BFREEHOMES

Deep Energy Retrofits & EnergieSprong in Canada

5 November 2019

Presented to: Ecology Action Centre

Presented By: Shawna Henderson, Bfreehomes Design Ltd.

Bfreehomes: Experience

- Individual clients, Deep Energy Retrofits & New NZE construction
- Clean NZ Upgrades, Bridgewater
- CHBA Working Group on NZE Renovations
- CANMET/NRCAN Working Group on Pre- Engineered Exterior Panels
- Industry Working Group on Deep Energy Retrofits/Net Zero Energy Retrofits

Approaching Net Zero in Existing Houses: CMHC 2006-2008

- 12 house types
- 6 cities
- Vintage: 1922 – 2000
- How does climate affect NZEEH?
  - Vancouver Bungalow: low EE costs and smaller RE option
  - Halifax: best case for GHG reductions

Why Deep Energy Retrofits

- Incremental Renovations – business as usual
  - Energy Efficiency Program Targets: 20 to 30% reduction
    - Low hanging fruit
    - ***Lock in emissions***
- Deep Energy Retrofits
  - 50 to 90% in space conditioning and water heating
    - Phased options
    - Roadmapped/planned

Why focus on DERs?

- ± 110,000 new houses in Canada/yr
- 14.5 million existing houses
- 50% of NS housing stock pre-1970
- Improve EE
- Increase density
- Decrease carbon footprint

What's in a name?

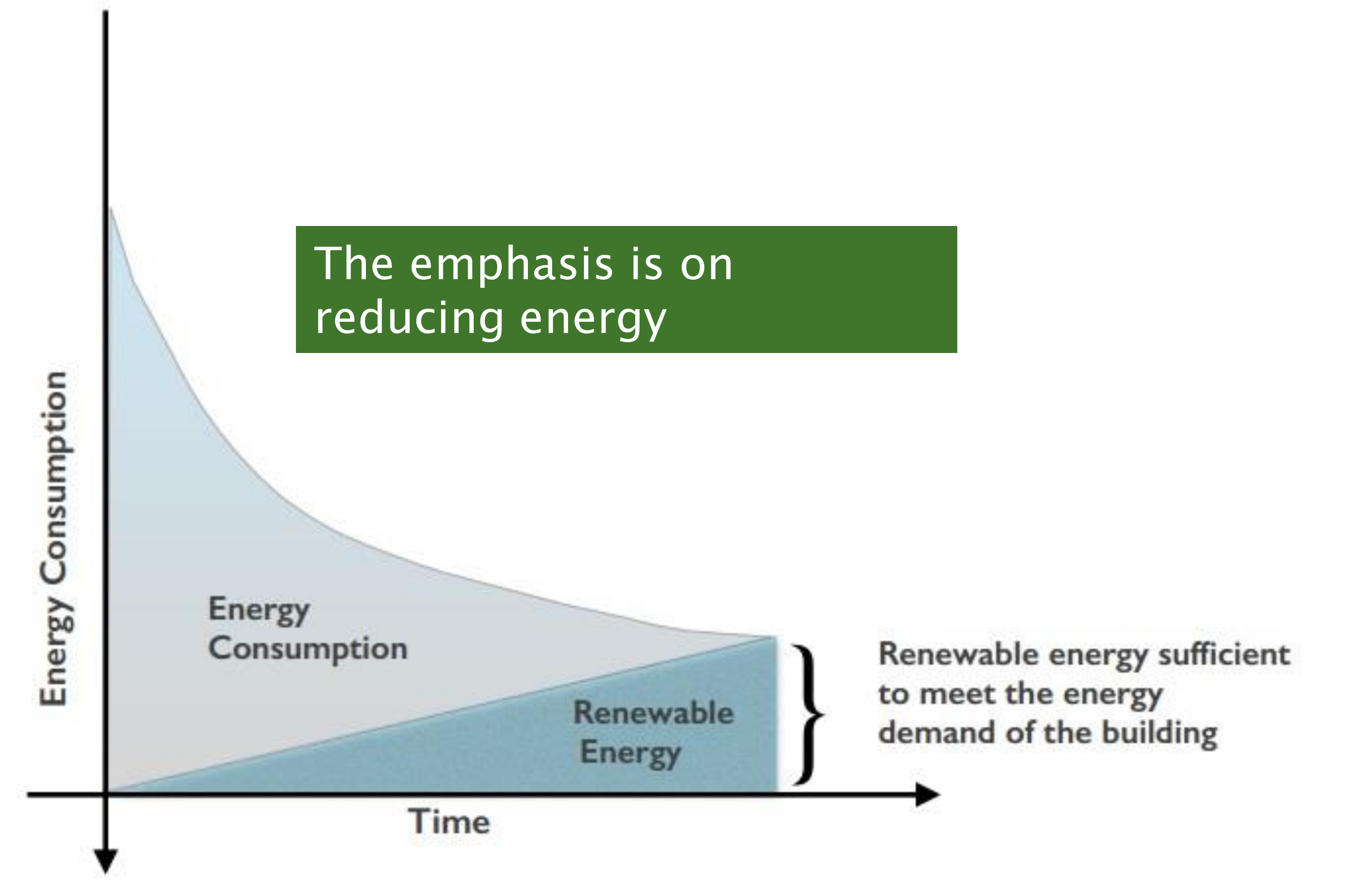
Deep Energy Retrofit

- 50 -90% drop in space & water heating
- Optimize building envelope
- Optimize resiliency/passive survivability
- Minimize mechanical systems
- Barrier free layouts + user friendly details
- Maximize renewables where possible

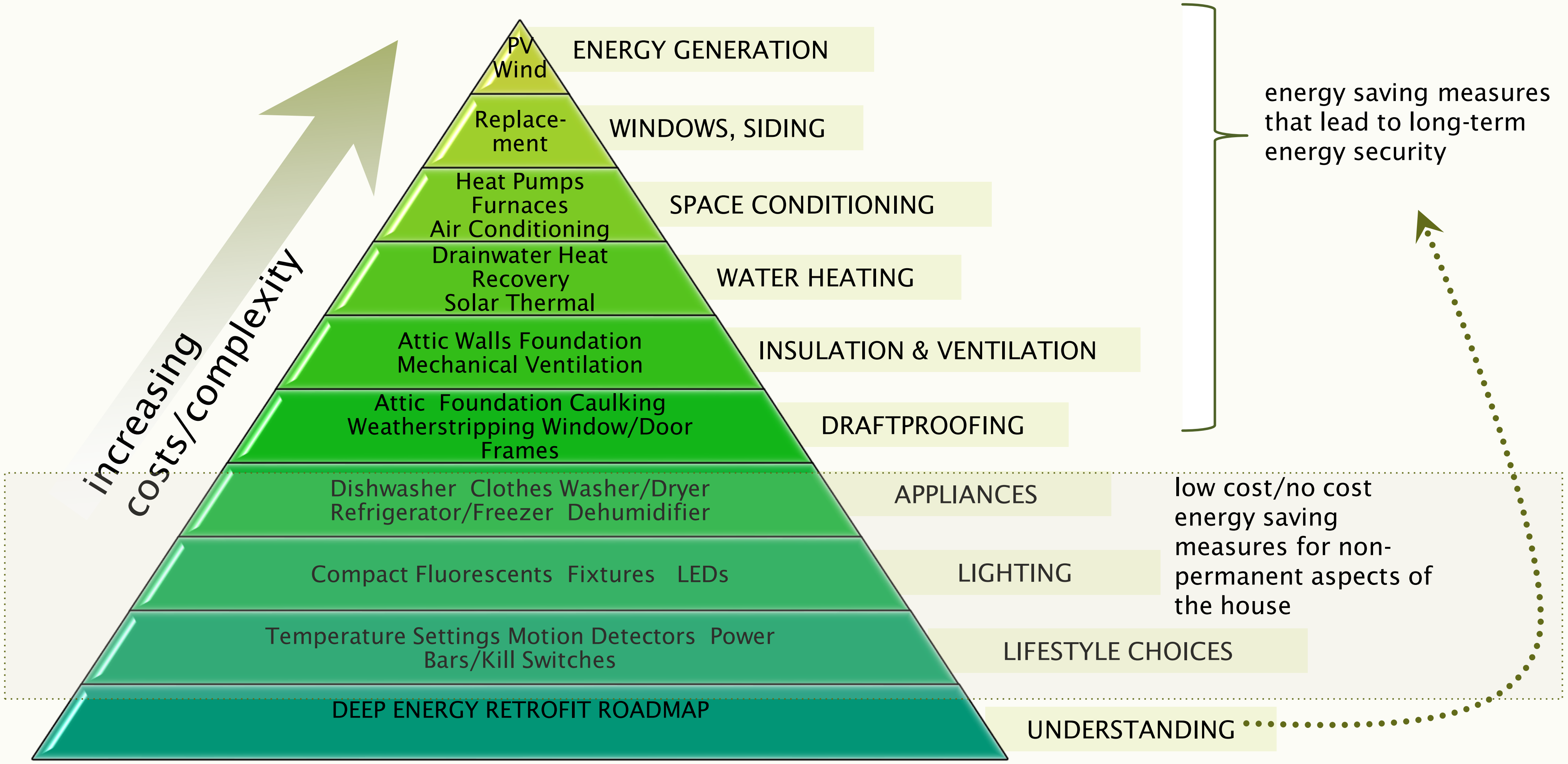
Net Zero Energy/NZE-r

- Produces as much energy as it consumes in a year
- Minimized heating and/or cooling loads
- Optimize/Upgrade mechanical equipment
- Optimize base loads
- Install renewables for site-based generation
- The 'r' is for 'ready' = pre-planning for PV

Reduce energy loads, add renewables



Renovation Pyramid



Halifax Gut Rehab: Income Property

4 bedrooms

Unfinished Attic

Unfinished Basement

Zero insulation

Damaged Windows

Improvement from interior – site constraints

Finished DER

2 – 4 bed suites

2x living space

50% energy consumption

√ Density

√ Occupancy Tenure

Rent includes utilities

- Bad storage practices = pictures on dead disk

SORRY

Modelled Business Case

DER =
1.85x up front
costs of
Conventional

Conventional =
1.7x projected
costs
of DER

Halifax Gut Rehab Summary

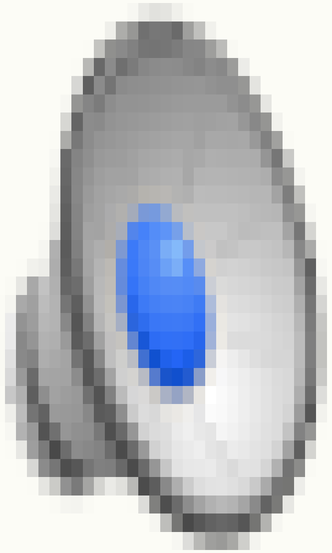
	EE Cost Estimate	EcoEnergy Rebates	Net EE Cost	Tot Annual Fuel and Associated Costs	Annual simple interest mortgage costs	Net Annual Costs	Net Projected Costs for Planning Horizon	Savings compared to Conventional Retrofit	What could you have earned by investing these incremental costs?
1. Conventional (L/oil at $1/L) 'A'	$41,845	-$6,000	$35,845	$9,274	$2,581	$11,854	$82,981		
2. with solar DHW 'B'	$48,845	-$8,100	$40,745	$8,393	$2,934	$11,327	$79,287	$3,694	$1,715
3. DER with comb system	$75,882	-$9,450	$66,432	$2,180	$4,783	$6,963	$48,744	$34,238	$10,705

Mortgage Interest Rate	7.20%	5 year closed rate
Planning Horizon	7	years
Investment Yield	5.00%	

Assumptions:
ecoENERGY rebates could be closer to $9k with new programme
No provision for inflation
Fuel prices assumed stable
Interest from investment not compounded
Option 2 and 3 include 15% provincial rebate on solar systems in Rebate column

Passive House Renovation: Gagetown NB

- 100 year old farmhouse
- Exterior retrofit
- 16” thick ‘Larsen Truss’ wall system

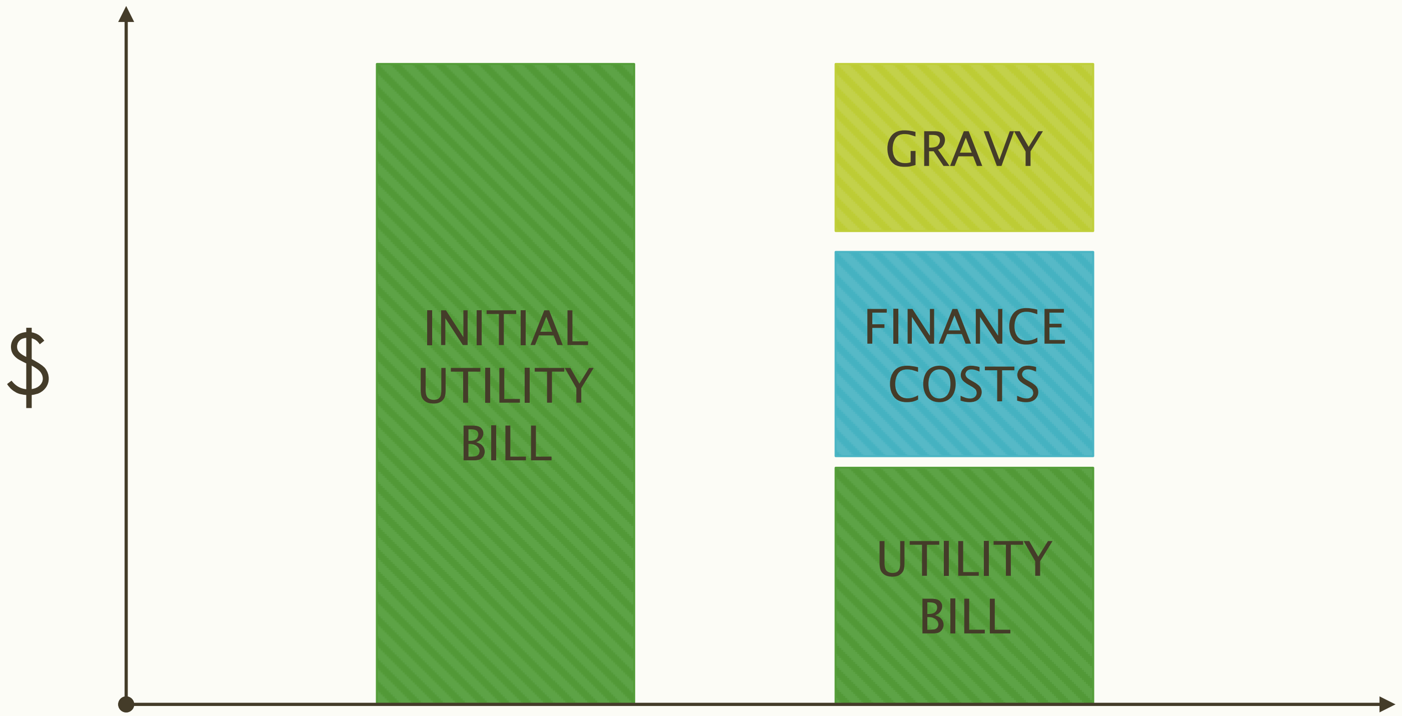


Video: RISE

Incremental Retrofits = Half Measures

- Homeowner vs. Property Owner
  - Shorter investment horizon
- More difficult, more expensive to reach goals
- Lock in emissions for generations
- Delay/save/phase with guidance
  - Longer investment horizon needed

