



# **The Telephone Game on Site**

HOW KNOWLEDGE BREAKS DOWN BETWEEN HOUSING POLICY  
AND CONSTRUCTION PRACTICE

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# Summary/Abstract

# Summary/Abstract

## The Telephone Game on Site: Why Trickle-Down Training Cannot Consistently Deliver Safe, High-Performance Housing

The housing industry in British Columbia and across Canada is under pressure to deliver more homes, at lower cost, with fewer people available to do the work. Affordability constraints, climate and energy targets, and expectations for healthier, more durable housing are converging with a shrinking and aging construction workforce. At this same moment, the industry continues to rely on business-as-usual, informal, trickle-down approaches to training, assuming that knowledge held by licensed builders will reliably reach crews and subcontractors through on-the-job communication.

This paper argues that this assumption has created a widening gap between policy intent, training structures, and on-site practice, and that this gap is now leading to a critical systems failure.

Drawing on more than thirty years of lived experience in training delivery, curriculum development, and observation of housing outcomes, the paper uses a systems lens to show how information degrades as it moves from policy and building code, through formal education and licensing structures, to the people actually doing the work.

The “telephone game” is used as an analogy to describe how intent, context, and risk awareness are lost across a fragmented and subcontracted industry.

This gap becomes especially acute in the current workforce pinch point. Formal trades training programs face limited seats and instructor capacity, while many home construction and renovations firms operate without Red Seal carpenters and rely heavily on subcontracted labour. Trickle-down learning is understandable in a mentorship-based trade culture, but it is no longer sufficient given the complexity of modern housing assemblies and the safety, health, and durability risks involved.

This paper also considers who current training models reach, and who they do not. Women and other underrepresented groups remain a small share of the home construction and renovation workforce, in part because industry structures, learning pathways, and site cultures were not designed with inclusive entry or long-term

participation in mind. Expanding workforce capacity and resilience will require training approaches that are accessible, relevant, and supportive, without assuming prior exposure or access to informal networks.

Recognizing the difficulty of changing the culture of an atomized industry, this paper does not propose a single fix. Instead, it identifies system-level options and enabling conditions for training ecosystems that better support consistent learning outcomes, distribute knowledge to the point of action, and treat direct-entry workforce learning as essential infrastructure for delivering cost-effective, safe, high-performance housing at scale.

# Introduction

# Introduction

Canada's housing sector is being asked to deliver more with less. New homes and retrofits must meet higher expectations for energy performance, durability, health, and climate resilience, while being built faster, at lower cost, and with a shrinking and increasingly fragmented workforce.

At the same time, the technical demands of construction have changed. Modern housing depends on the interaction of multiple systems, including airtight building enclosures, insulation, mechanical ventilation, and moisture control. These systems are governed by well-established building science principles that are reflected in building codes, standards, and best practice guidance.

Yet building science failures continue to occur in predictable ways. Most often, they occur when the knowledge required to implement best practices does not reach the people responsible for carrying out the work on site.

Let's call it the "telephone game" of construction knowledge. Here's how it works:

The housing system assumes that knowledge moves from research and policy into practice through a combination of building codes, formal training pathways, and on-the-job experience. In reality, the home construction and renovation industry operates as a distributed production system composed of small firms, subcontractors, and direct-entry workers carrying out work under a local building code.

A building code is a legal instrument. Its primary function was, and is, to ensure fire and structural safety through prescriptive requirements. Legally, a building code does not require training or knowledge, it requires compliance.

The current production distribution system relies on a 'trickle-down' education model, where key players are required to be more or less conversant in the building code and will guide or direct those who work for them. The building code effectively overrides the need for broad-based, consistent training. The system

That works for fire and structural safety. But building codes now incorporate energy performance targets, and those are far more nuanced than prescriptive fire and structural safety requirements. To begin with, energy performance goals are set to the heating and

cooling needs of the eight different climate zones in Canada. In addition, there are many permutations of materials and assemblies that will meet the energy performance goal. And just to complicate things more, not all of these permutations are applicable to variations in environmental conditions such as mild-humid, cold-dry, or mixed.

None of this applies to decisions and choices that drive renovations and upgrade/replacement work where a building permit is not required, but the building science still applies.

The nuanced nature of energy performance targets and energy conservation measures requires much more knowledge and understanding of the dynamic interactions the building has with the environment around it.

In the current system, building science knowledge passes through multiple layers of interpretation before reaching the point of installation. At each step, context is lost, simplified, or altered.

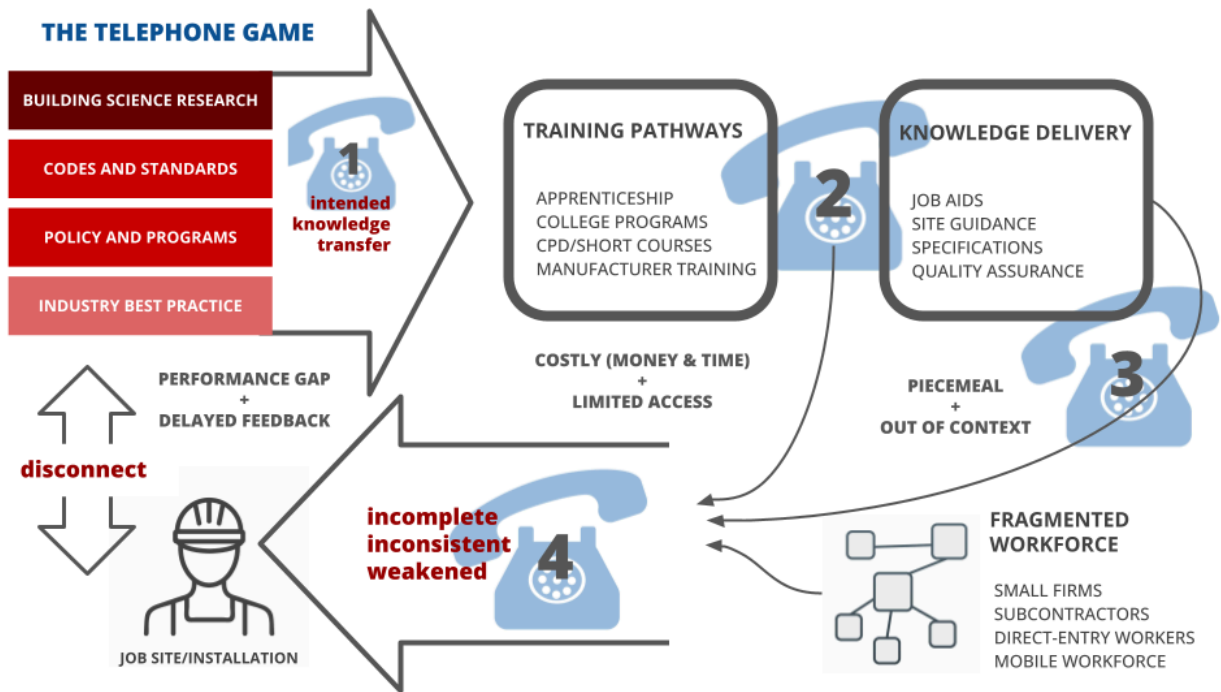


Figure 1. Knowledge in home construction is expected to move from research and policy to the job site through training and industry systems. In practice, workforce structure, fragmented training pathways, and weak delivery mechanisms disrupt this flow. The result is inconsistent knowledge at the point of installation and a gap between intended and actual building performance.

Understanding the problem requires examining the incomplete and inconsistent knowledge infrastructure that carries building science from research and policy into everyday construction practice. The result is not only a training gap, but a performance gap in the buildings themselves.

This gap is becoming more consequential as building performance expectations increase and code requirements become more stringent. The success of policies targeting energy efficiency, greenhouse gas reduction, and indoor environmental quality depends on correct implementation at the job site. However, existing training systems were not designed for the current structure of the home construction and renovation workforce, and informal learning pathways struggle to keep pace with increasing technical complexity. The result is a misalignment between what the housing system expects and what it enables.

A systems lens helps reveal how knowledge moves through the home construction sector and where it breaks down. Field observations, workforce research, and policy context point to three interrelated challenges:

- The structure of the construction workforce
- The limitations of existing training pathways
- The absence of mechanisms that reliably deliver applied building science knowledge to the point of installation

Addressing these challenges requires more than expanding traditional training programs. It requires a distributed learning ecosystem that aligns with how the workforce actually operates. Key components include vetted curriculum, accessible training formats, expanded trainer capacity, job-embedded learning tools, and portable credentials.

Together, these elements form the basis of a knowledge infrastructure capable of supporting consistent building performance across a distributed workforce.

If the housing sector is to deliver safe, durable, high-performance homes at scale, knowledge must be able to move through the system as reliably as energy, air, and water. Treating training as infrastructure is a necessary step toward achieving that outcome.

# 1. The Telephone Game of Construction Knowledge

# The Telephone Game of Construction Knowledge

The housing industry relies on trickle-down training structures that cannot reliably deliver the knowledge required to build safe, durable, high-performance housing.

As building systems become more complex and performance expectations rise, this knowledge gap is becoming a systemic risk within the housing sector.

Consistent energy/performance training must be treated as infrastructure within the housing system.

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## OPENING SCENARIO: The Moment of Failure on Site

After a home visit, complete with blower door test, an Energy Advisor develops an energy model for the house, makes some standard recommendations, often keyed to eligible incentives, and then hands off their report to the homeowner.

The homeowner can get a rebate from some of the recommendations in the report, so they hire a contractor to do air sealing and insulation work. The building envelope is tightened, insulation installed. Soon afterwards, condensation on windows becomes a problem. The occupants now complain the house is stuffy. These are new issues.

The failure is not mysterious, the physics of moisture, air, and heat movement are well understood.

The problem resembles the children's telephone game. Information begins with clear intent but becomes distorted as it passes through multiple intermediaries. In housing, knowledge travels from research to building codes, from codes to training programs, from training to builders, and from builders to crews on site. At each step interpretation increases and context is lost. By the time the information reaches the people installing materials, the rule may remain but the reasoning behind it has disappeared.

What's the missing element?

Adequate mechanical ventilation.

It was flagged in the report, but neither the homeowner nor the contractor understood that improving the building envelope includes mechanical ventilation as a *requirement*, not a 'nice to have' option.

## **Field Observations from Three Decades in Building Performance**

My name is Shawna Henderson. For more than three decades I have worked at the intersection of building science, energy efficiency, and housing performance. I began as an R-2000 evaluator and inspector and later became one of the first Energy Advisors in Canada. Over time I combined my building science background with communications and training, developing education programs for the home construction and renovation industry while continuing to advise homeowners on energy upgrades.

Across these roles I have observed the same pattern repeatedly: homeowners lack the information needed to make informed decisions, contractors perform the work requested, and the industry struggles to find workers with a working understanding of building science. The result is predictable. Energy efficiency upgrades stall at key decision points, and houses are sometimes damaged by well-intentioned improvements implemented without sufficient understanding.

A house is the largest single investment that most Canadians will make in their lifetimes. There are a lot of different roles in the value chain associated with the myriad decisions and choices that must be made when building or renovating a house. Yet, only Energy Advisors are required to have a comprehensive understanding of applied building science.

The result is that uptake of energy efficiency measures stalls out at key decision-making points. With uneven policies and erratic incentive programs at both federal and provincial levels and no consistent, vetted knowledge base to offer the whole industry, we stay in exactly the same state, one that harms homeowners and damages houses.

That's my in-the-field experience. My soapbox. My ongoing rant.

## The Risks of Good Intentions and Partial Knowledge

Peter Love, a well-respected climate scientist and the current chair of the Centre for Community Energy Transformation often uses a helpful analogy:

In Canada, you cannot charge for hairstyling or barbering services without completing a formal program of education, earning a license, and maintaining that license via continuing professional development requirements. What's the worst that might happen if an unlicensed person cuts hair? Someone might wear a hat for a few months until their hair grows back.

Now consider housing. To build a house, in many parts of Canada, there's no need for a license, let alone basic training. Builders must comply with building codes governing fire safety and structural integrity, and current codes also include energy efficiency requirements for new construction and major renovations involving structural work.

However, for most energy efficiency measures that are carried out on existing houses, there are no regulations. If you don't need to pull a building permit, you can do whatever you deem sufficient or correct. There are no requirements for training or certification.

Here, the risks are far greater.

