Understanding Energy Efficiency Retrofit Options for Your House

How do you decide what to do to make your house more energy efficient? There are so many questions, so many possible directions and so many possible answers. How do you get started? How are pre-existing problems addressed? What are your retrofit options? How can the retrofit work be organized to help ensure the best results? It is no wonder homeowners sometimes find themselves unsure of how best to proceed with energy efficiency retrofit projects.

While you can get good advice from qualified contractors, suppliers and other sources of renovation information, it’s a good idea to be generally informed about your energy efficiency retrofit options so you are aware of the possibilities and potential obstacles you might encounter. By increasing your understanding of some of the more common energy efficiency retrofit options available, you will be better prepared to sort through all the information you will be offered by renovation contractors. It can also give you a head start in developing a retrofit plan.

To help guide homeowners through energy efficiency retrofits, the following “decision trees” have been prepared. The decision trees were developed to help homeowners decide how best to approach an energy efficiency retrofit while, at the same time, addressing typical pre-existing conditions and avoiding problems in the future that can undermine their retrofit investment. Typical questions a homeowner might have concerning a number of common retrofits are asked and, based on a “yes” or “no” response, further options are provided to help them develop their energy efficiency retrofit strategy.

The decision trees provide a pathway toward aggressive energy saving retrofits, as these are often the most challenging for homeowners to fully understand and plan. For instance, the levels of insulation retrofit often recommended are close to what is required for modern, energy-efficient, new houses. While such retrofits may seem ambitious, it is worthwhile to note that you often have only one chance to cost-effectively make a renovation or retrofit project as energy efficient as it could be. Don’t let future energy costs leave you wishing that you had chosen to make your newly renovated house more energy efficient and comfortable.

RETROFIT CATEGORIES

The decision trees are grouped into three retrofit categories:

1. basement, crawl space and slab-on-grade foundation retrofits;
2. first- and second-storey retrofits  
   (walls, windows and roofs); and
3. mechanical system retrofits  
   (furnaces, water heaters and  
   ventilation systems).

They will not necessarily apply to  
all houses and all situations and  
are intended to provide general  
guidance only. The actual physical  
characteristics and condition of your  
house as well as the local availability  
of products and expertise will  
affect your actual retrofit decisions.  
However, by following the decision  
trees through their various steps,  
you will be better informed of the  
various options and considerations  
for your retrofit project and the  
ways in which various issues that  
amay arise may be handled.

**Basement, crawl space and  
slab-on-grade foundation  
retrofits**

If you plan on retrofitting your  
basement, cellar or crawl space,  
or slab-on-grade foundation,  
use Decision tree 1, on page 4,  
to establish which of the following  
retrofit decision trees best apply  
to your situation. More than  
one may apply.

1(a) Basement floor retrofits  
1(b) Basement wall retrofits  
1(c) Slab-on-grade  
    foundation retrofits  
1(d) Crawl space retrofits

**First- and second-storey  
retrofits**

If you plan on retrofitting your  
walls, windows or roof, use  
Decision tree 2, on page 9,  
to establish which of the following  
retrofit decision trees best apply  
to your situation. More than  
one may apply.

2(a) Wall retrofits  
2(b) Window retrofits  
2(c) Roof retrofits

**Mechanical system retrofits**

If you plan on upgrading your  
heating, ventilation or domestic hot  
water systems, use Decision tree 3,  
on page 13, to establish which of  
the following retrofit decision trees  
best apply to your situation. More  
than one may apply.

3(a) Space heating system retrofits  
3(b) Ground-source heat  
    pump retrofits  
3(c) Ventilation system retrofits  
3(d) Domestic water heating  
    system retrofits

**PRECAUTION**

Energy efficiency retrofits can have  
unintended effects, so before the  
work is started, the house should be  
checked for pre-existing problems.  
This will help anticipate the possible  
impacts of the retrofit work on  
indoor air quality, building envelope  
durability and heating appliance  
performance, as well as other  
potential issues.

**Pre-existing problems**

Often, houses may have pre-existing  
problems that should be corrected  
before starting an energy efficiency  
building envelope retrofit project.  
These might include moisture  
problems (high humidity, water  
leaks, dampness, mold, etc.) in the  
roof, walls, floors or foundation;  
indoor air quality problems (stale  
air, lingering odours, soil gas,  
pollutant emissions from household  
products, etc.); or structural sags,  
cracks and deflections in the walls,  
floors or ceilings. Undertaking an  
energy efficiency building envelope  
retrofit before dealing with the  
pre-existing problems may make  
the problems worse and may result  
in the loss of the time and money  
invested in the retrofit work.  
A qualified home inspector or  
a knowledgeable energy advisor  
can help identify pre-existing  
problems and develop solutions.