DER Phase-by-Phase Ideal Goal



DER Long-Term Feasibility

Phased Retrofit Plans

Capital Cost Summary

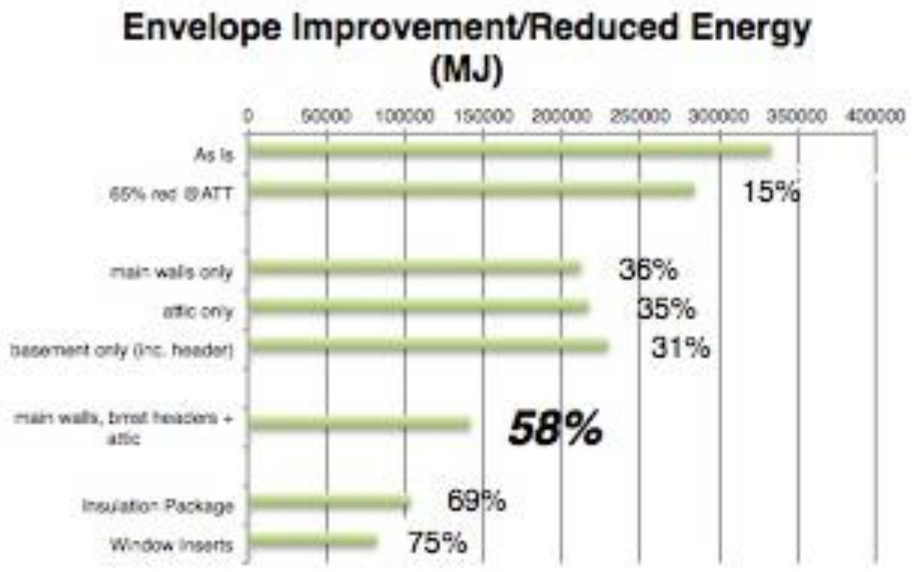
Phase I: $24,285
- Air sealing
- Insulation: basement, attic
- Spot Ventilation

Phase IIa: $10,565
- Insulating above grade walls
- Heat Recovery Ventilation

Phase IIb: $28,220
- Basement walls and slab – repairs, insulation
- Drainwater Heat Recovery

Phase IIc: $11,720
- Changing out the existing windows with vinyl inserts

Phase III: not priced – work to be carried out at Year 5 of plan
- Changing out mechanical system



Problem: House by House

- Numbers of houses to retrofit
- Amount of energy reduction
- Amount of carbon emissions

We will never make it

UNLESS

We move into bulk, aggregated retrofits

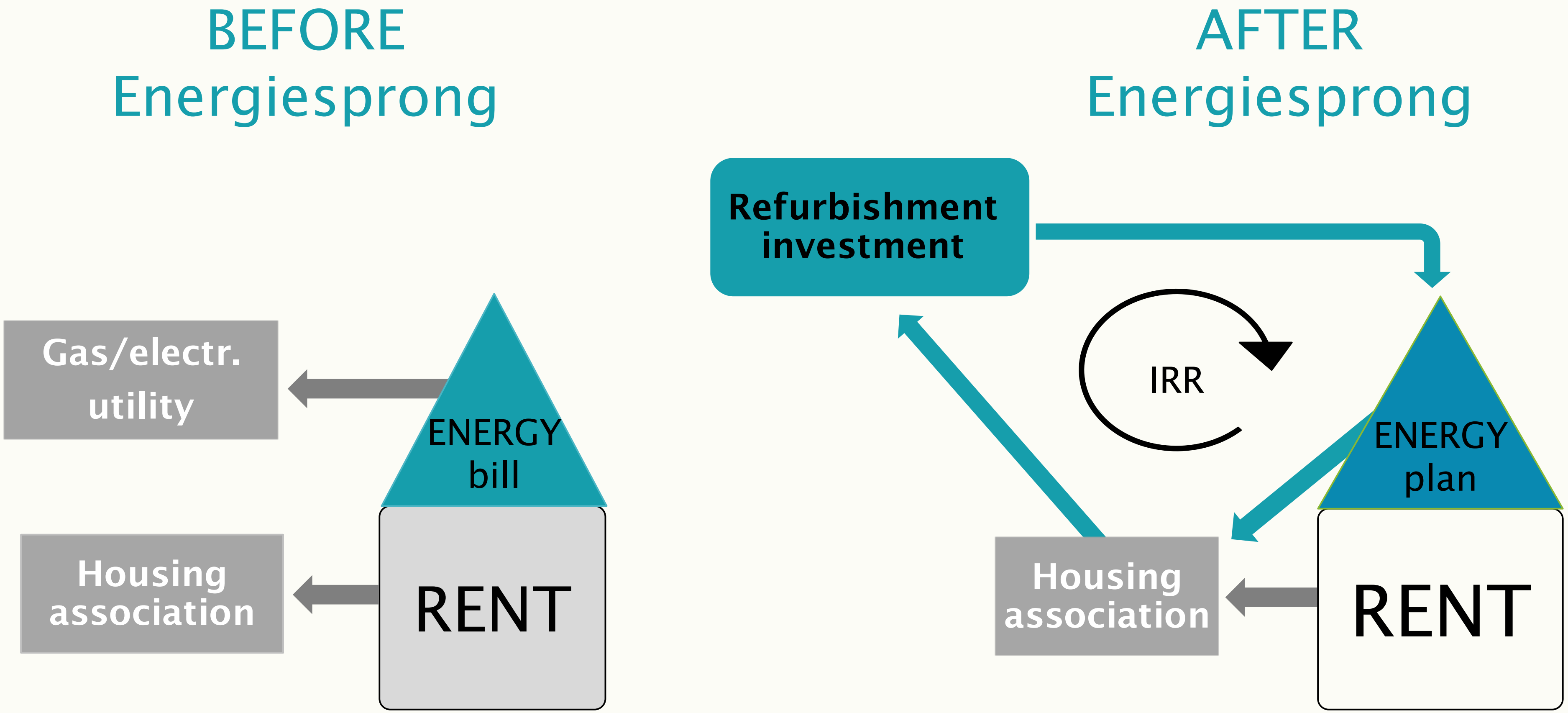
AGGREGATED RETROFITS

What is EnergieSprong?

- NZE retrofit
- Prefabricated façades
- Insulated rooftops + solar panels
- Smart heating/ventilation/coolin
- 40 year performance warranty

Photo: Energiesprong on Youtube

Energiesprong Includes Systemic Change



Financing Mechanism

Financed by future energy cost savings

PLUS

Budget for planned maintenance and repairs of 30 yr period

- Tenants pay housing association
  - Energy service plan = previous energy supplier bill
- Housing association income stream partly funds renos
- LEGISLATION: convert energy bill to energy service fee

Why it works in the Netherlands

- Large social housing network
- Few archetypes, many copies
- Social Enterprise
- Centralized manufacturing
  - Tight geographical areas
  - High density

How it works in the Netherlands

- EnergieSprong market development teams work with:
  1. Regulators: tune policy and regulations
  2. Banks: create viable path to scale

Working with 1 & 2 created

MOMENTUM

For offsite manufacturing & development of industrialized process

Within 5 years EnergieSprong Accomplished:

Retrofit 5,000 units

Cut price tag in half

Cut site time to less than 1 week*

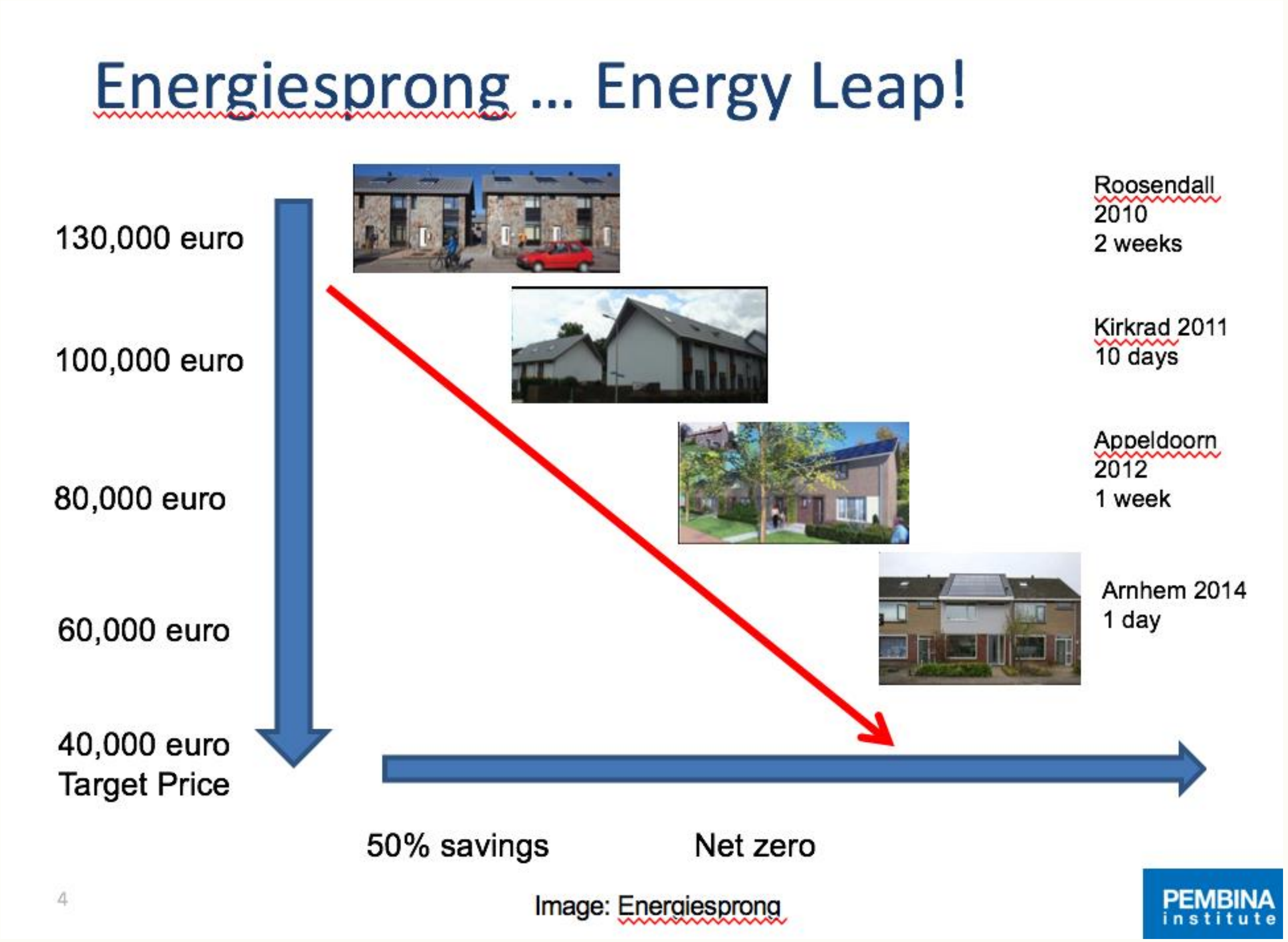
Initially did not include solar

Found efficiencies

Trades in-house

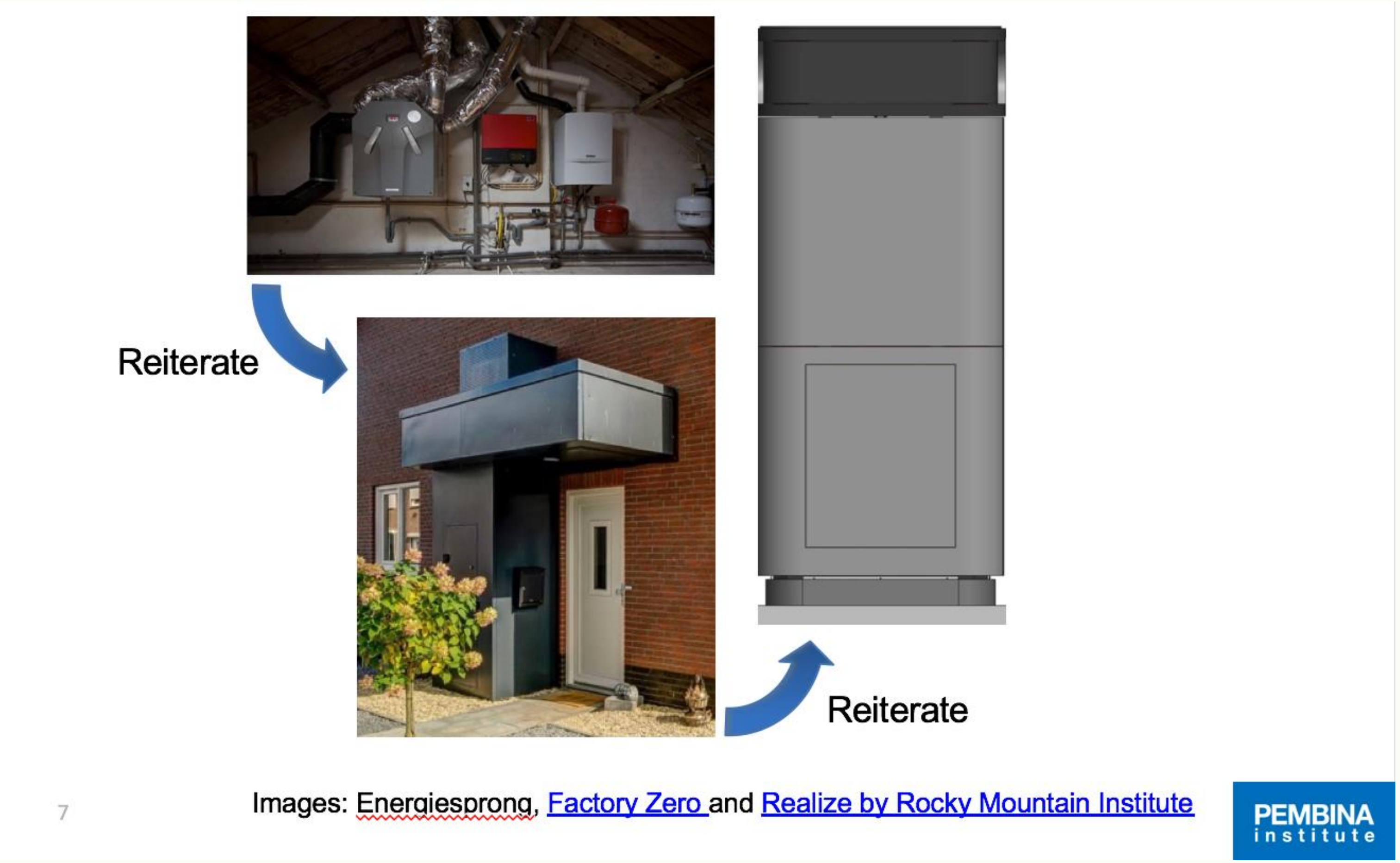
10,000 in process

NE PLAN: 110,000 retrofits



ADVANTAGE: Panelization at Scale

ITERATIONS: become an agent of change



FUNDING for EnergieSprong Demos

- International Funds
  - Transition Zero (H2020): UK, France, Netherlands
  - E=0 (InterregNWE): UK, France, Luxembourg, Netherlands, 30 demostrators
  - Mustbe0 (InterregNWE): NW Europe, 9 buildings, 415 units
- National funds
- Philanthropic funders

Advantages of Panelized DERs

- Lowest total cost of ownership
- Less expensive than component by component replacement
- Higher quality control/quality assurance
- Faster, less disruptive to occupants
- Easier to manage
- Better total solution
- Can be done, now – no waiting on technology

What's Different in Canada?