Air sealing a house without adding or providing adequate mechanical ventilation can result in depressurization, which can cause oil and gas fired furnaces and water heaters to backdraft, meaning carbon monoxide is pulled into the house. People can become very sick, in a worst case scenario, they can die.

Natural Resources Canada has identified a related challenge in the implementation of home energy labelling programs. Evaluations of these programs consistently show that technical assessments and recommendations alone do not guarantee improved outcomes. Homeowners often struggle to interpret energy labels and reports, while contractors and trades may lack the background knowledge required to understand how recommended measures interact.

As a result, recommended upgrades are sometimes implemented incompletely or incorrectly, limiting the effectiveness of energy efficiency programs. This growing concern

has led to increased federal focus on energy literacy as a necessary complement to technical assessment programs (Natural Resources Canada 2026).

## **The predictable nature of building failures**

Moisture, air movement, and temperature differences behave in predictable ways. Failures happen not because knowledge does not exist but because it never reaches the job site.

Energy efficiency measures made with good intentions and knowledge gaps will inevitably result in moisture problems that will degrade the structure and affect the quality of life and health of the occupants.

Moisture management is central to durable housing. Properly executed energy conservation measures can improve moisture control while reducing energy demand. But achieving these outcomes requires an understanding of building physics and system interactions. For example, it is not enough to know how to install an air barrier. Installers must understand how material choices affect the entire wall assembly and whether the assembly allows moisture to dry.

The ventilation failure described earlier was not a failure of science. The physics of moisture, air, and heat movement are well understood and form the basis of modern performance-based building codes. The failure was a failure of knowledge distribution: the information required to implement best practices did not reach the people performing the work.

The challenge is increasingly understood as an energy literacy problem within the housing system. The knowledge required to interpret and apply building performance information is unevenly distributed across homeowners, contractors, trades, and many other players involved in housing delivery. Without mechanisms to translate technical information into practical decision-making tools, building performance programs risk producing reports rather than results.

The housing industry relies on informal, trickle-down training structures that cannot reliably deliver the knowledge required to build safe, durable, high-performance homes.

If we expect the housing sector to deliver climate-ready high performance housing at scale, training must be treated as infrastructure within the housing system to ensure that well-intentioned policies and building codes will continue to break down at the job site.

The systems that move this information can be understood as a form of knowledge infrastructure. This includes the training pathways, credentials, job aids, and communication channels that carry building science from research and policy into everyday practice. When this infrastructure is incomplete or inconsistent, the result is not just a training gap, but a performance gap in the buildings themselves.

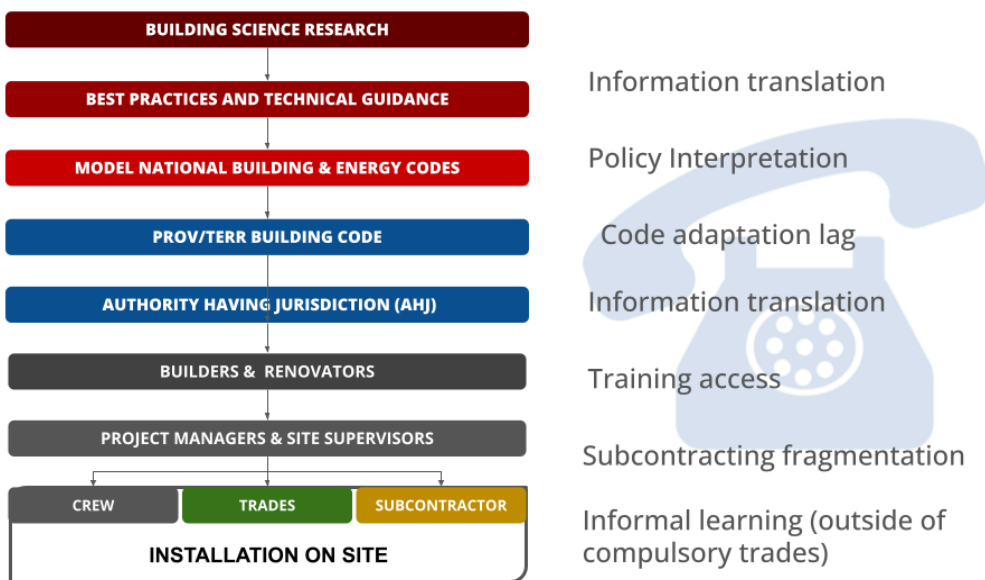


Figure 2. Knowledge flow through the housing system. At each step, interpretation and context loss can degrade the information needed for correct installation on site.

## The path knowledge takes through the housing system

As in the telephone game, information goes through many players with intent and reasoning degrading along the way. Each step adds interpretation and removes context.

At the vanguard of the industry is applied building science research. Applied building science research and emerging best practices are often several years ahead of code adoption cycles because regulatory change requires research validation, standards development, and provincial implementation processes (Straube & Burnett 2005).

The National Building Code of Canada (NBCC) is a model code that is updated every 5 years. Each province adopts/adapts the model code on its own timeline, and that can add another 5 to 10 year cycle.

Once adopted, codes are interpreted by the Authority Having Jurisdiction (AHJ), the building officials responsible for enforcement. Training and professional development requirements for these officials vary across provinces. In practice, the AHJ interprets code compliance based on their level of knowledge. The AHJ role is to confirm that prescriptive path requirements laid out in the code have been carried out and complied with, or to accept the energy performance target documentation generated by an Energy Advisors.

Builders are responsible for ensuring that the project meets code requirements. Professional training is available, but it is specific to industry organizations and is often limited to members. Where builder licensing is required in BC, Alberta, Ontario and Quebec, only BC and Quebec have continuing education requirements.

In all cases, a director of the company is the one who holds the license. Company leadership gets the training to get licensed. But, when it comes to construction technology and building science that underpins high performance housing, the individuals responsible for daily construction decisions on site may not receive equivalent training.

Builders who employ their own crews rely on project managers and site supervisors to oversee the work. It is difficult to determine how many have formal training versus those who learned on the job.

At the installation level, crews and subcontractors receive whatever information reaches them through project leadership, manufacturer workshops, or self-directed learning. Increasingly, that learning occurs through online platforms such as YouTube.

The hazard here is that there are some excellent building scientists and builders online, but most of them are from the US, which means they're working under a different building code, and likely operating in climate zones that don't match Canadian conditions.

By the time the information reaches the installation crew, workers may understand the rule but not the reason. As a result, they may be unable to solve a problem or consider an alternative method or material should a problem arise. Each layer filters, clouds, or confuses key information like:

Why a detail matters → What risks it prevents → How systems interact

Subcontracting serves to amplify the telephone game effect. Today's home construction and renovation projects involve independent trades, each responsible for a small portion of the building system. Few individuals get to see the full picture.

The consequences of degraded knowledge are informational failures that translate into building failures in terms of durability, comfort, health, and safety.

These failures also have economic consequences. When upgrades are implemented incorrectly, buildings require remediation, energy savings are not realized, and homeowner confidence in retrofit programs declines. This reduces the effectiveness of public incentive programs and slows progress toward housing affordability, climate targets, and building durability goals. Reliable knowledge distribution is a housing system performance issue.

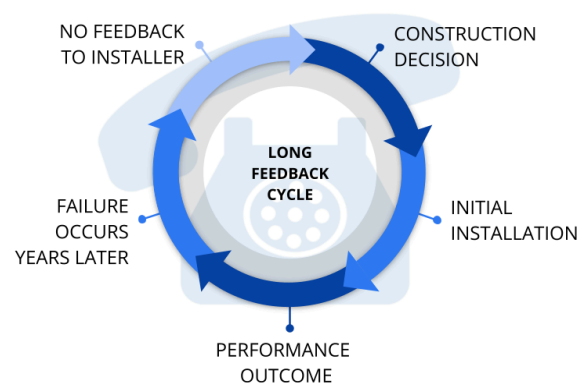
## Normalcy Bias and the Persistence of Outdated Practices

Another factor reinforcing the persistence of outdated practices is normalcy bias, our human tendency to assume that conditions will continue as they have in the past, even when underlying circumstances have changed.

Crews rely on assemblies that have “always worked,” even when materials, airtightness levels, insulation strategies, or ventilation systems have changed the physics of the building. A detail that performed adequately in a leaky 1970s house may fail in a modern airtight enclosure, yet the installation method persists because it appears familiar and safe.

The long feedback cycle of construction reinforces this bias. Building failures such as mold, rot, or moisture damage often take years to appear. The absence of immediate consequences reinforces the belief that existing practices are adequate.

In this environment, new knowledge must compete not only with fragmented



*Figure 3. Long feedback cycles in housing construction allow incorrect practices to persist.*

training pathways but also with deeply embedded habits shaped by past experience. Any workforce training strategy must therefore account for the powerful influence of routine and perceived normalcy on site practice.

Here's an example that illustrates several overlapping challenges, including normalcy bias: The idea that houses must "breathe" through uncontrolled leakage persists, even though it contradicts decades of building science research.

Anecdotal stories abound about crews deliberately cutting or puncturing the 6 mil poly interior air barrier after inspection because a house "has to breathe." The confirmed reality is that 6 mil poly interior air barriers are often torn, cut, or punctured by trades working on site due to mechanical damage from scaffolding, improper storage of materials, or careless installation of exterior cladding.

Vapour barriers were introduced into Canada's building code in the early 1950s to address moisture diffusion into building assemblies, with 6-mil polyethylene sheeting becoming standard by the 1970s. When research around the same time demonstrated that air leakage can transport roughly ten times more moisture into building assemblies than vapour diffusion alone, sealing the polyethylene to control air and moisture movement appeared to be a logical improvement (Lstiburek 2002; NRC/IRC 1993). This was a logical progression, but an incomplete solution that has led to a persistent, long-standing misunderstanding.

The very first airtight homes<sup>1</sup>, with 6 mil poly doing double duty as a vapour retarder and as an air barrier, experienced moisture and air quality problems because of higher interior moisture levels that led to condensation and mold growth in the living space. This cause and effect was quickly solved by identifying the need for mechanical ventilation *as well as* airtightness as part of a more efficient building envelope.<sup>2</sup>

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<sup>1</sup> Built in the late 1970s and early 1980s.

<sup>2</sup> Using mechanical ventilation as a foil against higher indoor humidity was first demonstrated by 1979's Saskatchewan House, a project led by the Saskatchewan Research Council. It was designed to showcase high-performance insulation, air tightness, and heat recovery ventilation technology to reduce energy consumption. The Saskatchewan House set new building standards, including the R2000 program, and is referred to as the first example of a Passive House.

Damage done. This early gaffe gave rise to the enduring belief that houses must “breathe” through uncontrolled leakage.

This, despite the fact that controlled mechanical ventilation has been required for compliance since the 1985 edition of the NBCC. This, despite research stemming back to the early 1980s has consistently demonstrated that airtight construction works when paired with controlled mechanical ventilation, summarized in the widely cited building science principle: build tight and ventilate right (NRC/IRC 1993; Lstiburek 2010).

Skepticism persists in parts of the industry, where linked energy-efficiency requirements are sometimes dismissed as unnecessary cost despite decades of monitored research demonstrating improved performance and reduced heating demand in airtight homes (CMHC 2010).

Viewed through a systems lens, this pattern reflects a breakdown in knowledge infrastructure rather than a failure of individual actors. Researchers, regulators, builders, trades, and homeowners each operate within limited scopes of responsibility and information. The housing system assumes that knowledge will move between these actors through informal communication, experience, and mentorship. In practice, however, we have a fragmented industry structure, uneven training pathways, and long feedback cycles that serve to reinforce normalcy bias. These factors in combination prevent knowledge from reliably reaching the point of construction. The result is not simply a training gap, but a structural knowledge distribution problem within the housing system.

The remainder of this paper examines why knowledge degradation occurs within the structure of the housing industry and explores the conditions required to deliver consistent learning outcomes across a fragmented workforce.

The analysis focuses on three structural challenges: the fragmentation of the construction workforce, the limits of existing training pathways, and the absence of mechanisms that reliably distribute applied building science knowledge to the point of installation.

## 2. The Intelligence of Building

# The Intelligence of Building

When trades are treated as second-tier careers, the industry loses talented people whose strengths lie in spatial reasoning, applied mathematics, and complex problem solving.

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Understanding why knowledge degradation matters requires recognizing the intellectual demands of construction work itself.

For several generations, education systems have framed university as the primary path to success, while trades have often been presented as a fallback option for students who are “not academic.”

