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The greenlight for government buildings: strategies for a low-carbon building portfolio

S. Adamson and A.S. Medeiros

School for Resource and Environmental Studies, Faculty of Science, Dalhousie University, Halifax, Canada

Corresponding author: **A.S. Medeiros** (email: andrew.medeiros@dal.ca)

Abstract

There is a global focus by governments on retrofitting buildings, as well as incorporating energy efficiency into new construction, as a means to address climate change. Initiatives to reduce energy use, source renewable electricity, and use low-carbon materials are aimed at leading by example, where governments attempt to showcase innovation through green building strategies. Greening government initiatives are promoted to reduce operating costs, improve energy system resilience, grow the "green" economy, support clean energy development, and encourage sustainable building practices. Here, we outline the benefits of greening government initiatives by examining Canada's Greening Government Strategy as a case study approach for transitioning to a low-carbon building portfolio. We focus our review on initiatives that outline how public institutions can transition buildings to reduce their carbon footprint by (1) pairing greening government mandates with adequate support structures for public agencies, (2) using an integrated energy management process for the planning and development of carbon-neutral portfolios, and (3) overcoming barriers to low-carbon project implementation with procurement standards, financial instruments, and staff training. These approaches are defined to offer leadership in the green building industry, strategically identify carbon reduction projects, and reduce barriers to a low-carbon building portfolio.

Key words: climate change, green public procurement, energy efficiency, energy performance, net zero, retrofit

Introduction

As governments implement policies and programs to address climate change, energy efficiency in the built environment has become a key focus. Globally, buildings contribute 37% of total CO_2 emissions due to operation and material needs (United Nations Environment Programme 2022). Seventy-two percentage of building emissions are due to energy use for operational needs, such as heating and cooling, and 28% result from manufacturing and processing building materials, such as cement, steel, and glass (Röck et al. 2020; Causone et al. 2021). Most emission reduction efforts that focus on built infrastructure concentrate on improving energy performance through retrofit measures, renewable energy installation, and energy-efficient designs (Attia et al. 2017; Röck et al. 2020). In addition to providing funding for regional energy efficiency initiatives and programs, governments can retrofit their own building portfolio and construct more energy-efficient buildings to take the lead on a low-carbon transition.

As of 2021, 41 countries have signed onto the Greening Government Initiative (GGI) as part of the U.N Framework Convention on Climate Change Conference (COP26; CSO 2022). This initiative enables countries to exchange information, promote innovation, and share best practices for green government operations (CSO 2021). These governments are already demonstrating leadership by formalizing green government policy commitments and establishing governance structures that provide support and resources to public agencies to reduce greenhouse gas (GHG) emissions. For example, Finland has created a state-owned sustainable development corporation to help support public administrations, businesses, municipalities, and consumers to implement resource-efficient and sustainable practices (Motiva 2021). Norway has created a Sustainable Public Procurement tool for the incorporation of environmental and social responsibility requirements and criteria (DFO 2022), and the United Kingdom has set out actions for government departments and partner organizations to reduce GHG emissions in their Greening Government Commitments (Department for Environment, Food and Rural Affairs 2021). Canada's Greening Government Strategy (GGS) is the primary action plan that outlines Canada's net-zero by 2050 commitment for government operations, including maintaining a net-zero climate-resilient property plan (TBS 2022). Homes and buildings account for 18% of Canada's GHG emissions, when also factoring in electricity use for cooling, lighting, and appliances (ECCC 2020). The federal government is the owner and manager of the largest fixed asset portfolio in Canada, including 32,000 buildings with 23 million m^2 of floor space; transitioning this portfolio to low carbon is a key aspect of the GGS strategy and overall climate change goals in the country (TBS 2021, 2022).

While carbon emissions from sources owned or generated by federal, provincial, and territorial governments in Canada account for only 0.6% of national GHG emissions, government leadership has impacts beyond specific emission reduction projects (ECCC 2016). Promotion and incorporation of greening government strategies into non-governmental sectors extends benefits such as energy cost reduction, building comfort, energy system resiliency, growth of the green building industry and market, demonstrating economic competitiveness of clean energy, and encouraging alternative sustainable practices (EPA 2009; ICF 2018). Greening government initiatives require low-carbon products, technologies, and solutions; through public procurement, the government creates demand for these innovative technologies (Uyarra and Flanagan 2010). Public procurement can be a tool to stimulate innovation in supply markets, support environmental objectives, and grow local markets (Walker and Brammer 2009). Investments in clean renewable electricity to reduce GHG emissions also support increased adoption of renewables by the broader public (TBS 2022). Government support to overcome barriers to retrofitting or building new energy-efficient and sustainable buildings can also include information generation and dissemination (Yu et al. 2021). By sharing information, governments can reduce barriers to achieving high-energy-performance buildings and bridge the gap between government and private sector standards (Yu et al. 2021).

Here, we examine current greening government initiatives with Canada as a case study and outline the approach being used to transition to a low-carbon building portfolio for both existing buildings and new construction. The Government of Canada has provided a methodological framework for their initiatives (NRCan 2018*a*), which is based on policy commitments, governance structure, and government-sponsored resources to achieve GHG reductions; however, non-government entities and other jurisdictions would need to further design pathways to effectively implement and achieve the same goals. As such, we review an approach that focuses on transitioning public buildings to reduce their carbon footprint by (1) pairing greening government mandates with adequate support structures for public agencies, (2) using an integrated energy management process for the planning and development of carbon-neutral portfolios, and (3) overcoming barriers to low-carbon project implementation with procurement standards, financial instruments, and staff training. By reviewing Canada's federal green governance strategy and comparing other global initiatives, we are able to outline how the transition to a low-carbon building portfolio can be applicable beyond specific government portfolios and help inform asset managers, non-government agencies, and global carbon reduction initiatives.

