Residential Energy and CO_2e Reductions in the Western Region of Nova Scotia

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Executive Summary

Problem Statement

The transition to a clean energy economy in the Western Region of Nova Scotia is a massive undertaking that needs a collaborative solution to implement the outlined August 2020 Western Region Energy Investment Plan (WREIP).[1] The WREIP targets three distinct elements in the residential sector requiring attention as a means of meeting energy and carbon reduction targets: envelope improvements, space heating, and domestic hot water.
Another component of this process considers community over gaining profit. According to the Canadian Urban Sustainability Practitioners (CUSP) study, roughly 37% of Nova Scotian households live with energy poverty (the national average is approximately 21%). Those households currently experiencing energy poverty could be identified and put into a high priority for a Deep Energy Retrofit (DER). Low-income households and affordable housing providers could likewise be prioritized. The challenge in meeting the aggressive energy and CO2e targets within the time frame of the WREIP is to ensure that DERs are widespread throughout each municipality and are not restricted to households with a certain income threshold or ability to finance a project.
This report is based on providing evidence-based, manageable clean energy programs that are accessible to the community at large.

Proposed Solution

First, addressing Residential Assessments and Retrofits can more readily attain 2050 Low Energy (2050LE) targets for energy and CO2e reductions by utilizing a systematic approach based on retrofits to the existing housing inventory using the "house as a system" model. The home's size, condition[2] and vintage will determine the reduction potential, and that will determine how stringent the target should be:

- DER up to 80% includes envelope upgrades and HVAC equipment upgrades, changing from strip (baseboard) electric and oil-fired boilers/furnaces to cold climate Air Source Heat Pumps
- DER up to 50% includes envelope upgrades and possible HVAC equipment upgrades, changing from strip electric and oil-fired boilers/furnaces to cold climate Air Source Heat Pumps.

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[1] https://westernren.ca/wp-content/uploads/2020/09/Western-Region-Energy-Investment-Plan-final.pdf

[2] The Residential Dwelling Characteristics dataset on The DataZone indicates that fully 25% of the SFD (Single Family Dwelling) in the WREN fall into low/fair construction grade categories. Accessed 15 March, 2021: https://www.thedatazone.ca/Assessment/Residential-Dwelling-Characteristics/a859-xvcs

- ECM 20- 50% includes modest envelope upgrades and possible HVAC equipment upgrades, changing from strip electric and oil-fired boilers/furnaces to cold climate Air Source Heat Pumps.

CO2e emissions are expected to be reduced by more than 35% by adopting these DER and ECM initiatives.

Reaching WREIP Targets with A Four-Part Strategy

A four-part strategy is recommended for the WREN to ensure that the WREIP targets are reachable. The plan includes identifying and sorting the housing stock, developing funding sources for homeowners, delivering products via small-scale, local shops, and project management through a designated Energy Concierge.

- Housing Inventory Dashboard (1A) and Retrofit Costing Packages (1B)
- Innovative Financing
- Exterior Retrofit Panelization Shops
- Energy Concierge Service

As illustrated in Figure ES.1, **A Model Ecosystem for Retrofit Capacity Building** outlines the framework which allows municipalities to identify and estimate the best candidate houses to undergo a DER. The chart further details the organizational flow of the program from implementation to supply chains to management and then to financing and costs. The four yellow boxes, which indicate identified gaps in the existing ecosystem, are discussed in this report.

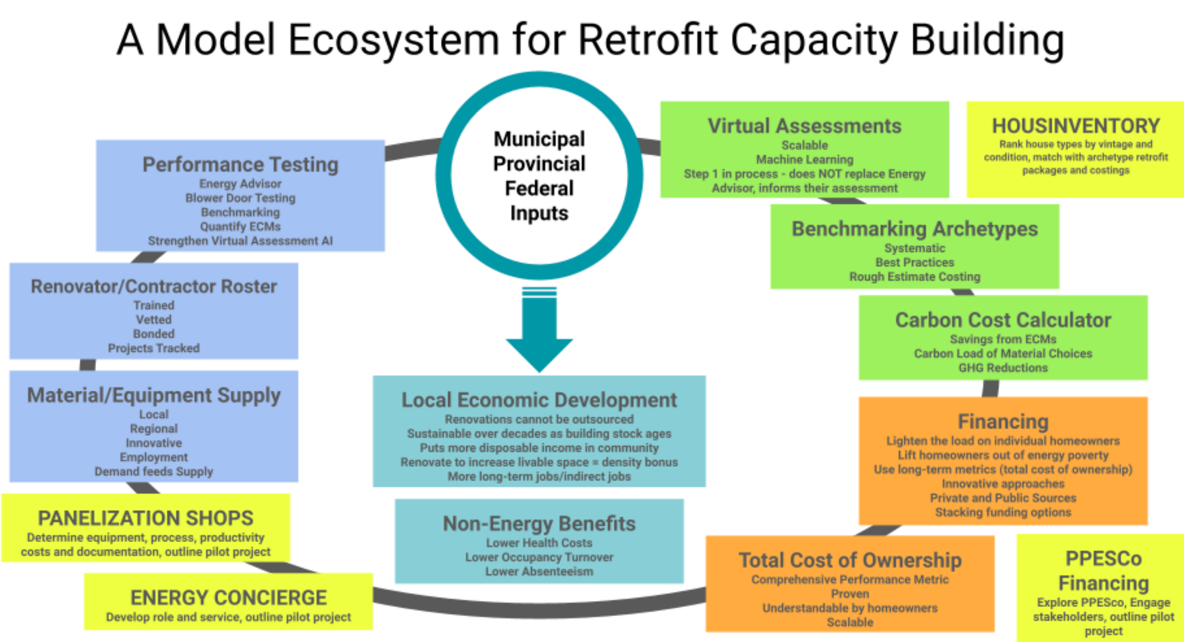

Figure ES.1: A Model Ecosystem for Retrofit Capacity Building

While Figure ES.1 shows an overarching ecosystem for developing retrofit capacity, Figure ES.2 is specific to the program being recommended for the WREN and other small municipalities going forward. This model ecosystem shows the various stakeholders and how the HousInventory helps identify and stream homeowners into the Exterior Deep Energy Retrofit Program. The proposed ecosystem includes an NGO or social enterprise that works with the PPESCo under the auspices of the municipality. The Energy Concierge Service is under the NGO or social enterprise, supporting the homeowner. The Energy Concierge ensures that each home being retrofitted has an Energy Advisor pre and post-upgrade, and that projects are kept on schedule. Energy advisors, project managers, shop managers, and site managers report back to the Energy Concierge for QA/QC.

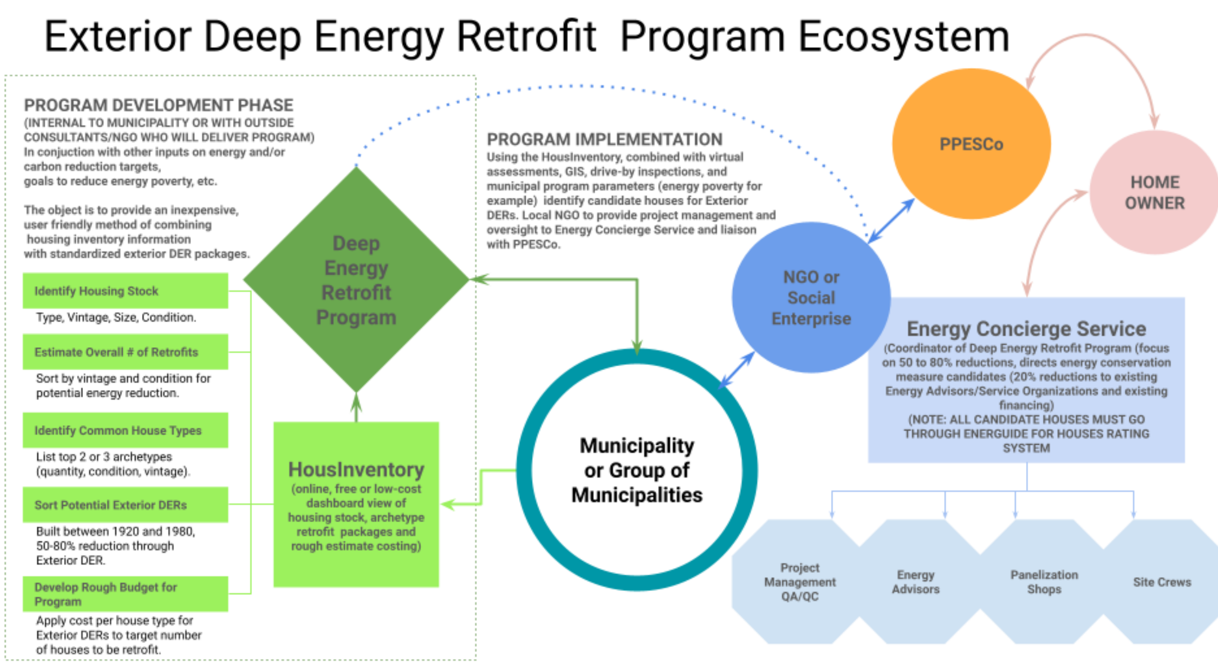

Figure ES.2: Exterior Deep Energy Retrofit Program Ecosystem

Value: Panelization and Job Creation

The creation of exterior retrofit panelization shops will have a significant, multi-level impact as a means to ensure the projected plan outlined in the WREN comes to fruition. A series of dedicated shops within a community can more readily supply the inventory needed for planned retrofits. With the shops comes more job opportunities in the construction sector and added professional development. As shop-based and site install processes are implemented and optimized, cost management will become more predictable to all players.

To meet the implementation plan and the WREIP targets, two shops completing 24 house projects each = 48/year @ DER 80 need to be in place for early 2022. After that:

2023: 3 shops completing 24 house projects each = 108/year @ DER 80

2024: 5 shops completing 48 house projects each = 240/year @ DER 80

2025: 6 shops completing 48 house projects each = 288/year @ DER 80

The 2025 production rate (6 shops/48 houses/year) carries on through to the end of 2035 when production shifts down as follows:

2036-2040: 5 shops completing 48 house projects each = 240/year @ DER 80

2041-2050: 3 shops completing 48 house projects each = 144/year @ DER 80

Orchestrating Deep Energy Retrofits at the Municipal Level

Deep Energy Retrofits impact the performance of a house in a much more significant way than the standard energy conservation measures (ECMs) recommended by an Energy Auditor. When a DER is carried out without proper investigation of building science, issues may arise that lead to unintended consequences such as structural damage and compromised occupant health due to moisture problems that lead to mold and rot in the building envelope. To minimize these risks, the new role of an Energy Concierge will:

- Give guidance for selecting the best efficiency opportunities.
- Ensure that these recommendations have no unintended consequences.
- Help owners make the most of available financing schemes to help pay for the upgrades.
- Communicate with and oversee reliable contractors do the work.
- Ensure that QA/QC requirements are met during and after retrofits.
- Coordinate financing and payback of loans

Final Thoughts and Next Steps

This report proposes a way forward to implement the energy and CO2e reduction targets outlined in the WREIP within a robust and sustainable residential deep energy retrofit ecosystem. The gaps in the current ecosystem have been identified, and potential solutions (HousInventory, Panelization Shops, and Energy Concierge Service) have been put forward. More time and effort needs to be put into verifying the feasibility of these solutions for small and rural municipalities. Implementation of any DER program at the municipal level must also include strategies and plans that create awareness among stakeholders and build confidence in the viability of the proposed DER program.

A proposal for a feasibility study has been developed for the four strategies outlined above. The feasibility study will determine the viability of measuring the existing housing stock and identifying standard retrofit packages with attendant rough cost estimates, find a way to pay for retrofits where targeted, produce specialized parts for the retrofits and train the people to build and install them, and help homeowners access and navigate the system to meet their retrofit needs. The project aims to develop a holistic and sustainable ecosystem for the municipalities of WREN to implement deep energy retrofits.

Specifically, the feasibility study:

- Gets deeper into the archetype retrofit packages, with construction details that allow for costing accuracy and applicability.
- Explores issues of financing vis a vis all households and income levels, property values, energy poverty. How can the PPESCo be accessible to all property owners who are interested?
- Defines the requirements (equipment, space, processes, staffing) of a panelization shop
- Explores the role and service provided by the Energy Concierge
- Integrates the need for awareness and attraction within the municipality of the whole DER program

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Background

The Western Region Energy Investment Plan (WREIP) published by SSG (August 2020) identified six key opportunities that would enable the communities within the WREN region to begin their transition to a clean energy economy, which include:

1. Building retrofits
2. Renewable energy
3. Renewable natural gas
4. Fuel switching in the marine fleet
5. District Energy from Forestry biomass
6. Electric vehicles

Using the six key opportunities, SSG prepared a summary of the anticipated emission reductions and required regional investment to carry out the plan.

The opportunity and scope in the WREIP are well laid out, with clear environmental, social, and economic benefits for the Western Region. However, the undertaking is massive. The WREIP does not outline a starting point and the necessary steps to complete such a transition. As such, the WREN approached the market and asked for proposals to develop a working implementation plan.

In September of 2020, the WREN formalized a contract with a collaborative team of Nova Scotian consultants to develop and implement the WREIP. The collective team comprises four diverse firms, all of which are directly involved in the fields of energy efficiency and power generation. Of the four firms, the principal consultants working on the implementation plan are:

1. Bruce McCulloch, President of MCC Energy Strategies Inc.
2. Shawna Henderson, CEO of Bfreehomes & Blue House Energy
3. William Marshall, President of Equilibrium Engineering Inc.
4. Rick Corradini, President of Sou'wester Exploration and Technology Inc.

The implementation team has assessed each of the twenty-six individual actions evaluated by SSG. The results of this collective assessment have identified four significant opportunities for the WREN to consider implementing within the region. These are:

1. Residential Assessments & Retrofits
2. Municipal Building Assessments & Retrofits
3. Wood residuals used as biomass for District Energy systems
4. Electric Vehicles through development of additional EV charging stations

This report is focused on the first opportunity listed above: Residential Assessments & Retrofits. This initiative is consistent with WREIP opportunities numbered 1 (Retrofit single-family residential homes), 8 (Residential space heating) and 9 (Residential space heating). Under these three steps the following overarching goals inform the 2050 Low Energy (2050LE) targets for energy and CO2E reductions:

- Energy for space heating decreases by 50% and electricity demand decreases by 50% in 75% of buildings by 2030
- By 2050 an additional 15% of buildings meet this standard
- 50% of the energy needed for space heating is electric (heat pumps) by 2030 and 50% of water heating in residential buildings is electric (heat pump water heater) by 2030[3]

> *NOTE: 'Net Zero Energy' and/or site-based solar electric (photovoltaics or PV) was NOT considered as one of the key reduction elements, as it cannot be applied universally across archetypes like a panelized DER. Variables that impact whether PV is viable for a site include roof size, clear area, pitch and orientation as well as surrounding obstructions that would create shading and reduce the efficiency of the panels. Also, there is increased interest in a much more effective and efficient way of providing solar-generated electricity to communities. The 'community solar garden' or 'virtual net metering' allows all interested citizens to subscribe to a solar project located somewhere else on the grid.[4] This type of project is far more equitable for all Nova Scotians, as they can support renewable energy within their community whether they own a house or rent, or whether their house has good aspects for PV or not. Nova Scotia introduced Bill 97 in April 2021 to amend the NS Electricity Act to include and increase the share of renewables on the grid, and to allow more opportunities for individuals, communities, and businesses in solar project development.*[5]

The WREIP report looked at two scenarios over the period 2020-2050. The first scenario extrapolates 'business as usual' (BAU) energy and CO2E levels from 2016 data. The second scenario outlines the depth of energy and CO2E reductions WREN needs to instigate between 2020 and 2050 to hit the Low Energy (LE) goals.

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[3] WREIP Report, page 24

[4] Website accessed 4 May 2021: https://www.saltwire.com/nova-scotia/news/local/industry-group-pushes-for-more-community-solar-gardens-in-nova-scotia-418562/

[5] Website accessed 4 May 2021: https://www.saltwire.com/nova-scotia/news/local/industry-group-pushes-for-more-community-solar-gardens-in-nova-scotia-418562/

This implementation report details a proposed approach to meet the energy and CO2e reduction targets of the residential sector outlined in the WREIP report.

It is broken out into 2 sections

Section 1: Breaking Down the WREIP Targets

1. Archetype Single Family Dwellings (SFD) and Streams of Retrofit Potential
2. WREN Housing Stock Inventory: analysis of house types, vintages, size and construction grade
3. Archetype Retrofit Packages and Costing
4. Potential Energy Reductions
5. Potential CO_2E Reductions
6. Potential Reductions in Energy Costs
7. Estimated Implementation Costs of Retrofits to Single Family Dwellings
8. Financing Retrofits

Section 2: An Implementation Plan to Meet the WREIP Targets

1. Housing Inventory Dashboard, Archetype Retrofit Packages and Costing
2. Financing using an innovative Public Purpose Energy Service Company (PPESCo)
3. Exterior Retrofit Panelization Shops
4. Energy Concierge Service

SECTION 1: Breaking Down the WREIP Targets

The WREIP looked at 3 different areas where energy reductions can be found (envelope improvements, space heating, and domestic hot water). All three elements need to be addressed in a deep energy retrofit (DERs).

The success of DERs is reliant on the 'house as a system' approach. An aggressive improvement to the building envelope can reduce the energy load enough to cause inefficiencies in space heating systems. Without the addition of controlled mechanical ventilation, air sealing measures to reduce heat loss can lead to indoor air quality problems. In addition, to meet the requirements for CO2E reductions and fuel switching (oil to electric in the WREN), existing combustion-fired equipment needs to be changed out for highly efficient cold climate air source heat pumps (ccASHP). Reducing the space heating load through envelope improvements while installing ccASHP ensures that electrification does not overwhelm the grid. It also optimizes the capacity of current and future solar electric installations in the region.

There is a significant amount of information and data about energy use that is used to estimate energy reduction targets such as those found in the WREIP. Sources include:

- Natural Resources Canada's EnerGuide for Houses Rating Service (ERS)
- Natural Resources Canada's Energy Mapping initiatives[6]
- Efficiency One/Efficiency Nova Scotia
- Virtual Assessment services (Energy X, Lightspark, My Heat)

Currently, the energy efficiency retrofit industry is project-by-project.

This can lead to poor practices and unintended consequences:

- Low reduction targets lock in energy use and emissions for generations
- It is more difficult and more expensive to reach energy targets on a one-off basis
- Reinventing the wheel renovator by renovator,

The industry needs to move into bulk-aggregated retrofits, automating a large portion of the data collection and improving the industry capacity while expanding the workforce. The WREN can take advantage of bulk-aggregated retrofits and automation through the approach laid out in this report.

There is limited information on housing inventories and how to determine what kinds of measures or retrofit packages will lead to these energy reductions. One place any small or rural municipality can start is with the property tax assessment database, which includes some basic residential dwelling characteristics that are very useful in creating a road map that will lead to success in DERs. In Nova Scotia, this can be accessed without charge through the public portal 'the DataZone'.[7]

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[6] Website accessed 5 May 2021: https://www.nrcan.gc.ca/maps-tools-publications/publications/energy-publications/publications/data-issues-and-promising-practices-integrated-community-energy-mapping/19118

[7] The information on the data zone portal is derived from the Property Value Service Corporation (PVSC). Website accessed 5 May 2021: https://www.thedatazone.ca/Assessment/Residential-Dwelling-Characteristics/a859-xvcs

From these basic characteristics (type of house, vintage, size range, and standardized construction grade) from the assessment database, a snapshot of the most likely pool of DER candidate houses emerges. Other data can be matched to these basic characteristics from the same data source, for example, assessed property values, parcel sales history, building permits for renovations, etc. This data can help refine the pool of DER candidates. Other data, such as socio-economic statistics can also be used to triage a retrofit program.

According to a recent study by the Canadian Urban Sustainability Practitioners (CUSP) Network,[8] at least one in five Canadian households are affected by energy poverty (energy poverty is defined as spending more than 6% of household income on securing continuous access to energy). Nearly 3 million homes have an undue burden on their utility bills. For these families, the lack of income means that adequate investments to make to lower energy consumption over time is untenable. This ensures the cycle of poverty continues.

In addition, the CUSP study shows that rural households are more likely to experience energy poverty than their urban counterparts. This is typically due to a combination of factors such as the larger size of homes in non-urban settings, as well as higher transmission charges on utility bills.

According to the CUSP study, roughly 37% of Nova Scotian households live with energy poverty (the national average is roughly 21%). Those households currently experiencing energy poverty could be identified and put into high priority for a DER. Low-income households and/or affordable housing providers could likewise be prioritized.

With the characteristics of the housing stock identified, the next step is to identify how they should be retrofitted to meet the target reductions, and how those retrofits can be optimized with regards to costs and sequencing over the time period 2022 to 2050. This report outlines three key retrofit packages that can be applied to various house types:

- DER 80: An 80% reduction in space and water heating energy use
- DER 50: A 50% reduction in space and water heating energy use
- ECM 20: A 20% reduction in overall household energy use

These packages take into consideration that not all houses will be good candidates for a complete deep energy retrofit due to a variety of circumstances including recent upgrades by owners that preclude further work, lower property values that might preclude financing, homeowners with limited borrowing capacity, etc.

Retrofit packages with associated costing then, allows a municipality to do a simple calculation of X number of houses at $Y cost to retrofit in each category of retrofit equals a rough estimate of how much the retrofits will cost. This is useful in determining how many houses could qualify for different financing programs and options.

Current financing programs don't fit well with the high cost of DERs, as they have ceilings for financing amounts and relatively short loan periods, among other limitations. A new and innovative approach that combines two well-established models could serve the WREN (and Nova Scotia) well in financing DERs. Combining an Energy Service Company (ESCo) with a social enterprise takes

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[8] Website accessed 5 May 2021: https://energypoverty.ca/#s2

financing out of a standard business model that requires profit, and focuses on what's of greatest societal benefit. This approach, called a public purpose Energy Service Company (PPESCo), has been pioneered in Vermont, and could be successful in Nova Scotia using one or more Community Economic Development Investment Fund (CEDIF) to provide the pool of funding for the PPESCo.

