Energy Management in Commercial Buildings: The Value of Best Practices
Preface

The operation of buildings accounts for a considerable amount of energy consumption. Commercial buildings are responsible for 14 per cent of Canada’s secondary energy consumption. Best practices in energy management and building operations present opportunities for substantial energy and capital savings, as well as greenhouse gas reductions. This report summarizes many best practices, reviews the benefits from adopting them, and examines the barriers that have hindered broad implementation. The roles of each of the stakeholders are discussed. Interviews with representatives of each stakeholder group have helped to further define the challenges and opportunities.
CONTENTS

Executive Summary ............................................................... i

Chapter 1—Introduction ......................................................... 1
Commercial Sector Energy Management Best Practices .............................. 1
Energy Consumption in Canada and Its Commercial Buildings ....................... 2

Chapter 2—Literature Summary ............................................... 5
General Issues Related to Energy Management ...................................... 5
Issues on Which Government Takes Leadership .................................... 7
Issues of Primary Importance to Building Owners, Operators, and Tenants ......... 8

Chapter 3—Best Practices ....................................................... 13

Chapter 4—The Business Case for Energy Efficiency Best Practices ............... 22
The Benefits of Energy Management Best Practices .................................. 23
Barriers to Implementing Energy Management Best Practices ...................... 23
Capturing the Opportunity—Balancing the Benefits Against the Costs ............. 24

Chapter 5—Conclusions ......................................................... 30
Incentive Programs .................................................................. 31
Government Pilot Programs ....................................................... 31
Non-Government Pilot Programs .................................................. 32
Codes and Standards ................................................................ 32
Building Information Databases and Benchmarking .................................... 32
Industry Studies ..................................................................... 32

Appendix A—Bibliography ....................................................... 33
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Executive Summary

Energy Management in Commercial Buildings: The Value of Best Practices

At a Glance

- Commercial buildings account for 14 per cent of Canada’s secondary energy consumption. Reducing that consumption will improve competitiveness and contribute to meeting Canada’s greenhouse gas emission reduction targets.
- Training, communications, data collection, and investments based on life cycle costs, rather than first costs, are keys to success in reducing energy consumption.
- Better alignment of the interests of all stakeholders can help to overcome the most common barriers to broad implementation of energy efficiency best practices.

Energy conservation, energy efficiency, and energy management are closely related concepts that play a key role in ensuring that Canadians reduce their energy consumption and properly manage the nation’s resource endowment. Commercial buildings account for 14 per cent of Canada’s secondary energy consumption, but several barriers currently discourage better energy management. These barriers include ownership, management and occupancy patterns, and the extended life cycles of both the buildings and the energy-consuming equipment they contain. This report examines some of those issues and presents a business case for broader adoption of energy efficiency best practices for commercial buildings.

Two decades from now, roughly three-quarters of the commercial building stock will be newly built or retrofitted. This provides an excellent opportunity to move toward best practices. Incorporating energy management early in the design phase will help to ensure that equipment is selected on a life cycle cost basis (rather than first cost), and that energy efficiency is a primary objective from the beginning of a project. New buildings and retrofits will both be able to benefit from proper commissioning of new equipment and building automation.

The literature identifies three main issues that apply to all stakeholders: managing the environmental and energy footprint of the building; disseminating best practices to a broad range of stakeholders; and focusing efforts on the energy consumption that can best reduce environmental pressures.

Governments play a role in developing energy policies and programs that support energy efficiency, working to continuously improve codes and standards, communicating the benefits of energy management to stakeholders, and coordinating efforts between governments.

Building owners, operators, and tenants adopt best practices by focusing on energy efficiency as a strategic priority; hiring qualified specialists as staff or advisors;
gathering and managing the necessary data; including energy efficiency in operating objectives; ensuring buildings and equipment are properly commissioned; adopting new technologies as they are proven; and communicating the importance of energy efficiency to all stakeholders. Performance tracking and continuous improvement are central to best practices implementation.

THE BUSINESS CASE FOR BEST PRACTICES

The literature summary, interviews with experts, and subsequent analysis identified 10 reasons to implement energy efficiency best practices:

1. Reduced energy costs
2. Reduced energy consumption and the resulting environmental benefits
3. Reduced greenhouse gas emissions
4. Reduced long-term costs of owning and operating the building
5. Reduced equipment failures and downtime
6. Higher building value
7. Attracting potential staff to a “green” building
8. Improved occupant productivity
9. Leadership in sustainability practices
10. Green branding

Most of these benefits are financial in nature, although many of them also reduce environmental pressures and contribute to an organization’s reputation for sustainable practices. Some of the benefits can be measured directly, or estimated accurately (the first three in particular); others will take years to demonstrate (benefits 4 through 6); and some are extremely difficult to measure (benefits 7 through 10). A long-term focus is essential to properly consider the benefits of best practices.

Short-term thinking, or poor alignment between the interests of stakeholders, is at the heart of several of the barriers encountered. For example, the building owner must bear the cost of an energy efficient building design, investments in retrofitting, and equipment purchases or replacement. If the owner takes the view that first cost is more important than life cycle cost, or if the owner has no effective means of encouraging building occupants to share those costs, there can be a bias toward first cost that impairs energy efficiency investments. Similarly, when energy consumption is not measured for each tenant (as is often the case in office buildings), individual tenants do not see the financial benefit from their efforts to reduce energy consumption. In other cases, if building operators treat energy costs as a pass-through item, there is a reduced incentive to optimize building energy consumption.

Each of the benefits can be captured, although their quantification and financial impact varies from building to building and location to location. And each of the barriers can be addressed, as described in the business case itself. Governments can act to accelerate best practices implementation in several ways: developing supportive policies, participating in pilot programs, implementing best practices in the buildings they own or operate, working to promote continuous improvement in codes and standards, and coordinating or harmonizing with other governments.
Introduction

Chapter Summary

- Commercial sector buildings account for 14 per cent of Canada’s secondary energy consumption.
- Energy management best practices can reduce commercial building energy consumption by as much as 14 per cent—coming close to Canada’s target to reduce GHG emissions by 17 per cent.
- Offices, retail centres, schools, and health facilities are the commercial sector’s most important energy consumers.

COMMERCIAL SECTOR ENERGY MANAGEMENT BEST PRACTICES

This chapter makes the case for broader adoption of best practices in Canadian commercial sector buildings. The findings are based on a literature survey, expert interviews, and analysis. Although there are several organizations that have identified best practices for commercial buildings, the progress toward implementation has been rather slow.

Commercial buildings include hospitals, schools, universities, shopping facilities, warehouses, offices, government buildings, and other buildings in the public administration and commercial sectors. There is a broad range of building types and uses, and these buildings consume a significant amount of energy, as indicated later in this chapter. Buildings have very long lives, and the equipment that heats, cools, and provides lighting lasts for a few years or a few decades, depending on the equipment.

The literature reviewed indicates that implementing best practices can reduce building energy consumption by an amount that is consistent with Canada’s overall target for GHG reductions.

As energy costs rise, and as the world transitions to a low-carbon future, energy efficiency and conservation opportunities in commercial buildings are receiving increasing attention. Energy efficiency and conservation result from a combination of efficient building design, equipment selection, efficient operating practices, preventive maintenance, and changes in occupant behaviour. Although individual decisions or actions may not always result in significant energy savings, collectively they do. The literature reviewed indicates that implementing best practices can reduce building energy consumption by an amount that is consistent with Canada’s overall target for greenhouse gas (GHG) reductions.
Energy efficiency best practices result in reduced energy consumption, reduced GHG emissions, reduced energy costs, a more productive workforce, and improved stewardship of our energy resources. Despite the significant benefits, best practices are not yet widely adopted. A number of reasons are examined, and options presented, to overcome the barriers to broader implementation.

ENERGY CONSUMPTION IN CANADA AND ITS COMMERCIAL BUILDINGS

Canada is one of the world’s leading energy producers and has the highest level of per capita energy consumption in the world.¹ These two realities—combined with a Copenhagen Accord commitment to significantly reduce GHG emissions to 17 per cent below their 2005 level by 2020—mean that the links between population, economic activity, energy consumption, and emissions must be redefined.

Commercial buildings are estimated to account for 14 per cent of Canada’s secondary energy consumption and 13 per cent of greenhouse gas emissions.

This report focuses on the role that energy management in commercial and institutional buildings will play in the transition toward a lower-carbon economy. Because more than 80 per cent of Canada’s GHG emissions result from the production, transformation, or use of energy, these are the activities where improvements must be sought to reduce emissions.

Chart 1² shows the context of secondary energy consumption for broad sectors of the Canadian economy in 2009. Secondary energy refers to energy in the form that it is delivered to end-consumers (as compared with the form in which it is initially produced).

The commercial and institutional sector includes a broad range of government functions and commercial services: wholesale trade, retail trade, transportation and warehousing, information and cultural industries, offices, education services, health care, arts and recreation, accommodation and food, and other services. As a whole, the sector accounted for 709.5 million square metres of floor space in 2009, as compared with 1.79 billion square metres of residential floor space. Secondary energy consumption and floor space for each subsector are shown in Chart 2. As the chart indicates, offices account for the largest share of both energy consumption (35 per cent) and floor space (41 per cent). And retail trade, education, and health care rank among the top four subsectors in terms of energy consumption. Commercial buildings are estimated to account for 14 per cent of Canada’s secondary energy consumption and 13 per cent of greenhouse gas emissions.³

Chart 3 shows that there is considerable variation in the energy intensity of the subsectors if we define intensity as energy consumption per square metre. The most energy intensive subsectors are food and accommodation (2.52 GJ/ [gigajoules] square metre) and health care (2.49 GJ/square metre), while warehousing is the least energy intensive (1.36 GJ/square metre) at just

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¹ Canada is also among the countries with the highest level of greenhouse gas emissions per capita.

