MODULAR CONSTRUCTION Council

Conseil de la CONSTRUCTION MODULAIRE

Canadian Home Builders' Association

Association Canadienne Des Constructeurs D'Habitations

Photo courtesy of: Royal Homes


Photo courtesy of: Triple M Housing


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Photo courtesy of: Royal Homes, Kohn Shnier Architects

WORKING WITH MODULAR

CHBA Webinar Series 2022/2023

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1. **MODULAR CONSTRUCTION 101** (APR 28)
2. **MODULAR AND THE ENVIRONMENT** (JUN 23)
3. **THE MODULAR PROCESS** (NOV 2)
4. **CODES, STANDARDS & REGS FOR MODULAR** (NOV 17)
5. **FINANCING FOR FACTORY-BUILT** (DEC 15)
6. **MARKET DATA, INDUSTRY TRENDS & PRODUCT SHOWCASE** (FEB/MAR 2023)

Photo courtesy of: Triple M Housing

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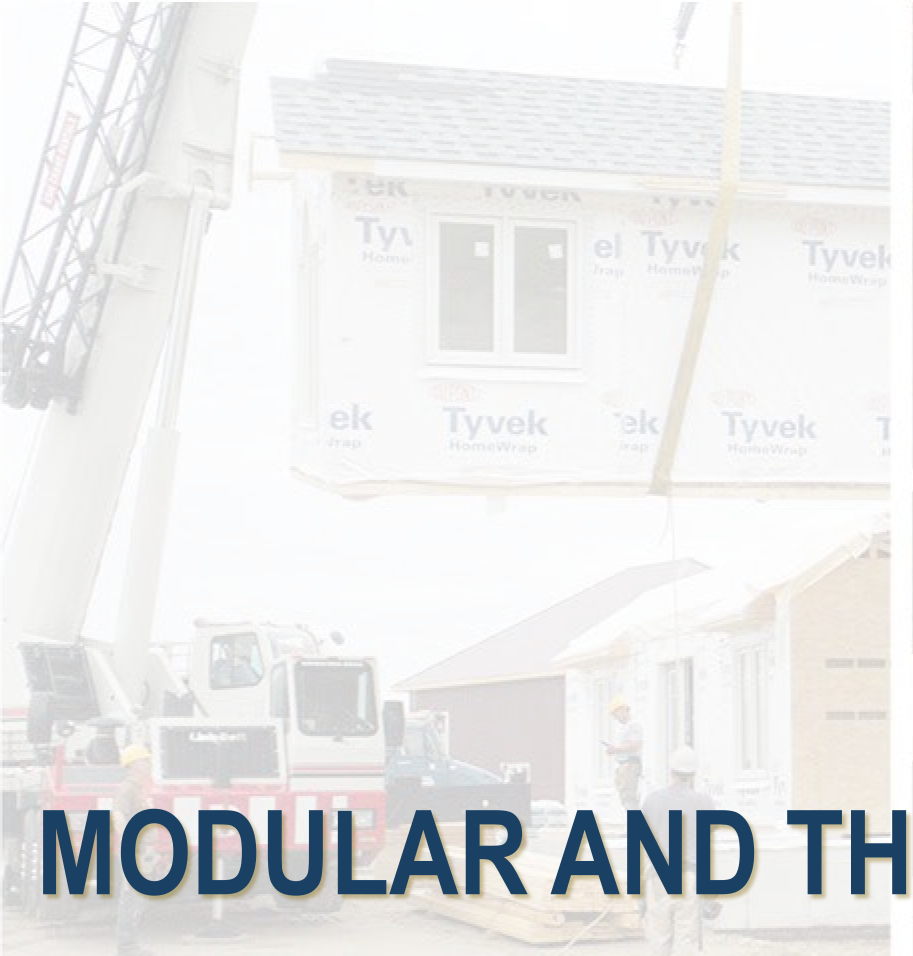

MODULAR AND THE ENVIRONMENT

1. Energy Efficiency / Net Zero Energy
2. Carbon Emissions & Sustainability
3. Resilience

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MODULAR AND THE ENVIRONMENT

Today's Guest Speakers:

- Clarice Kramer
- Cory Warms
- Dr. Mohamed Al-Hussein

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"Modular and the Environment" What are we talking about?

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

13 CLIMATE ACTION

7 AFFORDABLE AND CLEAN ENERGY

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

11 SUSTAINABLE CITIES AND COMMUNITIES

Climate Change			
Adaptation Accommodate changes in climate	**Resilience** Recover from extreme climate events	**Mitigation** Reduce adverse effects on climate	**Sustainability** Balance environment, equity, and economy
Better access to climate science & data, *infrastructure renewal, heat warning system, supporting vulnerable regions*	*Disaster mitigation funds, Smart Grids, smart technology,* ***renewable & alternative energies***, *supporting vulnerable regions*	***Net-Zero GHG Emissions by 2050***, *NZ Emissions Accountability Act, Home Energy Retrofits (Greener Homes Grant), Low-Carbon Economy Fund, Price on Carbon Pollution, Electric Vehicles*	***Reducing plastic***, *reducing waste, protecting & conserving nature, circular economy (reuse, recycle, repair), renewable building materials (wood)*

FRANK CLARICE CORY MOHAMED

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Modular Environmental Achievements

1. R2000 & EnviroHome®
2. CMHC Net Zero EQuilibrium™ home
3. BuiltGreen®
4. Winner of "Most Efficient House" Award & "Energy Efficient Community" Award 2012
5. North Ridge CO_2 Comparison

Modular Net Zero

Clarice Kramer

- **Case study #3**
- **NZ program requirements**
- **Carbon emissions**

Topic:

MODULAR and the ENVIRONMENT

Building construction, materials and energy performance all have a profound affect on the environment and these issues are all connected.

1. **Energy Efficiency** = how much energy is needed to keep a house comfortable and safe for its occupants
2. **Carbon** = a. what building materials were used
   b. how much energy was needed to make these materials
   c. how much energy was used to transport these materials to the site
   d. what was the source of that energy and what are the by-products
3. **Resilience** = our ability to endure a loss of power or resist/recover from damage due to flood, fire, wind, earthquake…

Focus:

MODULAR + NET ZERO

Net Zero Building Performance addresses these issues:
Energy Efficiency, Carbon and Resilience

MODULAR CONSTRUCTION IS AN IDEAL WAY TO ACHIEVE NET ZERO BUILDING PERFORMANCE

The following presentation takes a closer look at a factory-built home and identifies what was required to achieve Net Zero Certification

Background Info:
Net Zero Modular Case Study Project

Market ready, factory-built homes were studied in 10 locations across Canada

Factory Specs were modeled in Hot2000 and compared to Net Zero

Results: Minimal Upgrades were required to meet CHBA Net Zero Homes Performance Requirements

LEEP LOCAL ENERGY EFFICIENCY PARTNERSHIPS

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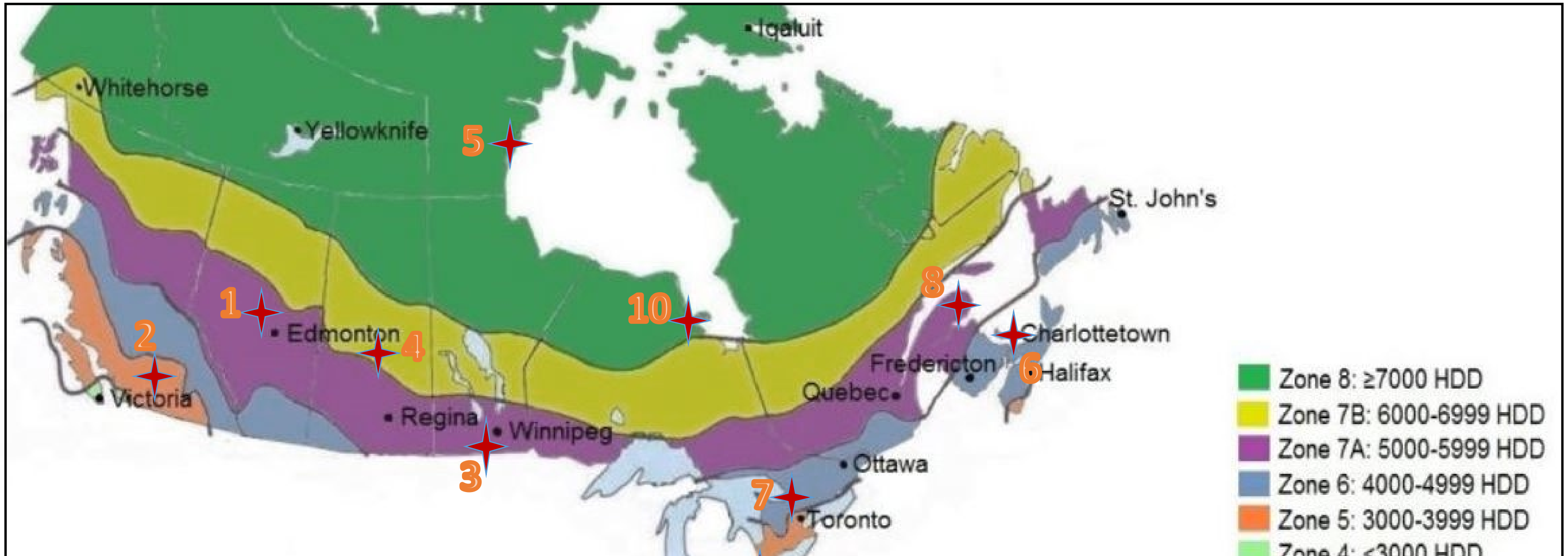
SUPREME

GUILDCREST HOMES

Grandeur HOUSING LTD.

Triple M Housing
Designed for Living, Crafted for Life

10 Case Study Locations



Canadian Climate Zones

LEEP Net Zero Modular Case Study Project

4 builders - 10 factory-built single detached homes

1085 SF - 1693 SF

above grade finished area

Grandeur
Leaders in Building

LEEP studied three variations of this one-piece modular home, in three climate zones

Case Study #3	Case Study #4	Case Study #5
PV System: $23,555 (South)	**PV System: $22-25K (S-E)**	**PV System: $ 31-35 (S-E)**
Winkler, Manitoba	Prince Albert, Saskatchewan	Arviat, Nunavut
Climate Zone 7A	**Climate Zone 7B**	**Climate Zone 8**
1375 SF modular + 967 SF site built garage and porch	1375 SF modular + side porch and separate front entry	1375 SF modular + wrap-around porch two entries
Insulated 8’ basement	Insulated 8’ basement	No bsmt/Piles+Insl Floor Plate
One piece modular	One piece modular	One piece modular

Only costs related to Net Zero Energy upgrades were considered. Base unit & transport costs were not compared.

Selected Highlights:

- Net Zero is possible in all climate zones
- Solar orientation is important to PV efficiency & cost
- Off-grid battery storage adds +- $11-28K
- Insulated basement shows a big energy advantage (but not a carbon advantage)
- Wind, hybrid or community-energy could be added

LEEP LOCAL ENERGY EFFICIENCY PARTNERSHIPS

NOW: A CLOSER LOOK AT THIS
‘NET ZERO CERTIFIED’ MODULAR HOME

Net Zero One-Piece Modular Bungalow
Builder: Grandeur Housing Ltd.
Location: Winkler, Manitoba
Completed: November 2020
Verification by: Sun Ridge Residential Inc.

netzero home
The ultimate in comfort and efficiency

Grandeur HOUSING LTD.

NZ Case Study #3

Climate Zone: 7A

Heated Floor Area:
1375 SF above grade
1218 SF below grade

Annual Energy Load:
42 GJ (11802 Kwh)

On-Site Renewable Energy Collection, via Solar PV:
44 GJ (12198KwH)

Compares to Tier 4 Code:
60.4% BETTER
(79% w/o appliances)

STANDARD FACTORY SPEC *vs* NET ZERO SPEC

Hot2000 energy modeling shows only minor upgrades were required

Case Study #3	Grandeur Factory Spec	Net Zero Targets	NZ Min Requirements*
Airtightness ACH@50Pa	2.5	0.6	1.5 for detached
Wall R-Value (effective)	35.8	No change needed	17.5 or by code
Foundation Wall R-Value	27 (ICF)	No change needed	16.9
Underslab R-Value	variable	8	5
Ceiling / Roof R-Value	61.6	No change needed	59.2
Window SHGC	0.4	No change needed	Check code on cooling
Window U-Value	1.6	1.19-1.5	(1.44) Energy Star or eq.
DHW System	NG Induced Draft	Heat pump COP 2.3	Use NRCan online lists
Drainwater Heat Recovery	Not installed	optional	
Space Heating	NG 95% AFUE	Heat pump HSPF 8.5	Use NRCan online lists
Heat Recovery Ventilator %	75%/65%	75%/65%	Use NRCan online lists
Heat system cost estimate	$4,100	$14,000	
AC cost estimate	$2,600	Integrated in heat pump (seer 18.9)	
Hot water tank cost estimate	$1,300	$2,700	
Panel Cost estimate	$48,800	$25,900	

Data generously shared by Grandeur Housing Ltd.