The next challenge to overcome is delivering DERs. Focussing on panelized exterior retrofits in the two DER scenarios (DER 80 and DER 50) offers up a solution that has been very successful across many countries in Europe called EnergieSprong. A simplified explanation of EnergieSprong consists of panelized exterior retrofits with a mechanical system package that are manufactured in centralized factories in small and densely populated countries like the Netherlands. The success of the program rests on two key aspects:

1. Very few housing archetypes
2. Dense populations in small geographic regions

Figure 1: EnergieSprong Panelization Process

Natural Resources Canada has been exploring and piloting panelized exterior retrofit programs through the Pre-Insulated Exterior Energy Retrofit (PEER) Initiative since 2017.

Photos: CanMet ENERGY/NRCan

Figure 2: Natural Resources Canada Panelization Pilot Project

Many of the technical challenges and questions have been identified and answered, with test panels installed and monitored on a building on the CANMET campus outside Ottawa. There are two pilot projects as a result of this initiative, one in Ottawa and one in Edmonton. Two studies have been carried out in Nova Scotia to date to determine the business case for panelized exterior retrofits on low-rise MURBs.[9]

The success of EnergieSprong hinges on the centralization of panel manufacturing. This works well in dense urban centres, but does not translate well into small and rural communities. That being said, the concept of standardization of processes, high levels of quality control, and bulk-buying of materials can be combined with vacant commercial space and under-employed/seasonal workforces to create a valuable local economic development initiative focussed on small shops scattered throughout the region.

To ensure the success of a retrofit program, the various stakeholders have to be managed, and processes within the program have to be easy to use by those various stakeholders. A new role is emerging across the residential renovation industry: an Energy Concierge (or Energy Manager, or Energy Coach). This service has a role that acts as a ‘hub' for homeowners, municipalities, financing organizations, contractors, renovators, energy advisors, etc.

While the focus of the Energy Concierge will be to shepherd the DER 80 and DER 50 panelized exterior retrofits with PPESCo financing from start to finish, they will also be the touchpoint for homeowners in identifying other energy improvement streams. For example, a house built in 1990 is likely not a good candidate for either DER 80 or DER 50. But it could be a great candidate for ECM 20, so the Energy Concierge would point that homeowner to existing programs such as local PACE financing, or Clean Foundation's Clean Energy Financing.

All retrofits will use the EnerGuide for Houses Rating Service (ERS) as a benchmark, and so will have a registered Energy Advisor to help guide each homeowner and the renovation team through the appropriate stream of energy improvement measures (DER 80, DER 50 or ECM20), ensuring that performance testing is carried out (part of the quality assurance).

[9] ReCover Initiative and WHERE-NS, both funded by NS Department of Energy & Mines, Low Carbon Communities Fund.

1.1 Archetype Single Family Dwellings (SFD) and Streams of Retrofit Potential

There are seven primary archetypes for single family dwellings (SFD) in Canada that fall under Part 9 of the National Building Code of Canada. For the purposes of this study, they have been analyzed by industry-acceptable size ranges, age cohorts, and construction grade[10], as shown in Figure 1.

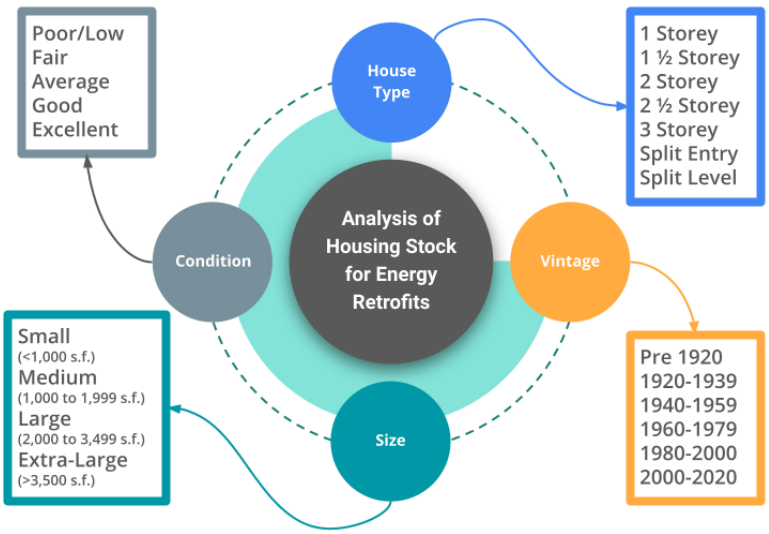


Figure 3: Factors used in analysis of housing stock

In addition to these factors, there are variable retrofit opportunities that can be defined, in part by house vintage and construction grade. These opportunities are split into four streams, with the focus of this report being on 80 and 50 percent reductions through Exterior Panelized Deep Energy Retrofits for houses built between 1920 and 1979.

[10] For the purposes of this analysis, poor and fair construction grade, from The Residential Dwelling Characteristics dataset is used as a proxy for house condition. Accessed 15 March 2021: https://www.thedatazone.ca/Assessment/Residential-Dwelling-Characteristics/a859-xvcs

Figure 4: Retrofit Streams (decreasing in energy savings, left to right)

1.2 Housing Stock Inventory

The focus for the retrofit program is single family dwellings (SFD).

In WREN, there are a total 24,266 SFD, according to the publicly-accessible DataZone, which shows the current Property Valuation Services Corporation (PVSC) database. The property assessment database includes these key points: municipality, civic address, house type, house vintage, house size, and construction grade (poor or low/fair/average/good/excellent).

A top level scan of SFD in the WREN shows the housing stock is made up primarily of 1 storey houses with basements (66.7%). Another quarter of the WREN housing inventory is made up of 1 ½ storey (15.6%) and 2 storey (10.8%). The remainder with a discernible percentage are split entry and split level homes, with 2 ½ and 3 storey homes making up a very small percentage. The five key house types identified for the WREN residential retrofit program are:

- 1 Storey
- 1 ½ Storey
- 2 Storey
- Split Entry
- Split Level

Looking at these 5 house types in the WREN, we establish a top-level energy reduction by taking the total number of each house type in the region, taking a modelled average energy use for space conditioning, water heating, and ventilation needs for each house type.

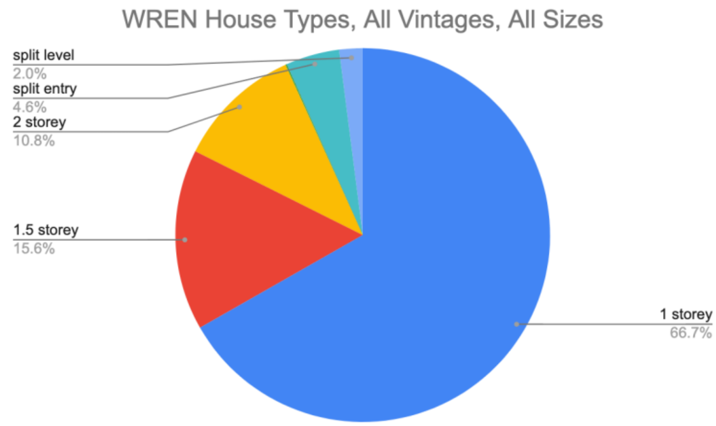


Figure 5: WREN House Types

Vintages and Deep Energy Retrofits

For the purposes of this implementation plan, the data set is limited to the 17,178 SFD that have a construction date attached to the record.

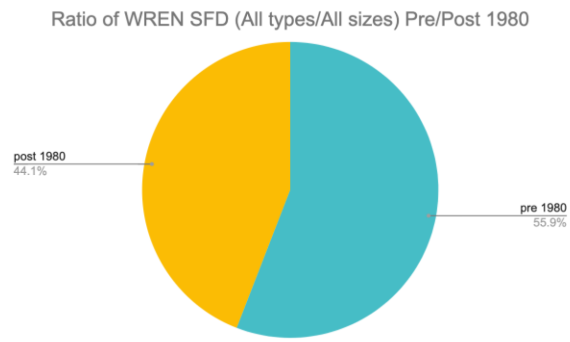
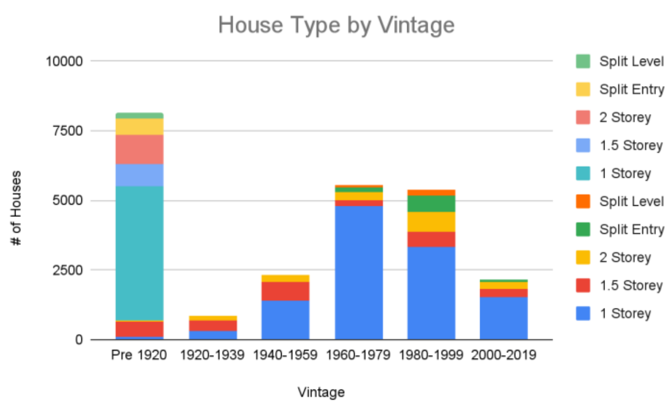
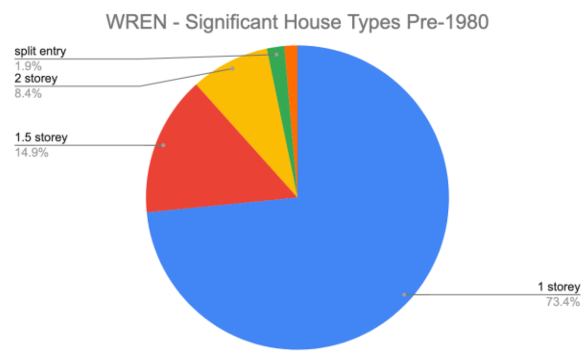


Figure 6: WREN Houses Pre/Post 1980

Through research and data analysis carried out by Natural Resources Canada and the CANMET Buildings group, it has been shown that the better candidates for deep energy retrofits were built prior to 1980, and the 'sweet spot' for excellent energy reductions is in buildings built between 1940 and 1979. This time frame represents the substantial post-war increase in houses built, in nearly every jurisdiction in the country. It also represents the largest cohort of houses that are in need of exterior improvements like cladding and window replacement, roof replacement, as well as mechanical system replacements or upgrades.

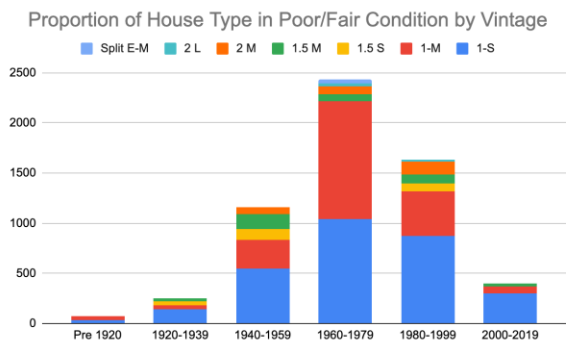


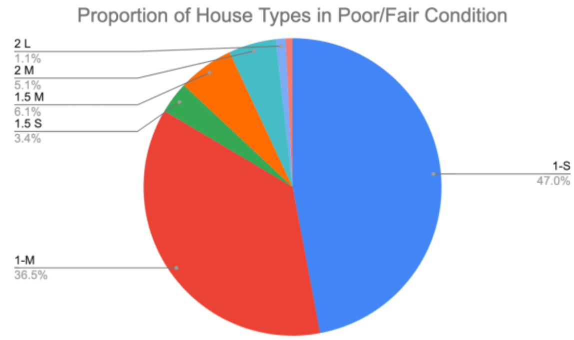


Figures 7 and 8: WREN House Types and Vintage

Houses Reported to be in Poor/Fair Construction grade

The assessment database indicates that 1687 houses were in ‘poor’ construction grade, with another 4,324 in ‘fair’ construction grade, for a total of 6,011 houses. Figure 5 and 6 show that the bulk of SFD rated as low construction grade fall into the 1960 to 1999 vintages. The bulk of SFD noted as low or fair construction grade (83.5%) are small and medium one storey houses.





Figures 9 and 10: WREN Low and Fair Construction Grade Assessment

Of the SFD with construction dates, 9,600 (55.9%) were built between 1920 and 1979. Within this cohort of aging SFD in the WREN, the key house types had a slightly different spread, with 1 Storey houses representing an even larger share of the inventory (73.4%), 1 ½ Storey houses remain static (not surprising, as this was a very popular type between 1920 and 1950). The split level house type drops off the chart, with 2 Storey and Split Entry making up 1/10th of the inventory.

Of the 9,600 SFD built in the time frame, 8,872 fall within the four main SFD types noted. Characteristics of a nominal version of each SFD type are noted below:

Table 1.2.1: House Type and Generic Characteristics in the WREN

House Type	Year Built	Avg Energy Use	Avg Floor Area		Characteristics
	mean	GJ/year	m2	s.f.	
1 Storey	1969	71	113	1211	2x4 stick frame (platform) w/removable siding, roof slope = 4/12
1.5 Storey	1952	91	127	1362	2x4 stick frame (platform) w/removable siding, roof slope = 12/12
2 Storey	1968	78	186	1999	2x4 stick frame (platform) w/removable siding, roof slope = 4/12
Split Entry	1975	73	143	1537	2x4 stick frame (platform) w/removable siding, roof slope = 4/12

1.3 Retrofit Packages and Baseline Costing

Three retrofit packages are modelled in this approach to meeting the WREIP targets. Each of these packages were estimated for a Small 1 Storey House and Medium 1 Storey House. The take off for the house quantities came from a generic house created in HOT2000[11]. The size of each house is the average of houses in that size range in the WREN.

DER 80 Scenario (up to 80% reduction in space and water heating)

- R30 panelized wall system with triple pane windows, two ways (price point is similar)
    - Cellulose-based stand off walls with new triple pane windows
    - Nail-base panel, triple track storm windows over double pane windows
- Additional R20 (interior or exterior) on foundation walls
- Upgrade attic/roof insulation to R50 (variable with roof configuration)
    - 3" min. Medium Density foam to seal attic, remainder blown cellulose
- Reduce air leakage by 50%
- Add whole house mechanical ventilation
    - Ducted HRV or ERV[12] or ductless through-the-wall HRV
- Switch out oil boiler with indirect DHW tank to cold climate Air Source Heat Pump (ccASHP)
- Switch out strip electric to cold climate Air Source Heat Pump (ccASHP)
- DHW is supplied by a hot water heat pump (HWHP)

DER 50 Scenario (up to 50% reduction in space and water heating)

- R30 panelized wall system with triple pane windows, two ways (price point is similar)
    - Cellulose-based stand off walls with new triple pane windows
    - Nail-base panel, triple track storm windows over double pane windows
- Additional R20 (interior or exterior) on foundation walls
- Upgrade attic/roof insulation to R50 (variable with roof configuration)
    - 3" min. Medium Density foam to seal attic, remainder blown cellulose
- Reduce air leakage by 50%
- Add whole house mechanical ventilation
    - Ducted HRV or ERV or ductless through-the-wall HRV
- Space and Water heating unchanged

ECM 20 Scenario (20 to 50% reduction in overall energy use - typical ERS measures)

- Additional R20 (interior or exterior) on foundation walls
- Upgrade attic/roof insulation to R40
- Reduce air leakage by 30%
- Add whole house mechanical ventilation

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[11] HOT2000 is an energy simulation modelling software developed and maintained by Natural Resources Canada to support the EnerGuide Rating System, ENERGY STAR for New Homes, and R-2000 residential energy efficiency initiatives.

[12] Heat Recovery Ventilation (HRV) is a system that uses the heat in stale exhaust air to preheat incoming fresh air. Energy (or Enthalpy) Recovery Ventilation (ERV) goes a little further than the HRV units, as this type of system also captures some of the humidity in the air to keep it on the same side of the thermal envelope that it came from.

- Switch out oil boiler with indirect DHW tank to cold climate Air Source Heat Pump (ccASHP)
- Switch out baseboard electric heaters to cold climate Air Source Heat Pump (ccASHP)
- DHW is supplied by a hot water heat pump (HWHP)

Baseline Cost for Retrofit Scenarios

As a baseline, a Class D costing was developed for the two most common house types in the WREN (Small and Medium 1 Storey). The component pricing (materials and labour) is based on estimates developed in late 2020/early 2021 for two Nova Scotian studies on panelized Net Zero Energy Retrofits for low-rise MURBs.[13] The Class D costing was extrapolated to determine a baseline square foot cost for the three retrofit packages. Actual package costing of each archetype is required for more accuracy. This rough cost per square foot is used as the basis for the costing in Section 1.7: Estimated Implementation Costs of Retrofits to Single Family Dwellings.

Table 1.3.1: Rough Costing for Retrofits by Building Size

	AVG s.f./ arche-type	DER 80 $78 square foot	DER 50 $62 square foot	ECM 20 $10 square foot
Small	740	$66,638	$55,165	$11,368
	900	$79,100	$65,146	$12,961
Medium	1000	$86,889	$71,385	$13,956
	1900	$156,988	$127,531	$22,917
Large	2000	$164,777	$133,769	$23,913
	3400	$273,821	$221,108	$37,852
Xlarge	3500	$281,610	$227,347	$38,847
	5000	$398,443	$320,924	$53,782

NOTE: square foot price does not include flat-fee consultant/design/engineering costs, but is reflected in the cost of the retrofit. These fees will drop as efficiencies of scale are met.
DER 80 and DER 50 flat fees estimated at $9,000/house, DER 20 flat fees estimated at $4,000/house

[13] Panelized Retrofit Studies: ReCover Initiative, Ecology Action Centre. Both unpublished at time of reporting.

1.4 Potential Energy Reductions

The WREIP target is to drop energy consumption in residential from 1,957,206 GJ/year (2016 data) to 845,032 GJ/year by 2050, representing a 56.8% overall reduction (1,111,174 GJ/year saved).[14]

The DER 80 scenario is applied to 37% of the SFD stock in the WREN, while the DER 50 scenario is applied to 56% of the housing stock. ECM 20 and 'other' SFD stock in the region (pre-1920 and post 1980) shown in Figure 5 can be addressed with 'standard' energy conservation measures (ECMs) and minor energy efficiency measures for the first decade of the energy reduction plan, as there will be fewer cost-effective ways of reaching the DER target of 50% energy reduction in newer houses.

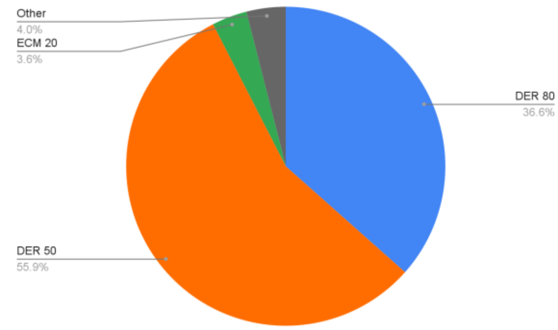


Figure 11: Proportion of DER Scenarios

According to the analysis[15], annual energy reductions by 2050 break out as follows:

DER 80: 469,579 GJ/year (42% of the WREIP target).

DER 50: 409,218 GJ/year (37% of the WREIP target)

ECM 20: 15,846 GJ/year (1% of the WREIP target).

The estimated annual reduction from houses built 1920-1979 meets 81% of the WREIP target.

Table 1.4.1: Combined Single Family Dwelling Annual Reductions (GJ/yr) by 2050

	DER 80	DER 50	ECM 20	
1 Storey	326,701	127,788		
1.5 Storey	84,973	139,585		
2 Storey	41,432	141,470		
Split Entry	8,606	298		
Split Level	7,867	78		
Manufactured			10,679	
Semi-Detached			1,387	
Duplex			3,366	
Triplex/Quad			414	ANNUAL ESTIMATED ENERGY REDUCTION
TOTAL	469,579	409,218	15846	894,643
	WREIP Residential Reduction Target (2050LE)			1,111,174

14 WREIP Report, Table A1: Energy Consumption Model, page 86

15 Estimation only, based on Hot2000 modelling of house types for this report and from data sets developed by Shawna Henderson for the 2007 CMHC report 'Approaching Net Zero in Existing Houses' (Appendix C)

Note: energy savings for manufactured homes, semi-detached, duplexes, triplexes, quadplexes have not been addressed in significant detail in this report, but are included in the ECM20 scenario.

DER up to 80% Reduction Analysis

To allow for variation in energy reduction potential across house types in this scenario, the range of reduction is 50 to 80%. However, to counter the lower retrofit potential in the newer homes in the region, two-thirds of the DER candidates should be brought to the more stringent energy target of up to 80% reduction. This DER package includes envelope upgrades and HVAC equipment upgrades. The breakout of house types for DERs that result in the highest range of reductions (50% to 80%) is shown in Table 1.4.2. In this scenario, this cohort of DERs sees a 71% reduction in annual energy use (469,579 GJ/year) by 2050 (Table 1.4.3).

Table 1.4.2: DER up to 80% Reduction by House Type

Type	DER 80	DER 50
1 Storey	4561	1955
1.5 Storey	925	396
2 Storey	522	224
Split Entry	116	50
Split Level	87	37
TOTAL	**6210**	**2662**

Table 1.4.3: Potential Energy Savings (GJ/year) by House Type (1920-1979)

HOUSING STOCK			ENERGY SAVINGS			
Type	# of houses	Avg Energy Use	Total Energy Use 2016	DER 80 Reduction	DER 50 Reduction	71%
1 Storey	6516	71	460,143	257,680	69,021	
1.5 Storey	1321	91	119,680	67,021	17,952	
2 Storey	746	78	58,355	32,679	8,753	**2050LE ENERGY USE**
Split Entry	165	73	12,121	6,788	1,818	191,800
Split Level	124	89	11,080	6,205	1,662	**TOTAL SAVED**
TOTAL	**8872**	74.6	**661,378**	**370,372**	**99,207**	469,579

NOTE: 2050LE Energy Use is the Total Energy Use 2016 less the Total Saved for this Scenario.

