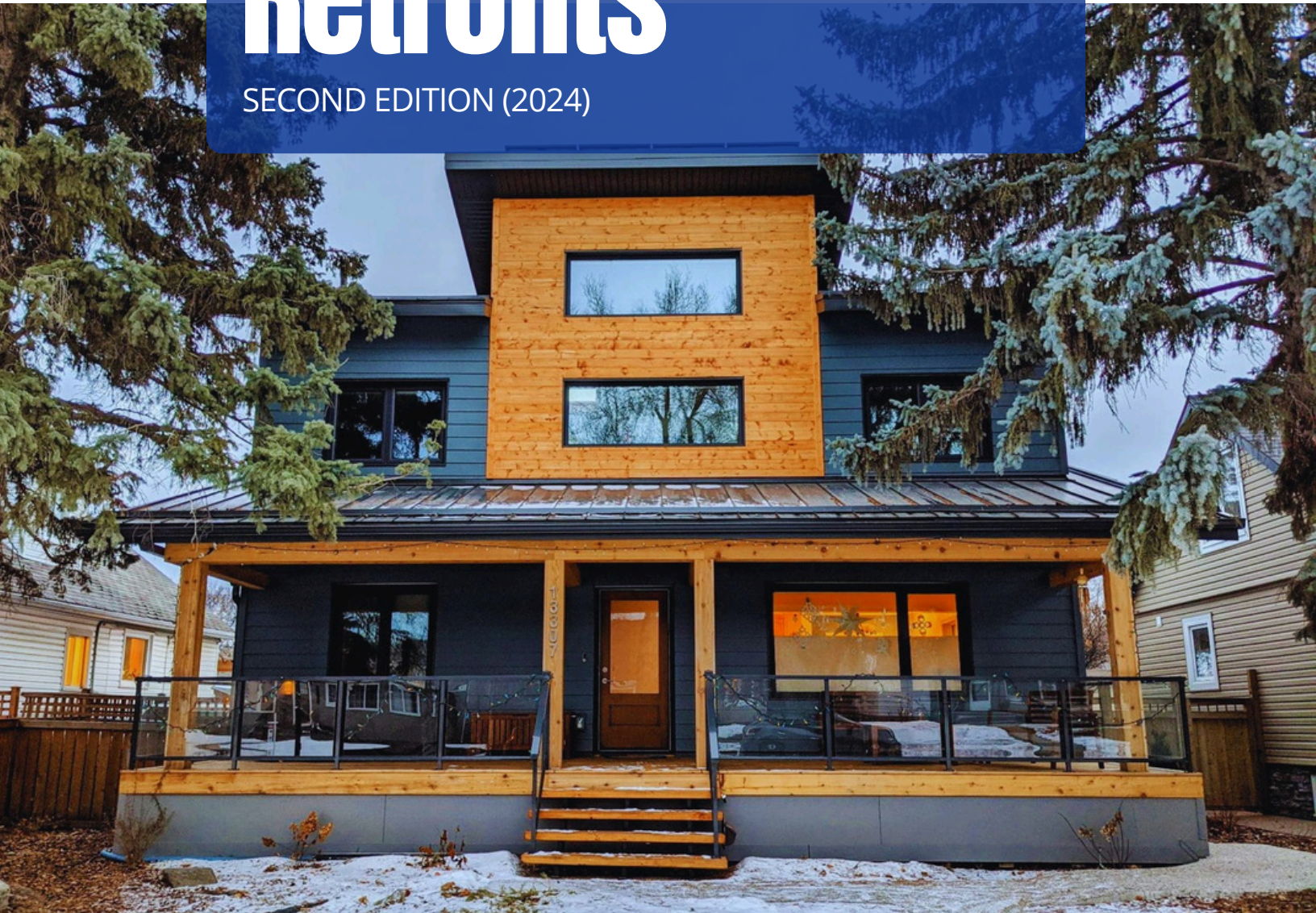


# A Guide to Deep Energy Retrofits

SECOND EDITION (2024)



# ACKNOWLEDGMENTS

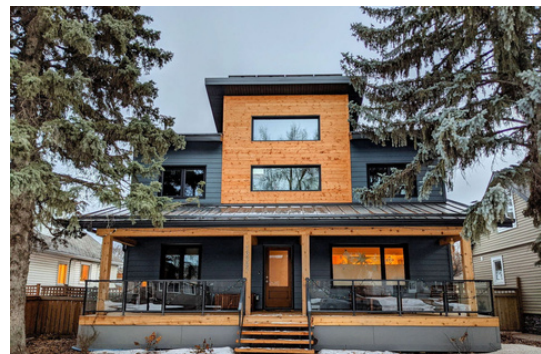
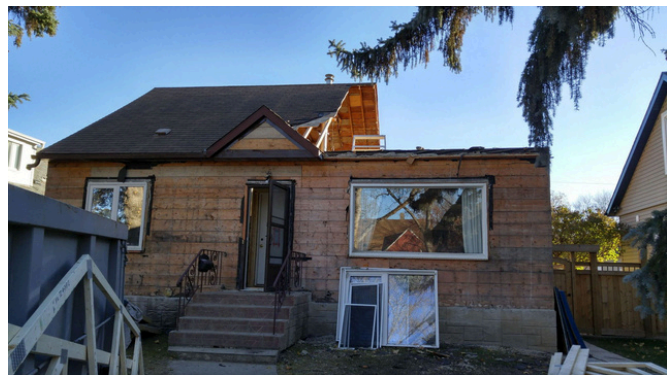
This guide was created by the Southern Alberta Institute of Technology (SAIT) Green Building Technology Access Centre (GBTAC).

SAIT's Green Building Technology Access Centre applied research group began in 2008, bringing SAIT and Green Building Technology researchers together with industry partners to identify and develop environmentally friendly technologies, processes, programs, systems and services that will fundamentally change the way we build, educate and develop skilled labour.

## Our Partners


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- [Retrofit Canada](#)
- [4 Elements Integrated Design Ltd.](#)
- [SNAP Building Inc.](#)
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# TABLE OF CONTENTS

Who is this guide for? **5**

Net-Zero Emissions in Canada by 2050 **6**

## **1 WHAT IS A DEEP ENERGY RETROFIT? 7**

Defining Deep Energy Retrofits  
 Retrofit Budget and Timeframes  
 Beware of Piecemeal Retrofits

## **2 A DEEP ENERGY RETROFIT ROADMAP 11**

Assesment Phase  
 Planning Phase  
 Implementation Phase

## **3 DER CASE STUDY 42**

## **4 RESIDENTIAL ENERGY EFFICIENCY 101 47**

House as a System  
 Energy Literacy  
 At-home Energy Use  
 Basic Energy Management  
 Energy Conservation

## **APPENDIX 56**

Terminology  
 Resources  
 References  
 DER Worksheet

# WHO IS THIS GUIDE FOR?

This guide is primarily for building professionals whose work provides opportunities for energy efficiency upgrades and effective **Deep Energy Retrofits**:

- General Contractors
- Designers
- Project Managers
- Energy Consultants (Advisors)
- Architects
- Tradespeople

The guide will also be useful to homeowners and building owners, educators, and advocates. It is intended to provide information associated with deep energy retrofits and to help users identify a pathway for retrofitting to net-zero emission performance for existing single-family homes. Although focused on single-family homes, the principles described herein are applicable to other building types.

## Purpose of this Guide



Define **Deep Energy Retrofits (DER)** and explain how they support Canada's emission reduction goals.



Provide process considerations through a general **Retrofit Roadmap**.



Provide guidance through content and case studies.

**MAJOR SKILL GAPS IN RESIDENTIAL CONSTRUCTION** have created demand for educated professionals to improve home energy efficiency through Deep Energy Retrofits.



Energy use in housing contributes a significant portion of Canada's carbon emissions. Inefficiencies of existing homes are a major contributor to these emissions. Tearing down every existing inefficient home and rebuilding new would result in large amounts of waste, emissions and embodied carbon.

Deep Energy Retrofits offer one solution to extend the life of the building and reduce carbon emissions and landfill waste.



# NET-ZERO EMISSIONS IN CANADA BY 2050

## Canada has set a goal to get to Net-Zero Carbon Emissions by 2050.

Most of the houses that will exist in 2050 already exist today and are not net-zero ready. The residential construction industry's best opportunity to diminish operational emissions and electricity consumption is to adopt **Deep Energy Retrofits** of existing homes, massively scaling up retrofit offerings over the years to come.

This is achieved by first reducing reliance on emissive activities to minimize new emissions and then implementing methods of capturing carbon dioxide from the atmosphere.

Due to the correlation between energy generation and emissions, net-zero from a household's perspective refers to reducing our energy demand and producing as much clean energy on-site as is consumed over a year.

Reducing emissions is the most applicable and affordable strategy for achieving net-zero. This can be done by building new homes that are constructed to a higher standard than current code, or renovating the existing housing market to improve operational efficiency.

A **Deep Energy Retrofit** can make any existing home energy efficient, decreasing its overall energy demand so that it can get all of its energy needs from renewable sources.

*"Achieving net-zero emissions means our economy either emits no greenhouse gas emissions or offsets its emissions, for example, through actions such as tree planting or employing technologies that can capture carbon before it is released into the air."*

- Government of Canada

## What is net-zero ready?

*"A CHBA Qualified Net-Zero Ready home that is labeled under the program is a home that is recognized by CHBA (...) to be a home that has a renewable energy system designed for it that will allow it to achieve Net-Zero Home performance, but the renewable energy system is not yet installed."*

- Canadian Home Builders Association (CHBA)

# **CHAPTER 1: WHAT IS A DEEP ENERGY RETROFIT?**

# 1 DEFINING DEEP ENERGY RETROFITS

A **Deep Energy Retrofit (DER)** is a change or series of changes that lower the energy needs of the building enough that the remaining energy needs can be provided by emissions-neutral sources. The most readily available form of renewable energy is electricity from hydro, solar photovoltaics or wind. Renewable gas and green hydrogen can be zero emissions sources as well, however, these resources are not yet readily available.

Transforming existing buildings to near net-zero – at least for the initial ones as the green building sector scales up capacity – will be challenging and expensive if not carefully planned. DERs represent a substantial departure from the piecemeal, low-hanging fruit approach to energy upgrades currently encouraged and supported by typical government and utility programs. In some cases, designers may consider each component or system of a house individually. For example, they may design the building envelope without considering the mechanical system.

To make a home net-zero ready, we must recognize that a house is a complex system with many sub-systems that work together to ensure optimum performance and comfort (refer to **Section 4 - House as a System** to learn more).

## Deep Energy Retrofit Benefits



### Improved Comfort / Healthier Living

Upgrading the building envelope by adding continuous insulation and making it airtight is like wrapping it in a warm coat. Reducing air leakage and installing a heat recovery ventilator (HRV) makes it possible to have healthy fresh air and ideal humidity – even in the middle of winter.



### Make necessary repairs anyway / Extend useful life of the building

DERs are a great opportunity to look after neglected maintenance in an efficient and cost-effective way. Exterior re-cladding using the best building science, extends the life of the building for many maintenance-free decades. Updating old heating systems with new technologies - for example, heat pump systems provide effective and efficient heating & cooling.



### Energy savings & security / Increased resale value

DERs protect you from high energy bills and the rising cost of carbon. The multitude of home improvements that come with DERs can help increase the resale value of the existing home.



### Greenhouse Gas Reduction / Energy Efficiency / Peace of mind

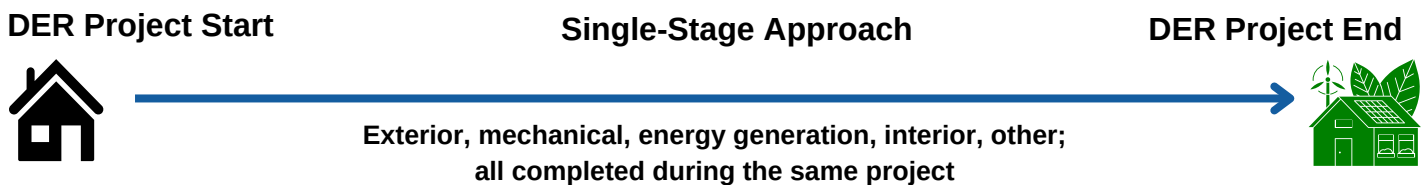
Canada's goal to be net-zero by 2050 means we have to make the homes we live in today net-zero ready. DERs are a solution that gives homeowners a practical and tangible opportunity to do their part to reduce emissions.

# 1 RETROFIT BUDGET AND TIMEFRAMES

Before starting any **DER** project, it is crucial to emphasize that they are a significant investment in time and money. As a result, there are two main **DER** categories: "**Single-Stage**" and "**Multi-Stage**". Keep in mind the retrofit project should always start with an energy audit and building assessment in order to develop a plan so that all of the upgrades are completed in the most efficient manner, and ultimately enable a home to be net-zero ready.

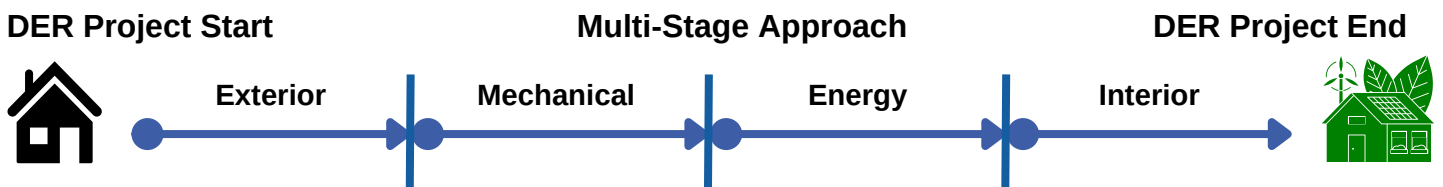
## Single-Stage DER

A **Single-Stage DER** considers all construction upgrades and improvements simultaneously (i.e. in 'one-shot' rather than over time), resulting in a more **significant upfront capital cost** and potential homeowner relocation until the project is complete. For example, panelized retrofits with an HVAC system upgrade exemplify a one-shot approach. However, in the long-term there may be more return on investments through net-zero rebates, government incentives and increased property values.



## Multi-Stage DER

**Multi-Stage DER** projects are planned and executed in stages to make the building net-zero ready. The **Multi-Stage** approach may apply to homeowners with limited funds, **allowing costs to be spread out over a longer timeframe**. The incremental steps of a **Multi-Stage** DER follow a detailed plan so that the improvements are carried out in a defined way, aligned with construction best practices as the homeowner secures additional project funds. If completing a **Multi-Stage** DER, refer to **Section 4 - House as a System** to learn more about approaching a DER using this method.



