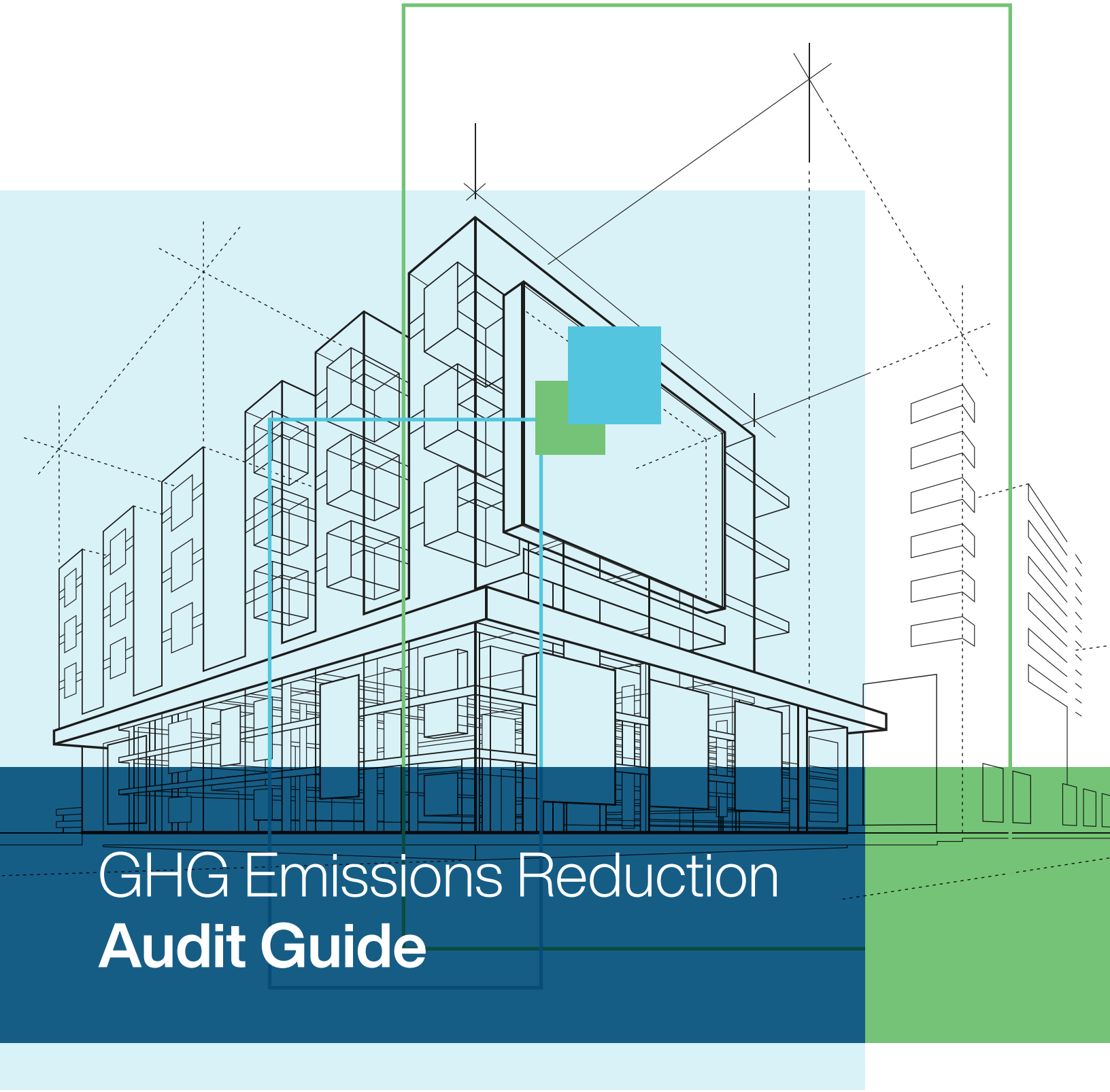

GHG Emissions Reduction
Audit Guide

A Checklist for Building Owners and Managers

Natural Resources Canada
Ressources naturelles Canada

Canada

This **GHG Emissions Reduction Audit Guide** is owned by Natural Resources Canada (the "NRCan Guide") and is an adaptation of the document entitled GHG Emissions Reduction Audit (the "US-DOE Guide") originally published by the US Department of Energy as part of the Better Climate Challenge.

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GHG EMISSIONS REDUCTION AUDIT GUIDE

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Introduction

This resource includes guidance and an accompanying checklist that details recommended services and deliverables for a building-level greenhouse gas (GHG) emissions reduction audit for operational Scope 1 and 2 GHG emissions[1].

The GHG emissions reduction audit scope is compatible with an ASHRAE Standard 211 Level 2 energy audit or ISO 50002 Tier 2 energy audit, but with a few key differences.

The emissions reduction audit specified in this guidance document:

- → includes a calculation of GHG emissions reductions in addition to energy and utility cost savings
- → focuses on major equipment and all fossil-fuel combustion equipment. An exhaustive inventory of all heating, ventilation and air conditioning (HVAC) equipment may not be required
- → includes evaluation of the following GHG emissions reduction strategies:
  - › reduce or eliminate on-site fossil-fuel combustion through electrification and system efficiency improvements
  - › reduce or eliminate fugitive emissions from refrigerants
  - › install on-site renewable energy sources
- → results in a long-term plan, with consideration of phased implementation of measures to align with capital planning

[1] Scope 1 emissions consist of direct GHG emissions from sources controlled or owned by an organization such as boilers, furnaces, and vehicle fleets. Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heating, or cooling.

The audit will determine achievable levels of emissions reductions at a building through energy efficiency, electrification, fugitive emissions reduction and the addition of on-site renewable energy.

Additional emissions reduction audit services such as off-site renewables, energy storage and electric vehicle (EV) charging are listed as optional in this guidance but may be included in the audit scope.

This audit guidance focuses on identifying on-site actions and does not include analysis of renewable energy credits (RECs) or clean energy purchases (such as clean electricity, renewable natural gas and biomass). However, emissions reductions at the building level will reduce the need for RECs and clean energy purchases.

