Local Energy Efficiency Partnerships (LEEP) – A Systems Approach to Innovation in Canada's Home Building Industry

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ABSTRACT

LEEP is a builder driven, facilitated initiative, that brings actors from across the innovation chain together to assess and select technologies that will reduce the time, risk and cost of improving the energy performance of Canadian housing. LEEP works to bridge the "Valley of Death" so commonly referred to in the innovation continuum, and accelerates the uptake of new energy positive technologies.

LEEP enables homebuilders to consider the component pieces of the home within the context of how they can be integrated into the house as a system. Builders are provided neutral third party technical information in a standardized format that allows quick assessment across a level playing field. The LEEP builder group progressively narrows their review of new technologies from an initial list of fifty or more, down to twelve which are examined in-depth before they test their final choices in a field trial home. LEEP also provides local, regional, and federal government partners, utility demand side management groups, as well as building component and systems manufacturers, with industry feedback that can improve and increase the market penetration of builder-selected technologies and home building practices.

Results from LEEP include: the integration of preferred technologies by over 50 builders in their demonstration homes; replication of these applications by builders in subsequent builds; the creation of new technology categories and products in response to builder feedback and identified need; codification of technologies considered through LEEP; and, technical guidelines to drive technologies more broadly across the industry.

Introduction

LEEP exists as a response to traditional market challenges identified in bringing technological innovation from Research and Development (R&D) in labs and academia through commercialization and to prominence in the housing market. The much discussed "valley of death" (Gulbrandsen 2009, Mcintyre 2014, Wessner, 2005) presents a key challenge in bringing energy efficient innovations to market. Much of the discussion on the valley of death is focused on innovation funding for Small and Medium Enterprises (SME) at the early phases of commercialization. Some authors speculate that there may be more than one valley that technologies must cross before successful commercialization occurs. This paper deals with the last phase of technology transfer, where innovative technologies have passed the demonstration

phase and are ready for commercial roll-out, but due to market forces are not adopted en masse. If one were to use NASA's Technology Readiness Levels (TRL) as a guide, LEEP would deal with TRL 6 through 8.

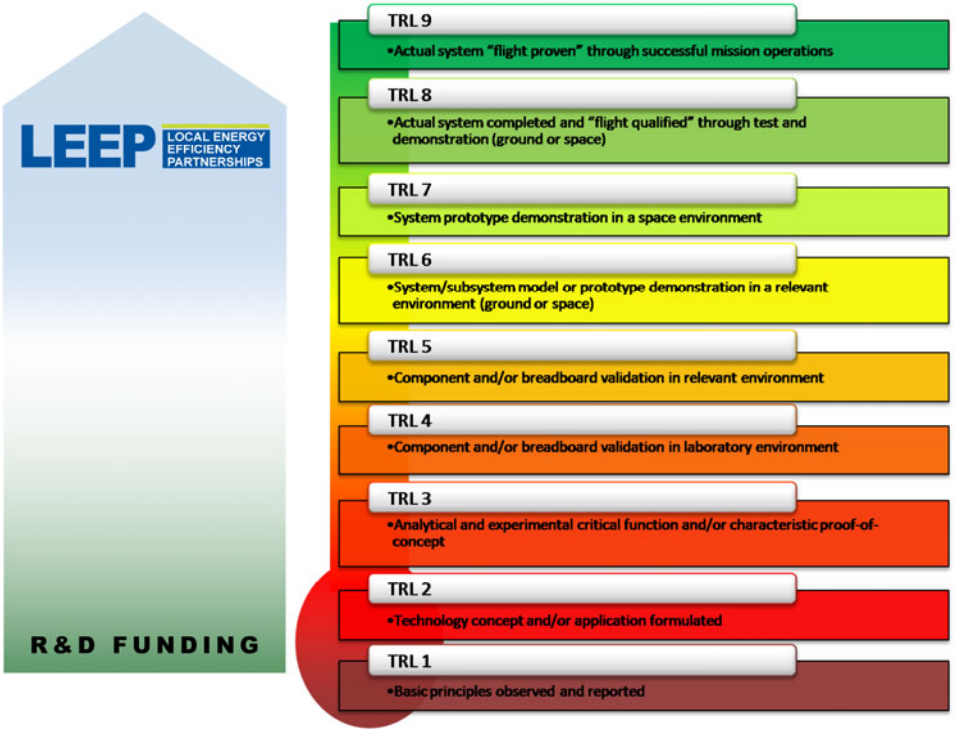

Figure 1. LEEP positioned within NASA's TRL continuum. *Source: NASA & Natural Resources Canada, 2016*