**Indoor air quality**

Reducing air leaks will reduce the  
amount of air entering and leaving  
the house. This may cause the air  
in the retrofitted house to seem stale  
and odours to linger longer. Odours  
from previously unnoticed sources
(such as hobbies, pets or stored items) may become more apparent and more objectionable. Measuring the air leakage of the house with a blower door depressurization test before and after the retrofit work can give an idea of how much the air leakage of the house has been reduced. If the reduction is significant, it may be necessary to add mechanical ventilation (bathroom fans, a range hood, an air exchanger or, better yet, a heat recovery ventilator). When properly designed and installed, mechanical ventilation is more energy efficient and effective than natural air leakage.

**Building envelope durability**

Adding insulation to exterior walls, basements and attic spaces can lead to moisture-related damage to the building envelope if inside and outside sources of moisture are not controlled. Outside sources of moisture can be controlled by ensuring that the roof properly drains water, that there are adequate roof overhangs to protect the walls and window openings below, that a rainscreen assembly is used on the exterior walls, that eavestroughs catch and drain water away from the foundation, that the foundation is protected from moisture and that the site is properly graded to flow surface water away from the house. Inside sources of moisture can be controlled by ensuring that there is adequate mechanical ventilation (bathroom fans, range hoods, air exchangers or heat recovery ventilators) to remove high interior humidity (for example, from showers or cooking). Installing a vapour retarder (such as a polyethylene sheet or vapour-retarding paint) and—more importantly—reducing air leaks will help prevent moisture from moving from the house into attic spaces and exterior walls.

**Combustion appliance backdrafting**

Reducing air leaks in houses with natural-draft furnaces, water heaters and fireplaces can decrease the air needed for the safe and efficient operation of these appliances. Also, the presence of powerful or numerous exhaust fans in a more airtight house could increase the risk that the appliances will not properly vent combustion gases when an exhaust fan is in operation—a situation known as “backdrafting.” Providing adequate combustion air for heating appliances and sufficient make-up air to balance exhaust air systems may be a necessary part of a building envelope insulation retrofit project. The safest solution is to convert combustion appliances to direct-vent units or sealed-combustion units. The backdrafting risk can often be assessed by a qualified energy advisor. Mechanical contractors can be consulted regarding make-up air systems as well as direct-vent and sealed-combustion appliance options for furnaces, hot water tanks, fireplaces, etc.

**Heating system performance**

An energy efficiency building envelope retrofit will reduce space heating needs and, as a result, the original furnace or boiler may be oversized for the house. Oversized heating equipment may not operate efficiently, as it tends to cycle on and off more frequently. If the furnace (or boiler) is old enough to consider replacing (15 years or older) as a part of the overall retrofit project, a qualified contractor can be consulted to perform a heat loss calculation and determine the right size of the new furnace or boiler based on the reduced heat loss from the house. This will help ensure the heating system runs as efficiently as possible.

**Renovation hazards**

Some interior finishes and materials, especially in older houses, may contain hazardous materials, such as asbestos in insulation and siding, lead in paint, and rodent or bird waste. Some equipment, such as knob and tube wiring, can represent
other hazards. When renovating, take care to protect workers and the home’s occupants from hazardous materials. For information on hazardous materials, visit Health Canada’s website at http://www.hc-sc.gc.ca/ewh-semt/index-eng.php.

GETTING THE HELP YOU NEED
Consult a qualified energy advisor, building professional, home inspector or contractor before the retrofit to better understand, and plan for, pre-existing conditions and possible unintended effects of the retrofit project. Often, corrective measures can be planned that not only prevent problems but also add value to the overall project. For more information on retrofit and renovation considerations, visit CMHC’s website at www.cmhc.ca.

Decision tree 1  Basement, crawl space and slab-on-grade foundation retrofits
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Decision tree 1(a)  Basement floor retrofits

Health Canada recommends that all houses be tested for radon gas, so arrange for a test or purchase a test kit and do it yourself. Does the house have a radon or other soil gas problem?

