Technology Collaboration Programme
by iea

Technology Collaboration Program on Heat Pumping Technologies (TCP-HPT)

HPT-Annex 46
Domestic Hot Water Heat Pumps

Annex 46

Task 1 Market Overview

Country Report Canada

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Natural Resources Canada / Ressources naturelles Canada

Canada

CanmetENERGY / CanmetÉNERGIE

Canmet ENERGY

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Report No. HPT-AN46-02-01

Preface

This project was carried out within the International Energy Agency Technology Collaboration Program on Heat Pumping Technologies (HPT TCP).

The IEA

The IEA was established in 1974 within the framework of the Organization for Economic Cooperation and Development (OECD) to implement an International Energy Program. A basic aim of the IEA is to foster cooperation among the IEA participating countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology and research and development (R&D). This is achieved, in part, through a Program of energy technology and R&D collaboration, currently within the framework of over 40 Implementing Agreements.

Disclaimer

The HPT TCP is part of a network of autonomous collaborative partnerships focused on a wide range of energy technologies known as Technology Collaboration Programs or TCPs. The TCPs are organized under the auspices of the International Energy Agency (IEA), but the TCPs are functionally and legally autonomous. Views, findings and publications of the HPT TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

The Technology Collaboration Program on Heat Pumping Technologies (HPT TCP)

The Technology Collaboration Program on Heat Pumping Technologies (HPT TCP) forms the legal basis for a Program of research, development, demonstration and promotion of heat pumping technologies. Signatories of the TCP, called participating countries, are either governments or organizations designated by their respective governments to conduct. The Program is governed by an Executive Committee (ExCo), which monitors existing projects and identifies new areas where collaborative effort may be beneficial.

Annexes

The core of the TCP are the "Annexes". Annexes are collaborative tasks conducted on a cost-sharing and/or task-sharing basis by experts from the participating countries. Annexes have specific topics and work plans and operate for a specified period, usually a number of years. The objectives range from information exchange to the development and implementation of heat pumping technologies. An Annex is in general coordinated by an expert from one country, acting as the Operating Agent (manager). This report presents the results of one Annex.

Triennial Heat Pump Conference

The IEA Heat Pump Conference is one of the three major products of the Technology Collaboration Program on Heat Pumping Technologies. The Executive Committee supervises the overall organization and its quality and selects from a tender procedure the host country to organize the Conference and establishes an International Organization Committee (IOC) to support the host country and the ExCo.

The Heat Pump Centre

The Heat Pump Centre (HPC) offers information services to support all those who can play a part in the implementation of heat pumping technologies. Activities of the HPC include the publication of the quarterly Heat Pumping Technologies Magazine and an additional newsletter three times per year, the HPT TCP website, the organization of workshops, an inquiry service and a promotion Program.
The HPC also publishes results from the Annexes under the TCP-HPT.

For further information about the Technology Collaboration Program on Heat Pumping Technologies (HPT TCP) and for inquiries on heat pump issues in general contact the Heat Pump Centre at the following address:
Heat Pump Centre
c/o RISE - Research Institutes of Sweden Box 857, SE-501 15 BORÅS, Sweden
Phone: +46 10 16 55 12

Contents

Key Facts in Canada [1]		
Capital	**Ottawa**	
GDP per capita	**42,2**	**USD (34,000 €)**
Housing		
Households	**Units**	**Energy Consumption (GJ)**
Total	**13,599,121**	**1,431,530,934**
Type of dwelling		
Single detached	8,230.596	1,102,766,918
Double/row house	1,751,055	149,480,266
Low-rise apartment	2,059,428	79,607,172
High-rise apartment	994,596	42,106,449
Mobile home	161,459	18,032,373
Not stated	401,987	39,537,757
Residential energy use by fuel type		
Natural gas	43%	
Electricity	38%	
Wood and wood pellets	12%	
Oil	6%	
Propane	1%	
Residential energy use by end use		
Space heating	63%	
Water heating	19%	
Appliances	12%	
Lighting	4%	
Space cooling	1%	
Renewable Energy		
Share of renewable energy	**18.9 % (of the total energy consumption)**	
Renewable generation share by source		
Hydro	72%	
Solid Biomass	25%	
Wind	2.1 %	
Solar PV	0.1 %	
Solar Thermal	0.1 %	

1. Energy use in Canada [2, 3, 4, 5]

1.1 Energy use in all five sectors of the economy

Energy is used in all five sectors of the economy: residential, commercial/institutional, industrial, transportation, and agriculture. In 2013, these sectors used a total of 8,924.0 PJ of energy, which makes Canada one of the highest per capita consumers of energy in the world. The industrial sector accounted for the largest share of energy, followed by transportation, residential, commercial/ institutional, and agriculture. Total GHG emissions associated with the energy use of the five sectors was 487.0 Mt in 2013.

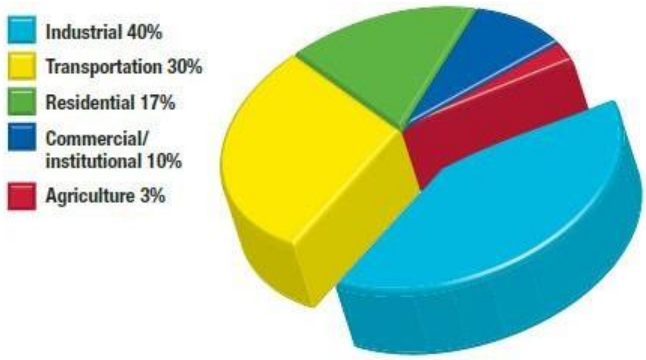

Fig 1.1 Secondary energy use by sector, Canada, 2013

Over the 1990–2013 period:

- The energy efficiency improved by 24.2%, saving 1,613.2 PJ or $37.6 billion in energy and avoiding 85.4 Mt of GHG emissions.
- The total secondary energy use in Canada increased 28%, from 6,957.1 PJ to 8,924.0 PJ. It would have increased 51 % without energy efficiency improvements.
- The Canadian population grew 27.0% (approximately 1% per year) and GDP increased 71.7% (about 2.4% per year).