² The data for all charts in this section are taken from Natural Resources Canada, Office of Energy Efficiency, Comprehensive Energy Use Database Tables. Aggregations or calculations made for graphical presentation are by The Conference Board of Canada.

³ National Round Table on the Environment and the Economy, and Sustainable Development Technology Canada, Geared for Change.
over half the level of food and accommodation. This is not surprising as warehousing is mostly a storage activity that often requires less heating or cooling energy; whereas the other two sectors add cooking and other energy service requirements. Offices rank second in energy efficiency (1.42 GJ/square metre) indicating that past efforts to improve energy management have paid dividends. In these data, offices include finance and insurance; real estate, rental, and leasing; professional, scientific and technical services; and public administration.

The trend in energy consumption through time is also revealing. Chart 4 shows total commercial and institutional energy consumption for each of the major energy-consuming activities, and Chart 5 shows the energy intensity of those activities. As is evident, secondary energy consumption has increased from 867 PJ (petajoules) in 1990 to 1,186 PJ in 2009—a compound annual growth of 1.5 per cent.

Given that floor space increased at an annual rate of 1.75 per cent, the aggregate of the energy intensities shown in Chart 5 improved slightly over the period. However, individual intensities bear on the theme of this report. The dotted lines in the chart represent weather-normalized intensities for space heating and cooling. Weather normalization is an important step because it removes the influence of abnormally cold winters or warm summers on space-conditioning intensities. The normalization is achieved by adjusting the raw data for the deviation of heating or cooling degree days from their long-term averages.

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4 Note that these intensities are calculated using total energy consumption in the sector divided by total floor space. As a result, they do not reflect the energy intensity of individual buildings.
Space heating accounts for about half of the energy consumed in the commercial and institutional sectors. It is, by far, the most energy intensive of the activities shown. The weather-normalized intensity of space heating has started to show an improvement in energy intensity only since 2005. Space cooling has not shown a clear intensity trend. The energy intensity of lighting has improved by about 20 per cent since 1990, reflecting both improved energy efficiency and conservation. The most significant shift has been in the level and intensity of energy consumed by auxiliary equipment. Intensity has doubled since 1990. Auxiliary equipment includes plug load items (computers, office machines, health care equipment, retail displays, etc.).

From 2005 to 2030, the stock of commercial buildings is projected to grow by 62 per cent, and 40 per cent of existing buildings will be retrofitted for energy efficiency. This represents a tremendous opportunity for investments that could accelerate the improvement in the energy intensity of commercial buildings.

Sources: Natural Resources Canada, Office of Energy Efficiency, Comprehensive Energy Use Database Tables; The Conference Board of Canada.

5 Adelaar and others, Green Building Energy Scenarios, 20, 37.
CHAPTER 2

Literature Summary

Chapter Summary

- There is a large potential for improving the energy efficiency of Canadian commercial buildings as new buildings are constructed and existing buildings are retrofitted in the coming decades.
- The diversity of building types and building uses, together with the large number of building owners and operators, creates challenges in broadly disseminating best practices information and facilitating their implementation.
- Best practices are based on aligning the interests of building owners, operators, and occupants to ensure that everyone is aware of conservation or efficiency opportunities and is contributing to their success.

There is a significant global potential benefit from improved building energy efficiency. The World Business Council for Sustainable Development estimates that buildings represent 40 per cent of global energy consumption. And by 2050, potential energy savings in buildings could be as large as current energy consumption in industry and transport combined.¹

In Canada, “... by the year 2035, three-quarters of Canada’s buildings will be new or renovated and this affords a great opportunity . . . .”² The energy savings potential for Canada’s commercial sector has been estimated at between 46 and 51 per cent by 2030.³ However, there are a number of obstacles that must first be overcome.

A literature review identified a number of themes that can be grouped into three broad categories: general issues related to building energy management and its implementation; specific issues that governments are focused on; and issues that are of primary interest to building owners, operators, and tenants. Table 1 summarizes the issues and the following subsections describe them in more detail.

GENERAL ISSUES RELATED TO ENERGY MANAGEMENT

Building energy management and energy efficiency programs have existed since the 1970s. However, the results have been judged by some to be disappointing—particularly the broad implementation of best practices. The literature consensus appears to be that the primary focus of energy management programs is to ensure efficient building operations, with energy savings emerging

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² Royal Architectural Institute of Canada, Climate Change and Architecture, 2.
³ Secretariat of the Commission for Environmental Cooperation, Green Building in North America, 43.
Managing the environmental and energy footprint of buildings. Disseminating and adopting of best practices for millions of buildings. The environmental benefits of energy management programs depend partly on the source of primary energy.

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<th>Issues on which government leads</th>
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<td>The role of subsidies and incentives.</td>
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<td>The role of regulations and standards.</td>
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<td>Coordination between levels of government.</td>
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<th>Issues for building owners, operators, and tenants</th>
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<td>Investment decisions are made separately from operating decisions.</td>
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<td>First cost and non-energy considerations drive investment decisions.</td>
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<td>The role of building design and performance certification programs.</td>
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<td>Integrating energy management strategic plans with the corporate budget and strategic plan.</td>
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<td>The role of energy measurement, management, and results communication.</td>
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<td>The importance of staff competencies and training programs.</td>
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<td>The underutilization of the advanced features of energy management systems.</td>
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<td>Intelligent buildings, building information management, and automated controls.</td>
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<td>The need to include energy efficiency early in building design.</td>
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<td>The value and importance of comparing building performance with that of other similar buildings.</td>
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<td>The long-term risks and reliability of new and advanced technologies.</td>
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Source: The Conference Board of Canada.

as one of the benefits of best practices. There is also a view that reliance on energy prices alone will not capture efficiency opportunities because of factors such as low prices, regulated prices, imperfect information, and long payouts for capital investments.4

**MANAGING THE ENVIRONMENTAL AND ENERGY FOOTPRINT OF BUILDINGS**

The primary reasons for energy efficiency initiatives are to reduce the cost of energy consumed, and to reduce the environmental impact of producing and consuming that energy. Neither benefit is simple to measure. The price of energy saved or consumed is readily available. However, the quantity of energy saved must be estimated through comparisons to historical energy consumption for a building. But the quantity cannot be measured directly as it depends on a range of operating conditions. Estimates of energy savings and related cost reductions are the primary basis for measuring improvements in the energy footprint of a building. The changes in energy consumption measured at the meter must be adjusted for weather conditions, building occupancy, building usage changes, etc. Further, the estimated energy savings in isolation may not provide an accurate picture of energy or environmental performance. Comparisons with other similar buildings are essential at both the design and operations stages of the building life. Energy efficiency may be included in the building design, but is only achieved through appropriate commissioning and operating practices.

Once energy savings have been estimated, the standard approach is to apply emissions factors to measure the environmental footprint. These factors represent approximations based on the mix of technologies used for a specified purpose in a given sector. Indirect measurements of energy and environmental footprints present a challenge to all stakeholders, particularly where performance-based or outcomes-based regulation is applied.

**DISSEMINATING AND ADOPTING BEST PRACTICES FOR MILLIONS OF BUILDINGS**

Best practices for the energy management of buildings have been identified and communicated at least since the late 1990s, yet widespread implementation has lagged. The World Business Council for Sustainable Development has stated that “... financial, behavioral, and knowledge barriers must be overcome for individuals, governments, and businesses to aggressively adopt energy savings options.” This global challenge is complicated by the number of buildings, building managers, tenants, government agents, equipment suppliers, and others whose decisions and activities must be coordinated and communicated.

**ENVIRONMENTAL BENEFITS PARTLY DEPEND ON PRIMARY ENERGY SOURCES**

The net benefits of energy management programs must be considered in the context of the energy form that is consumed. Building operators and occupants consume energy services rather than energy itself. Natural gas is consumed because of the heat it produces. Electricity is consumed because it produces heat, light, motive power, or allows office machines to function. These energy services can come from a variety of sources, making it important to consider the energy source as part of energy management practices. In the context of commercial buildings, electricity provides a significant share of energy services. As a result, the environmental benefits of reducing energy consumption vary with the primary energy source that is used to produce the electricity, as well as the efficiency of the equipment that converts electricity to energy services. For example, commercial electricity savings in Alberta or Saskatchewan would have a larger environmental benefit than similar savings in Quebec or British Columbia. That is because the former provinces generate electricity primarily from thermal sources (coal and natural gas), whereas the latter provinces generate electricity primarily from moving water.

It is also true that consuming energy during periods of peak demand can have a larger relative impact on the environment than consuming energy during periods of low demand. This is particularly true for electricity consumed in provinces that rely on thermal generation during periods of high consumption.

**ISSUES ON WHICH GOVERNMENT TAKES LEADERSHIP**

There are three primary areas where government plays a key role: coordination between levels of government; regulations, codes, and standards; and incentives and subsidies. Although the private sector is involved in each area, these are areas where governments take action and companies respond. Each area is driven by policies; is subject to legislated mandates; and requires complex analyses of policy options, interactions, benefits, and costs.