Yes → Measures to reduce the entry of soil gases (such as a subfloor ventilation system, fan, vent ducting and wiring) should be included as part of the retrofit work. Visit Health Canada's website at www.hc-sc.gc.ca for more information.

No → Contact a qualified contractor to discuss the installation of a soil gas remediation system.

Does the basement have moisture problems, such as standing water, water stains, moldy odours or condensation on the walls or floor?

Yes → Take steps to solve moisture problems before proceeding. Older foundations may need new exterior dampproofing and drainage tiles installed before investing in basement renovations to ensure the basement is dry and to prevent future moisture problems. Steps to identify and solve moisture problems may include:

- determining the source of moisture (roof runoff, local water table level, slope of site, leaky pipes, etc.);
- correcting the problems (fixing eavestroughs, directing downspouts away from the foundation, sloping the grade away from the foundation, repairing cracks, fixing plumbing leaks, etc.);
- cleaning up any mold and mildew; and
- if necessary, excavating the foundation to install a new foundation moisture protection and drainage system; exterior insulation and waterproofing can be added to the basement walls when foundation walls are excavated—see Decision tree 1(b).

No → If the height between the ceiling and floor is adequate, basement floors can be insulated by applying insulation on top of the floor and taking steps to protect the newly installed flooring system from moisture that may come up through the basement floor. The steps may include:

- placing a moisture barrier over the existing floor slab (or dirt floor);
- installing treated framing over the moisture barrier; the framing should be positioned to allow any water that may get under the floor to flow to a floor drain or other drainage point;
- placing appropriate insulation (extruded polystyrene board insulation, closed-cell spray foam insulation, etc.) between the framing members to provide wall-to-wall insulation coverage;
- placing plywood or oriented strand board (OSB) sheathing over the framing and covering with interior floor finish;
- alternatively, after the moisture barrier is put down, applying a 25- to 50-mm (1- to 2-in.) layer of extruded polystyrene and then pouring a concrete floor slab over the foam board;
- alternatively, installing a proprietary basement floor insulation and moisture protection product; and
- keeping the basement dry by dehumidification and providing well-distributed space heating and continuous air circulation.

Retest the house for radon and other soil gases. If necessary, connect the subfloor ventilation system to an exhaust fan, and operate the system to limit the entry of soil gases into the basement.
Health Canada recommends that all houses be tested for radon gas, so arrange for a test or purchase a test kit and do it yourself. Does the house have a radon or other soil gas problem?

No

Does the basement have moisture problems, such as standing water, water stains, dampness, moldy odours or condensation on the walls or floor?

No

Are the basement walls finished on the interior?

No

An interior insulation retrofit may be possible. The wall system should be designed and installed to allow any water or moisture that may get between the insulation and the foundation wall to drain out from behind the wall without wetting the wall assembly. Many different interior insulating options are available (such as glass or mineral fibre, foam board or spray foam). The approach for spray and board-type foam insulation can include:

- applying 50–to 100-mm (2–to 4-in.) thick extruded polystyrene board insulation over the inside surface of the foundation wall with compatible adhesives or fasteners;
- air sealing all penetrations and joints in the foam board with closed-cell spray foam insulation or compatible caulking or tape (spray foam can be used to insulate the walls, as well);
- insulating the rim joist area with closed-cell spray foam insulation or extruded polystyrene board insulation cut, fitted and sealed between the floor joists; and
- installing framing—39 x 39 mm (1½ x 1½ in.) or greater—over the insulation to provide space for electrical and mechanical services and to support new drywall; if a polyethylene vapour barrier is required, install it over the foam board before adding the framing.

Help keep the basement dry by dehumidification and provide well-distributed space heating and continuous air circulation.

Retest the house for radon and other soil gases. If necessary, connect the subfloor ventilation system to an exhaust fan, and operate the system to limit the entry of soil gases into the basement.

Yes

Can or will the interior finishes be demolished as part of the retrofit?

Yes

Take steps to solve moisture problems before proceeding. Older foundations may need new exterior dampproofing and drainage tiles installed before investing in basement renovations to ensure the basement is dry and to prevent future moisture problems. Steps to identify and solve moisture problems may include:

- determining the source of moisture (roof runoff, local water table level, slope of site, leaky pipes, etc.);
- correcting the problems (fixing eavestroughs, directing downspouts away from the foundation, sloping the grade away from the foundation, repairing cracks, fixing plumbing leaks, etc.);
- cleaning up any mold and mildew; and
- if necessary, excavating the foundation to install a new foundation moisture protection and drainage system.

