FUNDAMENTALS OF ENERGY EFFICIENCY

POLICIES, PROGRAMS AND BEST PRACTICES

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2022 Second edition

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PREFACE

This online textbook has been primarily written as a resource for professors and students at colleges and universities who teach/take courses on energy efficiency, energy policy, energy systems, energy regulation, environmental studies, environmental psychology, environmental economics, public policies, etc. Its focus is on the theory, policy, programs and best practices associated with energy efficiency. Other potential users of this text might include those who have made a career change into the energy efficiency industry and are seeking ways to better understand this new area.

For students who use this textbook and move on to have a career in the energy industry, the intent of this textbook is to provide them with a comprehensive understanding of the key elements associated with energy efficiency. A few examples of available career opportunities include employers such as governments; energy regulators; energy planning agencies; energy utilities; private energy companies; program design and implementation companies; companies that specialize in the evaluation, measurement and verification of energy-efficiency programs; energy service companies; non-governmental organizations; and manufacturers, retailers and installers of various energy-efficiency products and services. For others who take this course but end up pursuing careers outside the energy industry, the intent is to increase their overall energy literacy.

Developing and implementing effective energy-efficiency policies and programs is widely recognized as being critical if humankind is to reduce its reliance on fossil fuels. While important progress has been made over the past few decades, much more needs to be done. One essential component of making progress is ensuring graduates and undergraduates from colleges and universities are in a position to help achieve this. Although there are many excellent textbooks that deal with energy-efficiency technologies (e.g., Energy Efficiency and the Demand for Energy Services, Harvey, 2010), the impact of energy on the environment (e.g., Energy Systems and Sustainability: Power for a Sustainable Future, Boyle, 2012, and Energy, Society and Environment, Elliot, 2003), energy in Canada (e.g., Primer on Energy Systems in Canada, Second Edition, Pollution Probe, 2016) and public policy (e.g., Blue-Green Province: The Environment, The Political Economy of Ontario, Winfield, 2011, and Beyond Policy Analysis: Public Policy Management in Turbulent Times, Pal, 1997), there are no textbooks on the design, implementation and evaluation of energy-efficiency policies and programs.

This text is based on teaching a fourth-year course at York University's Faculty of Environmental Studies and Yorkville University's Bachelor of Business Administration Program for the last twelve years. This course, in turn, was built on a course developed by Dr. Alan Meier for courses he teaches at the University of California's Davis campus. The author gratefully acknowledges Alan's leadership in this area and the comments he provided on early drafts of this textbook. The text is also based on the experience of many other professors who teach similar courses in Ontario who shared their course outlines and ideas at the one-and-a-half-day workshop "Teaching Energy Efficiency at the Post-Secondary Level" that was organized by York University on July 16-17, 2014. Copies of presentations made at this workshop are available at York University's Sustainable Energy Institute's website. The results of this workshop were subsequently discussed at the International Green Educators Conference in Karlsruhe, Germany, on October 29-31, 2014, and at the Ontario Network for Sustainable Energy Policy workshop held April 27, 2015.

This is the second edition of this textbook. The first edition was published in 2018 and was thus based on policies in place in 2017 and data from 2016. Much has happened since then, so this edition updates the previous one and adds a few new elements and sections. The focus of this edition, like the first, is on the built environment as opposed to transportation or industry, the other major sources of energy use and this greenhouse gas (GHG) emissions.

The material in this textbook is broken down into three main sections.

The first section covers the theories, policies and programs applicable to all jurisdictions.

It consists of eleven chapters with extensive use of illustrations and numerous references. The definitions provided are designed for energy-efficiency practitioners so they are focused on energy.

- The first chapter is an introduction to energy efficiency where the different types of energy efficiency are identified and defined, the importance of energy efficiency is summarized as well as its benefits and challenges.
- The second chapter defines some of the energy-related terms that are used in the sector.
- The third chapter discusses building energy models, cabinet submissions and briefing notes. These are covered early in the textbook as they are suggested group projects. Doing this early allows student teams sufficient time to undertake these exercises.
- The fourth chapter summarizes the four main types of energy efficiency covered in this textbook: conservation behaviour, system operations, new technology and demand response.
- The fifth chapter summarizes the drivers, barriers and policy options.
- The sixth chapter focuses on the various aspects associated with the economics of energy efficiency and project financing.
- The seventh chapter is a brief summary of the various energy-efficiency measures currently available for the built environment as well as for transportation systems.
- The last three chapters cover the role of energy efficiency in energy planning (from both the system and community levels); the planning, design and implementation of energy-efficiency policies and programs; and the evaluation, measurement and verification of policies and programs. This section ends with some final thoughts on moving forward.

At the end of each chapter there are a few questions to test your understanding of the key concepts. They are in the form of Kahoot! questions, and you can go online to take them and see how you did. The log in address is www.kahoot.it and the pass code for each chapter's Kahoot! is noted at the end of each chapter.

The second section consists of a summary of current best practices.

The first five case studies are on the federal government, British Columbia, Nova Scotia, Ontario and Alberta. The B.C. case study is completely updated, and the federal and Alberta ones are new. The Nova Scotia and Ontario ones are unchanged but have updates as prefaces. The last five case studies are on Property Assessed Clean Energy (PACE) funding, industrial energy efficiency, energy service performance contracts, behavioural psychology in support of strategies to encourage personal action, and the economic impact of energy efficiency in Canada.

The third section consists of sample course materials such as templates for cabinet submissions and briefing notes. It also includes examples of regulatory submissions, a sample building audit and a mid-term test.

The development and free online availability of the first edition of this textbook was made possible by generous contributions from York University's Faculty of Environmental Studies, Enbridge Gas Distribution, the B.C. Ministry of Energy and Mines, FortisBC, and Efficiency One. This second edition was made possible by the generous support of FortisBC and Yorkville University.

A special thank you to the contributors to this textbook:

- Bojan Pourkarimi of Energitox for updating the B.C. case study initially written by Andrew Pape-Salmon and Tom Berkhout, and to Brendan Haley from Dalhousie University who authored the Nova Scotia case study.
- This edition features six new case studies. The first is a historical narrative of energy efficiency programs offered by the federal government's Office of Energy Efficiency and its precursors by the author of this textbook.
- The second is on what is required in Alberta to promote energy efficiency by Jesse Row of Alberta Energy Efficiency Alliance.
- The third is on Property Assessed Clean Energy (PACE) financing by the Canadian Home Builders Association.
- The fourth is on industrial energy efficiency by Professor Amit Kohli of Yorkville University.
- The fifth is a paper by the author on the behavioural psychology associated with encouraging personal action to reduce GHG emissions.
- And the last is on the economic impact of energy efficiency in Canada by Dunsky Energy Consulting for Clean Energy Canada.

Thank you to those authors and publishers for permitting them to be included in this textbook.

Thanks also to Econoler for granting permission to reprint the case studies on Energy Service Performance Contracts from Canadian Energy Efficiency Outlook; Energy Regulation Quarterly for granting permission to reprint the article "The Past, Present and Future of Energy Conservation in Ontario" and Natural Resources Canada for granting permission to publish the Historical Narrative.

DEDICATION

It is amazingly wonderful to love and to be loved. This book is dedicated to my wife, Melanie. Thank you for everything that makes my life so rewarding.

CHAPTER 1

INTRODUCTION TO ENERGY EFFICIENCY

DEFINITION OF ENERGY EFFICIENCY

One the first challenges in understanding energy efficiency is to clarify what, exactly, is meant by the term. The International Energy Agency (IEA) defines energy efficiency as:

Energy efficiency is a way of managing and restraining the growth in energy consumption. Something is more energy efficient if it delivers more services for the same energy input or the same services for less energy input. For example, when a light-emitting diode (LED) bulb uses 75% less energy than an incandescent bulb to produce the same amount of light, the LED is considered to be more energy efficient.

The IEA uses energy intensity as a way to measure energy efficiency and has found that energy intensity has decreased worldwide by an average of 2.1%/year since 2010, up from an average rate of 1.3%/year between 1970 and 2010.[1] A more general term is demand-side management (DSM), which was developed to differentiate solutions that focus on reducing the demand for energy as opposed to increasing the supply of energy. In Ontario, this is the term applied to energy efficiency in the natural gas sector, which is regulated by the Ontario Energy Board (see Ontario Case Study 4 in Section 2).

While this is a useful starting point, it will be beneficial to break down this broad definition into its main components. The six main categories of solutions that focus on reducing energy demand are:

- **Conservation Behaviour** – This is using existing technology in ways that reduce energy consumption. It is often referred to as energy conservation. Examples include turning off lights when leaving a room, turning off computers when not in use and programming smart thermostats to reduce energy consumption when not needed. The essential feature of these approaches is that they do not require the purchase of new technologies but do require a personal change in behaviour.
- **System Operations** – This is ensuring that entire systems are maintained and operated in the most efficient manner. Just as behavioural change has a large impact in homes, ensuring heating, ventilation and air conditioning (HVAC) systems are operating at their optimal level has a large impact in commercial, institutional and industrial facilities. Like behaviour change, this does not require the purchase of new technologies.
- **New Technology** – This is replacing older, less energy-efficient technologies with newer, more energy-efficient ones. It is often referred to as energy efficiency. As in the IEA's definition above, this can be replacing old incandescent light bulbs with newer, more energy-efficient LED ones. It can also include whole systems as in a house or office building.
- **Demand Response** – This is reducing electricity demand at certain times of the day when the system is nearing its system capacity limits. This is a uniquely electricity measure, as there is limited ability in current electricity systems to store excess electricity when there is surplus capacity to use it later when the system is at its peak.

- **On-Site Generation** – Although technically a generation approach, many jurisdictions consider small (< 10 kiloWatts or kW) on-site electricity generation to be a demand-side measure. Although mainly relevant for electricity in the past, this could also potentially apply for natural gas-generated biogas. Most electricity system operators consider generation loads of less than five megaWatts (MW) to be too small to be considered as part of the supply mix.
- **Fuel Substitution** – This occurs when one fuel is substituted for another. An example would be when a natural gas furnace is replaced with an electric heat pump; in this case, natural gas consumption would decrease but electricity consumption would increase.

This textbook will focus on the first four categories and refer to them jointly as “energy efficiency.” On-site generation of electricity is the subject of many other textbooks and is thus not discussed further here. And although fuel substitution has been the focus of various programs in the past, they were typically done because one fuel (e.g., natural gas) was less expensive and/or had fewer emissions than another fuel (e.g., heating oil), not because one was more energy efficient than the other.

IMPORTANCE OF ENERGY EFFICIENCY IN COMBATING CLIMATE CHANGE

Many courses and books deal extensively with the issues of climate change and the greenhouse gas (GHG) effect. While the details can be complicated, the key points can be summarized in five simple phrases:

- It’s warming
- It’s us
- We’re sure
- It’s bad
- We can fix it.

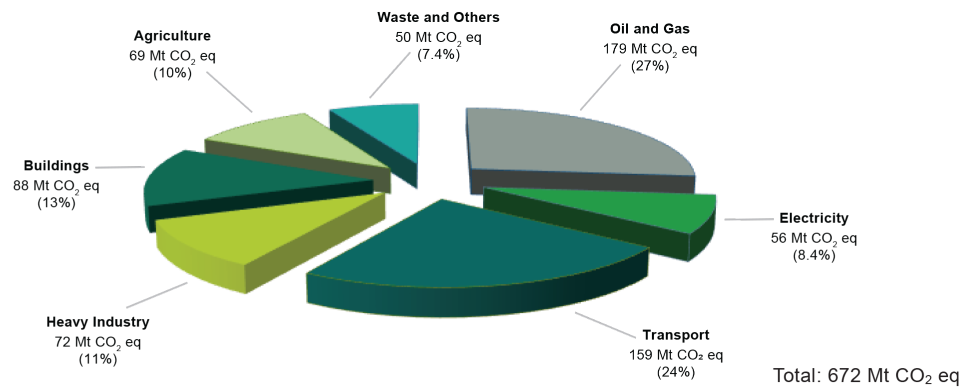
This is so simple, it nicely fits on a T-shirt, as illustrated in Figure 1.1. While many others focus on the first four points, this textbook focusses on the last.

Figure 1.1
Author with His Four Grand Children

Before moving on, a very brief summary of climate change is important. The reality of human impact on the climate has been confirmed by the vast majority of independent experts. Although there are some in society who still deny such changes, there are also some who still believe the earth is flat! In its most recent assessment report, the Intergovernmental Panel on Climate Change (IPCC), based on contributions from thousands of scientists and experts, concluded “it is unequivocal that human influence has warmed the atmosphere, ocean and land” and that “human-induced climate change is already affecting many weather and climate extremes in every region across the globe.”[2]

The most recent IPCC report also clearly noted the important role of reducing energy use in reducing this impact. The IEA, formed by G20 governments after the oil embargos of the 1970s, has concluded that “rising fossil-fuel energy use will lead to irreversible and potentially catastrophic climate change.”[3] Ban Ki-moon, when he was Secretary General of the UN and facing massive problems around the world, was quoted as saying that “slowing or even reversing the existing trends of global warming is the defining challenge of our age.”[4]

Figure 1.2
Breakdown of Canada's GHG Emissions by Economic Sector (2020)



Note: Totals may not add up due to rounding.

Source: Environment Canada[6]

Research has also clearly shown that it is the accumulation of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and few other gases that together have an effect similar to warming in a greenhouse. This effect was first identified in 1824. They are thus often referred to as greenhouse gas (GHG) emissions. The relative global warming potential (GWP) of CO_2, CH_4 and N_2O are 1, 25 and 298, respectively.[5] The most common method of reporting the GWP is using CO_2 equivalent (CO_2e), which is the quantity of CO_2 that would have the same GWP as the actual mixture of the GHG emissions over 100 years.

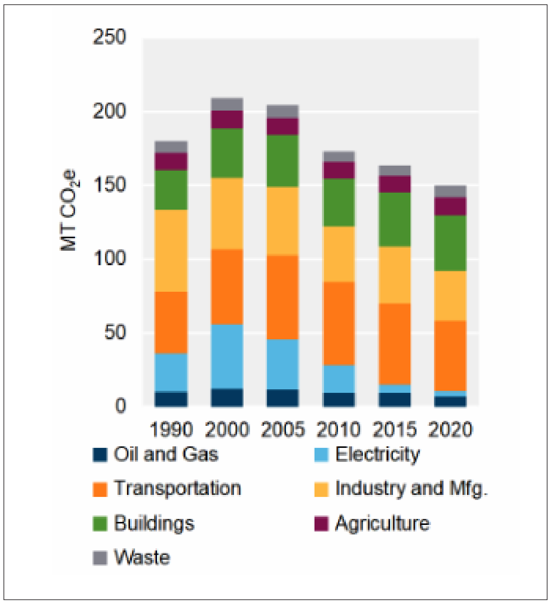
While there has been many reports and books on climate change, how it relates to CO_2 emissions and higher general public recognition of the issue, there is far less general public understanding of the causes of these emissions. This is despite the fact that the relationship between CO_2 emissions and the increase in GHG impacts was first described in 1896. As part of each country's reports on progress towards meeting GHG emission reduction targets, there is usually a summary of the sources of these emissions.

In Canada, the most recent report concluded that fully 83% of Canada's man-made greenhouse gases come from the production and use of energy.[6] Figure 1.2 summarizes the breakdown from all sources, including those associated with energy: oil and gas (27%), transportation (24%), buildings (13%), heavy industry (11%) and electricity (8%).

Although Canada's emissions have decreased by 9% since 2005, per capita emissions have decreased by 23% and emission intensity (measured in tonnes/GDP) has decreased 26%. Despite this progress, Canada remains one of the highest per capital emitters in the world. It is also important to realize that the sources of the emissions change widely in different regions, due mainly to the different sources of electricity generation as well as the size of the respective industrial sectors. For example, in Alberta, 51% of GHG emissions are from the oil and gas sector and 11% from electricity generation. In provinces where hydroelectricity dominates, emissions from that sector are very low, and so the main source of emissions come from other sectors. For instance, in Quebec and B.C., transportation represents 41% and 37%, respectively.

Figure 1.3 summarizes the breakdown of GHG emissions by source in Ontario; it shows that the contribution from transportation and buildings are higher than the national average, but that emissions from electricity are now less than the national average. This is primarily due to the closing of all Ontario's coal-fired electricity generation facilities by 2014.

Figure 1.3
Ontario's GHG Emissions by Sector



Source: Ontario Government[7]

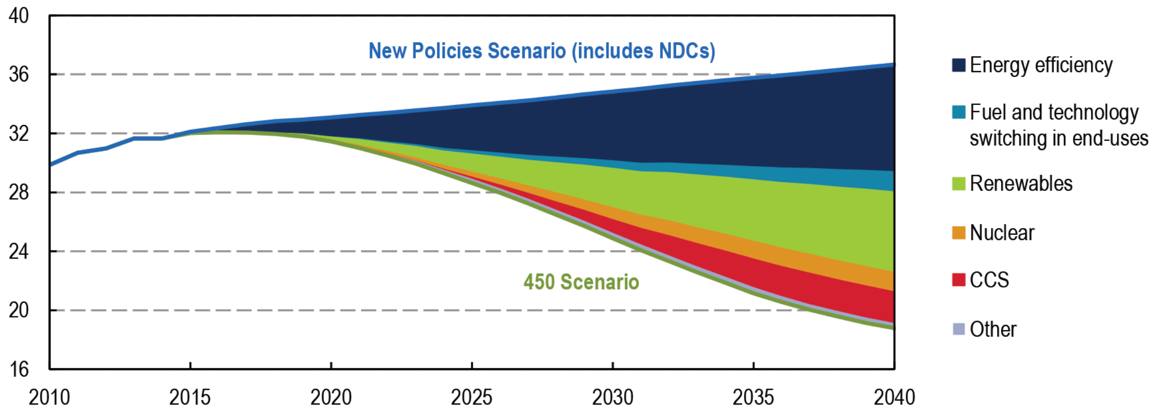
There are two main approaches to climate change; mitigation and adaptation. Mitigation refers to reducing the emission of GHGs whereas adaptation refers to changing the infrastructure to accommodate changes in the climate. A third more controversial and untested approach is use various geoengineering technologies to seed oceans or the air with material that might reduce the greenhouse gas process. Both mitigation and adaptation are essential and even some form of geoengineering may be required to meet our climate targets, but this textbook will focus on one of the two major components of mitigation: energy supply and energy demand.

- **Energy Supply** – Reduce the carbon emissions from the energy we use. One way to do this is to use non-fossil forms of energy (nuclear, solar, wind, geothermal, wave, etc.) to replace fossil fuels. Another is to reduce the carbon emissions when fossil fuels are burnt (e.g., replace high-carbon-content coal with lower-carbon-content natural gas, or carbon capture, utilization and storage (CCUS) to capture and then utilize or store carbon emitted when fossil fuels are burnt).
- **Energy Demand** – Reduce the amount of energy needed to perform a required task.

The great majority of public discussion has always been on the supply side. This text will focus on the demand side. Even in jurisdictions where electricity is mainly generated with little use of fossil-fueled generators (Newfoundland, Quebec, Ontario, Manitoba and B.C.), energy efficiency has a positive impact on GHG emissions as the electricity that is saved can be used to displace fossil fuels used in other applications (such as electric vehicles replacing gasoline-fueled ones) or exported to jurisdictions that rely on fossil fuel generated electricity.

It is also important to note that there are strong synergies that exist between supply and demand-side options. A recent report noted that "a combined approach to renewable energy and energy efficiency offers the most timely and feasible route to decarbonizing the global energy system."[8] Most advocates of renewable energy are also advocates for energy efficiency, as they know that energy efficiency reduces the overall cost of renewable energy projects as the capacity of these units has been reduced by energy efficiency.

Figure 1.4
Global Energy-Related GHG Emission Reductions



Source: International Energy Agency[9]

POTENTIAL FOR ENERGY EFFICIENCY

Given the relative lack of discussion on energy efficiency compared to supply-side options, one might ask if this is due to the relatively small contribution that can be made by energy efficiency. This could not be further from the truth. According to the IEA, improved energy efficiency could be responsible for the largest contribution to the GHG emission reductions required to meet the 2015 Paris Agreement commitments, about the same contribution as from renewables.[9] These findings are summarized in Figure 1.4.

