
Lark Scientific
Lowering Your Carbon Footprint
A guide for Ontario homeowners on spending wisely for real impact

What is the best value for your energy upgrade budget?

We often hear that it is a good idea to upgrade our home's energy efficiency with the goal of improving our carbon footprint. It seems only natural that a better-insulated house with improved windows would be a good thing to do. As they say, every bit helps.

The Canada Greener Homes Grant promotes various upgrades to your house, such as upgrading your windows and doors or improving your attic insulation as a way to cut back on your carbon emissions.

The program will refund homeowners for a portion of their improvements to encourage Canadians to spend on these emission-reducing upgrades.

But how effective are these upgrades? Are these home improvements the best use of your hard-earned income? Are they the best use of tax dollars?

We have taken a closer look at the numbers to understand the overall benefit from both cost and carbon emissions perspectives. Where should homeowners and the Canadian government spend their money to have the most significant impact on emissions?

We have come to a surprising conclusion.

What's the Canada Greener Homes program?

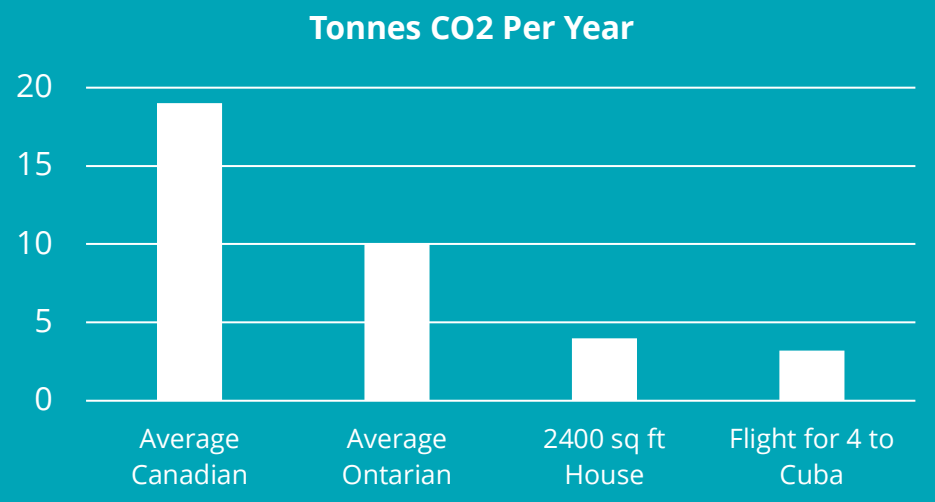
The Canada Greener Homes program was introduced in May of 2021 to help Canadians upgrade their homes, hoping to "fight climate change and create good jobs." Energy efficient retrofits are expected to be an "important component of Canada's commitment to reaching net-zero emissions by 2050."

IT ALL STARTS WITH YOU.

As we see more and more effects of climate change, we start wondering about ways to make positive changes. Some things — like taking shorter showers, recycling, or using energy-efficient light bulbs — are easy to do and don't cost serious money. But real change needs considerable investment; that is where most of us draw the line.

Here are some comparisons to put things into perspective:

- Canadians produce approximately 19 tonnes of Green House Gasses (CO_2 equivalent) per capita annually.
- In Ontario, total annual emissions are estimated at roughly 10 tonnes of CO_2 per capita.
- For a typical 2400 sq ft house in southern Ontario using a high efficiency natural gas furnace, the annual emissions for heating are approximately 4 tonnes of CO_2.
- One round-trip flight from Toronto to Havana in Cuba releases about 0.8 tonnes of CO_2 per person. That means a family of four generates about 3.2 tonnes of CO_2 emissions from one trip!



Windows can wait...

Based on a home energy audit performed in 2022, replacing ten windows on a 2400 sq ft house from older double pane windows to new windows was estimated to save roughly 0.2 tonnes of CO_2 per year. Although it does depend on the current state of the windows. Suppose a home has very old single-pane windows. In that case, the benefit will be significantly higher – potentially five times so.[2]

When many factors are considered, fixing and restoring original windows has been shown to be better for the environment than upgrading to new windows. We must also take into account that the manufacturing of windows will also generate some amount of greenhouse emissions.[4]

These are very difficult to estimate and will depend on the energy mix in the region of manufacturing as well as emissions for shipping. We estimated that ten windows would roughly give a 1-tonne emission of CO_2.

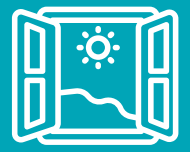
Cost / Benefit of a Window upgrade

Upgrading ten windows in a house costs about $25,0000-30,000. Even considering the grant, it's not as good an investment as it sounds. Assuming a lifetime for the windows of 30 years, at 0.2 tonnes per year, that's 6 tonnes of CO_2 emissions saved. If a homeowner received $3800 back in grants, that would cost approximately $630 to the government per tonne of CO_2. From the point of view of a homeowner, the cost is about $4,000/tonne of CO_2.