How to Use this Resource

This document consists of two main sections: (1) the GHG Emissions Reduction Audit Guidance, and (2) the GHG Emissions Reduction Audit Checklist.. The guidance portion includes a detailed description of each task that should be carried out by an auditor, with examples.

The owner can use the checklist to validate the scope of the audit. Both sections are meant to be used in parallel with one another. Additional resources are provided in Appendix B.

Owners or organizations with portfolio-level GHG emissions reduction targets can use this resource in parallel with the NRCan's Framework for GHG Emissions Reduction Planning: Building Portfolios (published in 2025).

The framework outlines how to scale the results of a building-level audit across a portfolio of buildings.

GHG Emissions Reduction Audit Guidance

This guidance is intended to be used by building owners to help develop a GHG emissions audit scope of work that is comprehensive and effective, resulting in building-level solutions that will reduce operational emissions to meet targets. A GHG emissions reduction audit can be broken into four specific tasks, as defined in Figure 1. At a minimum, the audit will involve the following parties:

- → building owner or owner's representative such as a property manager (owner)
- → GHG emissions reduction auditor (auditor)
- → building engineer and building operator (operator)

FIGURE 1. Tasks in a GHG Emissions Reduction Audit

Data Collection and Target Setting

- compile building documentation and energy data
- calculate Scope 1 and 2 emissions
- building-level GHG emissions reduction targets

On-site Inspections

- existing equipment assessment
- electrical service capacity
- combustion equipment inventory
- on-site renewable energy assessment
- initial assessment report

Analysis and Reporting

- emissions reduction measures
- electrification options
- on-site renewable energy analysis
- low-emissions measure packages
- emissions reduction audit report

Selection and Implementation by Owner

- evaluate scenarios and select strategy
- develop scope and solicit bids for work
- commission systems and monitor performance

Optional Audit Scope

- → EV charging assessment
- → electrical panel load study
- → existing building commissioning (EBCx) or monitoring-based commissioning
- → energy storage assessment
- → demand management and load flexibility assessment

TASK 1

Data Collection and Target Setting

Coordination between the auditor and owner on the goals of the audit will enable the auditor to develop emissions reduction measures that align with the owner's anticipated plans for the building. The two main goals in Task 1 are to define current operational emissions and to develop building-level GHG emissions reduction targets that will guide the audit.

Compile Building Documentation and Energy Data

The owner should compile relevant building documentation and share it with the auditor for review. Utilizing existing information will minimize the time spent collecting HVAC system information, and the GHG emissions reduction audit can build upon any energy efficiency improvements already implemented.

Relevant information can include:

- → as-built drawings
- → equipment inventories and data sheets or shop drawings
- → property condition assessments and capital plans
- → refrigerant leakage and repair documentation
- → prior energy or GHG emissions reduction audits (completed within the past five years)
- → access to data from a building automation system

The auditor will work with the owner to compile monthly historical energy consumption to determine annual consumption of electricity, natural gas, and any other sources (including on-site renewable energy) and their associated GHG emissions. The owner is encouraged to provide at least five years of data, including data from 2019 or earlier, to benchmark typical operation prior to COVID disruptions. The auditor should review the data to verify that it makes sense and includes the required data points.

Calculate Scope 1 and 2 Emissions

The historical energy consumption data can be used to calculate the building's Scope 1 and 2 emissions. The owner and auditor should agree on applicable GHG emissions factors according to local jurisdiction and for all energy sources, prior to the detailed analysis portion of the audit. Standard Canadian emission factors are published by Environment and Climate Change Canada (ECCC) in the report Emission Factors and Reference Values. If the building's emissions have been calculated for previous years as part of a GHG inventory, the owner can share them directly with the auditor to avoid duplication of effort.

Building-level GHG Emissions Reduction Targets

The auditor will collaborate with the owner to establish GHG emissions reduction targets for the building. The owner may instruct the auditor to evaluate multiple targets or offer projections for options that are phased over time to align them with long-term capital plans. Targets should be aligned with those of the Government of Canada or local jurisdictions.

GHG Emissions Baseline

A GHG emissions baseline is required to set the reduction target. This baseline is the total amount of emissions in a specific year, also known as the baseline year, and is used to validate GHG emissions reductions in quantity and percentage.

Under Canada's 2030 Emissions Reduction Plan, the emissions baseline year is 2005. However, this reference year may differ in certain circumstances, such as:

- → The building was built after 2005.
- → Emissions data for 2005 are not available.
- → Local regulations impose other rules on baseline setting.
- → Other building-specific objectives may also justify the choice of a different reference year (see **TASK 1**).

TASK 1

The building-level targets may be informed by:

- short- and long-term plans for the building
- long-term capital plans and upcoming equipment replacements
- changes in occupancy
- desired financial analysis needed (simple payback, net present value [NPV])
- the owner's portfolio-level emissions reduction plans
- local building performance standards (BPS) or GHG emissions reduction regulations
- Canada's 2030 Emissions Reduction Plan
- the Canadian Net-Zero Challenge

The building may be in a jurisdiction with local building performance standards that mandate a targeted energy and GHG emissions level for the building. The auditor should provide an overview of current jurisdictional requirements and any future requirements that are being developed by provinces, territories and municipalities. These requirements could influence the goals for the audit.

As noted in the introduction, unless desired by the owner, RECs and clean energy purchases will not be evaluated. Deep emissions reductions at the building level will reduce the need for RECs and clean energy purchases.

The emissions reduction target may require adjustment based on the outcome of the audit analysis. If it is too costly or not technically feasible to meet the emissions reduction target, then the target may need to be lowered based on conversations between the owner and auditor. However, the intent of this audit is to offer pathways to deep emissions reductions, beyond what is typically identified through energy audits.

TASK 2

On-site Inspections

On-site inspections provide the auditor with invaluable information to inform emission reduction options. Task 2 results in an initial assessment report that the auditor will review with the owner, which will inform the next two tasks.