**THE ROLE OF SUBSIDIES AND INCENTIVES**

Governments have put forward a broad range of programs to incentivize or subsidize energy efficiency and energy conservation in buildings. There are also programs to encourage the use of renewable energy. One of the key themes in the literature is the role that such programs should play, as well as the mix of instruments chosen. There is a consensus that at least some energy efficiency investments have very long payback periods and would not be made in the absence of incentives. There are also concerns that investing because of a subsidy or incentive program leaves a company exposed to changes in government policies that remove or reduce incentives. Such programs are often complex, with a rule of thumb.
being that payouts of longer than 10 years require incentives to make the investments possible. Some analysts estimate the acceptable payout at as little as two years. However, the balance between incentives for energy efficiency and incentives for renewable energy may need further consideration as programs are being designed.

There is a growing understanding of the need to integrate policies, regulations, and standards for energy efficiency with those for renewable energy.

Because governments account for a significant proportion of commercial and institutional sector buildings, government green procurement programs, capital maintenance programs, and operating practices can also be used as significant incentives to install leading-edge technologies.

THE ROLE OF REGULATIONS AND STANDARDS
Building codes and equipment standards can play a role in encouraging or facilitating energy efficiency for new construction. There is, however, a tendency to adjust codes and standards to eliminate the poorest practices rather than to adopt current best practices. Regulations that require energy efficiency improvements also play a key role. In fact, one study finds that “...in periods when strong energy productivity gains have been achieved in the commercial sector, they can be traced back to regulatory intervention.”

There is also a growing recognition of the need to integrate energy efficiency policies, regulations, and standards with renewable energy policies, regulations, and standards. This is because the determination of the most cost-effective way to reduce the energy or environmental impact is often site-specific and may include a mix of energy efficiency, energy conservation, on-site generation, and renewable energy purchases.

COORDINATION BETWEEN LEVELS OF GOVERNMENT
Canadian governments play a key role in establishing regulations, standards, and policies that impact investments in building energy efficiency. Each level of government (federal, provincial, municipal) has a legislative mandate that must be met. However, the mandates overlap. The federal government has no regulatory mandate over buildings; therefore, the National Building Code and National Energy Code for Buildings are only model documents. Provincial governments must adopt them for the codes to come into effect, and most of the enforcement is at the municipal level. There are also multiple programs that support energy efficiency investments with each program having its own objectives, investment criteria, application requirements, and review process. This can act as an implementation barrier, particularly for service companies that perform energy audits and establish energy management systems for smaller buildings.

ISSUES OF PRIMARY IMPORTANCE TO BUILDING OWNERS, OPERATORS, AND TENANTS

INVESTMENT DECISIONS ARE MADE SEPARATELY FROM OPERATING DECISIONS
Investment decisions related to building design, construction, equipment selection, and capital maintenance are made by the building owner. Maintenance programs and operating conditions are most often determined by the building operator. Decisions regarding the energy services required by building occupants are made by those occupants (usually tenants). Building occupants are not always (and perhaps not often) metered separately and charged directly for their energy use, which means that “...the benefit of energy savings does not go to

10 McKinsey Global Institute, Curbing Global Energy Demand Growth, 42.
11 Secretariat of the Commission for Environmental Cooperation, Green Building in North America, 51.
12 McKinsey Global Institute, Curbing Global Energy Demand Growth, 134.
the person making the investment” and that “… billing practices can mean tenants do not pay specifically for the energy used.”14 This is a key barrier to fully optimized energy efficiency programs, as the equipment selected may not be the most energy efficient available. As well, the operating conditions and energy consumption decisions may not be directly influenced by direct costs to the decision-maker.

**FIRST COST AND NON-ENERGY CONSIDERATIONS DRIVE INVESTMENT DECISIONS**

Whether in new construction or retrofit decisions, energy-related operating costs are not typically the most important considerations in investment decisions.15 The initial capital cost and performance characteristics are typically the first considerations. The focus on first cost can lead to building a lower level of building energy performance.16

One of the challenges of implementing energy efficiency programs within organizations is to find pathways that integrate life cycle energy costs into the decision process. An increasing focus on pollution, including greenhouse gas emissions, has helped to rebalance investment criteria. As companies pay increasing attention to sustainability and to GHG mitigation, energy savings are becoming an investment criterion. Convergence between renewable energy programs and energy efficiency programs, in jurisdictions such as California, also influence equipment choices—particularly as energy efficiency investments are often more cost effective at reducing emissions than renewable energy investments.17

The first cost barrier is often exacerbated by a perception that the first costs of energy efficiency will be higher, or it is worsened by negative past experiences.18

**THE ROLE OF BUILDING DESIGN AND PERFORMANCE CERTIFICATION PROGRAMS**

Two primary green building programs in Canada are the Leadership in Energy and Environmental Design (LEED) Green Building Rating System, and the Building Owners and Managers Association Building Environmental Standards (BOMA BEST).19 These programs exist to promote a broad range of sustainable practices, including energy efficiency. Both programs include design, construction, and operations. Each program offers certification based on independent verification that a building complies with program standards. These programs are receiving increasing attention for new building construction, retrofit investments, and building operations and maintenance. As a result, building owners and operators are paying increasing attention to the standards and certification requirements. Both BOMA BEST and LEED include O&M (operations and maintenance) practices in their rating systems.20

**INTEGRATING ENERGY MANAGEMENT STRATEGIC PLANS WITH THE CORPORATE BUDGET AND STRATEGY**

Efficient building operation is a key element of asset management, and adds to the value of the building.21 The integration of energy management plans into the corporate budget and strategic plan helps to ensure that the human and financial resources—necessary to implement energy management strategies—are available.

**THE ROLE OF ENERGY MEASUREMENT, MANAGEMENT, AND RESULTS COMMUNICATION**

Energy management plans typically include an energy accounting system. The accounting system relies primarily on utility billing data to track energy consumption. However, these results can be cross-referenced against the potential savings identified by a walk-through or detailed energy audit to capture opportunities to reduce energy consumption. These opportunities often involve adjusting operating practices, making it essential that...

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19 For details, see Canada Green Building Council, “Introduction to LEED”; or Building Owners and Managers Association of Canada, *BOMA BEST Application Guide*.

20 The LEED O&M certification is documented in Canada Green Building Council, *LEED Canada for Existing Buildings*.

energy accounting results and energy audit action items be effectively communicated to building operators.\textsuperscript{22} Best available diagnostic tools can also help to ensure that energy measurements are accurate and conservation or efficiency opportunities are properly identified.\textsuperscript{23} Further, there may be benefits from tracking the actual performance of major energy consuming equipment against historical performance, or against manufacturer specifications. Tracking performance and celebrating successful initiatives becomes an important element of continuous improvement.

The first and most important human resource is a full-time energy manager with appropriate training and understanding of all the energy systems in the building(s).

One of the primary challenges in this area is large organizations’ lack of in-house expertise in energy auditing.\textsuperscript{24} Building operators who do not seek external expertise may not be fully aware of existing, low-cost energy efficiency opportunities. The lack of standardized operating performance measurement systems represents a challenge for building operators, who often lack fundamental energy management data, or who must collect the data directly and do their own benchmarking.\textsuperscript{25}

THE IMPORTANCE OF STAFF COMPETENCIES AND TRAINING PROGRAMS

The first and most important human resource is a full-time energy manager with appropriate training and understanding of all the energy systems in the building(s). The energy manager will also face the task of promoting energy efficiency. In addition to technical skills, the energy manager will have a solid understanding of business decision-making, budgeting, and capital management. The energy manager is the champion of energy management in the organization.\textsuperscript{26}

Building operators must also have sufficient training, expertise, and experience to fulfill their role in energy management. The building operator must have current knowledge of utility invoicing practices, performance contracts, building automation and control systems, and building occupancy patterns to ensure that equipment use is optimal. This may include customized training programs.

There may also be situations where staff do not have the core competencies required. But because the operations are performed infrequently, it is more appropriate to hire external experts than train staff. Two examples are specialized functions related to commissioning equipment, or infrequent maintenance procedures. Acquiring outsourced services with properly structured performance-based contracts can bridge these gaps.

THE INSUFFICIENT USE OF THE ADVANCED FEATURES OF ENERGY MANAGEMENT SYSTEMS

Energy management systems (EMS) are designed to optimize the energy consumption of buildings. Many of these systems are complex and require specialized training. To achieve the full benefit of these systems, their advanced features must be used to ensure that equipment is operated to minimize energy consumption. Such targets need to be included in the energy management strategy.\textsuperscript{27} Independent assessments of EMS are important, and should be completed by specialists to ensure that all features have been explored and used to the extent practical for a given building.

As energy management practices have evolved, so has the understanding that “... mere specification of high-efficiency equipment is increasingly recognized as an inadequate solution. Systems and equipment frequently

\begin{itemize}
\item \textsuperscript{22} Portland Energy Conservation, Inc., \textit{Fifteen O&M Best Practices}, 7.
\item \textsuperscript{23} Portland Energy Conservation, Inc., \textit{Fifteen O&M Best Practices}, 20.
\item \textsuperscript{24} World Business Council for Sustainable Development, \textit{Energy Efficiency in Buildings}, 42.
\item \textsuperscript{25} Prill, Kunkle, and Novosel, \textit{Development of an Operation and Maintenance Rating System}, 4.
\item \textsuperscript{26} Portland Energy Conservation, Inc., \textit{Fifteen O&M Best Practices}, 9.
\item \textsuperscript{27} Portland Energy Conservation, Inc., \textit{Fifteen O&M Best Practices}, 27.
\end{itemize}
perform less efficiently than predicted due to suboptimal integration of subsystems and components, improper installation, poor maintenance, and limited ability to diagnose performance issues.”