- Many archetypes, fewer copies
- Geographically diverse and dispersed
- Social housing not the norm
- Abbreviated history of social enterprise
- No central manufacturing options
    - See bullet #2

PEER: Pre Engineered Exterior Retrofit

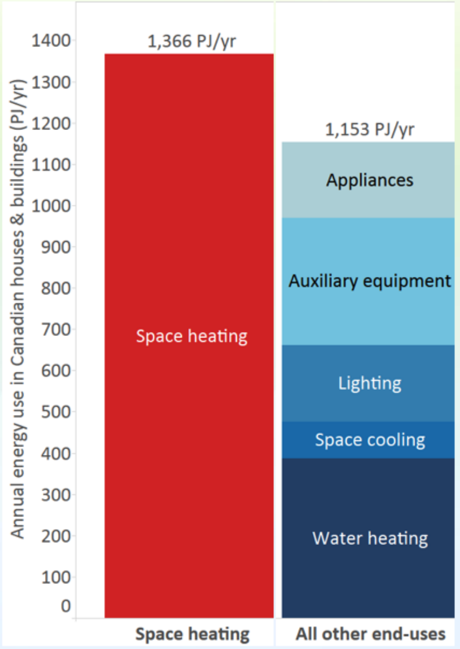
Photos: CanmetENERGY, NRCan

NRCan leads Industry Working Group

PEER Project (2016-2021)

- Goal: prefabricated building envelope retrofit solutions to achieve Net-Zero Ready heating demand
- Main research question:
  - Can factory-built, super-insulated, airtight panels be installed directly over existing finishes? Could this be a cheaper and more effective way to do deep retrofit?
- 3 primary research areas:

1. Building capture: rapid, accurate measurement
2. Panel prototypes, fabrication and installation
3. Building science: minimizing risks of failure



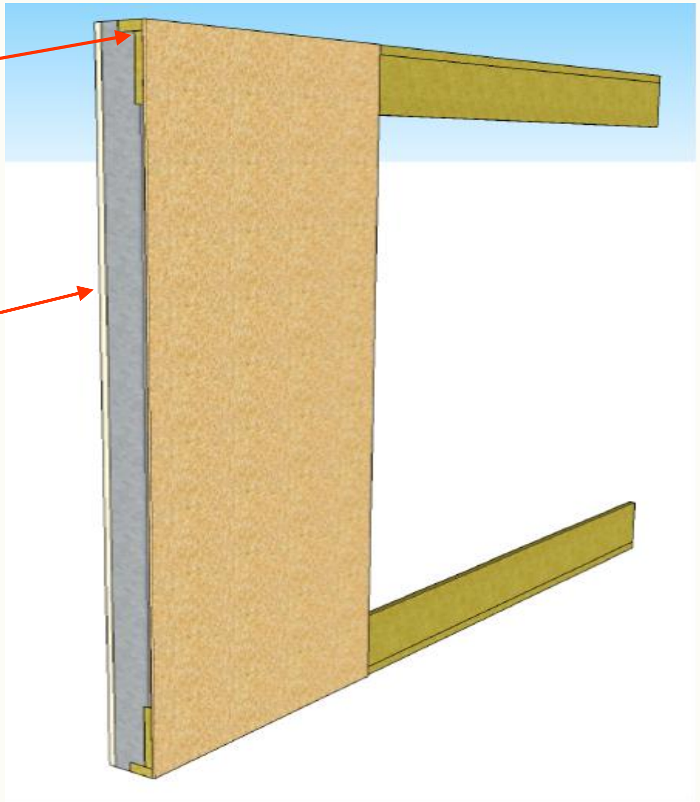
Rigid Foam Nail Base (SIP)

Let-in structure

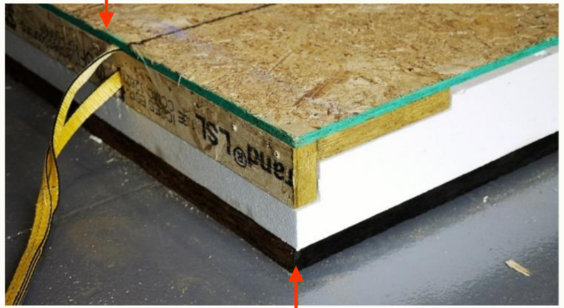
Ties sub-panels into superpanel
Stiffens superpanel and enables it to be lift into place

Squishy Layer

Helps with plumb/square
Absorbs surface irregularities
Provides dimensional tolerance
Vapour open



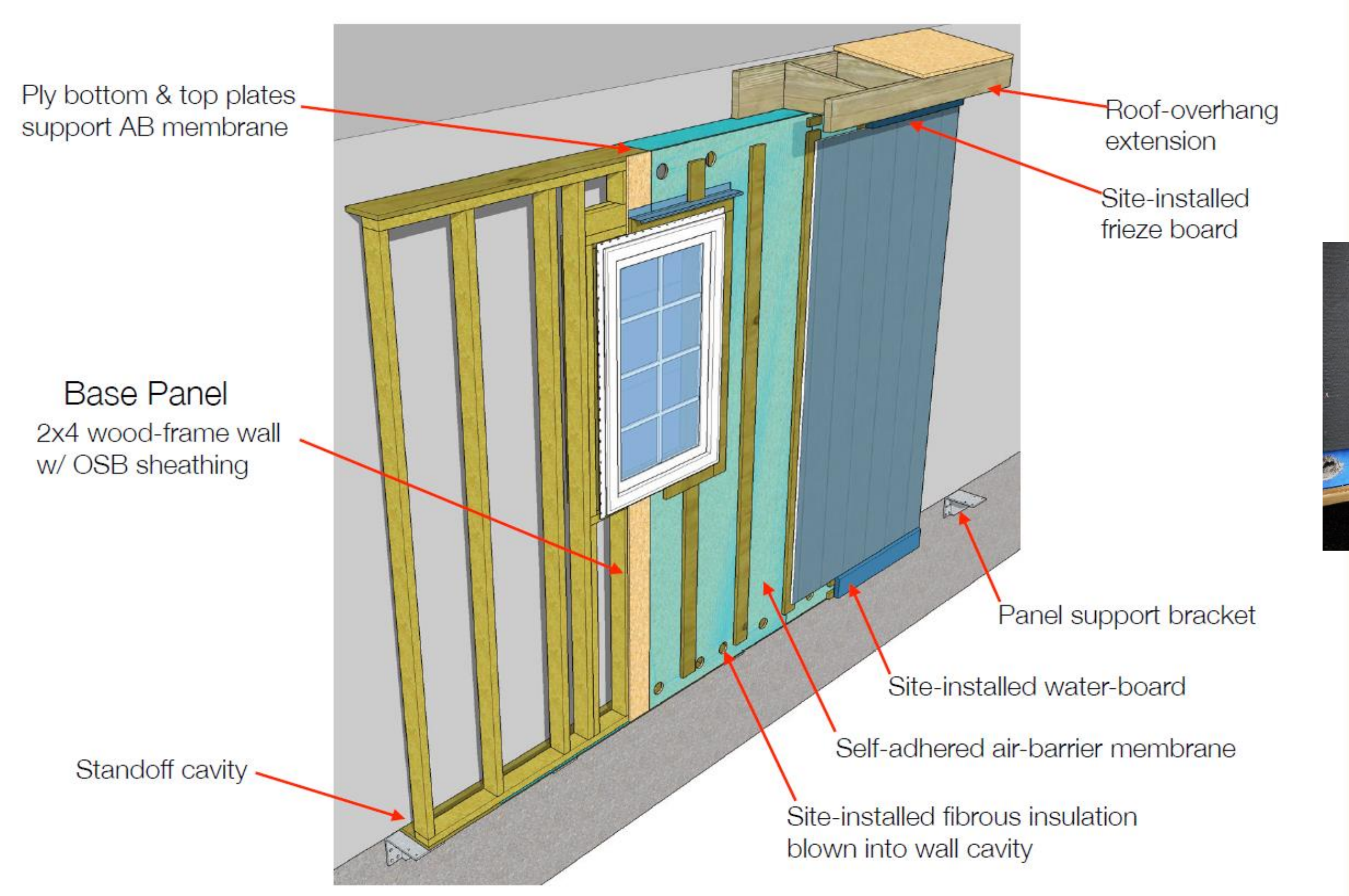
Integrated lifting straps

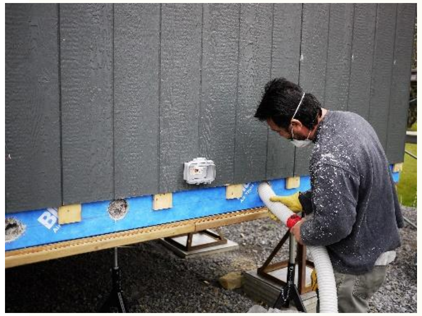


Squishy Layer

Graphics: CanmetENERGY, NRCan

Woodframe Standoff Panel





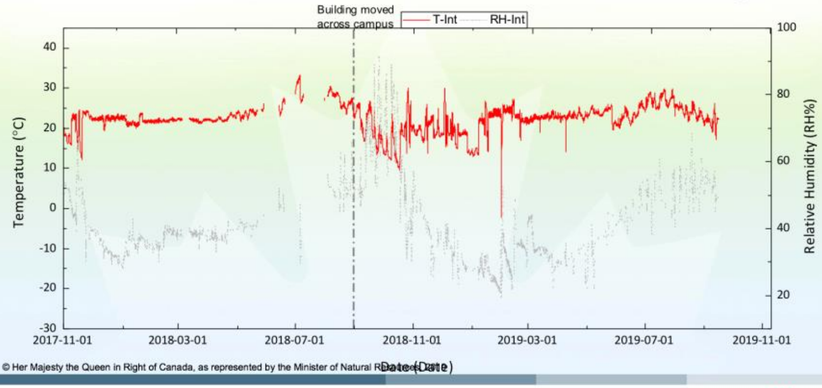
Graphics: CanmetENERGY, NRCan

2017 Proof of Concept Pilot

Performance Metric	Baseline	Retrofit	% Improvement
Tested Airtightness (ACH@50Pa)	7.62	0.82	89%
Normalized Leakage Area @ 10 Pa (cm2/m2)	1.84	0.20	89%
Simulated Heat loss – Walls (GJ)	15.2	4.7	69%
Peak thermal demand (@-25˚C) (W)	5760	2540	56%
Thermal Energy Demand Intensity (kWh/m2a)	230.3	64.7	72%

Graphics: CanmetENERGY, NRCan

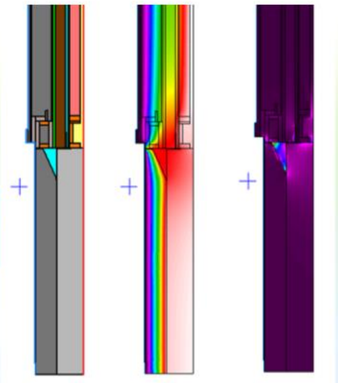
PEER Project Ongoing through 2021



Impact of thermal bridges and effective R-values

onclusions

	$U_{clear\ wall}$ (W/m²K)	Area (m²)	$U(\Psi_{flange})$ (W/m²K)	$U(\Psi_{web})$ (W/m²K)	# Brackets	U_{eff}(W/m² K)	Change %
Bracket only	0.131	394.4	0.035	0.001	32	0.134	2.2%
Lateral Effects	0.131	394.4	0.090	0.001	32	0.138	5.6%



Moisture Risk Assessment

#	Case	Overall Results
1-4	Above grade walls at centre of panel (8" EPS-II core SIP panel) Over **"dry"** (3.3 kg/m3) brick	Low risk temp of the interior surface of outmost OSB is quite close or cooler than dewpoint. However, temps very low during these periods, preventing mold growth.
5-8	Above grade walls at centre of panel (8" EPS-II core SIP panel) Over **"light wet"** (5.0 kg/m3) brick	Medium-Low risk mold index briefly exceeds threshold during dry-out on North facing wall.
9-12	Above grade walls at centre of panel (8" EPS-II core SIP panel) Over **"mid wet"** (10.0 kg/m3) brick	High Risk Mold growth potential on inner OSB
13-16	Above grade walls at centre of panel (8" EPS-II core SIP panel) Over **"really wet"** (19.0 kg/m3) brick	High Risk Mold growth potential on inner OSB Mold growth risk on existing sheathing Fastener corrosion
17-20	Base Case "as-is condition"	High Risk mold growth risk on existing sheathing. Likely benefitting from increased air leakage drying potential

Monitoring

1. Basic indoor air quality and comfort within the units before and after the retrofit to assess impacts to occupants' health and comfort;
2. The hygrothermal response of the retrofit panels and select building enclosure assemblies and details to assess moisture risk and validate / calibrate models. Specific questions include:
   - What is the mold growth index on surfaces of interest?
   - What are the boundary conditions and can these be used to "calibrate" hygrothermal models?
   - Does the inclusion of a vapour-open "squishy layer" in the wall panels facilitate upward drying by diffusion? Can this effect be quantified?
   - What potential for condensation exists at the panel joints? How can this joint be detailed to minimize this risk?
   - Does moisture from potentially rain-wetted existing finishes escape the retrofit assemblies? Is there a reasonable, safe threshold water content that can be established?
3. The annual overall energy balance (generation minus use) and daily energy use patterns of each unit to:
   - establish whether NZE performance was achieved;
   - understand and provide feedback to inform occupant behaviour; and
   - assess electrical demand and impacts to the grid and identify future opportunities for utility response measures.

