Sustainability Opportunities: Draft 1

Sunnyhill Housing Co-op: 787 – 3rd Street NW, Calgary, AB

Project Managed by: Urban Matters CCC | December 2019

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1 Executive Summary

Sunnyhill Housing Co-op (Sunnyhill) is a 66-unit multi-family development located in the inner-city community of Sunnyside in Calgary, Alberta. It is located in close proximity to several community amenities including the Downtown Core, Prince's Island Park, the Bow River, McHugh Bluff walking trails, and the Calgary Curling Club.

Recognizing the need to address the deteriorating condition of the exterior of the co-op's buildings, and recognizing the preservation funding recently made available under the National Housing Strategy (NHS) and administered by Canada Mortgage and Housing Corporation (CMHC), Urban Matters (Urban) was contracted in August 2019 to review previously prepared sustainability upgrade reports and provide a foundational understanding of the sustainability opportunities that could accompany a building envelope re-skinning for Sunnyhill. A goal of satisfying the NHS's 25% energy efficiency improvement goal was established to inform the design and sustainability recommendations.

Urban engaged local design firm Modern Office and Design (MoDA), noted for their creative use of inexpensive building materials, to prepare a design schematic of building envelope upgrades. Utilizing these proposed designs, and building condition reports and recommendations prepared by ReNu Building Science and the Communitas Group Ltd, Urban identified building envelope upgrades that would satisfy the sustainability requirements of the NHS. Additionally, a broader, aspirational goal of moving off of natural gas as a heating fuel and towards renewable electricity shapes a longer-term vision and phased implementation recommendations.

The primary focus of the upgrades prioritizes reductions in annual greenhouse gas emissions and reducing annual energy consumption . Within the scope of identifying sustainability opportunities, an attempt has also been made to, at a high level, correlate the capital cost of the retrofit activity to an annual economic savings projected over time. This takes into account both the capital cost of the upgrade, current cost per unit of various forms of energy, and a general expectation that renewable energy costs will fall over time.

2 Strategy & Approach

2.1.1 Membership Engagement

The intent of this sustainable opportunities approach is to, in tandem with design upgrade recommendations, identify relevant sustainability improvements that could satisfy the requirements of existing capital funding programs. Having identified the opportunity in order to apply for feasibility funding, future robust, exploration, design and costing of a viable program would be the next step in determining an appropriate development program for Sunnyhill. This undertaking is to identify what's possible. Urban's approach began with a membership engagement activity intended to document individual aspirational goals for the Co-op, and identify themes to guide both the design schematic and sustainability recommendations. Three key themes emerged. First, to move the co-op away from consuming carbon emitting, non-renewable resources. Ideally, switch from natural gas consumption to on-site photo-voltaic (PV) solar with electrical grid backup. Second, where possible the use of natural, environmentally sustainable materials and finishes was preferred, and lastly, addressing sustainable vehicle practices was of interest (such as electric vehicle charging or carshare).

2.1.2 Capital Funding

Building regeneration and energy efficiency improvements have been of interest to Sunnyhill for over a decade. Recognizing the significant capital requirements necessary to initiate a redevelopment program, Sunnyhill has proposed to target CMHC's preservation Program funding under the National Housing Strategy. The intent of the Preservation Program is to allow existing affordable housing units to upgrade their buildings to ensure a long-term supply of well-run non-market housing. Two of the key requirements for accessing the program are to ensure a minimum 20% of the units meet accessibility requirements, and that the development as a whole achieve an average 25% reduction in energy consumption. Funding targets building envelope improvements only, not mechanical or lighting upgrades. As a result, the focus of these recommendations is on improvements to the building envelope that are likely to achieve the necessary energy consumption reductions.
Future recommendations, using a phased approach, are outlined to coincide when lifecycle capital replacement of the HVAC system and lighting systems occur, and to prepare for future improved attractiveness of on-site photo-voltaic solar electrical generation and vending to the electrical grid.

2.1.3 Design Criteria

Recognizing that the limiting factor guiding decision-making is the availability of capital funding, recommendations are guided by the following general requirements, listed hierarchically,

- Satisfy a maximum $100,000 per unit capital cost
- Satisfy the NHS sustainability requirement
- Reduce operational costs of utility expenses
- Contribute to a future desire to move away from non-renewable resource consumption
- Support the incorporation of natural building envelope materials and finishes

Upgrades that satisfy these criteria shall likely have additional ancillary benefits of increased comfort and improved aesthetics.

2.1.4 Base Modelling

In a fall 2019 meeting with CMHC, it was noted that an energy audit is the preferred method of documenting the current energy performance of an existing building. An energy audit was considered during the proposal phase of this project, but was not undertaken as several information gaps were identified in the areas of accessibility of the Co-op property and housing units, asset management, land-lease opportunities and stakeholder support. the recommendation was that once a better understanding of the redevelopment options was achieved, an energy audit could be undertaken if required. Regardless, some understanding of the energy consumption patterns of the Co-op can be inferred from the era in which it was constructed. In general, 1970s and 1980s construction in Calgary was dominated by the following building science aspects – several items confirmed through review of the original blueprint drawings;

- 2x4 wood frame construction
- R12, fibreglass batt insulation
- Asphalt paper air barrier
- Low to mid (60%-80%) efficient furnaces for heat generation, and ventilation
- Single and double pane sliding windows
- Heating, Ventilation, Air Conditioning (HVAC) and Domestic Hot Water (DHW) appliances traditional utilizing pilot light combustion

While confirmation of wall performance through a future energy audit is an important next step, the attributes of similar wall configurations have traditionally generated insulative performance in the range of effectively R9 with an accompanying Air Change Per Hour (ACPH) of greater than 10 – considered to be poor and contributory to increased energy consumption.