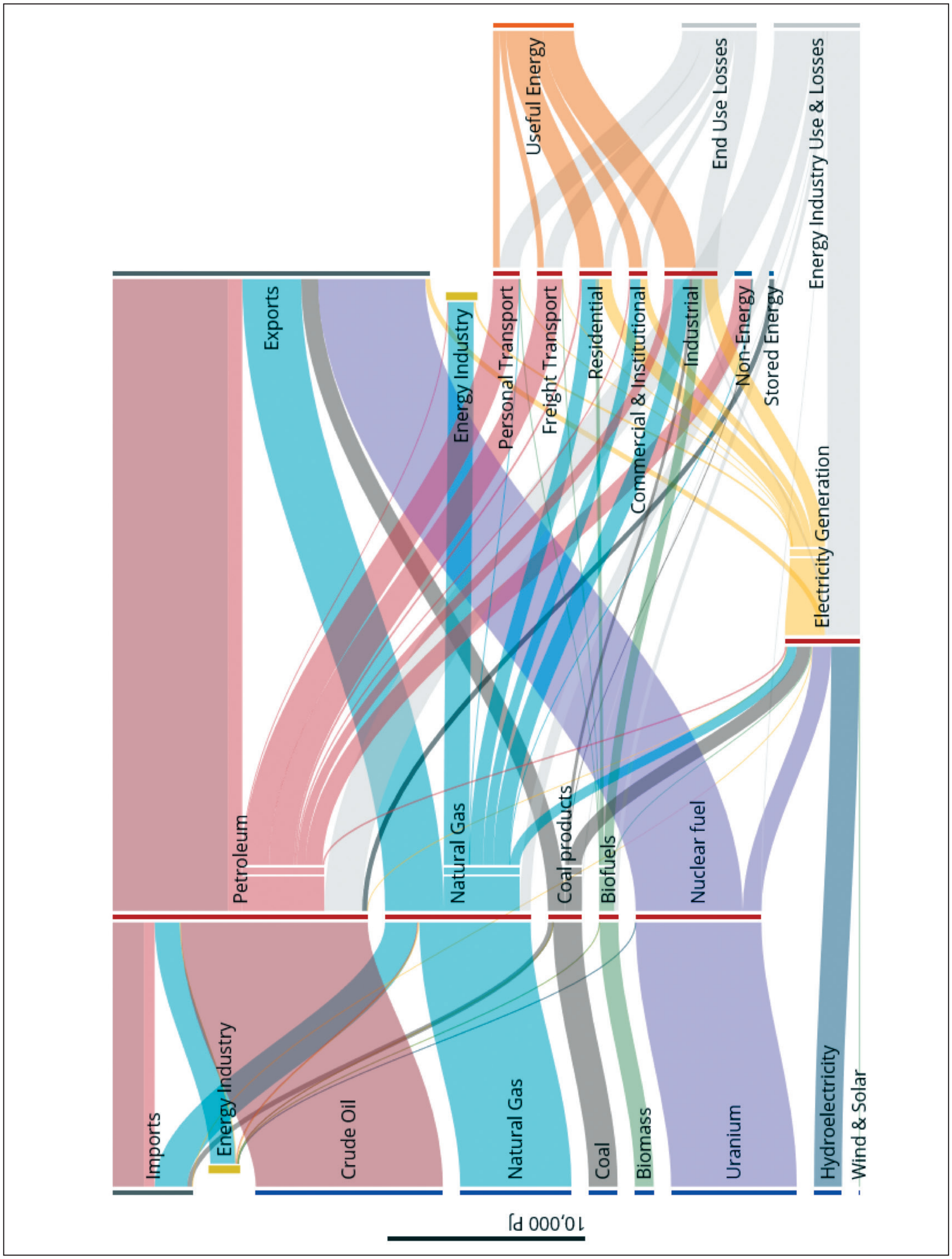
A Canadian study on the economic impacts of energy efficiency included a high energy-efficiency scenario, based on current best practices. It estimated that energy efficiency could represent nearly 40% of Canada's 2030 Paris climate commitment.[10] This study is so important that it has been printed as Case Study 8 in Section 2 of this textbook.

Information compiled by the University of Calgary as part of its Canadian Energy Systems Analysis Research concluded that about 60% of the energy used in the Canadian economy is lost through conversions. Figure 1.5 is the Sankey chart that illustrates these findings.[11] As noted in the case study on Nova Scotia in Case Study 3 in Section 2, energy flows for each province as well as many other charts can be developed using this site.

While many components of the illustration are hard to follow due to the multiple inputs, the component on transportation is relatively simple, as refined oil products (gasoline or diesel) are the main inputs and there are only two outputs: useful energy (about 20%) and wasted energy (the other 80%). This is an extreme example, as the efficiency of the internal combustion engine is very low.

A roadmap by IEA of achieving net zero by 2050 identified the potential energy savings by sector[12]: buildings were highest at 28%, followed by transportation (25%), oil/gas/mining (21%), other industry (12%) and other including energy supply and agriculture (14%). Although this textbook mostly focusses on buildings, many of the issues and approaches discussed also apply to these other sectors.

Figure 1.5
Energy Flows in Canada: 2013 (PJ or PetaJoules)



Source: Canadian Energy Systems Analysis Research[11]

BENEFITS OF ENERGY EFFICIENCY

One of the main benefits of energy efficiency is its impact on reducing GHG emissions, and thus it addresses the global issue of climate change. There are other benefits for a country like Canada that can be summarized as the "3Es": employment, economy and the environment. These benefits are illustrated and briefly described in Figure 1.6.[13]

As noted in Figure 1.6, it is particularly noteworthy that many of the direct jobs associated with energy efficiency are at the local level. While there are some jobs associated with manufacturing products that are not made locally and may even be in other countries, most of the jobs are local. This is because energy-efficiency projects require local contractors to actually do the on-site construction or installation.

The previously mentioned Canadian study[10] on the economic benefits of energy efficiency also found the following potential impacts are possible under a relatively aggressive energy-efficiency scenario (estimated cost would be $149 billion) over 13 years:

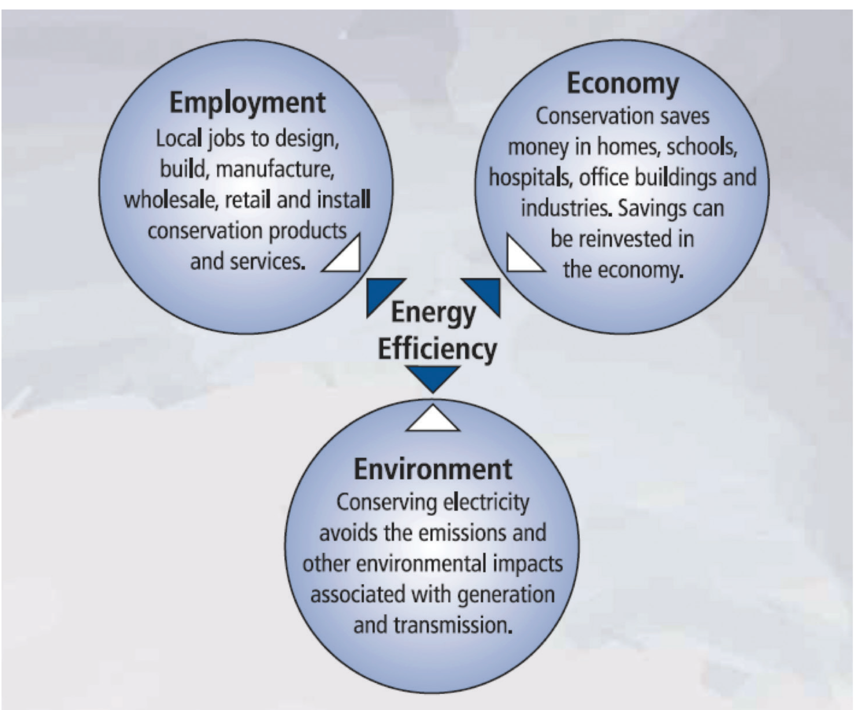
- Gross Domestic Product (GDP) could increase by $595 billion
- 280,650 full-time jobs could be added to the workforce per year
- Average annual household savings of $151 with cumulative savings of $53 billion; cumulative savings for commercial/industrial sector could be $141 billion.

There is a fourth benefit to energy efficiency in the many parts of the world not endowed with Canada's natural energy resources, and that is security of supply. In many parts of Europe that rely heavily on Russian natural gas imports and in much of Southeast Asia, this is a major issue. At a conference of energy policy experts in Europe in 2009, the potential for various energy-efficiency programs began to be measured in terms of "Russian gas pipeline equivalents." This concern was most recently illustrated by the Russian invasion of Ukraine in 2022 and their subsequent decision to limit their exports of natural gas to European countries.

It can also be argued that as a relatively wealthy nation, Canadians have a moral commitment to less wealthy countries as well as future generations to do all we can to reduce our impact on GHG emissions.

A more comprehensive discussion of the drivers behind energy efficiency is included in Chapter 5.

Figure 1.6
The Three "E Benefits" of Energy Efficiency



Source: Chief Energy Conservation Officer[13]

CHALLENGES OF ENERGY EFFICIENCY

With all these benefits, it would be reasonable to assume that energy efficiency would be at the top of any "to do" list of government, industry, public sector or homeowner. It is not. While there are a number of barriers, which will be discussed in more detail in Chapter 5, the following are three particularly important challenges:

- **Hard to See** – Most environmental issues like air pollution, garbage, water pollution, etc., are an assault on the senses. They stink, are ugly, and you can touch, feel and even taste them. Energy efficiency, as well as most forms of energy and even climate change itself, is largely invisible. Most energy-efficiency products are in the walls, in the furnace/mechanical room or in the controls. The only exceptions are transportation fuels we use, such as gasoline and diesel, and lighting. Ironically, it is the visibility of some forms of electricity generation, such as wind turbines, that leads some people to oppose them.
- **Hard to Measure** – Measuring energy efficiency is harder than measuring energy used, but it can and is being done. It requires the use of protocols to compare the amount of energy that was actually used with the amount that would have been used without the intervention. This is called evaluation, measurement and verification and is the subject of Chapter 10. While possible, it does require more work than just reading a meter on an energy supply.
- **Requires All In** – As will become clear in this textbook, successfully deploying energy efficiency will require active participation from all sectors of society: government (at all levels), private companies, public institutions, homeowners and tenants. By contrast, a great example of an environmental initiative that did not require such broad participation was the very successful Montreal Protocol on Substances that Deplete the Ozone Layer, which was signed in 1987 at a meeting of a few hundred representatives from governments, scientists and industry.

ENERGY PRODUCTIVITY

Another way of looking at and expressing energy efficiency is as a measure of productivity. For the last few years, the U.S.-based Alliance to Save Energy has used the slogan "Using Less. Doing More." and has called for a doubling of energy productivity.

- **Energy Productivity** – Measurement of the effectiveness of converting energy into economic output. It is calculated by dividing economic output (e.g., GDP) by energy consumed.

CHAPTER 1
POWER QUIZ

Energy efficiency is a way of managing and restraining the growth in energy consumption. Something is more energy efficient if it delivers more services for the same energy input or the same services for less energy input.

Kahoot!

Test your understanding of the key concepts in Chapter 1.
Answer the Kahoot! questions online to see how you did.
Log in at www.kahoot.it, pass code 009992202.

1. DEFINITION OF ENERGY EFFICIENCY

- **a.** Way of increasing supply of energy
- **b.** Way of managing and reducing the growth in energy consumption
- **c.** Way of changing the types of energy used
- **d.** None of the above

2. FOUR MAIN CATEGORIES OF ENERGY EFFICIENCY ARE:

- **a.** On-site generation, solar, wind & biomass
- **b.** Fuel substitution, heat pumps, LED lights & EnergyStar appliances
- **c.** Conservation behaviour, system operations, new technology & demand response
- **d.** None of the above

3. RELATIVE GLOBAL WARMING POTENTIAL (GWP) OF CARBON AND METHANE 1 AND 25

- True
- False

4. THE LARGEST SOURCE OF GHG EMISSIONS IN CANADA

- **a.** Electricity generation
- **b.** Transportation
- **c.** Heavy industry
- **d.** Oil and gas industry

5. 40% OF PRIMARY ENERGY IS LOST IN CONVERSION

- True
- False

6. THE BENEFITS OF ENERGY EFFICIENCY IN CANADA ARE:

- **a.** Employment, economy and environment
- **b.** Water, waste and well-being
- **c.** Solar, wind and biomass
- **d.** None of the above

7. THREE CHALLENGES OF ENERGY EFFICIENCY ARE:

- **a.** Expensive, hard to build and lack of technology
- **b.** Hard to see, hard to measure and requires all-in
- **c.** Takes too long, too confusing and too complicated
- **d.** None of the above

CHAPTER 2

ENERGY, POWER AND ENERGY SERVICES

Before proceeding further in the exploration of energy efficiency, it is first important to clarify a few key terms. This is important as there is a broad misunderstanding of what they mean or how they are different from each other. For those who remain in the field, misuse of these basic terms can undermine their credibility in the eyes of professionals, particularly those with a technical background.

ENERGY

For the purposes of this text, energy can be defined very simply as the capacity to do work.

Energy cannot be created or destroyed, only converted (First Law of Conservation of Energy) between forms of energy (e.g., chemical, nuclear, gravitational, kinetic and radiated). Electricity, natural gas and gasoline are all types of energy. Common units of energy are:

- **Electricity** – kiloWatt-hours (kWh) – 10^3 Watts x 1 hour
- **Natural Gas** – cubic meters (m^3) or millions of British Thermal Units (MMBTU)
- **Gasoline** – litres or gallons.

A less well-known but interesting measurement of energy is the Rosenfeld, named after the Vice Chair of the California Energy Commission who became an early champion of energy efficiency in the early 1970s. His leadership resulted in promoting energy-efficiency standards for appliances and buildings that were so successful that electricity consumption in the state levelled off, despite increasing population and GDP. This is referred to as the "Rosenfeld Effect."

ROSENFELD

1 gigaWatt-hour (GWh) – amount of electricity produced in a year from a 300 MW coal plant

The more theoretical way to measure energy as mechanical work is to use the Joule, which is the energy to move an object one meter against a force of one Newton. Likewise, the measurement of energy as heat is the British Thermal Unit (BTU), which is the heat required to raise one pound of water by one degree Fahrenheit.

TIPS ON PROPER USE OF UNITS

Short forms are commonly used to express units – km for kilometer, kg for kilogram, etc. A number of the common terms in this text are based on famous scientists; examples above are Watt and Joule. Whenever these terms are used, they should always be capitalized. So the correct unit for the measurement of electrical energy is kWh, not kwh.

It is also important to distinguish between primary energy and delivered energy.

Primary Energy – This is the energy content of the original resource. For fossil fuels, this is the BTU content of the fuel; for instance, 1,000 m^3 of natural gas contains 36.9 million (MM) BTU of energy potential.

Delivered Energy – This is the energy that is delivered to the energy user after conversion and transmission/distribution losses. For fossil fuel products, these losses can vary from as low as 5% for condensing gas furnaces to over 40% for older water heaters. For electricity, the losses can be as high as 66% (because a typical coal plant is only 33% efficient) or very low for hydro, other renewables and nuclear. The theoretical conversion factor used for electricity is 3,412 BTU/Watt, but this can be closer to 10,000 BTU/Watt in electricity grids where most of the electricity is generated from coal.

POWER

Again, for the purposes of this book, power can be defined as the rate at which energy can be converted from one form to another.

The essential difference between energy and power is that while energy measures the capacity to do work, power measures the rate at which energy can be converted. These two terms are very commonly confused, not just by the general public but also by many in the energy industry. Power is most commonly used to define the capacity of an electricity system. Common units are:

- **Electricity** – Watt – defined as one Joule/second. In larger quantities, measured as kW (10^3), MW (10^6) and GW (10^9).

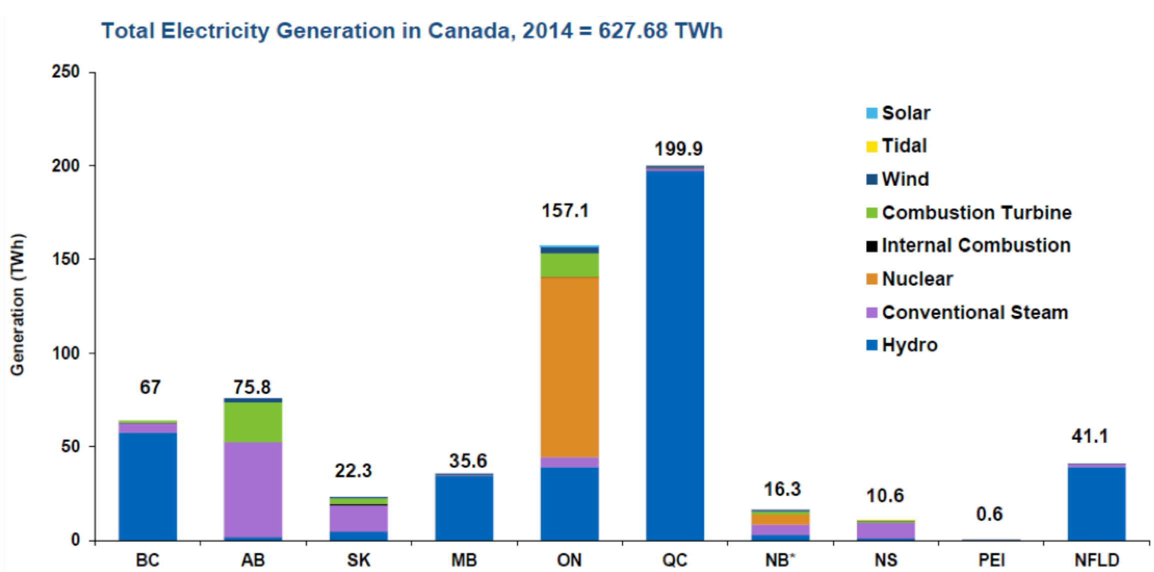
ELECTRICITY SYSTEMS IN CANADA

As mentioned in the previous section, electricity can be generated in many different ways, and each has a very different environmental impact. This difference is particularly pronounced in Canada, as illustrated in Figure 2.1.

As can be clearly seen, B.C., Manitoba, Quebec, and Newfoundland/Labrador generate almost all their electricity from hydro resources. Alberta, Saskatchewan and Nova Scotia generate most of their electricity from fossil fuels, while Ontario and New Brunswick have a mixed generation fleet. This difference has important impacts on policy. As an example, switching to an all-electric vehicle in B.C. results in a relatively large reduction in GHG emissions, as most of the electricity is generated from non-GHG emitting hydro. However, doing so in Alberta has a much lower impact as coal and natural gas are used to generate the electricity, which results in GHG emissions.

The fact that each province generates their electricity in very different ways is particularly important in Canada as there are limited interprovincial connections in the electricity system. If Canada were to have a truly national electricity grid, this distinction would be less important. Until then, it is not useful to use average emissions factors in making electricity policy decisions for Canada.

Figure 2.1
Electricity Generation in Canada by Province and Fuel Type, 2014



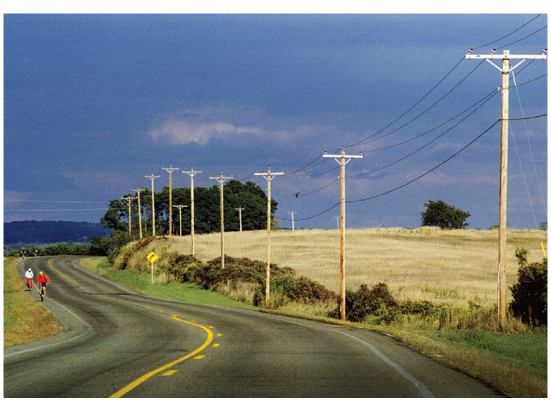
Source: Natural Resources Canada[14]

TRANSMISSION AND DISTRIBUTION SYSTEMS

Systems of wires, pipelines and trucks are required to deliver energy to the end users. In electricity systems, there are two levels of delivery systems. Transmission systems (Tx) are the large, high-voltage lines (typically 115 kiloVolt [kV], 230 kV or 500 kV) that are used to transmit electricity over longer distances; see Figure 2.2. Distribution systems (Dx) are the lower-voltage lines (typically 50 kV or less) used by local electric utilities that are the link between the high-voltage Tx system and the end-use customer (see Figure 2.3). There is a similar system of larger and smaller pipelines that transport natural gas from the wells to the end user. For oil products, trucks are the link between the pipelines and gas stations or homes.

Figure 2.2
Typical Electricity Transmission Tower

Figure 2.3
Typical Electricity Distribution Poles



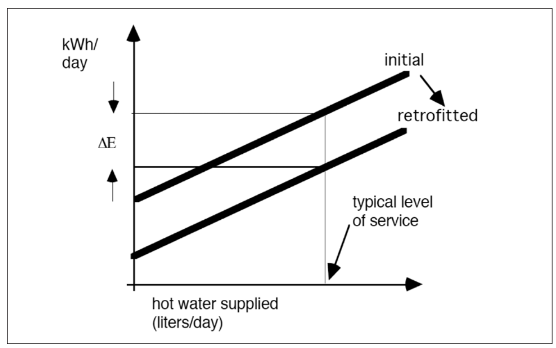
CONVERSION EFFICIENCY AND SERVICE PLOTS

As noted in the definition of energy, it cannot be created or destroyed, only converted. When it is converted, conversion losses occur.

- **Conversion Efficiency** – This is defined as the useful energy output divided by the total energy input. Its equation is:
  Conversion Efficiency = energy output/energy input

Another important concept is the Service Plot, which shows the amount of energy required to perform the required energy service. In Figure 2.4, the top line shows the amount of energy required to provide the typical amount of hot water for a house in a day. The lower line shows the impact of replacing a water heater with a more energy-efficient one that both requires less energy in standby and is able to produce the same amount of hot water with less energy, with the difference being ΔE.

Figure 2.4
Service Plot – Impact of Energy Efficiency



Source: Meier[15]

The fact that both lines start above 0 is due to the standby losses of the water heater. In the case of the retrofit, the heater is designed to result in lower standby losses.

Standby Losses – This is the energy that is used by an appliance even when it is not performing a useful function. There are two different modes of standby losses: passive (where no useful functions are performed) and active (where some functions are performed). These losses are also sometimes referred to phantom losses.

It has been estimated that about 600 MW of electrical capacity is required in Canada to power appliances while in standby. If all appliances were required to use a maximum of 1 Watt in standby mode, the savings are estimated to be over 430 MW.[16]

POWER QUALITY

Power quality is most often used to describe the steady stream of electrical voltage delivered within a prescribed range. Another way to think about power quality is to consider the quality of the energy source that is required for different uses.

Figure 2.5 summarizes an estimate that has been made of the quality of power in the U.S. economy, which would be similar to that found in Canada. One of the important features here is that fully 35% of the energy required is needed to produce heat of less than 100° C. Using very high energy-intense sources for such purposes, such as natural gas or electricity, is a clear mismatch. Also significant is that the second largest use of energy is for vehicles.

Figure 2.5
Thermodynamic Breakdown of U.S. Economy

Category	% of Energy	% of Energy
Heat	**58**	
< 100° C		35
100 - 200° C		6
200 0° C		17
Mechanical Work	**38**	
Vehicles		31
Pipelines		3
Industrial electrical drives	**4**	
Other Electrical	**4**	

Source: Meier[15]

CONSUMERS PERSPECTIVE ON ENERGY

Although experts and professionals in the field typically focus on particular types of energy (e.g., electricity, natural gas, gasoline, etc.), energy consumers don't really want any of these types of energy. What they want are the services the energy provides. The most common services homeowners want can be broken down into six basic categories:

- Comfort (heat/cooling/ventilation)
- Cleanliness (body, clothes, dishes)
- Light
- Appliances
- Mobility
- Products and services.

These same services, but on a larger scale, also are the ones required by commercial and institutional building owners and operators. Even large industry has similar requirements, although processing equipment would be an additional service.