If the moisture problem cannot be solved, it may not be advisable to invest in fully finishing a basement, given the continued risk of moisture damage. Water-resistant insulation, such as extruded polystyrene, closed-cell spray foam insulation or mineral wool, may still be applied to the walls and floors to save energy—though foam insulation must be covered by non-combustible material.

No

No

No

Yes

Exterior foundation wall insulation can be applied once the foundation has been excavated and waterproofed. This may involve:

- installing exterior insulation, such as 50–to 100-mm (2–to 4-in.) extruded polystyrene board insulation or semi-rigid mineral wool insulation, on the full height of the foundation walls;
- backfilling with free-draining material and regrading with finished surfaces sloping away from the foundation;
- inside the basement, insulating the rim joist area with closed-cell spray foam insulation or extruded polystyrene board insulation cut, fitted and sealed between the floor joists; and
- if possible, applying framing to the inside of the foundation walls to provide space to run electrical wiring and to support the drywall.

Help keep the basement dry by dehumidification and provide well-distributed space heating and continuous air circulation.

Retest the house for radon and other soil gases. If necessary, connect the subfloor ventilation system to an exhaust fan, and operate the system to limit the entry of soil gases into the basement.

Measures to reduce the entry of soil gases (such as a subfloor ventilation system, fan, vent ducting and wiring) should be included as part of the retrofit work. Visit Health Canada’s website at www.hc-sc.gc.ca for more information.

Contact a qualified contractor to discuss the installation of a soil gas remediation system.
Are there moisture problems with the existing slab, such as moldy odours, wet spots, or efflorescence (white chalky powder)?

Yes

Take steps to solve moisture problems before proceeding. Older slab-on-grade foundations may need new exterior dampproofing and drainage tiles before insulating to ensure long-term performance and to prevent future moisture problems. Steps to identify and solve moisture problems may include:
- determining the source of moisture (roof runoff, local water table level, slope of site, leaky pipes, etc.); and
- correcting the problems (fixing eavestroughs, directing downspouts away from the foundation, sloping the grade away from the foundation, fixing plumbing leaks, etc.).

No

A slab-on-grade foundation may be insulated as detailed for basement floors in Decision tree 1(a). Alternatively, the slab can be insulated by installing an underground “insulation skirt” around the outside of the slab. This may include:
- excavating around the perimeter of the slab (if this has not already been done to correct moisture problems) to expose the slab edge and frost wall to the footing;
- applying dampproofing and installing a new perimeter water drainage system, if needed;
- installing 50- to 100-mm (2- to 4-in.) thick extruded polystyrene insulation board or semi-rigid mineral wool insulation against the slab edge and foundation wall;
- running additional extruded polystyrene board insulation 600 to 1,200 mm (24 to 48 in.) horizontally out away from the wall just above the drain tile to form the “insulation skirt,” and slope the insulation skirt 25 mm (1 in.) downwards for every 250 mm (10 in.) that the insulation board travels outwards, to promote drainage away from the foundation;
- adding protective covering over any exposed insulation on the above-grade portions of the foundation walls and applying flashing over top edge of the insulation to ensure proper drainage; and
- backfilling and sloping the finished grade away from the foundation.
Health Canada recommends that all houses be tested for radon gas, so arrange for a test or purchase a test kit and do it yourself. Does the house have a radon or other soil gas problem?

Yes

Measures to reduce the entry of soil gases (such as a subfloor ventilation system, fan, vent ducting and wiring) should be included as part of the retrofit work. Visit Health Canada’s website at www.hc-sc.gc.ca for more information.

Contact a qualified contractor to discuss the installation of a soil gas system.

No

Does the crawl space have moisture problems, such as standing water, water stains, dampness, moldy odours or condensation on the walls or floor?

Yes

Take steps to solve moisture problems before proceeding with the crawl space insulation project. Older crawl spaces may need new exterior dampproofing and drainage tiles before investing in renovations to keep the crawl space dry and to prevent future moisture problems. Steps to identify and solve moisture problems may include:

- determining the source of moisture (roof runoff, local water table level, slope of site, leaky pipes, etc.);
- correcting the problems (fixing eavestroughs, directing downspouts away from the foundation, sloping the grade away from the foundation, fixing plumbing leaks, etc.);
- cleaning up any mold and mildew; and
- if necessary, excavating the foundation to install a new foundation moisture protection and drainage system; exterior foundation wall insulation, such as 50- to 100-mm (2- to 4-in.) extruded polystyrene or semi-rigid mineral wool insulation, can be applied at this time, as well.