*Overall Requirement:
Energy performance must be at least **33% better** than the base Reference House. (aprox = Tier 3)

*Refer to: CHBA *Net Zero Home Labelling Program v1.3 Technical Requirements*

Case Study #3 Loads:
27,918 btu heating
+1.67 tons cooling

(80,000 BTU NG furnace was way oversized)

RECORD LOWs the FIRST WINTER:
On February 13, 2021 Winnipeg set a new record of **-38.8 Celsius**, the old record of -37.8 C set in 1879.
This NZ home performed very well!

‘Net Zero’ as defined by the CHBA NZ Homes Program

- Is built on familiar NRCan Rating Systems:
  - NRCan ENERGUIDE RATING SYSTEM (ERS) V.15
  - NRCan 2021 R2000 STANDARD
  - NRCan ENERGY STAR for New Homes (ESNH)
- The Minimum Standards vary by climate zone
- NZ Minimum Standards often align with code but require overall 33% better performance

IMPORTANT NOTE:

Net Zero does NOT require +Tier 5 performance

Most Net Zero Homes are at Tier 3 / Tier 4 levels

Minimum Standards are well within reach

netzero home
The ultimate in comfort and efficiency

3.2 Airtightness

3.2.1 Tested Airtightness

1. The house shall be constructed sufficiently airtight such that the whole house air leakage is less th or equal to one of the airtightness targets specified in Table 3, when measured in accordance w the as-operated method based on CAN/CGSB 149.10 “Determination of the Airtightness of Buildi Envelopes by the Fan Depressurization Method” or NRCan “EnerGuide Rating System Techni Procedures Version 15”.

Familiar Metrics

Table 3: Minimum Airtightness Targets

Building Type	ACH@50Pa	NLA@10 Pa		NLR@50 Pa	
		cm^2/m^2	$in^2/100\ ft^2$	$L/s/m^2$	$cfm50/ft^2$
Attached	2.0	1.18	1.70	0.78	0.15
Detached	1.5	0.75	1.08	0.57	0.11

3.3 Opaque Assemblies

3.3.1 Minimum Effective Thermal Resistance of Opaque Assemblies

1. Effective thermal resistance of opaque assemblies shall not be less than those specified in Table 4 below. Where local prevailing code is more stringent than Table 4, refer to that code.

Table 4: Minimum Effective Thermal Resistance of Opaque Assemblies[1]

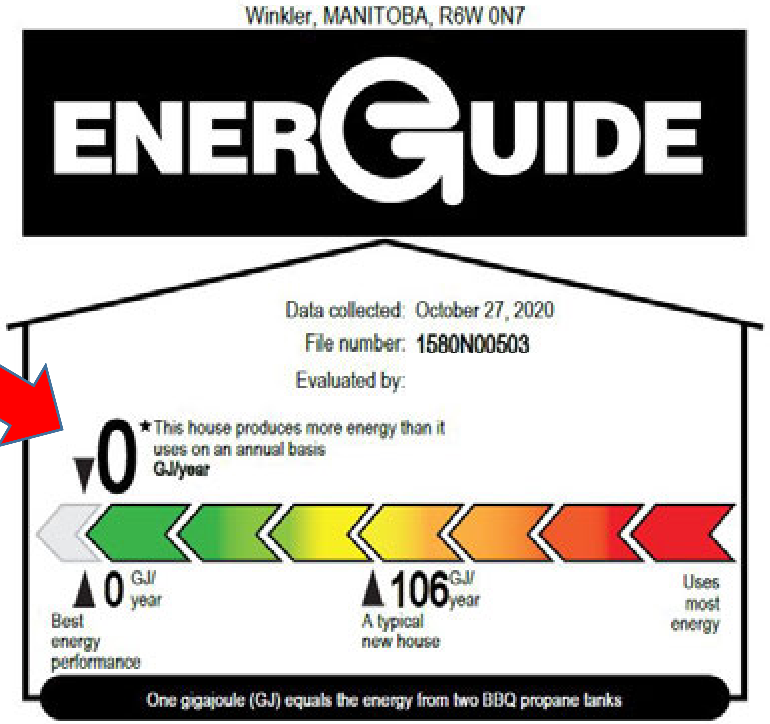
Building Assembly	Heating Degree Days[2]					
	<3000	3000-3999	4000-4999	5000-5999	6000-6999	≥7000
	RSI (R)					
	NBC Climate Zones					
	4	5	6	7a	7b	8
Ceilings below attics	6.91 (39.2)	8.67 (49.2)	8.67 (49.2)	10.43 (59.2)	10.43 (59.2)	10.43 (59.2)
Cathedral ceilings and flat roofs	4.67 (26.5)	4.67 (26.5)	4.67 (26.5)	5.02 (28.5)	5.02 (28.5)	5.02 (28.5)
Walls above grade[3]	2.78 (15.8)	3.08 (17.5)	3.08 (17.5)	3.08 (17.5)	3.85 (21.9)	3.85 (21.9)
Floors over unheated spaces	4.67 (26.5)	4.67 (26.5)	4.67 (26.5)	5.02 (28.5)	5.02 (28.5)	5.02 (28.5)
Foundation walls below or in contact with the ground	1.99 (11.3)	2.98 (16.9)	2.98 (16.9)	3.46 (19.6)	3.46 (19.6)	3.97 (22.5)
Unheated floors below frost line	0.88 (5.0)	0.88 (5.0)	0.88 (5.0)	0.88 (5.0)	0.88 (5.0)	0.88 (5.0)
Unheated floors on ground above frost line[4,5,6]	1.96 (11.1)	1.96 (11.1)	1.96 (11.1)	1.96 (11.1)	1.96 (11.1)	1.96 (11.1)
Heated or unheated floors on ground on permafrost[5]	-	-	-	-	4.44 (25.2)	4.44 (25.2)
Heated floors on ground[5]	2.32 (13.2)	2.32 (13.2)	2.32 (13.2)	2.85 (16.2)	2.85 (16.2)	2.85 (16.2)
Slabs on grade with integral footing[4,7,8]	1.96 (11.1)	1.96 (11.1)	1.96 (11.1)	3.72 (21.1)	3.72 (21.1)	4.59 (26.1)

NZ Performance Verification is Required

Energy Modeling is used to calculate Loads and confirm Net Zero Performance

Energy Used	=	Energy Produced
Minimize Loads with a great Building Envelope	⇨	To set lower PV Target / easier to reach Net Zero

This also means increased Resilience: Safety + Comfort for occupants



HOW YOUR RATING IS CALCULATED:

I.	Rated annual energy consumption	42 GJ/year
II.	Minus renewable energy contribution	- 42 GJ/year
	Equals your **EnerGuide rating**	**= 0 GJ/year**

I. Your rated annual energy consumption is the total amount of energy your house would use in a year based on the EnerGuide Rating System standard operating conditions. For your house, this includes 8.35 GJ of passive solar gain.

Energy Sources	Rated Consumption (GJ/year)	Equivalent Units (per year)	Greenhouse Gas Emissions (tonnes/year)
Electricity	42	11802 kWh	0.0
Total	42		0.0

II. On-site renewable power generation systems can offset some or even all of your home's energy consumption. Renewable energy contributions are factored differently for your rating and your greenhouse gas emissions calculations.[1]

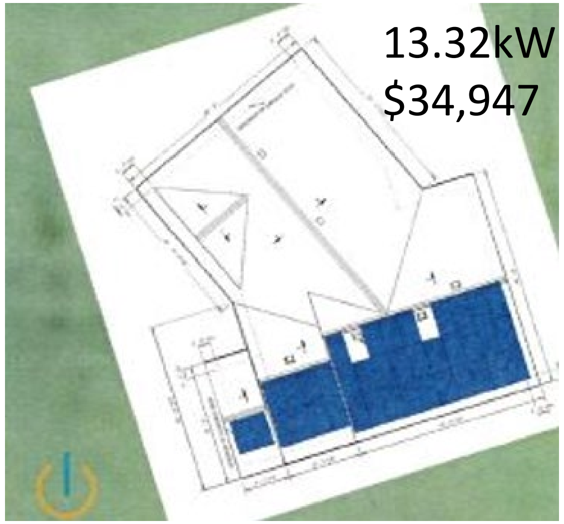
On-Site Renewable Energy	Estimated Contribution (GJ/year)	Equivalent Units (per year)	Offset Greenhouse Gas Emissions (tonnes/year)
Electricity	44	12198 kWh	0.0
Solar water heating	0	0	0.0
Total	44		0.0

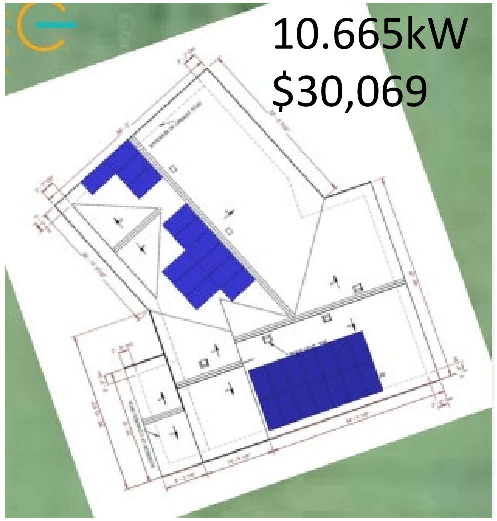
HOW YOUR CONSUMPTION COMPARES:

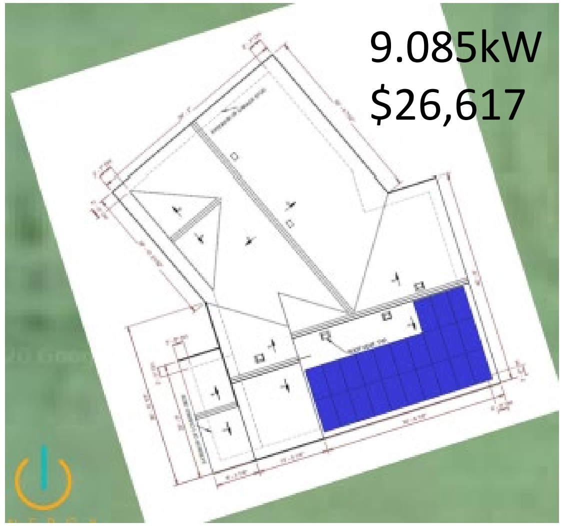
Compared to a typical new house, your house uses:

60.4% less energy;

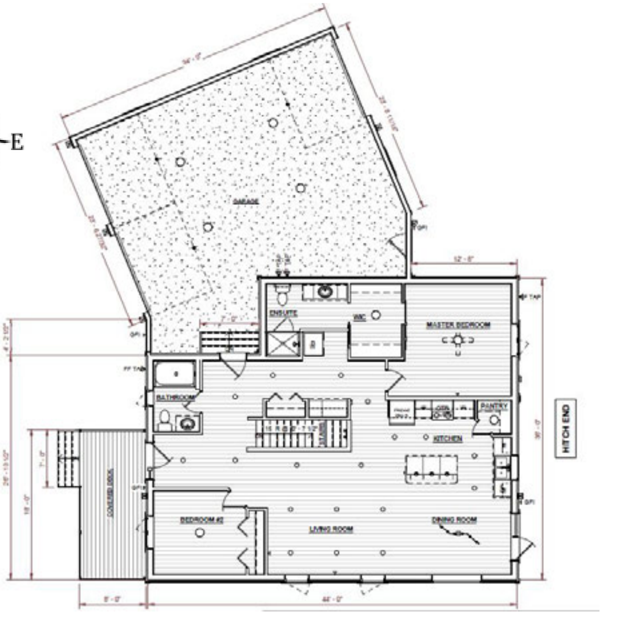
79.1% less energy, when excluding the estimated energy consumption of lighting, appliances and electronics.