1.2 Energy use in the Canadian residential sector

Natural gas, electricity, wood, heating oil and propane were the sources of energy being used. Within a household, these forms of energy were used for a variety of activities. Because of Canada's cold climate, 63 % of Canada's residential energy use was for space heating in 2013.

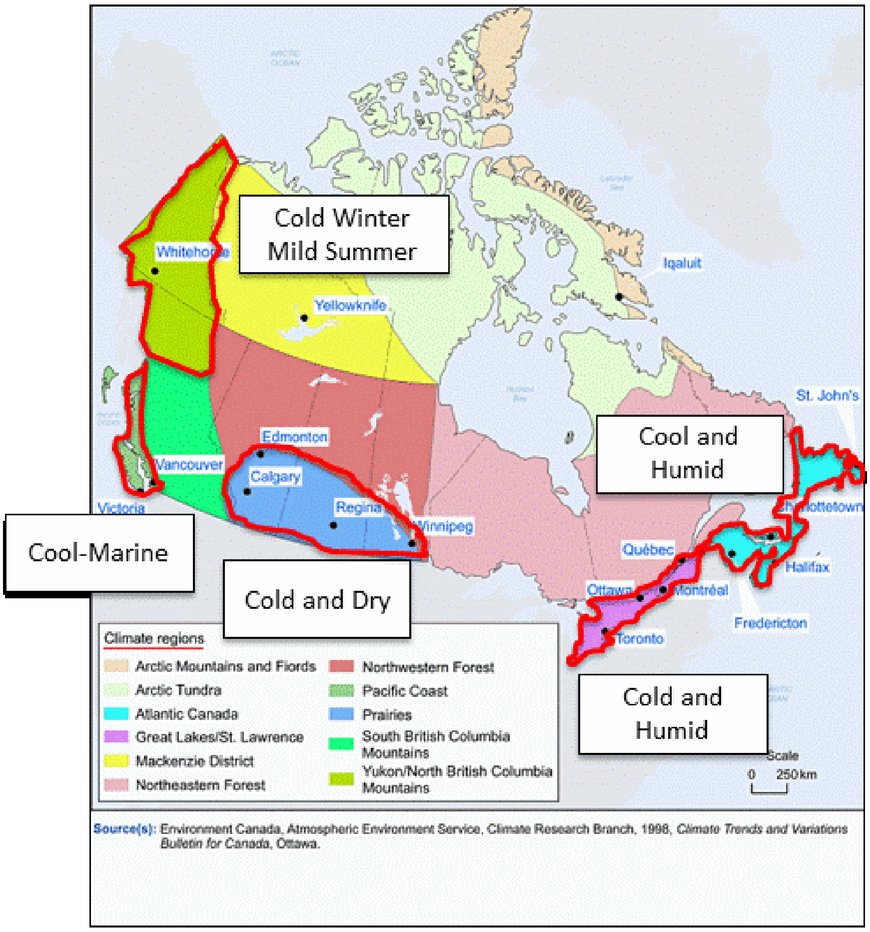

Fig 1.2 Weather in different regions of Canada

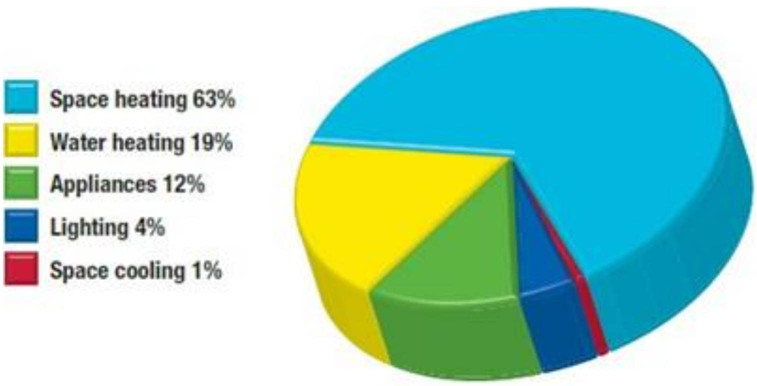

Fig 1.3 Distribution of residential energy use, Canada, 2013

Water heating accounted for 19% in 2013 and its share in energy use is likely to rise in the future, as improved building insulation levels and highly efficient mechanical systems reduce the energy required for space heating and cooling.

Appliances were also major energy users in Canadian dwellings, followed by lighting and space cooling.

Between 1990 and 2013, the population grew 27% (7.5 million people) and the number of households increased 40% (3.9 million). The rise in the number of households, combined with increased average living space and the higher penetration rate of appliances, contributed to the increase of 6.5%, or 93 PJ, in residential energy use from 1,424.5 PJ to 1,517.5 PJ. As homeowners gradually switched to cleaner energy sources, the associated GHG emissions decreased 9%, from 72.8 Mt to 66.2 Mt during the period

