CHBA NET ZERO HOME LABELLING PROGRAM
Summary Report - Pilot and Year 1

This report details the assemblies and technologies used in the homes qualifying under the Net Zero Home Labelling Program Pilot and in Year 1, and the resulting performance metrics they achieved. It documents the lessons learned, focussing on the challenges the builders faced and the opportunities and needs related to achieving higher levels of energy performance in Canadian homes.

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1.0 INTRODUCTION

Founded in 1943, **the Canadian Home Builders' Association (CHBA) is the voice of Canada's residential construction industry**. The residential construction industry is a vital part of Canada's economy in every community across the country:

- Directly and indirectly supporting more than 1.2 million jobs
- Paying more than $73.6 billion in wages
- Generating $150.9 billion in annual economic activity

The CHBA is one association serving our members at three levels. Membership with a local Home Builders' Association (HBA) automatically provides membership at the provincial and national levels. The national office is in Ottawa, Ontario. Representing more than 9,000 companies across Canada, CHBA members include home builders, renovators, land developers, trade contractors, product and material manufacturers, building product suppliers, lending institutions, warranty and insurance providers, service professionals, municipalities and more.

On April 3, 2014, the CHBA Board of Directors approved the motion to establish a Net Zero Energy Housing Council (NZC). The NZC supports innovation in the industry with the goal of creating a market advantage for builder and renovator members pursuing net zero energy performance. The Council's work will help the industry meet the housing aspirations of Canadians and renew Canadian leadership in high-performance housing. More information can be found at www.chba.ca/nzc.

On September 29, 2015, CHBA launched a Pilot of the Association's Net Zero Energy (NZE) Labelling Program—continuing CHBA's long history in leading energy efficiency in residential construction. **The pilot was used to validate both administrative and technical details prior to launching "version 1" of the Program on May 2, 2017. More information can be found at** www.chba.ca/nze **and** www.NetZeroHome.com**.**

The CHBA Net Zero Home Labelling Program (the Program) is a Program established under the CHBA Net Zero Energy Housing Council (NZC) to recognize builders and service professionals who commit to its Administrative Requirements. The Program recognizes houses that these builders and service professionals attest meet the Technical Requirements. Alongside marketing and communication, education and finance initiatives, the Program remains one of the four Net Zero Energy Housing Council key priorities established to combat industry-identified barriers to Net Zero/Ready Home construction.

1.1 Purpose

The purpose of this report is to support CHBA members' voluntary adoption of Net Zero Energy (NZE) Housing by building awareness and knowledge via the consolidation and sharing of information.

The desired outcomes of this report are to:

1. Communicate the activity of the CHBA Net Zero Home Labelling Program from the pilot and Year 1,
2. Share information about the construction assemblies, technologies, and performance of the homes,
3. Support current and future research regarding net zero/ready construction, and
4. Serve as a template for future reports.

2.0 DEFINITIONS

The Program terminology is provided below.

CHBA Qualified Net Zero Home ("Net Zero Home")
A CHBA Qualified Net Zero Home that is labelled under the Program is a home that is recognized by CHBA, on the basis of the attestations by the builder/renovator, its Qualified Net Zero Service Organization and a Qualified Net Zero Energy Advisor to have met the Technical Requirements, including the energy performance rating using Natural Resources Canada's (NRCan's) EnerGuide Rating System (ERS) to be designed, modelled and constructed to produce as much energy (from on-site renewable energy sources) as it consumes, on an annual basis.

CHBA Qualified Net Zero Ready Home ("Net Zero Ready Home")
A CHBA Qualified Net Zero Ready Home that is labelled under the Program is a home that is recognized by CHBA, on the basis of the attestations by the builder/renovator, its Qualified Net Zero Service Organization and a Qualified Net Zero Energy Advisor to have met the Technical Requirements, including the energy performance rating using NRCan's EnerGuide Rating System (ERS), to be a Net Zero Home that has a renewable energy system designed for it that will allow it to achieve Net Zero Home performance, but the renewable energy system is not yet installed.

Building Envelope / Space Cooling (BE/SC) Evaluation Tool
This spreadsheet tool tracks and calculates the elements of the home's design to document Program compliance.

3.0 PROGRAM TO-DATE

This section provides an overall evaluation of Program activity and uptake as of April 30, 2018, which includes participants and homes in the Pilot and Year 1 of the Program.

The Pilot September 29, 2015 – December 2, 2016
Year 1 May 2, 2017 – April 30, 2018

The differences in Program Requirements for qualifying a home in the Pilot vs. Year 1 can be found in **Appendix A and B**. The Pilot and Year 1 both used the same energy modelling software, HOT2000, but different versions (v10.51 and v11 respectively).

3.1 Uptake and Capacity

Currently there are four CHBA Net Zero Qualifications for participants:

1. CHBA Qualified Net Zero Service Organization ("SO")
2. CHBA Qualified Net Zero Energy Advisor ("EA"),
3. CHBA Qualified Net Zero Trainer ("Trainer"), and
4. CHBA Qualified Builder/Renovator ("Builder/Renovator").

The requirements for participants to become qualified under the Program can be found on the CHBA website at www.chba.ca/nze. **As of April 30, 2018, there were 12 SOs, 9 EAs, 2 Trainers, and 19 Builders that had been qualified under the Program.** Qualified SOs, EAs and Trainers can be found on the CHBA website at www.chba.ca/nze and Qualified Builders can be found at www.NetZeroHome.com, along with any additional participants that have become qualified since May 1, 2018.

TRAINING

Builders/Renovators, EAs, and Trainers are required to successfully complete the CHBA Net Zero Building Science / Builder Training offered through a Qualified Net Zero SO and delivered by a Qualified Net Zero Trainer. Additionally, EAs and Trainers are required to successfully complete CHBA Net Zero Energy Advisor (EA) Training offered through a Qualified Net Zero SO and delivered by a Qualified Net Zero Trainer.

Table 1: Number of Trained Participants by Province as of April 30, 2018

Province	Pilot		Year 1		Total	
	Builder	EA	Builder	EA	Builder	EA
British Columbia	32	0	81	10	113	10
Alberta	34	0	24	1	58	1
Manitoba	22	0	0	0	22	0
Ontario	138	22[1]	35	21	173	43
Nova Scotia	36	0	0	0	36	0
			Subtotal		**402**	**54**
			Total		456	

Of the 402 successful Building Science / Builder Training participants, 264 were builders, 45 were EAs, and the remaining 93 were other industry professionals (suppliers, manufacturers, architects, engineers, etc.) or Government.

Of the 54 successful Energy Advisor Training participants, 42 were EAs, 8 were from NRCan and the remaining 4 were other industry professionals.

[1] *The inaugural Net Zero Energy Advisor training for the Pilot held at the CHBA National office in Ottawa with participants from across Canada.*

3.2 Number of Homes

The total number of Net Zero/Ready Homes labelled under the Program as of April 30, 2018 is 47.

Table 2: Number of Homes by Net Zero or Net Zero Ready qualification in the Pilot and Year 1

Label	Pilot	Year 1	Total
Net Zero Home	26	9	35
Net Zero Ready Home	2	10	12
Total	**28**	**19**	**47**

The breakout below by climate zone provides context to the report. **Many of the observations made in this report are based on single-family detached housing in climate zones 5, 6, and 7a** simply because there are few homes in the other categories and/or climate zones.

Table 3: Distribution of the homes by climate zone in the Pilot and Year 1

Type of House by Climate Zone	Pilot				Year 1				Total			
	4	5	6	7a	4	5	6	7a	4	5	6	7a
Single-family detached	0	3	8	7	1	4	8	3	**1**	**7**	**16**	**10**
Double/semi-detached	0	0	0	0	0	0	3	0	0	0	**3**	0
Row-house (end unit)	0	0	8	0	0	0	0	0	0	0	**8**	0
Row-house (middle unit)	0	0	2	0	0	0	0	0	0	0	**2**	0
								Subtotal	1	7	29	10
								Total	47			

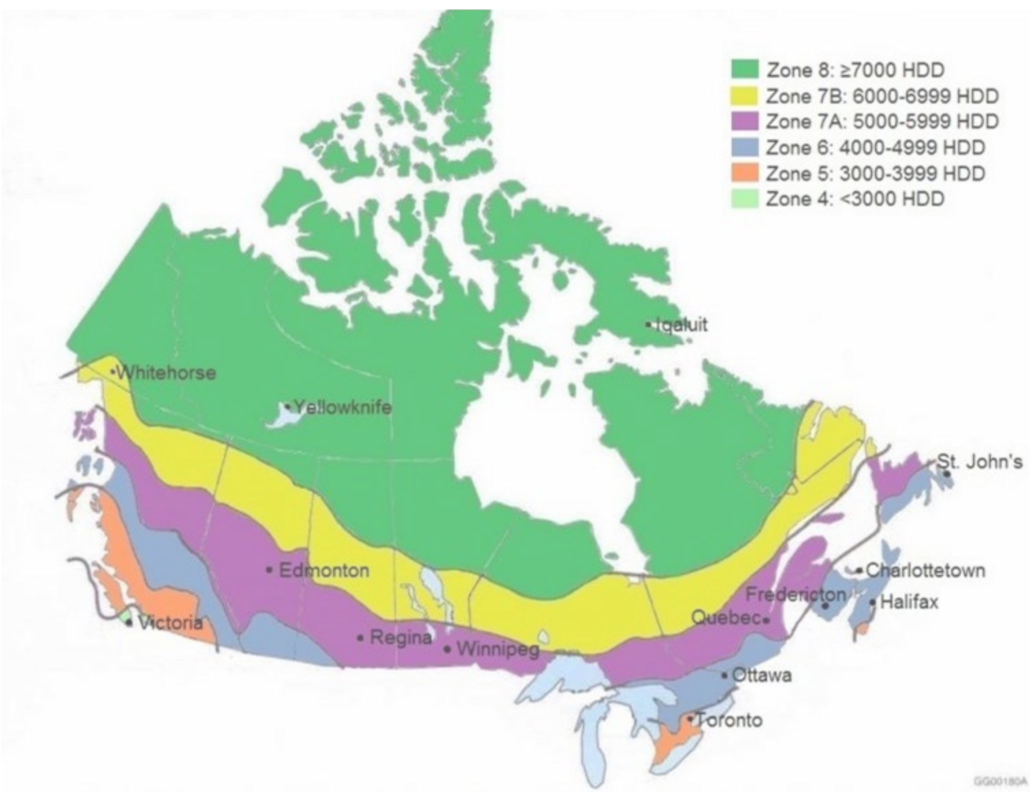


Figure 1: Climate Zone Map of Canada (source: Natural Resource Council of Canada, colour coding by NAIMA Canada).

4.0 ENVELOPE

This section explores the envelope assemblies used by the 47 homes labelled under the Pilot and Year 1. A summary of the individual project performance values can be found in **Appendix C**.

Table 4 summarizes the project types and their average thermal resistance values. The project types are:

- Single-family detached homes in the Pilot (SFD-Pilot) [2],
- Single-family detached homes in year 1 (SFD-Y1) [2],
- Double/semi-detached homes (Double),
- 4-unit townhome (TH),
- 6-Plex,
- Luxury single-family detached home (Luxury), and
- First Nations Health and Wellness Centre (FN H&W).

Table 4: Building envelope performance summary by project type and climate zone

Project Type	Climate Zone(s)	# of Labels	Avg. Area m^2	Avg. Area ft^2	Main Wall Eff. **Avg. RSI [R]** Min. RSI [R] Max. RSI [R]	Ceiling Eff. **Avg. RSI [R]** Min. RSI [R] Max. RSI [R]	Basement Wall Eff. **Avg. RSI [R]** Min. RSI [R] Max. RSI [R]	Slab Eff. **Avg. RSI [R]** Min. RSI [R] Max. RSI [R]
SFD-Pilot[2]	5,6,7a	18	272	2,925	**6.36 [36.1]** 5.33 [30.3] 8.23 [46.7]	**10.61 [60.2]** 8.39 [47.6] 14.9 [84.6]	**5.59 [31.8]** 3.72 [21.1] 7.4 [42.0]	**2.39 [13.5]** 1.76 [10.0] 3.52 [20.0]
SFD-Y1[2]	4,5,6,7a	14	384	4,129	**5.31 [30.2]** 4.05 [23.0] 6.69 [38.0]	**10.85 [61.6]** 8.35 [47.4] 13.97 [79.3]	**4.97 [28.2]** 3.81 [21.6] 7.45 [42.3]	**2.63 [14.9]** 1.23 [7.0] 5.53 [31.4]
Double	6	3	283	3,048	**4.16 [23.6]** 4.05 [23.0] 4.25 [24.1]	**10.78 [61.2]** 10.75 [61.0] 10.79 [61.3]	**4.41 [25.0]** 4.16 [23.6] 4.91 [27.9]	**1.95 [11.1]** 1.95 [11.1] 1.95 [11.1]
TH	6	4	201	2,161	**4.88 [27.7]** 4.78 [27.1] 5.03 [28.6]	**10.57 [60.0]** 10.57 [60.0] 10.57 [60.0]	**5.58 [31.7]** 5.53 [31.4] 5.62 [31.9]	**1.76 [10.0]** 1.76 [10.0] 1.76 [10.0]
6-Plex	6	6	101	1,084	**4.80 [27.3]** 4.66 [26.5] 4.89 [27.8]	**8.22 [46.7]** 6.27 [35.6] 10.35 [58.8]	N/A	N/A
Luxury	6	1	797	8,579	**5.37 [30.5]** 5.37 [30.5] 5.37 [30.5]	**10.31 [58.5]** 10.31 [58.5] 10.31 [58.5]	**5.88 [33.4]** 5.88 [33.4] 5.88 [33.4]	**1.76 [10.0]** 1.76 [10.0] 1.76 [10.0]
FN H&W	6	1	1,062	11,436	**5.87 [33.3]** 5.87 [33.3] 5.87 [33.3]	**7.15 [40.6]** 7.15 [40.6] 7.15 [40.6]	**4.07 [23.1]** 4.07 [23.1] 4.07 [23.1]	**2.64 [15.0]** 2.64 [15.0] 2.64 [15.0]
	Total:	47						

[2] *Throughout section 4.0 Envelope "SFD" **includes** both the Luxury and the FN H&W projects, except for Table 4 where they are separated.*

4.1 Above-Grade Wall Assemblies

- Traditional wood-frame construction: 83% (39/47)
  - 2x6: 79% (31/39)
  - 2x8: 21% (8/39)
  - Exterior insulation: 100% (39/39)
    - *1" XPS IV: 13% (5/39)*
    - *2" XPS IV: 82% (32/39)*
    - *3" XPS IV: 3% (1/39)*
    - *3" EPS II: 3% (1/39)*
  - Batt cavity insulation: 97% (38/39)
  - Spray foam / batt: 3% (1/39)
- Double-stud construction: 9% (4/47)
- Insulated concrete forms (ICF): 6% (3/47)
- Composite wood joist wall system: 2% (1/47)

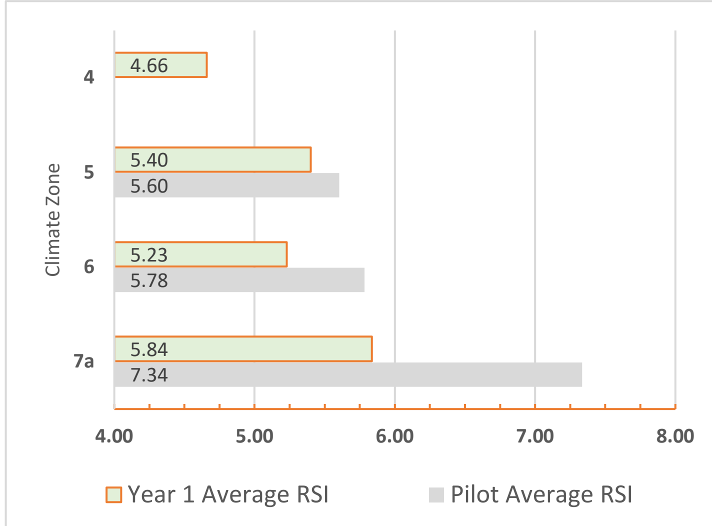


Figure 2: Above-grade wall RSI_{eff} by climate zone for the 34 SFD homes

Table 5: Above-grade wall assemblies (all)

Framing	Spacing	Cavity Insulation Type	Additional Insulation Thickness	Additional Insulation	Qty. Pilot	Qty. Year 1	Qty. Total
2x6	16"	Batt	1"	XPS IV (exterior)	0	1	1
			2"		11	4	15
	19"		2"		5	0	5
	24"		1"		0	4	4
			2"		2	3	5
			3"		1	0	1
2x8	16"	Spray foam / Batt	2"	XPS IV (exterior)	0	1	1
		Batt			1	0	1
	24"		2"		5	0	5
			3"	EPS II (exterior)	0	1	1
Double-stud (2x4 / 2x4)	16" / 16"	Loose/Blown Fill	2.5"	Loose/blown fill (between stud walls)	0	1	1
		Batt	3.5"	Batt (between stud walls)	1	0	1
	24" / 24"	Loose/Blown Fill	2.25"	Low density spray foam (between stud walls)	0	1	1
			5"	Loose/blown cellulose (between stud walls)	1	0	1
ICF (5.5")	N/A	N/A	N/A	EPS II (2-layers, 1 per side)	0	2	2
ICF (8")	N/A	N/A	N/A	XPS IV (2-layers, 1 per side)	0	1	1
Composite Wood Joist	16"	EPS II	12"	N/A	1	0	1
				Totals:	28	19	47

Table 6: Frequently used above-grade wall assemblies in each climate zone

Climate Zone	Wall Assembly	# of Labels using Wall Assembly	Avg. RSI_{eff} of Wall Assembly	Avg. R_{eff} of Wall Assembly
5	2x6 @ 24" O.C. c/w 5.5" cavity batt insulation + 2" XPS IV exterior insulation	4	5.44	30.88
6	2x8 @ 24" O.C. c/w 7.25" cavity batt insulation + 2" XPS IV exterior insulation	4	5.90	33.52
	2x6 @ 16" O.C. c/w 5.5" cavity batt insulation + 2" XPS IV exterior insulation	13	4.94	28.03
7a	2x6 @ 19" O.C. c/w 5.5" cavity batt insulation + 2" XPS IV exterior insulation	5	7.31	41.49

4.2 Ceiling Assemblies

- Not specified[3]: 4% (2/47)
- No ceilings[4]: 9% (4/47)
- Has ceilings: 87% (41/47)

Framing
- 2x4 member @ 24" O.C. 88% (35/41)

First Insulation Layer
- Blown fibreglass: 54% (22/41)
- Blown cellulose: 32% (13/41)
- Batt: 10% (4/41)
- Blown mineral fibre: 2% (1/41)
- Spray foam: 2% (1/41)

Second Insulation Layer
- None: 90% (37/41)
- 2" XPS IV: 7% (3/41)
- 1" EPS I: 2% (1/41)

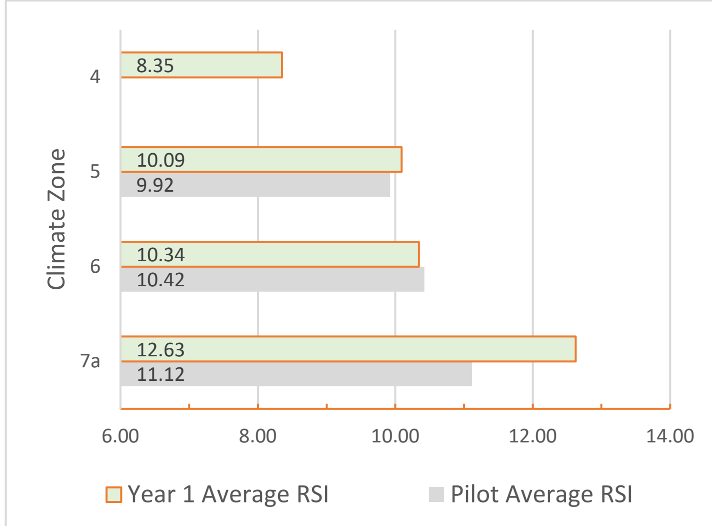


Figure 3: Ceiling RSI$_{eff}$ by climate zone of the 34 SFD homes

Table 7: Ceiling assemblies (all)

Framing			First Insulation Layer		Second Insulation Layer		Qty. Pilot	Qty. Year 1	Qty. Total
Type	Size	Spacing	Type	Thickness	Type	Thickness			
Attic Truss	2x3"	24"	Blown Cellulose	21.5"	N/A		0	1	1
	2x4"		Batt	22"			1	2	3
			Blown Cellulose	20"			0	4	4
				20"	XPS IV	2"	0	1	1
				24"	N/A		0	1	1
			Blown Fibreglass	20"			12	0	12
				23.5"			1	0	1
			Blown Mineral Fibre	14.5"			0	1	1
	2x48"		Blown Cellulose	26"			1	0	1
Wood-Frame	2x4"	24"	Blown Cellulose	20"	N/A		0	2	2
				20"	EPS I	1"	0	1	1
				24"	XPS IV	2"	0	1	1
			Blown Fibreglass	22"	N/A		7	0	7
				23.5"			0	2	2
	2x8"	19"	Blown Cellulose	20"			0	1	1
	2x10"	16"	Spray Foam	12.75"			0	1	1
Composite Wood Joist	2x12"	16"	Batt	12"	XPS IV	2"	0	1	1
None[4]	N/A						4	0	4
t.b.c.[3]	N/A						2	0	2
						Totals:	28	19	47

Table 8: Frequently used ceiling assemblies in each climate zone

Climate Zone	Ceiling Assembly	# of Labels using Ceiling Assembly	Avg. RSIeff of Ceiling Assembly	Avg. Reff of Ceiling Assembly
5	2x4" attic truss @ 24" O.C. c/w 20" blown cellulose	3	9.94	56.46
6	2x4" attic truss @ 24" O.C. c/w 20" blown fibreglass	7	10.49	59.56
	2x4" wood-frame @ 24" O.C. c/w 22" blown fibreglass	5	10.18	57.78
7a	2x4" attic truss @ 24" O.C. c/w 20" blown fibreglass	5	9.77	55.48

[3] *"User-defined input" modelling in HOT2000 (assembly not specified)*
[4] *Four lower-level units in the stacked six-plex*

4.3 Basement Assemblies

- No basement: 15% (7/47)
- Basement: 85% (40/47)
  - BCCB_4: 53% (21/40)
  - BCIB_4: 45% (18/40)
  - BCIB_1: 3% (1/40)

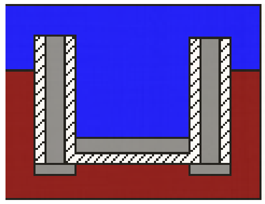


Figure 4: BCCB_4

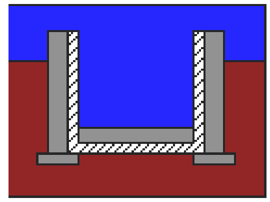


Figure 5: BCIB_4

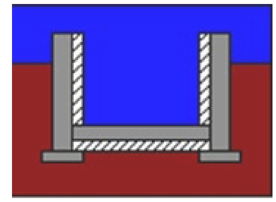


Figure 6: BCIB_1

Table 9: Basement assemblies (all)

Basement Assembly	Construction		Insulation					Thermal break between wall & slab	Qty. Pilot	Qty. Year 1	Qty. Total
	Wall	Floor	Wall Coverage (Interior)	Wall Coverage (Exterior)	Floor (Location)	Floor (Coverage)	Under footings?				
BCCB_4	Concrete	Concrete	Full	Full	Below Slab	Full	No	Yes	6	15	21
BCIB_4				None					16	2	18
BCIB_1								No	0	1	1
None	N/A								6	1	7
								Totals:	28	19	47

Table 10: Frequently used basement assemblies in each climate zone

Climate Zone	Basement Assembly	# of Labels using Basement Assembly	Avg. RSIeff of Foundation Wall	Avg. Reff of Foundation Wall	Avg. RSIeff of Slab	Avg. Reff of Slab
5	BCCB_4	4	4.91	27.74	1.85	10.50
	BCIB_4	3	4.53	24.08	1.88	10.66
6	BCCB_4	7	4.63	26.27	2.28	12.93
	BCIB_4	14	5.10	29.00	1.85	10.50
7a	BCCB_4	5	6.62	37.60	3.17	18.00

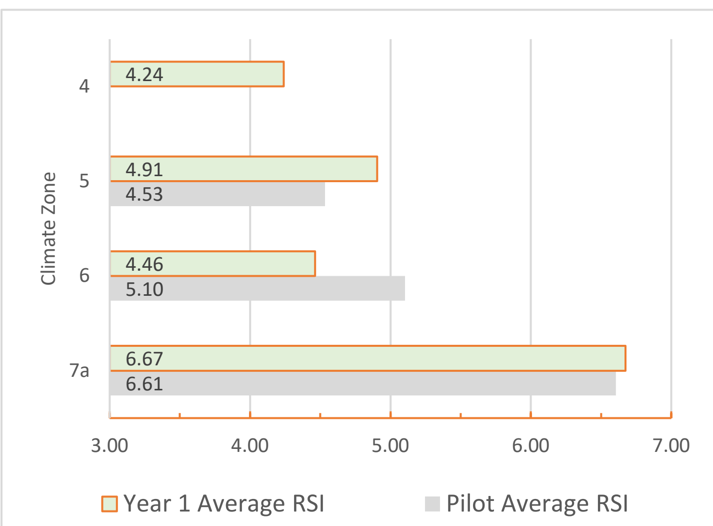


Figure 7: Foundation Wall RSI_{eff} by climate zone of the 34 SFD homes

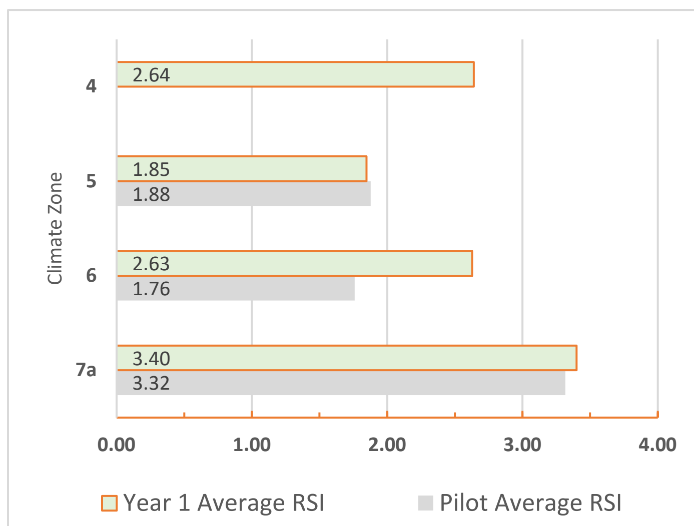


Figure 8: Slab RSI_{eff} by climate zone of the 34 SFD homes

4.4 Windows / Doors

- Double-Pane, Low-E Window: 4% (2/47)
- Triple-Pane, Low-E Window: 91% (43/47)
- Window fill identified: 43% (20/47)
  - Argon: 90% (18/20)
- Window spacer identified: 34% (16/47)
  - Insulating: 94% (15/16)