Position Roof to Maximize Southern Exposure



THE SOLAR PV SYSTEM

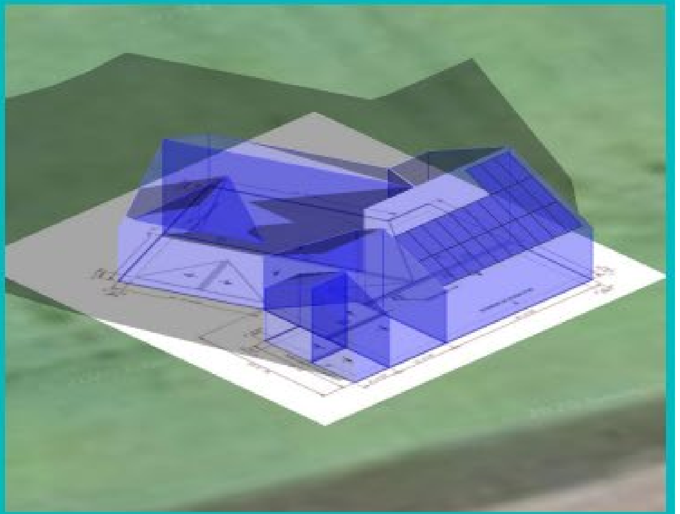
1. Calculate Energy Use & Max Loads (in Hot2000 or from utility bills)
2. A Solar PV Assessment will consider array options that meet Load requirements

Your Solar System Details

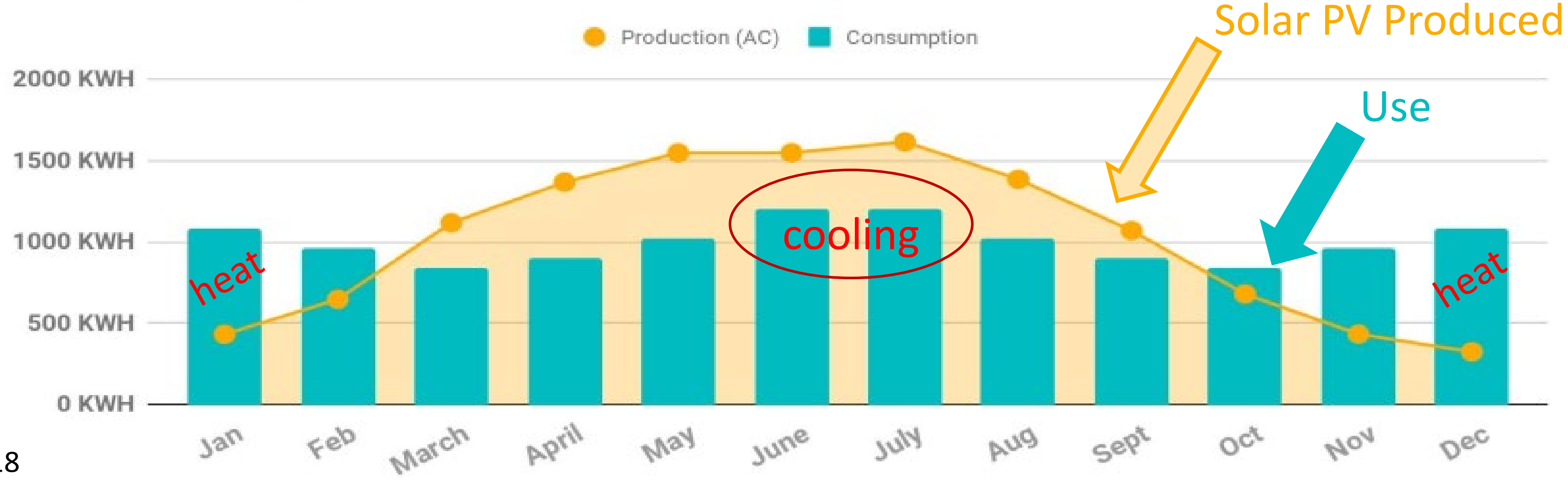
Item	MFT / Supplier	Model / Details	Comments	Quantity
Solar PV Panels	Hanwha	Q.Peak DUO L-G5.2 395W	Tier 1 Solar Panels Half-Cut. Includes 25 Year Warranty.	23
Inverter	Huawei	7.6KTL-USL0-WiFi	Tier 1 Inverter. Includes 10 Year Warranty. Battery Ready.	1
Optimizers	Huawei	SUN2000-375W-USP0	Solar Optimization	23
Monitoring	Huawei	Monitoring	Solar System Live Monitoring	1
Racking	HB Solar	SkyRail 3	Standard Roof Racking System	23
Critter Guard	Critter Guard	Critter Guard	Optional Critter Guard Will Cost $1174.38	0
Snow Guard	-	-	Snow Guard	0
Energy Storage	None	None		0
				1

YOUR SYSTEM SIZE

9.085 KW



Monthly Utility Bills, Post-Solar



Solar Power System Cost	$23,555
Estimated LDC connection fee *	TBD
Total Cost**:	$23,555.47
HST (13%)	$3,062.21
Grand Total To Make The Switch:	**$26,617.68**

Summary: Winkler, MB -Net Zero Modular Home CS#3

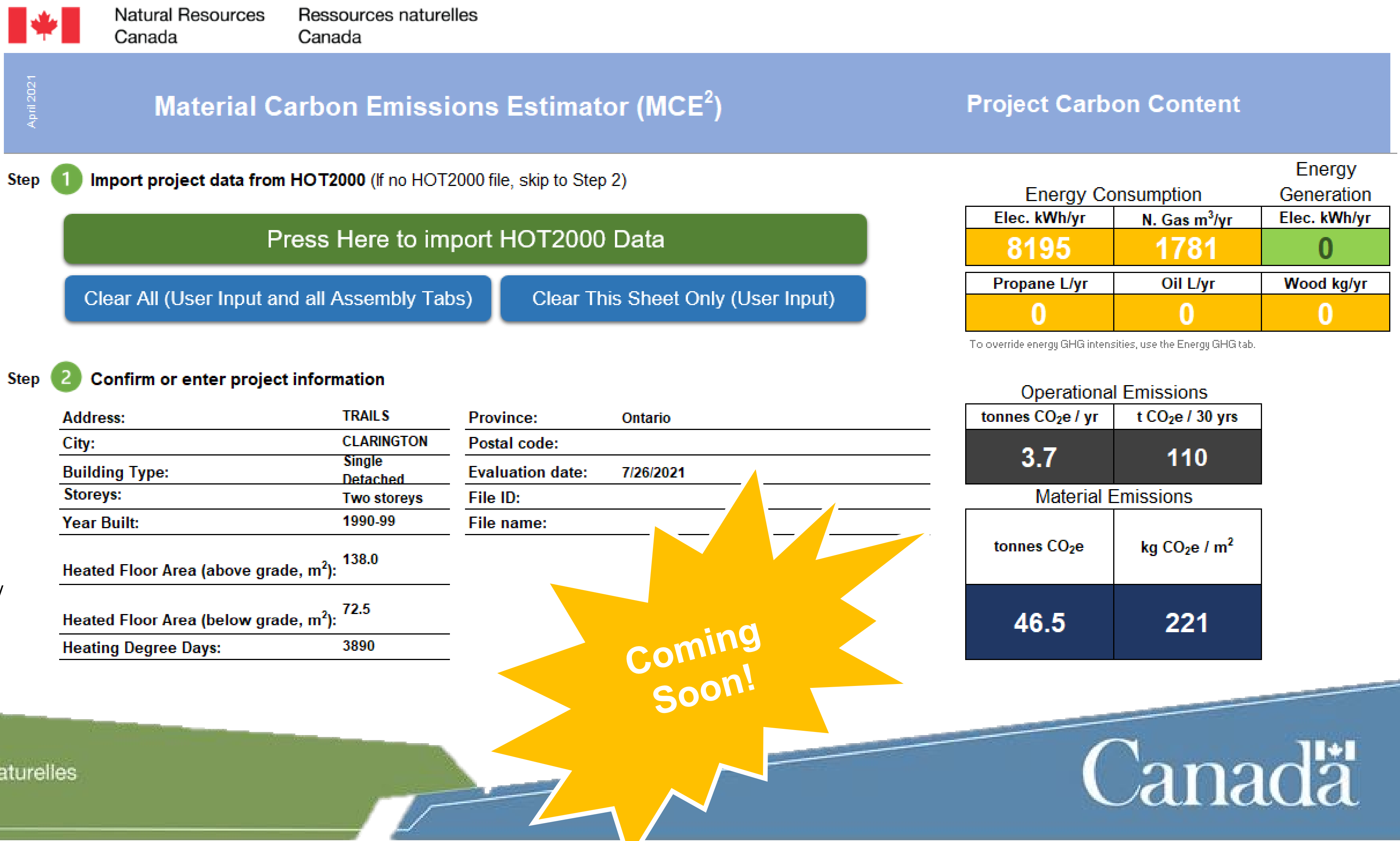
1. Building Envelope Performance:
   - Achieved 60.4% better (min 33% req'd) This compares to TIER 4
   - ACH of 0.54 is very impressive! -(exceeded requirement of 1.5 ACH)
   - ALL assembly R-values required NO CHANGES – (we could look at low-carbon materials)
   - R-5 under-slab insulation is required / Insulated basement provides energy advantage
   - Energy Star Windows: triple glazed, low-e, argon filled, insulated spacer

2. Renewable Energy System:
   - Plan for Solar PV at the start of the project / Integrate PV into roof structure (Use IDP)

3. HVAC, mechanicals & electricals:
   - Energy Star Appliances significantly reduced –lifetime- loads
   - An 80,000 BTU furnace would have been typical / This was way oversized
   - 'Right-Sized' the HVAC design to avoid waste and cost (consult HVAC designer, use F280)
   - *Air Source Heat Pump* technology reduced energy consumption dramatically
     - Heat Pump with ducting provides –both- heating and cooling (no additional ac unit is needed)
     - Heat Pump for domestic hot water heating
   - Electric equipment (rather than combustion)
     - Allows better Air-Tightness (no vents)
     - Reduces or eliminates harmful and dangerous emissions (no CO2, no carbon monoxide)

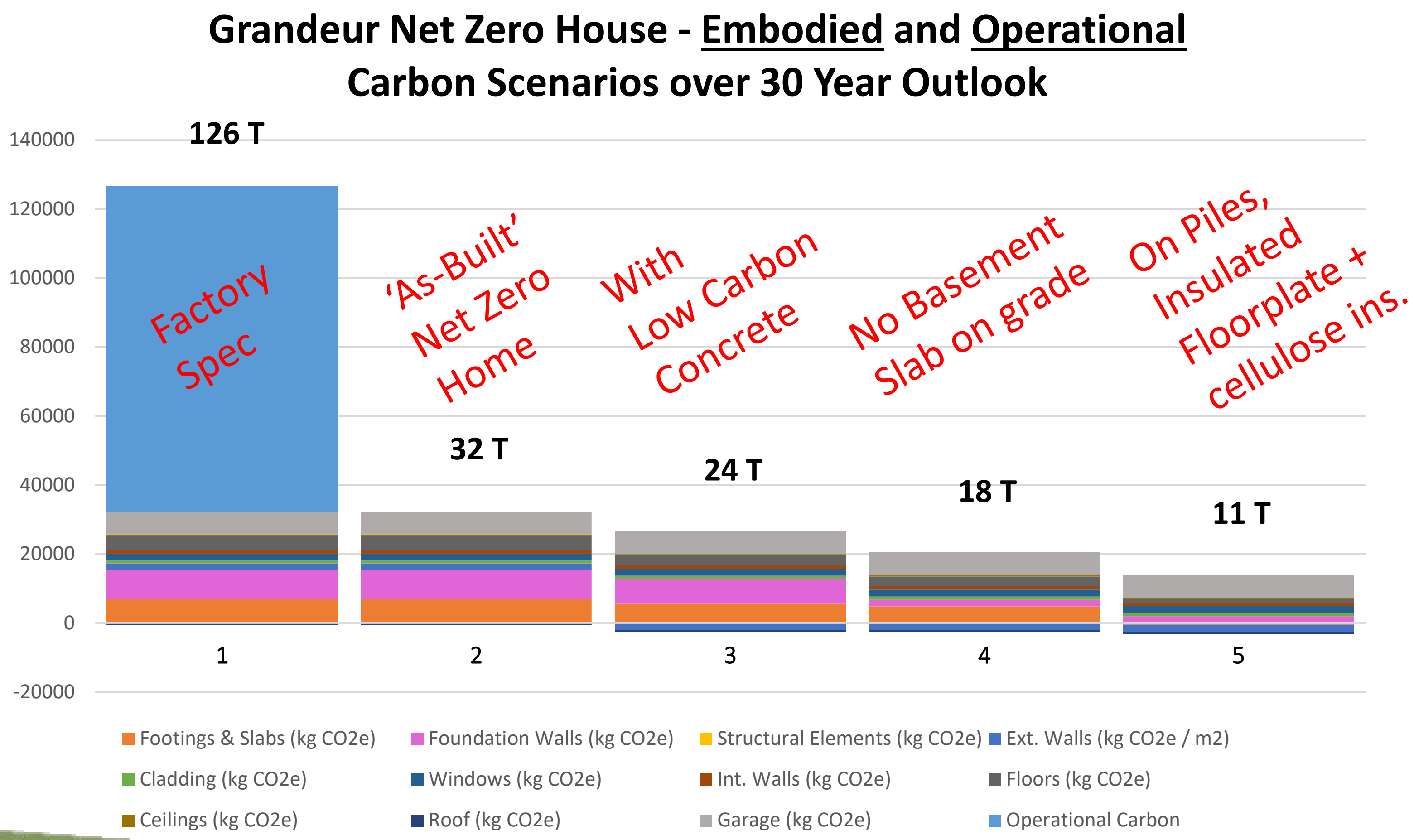
A few words on CARBON…
NRCan’s *Material Carbon Emissions Estimator*

- Free tool to help builders understand the carbon impact of the **building materials** selected
- Can help inform your product selections
- NRCan will be posting the MCE² on the LEEP website *very soon*.



