Natural Resources Canada
Ressources naturelles Canada

Major Energy Retrofit Guidelines

for Commercial and Institutional Buildings

PRINCIPLES

Canada

Natural Resources Canada | Ressources naturelles Canada

Major Energy Retrofit Guidelines

for Commercial and Institutional Buildings

PRINCIPLES

Canada

Aussi disponible en français sous le titre : Directives sur les réaménagements énergétiques majeurs – Bâtiments commerciaux et institutionnels : Principes

This report is available online at **nrcan.gc.ca/energy/efficiency/buildings/eeeb/retrofit/4111**.

Cat. No. M144-268/2016E-PDF
ISSN 978-0-660-04674-7

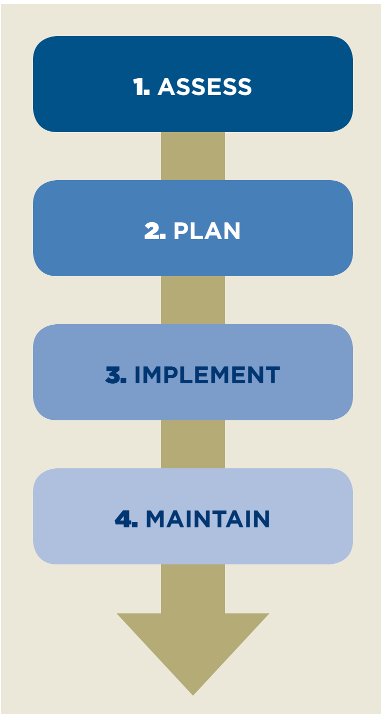
Natural Resources Canada's Office of Energy Efficiency
Leading Canadians to Energy Efficiency at Home, at Work and on the Road

ACKNOWLEDGEMENTS

The guidelines are an adaptation of the United States Environmental Protection Agency's *ENERGY STAR Building Upgrade Manual*. Natural Resources Canada gratefully acknowledges all those who contributed to their production.

DISCLAIMER

WHY SHOULD YOU READ THESE GUIDELINES?



Undertaking major retrofits offers significant opportunities to improve the energy performance of your building. Even modest investments can reduce energy and maintenance costs. The savings can be used to further improve building performance or redirected to other priorities.

Read the guidelines to discover how to manage and improve your facility's energy performance by following a proven, four-step process.

These guidelines provide a proven strategy for major energy efficiency retrofits, which includes benchmarking with ENERGY STAR Portfolio Manager. The guidelines will help you to:

- **Assess** the opportunity for energy improvement in your building and determine which energy efficiency measures are most appropriate.
- Develop a **plan,** incorporating appropriate timing with a compelling business case.
- Understand how to **implement** major energy retrofits.
- **Maintain** the post-retrofit performance to maximize the return on investment.

Since major retrofit projects are often driven by a desire to improve energy efficiency as well as regular asset renewal, they are best implemented using a systematic approach – to eliminate waste, improve efficiency and right-size equipment.

Major energy efficiency retrofits involve several energy retrofit measures across more than one building system. They typically lead to energy savings of 15 to 40% and can help you:

- Lower your energy bills and use the savings to invest in other priorities.
- Increase your property value and occupancy rates.
- Reduce your operating and maintenance expenses.
- Reduce your environmental impact.

CONTENTS

Figures

Tables

INTRODUCTION

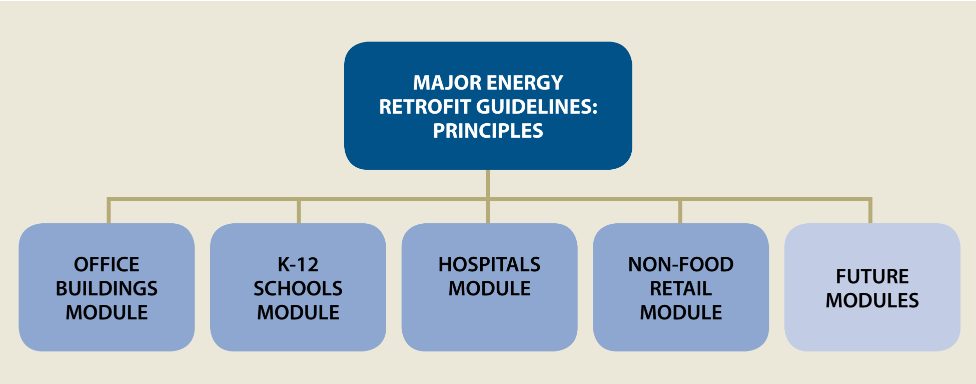
Purpose of these guidelines

The suite of *Major Energy Retrofit Guidelines* modules will help you improve the energy performance of your facilities. Although the information is most applicable to small and medium-sized facilities, larger buildings can also benefit.

Energy retrofit projects may be divided into three categories: minor, major and deep. While minor retrofits are a good first step, major retrofits will typically lead to savings of 15 to 40%. In general, major energy retrofits involve several measures across more than one building system. For example, a major retrofit could involve building envelope, lighting and boiler plant measures.

Once you have benchmarked your building using Natural Resources Canada's (NRCan) adaptation of ENERGY STAR Portfolio Manager, the guidelines will help you determine what questions you need to ask before you begin, what energy efficiency measures you can take and how to develop the business case.

The *Major Energy Retrofit Guidelines Principles* module provides an overview and approach to identifying and undertaking a major retrofit. Several building-specific companion modules provide strategies, priorities and opportunities unique to their respective building types.



Energy performance is the relationship between energy use and the variables that impact energy use. Variables include physical conditions (e.g. floor area), environmental conditions (e.g. heating degree days) and operational conditions (e.g. occupancy rates). A typical energy performance metric is **energy use intensity**, which presents energy use by floor area (i.e. gigajoules per square metre [GJ/m^2] or equivalent kilowatt-hours per square foot [ekWh/sq. ft.]).

Minor energy retrofits involve a single measure or focused group of measures that result in savings as high as 15%.

Major energy retrofits involve several measures across multiple building systems and can lead to savings between 15 and 40%.

Deep building retrofits are typically not driven by energy savings but by space changes, modernization or building renewal. Savings can be greater than 40% because the majority of the building's energy-using systems are improved.

INTRODUCTION

How to use these guidelines

Familiarize yourself with these guideline principles before you review the companion module that best suits your facility. Managing and improving any facility's energy performance involves the following four-step process, and each step has specific actions.

1. ASSESS

- Establishing commitment
- Benchmarking with Portfolio Manager
- Identifying opportunities

2. PLAN

- Staging project measures
- Determining timing
- Creating the business case
- Financing your project

3. IMPLEMENT

- Managing your project
- Selecting a contractor
- Commissioning and project hand-off

4. MAINTAIN

- Training staff
- Ongoing building optimization
- Monitoring and tracking

INTRODUCTION

Accordingly, these guidelines are divided into four core sections:

Section 1. Assessing opportunities in your building presents an approach to identify energy retrofit opportunities, starting with benchmarking.

Section 2. Building energy management planning outlines a planning strategy for your organization to follow. It explains how to access and stage major retrofit measures, how to integrate energy efficiency into your asset management plan, and how to develop a convincing business case.

Section 3. Implementing major retrofits explains how to ensure that your major retrofit project is executed successfully.

Section 4. Maintaining your performance explains how training, ongoing building optimization, and monitoring and tracking activities will maximize the return on your investment.

Immediately following Section 4, you will find a **sample case study** about a major retrofit of an office building. It illustrates many of the key concepts detailed in the first four sections of the guidelines.

Three supplementary sections follow:

- **Resources** that provide more information about the major retrofit process.
- Direction on how to leverage the **National Energy Code of Canada for Buildings (NECB).**
- A **glossary** that defines key concepts and terminology.

Sidebars throughout these guidelines provide additional examples, tips and recommendations, information on particular issues, and resources.

SECTION 1

ASSESSING OPPORTUNITIES IN YOUR BUILDING

For the first time in Canada, there is a standard national **energy benchmarking** system that can be used as a monitoring, tracking and comparison tool.

NRCan's adaptation of **ENERGY STAR Portfolio Manager** is available for all commercial and institutional buildings. As the only tool that uses national data, it is an excellent complement to any energy management software or benchmarking routine you may already have in place.

Owners and managers of eligible building types are able to compare their buildings' energy performance by assigning an **ENERGY STAR score** on a scale of 1 to 100. A score of 75, for example, indicates that a building performs better than 75% of all similar buildings.

Improved building performance starts with a well-defined assessment approach.

ASSESS
- establishing commitment
- benchmarking with Portfolio Manager
- identifying opportunities

Establishing commitment

The leadership to manage energy at your facilities needs to come from the top. If the head of your organization is not interested in energy management, why should anyone else be?

To ensure that energy performance is more than just an afterthought, it needs to be raised to the same level as corporate financial targets and operating objectives. This will facilitate commitment and buy-in from all building personnel within your organization.

Benchmarking with ENERGY STAR Portfolio Manager

After establishing commitment, benchmarking is the next step toward assessing opportunities in your building. Use Portfolio Manager to compare your building's energy use intensity (GJ/m^2 or ekWh/sq. ft.) against other like buildings.

For some building types, Portfolio Manager can provide an ENERGY STAR score by normalizing for factors such as climate, hours of operation and occupancy. This allows an office building in Vancouver, for example, to be fairly and consistently compared to an office building in Edmonton.

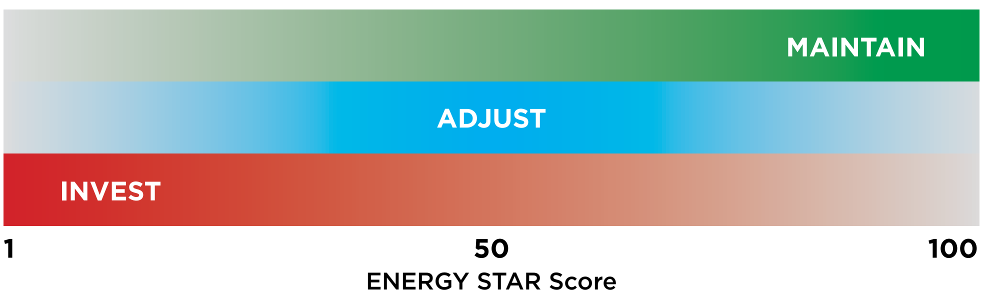
Once you have established your facility's energy use intensity (EUI) or ENERGY STAR score, you are ready to set improvement goals and create a retrofit plan. Benchmarking results provide an excellent baseline to measure improvements and are a powerful motivator to take action to improve building energy performance.