Graphics: CanmetENERGY, NRCan

PEER 2nd Pilot: Ottawa – Nail Base/SIP Panel

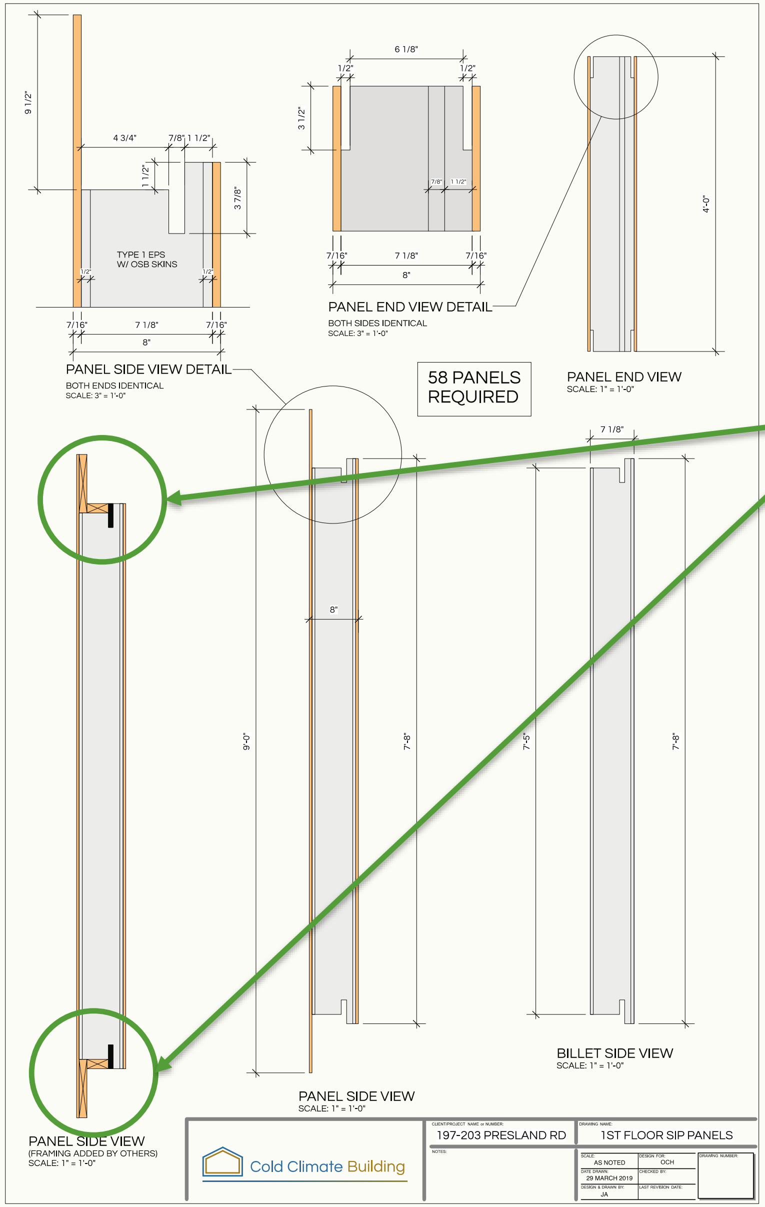
Graphics: CanmetENERGY, NRCan

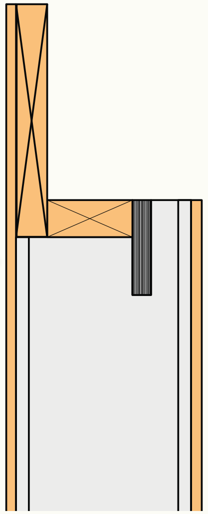
Predicted Energy Reductions

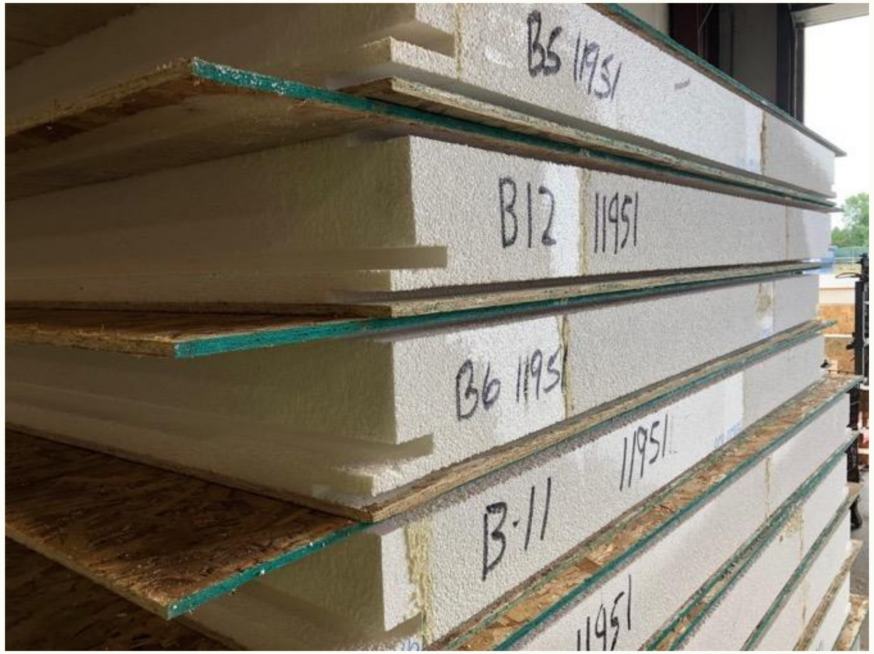
	Base Case						Post NZE Retrofit					
	Annual Energy Use (GJ)						Annual Energy Use (GJ)					
House	Space Heat	DHW	Lights & Appliances	Ventilation & Fans	Space Cooling	Total, (GJ/yr)	Space Heat	DHW	Lights & Appliances	Ventilation & Fans	Space Cooling	Total, (GJ/yr)
197	71.7	25.4	25.6	1.2	-	**124.0**	3.5	5.0	22.2	0.4	3.1	**34.2**
199	44.8	25.3	25.6	0.9	-	**96.6**	2.4	5.0	22.2	0.4	3.1	**33.0**
201	46.7	24.4	26.1	0.9	-	**98.1**	2.4	5.0	22.2	0.4	3.1	**33.0**
203	66.6	25.4	25.6	1.3	-	**118.9**	3.5	5.0	22.2	0.4	3.1	**34.2**
Total	229.9	100.6	103.0	4.1	-	**437.6**	11.7	20.1	88.8	1.5	12.3	**134.4**

Space Heating: 229.9 → 11.7 95% reduction (enclosure, air leakage, mech. efficiency)

Total Energy Use: 437.6 → 134.4 70% reduction (adds in mech. vent. & cooling)