Greening government mandates and support structures

Leadership commitments and legislation

Under Canada's Pan-Canadian Framework on Clean Growth and Climate Change, federal, provincial, and territorial governments have agreed to be leaders in sustainable and low-emission practices that support clean growth in Canada and address climate change (ECCC 2016). This now includes Canada's Greening Government Strategy, which commits to transitioning to low-carbon buildings and zero-emission fleet vehicles, utilizing green procurement approaches for goods, services, electricity, and clean technology, and implementing adaptation measures for resilience against climate change impacts (TBS 2022). Adoption of the strategy is mandated for all core departments and agencies of the Government of Canada (TBS 2022).

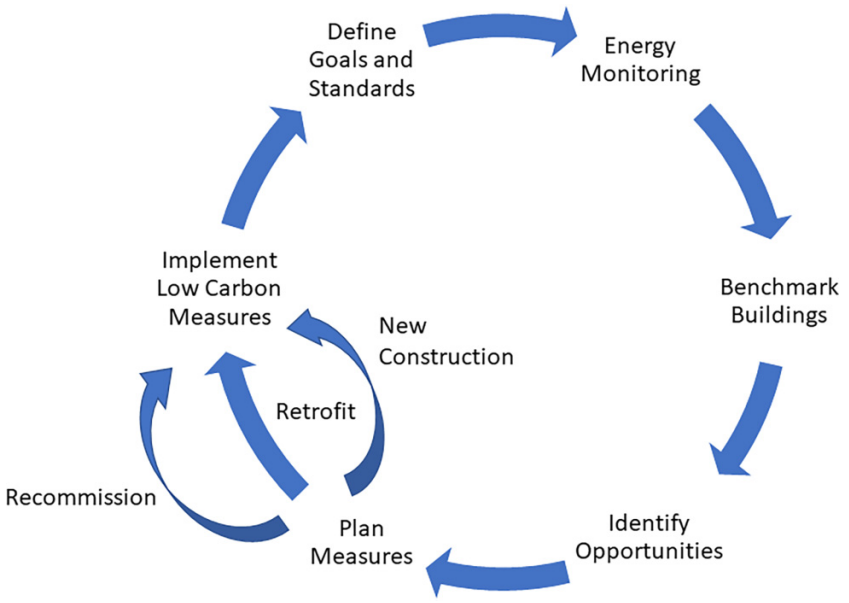
Governments can also enshrine greening government plans and strategies in legislation, which may be more effective when reduction targets and actions must continue in the long term, usually defined by 2050. Legislation has an advantage in that it can allow for the incentivization of green procurement for both market development and public procurer engagement (Pouikli 2021). For example, the European 2010/31/EU Directive legislates public administration and institutions of EU member states to lead on energy efficiency in the building sector. Distinct from regulations, directives within the 2010/31EU Directive set out goals for EU countries they are bound to; however, the pathway to achieve these goals is up to an individual EU member state to define (European Union 2023). Yet, member states must ensure that all new public buildings meet nearly zero-energy standards (Ascione et al. 2016).

Governance structure for public agency support and oversight

The Government of Canada is required to establish GHG reduction targets and demonstrate strategies for reductions in government operations under the Canadian Net-Zero Emissions Accountability Act (Government of Canada 2022). On a provincial level, British Columbia legislated that all provincial public sector organizations achieve carbon neutrality with required annual reporting on progress (SBC 2007). Nova Scotia has set a GHG reduction target of 75% for government-owned buildings by 2035 (SNS 2021). To effectively implement these commitments, the Government of Canada recommends establishing a governance structure. For example, the Centre for Greening Government (CGG), housed at the Treasury Board of Canada Secretariat, acts as a governance entity for greening government activities. By leading and coordinating initiatives, sharing knowledge and guidance with public agencies, tracking and disclosing GHG reductions and environmental performance, and driving results, the CGG is a key part of Canada's implementation strategy (TBS 2022).

Bureaucratic leadership is required to ensure management control frameworks incorporate environmental considerations ranging from procurement planning, identification and definition of requirements, acquisition, operation, and maintenance of assets to disposal of goods or closure activities of services. These are supported by other agencies, such as Natural Resources Canada, which extends technical support, guidance, and training across federal organizations (NRCan 2022).

Fig. 1. Integrated energy management process to optimize energy usage in building portfolios and implement low-carbon measures.



Defining net-zero buildings and performance goals

As part of the World Green Building Council's Net Zero Carbon Building Commitment, 19 cities around the world have regulations in place requiring new buildings to be carbon neutral by 2030 and existing buildings to reach the same goal by 2050 (Causone et al. 2021). As of 2019, the European Union has requirements that all public administrations build exclusively "nearly zero energy buildings" (Ascione et al. 2016). Canada's Greening Government Strategy requires all new federal buildings to be net zero carbon by 2025, which includes the carbon input necessary for construction materials (TBS 2022). For example, the Province of Nova Scotia now requires any new build or major retrofit in government buildings entering the planning stage after 2022 to have net-zero-energy (NZE) performance and be climate-resilient (SNS 2021).

The concept of green buildings emerged with the growing awareness of GHG emissions from the building sector (Darko et al. 2017). Green buildings are designed, built, and operated to use resources such as energy, water, materials, and land more efficiently than conventional buildings that meet code (Darko et al. 2017). The source of electricity is also a strong factor in whether buildings are designated as "green", where on-site or off-site renewable energy production is incorporated into construction or retrofitted during renovation (Zuo and Zhao 2014). Natural Resources Canada advocates for an energy reduction process that includes making a commitment, assessing performance, setting goals, creating an action plan, implementing the action plan, and evaluating progress (NRCan 2019). As the portfolio is reassessed, continuous improvements can be made through an integrated energy management process (Fig. 1). As an example, evaluating and updating policy goals ensures that energy management and actions reflect changing needs and priorities (NRCan 2019).

While lacking a standard definition, a NZE building is a highly energy-efficient residential or commercial structure; any energy used is sourced from on-, or near-site, or renewable energy sources (Torcellini et al. 2006; Shirinbakhsh and Harvey 2021). The term "net" implies that there is a net balance between energy consumed and energy output (Resende et al. 2021). The energy usage of NZE buildings can be reduced through an energy-efficient building envelope, heating and cooling equipment, appliances, passive solar design, and renewable energy sources to meet energy needs (Efficiency Canada 2021; Makvandia and Safiuddin 2021). Key considerations for net zero standards can include the building envelope, mechanical systems, energy performance targets, indoor air quality, water conservation, and other environmental features such as raw materials (NRCan 2018*b*).

