ice rinks, and data centres, are likely candidates for customized design of energy-efficient refrigeration solutions. These systems may be more likely to be assembled in Canada, either by the equipment manufacturer on site or on a skid prior to shipment. Canadian companies with expertise in refrigeration that provide both equipment and services include RefPlus (Saint-Hubert, Québec), CIMCO (North American head office in Burlington, Ontario), and Keeprite Refrigeration (Brantford, Ontario). Canadian companies like Vitalis[54] (Kelowna, British Columbia), Carnot (stationed in Trois-Rivières, Québec, acquired by Johnson Controls), and Zero-C (Saint-Bruno, Québec; with an office in Switzerland) specialize in using natural refrigerants like CO_2 and ammonia. These refrigerants can absorb and transfer heat more efficiently, and these energy efficiency improvements have higher value in Canada's cold climate. Natural refrigerants are increasingly preferred by industry as they are free from any future regulatory or compliance mandates that may discourage the use of synthetic refrigerants.

Energy can also be saved by capturing heat that would otherwise go wasted and reusing it, using heat exchangers. A relevant Canadian example is Harvest, a McMaster University spin-off company that captures waste heat from pizza ovens and fryers.[55] Heat recovery from ventilated air is an application well served by Canadian companies. For example, Canarm in Brockville, Engineered Air in Calgary and Newmarket, Nortek Air Solutions (U.S. owned; acquired Canadian pioneer Venmar CES), Tempeff and Solution Air in Winnipeg, System Air in Boutouche and ThermoPlus Air Industries in Saint-Jerome, Québec, and Bousquet in Saint-Jolie, Québec are all manufacturers of semi-customized, heat and energy recovery ventilators for large buildings in Canada. Several manufacturers also fabricate the sizable aluminum heat exchangers locally. There are also Canadian companies commercializing large-scale waste heat recovery systems for application in district heating systems, breweries, hotels, and multi-unit residential buildings. This includes Vancouver-based Sharc Energy with projects collecting heat from wastewater integrated with geothermal systems, which are used in both large district energy systems and for heating and cooling individual buildings. Toronto-based Noveta developed a large-scale wastewater heat exchange system for the Toronto Western Hospital, using its patented process technology. Noveta's Energy-as-a-Service

[54] Vitalis holds 3 patents

[55] Harvest Systems, "News – HARvEST Systems Inc."

financing model is supported through the Canada Infrastructure Bank.[56] Steam and hot water heat exchange can be improved by companies such as Preston Phipps (Canadian headquarters in Montreal), which manufactures highly efficient, compact heat exchangers for steam applications.

Optimizing the flow of liquids and gases through the design of distribution systems, more efficient equipment, such as pumps, blowers, and motors, and the digital monitoring and control of systems can also offer significant energy savings. Armstrong Fluid Technology is a 90-year-old Canadian company with facilities worldwide, specializing in energy-efficient, intelligent, fluid-flow equipment for applications in large buildings, data centres, industry, etc. They compete with international companies such as Xylem and Danfoss, holding patents in areas such as pumps, automation, graphical user interfaces, performance management, and heat exchangers.

This brief review of opportunities for energy savings in the complex and multi-faceted industrial, commercial, and institutional sector demonstrates a thriving ecosystem of Canadian expertise and examples of Canadian-based business leadership and innovation. This expertise, combined with the multiple potential configurations used to improve energy efficiency, enables Canada to adapt when faced with economic uncertainty. Canadian experts are capable of engineering and designing around problems, and innovators strengthen the Canadian position within complex global value chains.

[56] Canada Infrastructure Bank, “Canada Infrastructure Bank Invests $100 Million with Noventa to Decarbonize Buildings.”

Opportunities for Industrial, Commercial, and Institutional efficiency

- The Canada Infrastructure Bank's provision of patient capital to support building retrofits supports large-scale energy projects and Canadian companies with innovative technology solutions.
- Consider how aligning with international high-efficiency standards for products like electric motors or pumps, as well as energy and GHG building performance standards, could support innovation-oriented Canadian companies.