This framing misunderstands the intellectual demands of construction. One persistent misconception in education and workforce development is the belief that trades are less intellectually demanding than academic professions (BuildForce Canada 2023; Government of Canada 2022).

In reality, building a house requires multiple forms of intelligence beyond academic prowess. Building a high-performance home is applied physics carried out in real time, often by workers without access to the science behind what they are building.

Workers in the home construction and (especially) renovation industry routinely perform spatial reasoning, applied mathematics, systems analysis, and real-time problem solving. They translate two-dimensional drawings into three-dimensional structures. They diagnose structural problems, adapt to changing site conditions, and coordinate complex assemblies made up of dozens of interacting components (National Research Council Canada 2020; Straube & Burnett 2005).

Building a house requires the integration of several forms of intelligence that are rarely taught together in formal education systems: spatial, quantitative, systems, and problem-solving.

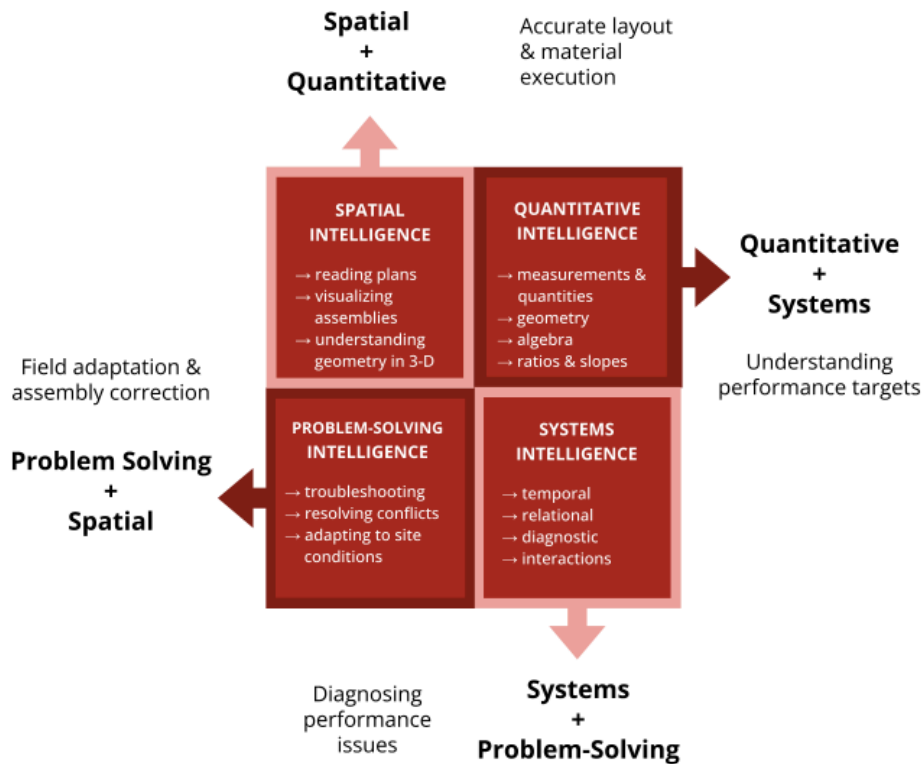


Figure 4. Four types of intelligence used in the home construction and renovation industry.

## Spatial Intelligence

Spatial intelligence is the ability to visualize objects and systems in three dimensions. Builders constantly translate drawings into physical structures:

- Reading construction drawings
- Visualizing framing assemblies
- Aligning walls and roof systems
- Understanding how structural loads move through a building

Many people who struggle with abstract classroom learning excel at spatial reasoning. Research on skilled trades has consistently identified spatial ability as a core competency in construction occupations (BuildForce Canada 2023; National Academies of Sciences 2017).

## Quantitative Intelligence

Construction relies on practical mathematics. Workers calculate measurements, angles, volumes, and material quantities every day:

- Using geometry to square foundations and walls
- Calculating roof pitch and structural loads
- Estimating materials and tolerances

This math is applied immediately and errors become visible in the structure itself.

Companies that rely on accuracy and hourly rates are at the mercy of poor math skills. The math used in construction is unforgiving. Mistakes are costly, and are measured in wasted materials, structural problems, and lost time.

Math is also a weak point for direct entry jobs. The importance of basic construction math is frequently raised by practitioners. In one widely discussed online thread asking tradespeople what schools should teach future construction workers, hundreds of responses converged on the same themes: reading a tape measure, calculating area and volume, squaring layouts, and interpreting plans. While informal, this feedback reflects a consistent industry concern about the gap between school preparation and on-site expectations.<sup>3</sup>

Workforce studies have similarly identified applied math and spatial reasoning as critical competencies for construction occupations (BuildForce Canada 2023).

## Systems Intelligence

Perhaps the least recognized form of intelligence in construction is systems thinking.

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<sup>3</sup> ([https://www.reddit.com/r/Construction/comments/13e0qi6/math\\_in\\_construction/](https://www.reddit.com/r/Construction/comments/13e0qi6/math_in_construction/))

Buildings are complex systems where many components interact. Workers must understand how air, heat, moisture, and mechanical systems interact. Moisture control and management are central to the House-As-A System approach, because moisture is the primary cause of durability problems in wood-frame construction (CMHC 2018; Straube & Burnett 2005).

Understanding building science means understanding how control layers work together and how decisions in one part of a building can affect performance elsewhere. This systems perspective is often summarized in the principle “build tight and ventilate right.” Without systems thinking, improvements in one part of a building can create failures elsewhere.

This is why building science knowledge is essential to modern construction.

## **Problem-solving intelligence**

Perhaps the most important form of intelligence on a construction site is problem solving. With on-site construction, no two projects unfold exactly as planned. For renovators making alterations to existing buildings, each project is unique. Materials vary, weather changes conditions, and existing structures often reveal surprises.

Site supervisors and crews constantly solve practical puzzles:

- How to correct framing errors without compromising structure
- How to adapt a detail when materials or conditions change
- How to coordinate work between multiple trades in tight schedules

These decisions often happen in real time with limited or missing information.

The ability to diagnose problems, solve puzzles, evaluate options, and implement workable solutions is central to construction expertise. Here’s where understanding the ‘why’ is key to applied building science. This is most critical in retrofit work, where the puzzle has to be worked out in real time.

When education systems treat trades as a fallback for students who are “not academic,” they overlook the intellectual demands of construction.

Students who might excel at spatial reasoning, applied mathematics, or systems thinking are often guided away from trades careers.

The result is both cultural and economic impacts: The construction industry struggles to attract talent. The workforce pipeline narrows. The knowledge gaps widen across the industry (BuildForce Canada 2023).

## **Reframing Trades as Technical Knowledge Work**

Building a high-performance home is not simply manual labour, it is applied physics, applied mathematics, and applied systems thinking carried out in real time (and toss in some applied chemistry for good measure).

One expression of this practical intelligence is the use of mechanical advantage. Skilled tradespeople rely on physics and tools rather than brute force to move heavy materials safely and efficiently.

High-performance new construction and retrofit work require workers who understand building science, materials behaviour, and system interactions. That's because home building and retrofit work is becoming more technical.

Recognizing both the advancing complexity of construction work AND the intellectual demands of building is essential if the industry is to attract and train the workforce required to deliver durable, healthy, climate-ready homes.

Modern construction work increasingly requires workers who can think in systems, understand material behaviour, and anticipate how building assemblies interact. Yet many of the people responsible for installing these systems have never been given access to the building science knowledge that explains how they work. As homes become more airtight, more insulated, and more mechanically complex, this gap between technical expectations and workforce knowledge becomes increasingly consequential.

### 3. Why Building Science Knowledge Matters

# Why Building Science Knowledge Matters

A house is a system: changing one part alters how the entire building performs.

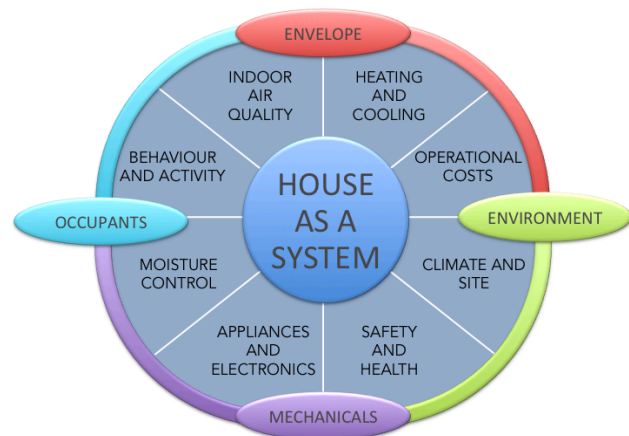
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Housing is no longer the straightforward construction of a shelter. It is constructing a controlled indoor environment that optimizes comfort, safety, and minimizes energy use.

Building science is the applied understanding of how buildings interact with their environment. It examines how heat moves through assemblies, how air leaks through enclosures, how moisture accumulates and dries, and how mechanical systems influence indoor conditions (Straube & Burnett 2005).

At the core of building science is the recognition that a house must function as an integrated system.

In Canadian housing policy and energy efficiency programs, this concept is commonly described as the 'House-as-a-System'. This framework emphasizes that individual upgrades cannot be evaluated in isolation: changes to one part of a building affect the performance of the entire system (Natural Resources Canada 2023; CMHC 2018).



*Figure 5. The House-as-a-System is the underlying concept of applied building science.*

Since the mid-1980s, Canadian homes have become significantly more energy efficient and airtight. Insulation levels have increased, windows perform better, and mechanical ventilation is now required by code in new construction.

These improvements have delivered substantial benefits. Energy consumption has declined, comfort has improved, and greenhouse gas emissions associated with household heating have been reduced (Natural Resources Canada 2023).

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While older houses were inefficient and uncomfortable, their high air leakage acted as a buffer against certain types of failures. For example, the uncontrolled air movement allowed assemblies to dry, and provided (more than) adequate make-up air for combustion appliances.

High-performance homes behave differently. As buildings become more airtight and insulated, they become more sensitive to design decisions, materials choices, and installation quality. Errors that once went unnoticed can now produce visible problems (Straube & Burnett 2005; Lstiburek 2010).

As knowledge moves through fragmented training pathways, critical building science principles are often diluted or misunderstood, increasing the likelihood of failure at the point of installation (Henderson 2026).

Natural Resources Canada promotes an “Envelope First” approach through programs such as the EnerGuide for Houses Rating Service and the Canada Greener Homes Initiative, where air sealing and insulation upgrades along with adequate mechanical ventilation are prioritized to reduce energy demand before mechanical system improvements are considered (Natural Resources Canada 2023; Natural Resources Canada 2021).

Improving insulation levels changes temperature gradients within assemblies. Increasing airtightness alters pressure relationships inside the house. Installing new windows can affect condensation risk. Adding insulation to an attic reduces heat loss but may also change ventilation dynamics.

These interactions are not always intuitive. They require an understanding of building physics and system interactions. The materials used in the assemblies of walls, roofs, foundations cannot be treated as independent components.

We are back at the fundamental, key slogan: ‘Build tight, Ventilate right’.

The building envelope determines how much energy a building requires in the first place. Reducing heat loss here lowers the demand placed on heating and cooling equipment. Mechanical systems can be sized appropriately and operate more efficiently (Natural Resources Canada 2023; CMHC 2018). The building code is grounded in The Envelope First approach, so its prescriptive paths act as a regulatory framework for builders working with new construction.

When it comes to energy retrofits, however, there is no regulatory framework. Energy upgrades must be understood within the context of the House-as-a-System framework. That's because improving the building enclosure changes the internal dynamics of the house. Individual changes can improve performance but also require adjustments elsewhere in the system.

For example, tightening the building envelope reduces natural air leakage. Without adequate mechanical ventilation, indoor humidity levels can rise and indoor air quality can deteriorate. Increasing insulation without addressing air leakage pathways creates the risk of condensation inside wall or roof assemblies. Higher insulation levels change temperature differences within assemblies. (CMHC 2018; NRC 1993).

These interactions are why building science emphasizes that the building envelope must manage four key elements: water, air, heat, and vapour. Control layers are used to regulate how these elements move through the building enclosure (Straube & Burnett 2005).