DER up to 50% reduction

This cohort of retrofits, which accounts for 13,566 houses (56% of the current housing stock), is focussed on envelope improvements or HVAC change out (from oil boiler to cold climate heat pump) that lead to up to 50% reduction in space conditioning and water heating energy use, and on houses that were built between 1980 and 2019. To account for variations in retrofit potential, half of the cohort was modelled to reach at least a 20% reduction, and half a 50% reduction by 2050. The breakout of house types is shown in Table 5. In this scenario, this cohort of DERs sees a 35% reduction in annual energy use (409,218 GJ/year) by 2050 (Table 1.4.5).

Table 1.4.4: DER up to 50% Reduction by House Type

Type	DER 50	ECM 20
1 Storey	2988	2988
1.5 Storey	2778	2778
2 Storey	1011	1011
Split Entry	6	6
Split Level	2	2
TOTAL	**6783**	**6783**

Table 1.4.5: Potential Energy Savings (GJ/year) by House Type (1980-2019)

HOUSING STOCK			ENERGY SAVINGS			
Type	# of houses	Avg Energy Use	Total Energy Use 2016	DER 50 Reduction	DER 20 Reduction	35%
1 Storey	5975	61	365,108	91,277	36,511	
1.5 Storey	5555	72	398,814	99,703	39,881	
2 Storey	2021	200	404,200	101,050	40,420	**2050LE ENERGY USE**
Split Entry	12	71	850	213	85	759,977
Split Level	3	74	223	56	22	**TOTAL SAVED**
TOTAL	**13566**	119	**1,169,195**	**292,299**	**116,920**	409,218

NOTE: 2050LE Energy Use is the Total Energy Use 2016 less the Total Saved for this Scenario.

ECM 20-50% Reduction

This cohort includes manufactured homes, semi detached, duplex and triplex or quad buildings in the WREN, built after 1980. No retrofit packages were determined for this cohort, instead an assumption was made about the range or depth of energy conservation measures that could be taken. To reach the target energy reduction in the WREIP, two-thirds of this portion of the housing stock needs to be brought to DER 50, while the other third is modelled as ECM 20 (shown larger portion to smaller, left to right in Tables 1.4.6 and 1.4.7). There are reasonable energy reductions to be found in this cohort, but the number of buildings is small, accounting for less than 5% of the total housing stock in the WREN. Individual municipalities could have a significantly larger proportion of one or more of these house types. In addition, some of these house types could be affordable housing units, which the WREN or individual municipalities might want to improve with a deep energy retrofit so that tenants can be brought out of energy poverty. In this scenario, this cohort sees a 38% reduction in annual energy use (15,846 GJ/year) by 2050 (Table 1.4.7).

Table 1.4.6: Breakout by House Type for ECM/EE

Type	DER 50	ECM 20
Manufactured	401	268
Semi-Detached	48	32
Duplex	62	42
Triplex/Quad	6	4
TOTAL	**518**	**345**

Table 1.4.7: Potential Energy Savings (GJ/year) by House Type (1980-2019)

HOUSING STOCK			ENERGY SAVINGS			
Type	# of houses	Avg Energy Use	Total Energy Use 2016	ECM 50 Reduction	ECM 20 Reduction	38%
Manufactured	669	42	28,103	8,431	2,248	
Semi-Detached	80	46	3,649	1,095	292	**2050LE ENERGY USE**
Duplex	104	85	8,857	2,657	709	25,853
Triplex/Quad	10	109	1,090	327	87	**TOTAL SAVED**
TOTAL	**863**	82	**41,699**	**12,510**	**3,336**	15,846

NOTE: 2050LE Energy Use is the Total Energy Use 2016 less the Total Saved for this Scenario.

Cumulative Energy Reductions

The WREIP target for cumulative energy reductions is 4,347,000 GJ[16], for all residential buildings. This cohort analysis results in an estimated 3,356,213 GJ for SFD, roughly 77% of the WREIP target. The difference (roughly 991,000 GJ) can be attributed to the remaining housing stock, with pre-1920 houses being targeted between 2022 and 2030, and post-1980s houses being targeted after 2030.

For this exercise, the potential number of DER 80 carried on in any time period in Table 1.4.6 (and any following cumulative tables) is based on a series of small panelization shops coming on line:

2022: 2 shops completing 24 house projects each = 48/year @ DER 80

2023: 3 shops completing 24 house projects each = 108/year @ DER 80

2024: 5 shops completing 48 house projects each = 240/year @ DER 80

2025: 6 shops completing 48 house projects each = 288/year @ DER 80

The 2025 production rate (6 shops/48 houses/year) carries on through to the end of 2035, when production shifts down as follows:

2036-2040: 5 shops completing 48 house projects each = 240/year @ DER 80

2041-2050: 3 shops completing 48 house projects each = 144/year @ DER 80

Table 1.4.6: Residential Cumulative Energy Savings (GJ)

	2022	2023	2024	2025	Sum 2025	2030	2035	2040	2045	2050	TOTALS
DER 80 Qty	*48*	*108*	*240*	*288*	***684***	*1,440*	*1,440*	*1,200*	*720*	*720*	*6,204*
Energy Savings	2,865	6,445	14,323	17,188	**40,821**	85,939	85,939	71,616	42,970	42,970	370,255
DER 50 Qty	*144*	*228*	*353*	*353*	***1,078***	*1,765*	*1,765*	*1,765*	*1,765*	*1,765*	*9,903*
Energy Savings	8,568	13,566	21,004	21,004	**64,141**	105,018	105,018	105,018	105,018	105,018	589,229
ECM 20 Qty	*43*	*86*	*104*	*112*	***345***						*345*
Energy Savings	708	1,415	1,698	1,840	**5,661**						5,661
Qty SFD improved	*900*	*1,751*	*2,291*	*2,481*	***7,423***	*3,205*	*3,205*	*2,965*	*2,485*	*2,485*	*21,768*
GJ saved/period	12,140	21,427	37,025	40,031	**110,623**	190,957	190,957	176,634	147,987	147,987	965,145
CUMULATIVE SFD, cohort within 1920					**110,623**	301,580	492,537	669,170	817,157	965,145	3,356,213
Potential further reductions, pre-1920 and post-1980 houses					**198,158**	198,158	148,618	148,618	148,618	148,618	990,788
CUMULATIVE SFD + Pre-20/Post-80 GJ					**308,781**	499,738	641,155	817,788	965,776	1,113,763	4,347,000
CUMULATIVE GJ Reduction Targets by 5 year increments, WREIP					177,000	756,000	723,000	874,000	890,000	927,000	4,347,000

[16] WREIP, Table 3, page 32 (sum of SFD Retrofit, Residential Space Heating, Residential Water Heating)

1.5 Potential CO_2E Reductions

The WREIP target is to drop CO_2E emissions from the residential sector from 314,053 tCO_2E/year (2016 data) to 14,483 tCO_2E/year by 2050. This represents an ambitious 95% overall reduction (299,570 tCO_2E/year). Switching from oil to electricity in the DER 80 scenario, and some of the DER 50 and ECM 20 scenarios provides significant reduction, and comes close to the WREIP target. However, increasing the proportion of renewable energy generation in the WREN will drop the amount of CO_2E per kilowatt generated, ensuring targets can be met with more electrification.

According to the analysis, annual CO_2E reductions by 2050 break out as follows:

DER 80: 124,445 tCO_2E/year (41.5% of the WREIP target)

DER 50: 145,883 tCO_2E/year (48.7% of the WREIP target)

ECM 20: 6,837 tCO_2E/year (2.3% of the WREIP target)

The estimated annual reduction from houses built 1920-1979 meets 93% of the WREIP target.

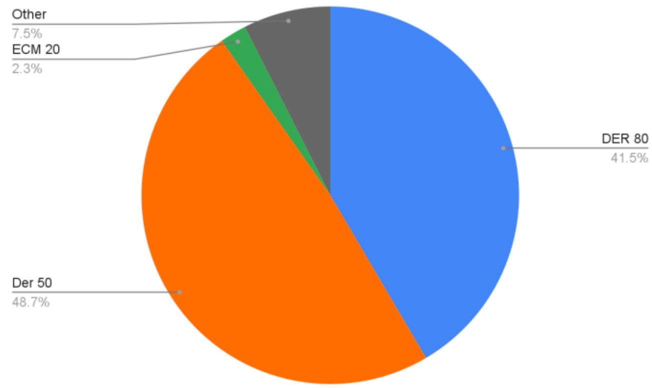


Figure 12: Potential Annual CO2E reductions by scenario

Table 1.5.1: Single Family Dwelling Annual CO2E Reductions (tCO2E/yr)

	DER 80	DER 50	ECM 20	ANNUAL ESTIMATED tCO2E REDUCTION BY 2050
1 Storey	73,626	55,139		
1.5 Storey	28,415	60,230		
2 Storey	15,116	30,351		
Split Entry	1,079	128		
Split Level	6,208	34		
Manufactured			4,608	
Semi-Detached			598	
Duplex			1,452	
Triplex/Quad			179	
TOTAL	124,445	145,883	6,837	277,165
	WREIP Residential Reduction Target (2050LE)			299,570

Note: CO2E reductions for manufactured homes, semi-detached, duplexes, triplexes, quadplexes have not been addressed in significant detail in this report, but are included in the ECM20 scenario.

DER up to 80%

This DER package includes envelope upgrades and HVAC equipment upgrades, specifically changing from strip electric (baseboards) and oil-fired boilers/furnaces to cold climate Air Source Heat Pumps (electrification). In this scenario, this cohort of DERs sees a 43% reduction in annual CO_2E emissions (124,445 tCO_2E/year) by 2050 (Table 1.5.2).

(Note: this figure does not line up with those shown in Figure 6, which shows the proportion of annual CO_2E reductions by 2050 compared to the WREIP target.)

Table 1.5.2: Potential CO2E Reduction (tCO2E/year) by House Type (1920-79)						
HOUSING STOCK			**CO2E SAVINGS**			
Type	**Avg tCO2E electric**	**Avg CO2E Oil**	**CO2E 2016**	**DER 80 CO2E Reduction**	**DER 50 CO2E Reduction**	**43%**
1 Storey	12	49	199,624	43,682	29,944	
1.5 Storey	15	63	51,870	20,635	7,781	
2 Storey	13	54	25,108	11,350	3,766	**2050LE tCO2E**
Split Entry	12	51	5,197	299	780	162,116
Split Level	15	62	4,762	5,494	714	**TOTAL REDUCTION**
TOTAL	**67**	49	**286,561**	**81,461**	**42,984**	124,445

NOTE: 2050LE CO_2E is CO_2E 2016 less the Total Reduction for this Scenario.

DER up to 50%

This DER package includes envelope upgrades and possible HVAC equipment upgrades, specifically changing from strip electric (baseboards) and oil-fired boilers/furnaces to cold climate Air Source Heat Pumps (electrification), but the assumption is that most houses will have envelope improvements and oil will remain in the mix. In this scenario, this cohort of DERs sees a 35% reduction in annual CO_2E emissions (145,883 tCO_2E/year) by 2050 (Table 1.5.3).

(Note: this figure does not line up with those shown in Figure 6, which shows the proportion of annual CO_2E reductions by 2050 compared to the WREIP target.)

Table 1.5.3: Potential CO2E reduction (tCO2E/year) by House Type (1980-2019)						
HOUSING STOCK			**CO2E SAVINGS**			
Type	**Ave tCO2E Electric**	**Ave tCO2E Oil**	**tCO2E 2016**	**ECM 50 tCO2E Reduction**	**ECM 20 tCO2E Reduction**	**35%**
1 Storey	10	43	157,541	39,385	15,754	
1.5 Storey	12	50	172,085	43,021	17,209	
2 Storey	17	69	86,718	21,680	8,672	**tCO2E 2050**
Split Entry	12	49	367	92	37	270,925
Split Level	12	52	96	24	10	**tCO2E reduction**
TOTAL	13	53	**416,808**	**104,202**	**41,681**	145,883

ECM 20-50% Reduction

This DER package includes some envelope upgrades and possible HVAC equipment upgrades, specifically changing from strip electric (baseboards) and oil-fired boilers/furnaces to cold climate Air Source Heat Pumps (electrification), but the assumption is that most houses will have envelope improvements and oil will remain in the mix. In this scenario, this cohort of DERs sees a 38% reduction in annual CO_2E emissions (6,837 tCO_2E/year) by 2050 (Table 1.5.4).

(Note: this figure does not line up with those shown in Figure 6, which shows the proportion of annual CO_2E reductions by 2050 compared to the WREIP target)

Table 1.5.4: Potential C02E Reduction (tCO2E/year) by House Type (1980-2019)

HOUSING STOCK			CO2E SAVINGS			
Type	Avg tCO2E electric	Avg tCO2E oil	Existing tCO2E	ECM 50 tCO2E Reduction	ECM 20 tCO2E Reduction	38%
Manufactured	7	29	12,126	3,638	970	
Semi-Detached	8	32	1,575	472	126	**2050LE tCO2E**
Duplex	14	59	3,822	1,147	306	11,156
Triplex/Quad	18	76	470	141	38	**TOTAL REDUCTION**
TOTAL	**12**	**49**	**17,993**	**5,398**	**1,439**	6,837

Cumulative Summary

The WREIP report has a cumulative emission reduction total of 3,427,000 tCO_2E by 2050. This is a very aggressive goal, given the current energy generation mix in Nova Scotia. WREIP indicates that the target for residential energy reductions includes significant electrification of housing stock:

- Energy for space heating decreases by 50% and electricity demand decreases by 50% in 75% of buildings by 2030
- By 2050 an additional 15% of buildings meet this standard
- 50% of the energy needed for space heating is electric (heat pumps) by 2030 and 50% of water heating in residential buildings is electric (heat pump water heater) by 2030[17]

Even with deep reductions in energy use, the corresponding CO_2E reductions, while meeting the final annual CO_2E emission goal, only reaches 36% of the cumulative emission reduction total. The analysis in this report does not include solar electric (PV) generation on residential buildings, but increasing the share of renewable energy generation in the WREN in the next 10 years will reduce CO_2E emissions associated with the residential sector.
The WREIP clean energy actions and assumptions includes solar PV in relation to residential, but does not include it as a rooftop program for houses, nor energy storage in houses. The goals are:

1. Scale up solar rooftop pv generating capacity to match 30% of electricity demand in residential 2030 (a total of 44 MW installed by 2030)
2. 100% of installed solar PV on residential includes storage, split between 50% thermal storage and 50% batteries

44 MW of PV installed by 2030 would impact the cumulative emission reductions associated with residential energy use significantly, with 30% of the supply essentially becoming CO_2E-free.

[17] WREIP Report, page 24

Table 1.5.5: Residential Cumulative CO2E Reduction (tCO2E) Single Family Dwellings & MURBS											
	2022	**2023**	**2024**	**2025**	**Sum 2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**TOTALS**
DER 80 Qty	*48*	*108*	*240*	*288*	***684***	*1,440*	*1,440*	*1,200*	*720*	*720*	*6,204*
DER 80 tCO2e Reduction	1,875	4,220	9,377	11,253	**26,725**	56,263	56,263	46,886	28,131	28,131	243,197
DER 50 Qty	*144*	*228*	*353*	*353*	***1,078***	*1,440*	*1,440*	*1,440*	*1,440*	*1,440*	*8,278*
DER 50 tCO2e Reduction	1,210	1,917	2,967	2,967	**9,061**	12,104	12,104	12,104	12,104	12,104	69,583
ECM 20 Qty	*43*	*86*	*104*	*112*	***345***						*345*
ECM 20 tCO2e Reduction	1,129	1,788	2,768	2,768	**8,453**						8,453
Qty SFD improved	*1,321*	*2,124*	*3,361*	*3,409*	***10,215***	*2,880*	*2,880*	*2,640*	*2,160*	*2,160*	*22,935*
tCO2e saved/period	4,215	7,924	15,112	16,988	**44,239**	68,367	68,367	58,990	40,236	40,236	320,435
CUMULATIVE SFD, cohort built 1920-1979					**44,239**	112,606	180,973	239,963	280,199	320,435	1,178,415
Potential further reductions, pre-1920 and post-1980 houses					**0**	19,147	14,361	14,361	14,361		62,229
CUMULATIVE SFD + Pre-20/Post-80 GJ					**44,239**	131,753	195,334	254,324	294,560	320,435	1,240,645

1.6 Potential Reductions in Energy Costs

As an example of the energy cost savings associated with the deep energy retrofits, the three energy reduction scenarios were modelled in the two most common house types in the WREN (Small and Medium 1 Storey). Both were modelled in HOT2000 starting "as is" with an oil boiler or strip electric (baseboard). See Appendix A for detailed tables.

Small 1 Storey House Energy Cost Reduction - Oil to Electric (Heat Pump)

The estimated cumulative energy costs (2022-2050) associated with space and water heating in the small 1 storey house in the business as usual (BAU) scenario starting is $110,164.

- The DER 80 scenario drops the estimated cumulative energy costs to $22,033
- The DER 50 scenario drops the estimated cumulative energy costs to $55,082
- The ECM 20 scenario drops the estimated cumulative energy costs to $88,132

Small 1 Storey House Energy Cost Reduction - Electric Update (Heat Pump)

The estimated cumulative energy costs (2022-2050) associated with space and water heating in the small 1 storey house in the business as usual (BAU) scenario starting is $120,835.

- The DER 80 scenario drops the estimated cumulative energy costs to $24,167
- The DER 50 scenario drops the estimated cumulative energy costs to $60,417
- The ECM 20 scenario drops the estimated cumulative energy costs to $96,668

Medium 1 Storey House Energy Cost Reduction - Oil to Electric (Heat Pump)

The estimated cumulative energy costs (2022-2050) associated with space and water heating in the small 1 storey house in the business as usual (BAU) scenario is $120,835.

- The DER 80 scenario drops the estimated cumulative energy costs to $24,167
- The DER 50 scenario drops the estimated cumulative energy costs to $60,417
- The ECM 20 scenario drops the estimated cumulative energy costs to $111,323

Medium 1 Storey House Energy Cost Reduction - Electric Update (Heat Pump)

The estimated cumulative energy costs (2022-2050) associated with space and water heating in the small 1 storey house in the business as usual (BAU) scenario starting is $143,435.

- The DER 80 scenario drops the estimated cumulative energy costs to $28,687
- The DER 50 scenario drops the estimated cumulative energy costs to $71,718
- The ECM 20 scenario drops the estimated cumulative energy costs to $114,748

Cumulative Summary

With this approach to meeting the energy targets laid out in the WREIP report, avoided energy costs at the end of 2050 reach nearly $185,000,000,000 (Table 1.6.1).

Table 1.6.1: Avoided Residential Energy Costs ($/GJ)

	2022	2023	2024	2025	Sum 2025	2030	2035	2040	2045	2050	TOTALS
DER 80 Energy Cost ($/GJ)	*$37.08*	*$37.45*	*$37.83*	*$38.21*		*$40.12*	*$42.12*	*$44.23*	*$46.44*	*$48.76*	
DER 80 Cost Savings	$5,099,084	$26,072,252	$130,039,381	$189,129,276	**$350,339,992**	$4,964,643,487	$5,212,875,661	$3,801,055,169	$1,436,798,854	$1,508,638,797	$17,274,351,960
DER 50 Energy Cost ($/GJ)	*$37.08*	*$37.45*	*$37.83*	*$38.21*		*$40.12*	*$42.12*	*$44.23*	*$46.44*	*$48.76*	
DER 50-Cost Savings	$45,753,339	$115,848,091	$280,472,297	$283,277,020	**$725,350,748**	$7,436,021,787	$7,807,822,877	$8,198,214,021	$8,608,124,722	$9,038,530,958	$41,814,065,112
ECM 20 Energy Cost ($/GJ)	*$37.08*	*$37.45*	*$37.83*	*$38.21*		*$40.12*	*$42.12*	*$44.23*	*$46.44*	*$48.76*	
DER 20 Cost Savings	$1,132,365	$4,574,753	$6,653,521	$7,886,733	**$20,247,371**	$7,886,733	$7,886,733	$7,886,733	$7,886,733	$7,886,733	$59,681,034
Energy Cost Savings	$51,984,788	$146,495,096	$417,165,199	$480,293,029	**$1,095,938,112**	$12,408,552,006	$13,028,585,270	$12,007,155,923	$10,052,810,308	$10,555,056,487	$59,148,098,106
CUMULATIVE Energy Cost Savings					**$1,095,938,112**	$13,504,490,118	$26,533,075,389	$38,540,231,311	$48,593,041,619	$59,148,098,106	$187,414,874,656

NOTE 1: The aggregate cost of energy/GJ[18] was used to estimate avoided energy costs. Assumed price increases: 1% per year up until 2025, then 5% per 5-year period until 2050. The aggregate energy cost in $/GJ is based on oil pricing found at https://www.efficiencyns.ca/tools-resources/guide/heating-comparisons/

NOTE 2: At the time the WREIP report was published, Canada had not yet targeted the Carbon tax to be $170/tCO2e. The assumptions made here, based on the WREIP report, may not be adequate to cover the carbon tax based on the 2016 BAU scenario in the WREIP report.