TABLE 1. On-site Inspection Scope

TYPICAL ENERGY AUDIT SCOPE
Building envelope:
• Evaluate glazing condition and quality of seals. • Visually assess the condition of the existing building envelope.
HVAC and domestic hot water systems:
• Inventory the HVAC system's condition. • Assess controls, including sequences and setpoints. • Evaluate ventilation flows, economizer operation, and heat recovery systems. • Identify equipment in need of repair or near end of life.
Lighting and plug loads:
• Assess current lamp technology and candidates for retrofits or replacements (interior and exterior). • Inspect lighting controls and operation (occupancy sensors, daylight sensors, time clocks). • Assess IT and equipment plug loads in typical spaces.
ADDITIONAL GHG EMISSIONS REDUCTION AUDIT SCOPE
HVAC and domestic hot water electrification:
• Assess feasibility for changes in HVAC system type for electrification or major efficiency improvement. • Analyze an inventory of all refrigerant volumes and refrigerant types. • Document any space constraints that would affect future equipment replacements.
Electrical service:
• Assess existing electrical service capacity by adding nameplate capacity of the connected equipment. • Identify and document electrical panels situated in locations suitable for future gas equipment replacements or EV charging. • Make note of available breakers for future electrification loads.
Combustion appliances:
• Assess gas-fired equipment such as cooking equipment, clothes dryers and fireplaces.
On-site renewable energy:
• Assess the roof condition and availability of space on the roof or elsewhere on-site for solar photovoltaic (PV) panels. • Consider other renewable energy sources, as appropriate.

On-site Inspection Scope

The auditor's on-site inspection will include assessment of all major building systems, as outlined in Table 1. The inspections should include all the major equipment outlined in the energy audit methodology of a standard such as ASHRAE Standard 211 or ISO 50002, with a focus on fossil-fuel combustion equipment on site.

Initial Assessment Report (IAR)

Shortly after the on-site inspection, the auditor will provide an initial assessment report (IAR) to the owner and schedule a meeting to discuss the findings. A recommended outline of the IAR is included in Appendix A. The IAR provides the following guidance:

- initial summary of inspection conditions (prior to detailed analysis)
- inventory of on-site emissions sources
- emissions reduction considerations
- operations and maintenance (O&M) improvements that should be addressed in the short term
- a list of potential emissions reduction measures (ERMs)

O&M improvements identified by the auditor in the IAR should be implemented by the owner and building operator in the short term. Examples of O&M improvements include:

- reprogramming of thermostats and lighting controls to setback during unoccupied hours
- coordination of setpoints to avoid simultaneous heating and cooling
- replacement/calibration of sensors, replacing clogged filters, and other maintenance issues
- adjustment of economizer operation

The owner should review the IAR and provide feedback to the auditor to confirm that the potential ERMs that will be investigated during the Analysis and Reporting task align with the owner's targets and capital plans. In discussing the IAR findings, the owner and auditor may consider revising emissions reduction targets higher or lower based on this initial assessment.

TASK 3

Analysis and Reporting

Task 3 includes a detailed analysis of emissions reduction measures and then combines measures into low-emissions measure packages that achieve intended reduction targets. In addition to cost and savings analysis, this task includes an assessment of implementation phasing. The task culminates in an emissions reduction audit report for the building.

TABLE 2. Scope of Emissions Reduction Measures

TYPICAL ENERGY AUDIT SCOPE
Energy Efficiency ERMs:
• Energy efficiency measures should include all major building systems (building envelope, HVAC, domestic hot water, electrical, lighting, receptacle loads, etc.). • As applicable, measures should include evaluation of building controls and additional sensor-based capabilities, such as daylight dimming, demand control ventilation, occupancy-based lighting and thermostat controls. • Measures should include an assessment of energy management and information system (EMIS) opportunities to enable tracking energy and emissions performance over time.
ADDITIONAL GHG EMISSIONS REDUCTION AUDIT SCOPE
Electrification ERMs (includes partial electrification solutions):
• Electrification ERMs provide at least one all-electric replacement option for all fossil-fuel combustion equipment on-site (boilers, furnaces, water heaters, unit heaters and other devices). Replacement of heating equipment should utilize heat pumps and limit electric resistance heating. The analysis of this option should include needs for upgrading building electrical service. • Partial electrification of fossil-fuel combustion equipment (also known as hybrid system) is a viable solution that can provide significant emissions reductions. An example of a partial electrification solution is the use of heat pumps to serve most loads, supplementing with gas equipment for peak loads or back-up heating. • Electrification may require reduction of peak electrical demand through a combination of thermal and electrical energy efficiency and energy storage. • As part of electrification solutions, various heat pump technologies may be considered, such as cold-climate heat pumps, which allow more operating hours during the cold season, ground-source heat pumps and high temperature heat pumps, which can produce heating water at 80 °C and above.
Fugitive Emissions Reduction ERMs:
• Include measures to mitigate leaks from equipment containing refrigerants. • Investigate the use of low-global warming potential (GWP) refrigerants as part of any ERMs with new heat pump or refrigeration equipment. Retrofit existing equipment with refrigerant conversion, drop-in options, etc.
Renewable Energy ERMs:
• Include a feasibility study of on-site renewable energy production based on the available space noted during the on-site inspection. • Renewables can include solar PV, solar thermal, and wind turbines, depending on the climate and solar/wind resources. • The assessment should include viability of installation on the building roof or surrounding property, such as PV parking canopies or on-grade installations. The assessment should include analysis of local shading conditions and code constraints that may limit the availability of space for potential solar capacity. • The owner may elect to use a separate consultant to provide the renewable energy assessment. In such an instance, the renewable energy assessment should be provided to the auditor for inclusion in the ERM analysis and measure packages. Other options may include providers of “energy as a service” for thermal and/or electrical energy procurements.

Emissions Reduction Measures

The ERMs that should be assessed in the Emissions Reduction Audit are shown in Table 2, organized by measures typically included in an energy audit and additional GHG emissions-reduction measures.

The auditor should provide a summary of all ERMs identified for the building. The summary should include the impacts on operational costs, energy use and emissions, as outlined in Table 3. The emissions reductions should be calculated using emissions factors coordinated between the owner and auditor in Task 1. At a minimum, the measure should include an estimate of capital costs and a simple payback calculation. However, the owner may elect to have the auditor conduct a more comprehensive lifecycle cost analysis to understand the long term financial effects.