Table 11: Doors (all)

Door Type	Qty. Pilot	Qty. Year 1	Qty. Total
Fiberglass polyurethane core	11	1	12
Steel polyurethane core	10	0	10
Steel polystyrene core	6	2	8
Fibreglass plostyrene core	1	0	1
Steel Medium density spray foam core	0	11	11
Fibreglass Medium density spray foam core	0	4	4
t.b.c.[3]	0	1	1
Totals:	28	19	47

Table 12: Frequently used doors in each climate zone

Climate Zone	Door Type	# of Labels Using Door
5	Steel polyurethane core	3
6	Steel polyurethane core	10
	Steel Medium density spray foam core	9
	Fiberglass polyurethane core	5
	Steel polystyrene core	5
7a	Fiberglass polyurethane core	7

Table 13: Windows (all)

Window Type	Qty. Pilot	Qty. Year 1	Qty. Total
Triple-Pane, Low-E Coating	27	16	43
Double-Pane, Low-E Coating	1	1	2
t.b.c.[3]	0	2	2
Totals:	28	19	47

Table 14: Frequently used windows in each climate zone

Climate Zone	Window Type	# of Labels Using Window
5	Triple-Pane, Low-E Coating	6
6	Triple-Pane, Low-E Coating	27
7a	Triple-Pane, Low-E Coating	7

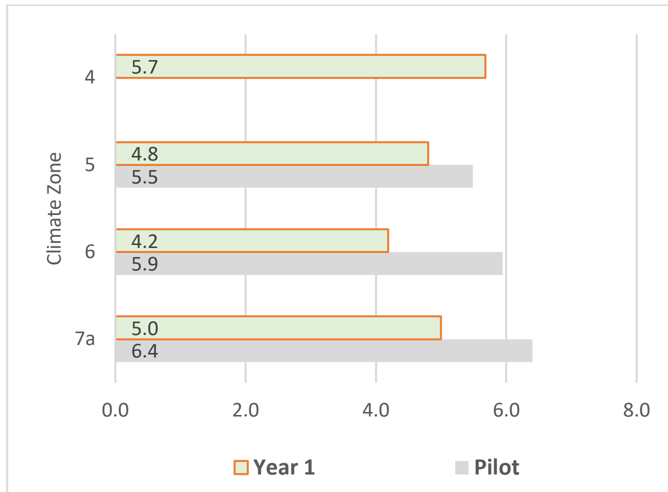


Figure 5: Average R-Value by climate zone

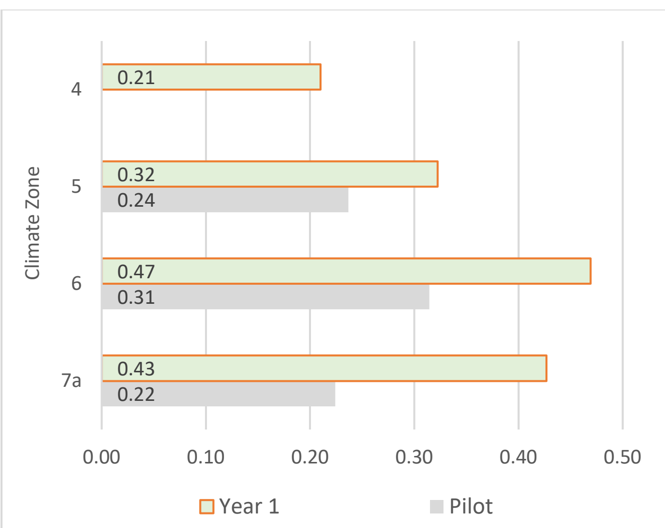


Figure 4: Average SHGC by climate zone

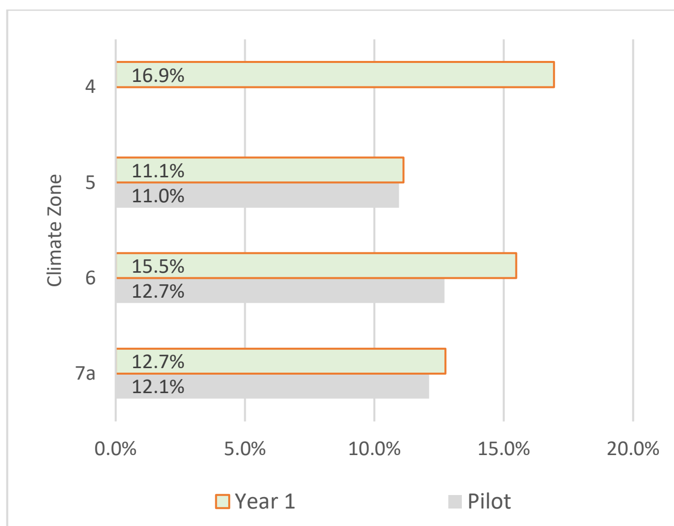


Figure 6: Window-to-wall ratio (%) by climate zone

5.0 MECHANICALS

This section explores the mechanical systems in the Pilot and Year 1 homes relating to

- space heating,
- hot water heating, and
- ventilation.

Space cooling was not included in this report because only three homes in the Pilot and Year 1 did not elect to install an air-source heat pump and therefore only those homes were required to install or model a space-cooling system. Air-source heat pumps provide both space heating as well as space cooling and the homes that installed air-source heat pumps would not have required stand-alone space-cooling systems.

A list of the makes and models of the products used in the homes can be found in **Appendix D**.

5.1 Space Heating

- **All electric source:** 57% (27/**47**) *Decreased from representing 71% (20/28) in the Pilot to 37% (7/19) in Year 1.*
- **All natural gas source:** 4% (2/**47**) *Increased from representing none in the Pilot to 11% (2/19) in Year 1.*
- **Dual source:** 38% (18/**47**) *Increased from representing 29% (8/28) in the Pilot to 53% (10/19) in Year 1.*

Note: *Only 2/47 (4%) of homes did not use an electric heat pump. (All 28 homes in the Pilot used an air-source heat pump.)*

Table 15: Space-heating configuration (all)

Primary Heating System	Secondary Heating System	Qty. Pilot	Qty. Year 1	Qty. Total
N/A	Condensing Furnace (Natural Gas)	0	2	2
Air-Source Heat Pump	Baseboard/Hydronic/Plenum(duct) heaters (Electric)	9	1	10
	Condensing Furnace (Natural Gas)	8	9	17
	Condensing Furnace (Propane)	0	1	1
	Furnace (Electric)	11	5	16
Ground-Source Heat Pump	Furnace (Electric)	0	1	1
	Totals:	28	19	47

Note: *The modelling software used, HOT2000, is designed to heat the home with the heat pump prior to the alternate source. As a result, heat pumps are shown as the primary heating system even though it will be the secondary system likely heating the home on the coldest day of the year.*

Table 16: Frequently used space-heating configurations in each climate zone

Climate Zone	Space Heating Configuration	# of Labels using configuration	% of Labels using configuration
5	Air-Source Heat Pump, Condensing Furnace (Natural Gas)	7	88%
6	Air-Source Heat Pump, Baseboard / Hydronic / Plenum (duct) heaters (Electric)	7	26%
	Air-Source Heat Pump, Condensing Furnace (Natural Gas)	9	33%
	Air-Source Heat Pump, Furnace (Electric)	8	30%
7a	Air-Source Heat Pump, Furnace (Electric)	8	73%

5.2 Ventilation

- **Heat Recovery Ventilation (HRV):** 60% (28/**47**) *Decreased from representing 68% (19/28) in the Pilot to 47% (9/19) in Year 1.*
- **Energy Recovery Ventilator (ERV):** 40% (19/**47**) *Increased from representing 32% (9/28) in the Pilot to 53% (10/19) in Year 1.*

Note: *Integrated Mechanical Systems have not yet been used in the Program.*

Table 17: Ventilation systems (all)

Type	Qty. Pilot	Qty. Year 1	Qty. Total
Heat Recovery Ventilation (HRV)	19	9	28
Energy Recovery Ventilation (ERV)	9	10	19
Totals:	**28**	**19**	**47**

Table 18: Frequently used ventilation systems in each climate zone

Climate Zone	Ventilation System	# of Labels using configuration	Average Efficiency of Unit at 0°C	Average Total Ventilation Exhaust Rate (L/S)	Average Total Ventilation Supply Rate (L/S)
5	HRV	7	67.0%	42.6	42.6
6	HRV	19	72.4%	42.3	41.9
	ERV	10	67.4%	41.8	41.8
7a	HRV	9	80.7%	51.1	50.6

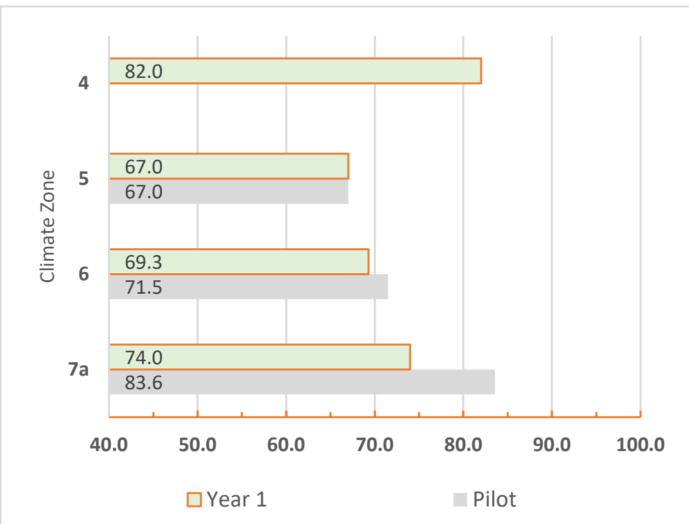


Figure 8: Average efficiency of ventilation unit (%) by climate zone

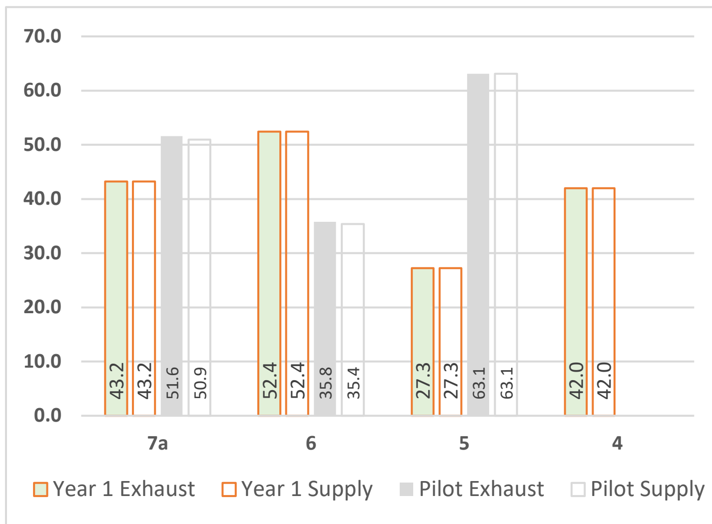


Figure 7: Average ventilation exhaust & supply (L/s) by climate zone

5.3 Water Heating

- **Electric water heating:** 72% (34/**47**) *Decreased usage from 89% (25/28) in the Pilot to 47% (9/19) in Year 1.*
- **Natural gas water heating:** 26% (12/**47**) *Increased usage from 11% (3/28) in the Pilot to 47% (9/19) in Year 1.*
- **Solar water heating:** 2% (1/**47**) *Increased usage from none in the Pilot to 5% (1/19) in Year 1.*

Note: *Drain water heat recovery (DWHR) was installed in 66% (31/47) of the homes, with a slight decrease in use representing 75% (21/28) in the Pilot to 53% (10/19) in Year 1.*

Table 19: Water-heating configurations (all)

Fuel Type	Equipment Type	Qty. Pilot	Qty. Year 1	Qty. Total	Percent of Total
Electricity	Conventional tank	25	2	27	57%
	Integrated heat pump	0	7	7	15%
Natural gas	Instantaneous (Condensing)	3	9	12	26%
Solar	Solar collector system	0	1	1	2%

Table 20: Frequently used water-heating configurations in each climate zone

Climate Zone	Water Heating Configuration	# of Labels using configuration	% of Labels using configuration
5	Natural gas instantaneous (condensing)	6	75%
6	Electric conventional tank	19	70%
	Natural gas instantaneous (condensing)	6	22%
7a	Electric conventional tank	8	73%

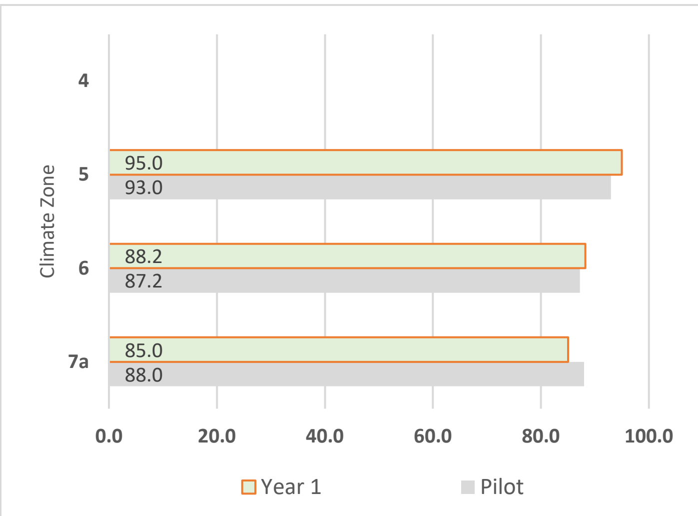


Figure 10: Average water- heating equipment efficiency (%) by climate zone

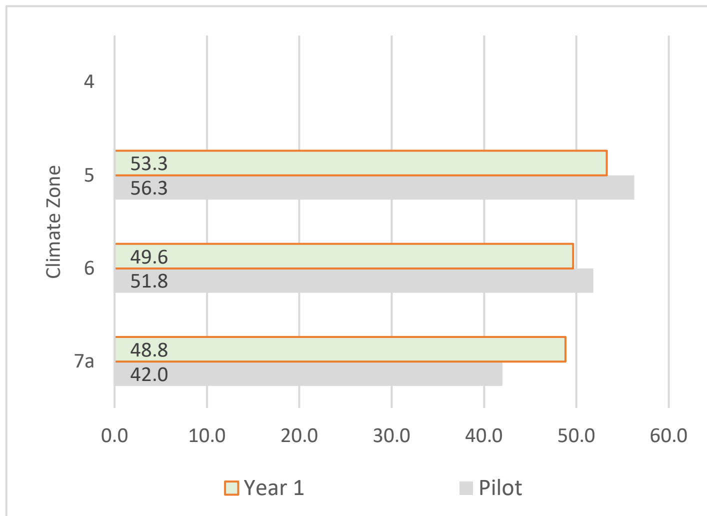


Figure 9: Drain water heat recovery efficiency (%) by climate zone

6.0 PHOTOVOLTAIC SYSTEMS

This section explores the photovoltaic (PV) systems in the Pilot and Year 1 homes. For a home to achieve CHBA Qualified Net Zero, the PV system must be designed to generate enough energy on an annual basis to offset, at a minimum, the annual energy consumption of the home.

Only PV systems were utilized for electricity generation in both the Pilot and Year 1. One home utilized solar thermal for domestic hot water heating (DHW). Future versions of this report may include other renewable energy systems such as geothermal or wind.

A list of the makes and models of the products used in the homes can be found in **Appendix D**.

Table 21: PV systems of the CHBA Qualified Net Zero single-family detached homes

Pilot or Year 1	Climate Zone	Client City	Floor Area m² (ft²)	PV Area m² (ft²)	Floor to PV Ratio	PV Efficiency (%)	PV Orientation	Generation (GJ)
Pilot	7a	Calgary	226.4 (2437)	60.0 (646)	26.5%	17.4	0.0	54.2
			226.4 (2437)	60.0 (646)	26.5%	17.4	0.0	54.2
			226.4 (2437)	60.0 (646)	26.5%	17.4	0.0	54.2
			226.4 (2437)	60.0 (646)	26.5%	17.4	0.0	54.2
			217.5 (2341)	60.0 (646)	27.6%	17.4	0.0	54.2
		Edmonton	307.2 (3307)	73.1 (787)	23.8%	17.1	0.0	15.8
			304.8 (3281)	63.8 (687)	20.9%	17.1	14.6	45.0
	6	Guelph	359.0 (3864)	65.0 (700)	18.1%	14.4	45.0	43.0
			233.5 (2513)	51.5 (554)	22.1%	16.2	48.0	37.0
			228.7 (2462)	50.9 (548)	22.3%	16.2	42.0	36.3
			226.3 (2436)	53.1 (572)	23.5%	15.8	42.0	37.4
			218.2 (2349)	51.5 (554)	23.6%	16.2	45.0	36.6
			201.5 (2169)	51.5 (554)	25.6%	16.2	42.0	37.4
		Kanata	346.7 (3732)	57.9 (623)	16.7%	17.0	40.0	47.7
	5	London	366.4 (3944)	33.3 (358)	9.1%	15.1	90.0	38.9
		St. Thomas	327.8 (3528)	54.5 (587)	16.6%	15.0	0.0	40.4
Year 1	7a	Edmonton	553.3 (5956)	160.2 (1724)	44.2%	15.9	0.0	31.8
			171.0 (1841)	57.4 (618)	33.6%	18.6	0.0	45.4
		Martensville	110.4 (1188)	63.7 (686)	57.7%	16.7	26.6	50.3
	6	Guelph	307.5 (3310)	67.3 (724)	21.9%	17.1	135; -45	43.4
		Halifax	615.2 (6622)	81.8 (880)	13.3%	15.2	45; -45	51.2
		Puslinch	797.5 (8584)	129.2 (1391)	16.2%	17.4	0.0	90.4
		Quispamsis	166.5 (1792)	72.1 (777)	43.3%	16.4	8.0	38.6
	5	Strathroy	320.4 (3449)	53.1 (572)	16.6%	15.8	45.0	37.3
	4	Victoria	463.7 (4991)	58.6 (631)	12.6%	15.6	0; 90	41.8

Table 22: PV systems of the CHBA Qualified Net Zero row-house units

Pilot or Year 1	Climate Zone	Client City	Floor Area m² (ft²)	PV Area m² (ft²)	Floor to PV Ratio	PV Efficiency (%)	PV Orientation	Generation (GJ)
Pilot	6	Laval	119.1 (1282)	30.0 (323)	25.2%	16.5	20.0	24.7
			119.1 (1282)	28.7 (309)	24.1%	16.5	20.0	23.7
			116.2 (1251)	29.9 (322)	25.7%	16.5	20.0	24.5
			116.2 (1251)	30.4 (327)	26.2%	16.5	20.0	25.1
			66.8 (719)	30.7 (330)	46.0%	16.5	20.0	25.3
			66.8 (719)	30.5 (328)	45.7%	16.5	20.0	25.1
		Ottawa	213.5 (2298)	53.9 (580)	25.2%	17.4	39.0	35.0
			213.5 (2298)	55.5 (597)	26.0%	17.4	39.0	35.0
			192.6 (2073)	49.0 (527)	25.4%	17.4	39.0	31.0
			183.6 (1976)	50.6 (545)	27.6%	17.4	39.0	31.0

7.0 PERFORMANCE

This section looks at the performance metrics used to evaluate these homes. Each metric is explained in detail in their respective sections. The metrics are:

- annual energy consumption, measured in in GJ/year (AEC),
- whole home heat loss, measured in GJ/year (WHHL),
- airtightness, measured in air changes per hour at 50 pascals (ACH50),
- mechanical energy use intensity, measured in kWh/m^2* per year (MEUI),
- thermal energy demand intensity, measured in kWh/m^2* per year (TEDI),
- percent better than reference house—whole house annual energy consumption (Ref AEC), and
- percent better than reference house—building envelope (Ref Env).

The overview below summarizes the project types and their average values in each performance metric. The project types are the

- single-family detached homes in the Pilot (SFD-Pilot),
- single-family detached homes in year 1 (SFD-Y1),
- double/semi-detached homes (Double),
- 4-unit townhome (TH),
- 6-plex,
- luxury single-family detached home (Luxury), and
- First Nations health and wellness centre (FN H&W).

A summary of the individual project performance values can be found in **Appendix C**.

Table 23: Performance metrics summary by project type and climate zone

Project Type	Climate Zones	# of Labels	Area Avg. m^2	Area Avg. ft^2	AEC Avg. Min. Max.	WHHL Avg. Min. Max.	ACH50 Avg. Min. Max.	MEUI Avg. Min. Max.	TEDI Avg. Min. Max.	Ref AEC* Avg. Min. Max.	Ref Env Avg. Min. Max.
SFD-Pilot[5]	5,6,7a	**18**	272	2,925	**41.1**	**50.9**	**0.77**	**19.2**	**21.6**	N/A	**66.0**
					32.6	28.0	0.43	11.4	14.5		46.1
					60.3	73.3	1.27	33.9	36.8		88.7
SFD-Y1[5]	4,5,6,7a	**14**	384	4,129	**50.3**	**69.5**	**0.88**	**24.9**	**36.5**	**72.4**[6]	**54.7**
					37.3	34.6	0.40	12.4	14.9	49.6	38.9
					71.8	134.4	1.46	69.7	132.2	82.0	71.4
Double	6	3	292	3,143	**45.9**	**49.4**	**0.60**	**20.0**	**27.4**	**72.9**	**66.0**
					39.7	46.3	0.46	13.5	17.5	68.7	64.9
					51.7	52.3	0.77	25.9	43.9	78.5	67.5
TH	6	4	201	2,161	**34.4**	**40.1**	**1.47**	**17.9**	**23.4**	N/A	**81.3**
					31.8	31.7	1.44	15.3	16.0		79.2
					37.3	50.2	1.50	21.7	30.4		82.9
6-Plex	6	6	101	1,084	**20.9**	**24.8**	**1.50**	**20.7**	**21.4**	N/A	**85.3**
					19.8	22.0	1.36	13.5	9.0		77.6
					21.5	26.6	1.63	31.0	36.1		93.3
Luxury	6	1	797	8,579	**90.4**	**227.6**	**0.89**	**23.5**	**41.0**	**74.8**	**40.5**
					90.4	227.6	0.89	23.5	41.0	74.8	40.5
					90.4	227.6	0.89	23.5	41.0	74.8	40.5
FN H&W	6	1	1,062	11,436	**77.4**	**145.3**	**0.49**	**13.5**	**28.4**	**76.2**	**48.2**
					77.4	145.3	0.49	13.5	28.4	76.2	48.2
					77.4	145.3	0.49	13.5	28.4	76.2	48.2
Totals:	47										

**The energy modelling software used in the Pilot did not calculate annual energy consumption percent better than reference house ("Ref AEC").*

The following sub-sections explore the performance metrics for the 32 SFD-Pilot[6] and SFD-Y1[6] project types against three key characteristics: 1) climate zone, 2) plan shape (per the energy model), and 3) floor area.

[5] *Throughout section 6.0 Performance, "SFD" **excludes** both the Luxury and the FN H&W projects.*

[6] *Avg. Ref AEC for SFD-Y1 based on 13/14 Labels. 1 home was modelled using HOT2000 v10.51 which does not provide an Avg. Ref AEC calculation.*

7.1 Annual Energy Consumption

DEFINITION

Annual energy consumption is defined as the amount of energy required to operate the home on an annual basis. This includes energy required for space heating, space cooling, hot water heating, ventilation, and occupant loads (lighting, appliances, and plug loads). Annual energy consumption is measured in GJ/year with a lower value being favourable. The CHBA Program has a modelled performance target of 0 GJ for the annual energy consumption, offset by the on-site renewable energy production.

Note: *the GJ values below reflect the energy consumption of the homes—without the renewable energy generation.*

OBSERVATIONS

- 66% (21/32) of the SFD projects were designed to consume < 45 GJ/year before renewables.
- Plan shape shows no noticeable effect on a project's energy consumption.
- 91% (10/11) of projects consuming > 45 GJ/year are in Climate Zones 6 and 7a.
- 91% (10/11) of projects consuming > 45 GJ/year are ≥ 230 m² (2,500 ft²).

Table 24: Statistics and distribution of annual energy consumption by GJ/year

Characteristic	[Number of Labels]	PILOT			YEAR 1			DISTRIBUTION					
		Min.	Max.	Avg.	Min.	Max.	Avg.	< 35	≥ 35 to < 40	≥ 40 to < 45	≥ 45 to < 50	≥ 50 to < 55	≥ 55
Climate Zone													
7a	[10 of 32]	42.4	60.3	46.1	45.4	71.8	55.9	0	0	6	1	1	2
6	[14 of 32]	32.6	49.0	37.9	38.6	65.1	54.2	5	1	2	2	1	3
5	[7 of 32]	36.0	40.8	37.8	37.3	46.3	42.3	0	3	3	1	0	0
4	[1 of 32]	N/A	N/A	N/A	41.8	41.8	41.8	0	0	1	0	0	0
Plan Shape													
L-Shape	[6 of 32]	43.3	43.8	44	50.3	50.3	50.3	0	0	5	0	1	0
Rectangular	[5 of 32]	36.0	60.3	46.1	45.4	45.4	45.4	0	1	1	2	0	1
5 - 6 corners	[7 of 32]	32.6	49	36.3	42.4	43.4	42.9	4	0	2	1	0	0
7 - 8 corners	[2 of 32]	N/A	N/A	N/A	37.3	41.8	39.6	0	1	1	0	0	0
9 - 10 corner	[6 of 32]	36.5	41.8	39.2	43.2	71.8	61.0	0	1	2	0	0	3
11 or more corners	[6 of 32]	33.9	40.8	37.3	38.6	62.9	49.8	1	1	1	1	1	1
Area													
< 230 (2,500 ft²)	[11 of 32]	32.6	44.8	39.2	38.6	50.3	44.2	4	0	6	1	0	0
≥ 230 (2,500 ft²) to < 325 (3,500 ft²)	[9 of 32]	34.0	60.3	43.2	37.3	43.4	41.3	1	2	2	0	1	3
≥ 325 (3,500 ft²) to < 465 (5,000 ft²)	[8 of 32]	36.5	49.0	42.7	41.8	65.1	54.3	0	2	3	3	0	0
≥ 465 (5,000 ft²)	[4 of 32]	N/A	N/A	N/A	51.2	71.8	56.9	0	0	1	0	1	2

7.2 Whole Home Heat Loss

DEFINITION

Whole home heat loss is defined as the total amount of heat lost from the whole home on an annual basis. This includes heat lost from air leakage and heat lost through the foundation, ceilings, walls, and windows and doors. Whole home heat loss is measured in GJ/year with a lower value being favourable. The CHBA Program has no performance target for whole home heat loss.