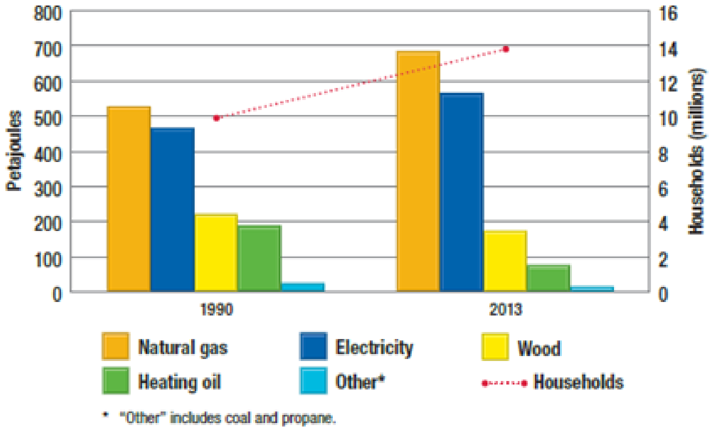

Fig 1.4 Residential energy use by fuel type, Canada, 1990 and 2013

The mix of energy used in the residential sector changed slightly over the period. Specifically, natural gas and electricity became even more dominant, while wood and heating oil use declined. Natural gas and electricity together accounted for 82.5 % of all residential energy use in 2013, compared to 70 % in 1990, while heating oil saw its share decrease from 13 % to 5 % over the period. The increase in natural gas and electricity share largely reflected the increased availability of natural gas and lower natural gas prices relative to oil. It was also in part the result of relatively higher efficiency ratings for gas and electric furnaces.

1.3 Utility rates and GHG emissions by regions

Even though electricity and gas prices vary considerably depending on the region, they are, in general, quite low compared to most countries. Moreover, the cost of using of natural gas for heating is much lower (up to 6 times) in most of Canadian regions. The table below presents the rates in GHG impact of electricity and natural gas (and oil) in some of these regions.

Region	Halifax	Montreal	Toronto	Edmonton	Vancouver	Whitehorse
Electricity Cost ($/GJ)	41	21	43	23	29	40
Natural Gas/Oil Cost ($/GJ)	--	--	6.8	4.0	7.0	24
Electricity GHG (kg CO_2/GJ)	205	2	55	255	6	14
Natural Gas/Oil GHG (kg CO_2/GJ)	--	--	50	50	50	69

Table 1.1 Utility rates and GHG emissions by Canadian regions

2 Water heating in the Canadian residential sector

Hot water for bathing and cleaning is an essential service in our homes and buildings and requires significant amounts of energy. Water heating is the second-largest source of energy use in buildings and accounts for 19% (as shown in section 1.2) and 8% of the total energy consumed in homes and commercial buildings, respectively. Energy consumption is directly tied to how efficiently water heating equipment uses energy and how often the system needs to run in order to provide water at the right temperature.

2.1 Residential water heating energy use and trend

In Canada, most hot water systems use three primary sources of energy: oil, natural gas and electricity. Solar domestic hot water systems are also used but to a much lesser extent. Energy sources tend to be distributed regionally depending on accessibility and cost; for example, oil is predominantly used in the North, electricity is predominant in Quebec, Manitoba and Atlantic Canada, and natural gas is the main energy source for water heating in Ontario, Saskatchewan, Alberta and British Columbia.

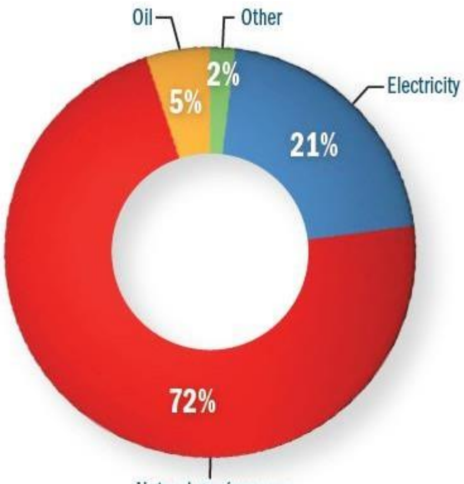

Fig 2.1 Water heating energy use in Canada

Less energy is required per household for hot water due to increased penetration of newer and more efficient natural gas water heaters and a decline in household size.

More Canadians shifted from using oil-fired water heaters to those that use natural gas and that are, on average, more energy-efficient.

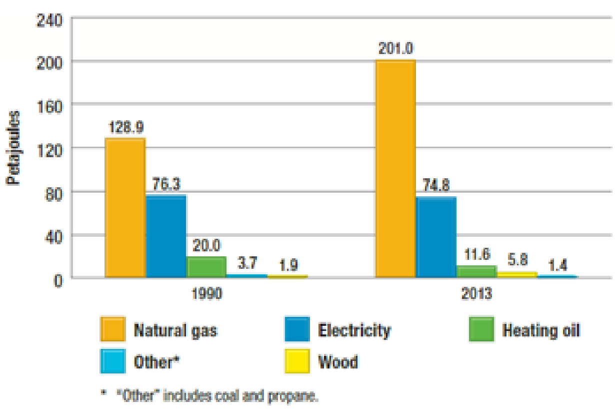

Fig 2.2 Water heating energy use trend by fuel in Canada, 1990 and 2013

In addition, current minimum energy performance standards mean that new water heaters use less energy than older models. As older stock is replaced by new stock, energy efficiency gains are achieved. These changes, combined with a

decrease in household size, resulted in a 9 % decrease in the energy used per household for heating water (from 23.3 GJ per household in 1990 to 21.3 GJ per household in 2013).

Although there was a decrease in per-household energy used to heat water, the total number of households grew more quickly than energy efficiency improvements from new equipment. The result was an overall increase of 28 % in residential water heating energy use, from 230.8 PJ to 294.6 PJ. In 2013, 19 % of the residential energy demand was used for water heating.

2.2 Water heaters in Canada [6, 7, 8]

Two main types of water heaters exist in Canada: the storage tank and the instantaneous water heater. For storage tank water heaters, there has been slow progress in moving to higher efficiencies and performance has remained somewhat stagnant.

2.2.1 Water heaters - market

There is one national manufacturer supplying residential and commercial water heating storage tanks in Canada. The remaining water heaters are imported mainly from U.S. manufacturers. Instantaneous water heaters are predominantly manufactured by companies based in Asia. The water heating market size is estimated at one million units annually, divided 20/80 between new construction and retrofit markets. The total annual sales for both residential and commercial are estimate at about $350 million.