Green building certification systems outline criteria that are used to evaluate GHG emissions from buildings (Roh et al. 2014). These certification systems reveal the resource and carbon intensity of buildings while objectively measuring their energy performance (Han 2019). Energy efficiency certification and labelling are used to assess and demonstrate a building's achievement in energy savings and sustainability (Yu et al. 2021). Widely recognized high energy performance and net zero standards for new construction and major retrofits (Table 1) all focus on improved resource efficiency and environmental responsibility, including R-2000, LEED, Net Zero Home Labelling Program, Passive House, Zero Carbon Building Standard, Green Globes, and BOMA BEST (Green Building Canada 2022).

Although net zero or carbon-neutral building standards are regarded as an emerging innovative and sustainable building approach, there is a need for a shared definition of what these terms mean, a greater understanding of the energy use for specific building services, what life cycle stages are included, the inclusion or not of embodied carbon and its accounting,

Table 1. Examples of green building standards in Canada for new construction and major renovations across building types (NRCan 2018*b*; BOMA Canada 2021; Green Building Initiative 2021; CAGBC 2022*a*, 2022*b*; Canadian Home Builders Association [CHBA] 2022; Green Building Canada 2022).

Green building standard	Building characteristics	Administrator	Description
R-2000	New construction; residential	Natural Resources Canada	Voluntary national standard to improve energy efficiency of new houses. Technical requirements include performance goals and prescriptive measures to be eligible for certification
LEED	New construction, major renovations; commercial and institutional, residential	Canada Green Building Council	Most widely used green building rating system in the world, available for virtually all building, community, and home-project types. Over 8500 buildings registered in Canada
Net Zero Home Labelling Program	New and existing buildings; residential	Canada Home Builder's Association	753 homes labelled across Canada (463 detached, 250 attached, 34 MURB units, and 6 renovations). Recognizes NZE and NZER homes
Passive House	New construction (EnerPHit for existing buildings)	International Passive House Association	Focus on optimizing a building's envelope and maintain heat through super-insulation, air tightness, high-performance windows, efficient heat recovery ventilation, and minimizing thermal bridges. High standard for lowering heating consumption
Zero Carbon Building Standard	New and existing buildings; commercial, institutional, Multi-unit residential buildings (MURBS)	Canada Green Building Council	Certified buildings produce onsite or renewable energy, or high-quality carbon offsets to counterbalance the annual carbon emissions from building materials and operations.
Green Globes	New and existing buildings; commercial, institutional, MURBS,	Green Building Initiative	Online assessment protocol, rating system, and guidance for green building design, operation, and management
BOMA BEST	Existing buildings	Building Owners and Managers Association	North America's largest environmental assessment and certification program for existing buildings. Over 5000 buildings obtained a certification or recertification

and less vagueness around net zero commitments (Causone et al. 2021). Natural Resources Canada (NRCan 2019) identifies setting goals as a key step of the building energy management process before further steps of planning and implementation are pursued. Further definition of the desired building performance and qualities is required to ensure net-zero building commitments are understood by public asset managers and achieve the desired GHG reductions for government buildings.

Understanding building energy usage

To inform investment decisions on energy efficiency upgrades of existing buildings, access to quality information on energy and carbon performance within a portfolio is needed. By measuring the performance of a building against other similar archetypes, energy usage, potential energy-saving opportunities, and energy management action plans can be identified and prioritized (Arjunan et al. 2022). Monitoring energy usage can help governments identify gaps in performance and quick pathways to reduce GHG emissions in the short term (Jradi et al. 2020; Ghajarkhosravi et al. 2020). Benchmarking, where buildings' energy usage is evaluated against others in a portfolio, informs carbon-neutral portfolio plans to help determine what energy upgrades should be implemented based on reduction potential (Ghajarkhosravi et al. 2020). It is especially useful for convincing senior management to pursue energy savings opportunities as it provides objective feedback on energy performance and potential (NRCan 2014).

Governments have started implementing energy benchmarking programs to improve the energy efficiency of commercial buildings (Arjunan et al. 2022). Some governments are monitoring and benchmarking within their own building portfolio, in addition to administering programs for other organizations. Canada's Greening Government Strategy has committed to metered energy use for government-owned buildings of more than 1000 m^2 and incorporating all facilities in the RETScreen Clean Energy Management Software by 2025 (TBS 2022). The RETScreen software was released by NRCan and allows energy efficiency and renewable energy projects to be assessed with tools to also track ongoing energy performance (NRCan 2021).

With energy usage data, GHG inventories can be developed for all of the public service or by individual departments and agencies. In British Columbia, each provincial public sector organization, including school districts, health authorities, crown corporations, post-secondary institutions, and the provincial government, prepares its own inventory with a centrally provided tool to standardize and support reporting (ICF 2018). Other provincial governments have also taken measures to track and report energy consumption and GHG emission data from their own operations. For example, Ontario's Ministry of Energy

has energy benchmarking programs and databases in place (CaGBC 2018).