The recommendations are therefore focused on increasing the effective performance of the insulation, incorporating a continuous air barrier, air sealing and insulating around window and door penetrations, and window and door performance upgrades. Reducing the rate at which heat dissipates through the building envelope is a proven, effective method of reducing energy consumption.

3 Building Envelope Opportunities

3.1 Exterior Walls

3.1.1 Existing Exterior Wall Assembly

Exterior Wall

- Existing wall is traditional 2X4 wood-frame construction and achieves a nominal insulative value of R12 and effective value of approximately R-9.
- 4”- fibreglass batt insulation
- Existing vinyl and stucco need repair
- Asphalt paper weather barrier
- Vinyl cladding overtop original stucco exterior

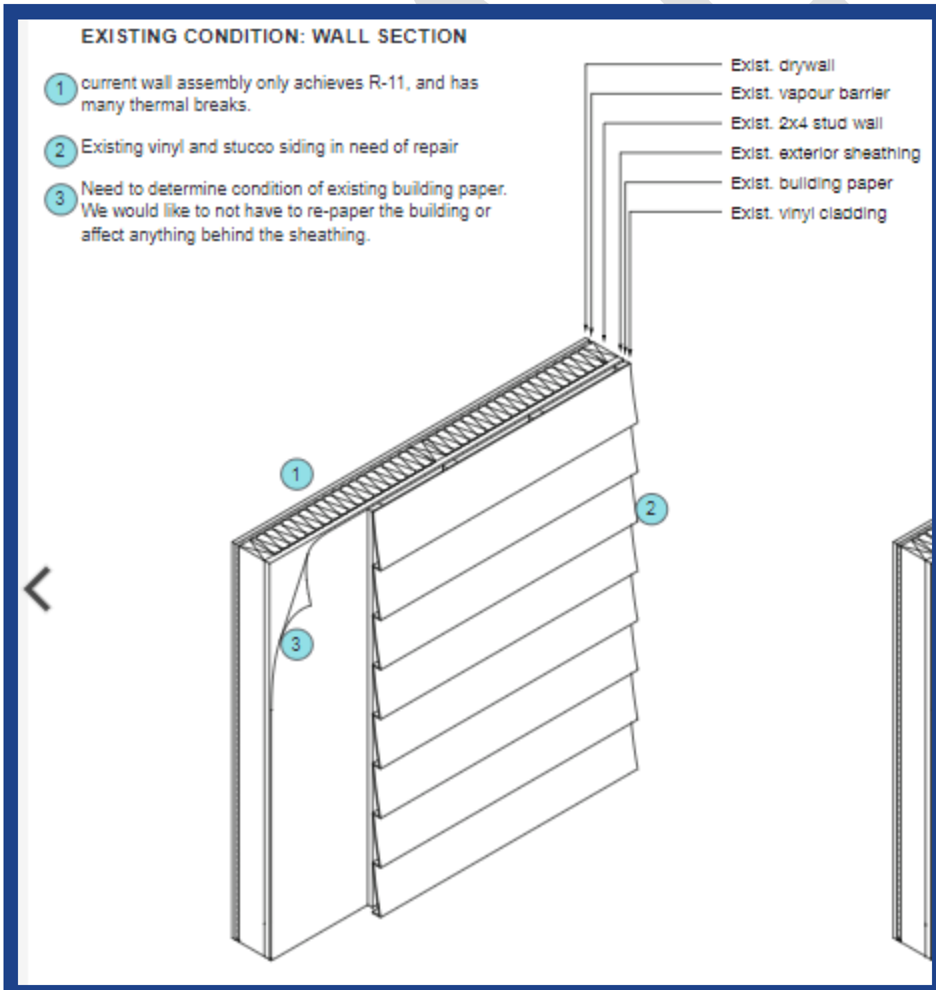


Figure 01: Existing exterior wall assembly.