# 1 BEWARE OF PIECEMEAL RETROFITS

A piecemeal retrofit differs from a properly planned, Multi-Stage retrofit because it does not incorporate a comprehensive plan to make the home net-zero ready. The lack of an overarching retrofit plan often results in higher costs and more work overall when compared to an adequately phased or **Single-Stage** retrofit. Preparing an existing home to be net-zero-ready is significantly more complex. For example, retrofits can begin by replacing the doors and a few windows, and then at a later date, the remaining windows and exterior cladding. However, without adding extra insulation before the cladding, this would prohibit further thermal comfort improvements. This piecemeal, unplanned approach may never get you to net-zero. Care must be taken to ensure upgrade work does not "lock-in" inefficiency or create re-work down the road when the next stage of work is implemented.

## Reasons to **avoid** Piecemeal Retrofits

1

Piecemeal retrofits make it challenging to achieve net-zero and ensure proper performance and comfort within the building during and after the retrofit work is completed.

2

They can cost significantly more than retrofitting through a cohesive and carefully phased plan.

3

Some portions of work may need to be re-done multiple times. For example, if you re-insulate your attic without addressing airtightness, you may have to remove all the new insulation before taking that step.

4

The overall retrofitting process will take longer, presenting inconvenience to the occupants.

## Reasons to **complete** Multi-Stage Retrofits

1

Assess and plan out the full DER project, then plan stages and transitions needed between the different improvements to prevent re-work and lost efforts.

2

By spreading retrofits costs out over time, borrowing costs can be reduced, therefore lowering the total cost, which reduces the need for additional credit.

3

With smaller scopes of work at each stage, occupants can likely stay in the home during the retrofit process.

**CHAPTER 2:  
A DEEP ENERGY  
RETROFIT ROADMAP**

# 2 A DEEP ENERGY RETROFIT ROADMAP

There are many ways to complete DERs because there are so many different building types, shapes, ages, starting conditions, and climate zones.

The most cost-effective pathway for any building requires careful planning that takes into account the current energy consumption of the building, such as where that energy is going and what can be done about it, the maintenance and repairs it may need independent of energy considerations, and the availability of renewable energy sources.

For example, DERs often include reducing the building's energy needs through improvements to the thermal resistance and airtightness of the building envelope (exterior walls, roof, foundation, windows, and doors), electrification of the building's mechanical systems (heating, hot water, and cooking) and tapping into a renewable energy source (solar). Because there are so many options to evaluate, determining the most cost-effective solution set can be complicated. This guide includes a Retrofit Roadmap based on a house-as-a-system approach to simplify that journey.

The Roadmap outlines an integrated design process where an energy model of the existing building and an existing condition assessment of that building are brought together with construction to dial in a plan for the most effective set of upgrades and changes that will make that building net-zero before 2050.

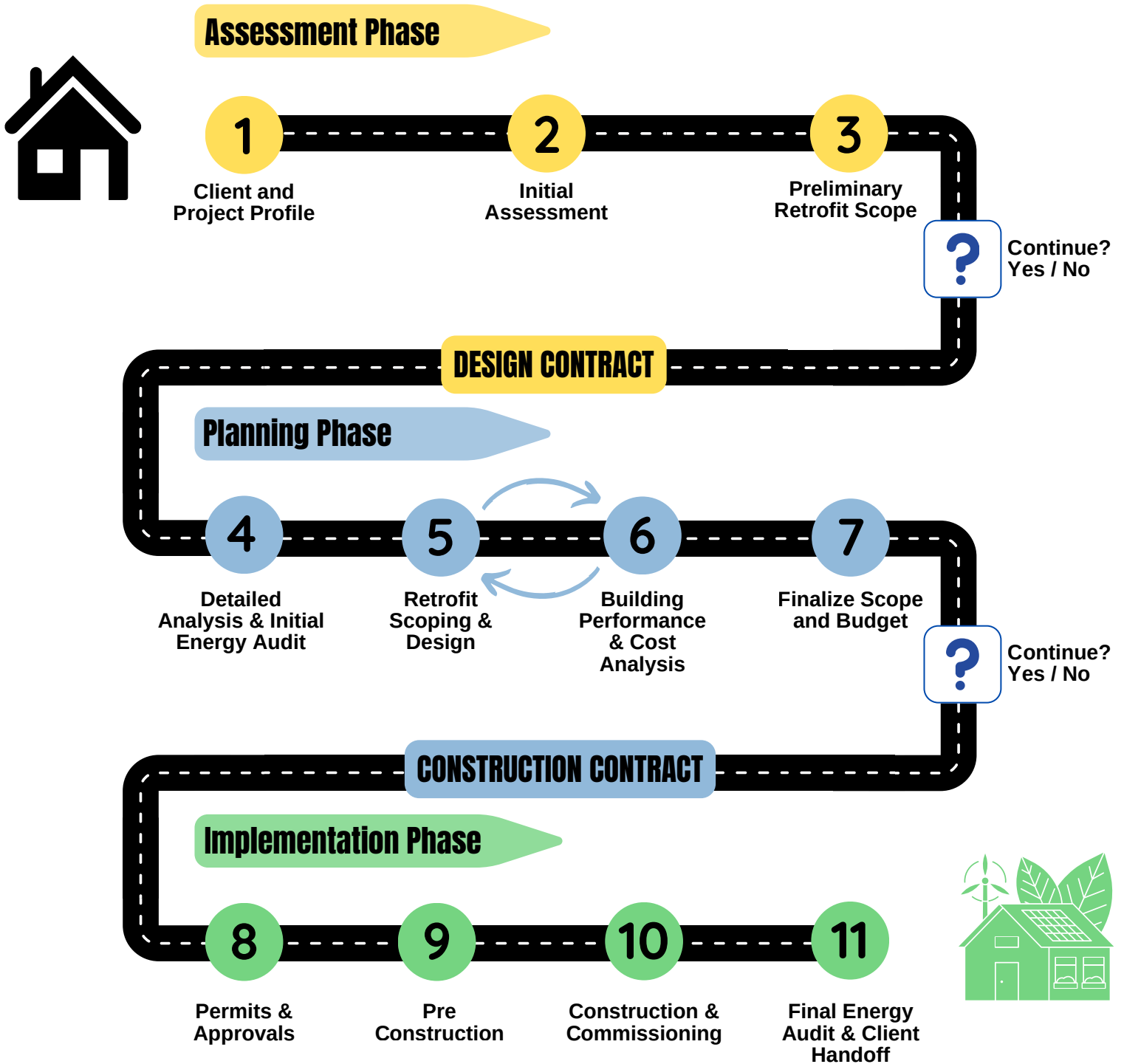
## Aligning Deep Energy Retrofit Goals with Traditional Renovations

Tyler Hermanson of 4 Elements Integrated Design Ltd. has provided some great context for how a DER project can align with traditional renovations:

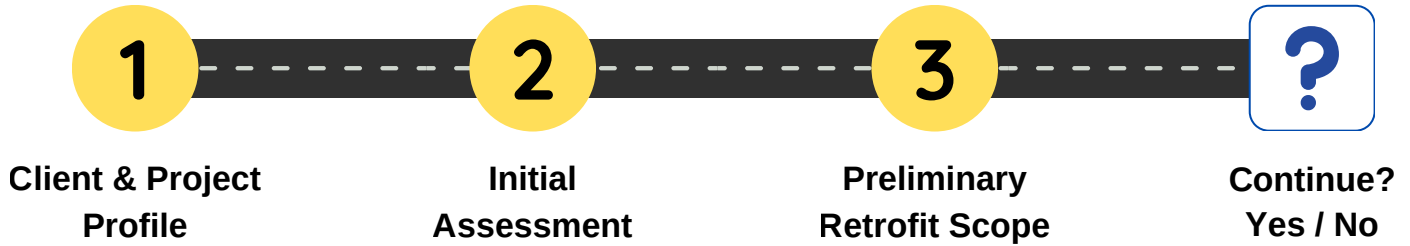
***"While there are some homes that should not conceive of a DER project, the reality is that very few homes are a totally bad candidate. Most will not be ideal but workable, and some will be easy. We have to stop separating out DER from traditional renovations (kitchen, bath, style) as likely these needs are going to weave into the initial needs that drive a DER.***

***We are human after all, and everyone has NEEDS and WANTS and will mix a little of both in. To gain traction and wide adoption the masses have to pick this up, and DER becomes something you do because you are renovating your house anyway, not the sole driver."***

# 2 FOLLOWING THE ROADMAP



# 2 ROADMAP: ASSESSMENT PHASE



The Assessment Phase is a critical first step in the DER process, and in many ways, this is similar to the steps taken for traditional renovations.

The initial phase of a DER focuses on learning and getting to know the client and their proposed project and aligning project goals to understand the scope of work from the customer's perspective.

Secondly, the building and site should be fully assessed in order to understand all existing conditions so that the most relevant retrofit strategies and building science principles can be applied to the retrofit project. With this information, you can complete a preliminary scope of the project.

The Assessment Phase of a DER is further detailed within the following three steps.

## 1 - Client & Project Profile

An important aspect of the success of any construction project, not just DERs, is understanding the client and the building they want to retrofit. Knowing this offers the opportunity to educate the client on specific improvement opportunities they may not be aware of. This can help align their needs with the appropriate DER improvements for their home while still achieving their desired outcome.

### Get to know the client

What are their short-term and long-term goals?

Is there input from others that needs to be considered (i.e. family members)?

Will accessibility (i.e. wheelchair) be a consideration in the future?

Why are they renovating?



What part of the project is most important to them?

Do they know anything about DERs and the multiple benefits?

How can a DER be incorporated into their traditional renovation?

How much are they able to invest in the initial assessment and planning?

# 2 ROADMAP: ASSESSMENT PHASE

## 1 - Client & Project Profile...*continued*

### Understand their goals

Understanding the client's motivations will help you realize the project goals. By first identifying goals, you can envision the desired project outcomes and then use these objectives to define what success looks like for the project. This sets the stage for identifying opportunities that bridge traditional renovations with a deep energy retrofit. At this point, it is also essential to recognize any constraints to completing certain aspects of the project. One of the largest constraints in any household upgrade project is the budget. Other constraints can include project timelines and occupancy (i.e., can the work occur with occupants in the building?). Addressing these constraints and restrictions is essential for planning and determining the type of DER schedule that can be used (i.e. **Single-Stage** or **Multi-Stage**).

## 2 - Initial Assessment

The next step is an onsite initial assessment to evaluate the home's existing conditions and project feasibility. A checklist (**see page 17**) can help guide the site visit, ensuring we gather essential data to inform the deep retrofit approach. By thoroughly analyzing the building and site, we can determine the feasibility of achieving the client's DER goals and identify potential challenges that may impact the project's cost and timeline.

### Key Considerations:

- **Project Budget:** Confirm whether the client's available budget, including potential government grants and subsidies, will likely cover the total project costs.
- **Structural Integrity:** Assess the foundation's condition and above-grade envelope and identify any structural damages.
- **Building Age and Materials:** Consider potential hazards from older construction materials and the need for remediation.
- **Site and Building Complexity:** Evaluate factors like building type, site access, and potential obstacles such as slopes, utilities, or overhead powerlines.
- **System Replacements:** Identify systems nearing the end of their life, such as roofing, siding, windows, doors, and mechanical and electrical equipment (furnace, hot water tank, electrical panel, etc.).
- **Thermal Comfort:** Assess areas of the home that may be drafty or uncomfortable and evaluate the efficiency of existing systems like windows, doors, and furnaces.
- **Solar Potential:** Determine the suitability of the roof or other structures on the property (i.e., a garage) for solar PV installation, considering factors like exposure, shading, and complexity.

## 2 ROADMAP: ASSESSMENT PHASE

### 2 - Initial Assessment *continued...*

The initial assessment will also help determine the project's viability. Is the home a suitable candidate for a deep retrofit? Are there any necessary maintenance tasks that can be addressed as part of the retrofit? Are there space constraints that might limit exterior retrofit solutions? And are there any underlying structural issues? Answers to questions like these are essential to giving you and your client the right information to make the right decisions for the project.

We can develop a well-informed deep retrofit plan that aligns with the client's goals and minimizes potential challenges by addressing these key considerations during the initial assessment.

This may seem like a lot of ground to cover in these first steps of the roadmap, but rest assured that this gets easier with experience.

#### CAUTION: HAZARDOUS MATERIALS



During the assessment of the existing conditions, there is a need to consider the construction material used in the past. A test should be conducted for hazardous material (i.e. asbestos, lead paint, lead pipes) and old / outdated building materials that will need to be replaced (i.e. poly B piping, outdated electrical wiring).



The remediation of hazardous materials and / or replacing outdated materials can be costly. Therefore, discovering early on whether the project will need to incur a remediation cost or replace outdated materials will help determine the achievable retrofit project goals and plan based on the remaining budget.



# INITIAL ASSESSMENT CHECKLIST

## Deep Retrofit Checklist

This checklist provides an overview of factors to consider when assessing a home's suitability for a deep energy retrofit. It can be adapted to specific local conditions, building codes, and individual client goals. Remember, the purpose of the first site visit is to get a feel for the home. A more detailed, comprehensive evaluation will take place later in the process.

Check all that apply:

## FINANCIAL CONSIDERATIONS

- Redevelopment Potential:** Area or community is not a prime candidate for redevelopment.
- Neighborhood Trends:** Recent renovations or rebuilds in the neighborhood.
- Long-Term Ownership:** Plan to own the home long-term.
- Layout Suitability:** Current layout meets needs.
- Lifespan Extension:** Retrofit will extend the home's lifespan.
- Interior Condition:** Interior has already been substantially renovated, or it is being considered as part of this project.

## BUILDING MAINTENANCE NEEDS

- Energy Efficiency:** Air leakage and poor insulation causing issues.
- Windows:** Leaky, condensing, or creating uncomfortable conditions.
- Siding:** Needs repair or replacement.
- Structural Integrity:** No major foundation or structural issues.
- Roof:** Requires maintenance or replacement, simple roof shape with good solar potential.
- HVAC:** Heating and / or cooling systems are at or nearing end of life.
- Indoor Air Quality:** Poor ventilation or presence of harmful substances.
- Utility Costs:** Unreasonably high utility usage and costs.