Development of carbon-neutral portfolios

A key aspect of greening government initiatives is based on planning and implementing projects that include GHG reduction potential. In the "Roadmap for Retrofits" report by the Canadian Green Building Council (CAGBC 2018), it was recommended that provincial public sector entities develop multi-year property retrofit strategies that include measures and metrics to both increase energy efficiency and reduce carbon emissions from building portfolios. Strategic evaluation of property portfolios is encouraged to determine cost-effective strategies to reduce emissions (TBS 2022). Under the Canadian Net-Zero Emissions Accountability Act (SC 2021), Canada has committed to net-zero emissions by 2050. This is reflected in the GGS requiring all federal departments to develop and maintain a real property portfolio plan outlining the pathway to the complete decarbonization of departmental real property holdings (TBS 2022). Carbon neutrality is defined as the efficient operation of buildings and portfolios to conserve energy and reduce GHG emissions internally, with fuel switching and renewable energy generation installation (PSPC 2017). Any energy consumption can be neutralized by procuring renewable electricity, RECs, or carbon-offset credits (PSPC 2017). Carbon-neutral action plans outline the approach to implementing climate change mitigation and resilience strategies. Usually, specific goals and targets are included, along with policies, programs, and projects (ICF 2018). The development of a carbon-neutral action plan includes prioritizing areas for reduction using GHG inventories, collaboration to identify actions and establish targets, developing evaluation criteria for action options, selecting options using the evaluation criteria, and identifying monitoring mechanisms to report on outcomes (ICF 2018).

Public Services and Procurement Canada (PSPC) published a carbon-neutral implementation plan in 2019, which identifies initiatives to achieve carbon neutrality across its portfolio of publicly owned buildings. High-level evaluations of energy savings, GHG emission reductions, and incremental capital and operational costs are identified (PSPC 2017). These measures exist within the main investment areas of operational carbon management, major retrofits, energy conservation measures, and clean electricity procurement. Deep retrofits, clean electricity procurement, asset divestment, district energy (DE) system modernization, procurement, fuel switching, smart buildings technology, LED lighting, retro commissioning, solar PV, and battery storage are the most significant measures to achieve GHG reductions in the PSPC government building portfolio (PSPC 2017).

Using an integrated design process

The integrated design process is an example of a best practice that governments can trial when it comes to designing and constructing NZE buildings and also undertaking major renovations to their existing portfolio. IDP is a widely used tool and best practice to achieve the required levels of energy performance (Lu et al. 2022). By viewing a building as a single integrated system that includes the building envelope, heatig, ventilation, and air conditioning (HVAC) system, renewable energy system, and operations, it can be analyzed and designed collectively rather than in isolation (Zhivov and Lohse 2021). If the relationship between these components when designing or retrofitting a building is considered, benefits such as reducing energy demand can be optimized. IDP brings together different project stakeholders to collaborate and share information in the design phase (Zhivov and Lohse 2021). Traditionally, information flow is linear from one discipline to another, but IDP involves a collective study of the design. Some project team members may include the client or owner, project manager, architect, engineers, landscape architect, and general contractor. Compared to a conventional design process, with IDP, the client is more involved, the architect becomes a team leader, and the engineering team, including climate and energy roles, is active early in the design process (Lu et al. 2022).

Stakeholder collaboration allows for a whole-building analysis that identifies synergistic relationships between system components (Zhivov and Lohse 2021). For example, a building with an improved envelope has less heating and cooling demand, which reduces the required size of duct systems, air-handling units, boilers, and chillers (Zhivov and Lohse 2021). PSPC's Real Property Branch is responsible for real property assets and provides accommodation to federal departments (PSPC 2019). They have adopted IDP for new construction, including major fit-ups or renovations (PSPC 2019). The benefit is that PSPC is better able to improve the energy performance of their building portfolio and meet their GHG reduction targets (PSPC 2019). By identifying optimal design solutions, IDP can help achieve higher energy performance, simplify construction, decrease costs, and shorten the build schedule (Lu et al. 2022).

Overcoming barriers to project implementation

Green procurement standards and approaches

Public expenditures on goods and services are significant, often representing between 8% and 25% of GDP (Walker and Brammer 2009). Green public procurement (GPP) can be defined as the procurement of goods, services, and works by public institutions that includes environmental criteria, resulting in the purchase of products and services that have a lesser negative impact on the environment compared to what would otherwise be procured (Pacheco-Blanco and Bastante-Ceca 2016; Pouikli 2021; Mendez and Atkinson 2021). There is increasing recognition of the importance of green procurement to drive innovation and incentivize industry to develop sustainable works, products, and services, especially in sectors such as construction where public purchasers represent a large share of the market (Walker and Brammer 2009; Uyarra and Flanagan 2010; OECD 2015).

Procurement can include various standards to transition public building portfolios to low-carbon. In the case of the EU, GPP criteria under the 2014/24/EU Directive provide for a supporting framework with clauses on public purchasing of greener products and defining the levels required (Pouikli 2021). GPP standards can include environmental requirements, criteria for environmental labels, and accounting for environmental factors in production and life-cycle analysis to ensure low-carbon investments and operational cost savings (ICF 2018; Pouikli 2021). The Government of Canada, as well as some Canadian provinces such as Newfoundland and Labrador, has green procurement policies where environmental performance must be considered in procurement decisions. For example, the "Policy on Green Procurement" defines objectives, expected results, and requirements for the government of Canada's Greening Government procurement strategy (Government of Canada 2018). Newfoundland and Labrador proclaimed the Public Procurement Act in 2018 to modernize procurement by provincial public bodies with provisions to incorporate environmental considerations in general procurement policies (ICF 2018). Procurement for services, such as electricity and rental properties, can also include environmental criteria, such as renewable energy standards, or require higher levels of energy performance.

The integration of standard environmental criteria into procurement procedures can facilitate GPP and eliminate barriers due to a lack of expertise (ICF 2018). The inclusion of existing environmental certification programs, such as ENERGY STAR, LEED certification, and eco-labelled product lists, in procurement specifications can facilitate the process of identifying vendors and products (OECD 2015; ICF 2018; Pouikli 2021). British Columbia has developed green procurement criteria and evaluation guidelines that can be used in Request for Proposals, with current resources for central supply arrangements for LED streetlights and electric vehicle chargers (Government of British Columbia 2022).

Project outcomes relating to sustainable design, construction, and management of buildings at the tender stage can also be prioritized (Lam 2020). Lam (2020) notes that public sector clients should be measuring project outcomes, rather than using prescriptive inputs. Outcome-based or solution-based procurement is a model whereby the procurement specifies the desired outcome rather than the means to achieve it (ICF 2018). Instead of focusing on the cost or number of a specific product required, solution-based procurement requests a "best value solution" and outlines the circumstances in which it is needed as a means to help drive innovation and encourage creative solutions (ICF 2018).