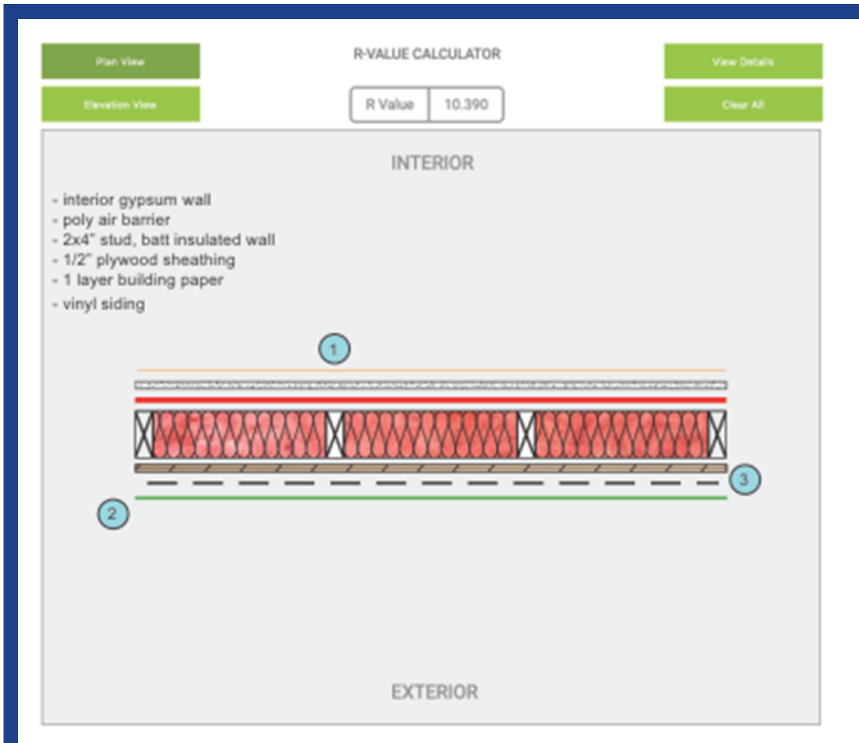


Figure 02: Existing exterior wall assembly R Value determination

3.1.2 Exterior Wall Performance Challenges

Building science investigations of these wall configurations have uncovered a variety of challenges that were mostly unknown, and there not addressed, during this area of residential construction. Two key building science principles contribute to the challenges with this type of wall configuration include. First, temperatures are constantly trying to achieve equilibrium, which translates into instances of higher temperature migrate towards areas of lower temperature until they are in balance. Second, areas of higher pressure migrate towards areas of lower pressure, again to achieve equilibrium. In a mechanically conditioned environment (like the interior of a house), the higher temperature interior will transfer heat towards the exterior of the house using the wall assembly as a conduit. Heat is transferred in three ways, structurally-borne, air-borne and through radiant-transfer. Walls are typically constructed to address the first two.

Structurally-borne heat transfer relies upon effective insulation to slow that transfer. A wood-frame 2x4 wall is challenged due to the smaller insulation cavity (3.5" in depth) which allows room for only a nominal R12 insulation. The insulation is not continuous as it is broken up by wall studs and wall plates, electrical outlets, window and door headers. These installations rarely achieve better than R9 in terms of effective **R value**. Effective R35+ is generally considered a good insulative value that meaningfully slows heat transfer and reduces energy consumption.

Air-borne heat transfer relies upon an effective air barrier to contain higher pressure (and warmer) interior conditioned air from migrating through the wall assembly to the lower pressure outdoors. Interiors are at a higher pressure because the forced-air furnace is continually adding more air to living spaces, increasing the air density. At a higher pressure, it finds any break in the air barrier, transferring air-borne heat with it. The critical role played by air barriers was not well-disseminated during this construction era, so it's common to find significant penetrations in the air barrier. Electrical outlets, fastener penetrations, window and door openings are common sources. Limiting air transfer to the exterior is another, effective measure of reducing the amount of heat required to condition a space, and thereby, reducing energy consumption. It is this air leakage that is tracked during an energy audit using a blower door test.

Air-Vapour-Barrier **(AVB)**and Rain Screens

Less related to energy efficiency, but no less important is addressing moisture. There are two key sources that impact the effectiveness of wall assemblies. The first is air-borne moisture transfer from the interior of a home. A similar building science principal to heat transfer is that areas of high moisture content migrate towards areas of lower moisture in an effort to achieve equilibrium. Vapour that migrates into a wall cavity can have a detrimental effect, by contributing to mould growth, and building material deterioration. Interior vapour barriers (poly) are intended to minimize vapour transfer.

The second source is exterior moisture that enters a wall assembly and contributing to materials deteriorating and potential building envelope leakage. Inadequate rain gutters, downspouts and wall assemblies can allow moisture infiltration. One of the more effective strategies is the use of the rain-screen principle. Design details that redirect rain away from the building and provide drainage channels for any moisture that does find its way into a wall help preserve the life and performance of building envelopes.