SECTION 1

Figure 1 can help you interpret your score and determine the appropriate next steps:

- If your facility has a **low score**, a focus on investing in major retrofits and undertaking a staged approach will likely have the greatest impact on your bottom line.
- If your facility has an **average score**, opportunities to make adjustments at your facility may involve a combination of major retrofit measures, less complex upgrades, and improved operations and maintenance practices.
- If you have a **top-performing** facility, you should maintain your performance by focusing on ongoing building optimization and regularly assessing major retrofit opportunities, particularly with respect to scheduled capital projects.

Figure 1. ENERGY STAR score interpretation



Adapted from the U.S. EPA's *Energy Performance Rating System*

Identifying opportunities

After establishing a performance baseline through benchmarking, you can begin identifying opportunities for improvement by collecting information and assessing the existing performance and conditions of your facility.

The two main areas of assessment are:

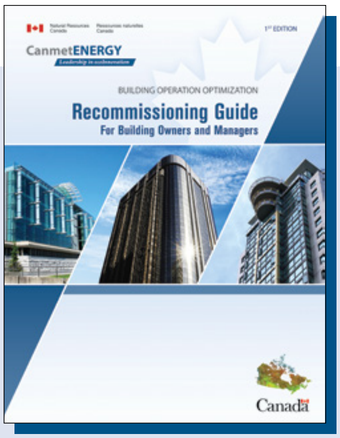
- existing building commissioning assessment and investigation
- energy audits

Once a commissioning assessment and/or audit has been completed, more detailed analysis can determine the level of investment needed to achieve the desired energy savings. The resulting plan should identify and prioritize the efficiency upgrade activities that yield the greatest returns by coordinating capital upgrades and retrofits with commissioning activities.

Retrofit **investments** do not only refer to dollars spent. You will also need to consider the amount of time and human resources, including any outside expertise, that will be required.

Recommissioning and **retro-commissioning** are terms often used interchangeably to mean the commissioning of an existing building. The difference in the terminology refers to whether the building has been previously commissioned. The commissioning industry has recently resolved the confusion by adopting the term **existing building commissioning (EBCx)** to cover the commissioning program of the building after its initial construction acceptance phase.

SECTION 1



For more information on existing building commissioning, see NRCan's *Recommissioning Guide for Building Owners and Managers* to learn how to reduce expenses and increase revenue through improved building operations.

There is also a national building commissioning standard, CSA Z320, which provides a comprehensive process for achieving and documenting the optimal performance for your facility.

Links to both of these documents are available in the **Resources** section.

Refer to the companion modules that accompany these guidelines to learn more about the major retrofit opportunities in building-specific subsectors. A questionnaire section, entitled **My Facility**, is at the end of each of these modules. It provides direction on how to set improvement goals based on your ENERGY STAR score and summarizes the applicable retrofit measures in the form of a questionnaire.

Existing building commissioning assessment and investigation

EBCx is a systematic process for optimizing energy performance in existing buildings. It focuses on improving the control of energy-using equipment, such as HVAC equipment and lighting. It typically does *not* involve equipment replacement.

The vast majority of existing buildings were never commissioned during their initial construction. Furthermore, with the ongoing operation of a building's systems, devices may no longer be properly calibrated, and mechanical equipment may no longer operate as originally specified. For these reasons, existing building commissioning is the only method of establishing or re-establishing the functional performance of a building's systems.

An EBCx program has four phases:

- assessment
- investigation
- implementation
- hand-off

The *assessment* and *investigation* phases build a knowledge base that lets you understand how the building systems are configured and how they function. The information gathered during these phases is critical for subsequent planning activities.

The *implementation* and *hand-off* phases result in a fully functioning building and include retraining operations staff in updated operational criteria.

SECTION 1

Energy audits

Energy audits identify energy saving opportunities by assessing current building equipment, operations and building energy use patterns. Audits differ from EBCx in their approach and results. Commissioning optimizes performance with the existing equipment, whereas energy audits examine how performance can be improved by upgrading or replacing equipment and systems.

An energy audit provides a cost-benefit analysis for potential energy efficiency measures and can be performed with varying levels of rigour and expense. While an energy audit can be done in several ways, ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) has created a set of audit standards – Levels I, II and III – that allow for a common understanding of service levels in the marketplace (*see the sidebar)*.

Energy assessment and modelling tools

Energy savings from proposed retrofit measures can be estimated by using engineering calculations or with the support of an energy model. If a measure is relatively common and its impact on other building components is insignificant, calculating savings by using a simple spreadsheet tool is likely appropriate. However, if a measure is more complex and its impact on other building components is meaningful, modelling its impact is likely the better option.

For example, reducing the air handling unit supply fan schedule for a facility will have several benefits. These may include not only direct fan savings, but also significant cooling and heating energy savings, because less conditioned ventilation air is needed for the space.

An energy model, or energy simulation, provides a comprehensive assessment of energy performance by determining a building's energy requirements, including the interaction of energy consuming systems, occupants, and envelope losses and gains on an hourly basis for the entire year. Energy simulations require many inputs to provide a detailed representation of the building geometry, thermal properties, equipment ratings and performance across a wide range of operational conditions. Consequently, energy simulations are the best choice when accuracy is important.

ASHRAE audits

An **ASHRAE Level I audit** involves a preliminary energy use analysis, a brief walk-through of the building and a survey of the building's energy consuming equipment. Given the limited information gathered in a Level I audit, the audit report only identifies no-cost and low-cost measures.

An **ASHRAE Level II audit** builds on a Level I audit by including a more in-depth investigation into the overall performance of the major building systems. All practical measures are analyzed for their cost-benefit and are presented in the audit report.

An **ASHRAE Level III audit** builds on a Level II audit by providing a more detailed and accurate analysis of building energy performance and identified measures. A Level III audit offers the most detailed engineering and financial analysis. The results can be used with a high level of confidence by the building owner to consider complex and significant capital investment decisions. Level III audits can be considered "investment grade" audits.

SECTION 1

Selecting technical resources

Hiring the right professionals to support the assessment and planning phases of a major retrofit project will have a positive impact on its outcomes.

Before any retrofit work is done, a **commissioning agent** can determine any issues related to how your building's systems perform and recommend a broad plan of action. When choosing a commissioning agent, look for a professional engineer with a *certification in commissioning*. The Association of Energy Engineers (AEE), ASHRAE and the Building Commissioning Association (BCA), among other organizations, deliver educational and certification programs. The BCA maintains a directory of commissioning professionals on its website (**www.bcxa.org**).

Before hiring a commissioning agent through a competitive process, an owner needs to understand their needs and terms of reference for commissioning. NRCan's *Recommissioning Guide for Building Owners and Managers* provides useful insight in selecting a commissioning provider.

To improve the objectivity of the results of the assessment and investigation phases, consider procuring these phases separately from the remaining phases (implementation and hand-off).

When hiring an **energy auditor**, a building owner should look for a practitioner who has at least three years of relevant experience and one of the following designations: professional engineer, certified engineering technologist (CET), certified energy manager (CEM) or certified measurement and verification professional (CMVP).

California Energy Commission's *How to Hire an Energy Auditor to Identify Energy Efficiency Projects Handbook* provides direction on how to develop a statement of work, evaluate bids, select a contractor and ensure that the audit is successful.

Selecting analysis and simulation tools

CAN-QUEST (**nrcan.gc.ca/energy/efficiency/buildings/eenb/16600**) is a Canadian adaptation of eQUEST, the popular United States (U.S.) building energy simulation software. It builds upon eQUEST 3.62 and includes complete Canadian weather data, support for metric and imperial units, and English and French language interfaces. CAN-QUEST is recognized as the Canadian building energy simulation tool for modelling whole-building energy performance and to demonstrate compliance with Part 8 of the NECB 2011 (performance path).

RETScreen® (**nrcan.gc.ca/energy/software-tools/7465**) is a spreadsheet-based energy analysis tool that uses a hybrid of calculations and simulation to help decision makers quickly and inexpensively determine the technical and financial viability of potential renewable energy, energy efficiency and cogeneration projects. The Energy Efficiency module in RETScreen 4, for example, compares energy efficiency upgrade options for a retrofit at a pre-feasibility level. The software is free and can be downloaded from the website.

ENERGY MANAGEMENT PLANNING FOR YOUR BUILDING

SECTION 2

Once energy efficiency opportunities have been identified, a plan should be developed to improve the energy performance of your facility.

PLAN
- staging project measures
- determining timing
- creating the business case
- financing your project

Planning a major retrofit project by using the staged approach (also known as an **integrated design approach**) ideally requires support from an interdisciplinary team of engineering, architecture and building science professionals.

Working in concert, these professionals will optimize the overall energy and cost savings from your project while enhancing the indoor environmental quality for your building occupants.