To ensure decisions favour optimal GHG reductions over the life of a building, procurement and specifications can include the use of life cycle assessment (Jalaei et al. 2022). Whole-building life cycle cost assessments help quantify environmental costs along a building's life cycle before and after ownership (ICF 2018). It is a comparable basis for assessment when evaluating various solutions to reduce environmental impacts (Jalaei et al. 2022). Life-cycle assessments can factor in GHG-related components such as embodied carbon, operational emissions, and the shadow price of carbon (ICF 2018; TBS 2022). Embodied carbon means supply chain emissions resulting from the processing, manufacturing, construction, and transportation of building products and materials (Jalaei et al. 2022). New approaches, regulations, and planning are required in construction procurement to reduce these embodied carbon emissions and are key for influencing how buildings are planned and designed (Jalaei et al. 2022). As part of the GGS, government property investments and major project funding proposals will require the submission of a life-cycle cost analysis, including the shadow price of carbon (TBS 2022). This helps to ensure investments are low-carbon and frames carbon emission reduction as cost-effective (Pouikli 2021).

Financing instruments

Barriers to energy efficiency investments often exist, with the requirements of up-front capital investment and risk-averse lenders limiting traditional financing mechanisms (Gouldson et al. 2015). While improved resource efficiency in buildings can yield long-term cost savings, short-term risk can make it difficult to secure the initial funding required (van der Heijden 2017). With the intent to overcome barriers to financing low-carbon building projects, governments have started applying novel forms of financing instruments (van der Heijden 2017). Energy performance contracts (EPCs) are a financing mechanism that can be used to implement building retrofits. An energy service company (ESCO) assumes the initial capital costs of energy upgrade projects (NRCan 2018*c*). In a shared savings contract, the ESCO and the customer share the energy savings, with energy savings significant enough to pay back the project installation and financing costs (Stuart et al. 2018). The organization, seeing the upgrades, then repays the company over a specified period from the resulting energy savings (NRCan 2018*c*). EPCs allow customers to finance energy projects without high up-front capital (Stuart et al. 2018).

A revolving fund can also be used to finance projects, where the savings from investments in energy efficiency and other low-carbon buildings can be realized and reinvested into further projects (Gouldson et al. 2015). These types of funds have been utilized for a variety of purposes, including energy efficiency upgrades, renewable energy, clean water provision, and the clean-up of contaminated land (Gouldson et al. 2015). The government of the Northwest Territories operates a Capital Asset Retrofit Fund (CARF), which is a type of revolving fund for energy efficiency improvements of government-owned assets. CARF was created to target energy efficiency investments in public buildings and aims to reduce energy consumption and operational costs, improve building user comfort, reduce GHGs, increase the life of assets, and identify new energy technologies (Government of Northwest Territories 2020). Buildings first undergo an energy audit, including facility benchmarking, to see how energy usage compares to other buildings. The Department of Public Works and Services is then responsible for determining which buildings to retrofit and has completed over 30 retrofits ranging from

$10,000 to $1 million between 2007 and 2014 (Government of Northwest Territories 2020). This mechanism has sustained funding for further investment in energy efficiency projects.

Demand aggregation is another potential mechanism to realize cost savings using purchasing power and provide consistency to buyers (Uyarra and Flanagan 2010). This involves aggregating demand for a product or service, pooling procurement into one tender, and collaborating with multiple organizations to drive down prices (Walker et al. 2013; ICF 2018). The province of British Columbia has developed centralized supply arrangements to be used by all provincial public sector organizations and local governments, including products such as LED streetlights and electric vehicle charging stations (ICF 2018). Centralized procurements also reduce the time and cost for organizations to run procurements individually and reduce barriers to GPP (ICF 2018). Aggregating demand also benefits suppliers; demand supports innovation when a significant level of production is guaranteed, which reduces uncertainty for producers and allows producers to benefit from economies of scale (Uyarra and Flanagan 2010).

When undertaking projects for both retrofits and new construction, standardized practices, such as retrofit underwriting, can make building renovation projects more appealing to investors. Additional quality assurance practices help improve confidence in the viability of deep energy retrofit projects as reliable investments (Zhivov and Lohse 2021). Retrofit project underwriting standards can help assess the quality and risk of retrofit projects, and the standard can help reduce the uncertainty of investors that the project will achieve the stated energy efficiency or carbon reduction targets (CAGBC 2018). A standard approach for retrofit underwriting, such as the Investor Confidence Project (ICP), reduces transaction costs and makes risk assessment more efficient (CAGBC 2018). The ICP is becoming increasingly popular as a global standard for underwriting, developing, and measuring energy efficiency retrofit projects to measure project risk against expected outcomes (CAGBC 2018). Projects based on ICP protocols are certified with an Investor Ready Energy Efficiency (IREE) certification, which is made available to investors (CAGBC 2018).

Retrofit project bundling is another approach that reduces project risk and makes retrofits more attractive. Buildings often require multiple renovations at the same time as energy efficiency upgrades. By addressing multiple retrofit needs in a single project, funding can be streamlined and asset conditions can be improved. Likewise, not all efficiency upgrades in isolation are cost-effective; yet, combining retrofits in both heating systems with improved airtightness can achieve greater efficiency at the same time (Zhivov et al. 2015). Thus, bundling several retrofit upgrades is a more cost-effective means of capitalizing on opportunities during a single renovation.

Training and capacity building

Greening government commitments and strategies for a low-carbon portfolio require a large commitment to staff training and capacity for implementation. For example, barriers to measuring and managing energy consumption exist due to a lack of experience in energy management (CAGBC 2018). When it comes to GPP standards, a commitment to training, counselling, and monitoring of both public procurers and the administrative process is required (Pouikli 2021). Public officials must be able to understand GPP regulations, evaluate their benefits, and determine green criteria when awarding tenders (Pouikli 2021). Where there are financial constraints, ineffective administrative structures, and a lack of human resources, barriers to implementation may arise (Pouikli 2021). These challenges need to be acknowledged and dealt with for proper implementation of low-carbon building processes and measures.