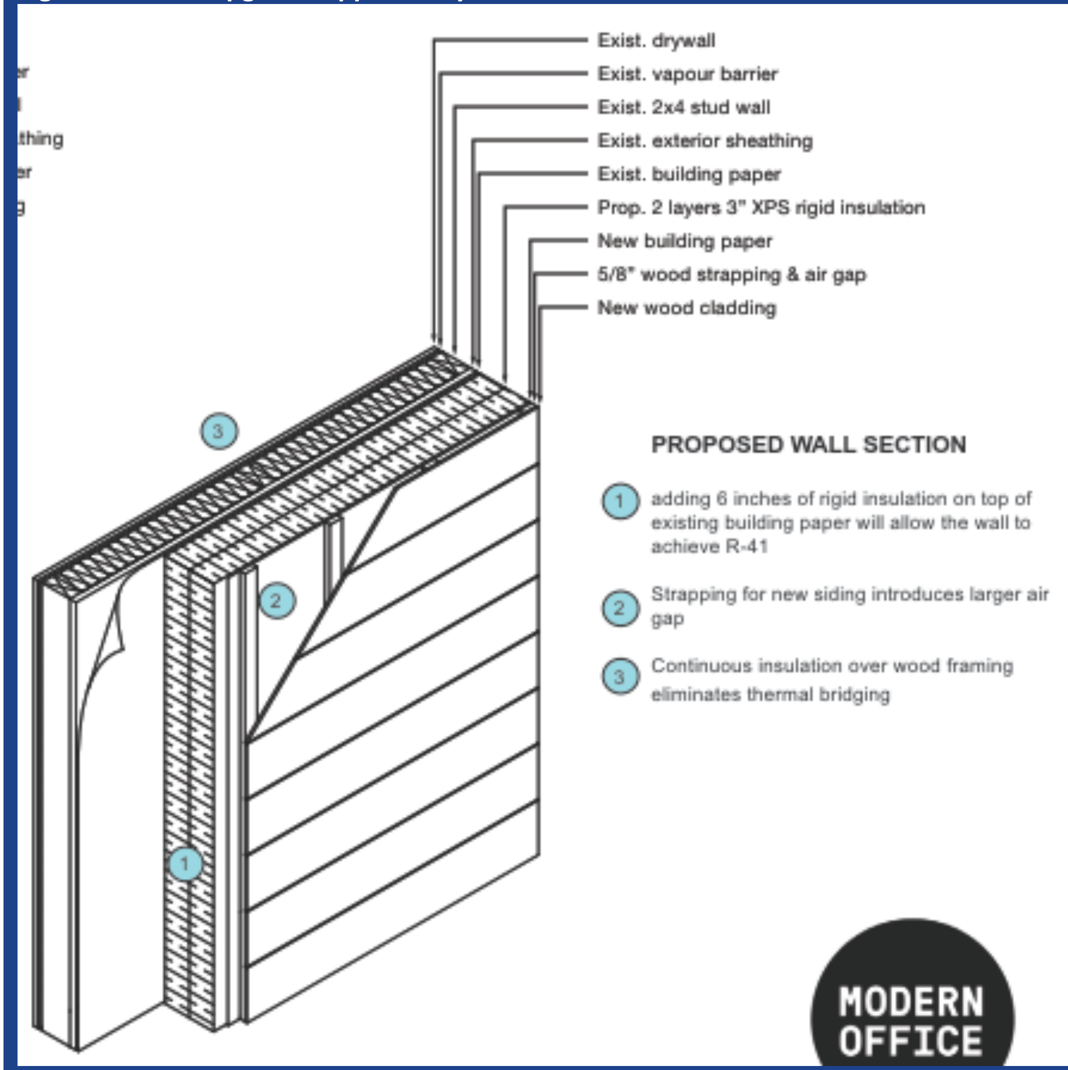
There is a general rule of thumb, with wall assembly design, that the condensation point within the wall occurs on the warm side of the wall. Condensation will occur on any surface that is below the dew point temperature. The AVB can be located anywhere within the wall assembly if enough of the insulation is on the cold side to keep the assembly warm and prevent condensation. In most regions in Canada this amounts to two thirds of the insulating value of the insulation is on the cold side. The assemblies presented in this document satisfy this general rule of thumb.

3.1.3 Exterior Wall Sustainability Opportunities

Note: Detailed energy modelling and cost estimating will help determine the most effective wall assembly, however based on experience the following options have historically helped achieve a 25-40% reduction in energy consumption with accompanying GHG emissions reductions.

Sustainability opportunities are available to address three of the four key performance challenges of the wall systems. Specifically, structurally-borne heat transfer, air-borne heat transfer and exterior moisture control. Interior-based moisture transfer relies upon a**n air-**vapour barrier installed on the warm (interior) side of the insulation. As the available funding targets improvements to the exterior building envelope, not the interior, upgrades to the vapour barrier are limited areas around window and door penetrations. The recommendations are as illustrated in Figure 03. Recognizing that increased air tightness beyond 3 ACPH can lead to excess moisture build up. Care should be taken remain above this threshold unless additional ventilation (i.e. HRV) is introduced. Initial review suggests the NHS standard is achievable even with the slightly higher air leakage.

Figure 03: Wall Upgrade Opportunity



- Removal of existing layers of vinyl siding and stucco coating
- Add 6 inches of exterior expanded polystyrene (EPS) insulation, applied overtop existing asphalt-paper air barrier and continuous from top of foundation to top of eave to minimize thermal bridging
- New air barrier (asphalt paper or vapour-permeable house-wrap)
- 1” X 3” strapping to create rainscreen moisture channel and finish material mounting surface
- New exterior wood cladding