The share of annual water heaters shipments in Canada, by energy performance, is shown in the table below.

Product	% of market with <90% Energy performance	% of market with <90–100% energy performance	% of market with >100% energy performance
Residential gas-fired storage water heater	99%	1%	0%
Residential oil-fired storage water heater	100%	0%	0%
Residential and commercial electric storage water heater	0.5%	99%	0.5%
Residential instantaneous water heater	25%	75%	0%
Commercial gas-fired storage water heaters	70%	30%	0%

Table 2.1 Share of annual shipments in Canada within each water heating technology, by energy performance

2.2.2 Water heaters – age

Of the households that know the age of their hot water heater, 48% are 5 years old or less, 38% are between 6 to 10 years old, 9% between the age of 11 and 15 years and the remaining 5% are older than 15 years. With a recommended replacement age of 13 years [9] it can be expected that over the next 7 years over 50% of Canadian households will be replacing their hot water heater. Therefore there is a clear window of opportunity for the government to deploy high efficient and environmentally friendly water heaters in Canada, such as heat pump water heaters that will be discussed in the section 2.3 of this report.

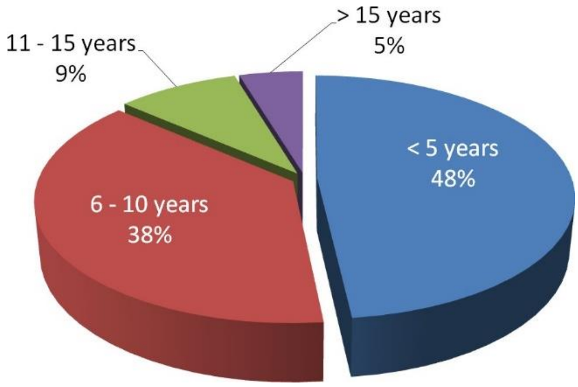

Fig 2.3 Age of water heaters – Canada

2.2.3 Water heaters - energy performance

Currently, gas- and oil-fired storage water heaters operate at around an Energy Factor (EF)[1] of 0.60-0.68 (equivalent to 70% to 80% in energy performance), while electric storage water heaters have a standby loss of less than 181 watts (equivalent to 100% in energy performance).

Much of the gas-fired instantaneous water heater market is at or above EF of 0.8 (equivalent to 90% in energy performance), with the higher efficiency products using condensing technology.

For gas-fired storage water heaters, condensing technology can take the performance of these storage tanks from 70 to 90%. These high efficiency products represent less than 1% of the residential market and roughly 30% of the commercial market. There is a potential for small incremental improvements to the electric storage water heater performance from increased insulation; however, new heat pump technology can take the performance of these storage tanks past 100% (EF greater than 1). Emerging heat pump technology using natural gas as a fuel source may significantly increase performance over current gas-fired equipment. Integrating more than one end-use function (e.g. space and water heating) into a single piece of equipment is also becoming more attractive.

2.3 Heat pump water heaters in North America

Heat pumps are very efficient heating and cooling systems that can significantly reduce energy costs, Green House Gas emissions and facilitate the use of renewable energy in buildings [10]. Most of the HPs in the market adress space heating and cooling requirements. Nevertheless, since domestic hot water is a major heat load in buildings, adressing this load with heat pumps (heat pump water heaters) offers the potential to efficiently address a major energy end use while at the same time opening a significant new market for heat pump and water heater manufacturers.

Heat pump water heaters (HPWH) were introduced to the market in the 1970s throughout North America, starting with small entrepreneurial companies, then utilized by utility support programs in the Northeast region of the U.S., and eventually produced and sold by major manufacturers like General Electric [11]. Expectations were high for HPWHs since their efficiency far exceeded that of traditional electric resistance water heaters. Because of this, consumers in states whose primary fuel source is electricity showed particularly high interest since HPWHs since it would help maximize their utility savings. Despite long-term savings, the up-front cost of these appliances as well as somewhat more complex installation requirements have combined to create a major barrier to wide scale adoption. Despite federal tax credits and significant outreach efforts in the US, HPWHs have struggled to gain market traction, accounting

[1] EF accounts for standby losses, whereas energy performance is an approximate measure of the %age of fuel that is converted into heating energy without standby losses.

for 2% or less of the U.S. electric water heater market for the past six years. At the close of 2016, only approximately 60,000 HPWHs are expected to be installed in the United States.

Currently, there is no statistics on HPWH in Canada, where HPWH are not even advertised and hard to buy off the shelf from the most used distribution channels used by consumers such as retailers of home improvement and construction products and services, plumbers and heat pump manufacturers. Some units such as the Rheem HPWHs can be bought off “Amazon”, but they are frequently out of stock and usually get shipped from the US.

2.3.1 Types of Heat Pump water heaters (HPWH) available in Canada

The simplest HPWH and by far the most common HPWH available in Canada is the ambient air-source unit, which removes heat from surrounding air. This system uses the indoor air as a thermal source, cooling the space while providing hot water and is a very good solution in warmer climates, since they provide hot water and cooling simultaneously. Nevertheless, in heating-dominated regions such as Canada, it is not as good, for it increases heating loads and overall building energy use. As such, this system requires a careful whole-building analysis to ensure that it improves overall energy efficiency.

Ducted HPWH and split system HPWH remove heat from outside air and work better in heating-dominated climates because they do not cool the ambient air. Some ducted units can even be converted between the two modes of operation (ducted and ductless) for optimum operation in either summer or winter. Nevertheless, additional ducting and or piping makes retrofit installations a challenge. Also, in Canada, these HPWH must be able to work at temperatures as low as -25 C.