POWER, ENERGY AND COST SAVINGS

The best way to understand the importance, as well as the differences, between power and energy is to calculate them for a typical energy-efficiency upgrade scenario and apply them to calculate cost savings. For this scenario, we will assume that the electricity price changes, depending on the time of day. Such "time-of-use" rates are becoming more popular but require new electricity meters that can record the amount of energy used at different times of the day.

Kahoot!

Test your understanding of the key concepts about Power, Energy and Cost Savings. Answer the Kahoot! questions online to see how you did.

Log in at www.kahoot.it, pass code 00101894.

EQUATION FOR COST SAVINGS

Cost savings = Power savings (kW) x Time (h) x Price ($/kWh)

A tip to make sure the calculations are correct is to see that when you multiple and divide the units themselves, they cancel out and result in the desired units. For example, kW x hours x $/kWh = $ because the kW and hours in the numerator are cancelled out by the kWh in the denominator.

1. HOW MUCH POWER (IN W) IS SAVED IF A 60 W INCANDESCENT LIGHT BULB IS REPLACED BY A 10 W LED BULB?

- **a.** 0 ☐
- **b.** 50 ☐
- **c.** 0.05 ☐
- **d.** 0.5 ☐

2. WHAT IS THE ANNUAL ENERGY SAVINGS IF THE LIGHT IS ON FOR 2,000 HR/YEAR?

- **a.** 100 kW ☐
- **b.** 100 kWh ☐
- **c.** 1,000 kW ☐
- **d.** 1,000 kWh ☐

3. WHAT IS THE ANNUAL COST SAVINGS, IF A LIGHT IS ON FOR 500 HOURS DURING PEAK TIMES, 500 HOURS DURING MID-PEAK TIMES AND 1,000 HOURS IN OFF-PEAK TIMES WITH ELECTRICITY COSTS OF $0.18/KWH ON-PEAK, $0.132/KWH MID-PEAK AND $0.087/KWH OFF-PEAK?

- **a.** $1.22 ☐
- **b.** $10.15 ☐
- **c.** $12.00 ☐
- **d.** $12.15 ☐

4. WHAT IS ANNUAL COST SAVINGS IF TX/DX & OTHER COSTS ARE $0.02/kWh?

- **a.** $14.15 ☐
- **b.** $12.15 ☐
- **c.** $141.50 ☐
- **d.** $1.42 ☐

CHAPTER 2
POWER QUIZ

Energy cannot be created or destroyed, only converted between forms of energy (e.g., chemical, nuclear, gravitational, kinetic and radiated). Electricity, natural gas and gasoline are all types of energy.

Kahoot!

Test your understanding of the key concepts in Chapter 2.
Answer the Kahoot! questions online to see how you did.

Log in at www.kahoot.it, pass code 005773262.

1. DEFINITION OF "ENERGY" AND EXAMPLE OF UNIT OF MEASUREMENT

- **a.** Rate at which energy can be converted, measured in MW ☐
- **b.** Capacity to do work, measured in kW ☐
- **c.** Rate at which energy can be converted, measured in kWh ☐
- **d.** Capacity to do work, measured in kWh ☐

2. DEFINITION OF "POWER" AND EXAMPLE OF UNIT OF MEASUREMENT

- **a.** Rate at which energy can be converted, measured in MW ☐
- **b.** Capacity to do work, measured in MW ☐
- **c.** Rate at which energy can be converted, measured in kWh ☐
- **d.** None of the above ☐

3. ELECTRICITY IN CANADA MOSTLY COMES FROM HYDRO SO DRIVING AN ELECTRIC VEHICLE IN ANY PROVINCE REDUCES GHG

- True ☐
- False ☐

4. DEFINITION OF "CONVERSION EFFICIENCY"

- **a.** Total energy input divided by useful energy output ☐
- **b.** Useful energy output divided by total energy output ☐
- **c.** Useful energy output minus total energy output ☐
- **d.** None of the above ☐

5. 600 MW OF ELECTRICITY IN CANADA IS USED TO POWER APPLIANCES WHILE IN STAND-BY MODE

- True ☐
- False ☐

6. LARGEST USES OF ENERGY IN THE U.S.

- **a.** Heat <100° C ☐
- **b.** Heat >100° C ☐
- **c.** Vehicles ☐
- **d.** Industrial electrical drives ☐

7. SIX ENERGY SERVICES THAT HOMEOWNERS WANT

- **a.** Happiness, wealth, power, prestige, status and employment ☐
- **b.** Comfort, cleanliness, light, appliances, mobility & products/services ☐
- **c.** Travel, big car, big house, new appliances, new technology & happiness ☐
- **d.** None of the above ☐

CHAPTER 3

STUDENT AND GROUP PROJECTS

This chapter occurs early in the textbook as it is recommended that students taking this course be required to model energy-efficiency upgrades to a specific building and write a cabinet submission, a briefing note or a submission to a regulatory panel or government agency near the end of this course. Each of these assignments can be done either as an individual or in a group. In order to facilitate this, these tools and templates should be discussed early on in the course.

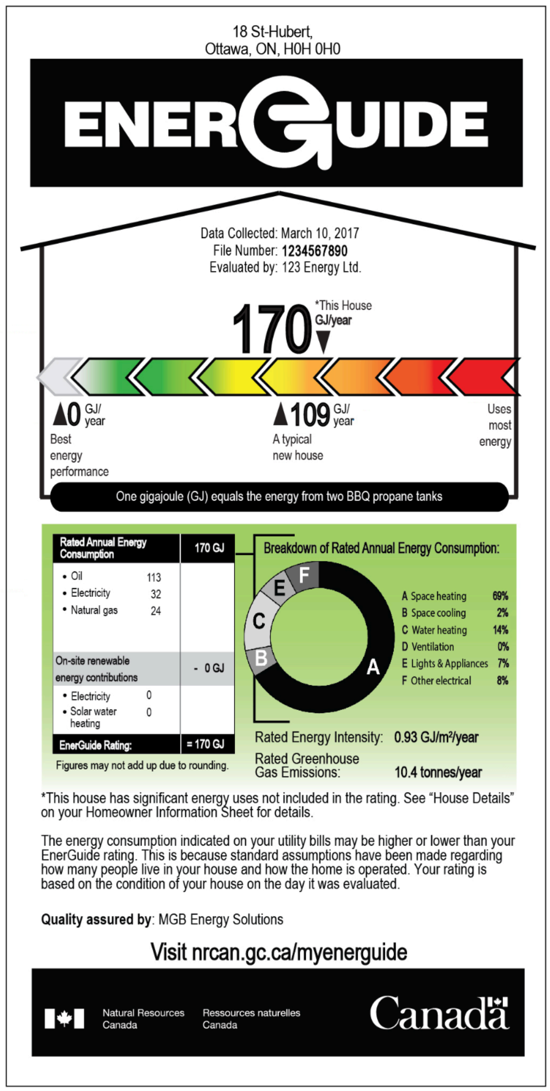
BUILDING ENERGY SIMULATION MODELS

There are many different building energy simulation modelling software tools that have been specifically developed to evaluate the impact of alternative technologies and practices in a building. They can be broken down into two main types: those meant for low-rise homes (single, semi, row or townhouse) or those meant for larger commercial buildings (office buildings, condos, university buildings).

In Canada, one of the more popular models for low-rise homes is the EnerGuide Home Rating System, which uses the HOT2000 software tool. Version 11.10 of this tool is currently available at no cost. NRCan also offers training courses for professionals using this software. The EnerGuide label has recently been updated; Figure 3.1 shows the newest version. The software automatically develops a range of recommended upgrades based on the initial assessment of the building. Students or groups of students could be assigned the task of modelling a particular house using this software and then modelling the impact of a range of energy-efficiency upgrades.

Information on this model is available from NRCan. One option instructors might consider if they are not familiar with this tool is to ask a local home energy auditor to be a guest speaker at a lecture to demonstrate how the students can use this tool.

Figure 3.1
EnerGuide for Houses Label



Source: Natural Resources Canada[16]

There are many building simulation tools for commercial buildings. One of them is RETScreen, which was also developed by NRCan. The Expert version is free-of-charge in “Viewer” mode and the Professional version is available by annual subscription. The best place to start learning about RETScreen is from NRCan’s eLearning YouTube channel. Third-party companies such as the Canadian Institute for Energy Training conduct regular RETScreen Expert workshops. The energy-efficiency module has been available since 2008. The upgraded version contains a list of a wide range of energy-efficiency upgrades. As with the EnerGuide label, one option instructors might consider if they are not familiar with this tool is to ask a local commercial building energy auditor to be a guest speaker at a lecture to demonstrate how the students can use this tool. Here is the link to this tool.

In both types of models, students or groups of students can be asked to model the impact of a range of energy-efficiency upgrades. One approach is to require that they identify and model one behavioural change, one energy-efficiency upgrade and one demand response change in a college or university building. More background on these three solutions is provided in Chapter 4. An example of a group project for a campus building is included in Chapter 7 of Section 3 of this textbook.

An alternative that might be more appropriate for technical/engineering courses might be an audit of an industrial facility. A Case Study of an industrial audit is included in Chapter 7 of Section 2 of this textbook.

CABINET SUBMISSION

The government has a critical role to play in the development of policies and programs to promote energy efficiency. Most governments require the submission of potential new policies and programs for discussion by the relevant decision-making body. In Canada, this is typically the cabinet and is done through discussion of a cabinet submission. The full template used by the B.C. government is provided in Chapter 1 of Section 3. As such submissions typically take a group of seasoned experts weeks to prepare with extensive research, this is not realistic for a student project. A suggested shorter version might consist of:

- Decision Being Recommended
- Background
- Best Practices
- Alternatives
- Assessment of Alternatives

BRIEFING NOTE

One of the most common formats to provide senior leaders with a short, concise summary of a specific situation or to make a specific recommendation is to use a briefing note. Such notes are common in both government, with the recipient often being a Minister, and in the private sector, with the recipient being the CEO or CFO. A short summary of how to write a briefing note, prepared by Susan Doyle of the University of Victoria, is included in Chapter 4 of Section 3.

CHAPTER 4

CONSERVATION BEHAVIOUR, SYSTEM OPERATIONS, NEW TECHNOLOGY AND DEMAND RESPONSE

Conservation behaviour is the first of the four types of energy efficiency that will be examined in this textbook. Although it is the simplest, fastest and least expensive, it is often the last to be considered.

CONSERVATION BEHAVIOUR

- **Conservation Behaviour** – Changing the use of existing technology that results in reduced energy usage. Examples include turning off lights when not in a room, programming a smart thermostat to reduce heating or cooling when not needed, walking instead of driving a car, etc.

It is certainly the oldest form of energy efficiency. It is not surprising that Indigenous peoples and early settlers, who had to cut down trees for fuel or feed livestock to provide motive power, were careful not to waste energy. During the last two World Wars, active programs were in place to promote energy, as well as material, conservation. More recently, the first of what became many calls to promote a more sustainable society was made in 1973 by the Science Council of Canada. Under the leadership of Dr. Ursula Franklin, its report, *Natural Resource Policy Issues in Canada*[18], was the first to promote the concept of a conserver society. More background on the history of energy conservation in Ontario is contained in the case study “The Past, Present and Future of Energy Conservation in Ontario,” which is reprinted in Case Study 4 in Section 2 of this textbook.

One of the main benefits of conservation behaviour is that there are no upfront or even ongoing costs because it relies on technology already in place. The payback is thus immediate. Another more subtle benefit is that once people have been convinced to change their behaviour, they are usually less likely to revert back to their old habits and more likely to be interested in other measures they might take to reduce their energy consumption. The ultimate hope is that such changes in behaviour will lead to the adoption of a culture of conservation.

- **Culture of Conservation** – Mindset of an individual or organization where saving energy has become automatic, second nature, ubiquitous.

The challenge with changing behaviour is that it is not top of mind for most people. It is difficult, and probably not desirable, to legislate and is difficult to encourage through an incentive program as it is hard to verify performance. It is also harder to measure its impacts than the other three types of energy efficiency. And system operators responsible for ensuring an adequate supply of electricity at all times are more reluctant to rely on it than they are on a change to a more energy-efficient product which does not require consumers to consciously do anything.

One of the best proven ways to promote behavioural conservation is by providing timely information on energy consumption, especially if it includes comparisons to others with similar buildings in the same geographic area. Such information is becoming more common on energy bills. Real-time monitors, in-home displays and information dashboards are also becoming increasingly available.

The potential carbon emission reductions from behavioural change in households can be as high as 20%, according to a recent estimate.[19] The International Energy Agency (IEA) uses a much broader definition of behaviour change that refers to any change in the way individuals do things which includes all decisions regarding any purchases. Under this broader definition, behaviour can represent about 63% of the energy reduction needed to reach net zero by 2050. The remainder would come from low carbon technologies where consumers are not the purchasers.[20]

The new fields of study that has already begun to be tapped for its potential to change behaviour are behavioural psychology and economics. The development of this new field of research began with the work of psychologists Daniel Kahneman and Amos Tversky; their work together, which resulted in Kahneman's sharing of the Nobel Prize in Economic Sciences in 2002, is the subject of the best-selling book The Undoing Project by Michael Lewis.[21] This led economists such as Richard Thaler, co-author of Nudge[22] to conduct research to better understand why people and organizations behave the way they do and how they employ decision-making tools. This research did not assume (as traditional economists had done for 150 years) that perfect information is available or that even if it were available, appropriate calculations are used to make rational decisions. Case Study 9 in Section 2 contains a paper on psychological support for five strategies to encourage personal action to reduce greenhouse gas emissions that focusses on individual action.

There is a great deal that can be learned from previous campaigns to change public attitudes and behaviour. One of the most well-documented is the anti-spitting campaign in the early 1900s.[23] Others include curbside recycling programs, non-smokers' rights and designated drivers. A review of these initiatives[24] identified a number of key elements that helped to make them effective:

- **Charismatic leadership** – From organizations, individuals and politicians
- **Irrefutable evidence**
- **Clear, simple, compelling, consistent messaging and supportive media**
- **Focus on the issue**
  "Pick the target, freeze it, personalize it, and polarize it."
  – Saul Alinsky, *Rules For Radicals*[25]
- **Don't be afraid to start small**
  "Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has."
  – Margaret Mead[26]

Another example of a successful attempt to change behaviour was the campaign launched by advertising executive Claude Hopkins for the toothpaste brand Pepsodent. It resulted in the number of households with toothpaste increasing from 7% to 65% in just 10 years in the early 1900s. The history of this campaign and others that resulted in various behavioural changes are related in the book The Power of Habit: Why We Do What We Do in Life and Business by Charles Duhigg.[27]

One example of a comprehensive approach to changing behaviour on energy use was developed in the UK for its Ministry of Defense.[28] It consists of six steps:

- **Identify what are the energy issues**
- **Identify what are the behaviours associated with these issues**
- **Prioritize behaviours based on the likelihood of change vs the impact of change**
- **Decompose behaviours** – Who, what, when, how, with whom
- **Identify what needs to change** – Capacity, motivation, opportunity
- **Identify potential interventions** – Education, persuasion, coercion, incentivization, training, restrictions, environmental restructuring, modelling and enablement

SYSTEM OPERATIONS

The second type of energy efficiency is system operations.

- **System Operations** – Optimizing system operations makes better use of existing technology and thus does not require new technology and the additional upfront capital costs that are required for new technology. This is similar to conservation behaviour but done for a large building or campus, not an individual home.

Examples of optimized system operations include proper commissioning of new equipment as well as retro-commissioning of existing equipment. Another critical component is on-site training of the operations staff to ensure they know and understand the equipment and its controls and how to optimize their operation. This is particularly important as building systems become more complex.

An indication of its importance can be seen from assessments that have been undertaken comparing the energy consumption of similar buildings. Figure 4.1 summarizes the results from a study of Ontario schools that were built to about the same building code. Some of the schools were found to consume up to three times more energy as a school built during the same time period.[29] Most of this variation can be attributed to system operations. Systems Operations is also referred to as Strategic Energy Management (SEM). It has been estimated that such programs and practices could represent up to 19% of the emission reduction objective for the industrial sector.[30]

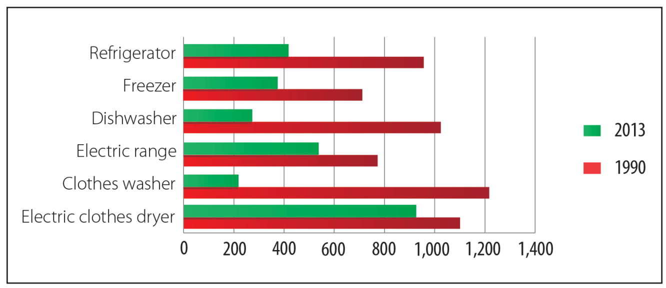
NEW TECHNOLOGY

This is the most commonly understood type of energy efficiency. In fact, as noted in Section 1, it is often referred to simply as energy efficiency.

- **New Technology** – Replacing older, less efficient products or systems with newer, more energy-efficient ones. Examples include replacing incandescent light bulbs with LEDs, EnergyStar appliances, Leadership in Energy and Environmental Design (LEED)-certified new buildings, etc.

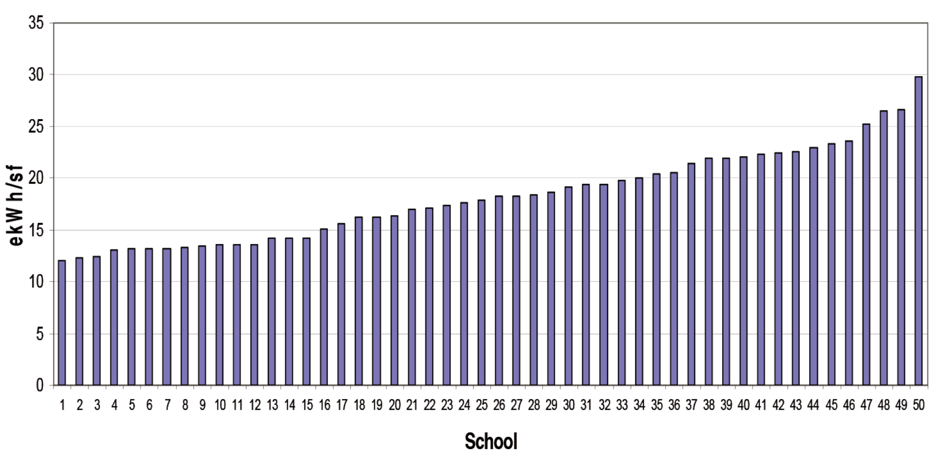
There are many successful examples of the wide-scale adoption of more energy-efficient products. Figure 4.2 illustrates the dramatic savings that have been achieved in the efficiency of six common appliances.

Figure 4.2
Energy-Efficiency Improvements in Six Household Appliances: 1990 - 2013



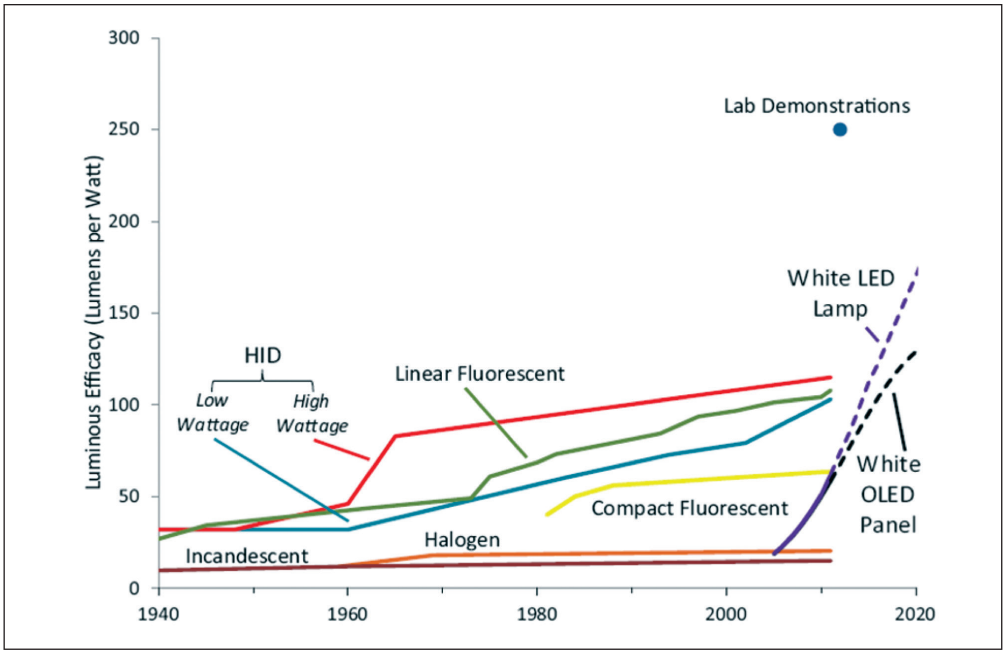
Source: NRCan[31]

Figure 4.1
Total Energy Consumption Intensity (Normalized for Toronto) 1971-2000



Source: Toronto Region Conservation Authority and EnerLife Consulting[29]

Figure 4.3
Trends in the Efficacy of Lighting Lamps



Source: Committee on Assessment of Solid-State Lighting[32]

Similar progress has been made with lighting. Figure 4.3 summarizes the dramatic advances that have been made in lighting technology.

Other important advances include variable speed drive motors, residential forced air furnaces (condensing units that operate at 92%+ efficiency now dominate the market) and cars (higher corporate average fuel economy or CAFE standards). These changes have come about through a combination of voluntary programs and mandatory minimum energy performance standards; these will be explored in future detail in Chapter 9.

There are a number of benefits to this type of energy efficiency. First, its potential impact is much easier to measure, as the relative efficiencies of the old and the new technologies are known. Second, the savings are reliable; once people have replaced their lighting, refrigerator or furnace, they are not likely to replace it again with a unit that is less energy efficient. For this reason, electricity system operators prefer new technology because they can count on it. And third, in most cases, it is visible; you can see and show off the new lighting, refrigerator and even furnace.