[18] The $/GJ price of $36.52 assumes 50% electric and 50% oil space and water heating.
Oil: $1.10/L * 27L/GJ = $29.70/GJ
Electric $0.16008 kWh * 277.8 kWh/GJ = $43.33/GJ
Conversion factors from Natural Resources Canada https://www.nrcan.gc.ca/maps-tools-publications/publications/energy-publications/energy-efficiency-publications/energy-efficiency-buildings/step-1-calculate-your-energy-costs-and-consumption/6561

1.7 Estimated Implementation Costs of Retrofits to SFDs

Summary Class D Costing for the two most common house types, the Small and Medium 1 Storey houses is presented in the tables below. The pricing is based on estimates developed 2020/2021 for two Nova Scotian studies on panelized Net Zero Energy Retrofits for low-rise MURBs.[19]

Table 1.7.1: Class D Costing for Small 1 Storey House (Average Size)

	Qty	Area (s.f.)	DER Panelized Envelope with HVAC	DER Panelized Envelope	ECM (one set of options)
Slab		647	$1,294	$1,294	$1,294
Foundation Wall		749	$4,257	$4,257	$4,257
Above Grade Wall		826	$32,864	$32,864	
Ceiling/Roof		694	$1,735	$1,735	$1,735
Windows		108	$4,320	$4,320	
Doors	2	39	$1,740	$1,740	
Air Sealing		2269	$860	$860	$860
2 ton HP, DHW + HRV	1 each		$20,000		$2,000
Consulting	flat fee		$4,500	$4,500	$500.00
		Total	$71,570	$51,570	$10,646
		cost/s.f.	**$103**	**$74**	**$6**

Table 1.7.2: Class D Costing for Medium 1 Storey House (Average Size)

	Qty	Area (s.f.)	DER Panelized Envelope with HVAC	DER Panelized Envelope	ECM (one set of options)
Slab		1225	$2,450	$2,450	$2,450
Foundation Wall		812	$4,615	$4,615	$4,615
Above Grade Wall		1379	$54,867	$54,867	
Ceiling/Roof		1290	$3,225	$3,225	$3,225
Windows		194	$7,760	$7,760	
Doors	2	39	$1,740	$1,740	
Air Sealing		3481	$1,319	$1,319	$1,319
3 ton HP, DWH + HRV	1 each		$20,000		$20,000
Consulting	flat fee		$4,500	$4,500	$500
		Total	$100,476	$80,476	$32,109
		cost/s.f.	**$78**	**$62**	**$10**

[19] Panelized Retrofit Studies: ReCover Initiative, Ecology Action Centre. Both unpublished at time of reporting.

Costs associated with other archetypes and sizes will vary, given more complex geometry and higher ratios of different components. More detailed analysis and costing for each archetype and size of archetype is required to implement the DER retrofit program in the WREN.

Using the information from Table 1.7.1: Class D Costing for the generic Small 1 Storey House, we can see a net reduction in expenses by 2050 if the house is retrofitted to DER 80 in 2022. Similar results are found with the Medium 1 Storey House. This analysis only looks at retrofit costs and energy cost savings. As the goal of the retrofit program is to improve the condition of houses already noted to be in poor or low construction grade, it is safe to assume that the modelled house requires new cladding and/or a new roof. If a simple replacement of cladding and roof ($35,000) were carried out in 2022 instead of DER 80, the DER 80 scenario results in a savings of over $51,500 by 2050. The up-front costs* associated with the DER 80 are recovered by year 2035 and everything beyond that is money in the pocket of the homeowner. Even this addition to the retrofit/energy savings analysis is still simplistic. Deep Energy Retrofits are best analysed using the total cost of building ownership (TCBO) as a key metric. TCBO takes into account all associated costs, such as insurance, financing costs*, property taxes, as well as ongoing maintenance, repair, and replacement over the period under consideration.

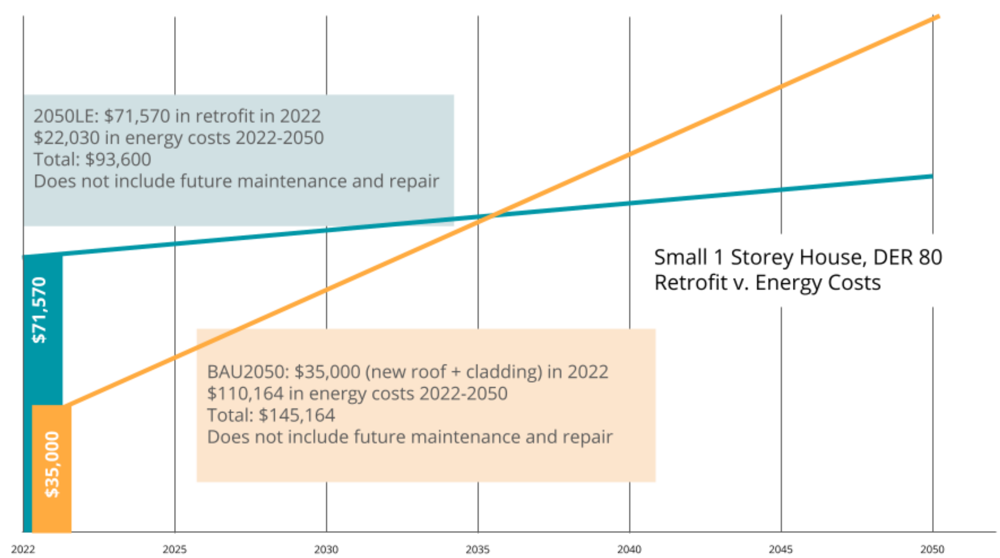


Figure 13: Retrofit Costs vs. Energy Cost Savings in Small 1 Storey House Model

* Note that if the extra costs of DER 80 ($36,570) need to be financed at say 5%, payments would be $201/month for 28 years, or $2412/year. Using the dollar savings outlined in Section 1.6, for a small 1 storey house (electric to electric conversion), the BAU annual energy use over the 2022-2050 time period would be $110,164 / 28 = $3935/yr and the DER 80 energy cost is $22,030 / 28 = $786/yr for a net average savings of $3148 per year.

Cumulative Summary

The WREIP report estimated the cumulative cost of carrying out retrofits would be roughly $653,400,00. Extrapolating the rough implementation costs shown in Part 1.7, results in an estimated cumulative cost ($867,376,000), roughly 33% higher than the cumulative cost estimated in the WREIP report. However, there are currently grants and incentive programs in place that would allow most, if not all, of the homeowners in the WREN who opt to carry out a DER to reduce costs by up to $10,000.[20] As well, there will likely be significant cost savings in the panelized exterior retrofit process that will bring this cost down, as witnessed by the EnergieSprong program in the Netherlands. That program saw a 50% reduction in costs after the first 5 years. However, it's unclear that such a deep reduction will be possible in the near future, as COVID has driven materials prices in 2021 over 300% of what they were in 2020. Assuming that in 5 years time a reduction of 30% in panel construction is possible, then the cumulative cost of retrofits that would meet the WREIP targets for energy and CO2E reductions is in line ($666,580,000) with the cumulative implementation cost estimated in the WREIP report (Table 1.7.4).

Table 1.7.3: Residential Cumulative Retrofit Costs (Houses Built 1920-1979)

	2022	2023	2024	2025	Sum 2025	2030	2035	2040	2045	2050	TOTALS
DER 80 Qty	*48*	*108*	*240*	*288*	***684***	*1,440*	*1,440*	*1,200*	*720*	*720*	*6,204*
DER 80 Costs	$2,333,043	$5,249,347	$11,665,216	$13,998,259	**$33,245,865**	$69,991,294	$69,991,294	$58,326,078	$34,995,647	$34,995,647	$301,545,824
DER 50 Qty	*144*	*228*	*353*	*353*	***1,078***	*1,765*	*1,765*	*1,765*	*1,765*	*1,765*	*9,903*
DER 50 Costs	$8,417,924	$13,328,380	$20,635,606	$20,635,606	**$63,017,517**	$103,178,031	$103,178,031	$103,178,031	$103,178,031	$103,178,031	$578,907,673
ECM 20 Qty	*43*	*86*	*104*	*112*	***345***						*345*
ECM 20 Costs	$9,886	$9,929	$9,946	$9,955	**$39,715**	$9,842	$9,842	$9,842	$9,842	$9,842	$88,927
Qty SFD improved	*235*	*422*	*697*	*753*	***2,107***	*3,205*	*3,205*	*2,965*	*2,485*	*2,485*	*16,452*
Retrofit Costs	$10,760,853	$18,587,656	$32,310,768	$34,643,820	**$96,303,096**	$173,179,167	$173,179,167	$161,513,952	$138,183,520	$138,183,520	**$880,542,424**

Table 1.7.4: Residential Cumulative Retrofit Costs (Houses Built 1920-1979) - 30% reduction in panelization costs after 5 years

	2022	2023	2024	2025	Sum 2025	2030	2035	2040	2045	2050	TOTALS
DER 80 Qty	*48*	*108*	*240*	*288*	***684***	*1,440*	*1,440*	*1,200*	*720*	*720*	*6,204*
DER 80 Costs	$2,333,043	$5,249,347	$11,665,216	$13,998,259	**$33,245,865**	$48,993,906	$48,993,906	$40,828,255	$24,496,953	$24,496,953	$221,055,836
DER 50 Qty	*144*	*228*	*353*	*353*	***1,078***	*1,765*	*1,765*	*1,765*	*1,765*	*1,765*	*9,903*
DER 50 Costs	$8,417,924	$13,328,380	$20,635,606	$20,635,606	**$63,017,517**	$72,224,622	$72,224,622	$103,178,031	$72,224,622	$72,224,622	$455,094,035
ECM 20 Qty	*43*	*86*	*104*	*112*	***345***						*345*
ECM 20 Costs	$9,886	$9,929	$9,946	$9,955	**$39,715**	$9,842	$9,842	$9,842	$9,842	$9,842	$88,927
Qty SFD improved	*235*	*422*	*697*	*753*	***2,107***	*3,205*	*3,205*	*2,965*	*2,485*	*2,485*	*16,452*
Retrofit Costs	$10,760,853	$18,587,656	$32,310,768	$34,643,820	**$96,303,096**	$121,228,370	$121,228,370	$144,016,128	$96,731,417	$96,731,417	**$676,238,799**

[20] Canada is offering up to 700,000 $5000 grants starting in late 2021. Efficiency NS offers up to $5,000 for envelope improvements and up to $2,500 for HVAC equipment replacement. Note: interest-free loans of up to $40,000 will also be available to homeowners, however, loans do not drop the cost to the owner of the retrofit.

1.8 Financing Retrofits

PACE programs in Nova Scotia are capped by the ability of the municipality to supply financing, and are reliant on a dollar-for-dollar calculation to ensure that there is no increase in homeowner financing burden (that is, every dollar spent must equate to at least one dollar of energy savings annually for the loan period).

Most PACE programs in Nova Scotia have a ceiling of $10,000 to $15,000 in financing per dwelling, and the loan period is 10-15 years. While this can be an adequate investment to reach the ECM 20 reduction target, PACE financing, by the limitations outlined above, cannot accommodate either the DER 50 or DER 80 scenario for the two sample houses, nor the extrapolated cost of other archetypes with the same retrofit packages.

The business model used by Energy Service Companies (ESCos), using future energy savings to finance energy improvements, has been successful for decades in the institutional, commercial and industrial (ICI) building arena. The residential market falls outside of this business model.

However, a modified version of an ESCo, called a public purpose energy service company (PPPESCo) combines the ESCo model with social enterprise, which allows prioritization of energy savings (and public benefit) over financial return. This allows a deep energy retrofit program to pursue measures that are beyond those of typical energy improvements. It also uses non-traditional capital to finance projects. Given the aggressive energy and CO2E reduction targets of the WREIP report, a PPESCo is likely the best candidate for a deep energy retrofit program in the WREN as outlined in this report.

The plain fact is that very few deep energy retrofits will see a positive equation on dollars spent to energy saved over a standard 10-15 year loan or PACE financing period. This is a limiting function. The complete picture for a community/municipal-level DER program has to include much more than simply dollars spent on ECMs versus dollars saved on energy. As previously stated, the DER program needs to consider issues such as energy poverty, energy security and community level energy conservation.

Further, most energy efficiency financing programs require a 1:1 ratio for energy savings, but this doesn’t address the whole cost of building ownership, and hamstrings any deep energy retrofit proposal. The PPESCO model, using the TCBO as one of the deciding metrics for the retrofit, offers patient capital working through a social enterprise to use a methodology better suited to a long-range plan like that outlined in the WREIP versus what is currently available for energy efficiency financing through conventional financing mechanisms such as consumer loans, LIC or PACE financing. Figure 13 shows the comparative long-term cost savings ($51,500) between business as usual vs. a DER.

SECTION 2: An Implementation Plan to Meet the WREIP Targets

A four-part strategy is recommended for the WREN to ensure that the WREIP targets are reachable. This strategy essentially connects the demand and supply-side initiatives. The aggregated demand enables the re-shaping of the manufacturing system with local panelization shops.

Housing Inventory Dashboard (1A) and Retrofit Costing Packages (1B): Identify and sort housing stock into candidates for different levels of retrofit, with top-level costing information on exterior deep energy retrofits (DERs) to frame up the scope of a municipal-level retrofit program, service, or application for funding/financing.

Innovative Financing: Develop a Public Purpose Energy Service Company (PPESCo) using a Community Economic Development Investment Fund (CEDIF) to help homeowners carry out deep energy retrofits. A PPESCo is a social enterprise, keeping money in the community while operating outside the conventional for-profit model.

Exterior Retrofit Panelization Shops: Deliver cost-effective exterior DERs through small-scale shops in each municipality that produce highly insulated panels for walls and roofs. The shops would work with site-based teams to install the panels.

Energy Concierge Service: Manage the municipal-level retrofit program through an Energy Concierge Service hosted with an existing or new NGO or social enterprise. The Energy Concierge acts as the 'hub' for all stakeholders (municipality, homeowner, renovator, contractor, consultants, panelization shops, sites crews, and energy advisors, etc.).

Gaps in the industry

To reach the WREIP targets, we must overcome identified gaps in the retrofit ecosystem:

- Lack of resources for municipalities to catalogue housing stock vis a vis retrofit potential and associated costs
- High cost of site-based energy assessments that are focussed on improving single houses vs. aggregate retrofits of house types
- Disconnect between homeowners and qualified contractors to get the correct work done
- Lack of financing mechanism for deep energy retrofits
- Lack of project management and streamlined resources for retrofits
- Lack of contractors versed in best practices for deep energy retrofits
- Rationalization of house archetypes and sets of exterior deep energy retrofit packages

This section of the report works from both ends of the process to bridge the gaps: first, the Housing Inventory Dashboard allows municipalities to identify and estimate the number of 'best candidate' houses potentially qualified to undergo a deep energy retrofit. The dashboard leads to Archetype

Packages and Costing for those ‘best candidate’ houses, allowing municipalities to get a sense of what it will cost to reduce space conditioning and water heating loads by 50 or 80 percent.

At the municipal level, there will be a wide variety of roles and expertise available to the program, as not every municipality has a specified planner or another person with a similar background, nor does each municipality have the resources to focus a person on energy conservation planning vs. day-to-day operations. To reduce cost and need for internal expertise, the Dashboard gives municipalities a rough-cut of their potential energy reduction budget for funding applications.

The innovative PPESCo financing program offers a way to fund these more costly retrofits.

The Energy Concierge Service provides a process to rationalize and streamline exterior deep energy retrofits, and helps the municipality channel homeowners into the appropriate retrofit stream.

The Panelization Shops improve industry capacity to deliver deep energy retrofits in a cost-effective and standardized manner, building up skills of unemployed, underemployed workforce as well as encouraging marginalized and racialized community members to join the industry. The panelization shops are part of a larger retrofit process that includes consultation, building capture technology[21], and site management as well as panel installation crews and subcontractors.

The following diagrams show:

Figure 14: An overarching model Retrofit Ecosystem for building capacity in the industry (the yellow highlighted blocks show how this project addresses gaps).

Figure 15: The proposed Exterior Deep Energy Retrofit Program ecosystem for the WREN.

[21] Building capture technology (also known as photogrammetry) is used to gather (capture) reliable information about physical objects and the environment via recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena.

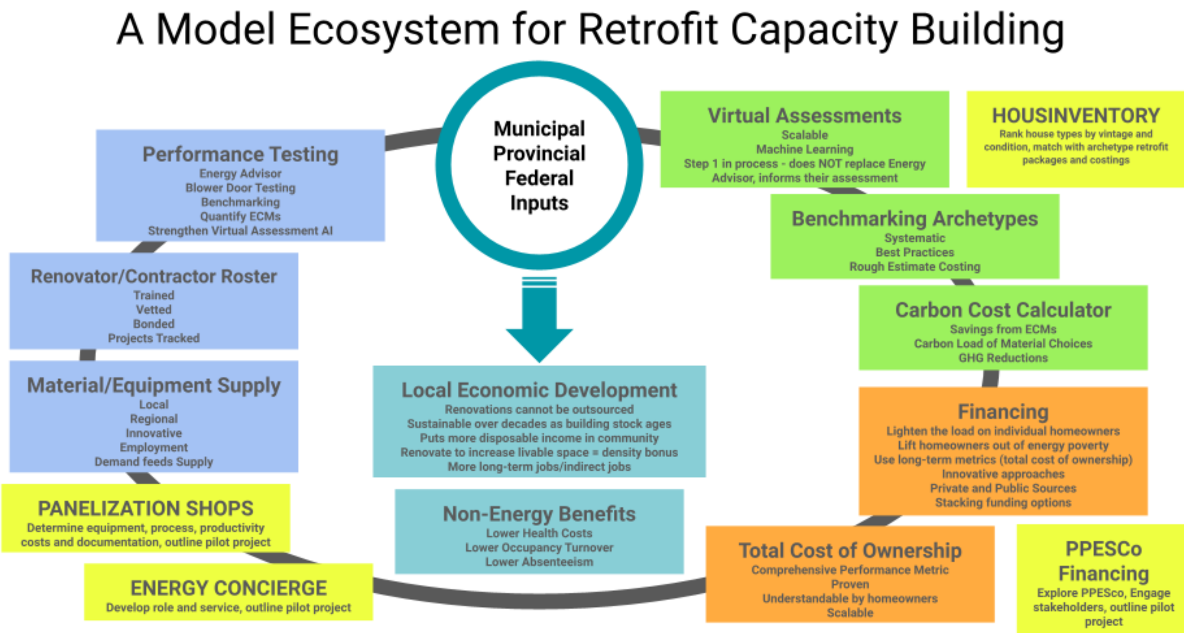


Figure 14: A Model Ecosystem for Retrofit Capacity Building

While Figure 14 shows an overarching ecosystem for developing retrofit capacity, Figure 15 is specific to the program being recommended for the WREN and other small municipalities going forward. This model ecosystem shows the various stakeholders, and how the HousInventory helps to identify and stream homeowners into the Exterior Deep Energy Retrofit Program. The proposed ecosystem includes an NGO or social enterprise that works with the PPESCo under the auspices of the municipality. The Energy Concierge Service is under the NGO or social enterprise, supporting the homeowner. The Energy Concierge ensures that each home being retrofitted has an Energy Advisor pre and post-upgrade, and that projects are kept on schedule. Energy advisors, project managers, shop managers, and site managers report back to the Energy Concierge for QA/QC.

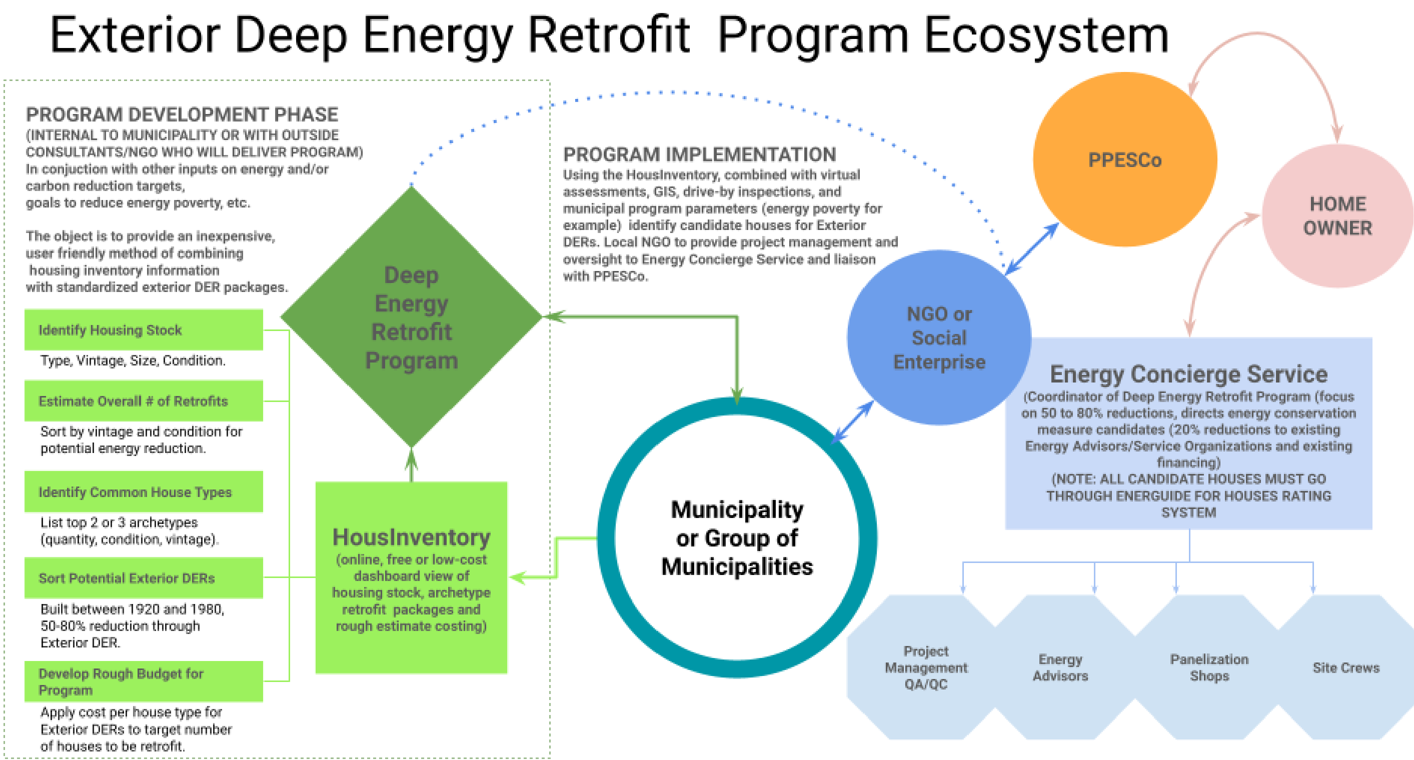


Figure 15: Exterior Deep Energy Retrofit Program Ecosystem

2.1 Housing Inventory Dashboard, Archetype Retrofit Packages and Costing

The first item that any municipality should investigate when considering a residential energy reduction strategy is the housing stock. The mix of house types, sizes, and vintages will help to determine what the municipality should focus on to ensure success in reducing energy use and carbon emissions, as well as reducing energy poverty and other socio-economic goals.