Conclusion

Governments can retrofit their own building portfolios and construct more energy-efficient buildings to lead the low-carbon transition, in addition to providing funding and leading the initiative to deliver programs for energy efficiency. While the federal, provincial, and territorial governments in Canada account for a small amount of overall national GHG emissions, government leadership has impacts beyond emission reduction. The incorporation of greening government strategies has extended benefits beyond specific government properties, such as reducing operating costs, building energy system resiliency, growing the green building industry and market, demonstrating the economic competitiveness of clean energy, and encouraging alternative sustainable practices.

Globally, governments have made greening commitments through the adoption of directives, policies, and legislation. Despite the importance of these mandates, targets and policies for energy efficiency are more effective when paired with adequate governance structures, as exemplified by the Government of Canada's Centre for Greening Government. When considering transitioning to low-carbon building portfolios, the recommended energy management process by Natural Resources Canada includes a commitment to assessing performance, setting goals, creating an action plan, implementation, and evaluation. While many jurisdictions have set goals to achieve net zero standards in their building portfolios, further definition of these goals and GHG reduction targets is required prior to project implementation. Through benchmarking and developing carbon-neutral portfolio plans, asset managers can strategically identify GHG reduction projects and reduce implementation costs. By applying best industry practices such as the integrated design process in the planning and construction of new buildings, governments can share information on the process and project outcomes with the private sector. To overcome barriers to implementation, procurement standards can prioritize low-carbon solutions and guide decision-making. For procurement procedures, integration of standard environmental criteria, prioritizing outcomes over inputs, and requiring life cycle assessments all help support low-carbon and cost-effective investments. Instruments such as ESCOs, revolving funds, demand aggregation, retrofit project underwriting, and retrofit

project bundling can help overcome financing barriers and yield cost effective investments. Beyond making greening government commitments and encouraging these measures, training and capacity building within staff and project proponents is key for implementation. Through these actions, implementing measures for a low-carbon building portfolio can be streamlined to achieve climate change goals and ensure the government is leading in this transition.

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Author information

Author ORCIDs

A.S. Medeiros https://orcid.org/0000-0002-7743-2560

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References

Arjunan, P., Poolla, K., and Miller, C. 2022. BEEM: data-driven building energy benchmarking for Singapore. Energy and Buildings, **260**: 111869. doi:10.1016/j.enbuild.2022.111869.

Ascione, F., Bianco, N., Böttcher, O., Kaltenbrunner, R., and Vanoli, G.P. 2016. Net zero-energy buildings in Germany: design, model calibration and lessons learned from a case-study in Berlin. Energy and Buildings, **133**: 688–710. doi:10.1016/j.enbuild.2016.10.019.

Attia, S., Eleftheriou, P., Xeni, F., Morlot, R., Ménézo, C., Kostopoulos, V., et al. 2017. Overview and future challenges of nearly zero energy buildings (nZEB) design in Southern Europe. Energy and Buildings, **155**: 439–458. doi:10.1016/j.enbuild.2017.09.043.

BOMA Canada. 2021. What we do. Available from https://bomacanada.ca/bomabest/ [accessed 2 August 2022].

CAGBC. 2018. A roadmap for retrofits in Canada II: building strong market infrastructure for the retrofit economy. Available from https://portal.cagbc.org/cagbcdocs/advocacy/CaGBC_Roadmap_for_Retrofits_in_Canada_II_2018.pdf [accessed 2 August 2022].

CAGBC. 2022a. Canada Green Building Council, LEED: the international mark of excellence. Available from https://portal.cagbc.org/CAGBC/LEED/CAGBC/Programs/LEED/_LEED.aspx [accessed 2 August 2022].

CAGBC. 2022b. Zero carbon: a made-in Canada solution. Available from https://portal.cagbc.org/zerocarbon [accessed 2 August 2022].

CHBA. 2022. Canadian Home Builders Association. Net zero home labelling program. Available from https://www.chba.ca/CHBA/HousingCanada/Net_Zero_Energy_Program/CHBA/Housing_in_Canada/Net_Zero_Energy_Program/NZE_Program_Landing_Page.aspx?hkey=4af3da17-b4da-42ef-bf20-261a9cfbe39f [accessed 2 August 2022].

Causone, F., Tatti, A., and Alongi, A. 2021. From nearly zero energy to carbon-neutral: case study of a hospitality building. Applied Sciences, **11**(21): 10148. doi:10.3390/app112110148.

CSO. 2021. Office of the Federal Chief Sustainability Officer [CSO](2021, October 18). Greening government initiative: concept note. Available from https://www.sustainability.gov/pdfs/ggi-concept-note.pdf [accessed 2 August 2022].

CSO. 2022. Office of the Federal Chief Sustainability Officer [CSO]: countries and year joining GGI. Available from https://www.sustainability.gov/ggi/countries.html [accessed 2 August 2022].

Darko, A., Chan, A.P.C., Ameyaw, E.E., He, B.J., and Olanipekun, A.O. 2017. Examining issues influencing green building technologies adoption: the United States green building experts' perspectives. Energy and Buildings, **144**: 320–332. doi:10.1016/j.enbuild.2017.03.060.

Department for Environment Food and Rural Affairs 2021, October 28. Policy paper: greening government commitments 2021 to 2025. Gov.UK. Available from https://www.gov.uk/government/publications/greening-government-commitments-2021-to-2025/greening-government-commitments-2021-to-2025 [accessed 2 August 2022].

DFO. 2022. A tool for sustainable procurement. Available from https://kriterieveiviseren.difi.no/en [accessed 2 August 2022].

Efficiency Canada. 2021. Net zero energy ready buildings in Canada. Available from https://codes4climate.efficiencycanada.org/net-zero-energy-ready-buildings-in-canada [accessed 2 August 2022].