Staging project measures

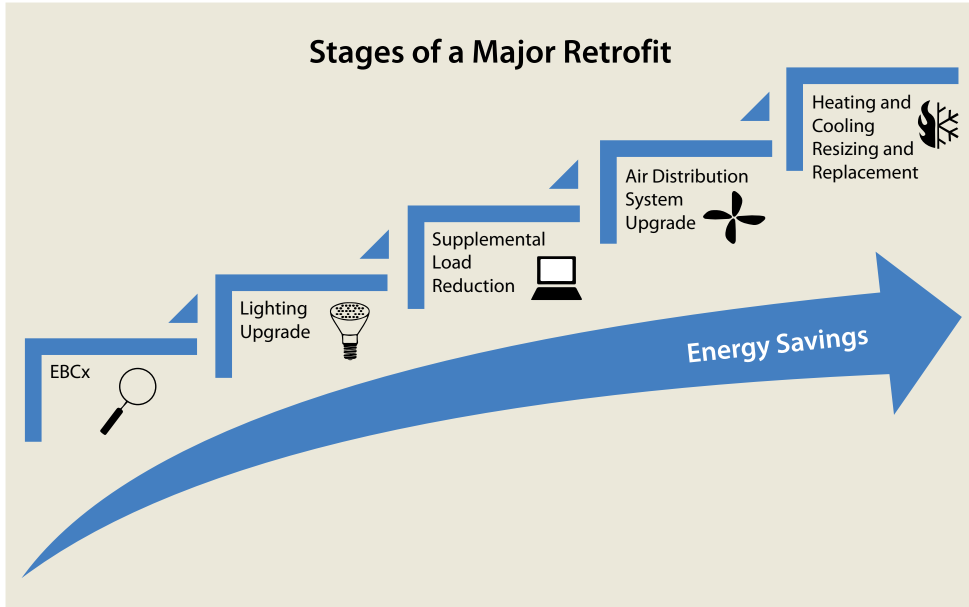
To account for all the energy interactions in a building, NRCan recommends a staged approach to implementing major retrofits. By working backward from the point of end use, a systematic process ensures that you improve facility performance in the most effective way possible.

Ideally these stages are undertaken sequentially as part of a comprehensive major retrofit project. However, it may make sense to focus more on individual stages. The choice depends on your ENERGY STAR score or EUI, the current state of the building, the nature of the opportunities applicable to your facility, and the characteristics of your asset management plan.

Using the staged approach improves facility performance by:

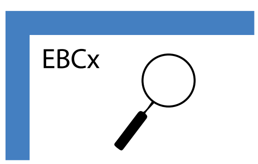
- **Reducing loads by eliminating energy waste.** Begin by finding opportunities to turn off equipment when it is not needed (e.g. lights, fans, pumps) and control equipment so that it delivers energy more precisely (e.g. temperature, water and air flow set points, lighting levels).
- **Improving efficiency.** This involves improving maintenance and operational practices (e.g. cleaning heat exchangers) and replacing equipment (e.g. implementing a lighting retrofit).
- **Optimizing the heating and cooling energy supply.** This process involves taking advantage of heat recovery where possible and selecting heating and cooling equipment that operates most efficiently at your facility's typical heating and cooling load conditions (e.g. installing modular boilers or a right-sized boiler with a large turndown ratio).

SECTION 2



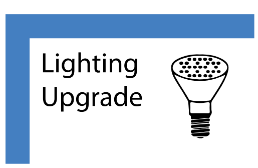
Adapted from the U.S. EPA's Energy Performance Rating System.

Each stage includes changes that will affect the upgrades performed in subsequent stages, thus setting the overall process up for the greatest energy and cost savings possible.



Existing building commissioning

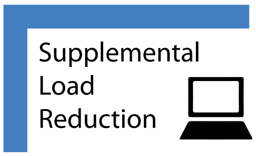
EBCx is the first stage because it provides an understanding of how a facility is currently operating and how closely it comes to operating as intended. Specifically, it helps identify improper equipment performance, equipment or systems that need to be replaced, and operational strategies for improving the performance of the various building systems.



Lighting upgrade

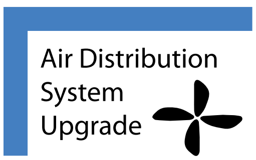
Lighting upgrades, which may include new light sources, fixtures and controls, come early in the process because the lighting system has a significant impact on other building systems, such as heating and cooling loads and power quality.

SECTION 2



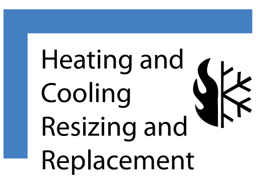
Supplemental load reduction

Supplemental load sources, such as computers and other electronic equipment, as well as the building itself, are secondary contributors to energy consumption and can affect heating, cooling and electric loads. Careful analysis of these sources and their interactions with HVAC systems can indicate how equipment size and upgrade costs can be reduced.



Air distribution systems upgrade

Air distribution systems bring conditioned air for ventilating, heating or cooling into the building, and therefore directly affect both energy consumption and occupant comfort. Fan systems can be upgraded and adjusted to deliver the air in the most energy-efficient way.



Resizing and replacing heating and cooling equipment

If the steps outlined in the first four stages are followed, cooling and heating loads are likely to be reduced. That reduction, coupled with the fact that many existing HVAC systems are oversized to begin with, means that it may be possible to justify replacing an existing system with a smaller one. A properly sized system can operate most efficiently at your facility's typical heating and cooling load conditions. In addition to saving energy, proper equipment selection will likely reduce noise, lower the first costs and optimize operation, often leading to less maintenance and longer equipment lifetimes.

National Energy Code of Canada for Buildings

A starting point when planning major retrofits is to consult the most recent version of the *National Energy Code of Canada for Buildings* (NECB) or a similar code relevant in your jurisdiction. The NECB outlines minimum performance requirements for various facility components, including the building envelope, lighting, HVAC systems, service water heating, and electrical power systems and motors. You should plan to meet, or ideally exceed, these requirements for the components of your facility impacted by your retrofit project.

*See the **National Energy Code of Canada for Buildings section** for direction on how to leverage its requirements at your facility.*

The ***National Energy Code of Canada for Buildings*** is updated every five years with increasingly stringent energy efficiency requirements. By building to meet or exceed the minimum standards set in the code, the Canadian buildings sector moves closer to the goal of net-zero energy performance.

SECTION 2

Fixed assets, such as facilities and equipment, are economic resources that belong to an organization that have future economic benefit and are the result of past financial transactions.

Asset management includes activities associated with the acquisition, operation, maintenance, renewal and replacement of an organization's fixed assets.

Capital planning is a structured approach for managing long-term assets (i.e. a strategic approach to asset management). Effective capital planning allows you to manage capital expenditures associated with your fixed assets, and identify and solve aging asset issues before they become problems. A capital plan categorizes and prioritizes the renewal of your physical assets.

See Figure 2 for an example of an asset management timeline.

Determining timing

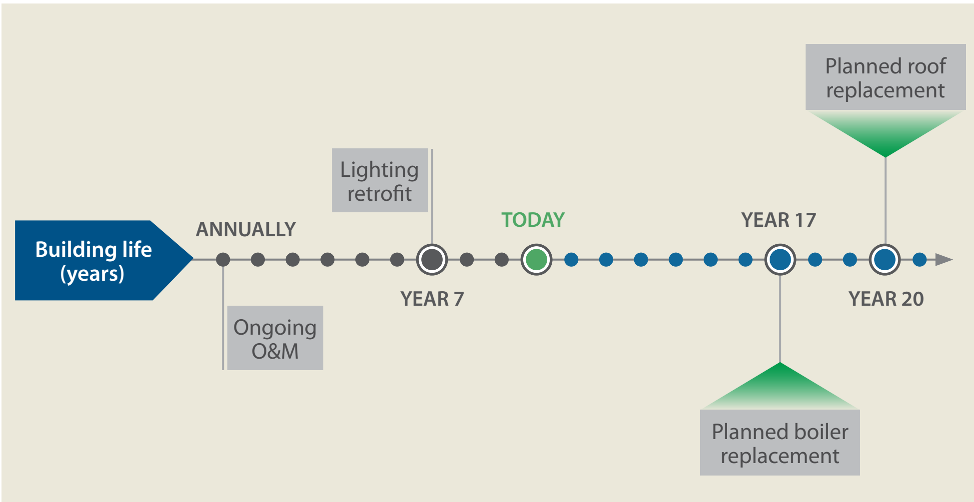
Before moving forward with a major retrofit, consider timing. Results may be impacted by both *how* and *when* you spend your dollars. The incremental cost of pursuing major energy savings may be significantly reduced if you were already planning to spend money on capital improvements or equipment replacement, which is something that all buildings require.

Start by incorporating energy efficiency into your capital plan. The total cost of ownership of an asset considers all of the purchase costs as well as the costs of operation and maintenance (O&M) over time. Spending in any one category can have a significant impact on the other categories. For example, variable costs, such as utility costs, can be influenced and should be targeted for optimization. The life-cycle approach to asset management is a widely accepted methodology that uses an expected useful life for assets and anticipates their replacement on or before the expiry of their operable or serviceable life. A capital plan develops a list of these assets and predicts when they are likely to break or fail.

In some cases, it makes more economic sense to replace an inefficient component, regardless of where it is in its life cycle. However, this is not always the case.

Comparing proposed major retrofit measures with your capital plan may provide opportunities to analyze planned projects for potential energy savings opportunities. For example, if a replacement boiler is already budgeted for, and, for a minimal cost premium, operational efficiencies can be gained, those efficiencies can be realized at the cost of only the premium. The comparison can identify projects that would *not* have been economically viable because of the large capital cost and make them the first priority since the replacement was already scheduled.

Figure 2. Example of an asset management timeline



Coupling major retrofit planning with asset management planning allows for a strategic asset management decision process, ideally allowing enough lead time to properly evaluate which facility components can be enhanced and what steps should be taken before replacement.

Table 1 outlines several key triggers that may provide retrofit opportunities or influence retrofit timing decisions.

Table 1. Major retrofit triggers

Trigger	Opportunity
Major envelope replacement	Planned replacement of major envelope components (roof, windows, etc.) is an opportunity to improve facility insulation levels and reduce air leakage at low incremental cost.
Major equipment replacement	Planned replacement of major equipment is an opportunity to right-size and install more efficient technology (e.g. a smaller chiller with better part-load efficiency). After reducing thermal and electrical loads, the marginal cost of replacing the equipment with properly sized, energy-efficient equipment can be minimal or even negative.
Upgrades to meet code	Life safety upgrades may require substantial disruption and cost – enough that the incremental investment and effort to radically improve the building efficiency becomes not only feasible, but profitable. For example, an upgrade to rectify an unsafe electrical system could be coupled with a lighting redesign retrofit project.
New acquisition or refinancing	New acquisition or refinancing can include attractively financed building upgrades (which may not have been possible at other times) as part of the transaction.
Major occupancy change	A company or tenant moving a significant number of people into a building or a major turnover in square footage presents a prime opportunity for a major retrofit for three reasons. First, a major retrofit can generate interior layouts that improve energy and space efficiency and can create more leasable space by downsizing mechanical equipment. Second, ownership can leverage tenant investment in the renovation. Third, tenant disruption can be minimized.