Created in Partnership with Chris Magwood and Builders for Climate Action

5 Scenarios – 30 year CO_2 Outlook



1. Grandeur Factory Spec. includes NG Furnace and DHW
2. Grandeur Factory Spec. NZE includes HPs for space heating and hot water
3. Low Carbon Concrete mixes
4. Low Carbon Concrete Mixes + Slab on Grade + Carbon storing insulations
5. Wood frame Floor + Carbon storing insulations

Tips for easier Net Zero Certification

1. Verification is Required – this can also be used for performance-based code compliance
   - Certified Energy Advisor or Service Org will help select targets, provide testing and submit required paperwork
   - Energy Modeling is necessary to identify Energy Loads (Hot2000 or similar)
   - Air-Tightness Testing is required: Blower Door Test – to confirm ACH

     *Use a two-step process (and a smoke test) to seal leaks; Before Drywall and After Drywall

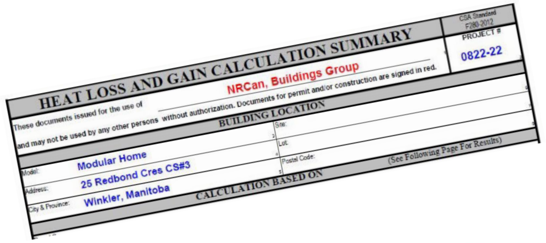
2. Familiar wall assemblies & '*reasonable*' R-values will work
   - Choose R-value target for climate zone (Higher R = Also more Resilient)
   - Energy Modeling allows some flexibility and trade-off, but… check minimum standards first
   - *LEEP NZ Wall Guides* show familiar wall types with better details for NZ performance
   - Use 'your best' building envelope = Lower Energy Loads = Less Renewable Energy needed/less cost

3. HVAC & mechanicals: Energy Loads must = Energy Collected
   - Select High Efficiency equipment & Energy Star Appliances (to reduce loads)
   - Cold Climate Air Source Heat Pump Technology makes Net Zero easier (its efficient & low carbon)
   - Heat Pumps can be paired with hydronic or forced air systems (radiant floors/zoned forced air/or vintage radiators)
   - 'Right-Size' your HVAC design – avoid waste and cost (for gas or electric systems)
   - Plan for Solar PV / Renewable Energy System at the start. Use *LEEP Solar PV Design Guide and IDP.*
   - Orient Roof to South to optimize Solar PV advantage

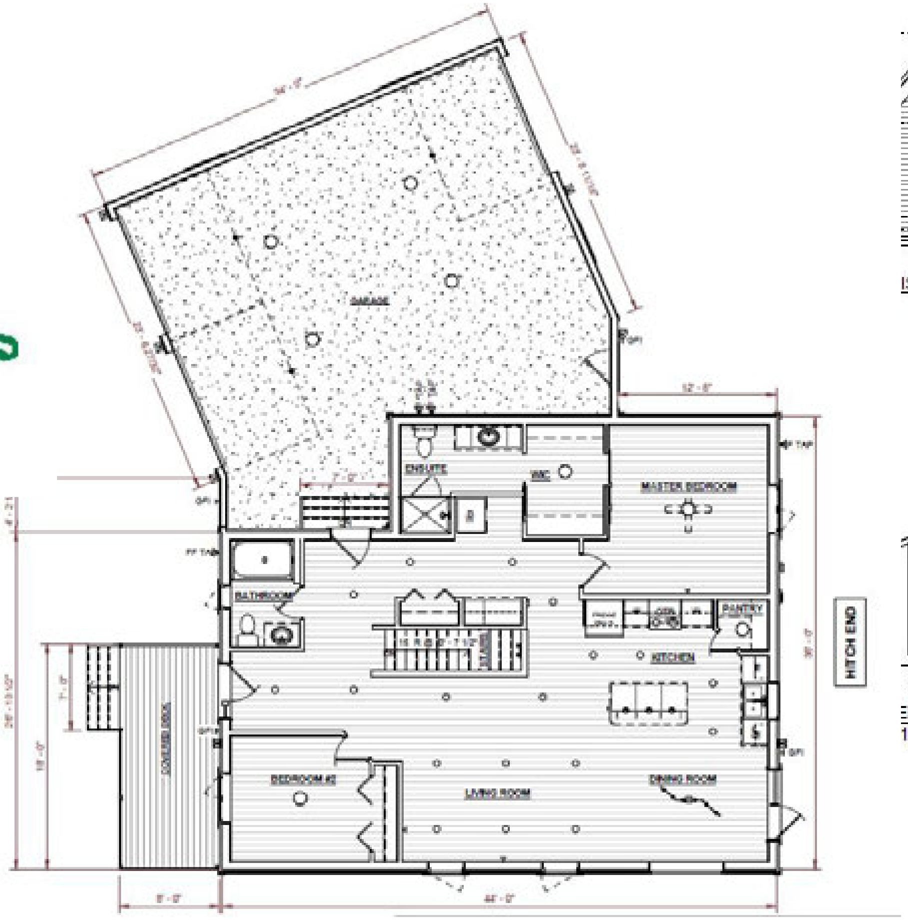
Modular Netzero
Cory Warms

- **Factory process for a NZ home**
- **Challenges and lessons learned**
- **NZ MURBs**