No

This retrofit strategy includes taking steps to better control the temperature and humidity conditions in the crawl space. This can include:

- covering, air sealing and insulating over crawl space vents on exterior walls;
- if not already insulated on the exterior, installing 50- to 100-mm (2- to 4-in.) thick rigid or semi-rigid insulation board or closed-cell spray foam insulation on the interior of the crawl space walls;
- insulating the rim joist area with closed-cell spray foam insulation or with cut, fitted and sealed extruded polystyrene board insulation;
- placing 50- to 100-mm (2- to 4-in.) thick extruded polystyrene insulation board over the entire crawl space floor;
- installing a well-sealed air and moisture barrier over the floor and walls of the crawl space, making it continuous up the inside face of the crawl space wall into the rim joist areas and sealing all seams with appropriate tape; and
- keeping the crawl space warm and dry by dehumidification and providing well-distributed space heating and continuous air circulation.

Retest the house for radon and other soil gases. If necessary, connect the subfloor ventilation system to an exhaust fan, and operate the system to limit the entry of soil gases into the basement.
Decision tree 2  First- and second-storey retrofits

Which aspects of your house will you be retrofitting?

- Walls
  - See Decision tree 2(a): Wall retrofits

- Windows
  - See Decision tree 2(b): Window retrofits

- Roof
  - See Decision tree 2(c): Roof retrofits
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Decision tree 2(a)  Wall retrofits

Do the distances to the property lines allow for increasing the thickness of the exterior walls by adding exterior insulation or can an exemption be obtained to encroach on setbacks to increase the thickness of the exterior walls? Consult a local building official.

No to both

Can the exterior siding be removed, considering:
- cost?
- heritage value?
- aesthetic value?
- difficulty (for example, stone or brick)?

No

Yes
to
either

Can the roof overhangs be extended or adapted to accommodate the additional thickness of the new exterior insulation, siding, etc.? (Larger roof overhangs also better protect windows and walls from rain.)

No

Yes

to
either

Yes to either

Do the interior finishes (for example, panelling or mouldings) of the house have heritage or aesthetic value that you would like to preserve or is a full-scale interior renovation too disruptive to consider?

Yes to either

No to both

A less disruptive interior insulation retrofit may include:
- drilling holes to access wall cavities and, if they are empty, filling them with appropriate insulation (such as blown-in insulation or spray foam); depending on the existing siding material, this might be done from the exterior or interior of the house;
- air sealing all openings, joints and connections;
- drilling holes in the ceiling to insulate and air seal the rim joist area between the floors with closed-cell spray foam insulation; and
- if needed, installing new windows or upgrading existing ones—see Decision tree 2(b).

In this case, interior finishes might be removed and the inside of the walls inspected.

If the wall cavities are empty, the work may include:
- installing insulation (such as fibre batt, blown-in loose fill or spray foam insulation) in the cavity and applying new air and vapour barrier systems and, for additional energy savings, adding horizontal framing over the existing framing to hold an extra 50 to 75 mm (2 to 3 in.) of insulation and electrical services, and then applying new interior finishes and trim.

If the wall cavities are insulated, the work may include:
- confirming that the existing insulation is properly installed and installing a new air and vapour barrier system and, for additional energy savings, adding horizontal interior framing over the existing framing to hold an extra 50 to 75 mm (2 to 3 in.) of insulation and electrical services, and then applying new interior finishes and trim.

Install new windows or upgrade existing ones, if needed—see Decision tree 2(b).
**Decision tree 2(b)  Window retrofits**

- **Do the existing windows have heritage value or do you want to retain the existing windows?**
  - No to both
  - Yes to either

- **Are the sashes, frames, hardware, weatherstripping and glass in good condition?**
  - Yes
  - No

- **Consider increasing the number of windows or increasing the size of windows on south-, southeast- and southwest-facing walls for more passive solar heat.**
  - NOTE: Exterior shading features (such as awnings) may be needed to control solar heat, so that the rooms don’t get uncomfortably warm in the spring, summer and fall.