Exhaust air units extract heat from a continuously exhausted air stream and are also a good fit for cold climate. However, the heat recovery ventilator can freeze up, reducing performance.

2.3.2 HPWH – models available in the Canadian market [12, 13, 14]

There are a few heat-pump water heaters that have been on the market for decades, but these never really reached the mainstream. All that has changed in the past few years, however, as the largest water heater manufacturers have all introduced HPWHs. These HPWH are mostly ambient air-source unit and some units can be ducted, although they do not work at temperatures lower than 7 C. A list of these manufacturers:

- A.O. Smith
- Rheem
- GE
- GWH water heaters
- John Wood
- Giant
- HTP
- MDV
- Midea
- Westinghouse
- Bradford White
- Richmond
- Ruud
- Vaughn
- Whirlpool

Fig 2.4 GE GeoSpring - ambient air-source HPWH

These are all US manufacturers but Giant, which is Canadian. Although these HPWH are on average 2 to 3 times more efficient than regular water heaters (depending on model, climate and operating conditions), they are 3 to 4 times more expensive as well.

There is a more efficient air-source HPWH in the market, the German-made Stieber Eltron, which is twice more expensive than the HPWHs (and therefore 6 to 8 times more expensive than regular water heaters) mentioned above.

Fig 2.5 Stiebel Eltron - ambient air-source HPWH

There is also a new HPWH in the market: SANC02 from the Japanese manufacturer SANDEN. It consists of a CO2 split system, in which the HP unit (which comprises the compressor, evaporator, condenser and other components) is installed outside the building and do not interact with the building's indoor air.

Exterior compresssor heat pump water heater © Sanden

Fig 2.6 SANCO2 - CO2 split HPWH

SABNCO2 produces hot water that circulates to an indoor storage tank. The manufacturer claims the unit can operate at temperatures as low as -29 °C and provides 3.5 kW of heat at -25 °C, with a COP of 1.7. Its seasonal COP, based on the hot water consumption of a family of four each taking an 8 minute shower every morning with a regular shower head delivering 9.5 L/min, would be about 3.4, which is quite impressive. The unit comes with a 163 or 314 L storage tank, and its installed cost is approximately 5 times higher compared to regular air-source HPWHs such as the GE GeoSpring.

3 Policy framework

Since 1995, most of the residential water heating energy use in Canada has been subject to energy performance standards under Canada's *Energy Efficiency Act* while the ENERGY STAR program been promoting high efficiency specifications since 2009. The regulated performance standards for gas and electric storage water heaters have been updated twice in the intervening years. Provincial regulations, where they exist, have generally been aligned with federal standards. Since 2012, the *National Building Code of Canada [15]* and the *National Energy Code of Canada for Buildings [16]* have included minimum energy performance requirements for all water heating equipment. Commercial equipment is only now starting to be added to federal and provincial regulations.

3.1 Quality label

3.1.1 ENERGY STAR in Canada [17]

ENERGY STAR Canada is a voluntary partnership between the Government of Canada and industry to make high efficiency products readily available and visible to Canadians.

Natural Resources Canada (NRCan) formally enrolls manufacturers, retailers and other organizations as Participants in ENERGY STAR Canada. Participants help promote ENERGY STAR and ensure ENERGY STAR certified products are prominent and readily available in the marketplace and to Canadian consumers. NRCan administers and promotes use of the ENERGY STAR name and symbol in Canada under an agreement with the U.S. Environmental Protection Agency (EPA). Canada became an international partner in the program in 2001.

NRCan works closely with the EPA to develop ENERGY STAR technical specifications for products. It also develops Canadian specifications for certain ENERGY STAR certified products.

ENERGY STAR is one of three tools that consumers, governments and businesses use to advance energy efficiency in Canada:

- Canada's Energy Efficiency Regulations set minimum energy performance standards for energy-using products.
- EnerGuide is Canada's energy-efficiency labelling program and rating system for major appliances, room air conditioners and some heating and ventilating equipment.
- The ENERGY STAR symbol identifies products that have met or exceeded technical specifications for high efficiency.

The ENERGY STAR name and symbol are administered and promoted in Canada by Natural Resources Canada and are registered in Canada by the United States Environmental Protection Agency.

3.1.2 EnerGuide in Canada

EnerGuide is the official mark of the Government of Canada for its energy performance rating and labeling program for key consumer items—houses, light-duty vehicles, and certain energy-using products.

The information provided by EnerGuide allows consumers to compare different models with confidence. The data may be a rating number based on a standard measure or a verified average of energy consumption. Energy efficiency helps Canadians save energy, lower utility bills and reduce our impact on the environment EnerGuide works in concert with Canada's Energy Efficiency Regulations and the ENERGY STAR® Canada program to promote energy efficiency in the Canadian marketplace. The ENERGY STAR name and symbol are administered and promoted in Canada by Natural Resources Canada and are registered in Canada by the United States Environmental Protection Agency.

3.1.3 The EnerGuide label [18]

The distinctive EnerGuide label is a familiar sight to most Canadians. They see it when shopping for new appliances, look at the literature for a new furnace or read the fine print on a light bulb package. The EnerGuide label lets Canadians know how much energy a product uses and how that compares to similar models.

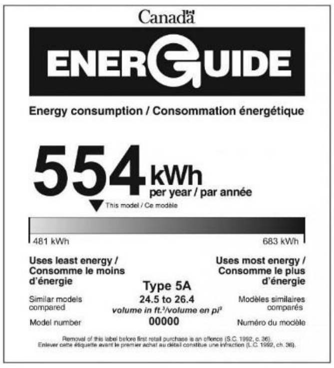

Fig 3.1 EnerGuide label for appliances

There are main information displayed on the label

1. Annual energy consumption of the model in kilowatt hours (kWh)
2. Energy consumption indicator, which positions the model compared with the most efficient and least efficient models in the same class
3. Type and capacity of models that make up this class
4. The model number

The EnerGuide label is mandatory for clothes dryers, clothes washers (including integrated washer-dryers), dishwashers, freezers, electric ranges, cooktops and ovens, refrigerators, refrigerator-freezers and wine chillers room air conditioners. It is voluntary for central air conditioners, furnaces (oil-, gas- or propane-fired), air-source heat pumps, gas fireplaces and water heaters.