The summary table also should include a recommended prioritization or implementation schedule, estimated capital cost, and simple payback period. Depending on the local electric grid emissions, electrification of systems may increase GHG emissions in the near term prior to the decarbonization of the electric grid. However, on-site renewables and clean power procurement can reduce this impact.

TABLE 3. Typical ERM Summary Example

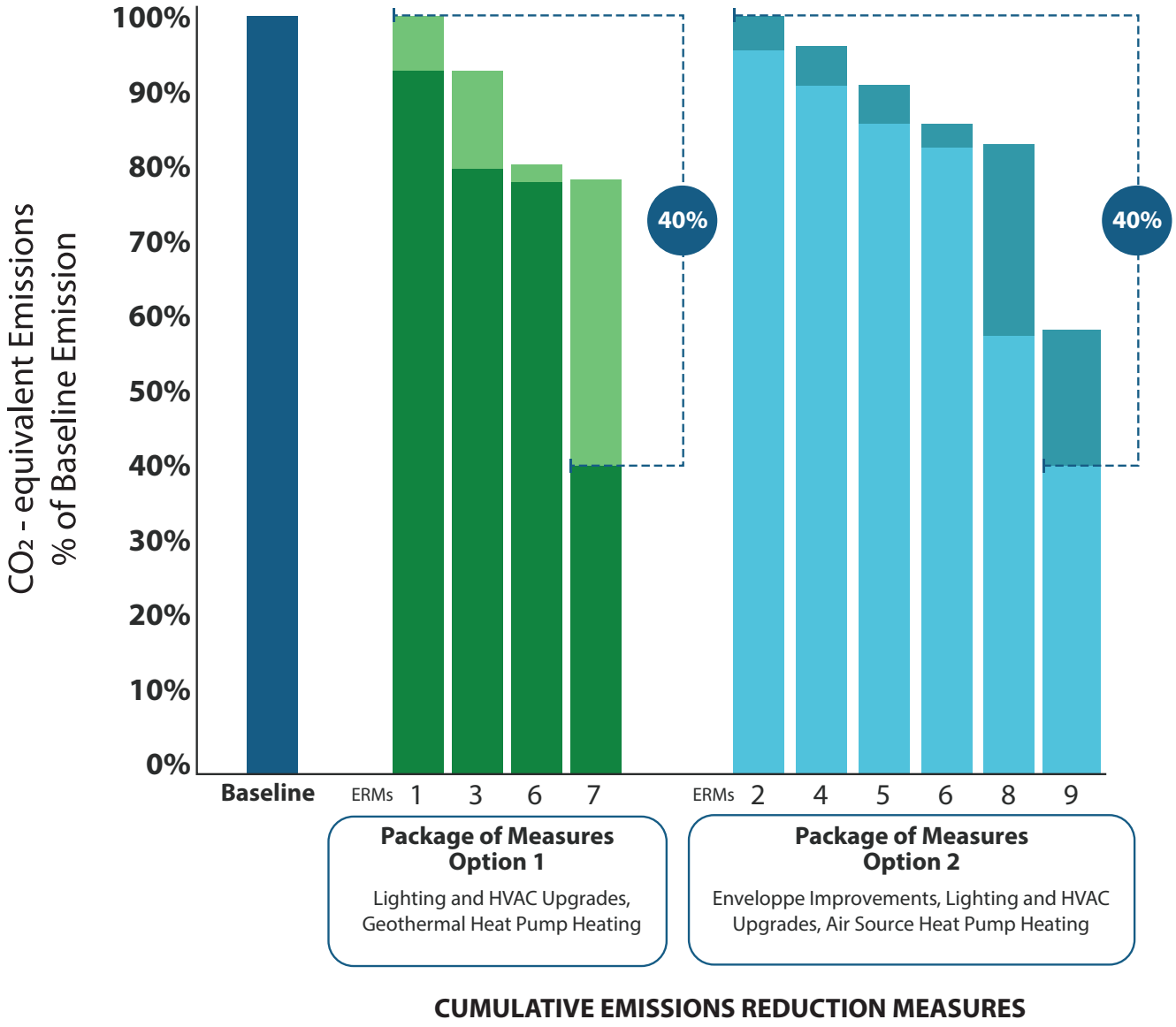
EMISSIONS REDUCTION MEASURE	ERM DESCRIPTION
ELECTRICITY SAVINGS	Annual kWh saved
NATURAL GAS SAVINGS	Annual Gigajoules or cubic meters saved
ENERGY COST SAVINGS	Annual cost saved
ANNUAL GHG EMISSIONS REDUCTION	Annual kilograms of CO2-equivalent saved (kg CO2e)
CAPITAL COST	Estimated implementation costs
SIMPLE PAYBACK	Capital cost/annual energy savings
IMPLEMENTATION TIME FRAME	Short, medium or long term

Low-Emissions Measure Packages

Based on the GHG emissions reduction targets established at the outset of the audit, the auditor will combine identified ERMs from the summary table into packages of measures that meet the building's emissions reduction targets.

The Auditor's recommendations should emphasize operational improvements and load reduction first, which can reduce the size of future equipment replacements and increase the impact of any on-site renewable energy systems.

FIGURE 2. Low-Emissions Measure Packages to Achieve 40% Emissions Reduction



Each low-emissions measure package should include the same information as noted for each individual measure in the ERM summary table but incorporate the interactive impact of multiple measures. For example, lighting upgrades reduce cooling loads, which reduce the required size of HVAC equipment.

The auditor should recommend an order in which each package's measures should be implemented to maximize the emissions benefit and align with the owner's future capital improvement plans. For example, a heat recovery device installed as part of a ventilation system upgrade can reduce peak heating loads, which in turn reduces the capacity requirement for a future heat pump replacement of an existing gas furnace.

The proposed packages may include replacements of fossil-fuel combustion equipment, but there may also be alternative packages that can achieve the intended emissions targets without full electrification. Figure 2 provides an example of how the auditor can bundle ERMs in different combinations to provide pathways to the emissions reduction target.

