Case study – A "2030 Ready" Deep Energy Retrofit

Chatham Hope, a non-profit affordable housing provider, operates 134 units of low-rise housing serving families. Much of their scattered housing is aging and in need of renewal. The Board of Chatham Hope sees energy efficiency as an avenue to renew their housing while lowering costs and preparing homes for Canada's 2030 emissions reduction target of 45%. The Board wanted to conduct a test project to understand the cost, benefits, and challenges of a deep energy retrofit. They had a limited budget through their capital reserve and need to stretch it with available grants. Chatham Hope and their property manager, Apex[1], hired Trim Tab[2], a Chatham-based start-up business, to perform the deep energy retrofit on a vacant unit that was undergoing tenant turnover.

The 3-month project, completed during the spring/summer of 2023 focused on improving the thermal performance of the building envelope and upgrading the electrical and heating systems. Electrical has been modernized to current code, the air leakage rate was cut dramatically using breakthrough technology, and central air conditioning was introduced as a byproduct of modernizing the heating system to a heat pump.

The energy rating of the house dropped by 45% from 119 GJ to 65 GJ. The GHG emissions dropped by 67%, from 4.9 tC02e/year to 1.6 tC02e/year, because of reduced heat loss and switching the primary heating source from natural gas to electricity. This GHG reduction far exceeds the 2030 goal for this project of 45%.

Tenants are guaranteed to save $28/month through the elimination of rental charges and are projected to save another $240 in utilities annually. Fuel switching means that electricity consumption is up 60% but natural gas consumption is down 75%. Leaving the gas furnace in place as a back-up heating source for very cold days provides some additional reliability and hedges the uncertainty in future gas and electricity prices.

Living conditions have dramatically improved for tenants. The living space is bigger and brighter. False ceilings were eliminated to return the house to its original shape, and additional LED lighting makes the space brighter. Summertime heat and humidity is now under control because the heat pump is also a very efficient air conditioner. Sealing up all the

[1] www.apmci.ca
[2] www.trimtabretrofits.com

major sources of air leakage will reduce drafts in the winter while providing fewer avenues for pests into the living space – making for a healthier indoor environment.

With core infrastructure modernized, the home is “future-proofed”, so-to-speak. It is ready for full electrification and will be low maintenance for the property manager for many years to come.

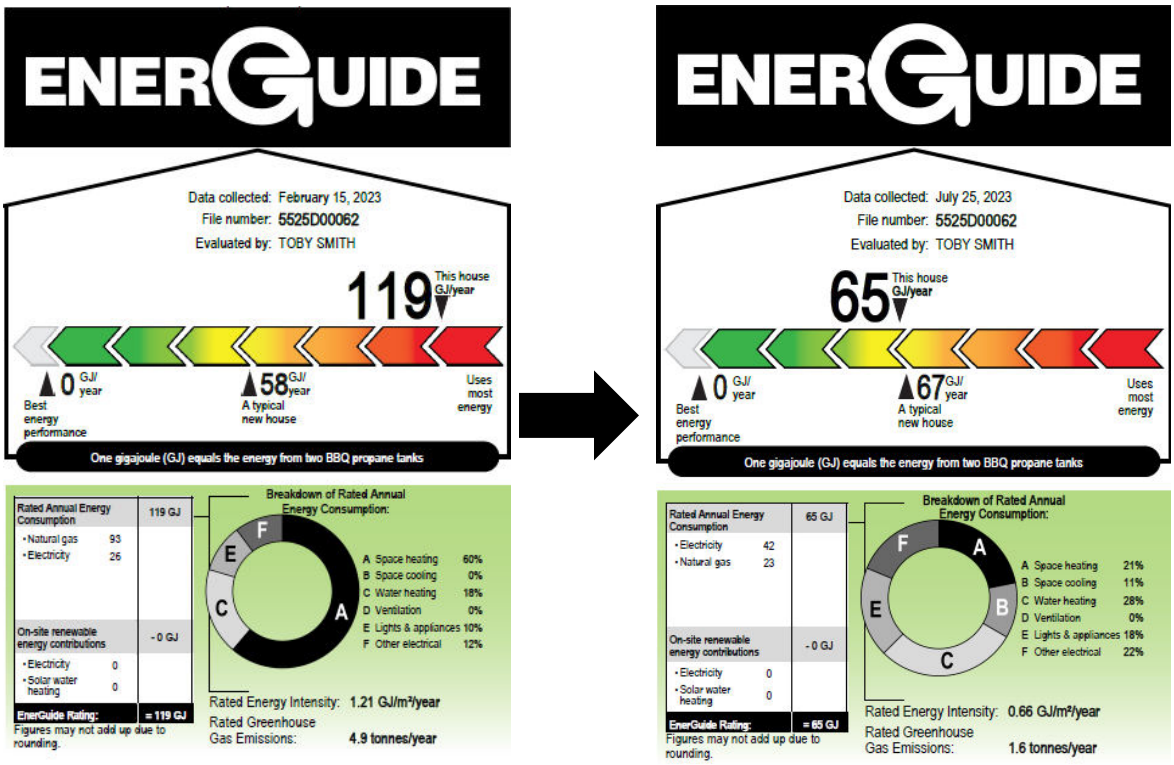


Figure 1: Before-and-after energy rating comparison of the home. Energy use is down 45% from a deep energy retrofit, even after you consider the fact that the has gained central air conditioning. (Please note the 'typical new house' reference point has changed as the home previously did not have air conditioning).