A detailed breakdown of the whole home heat loss by category can be found in **Appendix E.**

OBSERVATIONS

- 63% (20/32) of the SFD projects lost < 60 GJ of heat on an annual basis.
- Climate zone and plan shape show no noticeable effect on whole home heat loss.
- 91% (10/11) of projects losing < 40 GJ / year are < 230 (2,500 ft2).
- 100% (4/4) of projects losing > 70 GJ / year are ≥ 465 (5,000 ft2).

Table 25: Statistics and distribution of whole home heat loss by GJ/year

Characteristic	[Number of Labels]	PILOT			YEAR 1			DISTRIBUTION				
		Min.	Max.	Avg.	Min.	Max.	Avg.	< 40	≥ 40 to < 50	≥ 50 to < 60	≥ 60 to < 70	≥ 70
Climate Zone												
7a	[10 of 32]	40.6	62.6	48.5	50.2	130.5	80.3	0	5	1	3	1
6	[14 of 32]	27.5	71.8	48.3	57.7	111.8	76.7	4	1	3	2	4
5	[7 of 32]	52.0	59.9	55.5	34.6	66.7	47.0	2	1	3	1	0
4	[1 of 32]	N/A	N/A	N/A	75.3	75.3	75.3	0	0	0	0	1
Plan Shape												
L-Shape	[6 of 32]	40.6	45.6	43.0	60.1	60.1	60.1	0	0	2	2	1
Rectangular	[5 of 32]	52.0	70.4	61.8	50.2	50.2	50.2	0	5	0	1	0
5 - 6 corners	[7 of 32]	27.5	71.8	43.6	34.6	65.1	49.9	4	1	0	1	1
7 - 8 corners	[2 of 32]	N/A	N/A	N/A	47.9	75.3	61.6	0	1	0	0	1
9 - 10 corner	[6 of 32]	54.7	58.8	56.8	38.8	130.5	71.5	1	0	4	0	1
11 or more corners	[6 of 32]	39.0	59.9	49.4	63.3	111.8	86.3	1	0	1	2	2
Area (m^2)												
< 230 (2,500 ft^2)	[11 of 32]	27.5	45.6	40.0	34.6	50.2	42.4	5	5	1	0	0
≥ 230 (2,500 ft^2) to < 325 (3,500 ft^2)	[9 of 32]	40.7	62.6	54.4	38.8	63.3	55.8	1	1	3	4	0
≥ 325 (3,500 ft^2) to < 465 (5,000 ft^2)	[8 of 32]	54.7	71.8	63.1	47.9	66.7	59.9	0	1	3	2	2
≥ 465 (5,000 ft^2)	[4 of 32]	N/A	N/A	N/A	75.3	130.5	105.2	0	0	0	0	4

7.3 Airtightness

DEFINITION

Airtightness is a measurement of how resistant the dwelling unit is to inward and outward air leakage. Airtightness is measured in air changes per hour (ACH) with a lower value meaning better performance. The dwelling unit is pressurized to 50 pascals with a fan typically positioned and enclosed in the front door frame. The volume of air passing through the fan at a constant pressure is recorded. This amount represents the amount of air escaping the dwelling unit. ACH measures the number of times the air is replaced in one hour compared to the volume of the dwelling unit, for example, an ACH of 1, 2, and 0.5 means the amount of air replaced in one hour is the same, double and half (respectively) the volume of the unit being tested. The CHBA Program has a performance target of maximum 1.5 ACH for detached homes and maximum 2.0 ACH for attached homes.

OBSERVATIONS

- 72% (23/32) of the SFD projects achieved an ACH of 1.0 or less.
- 75% (24/32) are in Climate Zones 6 and 7a.
- 63% (20/32) have less than 9 corners.
- 63% (20/32) are under 325 m^2 (3,500 ft^2) in size.

Table 26: Statistics and distribution of airtightness by ACH

Characteristic	[Number of Labels]	PILOT			YEAR 1			DISTRIBUTION				
		Min.	Max.	Avg.	Min.	Max.	Avg.	< 0.50	≥ 0.50 to < 0.75	≥ 0.75 to < 1.00	≥ 1.00 to < 1.25	≥ 1.25 to < 1.5
Climate Zone												
7a	[10 of 32]	0.43	0.82	0.54	0.61	1.46	0.96	4	3	2	0	1
6	[14 of 32]	0.50	1.27	0.98	0.40	1.33	0.95	1	2	4	5	2
5	[7 of 32]	0.64	0.83	0.73	0.53	1.14	0.76	0	5	1	1	0
4	[1 of 32]	N/A	N/A	N/A	0.75	0.75	0.75	0	1	0	0	0
Plan Shape												
L-Shape	[6 of 32]	0.45	0.82	0.55	0.61	0.61	0.61	3	2	1	0	0
Rectangular	[5 of 32]	0.43	0.83	0.58	0.81	0.81	0.81	1	2	2	0	0
5 - 6 corners	[7 of 32]	0.87	1.27	1.05	0.73	1.23	0.98	0	1	2	3	1
7 - 8 corners	[2 of 32]	N/A	N/A	N/A	0.53	0.75	0.64	0	2	0	0	0
9 - 10 corner	[6 of 32]	0.64	0.93	0.79	0.63	1.46	1.10	0	2	2	0	2
11 or more corners	[6 of 32]	0.72	1.13	0.93	0.40	1.14	0.83	1	2	0	3	0
Area												
< 230 (2,500 ft^2)	[11 of 32]	0.45	1.13	0.74	0.40	0.81	0.64	3	2	4	2	0
≥ 230 (2,500 ft^2) to < 325 (3,500 ft^2)	[9 of 32]	0.43	1.27	0.78	0.53	1.23	0.80	2	3	2	0	2
≥ 325 (3,500 ft^2) to < 465 (5,000 ft^2)	[8 of 32]	0.50	1.24	0.81	0.75	1.33	1.05	0	4	1	3	0
≥ 465 (5,000 ft^2)	[4 of 32]	N/A	N/A	N/A	0.73	1.46	1.00	0	2	0	1	1

7.4 Mechanical Energy Use Intensity (MEUI)

DEFINITION

Mechanical Energy Use Intensity is the energy consumption of the home's mechanical systems compared to the size of the home. MEUI is measured in kWh/(m² per year) with a lower value indicating better performance. The MEUI calculation in this report follows the MEUI calculation as described in the BC Energy Step Code. MEUI includes the energy required for space heating, space cooling, domestic hot water heating, and ventilation and divides the total by the heated floor area. Occupant baseloads are excluded from this calculation. The CHBA Program does not have a performance target for MEUI; however, the highest step in the BC Energy Step Code includes a MEUI target of 25 kWh/m² per year as a compliance path.

OBSERVATIONS

- 66% (21/32) of the SFD projects achieved a MEUI of < 25 kWh / (m²·year). 41% (13/32) achieved < 15 kWh / (m² ·year).
- *Cold climate affects the ability to achieve a low MEUI:* Of the 34% (11/32) that were ≥ 25 kWh / m²·year, 73% (8/11) were in Climate Zone 7a and 27% (3/11) were in Climate Zone 6. (None were in Climate Zones 5 or 4.) Of the 20 SFD projects that achieved < 25 kWh / m²·year:
  - 5% (1/21) were in Zone 4
  - 33% (7/21) were in Zone 5
  - 52% (11/21) were in Zone 6
  - 10% (2/21) were in Zone 7a
- Of the 34% (11/32) that were ≥ 25 kWh / m²·year, 55% (6/11) were < 230 m² (2,500 ft²) and 45% (5/11) were between 230 m² (2,500 ft²) and 325 m² (3,500 ft²). No homes ≥ 325 m² (3,500 ft²) experienced a MEUI greater than 25 kWh / m2·year.

Table 27: Statistics and distribution of MEUI by kWh / m2·year

Characteristic	[Number of Labels]	PILOT			YEAR 1			DISTRIBUTION					
		Min.	Max.	Avg.	Min.	Max.	Avg.	< 15	≥ 15 to < 20	≥ 20 to < 25	≥ 25 to < 30	≥ 30 to < 35	≥ 35
Climate Zone													
7a	[10 of 32]	18.4	33.9	26.7	38.1	69.7	42.7	0	1	1	5	1	2
6	[14 of 32]	12.3	22.6	15.3	12.8	30.9	23.3	7	2	2	1	2	0
5	[7 of 32]	11.4	13.5	12.1	12.4	22.1	17	5	1	1	0	0	0
4	[1 of 32]	N/A	N/A	N/A	12.7	12.7	12.7	1	0	0	0	0	0
Plan Shape													
L-Shape	[6 of 32]	25.8	28.6	26.9	69.7	69.7	69.7	0	0	0	5	0	1
Rectangular	[5 of 32]	11.5	33.9	21.0	38.1	38.1	38.1	1	1	1	0	1	1
5 - 6 corners	[7 of 32]	12.3	22.6	14.8	18.4	22.1	20.3	4	1	2	0	0	0
7 - 8 corners	[2 of 32]	N/A	N/A	N/A	12.4	12.7	12.5	2	0	0	0	0	0
9 - 10 corner	[6 of 32]	11.4	14.6	13.0	18.4	30.3	24.6	2	1	1	1	1	0
11 or more corners	[6 of 32]	13.5	14.0	13.8	12.8	30.9	19.1	4	1	0	0	1	0
Area													
< 230 (2,500 ft²)	[11 of 32]	12.3	28.6	20.7	22.1	38.1	30.1	4	0	1	5	0	1
≥ 230 (2,500 ft²) to < 325 (3,500 ft²)	[9 of 32]	11.5	33.9	19.2	18.4	69.7	35.7	2	2	0	1	3	1
≥ 325 (3,500 ft²) to < 465 (5,000 ft²)	[8 of 32]	11.4	22.6	16.5	12.4	18.4	15.2	5	1	2	0	0	0
≥ 465 (5,000 ft²)	[4 of 32]	N/A	N/A	N/A	12.7	20.2	15.9	2	1	1	0	0	0

7.5 Thermal Energy Demand Intensity (TEDI)

DEFINITION

Thermal Energy Demand Intensity expresses the amount of energy required by the space heating and space cooling systems to maintain a desired temperature. TEDI is measured in kWh / (m^2 ·year) with a lower value indicating better performance. The TEDI calculation in this report follows the TEDI calculation as defined in the BC Energy Step Code. TEDI takes the auxiliary heating energy (the amount required outside of other gains such as solar gains, occupant generated heat, etc.) required by the home and divides it by the heated floor area. The CHBA Program does not have a performance target for TEDI, however, the highest step in the BC Energy Step Code includes a TEDI target of 15 kWh / (m^2 ·year) as a compliance path.

OBSERVATIONS

- 69% (22/32) of the SFD projects achieved a TEDI of < 25 kWh / (m2·year). 6% (2/32) achieved < 15 kWh / (m2 ·year).
- None of the homes from climate zones 4 and 5 experienced a TEDI ≥ 25 kWh / m2·year. Of the 32% (10/32) that achieved ≥ 25 kWh / m2·year, 30% (3/10) were in Climate Zone 7a and 70% (7/10) were in Climate Zone 6.
- Of the SFD projects that achieved < 25 kWh / m2·year, 41% (9/22) are < 230 m^2 (2,500 ft^2) and another 32% (7/22) are between 230 m^2 (2,500 ft^2) and 325 m^2 (3,500 ft^2).

Table 28: Statistics and distribution of TEDI in kWh / m2·year

Characteristic	[Number of Labels]	PILOT			YEAR 1			DISTRIBUTION					
		Min.	Max.	Avg.	Min.	Max.	Avg.	< 15	≥ 15 to < 20	≥ 20 to < 25	≥ 25 to < 30	≥ 30 to < 35	≥ 35
Climate Zone													
7a	[10 of 32]	14.6	24.3	19.2	36.4	132.2	66.1	1	4	2	1	0	2
6	[14 of 32]	20.3	36.8	24.6	17.4	74.6	36.7	0	2	5	3	1	3
5	[7 of 32]	18.6	19.8	19.3	14.9	23.0	17.6	1	5	1	0	0	0
4	[1 of 32]	N/A	N/A	N/A	21.5	21.5	21.5	0	0	1	0	0	0
Plan Shape													
L-Shape	[6 of 32]	17.0	22.0	19.1	132.2	132.2	132.2	0	4	1	0	0	1
Rectangular	[5 of 32]	14.6	26.2	21.2	36.4	36.4	36.4	1	1	1	1	0	1
5 – 6 corners	[7 of 32]	20.3	36.8	24.4	16.2	26.9	21.5	0	1	4	1	0	1
7 – 8 corners	[2 of 32]	N/A	N/A	N/A	14.9	21.5	18.2	1	0	1	0	0	0
9 – 10 corners	[6 of 32]	18.6	21.9	20.3	16.4	29.7	20.4	0	4	1	1	0	0
11 or more corners	[6 of 32]	19.8	26.6	23.2	23.0	74.6	45.2	0	1	1	1	1	2
Area													
< 230 (2,500 ft^2)	[11 of 32]	17.0	26.6	20.5	16.2	132.2	64.9	0	5	4	1	0	1
≥ 230 (2,500 ft^2) to < 325 (3,500 ft^2)	[9 of 32]	14.6	24.3	20.3	14.9	26.9	19.4	1	4	2	0	0	2
≥ 325 (3,500 ft^2) to < 465 (5,000 ft^2)	[8 of 32]	18.6	36.8	24.7	17.4	23.0	20.0	1	2	2	2	0	1
≥ 465 (5,000 ft^2)	[4 of 32]	N/A	N/A	N/A	21.5	51.7	33.6	0	0	1	1	1	1

7.6 Percent Better than Reference House—Whole House Energy Consumption (“Ref. AEC”)

DEFINITION

Percent Better than Reference House—Whole House Energy Consumption is a measure of how much better the proposed house is in the area of whole house energy consumption compared to its respective Reference House, which is a Code-minimum version of the proposed house. “Ref. AEC” is measured as a percentage (%) with a higher value indicating better performance. The “Ref. AEC” calculation in this report follows the “Ref AEC" calculation as defined in the BC Energy Step Code. Ref AEC includes the energy consumption of the home’s space heating, space cooling, hot water heating, and ventilation and excludes the occupant baseloads (lights, appliances, plug loads) from both the proposed house and the Reference House. The CHBA Program does not have a performance target for “Ref. AEC”. The highest step in the BC Energy Step Code does not include a “Ref. AEC” target, however, the second highest step in the BC Energy Step Code includes a “Ref. AEC” target of 40% better as a compliance path.

Note: *Only 13 SFD homes in Year 1 have this calculation because it was included in the updated version of HOT2000. The 18 SFD homes in the Pilot and 1 home in Year 1 do not have this calculation.*

OBSERVATIONS

- 85% (11/13) of the SFD homes in Year 1 achieved ≥ 60% better than the reference house for whole house energy consumption.
- Homes ≥ 465m^2 (5,000 ft^2) did not perform worse than 70% better.

Table 29: Statistics and distribution of percent better than reference house - annual energy consumption by %

Characteristic	[Number of Labels]	PILOT			YEAR 1			DISTRIBUTION				
		Min.	Max.	Avg.	Min.	Max.	Avg.	≥ 80	< 80 to ≥ 70	< 70 to ≥ 60	< 60 to ≥ 50	< 50
Climate Zone												
7a	[2 of 13]	N/A	N/A	N/A	67.4	77.9	72.7	0	1	1	0	0
6	[6 of 13]	N/A	N/A	N/A	49.6	82.0	69.5	0	1	3	1	1
5	[4 of 13]	N/A	N/A	N/A	69.9	80.1	74.7	1	2	1	0	0
4	[1 of 13]	N/A	N/A	N/A	80.6	80.6	80.6	1	0	0	0	0
Plan Shape												
L-Shape	[1 of 13]	N/A	N/A	N/A	77.9	77.9	77.9	0	1	0	0	0
Rectangular	[1 of 13]	N/A	N/A	N/A	67.4	67.4	67.4	0	0	1	0	0
5 - 6 corners	[2 of 13]	N/A	N/A	N/A	70.2	78.3	74.2	0	2	0	0	0
7 - 8 corners	[2 of 13]	N/A	N/A	N/A	80.1	80.6	80.5	2	0	0	0	0
9 - 10 corner	[3 of 13]	N/A	N/A	N/A	49.5	69.9	56.9	0	0	1	1	1
11 or more corners	[4 of 13]	N/A	N/A	N/A	75.9	82.00	79.1	1	3	0	0	0
Area												
< 230 (2,500 ft^2)	[4 of 13]	N/A	N/A	N/A	67.4	82.0	74.4	1	2	1	0	0
≥ 230 (2,500 ft^2) to < 325 (3,500 ft^2)	[3 of 13]	N/A	N/A	N/A	69.9	80.1	76.1	1	1	1	0	0
≥ 325 (3,500 ft^2) to < 465 (5,000 ft^2)	[4 of 13]	N/A	N/A	N/A	49.6	80.9	65.0	1	1	0	1	1
≥ 465 (5,000 ft^2)	[2 of 13]	N/A	N/A	N/A	75.9	79.9	77.9	0	2	0	0	0

7.7 Percent Better than Reference House—Building Envelope ("Ref. Env.")

DEFINITION

Percent Better than Reference House—Building Envelope is a measure of how much better the proposed house is in the area of building envelope compared to its respective Reference House, which is a Code-minimum version of the proposed house. "Ref. Env" is measured as a percentage (%) with a higher value indicating better performance. The "Ref. Env." calculation compares the space heating requirements from the proposed house energy model and the Reference House energy model. The CHBA Program includes a performance target of minimum 33% better than reference house for building envelope.

OBSERVATIONS

- The average for all 47 projects is 66% better than reference house.
- 90% (28/32) achieved ≥ 50% better than reference house.
- 65% (20/32) achieved ≥ 60% better than reference house.
- 35% (11/32) achieved < 60% better than reference house.
  - 72% (8/11) were in Zones 6 and 7a.
  - 91% (10/11) were ≥ 230 (2,500 ft^2).

Table 30: Statistics and distribution of percent better than reference - building envelope in %

Characteristic	[Number of Labels]	PILOT			YEAR 1			DISTRIBUTION				
		Min.	Max.	Avg.	Min.	Max.	Avg.	≥ 80	< 80 to ≥ 70	< 70 to ≥ 60	< 60 to ≥ 50	< 50
Climate Zone												
7a	[10 of 32]	64.7	78.0	67.4	53.1	60.5	57.7	0	1	7	2	0
6	[14 of 32]	46.1	88.7	64.9	38.9	71.4	55.4	1	1	6	3	3
5	[7 of 32]	62.6	66.8	65.3	56.3	62.8	59.4	0	0	5	2	0
4	[1 of 32]	N/A	N/A	N/A	53.7	53.7	53.7	0	0	0	1	0
Plan Shape												
L-Shape	[6 of 32]	64.7	66.2	65.4	53.1	60.5	57.7	0	0	6	0	0
Rectangular	[5 of 32]	62.6	88.7	74.0	62.6	88.7	74.0	1	1	2	1	0
5 - 6 corners	[7 of 32]	46.1	67.0	61.9	46.6	62.8	54.7	0	0	5	0	2
7 - 8 corners	[2 of 32]	N/A	N/A	N/A	53.7	56.3	55	0	0	0	2	0
9 - 10 corner	[6 of 32]	56.0	66.4	61.2	51.7	59.4	55.2	0	0	1	5	0
11 or more corners	[6 of 32]	65.1	66.8	66.0	38.9	71.4	54.8	0	1	4	0	1
Area												
< 230 (2,500 ft^2)	[11 of 32]	64.7	66.2	65.4	53.1	62.8	58.0	0	0	10	1	0
≥ 230 (2,500 ft^2) to < 325 (3,500 ft^2)	[9 of 32]	62.6	78.0	68.6	51.7	71.4	58.6	0	2	4	3	0
≥ 325 (3,500 ft^2) to < 465 (5,000 ft^2)	[8 of 32]	46.1	88.7	64.8	46.6	60.6	54.5	1	0	3	2	2
≥ 465m^2 (5,000 ft^2)	[4 of 32]	N/A	N/A	N/A	38.9	59.4	48.9	0	0	1	2	1

8.0 LESSONS LEARNED

Six, two--hour online workshops were held in March 2019 to gather information from Qualified Net Zero Builders and EAs about why they chose various assemblies, windows, mechanicals and renewable energy systems. (One session was held only with EAs with modified survey questions, as indicated by the blue text below.) Real-time surveys were utilized to discuss the results as a group during the workshops. Thirty builders and 15 EAs completed the surveys. (See **Appendix G** for the list.) The survey questions are listed below.

- Was there anything unique about the **DESIGN** of your home that helped you to achieve NZr levels of performance?

- WHY did you choose the **WALL/BASEMENT/CEILING ASSEMBLIES** that you did?
- WHY did you choose the **WINDOWS/DOORS** that you did?
- WHY did you choose the **MECHANICALS** that you did?
- WHY did you choose the (installed or designed) **RENEWABLES** that you did?

- What are the most effective "**UPGRADES**" to achieve Net Zero Ready performance for **DETACHED** vs **ATTACHED** homes?

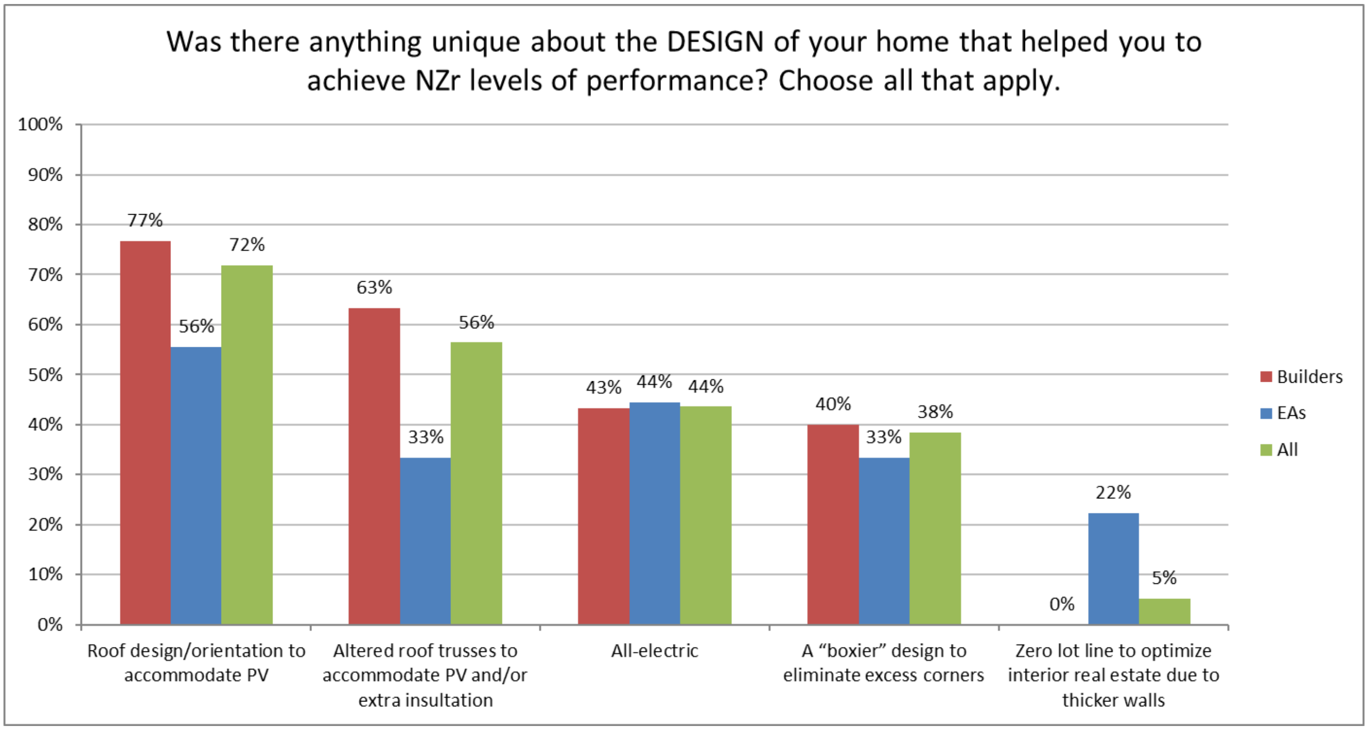
- What was your/is the most common **AIR BARRIER** strategy for the above grade walls?
- Is it typically different for the exposed floors/ceilings/garage drop or any other bump outs?
- What materials are most commonly used for the above grade walls?
- Was a pre-drywall blower door test performed? / Are pre-drywall blower door tests usually performed on the first home?
- What about for subsequent homes?

- What **CHALLENGE(S)** did you face in your FIRST NZ/r build? / What are the most significant CHALLENGES that you face working with builders on NZ/r Homes?
- Were these challenges expected or unexpected?
- Did you overcome these challenges in your subsequent builds? / Are you overcoming these challenges as you continue to work with the builders?
- Are these challenges preventing you from doing another/more NZ/r build?
- Did you face any NEW challenges in your subsequent builds? (That weren't experienced in the first build.)
- Were these NEW challenges expected or unexpected?
- What are the greatest challenges related to the mechanicals?

- Are builders choosing the newer/higher efficiency modules when going Net Zero?
- Do you use the solar PV default values in HOT2000 or are you getting the input values from solar contractors?
- Is the requirement of a PV system design from a solar contractor for every home a barrier?
- Is the requirement to include conduit for the PV in a Net Zero Ready Home a barrier?
- Is the requirement to include an Energy Monitoring System in a Net Zero Ready Home a barrier?
- Are you working with any builders that are collecting consumption/generation data from their homes?

- What **INSIGHTS/OBSERVATIONS** can you provide regarding the widespread adoption of NZr practices?
  A) What products/technologies/materials would make this easier/faster/cheaper?
  B) What R&D needs to be done before the entire industry would be able to build NZr homes?
  C) What regulatory/policy changes are needed?
  D) What changes do the energy utilities need to make?
  E) What skills should the trades have?
  F) What sales/marketing tools/support are needed to improve consumer awareness/acceptance?
  G) What would help with the financial barriers? (e.g. for driving down costs, financing, appraisals)
  H) What are the main opportunities that our industry should capitalize on?
  I) Other?
- Overall, what were the key **LESSONS YOU LEARNED** that could assist other builders (other EAs and/or builders) in achieving NZr levels of performance? (If you were to start from the beginning again, what would you do differently?)
- What needs to be done before the entire industry would be able to meet more stringent energy-efficiency regulations related to new home construction? *(Refer to the chart documenting a preliminary assessment of opportunities and challenges identified through CHBA's TRC.)*
- Are these costs to achieve Net Zero Ready for the average builder in the ballpark of the costs that you experienced for your FIRST Net Zero Ready build?