For comparison, the Canadian government has priced one tonne of reduced GHG emissions at $50 in 2022.[5] At the time of this article, the price per tonne of CO_2 in Europe is trading at approximately €93. The Canadian program may not be the best use of funds if we are serious about reducing our CO_2 emissions.

So, let's step back and think about potential savings on your heating bill. In 2023, natural gas prices are estimated at around 30 cents per cubic meter, and one gigajoule (GJ) of energy costs about $7.50. Your new windows could save you 4 GJ per year, so that's about $30 of yearly heating savings. This means that investing $25,000 would get you a whopping $1,200 in savings over the 30-year lifetime of the windows (not counting some cooling savings). The Green Energy grant might refund you approximately $3800, so in other words, costs cannot be recovered in the lifetime of the new windows.

Does that sound like a very cost-effective way of reducing your carbon footprint? Not to us. Let's have a look at some alternatives.



Window Upgrade?

NOT WORTH THE COST

Overall Cost: Very High

Climate Benefit: Low

How can you make your house more eco- friendly?

Fixing attic insulation and window and door leaks

Let's look at some of the other home improvement options for improving your home's insulation. You can start by fixing attic insulation and door leaks. According to Energy Star, this would help you increase your home's efficiency by up to 16% regarding heating and cooling. If you heat with natural gas, for a typical 2400-square-foot house, this can reduce about 0.4 tonnes of greenhouse gas emissions per year.

However, we can't ignore the fact that the costs could be high — about $3500 or more. That's about 12 tonnes of CO_2 saved in total if we assume that it would take 30 years until the insulation will need to be replaced.

This gives us a price of about $300 per tonne saved for the homeowner. All of it is approximate: every house is different, and if yours is in poor condition, the benefits might be greater. This option is certainly more reasonable regarding the costs and benefits to both your heating costs and greenhouse emissions.

Attic insulation and leaks?

ONLY IF IN BAD SHAPE

Overall Cost: Low

Climate Benefit: Low

Upgrading your Propane furnace to Geothermal

There are other options you can consider. If you rely on propane, you can replace it with a ground source heat pump. That alone can result in a 60% reduction in greenhouse emissions from heating if propane is used as the backup heat source.

Once again, doing so isn't cheap ($20-30,000), but due to the price of propane, the payback period is about 10-15 years, making this the most sensible of all house upgrades, both from a cost and an ecological perspective. Emissions would be as low as possible if electric heat is used as a backup. But, the operating costs would also be higher.

Propane to Geothermal?

YES

Overall Cost: Fast payback

Climate Benefit: High

Upgrade your Natural Gas furnace to Heat Pumps

One option to consider is replacing your natural gas furnace with an air source heat pump. In terms of efficiency, we expect that over the whole year, an air source heat pump will be less efficient than a ground source heat pump, but the up front cost difference means that far more households will be able to afford a heat pump. It will also be far easier to install, without the need for installation of piping in the ground. If natural gas is used as a backup for the coldest days, then we assume that this system will reduce emissions by about 50%-55%. That's about 2 tonnes of GHG emissions per house per year saved.

Based on current pricing, we expect the rebate to bring the price of a heat pump heating and cooling system to within about $2000 of a new natural gas furnace and air conditioner. If carbon tax prices continue to increase on natural gas, then the overall price of operation over 20 years should be fairly similar in both cases. This option makes the most sense to do at the time a homeowner is replacing their furnace and air conditioner – ***there is no reason to opt for a natural gas furnace over a heat pump system.***

Gas furnace to Heat Pumps?

YES

Overall Cost: Low

Climate Benefit: High

Going from natural gas to heat pump water heater

You can also consider upgrading your water heater to an electric heat pump water heater. This could help you reduce greenhouse emissions by about 0.13 tonnes annually and save money somewhere down the line. The amount of money saved depends on whether you have natural gas heat at home since the heat for the hot water is coming from the air inside the house, requiring more heating of the house. The upfront cost is $5000-6000, while the payback period is longer than the tank's lifetime.

This option is worth considering if you have non-fossil fuel heat and need a new hot water tank. The downside is that you'd also need to upgrade your wiring, which can somewhat increase the cost.

Water Heater Heat Pumps?

CONSIDER WHEN YOU NEED A NEW WATER HEATER

Overall Cost: Medium

Climate Benefit: Low

BEVs might be the answer

A new BEV is not cheap: an entry-level car will set you back $50,000 at least, which is double what you would pay for windows. Doesn't sound like the most economical solution, but let's think ahead. If we compare an extremely fuel-efficient gas car to an entry-level BEV, we estimate that the cost of purchasing the vehicle plus fuel or power over ten years and 200,000 km will be approximately the same.