A prototype 'dashboard' giving a high-level view of housing stock and construction-grade was developed for the WREN to visualize the housing stock and to create a hierarchy of energy reductions that focus on determining which houses are good candidates for deep energy retrofits. This gives the municipalities in the WREN a quick start on getting to the 5-year incremental changes outlined in the WREIP report.

While the dashboard focuses municipal savings on deep energy retrofits, it is also useful in sorting house types and vintages into silos or streams. Four retrofit streams based on the condition of specific vintages have been identified.

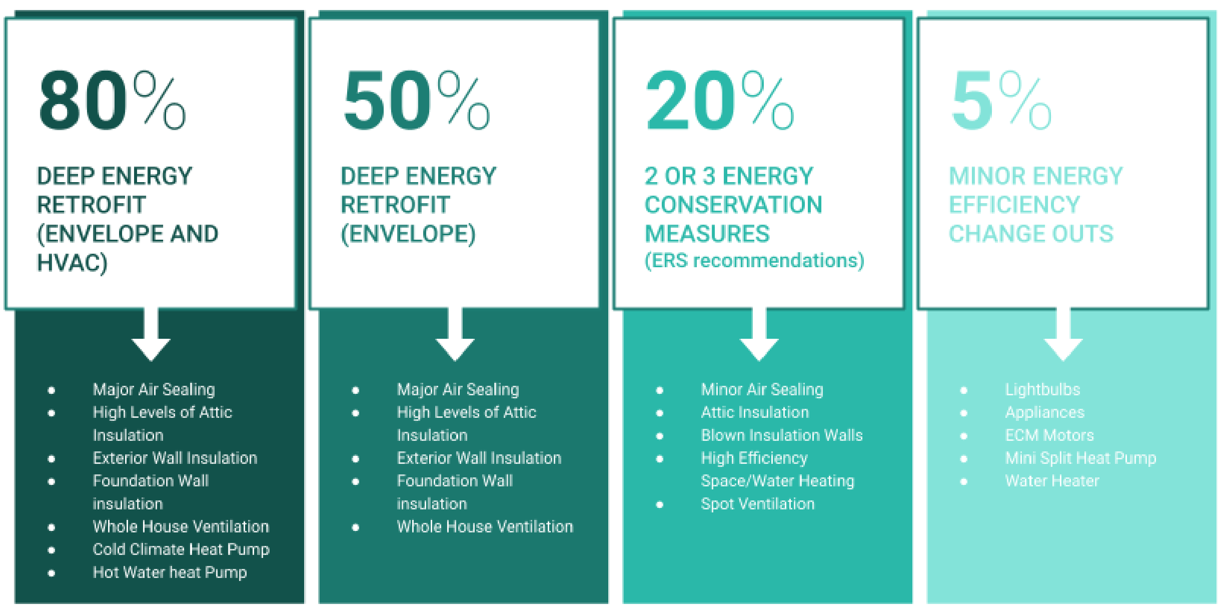


Figure 17: Retrofit Streams (decreasing in energy savings, left to right)

The following graphics show the concepts of how the data would be interpreted and presented. Figure 10 shows the first level of the dashboard: an overview of house types and sizes, with an indication of how common the house type/size was during the following time frames, pre-1920, 1920-1939, 1940-59,1960-79, 1980-1999, 2000-2020.

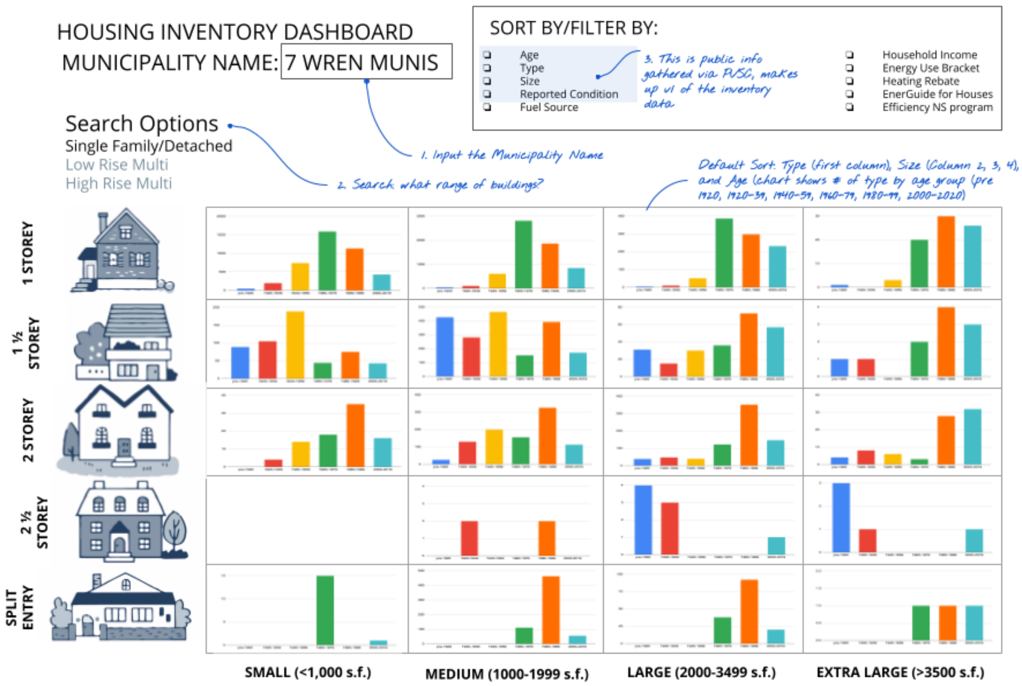


Figure 18: The HousInventory Dashboard Mockup

A second graphic (Figure 19) shows the proportional representation of house types in the WREN, with Nova Scotia's housing stock shown on the right for comparison.

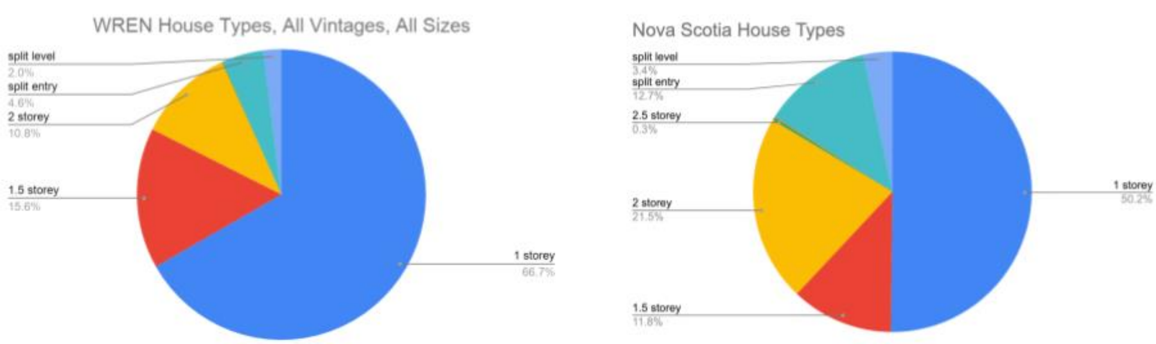


Figure 19: Comparison of WREN Housing Stock to Nova Scotia Housing Stock

Figure 20 shows four charts that detail the following:

Chart 1: More than 25 instances of a house type by all vintages. This shows the bulk of the houses in the WREN are Small 1 Storey (1-S) and Medium 1 Storey (1-M).

Chart 2: The number of houses by vintage. This shows that most houses in the WREN were built between 1960 and 1999.

Chart 3: The number of houses in poor/low and fair construction-grade by vintage. This shows that the bulk of houses noted as poor/low and fair construction grade in the assessment database were built between 1940 and 1999.

Chart 4: The number of houses in poor/low and fair construction-grade by type. This shows that the Medium 1 Storey House (1-M), the red portion of the columns, is the most common type reported as poor/low and fair construction grade.

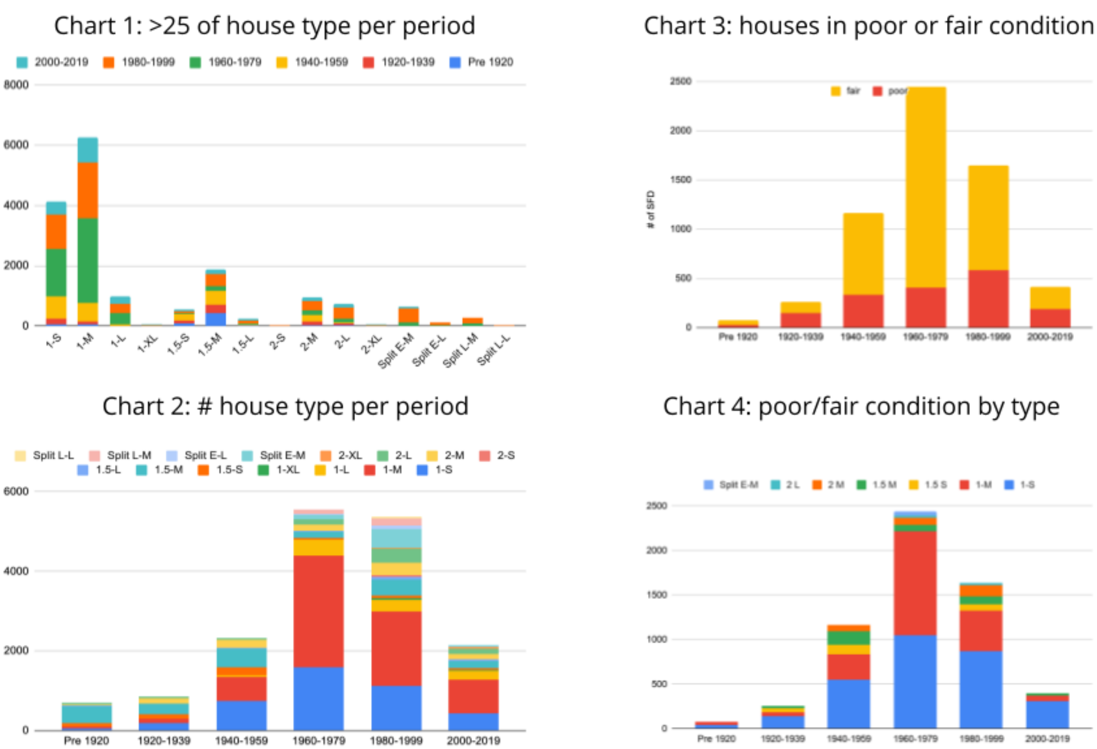


Figure 20: Four Charts Showing House Types By Age and Condition

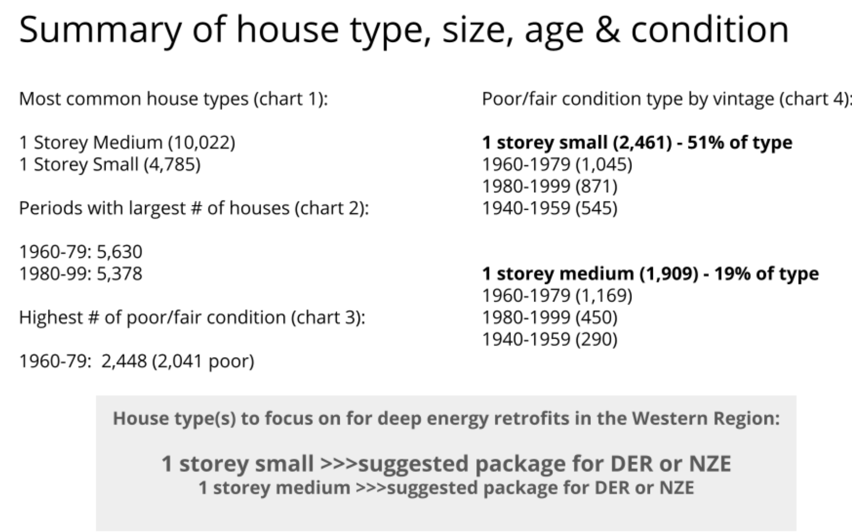
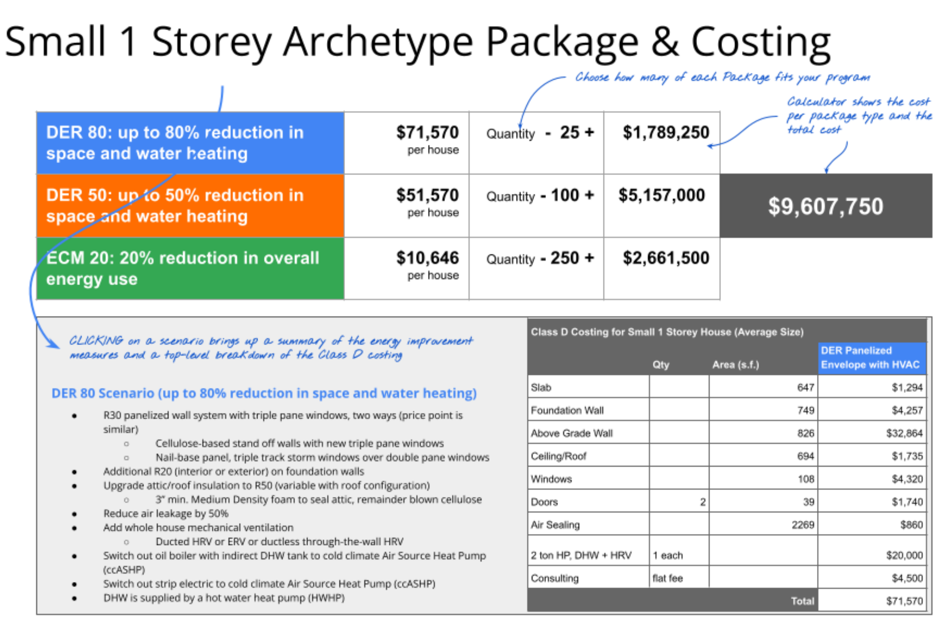


Figure 21: Summary of Archetypes Best Suited to a Deep Energy Retrofit

The next screen mock-up (Figure 21) shows the summary of the charts above and indicates which house type the municipality should focus on for an exterior deep energy retrofit. Clicking on the grey box in Figure 21 takes the user to another screen (Figure 22) that shows the retrofit packages and Class D costing for the house types indicated. A calculator will show the cost of multiple retrofits.



DER 80: up to 80% reduction in space and water heating	$71,570 per house	Quantity - 25 +	$1,789,250	
DER 50: up to 50% reduction in space and water heating	$51,570 per house	Quantity - 100 +	$5,157,000	$9,607,750
ECM 20: 20% reduction in overall energy use	$10,646 per house	Quantity - 250 +	$2,661,500	

DER 80 Scenario (up to 80% reduction in space and water heating)

- R30 panelized wall system with triple pane windows, two ways (price point is similar)
  - Cellulose-based stand off walls with new triple pane windows
  - Nail-base panel, triple track storm windows over double pane windows
- Additional R20 (interior or exterior) on foundation walls
- Upgrade attic/roof insulation to R50 (variable with roof configuration)
  - 3" min. Medium Density foam to seal attic, remainder blown cellulose
- Reduce air leakage by 50%
- Add whole house mechanical ventilation
  - Ducted HRV or ERV or ductless through-the-wall HRV
- Switch out oil boiler with indirect DHW tank to cold climate Air Source Heat Pump (ccASHP)
- Switch out strip electric to cold climate Air Source Heat Pump (ccASHP)
- DHW is supplied by a hot water heat pump (HWHP)

Class D Costing for Small 1 Storey House (Average Size)	Qty	Area (s.f.)	DER Panelized Envelope with HVAC
Slab		647	$1,294
Foundation Wall		749	$4,257
Above Grade Wall		826	$32,864
Ceiling/Roof		694	$1,735
Windows		108	$4,320
Doors	2	39	$1,740
Air Sealing		2269	$860
2 ton HP, DHW + HRV	1 each		$20,000
Consulting	flat fee		$4,500
		Total	$71,570

Figure 22: Archetype Package and Costing Calculator

2.2 Financing using an Innovative Public Purpose Energy Service Company (PPESCo)

The proposed project will explore a community-focused financing model and launch a revolving fund to cover the cost of identified energy efficiency upgrades. The preliminary focus of the financing study will be to assess the benefit of creating a Community Economic-Development Investment Fund (CEDIF) for the Western Region in conjunction with a provincially managed social enterprise (Link: Nova Scotia Securities Commission, 2021).

Proceeds from the CEDIF will be used as the preliminary capital for the creation of a community energy services company (ESCO). The ESCO model is a proven tool for private firms making energy investments in third-party organizations and typically includes comprehensive technical analysis, project management, construction services and the capital resources to finance the upgrades. Although ESCOs are currently injecting billions of dollars in energy upgrades across North America the providers are focused heavily on public facilities and large privately funded corporations, which leaves both a significant gap and opportunity in the residential marketplace.

The financing portion of the study will explore the opportunity to create a public-purpose energy services company (PPESCO), a model that has been tested and proven by the Vermont Energy Investment Corporation (VEIC). Under this unique funding model, the pooled fund is used to make deep energy retrofits in community projects. The financing model benefits end-users by providing capital to make deep energy retrofits, and immediate energy savings. The additional energy savings will be combined with funds from the sales of certified GHG/carbon credits to repay the loans and sustain the investment pool. Since the model will be a social enterprise, the focus will not be on maximizing profits but rather to sustain the fund and create real employment opportunities in the region. For more details of the PPESCO model, and context of Figures 23 and 24, see Appendix B.

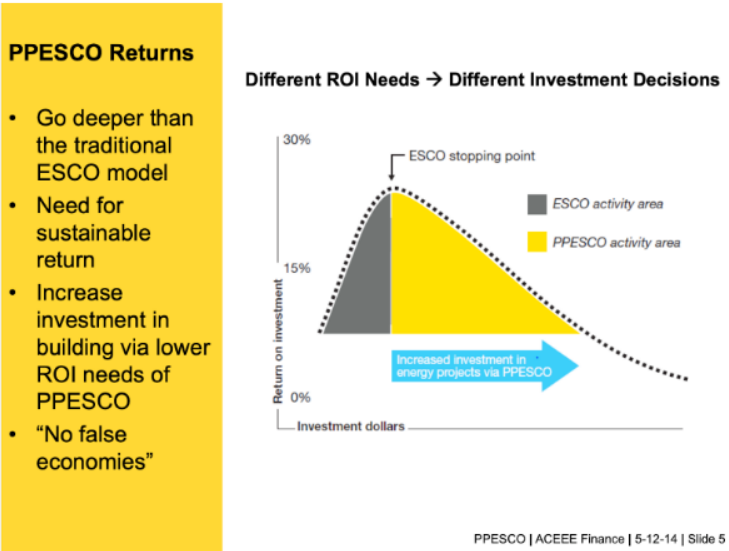


Figure 23 - PPESCO vs ESCO comparison

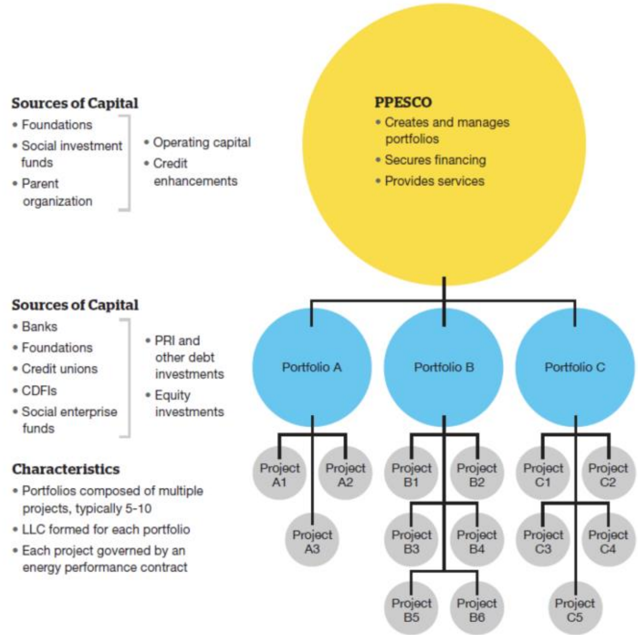


Figure 24 - PPESCO Portfolio Model

The newly formed PPESCO will look to create regional investment portfolios that spread the investment risk by bundling individual residential projects. Under this proposed model the PPESCO will work to create and train local trades and service providers to undertake the upgrades to maximize the regional economic benefits. In addition, the PPESCO will manage the up-front assessment, ongoing monitoring, and verification of all associated environmental benefits (e.g. GHG emission reductions).

The following points will be explored as they relate to the creation, implementation and sustainability of the proposed PPESCO model:

1. What percentage of the total fund needs to be generated by the CEDIF?
2. Should each Municipal unit within the scope of the study have it's own CEDIF, or would the region be better served to have a single CEDIF fund?
3. What conventional funding sources can be linked to the PPESCO to leverage the CEDIF funds raised?
4. Will the enterprise limit the available funding amount per home?
5. What is the ideal range for funding terms, and will the program be built around an assumed net savings from day one for the participants?
6. What is the planned interest/borrowing rate, and what portion of the project investments will need to be covered for program administration?

2.3 Exterior Retrofit Panelization Shops

Site installation teams and panelization shops will be needed to meet the demand for exterior retrofits as outlined in Section 1 of this report, and to make the most of the local economic development opportunity potential in the residential retrofit plan for the WREN.

A centralized automated manufacturing plant like that used in the Netherlands to deliver EnergieSprong works in densely populated urban areas, however, the WREN (and most of Nova Scotia) consists of low-density rural and suburban communities.

Ottawa Community Housing (OCH), part of NRCan's PEER pilot project, purpose-built a small shop to carry out their panel construction. OCH is an affordable housing provider with a very large portfolio of similar vintage and size low-rise MURB buildings, and the shop was built on OCH property, so this makes economic sense.