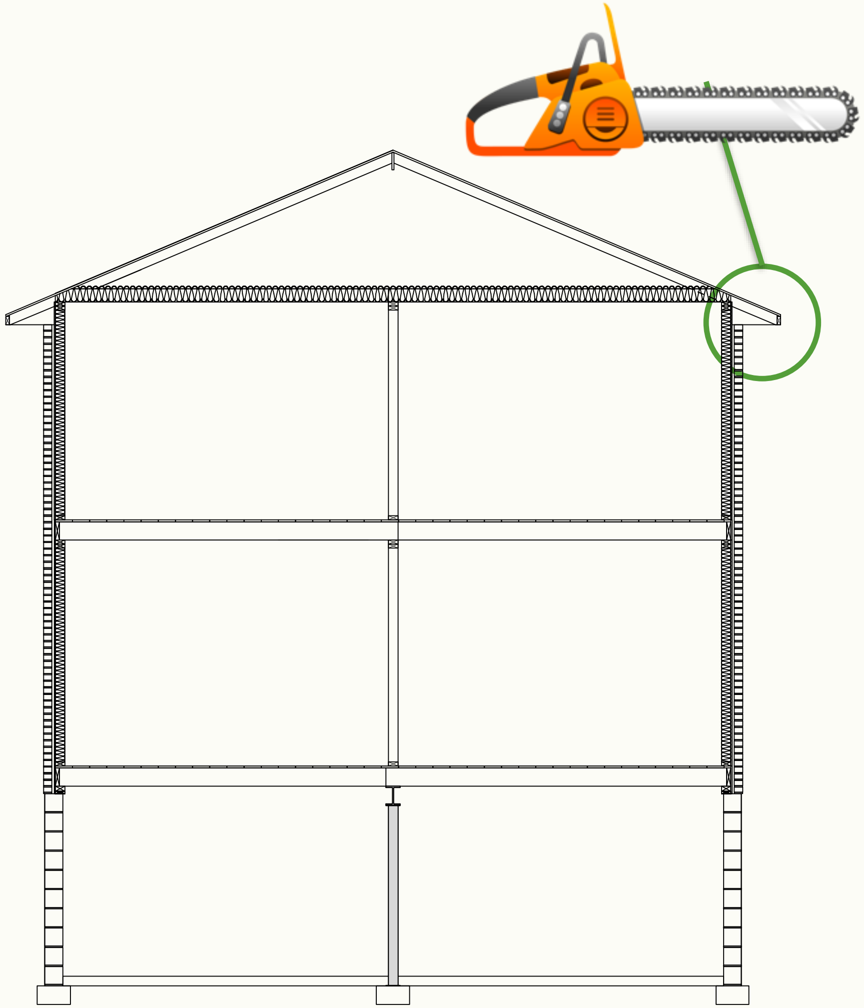




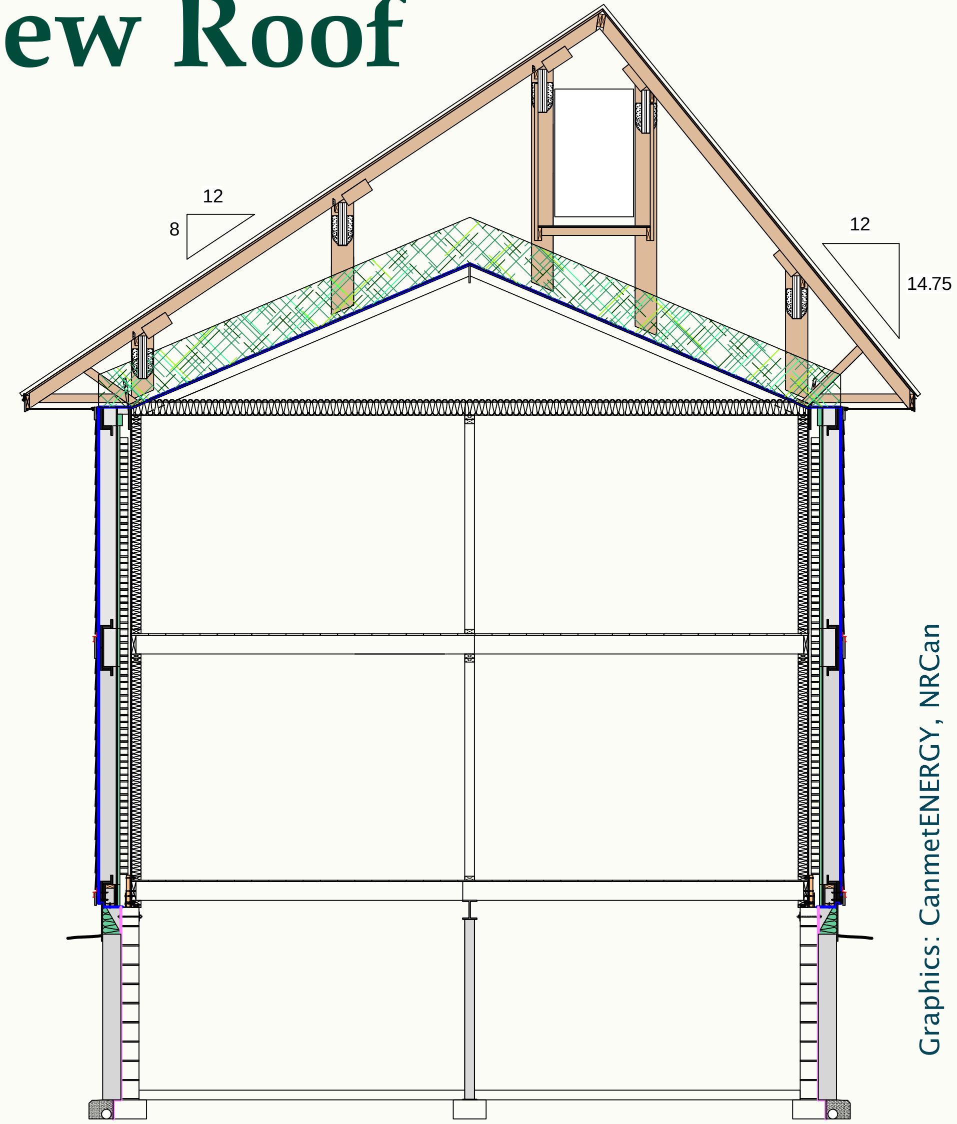


Graphics: CanmetENERGY, NRCan

Chainsaw Retrofit & New Roof



Before



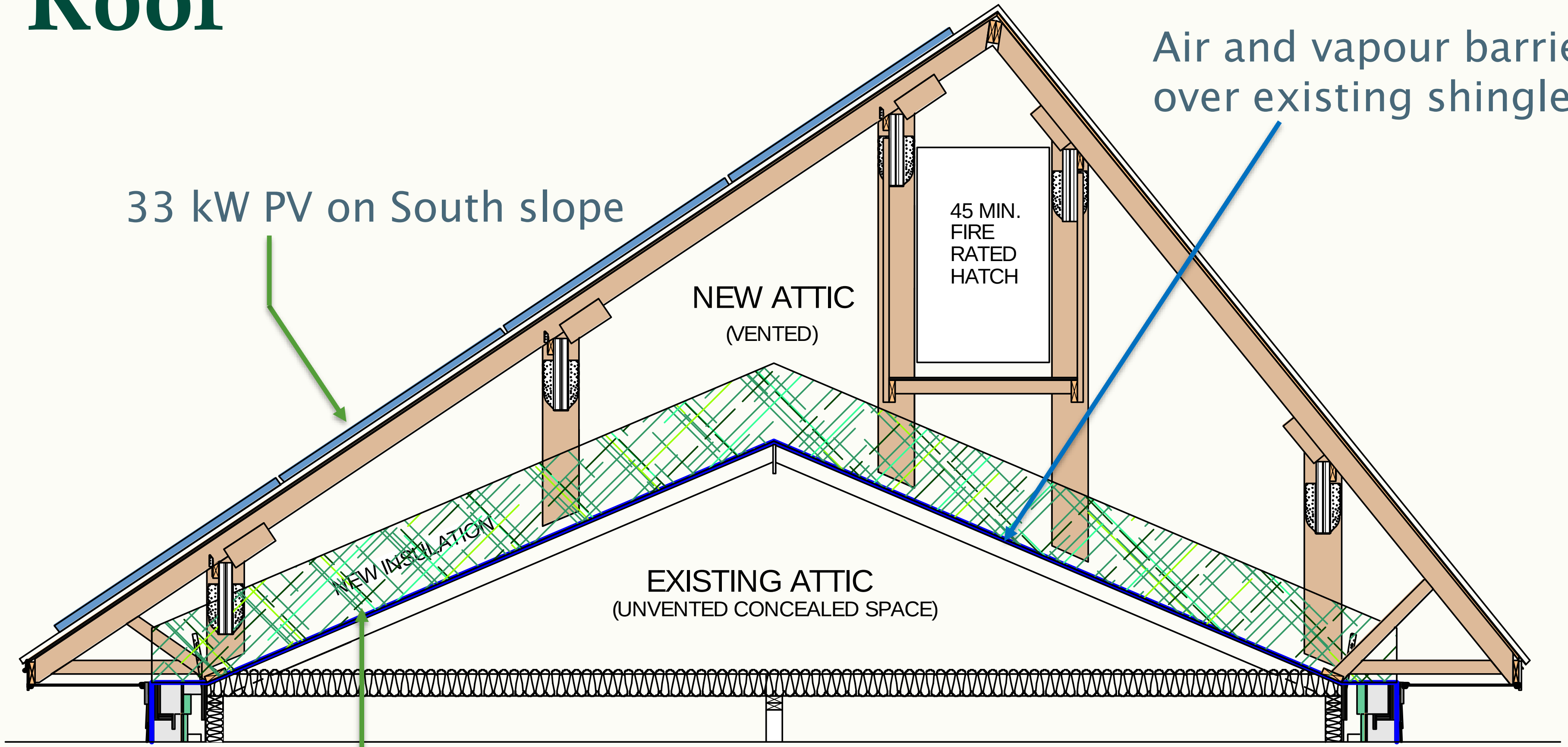
After

Graphics: CanmetENERGY, NRCan

PV Roof

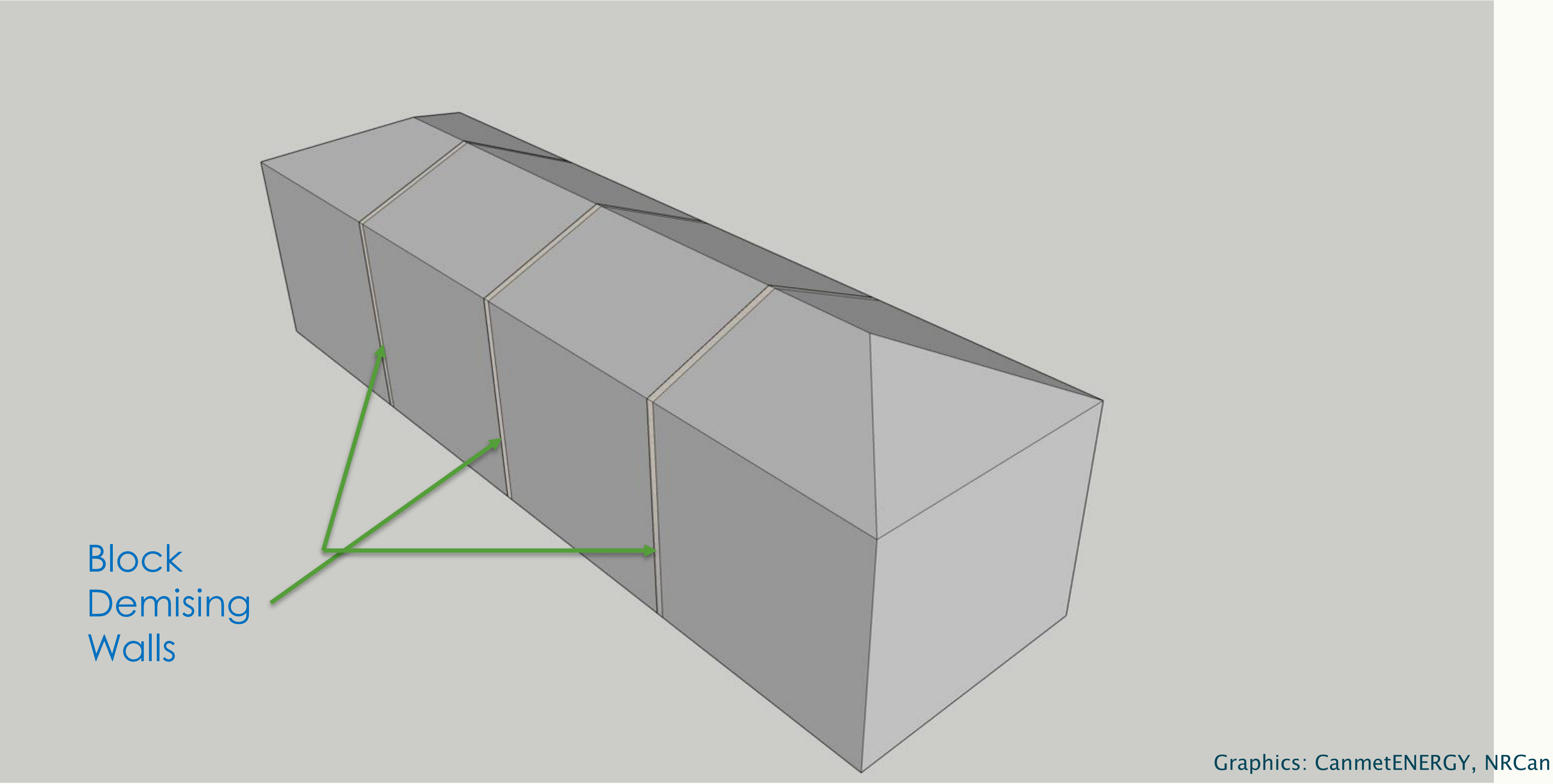
33 kW PV on South slope

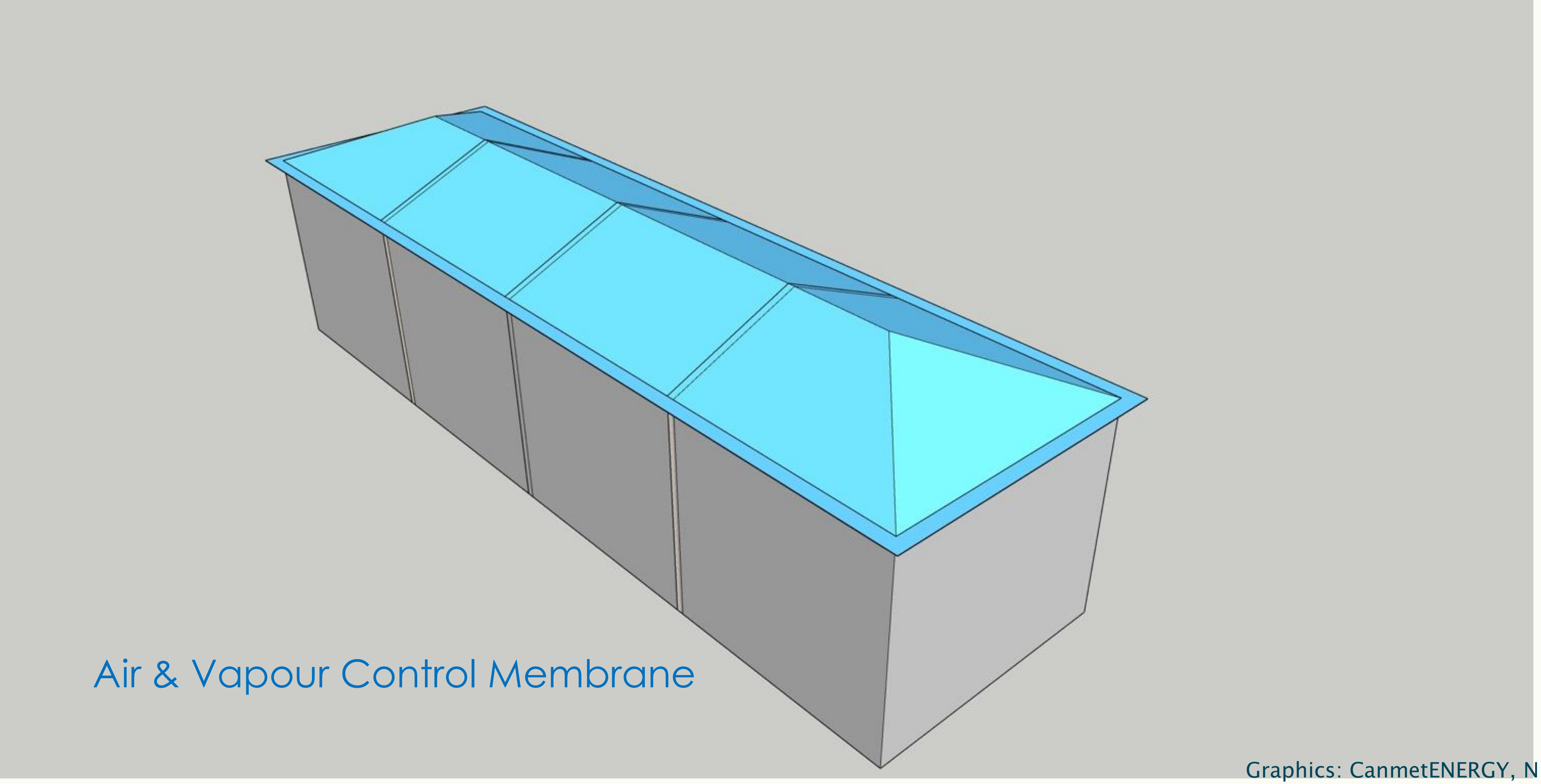
Air and vapour barrier
over existing shingles



Added insulation
to top of existing roof

Graphics: CanmetENERGY, NRCan


Block
Demising
Walls
Graphics: CanmetENERGY, NRCan



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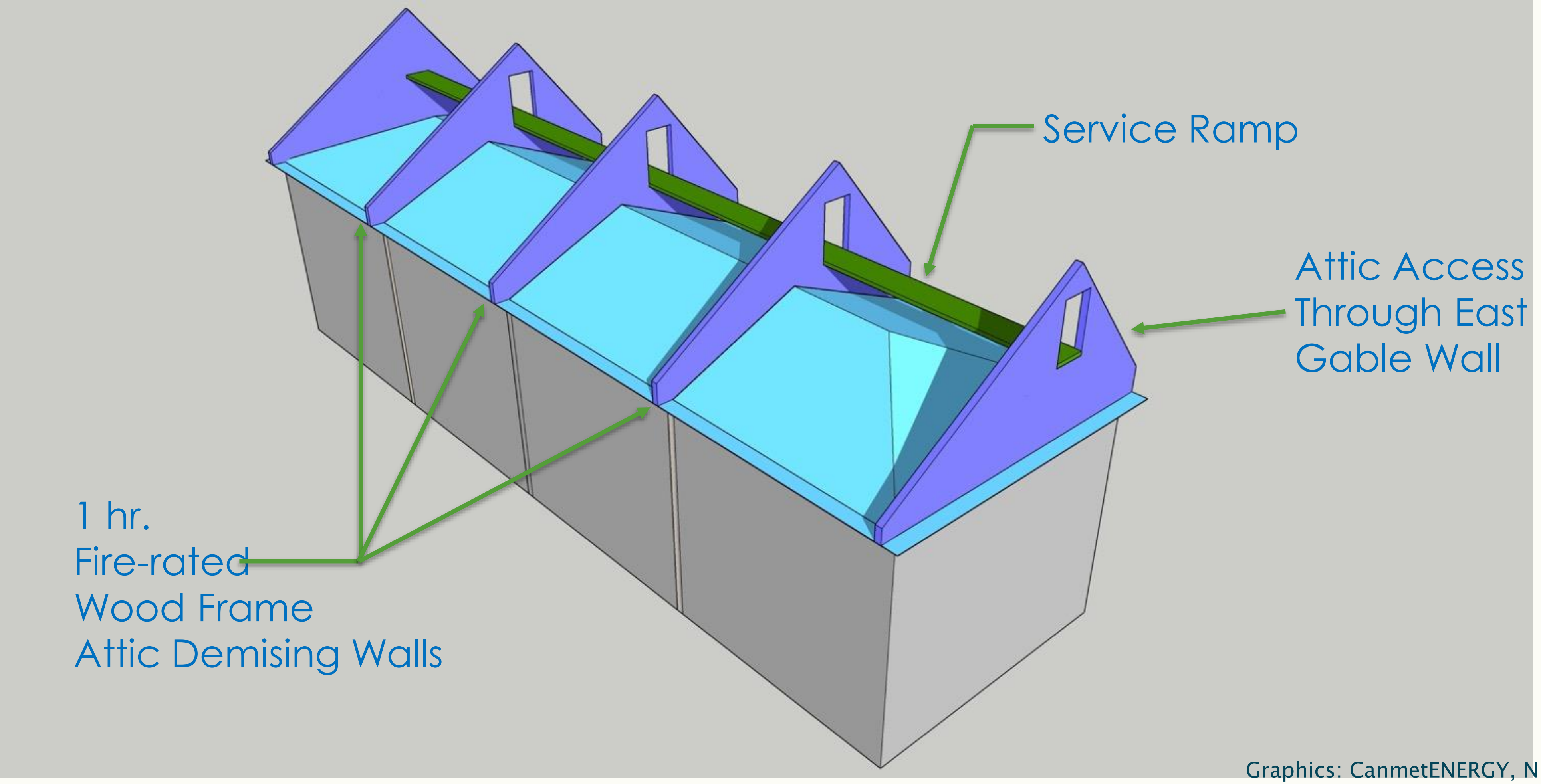

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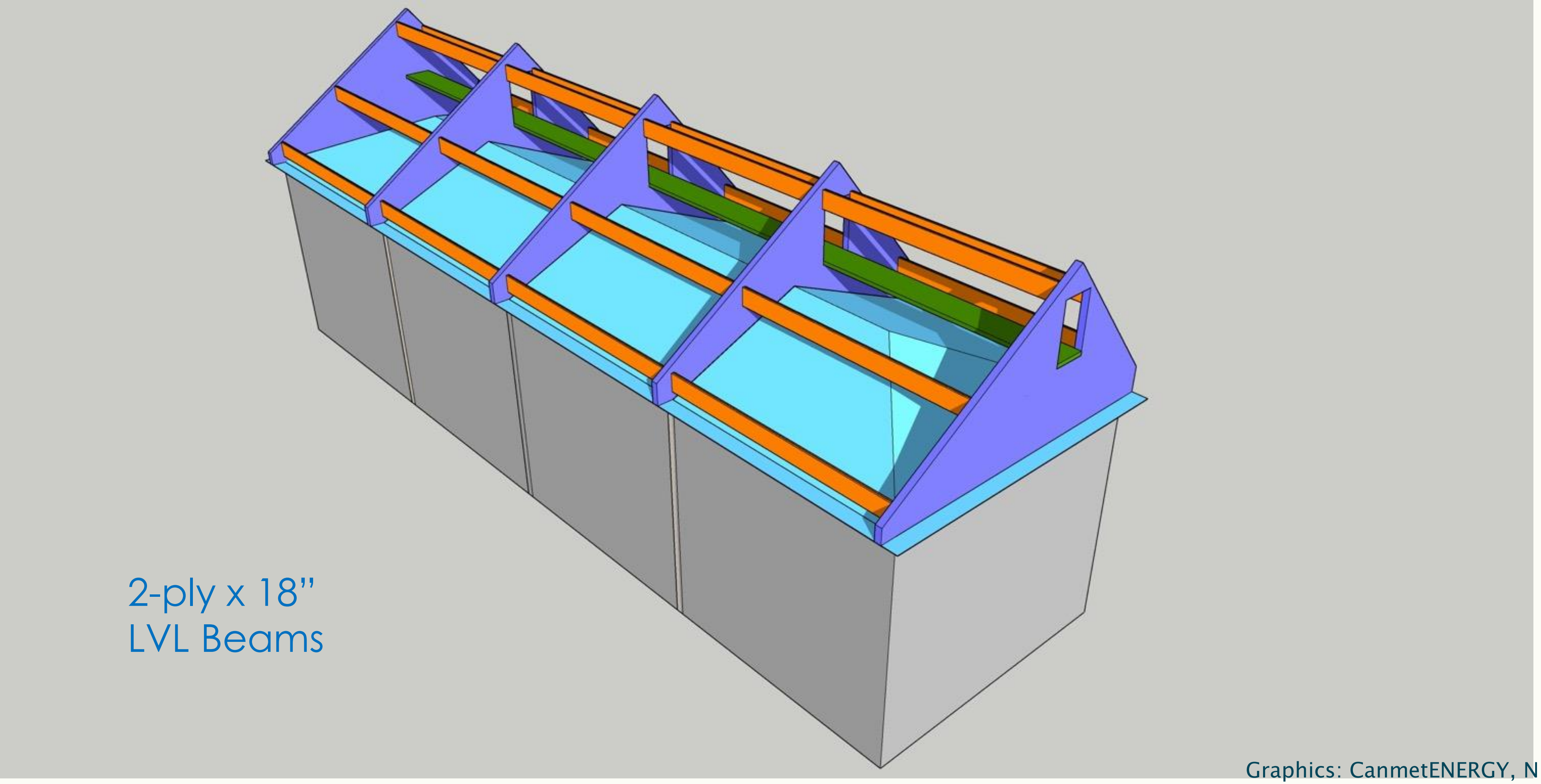