The drawback is that new technologies require an upfront payment that can be higher than the upfront cost of the less efficient, older technology. Although these higher upfront costs are paid back though the future energy savings, this requires consumers to believe that the savings will materialize. Many homeowners and businesses are reluctant to make an investment that does not pay back in two to three years, not realizing that this is equivalent to a 33-50% return on investment that they cannot get from anywhere else.

There are many types of programs that can be used to promote new technology such as direct install (contractors install the technology in the home or business), coupons (in store as well as online), rebates and tax incentives.

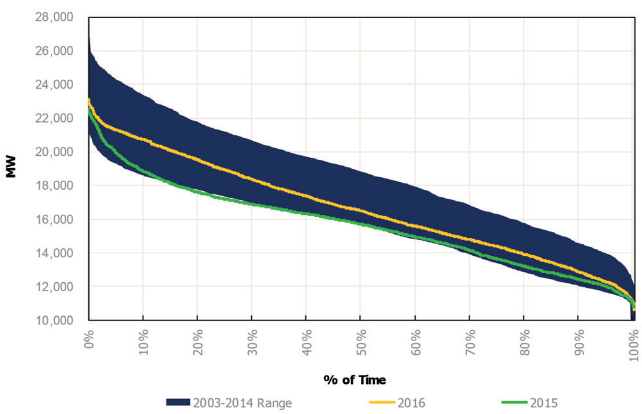
DEMAND RESPONSE

This is the least well understood of the four types of energy efficiency and is only applicable to electricity.

- **Demand Response** – changes in electricity usage by end-use customers from their normal consumption patterns in response to changes in price of electricity over time or to incentive payments.

One of the features of electricity is that the electricity system must be designed to be able to meet the peak demand at all times. As noted in Figure 4.4, this peak demand occurs for a relatively few hours per year.

Figure 4.4
Load Duration Curve for Ontario

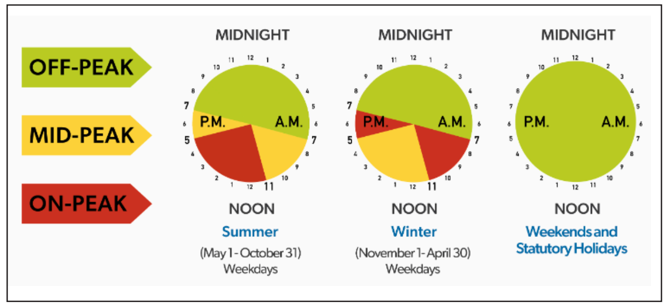


Source: “Ontario Demand Forecast: December 2016”. IESO, Toronto 2017[33]

The purpose of a demand response program is to encourage customers to switch from using electricity at peak times when the grid is at its maximum system capacity to using it at off-peak times. To be compensated for making this switch, consumers must have time-of-use electricity meters that record how much electricity is used at different times of the day, and there must be different electricity rates for these different times.

- **Time-of-Use Meters** – electricity meters that record how much electricity is used at each time interval.
- **Time-of-Use Rates** – electricity rates for different time periods, often changing for different seasons.

Figure 4.5
Ontario Time-of-Use Periods and Rates



Source: Ontario Energy Board[34]

To keep the system simple, there are typically three periods: peak, mid-peak and off-peak. Figure 4.5 illustrates the time-of-use rates in effect in Ontario for summer and winter, which are changed annually.

An alternative to fixed time-of-use rates is to use critical peak pricing in short periods when the electricity system is expected to be under extreme stress.

- **Critical Peak Pricing** – A higher price that is charged when the electricity system is expected to be under extreme stress. This is often communicated before the expected event to permit consumers to respond accordingly. This is sometimes also referred to as dynamic peak pricing.

The advantages of demand response include the following:

- Very cost-effective compared to gas peaker plants
- Can reduce future demand growth by up to 62%
- Contractual programs have very high reliability
- No footprint.

Demand response can also be used to enhance or retain industrial competitiveness. Under Ontario’s Industrial Conservation Initiative, it is estimated that qualified customers saved 1,200 MW and $200 million in 2016.[35]

CHAPTER 4
POWER QUIZ

Conservation behaviour is the first of the four types of energy efficiency. Although it is the simplest, fastest and least expensive, it is often the last to be considered.

Kahoot!

Test your understanding of the key concepts in Chapter 4.
Answer the Kahoot! questions online to see how you did.
Log in at www.kahoot.it, pass code 009542288.

1. DEFINITION OF "CONSERVATION BEHAVIOUR"

- **a.** Making it look like you are doing something good for the environment ☐
- **b.** Buying energy-efficient new products ☐
- **c.** Installing solar collectors ☐
- **d.** Changing the use of existing technology ☐

2. DEFINITION OF "CULTURE OF CONSERVATION"

- **a.** Saving energy has become automatic, second nature, ubiquitous ☐
- **b.** Saving energy means doing with less ☐
- **c.** Saving energy is expensive ☐
- **d.** We don't need to save energy ☐

3. CONSERVATION BEHAVIOUR IN HOUSEHOLDS CAN RESULT IN GHG SAVINGS OF 20%

- True ☐
- False ☐

4. EXAMPLES OF SYSTEM OPERATIONS

- **a.** Finding the simplest ways to operate a building, ignoring energy ☐
- **b.** Commissioning/recommissioning buildings ☐
- **c.** Buying expensive new heating systems ☐
- **d.** None of the above ☐

5. ENERGY USE BETWEEN BEST AND WORST ONTARIO SCHOOLS WAS ABOUT THE SAME

- True ☐
- False ☐

6. ADVANTAGE OF NEW TECHNOLOGY AS AN ENERGY EFFICIENCY INITIATIVE

- **a.** Does not require owner to do anything once it is installed ☐
- **b.** It is the least expensive form of energy efficiency ☐
- **c.** It looks good but does not work ☐
- **d.** It does not save much energy ☐

7. DEFINITION OF "DEMAND RESPONSE"

- **a.** Buying a more energy efficient appliance ☐
- **b.** Commissioning a new building ☐
- **c.** Reducing electricity use when it is expensive ☐
- **d.** Buying a solar collector ☐

8. CRITICAL PEAK PRICING IS CHARGING MORE FOR ELECTRICITY WHEN SYSTEM IS UNDER STRESS

- **a.** True ☐
- **b.** False ☐

CHAPTER 5

DRIVERS, BARRIERS AND POLICY OPTIONS

Chapter 1 included an overview of the benefits of energy efficiency (the 3Es – employment, economy and environment – with security as a fourth benefit for many countries outside North America) and its challenges (it is hard to see, hard to measure and requires all in). This chapter will go into more detail on these issues and will summarize the major types of policy responses.

One of the most comprehensive summaries of drivers and barriers to energy efficiency, as well as the policies used to address these barriers, was published by the IEA as part of its *Energy Efficiency Governance – Handbook*.[36] This chapter is largely based on this report with a few additional comments and ideas.

DRIVERS OF ENERGY EFFICIENCY

The IEA report identifies four main drivers for governments to pursue energy efficiency: energy security, economic development/competitiveness, climate change, and public health. Interestingly, energy security is indicated as the top driver; this is not surprising as most IEA members, unlike Canada, do not have large supplies of energy. The second and third drivers are closely related to the second and third Es: economy and environment. The fourth benefit, public health, is a combination of concerns around local air pollution from burning fossil fuels as well as a recognition that in many developing countries, biomass (in the form of wood, straw, animal waste, etc.) is burnt inside for cooking and heating where it can lead to poor indoor air quality. The driver that is not specifically included is employment, the first E mentioned in Chapter 1. It is, however, included in their second barrier, Economy/Economic Development and Competitiveness.

To better understand these drivers, the IEA report summarized four typical objectives associated with each driver; although not included in the IEA report, employment is added to this list as a fifth objective. These are used as the basis for the summary below:

- **Energy Security** – The major objectives are to reduce the amount of energy that needs to be imported, reduce domestic demand to maximize exports, increase the reliability of the energy systems and control energy demand growth. It is interesting to note that this objective is listed as the first by the IEA but, as discussed earlier in Chapter 1, this is not the number one concern in a resource-rich country such as Canada. As noted earlier, the Russian invasion of Ukraine in 2022 and their subsequent reductions in natural gas exports clearly illustrated the extreme importance of energy security.
- **Economy/Economic Development and Competitiveness** – The objectives are to reduce energy intensity, improve private sector competitiveness, use savings in the public sector to improve services offered, reduce production costs and provide more affordable costs of energy to consumers. As noted in Chapter 1, a Canadian study[10] estimated the potential economic benefits of a high energy-efficiency scenario could be as high as $595 billion increase in GDP.
- **Climate Change** – The objectives are to contribute to global mitigation efforts and meet international obligations under the United Nations Framework Convention on Climate Change.

- **Public Health** – The objectives are to reduce indoor and outdoor pollution. In terms of the public health benefits, the Ontario Medical Association had estimated in 2002 that fine particulate matter in Ontario's air contributed to approximately 1,900 premature deaths each year, and Health Canada researchers concluded that air pollutants were responsible for an average of 7.7% of premature deaths in large cities.[37] A further indication of the health benefits of this policy has been that, despite averaging 17 air quality advisories between 2006-2008 in Ontario, there were none in 2014 and only an average of one special air quality advisory for the next three years, which is after all the coal-fired electricity generating plants were closed.[38] As part of its decision to close these plants, the Ontario government committed to a series of aggressive conservation targets in 2005, including a peak demand reduction of 1,350 MW by 2007, which was achieved.[12]
- **Employment** – The major objectives are to increase local employment and increase the local, provincial and national tax base. As noted in Chapter 1, a Canadian study[10] estimated the potential employment benefits of a high energy-efficiency scenario (280,650 jobs would be added to the workforce over 13 years).

It is important to note that one of the objectives associated with energy security that is applicable even to energy-exporting countries is that it can help maximize exports. In Canada, B.C., Manitoba and Quebec have been recognized in the past as leaders in energy efficiency, despite very large hydroelectricity resources and resulting electricity prices that are the lowest in Canada.[39] Their energy-efficiency programs enabled them to export even more electricity to U.S. markets and were thus an important contributor to their respective provincial economies.

BARRIERS TO ENERGY EFFICIENCY

The IEA study[36] identifies five barriers to improving energy efficiency: market-based, financial, lack of information or awareness, regulatory and institutional, and technical. It is noteworthy that it considers market barriers first and technical barriers last. Although the report does not indicate that the barriers are listed in order of importance, this ordering is defensible. However, not included in this list are two barriers that were identified in Chapter 1 as challenges: that energy efficiency is hard to see and hard to measure. In the author's experience, particularly with politicians and the media, the relative invisibility of most energy-efficiency measures is the reason there is such an unbalanced focus on the supply side.

The following is an expanded list of barriers with examples:

- **Relative Invisibility** – Most energy-efficiency measures are hidden between walls, in the mechanical or electrical room, or in the compressor in the middle of an appliance where they cannot be seen. Supply-side options, such as solar collectors and wind turbines, are VERY visible (they offer politicians the all-important "photo op"); in fact, they are so visible that they can lead to local opposition. One of the few exceptions to this invisibility is lighting. Interestingly, lighting programs are often among the first to be launched in many jurisdictions.
- **Market** – The IEA study identifies three examples of market barriers: market organization or price distortions that prevent customers from appraising the true cost of energy efficiency; split incentive problems (also referred to as the Agency Problem, see below), which is created when building owners or landlords cannot capture the benefits of improved efficiency; and high transaction costs (costs to develop a project are high relative to the energy savings).

- **Financial** – Examples here are upfront costs with benefits realized over future years, the perception that energy-efficiency investments are complicated and risky with high transaction costs, and a lack of awareness of the financial benefits on the part of financial institutions.
- **Informational and Awareness** – The example here is a lack of sufficient information and understanding on the part of customers to make rational consumption and investment decisions. Note that, as was discussed in Chapter 4, behavioural economists believe that even if customers have sufficient information, even the most sophisticated may still not use it to make rational consumption or investment decisions.
- **Regulatory and Institutional** – Examples here are energy tariffs (e.g., prices decrease the more that is consumed) that discourage energy-efficiency investments, incentive structures that encourage energy distributors to sell energy rather than invest in cost-effective energy efficiency, and institutional biases towards supply-side investments (inertia).
- **Technical** – Examples include lack of affordable energy-efficiency technologies suitable to the local conditions and insufficient capacity to identify, develop, install and maintain energy-efficiency investments.
- **Hard to Measure** – Unlike supply-side measures that just require a meter to record their output, the savings from energy-efficiency measures are based on a change from what would have happened without them. As will be discussed in Chapter 10, such estimates can be made using standard, well-accepted protocols, but it is more difficult than supply measures and thus often viewed unfavourably by some.

One of the most common of the barriers noted above is the split incentive or Agency Problem.

- **Agency Problem** – A conflict of interest in a relationship where one party is expected to act in another's best interests. In energy efficiency, this refers to a landlord reluctant to improve the energy efficiency of a building where tenants pay for their own energy use and thus would reap the financial benefits of such investments. One way to overcome this barrier is through "Green Leases" whereby the tenant pays for their own energy use, not the landlord.

POLICY OPTIONS

Once again, the IEA study[36] provides the best summary of the policy options that are available to overcome the barriers summarized above. It identified seven policy areas and an eighth, House in Order, has been added based on the author's experience and insights. Although the IEA included it correctly as an example of a fiscal measure, it is sufficiently important to deserve a separate category.

- **Pricing Mechanisms** – These include time-of-use rates to encourage demand response (switching from on-peak to off-peak), minimizing fixed costs on energy bills (as these reduce the advantages of efficiency), and variable rates with higher consumption levels being charged higher per-unit prices.
- **Regulatory and Control Measures** – These include mandatory activities such as energy audits; energy management; minimum energy performance standards for appliances, products, and buildings; energy consumption reduction targets; and energy-efficiency investment obligations on private companies.
- **Fiscal Measures and Tax Incentives** – Examples here include grants, subsidies and tax incentives for energy-efficiency investments. As will be discussed in Chapter 6, there are a number of different ways funds for such programs can be raised that have very different policy implications.
- **Promotional and Market Transformation Mechanism**s – These include public information campaigns and promotions, inclusion of energy efficiency in school curricula, appliance labelling and building certification. A particularly interesting approach to market transformation is Community Based Social Marketing (CBSM) as developed by Canadian Doug McKenzie-Mohr and summarized in the following sidebar.

Community Based Social Marketing (CBSM)

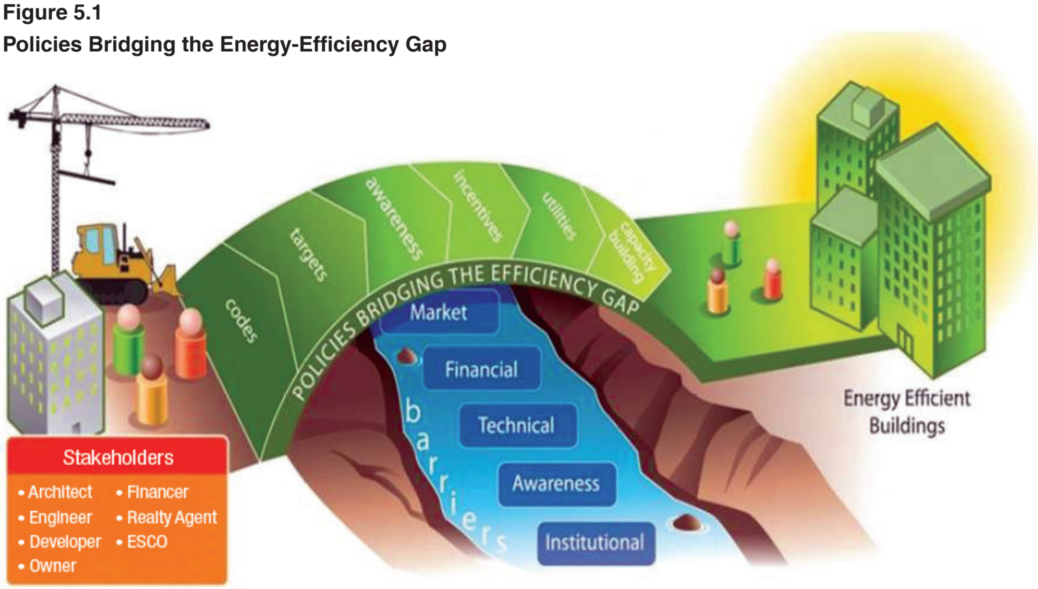
CBSM is based on the theory that "initiatives to affect behavior change are most effective when they are carried out at a community level, and involve direct contact with people".[40] Important tools used in CBSM methodology include:

- **Commitment** – Individuals are more likely to follow through with an action if they sign a pledge or make a public commitment to do so.
- **Prompts** – Visual reminders are placed in a location where the undesired action occurs and in close proximity of where the desired action should take place.
- **Norms** – If individuals observe members of their community acting a certain way, they are more likely to do the same.
- **Communication** – Messaging is targeted to the chosen audience; it is vivid, concrete, and personalized.
- **Incentives** – Use incentives to reward desirable behavior; delivering incentives at the location where the activity occurs increases the likelihood that employees will continue the desired behavior.

- **Technology Development** – This consists of funding for the development and demonstration of energy-efficient technologies.
- **Commercial Development and Capacity Building** – This includes encouraging the energy service company industry, training programs and development of the energy-efficiency industry.
- **Financial Remediation** – This includes revolving funds for energy-efficiency investments, project preparation facilities and contingent financing facilities.
- **House in Order** – This is where the government improves the energy efficiency of its own operations through direct procurement of energy-efficiency goods and services.

Figure 5.1 provides a great illustration of how these types of policies are bridging the energy-efficiency gap created by various barriers.

Figure 5.1
Policies Bridging the Energy-Efficiency Gap



Source: Nester[41]

CHAPTER 5

POWER QUIZ

The identified four main drivers for governments to pursue energy efficiency are energy security, economic development and competitiveness, climate change and public health.

Kahoot!

Test your understanding of the key concepts in Chapter 5.
Answer the Kahoot! questions online to see how you did.

Log in at www.kahoot.it, pass code 002583068.

1. WHICH OF THE FOLLOWING IS NOT A DRIVER OF ENERGY EFFICIENCY?

- **a.** Energy supply
- **b.** Energy security
- **c.** Economy/economic development/ competitiveness
- **d.** Climate change

2. WHAT IS THE FIRST BARRIER IN THE EXPANDED LIST OF BARRIERS?

- **a.** Not cost effective
- **b.** Poor performance
- **c.** Bad for the economy
- **d.** Relative invisibility

3. WHAT IS THE "AGENCY PROBLEM"?

- **a.** Too many regulatory agencies
- **b.** Not enough regulations
- **c.** One party expected to act in another's best interests
- **d.** None of the above

4. DEFINITION OF "COMMUNITY-BASED SOCIAL MARKETING"

- **a.** Initiatives most effective if carried out at community level
- **b.** New social marketing platform
- **c.** Digital community public notice board
- **d.** It does not save much energy

5. IN THE DIAGRAM WITH A RIVER AND BRIDGE, WHAT DOES THE BRIDGE SYMBOLIZE?

- **a.** Easiest way to get over the river
- **b.** Policies bridging the efficiency barriers
- **c.** Most modern way to cross the river
- **d.** None of the above

6. WHAT IS AN EXAMPLE OF AN EVENT THAT HAS HEIGHTENED CONCERNS REGARDING ENERGY SECURITY?

- **a.** Threats by China on Taiwan
- **b.** Unrest in Africa
- **c.** Russian invasion of Ukraine
- **d.** Challenges to democracy in the USA

CHAPTER 6

ECONOMICS OF ENERGY EFFICIENCY

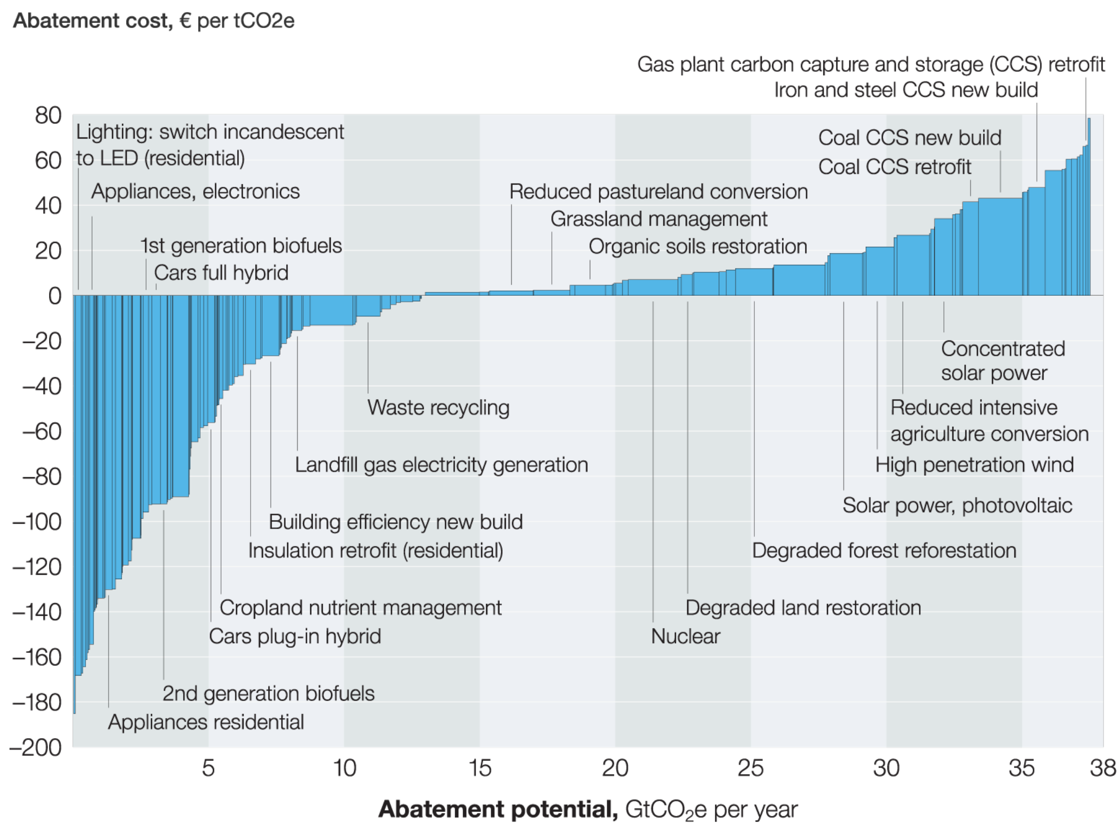
As noted in Chapter 1, one of the main benefits of energy efficiency is its cost-effectiveness. This chapter will explore this topic in greater detail, looking at both the relative cost-effectiveness of energy efficiency as well as the various calculations that are performed to quantify it.