GRANDEUR HOMES
Net Zero Home – Construction Tour

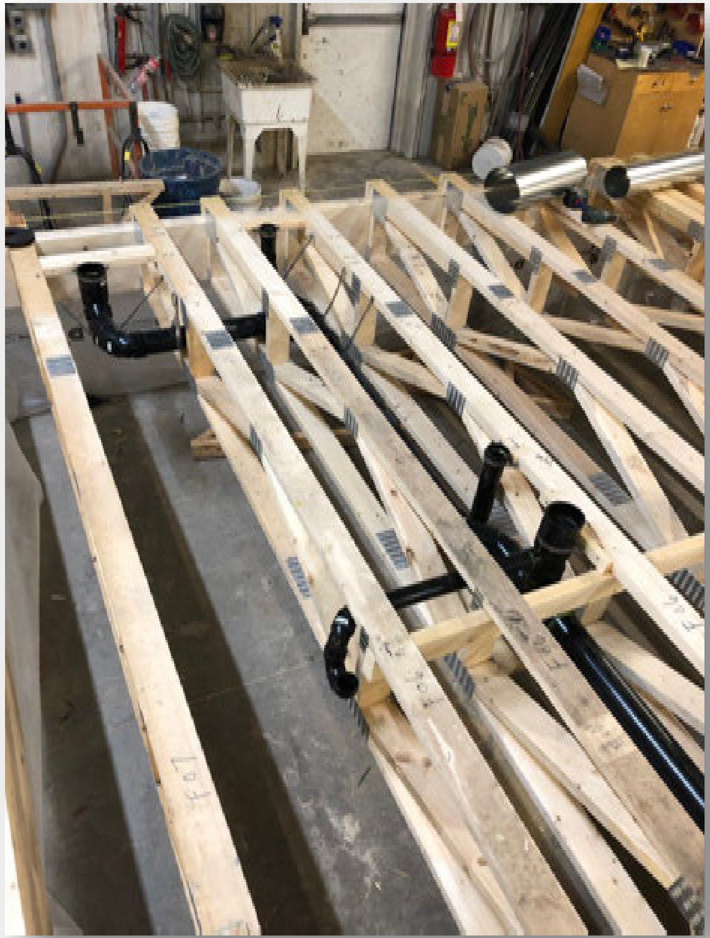


HOT2000
Natural Resources CANADA
Version v11.7

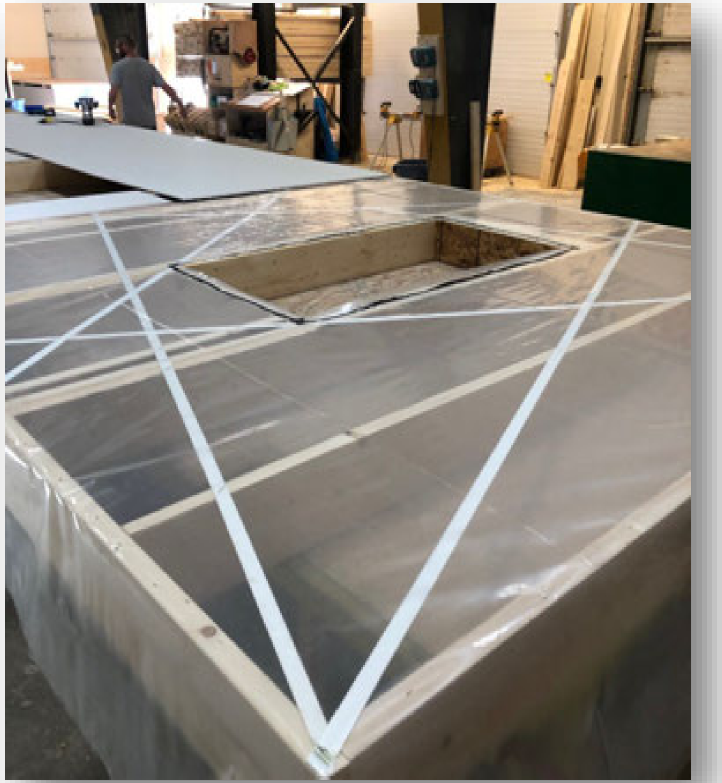


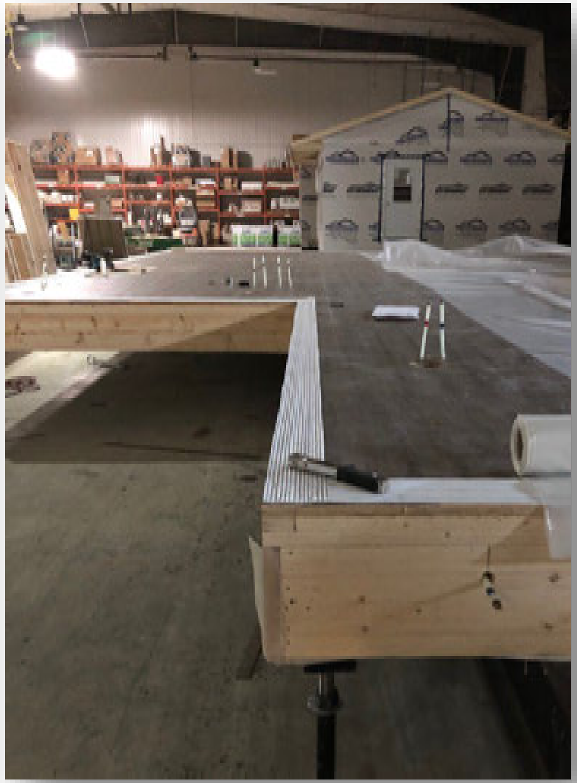
Floor Plate Framing

Plumbing & Floor Ducts



Flooring & Wall Fabrication





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Wall Framing

Grandeur

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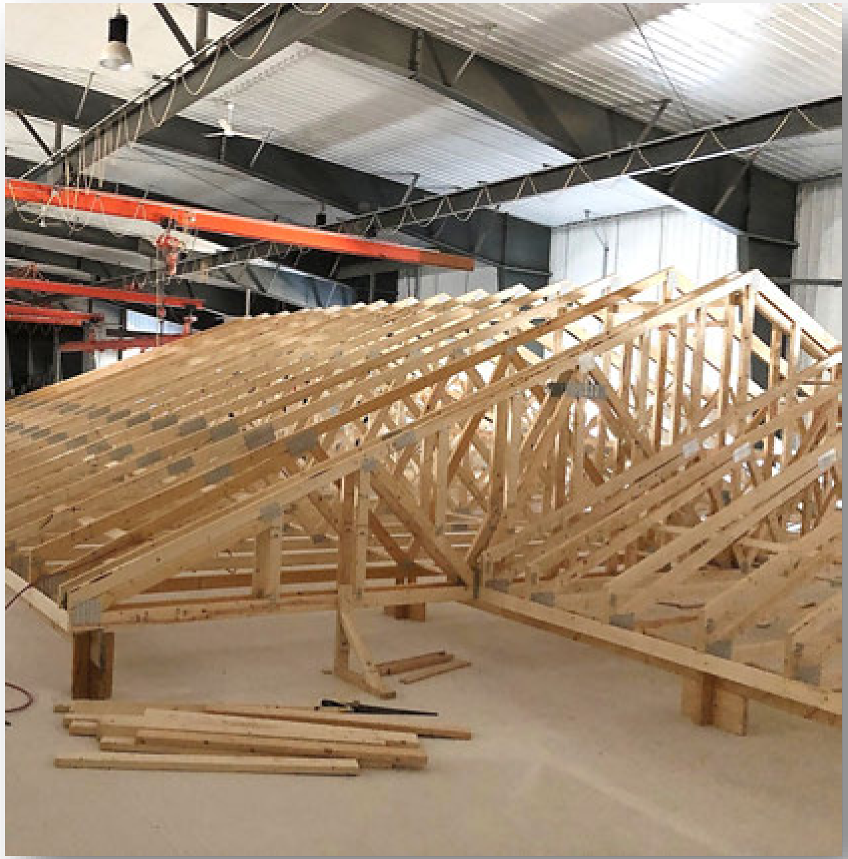
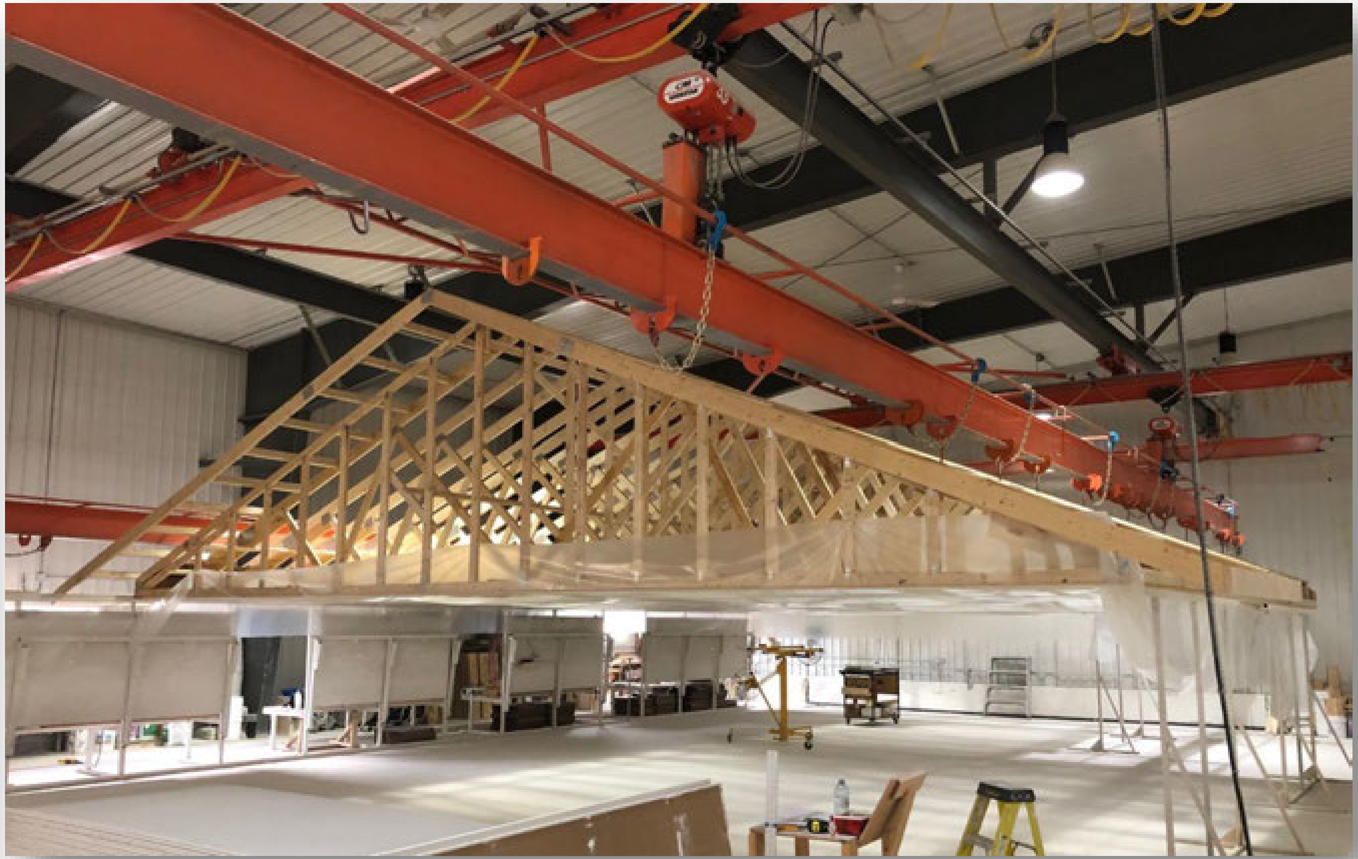
Roof Framing





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Roof Installation

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Wiring and Air Barrier

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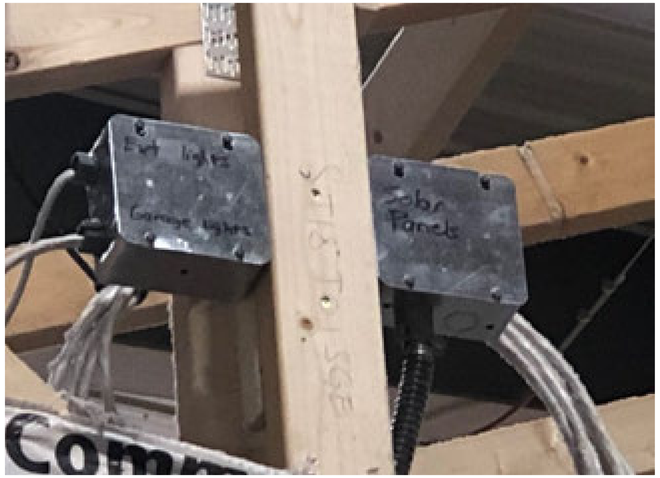
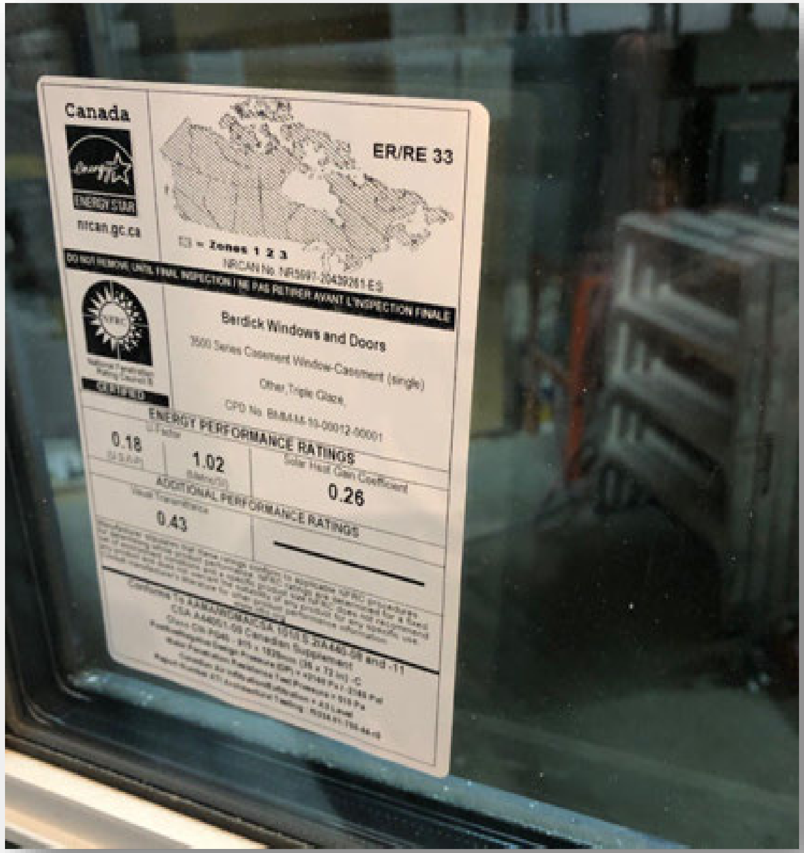
Insulation



Window Specifications



Window Sealing / Flashing Support

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Window Flashing



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Out of Factory



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Basement Site Work



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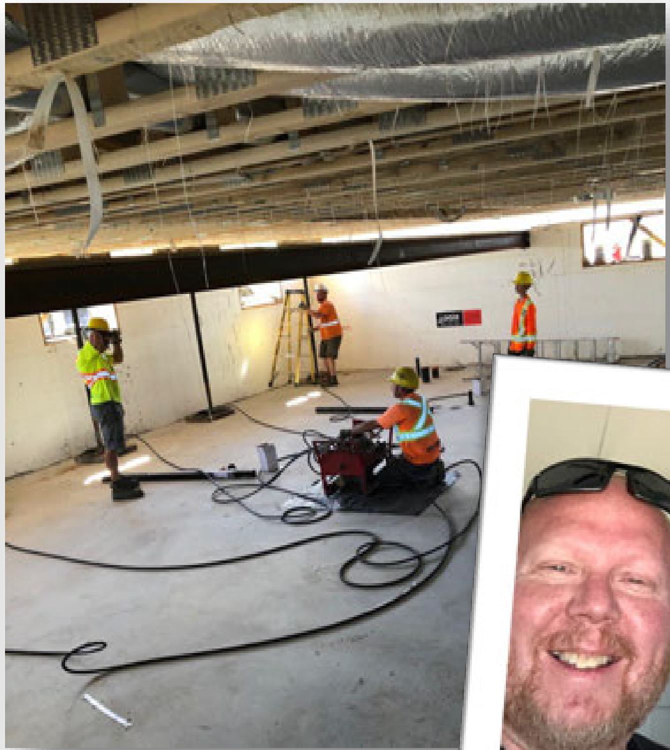
Moving Day! House on Foundation



Grandeur

Front Deck


THIS IS AN EXCITING
NEW HOME BUILT BY
GRANDEUR HOUSING!
THE FIRST MODULAR
NET ZERO HOME
CONSTRUCTED IN THE
WINKLER FACTORY.
For information, visit
grandeurhousing.com
Grandeur
netzero
home

Basement Windows

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Garage Foundation

Grandeur

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Garage

Grandeur

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Mechanicals & Solar PV

Grandeur

Interior & Finishes

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Conseil de la CONSTRUCTION MODULAIRE

NZ Home Finished!

Grandeur

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NZ feasible for modular MURBs





Willowview Heights Project (2020)
NRCan Project *"Affordable, Replicable, Marketable, Net Zero Ready MURB"*
Big Block Construction
Grandeur Housing
CHBA netzero

bigBLOCK construction
Grandeur
netzero home
The ultimate in comfort and efficiency
Natural Resources Canada

Sustainability

Mohamed Al-Hussein

- **GHG savings in the factory process**
- **Material Durability**
- **Waste Reduction**
- **Embodied Carbon**

Industrializing the Building Construction Reduces GHG

Sturgeon Foundation North Ridge CO_2 Analysis Report
Comparison between Modular and On-Site Construction

48 suites, (40 one-bedroom (594.60 sq ft) and 8 two bedrooms (929.21 sq ft))

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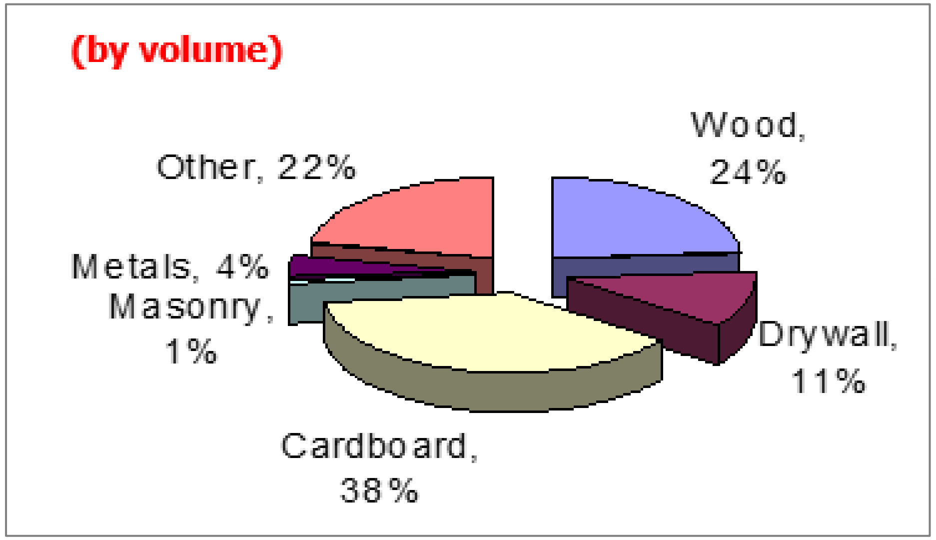
UNIVERSITY OF ALBERTA