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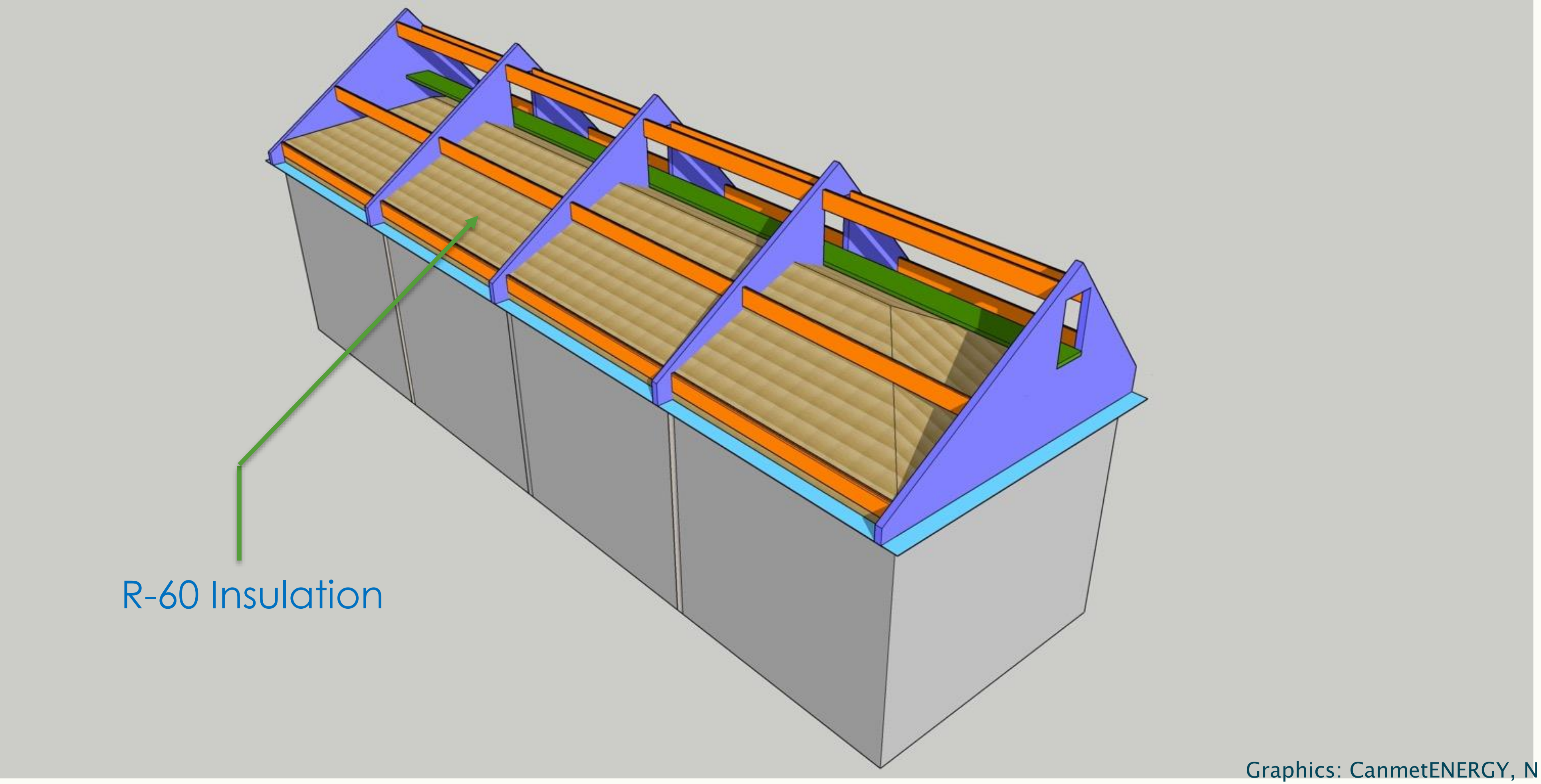

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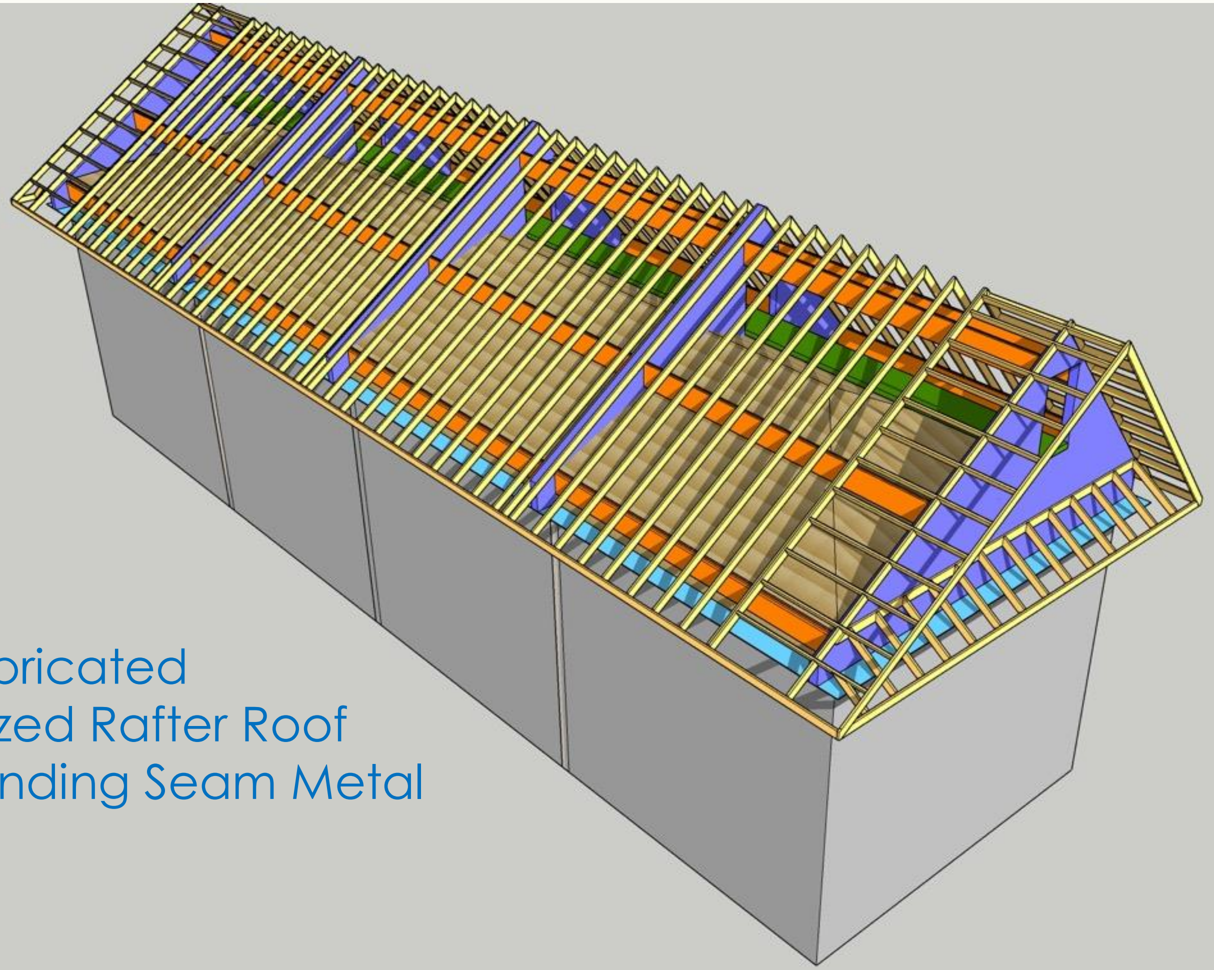


Pre-fabricated
Panelized Rafter Roof
w/ Standing Seam Metal

Graphics: CanmetENERGY, NRCan

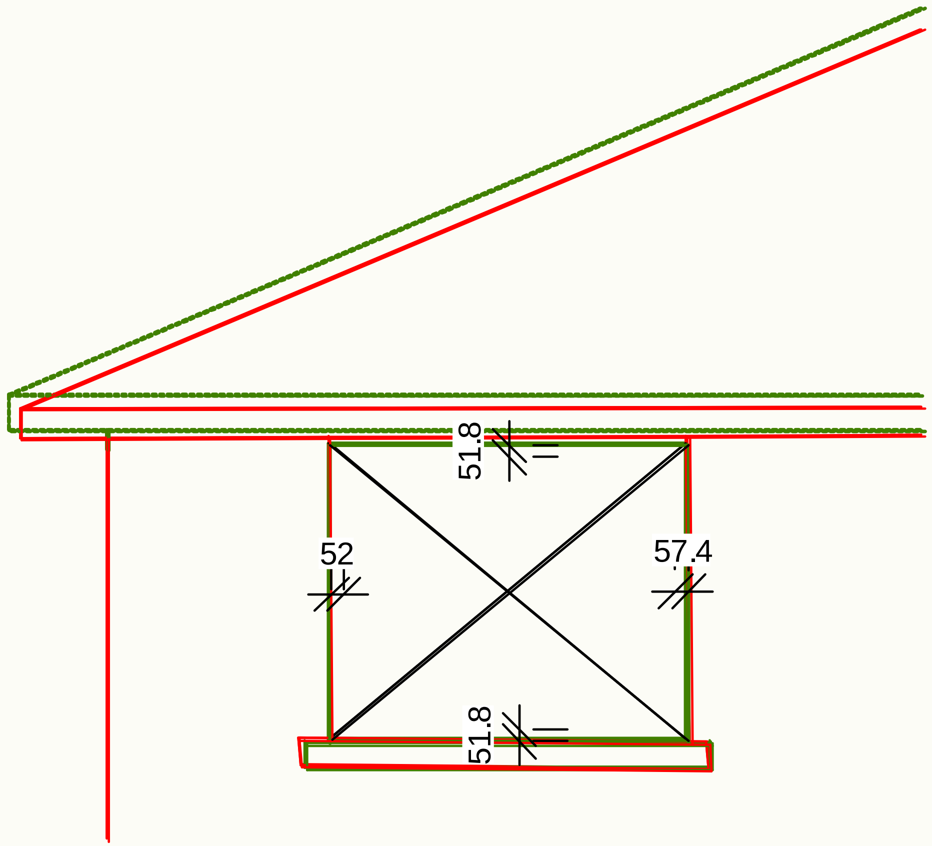
Building Capture: Process Needs Work

Ottawa:

Survey/Laser Scan

Discrepancies (red/green lines)

Human decisions in process



Kestrel Court Residence NZE Retrofit Pilot

FANSHAWE

Existing Conditions

- Residences are showing signs of age
- Damage to concrete foundations
- Deteriorating finishes
- Evidence of moisture damage

6th Semester Building Science Project

Sundance Housing Co-op Phase 1 Pilot

Pilot Project Unit

Comprehensive Energy Modelling

ReNü ENGINEERING

Figure 4: Screen capture of IES<VE> energy model representing the Sundance Housing Cooperative, plan view.

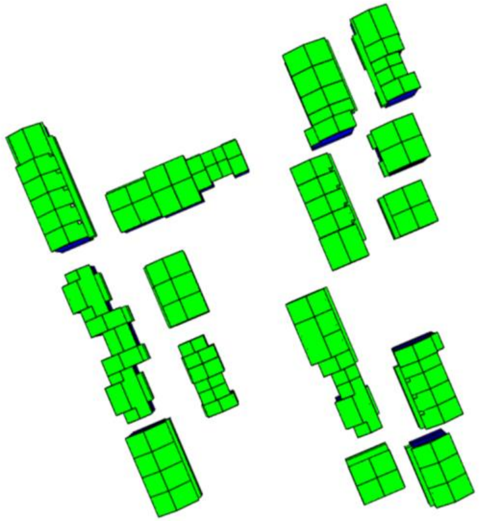


Table 1: Thermal description of the building envelope scenarios modelled as part of this Sundance BCA.

Sundance Housing Cooperative Building Envelope Scenarios				
Envelope Elements	Scenario #1	Scenario #2	Scenario #3B	Scenario #3A
Roof	R20	R60	R68	R68
Walls Above Grade	R13.6	R17.5	R42	R42
Foundation Walls	R1 + Contact	R1 + Contact	R1 + Contact	R20
Slab	R1 + Contact	R1 + Contact	R1 + Contact	R10
Exposed Floor	R12	R28.5	R28.5	R28.5
Windows	R2, SHGC:0.24	R2, SHGC: 0.24	R8, SHGC: 0.24	R8, SHGC: 0.24
Door	R1.2	R1.2	R7.5	R7.5
Airtightness (ACH@50Pa)	3.0	2.0	0.5	0.5
ERV Efficiency (%)	No HRV	No HRV	90%	90%

ReNü ENGINEERING

Our energy modelling has produced estimated peak heating and cooling load data for the Sundance site, shown in Table 2, as well as annual heating and cooling energy demand, shown in Table 3.

Table 2: Summary of estimated Sundance retrofit peak heating and cooling loads, using ASHREAE Heat Balance Method. Heating setpoint of 22°C, Cooling setpoint of 24°C.

Sundance - Avg Retrofit Heating & Cooling Load				
Scenario	Peak Load (BTU/h)		% Decrease in Peak Load	
	Heating	Cooling	Heating	Cooling
Scenario #1	37769	8141	-	-
Scenario #2	33618	7311	11%	10%
Scenario #3B	24399	5818	35%	29%
Scenario #3A	16309	5067	57%	38%

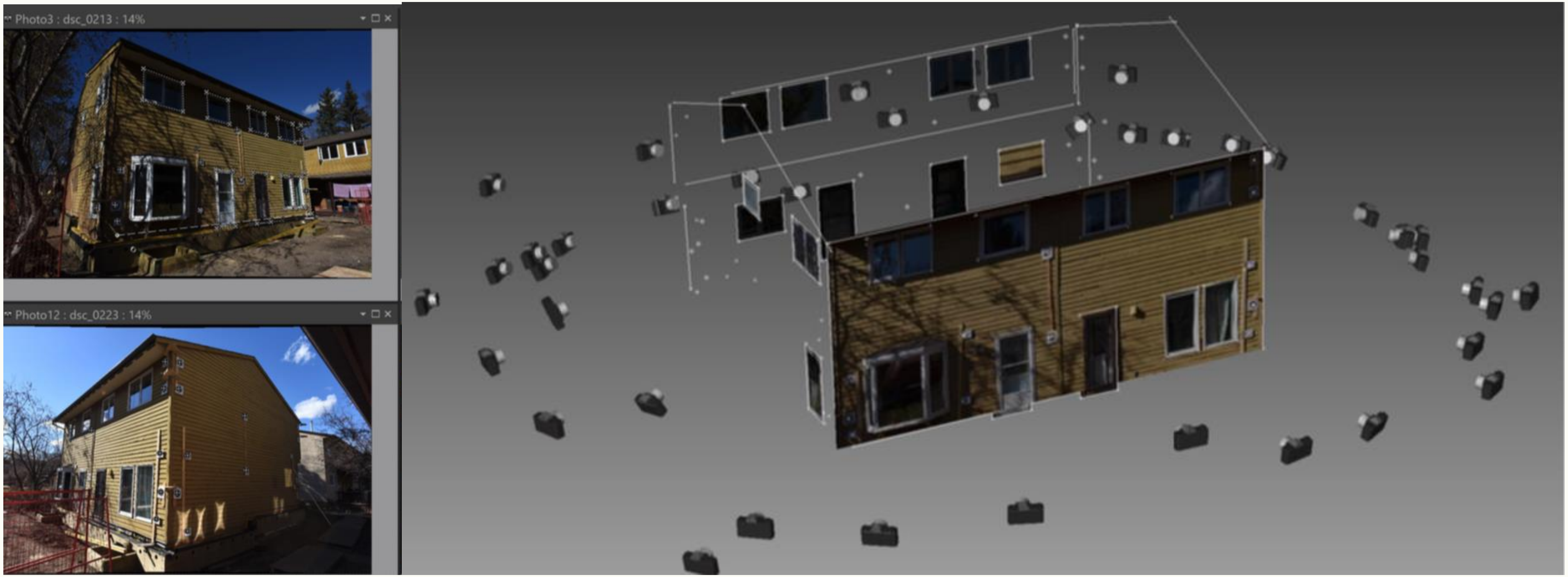
Table 3: Summary of estimated Sundance retrofit annual heating and cooling energy demand, from IES energy modelling. Heating setpoint of 22°C, Cooling setpoint of 24°C.