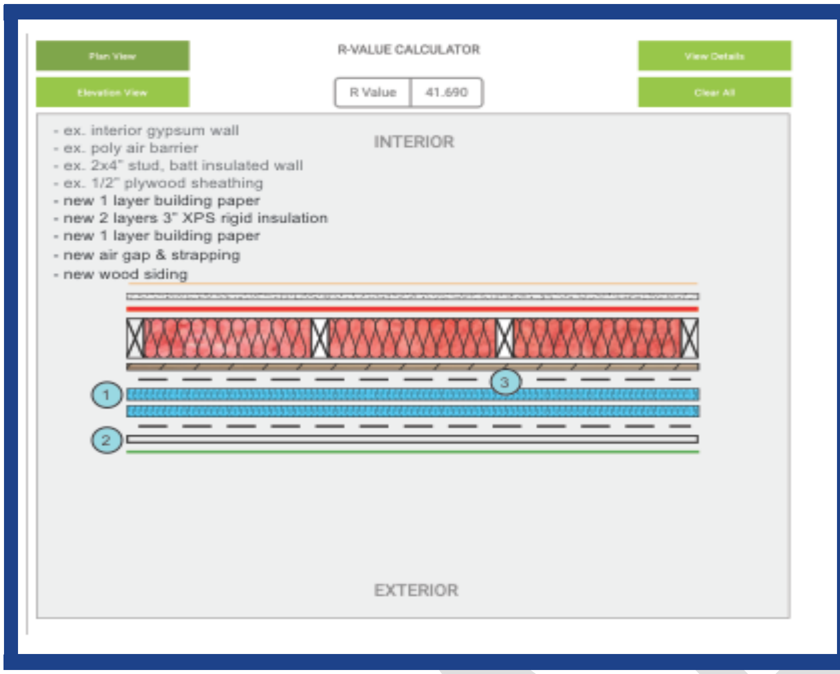


Figure 04: R-Value Calculation

Initial calculations (Figure 04) indicate the combination of existing wall configuration plus new insulation and air barrier would increase the R-value by more than three times to approximately R41. This is within the acceptable range for significantly reducing energy consumption and approximate to the optimal recommendations when the law or diminishing returns is considered.

3.1.4 Exterior Faux-Columns

One additional consideration is the non-structural exterior columns that appear to have been included in the original construction as an aesthetic design detail. In addition to acting as enhanced thermal bridges, transferring heat to the outdoors, they provide additional locations for water penetration and potential detrimental effects. Figure 05 illustrates the presumed existing faux-column assembly.

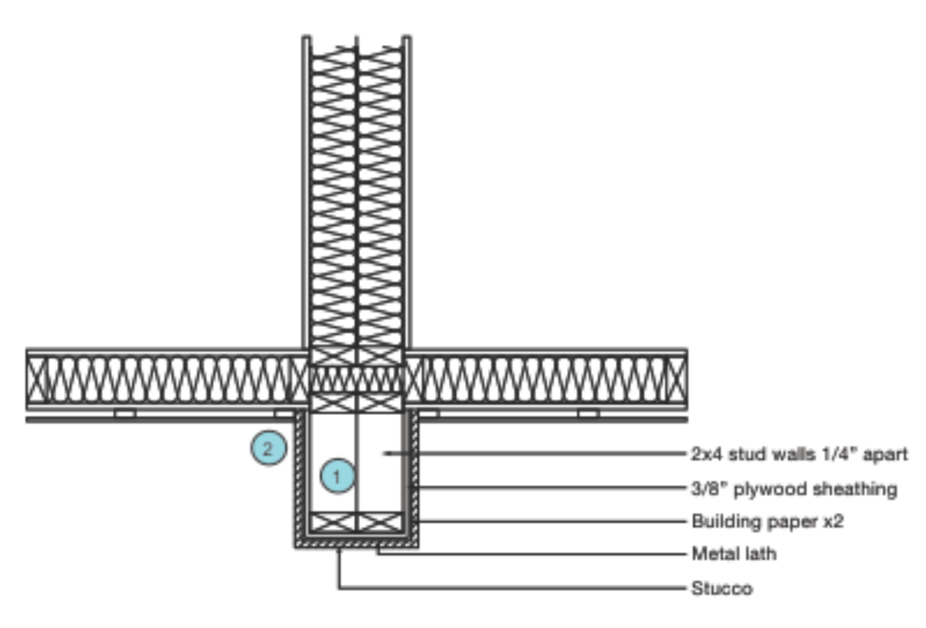


Figure 05: Existing faux-column/wall assembly

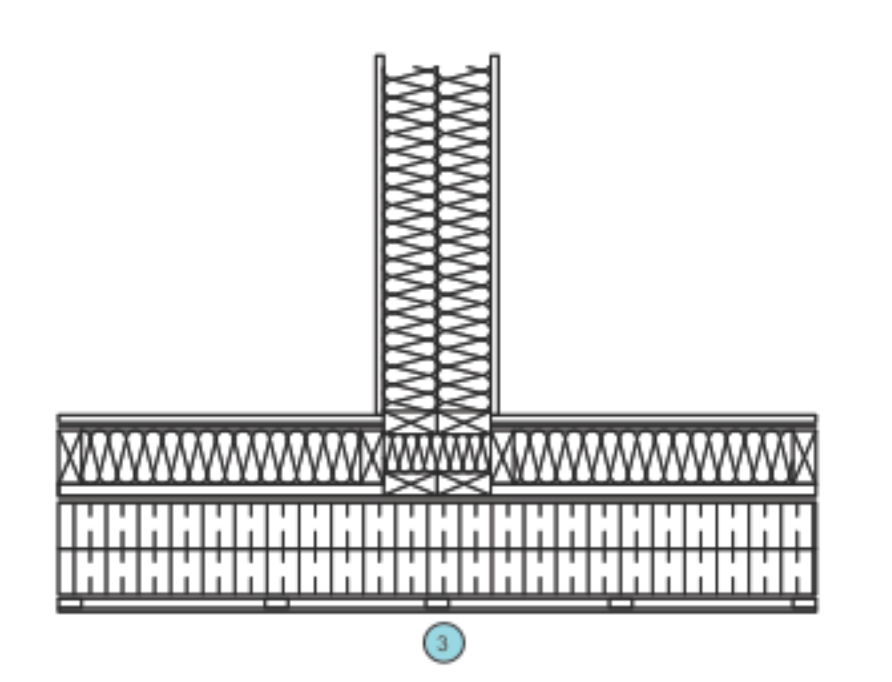


Figure 06: Proposed option for new wall assembly elimating the faux column.