DESIGN



ANALYSIS

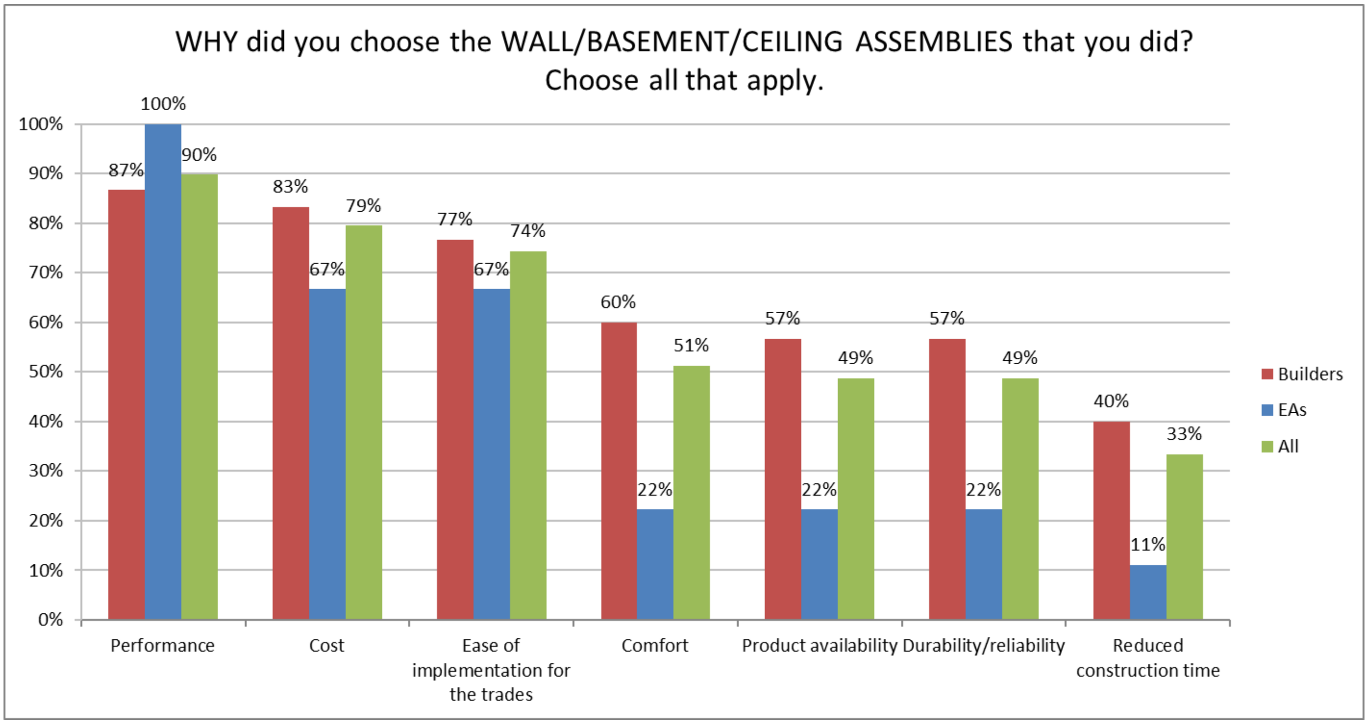
Overwhelmingly, the roof design/orientation and altered roof trusses to accommodate PV was the most significant design strategy to achieve NZ/r. This was expected considering that the potential onsite energy generation sets the consumption target for the house. Maximizing the energy generation capability will minimize the upgrades required for the rest of the house to meet the target.

The unique design changes differ between production and custom builders or rural compared to urban. Production builders tend to adapt their current plans to meet the NZr label requirements. They are constrained with tight lot lines, and often do not have the best orientation. Either increasing or decreasing the size of the windows was a strategy for some. Some also have many types of homes that they build, i.e. detached, attached, MURBs and back-to-backs. Each type of house has its own challenges to meet the NZr label requirements. Conversely, custom home builders can design to suit the site.

Another unique design consideration was that of the mechanical system. The choice to go all-electric or use a hybrid system was driven by several factors including the operational cost for the homeowner, the cost for the builder, and if the house is NZ or NZr.

During the workshops we heard that increasing the electrical service to the home to 200 amps was a challenge for some.

WALL/BASEMENT/CEILING ASSEMBLIES



ANALYSIS

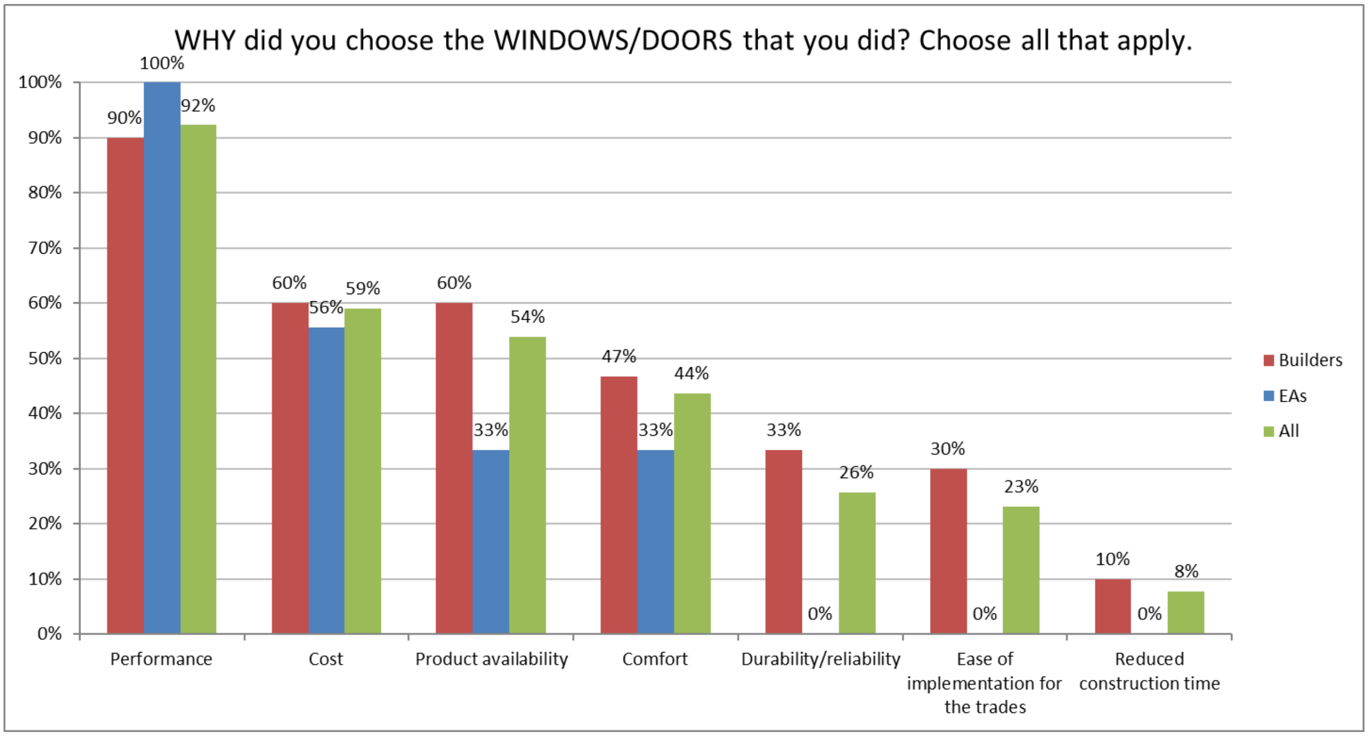
Performance at the lowest cost in a manner that the trades are comfortable with were the key factors across the board for the choice of wall/basement/ceiling assemblies. The decision was driven by performance, but guided by cost. Climate zone plays a big role in dictating how much of a deviation from code minimums is required for these assemblies. The more heating degree days, the higher the thermal resistance required, which increases the complexity of the assembly.

Some builders took advantage of incentive programs like LEEP and technical support from suppliers of building envelope systems to ensure that their chosen assembly met the R-value required without negatively impacting the durability of the system.

Another important performance criterion that needed to be met was the airtightness strategy.

EAs have the luxury of working on different projects which use different techniques.

WINDOWS/DOORS



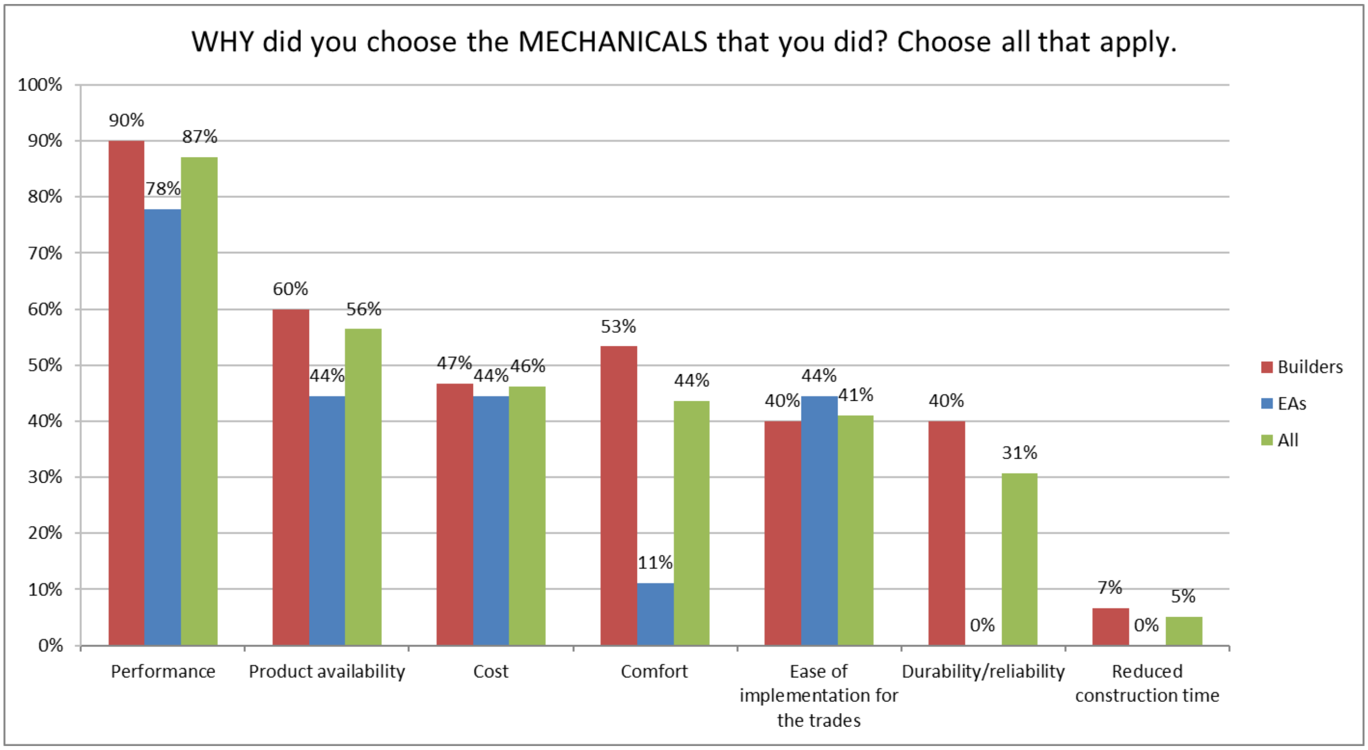
ANALYSIS

It's not surprising that performance was the main reason for the choice of windows. With double-glazed windows as code minimum, space-heating energy reductions are rewarded with the use of triple-glazed windows. The next consideration is the cost and availability of the product.

The comfort of the occupants was another consideration for the Builders because fewer comfort complaints mean fewer call-backs. However, some discovered that it is not enough to only choose a window based on its U-value. The Solar Heat Gain Coefficient (SHGC) needs to be considered as well, but not by using the Energy Rating (ER). Typically, a high ER will result in a higher SHGC. In an NZr home, this will overheat rooms that get direct sunlight, which leads to comfort complaints and call-backs. It was suggested that NRCan has reported that the estimated cooling related results from modelling in HOT2000 are about half of what real-world results have shown. It has been recommended that the space cooling demand be doubled to account for this difference. This would mean that most projects would likely require cooling to be installed and could also require the size of the ducting to be increased to accommodate the larger AC loads. It would also challenge the estimated total annual energy consumption, and the expectation to meet NZE in the real world. Access to energy monitoring data would be valuable to asses this. With this in mind, it has been suggested that the ER system should be re-evaluated for relevance as we move toward NZr. It was also suggested that the window industry should consider developing products that have integrated operable exterior shading devices.

Another issue with triple-glazed windows was the increased weight of the units. This made them more challenging to install.

MECHANICALS

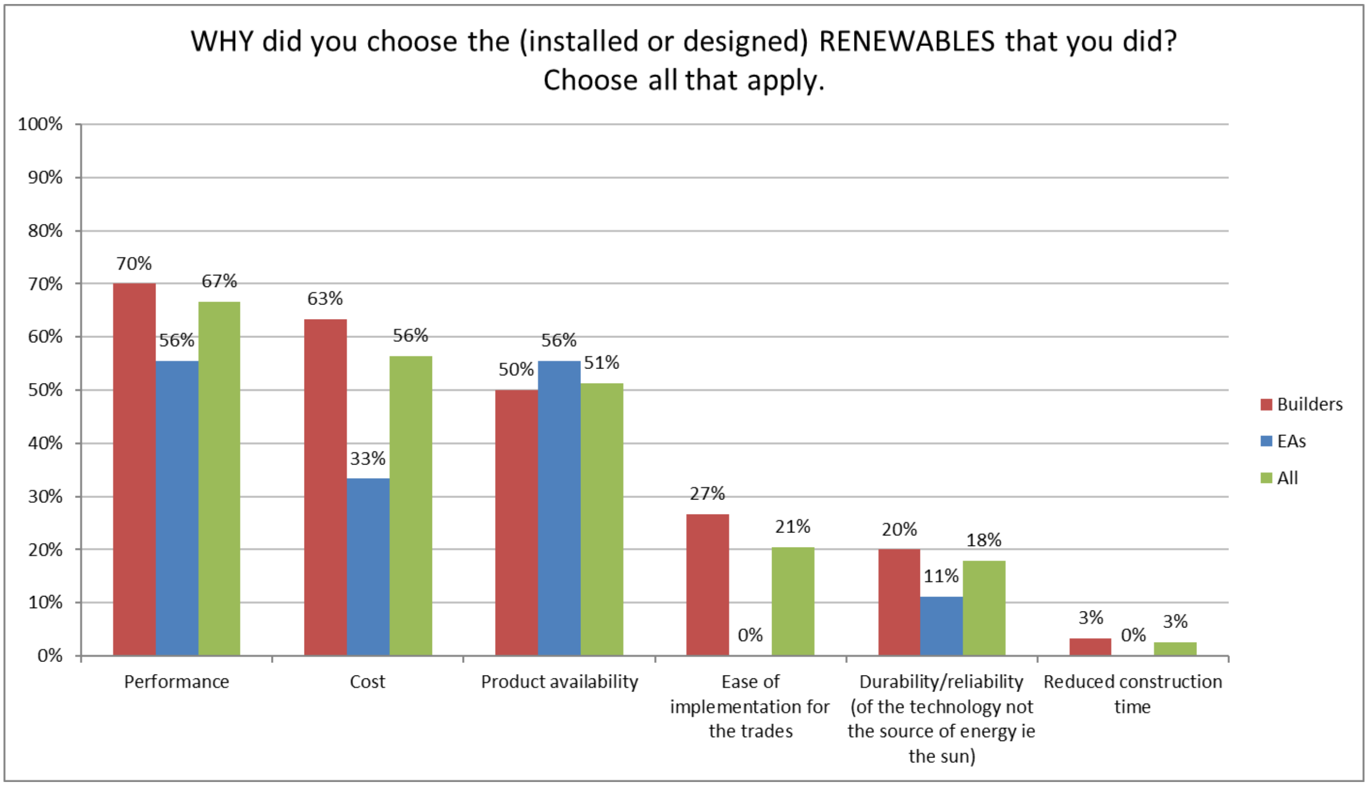


ANALYSIS

The energy efficiency of air-source heat pumps drove most projects to use this technology, even if they were paired with a back-up natural gas furnace in a hybrid scenario.

Product availability is a significant factor generally, but more so for builders in regions outside of large urban centres.

RENEWABLES

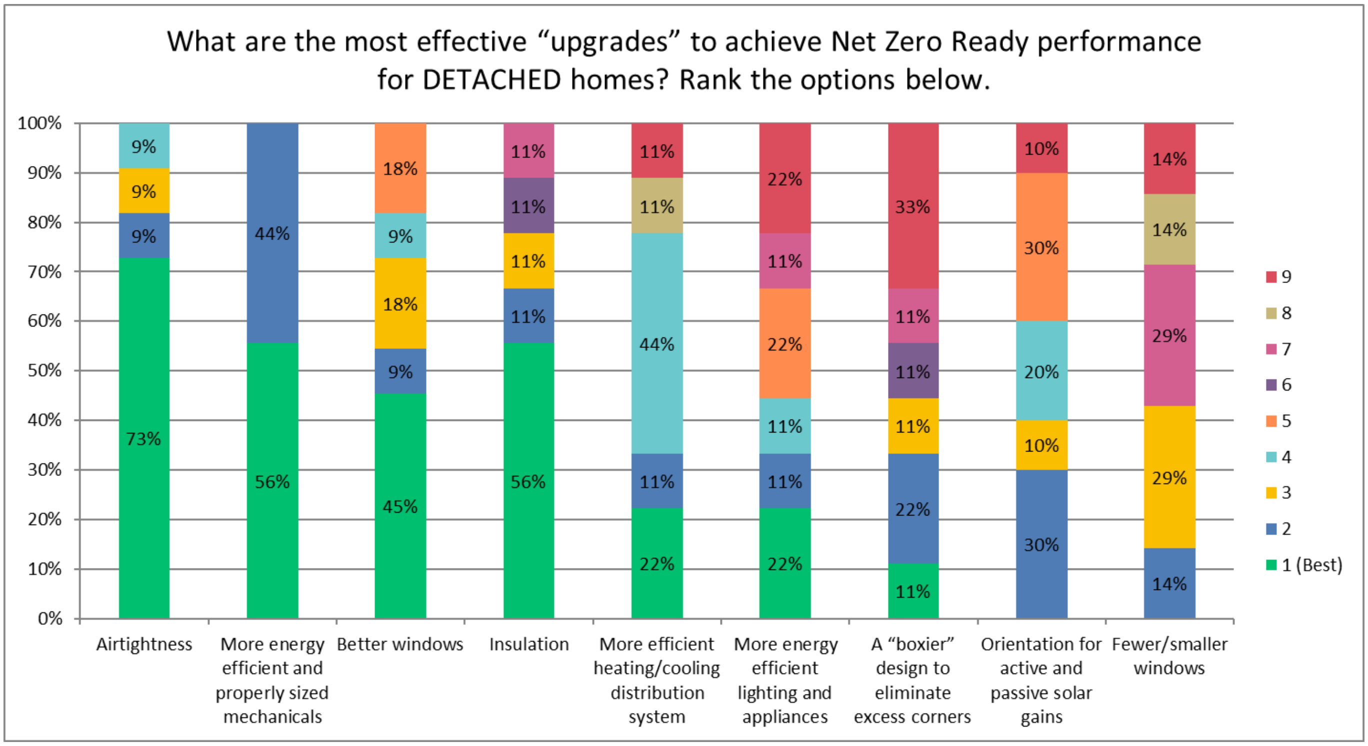


ANALYSIS

PV is the typical choice for renewables because the largest load demand in a NZ/r home is electricity based, not thermal. The choice of PV systems came down to a combination of performance, cost and availability.

Reference was made about a solar shingle product that was used. The widespread adoption of PV may require the aesthetics of PV systems to improve for the typical consumer, or the economics will need to be more compelling.

UPGRADES



ANALYSIS

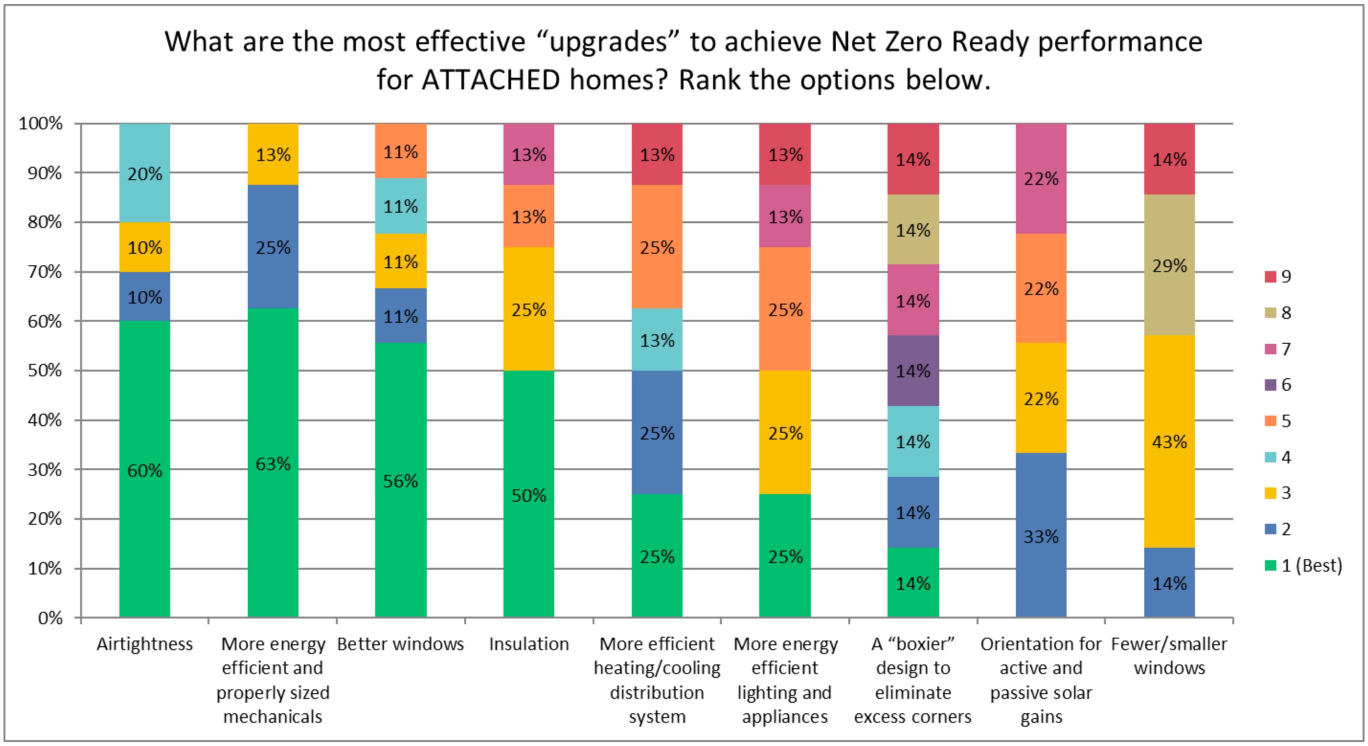
Shoe-horning NZr into current production builder models is challenging, and depends largely on their current baseline specifications, e.g. minimum code compliance, ENERGY STAR or R-2000.

The lowest-hanging fruit is airtightness. Mechanicals (including DHW) and windows are upgrades that can be performed without changing the geometry of the unit. Once those areas have been analyzed, then insulation upgrades can be assessed incrementally. The size of the house will also have a big impact on how much insulation will need to be added.

The roof's geometry will have a big impact on setting the performance target. For a production builder to implement NZr as a standard, every model would need to be analyzed using the worst orientation for the house with solar PV on its roof, which could prove to be very challenging.

It is relatively straightforward for low-volume homebuilders to make the most of each site they build on. Orientation is the biggest challenge, mostly for energy generation rather than consumption. Changes to the design to accommodate thicker walls or smaller windows may be a less-complicated process for low-volume builders than large-volume builders.

UPGRADES



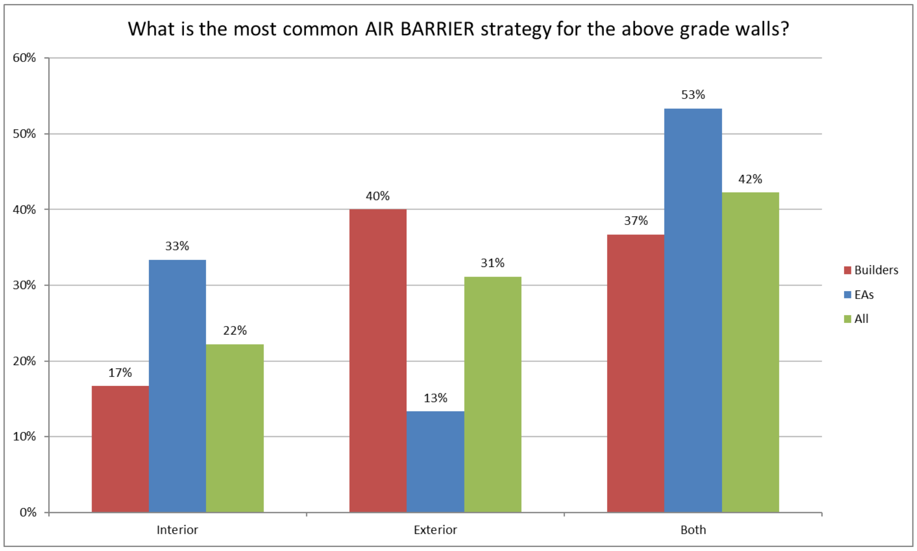
ANALYSIS

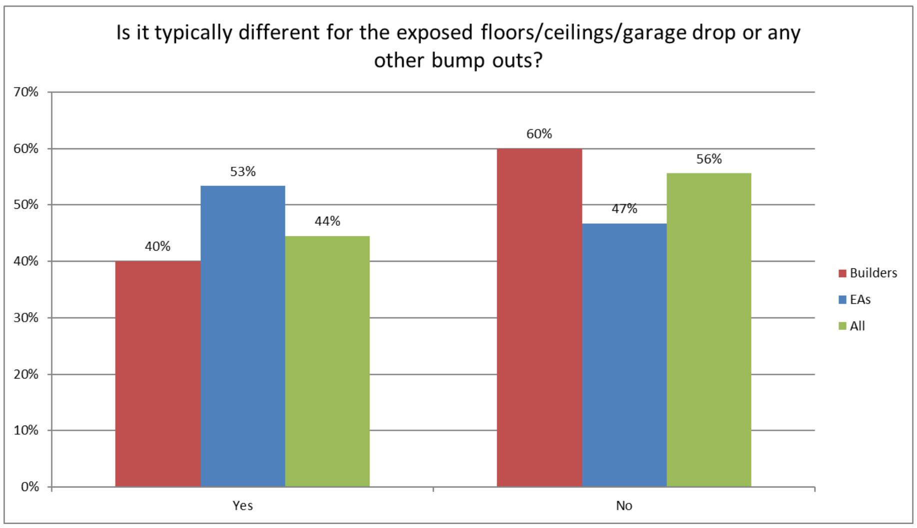
As with detached homes, shoe-horning NZr into current large-volume builder models is challenging, and depends largely on their current baseline specifications, e.g. minimum code compliance, ENERGY STAR or R-2000.