Winter protection & Temporary structures

CO_2 quantifications

Residential Construction Material Waste

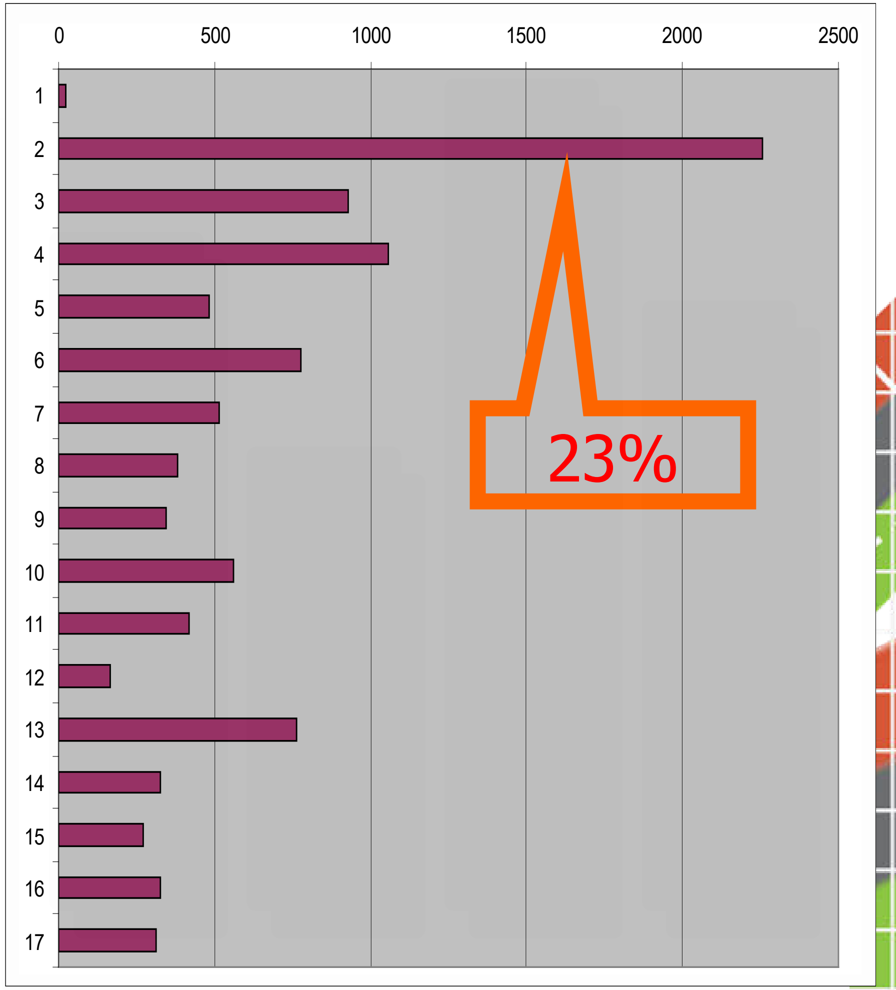
CO_2 quantifications



17 milestones

CO_2 quantifications

Stage	Description	co2 (kg)
1	Stake Out	23
2	Deep Services & Foundation Walls	2257
3	Backfill & Shallow Trenching	926
4	Capping Shallow Services	1057
5	Framing Main & Second Joists	482
6	Framing Second & Roof	778
7	Roofing	514
8	Siding & Rough-Ins	381
9	Electrical RI & Slabs	344
10	Insulation & Boarding	562
11	Drywall Taping & Texture	420
12	Stage 1 Finishing & Cabinets	167
13	Railing & Painting	763
14	Tile & Vinyl Flooring	326
15	Hardwood & Stage 2 Finishing	270
16	Carpet & Finals	326
17	Touch-Ups & Pre-Occupancy	311
	Total	9908



CO_2 quantifications

Stage 5 - Framing Tasks	Duration (hr)	Material Trips	Material Equipment	Labour Trips	Labour Equipment	Installation Equipment	CO2 (kg)	Unit	Qty / Model	Amt (kg/unit)
Framing Main & Second Joists										
Deliver first floor framing package -wall	1	0.5	5t truck				23.2	linear m of wall	63.1	0.37
Deliver first floor framing package -floor	1	0.5	5t truck				23.2	m2 of floor	82.3	0.28
Framing - main floor	16			8	0.5t truck	1 generator, 1 compressor	194.56	m2 of floor	82.3	2.36
Framing - main floor walls	16			8	0.5t truck	1 generator, 1 compressor	194.56	linear m of wall	63.1	0.32
Deliver second floor framing package -floor	1	0.5	5t truck				23.2	m2 of floor	82.3	0.28
Deliver second floor framing package -wall	1	0.5	5t truck				23.2	linear m of wall	63.1	0.37

Activity - Excavation to Gypcrete	Duration (days)	Material Trips Qty (trips)	Material Trips Vehicle	Crew trips Qty (trips)	Crew trips Vehicle	Equipment Qty (hrs)	Equipment Type	CO2 (Kg)
FRAMING MATERIAL DELIVERY (PER FLOOR)	3	15	Ten-Ton Truck			8	Lift	3536
FRAMING (PER FLOOR) WALLS and FLOOR ABOVE	14			112	Van/Car	224	Compressor	6523
						112	Generator	300

CO_2 quantifications

24kg of CO2 per kg of manufactured drywall[1]

8.64MJ/Kg of manufactured drywall[2]

0.76 kg CO2/sf of manufactured drywall[3]

A conventional 1/2-inch thick sheet of (4 x 8) drywall feet weighs around

57 pounds

CO2 Emissions from Transportation and Crew Trips

Tasks	Duration (hr)	Material Trips		Crew Trips		CO2 (kg)
Load Drywall	2	1	5t truck			46.4
Drywall Boarding	32		5t picker	4	0.5 truck	54.4

Sturgeon Foundation North Ridge CO_2 Analysis Report
Comparison between Modular and On-Site Construction

48 suites, (40 suites are one-bedroom suites and 8 two bedrooms)
(One-bedroom area of 594.60 sq ft; a two-bedroom suite has 929.21 sq ft.

	Construction Methodology			
Item	**Conventional**	**Modular**	**Difference**	**Difference (%)**
Construction Time (Months)	14.3	6.3	7.9	55%
CO_2 emissions - construction process (Tonnes of CO_2)	98.9	56.3	42.5	43%
CO_2 emissions - Winter Heating (Tonnes of CO_2)	431.3	247.2	184.0	43%
Total (CO_2)	**530.1**	**303.6**	**226.6**	**43%**
Note:				

These results reflect the comparison between both practices for a stick-frame, 4-storey building with 42 suites. The CO_2 emissions for both practices do not include embodied energy, as well emissions due to the usage of electricity. It is assumed then tha






Vehicle	kg/km
Concrete Pump	0.98
Five-Ton Concrete Truck	1.16
Five-Ton Truck	1.02
Half-ton Truck	0.34
One-Ton Truck	0.7
Ten-Ton Truck	1.26
Three axle dump Truck (9m3)	1.9
Three-Ton Truck	0.82
Two-Ton Truck	0.76
Van/Car	0.23

Equipment	kg/hr
Bobcat	28.63
Compactor	35
Compressor	2.68
Concrete Finisher	9.65
Concrete Pump	22.36
Excavator	40
Generator	2.68
Lift	16

sample of the activities for CO_2 emission

Finishing Stage

Activity - Finishing stage (Suites)	Conventional Construction: Duration (days)	Material Trips: Qty (trips)	Material Trips: Vehicle	Crew trips: Qty (trips)	Crew trips: Vehicle	CO2 (Kg)
Paint Walls- 1st coat	42	11	Half-ton Truck	84	Van/Car	922
Finishing Stage 1 (Interior doors, baseboard trim and casing)	21	21	Two-Ton Truck	42	Van/Car	1025
Paint Doors & Trim	21	7	Half-ton Truck	84	Van/Car	868
Tile Tub Surrounds	11	11	One-Ton Truck	11	Van/Car	409
Grout Tile tub surrounds	11			11	Van/Car	101
Kitchen+Bath Cabinets	42	11	Five-Ton Truck	84	Van/Car	1222
Boot & Duct OTR & Fan Covers	7	7	One-Ton Truck			196
Measure P.Lam Countertops	42			42	Van/Car	386
Sweep & Shop Vac	42			42	Van/Car	386
Lino	42	4	One-Ton Truck	42	Van/Car	498
Finishing Stage 2 (Baseboards in bathrooms, closets & laundry rms)	42			42	Van/Car	386
Measure & Drill Wire Shelves	7			7	Van/Car	64
Install Laminate Countertops	42	42	Half-ton Truck			571
Paint Final (bath+clos+laund)	42	11	Half-ton Truck	84	Van/Car	922
Mechanical Final	42	42	One-Ton Truck			1176
Carpet	42	42	One-Ton Truck			1176
Construction Clean Stage 1	42			42	Van/Car	386
Wash Windows	7			7	Van/Car	64
Window+Door Lockout	4			7	Van/Car	64
Final Paint (Kitchen+Bed+Liv)	42	11	Half-ton Truck	84	Van/Car	922
Wire Shelves Install	4	4	One-Ton Truck			112
Electrical Final	21	21	Half-ton Truck			286
Final Finish (bifolds)	42			84	Van/Car	773
Shower Doors+Mirror Install	7	15	Half-ton Truck	15	Van/Car	342
Window Coverings	7	7	Half-ton Truck	7	Van/Car	160
OTR & Dishwasher Delivery	7	7	Five-Ton Truck			286
Install Dishwashers	4			4	Van/Car	37
Install OTRs	11			11	Van/Car	101
Appliance Delivery & Install	7	7	Five-Ton Truck	7	Van/Car	350
Washer & Dryer Install	7			7	Van/Car	64
Initial Inspection	21			21	Van/Car	193
Deficiencies	38			114	Van/Car	1049
Pre-Occ Clean	14			14	Van/Car	129
Pre-Occ Orientation	14			14	Van/Car	129
Correct Deficiencies	38			114	Van/Car	1049
Final Clean - Possession	14			14	Van/Car	129
Possession	14			14	Van/Car	129
						17064

Activity - Finishing stage (Suites)	Modular Construction: Material Trips Qty (trips)	Material Trips Vehicle	Modular Material trips
Paint Walls- 1st coat	2	Two-Ton Truck	60.8
Finishing Stage 1 (Interior doors, baseboard trim and casing)	4	Two-Ton Truck	121.6
Paint Doors & Trim	2	One-Ton Truck	56
Tile Tub Surrounds	3	Two-Ton Truck	91.2
Grout Tile tub surrounds			0
Kitchen+Bath Cabinets	11	Five-Ton Truck	448.8
Boot & Duct OTR & Fan Covers	2	One-Ton Truck	56
Measure P.Lam Countertops			0
Sweep & Shop Vac			0
Lino	1	Two-Ton Truck	30.4
Finishing Stage 2 (Baseboards in bathrooms, closets & laundry rms)			0
Measure & Drill Wire Shelves			0
Install Laminate Countertops	4	Two-Ton Truck	121.6
Paint Final (bath+clos+laund)	2	Two-Ton Truck	60.8
Mechanical Final	5	Two-Ton Truck	152
Carpet	5	Two-Ton Truck	152
Construction Clean Stage 1			0
Wash Windows			0
Window+Door Lockout			0
Final Paint (Kitchen+Bed+Liv)	2	Two-Ton Truck	60.8
Wire Shelves Install	3	One-Ton Truck	84
Electrical Final	1	One-Ton Truck	28
Final Finish (bifolds)			0
Shower Doors+Mirror Install	5	One-Ton Truck	140
Window Coverings	2	Two-Ton Truck	60.8
OTR & Dishwasher Delivery	7	Five-Ton Truck	285.6
Install Dishwashers			0
Install OTRs			0
Appliance Delivery & Install	7	Five-Ton Truck	285.6
Washer & Dryer Install			0
Initial Inspection			0
Deficiencies			0
Pre-Occ Clean			0
Pre-Occ Orientation			0
Correct Deficiencies			0
Final Clean - Possession			0
Possession			0
			2296

17,064 Kg CO_2

86% CO_2

2,296 Kg CO_2

Transformation from conventional construction to panelized construction: Landmark Case study

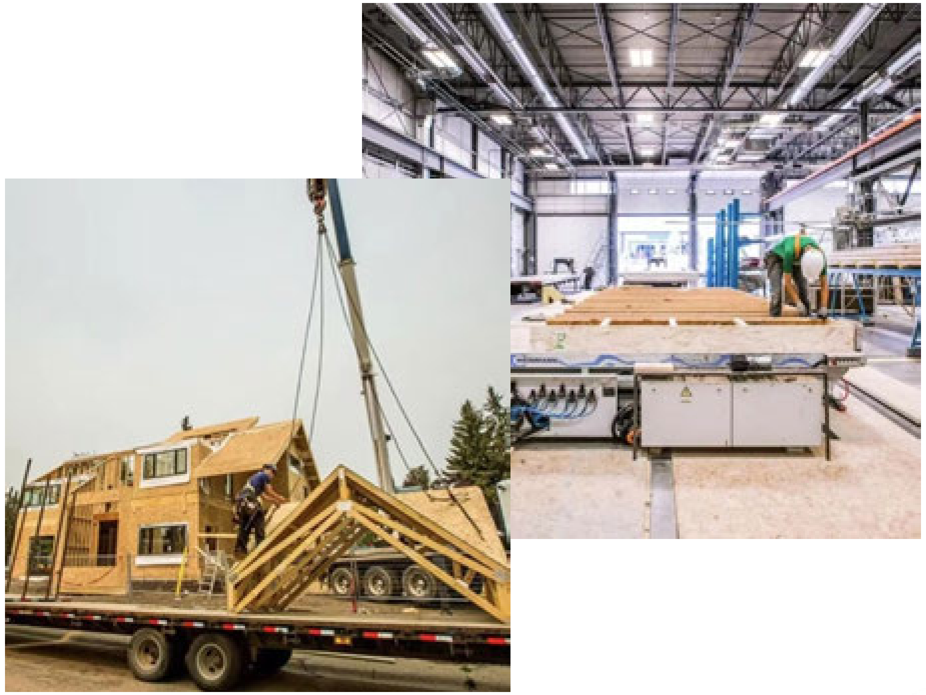
Dr. Mohamed Al-Hussein

June 2022

Background

Landmark, which has around 44-years' history, is a well-known residential home builder in Alberta. It started changing from conventional (stick-build) construction method to panelized construction method since 2005. Until 2012 it has built a completely panelized production line. By comparing Landmark's previous production with the current, we find that this kind of transformation will lead to a highly improvement on production rate and a reduction in CO_2 emissions and operation fees.