## OTHER FACTORS

- House Shape:** Simple shape for cost-effective renovation.
- Solar Potential:** Good roofline, southern orientation, and access to sunlight.
- Electrical Service:** Local transformer has capacity for upgrades.
- Future Adaptations:** Can accommodate generational change or aging in place.
- Expansion Potential:** Space for basement or garden suite.
- Exterior Insulation:** Space to add insulation to exterior walls.
- Local Bylaws:** Allows for additional insulation on exterior walls.
- Upgrades and Renovations:** Few or no recent major upgrades or renovations.
- Structural and Water Issues:** No structural damage or water intrusion.
- Hazards:** Few or no hazards (asbestos, vermiculite, lead, poor electrical, etc.).

*This example checklist provided by [SNAP BUILDING](#).*

## 2 ROADMAP: ASSESSMENT PHASE

### 3 - Preliminary Retrofit Scope

After the initial assessment is complete, you can start the preliminary scoping phase. This crucial step lays the groundwork for project planning. During this phase, the team aligns on the project's goals and determines the preferred approach, whether it's a comprehensive **Single-Stage** DER or a phased **Multi-Stage** process. As mentioned on **page 9**, a **Single-Stage** DER requires a larger upfront investment and possible relocation, whereas a **Multi-Stage** approach spreads costs and work over time and offers more flexibility but may cost more in the long run.

An essential task in scoping is identifying priorities: where do you start? The answer depends on what you learned during the Initial Assessment about the building's existing conditions. **Upgrading the building envelope should come before mechanical system upgrades**, as it impacts heating, cooling, and ventilation needs.

#### Developing High-Level Cost Estimates for a Retrofit

Costing a deep retrofit is typically iterative: you will start with a ballpark estimate. DER cost estimates follow the same principles as traditional renovations, covering materials, labour, equipment, overhead, and taxes. However, given the unknowns in retrofits—especially with hidden conditions behind walls or in attics—the estimate should include a recommended amount for a contingency fund.

Costing can also include incentives and rebates available to homeowners across Canada, which can help offset initial expenses. Retrofit professionals familiar with available programs can assist with managing these opportunities to enhance cost-effectiveness.

#### Developing a Rough Timeline for a Deep Retrofit

When planning an initial timeline for a deep retrofit, consider these factors:

- **Project Scope:** The extent of upgrades, such as building envelope improvements or HVAC replacement, affects the timeline.
- **Funding Availability:** The pace of the project depends on available funds from savings, loans, or incentives.
- **Home Occupancy:** If homeowners remain during the retrofit, the timeline should account for disruptions and potential relocations.
- **Local Regulations and Permits:** The time needed to obtain permits varies by location.
- **Contractor Availability:** The availability of qualified contractors also influences the schedule.

## 2 ROADMAP: ASSESSMENT PHASE

### Building the Project Team

A successful DER project needs an integrated team of consultants who understand each other's roles and are involved early to avoid costly mistakes. Ideally, the project is managed by a professional skilled in building science, energy efficiency, auditing, and project management to ensure the retrofit meets goals within budget. Some participants may manage multiple functions depending on their expertise, retrofit experience and availability.

Key team members may include:

- **Energy Advisor / Auditor:** Assesses energy efficiency and obtains certifications.
- **Building Science Consultant:** Advises on building envelope performance, moisture management, and compliance with applicable codes.
- **General Contractor:** Manages the project and construction.
- **Architects / Engineers / Designers:** Offer professional input and support in the design process.
- **Subcontractors / Trades:** Handle on-site work.

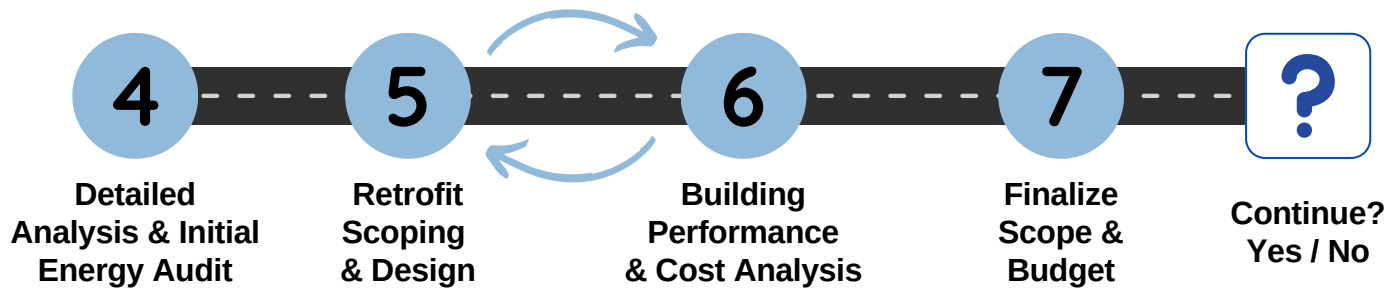
Other possible participants include building owners, occupants, authorities, and utility providers.

### Design Contract

After the assessment phase, the homeowner will need to decide whether to proceed with detailed planning for their DER project, as the subsequent steps come with additional costs. The next phase involves a detailed analysis of conditions, along with in-depth scoping and design, which will require investment. In most cases, contractors and designers will execute a design contract before moving into the planning phase of a DER project.



## 2 ROADMAP: PLANNING PHASE



The next phase of a DER project begins the formal planning and design process, preparing the project to start the work.

**The Planning Phase starts with an energy audit** that provides the baseline data about the building's performance that you will need to begin scoping and designing the retrofit. There will likely be several options on the table for the retrofit, and each one will have different costs and different impacts on the expected post-retrofit performance. This dynamic means you may find yourself moving back and forth between Scoping and Design in Step 5 and Step 6, where you balance the final building performance with the available budget.

Finally, at the end of the Planning Phase, you will finalize the scope and budget and confirm the homeowner's approval to proceed.

### 4 - Detailed Analysis & Initial Energy Audit

Engaging an Energy Advisor is the first step in collecting important information that will guide your retrofit goals. The EnerGuide Rating System (ERS) is the Government of Canada's energy performance rating and labelling program, which includes a designation for homes. The homeowner may have already had an ERS audit completed since the last efficiency improvements, in which case an updated audit is not usually required. The ERS for homes is carried out by energy advisors who work under a national system to consistently measure the energy consumption and efficiency of homes and provide standardized reports. This assessment includes an energy model to calculate energy consumption within the existing home, air tightness testing, and combustion spillage risk assessment, as well as identifying key areas for improvement.

**An energy model of a home takes many things into account, including:**

- Physical space and size
- Geographic orientation
- Building envelope design
- Windows and doors (sizes, orientation and thermal performance)
- Heating and ventilation systems
- Building air leakage rate
- Appliance efficiency
- Thermal bridges
- Shading

# 2 ROADMAP: PLANNING PHASE

## 4 - Detailed Analysis & Initial Energy Audit *continued...*

The ERS may be part of the DER project's building permit requirements and may also be required by household improvement loan and grant programs. The EnerGuide label is also used by third-party certification programs such as CHBA Net-Zero, LEED for Homes, and ENERGY STAR.

Below is an example of an EnerGuide Rating System label for homes.

### EnerGuide Label for Homes

#### LEARN ABOUT YOUR HOME'S ENERGY rating

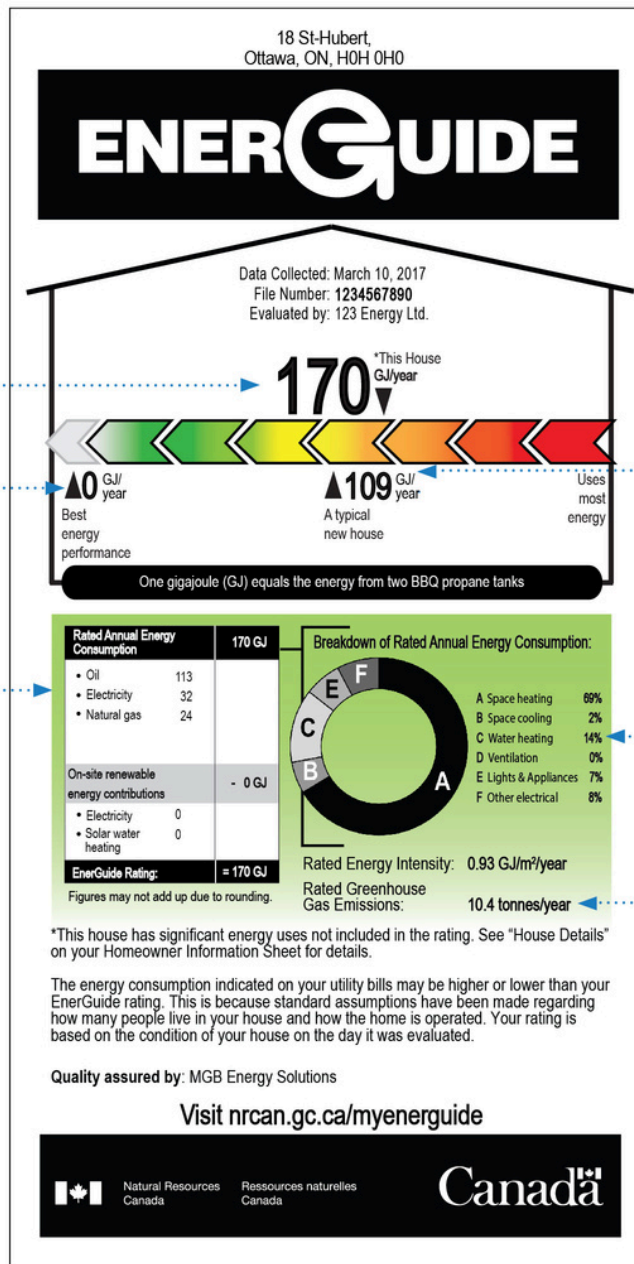
You will receive a rating of the home's energy consumption in gigajoules

#### AIM TOWARDS zero

The lower the number on the new **EnerGuide** scale, the better the energy performance of your home

#### UNDERSTAND HOW YOU USE energy

The label breaks down energy consumed by source



#### COMPARE YOUR HOME'S performance

The label shows how your home's performance compares to a benchmark home

#### FIND OUT WHERE MOST ENERGY IS consumed

The label shows proportion of energy consumed by heating, cooling, ventilation, etc.

#### SEE YOUR IMPACT ON THE environment

The label shows your home's Greenhouse Gas Emissions

## 2 ROADMAP: PLANNING PHASE

### 4 - Detailed Analysis & Initial Energy Audit *continued...*

#### Air Tightness Testing

Since air leakage makes up a large portion of energy loss within Canadian homes (20% - 40%), air tightness testing with a blower door is an essential step during the home's energy audit. This test uses a calibrated fan at a standard pressure of 50 pascals (Pa) that simulates a windy day to measure the flow of air (i.e. air leakage) through the building's envelope. The air leakage of a home is measured in air changes per hour at this standard pressure (ACH50), indicating the number of times per hour the entire volume of air within the home leaks out. A higher ACH50 value signifies increased air leakage in the home. This test provides valuable information on how the home's envelope is performing and where locations for air sealing exist.



#### Existing Conditions Investigations

In addition to confirming the energy performance of the home, other conditions need to be confirmed through further investigation, which will inform the strategies and costs for executing an effective DER as well as the potential for unforeseen repairs that may come up during the execution of the project.

Conditions which may require further investigation at this stage include:

- Presence of hazardous materials such as asbestos or lead.
- Likelihood of moisture damage and presence of mould (sometimes confirmed through opening up small sections of walls in suspect locations)
- Underlying structural components and integrity



## 2 ROADMAP: PLANNING PHASE

### 5 - Retrofit Scoping & Design

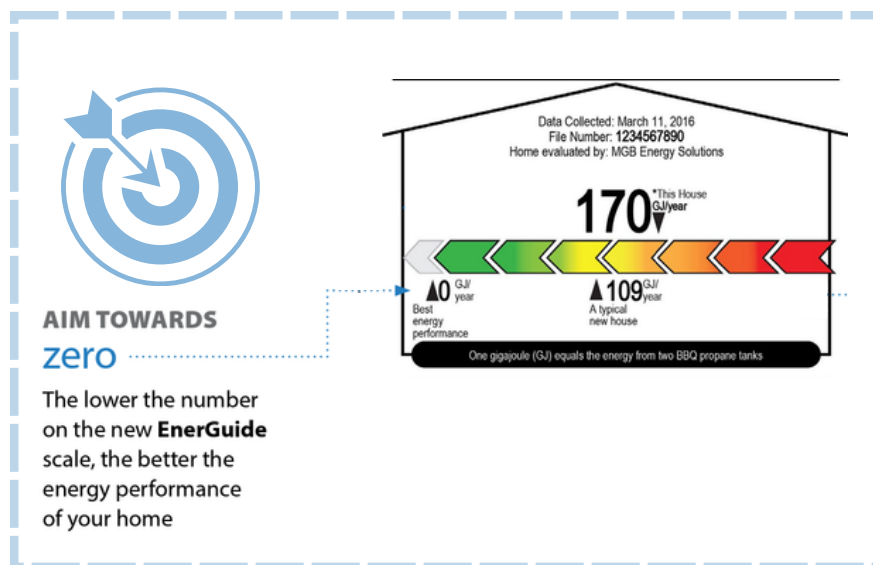
Retrofit Scoping and Design is the stage where the architectural and structural elements of a Deep Energy Retrofit (DER) are conceptualized and refined. This process is based on data from the modelling assessment and energy modelling conducted in earlier stages. Scoping and design help determine the most appropriate and cost-effective solutions for the retrofit while remaining flexible, as the project may move back and forth between the current step, Scoping and Design, and the next step, Building Performance and Cost.