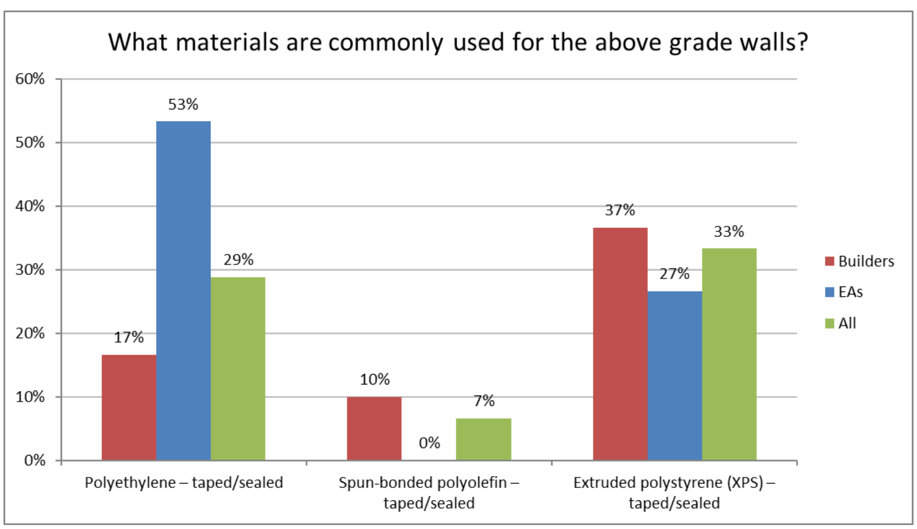
Again, similar to detached homes, the lowest-hanging fruit for attached homes is airtightness. However, achieving tight results is more difficult with attached units. Mechanicals (including DHW) and windows are upgrades that can be performed without changing the geometry of attached units. Once those areas have been analyzed, insulation upgrades can be assessed incrementally.

The roof's geometry will have a much bigger impact on setting the performance target than for detached homes. For a large-volume builder to implement NZr as a standard, every model would need to be analyzed using the worst orientation for the house with solar PV on its roof, which would prove to be very challenging for attached units due to the smaller roof space available. In addition, architectural controls may specify no street-facing solar.

AIR BARRIER



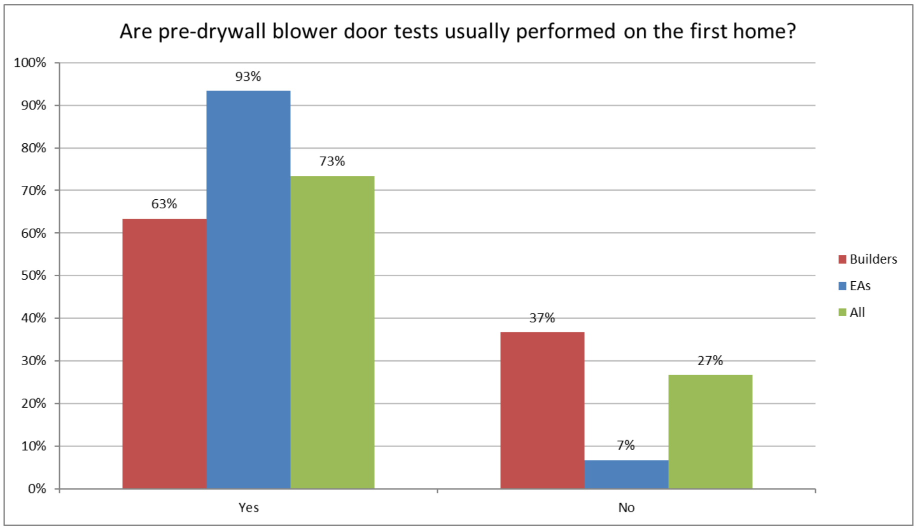


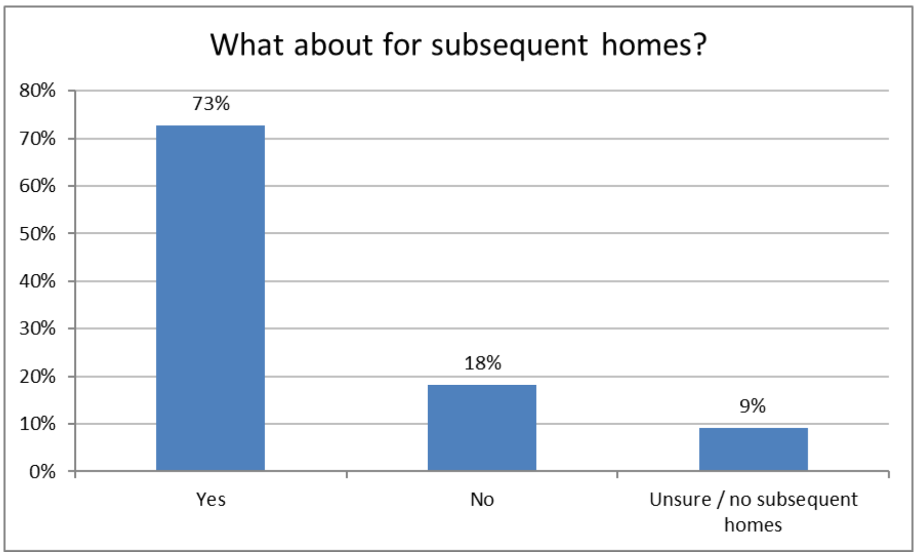


ANALYSIS

Many materials are being used in a successful air barrier strategy. The key is balancing the cost, ease of implementation, installation supervision and the durability of the system.

PRE-DRYWALL BLOWER DOOR TEST

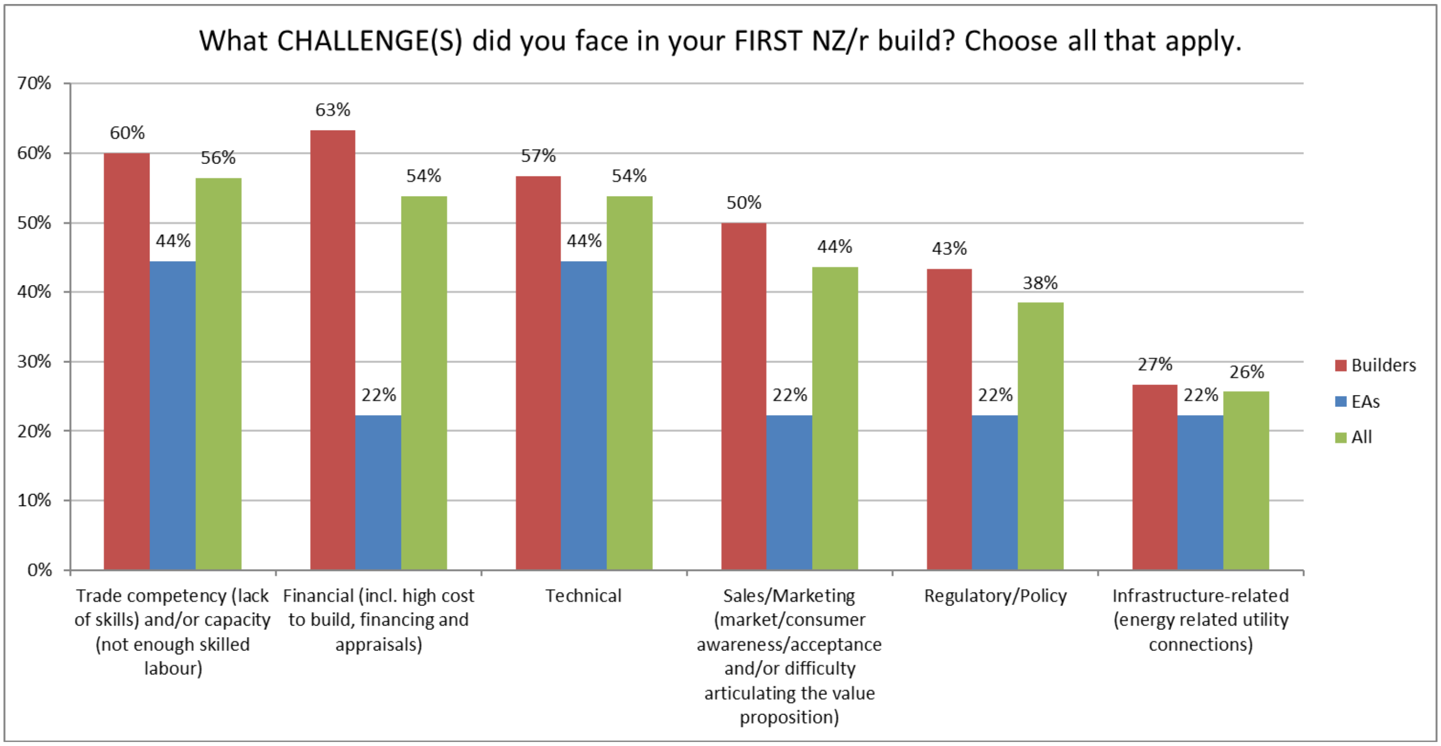




ANALYSIS

The benefit of performing a pre-drywall air test outweighs the costs associated with it. The risk of not achieving the required airtightness level, and perhaps not meeting the program requirement, is too high not to do a pre-drywall air test. The cost to find and seal air leaks once they are covered are avoided with pre-drywall testing.

CHALLENGES



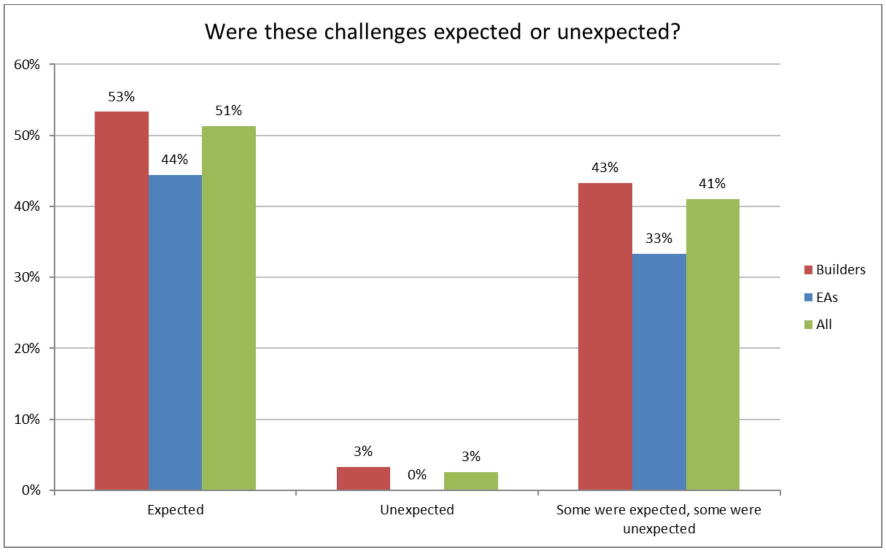
ANALYSIS

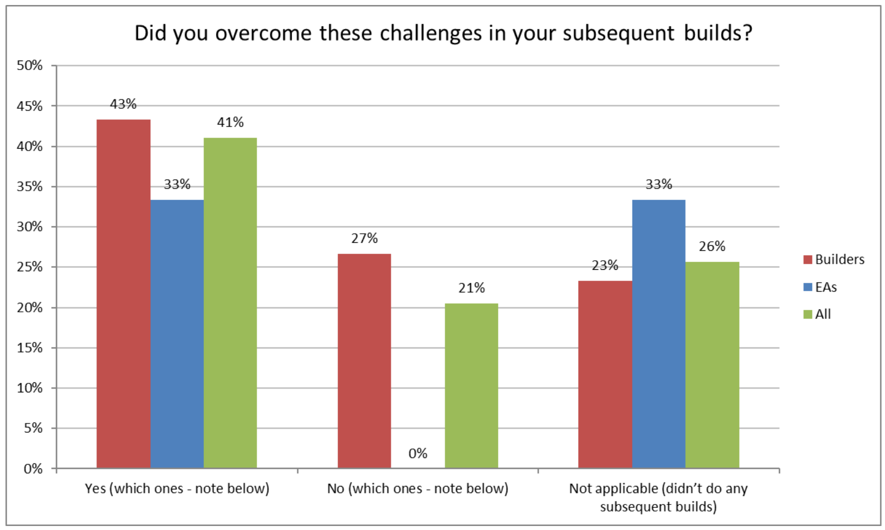
Education was the biggest challenge for most projects. This spans many fields, from trades, municipalities, financial institutions and appraisers to staff, sales teams and consumers.

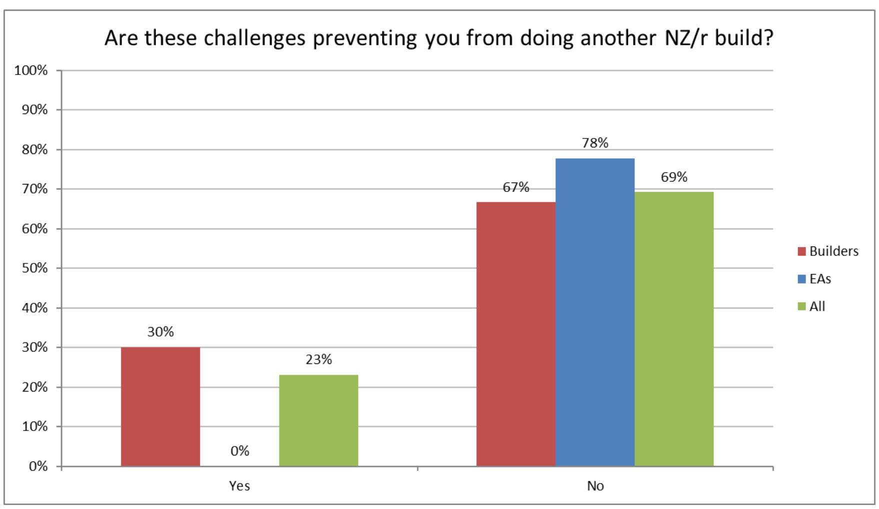
Some technical challenges included designing make-up air for rangehoods, difficulty controlling excess humidity, inability to be able to use "bleeding-edge" innovation, change in specs by sub-contractors and builders during construction, and difficulties reaching NZr for MURBS.

Finding the economic balance between achieving the performance targets and the marketability of the product was another big challenge. This is a moving target as builders streamline their processes and as products become more affordable.

Another challenge that was voiced in the workshops is the need to increase the electrical service to 200 amps, which increases the costs of a development. Some municipalities require this for all homes already due to the adoption of EVs.



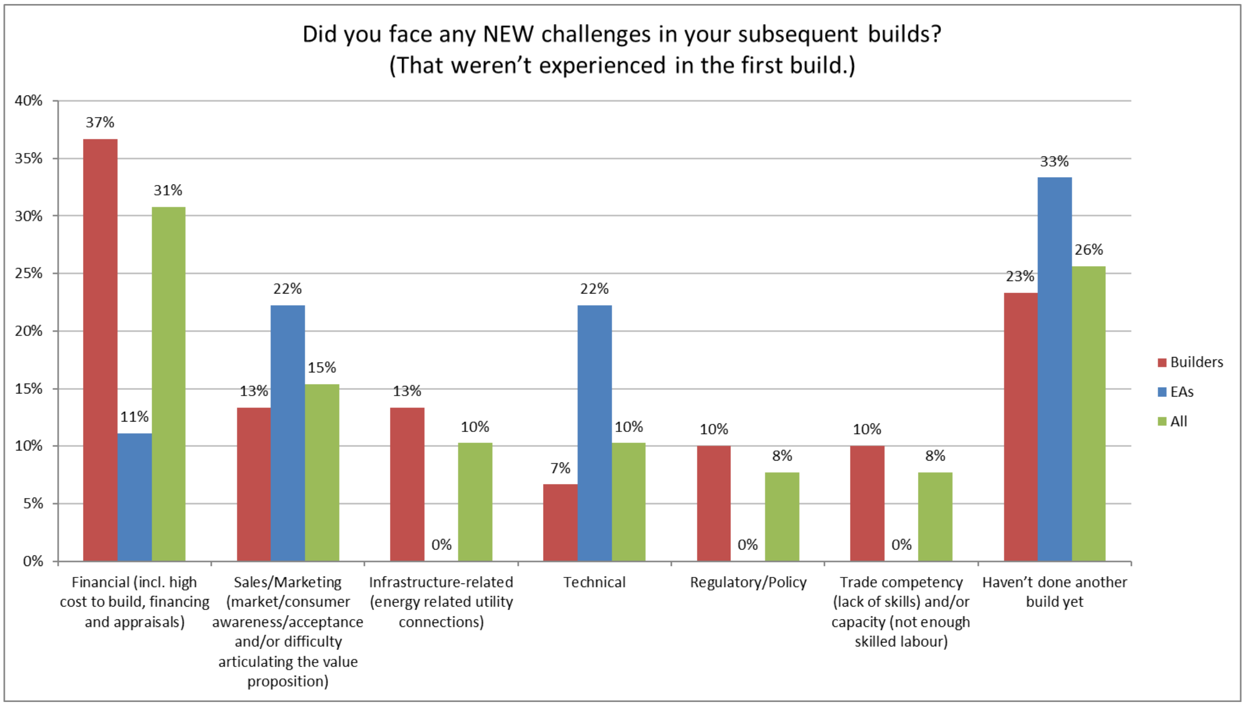


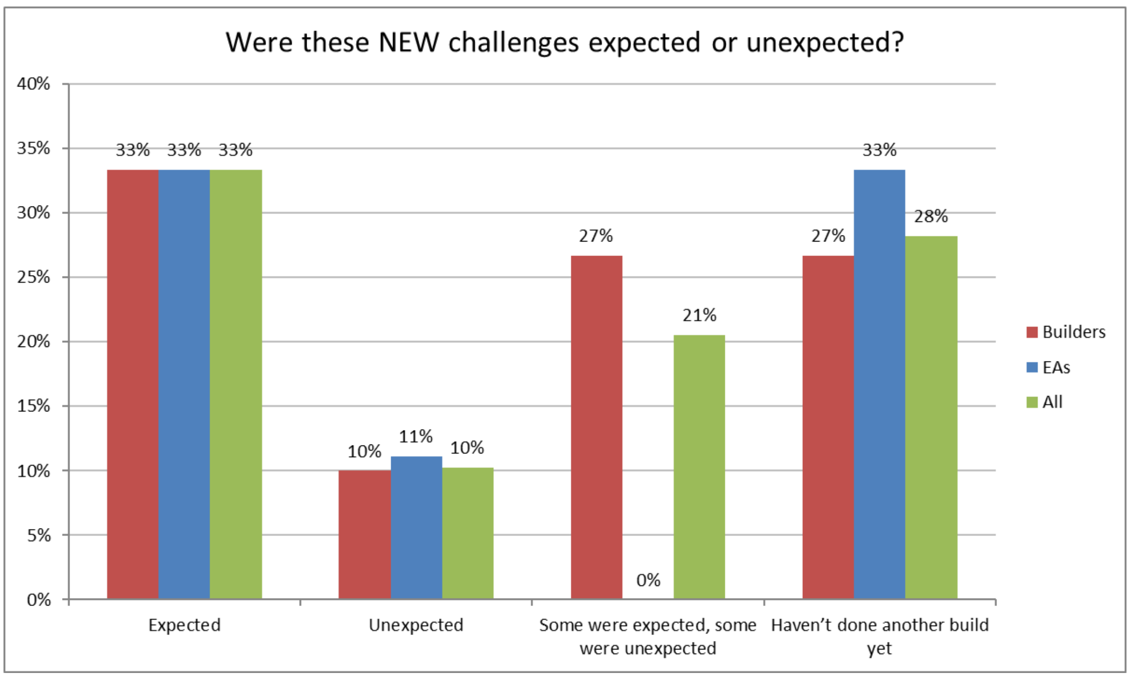


ANALYSIS

Trades and staff are slowly being educated on NZ/r. This is part of the learning curve that comes with adopting something new. Clients take a little longer to educate because they already have so many options to consider when purchasing a home. The issue is that the builders are being compared to other builders who may only be building to code minimums. Clients are typically price sensitive, so cost increases make code-minimum competitors look attractive.

LDCs and municipalities are gaining knowledge of NZ and Net Metering in some areas, which is helping to smooth the regulatory process.





ANALYSIS

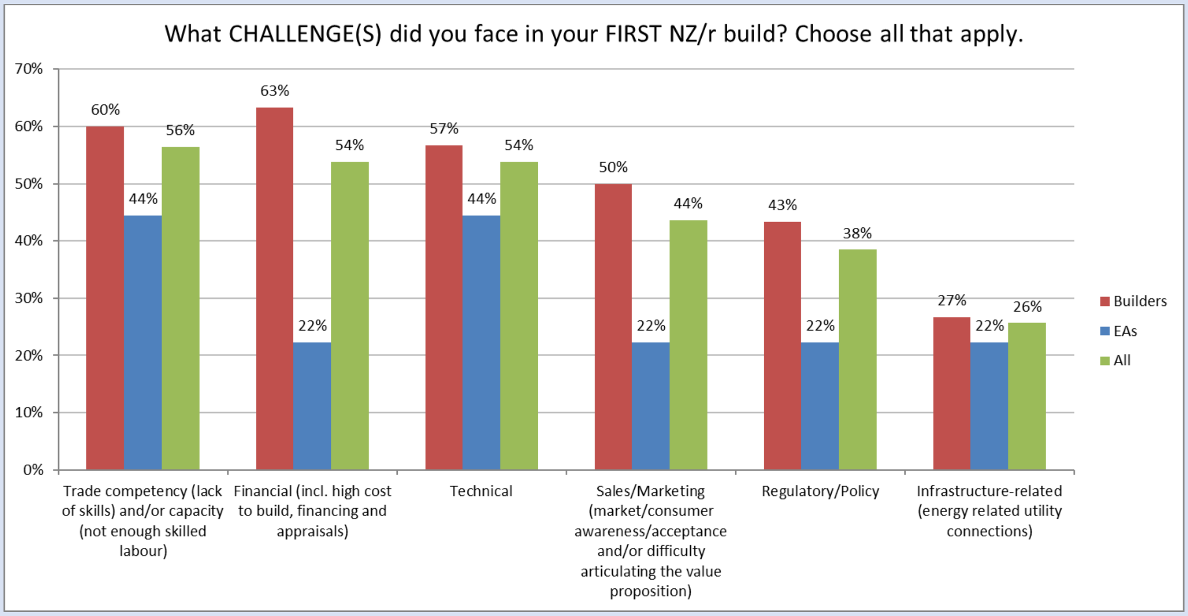
New technical challenges rose for those builders who wanted to try new assemblies. Those who continued using the same techniques found that trade competency was a lesser challenge. **Educating sales and marketing teams became more challenging.**
Financial institutions are slower to react and adapt without confidence in the numbers. This highlights the importance of gathering all the data possible to make the financial case for NZ/r.

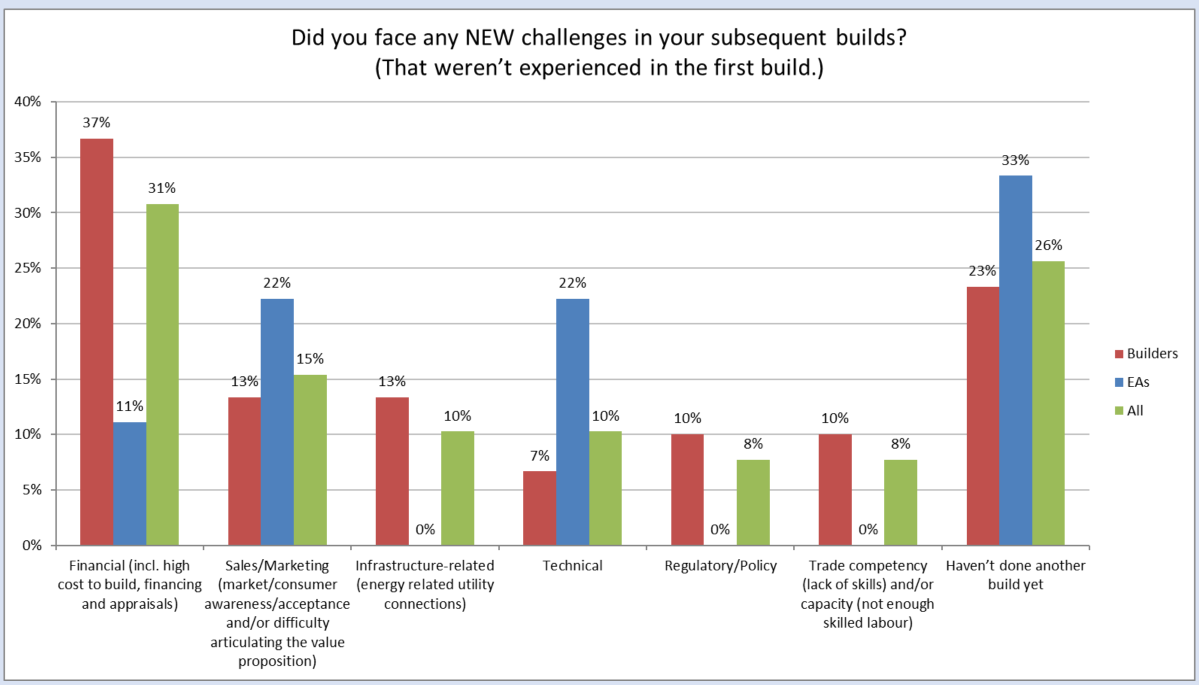
It was suggested that utilities are a challenge in some areas. Hydro companies can be a challenge for electricity generation installations as they need to develop strategies for homeowners who generate electricity on-site, such as the net metering program. And with the standing/fixed charges by gas utilities being significantly larger than the variable/consumption charges, some builders chose electrification of the homes.