GLOBAL CONTEXT

Before investigating the economics of particular energy-efficiency measures or programs, it is first useful to get a global perspective on the relative economics of energy efficiency. One of the most comprehensive global assessments of the economics of climate change was completed in 2006 by Sir Nicholas Stern for the United Kingdom government.[42] This report concluded that the global costs of a two- to three-degree Celsius increase in temperature could be around 0-3% in global world output. With a five- to six-degree Celsius warming, which the report considered a real possibility in the next century, loss in global GDP would be 5-10%, with poor countries suffering costs in excess of 10% of GDP. Stern's initial report estimated an upper bound for the expected annual cost of emission reductions of likely around 1% of GDP by 2050. In 2008, he doubled that estimate to 2% to account for faster-than-expected changes.[43] In his report, Stern notes that the technical potential for energy efficiency is substantial and refers to studies showing that energy efficiency has the potential to be the single biggest source of emission savings in the energy sector.

Another very strong indicator of the relative cost-effectiveness of energy efficiency is provided by McKinsey & Company in its various versions of the carbon cost abatement graphs developed for different countries. Figure 6.1 is its graph for the EU[44] showing the costs, in Euro/tCO_2e of carbon, of over 50 measures. The most interesting feature of this graph is that almost all the measures with a negative carbon price are energy-efficiency measures, and most of those with a positive carbon price relate to supply or storage options. Equally interesting is the fact that the area with a negative carbon cost exceeds the size of the area with a positive carbon cost, which means that all the measures would be undertaken at a cumulative negative life-cycle cost.

Figure 6.1
Carbon Abatement Cost Curve for the European Union



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

McKinsey&Company | Source: McKinsey Global GHG Abatement Cost Curve v2.1

Source: McKinsey & Company[44]

END-USER COST-EFFECTIVENESS TESTS

Individuals, institutions and private companies are continually making decisions on whether to make a wide range of purchases or investments. Among these are decisions on whether to purchase an energy-efficient model of a particular product, undertake an energy-efficiency retrofit of an existing building or require that a new building be built to be more energy efficient than required by the minimum standards in a building code.

The most common method used by both individuals and even many organizations to help make these decisions is the simple payback period.

- **Simple Payback Period** – Length of time required to recover the cost of an investment.

As an example, if an LED light saves $2/year in energy costs and it costs $2 more than a conventional incandescent bulb, the simple payback period is one year.

Figure 6.2 provides an estimate of the simple payback periods for a number of different energy conservation measures for a commercial or institutional building.

Figure 6.2
Typical Payback Periods of Energy Conservation Measures in Commercial/Institutional Buildings

Controls	Payback (yrs.)
Controls retrofits and controls strategies	3 - 4
Demand controlled ventilation	2 - 5
Mechanical	
Variable flow primary's secondary systems with controls, VFDs	2 - 4
HVAC	
Constant speed air handlers to variable air volume	2 - 4
VAV boxes, control setpoints, box flow minimums	5+
Boiler conversions from steam to hot water	5 - 8
High efficiency fully condensing boilers	6 - 8
High efficiency VFD chiller system	8 - 12
Lighting	
Install controls to schedule and interior systems	2 - 4
Convert incandescent to CFL	1 - 3
Replace exit signs with LED lights	<2
Convert T12 to high efficiency T8s with electronic ballasts	2 - 5

Source: Energy Information Administration and U.S. Department of Energy Buildings Energy Data Book[45]

A slightly more sophisticated version of this approach is the discounted payback period. This measure takes into account the time value of money, which recognizes the increased benefit of saving money now rather than in the future. This is done by discounting the future savings by a discount rate.

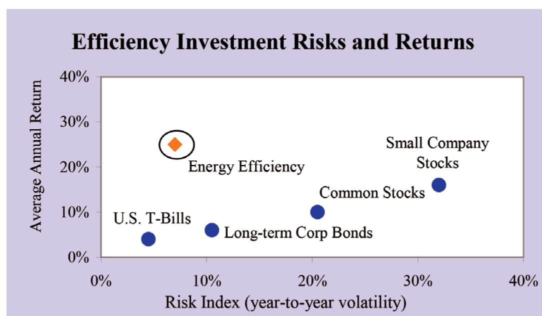
- **Discounted Payback Period** – Length of time required to recover the cost of an investment with future savings discounted by a discount factor.

Another common approach is to base the decision on the return on investment.

- **Return on Investment** – Annual savings from an investment divided by the initial investment.

Figure 6.3 compares the estimated annual rate of return on energy-efficiency investments with other common types of investments with their relative risk. Energy-efficiency retrofits have a higher rate of return than any of the other investments but with a very low level of risk.

Figure 6.3
Relative Return and Risk of Energy-Efficiency Investments



Source: American Council for an Energy-Efficient Economy[46]

Two other measures of cost-effectiveness that are used by more sophisticated organizations are net present value (NPV) and the related internal rate of return (IRR).

- **Net Present Value** – Sum of the discounted cash flows minus the original investment.
- **Internal Rate of Return** – Rate of return at which the NPV equals zero.

Tools to calculate NPV and IRR are readily available online.

COST-EFFECTIVENESS TESTS USED BY ENERGY REGULATORS

One of the first states where the energy regulator required energy utilities to undertake energy-efficiency programs was California. In 1983, the California Public Utilities Commission published the California Standard Practice Manual,[47] which defined four (later expanded to five) cost-effectiveness tests to determine when it is preferable for ratepayer money to flow to demand-side management (DSM) instead of power generation. As noted by energy expert Philippe Dunsky, the initial intent was to use multiple tests to inform decisions by reflecting different perspectives. Unfortunately, recent practice often uses a single test (Total Resource Cost) to make decisions and often does this incompletely, typically leaving out some benefits.[48]

The three most commonly used tests are the Total Resource Cost (TRC) Test, the Societal Cost Test (SCT) and the Program Administrator Cost (PAC) Test.

- **Total Resource Cost Test** – Measures the direct costs and benefits of a DSM program for both participants and the utility. It is most often expressed as a ratio of benefits divided by costs but can also be expressed as an NPV.
- **Societal Cost Test** – Measures the direct as well as indirect costs and benefits of a DSM program for participants, the utility as well as society (e.g., includes value of environmental savings).
- **Program Administrator Cost Test** – Measures only the costs and benefits of a DSM program to the utility.

In practice, while all the costs are typically included in each of these measures, most tests do not include all the benefits to utilities and often exclude the benefits to participants and society. In a detailed study of Vermont's energy-efficiency programs, it was concluded that the reported TRC was only 60% of the actual TRC and that the SCT was double the reported TRC.[48]

A detailed study of the use of the TRC in Ontario[49] identified five limitations and made recommendations on how they could be overcome. The limitations and related recommendations are:

- **Excludes avoided environmental costs and risks** – recommended a 15% adder be applied. This would mean that projects with a TRC ratio of 0.87 would pass the TRC test because the adder would bring the result above 1.0.
- **Excludes social benefits** – recommended an adder be applied but did not recommend a specific level.
- **Discourages new programs** – recommended waiving a TRC requirement for new programs costing less than 0.5% of revenues.
- **Hard for education and information programs to pass** – recommended development of a new assessment tool for these types of programs.
- **Does not encourage deep savings or market transformation** – recommended changing the structure of estimating avoided costs.

One of the first jurisdictions to makes changes to its calculation of TRC to overcome these limitations was British Columbia, which introduced a 15% adder onto all DSM programs, a 30% adder for low-income programs and provisions to assess TRC on a portfolio level, thus allowing education and information programs that do not pass the TRC test individually to be included, as long as the TRC for the portfolio passes.[50] Two years later, Ontario modified its TRC to include a 15% adder.

INCENTIVES USED BY REGULATORS TO ENCOURAGE UTILITIES TO SELL LESS ENERGY

One of the challenges faced by governments and energy regulators is how to encourage energy utilities to develop and manage effective energy-efficiency programs that will result in them selling less energy to their customers.

One of the main tools used to achieve this is to require that the utilities spend a certain amount on energy-efficiency programs and to report on their results. While this will ensure funds are spent, it does not ensure that programs will be successful or effective. To overcome this barrier, some regulators allow energy utilities to apply for two types of additional funding Lost Revenue Adjustment Mechanism (LRAM) and a Shared Savings Mechanism (SSM).

- **Lost Revenue Adjustment Mechanism** – This is a payment that is approved by the energy regulator to the energy utility to compensate for any revenue that is lost due to the success of energy-efficiency programs. It is typically included in the rates that the regulator allows the energy utility to charge its customers.
- **Shared Savings Mechanism** – This is an incentive payment that is approved by the energy regulator to the energy utility as a reward for exceeding the targets that were established for its programs. Like LRAM, it is typically included in the rates that the regulator allows the energy utility to charge its customers.

Although these mechanisms have proven to be effective, one limitation is that it is difficult for smaller utilities to justify the costs to prepare and defend applications to the regulator for relatively small amounts of money they might receive from these mechanisms.

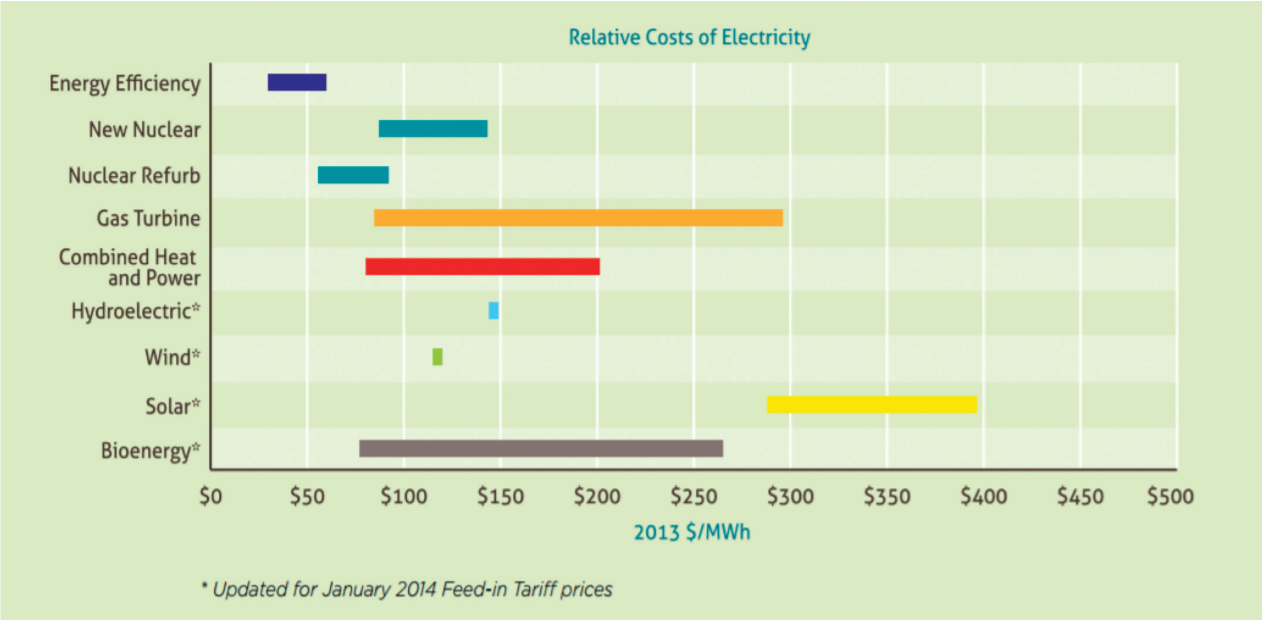
EVALUATING COST-EFFECTIVENESS OF ENERGY EFFICIENCY IN SYSTEMS PLANNING

Although the role of energy efficiency in long-term system planning studies is discussed in Chapter 8, it is important to note the different ways that can be used to evaluate the cost-effectiveness of energy efficiency in long-term system plans, sometimes referred to as Integrated Power System Plans.

Electricity systems are composed of a range of generation assets, typically referred to as a fleet. Some of these assets are older and the initial capital costs have been fully recovered, while others are newer and more expensive as their initial capital costs have not been fully recovered. Electricity consumers typically pay a blended average price for the resulting electricity, which includes both the less expensive as well as the most expensive units. The cost-effectiveness of a small amount of additional energy efficiency can be compared to the current average cost or the operating cost of the most expensive current generator. But the cost-effectiveness of a relatively large amount of additional energy efficiency should be compared to the cost of the next generator as well as the cost of additional transmission and distribution assets that would need to be added to the system. These are referred to as marginal costs.

- **Marginal Cost** – The cost of adding one more unit of new capacity. For small additions, the marginal cost is the same as the average cost, as no new investments in generation, transmission or distribution are required. For larger additions, it may be much more due to the costs associated with adding new generation, transmission and distribution assets.

Figure 6.4
Generation and Conservation Cost of Options



Source: Ontario Ministry of Energy[51]

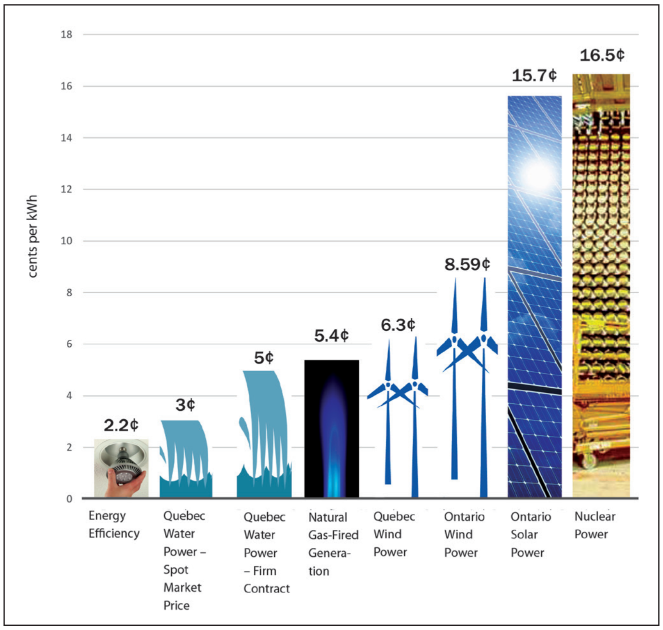
A commonly used measurement to compare different supply and demand-side options in a system plan is to use the Levelized Unit Energy Cost (LUEC).

- **Levelized Unit Energy Cost** – This is the average cost to produce or save a unit of energy over the life of the asset. In electricity, it is expressed in terms of cents/kWh or $/MWh.

Figure 6.4 summarizes estimates of LUECs for electricity in Ontario made by the government; it clearly shows energy efficiency being far more cost effective than any of the supply options

It is interesting to note that while the relatively low cost of energy efficiency is common to cost comparisons such as this, there is a very wide disagreement on the relative costs of the other supply options, particularly nuclear rebuild and new. As an example, Figure 6.5 is a summary of comparative costs according to the non-profit Ontario Clean Air Alliance.[52]

Figure 6.5
Cost Comparison of Ontario's Electricity Options



Source: Ontario Clean Air Alliance[52]

ALTERNATIVE METHODS OF FUNDING ENERGY-EFFICIENCY PROJECTS

As noted in Chapter 4, purchasing more energy-efficient alternatives or undertaking major energy-efficiency retrofits of buildings requires upfront funding. Even if this gets repaid by future savings, this money must come from somewhere. The following is a summary of the most common forms of financing entire projects.

- **Internal Funds** – This is using the individual's or organization's own existing funds. This includes both small purchases as well as larger ones that have been approved in an annual budget.
- **Bank Loans** – When individuals or organizations do not have sufficient internal funds for the purchase, they can negotiate a loan from their bank for the purchase.
- **Product/Service Financing** – In this case, the product/service provider accepts payment over a specified period of time under agreed-upon financing terms.
- **On-Bill Financing** – This is similar to the product/service financing but is provided by the energy utility, often with the support and encouragement of government and/or the energy regulator.
- **Guaranteed Energy Service Performance Contracts** – These types of contracts have been used for larger ($1 million to $50 million) building retrofits for more than 30 years. Under a guaranteed Energy Service Performance Contract (ESPC), an energy service company (ESCo) undertakes the upgrade and guarantees that the resulting energy savings will cover the costs for the upgrade. This transfers the technical and financial risk associated with such projects to the ESCo. Most of the projects using an ESPC are in institutional buildings (municipal and other levels of government buildings, universities/colleges, schools and hospitals – so called MUSH sector). Over the last 10 years, eight universities and colleges across Canada have undertaken such projects and a few more are underway.[53] More detail regarding ESPC contracts are contained in the Case Study 6 in Section 2 of this textbook.
- **Property Assessed Clean Energy (PACE) Loans** – This is the newest form of project financing and is based on the successful Local Improvement Charge used by business improvement areas to fund communal assets (hanging planters, festive lights, etc.). In this case, the municipality provides the financing for an energy-efficiency upgrade and payments are added onto the property bill over the period of the contract. One of the biggest benefits to this loan is that responsibility for paying for an energy-efficiency upgrade is passed on to new owners if the property is sold before the loan has been paid off in full. This overcomes the reluctance to invest in an energy-efficiency upgrade if the payback period is longer then the owner expects to own the property. Further information on this financing vehicle is available in Case Study 6 in Section 2 of this textbook as well as from a report from the David Suzuki Foundation[54] and from the U.S.-based PACENation.

In addition to funding entire projects, there are four major ways that incentive funding can be made available by governments, government agencies or energy utilities to partially reduce the initial additional cost of an energy-efficiency product or building. It should be noted that these different methods are not mutually exclusive, and it is likely that the most optimal form of funding would include the last three together as they each provide distinct benefits.

- **General Government Revenues** – Under this system, funding is provided out of general government revenues and can take the form of sales tax (e.g., PST/ HST) rebates, income-tax reductions or funding for any type of incentive program. As noted in a report on the restricting of the electricity industry in Ontario, programs that relied on this form of funding were subject to wide fluctuations in funding that were often terminated when governments faced budget deficits.[54]

- **Ratepayer-Funded Programs** – This is very different from general government revenue as funds are raised from ratepayers, not taxpayers. History has shown that once energy regulators approve the ability to deduct funds from ratepayer bills for such programs, they are much more stable than those from general government revenue. The majority of energy-efficiency incentive programs in North America are funded by ratepayer-based programs. They are sometimes referred to as System Benefit Funds that are used for System Benefit Programs. The programs they fund result in reduced requirements for electricity or natural gas and thus provide overall system benefits.
- **Carbon Pricing Programs** – This is the newest form of funding for incentive programs. There are basically two types of carbon pricing programs: carbon tax or cap and trade. Under the first, the price of carbon is set, and the market determines the resulting quantity of carbon that is reduced. Under the second, the quantity of carbon is set and the market determines the resulting price. Under both, revenues raised can be used either to reduce other taxes (thus making the programs revenue neutral) or to provide funds for various incentive programs. In Canada, B.C. has had a revenue-neutral carbon tax since 2008 and Quebec has a cap-and-trade system that includes California. Ontario and Alberta had carbon taxes, but these were removed by subsequent governments. Since 2019, the federal government has required that every province and territory in Canada is required to put a minimum price on carbon. This can either be their own system or the federal system. The minimum price in 2022 is $50/tonne and will increase by $15/tonne annually to $170/tonne by 2030. The federal plan was challenged by some provinces, but the Supreme Court of Canada ruled it was within federal powers.
- **Capacity Market** – Some electricity markets in Canada have or are investigating the introduction of capacity markets to handle the system peak loads for a limited number of hours per year. Energy-efficiency resources have been permitted to bid into these markets in two U.S. jurisdictions. In New England's wholesale electricity market, energy efficiency contributed about 4% of the total capacity, double what is was contributing five years ago.[55]

CHAPTER 6

POWER QUIZ

This chapter looked at both the relative cost-effectiveness of energy efficiency as well as the various calculations that are performed to quantify it.

Kahoot!

Test your understanding of the key concepts in Chapter 6.
Answer the Kahoot! questions online to see how you did.

Log in at www.kahoot.it, pass code 007986398.

1. WHAT DOES THE MCKINSEY GHG ABATEMENT CURVE SHOW?

- **a.** That demand side initiative are more cost effective than supply side ones
- **b.** That supply side initiatives are more cost effective than demand side ones
- **c.** That demand & supply side initiatives are the same in cost effectiveness
- **d.** That there is more potential savings from supply side initiatives

2. WHAT IS "SIMPLE PAYBACK PERIOD"?

- **a.** Time it takes to get even with someone
- **b.** Length of time required to recover cost of an investment
- **c.** Money saved by making an energy efficiency investment
- **d.** None of the above

3. DEFINITION OF "RETURN ON INVESTMENT"

- **a.** Annual savings divided by initial investment
- **b.** Initial investment divided by annual savings
- **c.** Tax owing on your income tax return
- **d.** None of the above

4. WHAT IS THE TRC TEST?

- **a.** Timed return cost test
- **b.** Total reduction cost test
- **c.** Total resource cost test
- **d.** None of the above

5. MODIFIED TRC MAKES IT MORE DIFFICULT FOR ENERGY EFFICIENCY MEASURES TO BE APPROVED

- **a.** True
- **b.** False

6. WHAT IS "LUEC"?

- **a.** Local utility energy cost
- **b.** Levelized unit energy cost
- **c.** Limited unfunded energy cost
- **d.** None of the above

7. WHAT IS THE MOST UNSTABLE FORM OF FINANCING ENERGY EFFICIENCY PROGRAMS?

- **a.** General government revenue
- **b.** Rate-payer funded programs
- **c.** Carbon pricing programs
- **d.** Capacity markets

8. WHAT ARE THE TWO TYPES OF CARBON PRICING PROGRAMS?

- **a.** Efficiency regulations and capacity markets
- **b.** Carbon tax and cap-and-trade
- **c.** Rate-payer funded programs and regulations
- **d.** None of the above

CHAPTER 7
ENERGY-EFFICIENCY MEASURES

The focus of this textbook is on the policies and programs that are used to promote the broader adoption of energy-efficient behaviour and technologies, not on the particular technologies. There are many excellent reference and textbooks that cover these technical details, including Energy and the New Reality 1: Efficiency and the Demand for Energy Services by Professor Danny Harvey from the University of Toronto.[56]

The EnerGuide for Houses model discussed in Chapter 3 of this text includes a report that recommends particular energy-efficiency measures for the home that is modeled. The RETScreen model also discussed in Chapter 3 includes a large number of technologies that can be accessed through pull-down menus.