Scoping and Design includes the consideration of these factors:

- Management of hazardous materials, if present
- Heating & ventilation requirements
- Structural changes & requirements
- Insulation type & location
- Reduction of envelope air leakage
- New window positions (recessed in or out)
- Trees / landscaping (kept or removed)
- Soffit overhangs

The following codes, standards and programs provide varying energy performance targets that can be referenced for DER projects:

- National Building Code of Canada Section 9.36
- ENERGY STAR
- CHBA Net-Zero Home Renovation Label
- Enerphit (Passive House Retrofits)
- Passive House



## 2 ROADMAP: PLANNING PHASE

### 5 - Retrofit Scoping & Design *continued...*

Residential DERs should increase thermal resistance and airtightness without compromising the durability of the building's assemblies. Common durability concerns include:

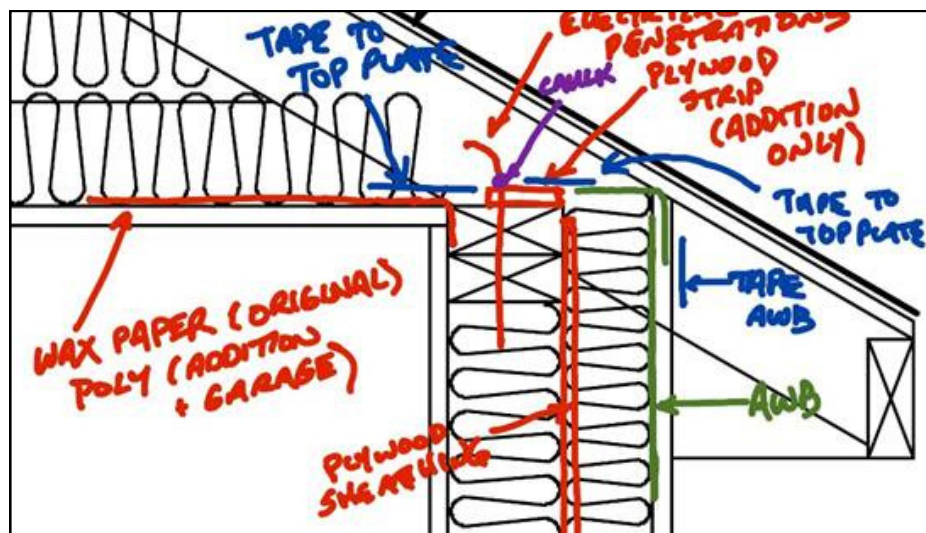
- Bulk water entry due to improper detailing
- Condensation from air leakage
- Material incompatibilities
- Condensation from vapour diffusion
- Proper selection and alignment of product and material lifespans

#### Retrofit Building Science Considerations

There are multiple options for achieving high-performance wall systems. Exterior insulation is highly beneficial for DERs, but poor building science application can lead to issues. A crucial aspect is ensuring the quality and continuity of the four control layers:

- Water control layer (water-shedding surface and water-resistive barrier)
- Air control layer
- Vapour control layer
- Thermal control layer

Each of these layers needs to be maintained or redone if required. In most cases, in existing Canadian homes, the vapour control layer is the air control layer, which is on the warm side of a wall assembly (and often not very air-tight). Because of this, DERs with exterior insulation being added will often add a new air control layer.



## 2 ROADMAP: PLANNING PHASE

### 5 - Retrofit Scoping & Design *continued...*

In Canadian homes, the vapour control layer often doubles as the air control layer, typically positioned on the warm side of a wall assembly. However, when adding exterior insulation, a new air control layer may be required.

**Avoid creating two vapour control layers, as trapped moisture could lead to damage. When using insulation that creates a vapour barrier, ensure enough insulation is installed to move the dew point to the exterior insulation. Fibrous, vapour-open insulations can help minimize this risk.**

When selecting a wall assembly, the key principles are to prioritize air tightness first and vapour control second. Air barriers must be fully effective, as even small air leaks can allow moisture infiltration, unlike vapour barriers, which are still effective when mostly intact. The vapour control layer is concerned with controlling the movement of moisture via diffusion through solid materials, so if it is 95% present, it is 95% effective. The air control layer is concerned with controlling the flow of air through a hole in the building fabric.

As it is driven by air pressure, air will flow preferentially towards a leak, so a 95% complete air barrier is NOT 95% effective. When air flows through a hole, it can also carry significant moisture.

Other considerations when adding exterior insulation include:

- Proper water drainage for the wall system
- Compliance with local building codes
- Fire rating requirements
- Lot coverage and setback regulations



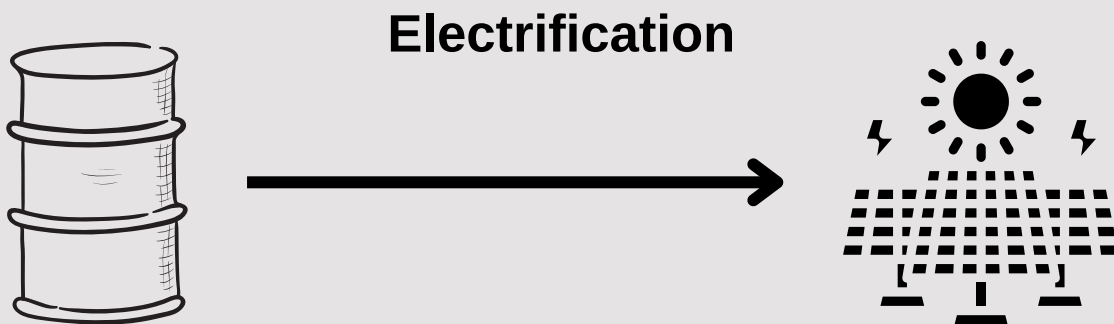
## 2 ROADMAP: PLANNING PHASE

### 5 - Retrofit Scoping & Design continued...

Retrofit Scoping and Design involves the careful consideration of architectural, structural, and energy performance factors. By focusing on elements such as heating and ventilation, insulation, airtightness, and electrification, this stage ensures that all retrofit components are aligned for maximum energy efficiency and durability. Proper attention to building science, especially with the control layers, and the integration of optimized electrification solutions help manage costs while avoiding potential performance issues. Ultimately, the iterative process between Retrofit Scoping and Design and Building Performance and Cost analysis leads to a holistic, efficient, and sustainable transformation of the home.

#### Electrification

Electrification, also known as fuel switching, means that fossil fuel consumption within the home is eliminated by switching all systems (i.e. heating, hot water, cooking, etc.) to those that only use electricity. The primary purpose of electrification is to reduce the greenhouse gas emissions associated with fossil fuel combustion within the building. However, there are several considerations that need to be addressed with electrification, one of which is the **amperage** of the electrical service within the home.



The electrical service of new homes is typically 100 amps. However, older homes undergoing a DER may only have a **60-amp service**, which means that 'electrifying' the home will require an electrical service upgrade, especially with the addition of more systems using electricity. It is essential to engage early with local electrical utilities if the amperage of the electrical service will need to increase as part of the DER. Furthermore, depending on the mechanical systems and appliances installed within a DER, electrification may require a greater than 100-amp service (i.e. 150-amp or 200-amp), which will also have cost implications for installation.

See Chapter 4, **At-Home Energy Use**, for further information on 'electrification'.

# 2 ROADMAP: PLANNING PHASE

## 6 - Building Performance & Cost Analysis

In this phase, you assess how the potential retrofit solutions developed during the Retrofit Scoping and Design phase impact both building performance and project costs. Your performance analysis and cost estimates often lead to design adjustments. By revisiting earlier decisions and refining them, you come up with a final plan that meets the client's goals while staying within their budget.

When analyzing each proposed retrofit, it's important to factor in projected performance along with energy savings, comfort, health benefits, environmental impact, and long-term durability. For example, improving insulation and upgrading heating and ventilation systems will increase energy efficiency while positively affecting air quality and moisture control. One key challenge is finding the right balance between the amount of insulation to install, its cost, and its impact on the heating load, as well as reducing the size and cost of heating and ventilation systems while staying within the overall retrofit budget.

<b>ATTIC &amp; ROOF</b>	
Remove existing attic insulation	\$2,763.60
Sprayfoam roof perimeter	\$1,745.73
Re-shingle roof with new low/high venting	\$9,948.67
Re-insulate attic with 17" loose fill cellulose	\$2,490.60
Remove & seal ceiling/roof penetrations	\$750.75
<b>ATTIC &amp; ROOF SUBTOTAL</b>	<b>\$17,699.35</b>
<b>MECHANICALS</b>	
Air source heat pump hot water tank	\$3,636.08
Air source heat pump, fan coil, backup heat element	\$13,900.00
ERV	\$3,255.00
<b>MECHANICAL SUBTOTAL</b>	<b>\$20,791.08</b>
<b>ELECTRIFICATION</b>	
Electrical rough ins & finish	\$9,851.69
Remove chimney & replace NG with electric fireplace	\$3,226.62
Replace NG with Induction Range	\$2,247.00
Replace standard with air source heat pump dryer	\$1,706.25
<b>ELECTRICAL SUBTOTAL</b>	<b>\$3,953.25</b>
<b>WINDOWS &amp; DOORS</b>	
Framing & install supply	\$2,525.02
Framing & install labor	\$2,627.63
Window, door, hardware supply	\$14,769.03
Interior finishing	\$2,535.34
Window Coverings	\$2,500.00
<b>WINDOWS &amp; DOORS SUBTOTAL</b>	<b>\$24,957.01</b>

As you fine-tune the retrofit solutions, costs for materials, labour, and contractor fees will come into focus. It's essential to align these with the client's budget and the project goals outlined in the Assessment Phase. Inevitably, trade-offs, such as opting for more cost-effective materials or systems that still meet performance requirements, will be necessary.

Retrofit design and costing analysis require an iterative approach, where various combinations of performance enhancements and costs are tested and adjusted. For instance, a high-end mechanical system may offer greater energy savings but exceed the budget. In such cases, you'll explore alternatives that provide similar benefits at a more manageable cost or assess whether the increased upfront cost can be managed based on the projected additional savings.

By the end of this phase, the retrofit plan will strike the right balance between energy performance, cost, comfort, and durability. This iterative process ensures that both the financial constraints and project objectives are in sync, paving the way for a successful retrofit.

# 2 ROADMAP: PLANNING PHASE

## 7 - Finalise Scope and Budget

After completing the performance evaluations and cost analysis, you will finalise the scope and budget for the project. This stage ensures that all project aspects align with the client's goals and budget. It is the critical last step before the construction phase.

At this point, the project team and client must reach a final consensus on the following:

- **Performance goals:** Specific targets for energy efficiency, comfort, and other improvements.
- **Scope of work:** The exact materials, systems, and components for the retrofit.
- **Design adjustments:** Final changes needed to balance cost with performance.

Taking the time to make sure everyone is on the same page will help prevent the risk of significant changes, delays and cost overruns after construction starts.

It is important during the planning stages of a deep energy retrofit to consider the various benefits and not focus solely on utility savings.

### Final Budget

The completed budget must include all estimated costs related to materials, labour, contractor fees, and equipment and systems, such as high-efficiency windows or heat pumps. Taxes, including GST, should be factored into the total. There should also be an allowance for contingency funds to cover unforeseen conditions or complications. This contingency planning is essential in DER projects, where unexpected issues—such as hidden moisture damage or structural challenges—arise after work begins.



**Less & Walker (2015) found that, on average, deep energy retrofits in the U.S. were cash-flow neutral on a monthly basis. However, variability was large, with some projects substantially reducing net monthly costs and others substantially increasing net costs. Questionable cost-effectiveness is thus seen as a barrier to widespread implementation of deep energy retrofits.**

## 2 ROADMAP: PLANNING PHASE

### 7 - Finalise Scope and Budget *continued...*

#### Financing Options and Incentives

Homeowners should explore available rebates, grants, or incentives offered by federal, provincial, or municipal programs, as these can help offset the upfront costs of the DER. Options like Clean Energy Improvement Programs (CEIP), which help finance energy upgrades through property taxes, may also be applicable. The homeowner may require your assistance to complete grant applications before work begins. These programs often require documenting completed work and reporting about the home's energy performance before the funder releases payments to the homeowner. Ensure you understand exactly what information you must provide to support the application and reporting process.

With the scope and budget in place, it is time to prepare the construction contract. This contract should detail the following:

- The list of tasks, materials, and associated costs
- A clear project timeline
- Performance benchmarks and quality standards

In addition to contractual details, the project must comply with local regulations, including building codes, fire safety standards, setback regulations, and any electrical upgrade requirements, particularly if electrification is involved.

The project is now ready for construction with a finalised scope, budget, and contract.



**Always check within the area of the DER project what incentive programs are available. There are incentive options for household efficiency improvements offered at the federal, provincial and municipal levels.**

## 2 ROADMAP: PLANNING PHASE

### 7 - Finalise Scope and Budget *continued...*

#### FINAL CONTRACT

A construction contract is a key document to have in place before securing permits or beginning work on site. In some cases, the design and construction contracts are combined. Many contractors prefer to keep them separate or at least broken into distinct contract phases, which allows homeowners a bit of peace of mind by only committing to the design of their DER project instead of to the full scope of the project before the details are fully worked out during the planning phase.

There are two primary contract delivery methods that can be utilized to execute a DER. Each one has different factors and considerations that determine the best approach for the project and the associated team.

#### Cost Plus

With a cost plus contract, the contractor usually provides a rough estimate of what the work will cost to complete. During execution of the work, they will bill actual labour, material, and overhead costs with a pre-agreed upon percentage for profit (i.e. 25%).

Due to the ease of pivoting when unforeseen conditions are uncovered, many DER contractors prefer to utilize Cost Plus contracts.

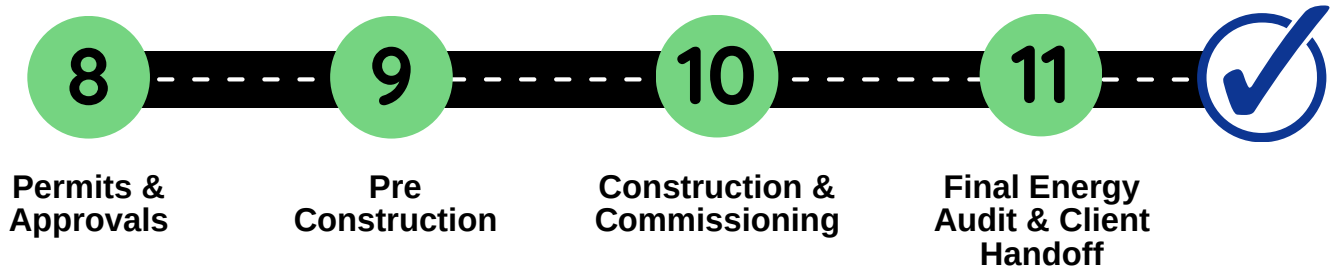
#### Fixed price Contract/Bidding

Under a fixed price contract, competing quotes are obtained from different contractors for a pre-defined scope of work. Based on the provided scope, each contractor will estimate labour, material, overhead, other costs, and profit to include in their bid, along with a timeline to complete the work. When a fixed price contract is awarded, the contractor is committed to doing the pre-defined scope of work for the cost originally quoted and within the quoted timeline, regardless of what it actually costs them to do the work.

One caveat to a fixed price contract is when additional work items are added to the original scope or unforeseen conditions are uncovered. In these instances, a Change Order is used to incorporate the additional costs and timeline delays into the contract.



## 2 ROADMAP: IMPLEMENTATION PHASE



This phase of the DER will focus pre construction activities and develop a timeline for project objectives. Risk assessment plays a vital role in successful construction outcomes, confirming goals, identifying risks, and developing mitigation strategies. It will touch on the work that needs to be done after the planning phase but before any hammers are swung. Lastly, this section highlights the high-level processes in the construction and commissioning of a DER.