- Water control layer sheds rain and prevents bulk water from entering the structure
- Air control layer limits uncontrolled air movement
- Thermal control layer manages heat flow
- Vapour control layer regulates moisture diffusion through materials

When these layers are continuous and properly installed, buildings remain durable and comfortable. When they are interrupted or poorly understood, failures can occur. Here are two common failures:

- An air barrier that is punctured or cut during construction will allow warm interior air to reach cold surfaces within a wall assembly. As a result, condensation forms, moisture accumulates on the sheathing and bottom plate. Over time this can lead to mold growth or structural rot (CMHC 2018; NRC 1993).
- Adding insulation to an attic without improving air sealing can increase condensation risk in roof assemblies because air leakage carries moisture into colder spaces where it condenses (Straube & Burnett 2005).

As described in Section 2, construction work requires spatial reasoning, applied mathematics, systems thinking, and real-time problem solving. Workers routinely make decisions that influence building performance.

They adjust details, sequence installations, and adapt to unexpected site conditions. When framing changes are required, when insulation must be fitted around structural elements, or when penetrations are sealed, the decisions made on site determine whether control layers remain intact.

Failures like the ones described above occur because the people responsible for installing building components have not been given access to the building science knowledge that explains why those details matter.

Policies and building codes increasingly require higher levels of building performance. Energy efficiency targets continue to rise. Airtightness requirements are tightening. Mechanical ventilation systems are standard practice in many jurisdictions (National Research Council Canada 2020).

The knowledge required to implement these changes reliably is unevenly distributed across the housing system. This is a prime example of the gap between technical expectations and workforce knowledge.

Design professionals may understand building science principles. Energy Advisors may model building performance. Manufacturers may publish technical guidance. But the people responsible for installing assemblies on site often receive this information indirectly, if at all.

## What do you need to know?

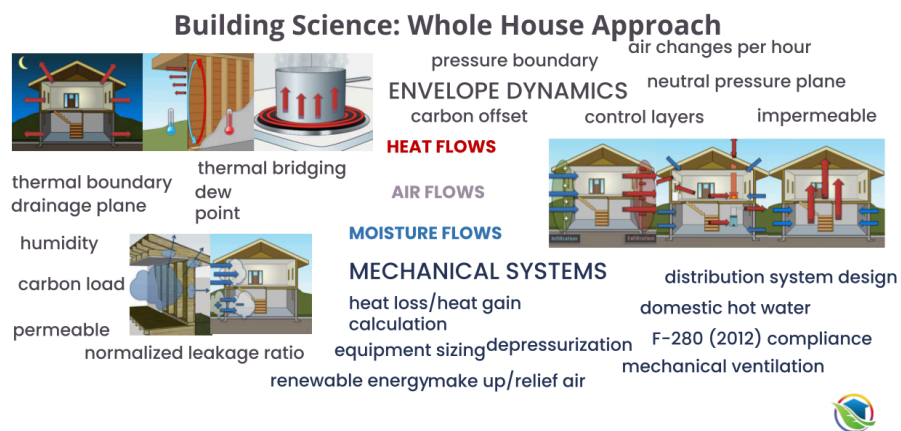


Figure 6. What do you need to know? A still from a Blue House Energy video showing the scope of topics that fall under the 'Building Science' competency guidelines for Energy Advisors.

As described in Section 1, knowledge must travel through multiple layers of interpretation before reaching the job site. Each layer filters context and reasoning. By the time instructions reach the installation level, workers may understand the rule but not the reason behind it.

Without understanding the reason, workers cannot adapt when conditions change. This challenge becomes particularly visible in retrofit work. Hidden conditions appear when walls are opened. Materials interact with older assemblies in unexpected ways.

In these situations, success depends on workers who understand how houses function as systems. Building science knowledge must reach the people responsible for carrying out the work.

If the housing sector expects to deliver durable, healthy, climate-ready homes at scale, building science literacy must become part of the core skill set of the construction workforce.

Understanding the science of how buildings work is only part of the challenge. The larger question is how this knowledge reaches the workforce responsible for building and renovating homes.

To answer that question, we need to look at how the housing industry is structured.

## 4. The Structure of the Housing Industry

# The Structure of the Housing Industry

home construction operates as a distributed production system composed largely of micro-enterprises and subcontractors.

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The structure of the home construction workforce further complicates the movement of building science knowledge. In Canada, the majority of home construction firms are small or micro-enterprises, and many workers enter the industry through direct entry rather than formal apprenticeship or post-secondary programs (BuildForce Canada, 2023). Field observations from across Canada reinforce this pattern, with most residential construction activity carried out by small firms operating with limited capacity for formal training or workforce development (Henderson 2025).

Training occurs largely through informal workplace transmission rather than structured educational pathways. While this model allows firms to remain flexible and responsive to fluctuating construction demand, it also means that technical knowledge is often passed through peer instruction or observation rather than systematic training.

Research on construction workforce development has shown that such informal learning environments can lead to uneven adoption of new practices, particularly when new code requirements or building technologies are introduced (International Energy Agency, 2022).

In practice, this structure amplifies the “telephone game” effect described earlier: information is filtered through multiple layers of interpretation before reaching the individuals responsible for installation on site.

## The microbusiness reality

Most home builders operate as small crews, owner-operators, and project managers coordinating subcontractors. home construction does not operate as a single organization. It functions as a network of microbusinesses, subcontractors, and temporary project teams.

Small firms lack HR departments and in-house training programs.

Formal mentorship systems are limited to the number of Red Seal carpenters who are active in the industry and the number of apprentices they can mentor.

Further limiting the formal apprenticeship route is the fact that business owners who are not Red Seal carpenters, and/or businesses that do not have Red Seal carpenters on staff are not in a position to offer formal mentorship or training to potential apprentices.

In this environment the telephone game becomes unavoidable. Each participant receives only a fragment of the full message, and the message changes slightly each time it is passed along.

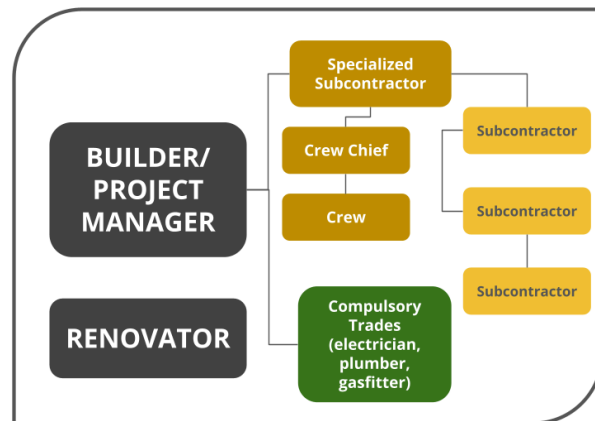
Subcontracting further distributes responsibility across multiple actors. No single party is responsible for the performance of the building as a complete system.

Builders often act as coordinators rather than direct employers of all trades. Each subcontractor is responsible for a specific scope of work, with limited visibility into how their work interacts with other systems.

This fragmentation complicates knowledge transfer. Information must move across organizational boundaries, trades, and scopes of work. In many cases, there is no clear mechanism to ensure that critical building science concepts are shared consistently across all participants.

With this fragmentation and abundance of microbusinesses, home construction and renovation projects are more often coordinated rather than centrally executed. Builders frequently act as project managers who oversee a network of subcontractors responsible for specialized tasks.

These subcontractors often perform the work that most directly affects building performance, including air sealing, insulation installation, window installation, and mechanical system installation. In this model, the individuals responsible for these critical



*Figure 7. The fragmentation of the home construction and renovation industry means that many building firms are, in fact, project management companies directing subcontractors rather than construction companies running in-house crews.*

details are not employees of the builder. They may work across multiple projects, for different clients, with varying expectations and levels of oversight. As a result, builders have limited direct control over how work is carried out in practice.

This structure raises a fundamental question for the housing system: if responsibility for construction is distributed across many actors, who is responsible for ensuring that building science knowledge reaches the point of installation?

## Industry Scale and Training Capacity

The construction workforce is large, but formal training capacity is limited. Colleges, apprenticeship programs, and industry training organizations cannot supply or retrain the entire workforce at the pace required to meet evolving building performance standards (BuildForce Canada 2023; Government of Canada 2022).

A significant portion of the workforce enters through direct entry, learning on the job rather than through formal education. While this model supports rapid workforce entry, it creates variability in baseline knowledge and limits exposure to building science principles. As building codes and performance expectations evolve, the gap between required knowledge and available training capacity continues to widen.

The home construction industry is also shaped by long-standing cultural norms. Recruitment has historically relied on informal networks, mentorship relationships, and family connections. While these pathways can support strong skill development, they can also limit who enters and advances within the field.

Women remain significantly underrepresented in construction trades, comprising approximately five percent of the workforce in Canada (Statistics Canada 2022; BuildForce Canada 2023).<sup>4</sup> This persistent imbalance reflects structural barriers in recruitment pathways, workplace culture, and training access.

Current training pathways also fail to reach many Indigenous, First Nations, and Métis communities, where access, delivery models, and knowledge systems differ from the assumptions built into formal and industry-led training structures.

If the industry is to expand workforce capacity, it must address not only technical training gaps but also the cultural structures that influence participation and retention.

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<sup>4</sup> <https://bluehouseenergy.com/blogs/bhe-blog/why-are-there-so-few-women-in-trades?>

## 5. The Training System We Built

# The Training System We Built

Formal training pathways play an important role in the construction industry, but they were designed for workforce structures that differ significantly from the way the home construction and renovation industry now operates.

Formal training pathways play an important role in the construction industry, but they were designed for workforce structures that differ significantly from the way the home construction now operates.

In Canada, construction training is typically delivered through a combination of community college programs, apprenticeship systems, trade certification, and continuing professional education (Government of Canada 2022; BuildForce Canada 2023). These pathways are intended to provide structured skill development from entry-level training through advanced certification.

Typical institutional pathways include community college and technical institute programs, as well as apprenticeship systems combining on-the-job training with classroom instruction. Both of these lead into certification systems such as the Red Seal program. Formal continuing education is delivered through professional associations and industry organizations.

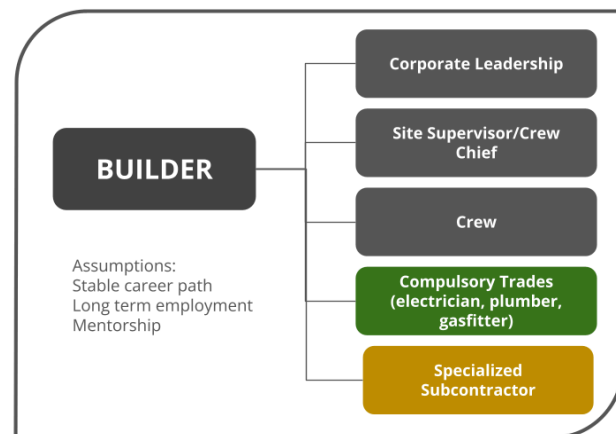


Figure 8. The training and education system feeding the home construction and renovation industry was created for a business model that is now the exception rather than the rule.

These systems assume workers progress through sequential stages of formal training over the course of a stable career.

Historically, this model reflected the structure of the construction workforce. Training systems evolved during a period when trades were organized around clearly defined craft

roles, long-term employment relationships, and predictable career progression through apprenticeship and certification (OECD 2021).

However, several structural constraints limit the ability of these systems to support the current homebuilding workforce.

## **Institutional Capacity Constraints**

Formal training systems have limited capacity relative to the size of the construction workforce.

Community colleges and apprenticeship programs operate within fixed institutional resources. Seats in training programs are limited, and instructor shortages constrain expansion in many regions. As construction demand increases, training systems often struggle to scale at the same pace as workforce needs (BuildForce Canada 2023; Canadian Apprenticeship Forum 2022).

Participation also requires workers to step away from the job site for periods of classroom instruction. For employees of large firms this may be manageable. For workers in small businesses or self-employed roles, time spent in training often represents lost income or project delays.

These structural limitations make it difficult for many workers to access formal education pathways once they are already active in the workforce. But, beyond capacity constraints, formal training systems assume career patterns that are increasingly uncommon in home construction.

Institutional training pathways typically assume that workers enter the industry through formal programs early in their careers, that they progress through structured apprenticeship systems, remain within a single trade classification, and advance through defined certification levels.

In practice, home construction careers are often far less linear.

Workers frequently enter the industry through direct-entry, whether it's short-term employment, seasonal work, or informal hiring networks. Individuals move between roles, trades, and employers as opportunities arise. Many acquire skills gradually through work experience rather than through formal credential pathways.

This mismatch between training system design and workforce reality means that a substantial portion of the home construction and renovation workforce develops skills outside institutional education systems.