Many jurisdictions with regulated energy-efficiency programs provide approved "Measures and Assumptions" lists that provide performance numbers for individual technologies that can be used to calculate savings when these technologies are used. An example is the "Measures and Assumptions" provided by the Independent Electricity System Operator (IESO) in Ontario.[57]

Rather than getting into the details of individual energy-efficient products, it is more useful for the purposes of this textbook to look at broad energy-efficiency measures. One of the most useful summaries of both these types of measures as well as their potential impact on energy use was undertaken by Professor Danny Harvey of the University of Toronto.[58]

Figure 7.1 summarizes the potential savings from 11 measures for buildings, measured as a percentage savings or factor by which off-site energy can be reduced. For each measure, the potential savings are estimated for on-site carbon-free supply, device efficiency (what we have referred to as new technology), system efficiency and behavioural change (the first type of energy efficiency discussed in Chapters 1 and 4). The 35 references supporting this table are available from the original paper, which concludes that energy intensity in new buildings can be reduced by a factor of two to three and that this could be achieved by 2020-2025. For existing buildings, it concludes that retrofits can reduce the average energy use of the entire stock by a factor of two to three by 2055.

Figure 7.2 is a similar summary of energy savings, measured in energy use per passenger km, for the four main modes of transportation: light-duty vehicles (LDVs), bus, rail and air. It assesses both technical measures as well as behavioural/system measures. Harvey's paper concludes that fuel efficiency for LDVs could double or triple by 2025-2035 and be largely phased into the fleet by 2040-2050. It estimated that a further 50-66% of fuel demand could be shifted to electricity by 2055, and a 50% reduction in the energy intensity of buses and of passenger rail and a 40% reduction for passenger air could be achieved by 2025 for new equipment and by 2045 for the entire stock.

Figure 7.1
Potential Off-Site Energy Savings for Buildings Relative to 2010

End Use	On-site C-Free Energy Supply[1]	Device Efficiency	System Efficiency	Behavioral Change
Heating	20-95% solar space heating[2]	Up to 30%[3] Up to factor of 5[4]	Up to factor of 10[5]	10-30% typical[6] 1/3 in Denmark[7]
Hot water	50-100% solar water heaters[8]	Up to 35%[9] Up to factor of 4[10]	Up to 40%[11]	Up to 50%[12]
Cooling	50-80% solar air conditioning and dehumidification[13]	Up to factor of 2[14] Up to factor of 4[15]	Up to factor of 3[16]	Factor of 2-3[17]
Cooking	0-30% solar cooking[18]	25-75%[19] Up to factor of 7-10[20]	Factor of 2[21]	Up to 50%[22]
Lighting	10-30% active solar tracking[23]	Up to factor of 4[24] Up to factor of 6-10[25] Up to factor of 600[26]	Factor of 5-15[27]	Up to 70%[28] Up to factor of 5[29]
Refrigerators		40%[10]		Up to 30%[30] Factor of 2[31]
Dishwashers		≥17%[10]		Up to factor of 4[32]
Clothes washers		~ 30% by 2030[10]		60-85%[33]
Clothes dryers		≥50%[10]		10-15%[34] Up to 100%[35]
Office computers & monitors		40%[10]		
General electrical loads	10-120%[36]			

Source: Harvey[58]

Figure 7.2
Potential Energy Savings by Transportation Mode

Mode	Technical measures – savings per passenger-km of travel	Behavioural and System Measures
LDVs	65% savings with advanced HEVs in urban driving, 60% in rural 2/3 further reduction in on-board energy use for each km shifted to grid electricity	Factor of two difference in total annual km travelled per person, Houston vs San Francisco Factor of six difference in percentage of trips by car, Houston vs Hong Kong 35% reduction, pickup truck vs midsize car 20% reduction, non-aggressive vs aggressive driving behaviour 10% reduction through car pooling
Bus	50% savings urban buses, 30% inter-city	
Rail	50% savings in diesel trains, 75% savings in shift from diesel to electric	
Air	40% reduction by 2050 relative to 2010	

Source: Harvey[58]

Figure 7.3 summarizes the potential savings, in energy savings per tonne km, for the four freight modes: truck, rail, ship and all. It concludes that a reduction of 60-75% is possible in energy intensity.

For the energy-savings potential in industry, Harvey summarized savings in the production of steel, aluminum, copper, zinc, cement, glass, paper, plastics and fertilizer. He concluded that savings factors, when recycling is possible, were 12 for steel, 10 for aluminum, two for copper, five for zinc and two for plastics (in at least some cases).[58] He also concluded that paper mills using virgin wood should become energy self-sufficient or even net energy exporters by using wastes.

Figure 7.3
Potential Energy Savings in Freight Energy

Mode	Technical measures and reduce ship speed – savings per passenger-km of travel	System-scale effects
Truck	45-50% reduction through engine improvements 60% reduction with additional aerodynamic changes	Tendency for truck modal share to increase Tendency for increasing proportion of more energy-intensive ships
Rail	60% reduction from all measures except electrification 75% reduction with electrification too	
Ship	60% reduction for all shipping modes except container ships 75% reduction for container ships	
All	Another 10% or so savings if H_2 is used in fuel cells	

Source: Harvey[58]

CHAPTER 7

POWER QUIZ

Rather than getting into the details of individual energy-efficient products, it is more useful for the purposes of this textbook to look at broad energy-efficiency measures.

Test your understanding of the key concepts in Chapter 7.
Answer the Kahoot! questions online to see how you did.

Log in at www.kahoot.it, pass code 006477035.

1. HOW MUCH COULD EXISTING TECHNOLOGIES REDUCE THE ENERGY INTENSITY OF NEW BUILDINGS BY 2025?

- **a.** Factor of 1
- **b.** Factor of 2
- **c.** Factor of 2 or 3
- **d.** Factor of 4

2. HOW MUCH COULD EXISTING TECHNOLOGIES SAVE FOR EXISTING BUILDINGS BY 2055?

- **a.** 50%
- **b.** 100%
- **c.** Factor of 2 or 3
- **d.** Nothing

3. PAPER MILLS USING VIRGIN WOOD COULD BECOME NET ENERGY EXPORTERS

- **a.** True
- **b.** False

4. POTENTIAL FOR FUEL EFFICIENCY OF LIGHT-DUTY VEHICLES (LDV)

- **a.** 50% increase
- **b.** 200-300% increase
- **c.** No increase
- **d.** None of the above

CHAPTER 8

ENERGY EFFICIENCY IN SYSTEM PLANS AND COMMUNITY ENERGY PLANS

One of the important features of energy, particularly electricity, is the very long lead times that are required to bring new resources into service. For electricity, this can include more than 10 years from initial assessment to final commissioning of a nuclear facility and more than five years for a large transmission line. Many jurisdictions, therefore, develop long-term energy plans to ensure that there are sufficient resources available to meet long-term energy requirements. This can take the form of a provincial or local plan. The role of energy efficiency in each is discussed in this chapter.

One of the first and by far the most well-known evaluations of the potential for conservation in such long-term plans was undertaken by Amory Lovins in 1977.[59] Since that time, there have been many other plans, with some limited to a strict focus on supply options but most including some assessment of the potential for energy efficiency.

ENERGY EFFICIENCY IN SYSTEM PLANS

Almost every jurisdiction has undertaken some form of energy planning, with many jurisdictions undertaking more than one. Rather than presenting different forms in theory, the following summarizes how they were used in one jurisdiction, Ontario, which has used a variety of different ways to undertake this assessment. These, as well as other aspects of energy efficiency policies in Ontario, are summarized in Case Study 4 in Section 2 of this textbook.

Over the last 60 years in Ontario, there have been three periods (late 70s, late 80s and early 2000s) where concerns regarding past growth trends and costs for electricity led to the decision to undertake major long-term energy plans. Interestingly, the last two plans were discontinued when electricity consumption began to level off and then decline.

The following summarizes the five long-term planning activities in Ontario and the role for energy efficiency in each:

- **Porter Commission 1975-1978** – Concerns over the cost of nuclear power, inflation and recessions that reduced the demand for electricity led the Ontario government to create the Porter Commission in 1975. Its 1978 report recommended a focus on demand management, not just new electricity supply.
- **Demand/Supply Plan** – In 1989, Ontario Hydro published its first Demand/Supply Plan (DSP), which proposed building several additional nuclear and coal-fired plants; it also identified a role for energy efficiency. The company published a revised DSP in 1992 that began to reflect a levelling-off of electricity consumption. Although the highlight of the plan was a call for an extensive expansion of nuclear generation capacity in the province, it also included a large commitment to conservation and demand management, which was based on studies that were undertaken on the potential for conservation. A budget of $3 billion for expanded conservation programs was included in this plan. In 1993, Ontario Hydro voluntarily withdrew the plan due to an oversupply of electricity from the new Darlington nuclear plant as well as dramatically reduced consumption, particularly by industry. It also closed its entire conservation department, which had been successful in reducing provincial demand for electricity by 1,200 MW.

- **Electricity Conservation and Supply Task Force** – Faced with increasing electricity consumption again, as well as concerns over the future of electricity supply following the August 2003 blackout in eastern North America, the government formed the Electricity Conservation and Supply Task Force (ECSTF). In its 2004 report, it concluded changes were required to Ontario's market approach and that a long-term plan for generation and conservation was required. In this report, the task force specifically noted that "Ontario needs to create a conservation culture that delivers cumulative and sustainable improvements in energy use and demand response. Ontario's long-term energy plan for electricity should include a comprehensive conservation strategy, reflecting a full analysis of the costs and benefits of conservation".[60]
- **Integrated Power System Plan** – Following the release of the ECSTF report, the newly elected government created the Ontario Power Authority (OPA) in 2005, with a mandate to produce an Integrated Power System Plan (IPSP), to contract for new supplies of electricity and to provide leadership in conservation. In preparing this plan, studies and consultations were undertaken on the potential for conservation to reduce consumption. These findings were summarized in an Appendix to the final plan. Shortly after hearings on the review of the plan began at the Ontario Energy Board (OEB) in 2008, the Minister of Energy directed that the plan be revised, and the OEB hearings were postponed. No subsequent hearings were organized. As in 1993, one of the reasons that the OPA was asked to revise the plan was that its assumptions regarding growth in electricity consumption did not materialize.
- **Long-Term Energy Plan** – Instead of requiring the IESO, which merged with the OPA in 2015, to produce another IPSP, the Ontario government issued its own Long-Term Energy Plan (LTEP). The first version of this plan was released in 2010. It was primarily a high-level electricity policy plan with limited details or analysis on conservation, but it did include conservation targets. An updated plan was released in 2013. Again, it was a very high-level policy document with a focus on electricity and few details, but it did note that conservation would be the first resource to be considered for electricity planning and it set new conservation targets. At the same time as this plan was released, the government also released "Conservation First: A Renewed Vision for Energy Conservation in Ontario," which again focused on electricity and clarified the expanded role for local distribution companies in delivering conservation and energy-efficiency programs.[61] In 2017, the government released its third LTEP. While this plan did include a larger discussion of energy sources other than electricity, its discussion on conservation was in the fifth of eight chapters. Unlike previous plans, it did not include scenarios on how electricity would be generated in the future and contained no long-term conservation targets.[62] While there have been no updates to the 2017 plan by the current government, IESO and the OEB did undertake an updated conservation potential study in 2019.[63]

Because the production, generation, transmission, distribution and use of energy has such a large environmental impact, all the energy plans in Ontario, as well as those in most other jurisdictions, include some assessment of the relative environmental sustainability of such plans. A comprehensive assessment of how the sustainability of such long-term energy plans should be evaluated was undertaken by Professors Robert Gibson, Mark Winfield and others, using the OPA's 2007 IPSP as a case study.[64] It identified eight core requirements for progress towards sustainability, one of which was resource maintenance and efficiency, which included reducing energy use per unit of benefit.

COMMUNITY ENERGY PLANS

The development of regional, local or community energy plans is a more recent concept. Like provincial, state or national governments, local governments also seek ways to manage the challenges associated with energy use, such as reliability, security, costs, emissions, pollutants and other social and environmental impacts. And as communities account for almost 60% of Canada's GHG emissions now, and estimates indicate this might increase to as much as 75% in the future,[53] managing energy at the community level is critical. Across Canada, more than 180 communities representing more than 30% of the population have developed Community Energy Plans (CEPs), with B.C. having the largest portion at 74%.[65]

One of the best guides on developing these plans was created by the Canadian Urban Institute for Quality Urban Energy Systems of Tomorrow (QUEST) with support from the Ontario government and the IESO.[66] Its primer was designed to assist municipalities to understand how they can work within the current regulatory framework to plan their communities' energy future. This primer notes that funding for the development of these plans was available from two sources nationally: the Federation of Canadian Municipalities' (FCM) Green Municipal Fund and Canada's Gas Tax Fund. The FCM funds are currently available through its Municipalities for Climate Innovation Program fund.

The QUEST primer starts with a list of things to consider before beginning: identification of general outcomes and deliverables (goals and vision), time frame, scope, identification of stakeholders, available funding, other resources, work team, project leadership within the municipality and framing the narrative. It then provides suggestions about engagement: preparing an introductory report to council, establishing an advisory group and holding roundtable energy workshops. QUEST has built on this primer with a new set of resources as part of its Getting to Implementation initiative.

The next step in this process is to gather baseline energy data. Figure 8.1 is a graphic illustration of the amount of money that London, Ontario, spends on energy. It is particularly noteworthy that only 18% of this revenue stays in the community.

This energy data can then be used to develop an energy map that can clearly identify spatial trends in the data and specific opportunities for different initiatives.

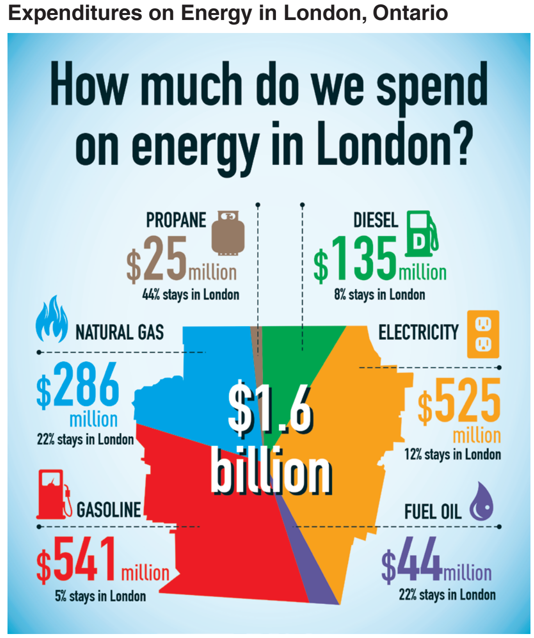
The QUEST primer then presents the following six technical principles for developing integrated CEPs:

1. **Improve Energy Efficiency** – First, reduce the energy input required for a given level of services.
2. **Optimize Energy** – Avoid using high-quality energy in low-quality applications (as discussed in Chapter 2 of this textbook).
3. **Manage Heat** – Capture all feasible thermal energy and use it, rather than exhaust it.
4. **Reduce Waste** – Use all available resources, such as landfill gas and municipal, agricultural, industrial and forestry wastes.
5. **Use Renewable Energy Resources** – Tap into local opportunities.
6. **Use Energy Delivery Dystems Strategically** – Use these systems to encourage reliability and for energy storage.

It is particularly interesting to note that the first three of these six principles relate to energy efficiency.

The primer also includes a list of six policy principles. It concludes with advice on how to integrate municipal priorities into a broader energy planning framework.

Figure 8.1
Expenditures on Energy in London, Ontario



Source: City of London[67]

CHAPTER 8
POWER QUIZ

One of the important features of energy, particularly electricity, is the very long lead times that are required to bring new resources into service. This can include more than 10 years from initial assessment to final commissioning of a nuclear facility and more than five years for a large transmission line.

Kahoot!

Test your understanding of the key concepts in Chapter 8.
Answer the Kahoot! questions online to see how you did.

Log in at www.kahoot.it, pass code 001323013.

1. AUTHOR OF ONE OF THE FIRST COMPREHENSIVE EVALUATIONS OF POTENTIAL FOR ENERGY EFFICIENCY

- **a.** David Suzuki
- **b.** Al Gore
- **c.** Amory Lovins
- **d.** Nicholas Stern

2. LONG-TERM ENERGY PLANS SHOULD ONLY LOOK AT FUTURE ELECTRICITY REQUIREMENTS

- **a.** True
- **b.** False

3. BEST REFERENCE ON HOW TO WRITE A COMMUNITY ENERGY PLAN

- **a.** Your provincial government
- **b.** QUEST (Quality Urban Energy Systems of Tomorrow)
- **c.** Your electric utility
- **d.** Your provincial energy regulator

4. HOW MANY OF THE 6 QUEST PRINCIPALS RELATE TO ENERGY EFFICIENCY?

- **a.** 3
- **b.** 2
- **c.** None
- **d.** All

5. PERCENTAGE SPENT ON ENERGY IN LONDON THAT STAYS IN THE COMMUNITY?

- **a.** 25%
- **b.** 18%
- **c.** 50%
- **d.** 62%

CHAPTER 9

POLICY AND PROGRAM DEVELOPMENT

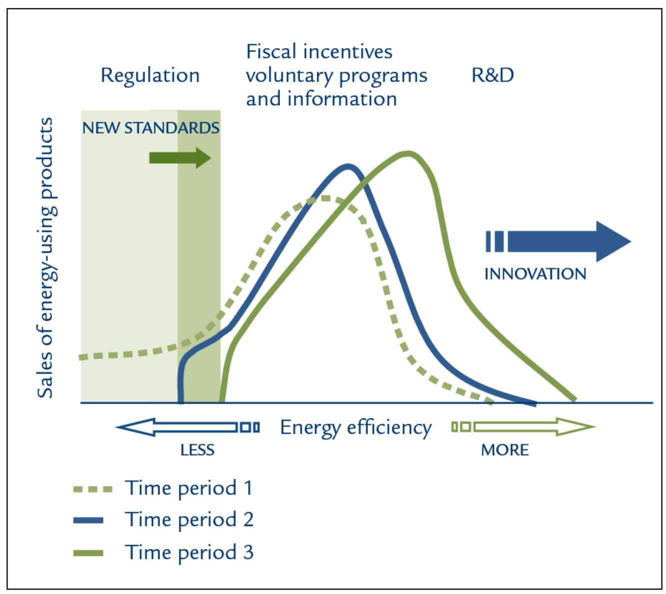
This chapter will focus on how policies and programs can be developed that will lead to the realization of the multiple benefits associated with energy efficiency.

The first and most important point here is that all such policies and programs should focus on market transformation and moving to a culture of conservation, not just promote the one-time purchase of a particular energy-efficiency product or technology.

- **Market Transformation** – The strategic process of intervening in a market to create lasting change in market behaviour or exploiting opportunities to accelerate the adoption of all cost-effective energy efficiency as a matter of standard practice.

There are two distinct but closely related types of policies to promote energy efficiency: mandatory mechanisms (codes and standards, pricing regulations and labelling) and voluntary (that encourage but don't require participation). Although these two approaches are often undertaken by different groups within the same government department, they are complementary and closely related. This is illustrated in Figure 9.1, which charts sales of a typical energy-efficient product over time. In time period 1, there are no mandatory minimum standards, so some very inefficient products are allowed to be sold and result in higher overall energy use. But there are fiscal incentives, voluntary programs and information activities that increase the demand for the more energy-efficient versions of this product. In time period 2, a new mandatory minimum energy performance standard (MEPS) is introduced that eliminates the sales of the more inefficient versions. This was feasible because more energy-efficient products had become widely available and popular as well as less expensive due to the demand created by the voluntary programs. In time period 3, this trend continues as the MEPS are further increased, and research, development and demonstration have resulted in innovative new products being introduced into the market.

Figure 9.1
Role of Mandatory Regulations, Voluntary Programs, and Research and Development in Transforming the Market



Source: NRCan[68]

An excellent example of this type of market transformation is residential natural gas furnaces. The following case study was prepared by NRCan.[69]

Governments have successfully transformed markets in the past; A case study of residential natural gas furnaces in Canada

Today's furnaces are much more efficient than their predecessors due to a combination of innovation and measures to broadly deploy them into over 5 million Canadian households that heat with natural gas. Furnaces now available on the Canadian marketplace are among the most efficient in the world.

In the wake of the energy crises of the 1970s, Canadians actively sought new technologies to reduce their rapidly growing energy bills. At the same time there were also safety concerns with the standard atmospherically vented furnaces of the day, which could leak poisonous gases back into the home or lead to costly furnace and chimney corrosion. By the mid-1990s, condensing furnaces emerged as a feasible solution. By recovering heat from exhaust gases, the new technology provided a significant increase in efficiency, up to 12% higher than the conventional furnaces on the market at the time.

Starting in 1999, Natural Resources Canada worked with industry to identify barriers and activities to advance the market for residential condensing gas furnaces with energy performance levels of 90% or higher. A market transformation strategy was implemented that included measures for research and development, demonstration projects to prove the potential for energy savings, incentive programs and labelling.