### 8 - Permits and Approvals

Before work on site can proceed, it is important to secure any required permits. There will likely be more than one type of permit required for the DER project, such as:

- Building
- Gas
- Electrical (will also cover on-site renewables for most jurisdictions)
- Plumbing (may be needed)
- Development permit: A development permit may be required depending on the project scope. Always confirm with the municipality where the project is located which permits are required.

When preparing for permits, it is important to understand what drawings or documentation will be required as part of the permit application process (and which will also be utilized to guide the completion of the DER work). The following are some considerations of information needed for permit drawings and to guide the actual work of the DER:

- **Architectural / Structural Design:** Working drawings, Real Property Report, envelope upgrade plan, component/material/installation details and specifications.
- **If required:** permit drawings, structural and mechanical engineering review, energy model based on final design.
- **Utility Planning:** Electrical upgrade design/planning/pricing, utility consultation, electrical engineering (if required).
- **Building Capture (if a panelized retrofit):** Digital capture and site measurements will be required for the accurate panel drawings and dimensions needed to construct the panels.

Regardless of the scope of DER work, it is important to reach out to the local municipality or permitting organisation to confirm which construction permits and documentation will be required.

# 2 ROADMAP: IMPLEMENTATION PHASE

## 9 - Pre Construction

- **Permits**
  - Confirm and secure required construction permits.
- **Order Major Components**
  - Lead times - some components will need to be ordered earlier since they will take longer to get delivered
  - Windows / doors
  - Mechanical equipment
  - Specialized lumber products
- **Homeowner / Occupant / Tenant Engagement**
  - Will the tenant be moving out for the duration of the retrofit? Will they be living in a different area of the home?
  - Ensure the tenant understands the construction process and how they will be affected.
  - Does there need to be site protection or containment for areas of the home that aren't being retrofitted, so they don't get damaged or filled with dust?
  - Putting more thought into making the retrofit process easier for the tenant / client goes a long way.
- **Final Construction Schedule**
  - Ensure time of year and weather implications have been considered.
- **Site Preparation**
  - Protect public infrastructure (i.e. sidewalks) and prepare surrounding area of building and landscape for construction work.
  - Ensure all OHS requirements for public safety, worker safety and municipal safety standards are in place.



# 2 ROADMAP: IMPLEMENTATION PHASE

## 10 - Construction

Moving from pre construction to construction is exciting since this is where all the details of the "Planning Phase" gets put into practice and the DER site work gets started. Below is additional information on site-built methods compared to panelized methods, followed by a generalized DER construction order of operations.

### 10 - Construction: Site-Built Methods

"**Site-built methods**" refers to retrofits where all of the construction takes place on-site, which is how the majority of traditional renovations are done. Typically, with DER projects, homeowners can remain in their homes during the construction phase with little disturbance or relocation. However, in retrofits requiring extensive interior work or very invasive exterior work, homeowners may want to find another residence during the retrofit.



### 10 - Construction: Site-Built Options

Below are some material options that can be used when constructing a site-built DER. The use and application of these materials will have been determined during the planning phase, however, the following are some considerations during construction.

There are several different types of **exterior insulation** that could be used in a DER. Some examples include:

- Blown-in Insulation (Dense Packed Insulation)
- Mineral Fibre
- EPS (expanded polystyrene) & GPS (graphite polystyrene - EPS core embedded with graphite)
- XPS
- EIFS

## 2 ROADMAP: IMPLEMENTATION PHASE

### 10 - Construction: Site-Built Options *continued...*

#### Blown-in Insulation (Dense Packed Insulation)

Blown-in insulation can also be added to the exterior of an existing wall assembly. If blown-in insulation is used, a cavity must be built that the insulation can be blown into, allowing for the proper density to be obtained. There are several techniques to making this cavity, such as using a Larsen truss or I-joist outriggers with a membrane around the exterior to hold the insulation. Strapping will often be used over the membrane to ensure it isn't bulging and affecting the siding installation.

The easiest option for installing blown-in is from the interior. This allows for more of a controlled environment and flat surface for the installers. This oftentimes isn't an option, though, if the interior of the home is not being completely renovated as well. If it is being installed from the exterior extra equipment may be needed, such as scaffolding or man lifts. The insulation must also be protected from weather conditions which can have an adverse effect on it, therefore try to get the insulation permanently covered as soon as possible.

The installation of blown-in insulation is also an important factor. A qualified and experienced installer should be hired to install the dense-packed insulation as it needs to meet a certain density so it will not settle. Improperly installed blown-in insulation can lead to issues down the road, mainly gaps of insulation at the top of the cavity.



# 2 ROADMAP: IMPLEMENTATION PHASE

## 10 - Construction: Site-Built Options *continued...*

### Mineral Fibre, EPS, GPS, XPS

Rigid board-type insulation is attached using strapping and structural screws or pre-made clips and brackets. An engineer or architect may be required to design the fastening system, which would have been done in the planning / design phase. This is to ensure it can support the loads of the exterior cladding and any other special requirements, such as fire rating.

If using the strapping and structural screw method, care must be taken to ensure the screws are hitting solid backing (stud, blocking, etc.) within the structural assembly of the wall (framing). Depending on the thickness of the insulation that is being added, this can become increasingly difficult. If a screw misses, it is advisable to leave that screw in and add a new one that connects to structure. Removing screws that have missed will create an unnecessary open hole in the wall assembly, which could include leaving a small hole in the air-tight layer.



### EIFS

One solution available for externally focused DERs is the Exterior Insulation and Finish System (EIFS). EIFS is a multi-layer exterior cladding system that incorporates continuous insulation, the water control layer and the finished surface in an integrated composite material system. An EIFS installation in a DER typically consists of removing the existing cladding system down to the structural sheathing, replacing any damaged sheathing, and then installing the following components:

1. Liquid Applied Air and Moisture Barrier
2. Cementitious Adhesive
3. Rigid board insulation (typically EPS)
4. Reinforcing mesh
5. Base coat and then finish coat

There are many considerations needed to ensure the proper installation of an EIFS system and this work should only be undertaken by properly trained crews.



# 2 ROADMAP: IMPLEMENTATION PHASE

## 10 - Construction: Site-Built Options *continued...*

### Air Sealing

When completing a site-built DER, air sealing is done on-site in the existing conditions. Variables to consider that may affect the air sealing process include, but not limited to:

- Cold weather, which can lead to the worker rushing, tapes and sealants not sticking correctly, etc.
- Adverse weather conditions like rain, snow, hail, wind, forest fire smoke, which can affect worker efficiency and scheduling.
- Site conditions like uneven ground, workers not being fully equipped with proper tools / machinery for the site conditions, etc.

**Extra attention to detail is needed to ensure air sealing is done correctly.**



## 10 - Construction: Panelized Method

A **panelized** retrofit is an efficient approach that uses digital imaging technology to capture the precise dimensions of a building to pre-fabricate airtight and well-insulated panels. The prefabricated panels are delivered to the project site and installed on the outside of the building.

Steps of the **panelized** method include:

1. Digital Capture (Photogrammetry)
2. Design Panels
3. Build Panels
4. Prepare Building
5. Installation
6. Finishing and detailing

## 2 ROADMAP: IMPLEMENTATION PHASE

### 10 - Construction: Panelized Method *continued...*

The following images depict panel installation for a DER of a 1,950-square-foot, 1940s home. This project, located in Edmonton, Alberta, was the first panelized DER of a single-family home in North America.



### 10 - Construction: Panelized Options and Building Science Considerations

Panelized retrofits generally consist of wood-framed panels that include structure, insulation and an airtight weather barrier. In some cases, windows may be pre-installed. In rare cases, cladding is installed before the panels are put on the house. The panels are most often installed in a "cladding-ready" state so that the final appearance of the building will not reflect all of the panel connections.

The lowest row of panels is typically supported by brackets or a ledger on the building's foundation wall. The upper panels bear on the lower panels, and upper retainer brackets secure and align the upper portion of the panel with the existing wall structure.

Joints between panels are typically treated by sealing the panels with an air barrier tape. Gaps are often filled with batt insulation.

# 2 ROADMAP: IMPLEMENTATION PHASE

## 10 - Construction: Order of Operations

Every DER project will differ, but the following list provides a suggested approach to the order of operations and considerations for each step of the construction process.

Knowing when inspections are required for each permit is also crucial, as they should be properly incorporated into the order of operations. Different municipalities will have different required inspections, therefore due diligence should be taken to understand the requirements of the local authority. Lastly, it is highly suggested to carry out continual quality control checks throughout the construction process.

### 1. Site Preparation and Protection

- a. Required safety measures
- b. Utility locates
- c. Recycling/waste containers
- d. Services turned off (with consideration whether there will need to be power or water from another source)
- e. Refer to section '10 - Pre Construction'

### 2. Excavation (if required)

- a. Foundation for built addition
- b. Foundation wall exterior insulation
- c. For ground source heating

### 3. Demolition (if required)

- a. Confirm extent/scope
- b. Assess what can be re-used, salvaged/re-sold, re-purposed, recycled, or disposed of
- c. Plan for unforeseen circumstances (i.e. structural components, mould, vegetation, etc.)

### 4. Structure/Envelope Framing

- a. Re-framing/framing (as needed)
- b. Confirm that window/door rough openings, wall, roof, and other assemblies are correct. Note: The added insulation of DERs can lead to costly re-work if not considered when framing
- c. Additional framing after control layers are installed (if needed)

### 5. Window & Door Replacement/Installation

- a. Confirm proper installation details are followed and executed properly

### 6. Mechanical Rough-in

- a. HVAC, electrical, plumbing, security systems, home management systems, ground source heating, on-site renewable energy system, etc.
- b. If penetrating the air control layer, it **MUST** be properly sealed (at the very least, notify the DER manager)

# 2 ROADMAP: IMPLEMENTATION PHASE

## 10 - Construction: Order of Operations *continued...*

### 7. Control Layer Installation

- The control layers should have all been established at the design phase. During implementation phase it is critical to follow the details and discuss any concerns
- Confirm each control layer component is installed, as per manufacturer's specifications
- Continually inspect for errors, discontinuity, and damage
- Water control layer: ensure proper installation to allow necessary drainage of any possible moisture
- Air control layer: advised to have an individual 'in charge' of the air control layer to ensure continuity, who is reported to for any cuts and punctures. Should perform an air-tightness test to confirm adequate air sealing and fix any issues before this layer is covered up

### 8. Exterior Finishing

- Siding and exterior trim installation, following manufacturer's specifications
- Maintain the quality/integrity of any affected control layer

### 9. Interior finishing

- Maintain the quality/integrity of any effected control layer
- Finish carpentry, paint, cabinetry, flooring, etc.

### 10. Construction Wrap-up

- Interior finishing repairs
- Final clean up
- Equipment commissioning
- Final energy audit
- Financial incentive follow-ups (as required)
- Finalize additional electrical systems (i.e. security, home energy management/monitoring etc.)
- Operational and maintenance considerations: homeowner education, window coverings and operation, equipment maintenance and servicing requirements
- Landscape restoration and clean up

## 10 - Construction: Quality Control

On top of the inspections required for construction permits (i.e. electrical, gas, plumbing, etc.), ongoing quality control and continual engagement with all members of the project is needed to ensure that the DER follows the project plan and design.

Moreover, continual quality control inspections help to confirm the building components and equipment are properly installed at each stage, following sound building science principles, while taking extra precautions to adequately seal any envelope penetrations along the way.



## 2 ROADMAP: IMPLEMENTATION PHASE

### 10 - Commissioning

Another step near the end of the construction stage is the commissioning of all newly installed equipment (i.e. mechanical / HVAC, solar PV, appliances, other) to ensure they are operating as designed. In an air tight house, this is an important step since HVAC systems that aren't operating properly (i.e. air balanced) can have an adverse affect on their efficiency and the health of the building's occupants. Ensuring that all equipment and appliances are operating efficiently is also key, since energy efficiency is a primary goal of a DER project.



### 11 - Final Energy Audit

Once construction is fully complete, it is strongly recommended that a final energy audit is performed to verify the project has achieved the goals set with the client in the planning phase. Doing the post-construction energy audit is important and will provide metrics that show the building's energy efficiency improvement resulting from the DER.

**This is also a requirement of many financial incentive programs that may have been used to finance the retrofit project.**



# 2 ROADMAP: IMPLEMENTATION PHASE

## 11 - Client Handoff

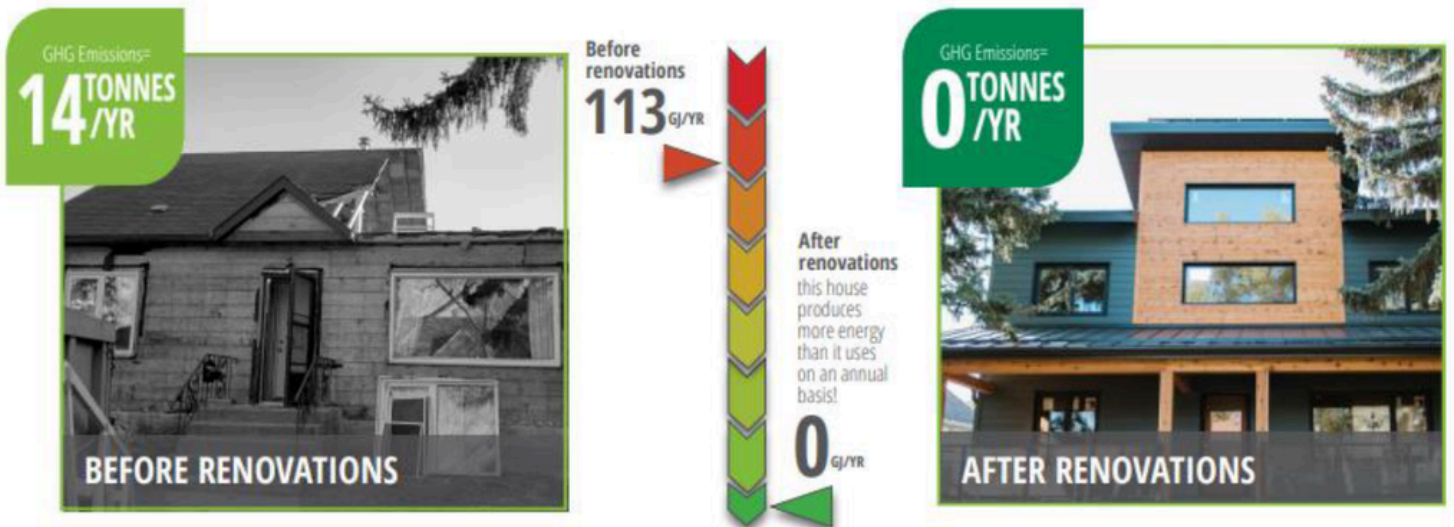
During the client handoff, a final walk through should be performed to identify any outstanding deficiencies.