Annual Heating and Cooling Demand for Each Scenario				
Scenario	Ann. Demand (kWh)		% Decrease in Ann Demand	
	Heating	Cooling	Heating	Cooling
Scenario #1	1719108	12259	-	-
Scenario #2	1497241	10192	13%	17%
Scenario #3B	690119	8744	60%	29%
Scenario #3A	304354	9648	82%	21%

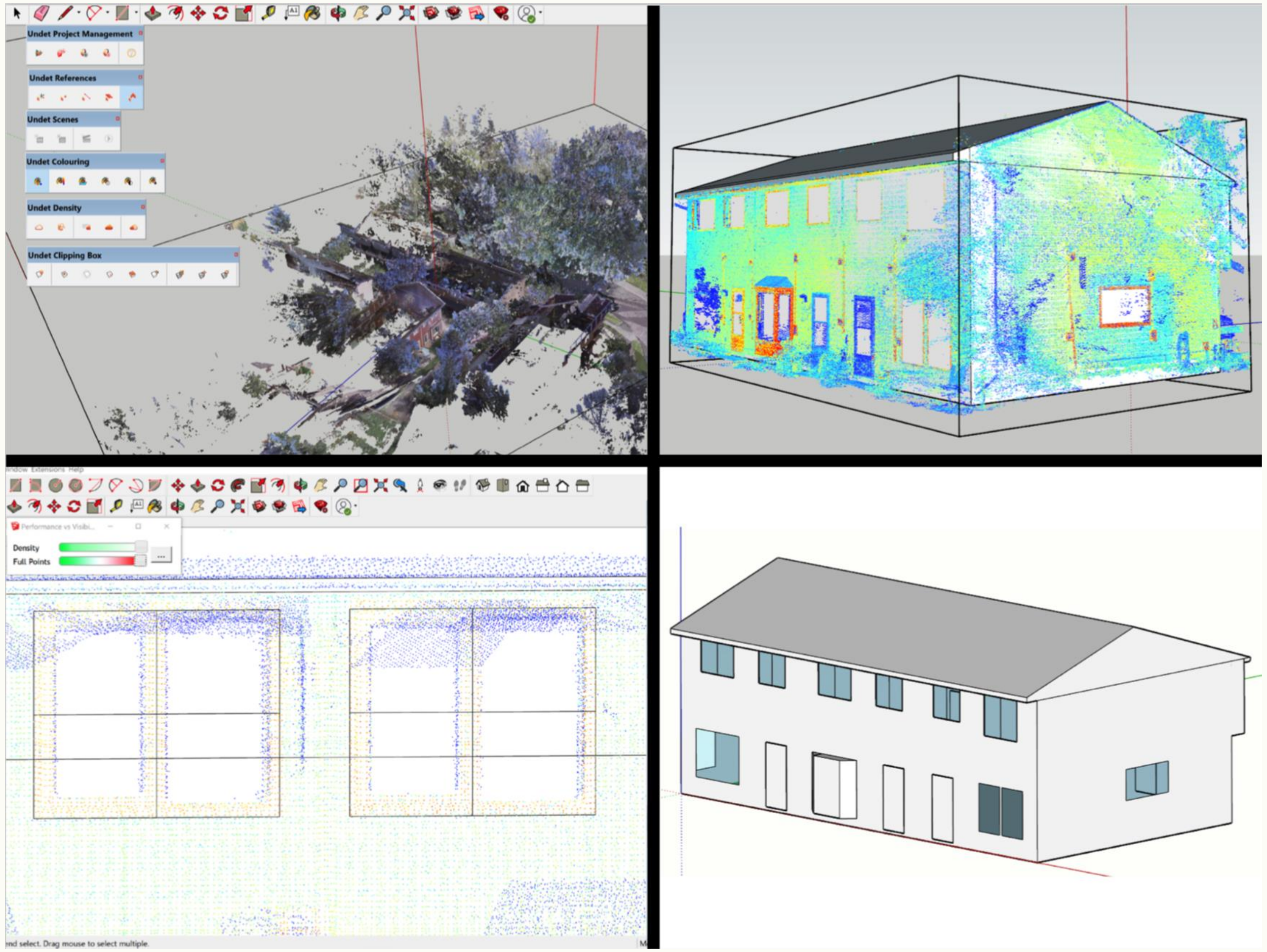
Our team has worked with Butterwick Construction and NüEnergy Systems to produce detailed capital cost estimates for the three proposed building envelope retrofit scenarios. This data is summarized in Table 4.

Challenges with Established Sites…

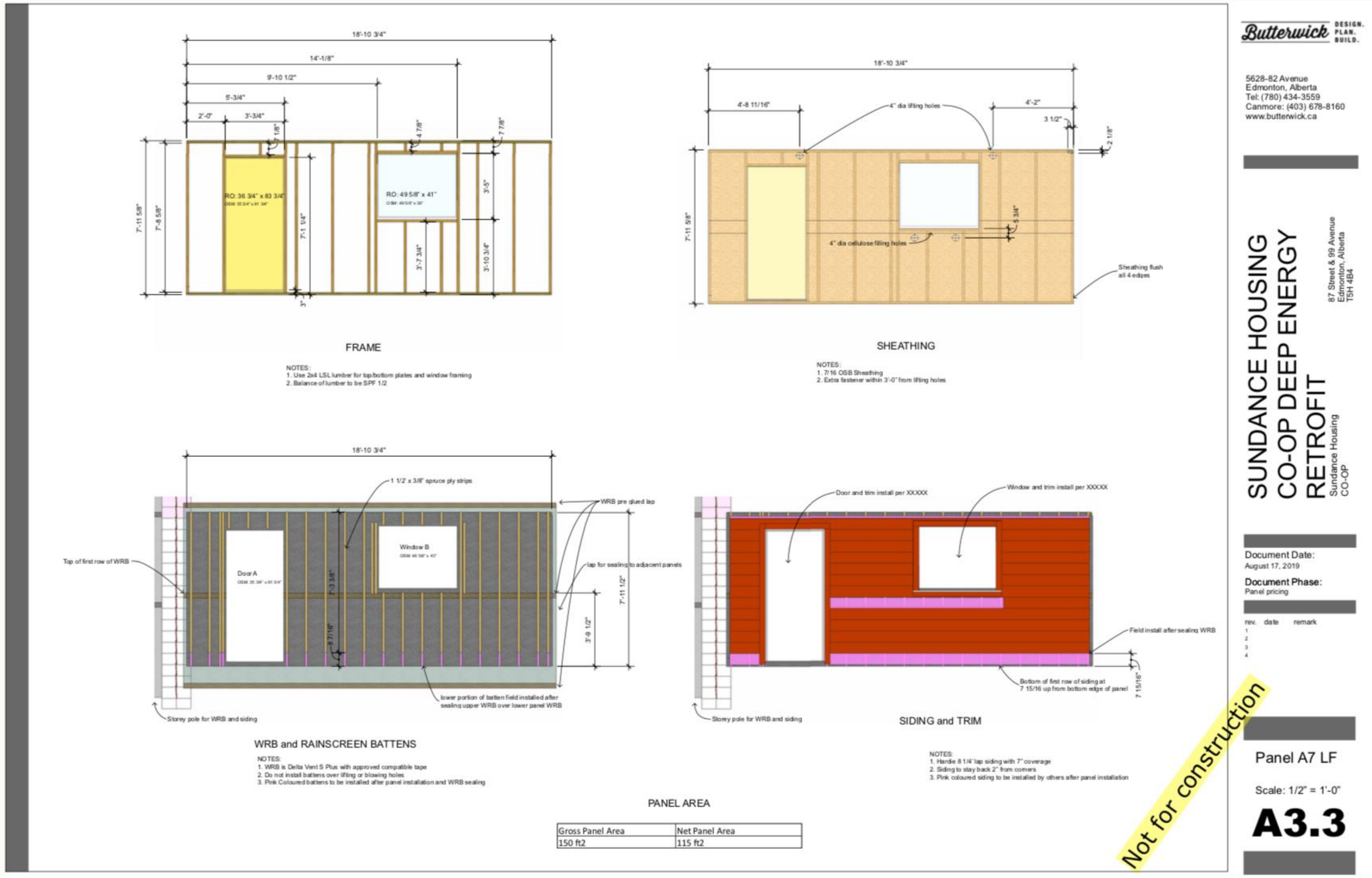
Building Capture: Photogrammetry (Laser)



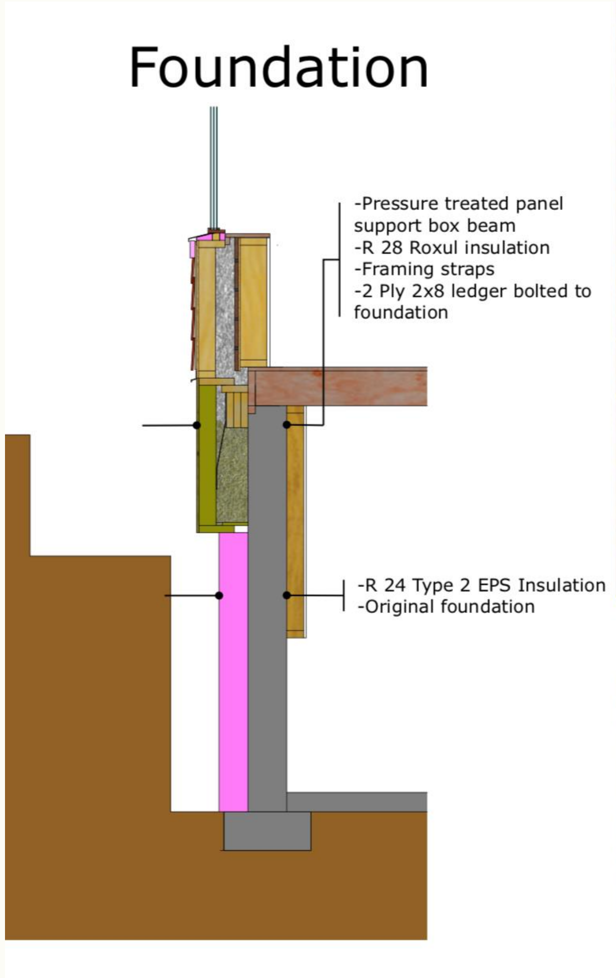
Model from a Million Cloud Points



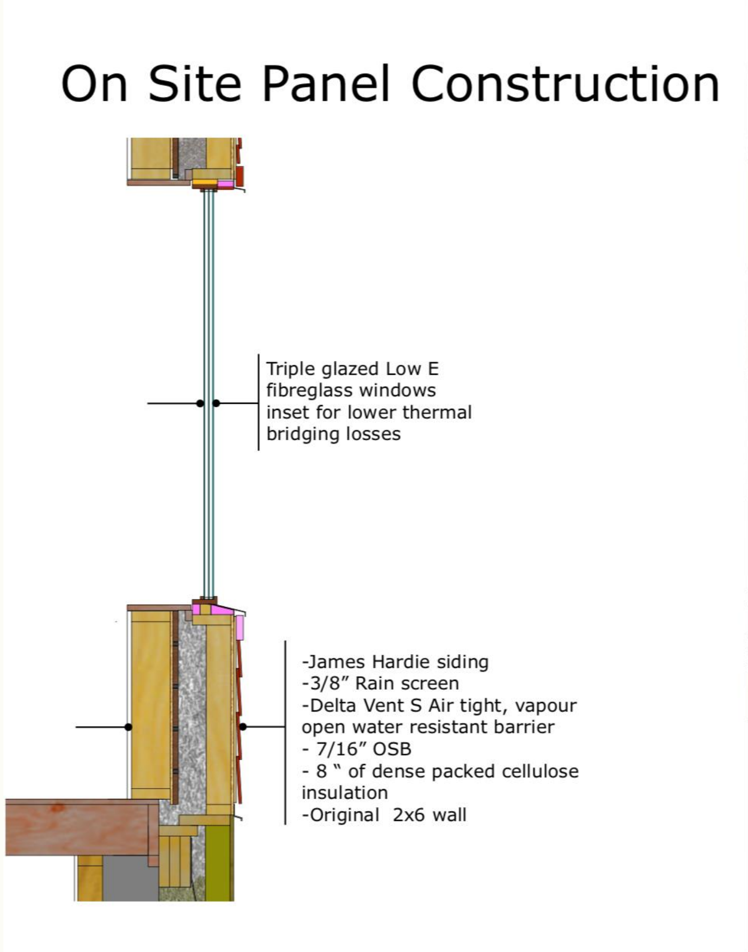
Drawings Map Each Wall Section

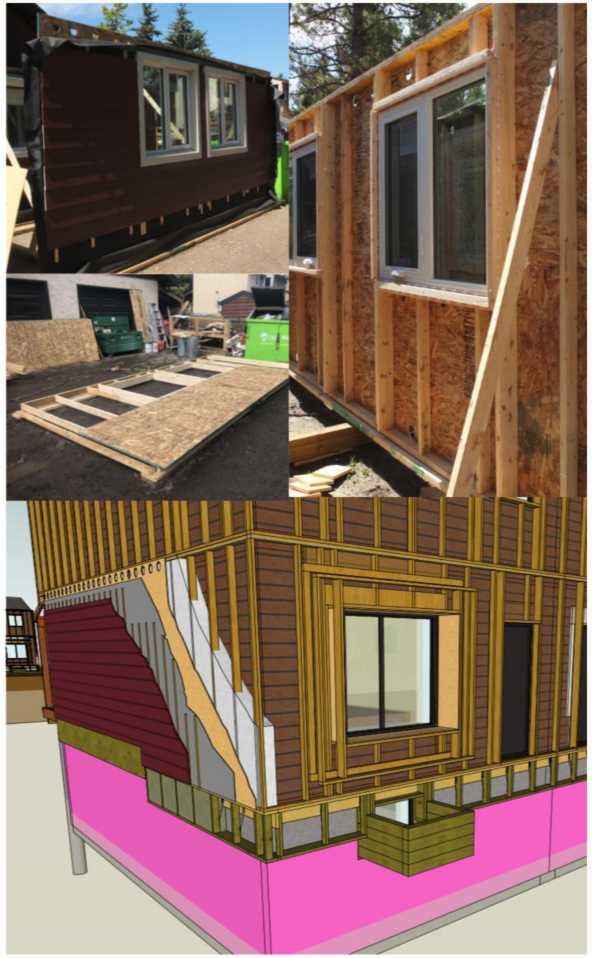


Real-world Projects: Foundations & Roofs



Stand-off Panel Construction – On-site

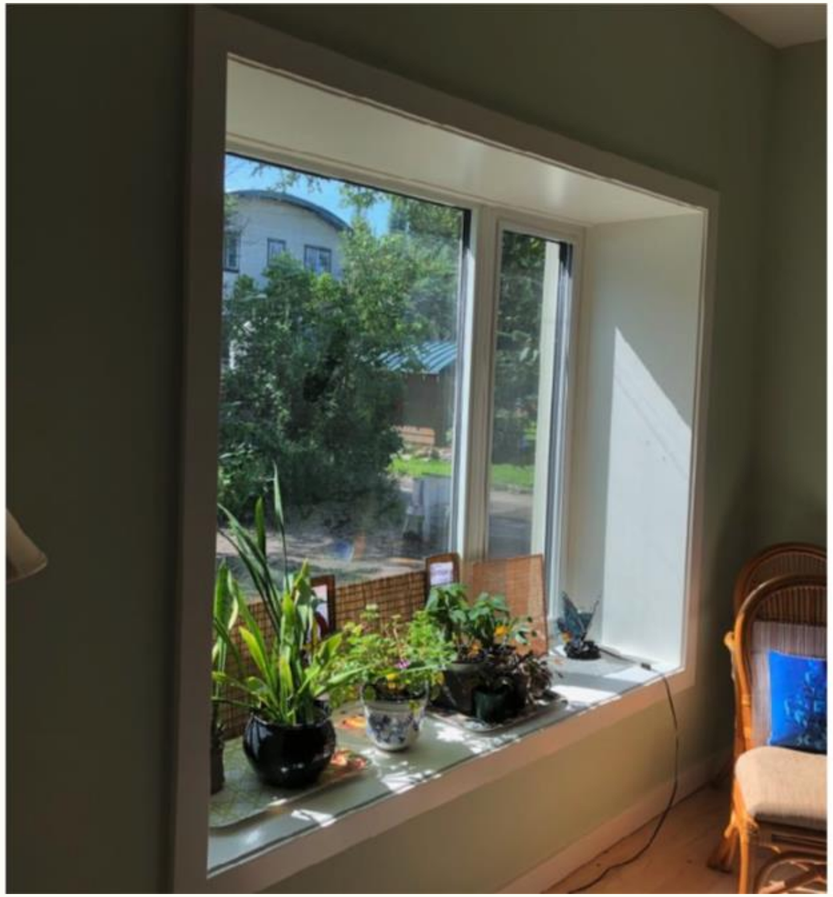




Installation time!