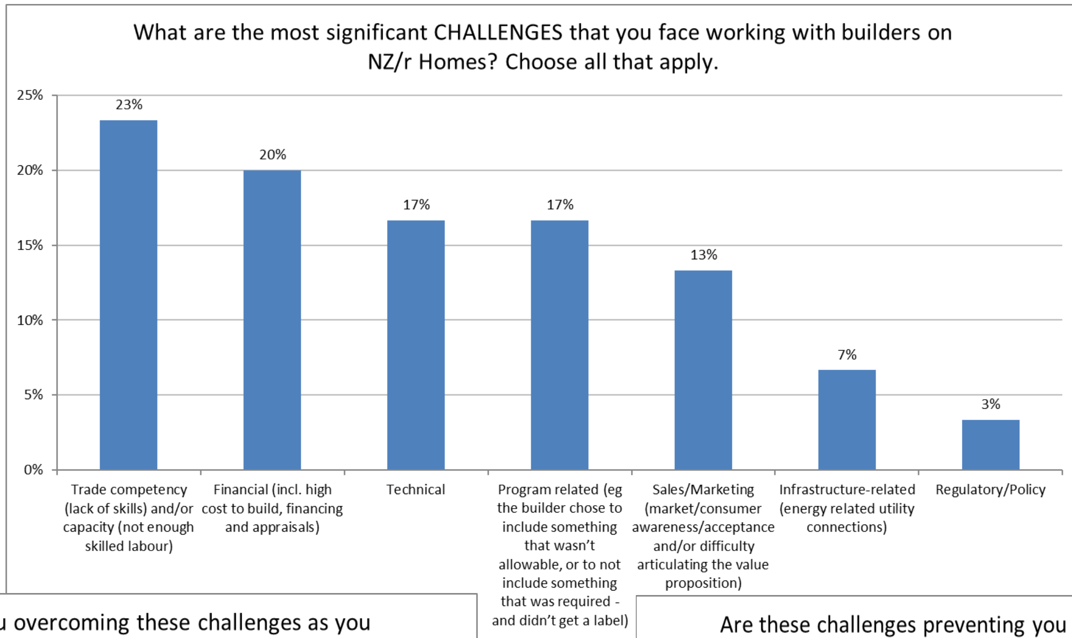
On homes with smaller footprints the available space for solar PV is reduced such that it would be impossible to meet the performance targets. The question then posed is: "can off-site renewable energy be used"?

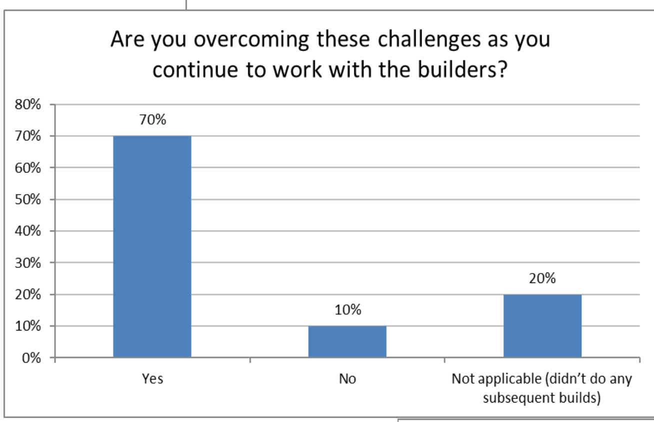
Comparison of challenges faced in first NZ/r build to subsequent builds:

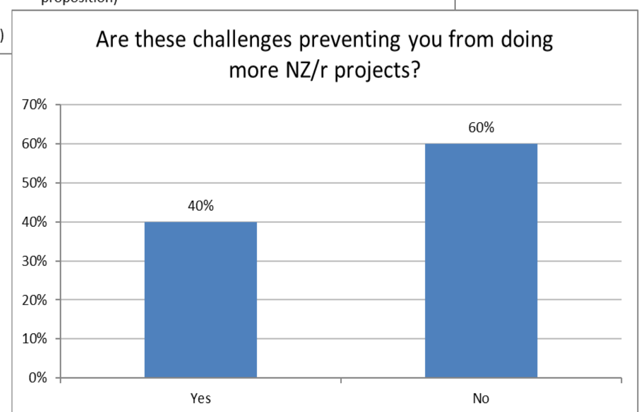
- Trade competency/capacity moved from 1st place to 6th place. *(Easy barrier to resolve?)*
- Financial moved from 2nd place to 1st place. *(Still biggest barrier?)*
- Technical moved from 3rd place to 4th place. *(The builders and EAs are figuring out what's required?)*
- Sales/Marketing moved from 4th place to 2nd place. *(Now they need a market to sell to?)*
- Regulatory/Policy stayed in 5th place. *(Not the biggest burning issue?)*
- Infrastructure moved from 6th place to 3rd place. *(Trying more innovative stuff after the first project?)*

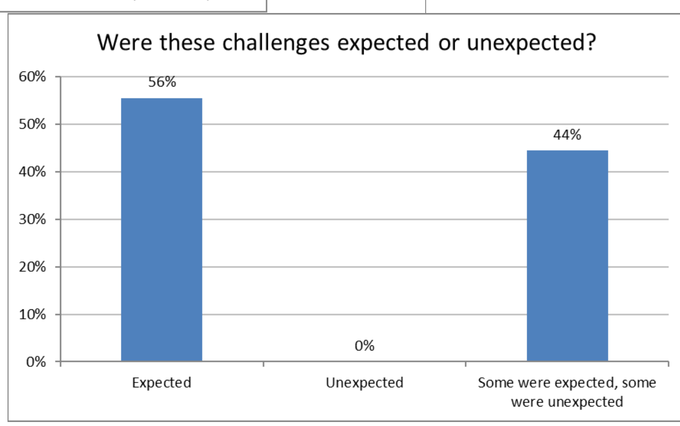








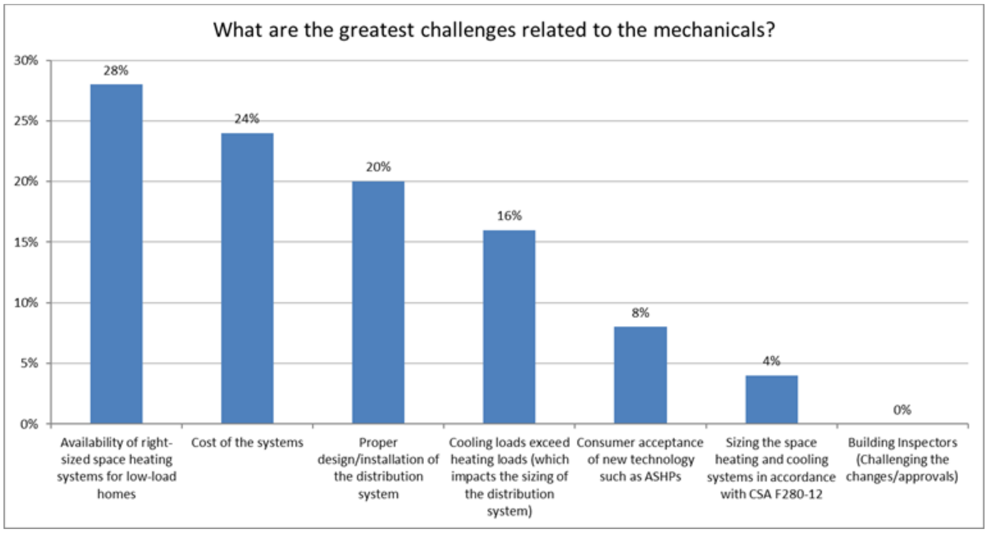




ANALYSIS

A significant challenge for EAs when working with the builders on NZr homes is developing specifications that are affordable and not too technical for the trades to adopt. Changes in subcontractors require retraining. Ensuring that the correct product and equipment makes and models are installed was another challenge.

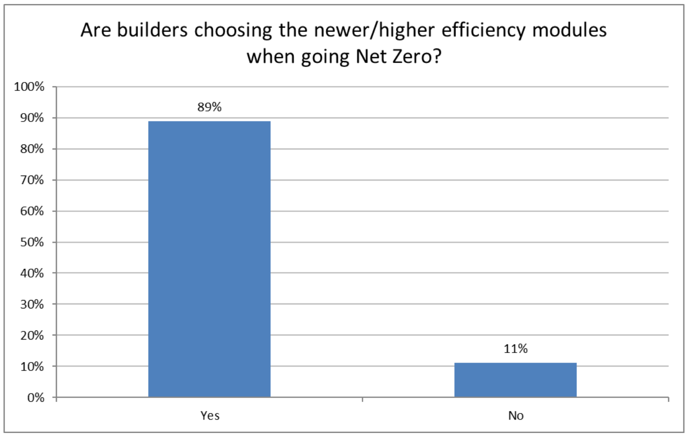
The biggest challenge for the EAs was from an administrative point of view. The modelling protocol required multiple HOT2000 files to be created for input into the calculation tools and for file submissions. Three files for NZ homes: Building Envelope Design Model, Space Cooling Evaluation Model, and Proposed Design Model, all with the renewable energy system to 0 GJ; and six files for NZr homes, which are the same as the NZ homes but include a duplicated set of files without the renewable energy system. Then, EnerGuide submission requires two additional files with different house file numbers; one for the house as-built (N), and one that is the proposed file (P). If the house is being dual- or triple-certified, i.e. ENERGY STAR and/or R-2000, then more files need to be created in HOT2000 appropriate to the respective programs.

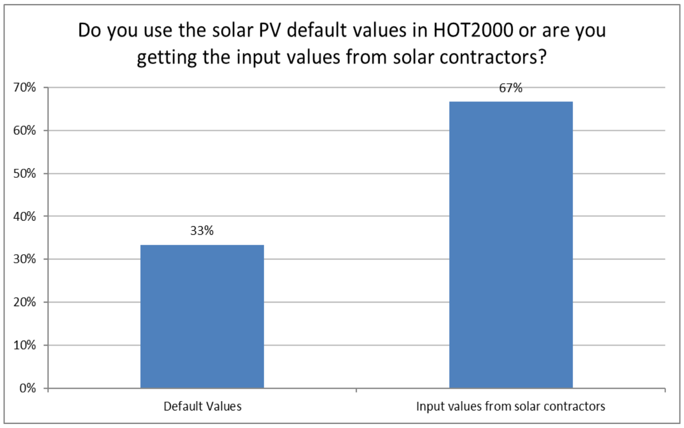


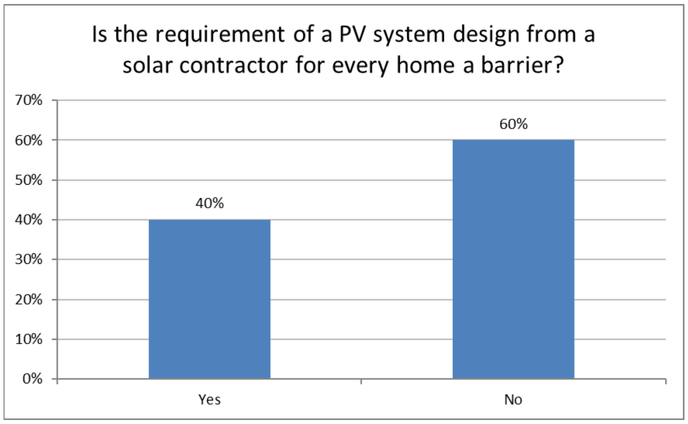
ANALYSIS

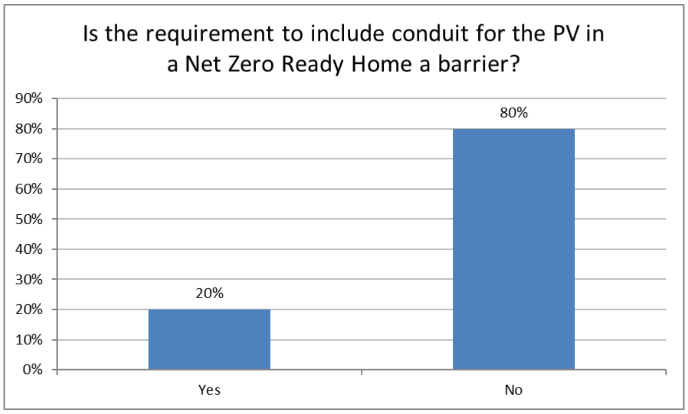
The challenges cited by EAs are similar to those cited by the builders. Right-sized equipment is still an issue. Availability of high-performance, climate-appropriate systems is another one. The heat loss / heat gain calculations can also be an issue. HOT2000 should be a dependable tool for this, but previous versions did not calculate cooling loads. Although NRCan has advised that this problem has been fixed, EAs remain cautious. It has been suggested that HVAC contractors should be enabled to conduct their own calculations, especially for high-performing homes like NZ/r.

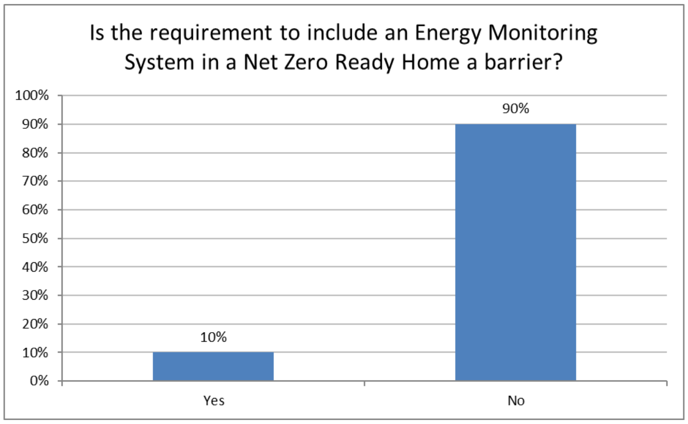
EA SURVEY









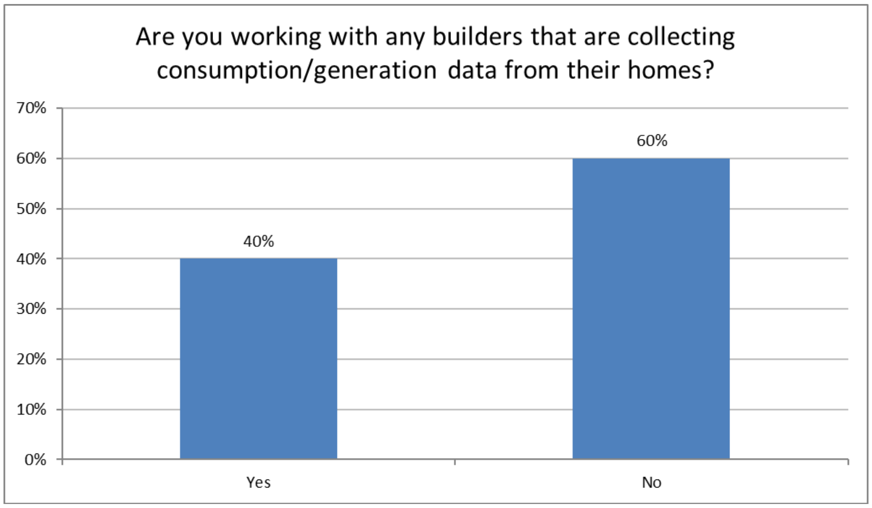


ANALYSIS

The sizing of the PV system, or the roof's potential, is critical to setting the performance target of the home. Some projects used solar contractors to help provide more precise sizing and generation estimates. Including solar contractors in the process can help maximize potential generation through the roof design, and reduce the thermal enclosure upgrades required. However, some PV contractors are hesitant to spend time on NZr projects as there is typically no compensation for their work or guarantee that they will win a contract in the future.

If PV conduit is not installed in NZr homes at time of construction, there is a concern that if it is installed at a later date, the contractor will not seal the penetrations effectively—regardless if PV conduit is installed on the exterior or interior.

The requirement for energy-monitoring systems to be installed was not a hurdle for most. NZ homes receive a monitoring system as part of the PV system; it was only being questioned for NZr homes.



ANALYSIS

During the workshops we heard that collecting data would be critical for the future of the program. Unfortunately, it is difficult to obtain the information once the homes are occupied. Homeowner consent would be required as would working with the utility.

What insights/observations can you provide regarding the widespread adoption of NZr practices?

A) WHAT PRODUCTS/TECHNOLOGIES/MATERIALS WOULD MAKE THIS EASIER/FASTER/CHEAPER?

ANALYSIS

Higher-performing, climate-appropriate, and affordable mechanical equipment was top of the list to make achieving NZr easier, faster and cheaper.

Airtightness strategies, for example the use of Aerobarrier™, was also suggested to overcome the air tightness challenge.

Window technology was suggested as a product that could make a big impact on the performance of homes. Lower U-values, lower SHGC, moving away from energy ratings, and the development of integrated, exterior operable shading were recommended.

Prefabrication of building assemblies was also mentioned to streamline the building process and associated costs.

B) WHAT R&D NEEDS TO BE DONE BEFORE THE ENTIRE INDUSTRY WOULD BE ABLE TO BUILD NZ/r HOMES?

ANALYSIS

R&D on mechanical system design and performance is highly sought.

Case studies/data on the actual energy and cost performance of completed and occupied projects could help identify cost-saving or cost-neutral solutions.

Financial institutions and insurance firms need to develop a model that can make NZ/r homes more affordable.

BIPV needs to be researched and developed. Some consumers do not like the aesthetics of typical PV modules.

Solar storage and its impact on an annual basis and at particular times of the year when they can be used for peak-shaving.

Utilities will need to do their own R&D to see what it will mean if all homes are NZ/r.

C) WHAT REGULATORY/POLICY CHANGES ARE NEEDED?

ANALYSIS

Provide monetary or administrative incentives to early-adopter builders and/or consumers.

More education and training for the municipalities on Net Zero building techniques and the benefits of Net Zero homes.

More acceptance from utilities to allow for the addition of photovoltaic energy generation.

Subsidizing homes that achieve NZE so that the utility bills are also 0. Allowing ground-mounted or offsite PV to offset the home's energy consumption for smaller homes, homes that are significantly shaded, rural, or MURBs.

D) WHAT CHANGES DO THE ENERGY UTILITIES NEED TO MAKE?

ANALYSIS

Utilities need to understand the role they will play in the adoption of NZ/r, how they will be able to handle the demand and how they will help homeowners transition to NZ.

Early-adopter builders should be provided support during the development of their projects, and homeowners should be provided support during occupancy.

E) WHAT SKILLS SHOULD THE TRADES HAVE?

ANALYSIS

In order to implement energy-efficiency building techniques, trades will require an understanding of building science and the reason behind what they are doing. They will need to be open-minded to change and willing to develop a better way of doing things. Once they know, they must be willing to apply and pass on the knowledge.

F) WHAT SALES/MARKETING TOOLS/SUPPORT ARE NEEDED TO IMPROVE CONSUMER AWARENESS/ACCEPTANCE?

ANALYSIS

The sales and marketing team should understand basic building science (features) and the "why" (benefits) of what they are selling. They need to be able to translate the technical information to potential homeowners, focusing on the benefits of the house as a system. They need case studies and/or model homes that show beneficial numbers associated with NZ homes, and how "new" technologies work in our climate.

G) WHAT WOULD HELP WITH THE FINANCIAL BARRIERS? (e.g. FOR DRIVING DOWN COSTS, FINANCING, APPRAISALS)

ANALYSIS

Operational cost savings realized by NZ/r homes need to offset increases in mortgage costs and monthly mortgage payments for homeowners.

Appraisers need information that demonstrates the value of highly energy-efficient homes.

Mandatory energy-rating labelling will allow potential homebuyers to compare the potential costs of operating NZ/r and other homes.

H) WHAT ARE THE MAIN OPPORTUNITIES THAT OUR INDUSTRY SHOULD CAPITALIZE ON?

ANALYSIS

Industry should promote the economic, health, comfort and environmental benefits offered by NZ/r homes. Energy rating labelling could help demonstrate economic benefits.

Accessing data and homeowner testimonials from NZ/r homes will help quantify and demonstrate the benefits of these homes.

With the imminent skilled trades shortage looming, prefabricated construction offers a significant opportunity to help the industry meet demand while maintaining quality and affordability.

I) Other?

Overall, what were the key lessons you learned that could assist other builders in achieving NZ/r levels of performance? (*If you were to start from the beginning again, what would you do differently*?)

ANALYSIS

The survey shows that significant work is required to simplify the process of designing and building NZ/r homes, and that careful planning is required, especially when building a NZ/r home for the first time.

From the builders' perspective, this means developing plans, details and specifications that make the construction process smoother and easier for the trades to implement and the municipalities to accept. This will be challenging for the majority of builders, who build only one to five homes per year. Simplifying designs to meet energy performance targets more easily, while keeping the home aesthetically pleasing is challenging.

From the EA's perspective, it is important to work with builders early in the process and throughout the build of their first few projects, and then provide ongoing technical support.

Sharing the experience of the early adopters will help other builders and EAs build NZ/r homes. Experiences and data collected will help to educate the community.

More effort is required to design and install appropriate HVAC system in NZ/r homes. These systems need to be correctly sized for the unit and must provide efficient and cost-effective space heating, cooling, dehumidification, ventilation and hot water.

What needs to be done before the entire industry would be able to meet more stringent energy-efficiency regulations related to new home construction?

Please refer to the chart documenting a preliminary assessment of opportunities and challenges identified through CHBA's TRC. See Appendix H.

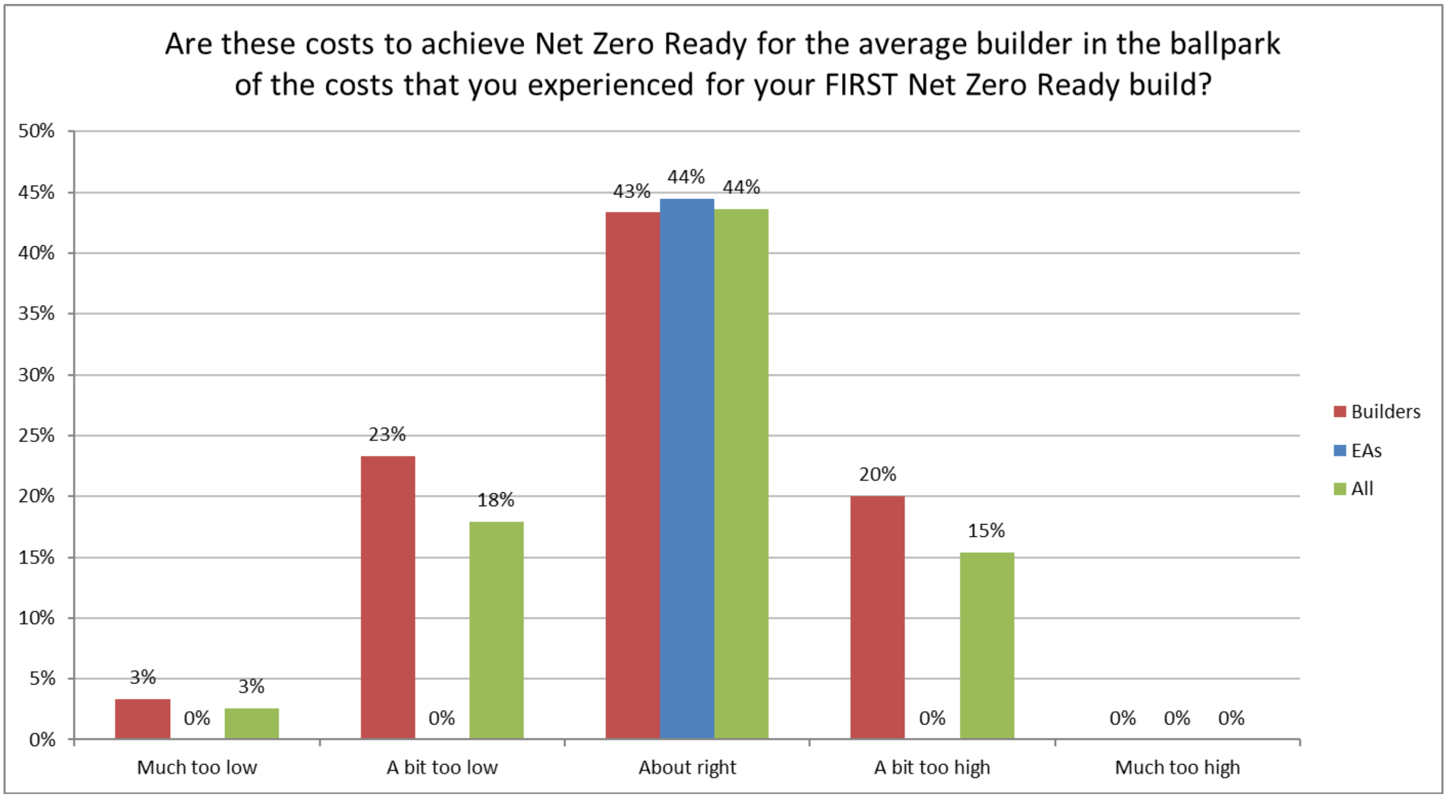
ANALYSIS

Research and Development into new technologies, particularly for space conditioning and windows, will help increase the available product options. There is a need to drive down the costs of these systems, reducing the upgrade costs from current code, ideally reaching parity.

Early-adopter NZ/r projects need to be subsidized/incentivized to bridge the affordability gap and allow more projects to be fully NZ rather than just "ready".

Education of high-performance, NZ/r homes far beyond builders needs to be increased for wide-spread adoption. Beyond builders and their teams, education is required for the EAs, homeowners, financial institutions, realtors, utilities and municipalities (especially building inspectors). Everyone needs to increase their understanding of NZ/r homes.

COSTING



Comparing Results from CHBA and B.C. Metrics Study

Going from 9.36 to NZr – without optimization

CHBA Results - *2,100 sq. ft. SDH*

Climate Zone	Initial Hard Cost	O&P	GST	Net Market Cost	Incremental $/sq.ft
4 (Victoria/Vancouver)	$19,375	$3,100	$1,124	$23,599	$11.24
5 (Toronto)	$25,025	$4,004	$1,251	$30,280	$14.42
6 (Halifax/Ottawa)	$25,265	$4,042	$1,263	$30,570	$14.58
7a (Edmonton)	$36,550	$5,848	$1,827	$44,225	$21.06
Average	**$26,554**	**$4,248**	**$1,366**	**$32,168**	**$15.30**

BC Results - *2,551 sq. ft. SDH*

Climate Zone	Initial Hard Cost	O&P	GST	Net Market Cost	Incremental $/sq.ft
4 (Victoria/Vancouver)	$17,448	$2,792	$1,012	$21,252	$8.33
5 (Toronto)	$23,750	$3,800	$1,188	$28,738	$11.26
6 (Halifax/Ottawa)	$45,076	$7,212	$2,254	$54,542	$21.38
7a (Edmonton)	$58,647	$9,384	$2,932	$70,963	$27.81
Average	**$36,230**	**$5,797**	**$1,846**	**$43,873**	**$17.20**

Overhead + Profit Factor = 16%
GST = 5%
Note BC study cites initial (unimproved) construction costs @ $190/sq.ft and incremental costs to Step Five @ 3.6%

ANALYSIS

The majority (44%) of the workshop participants felt that the range of costs (somewhere between the CHBA and BC Energy Step Code costing data) was within the ballpark of the costs they experienced for their first NZr build. A few felt it was either a bit too low (18%) or a bit too high (15%).