Adapted from Rocky Mountain Institute. 2012. *Retrofit Depot: Managing Deep Energy Retrofits*

Simple payback period: the value of an initial investment divided by the value of all annual cash flows resulting

P= I/CF

where:

P = payback period (years)

I = value of initial investment ($)

CF = annual cash flow resulting from investment ($/year)

For example, an energy efficiency investment (**I**) of $100,000, with annual savings (**CF**) of $40,000 would provide a simple payback (**P**) of 2.5 years.

Present value: the value of an expected cash flow resulting from a project

$$PV = CF/(1+r)^t$$

where:

PV = present value ($)

CF = future annual cash flow installment resulting from investment ($)

r = annual discount rate (%)

t = year in which cash flow is received

Net present value: the sum of the present value of all cash flows resulting from a project, including the initial investment (considered a negative cash flow at year zero)

Internal rate of return: the discount rate, r, which provides an NPV of zero for a given series of cash flows

Creating the business case

This subsection guides you through the process of comparing costs and benefits of a major retrofit opportunity to determine its cost effectiveness.

Cost effectiveness depends on a several factors. A retrofit opportunity that is cost effective for one facility may not be for another or even for the same facility at a different stage in its life cycle. The bottom line? Investing in major retrofits saves energy and lowers costs, and the money saved can be used as a source of future cash flow.

Choosing the right tool

Tools that compare the expected costs and future benefits of energy retrofit opportunities will help you make sound business decisions.

The attractiveness of an energy retrofit investment is typically assessed using one or more of the following three tools: **simple payback**, **net present value** (NPV) or **internal rate of return** (IRR).

Analyzing an energy retrofit investment in these terms lets you compare energy retrofit options against each other, against a minimum investment criterion or against other investment opportunities that could be made within your facility or organization.

For example:

- If your organization leases facility space and is responsible for energy costs, you might consider undertaking retrofit projects with a simple payback that is shorter than the lease period.
- If your organization can borrow money, you might consider undertaking retrofit projects that have a positive NPV by using your marginal borrowing cost to discount the value of future energy savings.
- If your organization can make investments with a known (or expected) annual rate of return, you might consider undertaking retrofit projects with an IRR that is higher than the rate of return.

SECTION 2

What tool should you use to analyze, compare and prioritize potential energy saving investments? If your organization uses one of these three tools to analyze other investments, include it in your analysis. If your organization uses only simple payback to analyze investment opportunities, consider calculating NPV and/or IRR as well to capture the value of your proposed project's benefits over its lifetime.

Valuing costs and benefits

Now that you have a tool box to analyze an energy investment, you will need to quantify the estimated costs and benefits of your proposed project.

Consider the following questions:

- What costs should I consider to enable a fair comparison between options?
- How much are future energy savings worth today?
- How will an energy investment affect the value of the underlying asset (building)? How might it affect other aspects of my organization? Are there other benefits beyond energy savings?
- How certain are the savings? Should any uncertainty be given a value?

Costs

Costs associated with retrofits can be discussed from two perspectives:

- **Full cost or gross capital cost** is the entire cost of a retrofit.
- **Incremental or marginal cost** is the portion of the retrofit cost that is attributable to energy improvements.

Consider the example of choosing to replace a failed light bulb with a standard light bulb that costs $2.00 or a more efficient light bulb that costs $3.00. In this case, the full cost of retrofitting with an efficient light bulb is $3.00. The incremental cost of the retrofit is $1.00 – the cost difference between the baseline and efficient options.

Costs typically associated with an energy retrofit:

- Equipment costs, ranging from the full cost of the piece of equipment to the incremental cost of more efficient equipment compared to the default option.
- Costs associated with assessing opportunities, design, engineering, installation and commissioning.

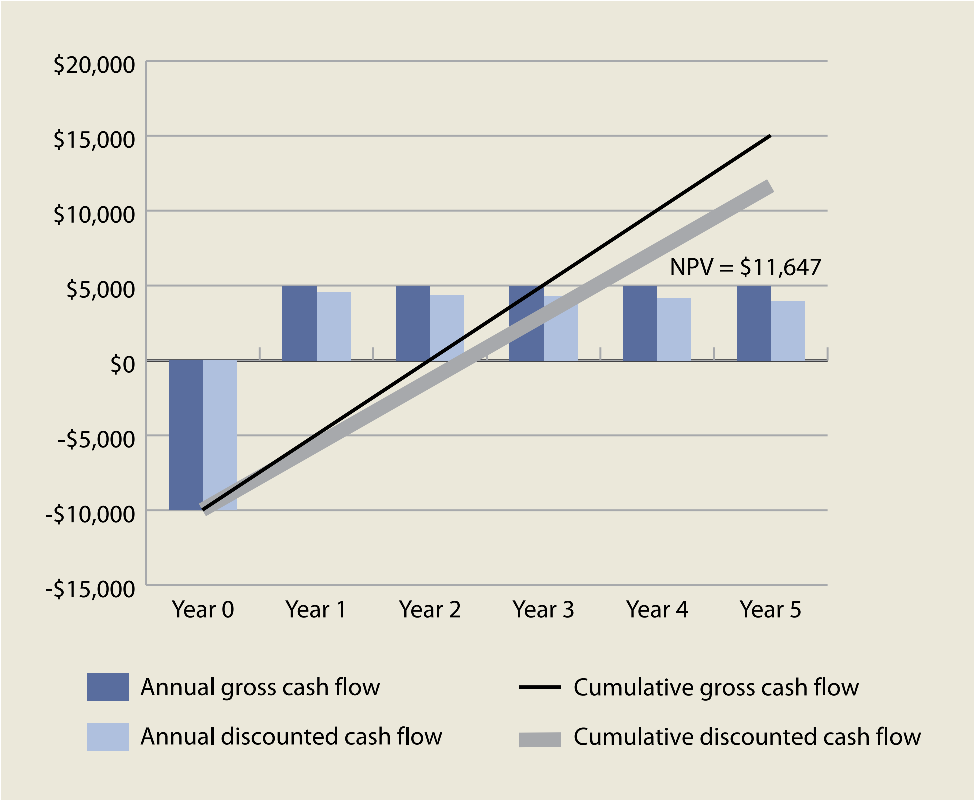
Benefits typically associated with an energy retrofit:

- Value of ongoing energy savings.
- Value of ongoing savings of other resources, such as water.
- Savings in energy demand charges, typically due to reducing peak monthly electricity use.
- Reduced maintenance costs.
- Non-energy factors such as improved occupant comfort.

Energy benefits

Ongoing energy savings can be thought of, and valued as, a series of future cash flows. In Figure 3, an investment of $10,000 in Year 0 results in energy savings of $5,000 for five years (dark blue bars). At a discount rate of 5%, the present value of the annual cash flow diminishes through time (light blue bars). In our example, the blue line shows the cumulative cash flow, which totals $15,000 by Year 5. The NPV of the investment is the sum of the annual discounted cash flows: $11,647.

Figure 3. Benefits vs. costs



Calculating the NPV of your project allows you to weigh the value of benefits versus costs over time. All else being equal, retrofits with higher positive NPVs are more attractive.

Value beyond energy cost savings

Major retrofits also often provide non-energy benefits, including:

- **Increased property value.** As a property owner or manager, your facility may be an income generating asset. In this situation, energy savings may result in both direct cost savings and a higher asset value. One of the most common methods to evaluate a building's asset value is the "income approach," in which commercial buildings are valued based on their annual net operating income (NOI). This is done by dividing NOI by a capitalization rate or "cap rate," the minimum rate of return that would be acceptable to investors. For example, if an investor has a cap rate of 10%, $1 in annual energy savings is worth $10 in asset value.

- **Reduced operations and maintenance expenditures.** Many retrofits can be done in a way that reduces required maintenance effort, thus providing additional ongoing savings. For example, replacing incandescent lamps that are difficult to access with long lasting, efficient light-emitting diode (LED) lamps may lead to ongoing maintenance savings that are comparable to the already attractive energy savings.
- **Increased rents and occupancy rates.** Recent studies have found that commercial buildings with green and efficient certifications are able to obtain higher rents, while maintaining higher occupancy rates than otherwise comparable buildings. A summary of recent U.S. studies[1] notes that ENERGY STAR buildings have associated rental premiums ranging from 3 to 9% and occupancy rates 1 to 11% higher than comparable non-ENERGY STAR buildings.
- **Qualitative benefits.** Various studies have noted several other benefits associated with major energy retrofits, including:
  - Higher productivity and lower employee absenteeism and turnover.
  - Progress toward corporate sustainability objectives.
  - Marketing and public relations value.
  - Reduced environmental impact of corporate operations, e.g. lower greenhouse gas emissions.

While many of these benefits can be difficult to quantify, there is broad agreement that they represent real and positive value.

Consideration of risk

There is some level of risk associated with every investment, and the amount of risk varies between investment opportunities. This is true for investments in general and for energy investments in particular.

Some energy retrofits have higher savings risk than others. A well-established measure, such as retrofitting a lighting system, should produce reliable, predictable savings. Savings from a newer or more complex measure may be less predictable, with higher associated risks.

Inaction may have its own risks. For example:

- Choosing not to retrofit an inefficient lighting system carries the risk of rising electricity costs.
- Choosing not to replace an old, inefficient chiller plant carries the risk of product damage if the equipment fails and the building's indoor environments cannot be maintained at a suitable temperature.

Example case:

Mississauga Executive Centre 2 (MEC2), Mississauga, Ontario (LEED-Existing Buildings, Gold)

As an example of the potential impact of reducing operating expenses on asset value, consider the case of MEC2, an office building that underwent several major energy retrofits.

Total initial investment: about $625,000

NOI impact of energy savings: $160,000/year

Capitalization rate: 6.5%, reflecting the 2014 office building market in the suburban Greater Toronto Area

Additional asset value using the income method ($160,000 / 6.5%) About $2.5 million

ENERGY STAR score: Improved from 53 in 2010 to 84 in 2014

[1] Institute for Building Efficiency (2011)

SECTION 2

Example elevator speech that targets a chief financial officer:

"We recently found out that 70% of similar buildings in Canada are more energy efficient than our facility. Because energy costs impact our bottom line, we should consider investing in an energy retrofit project to improve future cash flow.