Smart thermostats

Smart thermostats save energy by automatically adjusting temperatures to warm or cool buildings when they are occupied. They can communicate with utilities to pre-cool or heat buildings to alleviate peak demand grid constraints, and "pay people" for this service.[57] The granular data they collect can also encourage energy-saving behaviours and provide insights to plan building upgrades.

Smart thermostats deserve consideration because of the success of Canadian companies in a market with large players like Google Nest, Honeywell, Amazon, and HVAC system-specific thermostats.

Ecobee is a Toronto-based company that created the first Wi-Fi-enabled thermostat in 2007—the same year the iPhone was released. They expanded into smart home systems with sensors and doorbell cameras. In 2021, Ecobee was acquired by Generac, an American company with a history in backup power systems. Stuart Lombard remains the CEO of Ecobee and is the President of connected devices and services for Generac.

Mysa is a smart thermostat company started in 2016 in St. John's. The first thermostat was designed for electric baseboard heating, which is prominent in Newfoundland and Labrador and other provinces like Québec and New Brunswick. The thermostat app enables scheduling and control of multiple zones within the home. The technology has

[57] Haley, Pivnick, and Gibson, "Pay People Instead of Power Plants for Clean Electricity."

expanded to control electric in-floor heating, mini-split heat pumps, and portable air conditioners.

Québec-based Sinopé also offers smart thermostats that are integrated with other smart home and business energy management applications.

In 2023, 91 per cent of the dollar value of Canada's thermostat exports went to the U.S..[58] If trade disruptions reduce sales to the American market, these Canadian companies could be supported by increased domestic demand. Demand-side management programs for both energy savings and demand control offer rebates for these thermostats.

Smart thermostat opportunities

- Support smart thermostat companies through the expansion of demand response programs to reduce peak demands.
- Demand-side management programs can support Canadian companies through labelling Canadian-made products, providing forward guidance on anticipated demand, and other strategic partnerships. Hydro-Québec's recent expansion of energy efficiency programs includes a strategy to support Canadian expertise, and smart thermostats are marketed through their Hilo smart home service.[59]

Conclusion and policy recommendations

Energy efficiency is a "made-in-Canada" energy resource that is readily available to strengthen Canada's economic independence. Local expertise is used to reduce fossil fuel imports and/or ensure Canada's domestic energy resources are used most productively and strategically. Saving energy means more dollars circulate in local economies. In uncertain times, energy efficiency enhances economic resilience by

[58] Observatory of Economic Complexity, "Thermostats (HS6 90.32.10)."
[59] Hydro-Québec, "Mieux Consommer Ensemble: Trajectoire En Efficacité Énergétique."

optimizing existing energy systems and making the best use of existing equipment and production systems.

Our exploration of energy-efficient products and technologies demonstrates value chains with a strong degree of Canadian content and local production. However, this initial investigation into energy efficiency value chains paints an incomplete picture because energy efficiency is a diverse area with new solutions under continuous development. This diversity is why energy efficiency and demand-side energy solutions are resilient against economic changes and present numerous opportunities to create and grow Canadian expertise.

Retrocommissioning and strategic energy management are inherently local activities that can achieve energy savings with no material inputs or equipment replacements. Numerous Canadian companies provide these services.

Insulation is largely produced domestically. Efforts to improve its environmental performance could increase its localness by sourcing from nearby domestic recycling streams and using agricultural or forestry by-products.

We find Canadian companies with histories of invention and leadership in heat/energy recovery ventilators, ground source heat pumps, CO_2 refrigerants, heat exchange, industrial mechanical systems and building energy optimization. Smart thermostats are an area where technology start-ups have grown into successful companies.

Window and door sales also support thousands of Canadian companies. Domestic production of float glass would stabilize and reinforce the supply chain. Manufacturing within Canada could be low-carbon through the use of renewable energy and energy-efficient production processes. Recycling window frames could increase the Canadian content of windows.