Lastly, another factor in the success of a DER project is client education, especially as it relates to the newly installed equipment and appliances. The DER manager / builder should ensure that homeowners have been shown how to use all new equipment, and are provided with all necessary documentation (i.e. manuals) for ongoing operation and maintenance procedures.

If the DER is planned to be a rental, then it is important that the tenants are educated and also shown proper equipment operation and maintenance procedures.



## 11 - DER Complete



# **CHAPTER 3: DER CASE STUDY**

# 3 DER CASE STUDY



## Project Profile / Case Study Submission

1955 single family bungalow with legal basement suite + heated studio in garage, retrofitted & electrified to NetZero readiness for 15.41 kW solar PV design. Primary upgrade is site framed exterior 8" Larsen wall with dense packed cellulose, and 2" mineral fibre to exterior of garage.

A Building Profile			
	<b>Address</b>	Highwood, NW, Calgary, AB	
	<b>Year Built</b>	1955	<b>Type of building</b> Single-Family (bungalow)
	<b>Floor Area (m<sup>2</sup>)</b>	218.8	<b>Structure Type</b> Wood-Framed
	<b>Climate Zone</b>	7a	<b>Foundation Type</b> Concrete (Full Basement)
	<b>Retrofit Phasing</b>	Multi-Stage	<b>Retrofit Type</b> Envelope and Mechanical

B	Project Goals	Comments	Priority
	<b>Reduce Energy Consumption</b>	Reduce to Net-zero ready	x
	<b>Achieve Net-zero or Net-zero Ready</b>	Achieve Net-zero ready	x
	<b>Increase Thermal Comfort</b>	Reduce chill in 400sf addition with crawlspace, add cooling in summer	x
	<b>Improve Indoor Air Quality</b>	Control radon without dedicated fan, replace gas range & fireplace for reduced CO2	x
	<b>Reduce GHG Emissions</b>	Electrification	x
	<b>Repair and/or Renew Exterior</b>	Renew exterior	
	<b>Improve Home Value</b>	Long term durability with increased curb appeal, and energy target resilience	
	<i>Other Typical Renovation Goals</i>	Make garage art studio more comfortable/efficient	

# 3 DER CASE STUDY

C Stakeholder Profile			
<b>Builder</b>	SNAP Building Inc.	<b>Energy Advisor</b>	Tyler Hermanson – 4 Elements Integrated Design Ltd.
<b>Project Manager / Retrofit Coach</b>	Steve Norris (SNAP Building Inc.)	<b>Designer / Architect</b>	N/A
<b>Building Science Advisor</b>	Cory MacDermott - Beacon High Performance Homes	<b>Mechanical Engineer</b>	N/A
<b>Funding Source (if applicable)</b>	SSRIA	<b>Structural Engineer</b>	N/A

1 Retrofit Checklist		
Retrofit Type	Initial Assessment	Retrofit Improvement
<b>Envelope</b>		
<b>Airtightness - Penetration Sealing</b>	Appliance venting, ceiling penetrations	Chimneys, fans, vents removed, ceiling penetrations sealed
<b>Wall Insulation</b>	~R6 original walls, R20 in the addition	+ R30 (8" blown / dense packed cellulose)
<b>Ceiling Insulation</b>	~R8 wood chip & fibreglass	R60 (17" blown / dense packed cellulose)
<b>Foundation Insulation</b>	R12 interior walls, nothing on exterior	Crawlspace & perimeter insulated, 18" of exposed foundation above grade insulated with 4" XPS (R20)
<b>Window / Door Replacement</b>	Windows: 7 original windows, 2 double glazed, 2 triple glazed Doors: 2 exterior doors	Windows: 7 originals replaced, 2 double glazed Doors: 2 <u>exterior</u> replaced
<b>Other</b>	Crawlspace not air sealed	Crawlspace 90% air sealed, R8 added under heat run, 4" XPS added to exposed foundation, perimeter skirt re-insulated 4" XPS
<b>2 Mechanical and Electrical Systems</b>		
<b>Ventilation</b>	Furnace / bath fan ventilation only	Panasonic 100CFM ERV
<b>Heating</b>	Natural gas furnace	Air source heat pump (ASHP)
<b>Cooling</b>	N/A	Air source heat pump (ASHP)
<b>Hot Water</b>	Natural gas hot water tank	Air source heat pump with electric back-up hot water tank
<b>Electrical Service Amperage</b>	100-amp	200-amp (local transformer had capacity - minimal upgrade charges)
<b>Renewables</b>	N/A	Solar PV: 15.41 kW
<b>Other</b>		

# 3 DER CASE STUDY

3 Energy Performance			
	Initial	Goal / Actual	% Improvement
<b>Annual Electricity Consumption (kWh/a)</b>	7,500 kWh/a (27 GJ/a)	15,278 kWh/a (55 GJ/a)	N/A
<b>Annual Natural Gas Consumption (kWh/a) / (GJ/a)</b>	34,444 kWh/a (124 GJ/a)	0 kWh/a (0 GJ)	100%
<b>Energy Use Intensity (kWh/m2/a)</b>	192 kWh/m2/a (0.69 GJ/m2/a)		
<b>Annual Heating Demand (kWh/m2/a)</b>	27,778 kWh/m2/a (100 GJ)	6,389 kWh/m2/a (23 GJ)	77%
<b>Annual Cooling Demand (kWh/m2/a)</b>	0 kWh/m2/a (0 GJ)	833 kWh/m2/a (3 GJ)	N/A
<b>Air Leakage Rate (ACH50)</b>	5.74	2	65%
<b>Other</b>	No renewables	Solar PV: 15.41 kW	

4 Carbon Emissions			
	Initial	Goal / Actual	% Improvement
<b>Annual Operational Carbon Emissions from Electricity Consumption (KgCO2e/a)</b>	6100 KgCO2e/a	0	100%
<b>Annual Operational Carbon Emissions from Natural Gas Consumption (KgCO2e/a)</b>	6500 KgCO2e/a	0	100%
<b>Embodied Carbon in Retrofit Materials</b>			
<b>Embodied Carbon in Retrofit Processes</b>			

# 3 DER CASE STUDY

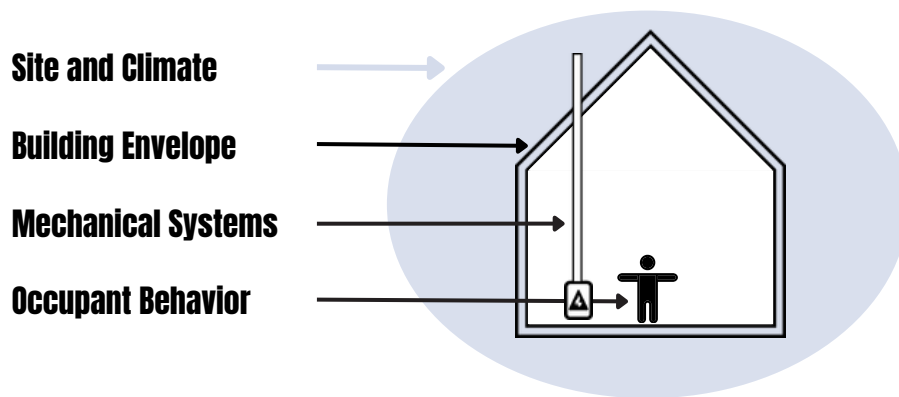
<b>5</b>	<b>Lessons Learned</b>	
	<p><b>BUILDING ASSESSMENT</b></p> <ul style="list-style-type: none"> <li>- Be realistic about amount of demolition required</li> <li>- Include asbestos testing</li> <li>- Identify potential additional scope that might be requested (ie. decks, lighting changes, landscaping, interior reno, etc.)</li> </ul> <p><b>ENERGY MODELLING</b></p> <ul style="list-style-type: none"> <li>- Doesn't account for accessory building loads, secondary suites, etc. that could prevent actually being "Net Zero"</li> <li>- Multiple heat pumps - i.e. HWT, Dryer in mech room</li> </ul> <p><b>OPTIMIZATION</b></p> <ul style="list-style-type: none"> <li>- Was a bit "token" - many decisions were based on values and gut feeling vs. data</li> </ul> <p><b>DESIGN</b></p> <ul style="list-style-type: none"> <li>- Account for additional wall thickness - impacts windows near corners, deck ledgers, secondary suite staircases, side yard setbacks, driveway width, entry landings</li> <li>- Consider improving window size, location, basement adds, etc.</li> </ul> <p><b>BUDGETING</b></p> <ul style="list-style-type: none"> <li>- Assess "hidden" labor costs</li> <li>- Removing perimeter obstructions - bushes, decks, etc.</li> <li>- Should assess potential scope creep issues (or opportunities!)</li> </ul> <p><b>SCHEDULING</b></p> <ul style="list-style-type: none"> <li>- Lead time for all supplies is critical</li> <li>- Compile material ordering/delivery as much as possible</li> <li>- Would be difficult in winter without tight scheduling</li> <li>- ATCO/Enmax timelines</li> </ul> <p><b>ATTIC/ROOF</b></p> <ul style="list-style-type: none"> <li>- Assess potential HRV runs before removing bath fans</li> <li>- Open up chimneys to assess time needed for removal</li> <li>- How to seal/insulate wall/roof connection</li> <li>- Electrical access will be limited</li> </ul> <p><b>WALLS</b></p> <ul style="list-style-type: none"> <li>- Do exploratory demo early to assess wall assembly</li> <li>- Do asbestos testing early for any materials to be removed</li> <li>- How much existing cladding will be removed...all?!</li> <li>- Don't leave windows with large performance gap</li> </ul>	<p><b>FOUNDATION</b></p> <ul style="list-style-type: none"> <li>- Hard surface obstructions that prevent insulation</li> <li>- Is it worth insulating? What is finishing plan</li> </ul> <p><b>HVAC</b></p> <ul style="list-style-type: none"> <li>- Understand peak heating load early to right-size equipment</li> <li>- Need to evaluate mechanical room(s) for new equipment including duct runs</li> <li>- Very difficult to get ERV/HRV ventilation runs to bathrooms</li> <li>- Homeowner education - difference of heat pump operation (lower setbacks, slower heat, control ice, defrost cycles, etc.)</li> <li>- Consider heat pump runoff solutions</li> <li>- Using existing ductwork can be challenging to get correct distribution and can be noisy depending on fan speed, duct configuration</li> </ul> <p><b>PLUMBING</b></p> <ul style="list-style-type: none"> <li>- Had to move sink drain/vent for ERV run to main bath</li> <li>- ATCO - \$1400 to completely remove, free to shut off/remove meter</li> </ul> <p><b>ELECTRICAL</b></p> <ul style="list-style-type: none"> <li>- Evaluate trench digging between garage/house</li> <li>- Transformer capacity</li> <li>- Where to run new power &amp; solar lines</li> <li>- Exterior boxes - extensions or rerouting?</li> <li>- What should be addressed prior to:             <ul style="list-style-type: none"> <li>- Attic insulation</li> <li>- Wall insulation</li> <li>- Soffit installs</li> </ul> </li> <li>- Replace wiring where appropriate</li> <li>- In attic where deeper insulation hides <a href="#">runs</a></li> <li>- Dedicated circuits - i.e. electric fireplace</li> <li>- Make lighting/power changes at same time</li> </ul> <p><b>INTERIOR FINISHING</b></p> <ul style="list-style-type: none"> <li>- Account for miscellaneous drywall repairs, trim, paint</li> </ul> <p><b>SOLAR</b></p> <ul style="list-style-type: none"> <li>- Need to clarify kW vs kWh calculation</li> <li>- Potential additional costs - bird screening, black clamps, etc.</li> <li>- Carefully evaluate tree shading</li> <li>- Future shading obstructions</li> <li>- Panel size differences</li> </ul>

**CHAPTER 4:  
RESIDENTIAL ENERGY  
EFFICIENCY 101**

# 4 HOUSE AS A SYSTEM

When beginning a DER project, treating the house as a "system" can help one understand how the building is influenced and interacts with the home's environment and occupants.

Building professionals must consider the interaction of several sub-systems within a house. For example, the airtightness of the envelope determines the degree to which air enters or exits through the structure. In addition, occupant habits and external weather conditions requires appropriate ventilation to prevent high moisture conditions. The following factors, amongst others, must be considered in the balanced design of a mechanical ventilation system:



## Examples of How Retrofits Impact Other Building Systems

**Benefit:**

**Air sealing makes a home less drafty and more comfortable, and helps reduce space conditioning costs.**

**Consideration:**

Improved airtightness can notably reduce the uncontrolled ventilation levels in a home (i.e., a leaky house), and can result in higher humidity levels and pressure imbalances. In severe cases, back drafting of combustion appliances and organic growth can result in hazardous indoor air quality within the home if proper ventilation isn't taken care of after a home is made air tight.

**Benefit:**

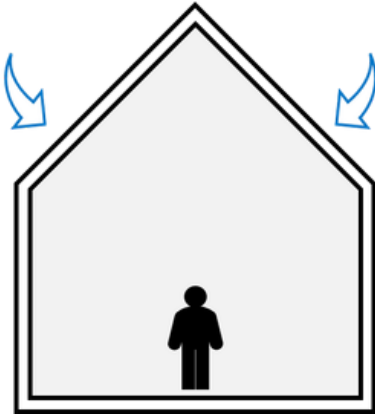
**Insulation improves thermal comfort, can reduce heating & cooling costs, while also reducing indoor condensation and subsequent deterioration.**

**Consideration:**

Increasing insulation without making airtightness improvements can significantly lower the effectiveness of the insulation and potentially lead to condensation and organic growth within insulated envelopes and assemblies.

# 4 HOUSE AS A SYSTEM

## Site and Climate



The primary purpose of a house is to separate and protect its occupants from the environmental elements, providing a centralized zone to 'house' their basic needs. The structures we build are vulnerable to all environmental factors, such as temperature, rain, wind, hail, snow, animals, and ultraviolet light. Therefore, considering each element and decision when designing a new home, or completing a renovation or DER, can offer an advantage in creating the structure we plan to build.

Local and micro climate factors can create unique effects to a building due to factors like exposure, elevation, and adjacent landscape and structures. Across Canada, different geographic locations have different climate zones associated with their respective average annual heating (and cooling) requirements. These various zones determine thermal performance requirements within local building codes.