The mandatory EnerGuide label can take the form of an adhesive tag, a flap tag (similar to a sticky note) or a hang tag. The voluntary EnerGuide label is usually presented as a graphic in product literature. Often products (such as appliances and room air conditioners), that are regulated and carry the EnerGuide label are also ENERGY STAR certified models. In these cases, the ENERGY STAR symbol will appear at the bottom of the EnerGuide label.

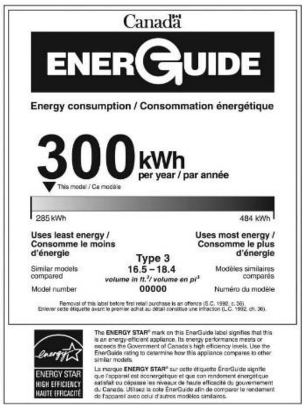

Fig 3.2 EnerGuide label for appliances

There are five main items displayed on the label

1. Annual energy consumption of the model in kilowatt hours (kWh)
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3. Type and capacity of models that make up this class
4. The model number
5. The ENERGY STAR symbol

3.2 Performance standard for water heaters and HPWH [19]

CAN/CSA-C745-03 (R2014) is the National Standard of Canada for Energy Efficiency of Electric Storage Tank Water Heaters and Heat Pump Water Heaters. It was published by the Canadian Standard Association (CSA) in 2003 and reaffirmed in 2014. Here is the scope of the standard:

- The Standard specifies the methods for determining the energy factor for electric storage tank water heaters and heat pump water heaters.
- The Standard establishes minimum energy efficiency levels for electric storage tank water heaters and heat pump water heaters.
- The Standard applies to:
    - electric storage tank water heaters:

    - with volumes of 76 to 454 L (20 to 120 US gal);
    - having electric heater elements with power inputs up to 12 kW; and
    - designed to heat and store water at a thermostatically controlled temperature equal to or less than 82 ºC (180ºF)
  - heat pump water heaters that have:
    - a maximum current rating of 24 A;
    - a single-phase maximum voltage of 250 V; and
    - ancillary equipment necessary for the device to function.
- The Standard does not apply to high-temperature water heaters.
- The tests contained in the Standard are not intended to represent actual efficiencies realized in the field. Instead, these tests provide a standardized method of comparing performance.
- The Standard is written in SI units. The values given in parentheses are for information only. The SI values have been calculated from the US Customary Units measurements found in the US Department of Energy publication 10 CFR, Part 430, appendix E, subpart B.

3.3 Legislation - Legionella [20]

"MD 15161 – 2013 Control of *Legionella* in Mechanical Systems" is the standard for the control of legionella published by Public Works and Government Services Canada (PWGSC). MD 15161 was developed for building owners, design professionals, and maintenance personnel and was first published in 1986. Its first edition reflected many of the requirements for the control of *Legionella* in mechanical systems, based on an exhaustive study of the subject.

The document was revised in 2006 considering the latest research in the field, including the development of new ASHRAE guidelines. Subsequently, there was an outbreak of Legionnaires' disease in Quebec City in 2012 that led to several fatalities; the source of this outbreak was traced to a cooling tower in a downtown Quebec City building. Following this outbreak, PWGSC carried out an extensive review of building maintenance programs as well as testing protocols for control of *Legionella* bacteria. It also reviewed current industry practices for *Legionella* control, with assistance from private sector consultants. This standard is the result of this extensive effort.

The standard states that hot water shall be maintained or stored above 60°C, distributed to each outlet at a minimum of 50°C, and reduced to below 43°C at the point of use. More often than not, however, visual inspections find that there is no thermostat on the hot water tank, or that the hot water tank temperature is kept as low as 45°C to save energy and to prevent scalding.

Cold water systems are generally not a problem for Legionella growth since the water is usually stored below 20°C. However, the water in "point of use" systems such as irregularly used spigots, drinking fountains, emergency eye wash stations, etc. can be found at higher temperatures. These systems often have minimum maintenance performed on them to limit bacterial growth.

The water distribution system should be designed to minimize "dead legs" (sections of pipe that are no longer in use but continue to contain stagnant water) and to reduce the water residence time with the use of recirculating pumps.

MD 15161 targets cooling towers and evaporative condensers, open water systems, HVAC systems and components and domestic hot water (DHW) systems.

4. Market transformation strategy and policy framework [8]

The *Pan-Canadian Framework on Clean Growth* and *Climate Change* outlines the commitments of the federal, provincial and territorial governments to reduce greenhouse gas emissions and promote clean, low-carbon economic growth for Canadians. Speeding up the development and mainstream adoption of clean and more energy-efficient equipment technologies is a key component to achieving these goals for Canadians.

Residential and commercial buildings account for 17% of total greenhouse gas emissions in Canada. For this reason, the Pan-Canadian Framework outlines a buildings strategy with measures to improve energy performance of new and existing buildings through codes and labels and set new standards for energy-using equipment.