**INTELLIGENT BUILDINGS, BUILDING INFORMATION MANAGEMENT, AND AUTOMATED CONTROLS**

Automated controls are becoming the standard for new buildings. These technologies are “. . . encouraging building owners, operators, managers, designers, and occupants to reassess their respective roles, and how they relate to the buildings in which they hold an investment.”

The major systems in any building can be automated, and automation can be used to improve performance. Common themes in the literature and in our interviews include: the extent to which automation can, and should be, implemented in smaller buildings; the training required for building operators; the need for specialized installation and commissioning services; and ongoing tracking to ensure continuous improvement. Automated building information systems can allow tenants a more active role in monitoring and improving their energy consumption, and are perceived to add to the value of a building. One of the challenges in implementing these systems is the perception of higher first costs.

**Automated demand response in the United States has also been highlighted as having the potential to reduce peak electricity demand in a building by 10–14 per cent.**

The area of automated demand response in the United States has also been highlighted as having the potential to reduce peak electricity demand in a building by 10–14 per cent. Where time-of-use electricity pricing has been implemented for commercial buildings, computer software is used to monitor real time pricing information and send signals to the building control system to reduce energy consumption in times of price peaks.

**THE NEED TO INCLUDE ENERGY EFFICIENCY EARLY IN BUILDING DESIGN**

Energy management is increasingly viewed as one of the key elements of green buildings. However, other issues—such as water, occupant productivity, and the environmental footprint of the building’s life cycle—are considered as part of the broader context of green buildings. As energy management continues to contribute to the broader objectives of green building design, programs such the LEED standards are encouraging a more integrated approach that is adopted earlier in the design phase. This allows energy, water, resource conservation, occupant comfort, and sustainability to be more fully integrated to the benefit of all stakeholders.

It also facilitates a broader life cycle assessment of construction and equipment selections, partially addressing the tendency to base all decisions on first cost.

As energy management continues to contribute to the broader objectives of green building design, programs such LEED are encouraging a more integrated approach.

One of the challenges is that energy efficiency modelling often requires detailed information regarding the building that may not be available in the early stages of design—a challenge that is beginning to be addressed. Fortunately, the cost of implementing energy efficiency at the early design stage has been estimated to be only 20 per cent of the cost of retrofitting.

**COMPARING BUILDING PERFORMANCE WITH THAT OF OTHER SIMILAR BUILDINGS**

The ability to benchmark building performance against that of other similar buildings provides energy managers with useful information regarding energy savings opportunities that have not yet been realized. The magnitude of energy reductions made in other buildings can be used as a realistic measure of the benefits that should be included in payout calculations. It is important, however, to ensure

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that comparisons are based on buildings of similar size, occupancy, uses, etc. A false comparison can lead to poorly informed investment decisions. There is also a perceived benefit from a common information base that includes a large number of buildings and adjustments for weather normalization, HVAC (heating, ventilation, and air conditioning) equipment data, lighting data, occupancy, etc.

THE LONG-TERM RISKS AND RELIABILITY OF NEW AND ADVANCED TECHNOLOGIES

There are few truly new technologies that produce energy efficiency solutions. But there are a great many technologies that are applied in new ways, and that are new to the building owner or operator who will implement them. One of the issues identified in the literature is the tendency to be unaware of the potential benefits, and to overestimate the risks and uncertainty attached to new technologies.34 This risk aversion may manifest itself in the form of extended pilot programs, a cautious approach to broad implementation, or financial analyses that use shorter equipment life or higher maintenance costs.

CHAPTER 3

Best Practices

Chapter Summary

- A key element of several best practices is ensuring that staff are trained, experienced, and have energy efficiency and its communication as a primary responsibility.

- Buildings are increasingly automated, and when equipment is properly commissioned, operators have ample opportunities to track and reduce energy consumption through time.

- Data capture, analysis, and performance tracking play key roles in continuous improvement.

- Early adoption of energy efficiency principles into building design can complement retrofits to existing buildings by ensuring that energy consumption is properly managed across the portfolio of buildings owned or operated by a company.

The literature survey and interviews identified a very broad range of best practices that are being implemented or could be implemented. In some cases, the best practices are identified and developed in some detail in the ISO 50001 standard. In other cases, they are based on performance management systems such as BOMA BESt. Table 2 lists 21 best practices for commercial building energy management sorted into five broad categories: equipment and technology; skills and training; data collection and use; corporate focus and communications; and investment criteria. The best practices are taken from reports published by the seven organizations listed in the table.

The list of best practices shows a reasonably strong correspondence between the practices, but does not establish a ranking. This is partly because there are multiple outcomes that could be used to rank the practices: first cost, life cycle cost, energy savings, emissions reductions, cost per unit of energy saved, the time required to implement, etc. A simplistic ranking of which best practices are most important or highest priority would probably not be useful because it would need to be modified for each building type, and perhaps for each building.

The following tables, and related discussion, group the best practices by theme. They also provide additional information regarding the differences between a basic implementation and a more complete implementation.

Practices that relate to the equipment and technologies being used to manage energy consumption are the first group. (See Table 3.) The practices relate to the way in which equipment is managed or operated. Practices related to equipment selection are listed under the investment category.
## Table 2

Summary of Building Energy Management Best Practices

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Use automatic controls to optimize efficient operation.</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Operate equipment only when needed.</td>
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<td>x</td>
</tr>
<tr>
<td>Equip O&amp;M staff with state-of-the-art diagnostic tools.</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Include energy efficiency items in preventive maintenance.</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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</tr>
</tbody>
</table>

### Skills and training

| Appoint a full-time energy manager.                  |             |                 |            |                         |     |           | x                 |
| Train building operators in energy efficient O&M practices. | x           |                 |            |                         | x   | x         |                   |
| Require service contracts that support energy efficient building operations. |             |                 |            |                         |     |           | x                 |
| Engage the services of a specialist.                  |             |                 |            |                         |     |           | x                 |

### Data collection and use

| Use an energy accounting system to locate savings opportunities and track success. | x           | x               | x          | x                       | x   | x         |                   |
| Perform comprehensive O&M site assessments | x           | x               |            |                         | x   | x         | x                 |
| Maintain continuity and reduce troubleshooting costs. Document and keep documentation up-to-date. | x           |                 |            |                         |     |           | x                 |
| Track actual performance against expected performance for major equipment. | x           |                 |            |                         |     |           |                   |
| Measure and invoice energy consumption at the tenant or office level. |             |                 |            |                         |     |           | x                 |
| Compare building's energy performance with that of other similar buildings. |             |                 |            |                         |     |           |                   |

### Corporate focus and communications

| Incorporate energy management goals into the strategic business plan. | x           |                 |            |                         |     |           |                   |
| Implement an energy management plan with energy efficient operation as a primary component. | x           | x               |            |                         |     |           | x                 |
| Implement an energy efficiency communication plan (tenants and stakeholders). |             | x               |            |                         |     |           |                   |

Source: The Conference Board of Canada.

(continued)
## Table 2 cont’d
Summary of Building Energy Management Best Practices

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Corporate focus and communications</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Acknowledge energy efficient operation as a cross-functional activity.</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengthen codes and labelling for increased transparency.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Investment criteria</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invest in energy efficiency retrofits.</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base construction and equipment purchase decisions on life cycle cost, rather than first cost.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

Note:
PECI—Portland Energy Conservation Inc.
BOMA—Building Owners and Managers Association of Canada Inc.
IEC—International Electrotechnical Commission
CABA—Continental Automated Buildings Association
CEC—Commission for Environmental Cooperation
ISO 50001—ISO 50001 Energy Management Standard
LEED—Leadership in Energy and Environmental Design
Source: The Conference Board of Canada.

## Table 3
Equipment and Technology Best Practices

<table>
<thead>
<tr>
<th>Description</th>
<th>Basic implementation</th>
<th>Best implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use automatic controls to optimize efficient operations.</td>
<td>Automatic controls are becoming the standard, but many smaller buildings are still lacking.</td>
<td>Fully automated control systems that allow the building operator to optimize performance, compare with other buildings in the portfolio, and notify occupants of opportunities to improve their energy consumption.</td>
</tr>
<tr>
<td>Operate equipment only when needed.</td>
<td>Equipment runs during business hours.</td>
<td>Equipment is shut down when not required, or cycled down based on actual building occupancy.</td>
</tr>
<tr>
<td>Equip O&amp;M staff with state-of-the-art diagnostic tools.</td>
<td>O&amp;M staff use equipment manuals, automated control systems, and experience to diagnose and address performance issues or opportunities to improve.</td>
<td>Advanced diagnostic software is used in combination with control systems data to identify issues and propose solutions for further evaluation.</td>
</tr>
<tr>
<td>Include energy efficiency items in preventive maintenance.</td>
<td>Preventive maintenance is scheduled to ensure availability and reliability of equipment.</td>
<td>Preventive maintenance is expanded to include items that will enhance energy efficiency.</td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.
Diagnostic tools and automated controls go hand in hand for organizations that implement technology-related best operating practices. They are also linked to the training practices listed below. Most buildings constructed in the last 15–20 years are equipped with some level of control automation. This automation may include varying levels of systems integration and operator interaction. And it is a key element of the transition from the role of building operator to energy manager. The operators will also have varying levels of training or may face time constraints that mean their primary goal is to keep systems running smoothly and reliably. The best practice would be to ensure that building operators have both the training and the time to ensure that the advanced features of automated controls are being used to achieve optimal energy efficiency. This includes the link between diagnostic tools and the operator. Diagnostic software can be used to detect opportunities to improve efficiency and recommend the actions to take. The operator must then investigate and implement, or improve upon, these solutions.