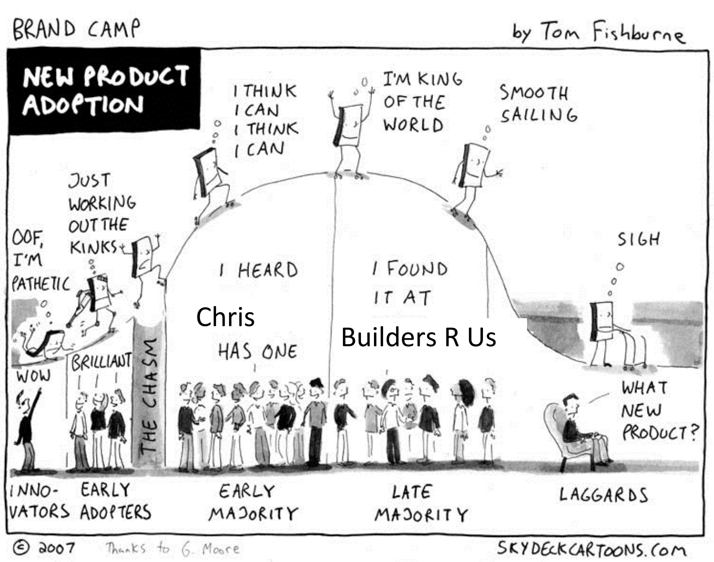
9.0 NEXT STEPS

This report serves to fulfil a few aspects of the CHBA Net Zero Council mandate, especially “to build awareness and knowledge through the consolidation and sharing of information”. It provides CHBA members with practical information on building Net Zero/Ready which, in turn, will help members assess the potential for offering higher levels of energy efficiency in the homes they build. Additionally, the results of this report will be used as supplementary information provided in the Net Zero training courses to assist builder members and Energy Advisors in designing Net Zero/Ready Homes.

To continue making advancements, some next steps **beyond the existing priorities of the Net Zero Council (found at** www.chba.ca/nzc) have been identified and include:

1. Exploring methods to encourage more voluntary participation in the NRCan LEEP process which has proven to be an excellent way to engage larger groups of builders in adopting higher levels of energy performance.
2. Conduct more consumer marketing via social media to build program/brand recognition and stimulate market demand.
3. Engaging post-secondary academic institutions to deliver the Net Zero training content to a wider audience, starting earlier in their career as opposed to how we’re currently doing - when they’re already working for a builder.
4. Investigating the opportunity to collect actual energy consumption (not just modelled energy consumption) from the utilities to validate the performance of the homes.

This document is available exclusively to CHBA Members. The digital version of this document can be found through the Council portal (www.chba.ca/nzc) or requested from the Program Coordinator at nzhlp@chba.ca. Feedback can also be provided at nzhlp@chba.ca which may influence future releases of the document.



- INNOVATORS (2.5%) are willing to take a risk on a good idea – they have the resources and desire to try new things even if they fail.
- EARLY ADOPTERS (13.5%) are selective about which technologies they start using - they are considered the “one to check in with” for new info & reduce others’ uncertainty about new technology by adopting it.
- EARLY MAJORITY (34%) needs solid evidence – willing to embrace a new technology as long as they understand how it fits with their lives.
- LATE MAJORITY (34%) adopt in reaction to peer pressure, emerging norms, or economic necessity – most of the uncertainty around an idea must be resolved before they adopt.
- LAGGARDS (16%) want solid proof that something works – are often economically unable to take risks on new ideas.

APPENDIX

A) Program Requirements for the Participants

- Pilot
  - Builder/Renovators:
    - Training: Must have successfully completed NRCan R-2000 Builder Training and CHBA NZ Builder Training delivered by NRCan R-2000 Service Organizations
    - License ERS: Must be licensed through NRCan to deliver EnerGuide Rating System (ERS).
    - License ESNH: Must be licensed through NRCan to deliver ENERGY STAR for New Homes (ESNH).
    - Labels NRCan: Obtain ERS, ESNH, and R-2000 label from NRCan.
    - Label CHBA: Obtain an NZ/r label from CHBA.

- Year 1
  - Service Organizations
    - Membership: Must be a member with the CHBA.
    - License ERS: Must be licensed through NRCan to deliver EnerGuide Rating System (ERS) v15.
    - License ESNH/R-2000: Must be licensed through NRCan to deliver ENERGY STAR for New Homes or R-2000.
    - Energy Advisors: Must employ/contract a minimum of one CHBA Qualified Net Zero Energy Advisor (EA) and ensure that they meet all the Program Requirements.
    - Training (Optional): Must employ/contract a CHBA Qualified Net Zero Trainer.
    - Insurance: Must provide proof of carrying and maintaining certain insurance policies.
  - Trainers
    - License ERS: Must be licensed through NRCan to deliver EnerGuide Rating System (ERS) v15 training.
    - License ESNH/R-2000: Must be licensed through NRCan to deliver ENERGY STAR for New Homes training for R-2000 training.
    - Qualified EA: Must be a CHBA Qualified Net Zero Energy Advisor (EA).
    - Training: Must have successfully completed an adult learning instructional skills/train-the-trainer course, and/or have experience in delivering technical training.
    - Mentoring: Must receive mentoring at their first session from a CHBA Qualified Net Zero Trainer.
  - Energy Advisors
    - License ERS: Must be licensed through NRCan to deliver EnerGuide Rating System (ERS) v15.
    - License ESNH/R-2000: Must be licensed through NRCan to deliver ENERGY STAR for New Homes or R-2000.
    - Training: Must successfully complete both CHBA Net Zero Energy Advisor Training and CHBA Net Zero Builder Training.
    - Consulting: Must successfully complete at least two (2) Net Zero Home files.
    - Insurance: Must provide proof of carrying certain insurance policies.
  - Builder/Renovators
    - License ERS: Must be registered through NRCan as an ERS builder
    - Membership: Must be a member with the CHBA.
    - Training: Must have successfully completed Net Zero Builder Training.
    - Label: Must successfully obtain their first Net Zero / Ready Label for a Home.
  - **All Qualified Participants must sign an Agreement with the CHBA whereas the CHBA has developed the Net Zero Home Labelling Program ("the Program") to recognize builders and service professionals who commit to its Administrative Requirements and recognizes houses that these builders and service professionals attest to meeting the Technical Requirements.**

B) Program Requirements for the Homes

- Pilot
    - ENERGY STAR for New Homes Certified
    - R-2000 Certified
    - Fenestration installed as per ESNH 4.2.3.1
    - Doors installed as per ESNH 4.2.3.2
    - Space cooling installed as per R-2000 NZE Pilot Space Cooling threshold manual calculation spreadsheet (.xslx)
    - NZE: Renewable energy system installed (Custom CHBA NZ Requirement)
      NZr: Renewable energy system designed (Custom CHBA NZ Requirement)
    - Energy monitoring system installed (Custom CHBA NZ Requirement)
- Year 1
    - Net Zero Homes
        - Comply with CHBA Net Zero Home Labelling Program Year 1 Technical Requirements
        - 3 HOT2000 files modelled with the renewable energy system to 0 GJ:
            - Building Envelope Design Model
            - Space Cooling Evaluation Model
            - Proposed Design Model
        - Building Envelope / Space Cooling (BE/SC) Evaluation Tool (.xls)
        - PV System Commissioning Report
    - Net Zero Ready Homes
        - Comply with CHBA Net Zero Home Labelling Program Year 1 Technical Requirements
        - 3 HOT2000 files modelled with the renewable energy system to 0 GJ:
            - Building Envelope Design Model
            - Space Cooling Evaluation Model
            - Proposed Design Model
        - 3 HOT2000 files modelled without the renewable energy system to 0 GJ:
            - Building Envelope Design Model
            - Space Cooling Evaluation Model
            - Proposed Design Model
        - Building Envelope / Space Cooling (BE/SC) Evaluation Tool (.xls)
        - PV Ready Checklist

C) Summary of Home Performance Values

Version	Climate Zone	City	Province	Type of house	Floor Area (ft²)	Year Built	Annual Energy Consumption GJ / Year	Airtightness Air changes / hour @ 50 pascals	MEUI kWh/(m²*year)	TEDI kWh/(m²*year)	% Better Reference Annual Energy Consumption	% Better Reference Building Envelope	Main Wall Effective R-Value	Ceiling Effective R-Value	Foundation Wall Effective R-Value
Pilot	7a	Calgary	AB	Single detached	2,437	2015	43.76	0.45	26.28	17.82	-	65.0%	41.5	55.9	37.5
Pilot	7a	Edmonton	AB	Single detached	3,307	2010	60.26	0.58	33.93	14.59	-	78.0%	46.7	79.9	42.0
Pilot	7a	Calgary	AB	Single detached	2,437	2015	43.33	0.52	25.76	16.97	-	66.2%	41.6	57.0	37.5
Pilot	7a	Calgary	AB	Single detached	2,437	2015	44.10	0.49	26.70	19.30	-	65.3%	41.6	52.0	37.5
Pilot	7a	Calgary	AB	Single detached	2,437	2015	44.25	0.49	26.89	19.58	-	64.7%	41.5	52.2	37.5
Pilot	7a	Calgary	AB	Single detached	2,341	2015	44.75	0.82	28.63	22.04	-	65.8%	41.2	60.2	37.5
Pilot	7a	Edmonton	AB	Single detached	3,281	2015	42.42	0.43	18.42	24.31	-	66.8%	37.4	84.6	33.2
Pilot	6	Ottawa	ON	Row house, middle unit	1,976	2015	31.79	1.50	15.50	18.48	-	82.7%	27.1	60.0	31.4
Pilot	6	Guelph	ON	Single detached	2,462	2016	33.12	0.81	12.30	20.33	-	64.8%	33.7	57.2	27.0
Pilot	6	Laval	QC	Row house, end unit	1,282	2015	21.20	1.63	16.65	14.83	-	93.3%	27.8	35.6	0.0
Pilot	6	Laval	QC	Row house, end unit	719	2015	21.51	1.63	31.00	36.14	-	77.6%	27.5	45.7	0.0
Pilot	6	Guelph	ON	Single detached	2,349	2016	32.91	0.87	12.63	20.71	-	65.6%	33.4	59.3	27.8
Pilot	6	Laval	QC	Row house, end unit	1,251	2015	21.18	1.63	17.03	19.00	-	85.7%	26.5	58.8	0.0
Pilot	6	Guelph	ON	Single detached	3,864	2016	41.84	0.93	14.58	21.95	-	56.0%	31.3	54.6	24.0
Pilot	6	Kanata	ON	Single detached	3,732	2015	49.05	1.24	22.56	36.77	-	46.1%	30.3	59.3	29.4
Pilot	6	Guelph	ON	Single detached	2,169	2016	32.59	1.06	13.22	21.36	-	66.2%	33.4	57.2	27.9
Pilot	6	Laval	QC	Row house, end unit	719	2015	21.34	1.36	30.28	34.64	-	77.6%	27.5	45.7	0.0
Pilot	6	Guelph	ON	Single detached	2,436	2014	33.86	1.13	13.98	26.58	-	65.1%	35.3	57.1	29.6
Pilot	6	Ottawa	ON	Row house, end unit	2,298	2016	36.05	1.47	19.38	30.39	-	79.2%	28.0	60.0	31.9
Pilot	6	Ottawa	ON	Row house, end unit	2,298	2015	37.27	1.47	21.65	28.53	-	80.6%	28.6	60.0	31.9
Pilot	6	Guelph	ON	Single detached	2,513	2016	33.97	1.27	13.05	22.71	-	67.0%	33.5	60.7	27.9
Pilot	6	Ottawa	ON	Row house, middle unit	2,073	2015	32.52	1.44	15.26	16.01	-	82.9%	27.2	60.0	31.5
Pilot	6	Laval	QC	Row house, end unit	1,251	2015	20.54	1.36	15.50	14.59	-	88.3%	26.5	58.8	0.0
Pilot	6	Laval	QC	Row house, end unit	1,282	2015	19.85	1.36	13.50	9.00	-	89.1%	27.8	35.6	0.0
Pilot	6	Flatrock	NF	Single detached	3,616	2014	45.64	0.50	20.21	26.19	-	88.7%	31.9	68.0	38.2
Pilot	5	London	ON	Single detached	3,944	2015	40.84	0.72	13.53	19.76	-	66.8%	33.6	66.0	30.8
Pilot	5	St. Thomas	ON	Single detached	3,528	2016	36.48	0.64	11.43	18.61	-	66.4%	31.5	55.4	25.3
Pilot	5	Welland	ON	Single detached	3,360	2015	35.97	0.83	11.55	19.73	-	62.6%	30.4	47.6	21.1

Version	Climate Zone	City	Province	Type of house	Floor Area (ft²)	Year Built	Annual Energy Consumption GJ / Year	Airtightness Air changes / hour @ 50 pascals	MEUI kWh/(m²*year)	TEDI kWh/(m²*year)	% Better Reference Annual Energy Consumption	% Better Reference Building Envelope	Main Wall Effective R-Value	Ceiling Effective R-Value	Foundation Wall Effective R-Value
Year 1	7a	Martensville	SK	Single Detached	3,286	2017	50.34	0.61	69.69	132.24	77.9%	60.5%	38.0	79.3	39.1
Year 1	7a	Edmonton	AB	Single Detached	1,817	2015	45.42	0.81	38.12	36.40	67.4%	53.1%	25.2	75.5	32.3
Year 1	7a	Edmonton	AB	Single Detached	5,956	2015	31.94	1.46	16.0	29.68	-	59.4%	36.3	60.2	42.3
Year 1	6	Fredericton	NB	Double/Semi-detached	3,090	2017	46.29	0.56	20.49	17.55	71.4%	65.6%	24.1	61.3	27.9
Year 1	6	Port Perry	ON	Single Detached	3,098	2016	65.14	1.33	30.26	18.27	49.6%	51.7%	29.9	56.0	22.0
Year 1	6	Guelph	ON	Single Detached	3,780	2017	43.39	1.23	18.42	26.90	78.3%	46.6%	29.2	55.1	28.4
Year 1	6	Fredericton	NB	Double/Semi-detached	3,147	2016	51.70	0.46	25.86	43.89	68.7%	67.5%	23.0	61.0	23.6
Year 1	6	Alkali Lake	BC	Single Detached	8,522	2017	77.44	0.49	13.55	28.36	76.3%	48.2%	33.3	40.6	23.1
Year 1	6	Halifax	NS	Single Detached	6,823	2016	51.18	1.06	12.83	51.75	79.9%	62.4%	33.2	74.0	23.6
Year 1	6	Port Perry	ON	Single Detached	3,098	2016	63.95	0.98	29.35	17.37	51.1%	51.9%	29.9	56.0	23.6
Year 1	6	Puslinch	ON	Single Detached	13,440	2017	90.37	0.89	23.47	40.96	74.8%	40.5%	30.5	58.5	33.4
Year 1	6	Quispamsis	NB	Single Detached	2,998	2017	38.64	0.40	30.86	74.57	82.0%	71.4%	28.4	70.5	27.0
Year 1	6	Fredericton	NB	Double/Semi-detached	3,193	2017	39.70	0.77	13.51	20.69	78.5%	64.9%	23.7	61.3	23.6
Year 1	6	Uxbridge	ON	Single Detached	7,765	2017	62.88	0.73	18.10	31.58	75.9%	38.9%	23.0	59.1	21.6
Year 1	5	St. Thomas	ON	Single Detached	2,688	2017	43.17	0.63	18.44	16.39	69.9%	57.7%	30.7	58.4	27.6
Year 1	5	Thamesford	ON	Single Detached	4,673	2017	46.32	1.14	14.84	22.98	78.5%	60.6%	29.9	59.8	28.4
Year 1	5	St. Thomas	ON	Single Detached	2,349	2017	42.44	0.73	22.10	16.20	70.2%	62.8%	30.6	52.4	28.7
Year 1	5	Strathroy	ON	Single Detached	3,802	2017	37.32	0.53	12.42	14.94	80.1%	56.3%	31.5	58.5	26.7
Year 1	4	Victoria	BC	Single Detached	5,677	2017	41.81	0.75	12.65	21.49	80.9%	53.7%	26.5	47.4	24.1

D) List of Makes and Models of Products Used

The list of products below is for reference only. It is the responsibility of the builder to confirm that a product complies with their prevailing building code and the energy efficiency regulations. It is the responsibility of the energy advisor to confirm that a product meets the performance needs of the project.

Space Heating (Primary):

Manufacturer	Model	Fuel Source	Heating Type	Steady State Efficiency
Chinook	C30-M-S	Natural Gas	Condensing furnace	96.6%
Climate Care	TP9C060B12MP12CB	Natural Gas	Condensing furnace	98.2%
Delphi	5kW backup	Electricity	Forced air furnace	100%
Dettson	Alize - GE2218EV15B	Electricity	Electric furnace	100%
Dettson	C015-M-V	Natural Gas	Condensing furnace	96.6%
Dettson	C030-M-V	Natural Gas	Condensing furnace	96.6%
Dettson	SUP 10	Electricity	Electric furnace	100%
Lennox	EL296UH070XV36B	Propane	Condensing furnace	97.3%
Lennox	SLP98DF070XV36C	Natural Gas	Condensing furnace	98.2%
Lennox	SLP98v	Natural Gas	Condensing furnace	98.2
Mitsubishi	EH17-MPAS-L	Electricity	Electric furnace	100%
Mitsubishi	MVZ-A18AA4	Electricity	Forced air furnace	100%
Mitsubishi	PUZ-HA42NKA	Electricity	Electric furnace	100%
Mitsubishi	PVA-A30AA	Electricity	Forced air furnace	100%
Mitsubishi	PVA-A30AA MX	Electricity	Forced air furnace	100%
Mitsubishi	PVA-A36AA4	Electricity	Forced air furnace	100%
Mitsubishi	PVA-A42AA	Electricity	Forced air furnace	100%
Ruud	U97VA	Natural Gas	Condensing furnace	97.8%
Stelpro	SDH18X20-4K230V	Electricity	Baseboard/Hydronic/Plenum(duct) htrs.	100%
Versati	GRS-CQ16.0	Electricity	Baseboard/Hydronic/Plenum(duct) htrs.	100%

Space Heating (Secondary):

Manufacturer	Heating Model	Heat Pump Source	Heat Pump Coefficient of Performance
Dettson	COND-18-01	Air	3.98
Dettson	COND-24-01	Air	4.27
Dettson	COND-30-01	Air	3.86
Direct Air	MOB30-09HFN1-MVOW/CTBU-	Air	4.22
Fujitsu	Out: AOU24RLXFZ In: AUO24RLF	Air	3.72
Lennox	XP25	Air	4.03
Maritime Geothermal Ltd.	TF-65-HACW-P-1T-CC-SDELF-14	Ground	3.99
Mitsubishi	ARI 8052678, See Info 8	Air	4.38
Mitsubishi	MXZ-2C2ONAHZ	Air	3.91
Mitsubishi	PUMY-P36	Air	3.82
Mitsubishi	PUZ-HA30NHA5	Air	3.95
Mitsubishi	PUZ-HA36NHA4	Air	4.38
Mitsubishi	PUZ-HA42NKA	Air	4.27
Ruud	UP20	Air	4.21
Trane	XR15	Air	1.99

Hot Water Heating:

Manufacturer	Model	Type	Fuel Source	Efficiency	Heat Pump Coefficient of Performance
A.O. Smith	PHPT80-102	Conventional tank	Electricity	85%	2.56
A.O. Smith	SHPT50	Conventional tank	Electricity	84%	3.056
A.O. Smith	PHPT-60 100	Conventional tank	Electricity	87%	2.67
A.O. Smith	PHPT-60	Integrated heat pump	Electricity	81%	2.4
Bradford White	RE2H80R108	Integrated heat pump	Electricity	90%	3.66
Envirosense	6g50100npdvh02	Condensing	Natural Gas	96%	0
Giant	172STE-3S8M-E8-HT	Conventional tank	Electricity	86%	0
John Wood	JWT-540H-DV	Instantaneous	Natural gas	95%	0
John Wood	JWT-240H-DV	Instantaneous	Natural gas	95%	0
Navien	NPE-210S	Instantaneous	Natural Gas	98%	0
Navien	NPE-240A	Instantaneous	Natural gas	97%	0
Rheem	PROPH50 T2 RH245	Conserver tank	Electricity	88%	2.72
Rheem	PROPH50 T2 RH350 D	Integrated heat pump	Electricity	90%	3.89
Rheem	CNRHE50	Condensing	Natural gas	80%	0
Rinnai	RU80	Instantaneous	Natural gas	96%	0
Rinnai	RUC80	Instantaneous	Natural gas	96%	0
Trinity	Tft399	Instantaneous	Natural gas	79%	0
Vaughn	S80	Integrated heat pump	Electricity	90%	2.56
Viessmann	Vitosol 200-F	Solar collector system	Solar	0%	0

Ventilation:

Ventilation System Manufacturer	Ventilation System Model	HRV Efficiency @ 0°C
Fantech	VHR200REC	67%
Fantech	SHR150	61%
Lifebreath	ECM 195	81%
vanEE	2000HE	84%
vanEE	60H-V+	75%
vanEE	90H-V ECM	74%
vanEE	g2400ee	74%
vanEE	2001ERV	69%
vanEE	90H-V ECM ERV	67%
Venmar	AVSHE1.8	84%
Venmar	X24ERVE	82%
Venmar	X24HRVECM	81%
Venmar	AVSX30HRVE	75%
Venmar	E15 HRV	75%
Venmar	AVS ERV EKO1.5	67%
Venmar	E15 ECM ERV	67%
Venmar	HE 1.8	67%
Venmar	HRVCONSTRUCTO2.0ES	65%

Drain Water Heat Recovery (DWHR):

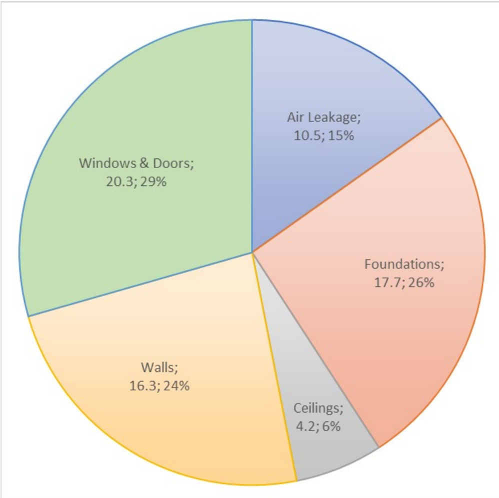
Drain Water Heat Recovery Make	Drain Water Heat Recovery Model	Drain Water Heat Recovery Efficiency
EcoInnovation Technologies Inc.	TD460B	57.3%
EcoInnovation Technologies Inc.	TD372B	55.6%
EcoInnovation Technologies Inc.	TD342B	42.8%
Power-Pipe	R3-72	58.9%
Power-Pipe	R3-60	53.3%
Power-Pipe	R3-48	46.6%
Renewability Energy Inc.	R3-72	58.8%
Renewability Energy Inc.	R3-60	53.7%
Watercycles Energy Recovery Inc.	DX-3058	42.0%

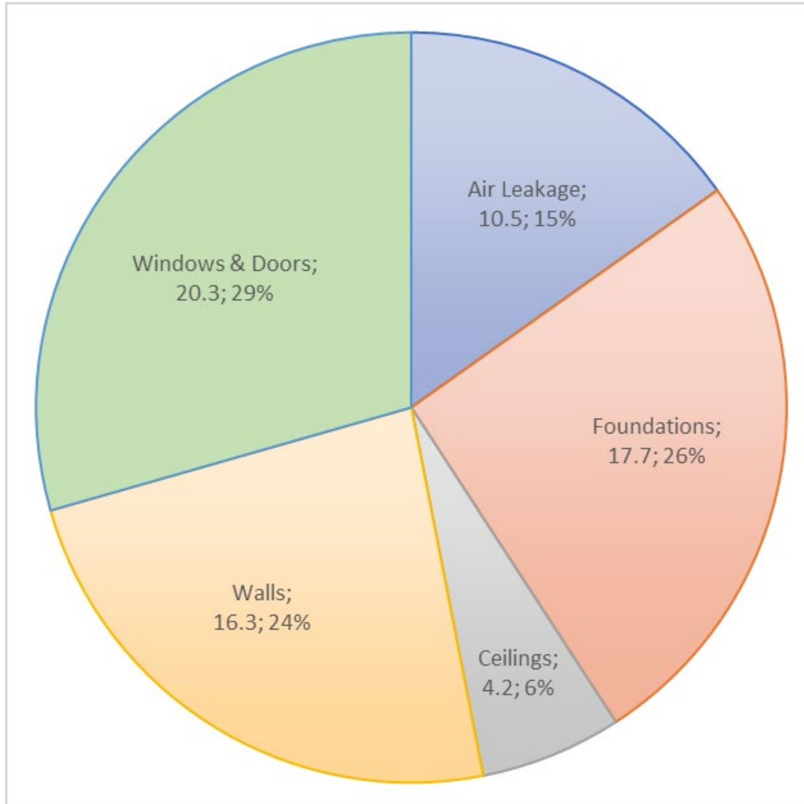
Photovoltaic Systems:

PV Manufacturer	PV Model	Average PV Efficiency
Canadian Solar	CS6U-340M	17.4%
Canadian Solar	CS6K-M 280	17.1%
Canadian Solar	CS6P-265P	16.5%
Canadian Solar	C56K-270	16.4%
Canadian Solar	CS6K-265M	16.2%
Canadian Solar	CS6P	15.8%
Heliene	60MHD-280	17.4%
Heliene	60PHD-275	17.1%
Jinko Solar	JKM250P-60	15.2%
Jinko Solar	JKM255P	15.0%
LG	LG 305	18.6%
Sanyo	HIT Power 215A	17.1%
Silfab Solar	SLA 285W	17.4%
Silfab Solar	SLA 235P	14.4%
Stark Energy	SM-260-BLK	15.6%
SunTegra Solar	STS 100	15.1%