The Canadian Housing Context

Challenges to technology adoption in the Canadian housing industry include: lack of industry knowledge of how best to integrate new technologies into current practices; a lack of an effective supply chain for some new and innovative products; an increased builder risk in trying something new in his or her practice; cost considerations; and, an inability to sell or market improvements to the end user. Simply put, builders need to find ways to minimize their risk in order to try new technologies. Housing markets are further challenged due to regional variations in construction practices, large differences in climate, and a fragmented industry with thousands of companies in the sector. As promising technologies are developed either with Federal Science and Technology (S&T) funding, in federal academic labs and private industry, these common barriers limit the industry's ready adoption of these innovations.

LEEP is a strategic initiative which aims to fill the innovation gap by using a market pull model rather than a more traditional technology push approach. LEEP does this by seeking to understand the technical challenges apparent in a local construction market, providing builders with 3rd party technology assessments from which they select the solutions that have the most potential to address their gaps, and then works with the supply chain to facilitate a response.

This paper will outline the mechanics of the LEEP process, and document some of the results achieved through LEEP for local and provincial governments, energy efficiency programs, manufacturers, and builders that have participated.

The LEEP Process

LEEP was first developed in 2007, with a group of builders in the Southern Ontario City of London. It was run in partnership with the City of London, the local utility, and the local home builders association. This initial process was informal, it gave builders an opportunity to define the challenges they faced as an industry, and receive technical information on potential building solutions to address these challenges. The initial project was a success, but it needed further refinement to maximize its potential benefit. In response, information materials were refined, the process tightened to reduce the time spent by builders, and the result was a tightly planned, facilitated process that was half the time of the original pilot (from 5+ full days of builder time to 2.5), with professional technical resources, all produced in a cost effective manner. Since 2007, NRCan has conducted 10 LEEP initiatives in regions across Canada.

At its core, LEEP focuses on builder driven technology selection. LEEP has evolved into a tightly facilitated process which is run in a workshop format with a subset of builders (10-12) who represent a large proportion (typically between 40-60%) of the local market share of new builds. The Canadian Home Builders Association (CHBA) received very positive feedback from its builder members and have requested that the project be replicated more broadly across the country.

A LEEP process is typically initiated when a local home building association or utility requests that LEEP be used to stimulate energy efficient innovation in their market. Natural Resources Canada (NRCan) then works with the local home building association to gather key partners (utilities and other levels of municipal and provincial government) in their region and recruit the leading builders in the region. This first step is critical in ensuring that there is momentum to support builders as they work to implement innovations in their homes.

The LEEP process itself is comprised of a series of four workshops designed to accelerate the ability of the builder group to quickly consider, and decide, which innovations are most suited to their local market. The first two workshops are designed for the builders to select and prioritize their technologies of interest that they believe will be of benefit to meeting their energy performance target, the price and performance expectations of their clients, and which their sub trades can install reliably. The sessions are highly interactive, led by one of our LEEP team facilitators. The remaining two workshops are reserved for manufacturers who were selected by the builder group to address their final areas of technology inquiry – usually related to best practice applications, potential technical challenges the builders are concerned about, cost, and local support for design and installation. The LEEP process is shown in Figure 2, and an example of the facilitation approach is shown in Figure 3:

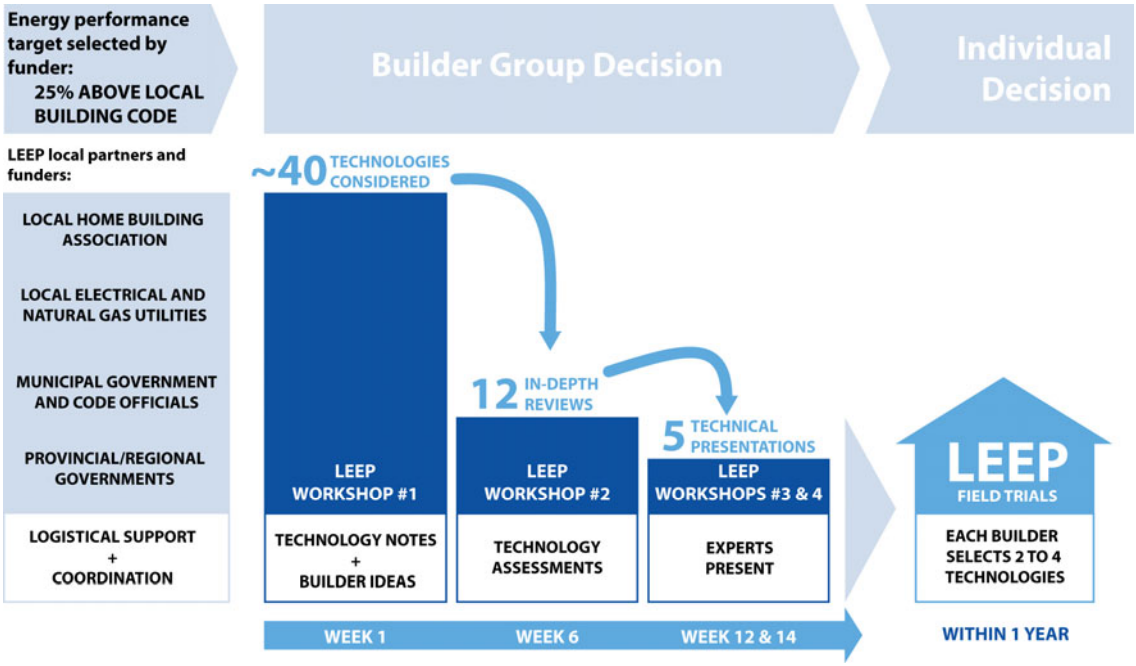

Figure 2. Diagram summarizing the LEEP process. *Source: Natural Resources Canada, 2016*

- **Workshop #1:** In this first level of filtering, the builder group considers over 40 technologies to select 12 of interest for deeper technical examination. An initial list of technologies is provided by Natural Resources Canada which is based on technology selections from prior LEEP session. The builder group augments this list with any technologies they feel are missing.
- **Workshop #2:** For their 12 selected technologies of interest, the builder group analyzes Technology Assessments provided by NRCan for each one[1]. In addition, they review associated costing and energy analysis to decide which 5 technologies require additional information from manufacturers and technical experts before the builders can make a decision on the technology use.
- During **Workshops #3 and #4**, system manufacturers and suppliers are invited to address the group to respond with fully costed technical solutions that meet the identified scenarios and questions provided by the builder group. The technical presentations are typically divided into manageable clusters across two workshops dealing with common elements such as envelopes and mechanical systems so as to make the time required manageable for builders.
- At the end of the technology selection phase of the LEEP process, participating builders use 2-4 of the technologies in a **field trial home** designed to achieve the energy performance level established at the outset of the process.

[1] Technology assessments are standardized technology profiles developed and provided by NRCAN, they include standardized information such as: the range of products within a technology class, potential applications, key characteristics, construction considerations, post construction considerations and food for thought. Cost analysis on technologies is provided through LEEP's third party validated costing database. Energy analysis is conducted with industry standard software such as HOT2000.