Operating equipment only when needed can be as simple as establishing and documenting steps to shut down equipment on a regular schedule. Examples might be reduced HVAC and lighting services during the hours or days when the building occupancy is reduced. Tenants might be instructed to ensure that lights and office equipment are turned off when the space is not in use, with some level of monitoring. These are steps taken by most, if not all, building operators in today’s environment. Operators might also choose to redefine which equipment is needed. Simple actions might include adjusting the range of temperatures or lighting levels that can be controlled or selected by building occupants. On a more elaborate scale, selecting the equipment that is needed might be included in the automated system based on simple rules or sensors that detect and respond to tenant activity.

An additional area that relates to the use of technology and equipment is that of maintenance practices. The standard approach is to perform maintenance to keep the equipment functioning at a target availability level at the least possible cost. The best practice is to include preventive maintenance based on equipment performance data. As equipment ages, there is a tendency for the energy efficiency to deteriorate before failures or necessary repairs take place.

### Best Energy Practices

"Automated systems are the only real answer. How to make that work from the human side is the challenge.“

"Simple, rugged and well-networked works best.”

(On building automation technology)

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However, the best practice faces an important barrier. “Implementation of an effective scheduled maintenance program can reduce energy bills by 5 to 20 per cent in commercial buildings. . . . The main reason for not implementing a scheduled maintenance program seems to be a lack of knowledge of the benefits and how to implement scheduled maintenance programs in addition to no clear way to identify the resulting cost savings generated by a scheduled maintenance program.”

Once the building is in service, energy management is primarily an operations function. In many cases, the building operator is tasked with identifying and implementing whatever energy management practices occur. However, this is neither efficient nor desirable as the building operator faces significant time pressures, and has reliability and availability of equipment as the first priority. (See Table 4.)

The best practice in this area is to appoint a full-time energy manager. This person often has a company-wide responsibility. The energy manager position is likely a...
Senior position that may have broader sustainability, corporate social responsibility, or operations mandates as well. The energy manager is tasked with helping to ensure that improvements in one location are communicated and translated into improvements elsewhere in the organization. This person should have the support of technical operating teams, capital maintenance teams, and interactions with tenants. The key job functions might include:

- supervising regular building walkthroughs or energy audits;
- managing and improving the energy accounting system;
- identifying energy efficiency training needed for operating staff;
- working with staff to build an organizational culture of conservation;
- communicating with tenants about their energy efficiency practices;
- developing a long-term energy plan for the organization that includes budget priorities; and
- working with senior executives to communicate the benefits of energy management to the organization.

Because most commercial buildings have automated control systems that track performance by subsystem, there is a ready opportunity to institute energy efficient management practices. However, one of the key impediments is that building operators often do not have the training or the time to take advantage of these advanced features. Where energy efficiency is not defined as a key objective, building operators likely won’t give it the required focus. This creates a key role for the energy manager: to ensure that operators understand the relative importance of energy efficiency to the operating budget and to the organization’s bottom line.

External resources may be required to round out necessary skills and training. This may involve nothing more than on-site training on control systems or advanced features of automated controls. It may involve engaging energy auditors to do site visits and propose energy efficiency solutions. Implementing those solutions may also be part of the external contribution. The need for external resources varies among organizations, so best practices in this area are not easily defined. For example,

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companies that operate a limited number of small office buildings are likely to have a smaller internal team dedicated to energy efficiency, or may not have a team at all. In that situation, external advisors would likely contribute to assessment, costing, implementation, and monitoring of energy savings. They may also be involved in collecting data for the organization.

Companies with a larger portfolio of buildings are more likely to have an internal team and focus their external expenditures on specialized skills that they do not need on an ongoing basis. Further, some of the interview responses indicated that a large firm with specialized equipment may have better expertise and more extensive experience with that equipment than any external advisor. As a result of these factors, the level of reliance on external advisors may not be the metric most relevant to best practices. Instead, a careful assessment of how external advisors are being used and the outcomes achieved is likely to be more relevant.

The data that are collected and the way those data are integrated into operating practices are important best practice elements. (See Table 5.) The underlying principle is that measuring and reporting energy use at a detailed level encourages optimal performance. Data collection includes hard data on energy consumption as well as soft data on process improvements and their results. Actual performance data should ideally be compared with the intended performance to determine whether equipment is operating at its expected efficiency, and whether the implemented changes are achieving their targets.

Energy accounting systems are now widespread, but vary in terms of what is collected and how. Some energy accounting systems are at a building level and based entirely on utility bills. A simple implementation might also include tracking total energy consumption through time to ensure that implemented efficiency measures are achieving results. However, a tracking system based on utility bills alone will have difficulty providing much detail regarding the impact of individual efficiency actions taken. A more elaborate energy accounting system might include regular logging of specific equipment, including when the equipment is in service, is idling, or is shut down. This information may be gathered through an automation system. It may also be analyzed by diagnostic software to flag anomalies for the building operator and to manage costs in near real time.

Data from the energy accounting system may be used with regular site assessments to identify opportunities to improve specific operating practices. The data collected may also be coordinated with logs that record maintenance schedules or changes in operating practices. If the benefits of regular maintenance can be demonstrated through lower operating costs in specific test situations, there is a greater probability that similar changes will be considered across the portfolio.

Energy data may also be linked to tenant behaviours. One of the key challenges identified in the literature is the separation between the decision-maker and the data’s financial impact. Buildings that do not have meters for individual tenants fall into this category. If the tenant’s energy consumption is not metered, and the operating costs to the tenant do not reflect the volume of energy consumed, a significant incentive to be efficient is removed. Individual tenant metering may not be practical for small buildings or small areas within a building, but should be considered where possible.
Finally, building owners and operators may find value in comparing the performance of each building in their portfolio with that of similar buildings elsewhere. One interviewee indicated that there is little value to this because their buildings are very specialized. For them, it is about managing costs within each building rather than benchmarking against others. Other interviewees indicated that benchmarking is important and that a single independent database would be most useful. Energy service companies often maintain their own databases against which to benchmark the results of an energy audit or against which to measure the value of proposed investments. Both approaches likely have merit depending on specific circumstances.

Internal and external communications help to ensure that energy management is top of mind for the building owner, operator, and tenants. (See Table 6.) There are two primary reasons for linking energy management goals to broader corporate goals. First, the linkage raises the profile of energy efficiency within the organization because it brings energy efficiency goals to the same level as financial targets and operating objectives. Second, it ensures that resource allocation for energy efficiency is more than an afterthought.

The energy management plan should properly balance the needs of capital investment, capital maintenance, and operations. As well, this brings together elements of the equipment and technology best practices. Because the

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**Table 5**

**Data Collection and Use Best Practices**

<table>
<thead>
<tr>
<th>Description</th>
<th>Basic implementation</th>
<th>Best implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use an energy accounting system to locate savings opportunities and track success.</td>
<td>Many organizations track energy performance based on utility invoicing.</td>
<td>The best practice includes energy use tracking as well as reduction targets, variance analysis against those targets, and plans for continuous improvement.</td>
</tr>
<tr>
<td>Perform comprehensive O&amp;M site assessments.</td>
<td>O&amp;M assessments typically relate to specific equipment or functions.</td>
<td>A comprehensive assessment that considers all operating and maintenance activities to determine their interactions and propose actions to reduce energy consumption for the site as a whole.</td>
</tr>
<tr>
<td>Maintain continuity and reduce troubleshooting costs.</td>
<td>O&amp;M practices follow manufacturer schedules with little additional documentation.</td>
<td>Log books are kept and maintained to document experiences with commissioning, control systems, equipment performance, preventive maintenance, process innovations, etc. These experiences are used throughout the organization for continuous improvement.</td>
</tr>
<tr>
<td>Track actual performance against expected performance for major equipment.</td>
<td>Equipment performance is tracked in aggregate against historical records.</td>
<td>Performance targets are set for each major system in each building, and actual performance is measured against the target. Negative variances are investigated and remedied. Positive variances are investigated for broader application.</td>
</tr>
<tr>
<td>Measure and invoice energy consumption at the tenant level.</td>
<td>Energy metered at the building level and energy costs are invoiced to tenants based on occupied area.</td>
<td>Provide the building occupant with real time information regarding energy use and invoice on the basis of actual consumption for each tenant/location.</td>
</tr>
<tr>
<td>Compare building’s energy efficiency with that of other similar buildings.</td>
<td>Some companies perform internal benchmarking; others perform limited external benchmarking. Many companies do not benchmark performance.</td>
<td>Benchmark energy consumption and efficiency against that of a representative set of other similar buildings and use the comparison to identify areas for improvement.</td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.
A complete energy management plan articulates all three elements, it acts as a coordination mechanism. A complete energy management plan provides the substance of what will be communicated. The communication plan determines how, when, and with whom that substance will be shared. The communication plan should also extract those elements of the energy management plan that will be shared with external stakeholders—such as building tenants, equipment suppliers, and external advisors. An effective communications plan will contribute to a cross-functional focus on energy efficiency.