Emissions Reduction Audit Report

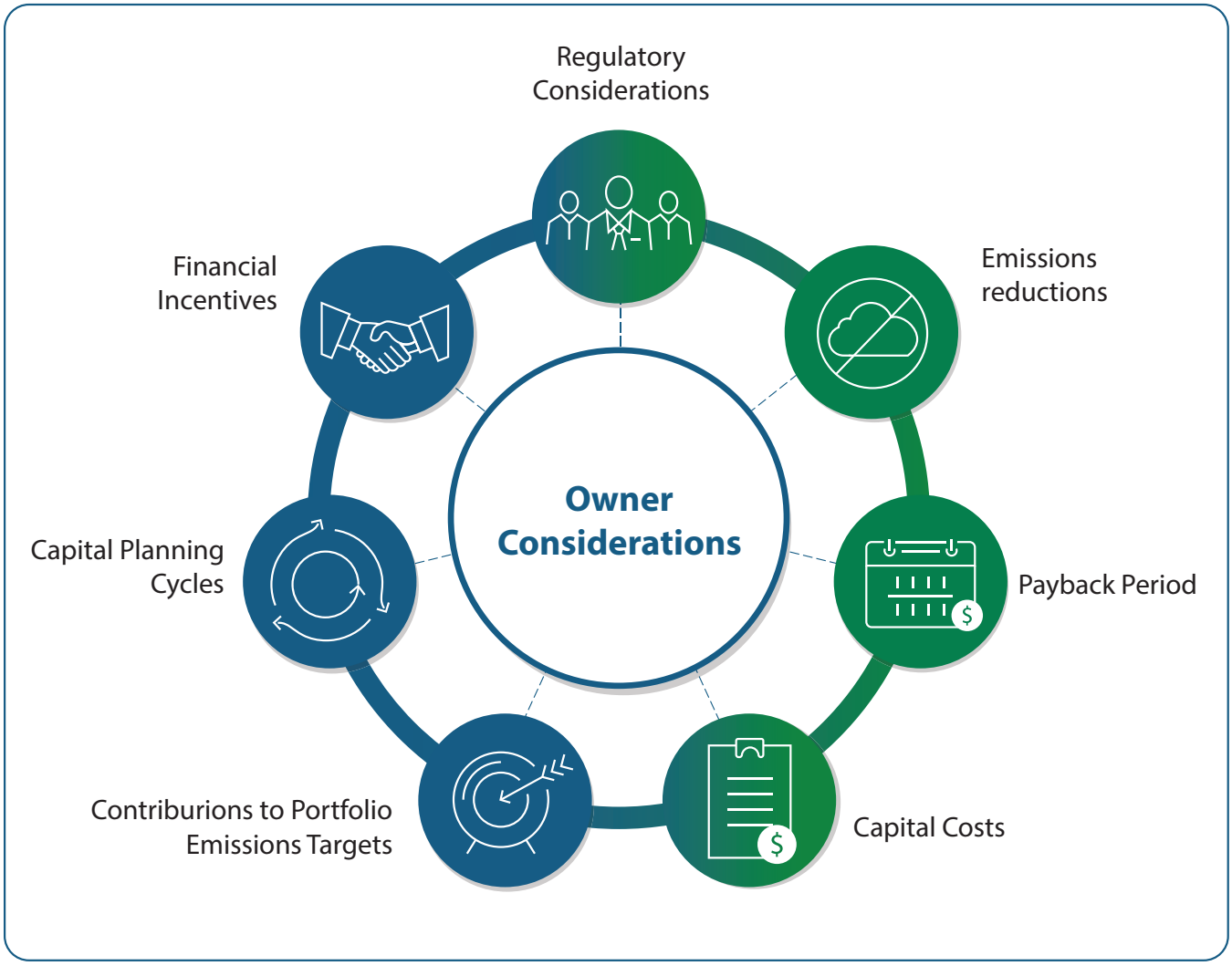
The auditor will provide all the inspection and analysis information, including the ERMs and low-emissions measure packages, in a summary report for the owner. An example audit report outline is provided in Appendix A.

TASK 4

Selection and Implementation by Owner

The owner should work with the auditor, building operator, and any other relevant stakeholders to evaluate the different low-emissions measure packages laid out in the audit report. When selecting one of the packages as the preferred pathway for implementation, the owner may consider things like capital planning cycles and financial incentives, as outlined in Figure 3.

FIGURE 3. Owner Considerations



Once a pathway has been selected, the owner can develop the scope of work for ERMs that may require a request for proposals (RFPs) to solicit bids. Some ERMs may be installed readily, while others may require design engineering and building permits for proper implementation. After the ERMs have been implemented, all equipment should be commissioned to verify that the modified systems will perform as intended.

The ERMs identified in the building-level emissions reduction audit also can be used to inform an owner's portfolio-level plans. The owner can extrapolate results from the audit across similar buildings to estimate emissions reduction impacts across their portfolio. This can help the owner understand additional efforts needed to meet portfolio-level emissions reduction targets, such as investment in off-site renewable energy capacity.

Optional Audit Scope

If possible, the following activities should be included in the Emissions Reduction Audit scope. Some of these tasks may not be applicable to the building (e.g., electrical panel load study) or may be planned for the future (e.g., monitoring-based commissioning).

Electrical Panel Load Study

Electrical capacity constraints can be a barrier to replacing fossil-fuel combustion equipment with electrically powered alternatives. New equipment, such as heat pumps or induction cooktops, may require electrical service that exceeds the "nameplate" rating of available electrical panel capacity. However, it is possible that previously connected equipment does not utilize all the allocated capacity.

The owner may consider implementing a detailed study of historical electrical loads to understand how much of the building's rated electrical supply is used during operation and develop a more detailed assessment of capacity availability to support heat pumps, EV chargers and other electrified equipment included in decarbonization measures. This analysis can help reduce or avoid the cost of installing additional electrical infrastructure.

A load study requires an electrical engineer to review historical meter data, measure building loads, and assess existing infrastructure and capacity at existing panels, which is beyond the basic scope of an audit. This study should be done prior to the audit analysis (Task 3) so an understanding of available capacity can be included in the development of ERMs and cost analysis.