Removing the faux-columns allows for a cleaner, more up-to-date wall aesthetic while enhancing the opportunity to ensure a continuous exterior insulation and air barrier. It would also eliminate a prime potential source of water penetration.

3.1.5 Exterior Windows & Doors

In addition to the changes to exterior siding, insulation and air barrier, consideration should be given to existing windows and doors. As identified in early sections, this era of construction was less informed on the benefits if continuous insulation and good air-sealing practices. Exterior doors and windows are significant penetrations through the building envelope and critical sources of air exfiltration and heat transfer. Best practices to achieve both the effective insulative value identified above and the complimentary reduction in energy consumption will require upgraded windows. Triple-pane, argon filled windows and insulated-core doors will provide the most effective insulative value as well as providing a significant improvement in resident comfort, both in the summer and winter periods. Care should be taken during installation to ensure gaps between the window/door frames and window bucks are properly treated with a window-specific foam sealant to ensure optimal insulative value and appropriate air-sealing.

3.2 Roof Assembly

3.2.1 Existing Roof Assembly

Roof Detail

Through a review of the construction blueprints, the existing roof appears to be of structural 2x8 wood-frame rafters with no cavity insulation. The configuration appears to incorporate sound building science principles including an interior vapour barrier, ¾" tongue & groove sheathing, and a weather barrier. The roof includes a 2" layer of rigid insulation overtop the sheathing, providing good coverage over thermal bridges. The insulation is protected with a second layer of asphalt paper weather barrier and a conventional shingle roof.