"With support from an energy efficiency professional, I have developed a scope of work with an incremental cost of $60,000 that will greatly improve the performance of our facility. Better yet, it has an IRR of 15%, more than 10% higher than our cost of borrowing.

"How can you help get this project approved?"

Risk can be managed in several ways, including:

- Choosing measures that have demonstrable savings and known costs.
- Dealing with qualified contractors and suppliers.
- Considering an arrangement such as an energy performance contract, in which risk is shared between the building owner and the contractor performing the retrofit.
- Ensuring that the discount rate used to analyze retrofit decisions reflects the relative level of investment risk. All else being equal, a higher risk investment should have a higher associated discount rate.

Making the pitch. After building a compelling business case by analyzing costs, benefits and risks, the next step toward implementing the proposed retrofit is communicating its value to decision makers. Consider these points:

- **Understand your stakeholders**. Often, decisions and associated benefits do not apply to the same stakeholders. For example, owners, managers and tenants each have differing interests regarding energy performance investments.
- **What's in it for them?** Your message may need to be tailored to different audiences. A decision maker directly responsible for your organization's day-to-day financial performance may be most interested in a project's NPV or IRR. Others may be more interested in effects on asset value or "soft" benefits such as improved employee productivity.
- **Practice your elevator speech**. Whatever you decide to emphasize, ensure that your value proposition is succinct, straightforward and easy to understand. Ideally, it could be communicated during a 30-second elevator ride!

Financing your project

There are a number of options for financing major energy retrofits. Depending on your organization, its available capital, access to credit and the type of retrofit, you may choose from a variety of funding structures.

Ideally, the funding structure you choose should provide your organization with a positive cash flow from energy savings while paying off the capital invested in major retrofit measures.

Table 2 outlines some common financing options.

SECTION 2

Table 2. Financing options

Funding structure	Description	Applications
Cash purchase	Cash on hand is used to fund upgrades without outside financing.	• Typically best for inexpensive measures likely to have a short payback period. • Typically not appropriate for organizations with limited cash flow.
Mortgage	Funds are obtained from a lender, secured against the property to be retrofitted.	• Typically best for projects that will provide cost savings sufficient to service the additional debt. • Typically not appropriate for projects that are relatively small. • A number of commercial lenders offer "green" mortgages, which provide more favourable borrowing terms for projects that have an energy efficiency component.
Green loan or lease	New equipment is used as loan security. Security is limited to the value of the equipment and is, therefore, typically viewed as less secure than a mortgage or other loan secured by real property. This may lead to higher financing costs to the borrower.	• Typically best for equipment that will provide cost savings sufficient to service the additional debt. • Typically not appropriate for projects that are relatively small and/or for equipment for which the manufacturer or installer does not offer a financing option.
Energy performance contract	Risk is transferred to a third party (an energy services company [ESCo]) that typically provides turnkey design and installation and secures financing at its own risk. The ESCo verifies energy savings annually and receives a portion of their value. Savings are often guaranteed for a defined period.	• Typically best for organizations unable or unwilling to secure financing or that value risk-mitigation highly. • Typically not appropriate for small projects. ESCos usually take on projects with large commercial or institutional buildings or owners with a portfolio of buildings.

SECTION 2

Funding structure	Description	Applications
Property-assessed financing	Property tax-based financing offered by municipalities to property owners. The loan is secured by a tax lien on the property and transfers with the property in the case of a sale.	• Limited to facilities in municipalities and provinces that have passed appropriate enabling legislation. • Most appropriate for retrofits with long lifetimes and relatively long payback periods. • In some cases, permission may be required from the owner's mortgage lender.
On-bill financing	Financing through a utility, with repayment of principal and interest included on the customer's energy bill. Repayment schedules are arranged so that loan repayment amounts are less than the value of energy savings. Financing costs may be higher than loans secured by real property.	• Limited to facilities with utility providers that offer such products. • Appropriate for organizations unable or unwilling to take on debt secured against property.
Utility and government grants and incentives	Non-repayable grants and incentives provided by utilities or provincial efficiency organizations for specific measures or comprehensive retrofits.	• Appropriate for eligible project measures. • Grants and incentives are more often available for specific prescriptive projects, but may also be available for comprehensive projects.

IMPLEMENTING MAJOR RETROFITS

SECTION 3

Section 3 provides advice on how to ensure that your major retrofit project is executed successfully.

IMPLEMENT

- managing your project
- selecting a contractor
- commissioning and project hand-off

Managing your project

The size of your facility, the complexity of its systems and the scope of your project will be factors in deciding how to manage the project and who should do it.

Facilities that aim to improve their performance by undertaking simple, low-cost measures (e.g. facilities with ENERGY STAR scores higher than 50) may be able to manage project activities internally. Facilities that implement major retrofits (e.g. facilities with ENERGY STAR scores below 50) will likely require the services of a professional who has experience in this area.

A complex project may involve managing multiple contracts simultaneously or in sequence. For example, your project could involve a design engineer, a general contractor and a commissioning agent.

Clear communication among the building owner, tenants and contractors throughout the project is an important aspect of successfully managing your retrofit project. Communication strategies may include involving both the owner and contractor in regular project meetings, providing progress updates to tenants, and sharing project management information such as Gantt charts.

The project management process has five steps:

- **Initiating** involves defining your project and obtaining authorization to proceed.
- **Planning** involves establishing the scope of work, project objectives and the course of action.
- **Executing** involves selecting contractors and completing the project work.
- **Monitoring and controlling** happens in parallel with the execution step and involves ensuring that the project work is undertaken as planned, as well as managing any necessary change orders.
- **Closing** involves finalizing project activities and formally closing contracts.

Source: Project Management Institute. 2013. *A Guide to the Project Management Body of Knowledge (PMBOK Guide) – Fifth Edition*

SECTION 3

Managing risk

Regardless of the scale of your project, risk management is a critical element of the project management process. Potential project risks should be identified upfront and updated regularly over the course of the project. Key areas of focus should be the triple constraint of scope, schedule and budget:

- Is there a risk that the project **scope** could be in jeopardy? For example, has the project scope been clearly defined in the contract?
- Is there a risk that the project **schedule** could be delayed? For example, if large or unique equipment is to be purchased, have appropriate lead times been accounted for in the project schedule?
- Is there a risk that the project could go over **budget**? For example, does your budget include a contingency reserve? How is the risk shared between your organization and the contractor with regard to budget overruns?

Selecting a contractor

The selection of experienced, competent contractors and other energy professionals is critical to the success of your major retrofit project.

Many organizations have formal procurement policies, procedures and guidelines. In addition to these, you should consider the following questions when choosing a contractor:

- Have cost estimates been provided in writing?
- Does the contractor have experience installing and working with energy-efficient equipment?
- Is the contractor licensed and insured?
- Does the contractor certify that the work will conform to provincial and local regulations and codes?
- Can the contractor provide proof that they carry workers' compensation insurance?
- Have multiple, current references been provided?

Several procurement-related documents may need to be prepared, including a statement of work and a contract template.

A statement of work defines the project scope in sufficient detail to allow prospective contractors to determine if they can provide the services. For a major retrofit project, it may also be accompanied by drawings and specifications.

In addition to creating well-defined procurement documents, holding a bidders' meeting is a constructive way to ensure that all prospective contractors have a clear and common understanding of the project requirements.

SECTION 3

Contracts fall into three broad categories:

- **Fixed-price** or lump-sum contracts involve a fixed total price for a well-defined product or service.
- **Cost-reimbursable** contracts involve payment (reimbursement) to the contractor for their actual costs. Costs are usually classified as direct or indirect. Direct costs are incurred directly by the project, such as wages for the project team. Indirect costs are costs allocated to the project by the performing organization as a cost of doing business, such as salaries for corporate executives. Indirect costs are usually calculated as a percentage of direct costs.
- **Time and material** contracts are a hybrid type of contractual arrangement that contains aspects of both cost-reimbursable and fixed-price arrangements. Time and material contracts resemble cost-type arrangements in that they are open-ended because the full value of the arrangement is not defined at the time of the award. Therefore, time and material contracts can grow in contract value as if they were cost-reimbursable arrangements. Conversely, time and material arrangements can also resemble fixed-price arrangements when, for example, the unit rates are preset by the buyer and seller, as when both parties agree on the rates for the category of "senior engineers."

Source: Public Works and Government Services Canada. "Time Management Definitions." http://www.tpsgc-pwgsc.gc.ca/biens-property/sngp-npms/bi-rp/conn-know/temps-time/definition-eng.html#c

Commissioning and project hand-off

Commissioning will verify the functional performance of your new equipment and systems, and involves developing a systems manual to document critical information about their operations and maintenance. This information can also be used to train new staff.

The commissioning process will answer questions such as:

- Are your retrofit measures functioning as intended?
- Is energy performance being maintained by your operations staff?

Once your retrofit has been properly commissioned, several issues should be considered before responsibility for retrofit equipment passes from the contractor to the building owner. These may include:

- Ensuring that the terms of all procurement and service contracts have been met.
- Ensuring that any equipment warranty information has been communicated and transferred as necessary.
- Implementing a measurement and verification (M&V) plan to ensure that your retrofit will realize anticipated savings and that unexpected energy performance can be diagnosed. (See **Monitoring and tracking** in Section 4).

Systems manuals differ from traditional operations and maintenance manuals because they include operational narratives, schematic diagrams, operational sequences, set points and schedules, control points, and troubleshooting guides. They also outline calibration schedules and replacement schedules (for devices, filters, etc.).

SECTION 4

MAINTAINING YOUR PERFORMANCE

Even the best energy efficiency projects are not foolproof and can fail for several reasons:

- Operational information is not documented.
- Key personnel are not trained to handle new systems, processes or technologies.
- Building performance is not monitored.

By adopting a high-performance operational program, you can protect your major retrofit investment and ensure that its intended benefits are fully realized.