Energy Audit Findings – a very leaky home.

The test home is a 1100 ft2 bungalow built around 1925, located in Chatham, Ontario. It sits on a concrete block foundation with a 3-foot crawlspace. It has a sturdy wood frame structure consisting of rough cut 2x4s and sheathed in barn board, with an aluminum siding exterior. It has seen multiple remodels and tenants over the decades. The crawlspace was previously encapsulated with spray foam and the exterior walls were partially “drilled and filled” with cellulose to provide some nominal amount of insulation.

Building Knowledge Canada[3] was brought in for an independent energy audit. The energy audit found, from conducting a blower door test, that the house was extremely leaky with lots of drafts. The audit found that the T-bar ceiling throughout the house was disguising many sources of air leakage due to degraded plaster, holes from lighting/smoke detector

[3] www.buildingknowledge.ca

retrofits, and ductwork existing outside the conditioned space. The audit also found that there was no insulation in large portions of exterior walls. The audit recommended filling in insulation gaps, improving the home's airtightness, and introducing a heat pump. The home received an energy rating of 119 GJ/year, which is very high for a small home.
The high energy use was only one consequence of the poor condition of the building envelope. The house was clearly uncomfortable from being drafty – the original furnace would frequently cycle. There was evidence of rodents throughout the house.

Above: Investigative work to uncover sources of air leakage, rodent ingress, and heat loss.

Implementing the audit recommendations with a deep energy retrofit

Trim Tab used the audit findings as the basis for a deep energy retrofit that would implement the main recommendations from the energy audit. The following work was completed by a local team of contractors:

1. HVAC: Upgraded furnace to a hybrid heating system (heat pump + gas furnace back-up)
2. Water heating: installed direct vent water heater; eliminated B-vent from old tank.

3. **Demolition**: Removed false ceilings, fireplace, and opened the walls to expose studs and barnboard.
4. **Rough wiring**: Removed existing electrical and re-wired it to current electrical code.
5. **Insulation**: Filled gaps in exteriors walls; maximized attic/ceiling insulation.
6. **Air sealing**: Strategically used spray foam to seal the main floor from the crawl space and attic. Installed new vapor barrier and drywall. Performed Aerobarrier to seal smaller sources of air infiltration.
7. **Finished electrical**: new plugs, switches, LED lighting, smoke/CO detectors.
8. **Finishing work**: floor trim, door jambs, window trim.

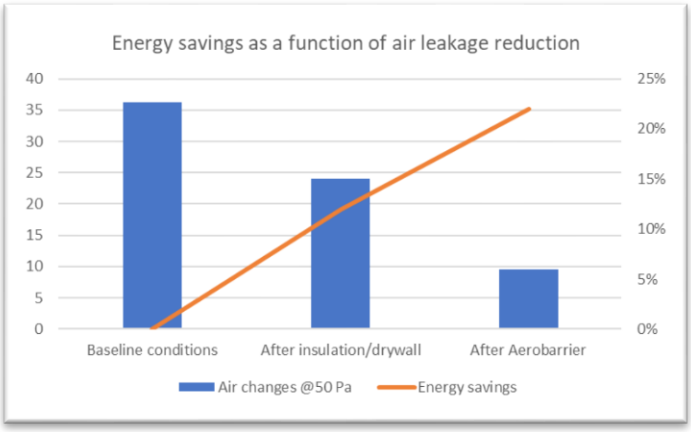
Upon completion, Trim Tab handed the unit back to the property manager for the remainder of its customary remodeling (e.g., floor repair and painting) before moving in the new tenant.

Above: Before (left) and after (right) living room. Ceilings raised 24". Draft free.

Above: Before (left) and after (right) kitchen. Strategically used spray foam to fill gaps in exterior wall insulation and to seal off the main floor from the attic and crawl space.