Existing Building Commissioning (EBCx[2]) or Monitoring-based Commissioning

The owner may request that the auditor provide an in-depth commissioning process to address operational improvements of existing systems, especially when the HVAC systems are complex. Existing building commissioning generally includes a deeper level of control-system trend data analysis than an energy audit; see NRCan's documents entitled Existing Building Commissioning (EBCx) and Retrofit Hub for useful information in this area..

Further, the commissioning provider can support the owner in implementing an energy management and information system (EMIS) to continuously track building performance and identify areas of degradation and additional savings opportunities. For information on monitoring-based commissioning using an EMIS, see NRCan's Energy Management Information Systems (EMIS) and DOE's Smart Energy Analytics Campaign Toolkit.

[2] EBCx includes Recommissioning, Retro-Commissioning and Ongoing Commissioning.

Energy Storage Assessment

The owner may request that the auditor evaluate the potential for on-site battery storage and thermal energy storage. While storage does not directly reduce energy consumption, it reduces the need for additional heat pump capacity and associated electrical service capacity when transitioning away from on-site fossil-fuel usage. Energy storage also reduces peak demand charges and dependency on fossil fuel-based emergency backup generators.

Thermal energy storage can supplement either heating or cooling. Heat pumps or other heating and cooling equipment can be used in conjunction with on-site water tanks, which are heat banks to store excess thermal energy. Thermal storage can augment the use of heat pumps for space heating and service hot water, providing additional heat during extreme cold events and reducing the overall heat pump capacity necessary to meet peak design conditions, thus decreasing heat pump captital costs. Thermal storage can also be leveraged to flatten peak cooling demand during the summer, lessening the load on chillers and reducing peak demand charges for electricity.

Battery energy storage systems (BESS) can be utilized as on-site storage of electricity generated from on-site solar production or electricity sourced from the grid during periods of low carbon emissions. The stored electricity can be tapped during periods of peak demand (either at the site or on the grid) or serve as short-term emergency power.

Demand Management and Load Flexibility Assessment

The auditor may evaluate the current controls infrastructure for the feasibility of participating with local demand management programs. Load flexibility can help alleviate peak loading on power grids and potentially allow the building to respond to time-based carbon emissions factors. Examples of methods to reduce peak demand include:

- → adjustment of thermostat setpoints
- → shutoff of non-essential lighting
- → operation of energy storage equipment

The auditor may present options to the owner to implement demand management and evaluate the financial benefits of participating in a demand management program.

EV Charging Assessment

The auditor may evaluate the feasibility of adding EV charging stations to the building and consider smart charging strategies to manage peak demand. This assessment would require evaluation of electrical capacity, ability to submeter the chargers for energy monitoring and necessity of additional electrical infrastructure to handle the loads in parking areas.

GHG Emissions Reduction Audit Checklist

This checklist is a summary of the steps necessary for a successful greenhouse gas (GHG) emissions reduction audit. The building owner can use this checklist to validate the scope of the audit. Please refer to the Emissions Reduction Audit Guidance narrative for a detailed description of audit tasks and additional services that could be included.

Task 1

Data Collection and Goal Setting

- ☐ The owner compiles records of all metered energy data, as-built drawings, and equipment submittals for the auditor, as well as results from any previous energy audits. At a minimum, monthly energy use data for the most recent year as well as for the baseline year of 2005 should be provided.

- ☐ The owner or auditor calculates current Scope 1 and 2 emissions for the total building based on metered data and applicable GHG emissions factors (using the Emission Factors and Reference Values report published by Environment and Climate Change Canada (ECCC) with GHG Inventory data if available).

- ☐ The owner and auditor work together to develop goals for the Scope 1 and 2 operational emissions reductions for the audited building. This audit is intended to confirm this building's potential contribution to the portfolio-level target through improvements to the site. Targets should not include the use of RECs or clean energy purchases.

Owner Considerations:

- → The building's emissions may already have been calculated as part of a portfolio-level analysis. In this case, the owner can share monthly energy and emissions data directly with the auditor.
- → Consider how the emissions reductions targets for this building relate to your organization's portfolio-level emissions goals. These may be driven by internal mandates, local building performance standards, upcoming GHG emission legislation or Canada's 2030 Emissions Reduction Plan.
- → The GHG emissions factors used in the analysis should be agreed upon prior to the audit and should follow industry standard emission factors as published by Environment and Climate Change Canada in Emission Factors and Reference Values. The owner may elect to also evaluate projections of future emissions factors to reflect changes on grid emissions.
- → Communicate to the auditor any significant capital plans for the building in the next five years, known end- of-life equipment replacement, or anticipated changes in occupancy or operations.

Task 2

On-site Inspections

- ☐ Assess the building systems for potential operational deficiencies and opportunities for emissions reductions:
  - → building envelope
  - → HVAC equipment and controls
  - → domestic hot water heating
  - → lighting and controls
  - → receptacle loads
  - → refrigeration systems
  - → fossil-fuel combustion appliances and equipment
- ☐ Evaluate electrical service capacity to the building and panel locations where future equipment could be added. Identify and document electrical panels in locations where future gas equipment replacements or EV chargers may be located. Make note of available breakers for future loads.
- ☐ Analyze an inventory of all equipment containing refrigerants.
- ☐ Investigate solar readiness and availability of space for PV or solar thermal.
- ☐ Identify O&M improvements for immediate rectification.
- ☐ Provide an Initial Assessment Report (IAR) after the inspections but prior to the detailed analysis. The auditor, owner, and building operator should coordinate on measures to include in the Analysis portion of the audit.

Owner Considerations:

→ Meet with the auditor to discuss the Initial Assessment Report and review the findings together. Confirm that the auditor inspected all major building systems and agree on a selection of potential options to analyze as part of the Task 3 analysis.