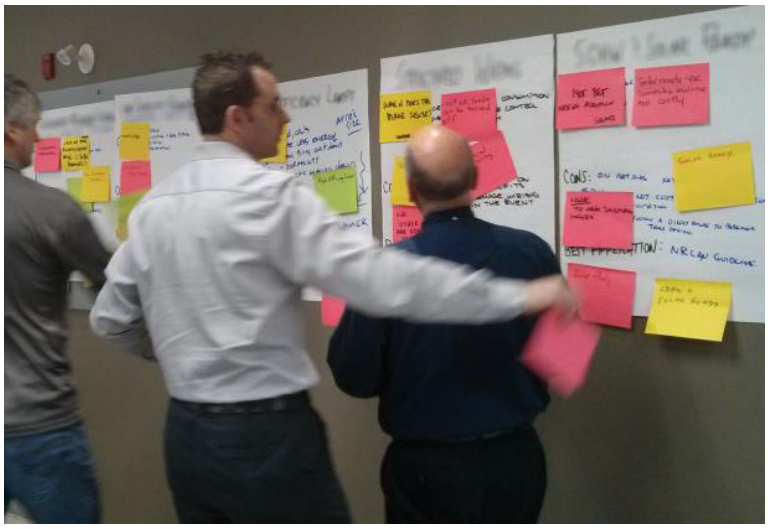

Figure 3. Builders prioritizing technology selections during a LEEP process.
Source: Natural Resources Canada, 2015

LEEP is a technology selection and trial process, but it should be emphasized that it is also a means of gathering market intelligence on technical gaps and technology preferences. LEEP provides aggregated industry feedback to the funding partners on the group's views on: a) which technologies are ready for the market, b) what technical and implementation gaps exist within the market, c) what design and installation capacity exists, and d) what regulatory hurdles require consideration. In this way LEEP provides a three hundred and sixty degree view of the path required for innovations to enter the market.

Technology Selections

LEEP Builder groups have prioritized technology interest according to their market (business) drivers and innovation needs. These drivers have included:

- reduction of call-backs
- improvement to occupant home comfort
- finding cost effective upgrades
- reducing energy consumption
- reducing construction timelines
- complying with energy efficiency programs (EnergyStar, R-2000, LEED)

This section will discuss some of the technology prioritizations selected by LEEP builder participants during Workshop #2 in a Canadian home building market. The builders are asked to rank technologies according to their interest in using the technology, and whether they would require additional information before making a decision on its use in a field trial. Figure 4 shows the result of builder technology prioritization for a market in British Columbia.

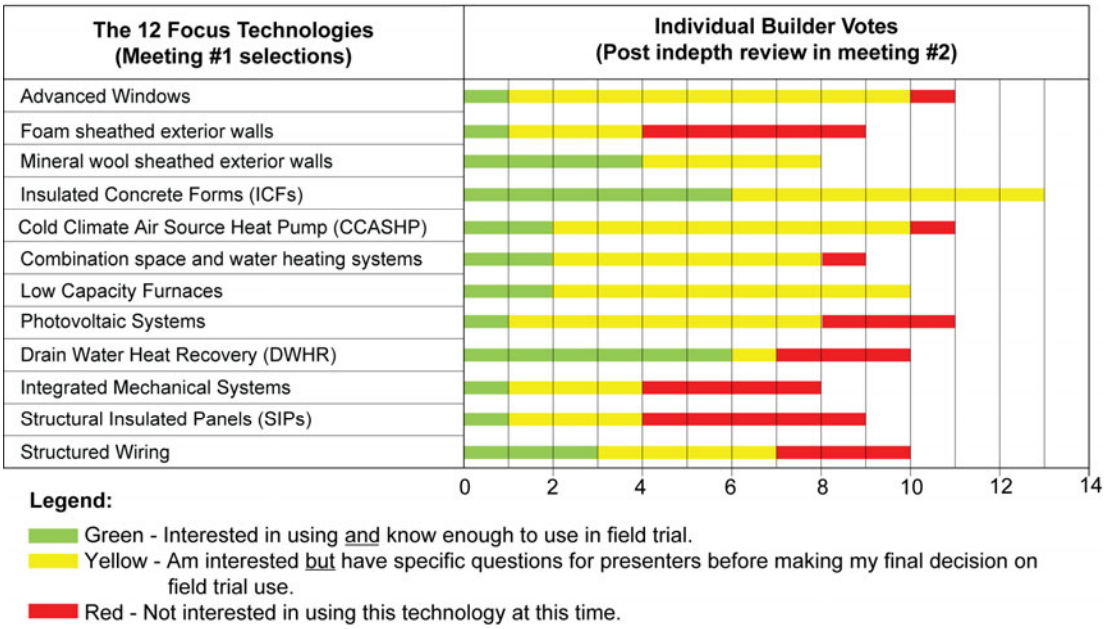

Figure 4. Builder technology prioritization through LEEP, *Source: Natural Resources Canada, 2016*

The builder group came to a consensus on the technologies they most wanted presentations on during the workshop. In total, presentations were requested on 8 technologies.