LANDMARK HOMES



Conventional Construction to Panelized Construction

Number of Superintendents

Production Rate

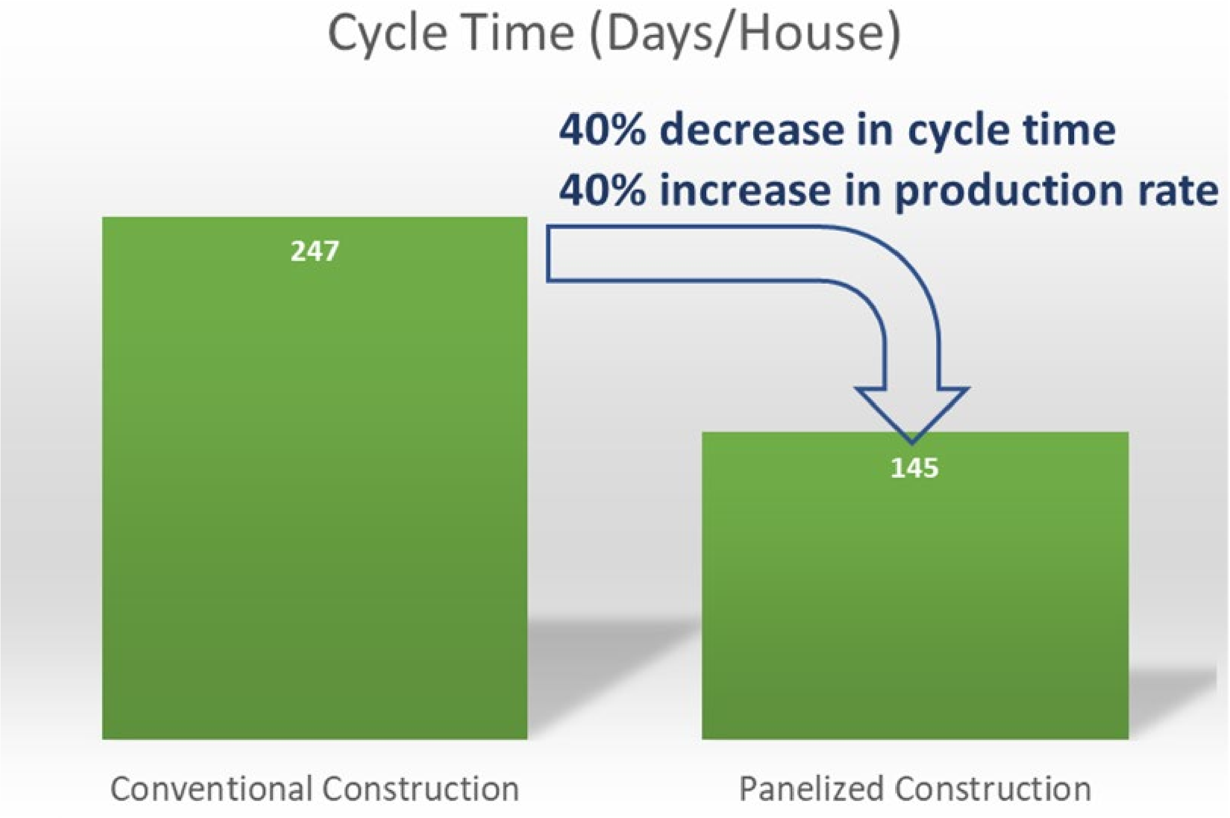
Invoices

Inspections

Office Space vs Plant Space

Production Rate

Comparing with conventional construction method, the cycle time of panelized construction will decease about 97 days, changing from 247 days per house to 145 days per house.



Cycle time reduced by:

- Less uncertainties related to the hand-off to different trades
- Smoother turnover from house to house
- Higher predictability

Number of Superintendents

The required number of superintendents will reduce from **46** to **27**.

For building **1000 houses / year**:

	Conventional	Panelized
Average cycle time:	247 Days/ House	145 Days/House
Turn over rate:	365 / 247 = 1.478 Batches / year	365 / 145 = 2.517 Batches / year

Average number of houses one superintendent can manage at the given cycle time:

15 houses/batch/superintendent | 15 houses/batch/superintendent

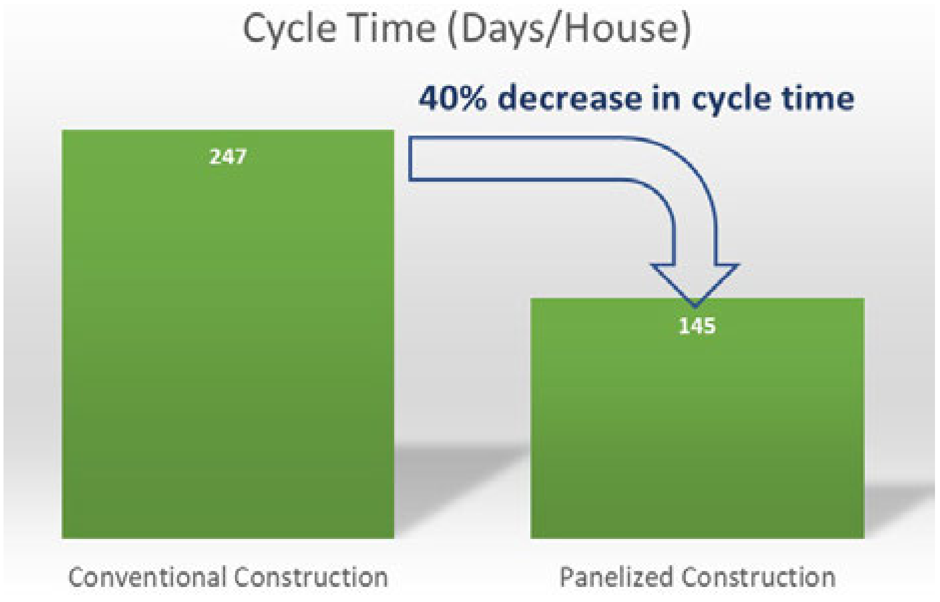
Number of the inspected houses per superintendent per year:

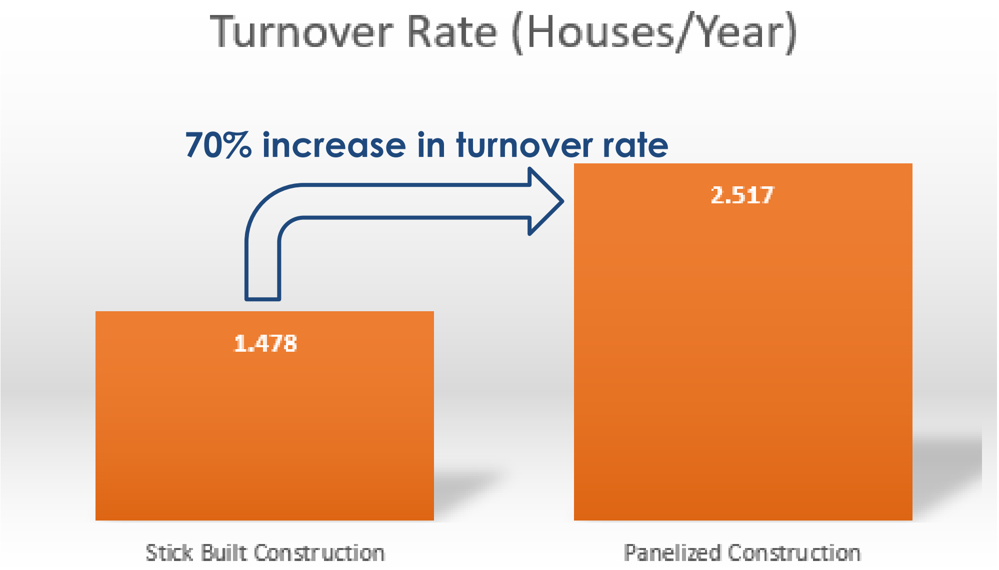
1.478 * 15 = 22.17 houses/superintendent/year | 2.517 * 15 = 37.75 houses/superintendent/year

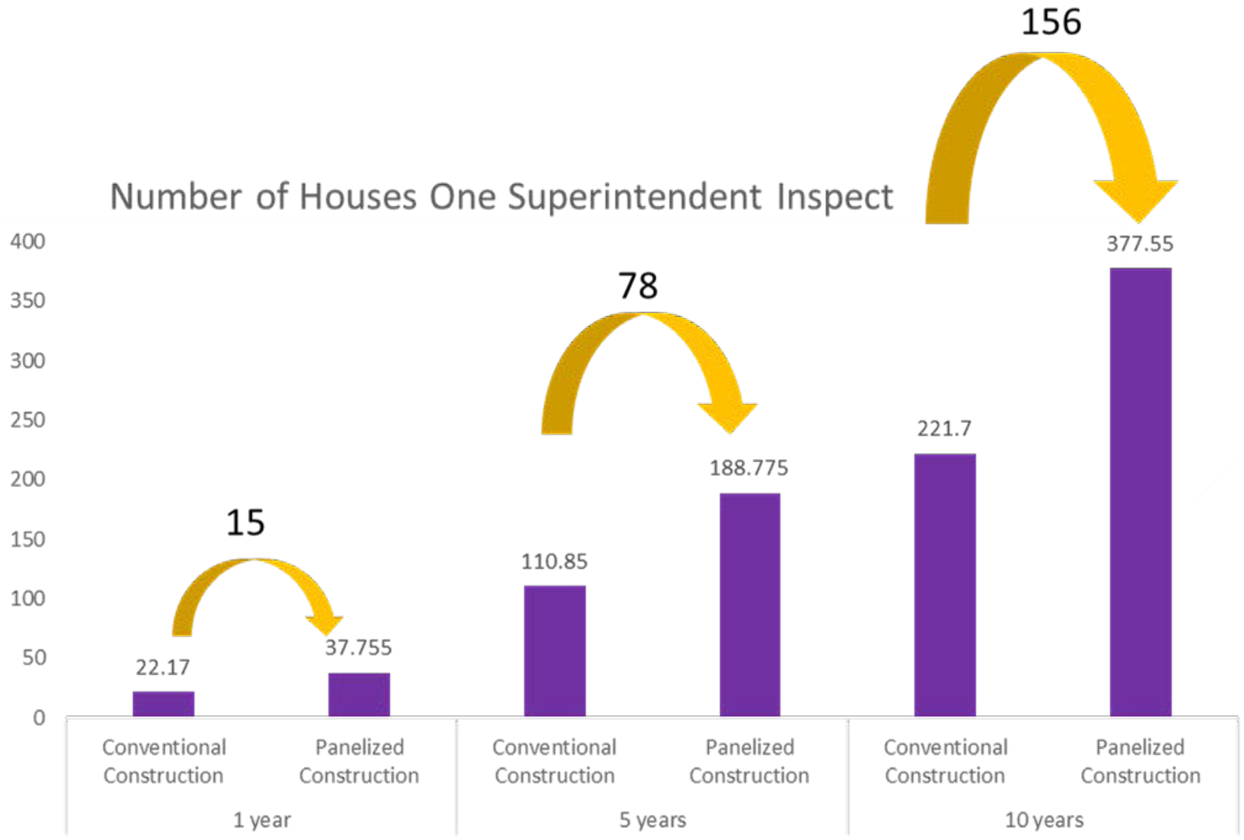
Number of the required superintendents:

1000 / 22.17 = 46 superintendents | 1000 / 37.75 = 27 superintendents

Number of the managed houses per superintendent



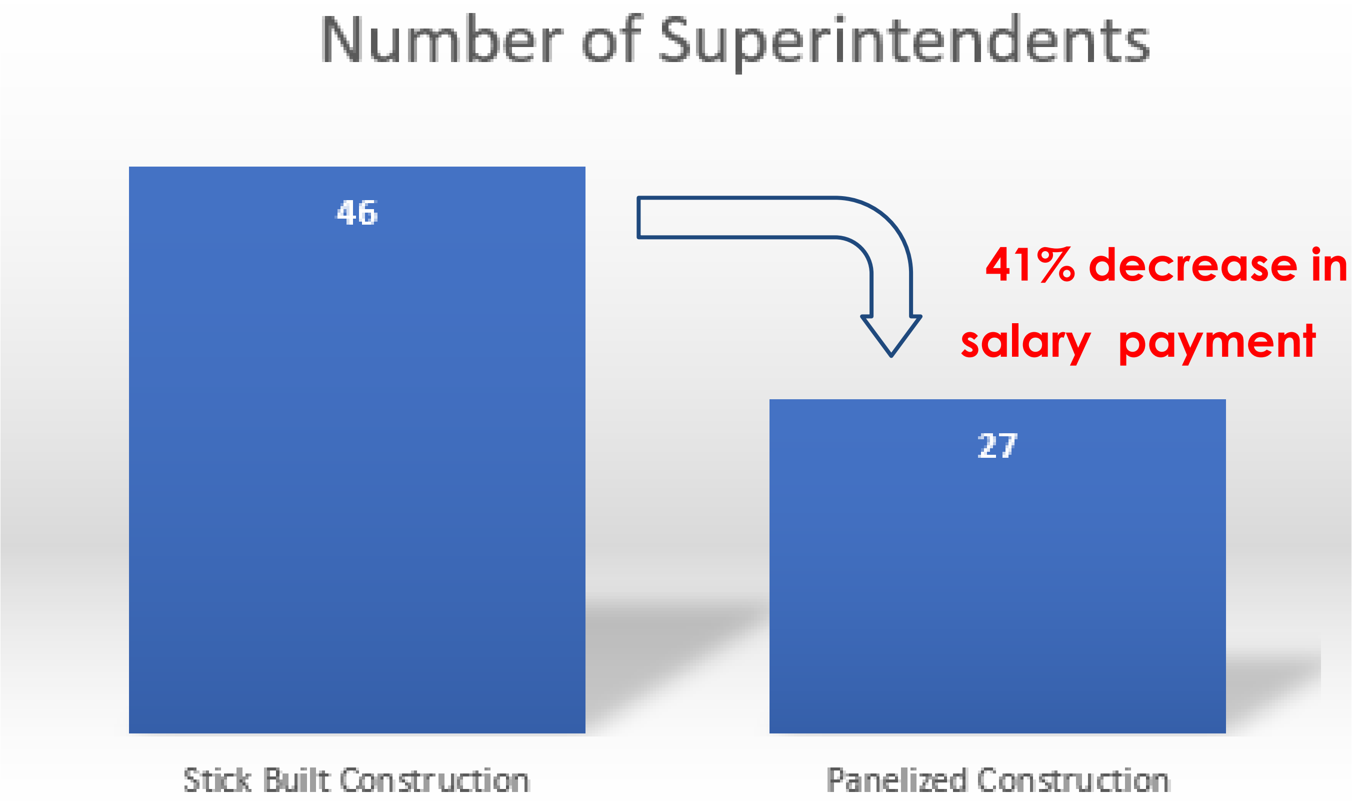




With the application of panelized construction, the number of the houses one superintendent can inspect per year will increase by 15 (5 years increase by 78, 10 years increase by 156).