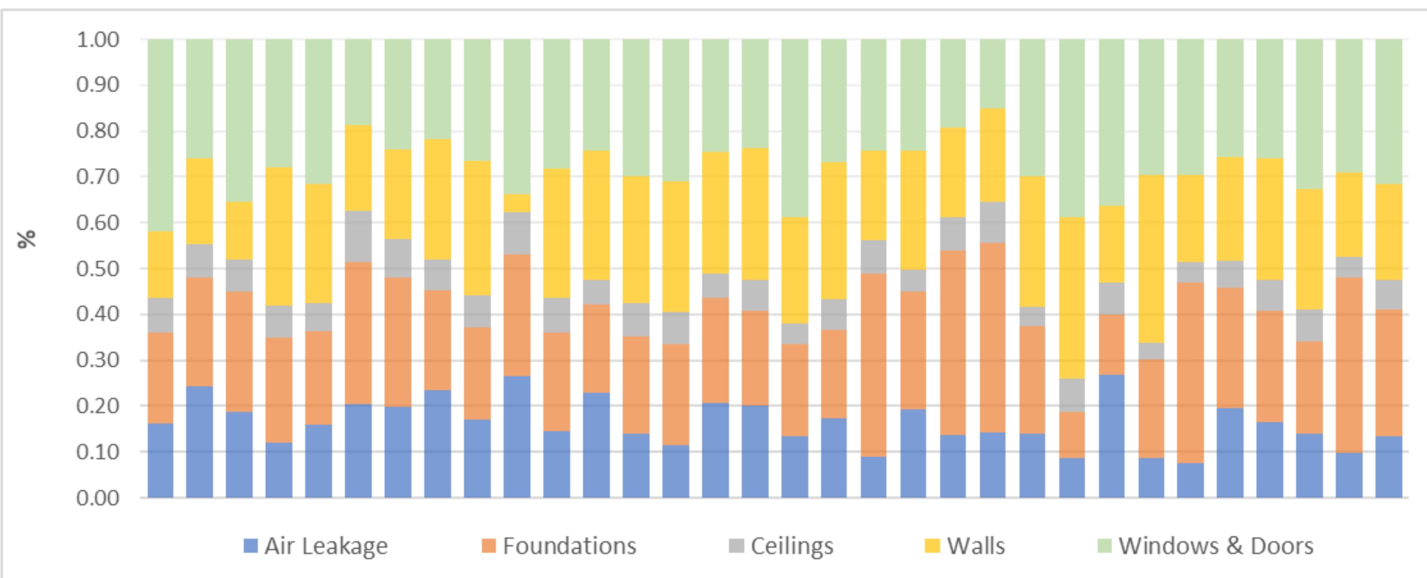
E) Whole Home Heat Loss (Detailed)

Pilot (Left): Avg. 49.6 GJ / year; Year 1 (Right): Avg. 68.9 GJ / year; 1.4x larger



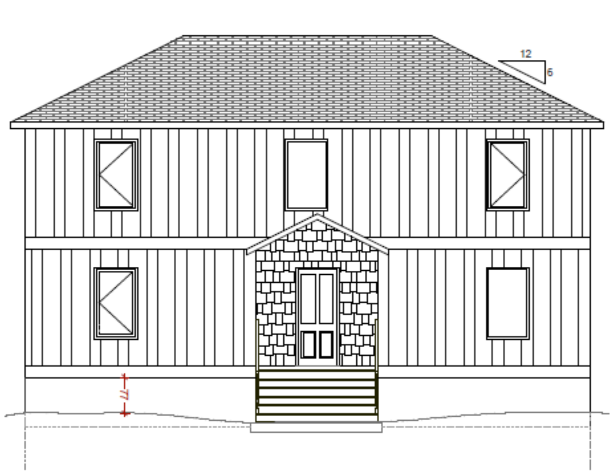


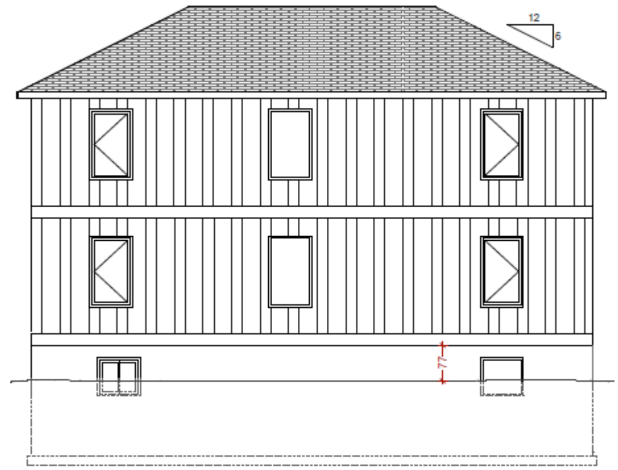
Visualization: Areas of Whole Home Heat Loss as Percentage of Contribution to Total Whole Home Heat Loss for the 32 SFD Projects

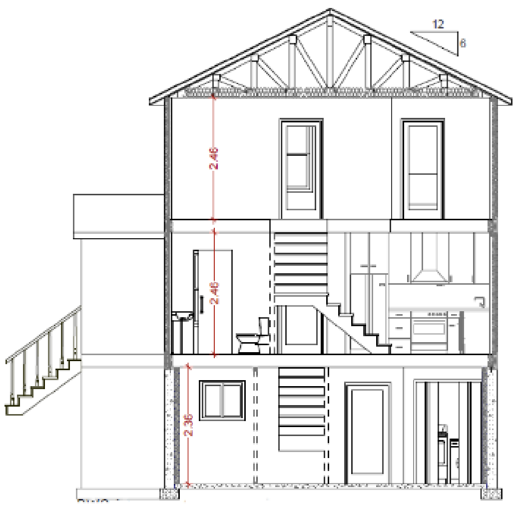


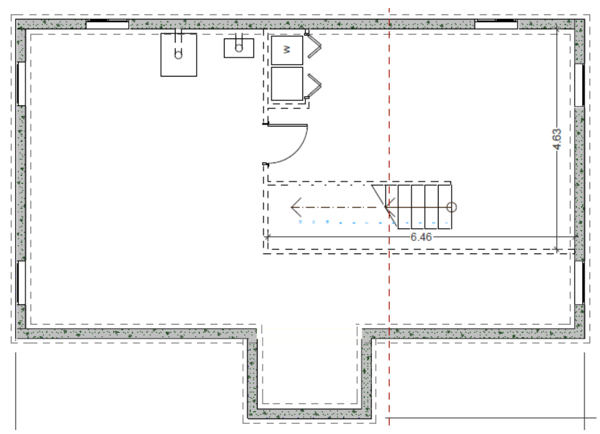
F) Archetypes Used in Costing Data

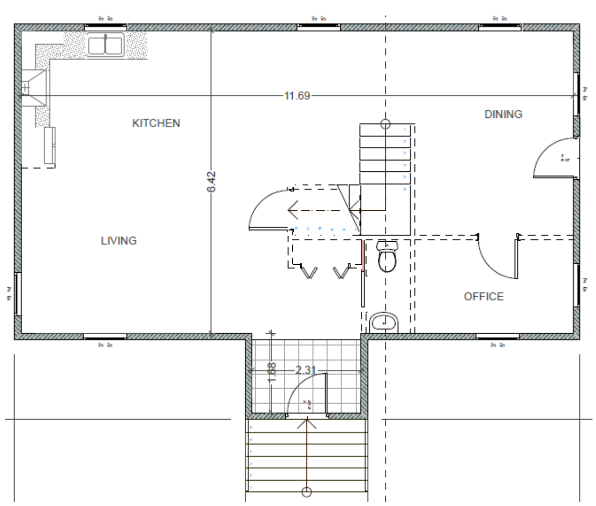
Archetype 4: Two storey, full basement (Front elevation, back elevation; section, basement plan; main floor plan, upper floor plan)

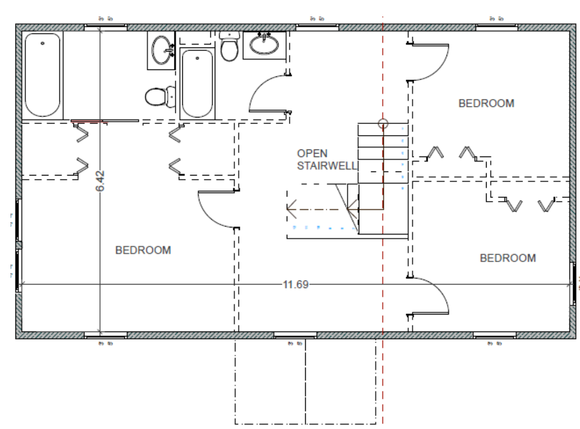




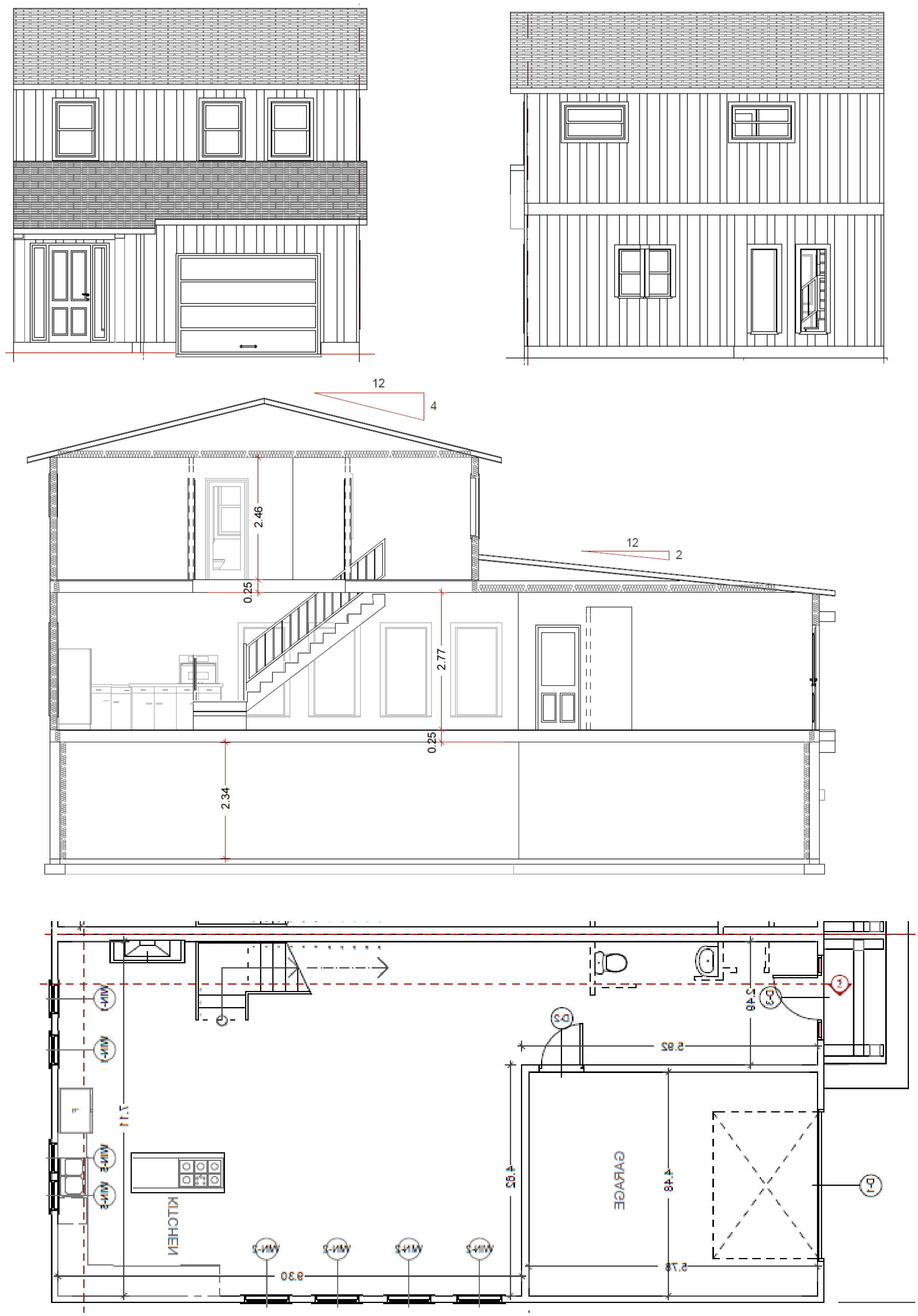








Archetype 10: Two storey, row, end (Front elevation, back elevation; section; main floor plan)



Archetype 11: Two Storey Mid, Middle unit to Archetype 10 (render)

G) Survey Participants

We would like to thank all of the participants for their time to participate in the online workshops as well as for their candid and constructive input and feedback!

BUILDERS									
Company	**Contact**	**City/Town**	**Prov.**	**What geographic region(s) do you build homes in?**	**How many homes per year do you build?**	**Who is your target audience? (eg First time buyers, luxury, etc.)**	**How many homes have you built targeting ERS 86+ (next Gen R-2000) energy performance?**	**Do you plan to build more homes targeting ERS 86+ (next Gen R-2000) energy performance? (If yes, how many/year?)**	**What energy labelling programs have you participated in?**
Clay Construction Inc.	Larry Clay	Langley	BC	Greater Vancouver	8-12	Luxury	Energy Star, R-2000 and Net Zero in a variety of stages	Yes, approximately 6	Energy Star, R-2000, Net Zero
Ian Paine Construction	Dwight Lochhead	Kelowna	BC	5	Less than 10	custom	8	1-2	Energy Star, R-2000, Built Green
Insightful Healthy Homes Inc.	Arthur Lo	Vancouver	BC	BC	4	energy efficiency home	over 50	yes, 4	Net Zero Ready, Living Building Challenge
Northern Homecraft Ltd.	Shay Bulmer	Vanderhoof	BC	Vanderhoof, Fort St. James, Fraser Lake	2-3	Anyone interested in a new home of any degree.	1	We would love to. At the moment we have had only one enquiry about such a home.	Energy Star, Net Zero
RDC Fine Homes	Bob Deeks	Whistler	BC	British Columbia South Coast	3-5	High Performance net zero both luxury and move up	5	yes	Energy Star, Built Green
Zirnhelt Timber Frames	Sam Zirnhelt	150 Mile House	BC	BC	15	all	4	yes - hopefully 10-20	Net Zero
Avalon Master Builder	Neil Hawkins	Calgary	AB	Alberta, Calgary	100	First time buyers	100	100	EnerGuide, LEED
Brookfield Residential	Doug Owens	Calgary	AB	North America	>3,000 / year in NA >1,000 / year in AB	multiple segments		Potentially	EnerGuide, Passive House
Effect Home Builders Ltd	Dale B Rott	Edmonton	AB	Alberta	7-10	Custom home customers	50+	7 -10 (all)	Built Green, R-2000, CHBA Net Zero, Holmes Approved Homes
	Peter Amerongen	Edmonton	AB	Alberta	10 luxury	Luxury, but moving toward affordable multifamily	~20	~6	CHBA Net Zero, R-2000, EnerGuide
Landmark Homes Canada	Haitao Yu	Edmonton	AB	Edmonton/Calgary, Alberta	400	Production builder targeting all sections of the new home market, except customer homes	75	about 30 - 50 per year	EnerGuide, Built Green, CHBA Net Zero
Net Zero Developments	Sikander Singh	Edmonton	AB	Edmonton	3	Anyone	6	Yes	Net Zero Energy
Solar Homes Inc	Peter Darlington	Calgary	AB	Southern Alberta	0	Renovations	renovated 5	yes 10/year renovations	EnerGuide
North Ridge	Errol Fisher	Saskatoon	SK	Saskatchewan	200	all	70	yes, 40	Energy Star, EnerGuide, Net Zero
Piller & Putz Construction Ltd.	Adam Putz	Regina	SK	Regina, SK and surrounding area (100 km radius)	1-2	Luxury, custom homes	0	0	EnerGuide, often do not label homes as Passive House and Net Zero standards do not always work well in our climate
Doug Tarry Homes	Doug Tarry	St. Thomas	ON	Ontario	80	Move Up / Move Down	100+	100+ (As Net Zero Ready)	Energy Star, EnerGuide, Net Zero/Ready
Dunsire Developments Inc.	Shawn Keeper	Burlington	ON	Kitchener, Mississauga, Guelph, Caledon, Jamaica	~50	second/third time, luxury	0	12 in 2019	Energy Star
Gemini Homes Inc.	Jason Fabbian	Guelph	ON	Southern Ontario	20-25	Luxury towns and large singles	7	2-4	Energy Star, Net Zero
Minto Communities	Paul Sagriff	Ottawa	ON	Ottawa- East, West, South	700-800	First time buyers, downsizers, families	None this year	1 Net Zero Project/ 2019	Net Zero
Reid's Heritage Homes	Jennifer Weatherston	Cambridge	ON	South Central Ontario - Cambridge, Paris, Guelph, Collingwood	350 low rise and midrise	wide range - investors, first time, retiree, 2nd home	10+	yes - converting product lines over for new sites - avg 25 a year and increasing year after year	Energy Star, CHBA Net Zero Ready, Sweet Home, LEED
RND Construction	Roy Nandram	Ottawa	ON	Ottawa	3 to 6	luxury	10	yes -all	R-2000, Net Zero Ready
Seaman and Sons Builders	Derek Seaman	Southampton	ON	Saugeen Shores	4-7	Cottagers, luxury homes	10-15	3	R-2000, LEED, Energy Star
Sifton Properties	Neil Carter	London	ON	Southwestern Ontario/London	60-100	Moderate to Custom	Not sure but every home is built to Energy Star	Yes	Net Zero, R-2000, Energy Star, LEED
Steve Snider Construction Inc	Stephen Snider	Port Perry	ON	Ontario	3 to 4	Educated Professionals	All homes meet or exceed this target since 2000	Yes / 3 or more per year depending on size and complexity	R-2000, Green Home, Energy Star, Net Zero/Ready
WrightHaven Homes	Steven Wright	Fergus	ON	Centre Wellington Elora Fergus	35	Move up move down buyer	50+	10+	R-2000, Energy Star, Net Zero
Construction Voyer	Jean-Francois Voyer	Laval	QC	Montreal - Laval (QC)	50	Luxury	One 6-unit MURB	No	NovoClimat
	Caleb Howden		NS	Nova scotia	10-15		25	yes 12	EnerGuide, Energy Star, R-2000, Net Zero

MCL Construction Ltd.	Brad McLaughlin	Quispamsis	NB	Great Saint John Region	1-2 plus 40 Reno's and/or Additions	All targets	3 since next gen many prior since the 80's	1-2	R-2000, Net Zero
Riko Passive Homes	Richard LeBlanc	Dieppe	NB	50 km radius of Moncton, NB	3-6	Second home buyers, higher end custom homes	5	yes 2-3 a year	
Anonymous Builder				Western Canada	3000+	All segments	2	20	

ENERGY ADVISORS

Company	Contact	City/Town	Province	What geographic region(s) do your builders work in?	How many builders are you working with that are doing NZ/r?	What other energy labelling programs have you participated in?
4 Elements	Tyler Hermanson	Calgary	AB	AB	3-4	EnerGuide, Built Green, R-2000, LEED, Passive House
Ecosynergy	Amelie Caron	Airdrie	AB	BC, AB, SK	3	EnerGuide, Built Green, R-2000, LEED, Passive House, NovoClimat
Sun Ridge Residential Inc	Darcy Bzdel	Saskatoon	SK	SK & AB	5	EnerGuide, Built Green, LEED
A & J Energy Consultants	Jack Zhou	Toronto	ON	SW ON	3	EnerGuide, Energy Star, R-2000, Super E, LEED
Building Energy Inc.	Mark Rosen	Ottawa	ON	Greater Ottawa area	2	EnerGuide, Energy Star, LEED, Passive House
Building Knowledge Canada	Kyle Anders	Cambridge	ON	Southern Ontario	>5	EnerGuide, Built Green, Energy Star, LEED, Green Seal
Building Knowledge Canada	Andrew Oding	Cambridge	ON	ON & 4-5 other provinces	~30	EnerGuide, Built Green, Energy Star, LEED, R-2000, Living Building Challenge, Zero Energy Ready (US DOE), etc.
Building Knowledge Canada	Angela Bustamante	Cambridge	ON	GTA/Niagara/SW ON	10	EnerGuide, LEED
Building Knowledge Canada	Mehmet Ferdiner	Waterloo	ON	SW ON	8-15	EnerGuide, Energy Star, R-2000
EnviroCentre	Greg Furlong	Ottawa	ON	Eastern Ontario	1	EnerGuide, Energy Star, R-2000, LEED
Homesol Building Solutions	Stephen Magneron	Perth	ON	ON & Atlantic	>5	Energy Star, R-2000, LEED, Passive House
Trillium Inc.	Robert Weatherseed	Toronto	ON	ON	1	Energy Star, HERS
EnergyWise Consulting	Lauren Lipka	Fredericton	NB	NB, NL	2	EnerGuide, Energy Star, R-2000
Summerhill Group	Peter Bohan	Halifax	NB	NS & NB	2	EnerGuide, Energy Star, R-2000
Summerhill Group	Dennis Naugler	Halifax	NS	NS & NB	3	EnerGuide, Energy Star, R-2000

H) CHBA “What Needs to be Done – Energy Efficiency and Part 9 NBC”

2019-01-10	WHAT NEEDS TO BE DONE—ENERGY-EFFICIENCY AND PART 9 NBC	
CODE DEVELOPMENT INFORMATION REQUIRED	**WHAT NEEDS TO BE DONE**	**NEXT STEPS**
• Differing interpretations of the term “net-zero-energy ready”; target(s) undefined	• Define “net-zero-energy ready” or adopt new term to clarify objective • Establish targets for code development (e.g. percentage improvement)	• Publish CCBFC-approved definition of “net-zero-energy ready” or alternate term to provide direction to SC-EE
• Technical challenges and potential unintended consequences need to be identified and addressed	• Identify solutions and make code developers and industry aware of them	• Review technical challenges and solutions identified through: o Cross-country survey and workshop with builders, building code officials, energy advisors and warranty providers o Development of 2012 9.36 provisions o Implementation of current energy-efficiency requirements o Development and implementation of the BC Step Code o CMHC EQuilibrium Initiative o NRCan R-2000 Net Zero Energy Pilot o CHBA Technical Research Committee (see initial list attached) o CHBA Net Zero Home Labelling Program o Other voluntary programs, e.g. EnergyStar
• A coordinated research plan is needed to support code development	• Identify research—completed, in progress and planned • Conduct research required to resolve technical challenge and tools for implementation • Determine how to keep the compendium up-to-date	• Develop research compendium • Post the compendium online • Use compendium to identify gaps and inform research plans • Maintain the compendium (add results of new research as completed)
• Cost information is required to assess impact	• Identify required information • Create and maintain costing database with Canadian data	• Identify funding to develop and maintain costing database
IMPLEMENTATION TOOLS	**WHAT NEEDS TO BE DONE**	**NEXT STEPS**
• Tools required to support implementation need to be updated or created	• Update airtightness testing standard or identify replacement standard • Update the depressurization testing standard or identify replacement standard • Develop user guides and training materials for designers, builders, trades and building officials • Support and encourage employer-directed training and partnerships among employers and post-secondary educational institutions, including co-op placements and other work-integrated learning opportunities	• Identify funding for update or replacement of airtightness testing standard • Identify funding for update or replacement of depressurization standard • Review CHBA capacity report • Review ACBOA capacity report • Identify technical challenges and solutions (see Code Development Information Required, above)
• Consumer readiness o Consumers and building owners/managers need information on operation and maintenance to optimize performance and avoid negative unintended consequences	• Conduct communications	• Develop communication plan identifying tactics, collateral, channels and timeline

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TECHNICAL CHALLENGES IDENTIFIED TO DATE BY CHBA TRC	PROPOSED SOLUTION	NEXT STEPS
• Multi-unit and other small floorplans ○ Limited efficiency gains are made in small homes and multi-unit buildings through enclosure upgrades—majority of load is occupant ○ Liveable space decreased in small factory-built floorplans due to allowable transport height, width, length and weight	• Ensure evaluation of proposed code requirements accounts for variety of archetypes • Ensure factory- and site-built, multi-unit and small floorplans are included in archetypes and are not disproportionally assessed in relation to energy use • Evaluate cost-benefit depending on tier, climate zone and building size and form	• Identify the archetypes to be used • Identify the costing methods to be used • Identify and obtain supporting information required
• Limitations on ability to meet minimum attic insulation levels at heel	• Provide alternate solutions for compliance	• Preserve current code provision 9.36.2.11. allowing for less effective thermal resistance of floor insulation or ceiling insulation in attics
• Opaque assemblies, enclosure insulation—fastening and fire protection	• Ensure implications for cladding fastening and fire protection are considered in tandem with development of new energy-efficiency requirements	• Document issues and solutions identified to date • Survey builders, building code officials, energy advisors, and warranty providers if more information required (see Code Development Information Required, above)
• Current CGSB airtightness standard for residential construction is out of date	• Update airtightness testing standard or identify replacement standard	• Identify funding for update or replacement of airtightness testing standard
• Current CGSB depressurization testing standard is out of date	• Update the depressurization testing standard or identify replacement standard	• Identify funding for update or replacement of depressurization standard
• 9.36 performance compliance not widely understood by building officials	• Develop user guides and training materials for designers, builders, trades and building officials • Deliver education and training	• Determine what's needed by building officials with the Alliance of Canadian Building Officials Associations
• Mandatory airtightness testing would present a challenge for rural and remote locations, where the availability of equipment and qualified testers is limited	• Provide alternate approaches to mandatory airtightness testing	• Ensure impact assessment considers cost and feasibility of testing in rural and remote locations • Ensure impact assessment considers feasibility for factory-based construction
• Increased airtightness may affect depressurization of combustion appliances and radon ingress	• Evaluate impact of increased airtightness and depressurization on performance of non-direct vent appliances and potential radon ingress • Ensure alignment between code provisions for radon ingress and code provisions for energy efficiency	• Review code provisions and code change requests related to radon ingress • Document how depressurization is addressed in the codes, rating systems (e.g. Energuide) and voluntary programs
• Airtightness and compartmentalization ○ Anecdotal testing in Canada suggests 30-40% of leakage in attached units is from adjoining units ○ Enhanced exterior air barrier detailing in 9.25 may be causing an increase in odour, sound and air-transmission complaints in attached housing projects	• Identify effective air barriers for common assembly walls/ceilings/floors	• Review related code provisions and submit code change requests as appropriate
HVAC • Efficient housing has resulted in decreased heating loads; lower loads are more challenging for manufacturers, designers, builders and trades • Consistent (across Canada) application of CSA F280 is required for heating equipment sizing in low-rise homes and buildings • Code requirements for ventilation (principal) in low-rise housing and the energy modeling of ventilation systems are not aligned (continuous vs 8-hr operation) • Installation of mechanical ventilation systems not well understood • Operation of mechanical ventilation systems not well understood	• Smaller heating appliances required • Develop user guides and training materials for designers, builders and building officials • Deliver education and training for designers, builders, trades, building officials • Conduct communications with consumers (see above)	• Identify small heating appliances • Identify education and training needs
Air Barrier vs Vapour Barrier • Lack of consistent industry understanding (designers, builders, building officials) of air barrier vs vapour barrier	• Include detailed information in the National Building Code • Industry training required • Identify key new research from NRC and related to vapour barriers, inboard-outboard ratios, and highly insulated assemblies	• Support the inclusion of the detailed information that has been proposed for the National Building Code during the fall 2018 public review • Review details in the Illustrated Guide
Windows • ER value causing substantial challenges in new homes • ERS window-modeling protocol encourages high solar-gain windows and gives limited credit for better, less-conductive window products	• Identify solutions to address ER value issues • Update ERS modelling protocol	• Identify and document challenges (e.g. use of ER for code compliance results in comfort complaints, high AC loads, high fan motor consumption and large air delivery system ducts) • Identify and document ERS modelling issues

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