Yellow technology votes showed a need for presentations as they related to both builder interest and a need for more information before being able to make a decision on use. (By contrast, green and red votes for technologies indicated builders could already make or had already made decisions on use.)

To make their presentation decisions, the builder group started by prioritizing the technologies based on the number of yellow votes received. They then reviewed individual comments, discussed which ones they may have wanted to move up or down on the priority list, and came to a consensus on the technologies that would go to presentation.

Based on the result of the technology prioritization shown in Figure 4 and their group reviews of each technology, the builders requested additional technical presentations from experts and manufacturers for the following technologies:

- Advanced Windows
- Foam Sheathed Exterior Walls
- Mineral Wool Sheathed Exterior Walls
- Insulated Concrete Forms (for below grade applications)
- Cold Climate Air Source Heat Pumps
- Combination Space and Water Heating Systems
- Low Capacity Furnaces
- Photovoltaic Systems

Builders in this process identified 13 technology manufacturers and suppliers and 5 technology experts that they were interested in hearing from as a result of this deeper

technical discussion. The builders further identified specific technical questions that they required be addressed through the customized presentations.

NRCan, on behalf of the builder group invited the builder identified manufacturers and suppliers, and used the builder feedback to develop a customized presentation template that was sent to all presenters on each specific technology. The LEEP presentation templates include the specific builder questions, as well as a local archetype with base case application costing for manufacturers to provide their own system costing for each application. NRCan's LEEP team works with one builder per technology area to vet the presentations to ensure that the resulting manufacturer presentations are in alignment with builder needs. This discussion provides valuable market intelligence to manufacturers who get a clear understanding of the specific market barriers to the adoption of their technologies, as well as feedback and support from NRCan's LEEP team in crafting their message.

Builders then move to trial the technologies that fit within their particular business practice. At this phase of the project, market forces are allowed to take hold, and builders negotiate with manufacturers directly on technology costing and configuration.

LEEP's Results

The LEEP process is focused on delivering results for the various actors in the innovation system. As described earlier, these include local and provincial governments, utilities demand side management groups, builders, and manufacturers. This section will discuss what the outcomes look like for these particular groups, where they have occurred, and why these are significant within the Canadian context.

Local and Provincial Government

At the outset of LEEP, NRCan brings actors from various levels of Government to the table to be active participants in the LEEP process. This allows partners to listen to the proceedings of the workshops and understand the technological preferences of the builder group. Municipal governments are typically responsible for implementation of local and regional building codes, and as such have a stake in understanding how new technologies comply with the technical requirements of the building code. Many municipalities also have energy performance requirements, or GHG goals. LEEP helps to build market capacity for achieving these.

LEEP can enable building officials to better understand upstream technologies and ease their initial application within the market. It can also provide building science insight on which solutions can improve the durability and energy efficiency of homes built.

At the end of each LEEP process, a formal report is presented to partners that documents the builder technology selections made through the LEEP Process, the market gaps that require additional effort to overcome, and the opportunities highlighted by the builder group. These reports can help to inform how governments design their programs to achieve energy efficiency and GHG reduction goals.

A case in point can be found in Manitoba, where many of the builders who participated in the LEEP process in the City of Winnipeg, were also participants on the

industry committee examining the adoption of energy upgrades to the Manitoba Building Code (MBC). Through LEEP the builders learned about Drain Water Heat Recovery (DWHR)[2], shown in figure 5 below.

Figure 5. Drain Water Heat Recovery unit installed in a LEEP field trial home. *Source: Gary Proskiw, 2015*

This technology had very little presence within the Manitoba home building market beyond a few installations in a few custom homes. The builder group learned enough about the technology to recommend its inclusion in the energy efficiency measures adopted in the most recent Manitoba Building Code which came into effect on April 1st of 2016. With this change, Manitoba is the first jurisdiction in Canada to mandate the use of DWHR in every new home (Manitoba Building Code, 2015).