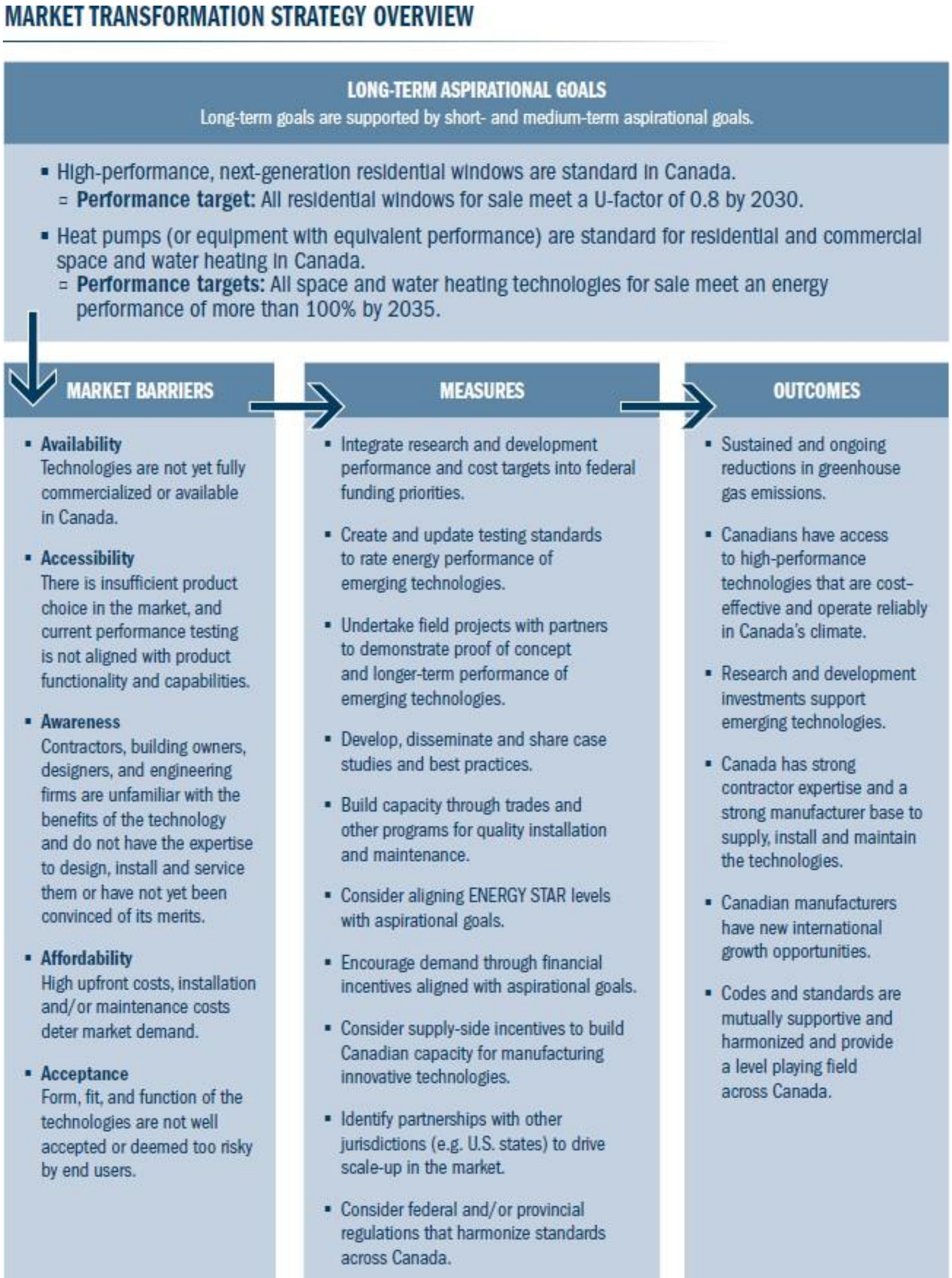
Market transformation requires a series of strategic interventions designed to overcome barriers to the adoption of new technologies, with a view to accelerating market uptake. As part of the shared priorities identified during the Energy and Mines Ministers' Conference, Governments are focusing collaborative efforts on market transformation in three equipment areas, based on their current energy use and potential to reduce greenhouse gas emissions, as showed below:

WINDOWS	SPACE HEATING	WATER HEATING
Account for up to 35% of the heat loss from a home's envelope.	Represents 56% to 64% of energy use in homes and buildings, the largest source of direct sector emissions.	Represents 8% to 19% of energy use in homes and buildings.
If all residential windows were replaced with next-generation technology (U-factor of 0.8) today: ▪ Total home energy use would decrease by 9%. ▪ Greenhouse gas emissions would be reduced by more than 5 Mt.	If all residential heating systems were replaced with heat pump technology today: ▪ Total home energy use would decrease by 30%. ▪ Greenhouse gas emissions would be reduced by 18 Mt.	If all residential water heating systems were replaced with heat pump technology today: ▪ Total home energy use would decrease by 5%. ▪ Greenhouse gas emissions would be reduced by more than 3 Mt.
Increased performance and design of residential windows, space heating and water heating will also encourage and complement planned updates to codes for new and existing homes and buildings.		

Table 4.1 Market transformation - Target equipment areas

To Office of Energy Efficiency (OEE) of Canada has taken the lead in this program and a series of stakeholder workshops was held in 2017. Participants included manufacturers, gas and electric utilities, industry associations, advocates, and building code developers. Their input was used to identify the key market barriers in order to devise a market transformation strategy.

The table below outlines the strategy that is being implemented, as well as the Governments' aspirational goals for ambitious but achievable energy performance levels for residential windows, space heating and water heating equipment. The goals support the broader objectives of the Pan-Canadian Framework—to reduce greenhouse gas emissions, promote adoption and support clean technology innovation, and to ultimately shift to a low-carbon economy.