## **Structural Bias Embedded in Training Design**

The design of institutional training pathways also embeds assumptions about who can access these systems. Formal training models make some assumptions that workers:

- Can leave the workforce temporarily to attend training
- Have access to institutions delivering trades education
- Are familiar with apprenticeship systems and certification pathways
- Follow linear career trajectories within a single trade

These assumptions are characteristics of the training system rather than of the workforce itself. When workers do not meet these assumptions, access to formal training becomes more difficult. Individuals who enter construction through non-traditional pathways may find few opportunities to acquire structured building science education later in their careers.

Training pathways are also shaped by broader cultural attitudes toward trades and academic education.

For several generations, North American education systems have emphasized university pathways as the primary route to economic mobility. Skilled trades have often been presented as an alternative for students who are “not academic,” rather than as professions requiring substantial technical expertise (Government of Canada 2022; BuildForce Canada 2023).

This framing influences how students encounter the construction industry, and affects workforce development long before individuals reach job sites.

Young people whose strengths lie in spatial reasoning, applied mathematics, or technical problem solving are frequently encouraged toward academic pathways instead of trades careers. As a result, construction training systems begin with a smaller and less diverse pool of entrants.

Formal education and apprenticeship systems remain essential components of the construction workforce. However, their design alone cannot ensure that building science knowledge reaches the full home construction and renovation workforce.

Institutional capacity constraints, non-linear career pathways, and cultural assumptions about trades education all limit participation in these systems. As a result, much of the industry's practical knowledge continues to develop outside formal training environments.

The next section examines how knowledge actually moves through the homebuilding workforce in practice.

## 6. The Training System We Actually Use

# The Training System We Actually Use

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The training gap described in this paper is not caused by a single failure. It emerges from the interaction of several independent factors:

- Education systems that skew to academic prowess
- Apprenticeship systems with limited capacity
- Changes to the home construction industry structure
- Building code changes that include climate-specific energy performance
- Changes in materials and methods available in the market
- Housing policy frameworks

These intersect most directly at the job site, where workforce training, code requirements, materials, and project delivery must align in real time. Each factor operates with its own aspect of normalcy bias along with assumptions about how knowledge moves through the workforce. When those assumptions do not align, knowledge fails to reach the job site.

The result is a housing system that asks the workforce to deliver increasingly complex performance outcomes without providing reliable access to the knowledge required to achieve them.

Then there's the structure of the workforce itself. The majority of the home construction and renovation workforce enters the industry through direct entry rather than formal training pathways. Many workers begin with entry-level jobs and develop skills through on-site experience rather than institutional education (BuildForce Canada 2023; Statistics Canada 2022).

Progression typically occurs through observation, repetition, and informal mentoring.. Common learning sources include coworkers and supervisors, manufacturer product demonstrations, supplier guidance and technical sheets, and finally, trial and error on job sites. This pathway allows the industry to respond quickly to fluctuating labour demand, but it also generates costs in the form of time and callbacks.

The assumption is that experienced workers will pass knowledge along to newer workers. In theory this resembles apprenticeship. In practice, information is often passed along in fragments, without the original context or underlying reasoning. If the first time a detail is encountered is on the job site, under time pressure, there is likely no opportunity to verify or revisit the underlying principle. Workplace learning research has long recognized that informal learning environments can produce uneven knowledge transfer (International Energy Agency 2022; OECD 2021).

Informal knowledge transmission developed under conditions where it was largely effective. Homebuilding initially involved simpler assemblies and fewer interacting systems. Building codes focused primarily on structural integrity and fire safety, with prescriptive methods guiding construction practices. Workers could learn through repetition and experience, applying standard details across many projects.

Carpentry, which remains a non-compulsory trade in most Canadian jurisdictions, could be learned through practical experience, with or without formal certification requirements. Under these conditions, repetition and peer instruction were often sufficient to develop competence in common building practices. The conditions that supported informal learning have changed significantly.

Modern housing requires coordination between multiple interacting systems, including building enclosures, mechanical ventilation, airtightness, insulation, and moisture control. Building codes have evolved accordingly, moving toward performance-based frameworks such as objective-based codes and tiered or step-code systems that emphasize energy performance and building durability (National Research Council Canada 2020).

## **A parallel system that still doesn't reach the job site**

Since 2012, my company, Blue House Energy, has attempted to work alongside this informal system by creating accessible, industry-vetted training for working professionals.

Blue House Energy was developed from my field experience as an R2000 evaluator, Energy Advisor, and building science consultant, with the goal of translating applied research and building science into modular, just-in-time online training. We have a library of more than 40 hours of video content and hundreds of supporting resources, including job aids and field-ready reference materials. The content is intentionally program-agnostic and climate-aware, designed to be relevant across regions, roles, and project types.

The response from the industry has been consistent.

When training is required, be it mandatory competency or continuing professional development for builders, or exam preparation for Energy Advisors, our course starts are strong<sup>5</sup>. Where training is optional, uptake is minimal.

This reveals a second dimension of the “telephone game.” In many cases, the issue is not that information changes as it moves through the system. It is that the information is never picked up at all.

Attempts to distribute this content through industry associations, workforce programs, and direct outreach have shown the same pattern. Without a requirement, even directed, industry-supported training does not consistently reach the people doing the work.

With home construction firms being in high demand, it’s also nearly impossible for them to justify the cost of outside training let alone convince them of the value and benefits of performance management practices that are accepted as standard operating procedures in many other industries that have such a large impact on the economy as a whole.

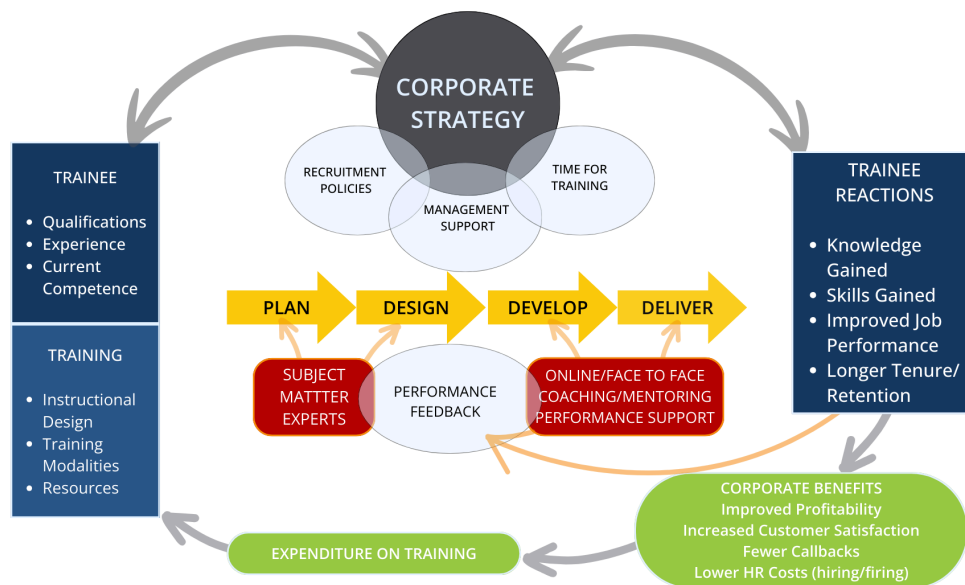


Figure 9. A typical performance management model uses ongoing feedback loops to optimize a business.

<sup>5</sup> It's worth noting that mandatory competency training and continuing professional development is required *only* by directors of the companies applying for, or maintaining, their license. This training is still not directly reaching the workers on site.

## Policy Frameworks and increasing complexity

At the same time, expectations placed on the industry have increased. Policy frameworks expect the homebuilding industry to deliver improved energy efficiency, reduced greenhouse gas emissions, and better indoor environmental quality (Natural Resources Canada 2023).

Although prescriptive construction pathways remain available in many jurisdictions, they do not always reflect best practices and are subject to interpretation by Authorities Having Jurisdiction (AHJ), the building official. The depth of building science knowledge among building officials can vary, particularly when evaluating non-traditional materials or assemblies.

New materials, technologies, and methods have further increased the technical complexity of home construction and renovation.

Without a conceptual understanding of building science principles, workers are often asked to apply rules without understanding the underlying mechanisms that make those rules necessary.

When knowledge is transmitted without context, workers may understand what to do but not why it matters. This limits their ability to adapt details when site conditions change or when new materials are introduced. Informal learning pathways struggle to keep pace with this level of system complexity.

Feedback cycles in construction are also long. Moisture damage, air leakage problems, and ventilation failures often take years to become visible. By the time failures appear, the original installation crews may no longer be involved in the project.

These delayed feedback loops reduce opportunities for learning and reinforce existing practices, even when those practices no longer align with current building science understanding (CMHC 2018; Straube & Burnett 2005).

The interaction between informal learning pathways and increasing system complexity creates a structural vulnerability within the housing system.

Workers are expected to deliver high-performance housing outcomes in environments where technical knowledge and training pathways are unevenly distributed. When

feedback cycles are delayed, the system interactions that cause failures are not always recognized as, nor understood to be, the cause.

This gap between performance expectations and workforce knowledge contributes directly to the building failures described earlier in this paper. This gap does not reflect a lack of effort or professionalism within the workforce. It is a lack of reliable mechanisms for ensuring that applied building science knowledge reaches the point of installation.

If knowledge in the home construction sector moves primarily through informal and fragmented pathways, improving outcomes requires more than expanding traditional training programs. It requires approaches capable of delivering practical, applied building science knowledge directly to the distributed workforce.

The next section describes a training approach developed with this constraint in mind.

## 7. Policy Intent vs Field Reality

# Policy Intent vs Field Reality

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Governments are setting goals not only for energy efficiency but also for climate resilience and carbon reduction. Building performance outcomes are ultimately determined by the decisions made by builders, contractors, and trades during construction and renovation.

These goals depend on correct implementation.

At the national level, the federal government has established a goal for net-zero energy ready (NZER) building performance in new construction by 2032 through the progressive tightening of the National Building Code of Canada which includes the addition of Tiered energy performance targets in NBCC 2020 (Government of Canada 2022; National Research Council Canada 2020).

The 2020 Tiered NBCC is harmonized with British Columbia's Energy Step Code, which was introduced in 2017 as a voluntary compliance pathway that gradually increases energy efficiency requirements leading toward net-zero energy ready construction (Province of British Columbia 2017).

The Energy Step Code demonstrated a predictable pathway for improving building performance while allowing local governments to adopt higher performance tiers over time. It has also supported market transformation by encouraging builders to experiment with higher-performance construction methods before they become mandatory requirements.

However, the rollout of the Step Code has also revealed important lessons about implementation, namely, that technical requirements alone are insufficient to ensure consistent outcomes. Successful adoption depends heavily on workforce capacity, training, and access to practical knowledge resources (RDH Building Science 2021; Province of British Columbia 2020). Without workforce capacity, compliance becomes a checklist exercise rather than a systems-based approach to building performance.

This implementation gap becomes visible when new technologies intersect with building codes that have not yet adapted to them.

Policy frameworks often assume that new technical requirements will diffuse through the construction industry automatically. In practice, building codes frequently lag behind current research findings and emerging best practices. Because of this lag, new materials and technologies can enter the market before code provisions or reference standards exist to support them. Builders may therefore encounter products that improve performance but lack clear regulatory guidance for their use.

Mechanical ventilation provides a current example. When renovating a house to create a secondary suite, building codes require a dedicated whole-house ventilation system. In my own home in Nova Scotia, converting a basement into a one-bedroom suite requires installing a second ventilation system.

The option I would prefer is a German through-the-wall balanced heat recovery ventilator (HRV) composed of a pair of small units that alternate every ninety seconds between supplying fresh air and exhausting stale air. This technology has been used in Europe for decades and has been available in Canada for more than twenty years. It offers high efficiency and can be installed without the ductwork required by a centralized HRV system.

The alternative required by code compliance is a fully ducted central HRV. Installing this system requires bulkheads, duct runs, and dedicated mechanical space, significantly increasing both cost and space requirements within the suite.

The modular HRV units I propose to use have been successfully installed in multi-unit buildings governed by Part 3 of the building code, both in retrofit and new construction. However, my project falls under Part 9. Whole-house ventilation systems in this section must comply with a specific CSA performance standard. Because this standard was written around centralized HRV systems, it does not accommodate the modular ventilation strategy used by paired through-the-wall units. As a result, the Authority Having Jurisdiction has rejected the product.

To use this proven, high-efficiency technology, I must pursue an alternate solution pathway involving a mechanical engineer and technical documentation from the distributor.