MAINTAIN
- training staff
- ongoing building optimization
- monitoring and tracking

Training staff

Developing highly trained staff is essential if you want to maximize the performance of your recently completed major retrofit. Investing in equipment and technology is only the tip of the iceberg. Unless this is accompanied by a commensurate adjustment in behaviour, major energy savings will not be realized.

- Do building operators in your organization have the capacity to take full advantage of your retrofit investment?
- Is your energy manager comfortable performing ongoing commissioning activities?

By undertaking a needs assessment for relevant facility staff, you can identify capacity gaps and develop a customized training program.

Visit NRCan's Energy management training section at **http://www.nrcan.gc.ca/energy/efficiency/buildings/emt/3707** for more information.

Building automation systems optimize the energy consumption of buildings. Many of these systems are complex, and building operators may require specialized **training** to realize the full benefit of an automation system.

Energy managers may require **training** on monitoring and tracking to ensure that they can perform their roles effectively.

SECTION 4

Ongoing building optimization

After your project has been properly commissioned, there are two general approaches to ongoing commissioning. One approach is to recommission periodically (the BOMA BEST standard recommends recommissioning at a minimum every five years). The other approach is to implement a continuous commissioning program as part of a preventative maintenance program (the LEED Canada for Existing Buildings rating system recommends that time lapses between reviews of building systems and equipment should not exceed 24 months).

The advantage of a continuous program is that operational deficiencies are more likely to be discovered and corrected sooner than under a periodic recommissioning approach. Regardless of the program implemented, maintaining current records of systems and equipment is useful for reference, comparison and future planning.

Monitoring and tracking

Simply put, you cannot manage what you do not measure. Tracking energy use data provides the basis for setting and revising energy performance targets and allows your organization to prove the benefits of your retrofit project activities.

- Do you have a clear and well-defined process to monitor and verify energy performance at your facility?
- How does your facility's performance compare to other, similar facilities?

You can address these questions by tracking and analyzing your energy data using proven techniques and approaches.

After measures are implemented, they require periodic monitoring to ensure that their benefits are realized over time. Sufficient resources and strategies must be put into place to ensure that measurements are recorded and analyzed on a periodic basis. Energy data can be monitored at the facility level by using utility meters and at the system level, such as your chiller plant, by using submeters. Historical energy data can be used to develop baselines for your building, as well as for individual projects.

The most basic method of tracking performance is to add monthly energy billing data into ENERGY STAR Portfolio Manager. For larger, more complex major retrofit activities, project-level savings can be assessed through measurement and verification by following the International Performance Measurement and Verification Protocol (IPMVP). If your organization has entered into an energy performance contract, the ESCo may be responsible for measurement and verification activities.

Forecast future energy consumption trends based on your planned major retrofit measures.

Monitor your actual energy consumption against the baseline you established using Portfolio Manager and your forecast. Variances should be investigated and explained.

Continue to benchmark your organization's performance over time by comparing your facilities to other similar Canadian facilities using Portfolio Manager.

THE ABC BUILDING: AN EXAMPLE

In 2013, the ABC Building, a six-storey office building built in 1983, was ripe for a major retrofit. For several years, tenants had complained to the building manager about the building conditions. It was either too hot or too cold; it was drafty; the lobby lighting was not adequate. Some tenants were even beginning to look for new office space. When a new building manager, Joe Smith, took over, things started to change.

> "One of the first things I did was walk around the building one night, after hours," Joe recalls. "I went ahead and fixed some of the small things myself – caulked some windows and doors. But if I really wanted to make a dent – make things better for the tenants – then I'd need money."

Establishing commitment and benchmarking

Joe decided to review the utility bills for the last year to get a better idea of how much energy the building was using. He noticed that although a new direct digital control (DDC) system had been installed, the controls had not been optimized. Using ENERGY STAR Portfolio Manager, Joe found that the building's ENERGY STAR score was 24. He took all that information to the building owner, who agreed to hire an experienced auditor to identify energy saving opportunities.

In the summer of 2013, DEF Engineering was hired to assess the opportunity for improvement in the building by determining what existing equipment could be improved or recalibrated. Their scope of work included implementing an ASHRAE Level II audit, as well as the assessment and investigation phases of the existing building commissioning process.

Existing building commissioning and energy audit

Aided by Joe's investigations, a consultant with DEF Engineering started by conducting a detailed survey of the building's existing systems and reviewed the utility bills from past three years. The average annual utility costs (electricity and natural gas) totalled almost $100,000, with space heating accounting for almost half of the building's energy use. The consultant also conducted a thorough walk-through.

CASE STUDY

ABC BUILDING

Area:
4,100 m^2 (44,000 sq. ft.)

Envelope:

- two thirds glazing units, one third wall assembly
- satisfactory condition

Lighting:

- T12 main floor, basement, stairwells, utility, storage rooms
- T5 pendant and compact fluorescent lamp pot lighting on the 2nd to 6th floors

HVAC:

- Central air handling unit (AHU)
- 1,025-kW (3,500-MBh) fire tube hot water boiler
- 527-kW (150-ton) centrifugal chiller

Energy use intensity:

- 1.4 GJ/m^2 (pre-retrofit)
- 1.0 GJ/m^2 (post-retrofit)

ENERGY STAR score:

- 24 (pre-retrofit)
- 62 (post-retrofit)

Energy costs, annual:

- $100,000 (pre-retrofit)
- $84,000 (post-retrofit)

CASE STUDY

Lighting

The consultant discovered that the building was equipped with about 125 two-lamp T12 luminaires, which were outdated and inefficient. She recommended that the building keep the light fixtures but replace the ballasts and lamp holders with 25-watt T8 lamps that use high ballast factor ballasts and specular reflectors.

Note: LED technology is advancing very rapidly and may already be cost competitive in many applications.

Supplemental loads

During the audit, both the consultant and Joe spoke with the building's tenants. They found that many pieces of office equipment were old and inefficient and were often left on when not in use.

Envelope

An inspection found that wall insulation levels were adequate but that the roof insulation was well below current requirements. Insulation could be added at the next scheduled repair to bring its RSI-value above minimum NECB requirements without any undue interruption to the building's occupants.

Air distribution system

The AHU was running for more hours than was necessary, the building temperatures were never adjusted during unoccupied periods, and user comfort was a major tenant complaint. The consultant determined that replacing the AHU supply fan motor would raise the motor efficiency above the minimum levels required under Canada's *Energy Efficiency Regulations*. This upgrade and optimizing the building's existing DDC system to better schedule the building's systems could improve energy performance and user comfort.

Heating and cooling equipment

The original boiler was operating at less than 65% efficiency. It had been installed 30 years earlier and was scheduled for replacement in 2016. A new, high-efficiency model would cost about $100,000 but would save more than $10,000 per year at current gas prices, for a simple payback period of about 10 years.

The original 527-kW (150-ton) centrifugal chiller was also installed when the building was constructed and was deemed to be oversized for the building's needs, which reduced its operating efficiency. The consultant estimated that, simply because of the advances in technology over the last three decades, energy consumption could be cut in half by using a new unit. A new $70,000 chiller would save almost $7,000 per year in electricity consumption and demand charges.

Domestic hot water was supplied by a gas-fired, 320-litre (85-gallon) hot water tank and a 10-year old recirculation pump. The tank was still operating efficiently, but could be optimized by rescheduling the recirculation system to run only during occupied hours. The consultant also recommended installing aerators on all taps and replacing all toilets with low-flow models as ways to reduce resource consumption.

CASE STUDY

Planning

The consultant started developing the business case by obtaining cost estimates and determining savings and simple payback period estimates for the list of viable opportunities.

Table 3. Costs, savings and simple payback periods of retrofit measures

Summary of measures	**Investment cost** ($)	**Annual savings*** ($)	**Simple payback period**** (years)
DDC optimization	1,500	200	7.5
Lighting	7,500	1,950	3.8
Water upgrades (toilets, aerators)	17,000	4,250	4.0
AHU motor upgrade	1,200	160	7.5
Boiler upgrade	100,000	10,000	10.0
Chiller upgrade	70,000	7,000	10.0
Roof insulation	80,000	4,500	17.8
Total	**277,200**	**28,060**	**9.9**

* Includes both water and energy savings.

** All measures have a simple payback period well within the life expectancy of the proposed measure.

The consultant learned from Joe that the owner's capital plan had funds allocated for a boiler replacement in 2016, a chiller replacement in 2018 and a roof replacement in 2023. Consequently, the consultant revised the measure table to account for incremental costs and savings and proposed a timeline that fit with the capital plan. The revised estimates reduced the simple payback period from about 10 years to less than 4 years.

CASE STUDY

Table 4. Proposed retrofit timeline and simple payback period

Summary of measures	Proposed timing	Investment cost (incremental) ($)	Annual savings (incremental) ($)	Simple payback period (years)
DDC optimization	2014	1,500	200	7.5
Lighting	2014	7,500	1,950	3.8
Water upgrades (toilets, aerators)	2014	17,000	4,250	4.0
AHU motor upgrade	2014	1,200	160	7.5
Boiler upgrade	2014	15,000	3,000	5.0
Chiller upgrade	2015	10,000	2,000	5.0
Roof insulation	2023	9,000	4,500	2.0
Total		**61,200**	**16,060**	**3.8**

Doing the major retrofit

Staged approach

The major retrofit project was completed in stages. This was logical from a system perspective (eliminating waste, improving efficiency, and then optimizing heating and cooling energy) and also garnered further support from building management.

> “The building owner wasn't sure whether some of the investments would be worth it, like a high-efficiency boiler, so we agreed to go after the easy stuff first,” Joe says. “I set the temperatures back, installed aerators in all the faucets, and brought in a contractor to recommission the DDC system. After three months, the owner was so impressed with the energy savings that she went ahead and committed to a full retrofit.”

CASE STUDY

Value beyond energy savings

"The tenants who were the most vocal about the temperature are the ones who are always at the EASE meetings," says Joe. "By showing that we were serious about improving their comfort levels and making the building more energy efficient, I am happy to say that we didn't lose a single tenant during the retrofits. In fact, we now have a waiting list of future tenants."