In the WREN, and throughout most of Nova Scotia, there are many vacant commercial/retail spaces that could be leased as panelization shops. The space needed for the workshop, as defined by OCH, is a 32'x32' shop with a 12' ceiling (Figure 16).

Figure 25: Ottawa Community Housing Panelization Shop

How Many Shops?

To meet the implementation plan and the WREIP targets, 2 shops completing 24 house projects each = 48/year @ DER 80 need to be in place for early 2022. After that:

2023: 3 shops completing 36 house projects each = 108/year @ DER 80

2024: 5 shops completing 48 house projects each = 240/year @ DER 80

2025: 6 shops completing 48 house projects each = 288/year @ DER 80

The 2025 production rate (6 shops/48 houses/year) carries on through to the end of 2035, when production shifts down as follows:

2036-2040: 5 shops completing 48 house projects each = 240/year @ DER 80

2041-2050: 3 shops completing 48 house projects each = 144/year @ DER 80

How Much to Run a Shop?

A cursory review of leasable commercial space in the WREN in early 2021 showed that potential spaces with adequate interior storage would cost $3,000 to $5,000/month (including utilities).

Other significant cost items include (notional costs only):

Chain Hoist and installation: $2,500

Large work table materials and labour: $2,500

Tools and Equipment: $25,000

Shop set up: $30,000

Lease: $5,000/mo x 12 = $60,000

Insurance: $7,000/year

Shop Manager: $80,000/yr

Crew of 4: $288,000/yr

Shop Operations: $435,000

The implementation plan calls for two shops to produce panels for 24 houses each year in 2022. To put two shops in operation, the notional cost to set up and run two shops would be $930,000, or roughly $19,375 for the labour for panels per house.

Other costs associated with the exterior panelized retrofit process:

- Materials (lumber/structure, insulation, rainscreen, cladding, windows, doors)
- Panel transport

- Crane Services
- Pre-Build Costs (design/building capture/energy and financial modelling/engineering)
- Site Installation Team
- Mechanical System Upgrades/Replacements
- Site-required Demolition/Dismantling
- Foundation Insulation (interior or exterior)
- Roof Insulation

The Panelization Shop approach allows DERs to be carried out with greater speed and quality control than site-built or site-applied insulation and gives an excellent opportunity for workforce development, and the creation of new or expanded roles.

Workforce Development

Upskill existing trades workforce

Crew • Manager • Coordinator

Nurture 'non-traditional' workforce

(women, racialized communities)

Needed for Fulfillment

TEAM:
Program Coordinator
Design Team(s)
Building Capture
Building Science Specialist
Engineer(s)
Designer/Architect
Mechanical Design Specialist

Overarching/Engagement:

Define the program

Orientation/program parameter training for Design Teams

Info sessions for Building Officials, Municipalities, Financiers, Insurers

Training for crews to meet standard - define the panel standards

!!!QA/QC & inspection: parameters/procedures/remedies

Figure 27: Workforce Development and Roles Within the Exterior Panelization Retrofit Process

The panelization shops do not stand alone, there is a larger team associated with a deep energy retrofit that does design and consulting work prior to the panels being constructed, installs the panels and completes the work associated with the full retrofit (moisture mitigation, foundation and ceiling/attic insulation, air sealing, mechanical ventilation, HVAC replacement/upgrade). The retrofit work will require project coordinators/managers to supervise each DER, who will work with the Energy Concierge under the Energy Concierge Service.

2.4 Energy Concierge Service

Uptake of conventional energy conservation measures (ECMs), like those that are largely recommended by Energy Advisors through the EnerGuide for Houses Rating Service (ERS) can be carried out with reasonable success without the homeowner requiring a special project manager. The ERS recommendations target roughly 20% reductions in overall household energy use.

Deep Energy Retrofits impact the performance of a house in a much more significant way. When carried out without proper investigation of building science issues prior to the retrofit lead to unintended consequences that can include structural damage as well as compromised occupant health due to moisture problems that lead to mold and rot in the building envelope.

To support the panelized exterior retrofits, a new service, with a new role is required. As noted below in the Domino example, the concierge service must be housed within a regional NGO or social enterprise. The business model needs to support societal good as opposed to generating profit as a primary goal.

Homeowners are often overwhelmed with what they need to do to carry out an energy improvement project: coordinating between banks, auditors, contractors, and utilities. The problems multiply quickly:

What's the right pathway for me to take?

How do I pay for a deep energy retrofit?

Who do I trust for advice?

Who can do the work?

These questions, combined with an overall lack of awareness of the opportunities for savings, are the reason for an Energy Concierge. An energy concierge program simplifies the process, giving owners a single point of contact to complete their energy retrofits.

Energy Concierge or Energy Manager roles, programs, and services are coming to the forefront now that there is an emphasis on DERs. Halifax is considering a pilot program that would address low-level energy conservation measures, with a heavy emphasis on web-based solutions for the large urban population. The Atmospheric Fund (TAF) champions a tailored concierge program as the key to enabling full-scale uptake of DERs in a manner that ensures "consistent social, environmental and economic outcomes."[22]

Indeed, this type of service is exactly the way that EnergieSprong[23] is working in many European countries and some US jurisdictions approach a full-scale retrofit strategy. The financial community is engaged as well. For example, Connecticut started the first green bank in the US (2011) to

[22] Website accessed 2 May 2021: https://taf.ca/investing-in-retrofits-heres-how/
[23] Website accessed 2 May 2021: https://energiesprong.org/

“accelerate green energy adoption in Connecticut by making green energy financing accessible and affordable for homeowners, businesses and institutions.”[24]

The NYSERDA (New York State Energy Research & Development Authority) has an initiative called RetrofitNY. This project is focused on multi-family buildings in the affordable housing sector. The goal is “… to make net-zero energy (NZE) retrofits a reality and electrify the building stock in New York in a cost-effective way.”

Programs like these in Connecticut and NYSERDA rely on systems that include managerial or concierge roles to shepherd projects through from application to final sign-off.

In 2015, an energy concierge service called Domino was formed in California as a for-profit entrepreneurial initiative to provide energy concierge services to homeowners. The consumer pays nothing for the concierge service. Domino makes its money through payment by vendors for customer acquisition and lead generation. From a 2015 article:

> Customers contact Domino and get paired with energy concierges. During a discovery phone call, the energy consumer is offered three different options.
>
> 1. Education about ways to save energy and improve the home at no cost.
> 2. Approaches that involve a small amount of spending, like installing LED
> 3. Deeper investments, such as installing solar, fuel switching or buying an electric vehicle.
>
> Domino acts as a neutral third party in helping the consumer make choices. It is product and vendor agnostic, although it offers a list of contractors that it has vetted. The key is to give the customer enough unbiased information to make intelligent choices.
>
> The energy concierge is not compensated through a sales commission. Instead, Domino pays the concierge a base salary plus bonuses based on action taken by customers. The bonuses are given for any meaningful action by the household, from turning down the thermostat (verified by a photo) to undertaking a home energy retrofit or installing solar panels and everything in between.[25]

It appears that Domino did not survive as a for-profit service, articles are all dated 2015 and revolve around the same media release. The domain is for sale. This is unsurprising, as the complexity of a business model that relies on funding from contractors is challenging. Contractors work on relatively small margins, and fluctuations in material and equipment costs can reduce profit significantly. Getting buy-in to a program that essentially requires a revenue share is difficult when contractors are also in high demand and do not need to participate in the program to fill their schedules.

[24] Website accessed 2 May 2021: https://www.ctgreenbank.com/

[25] Website accessed 5 May 2021: https://energyindemand.com/2015/05/01/the-energy-concierge/

The Federation of Canadian Municipalities (FCM) has a similar role for energy coaches working with affordable housing providers. From the FCM website:

> FCM's Sustainable Affordable Housing (SAH) initiative is collaborating with organizations across Canada to create more sustainable communities through the Regional Energy Coaches (REC) pilot project.
>
> These coaches will help affordable housing providers – including municipal, not-for-profit organizations and housing co-operatives – initiate and plan energy efficient retrofits and new builds. From project management and technical support to walk-through energy assessments and one-on-one coaching, RECs will:
>
> - guide you through the process of identifying opportunities and evaluating the feasibility of energy retrofits
> - demonstrate what technologies you can leverage
> - provide insights on how to maximize the environmental impact of your project
> - support the preparation of a successful funding application [26]

Clean BC's 'Better Homes' program also has a free energy coaching service for homeowners and commercial building owners and managers. This service is limited and does not include project management or oversight of work to be done. Clean BC's Energy Coach services include:

- Access to Energy Coaches via a toll-free hotline and email
- Information and general advice about energy efficiency upgrades and rebates
- If needed, directing you to appropriate program representatives

The Atmospheric Fund (TAF) recommends a concierge-like experience for building owners to enable full scale uptake of deep energy retrofits (although this is in the context of larger buildings, not houses).[27]

Putting the Energy Concierge role under the wing of an NGO or social enterprise funded by an innovative financing program such as the PPESCo model shifts the focus of the program on sustaining itself through a revenue share with contractors, and puts it back into the proper place: helping homeowners reduce their energy costs while improving the value, durability, and overall health of the building.

The other advantage of using an NGO/social enterprise is to build on the energiesprong "market development team" model. The entity has no material interest in the contracts signed between building owners and retrofit solution providers and thus can focus on re-shaping those

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[26] Accessed 15 June 2021: https://fcm.ca/en/resources/gmf/regional-energy-coaches
[27] Accessed 30 May 2021: https://taf.ca/investing-in-retrofits-heres-how/

relationships. The entity helps draw up performance contracts signed for the retrofits which could include things like airtightness targets, price of panels etc.

It also allows information exchange going up and down the supply chain (e.g. panel manufacturers) through workshops etc - so they can prepare, but in a manner that still allows competition where appropriate.

The concierge approach can help homeowners solve the energy efficiency puzzle. One or more qualified people serve as a reliable guide for people interested in energy retrofits. The concierge service creates the space for 'efficiency as service' or energy performance contract model where another party (in this case, the PPESCo) handles the financing. Specifically, the Energy Concierge will:

- Give guidance for selecting the best efficiency opportunities.
- Ensure that these recommendations have no unintended consequences.
- Help owners make the most of available financing schemes to help pay for the upgrades.
- Create space for an "efficiency as a service" or energy performance contract model where another party handles the financing.[28]
- Communicate with and oversee reliable contractors doing the work.
- Ensure that QA/QC requirements are met during and after retrofits have been performed to ensure energy savings are being met.
- Coordinate financing and payback of loans

Having a central entity ensures the best improvements are made in places where there are the greatest opportunities for savings and reductions of emissions. Furthermore, it encourages property owners to perform upgrades by simplifying the process and helping them realize the savings quicker. The benefits of an Energy Concierge include:

- Personalized help with big-ticket items and complex processes
- Neutral third party, doesn't represent any company, product, or service
- Oversight and verification of performance testing (pre and post-retrofit blower door tests)

With the approach outlined in this report, the Energy Concierge does not need to have an in-depth understanding of building science and would be working with a restricted set of pre-defined options for DER 80 and DER 50 retrofits. This allows candidates for the Concierge position to have strong project management skills with the understanding that they have building science experts to collaborate with on each project in the role of an Energy Advisor.

For the purposes of Deep Energy Retrofits and streamlining processes, Figure 28 shows a simplified decision tree for sorting houses into various streams according to the level of potential energy reduction. With this decision tree, the Energy Concierge would direct the owners of a home built

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[28] This is what VEIC's PPESCo does with multi-unit residential, and what Sealed in NY is trying to do with single-family dwellings https://sealed.com/

after 1980 to an energy advisor who would help them determine what, if any, energy conservation measures they could take in their newer home. Owners of older homes could be eligible for a DER if they haven't already carried out significant renovations (with or without energy conservation measures included). If they have installed new siding or cladding, and/or replaced space conditioning equipment recently, they would move to the 'ECM 20' stream, where an energy advisor would help them determine what reasonable energy conservation measures are open to them now. Once past this sorting stage, the Energy Concierge would focus only on Exterior DER candidates.

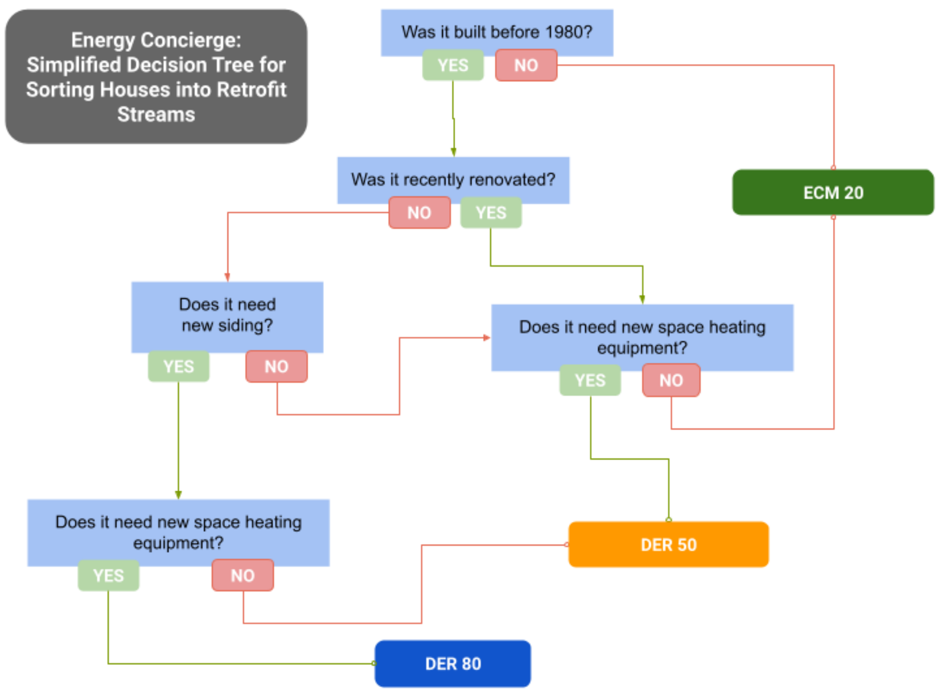


Figure 28: Simplified Decision Tree for Retrofit Streams

Who Does What When?

Figure 29 shows a possible flow chart for an Energy Concierge working within an Exterior DER ecosystem. The concierge service is run as an NGO or social enterprise, perhaps the PPESCo, and provides reporting to the PPESCo and the municipality. The Concierge role is the 'hub' between the homeowner, energy advisor, PPESCo financing, project manager and design/engineering consultants. The Energy Concierge is responsible for shepherding each project from start to finish.

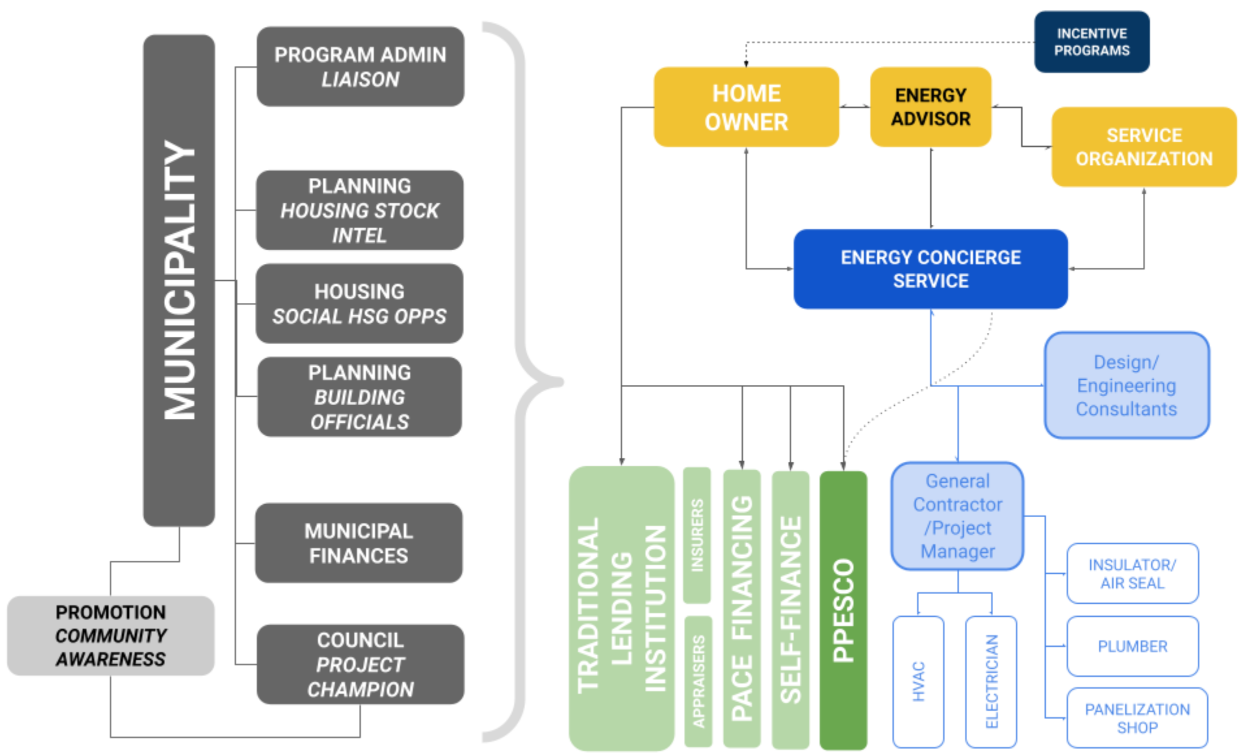


Figure 29: Relationship of the Energy Concierge Service to the Retrofit Process

2.5 Conclusion, Next Steps

Implementing this plan: A feasibility study has been developed for the four strategies outlined above. The feasibility study will determine the viability of measuring the existing housing stock and identifying standard retrofit packages with attendant rough cost estimates, find a way to pay for retrofits where targeted, produce specialized parts for the retrofits and train the people to build and install them, and help homeowners access and navigate the system to meet their retrofit needs. The project aims to develop a holistic and sustainable ecosystem for the municipalities of WREN to implement deep energy retrofits.

Specifically, the feasibility study:

- Gets deeper into the archetype retrofit packages, with construction details that allow for costing accuracy and applicability. Costs can be reduced through volume purchases, and efficiencies can be found through the panelization shop process.
- Explores issues of financing vis a vis all households and income levels, property values, energy poverty. What are the metrics used to value a DER (TCBO vs. ROI, for example)? What is the outcome of matching patient capital, social enterprise and TCBO for long-term savings associated with DERs? How can the PPESCo be accessible to all property owners who are interested?
- Defines the requirements (equipment, space, processes, staffing) of a panelization shop
- Explores the role and service provided by the Energy Concierge
- Integrates the need for awareness and attraction within the municipality of the whole DER program

APPENDICES

Appendix A : Comparison of Avoided Energy Costs

Table A.1: Comparison of Avoided Energy Costs for Generic Small 1 Storey House											
	2022	2023	2024	2025	Sum 2025	2030	2035	2040	2045	2050	TOTALS
As Is - Oil (FUEL SWITCH)	**$3,245**	**$3,277**	**$3,310**	**$3,343**	**$13,176**	**$17,552**	**$18,430**	**$19,352**	**$20,319**	**$21,335**	**$110,164**
DER 80 Energy Cost	$649	$655	$662	$669	$2,635	$3,510	$3,686	$3,870	$4,064	$4,267	$22,033
DER 80 Cost Savings	*$2,596*	*$2,622*	*$2,648*	*$2,675*	*$10,541*	*$14,042*	*$14,744*	*$15,481*	*$16,255*	*$17,068*	*$88,132*
DER 50 Energy Cost	$1,623	$1,639	$1,655	$1,672	$6,588	$8,776	$9,215	$9,676	$10,160	$10,668	$55,082
DER 50-Cost Savings	*$1,623*	*$1,639*	*$1,655*	*$1,672*	***$6,588***	*$8,776*	*$9,215*	*$9,676*	*$10,160*	*$10,668*	*$55,082*
ECM 20 Energy Cost	$2,596	$2,622	$2,648	$2,675	$10,541	$14,042	$14,744	$15,481	$16,255	$17,068	$88,132
DER 20 Cost Savings	*$649*	*$655*	*$662*	*$669*	*$2,635*	*$3,510*	*$3,686*	*$3,870*	*$4,064*	*$4,267*	*$22,033*
As Is - Electricity	**$3,543**	**$3,579**	**$3,615**	**$3,651**	**$14,388**	**$19,166**	**$20,125**	**$21,131**	**$22,187**	**$23,297**	**$120,294**
DER 80 Energy Cost	$709	$716	$723	$730	$2,878	$3,833	$4,025	$4,226	$4,437	$4,659	$24,059
DER 80 Cost Savings	*$2,835*	*$2,863*	*$2,892*	*$2,921*	*$11,510*	*$15,333*	*$16,100*	*$16,905*	*$17,750*	*$18,637*	*$96,235*
DER 50 Energy Cost	$1,772	$1,789	$1,807	$1,825	$7,194	$9,583	$10,062	$10,565	$11,094	$11,648	$60,147
DER 50-Cost Savings	*$1,772*	*$1,789*	*$1,807*	*$1,825*	*$7,194*	*$9,583*	*$10,062*	*$10,565*	*$11,094*	*$11,648*	*$60,147*
ECM 20 Energy Cost	$2,835	$2,863	$2,892	$2,921	$11,510	$15,333	$16,100	$16,905	$17,750	$18,637	$96,235
DER 20 Cost Savings	*$709*	*$716*	*$723*	*$730*	*$2,878*	*$3,833*	*$4,025*	*$4,226*	*$4,437*	*$4,659*	*$24,059*