Ironically, if the suite renovation did not require a building permit, I could simply purchase the same product from a local supplier and have it installed without regulatory review.

Modular HRV systems are a niche product in Canada, but they represent a practical solution for many retrofit situations. They perform better than the typical default of bath fans and range hoods, which are exhaust-only and can cause depressurization.

The building code should address this option, but that may be decades out. In the meantime, there is a workaround for innovative products and materials, the Canadian Construction Materials Center (CCMC), part of the National Research Council of Canada (NRC). The CCMC provides technical assessments verifying whether products meet code-referenced standards or can be accepted as alternatives. CCMC approval is voluntary and requires manufacturers to fund third-party testing and evaluation.

On top of regulatory constraints, builders operate within a set of practical constraints that further complicate implementation. Home construction projects are shaped by tight timelines, cost pressures, and fluctuating labour availability. Builders must coordinate multiple trades, manage project budgets, and respond to changing client expectations.

Participation in training programs often requires time away from the job site, which can be difficult for businesses operating on narrow margins (BuildForce Canada 2023). This challenge is particularly pronounced outside major urban centres, where access to training institutions and technical support resources may be limited.

Delivering high-performance housing depends not only on the technical skills of individual trades but also on the knowledge of the people making project-level decisions. Building specifications, sequencing and scheduling all shape the conditions under which trades perform their work. If the decision-makers lack a working understanding of building science, even well-trained trades may struggle to apply best practices effectively. For example, workers responsible for installing air barriers, insulation, or ventilation systems may be following current technical guidance. Their efforts can be undermined if project-level decisions about materials, assemblies, or sequencing were made without understanding how building systems interact.

In these situations, performance failures are not the result of individual mistakes. They emerge from a mismatch between decision authority and system knowledge.

## 8. Workforce Access and Inclusion

# Workforce Access and Inclusion

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The previous sections describe how knowledge degrades as it moves through the housing system, how the construction workforce operates as a network of small firms and subcontractors, and how formal training pathways reach only a portion of that workforce. Together these dynamics shape who can access building science knowledge and who cannot.

Workforce access is therefore not only a training issue. It is a structural feature of how knowledge moves through the home construction sector.

As discussed in Section 5, formal training pathways such as apprenticeship programs, college courses, and certification systems are designed around stable employment patterns and institutional participation.

Workers who are most likely to access these systems typically have access to training institutions, familiarity with apprenticeship structures, financial capacity to step away from work for classroom learning, and connections to employers who participate in formal training systems

These pathways remain essential components of workforce development. However, they reach only a portion of the home construction workforce.

As described in Sections 4 and 6, many workers enter home construction through direct entry rather than institutional training pathways. Groups underserved by existing training systems include:

- Direct-entry workers learning on job sites
- Immigrant tradespeople unfamiliar with cold-climate construction practices
- Workers employed by small subcontracting firms
- Individuals without access to industry networks or mentorship relationships

Even when training opportunities exist, workers may face practical barriers to participation. For workers employed by small firms or working as independent contractors, time spent in formal training can represent lost income or project delays. These structural barriers limit participation even when interest in training exists.

Industry culture also shapes how workers enter and advance within construction. As discussed earlier, the industry relies heavily on informal recruitment and mentorship networks.

These networks can be effective for transmitting practical knowledge, but they may also restrict access for individuals who are not already connected to them.

Construction workplaces have historically been male-dominated environments. Across Canada, women represent roughly five percent of the construction workforce (Statistics Canada 2022; BuildForce Canada 2023). Participation rates have changed slowly despite ongoing recruitment initiatives.

These patterns suggest that workforce development challenges are influenced not only by training capacity but also by how industry networks shape access to opportunities.

## **Mechanical Advantage and Workforce Access**

Construction work is often perceived as requiring exceptional physical strength and a disregard for perceived weakness or softness. This is part of the industry culture that results in workers not using appropriate PPE, or pushing beyond a reasonable safety threshold for lifting.

In practice, many of the most physically demanding tasks can be performed more safely and efficiently using mechanical advantage. However, even though power tools abound, construction is second to last in uptake of technology (just above hunting and fishing). The key areas where construction is accelerating are AI/BIM, robotics, drones, and Internet of Things (IoT) sensors (Statistics Canada. 2025, Epicflow. n.d.).

Incorporating robotics and tools that offer mechanical advantage could be ways to shift the industry culture and establish a broader base for the workforce . Tools such as beam jacks, drywall lifts, material hoists, vacuum glazing lifters, and compact telehandlers allow heavy materials to be positioned with greater precision and reduced physical strain.

Normalizing the use of these tools expands who can participate in construction work. Workers who might otherwise be excluded by assumptions about physical strength (women, smaller workers, older tradespeople, and workers managing physical limitations) can contribute effectively when tasks are organized around tools and planning rather than brute force.

Assistive technologies reduce cumulative physical strain on experienced crews, helping extend careers and lower the risk of injury (CPWR 2021; CCOHS 2021; WorkSafeBC 2020).

Workforce access is often framed as an equity issue. In the context of housing delivery, it is also a capacity issue. As outlined throughout this paper, the home construction industry faces increasing technical demands while operating within a fragmented workforce structure.

Reframing construction as work that rewards skill, judgment, and mechanical advantage rather than brute strength is both a workforce strategy and a safety strategy. It expands who can enter and remain in the field and increases the industry's ability to absorb new knowledge and implement evolving building performance practices.

A resilient housing workforce depends on broadening both who builds and who learns. Improving workforce access strengthens not only social inclusion but also the system's capacity to deliver durable, high-performance housing.

The next section examines how knowledge infrastructure can be expanded to support learning across this distributed workforce.

# 9. Toward a Housing Knowledge Ecosystem

# Toward a Housing Knowledge Ecosystem

Canada has invested heavily in the infrastructure required to finance, regulate, and inspect housing. Much less attention has been given to the infrastructure required to move knowledge through the workforce responsible for building it.

Housing is not a single sector, it is a system that functions within a complex value chain. Housing has a significant impact on the economy of a developed country like Canada (OECD 2021). When construction, real estate, and housing-related services<sup>6</sup> are considered together, housing-related activity accounts for a significant share of Canada’s economy, approaching 20% of GDP in some estimates (Statistics Canada; CMHC; Bank of Canada).

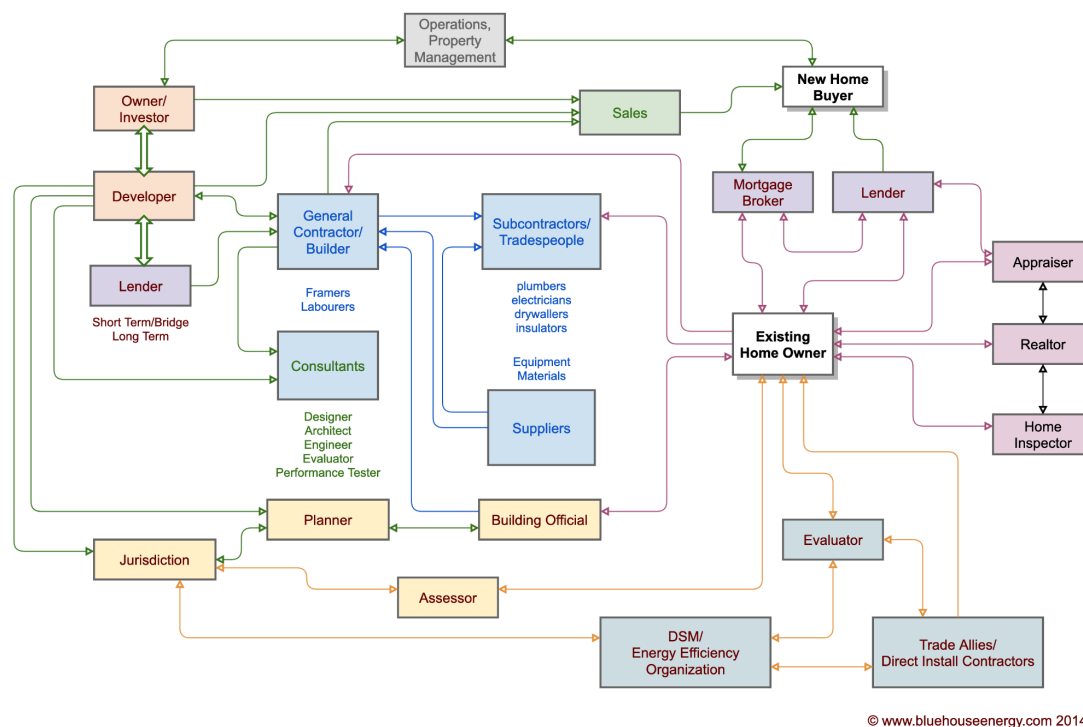


Figure 10. A partial model of the value chain associated with home construction and renovation in Canada.<sup>7</sup>

<sup>6</sup> Statistics Canada, *Residential Investment and Its Role in the Canadian Economy*, Catalogue no. 11-626-X (Ottawa: Statistics Canada).

<sup>7</sup> <https://bluehouseenergy.com/blogs/bhe-blog/12684821-value-chain-and-core-competencies>

Canada has invested heavily in the infrastructure required to finance, regulate, and inspect housing. Much less attention has been given to the infrastructure required to move knowledge through the workforce responsible for building it. Part of the reason for this is the fact that housing is a provincial responsibility. Creating a national infrastructure relies on cooperation and alignment across a wide spectrum of political and economic drivers.

Home construction is dominated by small firms, subcontracting networks, and a workforce that often enters through direct employment rather than formal training. In this environment, knowledge cannot depend on institutional pathways alone. Instead, the sector requires a learning ecosystem capable of delivering reliable, vetted building science knowledge through multiple channels to a distributed workforce. The goal is to move knowledge closer to the point of action. This requires aligning training systems with the structure of the workforce rather than expecting the workforce to conform to traditional education models. Several complementary mechanisms can support this shift.

Research on socio-technical transitions reinforces this point. Changes in complex systems do not occur simply because better technologies exist or because new policies are introduced. They occur when knowledge, skills, and practices move through networks of actors and institutions and are adopted in everyday work (Sovacool & Ryan, 2016). In housing, this means that improving building performance cannot depend on a single training pathway or centralized education system. Knowledge must circulate through multiple channels and reach the people making decisions and carrying out the work on site.

A builder may carry legal responsibility for the performance of a home, but the knowledge required to achieve that performance is distributed across many independent trades. Builders influence outcomes through clear specifications for air barriers, insulation installation, and mechanical systems. Detailed scopes of work reduce ambiguity and help subcontractors understand the performance expectations associated with their tasks.

Builders can also influence the baseline knowledge expected from subcontractors through hiring decisions and project requirements. While builders cannot retrain the entire workforce, they can gradually shift expectations about knowledge and performance by preferring contractors who understand system interactions, encouraging participation in training programs, and engaging contractors in developing mockups of proposed assemblies. However, these builder-based strategies will not transform workforce knowledge systems on their own. Knowledge must be distributed through mechanisms that reach subcontractors directly. This is why broader training ecosystems are necessary.

## Vetted Curriculum and Accessible Learning Formats

A foundational requirement is the development and distribution of a vetted curriculum aligned with building science research, codes, and emerging best practices. Workers, builders, and educators must be able to rely on training materials that are technically sound, climate-appropriate, and consistent with regulatory frameworks.

For a distributed workforce, that curriculum must be delivered through multiple formats:

- Short-format professional training
- Online learning accessible to working professionals
- Workforce development programs delivered through industry associations
- Collaboration between education institutions and industry organizations

Research on workforce training in project-based industries indicates that flexible, modular training approaches improve participation and knowledge retention among working professionals (International Energy Agency, 2022). Distributed learning systems are increasingly recognized as effective approaches for sectors characterized by small firms and project-based work (Sovacool & Ryan, 2016; International Energy Agency, 2022).

Short, modular learning formats are particularly important in home construction and renovations, as workers cannot leave the job site for extended training periods. Modular instruction allows technical concepts to be delivered incrementally and updated as building practices evolve.

As Chair of the Housing Construction Council of Nova Scotia (HCC), I am familiar with a very successful direct-entry training model aligned with workforce reality. HCC's Tiny House Construction provides direct-entry participants with hands-on training in home construction over an 18-week period.<sup>8</sup> Participants develop foundational skills in framing, air sealing, insulation, and finishing through supervised, project-based learning. The courses are co-led by Red Seal carpenters and qualified instructors from regional Adult High School programs.