Innovations at the Natural Resources Canada's CanmetENERGY labs helped to overcome early technical challenges such as the selection of appropriate materials and manufacturing techniques to ensure the safe operation of condensing furnaces. Natural Resources Canada also worked with Canadian manufacturers to achieve efficiencies over 90% and assisted with the development of energy performance test procedures. Federal, provincial and utility programs provided incentives for the installation of over 300,000 condensing gas furnaces between 2007 and 2012 (for example, through the ecoENERGY Retrofit – Homes program). As the technology became more familiar to homeowners, the home construction industry and trade associations continually improved installer training so that a qualified workforce would be available in the future to respond to expanding consumer demand. Training was supported by ongoing research and building code changes to ensure high energy efficiency levels, safe operation and long-term durability.

As a result of these measures, the market share of condensing gas furnaces increased from 40% to 80% between 1998 and 2008, and the price decreased by 30%, paving the way for regulated minimum energy performance standards. Following the lead of Ontario and British Columbia, Natural Resources Canada implemented federal standards in 2010, eliminating from the market the least efficient products and enabling even greater uptake. Since federal standards were introduced, market transformation continued through programs like ENERGY STAR®, so that today over 85% of residential gas furnaces for sale in Canada are at least 95% efficient.

Minimum energy performance standards for condensing natural gas furnaces will save Canadian homeowners $124 million on their heating bills in 2020.

Source: NRCan[69]

MANDATORY REGULATIONS

As noted above, there are three main types of mandatory regulations. The first relates to having MEPS for energy-consuming products as well as for different types of buildings. California was the first jurisdiction to require MEPS in 1973 and remains a leader in North America. In Canada, the federal government (covering products entering Canada) as well as five provinces (Nova Scotia, New Brunswick, Quebec, Ontario and British Columbia) have legislation that covers energy efficiency and pass regulations to increase the MEPS of existing products or add MEPS for new product categories. In Ontario, more than 50 product categories that consume 80% of the electricity used in the residential sector and 50% in the commercial/institutional sector are covered. Figure 4.2 in Chapter 4 of this text illustrates the dramatic improvements that have been made in the energy efficiency of six major household appliances; these were largely due to increasing MEPS. The IEA recently found that some leading jurisdictions has resulted in savings of more than 80% over the lifetime of the programs for electronics and room air conditioners.[70]

The federal government also develops and updates its model building codes for houses (smaller, low-rise buildings) and for buildings (mid- and high-rise buildings). Nine of the 10 provinces (P.E.I. being the only exception) have provincial building codes and most include the minimum energy-efficiency requirements found in the model national codes.

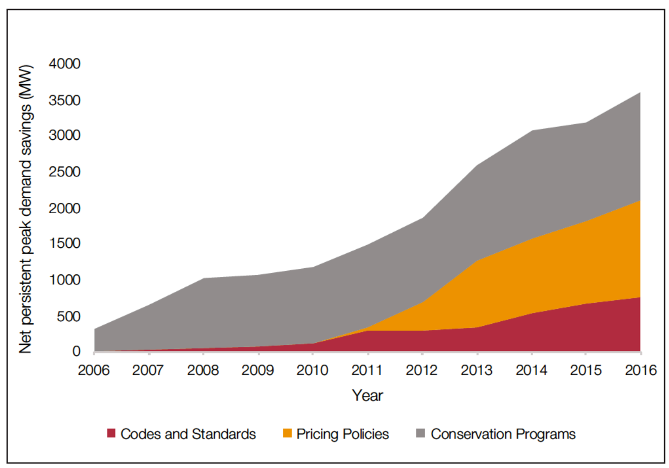
The second form of mandatory regulation relates to energy pricing. For many years, this has mainly consisted of subsidies to encourage the development of fossil-fuel resources. More recently, it has included requirements that regulated electricity and natural gas distribution utilities collect funds from their ratepayers and use those to fund various approved energy-efficiency programs. This type of funding was discussed in the previous chapter. While participation in these programs is voluntary, the payments into them are not. These charges are often referred to as System Benefits Charges.

Another, more recent, method of regulation relating to energy pricing is putting a mandatory price on carbon. This was also discussed in the previous chapter.

The third form of mandatory regulation involves requiring some form of energy consumption information to be provided to consumers before they purchase a product. The most common example of this is the EnerGuide label for most residential appliances, which informs consumers how much energy a certain product uses compared to other similar products. Another example that has been common in Europe is mandatory labelling of commercial buildings. A third example here is the requirement in Ontario that all public buildings must report their annual energy consumption and GHG emissions.

Experience has demonstrated that the combined impact of mandatory standards, pricing and voluntary programs can be large. Figure 9.2 below shows that their combined impact in Ontario was estimated to be about 3,500 MW or 14% of the maximum energy demand.

Figure 9.2
Electricity Savings from Conservation: 2006-2016



Source: Environmental Commissioner of Ontario[71]

POLICY DEVELOPMENT

Energy and, more particularly, energy-efficiency policy development can be considered as taking one of two main forms: ongoing updates/minor improvements and fundamental shifts. The first usually involves some form of ongoing consultation and analysis and is not unlike how governments handle most other issues. The second occurs much less frequently. This is because to be effective, any one government is only capable of taking on a limited number of new initiatives at the same time. The number of new initiatives is also limited by the understanding that the government will be forced to deal with other issues that it is not expecting.

One of the most insightful assessments of how policy is developed was advanced by John Kingdon.[72] He identified and described the following three processes that were used to set a government's agenda:

- **Problems** – These problems can come from a dramatic change in a set of key indicators, a particularly traumatic focusing event or feedback from one or more particularly important stakeholders. He further distinguishes problems from conditions, with problems being something that the government believes they can take effective action, whereas conditions are something that they must just accept.
- **Politics** – This can come from swings in the national mood, a new government in power or a new distribution of power. Kingdon further notes that politics can be influenced by both visible and invisible participants who can affect both the agenda itself and the alternatives that are considered.
- **Policy** – This is the end result and often requires a long softening-up process.

Kingdon believes that "policy windows" can open up for major new initiatives when all three of these streams are joined. He further notes that sometimes there is an "open window" of opportunity created by events in either the political or policy stream. This is the time for advocates to push their particular solution on which they have been working for a number of years. He thus identifies an important role for policy entrepreneurs in investing their time and resources in developing policy solutions so that they are ready with these solutions when the policy window opens.

VOLUNTARY PROGRAMS

There are four major types of voluntary programs to encourage energy efficiency. Before summarizing them, it is very important that an integrated approach to the design of such programs be taken and not to rely on one to the exclusion of others. This is particularly true for financial incentives as on their own, they may not end up leading to full market transformation.

- **Education and Information** – This can include programs to increase general awareness of the environmental impact of energy use and to encourage movement towards a culture of conservation, as well as programs with more specific messages. It can also include support for voluntary leadership programs such as ENERGY STAR certification for the most energy-efficient products or LEED for energy-efficient commercial buildings. Activities and products can include publications, advertisements, exhibits, social media, toll-free info lines, conferences, websites, workshops, training, software and other promotional products.
- **Financial Incentives** – These can take the form of direct install programs (products are installed at no cost, usually for low-income or hard-to-reach customers such as small or medium-sized businesses), coupons, instant rebate and mail-in rebate programs for product discounts (similar to those offered by many companies for a broad range of energy-using and other types of products) and tax refunds.

  Research by Loren Lutzenhiser and others have concluded that incentive programs are improved if they focus on human choice and behaviour.[73] They should be based on detailed research of the social context as well as the particular markets into which they are introduced. A useful concept here is to use polling to develop insights into particular market segments and to characterize typical consumers within each segment.
- **Support for Other Financing Mechanisms** – A recent example of this is the growing support for Property Assessed Clean Energy loans. These programs were discussed in the previous chapter.
- **Leadership** – It is also critical that governments set an example for the rest of society on how to reduce their energy consumption and thus the environmental footprint from their own operations. This includes improving the energy efficiency of their own buildings and fleets as well as being among the first to purchase new, innovative technology, particularly when it is developed by Canadians and Canadian companies.

One interesting approach to ensure that programs are designed to truly transform the market was developed by Natural Resources Canada and Navigant Consulting.[74] This research concluded that permanent energy-efficiency improvements can only be achieved if the following five conditions are met:

- **Awareness** – Are consumers aware that the product is available?
- **Available** – Is the product readily available?
- **Accessibility** – Is the product readily accessible?
- **Affordable** – Is the product affordable?
- **Acceptance** – Is the product quality acceptable?

PROGRAM DEVELOPMENT, IMPLEMENTATION AND EVALUATION

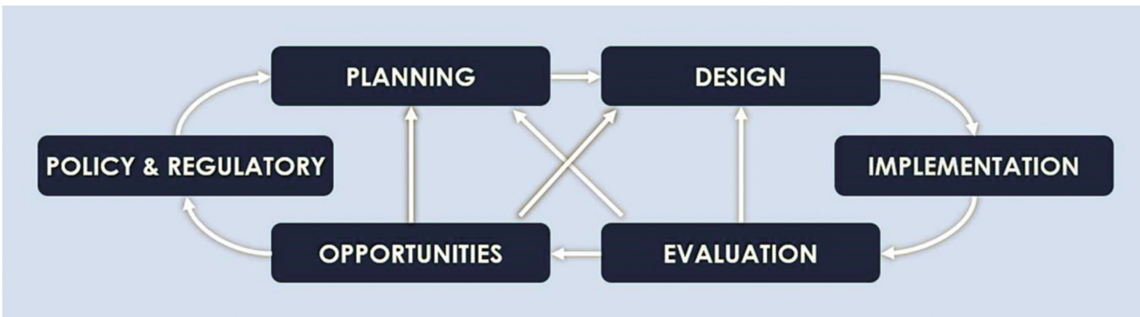
One of the leading companies in Canada in the design and evaluation of energy-efficiency programs is Dunsky Energy Consulting.[75] It has identified the following six key elements in the program development cycle:

- **Opportunities** – In an ideal world, the cycle would start with a comprehensive study of the potential for energy efficiency in the particular jurisdiction by each segment for different technologies. In the real world, the cycle can and has been started at almost every stage except evaluation. This recommended study would build on existing information currently available as well as primary research to fill in the gaps. It would also include development of a technical resource manual with required background information for program designers and implementers as well as an opportunities assessment. Such studies typically involve a complex model with many variables. A recent trend is for this type of assessment to be outsourced to a firm that has done these studies before in other jurisdictions; the firm then provides the client with the model and ideally with training on how to update it in the future as better and/or more up-to-date information becomes available.
- **Policy and Regulation** – In this stage, multi-year energy-efficiency targets are set, the scope of future activities is established and sources of funding for programs are identified. The necessary regulatory framework is developed, and other guidance is provided as needed. Complementary regulations regarding MEPS and building codes are also introduced or tightened.
- **Planning** – In this stage, a portfolio of programs that are targeted for particular sectors are identified, budgets are set, savings are estimated and an evaluation plan is developed. It is preferable to develop the evaluation plan at this stage to ensure that the information that will be required to undertake the evaluation is collected during program implementation.
- **Design** – In this stage, each program is clearly defined, based on research of similar programs in other jurisdictions as well as further market research. The program strategy is refined and logic models are developed. And finally, success metrics are developed.
- **Implementation** – This starts with deciding on whether the program will be implemented with in-house staff or using outside contractors. Programs are then launched with their associated marketing campaigns, and protocols regarding oversight are developed and implemented. A key final element is continuous improvement; it is important to continually identify issues and challenges and to respond with program improvements even before the full program evaluation.
- **Evaluation** – This includes undertaking a baseline study, followed by a process evaluation to identify opportunities to improve the program, and then an impact evaluation to confirm the savings as well as the cost-effectiveness of the program. Many leading jurisdictions allocate up to 5% of the program funds for evaluation. Many also use independent third parties to undertake these assessments, which should ideally be done for each program every second or third year. Chapter 10 of this text discusses program evaluations in more detail.

Figure 9.3 illustrates how these six elements are interrelated with multiple feedback loops. As noted, it would be ideal to start with an evaluation of opportunities, but time often does not permit this in the real world. Regardless of where the process starts, the order and interrelationships in the cycle should be maintained to the extent possible.

As noted at the end of Chapter 8, there are four main ways to fund these voluntary programs: general government revenue, ratepayers through their utility bills, as part of a carbon pricing system (tax/levy or cap and trade) and by the electricity capacity market.

Figure 9.3
The Program Development Cycle



Source: Dunsky[75]

CHAPTER 9

POWER QUIZ

Policies and programs should focus on market transformation and moving to a culture of conservation, not just promote the one-time purchase of a particular energy-efficiency product or technology.

Kahoot!

Test your understanding of the key concepts in Chapter 9.
Answer the Kahoot! questions online to see how you did.

Log in at www.kahoot.it, pass code 007972375.

1. DEFINITION OF "MARKET TRANSFORMATION"

- **a.** Increasing the sales of a product over a short period of time ☐
- **b.** Substituting one product for another ☐
- **c.** Intervening in a market to create lasting change ☐
- **d.** Intervening in a market to make a temporary change ☐

2. DEFINITION OF "MEPS"

- **a.** Minimum Energy Performance Standards ☐
- **b.** Maximum Energy Performance Standards ☐
- **c.** Minimum Electricity Price Standards ☐
- **d.** Minimum Energy Persistence Standards ☐

3. LIFETIME ENERGY SAVINGS OF MEPS FOR ELECTRONICS AND ROOM AIR CONDITIONERS

- **a.** 25% ☐
- **b.** 80% ☐
- **c.** 50% ☐
- **d.** 40% ☐

4. MANDATORY REGULATION AND VOLUNTARY MEPS ARE COMPLIMENTARY

- **a.** True ☐
- **b.** False ☐

5. WHEN DOES A POLICY WINDOW OPEN UP FOR A PARTICULAR ISSUE?

- **a.** When the price of energy is high ☐
- **b.** When problems, politics & policy are joined together ☐
- **c.** When ever a new government comes to power ☐
- **d.** Happens all the time ☐

6. WHICH IS NOT ONE OF THE A'S OF MARKET TRANSFORMATION?

- **a.** Awareness ☐
- **b.** Acceptance ☐
- **c.** Approval ☐
- **d.** Availability ☐

7. WHICH OF THE FOLLOWING IS NOT PART OF THE PROGRAM DEVELOPMENT CYCLE?

- **a.** Policy & regulation ☐
- **b.** Design ☐
- **c.** Evaluation ☐
- **d.** Popularity ☐

CHAPTER 10

EVALUATION OF POLICIES AND PROGRAMS

It is critical that energy-efficiency policies and programs continue to improve. This is only possible if thorough, honest and independent evaluations are undertaken and the results from these assessments are used to further improve the initial policies and programs. It should be recognized from the outset that this is difficult to do, and the tendency for any organization with policies or programs that could be improved is to bury or ignore suggestions for improvements to avoid embarrassment or criticism.

POLICY EVALUATION

One approach to evaluating different jurisdictions that has become more common is to use evaluation criteria and to rank the different jurisdictions, coming up with a final score for each one. While acknowledging that such a process is not perfect and may miss many important aspects, the criteria themselves are a useful summary of the most important features of moving towards a more energy-efficient economy.

One of the first attempts to evaluate the overall effectiveness of the energy-efficiency policies by different jurisdictions was undertaken by the Canadian Energy Efficiency Alliance in 1999[75] using a set of nine parameters. These reports were issued every two years until 2011. In 2006, the Pembina Institute identified five key elements of a successful energy-efficiency strategy.[77] In the same year, the American Council for an Energy Efficient Economy (ACEEE) issued its first report card on state energy-efficiency policies. Most recently, this report included four categories and 35 individual policy metrics.[78] The ACEEE has recently been producing an international scorecard that uses five categories and 35 individual metrics, 62% related to policy and 38% for performance.[79]

The 2022 evaluation ranked France first, UK second, Germany and Netherlands tied for third, China ninth, U.S. tenth and Canada thirteenth among the 23 countries assessed. The report also provides summaries for each country and includes specific recommendations on how each could improve its score.

Efficiency Canada has recently begun to assess provincial leadership in energy efficiency. Figure 10.1 summarized the criteria used and Figure 10.2 the results from the 2021 report card.[80]

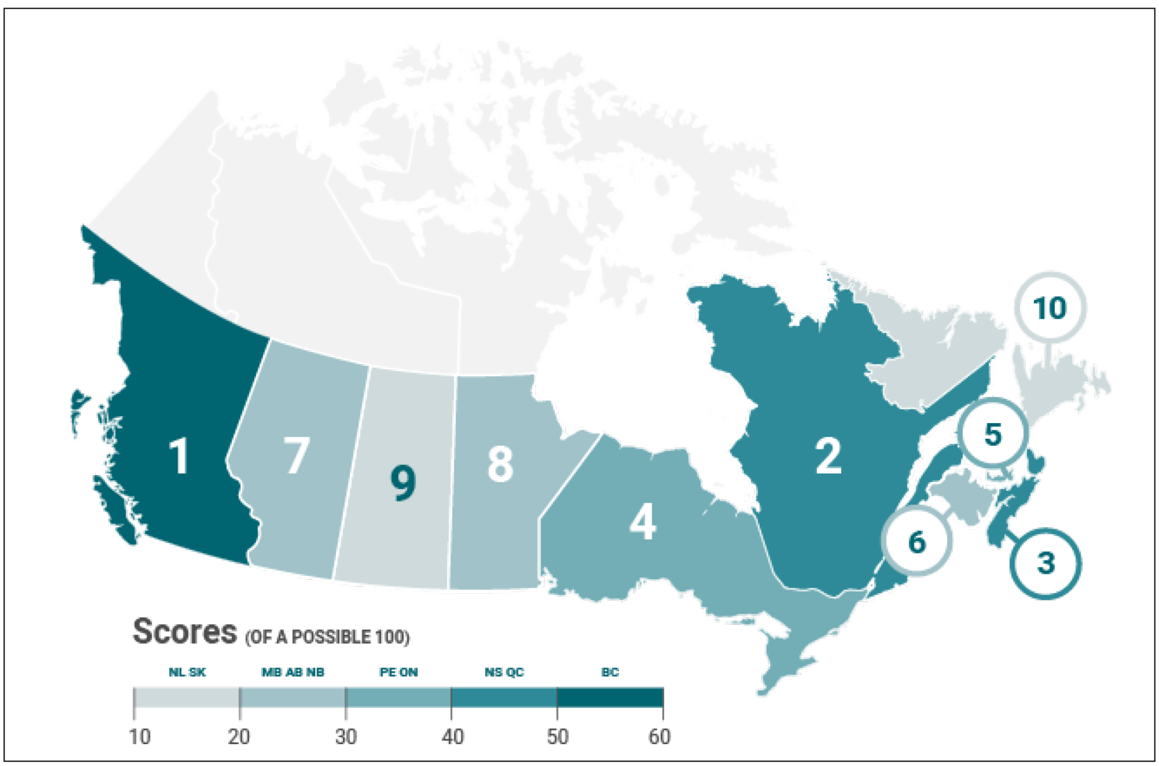
Figure 10.1
Policy Areas, Topics and Metrics Weighting

Metric	Points
Energy efficiency programs	
Program savings	18
Program spending	10
Equity and inclusion	4
Energy efficiency targets	6
	38
Enabling policies	
Financing and market creation	4
Research, development and demonstration and program innovation	3
Energy management capacity	3
Training and professionalization	3
Grid modernization	4
	17

Metric	Points
Buildings	
Building codes	11.5
Performance, rating and disclosure	4
Energy advisors	2
	17.5
Transportation	
Zero-emission vehicles	8.5
Transport electrification infrastructure	7
Active transportation	2
Public transport	3
	20.5
Industry	
Support for energy management	4
Energy management systems/ Strategic energy management	3
	7
Total	**100**

Source: Gaede[80]

Figure 10.2
Results from the 2021 Report Card



PROGRAM EVALUATION

As noted in the last chapter, program evaluation is the last of five steps in the program development cycle. It is a particularly important activity because, unlike supply-side options, measuring the impact of energy-efficiency programs is more difficult than just putting a meter on a source of energy generation.

The first work in this area was undertaken by investor-owned utilities in California in 1990. This was followed by the development of detailed energy-efficiency protocols by the California Public Utilities Commission in the late 1990s, which have been updated a few times since then. In 1997, the Efficiency Valuation Organization was established and developed the International Performance Measurement and Verification Protocol. The Canadian Institute for Energy Training provides training and certification for the Certified Measurement and Verification Professional (www.cietcanada.com). In 2007, the Ontario Power Authority developed a comprehensive evaluation, measurement and verification protocol in Canada, which has subsequently been updated by the Independent Electricity System Operator.[81] The remainder of this chapter draws extensively from this work.

There are three main components of program evaluation: evaluation, measurement and verification, referred to as EM&V. Other than being a requirement in most jurisdictions, there are four main reasons EM&V is undertaken:

- **Ratepayer Value** – Ensures that ratepayer funds being invested in energy-efficiency programs are providing a net positive value.
- **Performance** – Determines and explains the performance of a particular program.
- **Recommendations** – Makes recommendations to improve each program.
- **Verify savings** – Verifies that energy savings were achieved by a program and can thus be relied upon for planning purposes.

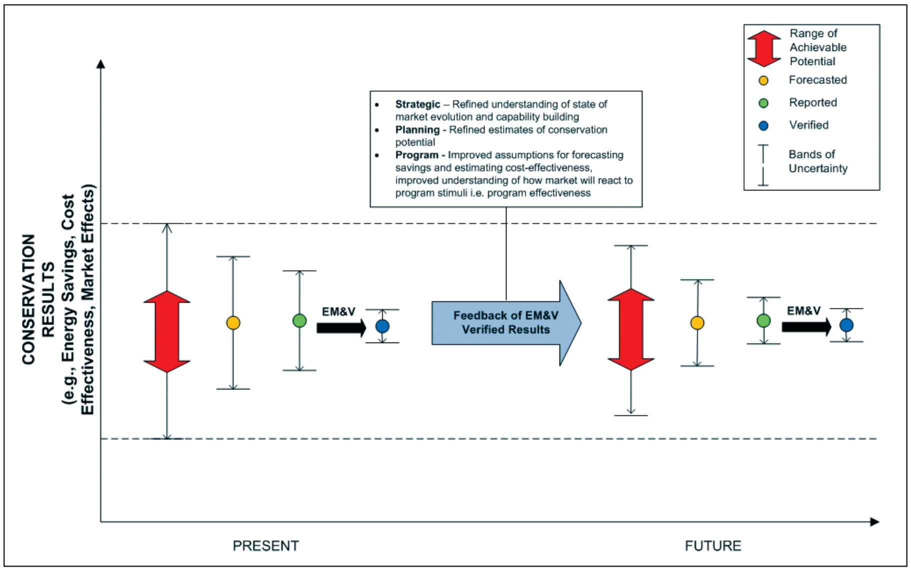
To ensure credibility of the results, it is often recommended that EM&V be undertaken by an independent third party, with each program being reviewed on a regular (but not necessarily annual) basis. At the very least, the department responsible for program delivery should never be responsible for assessing its own performance. Regardless of who undertakes the assessments, it is critical that they be shared publicly and that opportunities for improvement are acknowledged and recommendations followed. In both public and private sector organizations, this is very difficult, as there will always be a desire not to draw attention to such opportunities.