Another example of Governments using the builder feedback and field trial experiences from LEEP is with regards to defining stretch code requirements for housing across a region, and the likely technology pathways and first costs to builders for achieving these. This is the case in British Columbia, where the partners in LEEP include representatives from the provincial government, the natural gas and electric utilities as well as various municipal governments. The LEEP technology selections are helping to define cost effective whole home specifications to achieve performance levels from code, all the way to Net Zero Energy Homes for use across British Columbia. This is especially true with regards to building envelope systems, where durability and the impact of improvements on the sizing of mechanical systems were closely considered during LEEP and which have become important factors in the stretch code considerations.

[2] Energy savings associated with DWHR systems are well documented. An online energy savings calculator (http://www.ceati.com/calculator/) developed by NRCan and based on a multi-year study of the performance of DWHR systems at the Canadian Centre for Housing Technology (CCHT), is housed on the Centre for Energy Advancement through Technological Innovation (CEATI) website.

Government and Utility Energy Efficiency Programs

In the Province of Manitoba, LEEP helped a local utility learn which energy efficient technologies could practically be brought into local building practice, developed these local practices with a critical mass of builders, and costed them. This supported Manitoba Hydro in developing its next generation of Power Smart for New Homes with a feasible target for market uptake, and a way of meeting the new target with technology clusters that the builders had proven they could use.

To provide one technology example, builders in the Manitoba market learned about and trialed innovative above grade wall assemblies which are crucial to achieving the energy requirements of the program. Through LEEP, builders:

- came to understand how best to apply exterior insulation to above grade walls
- educated their trades on the installation details
- identified technical gaps and barriers to implementation in the Manitoba context and worked to resolve these with a manufacturer
- identified a suite of technologies capable of achieving the higher levels of energy efficiency required by programs

Without a LEEP process to short-circuit this learning curve, builders would have had to, on their own, consider which technologies they should employ in order to achieve the 20% energy efficiency gains required to meet the energy efficiency target of the Power Smart program.

Manufacturers

Through LEEP, manufacturers are invited by builders to provide technical presentations on their technology applications. This provides manufacturers with an opportunity to pitch their solutions to key industry players, and an opportunity to understand key builder insights into the needs of the industry. This generally allows builders and manufacturers to ensure the right technological "fit" for local application. Examples of a manufacturer tailoring their product to meet builder needs are apparent across technology classes, including building envelope, mechanical and renewable systems.

One example relates to forced air zoning. Many builders have expressed their comfort concern in the townhome market where space is at a premium, three or more floors are often finished, and there is little space to run distribution duct work. Hot air typically pools at the top of the home and making top story bedrooms comfortable during the air conditioning season often makes basements uncomfortably cold, overusing the air conditioner in the process. NRCan's CanmetENERGY housing researchers worked with a small Canadian manufacturer to develop an innovative zoning system that integrated the dampers and controls directly into the space heating product, making it mass production ready and eliminating the need for custom installations in homes. The manufacturer developed prototypes, launched a commercial system in 2006, and went on to realize modest sales on a year over year basis.

Through a LEEP processes in the Greater Toronto Area, builders were made aware of this particular approach and compared it to a site built zoned system. The

manufacturer was able to secure a large contract with a prominent builder based on their technical presentation during the LEEP process and follow-on discussions. As a result, other manufacturers took notice of the design approach and have since developed competing systems. Figure 6 below shows the air handling unit of a combination space and water heating system. This unit has 3 built in dampers and a modulating fan to direct the required amount of conditioned air to each zone.

Figure 6. Zoned forced air, combination space and water heating system. *Source*: Natural Resources Canada, 2015

As of the writing of this article, there are now three combination systems manufacturers who offer zoned systems for the Canadian market, several of which are tested to the CSA P.9-11 standard[3].

LEEP can also lead to the creation of new products based on industry requests. Furnace manufacturers have only recently begun to take notice of this particular approach to air distribution. A Canadian furnace manufacturer learned about builder interest in forced air zoning during a LEEP mechanicals workshop, and has since carried out R&D to launch the first fully integrated zoning module for furnaces (eliminating the need for field wiring of individual zoned dampers).

Builders

LEEP has led to the construction of demonstration homes by over 50 builders and the adoption of advanced technologies and practices by a number of builders across Canada. This section will explore a few examples where builders used LEEP to learn about, select and trial technologies that they have gone on to use more broadly in their new housing developments. These technologies can vary between regions due to the wide range of construction practices and climatic conditions seen across Canada.