Heat pumps and air barriers present examples of technologies where Canada could diversify its trading relationships to be less dependent on the U.S., and where Canadian expertise should aim to find advantages in global production networks.

Grow and coordinate demand

We see the need for further research on business support policies to help Canadian energy efficiency companies gain advantages in global value chains. However, an immediate and primary way to support the Canadian economy is to grow and coordinate demand for energy efficiency. Canadians who have spontaneously started purchasing “made-in-Canada” products intuitively understand this.

Expanding demand-side management programs through long-term plans (recently seen in Ontario and Québec) provides an avenue to coordinate demand for Canadian energy efficiency solutions. These initiatives could fall under government directions to restrict the use of American contractors and increase support for Canadian companies.[60]

On a national level, it is possible to better coordinate and scale energy efficiency demands as part of a strategy to support the growth and innovation of energy efficiency solution providers. A 2024 Efficiency Canada report by Lockhart and Haley titled *Policy Strategies to Support Innovation in New Housing Construction* discussed how high-performance building codes and related standards could accelerate the transition towards more productive pre-fabricated and modular construction techniques, and increased use of biological building materials, digital technologies, and heat exchange systems.

This report demonstrates that Canadians can supply many innovative solutions to build more and greener homes. Clear and ambitious building codes and standards would coordinate demand to produce two positively reinforcing effects. First, they will ensure emerging production systems are configured to meet high energy efficiency and carbon reduction performance. Second, they increase the value proposition of potentially transformative construction technologies by encouraging competition on performance and price. However, this demand signal is not being sent because few provinces have committed to progressing up the performance tiers of Canada’s model national building code towards a net-zero energy-ready or net-zero emissions standard, and the federal government’s housing strategy has no formal requirements for energy efficiency or carbon performance.[61]

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[60] See for example Office of the Premier, “Premier Directs Government to Cancel American Contracts Wherever Viable.”

[61] See policy tracking of provincial building code adoption: Efficiency Canada, “Building Codes | Policy Tracking System.”

See sign-on letter supporting that the federal government requires upper tier performance in the building projects they undertake or fund and providing incentives for provinces to adopt upper tiers when accessing the Housing Infrastructure Fund

“Letter to the Prime Minister of Canada Regarding Building Energy Efficiency Performance in Canada’s Housing Plan,” June 7, 2024.

Yet, the existing building stock provides an even larger and longer-term opportunity to scale and coordinate demand. A 2021 Efficiency Canada report by Haley and Torrie titled *Canada's Climate Retrofit Mission* called for the creation of "market development teams" that would coordinate similar retrofit needs of buildings across the country and use those coordinated demands to foster innovation and productivity in the retrofit production and delivery process.

The federal government responded by supporting retrofit accelerators for large building retrofits through the Deep Retrofit Accelerator Initiative. Retrofit accelerators are focused on providing building owner concierge services, assembling trade ally networks, helping coordinate private and public capital funding and general capacity building. The federal government also introduced the Greener Neighbourhood Pilot Program, which supports demonstration of innovative technology in smaller buildings and homes by market development teams. Recipients of both program funds are about halfway through their delivery terms.

While these programs are the first of their kind for building retrofits in Canada, they are small-scale pilots. Program participants work within the rules of the same market they are tasked with transforming, instead of building up large-scale demands to change the nature of supply chains and market structures. Without a mission-led organization capable of coordinating national-level demands to spur supply-side change, market transformation will give way to cyclic investments and failures. A retrofit mission could focus on achieving higher performance energy savings at an increased pace.

The market development teams created by existing federal programs are also institutions that could be deployed to aggregate and coordinate demand to meet Canadian self-reliance and resilience goals. This would help make energy efficiency even more of a "made-in-Canada" resource, preparing our country for whatever macro-political and economic storms are on the horizon.

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