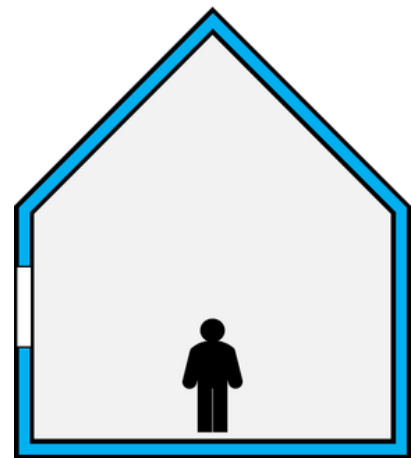
## Building Envelope

This guide has referenced the term "building envelope" in previous sections. The building envelope (often referred to as the building enclosure) is the division between conditioned and unconditioned space. It is where most building science considerations take place and is a crucial system to ensure the proper temperature control, ventilation, and overall comfort of occupants. Ideally, it is resistant to air, water, heat, light, and external noise. In order of importance for durability, the building envelope consists of:

- a water control layer
- an air control layer
- a vapour control layer
- a thermal control layer.

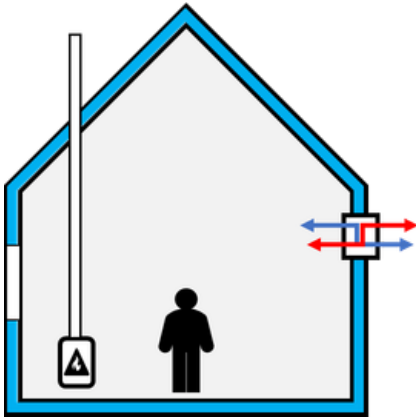
A well-constructed building envelope should avoid air leakage, vapour diffusion, and condensation, and ensure materials are compatible with each other.

Another aspect of the building envelope to consider is penetrations such as windows, doors, and utility connections. The constant fluctuations and transitions in the control layers presents challenges for potential gaps in protecting the building envelope and the overall success of the DER project.



# 4 HOUSE AS A SYSTEM

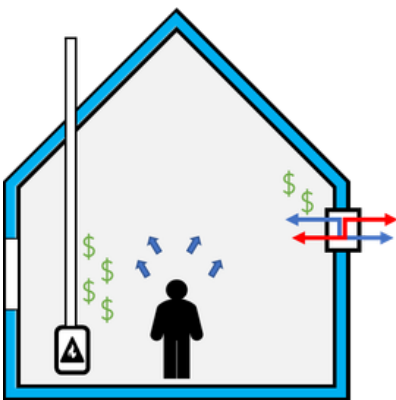
## Mechanical Heating, Ventilation, and Air Conditioning (HVAC)



Mechanical systems, namely HVAC systems, are typically made for heating, cooling and controlling moisture. These systems are primarily responsible for conditioning the building's interior space and help to reduce the risk of moisture buildup, unhealthy indoor air quality, and uncomfortable living conditions. In addition, buildings rely on these components to move air through the home in a stable, even manner, traditionally seen as forced-air ventilation ducts in single-family homes.

These mechanical systems are a significant component of energy use in any residence, and directly correlates to the size of the home being conditioned. Therefore, it is essential to consider the load and efficiency of your mechanical systems relative to the airtightness and insulation levels of your envelope, as well as occupant behaviour.

## Occupant Behavior



How an individual or family lives and interacts within a home notably impacts its performance. Impacts on system performance include temperature preferences, desired humidity levels, increased moisture in the air from cooking, bathing and breathing, use of appliances and electronic devices, and general wear and tear.

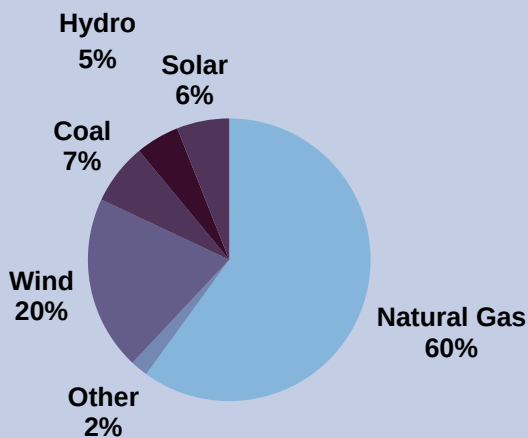
Accounting for occupant behaviour will help ensure occupant health and comfort, while maintaining the building's peak performance. However, this can be difficult, especially if the home's occupants change (i.e. the house was sold). This is where occupant education is important, whether it be current or new homeowners, so that information is conveyed and the occupants understand how to properly operate their home (i.e. the mechanical systems, appliances, etc.)

# 4 ENERGY LITERACY

Energy generation and transmission have been contentious topics in economic, political, and social circles due to the pollutant emissions (i.e., CO<sub>2</sub>) associated with different energy generation strategies. However, whether you are burning natural gas at home, or using electricity to power your lifestyle, most of the energy that is accessed from the utility grid in Alberta, as well as many other areas in Canada, currently relies on the burning of fossil fuels.

For this reason, there needs to be a high importance on using energy efficiently by reducing both consumption and reliance on heavy emissions generation sources.

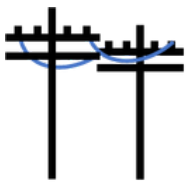
## Electrical Generation in Alberta



As of 2022, roughly 67% of electricity in Alberta is produced from fossil fuels – 60% from natural gas and 7% from coal.

Of note, in recent years, electricity generated by wind and solar has increased to 20% and 6%, respectively. The remaining 7% is produced from hydro at 5%, and other sources (i.e. biomass) at 2%.

-AESO, Understanding Electricity in Alberta



**Electricity from the grid** - is generated at power plants and distributed across grid infrastructure such as powerlines and transformers. Electricity is measured in Kilowatt hours (kWh). One kWh is equivalent to 1,000 Watts being consumed for an entire hour. Therefore, when turned on, a 100-Watt light bulb uses 1 kWh every 10 hours. (ATCO Gas, Energy 101)



**Natural gas** - is produced at upstream facilities, distributed by pipe to residential districts, and also combusted on-site to generate energy to transport to our homes. Gas meters measure the volume of gas that flows, measured in cubic feet or meters, and quantify the amount of energy in Gigajoules (GJ). One GJ of natural gas could heat 6000 gallons of water, enough water for 150 bathtubs. (ATCO Gas, Energy 101)



**1 GJ = 277.8 kWh**

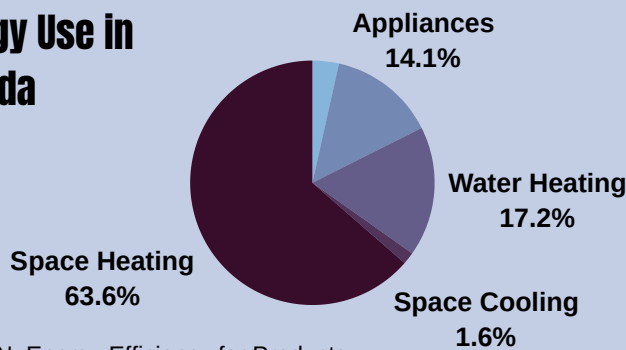
# 4 AT-HOME ENERGY USE

To access energy, Alberta utility providers charge consumers distribution and transmission fees, system maintenance fees, and a per-unit usage rate - kWh for electricity and GJ for gas.

The average home in Alberta uses 600 kWh of electricity and 10 GJ of natural gas every month (ATCO Gas, Energy 101). However, this differs from home to home and season to season. For example, Albertans use as low as 2 or 3 GJ of natural gas in the summer, but closer to 10 or 12 GJ a month in the winter due to increased home heating needs.

Space and water heating make up the vast majority of residential energy use within Canada. Traditionally, both systems run on fossil fuel, primarily natural gas, since burning fossil fuels emits thermal energy for use within the mechanical systems.

## Residential Energy Use in Canada



All appliances, lighting, TV's, computers, fans, air conditioning

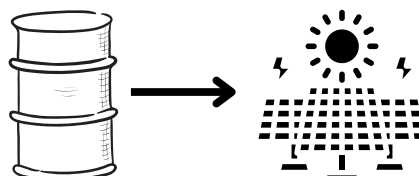
Space heating, water heating, cooking

-NRCAN, Energy Efficiency for Products

## Electrification of Homes (Fuel Switching)

As described earlier in the guide, electrification (also known as fuel switching), means eliminating fossil fuel consumption by only using electricity in a home. As the transitioning of household energy systems to full electrification becomes mainstream, essential appliances and mechanical HVAC systems will become more dependent on electricity (either produced on-site from renewables or from the electrical grid) than natural gas.

### Electrification



# 4 AT-HOME ENERGY USE

## Electrification of Homes (Fuel Switching) *continued...*

Older homes undergoing a DER that have a 60-amp service, will require, at the very least, an upgrade to the current requirement of a 100-amp service, 240-volt connection. If the current service in a DER project is 100-amp, the electrical service may need to be further upgraded to a 150-amp or 200-amp service, depending on the household electrical needs of the newly installed systems (i.e. mechanical: heat pump, ERV / HRV, hybrid heat pump hot water tank, etc.; appliances (i.e. electric / induction stove top); solar PV system; electric vehicle charger; etc.).

However, the installation of a larger household electrical service (i.e. 150-amp or 200-amp), which includes the removal of the existing electrical panel, installing a new electrical wire mast, new larger gauge wires, labour and electrical permit, comes with added costs. The cost of electrical service upgrade can range from approximately \$7,000 in a simple overhead electrical line scenario to around \$20,000 for a more complex underground electrical line scenario.

Furthermore, if many homes on a street all upgrade to a 200-amp, 240-volt electrical service, utility capacity may become a significant issue for electrification and the electrical grid may not be able to accommodate the additional peak load.

Therefore, to avoid additional costs to the DER project budget and to avoid costly upgrades to the electrical grid distribution infrastructure (which are passed on to homeowners in the form of "fixed utility connection fees"), a pathway for optimizing home electrification using a 100-amp, 240-volt service is needed.

This is where '**optimized electrification**' can play a role.

'Optimized electrification' refers to the electrification of a home while maintaining the existing 100-amp, 240-volt electrical service connection. Potential solutions to 'optimized electrification' include **Load Share Devices** and **Energy Management Systems**. For additional information on these solutions, reference the following: <https://b2electrification.org/home-electrification-service-upgrade-not-required>



# 4 BASIC ENERGY MANAGEMENT

Homes contain many devices and mechanical systems that operate consistently without user intervention. However, these devices have varying efficiencies, often decreasing as they age from the time of installation.

From the occupant's perspective, there are some things that you can do to consider greater efficiency in your home that don't require a DER or any professional involvement. However, a home's overall efficiency can see significant improvement by a DER that considers the house as a system and sets a high standard for energy efficiency and conservation.

## Things to consider

### Phantom Loads

Many electronics such as TVs, computers, microwaves, and coffee makers, among others, can consume small amounts of electricity even when turned off. These are known as phantom loads. Having controlled outlets, switches, or simply unplugging devices can help to minimize additional energy consumption from phantom loads.

### Energy Star

Energy Star appliances consume less energy and should be an essential consideration when replacing old appliances such as fridges, freezers, clothes washers / dryers, dishwashers, and ovens / ranges.

### LED Light Fixtures

LED light bulbs consume up to 75 percent less energy than traditional incandescent bulbs. Implementing small changes such as replacing old light bulbs and turning off lights when not in use can make a noticeable difference in electrical consumption and monthly energy bills.

### Shading Considerations

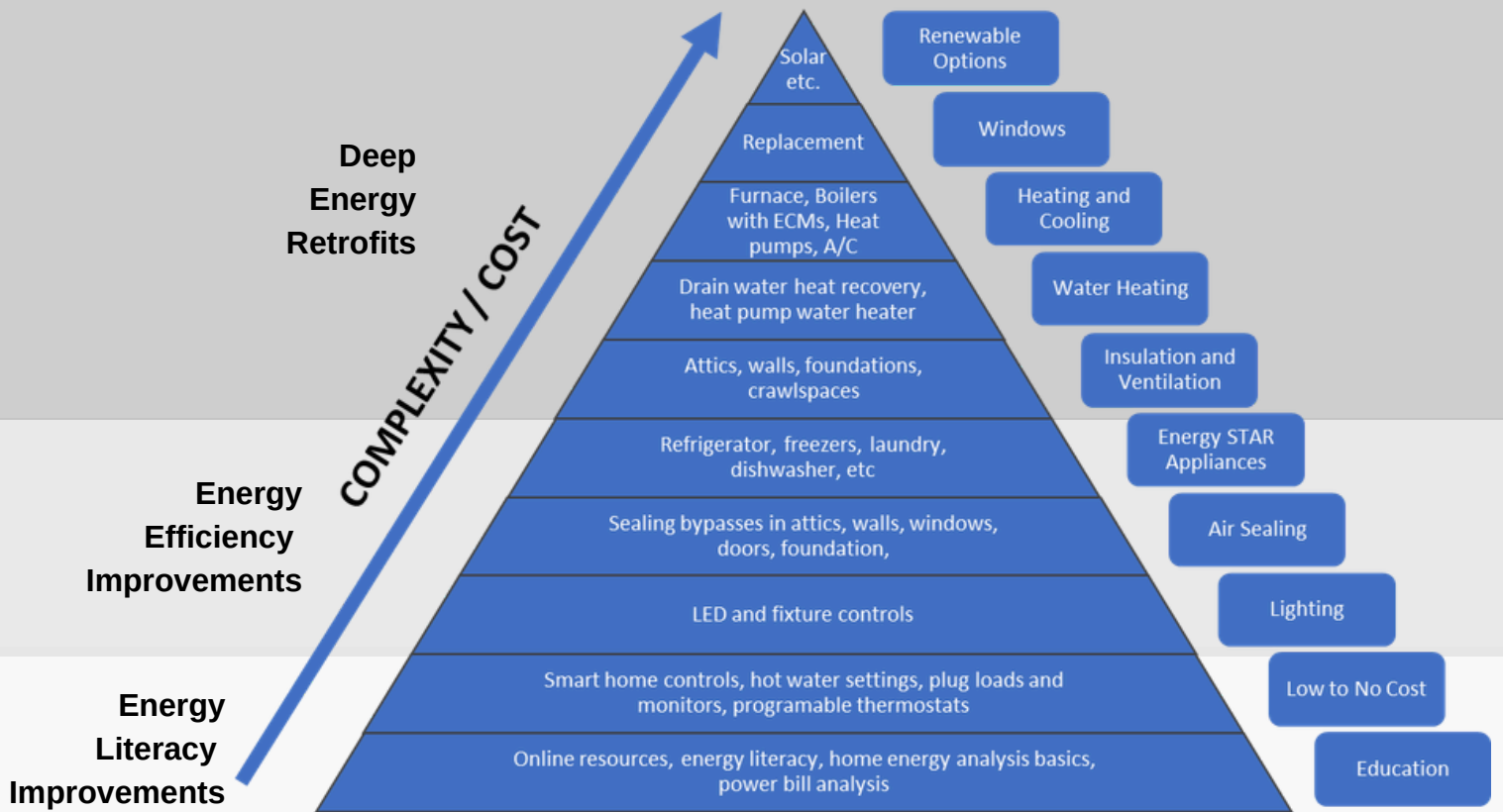
Using awnings or large overhangs can help mitigate the intensity of the sun's heat coming into the home and notably reduce the energy required to cool a home in the summer. Planting deciduous (leafy) trees on the home's south side (sunny side) can also help mitigate the amount of sunlight hitting the home throughout different times of the year. During summer, the leaves provide shade; and in winter, the bare branches let the warm sunlight through, passively heating the home.