Builders are very interested in using LEEP to explore building envelope technologies and practices. This is not surprising given Canada's diverse and extreme climates (2,600 to 12,000 heating degree-days). However, builders are challenged by

[3] The CSA P.9 standard can be used to provide efficiency and capacity ratings in combined space heating and water heating modes. Product performance ratings are available and can be consulted at the following location: http://oee.nrcan.gc.ca/pml-lmp/index.cfm?action=app.search-recherche&appliance=P9COMBO

the large upfront cost of envelope upgrades, the related disruption to their current building practices, and the lack of additional aesthetic benefits they provide to potential home buyers. Given these factors, NRCan has worked with insulation manufacturers to explore envelope systems solutions that eliminated costs from other areas of the home's construction. These types of systems typically perform double or triple duty, replacing the conventional air barrier, the weather barrier, providing increased thermal performance, and reducing the size of mechanicals needed to meet the loads. Manufacturers presenting solutions run the gamut from small local manufacturers and suppliers to large multinational players. The resulting cost effective system solutions helped builders upgrade their product to meet energy efficiency program targets, while minimizing disruption to their building schedule.

One large builder with operations in markets both in Canada and the United States, used their field trial to introduce a new exterior insulation approach. This builder was looking for an insulation system that allowed them to streamline their construction process and reduce the amount of steps required during construction of the above grade walls. They chose to trial a composite insulation product which combines a layer rigid Expanded Polystyrene (EPS) foam and one layer of Oriented Strand Board (OSB) sheathing. This approach maintains racking strength of the home prior to the application of drywall by incorporating a structural sheathing, while reducing the labour required in applying the two components separately. This change in construction practice increased the energy performance of their homes on average by 25% above the local building code and into the realm of accessing energy efficiency programs. The builder has since implemented the new wall system across their entire product line in the Ottawa market, and is exploring some of their other markets in North America.

Another tract home builder learned about new mechanical technologies through LEEP and is now considering changing their mechanical systems across their low rise production home developments. The change was precipitated to help manage issues they were having with:

- oversized equipment that was leading to short cycling of heating or cooling, inadequate distribution (too little supply to rooms far from the equipment), and occupant discomfort
- round ducts squeezed into wall cavities that are too small, leading to increased leakage across the system and leading to reduced air flow at the register
- duct elbows installed too close to the rim-joists, requiring on-site framing repair at high cost to the builder
- large supply plenum in the basement impacting livable space

Through LEEP, the builder has entered into a collaborative innovation process with a manufacturer to develop appropriate solutions. This is an example of how LEEP can give builders a voice in shaping innovative approaches and technology development so it responds to industry needs. From a manufacturer perspective, this collaboration ensures that product innovations meet the need of the industry and that they are positioned from a market perspective for successful launch.

Summary and Conclusion

Innovation initiatives that bring all relevant actors in the system together to pull through the energy saving technologies that best respond to market needs are an important part of bridging the valley of death. They can also speed up the commercialization process so that investors receive earlier returns, and thus have the potential to increase private sector investment in further innovations, and can leverage all of the partners' efforts to drive results for each actor within the process.

For initiatives like LEEP to work, all participants need to have a stake, both financially and operationally in achieving success. Part of this is in understanding and responding to the metrics for success for each actor and organization involved at the outset and working to create the conditions to achieve these. For builders, this includes gaining market advantage, reducing call-backs, finding cost effective energy upgrades, increasing homeowner comfort, and saving time in finding innovations. For utilities, market transformation is the prime driver. Under this broad umbrella, programs for individual technologies as well as for whole home energy performance are considered. For municipalities, as arbiters of local building codes, LEEP provides an opportunity to understand which innovations builders are likely to try and adopt in a market, and what the implications are from a building code compliance perspective. For manufacturers, LEEP provides a sales forum to present technologies to a captive audience, and to understand how to position and improve their products relative to the needs of local building industries.

By highlighting and strategically addressing market gaps with all of the actors at the table in a local initiative, LEEP is increasing the pace of market transformation towards greater energy efficiency in the Canadian new housing sector.

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