Technology spotlight: Aerobarrier

The greatest challenge with this project was addressing the very high rate of air leakage into the house. The retrofit strategy was to create an air barrier from the inside of the house, by rehabilitating the walls and ceilings, complete with the use of spray foam behind the walls to seal off the attic and crawlspace. Significant air leakage remained following a mid-construction air tightness test, so Aerobarrier[4], an air sealing technology, was deployed to further improve the air tightness. The overall result was a 74% reduction in air leakage. The breakdown is provided in the graph below. There wasn't enough budget to address all sources of air leakage (e.g., ductwork in the crawl space), but the result is substantial enough to make a noticeable difference in health (i.e., all sources of rodent ingress have been plugged), comfort (heating system cycling less) and energy costs.



Above: Air sealing progress after each stage of the energy retrofit.

Above: Photos of the Aerobarrier setup and results.

[4] https://aeroseal.com/aerobarrier/

Benefits

In summary, the result is a modern looking home from the inside that is bigger, brighter, healthier, and cheaper to operate. Low-income tenants are disproportionately impacted by rising energy costs, so reducing energy bills is one of the big wins. Rental water heater charges of $28/month have been eliminated and heating costs are certain to drop now because the house holds its heat better and because the heat pump can warm the house much more efficiently than a gas furnace. The lower heating costs make it affordable for tenants to run central air conditioning so that they protected from extreme heat. The home is much brighter with a lighting retrofit and the encapsulation of the main floor now keeps the mice away – a much more nurturing environment for a family.

> *"The new tenants will love the brighter environment with the LED lighting in the living room and kitchen…this should foster a sense of pride to take good care of this place."*
>
> - Debbie Grant, Chatham Hope Tenant Relations Worker

With modernized mechanical systems and electrical infrastructure, the property manager will have less maintenance and fewer tenant concerns to address for years to come.

The Board of Directors of the housing operator benefits from being able to better fulfill their mission of providing adequate and affordable housing. Many of the costs incurred in the retrofit are inevitable, and they have stretched their budget by capturing the synergies from expanding a unit turnover into a deep energy retrofit and making full use of existing rebates. Now, this house exceeds the sustainability requirements that are coming for housing as the economy transitions to net zero in the coming decades.

Cost and Value

The total cost of the project was $61,656 before tax. Rebates through the Enbridge Gas Home Efficiency Rebate[5] program maxed out at $10,600, making the net cost $51,900. Air sealing was performed free of charge because the house presented a compelling use case for the technology. The breakdown of the project cost is provided in the table below.

Task	Cost (including 13% HST)
Energy Audit Services	$ 1,130.00
HVAC	$ 15,763.50
Building permit	$ 600.00
Demo, framing, drywall	$ 21,579.37
Insulation	$ 8,137.94
Electrical	$ 11,254.80
Finishing	$ 3,191.20
Total cost	**$ 61,656.81**
Less: Rebates	$ 10,600.00
Total cost, after rebates:	**$ 51,056.81**

Above: A breakdown of the project costs.

[5] https://www.enbridgegas.com/en/residential/rebates-energy-conservation/home-efficiency-rebate-plus

A large amount of these costs is inevitable to simply maintain housing adequacy – so the actual spend related to energy efficiency should be viewed as only an incremental component of these costs, not the entire costs. We provide two examples.

1. Repairing decaying plaster and patching holes ultimately required refinishing large portions of the walls and ceiling. Chatham Hope would have had to spend a fair amount to simply patch up the areas of immediate concern – estimated at about $10,000-$15,000. However, by spending more to open and refinish all the walls, Trim Tab was able to address the root cause of air leakage and fill in major insulation gaps behind the walls.

2. The need for central air conditioning ensures a healthy level of indoor comfort and is increasingly becoming a necessity, as some municipalities are now enacting adequate temperature by-laws[6] that require landlords to maintain a suitable range of indoor temperature during fluctuating and extreme temperature. Spending a few thousand dollars more to install a heat pump instead of a traditional air conditioner also provides a second, more efficient source of home heating. This decision was made easier with available rebates.

Furthermore, performing these retrofits during the narrow window of opportunity of a unit turnover provides cost savings opportunities that would not otherwise exist. We highlight an important example with Aerobarrier. The property management process to remodel and prepare a unit for new tenants typically involves replacing carpet as well as repairing and painting walls. By enabling Aerobarrier to be performed prior to replacing carpeting, and to leverage the existing floor protections in place from the renovation, the cost of Aerobarrier is 25% lower because it reduced the amount of preparation time. This cost could be further reduced by mobilizing Aerobarrier to perform two homes in a day.

In summary, it is substantially cheaper over the life of the home to leverage “trigger points” in the asset management process than to react, patch or replace like-for-like. The turnover of a unit is a narrow window of opportunity for deploying envelope retrofits at a much lower cost when the house needs to be modernized anyways to maintain adequacy.

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[6] https://www.mississauga.ca/city-of-mississauga-news/news/mississauga-by-law-ensures-tenants-have-adequate-building-temperatures-during-fluctuating-weather/