By focusing on short-duration, practical training aligned with real construction tasks, the program produces job-ready entry-level workers with relevant skills in a short time frame. Graduates are able to contribute on site more quickly, gaining experience and further development over time. In fact, 80% of the graduates are employed in the industry.

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<sup>8</sup> Details of HCC's workforce development programs: <https://housingconstruction.ca/programs>

This type of model does not replace apprenticeship systems, but it complements them by expanding access to foundational training and creating additional entry points into the industry. It also reflects the reality that much of the workforce will not enter through formal apprenticeship pathways and requires alternative routes to develop core competencies.

Expanding the reach of building science education also requires increasing trainer capacity. Train-the-trainer programs allow experienced practitioners, instructors, and industry leaders to deliver consistent technical training across regions and organizations. These programs can operate both within formal educational institutions and through workforce development initiatives.

By equipping experienced professionals to serve as trainers, the industry can expand training capacity without relying solely on a limited number of institutional instructors. This approach is particularly valuable in home construction, where experienced builders and trades often possess deep practical knowledge that can be translated into effective training when supported by a structured curriculum.

## **Job-Embedded Learning Tools**

Knowledge must also reach the job site directly.

Job-embedded learning tools provide short, practical guidance at the moment work is being performed. Examples include product-agnostic installation guides, sequencing diagrams, inspection checklists, and short digital modules explaining the reasoning behind critical construction details.

These tools support workers who cannot leave the job site for formal instruction and help reduce the degradation of knowledge that occurs when information is transmitted informally between workers. By placing technical guidance directly within the workflow of construction, job-embedded learning tools address the last-mile problem of knowledge delivery.

## **Portable Credentials: A National Building Performance Certification Framework**

One component of a distributed training ecosystem is a system of portable credentials that recognize competence in building performance work. Portable credentials allow knowledge and verified skills to move with workers across employers and projects without requiring long apprenticeship periods or dedicated mentors. In a highly mobile workforce, credentials tied to a single employer or training institution have limited reach. Portable credentials recognize verified skills and knowledge regardless of where a worker is currently employed.

Portable credentials are already used to create trusted signals of competence in a fragmented industry. Builders hire workers knowing that certain knowledge standards have been met. Workers benefit because their training becomes a recognized asset rather than something tied to one employer. In practice, many of the portable credentials currently used in construction are tied to product manufacturers and installation methods. Examples include certification programs for tile installation systems that specify mortar and grout assemblies, or waterproofing credentials tied to particular shower membrane systems.

The next step is to extend this concept to applied building science in a product-agnostic way. Portable credentials could recognize competence in areas such as building envelope installation, ventilation commissioning, air barrier continuity, or high-performance insulation practices. These competencies cut across multiple trades and materials and are directly related to the durability, energy performance, and health outcomes of housing.

In Canada, most training and certification systems are tied to specific professions, programs, or regions. Energy advisors are certified through the EnerGuide system, Passive House consultants follow an international training pathway, and tradespeople pursue Red Seal certification within individual trades. None of these systems directly address the building performance competencies required of installers and contractors working across the building envelope.

One existing model demonstrates how such a system can operate at scale. The Building Performance Institute was created to establish professional standards for the home performance industry. It develops job task analyses and certification exams for technicians, installers, and contractors working on home energy upgrades. Individuals earn certifications through independent testing, while training is delivered by accredited training

organizations. Contractors can also obtain company accreditation by demonstrating insurance, qualified staff, and quality assurance practices. The goal is to provide a consistent benchmark for competence in building performance work and to give consumers confidence that retrofit work will be carried out correctly (Building Performance Institute, 2023).

A Canadian version of this model would focus on installation competencies related to building envelope performance, moisture management, and energy efficiency. Credentials would be organized around common tasks such as air sealing, insulation installation, window and door installation, cladding systems, and basic building science principles. Each credential would be based on a clearly defined job task analysis that describes the knowledge, skills, and abilities required to carry out the work. Certification would be granted through independent examination aligned with internationally recognized personnel certification standards such as ISO/IEC 17024.

A key feature of this model is the separation of training delivery from credentialing. Colleges, private trainers, manufacturers, industry organizations, and workforce development programs can all deliver training aligned with national competency standards. Workers may gain knowledge through short courses, job-site learning, mentorship, or prior experience, and then demonstrate competence through certification exams. Because the credential is independent of any single training provider, it becomes portable across employers and regions.

Portable credentials are particularly important in the home construction sector, which is dominated by small businesses and subcontracted labour. A national building performance credential framework would provide a practical way for installers and subcontractors to accumulate recognized credentials over time as they gain experience in specific building performance tasks. Employers would gain a clearer signal of competence when hiring or assembling project teams, and project owners would have greater confidence that work affecting energy performance and building durability is being carried out by qualified individuals.

Portable credentials also support distributed learning ecosystems. Short-format professional training, train-the-trainer programs, job-site learning tools, and continuing education modules can all contribute to workforce development, while national certification provides a consistent benchmark for competence. This structure allows knowledge to circulate through many different channels while maintaining a shared national standard.

## AI & Training in the Home Construction Industry

Emerging tools like artificial intelligence are often framed as a solution to training gaps. In practice, their impact will depend on how they are used. AI can help translate complex building science into accessible, just-in-time guidance, support decision-making, and extend the reach of training without requiring time off tools. But it also carries risk. If the underlying knowledge is incomplete, outdated, or misapplied, AI can accelerate the spread of errors at scale.

In a sector already struggling with degraded information flow, this matters. AI should be treated as a delivery mechanism, not a source of truth, and grounded in vetted, climate-specific, field-tested knowledge.

## Community-Defined Curriculums

Current training systems assume that knowledge can be standardized, centralized, and distributed outward. That assumption does not hold across all communities.

When we are discussing and determining future training systems and knowledge infrastructure, it's vital to keep this in mind. All underrepresented/marginalized groups must be at the table and their voices must not only be heard, but incorporated into an evolving housing system.

Indigenous, First Nations, and Métis communities have long-standing building knowledge rooted in place, climate, materials, and cultural use of space. Training that is developed externally and delivered into these contexts often fails to land, not because the content is wrong, but because it is not owned, adapted, or trusted.

Community-led training models shift both control and relevance. They support local delivery, integrate traditional and technical knowledge, and build capacity within the community rather than extracting labour into external systems.

A functional housing knowledge ecosystem must include pathways for community-defined curriculum, local trainer capacity, and regionally grounded delivery. Without this, the system will continue to miss both workforce capacity and critical knowledge already in place.

## Strategizing Outside the Box

In early 2020, while we were in COVID lockdown, I was asked to consider how Nova Scotia could develop a forward-thinking Net Zero Energy housing showcase. The next four figures outline my thoughts on a strategy that could be implemented to leverage the recovery period and optimize the next decade of home building for the province.

I share this to show that efforts to create high-quality, accessible training already exist within the industry, but their impact is limited when they rely on voluntary uptake and political will to underwrite significant change.

This also shows that expanding training supply alone is not sufficient. Knowledge infrastructure must be embedded into systems where it is encountered, used, and reinforced as part of the work itself.

Improving housing performance requires more than new technologies or stronger policies. It requires strategic plans that create, develop, and support a set of decentralized systems that allow knowledge to circulate reliably through the workforce responsible for building and renovating homes.

A distributed learning ecosystem built on vetted curriculum, expanded trainer capacity, job-embedded learning tools, and portable credentials offers one pathway toward aligning workforce knowledge with the growing technical demands of modern housing. These are the elements that, together form the basis of a knowledge infrastructure capable of supporting consistent building performance across a distributed workforce.

## NET ZERO/R SHOWCASE PROJECT: 3 PILLARS TO RECOVERY IN RESIDENTIAL CONSTRUCTION

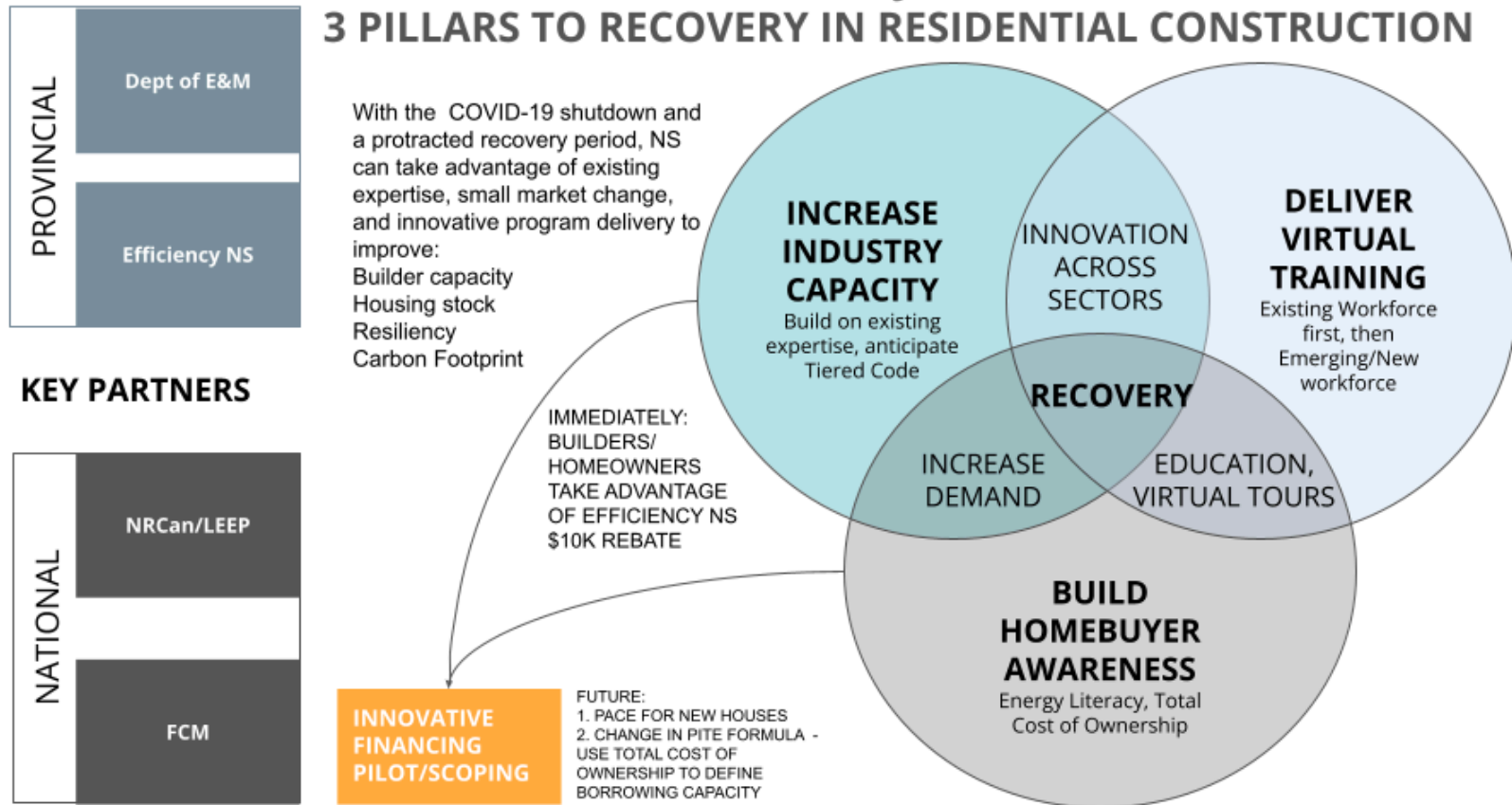
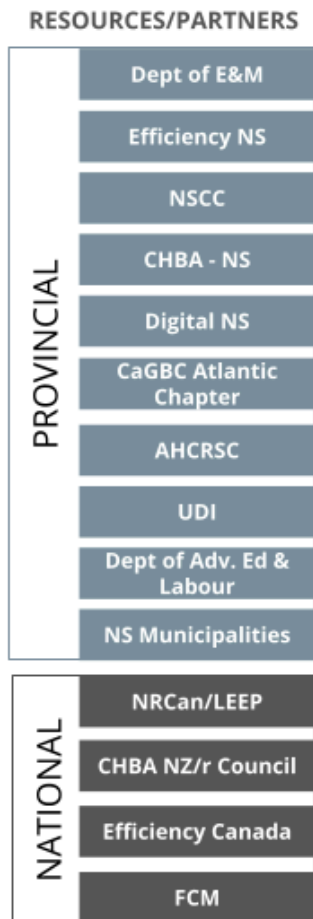
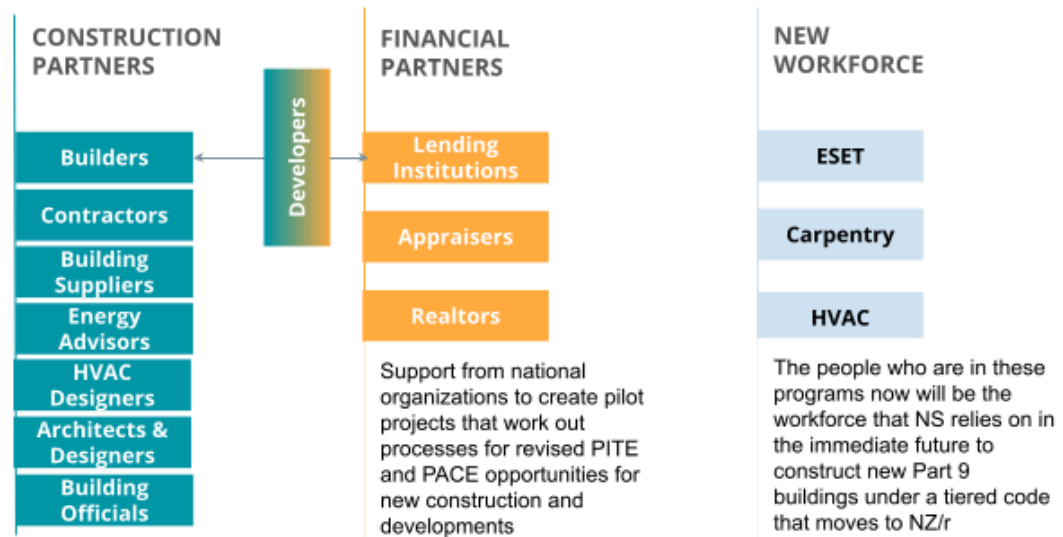