Codes and standards with energy efficiency components that are regularly updated play a key role. This is mainly due to the long payouts on efficiency investments, and because the demand for energy services shows only a very modest response to price changes. Once the investment decision is made, the equipment selected follows its design characteristics, leaving operating practices to drive continuous improvement. Government and industry must work together to ensure that the established codes and standards provide a workable balance between reducing energy consumption and payback. Architects and equipment designers play a key role in ensuring that new equipment is more energy efficient and that energy efficient design principles are considered early. Equipment suppliers and construction companies must

### Table 6

<table>
<thead>
<tr>
<th>Description</th>
<th>Basic implementation</th>
<th>Best implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporate energy management goals into the strategic business plan.</td>
<td>For many organizations energy management goals are established independently and not linked to the overall strategic plan.</td>
<td>The best practice is to ensure that energy management goals are linked to and support the overall strategic business plan. The linkages would include performance targets, budgets, and cross-functional communications.</td>
</tr>
<tr>
<td>Implement an energy management plan that includes efficient operation.</td>
<td>Energy management plans that focus on reductions from historical levels of energy consumption.</td>
<td>The best practice includes both historical performance and metrics that target reductions possible through operating efficiencies. These targets will focus on what is possible in specific operating areas.</td>
</tr>
<tr>
<td>Implement an energy efficiency communication plan.</td>
<td>Energy efficiency initiatives are not broadly communicated within an organization or between stakeholders.</td>
<td>Energy efficiency includes a communication plan that creates awareness, celebrates successes, and identifies actions that each building occupant can take. It is shared with tenants.</td>
</tr>
<tr>
<td>Adopt a cross-functional approach to energy management.</td>
<td>Energy management is the responsibility of building operators.</td>
<td>The best practice takes advantage of a full-time energy manager to coordinate efforts of the operator, tenants, and technical teams in support of energy efficiency and conservation.</td>
</tr>
<tr>
<td>Strengthen codes and labelling.</td>
<td>Building codes are evolving to place more emphasis on energy use. Equipment labelling is more advanced.</td>
<td>Building codes that include energy consumption and are regularly updated to make the best performance the new minimum level.</td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.

### Best Energy Practices

“Great-West Life Realty Management is a prime advocate of a single database.”

“Strategically we should be looking solely to life cycle costs and make our decisions for long-term success. Practically, however, there are limits on the up-front costs that can be supported at any one time.”

1  Bernal, interview.
2  Earl Taylor (Plant Engineering Leader, 3M Canada), Telephone interview by Sarah Dimick. February 24, 2012.
Table 7
Investment Best Practices

<table>
<thead>
<tr>
<th>Description</th>
<th>Basic implementation</th>
<th>Best implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement energy efficiency retrofits.</td>
<td>Energy retrofits are considered only when necessary and decisions are based on first cost.</td>
<td>An active program to identify retrofit opportunities and base decisions on life cycle costs.</td>
</tr>
<tr>
<td>Base decisions on life cycle cost rather than first cost.</td>
<td>First cost dominates investment decisions.</td>
<td>Life cycle costs are incorporated early in the design phase, or early in selecting replacement equipment. The incremental first cost of efficiency investments is balanced against longer-term operating costs and competitive pressures.</td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.

stay informed of evolving standards and contribute to practical improvements through time. It is also important to follow codes and standards that relate to building commissioning. This helps ensure that new buildings, new equipment, and retrofitted equipment function as designed and achieve the energy efficiency results for which they have been installed.

Because the building owner treats operating costs as a pass-through to tenants, there is little incentive to invest extra in energy efficient equipment or buildings.

One of the most daunting challenges in this area is the separation of investment decisions from operating decisions. (See Table 7.) Commercial buildings are typically a highly competitive business, which creates a strong focus on lowest first cost as a key decision criterion. Because the building owner treats operating costs as a pass-through to tenants, there is little incentive to invest extra in energy efficient equipment or buildings. It is also true that some owners acquire buildings with the intent to hold them for a short period of time and then resell at a profit. For these owners, efficiency investments are unlikely. The slow turnover of building capital stock is a further issue.

“The real issue today is to activate all levers and implement existing and proven technologies . . . the issue is not understanding what needs to be done, or finding new technologies and solutions. It is true that there is some progress with existing solutions in new buildings, but they are poorly implemented in existing buildings, and a key factor hindering progress is the slow construction rate. This is why renovation is crucial.”

Governments can play a key role in the retrofit market, through mandating best available equipment for retrofits. Mandated performance standards can ensure that the market for energy efficiency expands.

The Business Case for Energy Efficiency Best Practices

Chapter Summary

- Energy efficiency/management best practices reduce energy consumption, reduce operating costs, reduce GHG emissions, and improve the productivity of building occupants.
- Most of the barriers to energy efficiency best practices arise from challenges in aligning the interests of stakeholders, or in aligning the benefits with those who bear the costs of improvements.
- Collecting the right information and tracking performance is an important key to success.
- Effective communication with all stakeholder groups (owners, operators, tenants, contractors, and consultants) is essential to ensure that everyone sees the actions they can take and shares in the benefits.

When energy management practices are successfully implemented, they can significantly reduce the amount of energy used and therefore cut energy costs and greenhouse gas emissions. Even just the opportunity for cost savings makes a solid business case for the development and implementation of energy management practices. However, there are additional benefits to energy management practices. These benefits include company pride, developing desirable buildings, a more productive workforce, and developing a positive reputation for environmental stewardship. The process of developing and implementing effective energy management practices can be challenging and demanding. It is also rewarding.

Even just the opportunity for cost savings makes a solid business case for the development and implementation of energy management practices.

This section of the report will present the case for adopting energy management best practices based on evidence found in the literature. Evidence was also derived from a series of interviews conducted with individuals involved in a variety of roles devoted to energy management for buildings. Given the similarity in benefits and obstacles for a number of items, best practices will mostly be presented as a group. Where appropriate, the benefits and weaknesses will be discussed relative to specific practices. Using the literature reviewed in the previous section—combined with the insights gleaned through the interviews—this section will reflect on each of the best practice categories to draw out the strengths, weaknesses, opportunities, and threats. The best practice categories include equipment and technology, skills and training, data collection and use, corporate focus and communication, and investment criteria.
Each of these areas has a range of activities. Some, considered “low-hanging fruit,” are simple and produce the greatest return on investment. Other practices require greater commitment and investment in order to be effective. Of course, every situation is unique, with one interviewee describing buildings as “living, breathing, and evolving.”¹ This poetic image is true in many ways. Buildings are not stagnant—they have systems running them that need to be maintained and updated. They are located in difference climatic zones and have difference sorts of tenants. The focus here, therefore, is to draw out themes, observations, and trends, and complement these with more precise facts and figures, where available.

THE BENEFITS OF ENERGY MANAGEMENT BEST PRACTICES

The literature review and interviews conducted for this report compiled similar lists of benefits that arise when commercial building energy consumption is properly managed. Table 8 lists these benefits in order of decreasing apparent financial impacts. Several of the benefits related to items such as employee satisfaction are nearly impossible to quantify. The lower ranking in the table for such items may not properly reflect their importance to any given organization. Further, because the commercial and institutional sectors include such a wide range of activities, a sector-wide ranking of the benefits would probably not be useful. For example, a supermarket operates in a highly competitive market and places a high relative value on cost control, whereas a hospital, by its very nature, must focus on the comfort and care of its occupants.

From the list, it is clear that financial benefits dominate. These benefits are often site-specific, and their capture clearly depends on whether the building owner and occupant are the same organization. In places such as office buildings—where the owner, operator, and tenants are often separate entities—capital maintenance and investment will focus primarily on issues such as first cost, service life, and reliability. There are also areas where the benefit is real but difficult to quantify. The benefits of improved productivity, recruiting advantages, and green branding provide examples.


BARRIERS TO IMPLEMENTING ENERGY MANAGEMENT BEST PRACTICES

There are numerous barriers to best practice implementation. Many of them relate to stakeholder relationships. Building owners, operators, and occupants face different incentives and use different decision criteria. Equipment suppliers and service companies bring their own perspectives. The large number of commercial buildings in service, and the broad range of ways they are used, further complicates identifying and broadly implementing best practices. Table 9 provides a summary of the more important barriers and observations on how they can best be addressed. The actual solution is likely to be much more complex than the suggestions, and will vary based on the building and its stakeholders.

The first two barriers are related to each other, but could be resolved using an approach that has been used in the utility industry. Regulated utilities that provide natural gas, or electricity transmission, or distribution services face a similar predicament. The dilemma is that investments or innovative practices that improve efficiency may not always provide a commensurate financial return to shareholders. Various approaches to incentive regulation have been tested and adopted to improve the situation. The central objectives are to create sharing mechanisms that ensure the company faces incentives to invest or to improve performance (typically by keeping a portion of the resulting savings), and that the initiatives that are actually implemented generate enough savings to provide a cost reduction to the customer.

Several of the barriers relate to how data is gathered and used. Organizations that have implemented best practices have found that people are the answer. Dedicated staff with a clear mandate from senior executives will work diligently to ensure that the right data are gathered, the right experts are engaged, and that the analysis
is done to constantly improve energy efficiency. This will lead to recommendations relating to investments, capital maintenance, operating practices, stakeholder engagement, and communications with staff.