- **Replace existing windows with new wood-, vinyl- or fibreglass-framed windows.**
  - Glass panes should be at a minimum double-glazed, with 12-mm (½-in.) spacing, low-emissivity coating, insulated spacers between the panes and argon gas fill. In colder climates, triple- or quadruple-glazed windows could be considered. Consult Natural Resources Canada’s website for more information on ENERGY STAR® windows for your area.

- **Air seal the windows. If the interior window trim cannot be removed, this trim can be sealed to the wall and to the window frame with an appropriate caulking. Alternatively, if the trim can be removed, seal the space between the window frame and the rough wall opening with a backer rod and caulking or closed-cell spray foam for larger gaps.**

- **Upgrade the thermal performance of existing windows, by installing interior storm windows over existing fixed (non-operable) units.**

- **Obtain a further upgrade by installing new double-glazed window units with 12-mm (½-in.) spacing, low-emissivity coating and argon gas fill, on the interior of existing fixed (non-operable) units.**

- **Repair and replace window components, and rebuild frames, as required.**

- **If possible, consider replacing glass panes with double-glazed units with 12-mm (½-in.) spacing, low-emissivity coating, insulated spacers between the panes and argon gas fill. Where less thick glass panes are needed, double-glazed units with a 6-mm (¼-in.) air space and krypton gas fill could be used. Be aware that the new glass colour will not match existing glass colour.**

- **Air seal windows to walls by air sealing the window frame directly to the rough opening with a backer rod and sealant or spray foam. Protect against water penetration with appropriate window head, rail and sill dam flashings.**

- **Add exterior shading features (such as retractable awnings) to prevent overheating, so that the rooms don’t get uncomfortably warm from the solar heat through east-, south- and west-facing windows.**
**Decision tree 2(c)  Roof retrofits**

Do you have the option to change the roof structure and height? Check with your local municipal planning department.

- **No**
- **Yes**

**New roof option**
- Remove the existing roof to have an opportunity to design and install new rafters or raised heel trusses in order to accommodate full-depth RSI-10.6 to RSI-14 (R-60 to R-80) insulation out to, and over, the exterior wall. Make sure that the new roof system provides an adequate overhang to protect the walls and windows from the rain. Apply air and vapour barriers on the underside of the new trusses, and seal them to the existing exterior wall air barrier system.

**Over-roofing option**
- Alternatively, design and install a new roof structure over the existing roof. In this case, remove the existing roofing material (shingles, steel), and install new air and vapour barriers over the old roof sheathing. Connect the roof air barrier to the exterior wall air barrier system to reduce air leakage.
- Then, install parallel cord trusses or rafters over the new air and vapour barrier systems aligned with the existing rafters, fill the spaces between the trusses and rafters with RSI-10.6 to RSI-14 (R-60 to R-80) insulation, leaving adequate space above the insulation for ventilation. Apply new sheathing and cover the sheathing with new roofing material.

**Existing attic**
- Explore options to remove the existing attic insulation to allow for thorough air sealing between the attic and the house. Be careful to protect any existing air and vapour barrier material located above the ceiling drywall. Do not remove any insulation that is adhered to building paper, unless all existing insulation and air and moisture barrier systems are to be replaced.
- Before adding insulation, make sure to air seal all openings in the attic floor, including around ducts, pipes and wiring, as well as gaps between partition wall top plates and interior wall finishes. Cover bathroom fans with sealed boxes made from rigid polystyrene board insulation caulked to an air and vapour barrier. Replace any recessed pot lights with approved airtight units. Air sealing helps prevent heat loss and moisture transfer between the house and the attic.
- Place insulation dams under the roof sheathing at the exterior walls to ensure that ventilation from soffit areas into the attic space is maintained. Install closed-cell spray foam insulation between the insulation dams and the top of the exterior walls to maximize the insulation in these typically low-clearance areas.
- Insulate the attic by reinstalling the original insulation and adding new batt or blown-in insulation to achieve the desired RSI value. Closed-cell spray foam insulation offers the best insulating, air sealing and vapour retarder system—especially where attic space is limited.
- Insulate the top of the attic hatch with 200 mm (8 in.) of rigid board insulation or add a plywood box to the top of the hatch to contain the batt or blown-in insulation. Ensure that the joint between the attic hatch and the ceiling has a gasket.
- Ensure that the attic ventilation meets code requirements.