Table A.2: Comparison of Avoided Energy Costs for Generic Medium 1 Storey House											
	2022	2023	2024	2025	Sum 2025	2030	2035	2040	2045	2050	TOTALS
As Is - Oil (FUEL SWITCH)	**$3,773**	**$3,811**	**$3,849**	**$3,887**	**$15,320**	**$20,408**	**$21,429**	**$22,500**	**$23,625**	**$24,807**	**$128,090**
DER 80 Energy Cost	$755	$762	$770	$777	$3,064	$4,082	$4,286	$4,500	$4,725	$4,961	$25,618
DER 80 Cost Savings	*$3,018*	*$3,049*	*$3,079*	*$3,110*	*$12,256*	*$16,327*	*$17,143*	*$18,000*	*$18,900*	*$19,845*	*$102,472*
DER 50 Energy Cost	$1,887	$1,905	$1,924	$1,944	$7,660	$10,204	$10,714	$11,250	$11,813	$12,403	$64,045
DER 50-Cost Savings	*$1,887*	*$1,905*	*$1,924*	*$1,944*	***$7,660***	*$10,204*	*$10,714*	*$11,250*	*$11,813*	*$12,403*	*$64,045*
ECM 20 Energy Cost	$3,018	$3,049	$3,079	$3,110	$12,256	$16,327	$17,143	$18,000	$18,900	$19,845	$102,472
DER 20 Cost Savings	*$755*	*$762*	*$770*	*$777*	*$3,064*	*$4,082*	*$4,286*	*$4,500*	*$4,725*	*$4,961*	*$25,618*
As Is - Electricity	**$4,206**	**$4,248**	**$4,291**	**$4,334**	***$17,078***	**$22,751**	**$23,889**	**$25,083**	**$26,337**	**$27,654**	**$142,793**
DER 80 Energy Cost	$841	$850	$858	$867	$3,416	$4,550	$4,778	$5,017	$5,267	$5,531	$28,559
DER 80 Cost Savings	*$3,365*	*$3,399*	*$3,433*	*$3,467*	*$13,663*	*$18,201*	*$19,111*	*$20,067*	*$21,070*	*$22,123*	*$114,234*
DER 50-Cost Savings	*$2,103*	*$2,124*	*$2,145*	*$2,167*	*$8,539*	*$11,376*	*$11,944*	*$12,542*	*$13,169*	*$13,827*	*$71,396*
DER 50 Energy Cost	$2,103	$2,124	$2,145	$2,167	$8,539	$11,376	$11,944	$12,542	$13,169	$13,827	$71,396
ECM 20 Energy Cost	$3,365	$3,399	$3,433	$3,467	$13,663	$18,201	$19,111	$20,067	$21,070	$22,123	$114,234
DER 20 Cost Savings	*$841*	*$850*	*$858*	*$867*	*$3,416*	*$4,550*	*$4,778*	*$5,017*	*$5,267*	*$5,531*	*$28,559*

Appendix B : PPESCo Supporting Documents

Paper:

Looks Like Finance, but It's All About Solutions: The Public-Purpose ESCO Enterprise Model

Elizabeth Chant, Peter Adamczyk, David Barash, Beth Sachs Vermont Energy Investment Corporation

2014 ACEEE Summer Study on Energy Efficiency in Buildings

Presentation:

Public Purpose ESCO for Multifamily Affordable Housing

Elizabeth Chant, Principal Consultant, VEIC

ACEEE Finance, May 12, 2014

Looks Like Finance, but It's All About Solutions: The Public-Purpose ESCO Enterprise Model

Elizabeth Chant, Peter Adamczyk, David Barash, Beth Sachs
Vermont Energy Investment Corporation

ABSTRACT

The public-purpose energy services company (PPESCO) is grounded in neither a government mandate nor a public subsidy model. Instead, it is built on a sustainable earned revenue model with a mission to achieve deep energy savings in buildings that serve public purposes while providing returns to private investors.

Multiple barriers to comprehensive energy improvements have left large and important segments of our nation's building stock unserved, including smaller buildings serving public purposes such as affordable housing, education, health care, and municipal and community functions. PPESCO's comprehensive services—technical assistance, financing, installation oversight, and energy performance contracting—result in building owners achieving cash-flow positive results. The client relationship requires transparency about services and costs, and enables energy savings of 30% or more, savings that can go toward the building owner's public-serving mission.

PPESCO offers an innovative and practical way for building owners to address barriers related to access to capital, technical staff capacity, and trust in service providers. More important, it is a model designed to go to full-scale commercialization. This paper provides the blueprint of the PPESCO business model that will: (1) attract investors who wish to reduce carbon emissions, support local economies, and invest in mission-related organizations; (2) appeal to owners of buildings that serve public purposes; and (3) be sustainable as a business. Creating entrepreneurial PPESCOs nationwide will preserve and fortify public buildings, provide substantial reductions in greenhouse gas emissions, and strengthen local communities.

Background

Two very different business models that have matured over very different tracks in the last three decades have combined in the past year to yield a new business model that has key relevance for the building retrofit market. That new model, the public-purpose energy services company, is the marriage between the energy services company (ESCO) model and the social enterprise model.

Traditional ESCOs provide comprehensive energy services and annually bring billions of dollars of private-sector capital to energy efficiency projects in the United States. ESCOs provide the full complement of energy services, including technical analysis, project management, construction services, and access to financing, with a performance guarantee that offers surety to both the client and the capital source that the energy savings will be sufficient to repay the capital used to finance the project. The client acquires a project that has guaranteed savings, no upfront cost, and few headaches.

The ESCO model operates in a narrow part of the market. The vast majority of ESCO work is in the federal sector and the municipal, university, state, and hospital (MUSH) markets.

Energy improvement projects generally are at a scale of $1 million or more, and they involve energy conservation measures for which baselines are relatively easy to establish, and the project results relatively easy to measure, monitor, and verify.

The ESCO implementation model leaves too many markets underserved and too many buildings unserved, at a time when the imperatives of climate disruption and energy price volatility drive the need for deep energy reductions in buildings.

Overlaying the social enterprise model—using commercial strategies to achieve economic, social, and environmental objectives—onto the ESCO model is the first step in establishing this new model and putting it to work. The roots of the social enterprise model are in the alleviation of poverty through the commercial vending of appropriate technology and process. A good example of this is the manufacture and sale of pumping equipment to increase yields and incomes for subsistence farmers. Recently, entrepreneurs have begun to use the model to achieve goals in environmental sustainability. In fact, it is not unusual for social enterprises today to judge their success to the triple bottom lines of profit, people, and planet.

PPESCO has been designed to be such an enterprise, with a triple bottom line of (1) economic profit to the PPESCO; (2) public benefit through increased efficiencies resulting from the project; and (3) environmental benefits of reduced carbon emissions. Three private funders have supported the development of this model: the High Meadows Fund, the Kresge Foundation, and the MacArthur Foundation.

Meeting Challenges with PPESCO

PPESCO reaches buildings not served by traditional ESCOs. It is an innovative and practical business model made possible by, and explicitly intended to solve, existing market failures, including the principal-agent problem and information asymmetry. With one PPESCO already established and as more come onto the market, PPESCOs will make possible comprehensive energy improvements in a subset of buildings that are of great value to our communities and society. If buildings serving public purposes have lower operating costs because they are more energy efficient, their owners can re-allocate funds normally spent on paying energy bills to those agencies' missions. The missions might be education, public safety, shelter, or any other critically important elements to a well-functioning society. And because PPESCOs will make it possible for project debt to be paid from energy savings, efficiency projects can be structured so that the building owners are saving actual dollars (making their bottom lines cash flow positive) as soon as the energy improvements are completed, as shown in Figure 1.

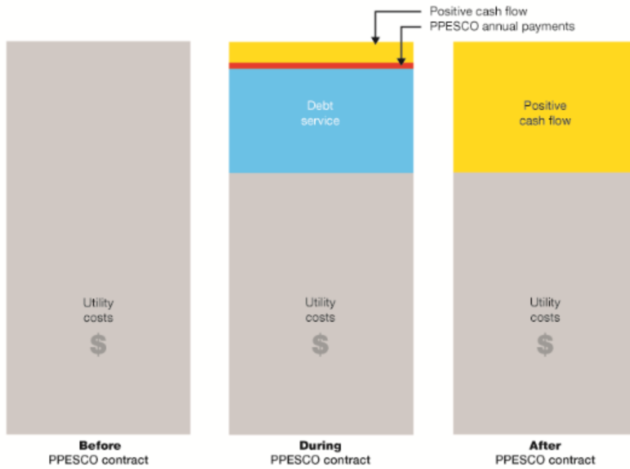


Figure 1. How a PPESCO provides positive cash flow for the client.

The PPESCO model is for owners of public-purpose buildings in the affordable housing, education, health care, and municipal government markets. Working with owners, PPESCO makes major energy improvements to buildings—at very low financial risk, and with no up-front cost. When energy use is reduced, building owners save money that can then be used to fund more of the owners' public- purpose missions. PPESCO customizes technical assistance and financing for each project, and achieves net savings for the owner from the start.

PPESCO investors who provide capital for these projects receive a reasonable, though not maximized, return on investment.

There are two foundational elements of the business proposition—one for investors and one for clients; each has its own essential features:

- Investors can achieve reasonable return at reasonable risk and provide social benefit through:
  - The aggregation of projects into portfolios to reduce investor risk, by combining multiple capital sources investing in multiple projects
  - Smart partnerships with non-traditional capital sources, such as program- or mission-related investment from foundations
  - Solid technical experience and organizational credibility
- Clients gain access to technical expertise and financing from a trusted source through:
  - A PPESCO that meets clients where they start—technologically, economically, and managerially
  - The necessity of transparency and a practice of open books
  - The risks of a project's ability to meet its energy savings goals, and the size of those risks
  - The effect of taking advantage of all available supplemental resources

These elements over time will create a record of performance, first by one PPESCO, but then later, through a network of PPESCOs. Once the record of performance is in place, PPESCOs will be able to attract more traditional capital, close the gap between perceived risk and measured risk, and in turn catalyze more PPESCO activity.

A PPESCO can be established as a social enterprise with an earned-income business structure. That enterprise would have a mission of helping owners of public-purpose buildings reduce energy consumption, save on energy costs, reduce their vulnerability to energy price volatility, improve the performance of buildings that serve the public, and reduce pressures on often-declining operating budgets.

Barriers to Building Energy Improvements in Public-Purpose Buildings

As discussed above, the PPESCO concept was designed to address market failures that present barriers to public-purpose building owners. Many of these barriers are well known:

- Building owners often lack access to valid and reliable information from service providers that have no stake in a specific technology or equipment brand.
- The project costs are up-front and prohibitive, and the owner might not have access to traditional credit.
- The owners lack the organizational capacity and / or capability to tackle energy improvement projects.
- Split incentives often exist—the phenomenon of neither owner nor occupant having an interest in improving a building, because:
    - Building owners do not reap the benefits of reduced energy costs from an investment in building improvements if occupants pay the utility bills, and
    - Tenant occupants who are uncertain if they will be in the building for the entire payback period tend not to invest in improvements because they perceive their planned occupancy to be sufficiently short that they will not fully benefit from their investment in such improvements.
- Laws and regulations unique to the funding sources of the public-purpose building can present obstacles to specific energy improvements or to types of financing to make such improvements.

The barriers to making significant energy improvements to buildings in the underserved markets identified in the public-purpose sector involve all of the above. Some of these affect one subsector more than another: split incentives are often a barrier in multifamily affordable housing, but rarely a barrier for a library or fire station, for example. Because these barriers exist, no one to date has taken action in a coordinated, systemic manner to serve these markets.

Addressing Barriers: Traditional ESCO and PPESCO

ESCOs reduce or eliminate some barriers, but the necessary returns on capital often constrain an ESCO's ability to deliver deep energy savings. As shown in Figure 2, an ESCO will stop at the maximum ROI or at the point at which its ROI needs are met. PPESCO can deliver more investment in the building systems and produce deeper savings (including both the grey and yellow areas) because it only requires a sustainable investment return, not a profit-maximizing one.

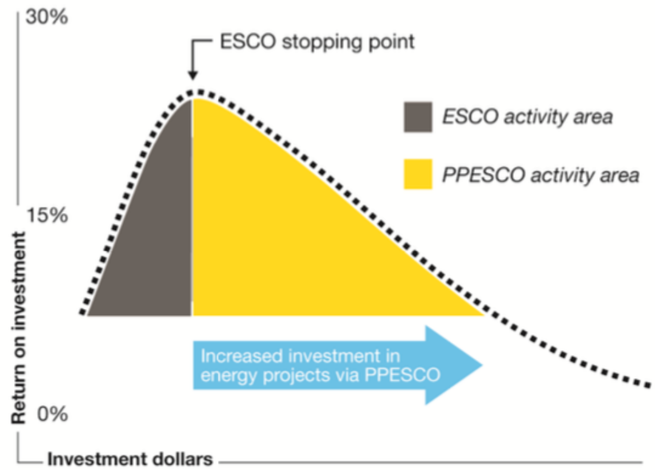


Figure 2. How return on investment drives ESCOs and the PPESCO.

ESCOs can achieve significant energy savings in large buildings, but they generally do it without providing truly comprehensive energy services. They install and control equipment, lighting, and appliances, but they do not typically airseal and insulate the building. All of these measures are important energy improvements that significantly increase building performance.

The reason is simple: Compared to typical ESCO measures, it is more difficult to estimate costs and savings on building shell measures prior to initiating a project, and difficult to meter and control them after they are installed. The ESCO business model thus overlooks two of the most proven and reliable energy-saving measures in most buildings. In addition, airsealing and insulation are time consuming and labor intensive, and thus contribute to smaller ESCO profits.

Sometimes these improvements are not a part of the ESCO project, because they do not involve products or services from affiliated or preferred suppliers and vendors. Many ESCOs are owned by or affiliated with organizations that sell energy or specific products; thus, improvements are often limited to specific energy sources or products. A PPESCO has no such limitations.

Integrated Services, Driven by Mission

Although often seen as a financing model, the ESCO model, and its PPESCO counterpart, provide owners with much more than access to project financing. Both ESCOs and PPESCOs share the integration of four services to clients: (1) technical assistance, (2) construction / installation, (3) financing, and (4) energy performance guarantee. A PPESCO's emphasis on mission mandates that it go beyond those four services. It provides additional value to clients by adhering to its core practices and outcomes:

- Deep, cost-effective energy improvements that comprehensively address the whole building
- Cash-flow-positive results for the client, with an objective of providing immediate savings
- Access to and / or coordination with long-term capital that allows projects to achieve deeper energy savings
- Transparent pricing on products and services presented by a trusted partner
- Bias-free recommendations on energy sources and technologies
- Contracting for installations, including airsealing and insulation, that do not lend themselves to individual controls for measurement and verification
- Ability to coordinate PPESCO services so that the services can be integrated into a larger rehabilitation or new construction project
- Continued engagement with building owners and managers, after the installation project is complete, both to sustain energy savings and to find additional savings as new, appropriate technologies and services come onto the market
- Ongoing work with building staff to increase internal capabilities about energy use and performance

A PPESCO treats the costs of technical services in project development and construction management as development costs that can be financed as part of construction costs. The client pays for ongoing technical services via an annual fee. As shown in Figure 1, the combination of post-retrofit utility costs plus financing, plus ongoing annual costs, are designed to be less than the pre-retrofit utility costs, and therefore provide the owner with a cash-flow-positive result.

Serving Public-Purpose Markets

Defining itself as serving public-purpose organizations has clearly ruled out some market sectors that could potentially benefit from ESCO-like services. In particular, small commercial and industrial facilities are not part of the intended client base for PPESCO. The second line of the triple bottom line for a PPESCO—providing social good—drives its dedication to public-purpose facilities. If resources can be unlocked from sectors that are charged with providing the services that the public needs, then those organizations can provide additional social good. Indeed, many of these sectors have affinity sources of capital for precisely this reason. The sectors on which the PPESCO will target services are affordable housing, education, health care, and municipal services. These are not the only sectors in which a PPESCO could offer services to underserved markets, but they are the sectors that hold the greatest promise for a successful launch of the concept. Throughout its development, the PPESCO is designed to adjust the targets on both clients and services, depending on market and business conditions.

The Benefits of a Portfolio Approach

The portfolio concept, shown in Figure 3, is essential to the PPESCO business model. It mitigates the naturally occurring risk associated with the PPESCO's choice of unserved, smaller projects with longer payback characteristics. One significant feature of a PPESCO project that mitigates this risk is the higher likelihood of operational stability at public-purpose buildings, which tend to have long-term ownership or control. This translates to lower risk of default.

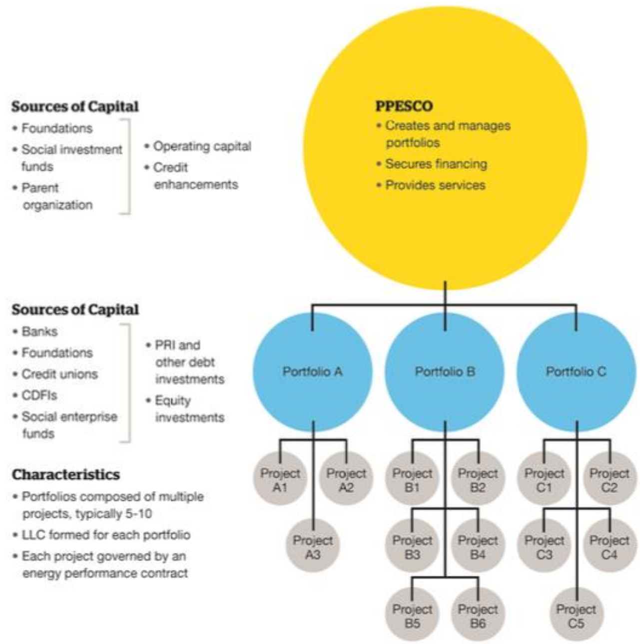


Figure 3. The PPESCO portfolio model.

Attention to portfolio composition makes marketing, partner development, and financing easier. Diversifying the portfolio reduces risks associated with:

- Uniformity. Whether in relation to geography or sector, portfolio diversification helps lessen the impact, should a particular region or market segment experience an economic downturn.
- Economics. The PPESCO will seek to mix small projects with large ones to create a risk-balanced viable portfolio. Combining multiple investment types within a portfolio is a standard risk mitigation investment strategy in other markets, and there is no reason that this approach will not work with a PPESCO. Further, this approach enables the launch of smaller projects (a significant segment of the underserved market) with thinner client economics when those projects are mixed with the strength of larger, more economically resilient projects.

Some likely capital providers for PPESCOs have unique sector, geography, or other defining attributes and therefore need to be matched with a portfolio that represents those target elements. Some lenders specialize in health facilities, and some foundations exclusively support affordable housing. (For example, some Community Development Financial Institutions [CDFIs] target investments to affordable housing or charter schools.) Others might have broad carbon reduction interests that extend across all sectors and types.

PPESCO can attract capital providers by segmenting client projects into like-minded, equivalent-risk-profiled asset portfolios. This portfolio segmentation offers a relatively easily pooled investment vehicle for different types of investors. The PPESCO may create separate corporate structures for particular portfolios, mitigating risk to the capital providers and to the PPESCO itself. Separate subsidiaries offer a rigor and discipline that help match contract and financing terms, expectations for return on investment, and risk mitigation strategies, such as the presence of credit enhancement assigned to a portfolio.

This access-to-financing service of the PPESCO will likely require partnerships with one or more financial intermediaries capable of aggregating asset portfolios and / or aggregating capital sources. To the extent that capital sources are aggregated into a fund or funds, a financial partner will underwrite, originate, and service the loans.

Organizational Structure that Balances Mission and Profit

A PPESCO must be structured to allow it to appropriately balance mission with profits, while maintaining its ability to operate in a way that assures self-sufficiency. As it matures and as operations normalize past the start-up stage, portfolio revenue is expected to exceed overhead and growth reserve needs. In this instance, a PPESCO can elect to reduce its mark-up to allow more project capital to go to direct project costs.

Nonprofit and for-profit businesses each can direct any excess of revenues over expenses into growth, including growth that might not generate the same profit level. For-profit businesses generate a financial return to their investors. A PPESCO's objective is to enable as much available financing capital as possible to go to projects—with reasonable, but not maximized, profits as the organizational goal. This means that certain legal structures are ill-suited to the PPESCO model—specifically, those that are complex and / or whose obligations to investors dictate that the business prioritize profits over mission.

Just as it can be problematic for a standard corporate entity to balance mission with profit, it can be challenging for a nonprofit to balance profit with mission—or to create the optimal balance between the two. Because the PPESCO needs to be commercially viable, a nonprofit structure might not be ideal.

Because program- or mission-related investment (PRI / MRI) from foundations is a sound and likely source for early project financing, the legal structure for a PPESCO should be compatible with their requirements.

Furthermore, a nonprofit structure could inhibit a PPESCO's ability to use equity investments from social-enterprise or other private-sector sources, be those investments at the project, portfolio, and / or entity level. In certain cases, a for-profit structure can also allow the PPESCO, on behalf of its projects, to take advantage of investment tax credits that would not be available to a nonprofit.

One additional advantage of a for-profit entity is that it can significantly enhance the ability for PPESCO work to transform the market of existing service providers. A for-profit entity that appeals to small-business people and entrepreneurs who seek a profit, albeit a modest one, offers an easily replicable model. This model, once established, makes it possible for other PPESCOs to be created and move through the market quickly.

Necessary Experience

A PPESCO needs a strong track record, which, of course, does not exist at start-up. Therefore, a new PPESCO needs a parent or partner organization that has these attributes to launch it, with a staff and trusted contractors who bring deep experience in accurately predicting and measuring energy savings from installed improvements in buildings. Because financing for a project is typically based on projected savings, the savings estimates need to be as accurate as possible.

A PPESCO also needs deep roots in the communities in which it plans to work. Although the network of technical expertise should be grounded in local conditions, the use of portfolios and national pools of capital can provide geographic diversity as a way to mitigate risks. A new PPESCO also needs collaborative relationships with partners and networks that can bring projects (and in some cases, capital) to the PPESCO. Potential PPESCO clients need and value these relationships and possible sources of capital. One of the first qualifying questions will be the "but-for" test: Were it not for the PPESCO, would this work get done? These roots, partners, and market or sector networks will provide the access to decision makers to help move projects forward. Growing through networks is a core strategy of the PPESCO business model.