Finished Pilot Project

Interior: Deep Walls = Deep Sills!



KEY: Run the numbers

- Energy Savings Possible
- GHG Reduction Possible
- Financial Package
  - Property owners look at long range
  - PACE could encourage

Possible How To in Canada: Basic Panel Shop

32’ x 32’ x 12’ high

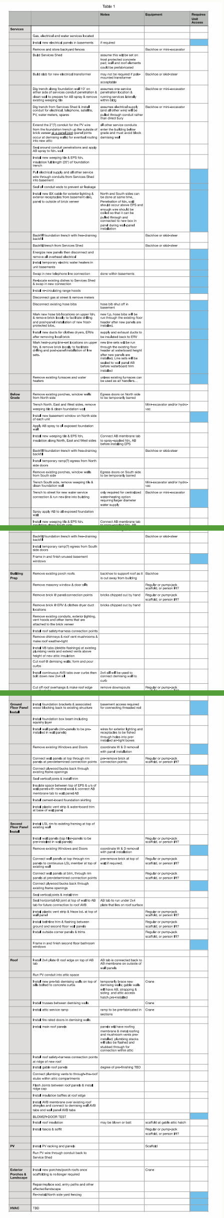
Concrete Slab

2x20’ Cont. Storage

10’ x 18’ Rolling Table

Lifting Rail w/ Chain Hoist

Construction Process



		Notes	Equipment	Requires Unit Access
Services				
	Gas, electrical and water services located			
	Install new weeping tile & EPS fdn. insulation along South side	Connect AB membrane tab to spray-applied fdn. AB before installing EPS		
	Backfill foundation trench with free-draining backfill		Backhoe or skid-steer	
	Install temporary ramp(?) egress from South side doors			
	Frame in and finish unused basement windows			
Building Prep	Remove existing porch roofs	backhoe to support roof as it is cut away from building	Backhoe	
	Remove masonry window & door sills		Regular or pump-jack scaffold, or person lift?	
	Remove brick @ panel connection points	bricks chipped out by hand	Regular or pump-jack scaffold, or person lift?	
	Remove brick @ ERV & clothes dryer duct locations	bricks chipped out by hand		
	Remove existing conduits, exterior lighting, vent hoods and other items that are attached to the brick veneer			
	Install roof safety-harness connection points			
	Remove chimneys & roof vent mushrooms & make roof weather-tight			
	Install VB tabs (dektite flashings) at existing plumbing vents and extend vents above height of new attic insulation			
	Cut roof @ demising walls; form and pour curbs			
	Install continuous AVB tabs over curbs then bolt down new 2x4 sill	2x4 sill will be used to connect demising wall to curb		
	Cut off roof overhangs & make roof edge weathertight	remove downspouts	Regular or pump-jack scaffold, or person lift?	

Challenges

- Building Capture
- Local skilled labour
- Municipal champion for PACE

Financing Deep Energy Retrofits

Always the challenge…change the investment horizon and it works

Code v. NZE 30 yr costs (new const)

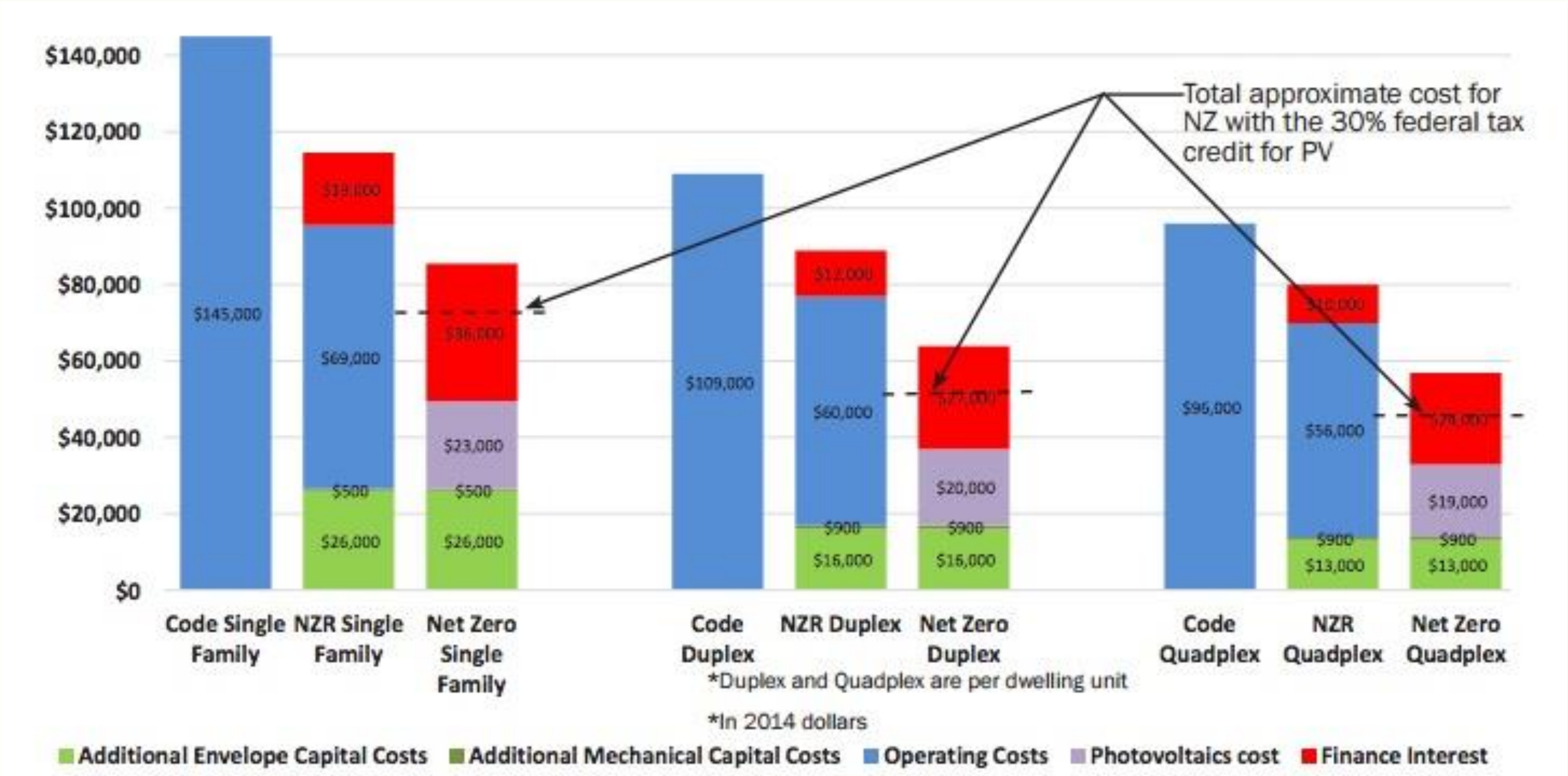


Figure 1.1: Residential 30-year capital, operating, and finance costs

- Overall cost savings in first year and every year after

source: Efficiency Vermont

Take it off the backs of property owners

Treat Energy Efficient Upgrades/GHG Reduction

as **INFRASTRUCTURE**

To amortize improvements over a long period

- Municipalities can benefit from stable tax base
- Avoid locking in emissions
- Avoid short-circuiting appropriate upgrades
- Infrastructure vs. individual responsibility

Who makes the rules?

- Provincial Government
- Municipal Government Act (or City Charter)
  - Allows municipality to take on PACE or LIC
  - Defines what is allowed – energy, water, C-CAPS
- Municipal Government
  - Bylaws
  - Risk Thresholds
  - Program Financing Caps

Definitions

PACE

Property Assessed Clean Energy

LIC

Local Improvement Charge

PACE

- PACE originated in the USA in 2008
- Energy Efficiency/Renewable Energy
- Financed like infrastructure
- Not tied to federal funding programs
- PACE **voluntarily** added to property tax bill
- Remains with the property not the occupant upon sale

Local Improvement Charge (LIC)

- Funding for infrastructure projects
- Gov't issues bond
- Municipality amortizes capital costs
- Fixed annual charge on a property for X years
- **Addition** to property taxes (not voluntary)
- Lien stays with property

PACE in US - Since 2008

- Over 200,000 homeowners
- +$5 billion in EE & other improvements
- Enabled through state legislation
- Authorized at the local government level
- Municipalities:
  - Directly administer residential PACE programs

    OR
  - Develop public-private partnerships w/**PACE providers**

PACE Enabled via Legislation

The Municipality

1. Assesses the loan as a Local Improvement Charge on Property tax bill
2. The municipality acts as a ‘conduit’

Tax account collects from homeowner

passes payment

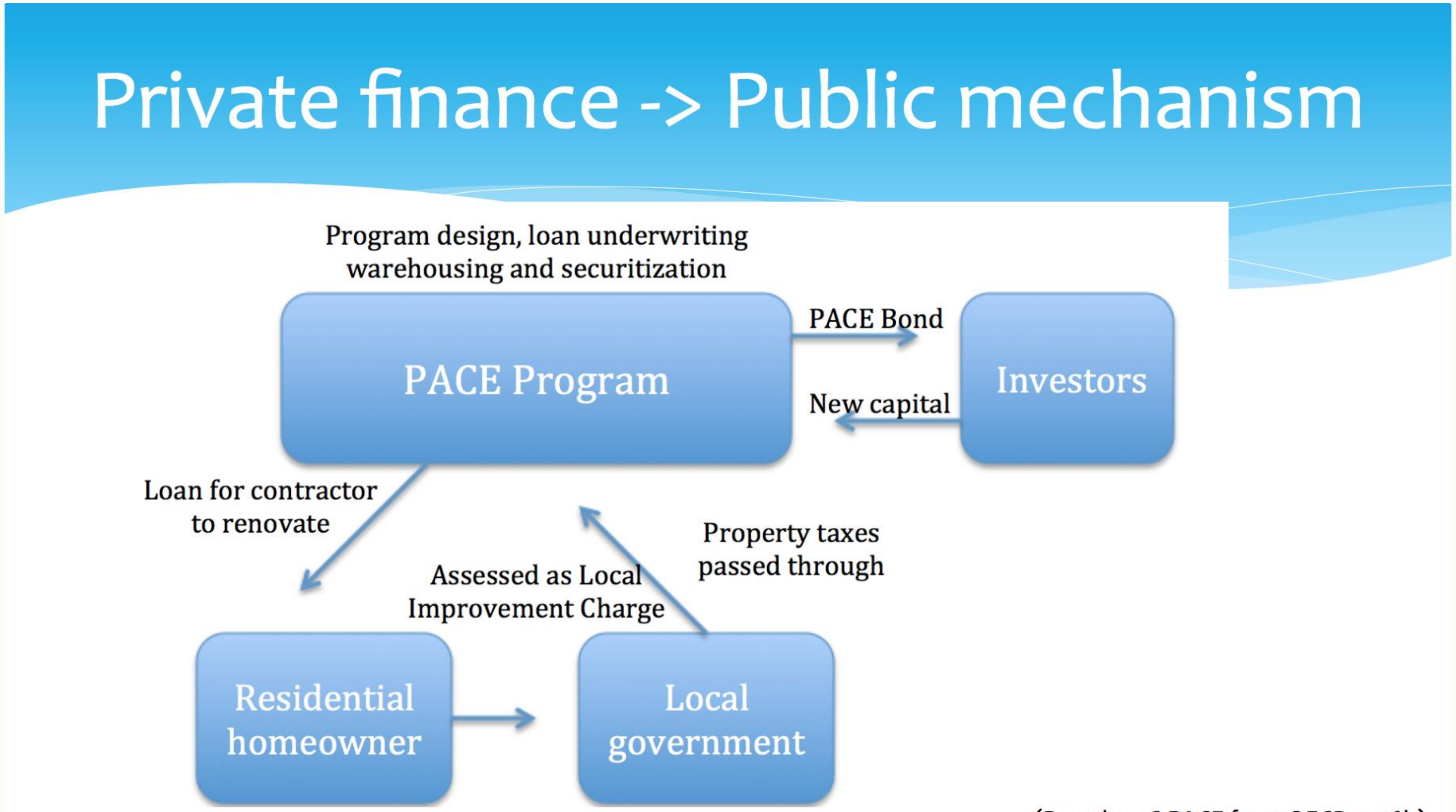
To PACE program funders

How it works – Funding Sources

- PACE program accepts loan payments from municipality
- Loans warehoused together and securitized into bonds

- PACE bonds are safe investments:
  - Few defaults on property taxes
  - Property is used as collateral
  - Cash purchases provide new capital for new PACE loans

Financing Map



(Based on C-PACE from OECD 2016b)

How it works - Homeowner

- Repayable before all other liens
- Assessed property taxes & home equity
- No credit score required for approval
- Does **NOT** add to household debt
- Uses property as collateral for repayment
- Mortgage lenders approached for permission

PACE Programs in Canada

Nova Scotia

1. Halifax Regional Municipality
2. Guysborough County
3. Town of Bridgewater
4. Municipality & District of Lunenburg
5. Town of Digby
6. Town of Yarmouth
7. Town of Shelburne
8. Town of Barrington
9. Cumberland County
10. Town of Amherst
11. Colchester County
12. Town of Berwick
13. Town of Inverness
14. Richmond County (2014)

Rest of Canada

1. Toronto
2. Quebec
3. Quebec
4. Quebec
5. Vancouver

Department of Energy & Mines offers start-up money for PACE

Canadianization of Energiesprong?

PEER Technical Solutions - Researched & Piloted Now

PLUS

PACE/LIC financing that puts projects on long investment horizon