Figure 11. Diagram showing the 3 pillars to recovery in home construction, developed for a COVID recovery phase, but still relevant to current housing systems and the gaps in knowledge infrastructure.



## WHO NEEDS TO BE ON BOARD?

Need everyone to rebuild industry post-COVID 19



Without buy-in from industry players from Building Officials, Financial Partners, Builders cannot move this forward. Without buy in from Builders, Community College has no impetus to engage students in NZ/r curriculum and provide new workforce that can build to tiered code.

Energy Advisors, performance testing and energy modelling need to be standardized/accepted by building officials and financial institutions to ensure that risk is managed.

Figure 12. Diagram showing the various partners across several sectors who need to be on board with change in the current housing system to breach the gaps in knowledge infrastructure, regardless of the project being discussed. Cross-silo, full value chain support (versus isolated pockets of support) is key to evolving the housing system..

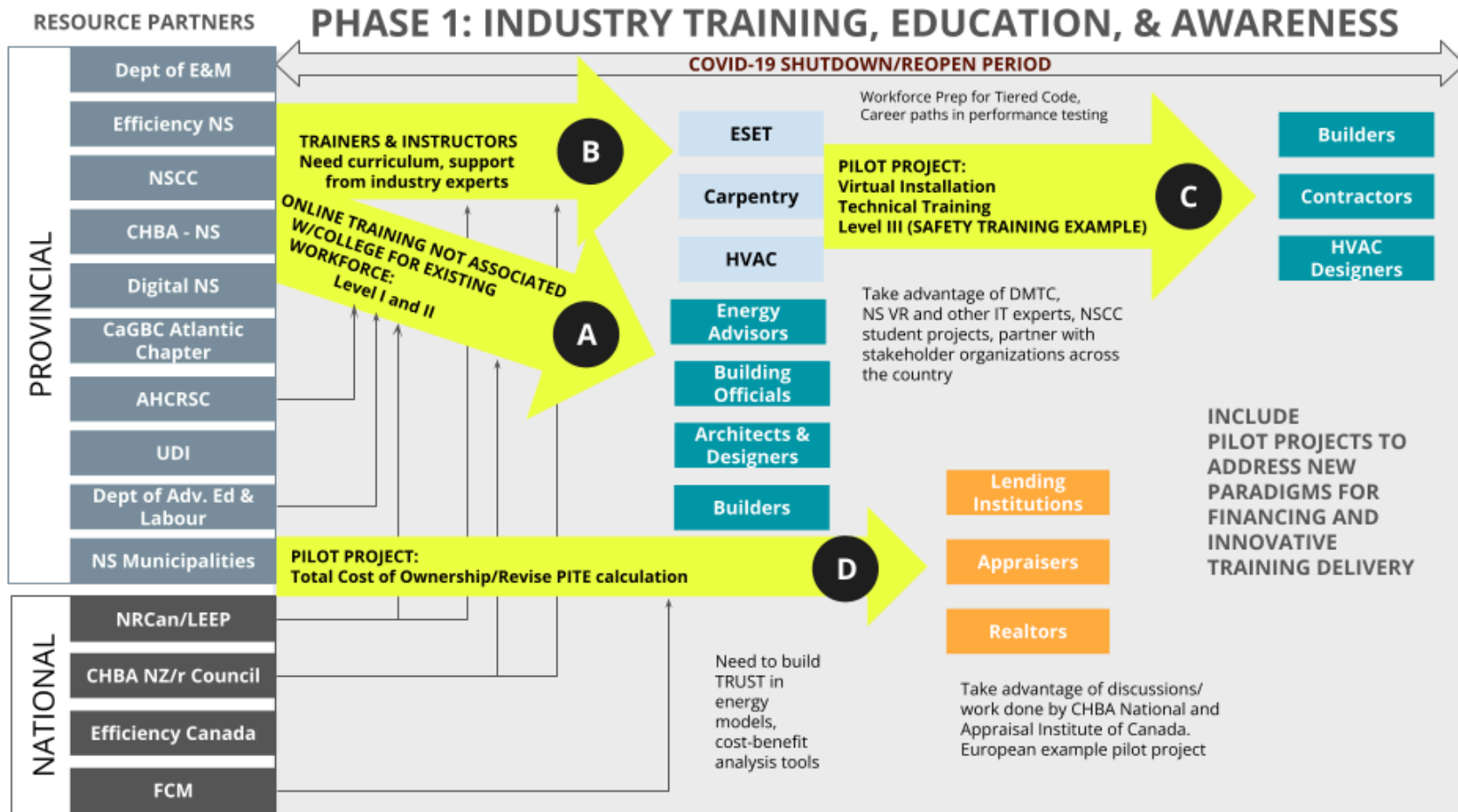


Figure 13. Diagram showing proposed Phase 1: Industry Training, Education and Awareness for a Net Zero 100 Showcase, developed for a COVID recovery phase, but still relevant to current housing systems. Arrow 'B' points to the intermediary need for train-the-trainer initiatives to boost formal education pathways, Arrow 'A' points to the wider range of the existing workforce that is not involved with college-level curriculum.

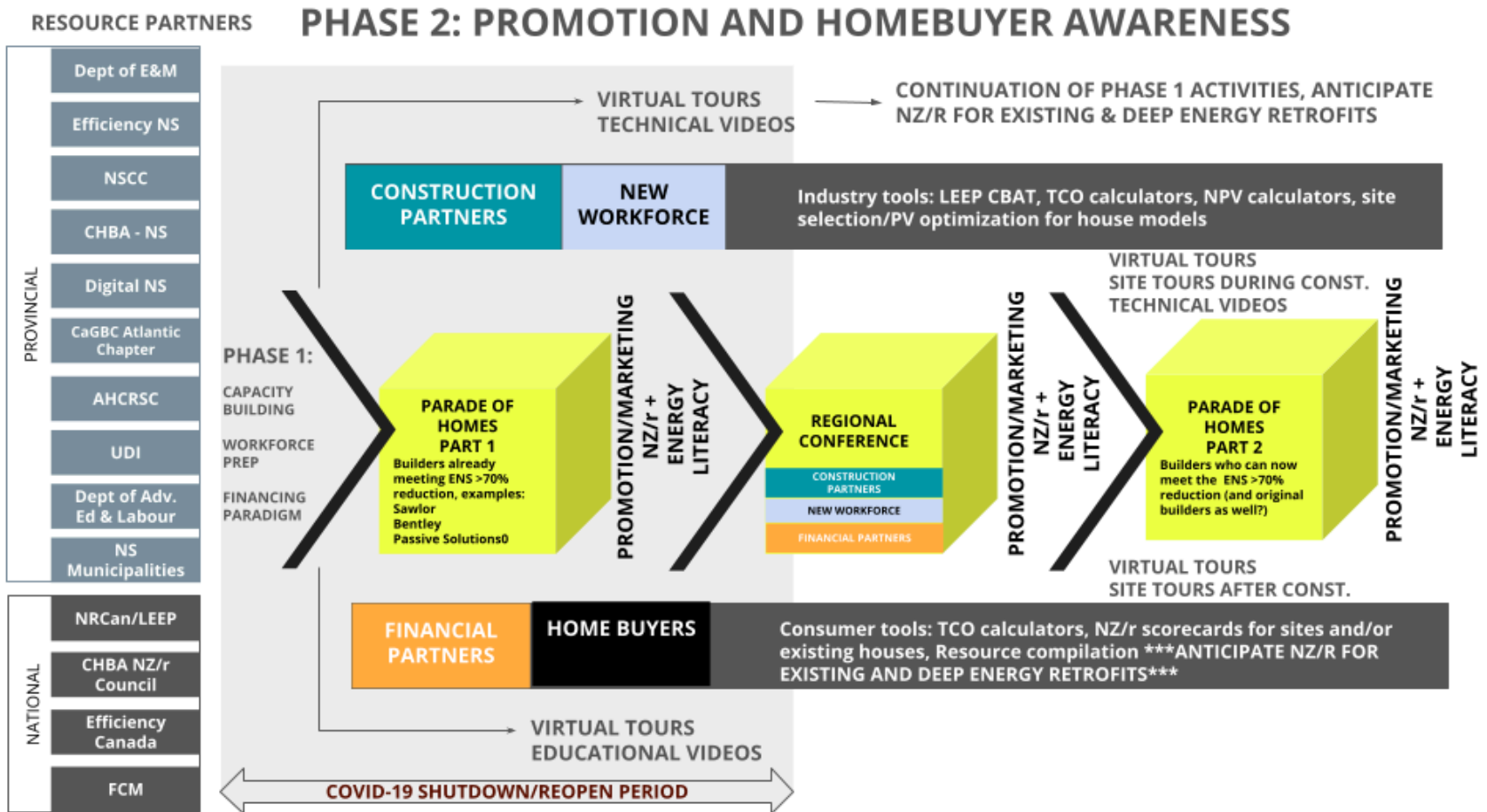


Figure 14. Diagram showing proposed Phase 2: Promotion and homebuyer awareness for a Net Zero 100 Showcase, developed for a COVID recovery phase, but still relevant to current housing systems and uptake of high performance housing by builders and homeowners.

# 10. Training as Infrastructure

## Conclusion: Training as Infrastructure

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Homes are more than assemblies of materials. They keep people comfortable, safe, and healthy through an envelope-first approach and a set of systems that move essential elements through the building. Electrical systems move power, plumbing moves water, and mechanical systems move air.

Housing performance also depends on another system that is less visible but just as critical: the movement of knowledge through the workforce.

When knowledge fails to reach the job site, the result is similar to a failure in an air barrier, plumbing, or electrical system. The building may look complete, but it does not function as intended.

This paper has shown how knowledge degrades as it moves through fragmented training pathways, subcontracting chains, and informal job-site communication.

A knowledge infrastructure built on vetted curriculum, job-embedded learning tools, expanded trainer capacity, and portable credentials changes how information moves through the system. Instead of relying on informal transmission, knowledge becomes accessible, verifiable, and usable at the point of work.

High-performance housing, as required by modern building codes and energy targets, depends on infrastructure that can reliably move knowledge from research and policy to the people installing the work.

When that knowledge infrastructure is weak, the industry falls back on the same informal communication patterns that allow the telephone game to continue. When it is strong, the message arrives intact.

Treating training as infrastructure means investing in the systems that move knowledge with the same intent and consistency as the systems that move energy, air, and water. When knowledge can reach the job site reliably, the telephone game begins to disappear and homes are more likely to perform as they were designed to.

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