Task 3

Analysis and Reporting

- ☐ Identify Emissions Reduction Measures (ERMs) to lower GHG emissions:
- ☐ Energy Efficiency ERMs
  - → Provide measures that reduce primary energy consumption within the building.
  - → Include options for all major building systems (building envelope, HVAC, domestic hot water, electrical, lighting, receptacle loads, etc.).
  - → Evaluate upgrades to building controls and additional controls for lighting and HVAC systems.
  - → Energy efficiency ERM scope should be aligned with an energy audit scope of work (such as ASHRAE Standard 211 Level 2 or ISO 50002 Type 2).
- ☐ Electrification ERMs
  - → Provide at least one all-electric ERM option to replace all the fossil-fuel combustion equipment on-site.
  - → Consider partial electric or hybrid solutions to supplement existing fossil-fuel combustion equipment or provide backup to a heat pump during extremely cold temperatures.
  - → Consider thermal and electrical energy storage to reduce peak electrical and heating loads in support of heat pump retrofit.
  - → Evaluate opportunities to electrify process loads, such as domestic water heaters, unit heaters and cooking appliances.
- ☐ Fugitive Emissions ERMs
  - → Include measures to mitigate leaks from equipment containing refrigerants.
  - → Consider low-GWP refrigerants during equipment replacements or as replacement refrigerants in existing equipment.

- [ ] Renewable Energy ERMs
  - → Include a feasibility study of on-site renewable energy on the rooftop or surrounding property.
- [ ] Provide estimates for each ERM in terms of energy savings, cost savings, and carbon emissions reductions using grid emissions factors determined in Task 1.
  - → Include estimates for capital cost, simple payback and the timeline for implementation.
- [ ] Develop low-emissions measure packages that represent achievable levels of emissions reductions at the building level (without the use of RECs or clean energy purchases).
  - → Outline potential implementation phasing and scheduling of retrofits.
  - → Assess whether low-emission measure packages meet the owner's emissions reduction targets.
  - → Address compliance with any current or upcoming GHG emissions mandates for existing buildings such as national, provincial, territorial and municipal standards.
  - → Provide a preliminary assessment of capital costs, including costs required to upgrade building infrastructure. Include potential grants, incentives or rebates.
- [ ] The auditor provides an emissions reduction audit report to the owner and meets to review the results.

Owner Considerations:

- → The auditor should include savings in terms of percent reduction of each fuel type for the measure packages for use in portfolio-level planning estimates.
- → The renewable energy assessment could be provided by a separate consultant. The results of this assessment should be provided to the auditor for inclusion in the low-emissions measure packages.
- → The auditor should recommend an order in which the ERMs should be implemented to maximize the emissions benefits and align them with the owner's future capital improvement plans.
- → The auditor should evaluate and recommend any grant, incentive or rebate applicable to the facility and the recommended ERMs.The use of RECs, off-site renewable energy capacity, or clean energy purchases (generally purchased at a portfolio level) is outside the scope of this building-level audit. These procurements could be considered by the owner to bridge the difference between practical levels of emissions reductions at a building site level and overall portfolio emissions reduction targets.

Task 4

Selection and Implementation (Owner Tasks)

- ☐ Evaluate options and work with the auditor to select a preferred strategy to achieve the emissions reduction targets.
- ☐ Evaluate how proposed building improvements can be integrated into long-term capital plans.
- ☐ Develop a scope and solicit bids for emissions reduction projects.
- ☐ With the auditor, develop commissioning plans to verify that new or modified equipment is performing as intended.
- ☐ Carry out the emissions reduction projects.

Owner Considerations:

→ Evaluate emissions reduction options based on the energy and emissions savings, capital cost, lifecycle cost and payback period. The options should align with capital planning cycles and could be implemented as a single retrofit or phased over time.

→ The owner can use building audit results to help inform progress towards portfolio-level emissions reductions targets.

Audit Deliverables

This appendix includes suggested outlines for the reports to be provided by the auditor to the owner. It outlines the information and level of detail that should be expected of the auditor's deliverable.

Initial Assessment Report (IAR) Outline

This report is delivered to the owner after the on-site inspection and prior to detailed analysis.

ON-SITE INSPECTIONS SUMMARY	
SUMMARY OF INSPECTED CONDITIONS	• Building envelope • HVAC • Domestic hot water systems • Lighting/electrical • Plug loads
INVENTORY OF ON-SITE EMISSIONS SOURCES	• Space heating equipment • Hot water heaters • Combustion appliances (cooking equipment) • Miscellaneous combustion equipment (unit heaters) • Assessment of refrigerant volumes and types
EMISSIONS REDUCTION CONSIDERATIONS	• Assessment of existing electrical service • Evaluation of space constraints for future equipment replacements • Assessment of roof condition and availability of space for renewable energy • Impact of the electric grid emissions intensity on electrification retrofits
PROPOSED ANALYSIS AND IMPLEMENTATION	
O&M IMPROVEMENTS	• Energy performance deficiencies that require little cost or time to implement
POTENTIAL EMISSIONS REDUCTION MEASURES FOR FURTHER STUDY (ERMS)	• Auditor recommendations for further study during the Analysis and Reporting task • Description of ERMs provided for owner feedback

Emissions Reduction Audit Report Outline

This report is delivered to the owner as the final audit deliverable.

EXISTING BUILDING EMISSIONS ASSESSMENT	

BUILDING DESCRIPTION	• Facility Description
	• Summary of Existing Conditions
	  • Building envelope
	  • HVAC systems
	  • Service hot water systems
	  • Lighting
	  • Process and plug loads
	  • Fossil-fuel combustion equipment
	  • Electrical service description

HISTORICAL EMISSIONS ANALYSIS	• Historical Energy Use Analysis • Historical Emissions Analysis including the baseline emissions • Benchmarking (ENERGY STAR Portfolio Manager, RETScreen or other suitable comparison) • Definition of emissions factor for each energy source
EMISSIONS REDUCTION TARGETS	• Discussion of target for GHG emissions reduction • Analysis of mandated emissions requirements
BUILDING IMPROVEMENTS	
O&M IMPROVEMENTS	• Energy performance deficiencies that require little cost to implement

PROPOSED EMISSIONS REDUCTION MEASURES (ERMS)	• Energy and GHG emissions savings for each ERM
	  • Energy efficiency ERMs
	  • Electrification ERMs
	  • Fugitive emissions ERMs
	  • Renewable energy ERMs
	• Cost estimates and payback analysis
	• Capital planning on measure implementation