By the end of 2015, all of the building's T12 lighting was replaced with new, reduced wattage lighting, all lamps in the stairways and exit routes had been replaced with LED fixtures, the domestic hot water recirculation pump was rescheduled, toilets were replaced, and a new fan motor was installed on the AHU.

> "The consultant had told me that all of the upgrades in the world wouldn't work unless people changed their behaviours," recalls Joe. "That got me thinking about the city-wide power failure last summer that lasted three days. Even after we got the power back, the temperatures were still really hot that year, and the local utility had been asking everyone to conserve energy. I remember a lot of tenants asking me at the time if there were things that they could do. That was the start of our EASE (Energy Awareness Starts Early) program."

Tenants meet every month for lunch in the building's multi-purpose room to discuss ways of reducing energy at work. Some tenants also worked together to buy new ENERGY STAR office equipment in bulk.

The boiler and chiller were replaced as scheduled in the owner's updated capital plan. However, instead of putting in the equipment that only met minimum efficiency requirements, properly sized high-efficiency units were installed.

The roof replacement, slated for 2023, will involve increasing roof insulation and will mark the end of the major retrofit project.

Financing

The owner was able to finance the project through a mortgage lender by securing the loan against the property. The estimated annual cost savings were sufficient to service the additional mortgage debt on their own. However, cash flow was further improved by leveraging more than $6,000 in incentives through the local electricity and natural gas utilities.

CASE STUDY

Project management – contractor selection

Joe hired a single contractor to do all of the work.

> “He had more than 20 years’ experience, specific to office buildings, and had worked with many energy consultants in the past, including the one who did our audit.”

Training/monitoring and tracking

To ensure that energy savings continue into the future, Joe enrolled in an energy management workshop to learn more about monitoring energy performance.

> “Now I check our energy consumption every month with Portfolio Manager. It’s great being able to see what the real energy savings are compared to the original estimates and track how the building is doing over time.”

RESOURCES

References and additional resources are listed for each of the four sections of these guidelines (Assess, Plan, Implement and Maintain) to provide further information and assistance in planning and undertaking your major retrofit project.

Assess

Benchmarking

Natural Resources Canada's adaptation of ENERGY STAR Portfolio Manager
nrcan.gc.ca/ENERGYSTARPortfolioManager

Existing building commissioning

Natural Resources Canada's *Recommissioning Guide for Building Owners and Managers*
nrcan.gc.ca/energy/efficiency/buildings/research/optimization/recommissioning/3795

CSA Z320 Building Commissioning Standard & Check Sheets
shop.csa.ca/en/canada/building-systems/z320-11-/invt/27032582011

Auditing

Natural Resources Canada's Energy Savings Toolbox
nrcan.gc.ca/energy/efficiency/industry/cipec/5159

RETScreen 4
Natural Resource Canada's Project analysis software tool
nrcan.gc.ca/energy/software-tools/7465

California Energy Commission's *How to Hire An Energy Auditor to Identify Energy Efficiency Projects Handbook*
www.energy.ca.gov/reports/efficiency_handbooks/400-00-001C.PDF

American Society of Heating, Refrigerating and Air-Conditioning Engineers' Procedures For Commercial Building Energy Audits
www.ashrae.org

RESOURCES

Plan

Capital planning

Rocky Mountain Institute's *Managing Deep Energy Retrofits*
www.rmi.org/Content/Files/RetroFit_Depot_Managing_Guide_1.1.pdf

Canada's energy code
nrcan.gc.ca/energy/efficiency/buildings/eenb/codes/4037

Business case development

RETScreen 4
Natural Resource Canada's Project analysis software tool
nrcan.gc.ca/energy/software-tools/7465

Rocky Mountain Institute's *How to Calculate and Present Deep Retrofit Value: A Guide for Owner-Occupants*
www.rmi.org/retrofit_depot_deepretrofitvalue

Rocky Mountain Institute's *Guide to Building the Case for Deep Energy Retrofits*
www.rmi.org/Content/Files/RMI_Retrofit_Guide_BuildingTheCase_1.1.pdf

Financing

Bryan Purcell's article in *ReNew Canada*, "Money and Power: New Financing Options for Energy Retrofits to Existing Building"
www.towerwise.ca/wp-content/uploads/2013/05/ReNew-Canada-Money-and-Power-March-2012.pdf

Natural Resources Canada's *Directory of Energy Efficiency and Alternative Energy Programs in Canada*
oee.nrcan.gc.ca/corporate/statistics/neud/dpa/policy_e/programs.cfm

Environmental Defense Fund's Investor Confidence Project
www.eeperformance.org/

RESOURCES

Implement

Project management

Project Management Institute's *A Guide to the Project Management Body of Knowledge (PMBOK Guide®)*
www.pmi.org/pmbok-guide-standards/foundational/pmbok

California Energy Commission's *How to Hire A Construction Manager For Your Energy Efficiency Projects*
www.energy.ca.gov/reports/efficiency_handbooks/400-00-001E.PDF

Contractor selection

Natural Resources Canada's *Energy Performance Contracting: Guide for Federal Buildings*
nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/files/pdf/communities-government/buildings/federal/pdf/12-0419%20-%20EPC_e.pdf

California Energy Commission's *How to Hire An Energy Services Company*
www.energy.ca.gov/reports/efficiency_handbooks/400-00-001D.PDF

Maintain

Best Practices

Natural Resources Canada's *Energy Management Best Practices Guide for Commercial and Institutional Buildings*
nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/files/pdf/publications/commercial/best_practices_e.pdf

Training

Association of Energy Engineers (AEE) Certified Energy Manager program and Building Operator Certification program offered by the Canadian Institute for Energy Training (CIET)
cietcanada.com/

Building Owners and Managers Association (BOMA) Energy Training for Building Operations **www.bomalearning.com/home2**

Natural Resources Canada's *Energy Management Training Primer*
nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/files/pdf/publications/commercial/EMT_Primer_en.pdf

RESOURCES

Monitoring and tracking

Natural Resources Canada's adaptation of ENERGY STAR Portfolio Manager
nrcan.gc.ca/ENERGYSTARPortfolioManager

RETScreen Plus
Natural Resource Canada's energy management software tool
nrcan.gc.ca/energy/software-tools/7465

IPMVP – Volume 1
Efficiency Valuation Organization's International Performance Measurement and Verification Protocol
www.evo-world.org/

NATIONAL ENERGY CODE OF CANADA FOR BUILDINGS

The *National Energy Code of Canada for Buildings* (NECB) is an energy code for new buildings that defines a set of minimum energy performance requirements for various building components. Those components include the building envelope; interior and exterior lighting; heating, ventilating and air conditioning systems; service water heating; and electrical power systems and motors.

The most recent version of the NECB should always be consulted as a starting point when planning major retrofits. In new buildings, compliance with the NECB can be accomplished through a performance path (energy modelling) or by following a prescriptive path. Compliance can also be reached through "trade-off" calculations, in which enhanced energy efficiency of one component can be traded against decreased energy efficiency of another component within the same part of the code.

The following subsections describe the nature of the prescriptive requirements associated with each building component. Although compliance with the NECB is applicable only to new buildings, you should aim to meet, or ideally exceed, the latest NECB requirements for the components of your facility impacted by your retrofit project.

Building envelope

Building envelope requirements are designed to minimize uncontrolled infiltration of outdoor air and to minimize the transmission of heat through the envelope. The NECB prescribes minimum insulating values of various envelope components, including walls, roofs, floors, windows and doors. The requirements are listed in various tables for each component and are more stringent in colder climate zones.

The prescriptive requirements include maintaining a continuous layer of insulation to minimize heat loss. Where this is not possible, the NECB permits limited penetrations and breaks in the continuity by applying alternative insulating methods. The methods must compensate for the increased thermal transmittance of the penetration and result in a thermal performance equivalent to that of a continuously insulated envelope.

NECB

Interior and exterior lighting

Lighting power density limitations in the NECB are specified in watts per square metre based on building type or space usage (e.g. offices, hospitals, retail stores).

For retrofits, these limitations can be used as a guideline for determining whether a given lighting design meets this minimum energy efficiency level.

Interior lighting must have automated controls to shut off lights when spaces are unoccupied.

Controls that can dim interior lighting when adequate daylighting is available are required in large areas that are lit during the day by skylights and/or vertical fenestration.

Exterior lighting power is also regulated, and astronomical time clocks or photo sensor controls, which turn lights off during daylight hours, are required.

Heating, ventilating and air-conditioning systems

Requirements for HVAC systems address a wide range of system components and include:

- Right-sized equipment.
- An air handling system designed so that it can be balanced.
- Sealing of all ductwork, and insulation and protection of ductwork located outside of conditioned spaces.
- Heat recovery on exhaust air in some cases.
- Economizers that can bring in extra outdoor air for free cooling, and water-side economizers than can save cooling energy by bypassing the chiller plant.
- Outdoor air dampers that close automatically when the ventilation system is turned off.
- Insulation of hot and chilled water piping.
- Controls and systems designed to eliminate wasteful reheating of previously cooled air and re-cooling of previously heated air.
- Thermostats and controls that allow HVAC systems to be controlled by thermal zone to maximize comfort and save energy.
- Automatic controls that shut off ventilation systems when spaces are unoccupied and for nighttime setback of heating and cooling systems.
- Minimum efficiency standards for all components of HVAC systems, including chillers, boilers, furnaces, heat pumps, fluid pumps, fans, etc.
- Automated controls for snow and ice melting systems to turn them off when they are not needed.

NECB

Service water heating

The NECB addresses insulation of hot water piping and storage tanks and includes a table of minimum efficiency requirements for water heating. Controls are required for recirculation systems to reduce heat loss during unoccupied hours. Maximum flow rates are prescribed for showerheads and lavatory faucets to reduce the demand for hot water.

Electrical power systems and motors

A design that allows submetering is required when a capacity threshold is reached. Minimum efficiency standards are mandated for electrical transformers and for electrical motors (pumps, fans, etc.).