EPA (Environmental Protection Agency). 2009. Clean energy lead by example guide: strategies, resources, and action steps for state programs. Available from https://www.epa.gov/sites/default/files/2015-08/documents/state_lead_by_example_guide_full_report.pdf [accessed 2 August 2022].

ECCC (Environment and Climate Change Canada). 2016. Pan-Canadian framework on clean growth and climate change: Canada's plan to address climate change and grow the economy. Government of Canada, Ottawa, Canada. 78p.

ECCC (Environment and Climate Change Canada). 2020. A healthy environment and a healthy economy: Canada's strengthened climate plan to create jobs and support people, communities and the planet. Government of Canada, Gatineau, Canada.

European Union. 2023. Types of legislation. Available from https://european-union.europa.eu/institutions-law-budget/law/types-legislation_en.

Ghajarkhosravi, M., Huang, Y., Fung, A.S., Kumar, R., and Straka, V. 2020. Energy benchmarking analysis of multi-unit residential buildings (MURBs) in Toronto, Canada. Journal of Building Engineering, **27**: 100981. doi:10.1016/j.jobe.2019.100981.

Gouldson, A., Kerr, N., Millward-Hopkins, J., Freeman, M.C., Topi, C., and Sullivan, R. 2015. Innovative financing models for low carbon transitions: exploring the case for revolving funds for domestic energy efficiency programmes. Energy Policy, **86**: 739–748. doi:10.1016/j.enpol.2015.08.012.

Government of British Columbia 2022. Goods and services catalogue. BC procurement resources. Available from https://www2.gov.bc.ca/gov/content/bc-procurement-resources/buy-for-government/goods-and-services-catalogue [accessed 2 August 2022].

Government of Canada. 2022. Canadian net-zero emissions accountability act. Available from https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050/canadian-net-zero-emissions-accountability-act.html[accessed 22 June 2023].

Government of Northwest Territories. 2020. Tom Beaulieu: capital asset retrofit fund program update. Retrieved from https://www.gov.nt.ca/newsroom/tom-beaulieu-capital-asset-retrofit-fund-program-update [accessed 2 August 2022].

Green Building Canada. 2022. Green building certifications/rating systems. Retrieved from https://greenbuildingcanada.ca/green-building-guide/green-building-certifications-rating-systems-canada[accessed 2 August 2022].

Green Building Initiative. 2021. A practical approach to green building. Available from http://www.greenglobes.com/home.asp [accessed 2 August 2022].

Han. 2019. Governance for green urbanisation: lessons from Singapore's green building certification scheme. Environment and Planning C, Politics and Space, **37**(1): 137–156.

ICF. 2018. Lights on the path: a compendium of best and promising practices for reducing greenhouse gas emissions and building resilience in government operations. Available from https://ccme.ca/en/res/compendium_for_greening_govt_ops_en.pdf [accessed 2 August 2022].

Jalaei, F., Masoudi, R., and Guest, G. 2022. A framework for specifying low-carbon construction materials in government procurement: a case study for concrete in a new building investment. Journal of Cleaner Production, **345**: 131056. doi:10.1016/j.jclepro.2022.131056.

Jradi, M., Liu, N., Arendt, K., and Mattera, C.G. 2020. An automated framework for buildings continuous commissioning and performance testing–a university building case study. Journal of Building Engineering, **31**: 101464. doi:10.1016/j.jobe.2020.101464.

Lam, T.Y.M. 2020. A sustainable procurement approach for selection of construction consultants in property and facilities management. Facilities (Bradford, West Yorkshire, England), **38**(1/2): 98–113.

Lu, Y., Sood, T., Chang, R., and Liao, L. 2022. Factors impacting integrated design process of net zero energy buildings: an integrated framework. International Journal of Construction Management, **22**(9): 1700–1712. doi:10.1080/15623599.2020.1742625.

Makvandia, G., and Safiuddin, M. 2021. Obstacles to developing net-zero energy (NZE) homes in greater Toronto area. Buildings, **11**(3): 95. doi:10.3390/buildings11030095.

Mendez, C., and Atkinson, C.L. 2021. Sustainability certification and green public procurement: ideals and outcomes in a New Jersey school district. Journal of Education for Sustainable Development, **15**(1): 122–145. doi:10.1177/09734082211012555.

Motiva. 2021. Sustainable development company. Retrieved from https://www.motiva.fi/motiva [accessed 2 August 2022].

NRCan (Natural Resources Canada). 2014. Improve your building's energy performance: energy benchmarking primer. Available from https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/files/pdf/publications/commercial/BenchmarkPrimer_eng.pdf [accessed 2 August 2022].

NRCan (Natural Resources Canada). 2018a. Recommended methodology. Available from https://natural-resources.canada.ca/energy-efficiency/buildings/nrcans-greening-government-services/recommended-methodology/20753 [accessed 22 June 2023].

NRCan (Natural Resources Canada). 2018b. Details of the R-2000 Standard. Available from https://www.nrcan.gc.ca/energy-efficiency/homes/professional-opportunities/become-energy-efficient-builder/details-the-r-2000-standard/20588[accessed 2 August 2022].

NRCan (Natural Resources Canada). 2018c. Project planning and implementation. Government of Canada. Available from https://www.nrcan.gc.ca/energy/efficiency/energy-efficiency-buildings/nrcans-greening-government-services/support-federal-facilities/project-planning-and-implementation/20745 [accessed 2 August 2022].

NRCan (Natural Resources Canada). 2019. Guidelines for energy management. Government of Canada. Available from https://natural-resources.canada.ca/sites/www.nrcan.gc.ca/files/energy/pdf/EM%20Guidelines%20Eng%20Mar_27_2019.pdf [accessed 22 June 2023].

NRCan (Natural Resources Canada). 2021. RETScreen. Government of Canada. Available from https://www.nrcan.gc.ca/maps-tools-and-publications/tools/modelling-tools/retscreen/7465 [accessed 2 August 2022].

NRCan (Natural Resources Canada). 2022. NRCan greening government services. Government of Canada. Available from https://natural-resources.canada.ca/energy-efficiency/buildings/nrcans-greening-government-services/3705 [accessed 23 June 2023].