LOW-EMISSIONS MEASURE PACKAGES	• Recommended measure packages proposed by the auditor to achieve emissions reduction targets • Estimate of phased implementation • Measure package cost assessment

ADDITIONAL AUDIT SERVICES (OPTIONAL)	
ADDITIONAL AUDIT SERVICES	• Electrical panel load study • Existing building commissioning (EBCx) or monitoring-based commissioning • Energy storage assessment • Demand management and flexibility assessment • EV charging assessment • Potential grant, incentive and rebate assessment
SUPPORTING DOCUMENTATION	• Data collected from on-site inspections • Calculations supporting analysis results • Tabulated utility data and rates

APPENDIX B

Resources

- The 2030 Emissions Reduction Plan outlines a sector-by-sector path for Canada to reach its emissions reduction target of 40 percent below 2005 levels by 2030 and net-zero emissions by 2050. Environment and Climate Change Canada.
  Canada's 2030 Emission Reduction Plan: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.
- Environment and Climate Change Canada provides emission factors and reference values to be used in the calculations of GHG emissions in Canada.
  Emission Factors and Reference Values: https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system/federal-greenhouse-gas-offset-system/emission-factors-reference-values.
- Environment and Climate Change Canada proposes the Net-Zero Challenge to encourage businesses in developing and implementing credible and effective plans to transition their facilities and operations to net-zero emissions by 2050.
  The Net-Zero Challenge: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050/challenge.
- Natural Resources Canada's Retrofit Hub hosts a collection of resources to help plan, finance, and implement retrofit projects in commercial real estate (CRE), institutional and public buildings, and multi-unit residential buildings (MURBs). These resources support the acceleration of retrofits across Canada's building sector to deliver both improved energy efficiency and decarbonization measures.
  NRCan. Retrofit Hub: https://natural-resources.canada.ca/energy-efficiency/buildings/retrofit-hub/26029
- Natural Resources Canada (NRCan) offers a range of tools and services for engineers, managers, owners and stakeholders of institutional and commercial buildings who want to use RCx to improve their buildings' performance.
  NRCan. Existing Building Commissioning (EBCx): https://natural-resources.canada.ca/energy-efficiency/buildings/existing-buildings/recommissioning/20705

  NRCan. Tools and resources for recommissioning existing buildings: https://natural-resources.canada.ca/energy-efficiency/buildings/existing-buildings/recommissioning/existing-building-commissioning-ebcx-tools-and-resources/26420
- Natural Resources Canada. Tuning Up: A Framework for Existing Building Commissioning is a model blueprint for increasing the uptake of Existing Building Commissioning (EBCx) in Canada. It is intended to broaden awareness and to help identify opportunities for decision-makers.
  Tuning Up: A Framework for Existing Building Commissioning: https://natural-resources.canada.ca/energy-efficiency/buildings/existing-buildings/recommissioning/tuning-framework-for-existing-building-commissioning/23969.
- Natural Resources Canada.
  Recommissioning Guide for Building Owners and Managers: a guide to successfully use recommissioning (RCx) as a cost-effective method of improving performance and saving energy through a more rational operation of institutional and commercial buildings: https://natural-resources.canada.ca/energy/efficiency/data-research-and-insights-energy-efficiency/buildings-innovation/building-optimization/recommissioning/rcx-guide/3795.
- Natural Resources Canada publications on Energy Management Information Systems (EMIS) enable individuals and organizations to plan, make decisions and take effective actions to manage energy use and costs.
  Energy Management Information Systems (EMIS): https://natural-resources.canada.ca/energy-efficiency/energy-efficiency-for-industry/energy-management-industry/energy-management-information-systems/20403

- ASHRAE/ACCA Standard 211 establishes consistent practices for conducting and reporting energy audits for commercial buildings.
  ASHRAE. 2018. Standard 211-2018: Standard for Commercial Building Energy Audits: https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards.
- ISO 50002:2014 specifies the principles, process and deliverable requirements for carrying out an energy audit in relation to energy performance.
  International Organization for Standardization. 2014. ISO 50002:2014: Energy audits — Requirements with guidance for use: https://www.iso.org/standard/60088.html
- This framework for GHG emissions reduction planning (ERP) provides guidance to organizations seeking to significantly reduce GHG emissions for their building portfolios and vehicle fleets.
  Kramer, H., T. Abram, N. Hart, J. Granderson. 2023. Framework for Greenhouse Gas Emissions Reduction Planning: Building Portfolios: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/ERP_Framework_Building_Portfolios.pdf.
- This GHG fact sheet provides an introduction to GHG emissions accounting for operation of buildings including equipment replacements and operational material purchases.
  National Renewable Energy Laboratory. 2022. Greenhouse Gas Emissions Accounting in Buildings. Fact Sheet: https://www.nrel.gov/docs/fy22osti/81671.pdf.
- The Low Carbon Technology Strategies Toolkit provides building owners and operators with guidance to aid in planning retrofit and operational strategies to achieve deep carbon reductions in.
  U.S. Department of Energy. 2022. Low Carbon Strategies Toolkit: https://betterbuildingssolutioncenter.energy.gov/toolkits/low-carbon-technology-strategies-toolkit.
- DOE's Smart Energy Analytics Campaign Toolkit helps facility owners and managers take advantage of savings opportunities and performance improvements from energy management and information systems (EMIS) and ongoing monitoring practices.
  U.S. Department of Energy. No date. Smart Energy Analytics Campaign Toolkit: https://betterbuildingssolutioncenter.energy.gov/smart-energy-analytics-campaign-toolkit.
- Decarbonizing HVAC and Water Heating in Commercial Buildings is a guidance document that provides building owners and facilities engineers with heating options and design considerations, with a focus on electrification and decarbonization of space heating and water heating loads using electric heat pump systems.
  U.S. Department of Energy. 2021. Decarbonizing HVAC and Water Heating in Commercial Buildings: https://betterbuildingssolutioncenter.energy.gov/resources/decarbonizing-hvac-and-water-heating-commercial-buildings.

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