There are five different types of program evaluations:

- **Outcome Evaluation** – These are undertaken to verify the actual (referred to as ex post) cognitive and behavioural changes produced by a program.
- **Impact Evaluation** – This evaluates the energy savings directly attributable to a specific program using both qualitative and quantitative research. These assessments can then be used to develop new or improved assumptions (referred to as ex ante savings estimates) for the program in the future.
- **Process Evaluation** – This is an assessment of program operations to identify and recommend specific improvements to improve program efficiency or effectiveness while maintaining high levels of participant satisfaction.
- **Market Effects Evaluation** – This assesses changes in both short- and long-term structural elements of the marketplace as well as the individual cognitive processes and behaviours. These are often done using market characterization studies.
- **Cost-Effectiveness Evaluations** – The four types of cost-effectiveness tests (TRC, SCT, PAC and LUEC) were discussed in Chapter 6.

These five types of evaluations are often combined and undertaken at one time to achieve cost efficiencies and improve quality.

Figure 10.3
Cycle of Evaluation



Source: IESO[82]

The goal of EM&V is to determine the NET savings of a particular program with a high degree (90%) of certainty. Figure 10.3 summarizes the evaluation cycle. It starts out with a very rough estimate of the forecasted savings before the program is launched, which have a high degree of uncertainty. Once the program has been launched and results are reported, the estimated or gross savings have a lower uncertainty band but still higher than optimal. After EM&V has verified the savings, the uncertainty band is at a lower, more acceptable level. In future programs, the outer ranges of each of these estimates is narrower based as experience with the program is gained.

There are seven concepts associated with EM&V that are part of determining the NET energy savings of a particular program or measure:

- **Energy Conservation Measure (ECM)** – This is any activity or set of activities designed to increase the energy efficiency of a product or system, such as a building. It can include a change in behaviour, technology or operational improvement.
- **Persistence** – This is the duration, in years, that an ECM will continue to generate energy savings. It takes into account business turnover, early retirement of installed equipment, upgrades to codes and standards, and other reasons ECMs might be removed or discontinued over time. Persistence is best if it is updated on a regular, annual basis.
- **Attribution** – This measures the degree to which a particular program influenced a customer's decision to purchase and install a particular ECM. It is typically determined through participant surveys.
- **Intervention** – This refers to the method by which an ECM is introduced into the market or offered to a program participant. The three main types of methods are downstream (e.g., at the retail level), mid-stream (e.g., at the distributor level) or upstream (e.g., at the manufacturer level).
- **Realization Rate** –This results from a set of adjustments to account for quantities, persistence, in-service rates, interactive effects and data modelling. The adjustments are based on either observations or measurements made as part of the evaluation.

- **Free Riders** – This refers to program participants who would have implemented the ECM regardless of whether there was a program or not. There are three types of free riders: total (participant's activity would have been completely replicated in the absence of the program), partial (participant's activity would have been partially replicated in the absence of the program) and deferred (participant's activity would have been completely replicated in the absence of the program but at a future time rather than during the program's timeframe). As with other concepts, free ridership is determined using participant surveys.
- **Spillover** – This refers to additional energy-efficient equipment installed by a customer due to program influences (e.g., saw a flyer or ad) but the customer did not access any financial or technical assistance from the program. In many ways, this is the opposite of free ridership.

The following are the equations that are used to calculate the net savings from a particular ECM, taking into account the concepts noted above:

Using information gathered during the measurement and verification stage of EM&V:

- **Gross Savings =**
  Reported Savings x Realization Rate

Using information gathered during evaluation stage of EM&V:

- **Net-to-Gross Ratio =**
  (1 – Free Ridership Fraction) + Spillover Fraction
- **Net Savings =**
  Gross Savings x Net-to-Gross Ratio

Although not usually taken into account when energy-efficiency programs are evaluated, it should be noted that increases in efficiency have been found in some cases to result in increases in resource use. This effect was first discovered by William Jevons in 1865.

- **Jevons Effect** – Improvements in the efficiency of a resource from improved technology results in increased resource use due to an increased rate of consumption.

The example Jevons provided was with coal; he observed that technical improvements to the efficiency in steam engines resulted in increased use of coal as the steam engines began to be used in other applications. This effect is also referred to as the rebound effect. Subsequent research[83] has identified the potential for both direct rebound effects (as in the case of steam engines) as well as indirect effects (money saved by using less energy is spent on an energy-intensive activity that otherwise would not have been undertaken). Recent studies suggest estimates of this effect in the range of 5-15% in developed countries.[84] One counter argument is that if the purchasers of the more energy-efficient technology bought it because they want to improve their environmental footprint, then they might be expected to invest the savings generated in additional energy-saving technologies and thus save even more energy.

CHAPTER 10
POWER QUIZ

It is critical that energy-efficiency policies and programs continue to improve thorough, honest and independent evaluations and the results are used to further improve the initial policies and programs.

Kahoot!

Test your understanding of the key concepts in Chapter 10.
Answer the Kahoot! questions online to see how you did.
Log in at www.kahoot.it, pass code 009528809.

1. CANADA'S RANKING BY ACEEE FOR ENERGY EFFICIENCY

- **a.** First ☐
- **b.** Thirteenth ☐
- **c.** Fifth ☐
- **d.** Twentieth ☐

2. TOP 3 PROVINCES WITH HIGHEST RANKING FOR ENERGY EFFICIENCY

- **a.** B.C., Quebec & Nova Scotia ☐
- **b.** Ontario, Alberta and B.C. ☐
- **c.** Quebec, B.C. and P.E.I. ☐
- **d.** Nova Scotia, Alberta & Manitoba ☐

3. WHAT DOES EM&V STAND FOR?

- **a.** Emission, Motion and Vehicles ☐
- **b.** Evaluation, Measurement & Verification ☐
- **c.** Evaluation, Meaning and Verification ☐
- **d.** None of the above ☐

4. GOAL OF EM&V

- **a.** Determine net savings of a particular program with 90% of certainty ☐
- **b.** Provide as good a picture of a program for inclusion in an annual report ☐
- **c.** Provide as good a picture of a program to enhance chances of promotion ☐
- **d.** Keep any potential problems or solutions from being reported ☐

5. WHAT IS THE JEVONS EFFECT?

- **a.** Improvements in energy efficiency result in reduced resource use ☐
- **b.** Improvements in energy efficiency result in increase of resource use ☐
- **c.** Improvements in energy efficiency have no net impact on resource use ☐
- **d.** None of the above ☐

6. WHAT IS THE ESTIMATED POTENTIAL FOR THE JEVONS EFFECT?

- **a.** Nothing ☐
- **b.** 5-15% ☐
- **c.** 50% ☐
- **d.** 62% ☐

7. WHICH OF THE FOLLOWING CONCEPTS ARE NOT ASSOCIATED WITH EM&V?

- **a.** Attribution ☐
- **b.** Free rider ☐
- **c.** Spillover ☐
- **d.** None of the above ☐

CHAPTER 11

MOVING FORWARD

It is my sincere hope that after having read this textbook, a few things will stay with you. I fully expect that you will find, like I do, when the topic turns to energy in almost every forum, almost all the focus will be on supply options.

I hope that you will be confident enough to remind those in the conversation about the enormous potential (generally, we waste almost 60% of the energy we use) and advantages of energy efficiency (employment, economy and environment). At its core, what is needed is a new culture of conservation, not just the installation of a few more energy-efficient light bulbs because you get some money back for doing so.

While governments at all levels certainly have a role to play, they cannot do it alone. They need an informed electorate that understands the importance of providing adequate financing for energy-efficiency programs. And to achieve a culture of conservation where energy efficiency is ubiquitous, we need everyone, from school children to multinational companies and everyone in between, to be an advocate for energy efficiency. And don't get overwhelmed by the challenge. Start your journey and don't think you have to do everything all at once.

To those of you currently working for an organization with an interest in energy efficiency, I hope this text has provided a useful context for the important work you do.

To those students who do not end up having a career in energy efficiency, I hope that you will remember some of the key things you have learned, apply them to your own life and that you help implement energy efficiency where you do end up working.

And for those students who will have a career in energy efficiency, welcome to a most exciting and important journey.

I encourage you to stay in touch with your classmates and professors as you move forward.

A final request is to please send me any thoughts, suggestions or criticisms on the information contained here, as I will be updating this text on a regular basis.

I will leave you with these inspiring words by Martin Luther King Jr. Although he was referring to racial issues, I think they are equally applicable to our climate crisis:

> **And so, as you go out today, I call upon you to not to be a detached spectator, but involved participants, in this great drama that is taking place in our nation and around the world.**[85]

REFERENCES

1. International Energy Agency (IEA). Energy Efficiency 2017: Market Report Series. IEA, Paris, 2017.
2. International Panel on Climate Change (IPCC). Summary for Policy Markers: Climate Change 2021: The Physical Science Basis. IPCC, Geneva, 2021.
3. IEA. “World Energy Outlook 2011: Factsheet”. IEA, Paris, 2011.
4. Ban Ki-moon. “UN News – November 17, 2007”. United Nations, New York, 2007.
5. IPCC. Climate Change 2007:Working Group 1: The Physical Science Basis. IPCC, Geneva, 2007.
6. Environment Canada. “Greenhouse Gas Sources and Sinks in Canada: Executive Summary 2022. Environment Canada, Ottawa, 2022.
7. Ontario Government. Ontario’s Five Year Climate Change Action Plan: 2016-2020. Ontario Government, Toronto, 2016.
8. International Renewable Energy Agency (IRENA). “Synergies between renewable energy and energy efficiency: Working Paper”. IRENA, Masdar City, 2017.
9. IEA. “Energy, Climate Change & Environment: 2016 Insights”. IEA, Paris, 2016.
10. Dunsky Consulting. “The Economic Impact of Improved Energy Efficiency in Canada: Employment and Other Economic Outcomes from the Pan-Canadian Framework’s Energy Efficiency Measures”. Clean Energy Canada, Vancouver, 2018.
11. Canadian Energy Systems Analysis Research. www.cesanet.ca. University of Calgary, Calgary, 2018.
12. IEA and NRCan. Energy Efficiency Potential in Canada to 2050. IEA, Paris, 2018.
13. Natural Resources Canada. Energy Fact Book: 2015-16. NRCan, Ottawa, 2017.
14. Meir, Alan. “Fundamentals of Energy Efficiency: Understanding the Other Side of the Meter”. University of California – Davis, Davis, 2009.
15. Peloquin, Nathalle and Saint-Laurent, Isabelle. “Standby Power … the Phantom Menace”. NRCan, Ottawa, 2006.
16. NRCan. http://www.nrcan.gc.ca/energy/efficiency/housing/new-homes/18701
17. Dale, Susan. “How to Write a Briefing Note”. University of Victoria, Victoria, 2013.
18. Science Council of Canada. “National Resource Policy Issues in Canada”. Science Council of Canada, Ottawa, 1973.
19. Dietz, Thomas, et al. “Household actions can provide a behavioral wedge to rapidly reduce U.S. carbon emissions”. Proceedings of the National Academy of Sciences of the United States of America (PNAS), 106 (44) 18452-18456, Washington DC, Nov 3, 2009.
20. International Energy Agency. “Net Zero by 2050: A Roadmap for the Global Energy Sector”. IEA, Paris, 2021.
21. Lewis, Michael. The Undoing Project: A Friendship that Changed our Minds. W.W. Norton, New York, 2016.
22. Thaler, Richard and Sunstein, Cass. Nudge: Improving Decisions about Health, Wealth, and Happiness. Penguin Books, New York, 2008.
23. O’Connor, Patrick. “A Public Revolt against Spitting: Education and Politics in the Progressive Era”. ScholarWorks at University of Montana, Missoula, 2015.
24. Love, Peter. “Lessons Learned from Past Behavioural Change Initiatives: A View from the Trenches”. Behavior Energy Climate Change Conference (BECC), Washington DC, 2016. Available at www.loveenergyconsultants.com.

25. Alinski, Saul. Rules for Radicals: A Pragmatic Primer for Realistic Radicals. Random House, New York, 1971.
26. As quoted in Keys, Donald. Earth to Omega: Passage to Planetization. Findhorn Press, Forres, UK, 1982.
27. Duhigg, Charles. The Power of Habits: Why We Do What We Do in Life and Business. Random House, New York, 2014.
28. Forrest, Eleanor, et al. " FISHing for Energy Efficiency in UK MOD". BAE Systems, Preston UK, 2017.
29. Toronto Region Conservation Authority (TRCA) and Enerlife Consulting. "An Introduction to "Sustainable Schools". TRCA, Toronto, 2007.
30. Whitlock, Andrew, et.al. "Canadian Strategic Energy Management Market Study". American Council for an Energy Efficient Economy, Washington DC, 2021.
31. Natural Resources Canada (NRCan). "Improving Energy Performance in Canada: Report to Parliament Under the Energy Efficiency Act: 2013-2015". NRCan, Ottawa, 2016.
32. Committee on Assessment of Solid-State Lighting. "Assessment of Advanced Solid-State Lighting". The National Academic Press, Washington DC, 2013.
33. Independent Electricity System Operator (IESO). "Ontario Demand Forecast: December 2016". IESO, Toronto, 2017.
34. Ontario Energy Board (OEB). From www.oeb.ca. OEB, Toronto, 2017.
35. IESO. "Industrial Conservation Initiative Backgrounder: September 2017". IESO, Toronto, 2017.
36. IEA. "Energy Efficiency Governance: Handbook". IEA, Paris, 2010.
37. Ontario Public Health Association (OPNA). "Beyond Coal: Power, Public Health and the Environment". OPNA, Toronto, 2002.
38. Ontario Ministry of Environment and Climate Change (MOECC). "Smog Advisory Statistics: 2003 – 2014". MOECC, Toronto, 2015.
39. Canadian Energy Efficiency Alliance (CEEA). "Energy Efficiency Report Card: 2007". CEEA, Ottawa, 2008.
40. Mckenzie-Mohr, Doug. Fostering Sustainable Behaviour: An Introduction to Community-Based Social Marketing. New Society Publishers, Gabriola Island, B.C., 2011.
41. Clay, Nesler et al. "Driving Transformation to Energy Efficient Buildings: Policies and Actions: 2nd Edition". Institute for Building Efficiency, Milwaukee, 2012.
42. Stern, Nicholas. "Stern Review: The Economics of Climate Change: Executive Summary". HM treasury, London, 2006.
43. Jowit, Juliette and Wintour, Patrick. "Cost of tackling global climate change has doubled, Stern warns". The Guardian, June 26, 2008.
44. McKinsey and Company. "Greenhouse Gas Abatement Cost Curves". McKinsey and Company, Chicago, 2009.
45. DB Climate Change Advisors and Rockefeller Foundation. "United States Building Energy Retrofits: Market Sizing and Financing Models". DB Climate Change advisors and Rockefeller Foundation, New York, 2012.
46. Ehrhardt-Martinez, Karen and Laitner, John A. "Skip". "The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture". American Council for an Energy Efficient Economy (ACEEE), Washington DC, 2008.
47. The TecMarket Works Team. "California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals". California Public Utilities Commission, Sacramento, 2006.
48. Dunsky, Philippe. "It Matters Too Much to Get it so Wrong: Revisiting Cost-Effectiveness Screening". Presentation to Bright Business: A Global Perspective on Energy Efficiency, Halifax 2013.

49. Winfield, Mark and Koveshnikova, Tatiana. "An Efficient Balance? Applying the Total Resource Cost Test to Conservation and Demand Management Initiatives of Local Electricity Distribution Companies in Ontario". York University, Toronto, 2009.

50. B.C. Ministry of Energy and Mines. "Guide to the Demand-Side Measures Regulation". B.C. Ministry of Energy and Mines, Victoria, 2012.

51. Ontario Ministry of Energy (MOE). "Conservation First: A Renewed Vision for Energy Conservation in Ontario". MOE, Toronto, 2013.

52. Ontario Clean Air Alliance (OCCA). "Ontario's Electricity Options: A Cost Comparison". OCCA, Toronto, 2017.

53. Energy Services Association of Canada (ESAC). "Guaranteed Energy Savings: The Official Publication of the Energy Services Association of Canada." ESAC, Toronto, 2017.

54. Persram, Sonja. "Property Assessed Payments for Clean Energy: Recommendations for Regulatory Change and Optimal Program Features". David Suzuki Foundation, Vancouver, 2011.

55. Hurley, Doug. "Energy Efficiency in Wholesale Capacity Markets". Presentation at the Alberta Energy Efficiency Conference, Calgary, 2017.

56. Harvey, L. D. Danny. Energy and the New Reality 1: Efficiency and the Demand for Energy Services. earthscan, London, 2010.

57. IESO. "IESO Prescriptive Measures and Assumptions List". IESO, Toronto, 2015.

58. Harvey, L.D. Danny. "Aggressive reductions through efficiency in systems, devices and behavioral changes". Presentation to Aspen Global Change Institute Workshop, Aspen, 2014.

59. Lovins, Amory. Soft Energy Paths: Towards a Durable Peace. Harper & Row, New York, NY, 1979.

60. Electricity Conservation and Supply Task force (ECSTF). Tough Choices: Addressing Ontario's Power Needs – Final Report to the Minister. MOE, Toronto, 2004.

61. Ministry of Energy, Northern Development and Mines. "Conservation First: A Renewed Vision for Energy Conservation in Ontario". Ontario Government, Toronto, 2015.

62. MOE. "2017 Long-Term Energy Plan: Delivering Fairness and Choice". MOE, Toronto, 2017.

63. Navigant Consulting Inc. 2019 Integrated Ontario Electricity and Natural Gas Achievable Potential. IESO and OEB, Toronto, 2019.

64. Winfield, Mark et al. "Implications of sustainability assessment for electricity system design: The case of the Ontario Power Authority's integrated power system plan." Energy Policy 38 (2010) 4115-4126, Amsterdam, 2010.

65. Littlejohn, Dale and Lazlo, Richard. "Community Energy Planning: Getting to Implementation in Canada – National Report on Policies Supporting Community Energy Plan Implementation". Quality Urban Energy Systems of Tomorrow (QUEST), Ottawa, 2015.

66. Evenson, Jeff et al. "Advancing Integrated Community Energy Planning in Ontario: A Primer". QUEST, Ottawa, 2013.

67. City of London. "How much do we spend on energy in London". Environmental Programs Information, London, 2017.

68. NRCan. "Improving Energy Performance in Canada – Report to Parliament Under the Energy Efficiency Act for fiscal Year 2007-2008". NRCan, Ottawa, 2009.

69. NRCan. "Market transformation strategies for energy-using equipment in the building sector: Supporting the transition to a low-carbon economy". Presentation to the Energy and Mines Minister's Conference, St. Andrews, 2017.

70. IEA. "Energy Efficiency 2021". IEA, Paris, 2021.

71. "Making Connections: Straight Talk About Electricity in Ontario: 2018 Energy Conservation Progress Report, Volume One". Environmental Commissioner of Ontario, Toronto, 2018.

72. Kingdon, John. Agendas, Alternatives and Public Policy. The Oxford Handbook of Classics in Public Policy and Administration, Oxford, 1984.

73. Lutzenhiser, Loren. “The Evolution of Electricity Efficiency Policy: The Importance of Behavior and Implications for Climate Change Initiatives”. Printed in Reeve, Doug et al Current Affairs: Perspectives on Electricity Policy in Ontario. University of Toronto Press, Toronto, 2010.

74. Delve, Katherine and Wilkens, Anne. “Five A’s: Barrier Classification and Market Transformation Program Design for Energy Efficiency Technologies”. NRCan, Ottawa, 2004.

75. Dunsky, Philippe. Personal communication, September 19, 2017.

76. CEEA. “Energy Efficiency Report Card: 1999”. CEEA, Ottawa, 2000.

77. Pembina Institute. “Successful Strategies for Energy Efficiency: A Review of Approaches in Other Jurisdictions and Recommendations for Canada”. Pembina Institute, Drayton Valley, 2016.

78. ACEEE. “The State Energy Efficiency Report Card”. ACEEE, Washington DC, 2017.

79. ACEEE. “The International Energy Efficiency Scorecard”. ACEEE, Washington DC, 2017.

80. Gaede, James, et. al. “2021 Canadian Provincial Energy Efficiency Scorecard”. Efficiency Canada and Carlton University, Ottawa, 2021.

81. Gaede, James, et. al. “2021 Canadian Provincial Energy Efficiency Scorecard”. Efficiency Canada and Carlton University, Ottawa, 2021.

82. IESO. “Evaluation, Measurement and Verification (EM&V) Protocols and Requirements”. IESO, Toronto, 2016.

83. “Evaluation, Measurement & Verification Framework for Ontario Power Authority Conservation Programs: Final Version 1.0”. IESO, Toronto, 2008.

84. Sorrell, Steve. “A Review of the Rebound Effect in Energy Efficiency Programs”. Printed in Reeve, Doug et al Current Affairs: Perspectives on Electricity Policy in Ontario. University of Toronto Press, Toronto, 2010.

85. Gillingham, Kenneth. “Rebound Effects”. Prepared for the New Palgrave Dictionary of Economics. Palgrave Macmillan, London, 2017.

86. Martin Luther King Jr. “American Dream”. Lincoln University, Pennsylvania, June 6, 1961.