CAPTURING THE OPPORTUNITY—BALANCING THE BENEFITS AGAINST THE COSTS

One of the keys to implementing best practices in any area is ensuring that the benefits more than offset the incremental costs. The commercial and institutional sectors are highly diverse in terms of the type, size, uses, and occupant density of their buildings. They also face different competitive pressures. As a result, a quantitative cost-benefit analysis was not undertaken as part of this report. However, the following sections provide a qualitative discussion of the trade-offs.

EQUIPMENT AND TECHNOLOGY

The category of equipment and technology contains four practices:

- Use automatic controls to optimize efficient operations.
- Operate equipment only when needed.

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost savings</td>
<td>The single most compelling reason to manage energy is that it reduces cost.</td>
</tr>
<tr>
<td>Energy savings</td>
<td>Energy savings are closely linked to cost savings. Energy saved in one area</td>
</tr>
<tr>
<td></td>
<td>can be reallocated elsewhere in the building, thereby making energy-use</td>
</tr>
<tr>
<td></td>
<td>decisions more flexible.</td>
</tr>
<tr>
<td>Reduced GHG emissions</td>
<td>As we transition to a low-carbon economy, innovation will continue to</td>
</tr>
<tr>
<td></td>
<td>reduce GHG emissions.</td>
</tr>
<tr>
<td></td>
<td>The buildings sector must keep pace. Energy efficiency best practices</td>
</tr>
<tr>
<td></td>
<td>contribute to this goal.</td>
</tr>
<tr>
<td>Lower long-term cost</td>
<td>When life cycle costs are considered early in building design, the result</td>
</tr>
<tr>
<td></td>
<td>is a more energy efficient building where reduced energy expenses more</td>
</tr>
<tr>
<td></td>
<td>than offset any incremental first cost.</td>
</tr>
<tr>
<td></td>
<td>This benefit is most apparent for companies that occupy the buildings they</td>
</tr>
<tr>
<td></td>
<td>own and operate.</td>
</tr>
<tr>
<td>Reduced equipment failures and</td>
<td>When preventive maintenance and energy efficient operating practices are</td>
</tr>
<tr>
<td>down time</td>
<td>adopted, equipment performance is monitored and unplanned outages reduced.</td>
</tr>
<tr>
<td>Higher building value</td>
<td>A more energy efficient building has a higher market value.</td>
</tr>
<tr>
<td>Recruiting</td>
<td>Building owners, operators, and tenants are finding that prospective staff</td>
</tr>
<tr>
<td></td>
<td>are attracted to organizations that are socially responsible and minimize</td>
</tr>
<tr>
<td></td>
<td>their impacts on the environment.</td>
</tr>
<tr>
<td>Improved occupant productivity</td>
<td>A best practices building provides a working environment that allows building</td>
</tr>
<tr>
<td></td>
<td>occupants to focus on the task, not the surroundings. This saves time and</td>
</tr>
<tr>
<td></td>
<td>improves focus.</td>
</tr>
<tr>
<td>Sustainability leadership</td>
<td>Companies that own, operate, or occupy best practices buildings are reducing</td>
</tr>
<tr>
<td></td>
<td>environmental impacts, saving money, and are more likely to focus on other</td>
</tr>
<tr>
<td></td>
<td>sustainable practices.</td>
</tr>
<tr>
<td></td>
<td>Buildings contribute to staff awareness and corporate sustainability focus.</td>
</tr>
<tr>
<td>Green branding</td>
<td>Customers and clients respond positively to organizations that incorporate</td>
</tr>
<tr>
<td></td>
<td>energy efficiency best practices.</td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.
### Table 9
The Barriers to Implementing Energy Management Best Practices

<table>
<thead>
<tr>
<th>The barrier</th>
<th>Addressing the barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dislocation between costs and rewards—the building owner pays the capital</td>
<td>This barrier applies only to buildings that the owner does not occupy. It can be addressed by any mechanism that shares operating cost reductions between the building owner and tenants. The objective is to return the investment (including a return for shareholders) to the building owner and pass additional savings to tenants.</td>
</tr>
<tr>
<td>cost, the tenant benefits from the operating cost savings.</td>
<td></td>
</tr>
<tr>
<td>First-cost bias in decision-making.</td>
<td>The first-cost bias can be removed by including life cycle cost analysis early in the design or investment decision and ensuring that the building owner and occupants share the long-term costs and benefits appropriately.</td>
</tr>
<tr>
<td>Invoicing practices do not provide energy conservation incentives—tenants</td>
<td>There is an increasing trend toward metering at the tenant level. Although this may not be practical for small leases, where it can be implemented, it ensures that price signals are passed through properly.</td>
</tr>
<tr>
<td>pay per square foot operating cost and are not always metered and invoiced</td>
<td></td>
</tr>
<tr>
<td>for their actual energy consumption.</td>
<td></td>
</tr>
<tr>
<td>Lack of knowledge of benefits.</td>
<td>Expanded and intensified communication programs can improve knowledge. Pilot program results must also be communicated broadly so that the savings are quantified.</td>
</tr>
<tr>
<td>No clear way to identify cost savings.</td>
<td>Baseline data are the key. Although the actual savings can’t be quantified, using recent baseline data and tracking post-implementation performance against pre-implementation provides reliable estimates of the savings.</td>
</tr>
<tr>
<td>Professional resources lacking—no in-house energy auditors; investment</td>
<td>The best practices of appointing a full-time energy manager, and including an energy management plan in the broader strategic plan, will help to identify the resources that are needed.</td>
</tr>
<tr>
<td>decisions not supported by life cycle cost analysis.</td>
<td></td>
</tr>
<tr>
<td>Physical constraints may make some actions more challenging or expensive—</td>
<td>The best practice is to focus first on what can be achieved. This barrier is more prevalent in existing buildings than in new buildings because there is often some design flexibility.</td>
</tr>
<tr>
<td>e.g., roof-top space may make solar photovoltaic (PV) impractical.</td>
<td></td>
</tr>
<tr>
<td>Concern over the reliability and service life of new technologies.</td>
<td>Best practices organizations implement pilot programs to establish the operating characteristics of new technologies in their establishments. Successful programs are expanded. This properly manages the risk.</td>
</tr>
<tr>
<td>Existing standards and codes may not accommodate specific improvements.</td>
<td>Governments, standards organizations, equipment suppliers, and installers are constantly examining codes and standards to update them. Where conflicts exist, there is an opportunity to work toward an appropriate resolution.</td>
</tr>
<tr>
<td>Service life of existing equipment and building fabric. Refits may not be</td>
<td>Better use of life cycle cost analysis is a step toward addressing this barrier. Government financial support for retrofits is another step. Better investment decisions (life cycle vs. first cost) will provide longer-term improvement.</td>
</tr>
<tr>
<td>required for 25 years, so upgrades may be depleting capital before refits</td>
<td></td>
</tr>
<tr>
<td>are actually required.</td>
<td></td>
</tr>
<tr>
<td>Lack of mandated benchmarks or standards.</td>
<td>Mandated equipment or performance standards can be set to require best available energy efficiency technologies, but must ensure that they are competitiveness-neutral.</td>
</tr>
<tr>
<td>Staff training required.</td>
<td>An effective energy management plan identifies training requirements. Integrating the energy management plan with the corporate budget and strategic plan ensures that training priorities are set and resources allocated.</td>
</tr>
</tbody>
</table>

Source: The Conference Board of Canada.
Equip operations and maintenance staff with state-of-the-art diagnostics tools.
Define preventive maintenance to include energy efficient operation.

Of these, the simplest and most cost effective to implement is the practice of operating equipment only when needed. This common sense solution can have a significant impact, whether it is shutting down computers and lights after hours or working through more complex cycling-down, based on actual building occupancy.

Including energy efficiency in preventive maintenance will likely represent a greater investment in terms of time and money, but will also pay off. All of the interviewees for this report supported preventive maintenance in principle. Some were actively engaged in preventive maintenance, including energy efficiency, whereas others hoped to be that proactive in the future.

Automatic controls are another significant tool in energy management. These controls can be costly and require commitment through training for operations staff. They also require maintenance, including recalibration. When used well, and where appropriate, automatic controls can generate significant improvements in energy efficiency.

The most expensive equipment and technology best practice is to equip operations and maintenance staff with state-of-the-art diagnostics tools. The technologies behind energy efficiency are changing rapidly and are evolving to suit a variety of specialized needs. Many of the interviewees indicated that they would rather use an adequate, affordable, and user-friendly tool than invest a large portion of their budget in new technologies that may not be compatible with existing technologies or would require additional training for their operators. (See Exhibit 1.)

### SKILLS AND TRAINING

Four practices found in the skills and training category are:
- appoint a full-time energy manager;
- train building operators in energy efficient operations and management;
- require service contracts that support energy efficient operations; and
- appoint a full-time energy manager.

Like those for equipment and technology, these practices run the gamut and vary from low to high cost. (See Exhibit 2.)

The lowest cost, and least onerous, of these practices is to require service contracts that support energy efficiency. This essentially shifts the onus of energy efficiency...
from the building owner and operators to a subcontractor. It is an inexpensive practice and fairly simple to implement. However, the results are difficult to measure.

Beyond service contracting, there are specific training practices that have a more significant impact on energy efficiency. Training building operators in energy efficient operations and management practices is both an essential and effective practice for increased efficiencies. These operators control the day-to-day use of energy and are able to make meaningful impacts on efficiencies.