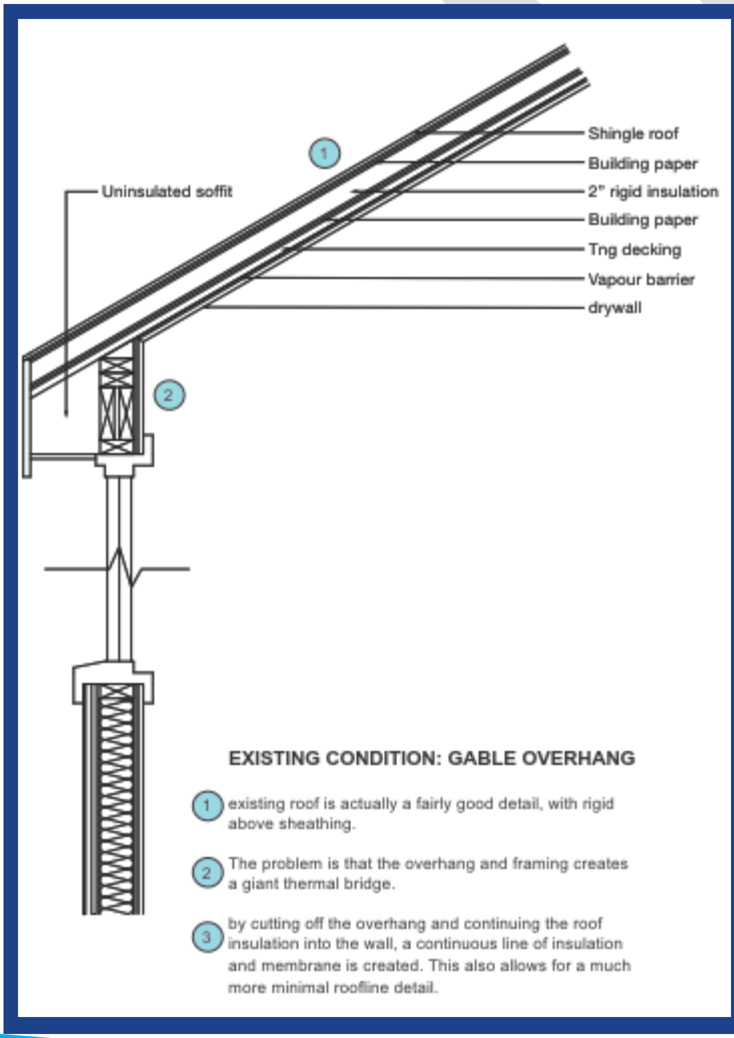


Figure 07:
Existing Roof Assembly

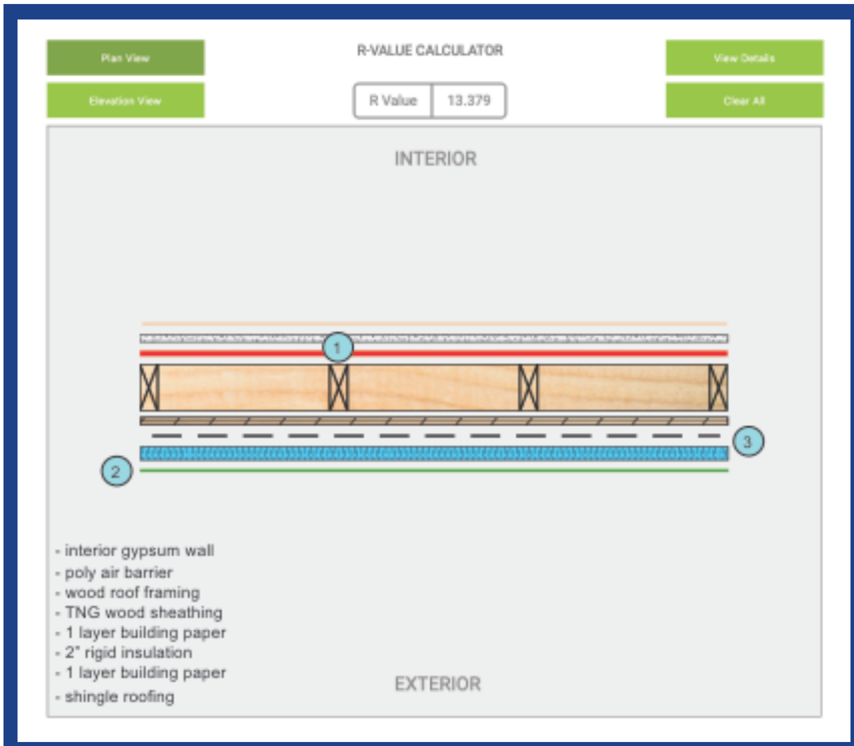


Figure 08:
Existing roof assembly R Value determination.

While a good roof configuration, it provides limited insulative performance for both air and structure-borne heat transfer. It does, however, protect against vapour transfer. Building science research in the ensuing years post-construction identify a few areas for improvement. The following upgrades would contribute significantly to satisfying the sustainability requirements of the NHS, and position the Co-op to address long-term goals of some on-site electrical solar PV electrical generation.

- The current effective insulative value of the roof is approximately R13. Insulation levels closer to R50 is a rule-of-thumb target for achieving significant energy consumption reductions
- The roof overhang (soffit) past the wall façade, while an effective technique for channelling water away from the building, leaves significant thermal bridging at the roof plates and headers where neither the insulation or air barrier can remain continuous traditional overhang is creating a large thermal bridge

3.2.2 Energy Efficiency and Sustainability Recommendations for Roof Assembly

Note: Similar to the wall system, energy modelling and cost estimating will help determine the actual wall assembly recommendation, based on experience the following options will contribute to achieving a 25-40% reduction in energy and GHG emissions.

Reconfiguration opportunity for roof assembly;

- Replace the existing 2” of rigid insulation with 12” EPS to achieve R60 insulative rating
- Replace weather/**air** barrier (if required)
- Air gap and building paper atop new insulation
- Standing seam metal roof for long-term durability, design aesthetic upgrade and future support for solar PV
- Eliminate eave overhang to allow uninterrupted rigid insulation at juncture of wall and roof

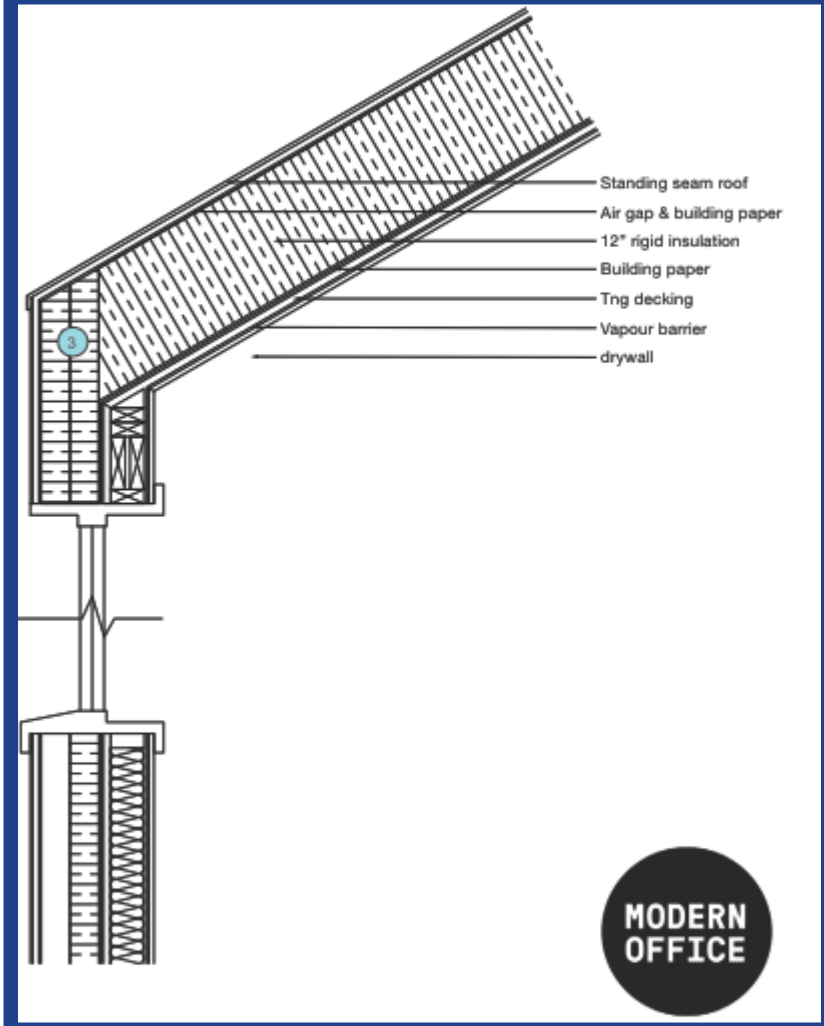


Figure 09:
New option for roof assembly

3.2.3 Rain Gutter, Downspouts

It was noted during the 19-09-27 membership presentation that removing the eaves would remove some of the rain protection for the exterior wall, exposing it to additional moisture. By introducing a rain screen, MoDA provides a drainage cavity behind the siding to allow any moisture that penetrates the exterior finish to drain away without impacting the underside of the siding. MoDA has also demonstrated a hidden gutter system (Figure 10) to collect rainwater at the roof edge, and channel it to downspouts for removal from the building area.