**If you were not able to obtain desired insulation levels in the attic, you can also consider adding insulation to the underside of the ceiling under the attic, if the height between the floor and the ceiling permits it.**
- Apply 50 to 75 mm (2 to 3 in.) of rigid insulation over the existing ceiling finish. Alternatively, install a dropped ceiling and fill the resulting ceiling space with batt, blown-in or spray foam insulation.
- Provide a continuous air and vapour barrier across the entire ceiling beneath the newly installed insulation. Install ceiling gypsum board.
Decision tree 3  Mechanical system retrofits

Which systems are you retrofitting?

- Space heating
  - See Decision tree 3(a): Space heating system retrofits, or Decision tree 3(b): Ground-source heat pump retrofits

- Ventilation
  - See Decision tree 3(c): Ventilation system retrofits

- Water heating
  - See Decision tree 3(d): Domestic water heating system retrofits
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Decision tree 3(a)  Space heating system retrofits

Complete building envelope energy efficiency, insulation and air sealing retrofit measures to reduce space heating requirements.

Have a heat loss calculation for the house prepared by a qualified contractor or design professional, based on the design-day heat loss, plus an oversizing margin of safety (typically no more than 25 per cent).

Will the existing heating system be retained?

- Select a heating system to minimize space heating energy consumption within budget constraints.
- Select the highest-efficiency oil- or gas-fired boiler or furnace that matches the house design heat loss calculated above.
- For forced-air systems, select brushless direct current motors for the circulation fan to reduce electricity consumption.
- Have the ductwork modified to suit the new furnace. Inspect the ductwork for disconnections or closed dampers and make any needed corrections. Air seal all joints and seams in the ductwork with mastic sealant. Have the ductwork cleaned, if necessary. Clean the grilles and diffusers. Check the airflow.
- Ensure that all the ductwork passing through unconditioned spaces is insulated.
- For boilers, inspect the system for leaks and correct the valve positions. Insulate all the piping.
- Install a programmable thermostat to modify the temperature during unoccupied periods or overnight.

If the heating plant is a furnace or a boiler, can the capacity be downsized to match the design heat loss requirements?

- If not, have a heat loss calculation for the house prepared by a qualified contractor or design professional, based on the design-day heat loss, plus an oversizing margin of safety (typically no more than 25 per cent).
- Have the furnace or boiler system inspected, cleaned and serviced to ensure proper operation.
- Explore options to downsize burners or heating elements, and modify controls to match the new heating requirements.

- Install a programmable thermostat to modify the temperature during unoccupied periods or overnight.
- Have all joints and seams in the ductwork air sealed with mastic. Inspect and correct any disconnections and improper damper positions. Clean the ductwork, if necessary.
- Ensure that all the ductwork passing through unconditioned spaces is insulated.
- Inspect, clean and adjust the airflow dampers, diffusers and grilles to ensure good airflow.
- For boilers, inspect the system for leaks and correct the valve positions. Insulate all the piping.
Consider a ground-source heat pump (GSHP) with a minimum heating coefficient of performance (COP) between 3.5 and 4 and a minimum cooling COP between 5 and 5.5. A ground-source heat pump equipped with a desuperheater can also help provide domestic hot water.

Is the house located next to a body of water (lake, river or ocean), or does it have a well with adequate capacity?

- No

Do the lot size, soil conditions and lot area allow for an in-ground, closed-loop, coiled-tube heat exchanger?

- No

Do the lot size, soil conditions and site access allow for the use of a closed-loop system using vertical or horizontal trenches?

- No

Consider using a dual-source heat pump to reduce well or coil field requirements.

Will governing regulations allow for the placement of a heat exchanger in the body of water or the use of well water as a heat source or heat sink?

- No

Is a heat pump system using the body of water or well as a heat source and heat sink a feasible and cost-effective option?

- No

Size the space conditioning system with no more than 50 to 75 per cent of the design space heating capacity.

- For forced-air systems, modify the existing ductwork to suit the airflow requirement of GSHP system.

- Air seal all duct joints and seams, and install insulation in all unconditioned spaces.

- Consider incorporating a desuperheater for domestic hot water.

- Yes

Yes

Yes
Decision tree 3(c)  Ventilation system retrofits

Air sealing or installing a new continuous air barrier system when retrofitting walls, ceilings and foundations is necessary to reduce heat loss, protect the house's structure from moisture accumulation and help keep the house more comfortable. However, air sealing reduces natural ventilation and so must be balanced by the addition of a mechanical ventilation system to help ensure healthy indoor air quality. An airtightness test performed after the completion of the retrofit work can help determine the need for mechanical ventilation.