ABBREVIATIONS

ACH	Air changes per hour
AEE	Association of Energy Engineers
AFUE	Annual fuel utilization efficiency
AHU	Air handling unit
ARI	Air-Conditioning and Refrigeration Institute
ASHP	Air-source heat pump
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BAS	Building automation system
BCA	Building Commissioning Association
BOMA	Building Owners and Managers Association
CaGBC	Canada Green Building Council
CBSM	Community-based social marketing
CEE	Consortium for Energy Efficiency
CEM	Certified energy manager
CET	Certified engineering technologist
CFCs	Chlorofluorocarbons
CFL	Compact fluorescent lamp
CHP	Combined heat and power
CMVP	Certified measurement and verification professional
COP	Coefficient of performance
CRI	Colour rendering index
CV	Constant volume
DALI	Digital addressable lighting interface
DCV	Demand control ventilation
DDC	Direct digital controls
DOAS	Dedicated outdoor air system

ABBREVIATIONS

DV	Displacement ventilation
DX	Direct expansion
EBCx	Existing building commissioning
ECDM	Energy conservation and demand management
EER	Energy efficiency ratio
EES	Energy Efficient Schools
EIFS	Exterior insulation finish system
EMS	Environmental management system
EPA	Environmental Protection Agency (U.S.)
ERV	Energy recovery ventilator
ESCo	Energy services company
EUI	Energy use intensity
GHG	Greenhouse gas
GSHP	Ground-source heat pump
GWP	Global warming potential
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HID	High-intensity discharge
HRV	Heat recovery ventilator
HVAC	Heating, ventilating and air conditioning
HVLS	High-volume, low-speed [fans]
IAQ	Indoor air quality
IECC	International Energy Conservation Code
IEER	Integrated energy efficiency ratio
IESNA	Illuminating Engineering Society of North America
IGCC	International Green Construction Code
IGU	Insulating glass unit
IPLV	Integrated part-load value
IPMVP	International Performance Measurement and Verification Protocol
IRR	Internal rate of return
LED	Light-emitting diode

ABBREVIATIONS

LEED	Leadership in Energy and Environmental Design
LPD	Lighting power density
MH	Metal halide
MRI	Magnetic resonance imaging
NBC	*National Building Code*
NECB	*National Energy Code of Canada for Buildings*
NEMA	National Electrical Manufacturers Association
NFRC	National Fenestration Rating Council
NOI	Net operating income
NPV	Net present value
NRCan	Natural Resources Canada
ODP	Ozone-depleting potential
OPA	Ontario Power Authority
PNNL	Pacific Northwest National Laboratory
RealPAC	Real Property Association of Canada
RTU	Rooftop (air handling) unit
SEER	Seasonal energy efficiency ratio
SHGC	Solar heat gain coefficient
T5-HO	T5 high-output
UPS	Uninterruptible power supply
U.S.	United States
VAV	Variable air volume
VFD	Variable frequency drive
VRF	Variable refrigerant flow
VSD	Variable speed-drive

GLOSSARY

Adaptive reuse (also known as repositioning or repurposing)	Changes the function or identity of a building to meet current needs of clients and tenants.
Air distribution system	Distributes ventilation air and typically provides some or all heating, cooling and humidification to a building's spaces.
Asset management *See also Fixed assets*	Includes activities associated with the acquisition, operation, maintenance, renewal and replacement of an organization's fixed assets.
Baseline	Quantitative reference that provides a basis for comparison of performance that applies to a specific period and provides a reference for comparison before and after energy improvements.
Building envelope	The entire building exterior, including the roof, walls, foundation, windows and doors, that separates the conditioned space from the exterior.
Capital planning	Structured approach for managing long-term assets. A capital plan categorizes and prioritizes the renewal of physical assets.
Capitalization rate	The ratio between the net operating income produced by an asset and its capital cost (the original price paid to buy the asset) or, alternatively, its current market value.
Commissioning	Verifies the functional performance of new equipment and systems and documents critical information about their operations and maintenance.
Condensing boiler	Recovers the condensation heat retained latently in flue gases. Water vapour contained in the flue gases condenses on the cooler heat exchanger surfaces of the boiler, transferring heat into the boiler water. The heat released from condensation is transmitted directly into the boiler water.
Constant volume (CV) (also known as constant air volume [CAV])	Uses a constant supply of air in the building's air distribution system.

GLOSSARY

Daylight harvesting	Makes use of natural light as a source of illumination, allowing electric lighting to be switched off or dimmed.
Delamping	Permanently removes unnecessary lamps or fixtures in areas that have more illumination than is needed.
Energy audit	Identifies energy saving opportunities by assessing current building equipment, operations and building energy use patterns.
Energy efficiency ratio (EER) *See also Integrated energy efficiency ratio (IEER) and Seasonal energy efficiency ratio (SEER)*	The ratio of a heating or cooling system's output, per hour, in British thermal units to the input in watts, used to measure the system's efficiency.
Energy benchmarking	Compares a building's energy use against similar buildings that have been "normalized" for site-specific characteristics such as weather conditions, hours of operation and occupancy.
Energy performance	The relationship between energy use and the variables that impact energy use. Variables include physical conditions (e.g. floor area), environmental conditions (e.g. heating degree days) and operational conditions (e.g. occupancy rates).
Energy services company (ESCo)	Company that provides turnkey design and installation of energy efficiency measures and secures financing at its own risk.
ENERGY STAR Portfolio Manager	An online tool to measure and track energy and water consumption, as well as greenhouse gas emissions. Used to benchmark the performance of one building or a portfolio of buildings. The tool was developed by the U.S. Environmental Protection Agency and adapted for use in Canada by NRCan.
Energy use intensity (EUI)	A building's annual energy consumption divided by floor area, expressed per square metre or square foot.

GLOSSARY

Existing building commissioning (EBCx) *See also Recommissioning/ retro-commissioning*	Provides an understanding of how a facility is currently operating and how closely it comes to operating as intended. Specifically, it helps identify improper equipment performance, equipment or systems that need to be replaced, and operational strategies for improving the performance of the various building systems. The term "existing building commissioning" has been widely adopted by the industry to refer to any commissioning of a building after its initial acceptance phase, replacing the terms "recommissioning" and "retro-commissioning."
Fixed assets *See also Asset management*	Facilities and equipment owned by an organization.
Full cost (also known as gross capital cost)	Considers the entire cost of the retrofit.
Incremental cost (also known as marginal cost)	Considers the portion of the retrofit cost attributable to energy improvements.
Integrated energy efficiency ratio (IEER) *See also Energy efficiency ratio (EER)*	A single number of merit expressing cooling part-load EER efficiency for commercial unitary air conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.
Internal rate of return (IRR)	The discount rate that makes the value of energy savings (as well as other ongoing benefits or costs that accrue over time) equal to the cost of the initial retrofit. Retrofits with higher IRRs are more attractive.
Light-emitting diode (LED)	An electronic device that emits light when an electrical current is passed through it.
Major retrofits	Retrofits that involve several energy measures across more than one building system.
Net operating income (NOI)	The income stream generated by the operation of the property, independent of external factors such as financing and income taxes. A property's yearly gross income less operating expenses.

GLOSSARY

Net present value (NPV)	The sum of the (positive) value of energy savings and other ongoing benefits or costs that accrue over time as a result of the energy retrofit and the (negative) value of the initial retrofit investment. Benefits or costs that occur in the future are discounted to reflect the time value of money. All else being equal, retrofits with higher positive NPVs are more attractive.
On-bill financing	Financing through a utility, with repayment of principal and interest included on the customer's utility bill. Repayment schedules are such that the loan repayment amounts are less than the value of the energy savings.
Property-assessed financing	Property tax-based financing in which municipalities offer loans to property owners, secured by a tax lien on the property.
Recommissioning/ retro-commissioning *See also Existing building commissioning*	Recommissioning/retro-commissioning are terms often used interchangeably to mean the commissioning of an existing building. The difference in the terminology refers to whether the building has been previously commissioned. Recommissioning is used when a building has previously been commissioned, and retro-commissioning is used when it has not. To resolve confusion, the industry has largely adopted the term "existing building commissioning" to refer to any commissioning done on a building after its initial construction acceptance phase.
Right-sizing	Reducing the size of a piece of equipment so that it provides the correct peak energy service. This avoids excessive energy use by operating more often in an efficient range of the equipment part-load performance curve.
Rooftop air handling unit (RTU)	A packaged heating and cooling unit mounted on the roof.
RSI factor (also known as R-value or R-factor when using imperial units)	The capacity of an insulating material to resist heat flow. The higher the RSI value, the greater the insulating properties.
Seasonal energy efficiency ratio (SEER) *See also Energy efficiency ratio (EER)*	Describes the seasonally adjusted rating based on representative residential loads.

GLOSSARY

Simple payback period	The value of an initial investment divided by the value of all annual cash flows resulting from that investment. Formula: P (payback period) = I (investment)/CF (annual cash flow).
Solar heat gain coefficient (SHGC)	The fraction of incident solar radiation entering a building through the entire window assembly.
Specular reflector	A luminaire component with a highly polished surface to reflect more light down to the occupied space, increasing the useful light output and overall luminaire efficiency.
Supplemental load	Additional equipment that contributes to and affects a building's energy load. Includes computers, electronic equipment, plug loads, etc.
U-factor	The rate of heat loss of an insulating material (i.e. the inverse of R-value). The lower the U-factor, the greater the insulating properties.
Urban heat island effect	Describes built-up areas (i.e. metropolitan areas, cities) that are hotter than nearby rural areas because of human activities. The annual mean temperature of a city can be 1 to 3 °C warmer than its surroundings.
Variable air volume (VAV)	A type of HVAC system that can provide variable airflow rates to different zones based on zonal requirements. The simplest VAV system incorporates one supply duct that distributes approximately 13°C (55°F) supply air when in cooling mode.
Variable refrigerant flow (VRF)	Composed of distributed heat pumps that serve zone conditioning needs. Some systems can be configured to deliver simultaneous heating in certain zones and cooling in others (conditions that apply during shoulder seasons and in large interior zones).
Variable speed-drive (VSD)	Allows the motor speed to vary depending on actual operating conditions, rather than operating continuously at full speed. Varying the fan or pump speed to match changing load conditions reduces the power draw.
Zone temperature deadband	A temperature range that is above the heating set point but below the cooling set point, in which neither heating nor cooling is provided to the zone.