4.1 Short-, medium- and long-term aspirational goals for residential water heating technologies

The government's aspirational goals cover commercial and residential water heating technologies that use natural gas and electricity (oil-fired technologies would be subject to the aspirational goals, but more work is required to understand the market barriers. For this reason, oil-fired equipment is not considered presently). The goals also include research and development targets to support the development of next- generation technologies. Here they are:

- **Short term:** By 2025, all fuel-burning water heating technologies for sale in Canada meet an energy performance of at least 90% (condensing technology).
- **Medium term:** By 2030:
  - All electric water heaters for sale in Canada meet an energy performance of more than 100% (EF greater than 1).

  - A residential gas heat pump with an EF greater than 1.4 can be manufactured and installed cost-effectively. This research and development target is only for residential applications. Given the absence of data on the commercial building sector, it was not possible to produce a target for this report. Cost equivalent to a 30% premium over a condensing gas-fired storage water heater. This is the estimated cost at which a gas heat pump with an EF greater than 1.4 will become cost-effective versus a condensing tank with an EF of 0.82. This cost is based on manufacturer and industry estimates collected through Natural Resources Canada's Local Energy Efficiency Partnership Initiative and CanmetENERGY's research programs

- **Long term:** By 2035, all water heating technologies for sale in Canada meet an energy performance greater than 100% (EF greater than 1).

The short term goals will transition the entire market for gas-fired equipment to condensing technology. In the medium term, electric water heaters would transition to heat pump technology. The medium-term goals also lay out research and development targets to support both the commercialization, deployment and performance improvements of gas heat pump technology. The long-term aspirational goal is to transition the entire market to technologies that have an energy performance greater than 100%. While not directly addressed, it is also expected that the performance and cost of electric heat pumps will also improve between now and 2035.

4.2 Key market barriers for the adoption of high efficiency water heater technologies

The following have been identified as key barriers to market adoption of water heating technologies needed to achieve the aspirational goals. Products subject to ongoing regulatory development at the federal level are not included.

4.2.1 Overarching challenge

Reducing the upfront cost of a water heater is a critical issue because replacing a water heater is a reactive and often urgent decision for consumers (e.g. when the existing water heater breaks). For this reason, high upfront costs are one of the biggest barriers to adoption of more efficient products, even when the consumer benefits from a favourable payback in energy savings over the life of the product.

4.2.2 Barriers to meeting the short-term aspirational goal – Condensing gas technology

The short-term aspirational goal would complete the transition of the market for fuel- burning equipment to condensing technology. The focus here is on residential gas- fired storage water heaters, and the key barriers are:

- **Accessibility**: Storage tanks using condensing technology are not widely accessible in all sizes of residential water heaters sold today, which makes them less attractive to wholesalers and contractors that want to have product lines marketable to all end-use applications. This translates into a limited number of product models being available in the market.
- **Awareness**: Mechanical contractors and consulting engineers are not very familiar with this technology. When contractors and engineers are uncomfortable with a new technology due to lack of "know-how" or ability to install, they are unlikely to recommend the product.
- **Affordability:** The high upfront cost, coupled with the low cost of natural gas, makes the economic payback longer than the life expectancy of the product. The demand for this product is also very low, and consequently the volume of current sales is not sufficient to bring costs down. Even with a positive payback, the purchaser will have little incentive to buy the more efficient equipment if they are not directly paying the cost of heating the water (e.g. condo owner versus renter; provinces with water heater rental markets).

4.2.3 Barriers to meeting the medium-term aspirational goal: Electric heat pumps

The medium-term aspirational goals would transition electric water heaters to heat pump technology. The key barriers are:

- **Accessibility**: There is no standard approach for calculating the energy performance of heat pump water heaters in Canadian climate conditions while ensuring it also meets national health requirements for minimum water temperature. It is therefore difficult to predict energy savings over the life of the product. There is also very limited access to these products in the market.
- **Awareness**: Mechanical contractors, consulting engineers and specifiers are not very familiar with this technology. When contractors and engineers are uncomfortable with a new technology due to lack of "know-how," they are unlikely to recommend the product. There are also no commonly accepted installation practices and guidelines for retrofit applications.
- **Affordability**: The high upfront cost currently means that consumers may not see a positive payback. The demand for this product is very low, and consequently the volume of current sales is not sufficient to bring costs down. Even with a positive payback, the purchaser will have no incentive to buy the more efficient equipment if they are not directly paying the cost of heating the water (e.g. condo owner versus renter, provinces with water heater rental markets).
- **Acceptance:** Electric heat pumps have a number of outstanding technical issues that need to be resolved. For example, water heaters are located in a heated space such as the basement, which means that the heat pump is using useful energy form heated air around the storage tank (instead of free energy from other sources such as outside air, for example). Avoiding this situation can require additional ducting, which makes retrofit installations a challenge. If heat is taken from the outdoor air, the heat pump must be able to work down at very low temperatures. Moreover, the use of heat recovery ventilators (HRVs) is an issue as well, since the heat exchanger can freeze up, reducing performance. In addition, maintenance requirements and durability, such as filter replacements and refrigerant recharging, are not well known and understood. There may also be technical barriers to meeting higher loads in commercial applications. Finally, heat pumps installed in small spaces may create noise, and have size constraints.

4.2.4 Barriers to meeting the long-term aspirational goal: Gas heat pumps

The long-term aspirational goals would transition the entire water heating market to heat pump technology or integrated heating systems that can achieve greater than 100% energy performance. The focus here is on gas absorption heat pump technology.21

Gas absorption heat pumps may offer a significant increase in energy performance beyond existing condensing gas heating systems. However, they face barriers to availability, accessibility, awareness, affordability and acceptance because they are not yet commercialized in Canada. The technology is lacking key market and technical development, including making the case for performance and economic payback, ensuring there are no impediments to its commercialization (e.g. in existing codes and standards), demonstrating the technology can work in cold climates, developing standardized testing procedures and making the market players aware the technology exists. It is expected that support for research and development through the medium term will resolve some of these issues.

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