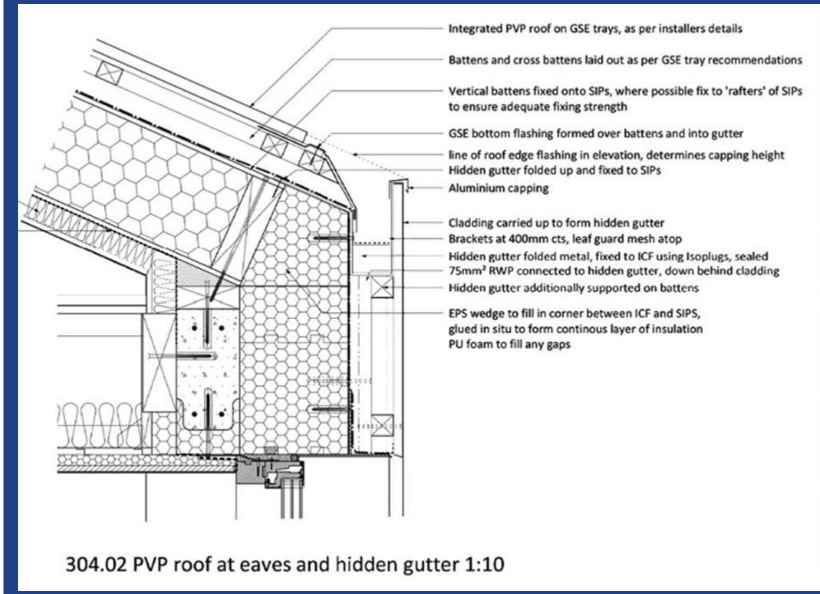


Figure 10:
Example of Hidden Rain Gutter & Downspout

4 Future HVAC, DHW and Water Conservation, Considerations

As identified in the Capital Funding section, these Phase 1 design details have purposely focused on opportunities that exist within the scope of CMHC preservation funding, namely improvements to the building envelope. Initial reviews suggest they may be sufficient to address the minimum energy consumption reductions necessary to qualify for preservation funding. However, recognizing the aspirational goals of the membership, significant additional improvements in energy efficiency can also be achieved through changes to the HVAC and electrical systems. Over time, these could also lead to a transition from natural gas consumption to renewable energy sources. The following introduces two addition stages of sustainability upgrades that can be investigated through the feasibility funding stage, and potentially added in to the long-term asset management plan.

4.1.1 Phase 2: HVAC Upgrades

As the existing furnaces and water heaters age-out and are due for replacement, a couple of options can be explored by Sunnyhill. The first option could be to include high efficient natural gas furnace (98%) combined with a condensing natural gas high efficient domestic hot water heater (DHW) tanks. This would likely maintain the lowest annual utility bills but would maintain on site green house gas emissions through the combustion of natural gas.

The second option, which could also be explored as a third phase is to introduce air source heat pumps (ASHP) for both space heating and DHW. An ASHP is effectively an air conditioner that provides heating and cooling. The heating zone, in the Calgary climate, would be effective from about 20 C down to about -18 C and below this temperature either a natural gas back up heater is needed, or electric resistive heating as a backup.

Should the co-op wish to explore eliminating the on-site emissions from natural gas, the energy modelling would need to be completed and explore the new energy intensity of the buildings post the Phase 1 exterior retrofit, combined with available space for solar PV to offset as much of the cost of the electricity needed for space heating and DHW.

The annual utility expenditures would be compared between the scenarios and decisions could be made on which pathway Sunnyhill wishes to explore based on annual expense, total GHG reductions and alignment to vision and goals.

4.1.2 Energy Efficiency by Phase

- Phase 1: Exterior insulation of walls and roof; new roof deck for PV installation, upgraded R value windows and doors; new weather/air barrier; Approximate energy savings 25%; Optional: HRV if budget allows.
    a. Economic savings for annual utility expenditures can be modelled, forecasted , and measured.
    b. GHG reductions can be modelled, forecasted and measured.

- Phase 2: Upgraded HVAC with 98% natural gas furnace, condensing domestic hot water; HRV addition; approximate additional savings estimate up to 10-20% additionally.
- Phase 3: Air Source Heat Pump addition for space heating and DHW. Approximate savings estimate up to 20% additionally.

4.1.3 Cost Targets

Recognizing that the rule-of-thumb upgrade requirement sufficient to allow switching from traditional energy sources to solar PV is to achieve the passive house standard. The passive house standard comes with an order-of-magnitude cost of around $200,000 per unit. for upgrading a unit sufficiently to be able to operate solely on solar PV energy. Urban Matters used a estimated $100,000 capital cost ceiling as a guide when determining the recommended concept to be explored through the feasibility phase, believing this to be a more defensible capital cost request. A rough breakdown of related costs is;

- Passive House Low Energy standard - $200,000
- Recommended building envelope upgrade, 3 sided units $100,000
- Recommended building envelope upgrade, 2 sided – middle unit) $70,000
- High-efficient furnace upgrade- $4,000 (20-30% additional improvement in natural gas bills)
- High efficiency DHW upgrade- $4,000
- Electric air source heat pump upgrade $5,500