These requirements lead to the conclusion that in most cases, a PPESCO will be launched as a subsidiary of an existing organization that has experience and credibility in specific markets. A PPESCO might also be launched as a joint venture, bringing together the talent and market connections of more than one organization.

"Mind the Gap" – Perceived versus Actual Risk of Energy Performance

Energy professionals understand well the risks of the underlying energy conservation measures that a PPESCO will complete. The financial markets will have less understanding of such risks. However, these risks can be calculated and planned for. The risk of not meeting energy savings goals is cited most often, but industry professionals with many years of experience and substantial project knowledge characterize this risk as minimal and manageable.

The risk is not binary: It is not that the savings will result or they won't, but that the installations might under-perform. These are usually easily observable and can be readily fixed. The PPESCO's technical expertise and its monitoring after the installation lower the risk for under-performance. Essentially, under-performance is the degree to which realized savings vary on the low side from prediction.

Until financing is more readily available through standard commercial mechanisms (which will happen when energy savings are seen as a source of sound and financially secure debt repayment), non-traditional capital sources need to be identified, nurtured, and deployed. A primary source at the start is the philanthropic community. Mission-aligned investments that qualify as PRI are one such source for the parent organization that starts a PPESCO, and can lead to a wider range of social-enterprise capital. Such capital, drawn at both the local and national levels, can be matched with projects through portfolios that encompass specific geographic interests, sector interests, or both.

There are many reasons that patient, non-traditional financing is needed in the short term to achieve the long-term goal of wide capital access through traditional commercial lending channels. The case will need to be made that energy savings are a logical, safe, and predictable source of repayment.

A strong body of experience is necessary to make this case. The existence of multiple, successful PPESCOs, with accumulated experience and data, will inspire confidence in the lending community. When this happens, access to traditional commercial financing is more likely to occur. This in turn will enable expansion of the PPESCO model, significantly accelerating the opportunities to reduce energy use in public-purpose buildings across the United States. The long-term goal is to create access to standard commercial sources for long-term financing. This is many years off, but it is what the PPESCO vision leads to.

Conclusion: Transforming Markets Through a Triple Bottom Line

Good business models can transform markets. In the decades since the ESCO model entered the energy marketplace, many of the largest energy users have been able to lower their costs because of it. Although the model works for them, it has left a large part of the building sector underserved. As utility costs continue to rise, the needs of that wider range of clients have become more pronounced. Serving this wider market is both an opportunity and an imperative.

The existing energy services industry cannot easily apply its model to this wider range of clients, particularly not to those considered hard to reach and outside the basic business model. With a new model in place, however, redesigned to be attractive to the underserved markets, while providing benefits to society at large, the next generation of services to fill those needs is now ready to enter the marketplace.

The idea of using future energy savings to finance energy improvements—and putting that idea to work in the underserved building market—has been percolating for many years. PPESCO takes this idea further by specifying that the highest and best use of this proven concept is to apply it in sectors that explicitly exist to serve public interests. It does so by using another proven model, the social enterprise, which allows for the prioritization of energy savings and public benefit over financial return, installing measures that achieve more savings than an average energy improvement project, and finding and using non-traditional capital to finance projects. The PPESCO model emphasizes the best client solutions, regardless of technology or energy source. It operates transparently to engage the client as an active stakeholder in selecting the best choices for the client organization, the purpose of the building, and the building itself.

A PPESCO seeks a balance of mission and profit. The PPESCO mission is critical to enabling significant greenhouse gas emission reductions in important, underserved sectors. Providing services to public-purpose clients also creates significant positive cash flow for public-serving institutions.

Long-term financial sustainability is essential to successfully operating a PPESCO. Even though it has evolved from the ESCO model, the PPESCO is less a modification of an ESCO, and more an innovative twist on the savings-as-debt-service concept.

This model could bring significant benefits to organizations that are not able to access the expertise and financing they need to make their buildings more efficient. Potential PPESCO clients also would see lower operating costs and would reduce their environmental impacts by completing customized, comprehensive energy improvement projects in their buildings.

More important, this model can be widely scaled across many organizations, bringing new talent and capital to the task of deep energy savings in buildings. Multiple PPESCOs across the country, networked together, can catalyze energy and water savings in sectors that need both the cost savings and price stability. Finally, the deep carbon reductions that result will help in the urgent fight to move to a sustainable planetary carbon level.

Public Purpose ESCO for Multifamily Affordable Housing

Elizabeth Chant
Principal Consultant, VEIC

ACEEE Finance

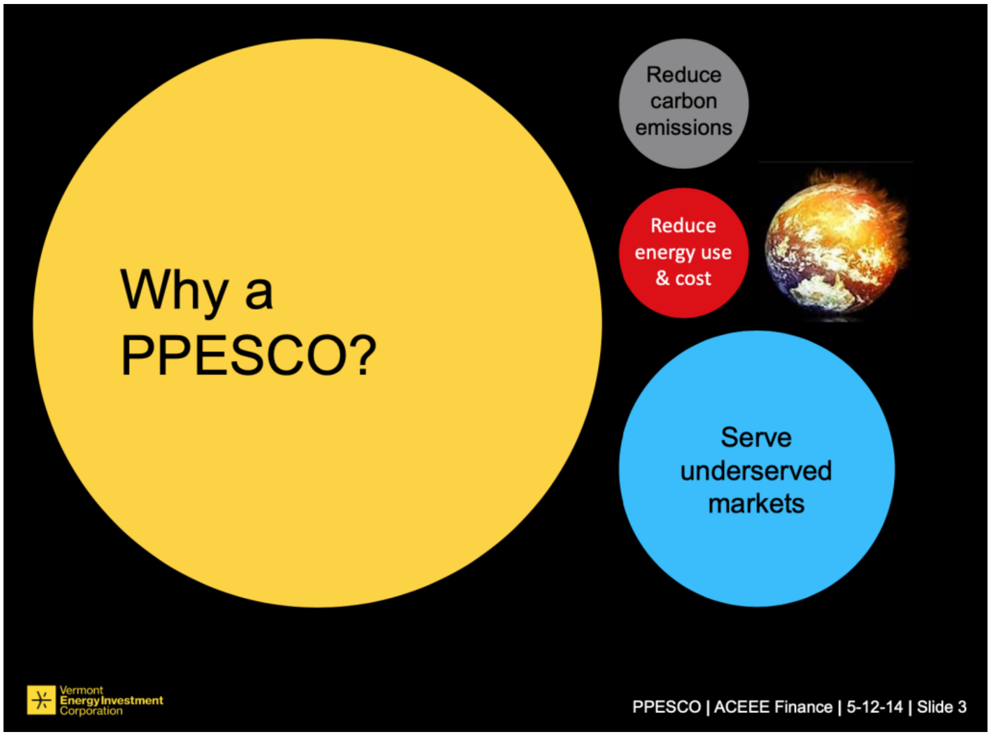
May 12, 2014

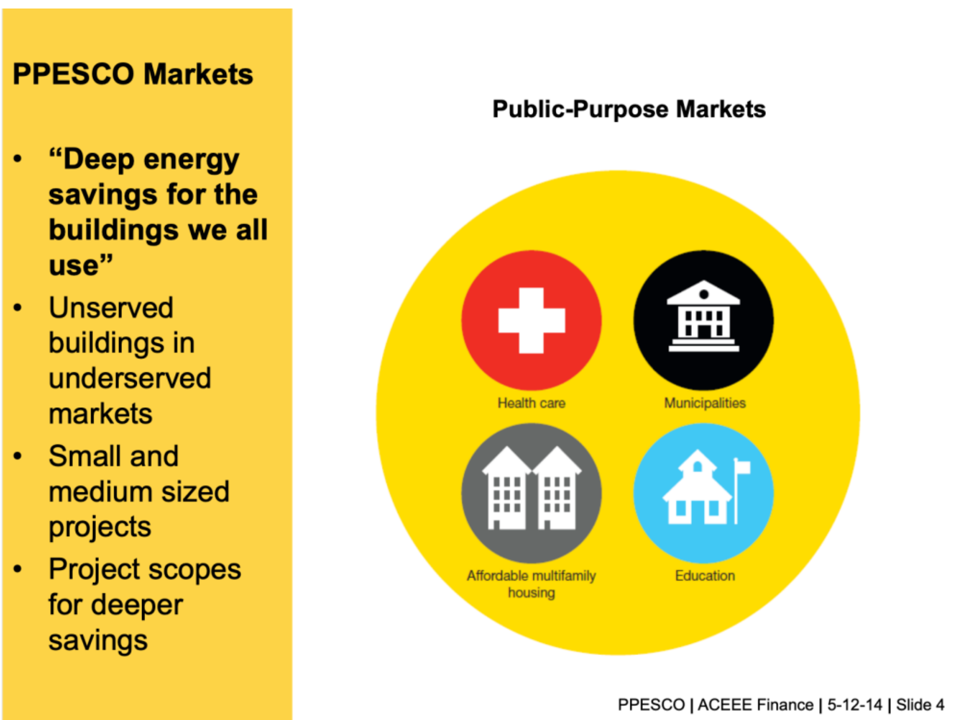
Vermont Energy Investment Corporation

Introduction to VEIC

- Nonprofit founded in 1986
- Mission: "to reduce the economic and environmental costs of energy use"
- Energy efficiency, renewable energy, and transportation
- Consulting and implementation
- 3 energy efficiency utilities

Efficiency Vermont
EFFICIENCY$MART
DC SUSTAINABLE ENERGY UTILITY


Why a PPESCO?
Reduce carbon emissions
Reduce energy use & cost
Serve underserved markets
Vermont Energy Investment Corporation
PPESCO | ACEEE Finance | 5-12-14 | Slide 3


PPESCO Markets
• "Deep energy savings for the buildings we all use"
• Unserved buildings in underserved markets
• Small and medium sized projects
• Project scopes for deeper savings
Public-Purpose Markets
Health care
Municipalities
Affordable multifamily housing
Education
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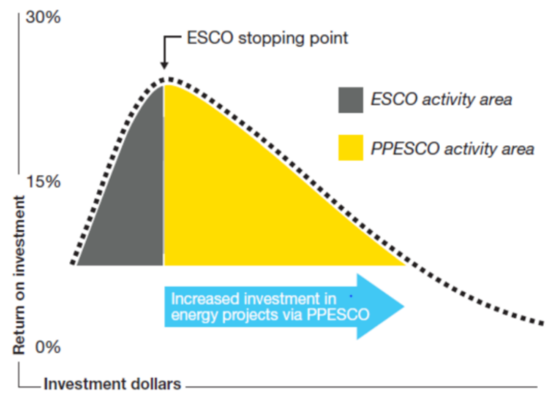
PPESCO Returns

- Go deeper than the traditional ESCO model
- Need for sustainable return
- Increase investment in building via lower ROI needs of PPESCO
- "No false economies"

Different ROI Needs → Different Investment Decisions



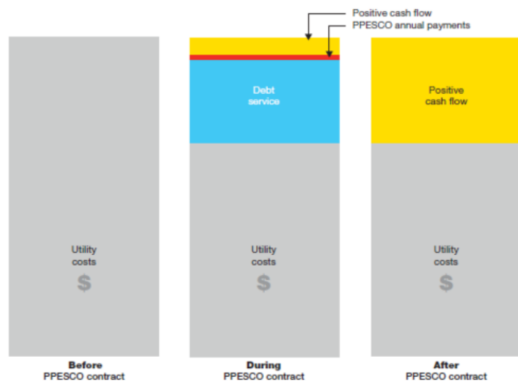
Early "PPESCO" Work

- VEIC as nonprofit ESCO
- Provided ESCO services to mission-aligned organizations
  - PHAs
  - Municipality
- Five projects
  - Fuel switch
  - Central woodchip heating plant
  - Cogen system
  - Airsealing & insulation
  - Lighting, etc.
- All projects successful
- Final one closed 2 years ago

PPESCO Model

- Energy improvements financed by energy savings
- Long-term patient capital from mission-aligned sources
- Terms out to 15 years
- Rates lower than commercially available
- Positive cash-flow goal

Positive Cash Flow for Client



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PPESCO Projects

- Four market sectors – all underserved
  - Education
  - Health care
  - Municipal & community
  - Multifamily housing
- Energy projects ranging from $100,000 to $800,000
- Project types
  - “Energy only”
  - New construction / rehabilitiation
- Competition – the “but-for” test

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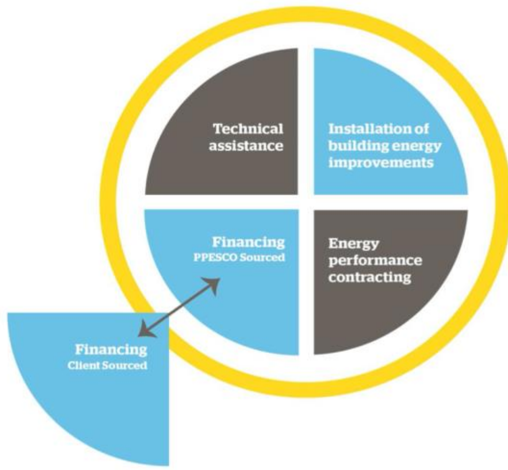
PPESCO Services

- Comprehensive energy services
- Technical assistance from walk-through to M&V and beyond
- Construction services
- Financing from PPESCO or client
- Energy savings guaranteed

PPESCO's Integrated Services Model



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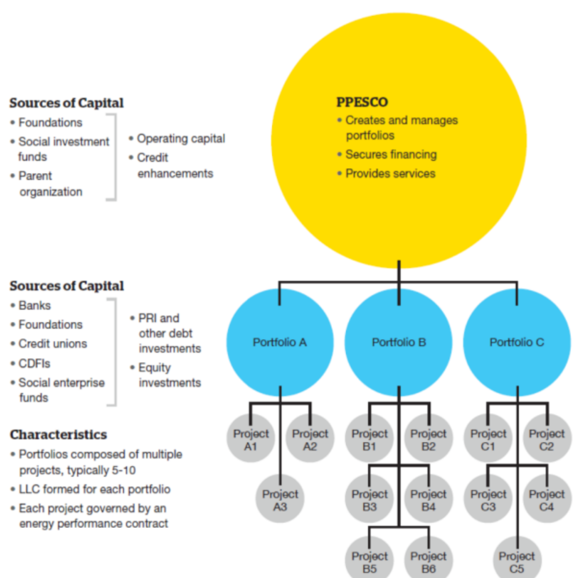
PPESCO Portfolios

- Projects bundled into portfolios
- Affinity-aligned capital
- Multiple investors in each portfolio
- Each portfolio an LLC

Relationship of Projects to Portfolios



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PPESCO Multifamily Projects

- 3% of ESCO activity is in multifamily sector
- Only 9% of PHA units with EPCs were in PHAs < 500 units
- What barriers can PPESCO solve?
  - Need for technical capability
  - Need for technical and project management capacity
  - Capital access
  - Uncertainty about savings
- What barriers are not solved?
  - Split incentive
  - Backlog of capital improvements

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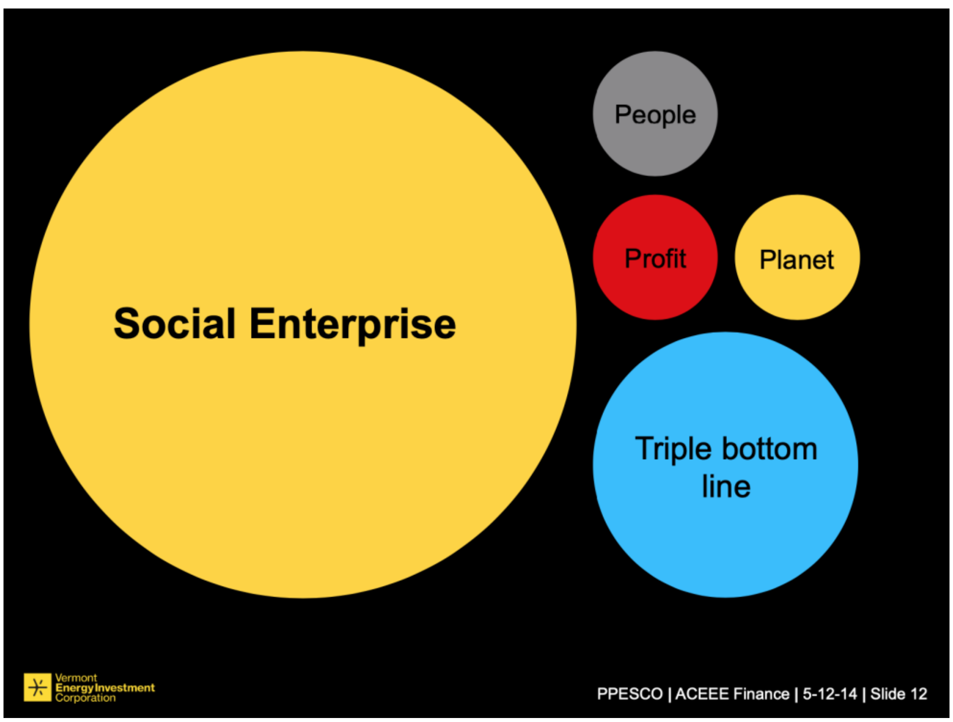

PPESCO in the Market

- PPESCO as the generic form
- Create a wholly owned subsidiary of VEIC
- Use L3C legal structure
- New brand

Commons Energy

Energy Savings for Public-Purpose Buildings

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PPESCO Transforming Markets

- In the long-term, multiple PPESCOs
  - Roots in local markets
- Central guidance and resources
  - Quality control
  - Data
  - Financing
- "Mind the gap" – the difference between perceived and actual risk
- Aggregate large pool of friendly patient capital

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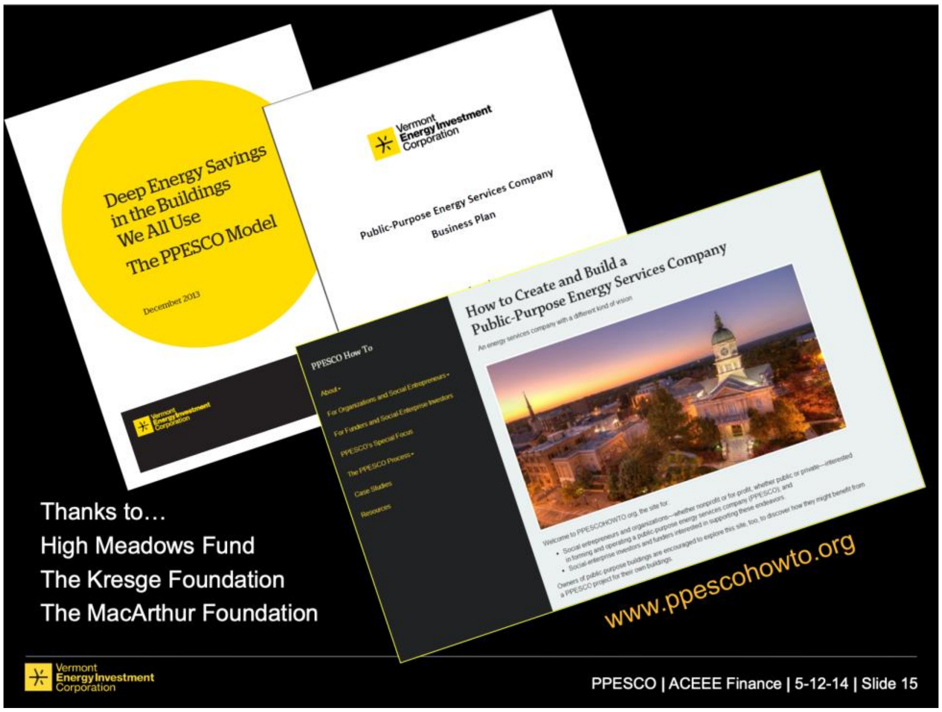
Deep Energy Savings in the Buildings We All Use
The PPESCO Model
December 2013
Vermont Energy Investment Corporation
Public-Purpose Energy Services Company
Business Plan
How to Create and Build a Public-Purpose Energy Services Company
PPESCO How To
Thanks to…
High Meadows Fund
The Kresge Foundation
The MacArthur Foundation
www.ppescohowto.org
Vermont Energy Investment Corporation
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Thanks!
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mailto:echant@veic.org
Vermont Energy Investment Corporation

Appendix C : Incentives & Grants (June 2021)

Table C.1: Efficiency NS Incentives for Existing Houses		
NS Incentive combinations are capped at $5,000		
Thermal Envelope		
Draft Proofing	$200	max
Basement Header Insulation	$150	max
Basement Slab Insulation	$200	max
Ceiling Insulation	$750	max
Exposed Floor Insulation	$200	max
Exterior Wall Insulation	$1,500	max
Basement Insulation	$1,200	max
Windows/Doors	$30	per rough opening
Mechanicals		
Domestic Hot Water Heat Pump	$400	in-store rebate
Drain Water Heat Recovery	$100	
Ductless mini split	$200-$300	ton
Central ducted	$400-$500	ton
Air to Water HP	$400-$500	ton

Table C.2: Greener Homes (Canada) Grant for Existing Houses		
Greener Homes Grant combinations are capped at $5,000 PLUS $600 for Pre/Post Retrofit ERS		
Thermal Envelope		
Attic insulation	$1,800	max
Above ground walls	$3,800	max
Exposed floor	$350	max
Foundation walls and headers	$1,500	max
Air sealing	$550-$1000	based on delta BDT
Windows and doors	$125-$250	per rough opening
Mechanicals		
Ground Source Heat Pump	$5,000	Install new
	$3,000	Replacement
Air source heat pump	$2500-$5000	Install new/Replace
Domestic Hot Water Heat Pump	$1,000	install
Solar panels	$1,000	per kW
Resiliency measures		
Batteries connected to solar	$1,000	
Roofing membrane	$150	
Foundation waterproofing	$875	
Moisture proofing crawl space	$600	