Note: HRV = Heat Recovery Ventilation, ERV = Energy Recovery Ventilation

![Decision Tree Diagram]

**Energy-efficient HRV/ERV system features**

- ENERGY STAR®-certified
- Heat/energy recovery efficiency greater than 70 per cent
- Brushless direct current motors
- Proper design to meet specific ventilation needs of the house
- Centrally located control panel to adjust airflow speed and operating schedule
- Controls in bathrooms to operate HRV/ERV on high speed as needed
- Installation by a trained contractor (certified by the Heating, Refrigeration and Air Conditioning Institute of Canada, for example) in compliance with local codes and regulations
Understanding Energy Efficiency Retrofit Options for Your House

### Decision tree 3(d)  Domestic water heating system retrofits

**For all systems**
- Repair all leaky faucets.
- Install low-flow shower heads and aerators on faucets (except on utility sinks).
- Install an ENERGY STAR®-rated dishwasher and clothes washing machine.
- Insulate hot water pipes.
- Install heat traps in cold and hot water pipes at hot water tank.

**Is the hot water tank less than three years old?**

- **Yes**
  - **For an electric water heater**
    - Replace the existing hot water tank with a high-efficiency electric hot water tank (energy factor of 0.93 to 0.95) or a heat pump water heater, or convert to natural gas (if available and less expensive).
    - If possible, locate the water heater as close as possible to where the hot water is used.
    - Set the temperature at 60°C. Install a mixing valve to deliver hot water at lower temperatures.
  - **For an oil-fired water heater**
    - Replace the existing hot water tank with a higher-efficiency unit, if available.
    - If a mid-efficiency boiler is used for space heating, replace it with a high-efficiency boiler sized for both hot water and space heating loads.
    - If possible, locate the water heater as close as possible to where the hot water is used.
  - **For a gas-fired water heater**
    - Replace the existing water heater with a high-efficiency, sealed-combustion or induced-draft unit.
    - Instantaneous (or tankless) water heaters can offer significant savings over conventional units.
    - If possible, locate the water heater as close as possible to where the hot water is used.

- **No**
  - **For an electric water heater**
    - Replace the existing hot water tank with a high-efficiency, sealed-combustion or induced-draft unit.
    - Install a desuperheater on the GSHP.

**Is the main vertical drain pipe that serves at least one shower in the house accessible?**

- **Yes**
  - Look into the installation of a drain water heat recovery unit.

- **No**
  - **Does the house have unshaded roof areas facing east, west, south, southeast or southwest?**
    - **Yes**
      - Look into the installation of a solar water heating system.
    - **No**
      - Look into the installation of a drain water heat recovery unit.

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ADDITIONAL RESOURCES

For more information about energy-efficient windows, appliances and mechanical systems, contact Natural Resources Canada at 1-800-387-2000 or visit the Office of Energy Efficiency’s website at www.oee.nrcan.gc.ca (see direct links below).

Office of Energy Efficiency—ENERGY STAR® in Canada
http://oee.nrcan.gc.ca/residential/10759

Office of Energy Efficiency—
Keeping the Heat In
http://oee.nrcan.gc.ca/publications/residential/8584

Office of Energy Efficiency—
Windows, Doors and Skylights
http://oee.nrcan.gc.ca/equipment/windows-doors/4753

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To find more About Your House fact sheets and other housing-related information products, visit our website at www.cmhc.ca. You can also reach us by telephone at 1-800-668-2642 or by fax at 1-800-245-9274.

Free Publications

About Your House fact sheets
Before You Start an Energy-Efficient Retrofit
—The Building Envelope order no. 62264
Before You Start an Energy-Efficient Retrofit
—Mechanical Systems order no. 62262
Insulating Your House order no. 62039

Renovating for Energy Savings case studies
1960s or 70s One-Storey Homes order no. 63706
Common Additions order no. 63718
Duplexes and Triplexes order no. 63714
Homes with Walkout Basements order no. 63716
Mobile Homes order no. 63712
Post-60s Two-Storey Homes order no. 63681
Post-war 1½-Storey Homes order no. 63704
Pre-World War II Houses order no. 63643
Row Houses order no. 63720
Split Entry Homes order no. 63710
Split-Level Homes order no. 63708

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