The bottom line is that the upfront higher price of a BEV will be made for in fuel savings. The BEV will cost the same as a gas-engine vehicle over ten years. This assumes that Ontario's 2023 gas and electricity prices will remain unchanged over the next ten years.

Where the BEV has an advantage is in lower emissions. Let's consider the emissions during manufacturing, and we assume that we are in Ontario, where the grid is 90% non- emitting. In that scenario, a BEV saves you about 2.5 tonnes of CO_2 if you drive 20,000 km annually. Over ten years, that would prevent the emission of 25 tonnes of CO_2! With no added cost to the owner vs. a gas vehicle.

In terms of hybrid vehicles, as expected, they are somewhere in the middle, saving you approximately 1.3 tonnes of CO_2 per year vs. a gas vehicle.

BEV?

YES

Overall Cost: **Low**

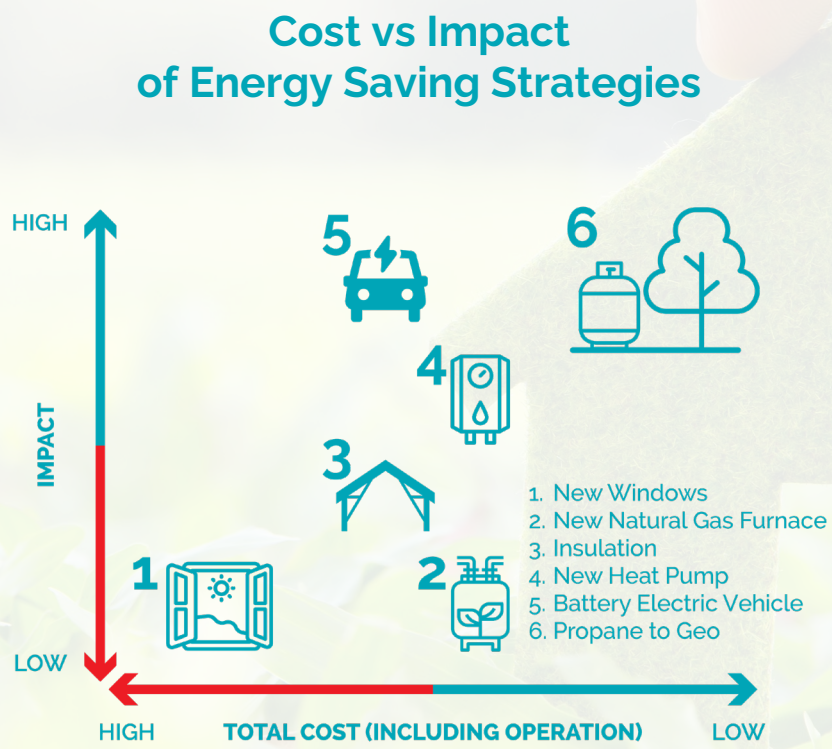
Climate Benefit: High

Some key takeaways

In terms of house upgrades, we conclude that significant upgrades to a house's insulation or windows should be done only when absolutely required. We should do our best to maintain and repair existing windows and doors.

If you are replacing a furnace, consider your options before you are locked in for decades to come. Consider geothermal, if possible, as well as heat pumps. If you use a propane furnace, the transition to a geothermal system will pay for itself in several years.

Consider a BEV or a plug-in hybrid if you are replacing a vehicle. If these are not good options for you, try purchasing the most fuel-efficient car you can live with. Don't buy a large SUV or truck if you don't need one.



Where do we go from here?

Because of the analysis presented above, we feel that it is crucial to begin the transition to lower GHG-emitting houses immediately. All new construction should be transitioned to non-fossil fuel heat and hot water – at the very least they should have heat pumps for heating and cooling with natural gas backup. Once a house is built with a natural gas furnace, replacing the system with geothermal or another heat source will not happen for at least 20 years or more.

The Canadian government should consider increasing rebates for the installation of heat pumps to replace fossil fuel furnaces in provinces with relatively green grids. For example, Germany is funding heat pump installations with 45% rebates in their drive to reduce GHG emissions. At the same time, they are actively working to improve their grid emissions. An increased rebate in Canada would be a much better use of funds than funding window upgrades – if we are serious about tackling GHG emissions.

We must also look at the price of electricity in Ontario. The high cost of electricity relative to natural gas has contributed to the increased use of natural gas heat in Ontario (approximately 60% of homes use natural gas heat). Our tax dollars would be better spent on renewable energy projects to create affordable electricity to shift the financial analysis in favour of non-fossil fuel home heating.

For example, in Quebec, the price of electricity is roughly 7 cents per kWh, whereas it is approximately 13 cents in Ontario. Because of this much cheaper power, most Quebec homes are heated with electric heat generated by an over 90% green grid. See? It can be done.

- Legislate low GHG new construction
- Increase rebates for heat pumps
- Poor value rebates for window upgrades should stop
- Cheaper power in Ontario

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