# 4 ENERGY CONSERVATION

A typical reference in DER literature refers to the Pyramid of Conservation. The pyramid shows a progression in options in terms of complexity and affordability relative to the potential advancement from an inefficient building to a highly energy-efficient home. When planning strategies for energy conservation, the most effective use of time and money is to start at the base of the pyramid and work upwards. This mainly applies when the budget does not allow for an entire DER.

## The Pyramid of Conservation (Residential Version)



-Minnesota Power



"The greenest unit of energy is the unit of energy that is never generated thanks to efficiency and conservation."

- Amory Lovins, 1990

# APPENDIX

# APPENDIX: TERMINOLOGY

**Annual Energy Use:** the total energy required to operate a home for an entire year. The metric is typically expressed in GJ / year or kWh / year, and includes energy used for all mechanical systems (i.e., HVAC, water heating), appliances, and lighting.

**Annual Heating Demand:** The total energy used to heat a home for an entire year. It is most often expressed in kWh / m<sup>2</sup> / year.

**Building Envelope:** The division between the conditioned and unconditioned space of a home or building.

**Constructability:** Ease of construction.

**Digital Capture:** Produce accurate measurements of the existing building using a digital device and software (Camera, Drone, Lasers, Sensors, Computers, etc.).

**Electrification:** The process of replacing technologies that use fossil fuels (coal, oil, and natural gas) with technologies that use electricity as a source of energy.

**Embodied Carbon:** Accounts for the total emissions used to source, manufacture and transport materials used to construct a building as well as the construction methods employed to erect the structure and the end-of-life demolition.

**Energy Audit:** Testing and analysis of a building's energy efficiency. Most commonly determined using a blower door test and energy modelling analysis.

**Energy Efficiency:** The rate at which energy is converted and captured from one form and / or use to another.

**Energy Use Intensity / Rated Energy Intensity** This metric takes the annual energy use and applies it to the total area of a home. It is expressed as GJ / m<sup>2</sup> / year or kWh / m<sup>2</sup> / year, and this shows efficiency over floor area of the home but tends to favor larger homes.

**Geothermal:** Relating to or produced by the internal heat of the earth.

**High-Performance Home:** Home that goes above and beyond minimum building standards, specifically in the areas of energy use, air quality and thermal comfort.

**Integrated Project Team** To be brought together. In terms of construction, bringing everyone involved in the project together.

**Mitigation:** Action of reducing the severity, seriousness, or painfulness of something.

**Mechanical Load:** Amount of stress a home's entire mechanical system causes to the grid or on-site energy-producing devices.

**Net-zero:** In terms of national carbon emissions, targeting net-zero means negating an equal amount of greenhouse gases to the amount produced by human activity. This is achieved by first reducing reliance on emissive activities to minimize new emissions and then implementing methods of absorbing carbon dioxide from the atmosphere.

**Net-zero ready:** "A home that is recognized by CHBA and NRCan's EnerGuide Rating System to be a home that has a renewable energy system designed for it that will allow it to achieve Net Zero Home performance, but the renewable energy system is not yet installed."- CHBA.

**Operational Emissions:** Refers to all the energy used in managing and maintaining the function of a building. It can include heating, cooling, lighting, and any other power usage needed to run programs.

**Panelized:** A method of construction consisting of capturing the precise dimensions of a building to pre-fabricate airtight and well-insulated panels. As a result, these panels are delivered to the project site, then are later installed on the exterior of the building.

**Peak Load:** The maximum of electrical power demand. In Canada it usually occurs in the winter when everyone is running their heaters, but can also occur in the summer when using air conditioners.

# APPENDIX: TERMINOLOGY *continued...*

**Perm Rating:** A standard measure of the water vapor permeability of a material. The higher the number, the more readily water vapor (in the gaseous state) can diffuse through the material.

**Reference House:** A comparative energy model of the same house built to the minimum requirements of the National Building Code, this represents a "typical home" and allows for comparison.

**Retrofit:** An act of adding a component or accessory to something that did not have it when manufactured.

**Tenant:** A person who occupies land or property rented from a landlord.

**Thermal Bridge:** An area or component of an object which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer.

**Thermal Resistance:** A heat property and a measurement of a temperature difference by which an object or material resists a heat flow. It is often expressed as the R-Value. It is the reciprocal of thermal conductance which is usually expressed as a U-Value.

**Traditional Renovation:** A renovation (or retrofit) that does not incorporate improved energy efficiency / net zero practices

**Utility Capacity:** The maximum output an electricity generator can physically produce, whether it is the grid or on-site energy producing devices.

## Abbreviations

**ACH:** Air Changes per Hour

**CHBA:** Canadian Home Builders' Association

**DER:** Deep Energy Retrofit

**EA:** Energy Advisor

**EIFS:** Exterior Insulation and Finish Systems

**EPS:** Expanded Polystyrene Insulation

**ERS:** Energuide Rating System

**ERV:** Energy Recovery Ventilators (transfers heat and humidity)

**GJ:** Gigajoules

**HRV:** Heat Recovery Ventilator (transfers heat)

**HVAC:** Heating, Ventilation, and Air Conditioning

**IPD:** Integrated Project Delivery. Not to be mistaken with the construction term of IPD, which means Insulation / Poly / Drywall.

**kWh:** Kilowatt hours

**NBC:** National Building Code

**NRCan:** Natural Resources Canada

**OHS:** Occupational Health & Safety

**PACE:** Property Assessed Clean Energy

**Pa:** Pascals

**PH:** Passive House

**PV:** Photovoltaics

**kWh:** Kilowatt hours

**NBC:** National Building Code

**NRCan:** Natural Resources Canada

**OHS:** Occupational Health & Safety

**PACE:** Property Assessed Clean Energy

**SEEFAR:** Sustainable Energy Efficient Facility Asset Renewal

**XPS:** Extruded Polystyrene Insulation

**WRB:** Water Resistive Barrier

# APPENDIX: RESOURCES

This guide has provided information for professionals and homeowners to use as a starting point when considering a residential DER. The following list includes additional resources that will help increase your knowledge of DERs.

## **Alberta Electric System Operator (AESO)**

### ***Understanding Electricity in Alberta***

<https://www.aeso.ca/aeso/understanding-electricity-in-alberta/>

## **Alberta Municipalities**

### ***Clean Energy Improvement Program***

<https://ceip.abmunis.ca/>

## **The American Institute of Architects**

### ***Integrated Project Delivery: A Guide***

[https://zdassets.aiacontracts.org/ctrzdweb02/zdpdfs/ipd\\_guide.pdf](https://zdassets.aiacontracts.org/ctrzdweb02/zdpdfs/ipd_guide.pdf)

## **ATCO**

### ***Energy 101***

<https://gas.atco.com/en-ca/products-services-rates/rates-billing-energy-savings-tips/energy-101.html#:~:text=The%20average%20home%20in%20Alberta,of%20natural%20gas%20every%20month>

## **Building to Electrification Coalition**

### ***Home Electrification: Service Upgrade Not Required!***

<https://b2electrification.org/home-electrification-service-upgrade-not-required>

## **Canadian Home Builders Association**

### ***Net Zero Homes***

<https://www.chba.ca/CHBA/BuyingNew/Net-Zero-Homes.aspx>

### ***Net Zero Renovations***

[https://www.chba.ca/CHBA/HousingCanada/Net\\_Zero\\_Energy\\_Program/NEW\\_Net\\_Zero\\_Renos/CHBA/Housing\\_in\\_Canada/Net\\_Zero\\_Energy\\_Program/Net\\_Zero\\_Renovations.aspx?hkey=b852ae22-f006-4b50-9ed6-7754cfbc6652](https://www.chba.ca/CHBA/HousingCanada/Net_Zero_Energy_Program/NEW_Net_Zero_Renos/CHBA/Housing_in_Canada/Net_Zero_Energy_Program/Net_Zero_Renovations.aspx?hkey=b852ae22-f006-4b50-9ed6-7754cfbc6652)

### ***Renovators' Manual***

<https://www.chba.ca/CHBA/Publications/Renovators-Manual.aspx>

## **City of Calgary**

### ***Residential Solar Calculator***

<https://www.calgary.ca/environment/programs/residential-solar-calculator.html>

## **CHRON. Small Business**

### ***What Is a Cost-Plus Contract in Construction?***

<https://smallbusiness.chron.com/costplus-contract-construction-66735.html>

## **cove.tool**

### ***Energy Use and EUI***

<https://help.covetool.com/en/articles/2499676-energy-use-and-eui>

# APPENDIX: RESOURCES *continued...*

## **Green Building Advisor**

### ***Collection of Deep Energy Retrofit Articles***

<https://www.greenbuildingadvisor.com/collection/deep-energy-retrofits>

## **London Energy Transformation Initiative (LETI)**

### ***Climate Emergency Retrofit Guide***

<https://www.leti.uk/retrofit>

## **National Research Council of Canada**

### ***National Building Code of Canada 2020***

<https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications/national-building-code-canada-2020>

## **Natural Resources Canada**

### ***ENERGY STAR Certified Homes***

<https://natural-resources.canada.ca/energy-efficiency/energy-star-canada/energy-star-for-new-homes/energy-starr-certified-homes/5057>

### ***Canada Greener Homes Grant***

<https://natural-resources.canada.ca/energy-efficiency/homes/canada-greener-homes-initiative/canada-greener-homes-grant/canada-greener-homes-grant/23441>

### ***Canada Greener Homes Loan***

<https://natural-resources.canada.ca/energy-efficiency/homes/canada-greener-homes-initiative/canada-greener-homes-loan/24286>

## **NORR**

### ***Understanding Operational and Embodied Carbon***

<https://norr.com/blog-series/our-journey-to-carbon-neutrality/understanding-operational-and-embodied-carbon/>

## **OSLER**

### ***Integrated Project Delivery model in Canada: What you need to know***

<https://www.osler.com/en/resources/transactions/2018/integrated-project-delivery-model-in-canada-what-you-need-to-know>

## **Passive House Canada**

### ***About Passive House***

<https://www.passivehousecanada.com/about-passive-house/>

### ***EnerPHit Certification***

<https://www.passivehousecanada.com/enerphit-certification/>

## **Retrofit Canada**

### ***Case Studies***

<https://www.retrofitcanada.com/case-studies>

### ***Reasons to do a Deep Retrofit***

<https://www.retrofitcanada.com/news/retrofitstop5>

## **U.S. Department of Energy - Energy Efficiency and Renewable Energy**

### ***Measure Guideline: Incorporating Thick Layers of Exterior Rigid Insulation on Walls***

[https://www1.eere.energy.gov/buildings/publications/pdfs/building\\_america/incorporating-thick-layers-exterior-insulation.pdf](https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/incorporating-thick-layers-exterior-insulation.pdf)

## **U.S. Department of Energy - Office of Scientific and Technical Information**

### ***A Path to Successful Energy Retrofits: Early Collaboration through Integrated Project Delivery Teams***

<https://www.osti.gov/servlets/purl/1169479>

# APPENDIX: REFERENCES

In order of appearance

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# DER WORKSHEET P.1

## Project Profile / Case Study Submission

Description:

A Building Profile			
	Address		
	Year Built		Type of building
	Floor Area (m <sup>2</sup> )		Structure Type
	Climate Zone		Foundation Type
	Retrofit Phasing		Retrofit Type

B Project Goals		Comments	Priority
	Reduce Energy Consumption		
	Achieve Net-zero or Net-zero Ready		
	Increase Thermal Comfort		
	Improve Indoor Air Quality		
	Reduce GHG Emissions		
	Repair and/or Renew Exterior		
	Improve Home Value		
	<i>Other Typical Renovation Goals</i>		

C Stakeholder Profile			
	Builder		Energy Advisor
	Project Manager / Retrofit Coach		Designer / Architect
	Building Science Advisor		Mechanical Engineer
	Funding Source (if applicable)		Structural Engineer

# DER WORKSHEET P.2

Retrofit Checklist		
Retrofit Type	Initial Assessment	Retrofit Improvement
<b>Envelope</b>		
<b>1</b>	<b>Airtightness - Penetration Sealing</b>	
	<b>Wall Insulation</b>	
	<b>Ceiling Insulation</b>	
	<b>Foundation Insulation</b>	
	<b>Window / Door Replacement</b>	
	<b>Other</b>	

<b>Mechanical and Electrical Systems</b>		
<b>2</b>	<b>Ventilation</b>	
	<b>Heating</b>	
	<b>Cooling</b>	
	<b>Hot Water</b>	
	<b>Electrical Service Amperage</b>	
	<b>Renewables</b>	
	<b>Other</b>	

# DER WORKSHEET P.3

3 Energy Performance			
	Initial	Goal / Actual	% Improvement
Annual Electricity Consumption (kWh/a)			
Annual Natural Gas Consumption (kWh/a) / (GJ/a)			
Energy Use Intensity (kWh/m <sup>2</sup> /a)			
Annual Heating Demand (kWh/m <sup>2</sup> /a)			
Annual Cooling Demand (kWh/m <sup>2</sup> /a)			
Air Leakage Rate (ACH50)			
Other			

4 Carbon Emissions			
	Initial	Goal / Actual	% Improvement
Annual Operational Carbon Emissions from Electricity Consumption (KgCO <sub>2</sub> e/a)			
Annual Operational Carbon Emissions from Natural Gas Consumption (KgCO <sub>2</sub> e/a)			
Embodied Carbon in Retrofit Materials			
Embodied Carbon in Retrofit Processes			

5 Lessons Learned	
Describe any relevant issues and the associated lessons learned.	