Engaging the services of a specialist is typically one of the more expensive business practices. It also has the potential to bring a new perspective and expertise into the revitalization of an energy management system. Many of the interviewees, who had benefited from a specialist, spoke very highly of their partnerships.

Training building operators in energy efficient operations and management practices is both an essential and effective practice for increased efficiencies.

Each of the interviewees argued strongly in favour of having an energy manager—an individual whose full-time role is devoted to energy efficiencies. This role can be scaled up or down as appropriate. Although there were many reasons given for appointing an energy manager, participants frequently mentioned the need for leadership, a coherent strategy, and centralized planning for energy management issues. Various examples from the interviewees included thousands of properties managed by one corporation, which has a team of internal (about 50) and external experts on energy management; an office department of about 15 within a multi-building setting; and a single energy manager in a large office tower.

**DATA COLLECTION AND USE**

The stress on the importance of data collection was mentioned repeatedly during the interview process. Interviewees constantly stressed that they couldn’t change something they couldn’t measure.

There are many levels of data collection available. They range from tracking energy documented on utility bills and creating a baseline from which to work, to using detailed energy metering within subsections of buildings. Exhibit 3 shows an assessment of the cost and effectiveness of each of the six practices identified in the literature review. The bottom three practices are all similarly positioned as fairly inexpensive and effective tools of energy management.
The top three practices have the potential to garner great results, yet are more expensive. One interviewee declared that “sub-metering is the way of the future,” and stated that every building manager would like to be able to measure consumption at a tenant level.

**CORPORATE FOCUS AND COMMUNICATIONS**

Essential to energy management is corporate participation at all levels. The best practices displayed below include practices focused at the executive level. They include the incorporation of energy management goals into the corporation’s strategic business plan—which will clearly have a trickle-down effect on the whole organization. (See Exhibit 4.)

One interviewee stated that “sub-metering is the way of the future” and that every building manager would like to be able to measure consumption at a tenant level.

Interviewees responded consistently that communication between the organization and all who use the buildings was essential to achieving energy efficiency. This speaks to additional education and public relations campaigns that encourage turning off equipment at the end of the day to more interactive competitions between sub-metered areas or buildings to reduce overall energy use. Beyond the building, government and industry must work together to ensure that established codes and standards provide a workable balance between reducing energy consumption and payback. Educating and engaging staff beyond the core operations and maintenance team is a key goal.

**INVESTMENT CRITERIA**

The interviewees repeatedly stressed the shift within their respective businesses toward examining every expenditure as a life cycle cost over a first cost. This applied to expenditures on new equipment and technologies as well as on retrofits and renovations aimed at increasing energy efficiency. (See Exhibit 5.)
The business case for energy efficient retrofits—including those aimed at improving the “envelope” of the building—can be summed up fairly quickly in the 2006 report from the Continental Automated Buildings Association (CABA), which states:

“Typically two-thirds of the heat generated in a building is lost through the building fabric itself. . . . It is estimated that around 10–15 per cent of total energy costs is wasted through heat losses through the building fabric.”

Given that heating and cooling costs are some of the most significant costs of energy in buildings, these statistics should be sufficient to have building managers and CEOs looking for ways to improve the fabric or envelope of their buildings.

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Conclusions

Chapter Summary

- Best practices can be achieved only through collaboration among building owners, operators, and occupants. Their collective actions are critical to success.

- Governments play two key roles: supporting best practices through policies, incentives and pilot programs; and coordinating or harmonizing policies, standards, codes, and other initiatives between governments.

- Governments can provide further support through communications efforts, and by providing public access to benchmarking data.

This report considers best practices in energy management for commercial and institutional buildings through a literature review and interviews. The primary focus is on Canadian buildings, although much of the literature applies more broadly to North America. The sector includes a broad range of building types, sizes, and uses. As a result, general conclusions around best practices may not have full applicability to individual sectors.

There are many thousands of commercial buildings in Canada, including schools, hospitals, warehouses, offices, and retail establishments. The buildings range from just a few thousand square feet to millions of square feet. Most house people for at least part of the day, although some are used primarily to store goods. The most important unifying factors are that they consume energy to provide heat, light, and equipment operations (whether office equipment or larger).

In Canada, this means that electricity and natural gas are the two most significant energy sources. It is also true that for most buildings, the building operator is responsible for the day-to-day energy consumption of the building, but occupants make the decisions regarding the level of energy services provided while they are occupying the building. Thus, energy efficiency and energy management are shared responsibilities. The building owner is also an energy stakeholder and is the primary decision-maker for capital investments and capital maintenance. This complexity over a broad range of building types and locations is the key challenge.

The report summarizes many best practices, and reviews the benefits from adopting them, as well as the barriers that have hindered broad implementation. The roles of each of the stakeholders are discussed. Interviews with representatives of each stakeholder group have helped to further define the challenges and opportunities.

The following recommendations could improve the level of implementation of energy management and energy efficiency best practices:

- Harmonize and consolidate incentive programs with provincial and municipal governments to reduce the effort needed to capture the funding.
• Use government buildings for pilot programs to demonstrate the benefits of new equipment or operating practices, and communicate the results proactively.
• Include pilot programs as a major focus for incentive funds.
• Expand the effort to update codes and standards, including by identifying any barriers to energy efficiency technology implementation and any incentives or disincentives that the codes and standards create.
• Building information databases are essential. However, there is a broad range of proprietary systems. One of the challenges is to harmonize, standardize, or settle on a single data database, and to ensure that the tool selected properly reflects the impact of building equipment and building occupants.
• Consider more focused studies of best practices within the commercial buildings sector and tailor programs to specific building types or uses.

INCENTIVE PROGRAMS

The federal government and each province provide, or have provided, energy efficiency programs.1 These programs are complex and could be strengthened. Some of the organizations interviewed felt they are making full use of available programs. Others felt that the effort required to qualify for the funds would cost more than the incentive is worth. A third group knew little about the available incentives. This suggests that governments at all levels could review their incentives and how they are communicated. There may be opportunities to combine resources to support shared incentives. There may be opportunities to jointly administer multiple application processes. There may also be a benefit to examining the incentives against the barriers to best practices to ensure that the incentives reduce the barriers. The communications strategy might also be improved through further stakeholder engagement.

GOVERNMENT PILOT PROGRAMS

Governments across Canada are committed to expanding the market for green technologies through their own procurement programs and through pilot projects. This improves access to new technologies and reduces the early adoption risk for others. These are important benefits. This report identifies the importance of developing an energy management plan and linking that plan to the organization’s strategic plan and operating budget. The energy plan is then communicated to all stakeholders to promote full implementation. This is important because energy services are required by every building occupant. Everyone must play a role.

This suggests that governments at all levels could review their incentives and how they are communicated. There may be opportunities to combine resources to support shared priorities.

This approach can be mirrored by government pilot programs. Pilot programs are used to test the benefits and costs of new and emerging technologies. However, the resources available for pilot programs may not be sufficient to test all available technologies. Where selections must be made, there is a benefit to including strategic objectives in the decision criteria, and communicating those criteria to all stakeholders. The objectives don’t need to specify technologies directly. The introduction described the relative importance of heating/cooling and auxiliary equipment to the growth in energy demand by Canada’s commercial buildings. Government pilot programs that are results-driven and address those two strategic priorities can provide other stakeholders with incentives to adopt similar priorities.

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NON-GOVERNMENT PILOT PROGRAMS

Governments also engage other stakeholders to implement pilot programs, and may provide financial support. This is an important way to accelerate market confidence in new technologies, which will accelerate adoption. Regular review of the support given to these pilots will help to ensure that they are addressing the most important needs and overcoming barriers to best practices. Proactive communication of the result is critical.

CODES AND STANDARDS

Although this is a joint responsibility, government must set a regulatory framework that encourages energy efficiency. Government must also regularly review opportunities to update codes and standards and develop new standards as required. This report identified the important role that codes and standards play in adopting new practices or technologies. Continued emphasis in this area is important, as is continuous improvement in the interactions between governments. The objective is to achieve the regulatory outcome as efficiently and effectively as possible.

BUILDING INFORMATION DATABASES AND BENCHMARKING

There is a consensus that building operators, in particular, can benefit from comparing the performance of their building with that of other similar buildings. This is true for most, but not all, of the industries included in the commercial and institutional sectors. A single information database and benchmarking tool has the advantage that assumptions and calculations are consistent among organizations using the tool.

There are currently many proprietary databases and benchmarking approaches in use. Energy services companies often develop their own tools and use them as part of their selling proposition. These tools will continue to exist. In order to establish a single tool, there will be a period in which each of these proprietary tools is benchmarked against the single benchmarking tool to ensure that accurate comparisons are being made. A single tool has advantages, but must gain a minimum level of market acceptance.

There is also the challenge of benchmarking buildings based on varying stakeholder approaches. Given the very strong influence that building occupants have on energy consumption, one of the benchmarking challenges is to separate the influences of occupants, operators, and equipment.

INDUSTRY STUDIES

The commercial and institutional sector is very broad. This report reviews it as a whole. At least four studies could be undertaken to get to the next level of detail for offices, retail trade, hospitals, and academic institutions. The best practices could be tailored to the specific energy-using capital, operating practices, and occupant requirements for each group. This would help to ensure that incentives and programs are properly encouraging best practices for each industry.

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2 See section “The Role of Regulations and Standards” in Chapter 2 “Literature Summary.”
APPENDIX A

Bibliography


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