OECD (Organisation for Economic Co-operation and Development). 2015. Going green: best practices for sustainable procurement. Available from https://www.oecd.org/gov/ethics/Going_Green_Best_Practices_for_Sustainable_Procurement.pdf [accessed 2 August 2022].

Pacheco-Blanco, B., and Bastante-Ceca, MJ. 2016. Green public procurement as an initiative for sustainable consumption. An exploratory study of Spanish public universities. Journal of Cleaner Production, **133**: 648–656. doi:10.1016/j.jclepro.2016.05.056.

Pouikli, K. 2021. Towards mandatory Green Public Procurement (GPP) requirements under the EU Green Deal: reconsidering the role of public procurement as an environmental policy tool. ERA Forum, **21**(4): 699–721. doi:10.1007/s12027-020-00635-5.

PSPC (Public Services and Procurement Canada). 2017. Carbon-neutral portfolio plan. WSP Canada Ltd., Toronto, Canada. Project no: 161-15230-02.

PSPC (Public Services and Procurement Canada). 2019. Integrated design process. Government of Canada. Available from https://www.tpsgc-pwgsc.gc.ca/biens-property/sngp-npms/bi-rp/conn-know/enviro/pci-idp-eng.html [accessed 22 June 2023].

Resende, J., Monzon-Chavarrias, M., and Corvacho, H. 2021. The applicability of nearly/net zero energy residential buildings in Brazil—a study of a low standard dwelling in three different Brazilian climate zones. Indoor and Built Environment, **30**(10): 1693–1713. doi:10.1177/1420326X20961156.

Röck, M., Saade, M.R.M., Balouktsi, M., Rasmussen, F.N., Birgisdottir, H., Frischknecht, R., et al. 2020. Embodied GHG emissions of buildings–the hidden challenge for effective climate change mitigation. Applied Energy, **258**: 114107. doi:10.1016/j.apenergy.2019.114107.

Roh, S., Tae, S., and Shin, S. 2014. Development of building materials embodied greenhouse gases assessment criteria and system (BEGAS) in the newly revised Korea Green Building Certification System (G-SEED). Renewable and Sustainable Energy Reviews, **35**: 410–421. doi:10.1016/j.rser.2014.04.034.

SBC (Statutes of British Columbia). 2007. Climate Change Accountability Act. SBC (2007, c.42). Available from https://canlii.ca/t/84p6 [accessed 2 August 2022].

SC (Statutes of Canada). 2021. Canadian Net-Zero Emissions Accountability Act, SC (2021, s.6.). Available from https://canlii.ca/t/5552q [accessed 2 August 2022].

SNS (Statutes of Nova Scotia). 2021. Environmental Goals and Climate Change Reduction Act [EGCCRA], SNS (2021, s.7(f)). Retrieved from https://canlii.ca/t/556t6[accessed 2 August 2022].

Shirinbakhsh, M., and Harvey, L. 2021. Net-zero energy buildings: the influence of definition on greenhouse gas emissions. Energy and Buildings, **247**: 111118. doi:10.1016/j.enbuild.2021.111118.

Stuart, E., Carvallo, J.P., Larsen, P.H., Goldman, C.A., and Gilligan, D. 2018. Understanding recent market trends of the US ESCO industry. Energy Efficiency, **11**(6): 1303–1324. doi:10.1007/s12053-018-9633-9.

TBS (Treasury Board of Canada Secretariat). 2022. Greening Government Strategy: A Government of Canada Directive. Government of Canada. Available from https://www.canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/strategy.html [accessed 2 August 2022].

TBS (Treasury Board of Canada Secretariat). 2021. Horizontal fixed asset review: executive summary of the final report. Government of Canada. Available from https://www.canada.ca/en/treasury-board-secretariat/corporate/reports/improving-results-2017-horizontal-depa

rtmental-reviews/horizontal-fixed-asset-review-executive-summary-final-report.html [accessed 2 August 2022].
Torcellini, P., Pless, S., Deru, M., and Crawley, D. 2006. Zero energy buildings: a critical look at the definition (No. NREL/CP-550-39833). National Renewable Energy Lab, Golden, CO.
United Nations Environment Programme. 2022. 2022 Global status report for buildings and construction: towards a zero emission, efficient and resilient buildings and construction sector. Nairobi.
Uyarra, E., and Flanagan, K. 2010. Understanding the innovation impacts of public procurement. European Planning Studies, **18**(1): 123–143. doi:10.1080/09654310903343567.
van der Heijden, J. 2017. Eco-financing for low-carbon buildings and cities: value and limits. Urban Studies, **54**(12): 2894–2909. doi:10.1177/0042098016655056.
Walker, H., and Brammer, S. 2009. Sustainable procurement in the United Kingdom public sector. Supply Chain Management: An International Journal, **14**(2): 128–137.
Walker, H., Schotanus, F., Bakker, E., and Harland, C. 2013. Collaborative procurement: a relational view of buyer–buyer relationships. Public Administration Review, **73**(4): 588–598. doi:10.1111/puar.12048.
Yu, Z., Geng, Y., He, Q., Oates, L., Sudmant, A., Gouldson, A., and Bleischwitz, R. 2021. Supportive governance for city-scale low carbon building retrofits: a case study from Shanghai. Climate Policy, **21**(7): 884–896. doi:10.1080/14693062.2021.1948383.
Zhivov, A., Lohse, R., Shonder, J.A., Nasseri, C., Staller, H., Moerck, O., and Nokkala, M. 2015. Business and technical concepts for deep energy retrofit of public buildings. ASHRAE Tranactions, **121**(2): 111–129.
Zhivov, A.M., and Lohse, R. 2021. Deep energy retrofit—a guide for decision makers. Springer International Publishing, Champaign, IL. 96p.
Zuo, J., and Zhao, Z. 2014. Green building research–current status and future agenda: a review. Renewable and Sustainable Energy Reviews, **30**: 271–281. doi:10.1016/j.rser.2013.10.021.