Number of Superintendents

For building 1000 houses per year, the required number of superintendents will reduce from **46** to **27**.

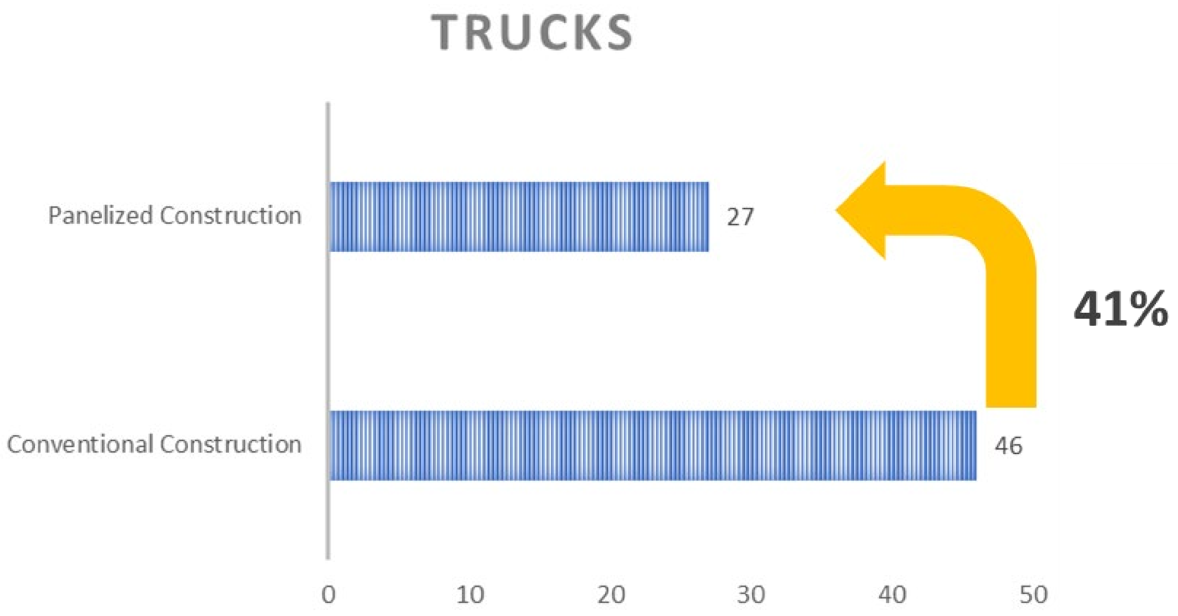


For building **1000** houses / year

Further Effect

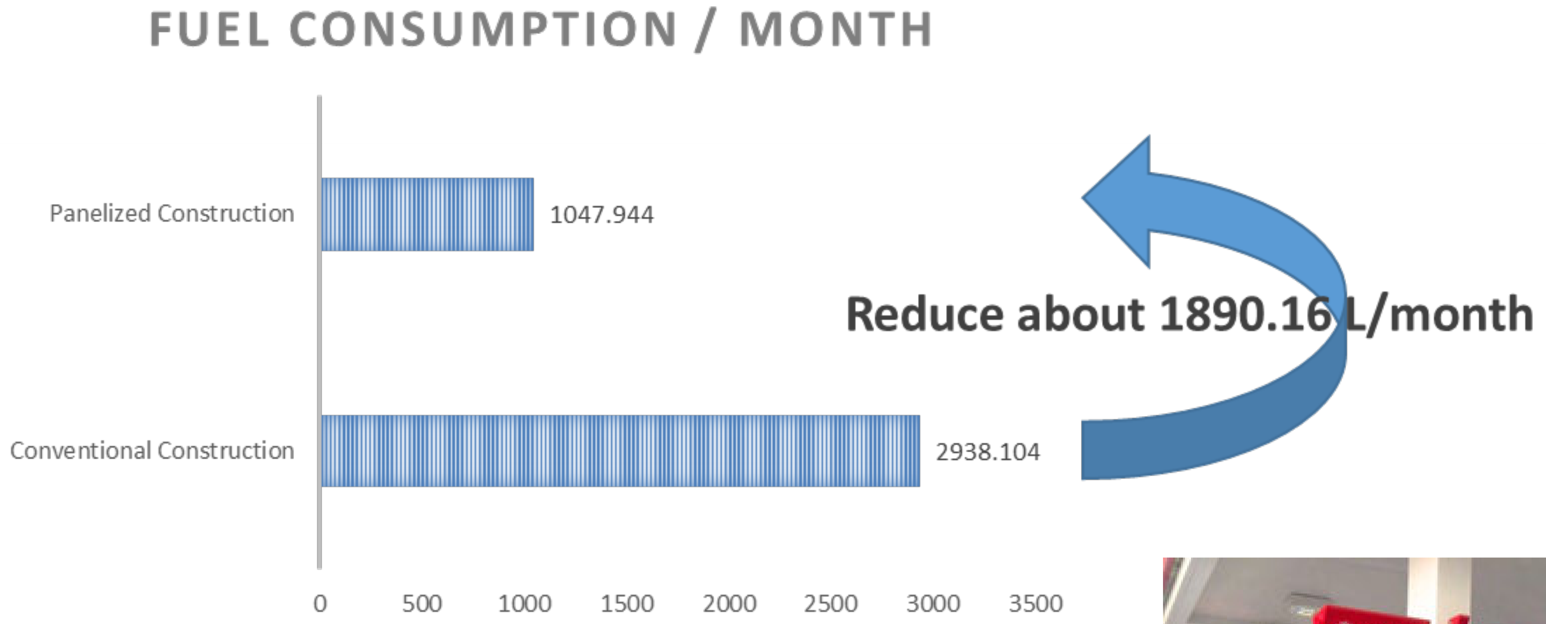
- → Number of pickup trucks
- → Oil consumption
- → CO_2 Emission

Number of Superintendents - Pickup trucks



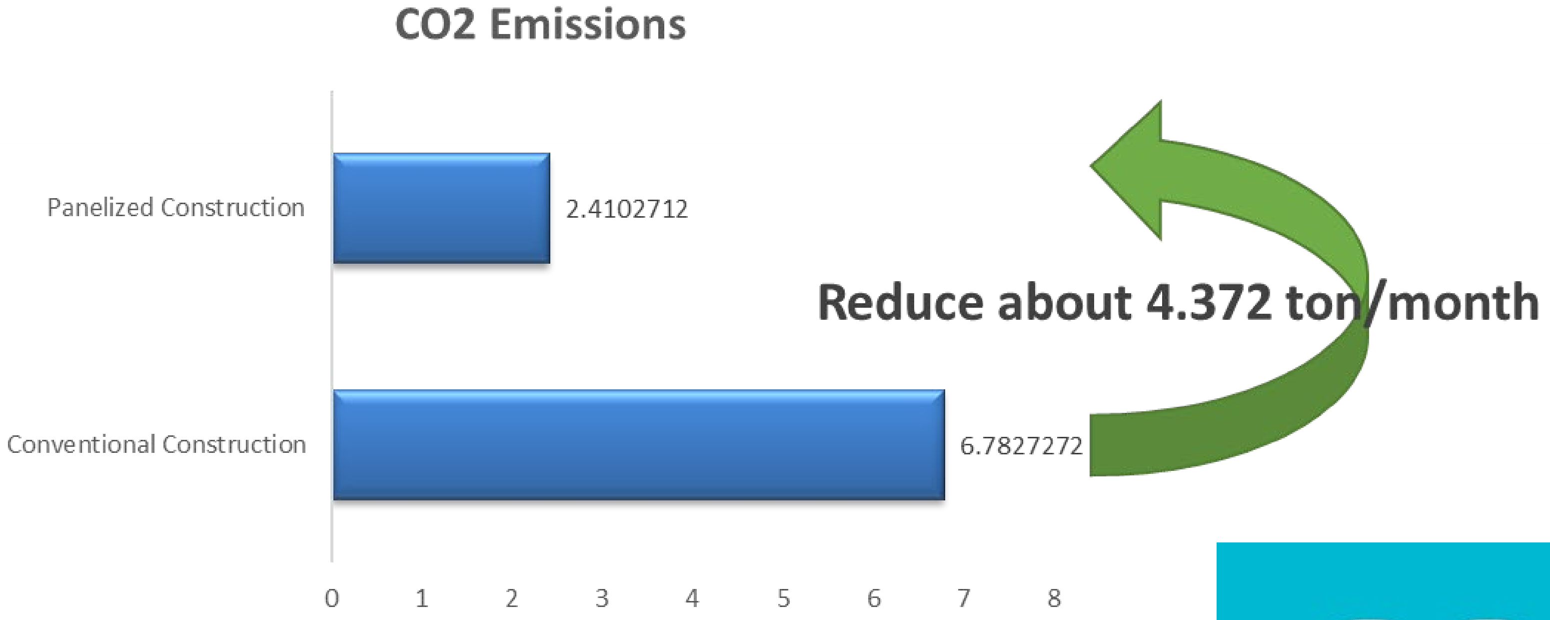
The reduction of superintendents will lead to about 41% reduction on pickup trucks.

Number of Superintendents - Fuel Consumption



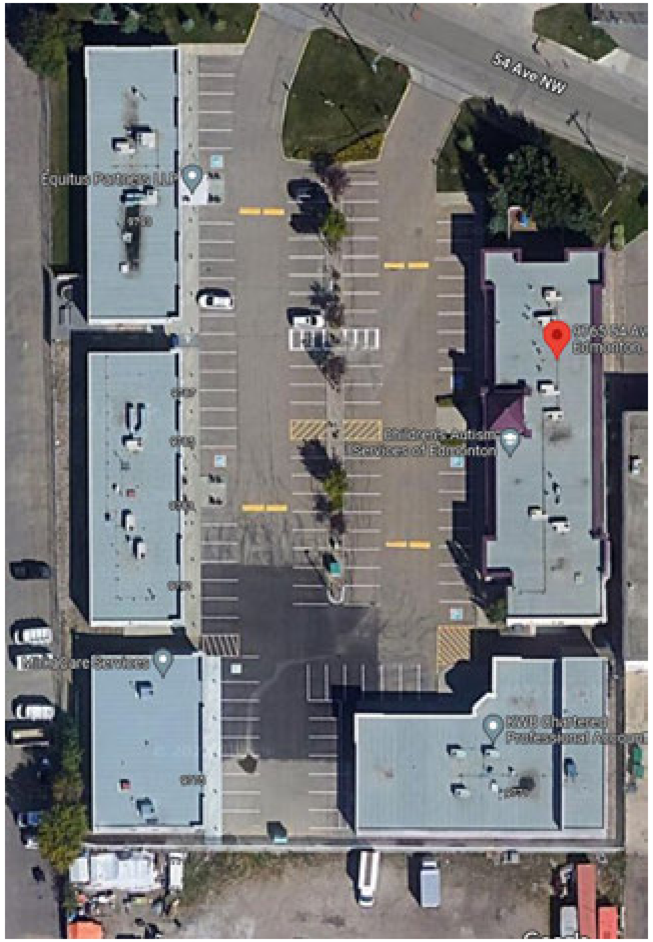
The reduction of trucks will reduce fuel consumption 1890.16 Litres/month which is 22,681.92 L/year

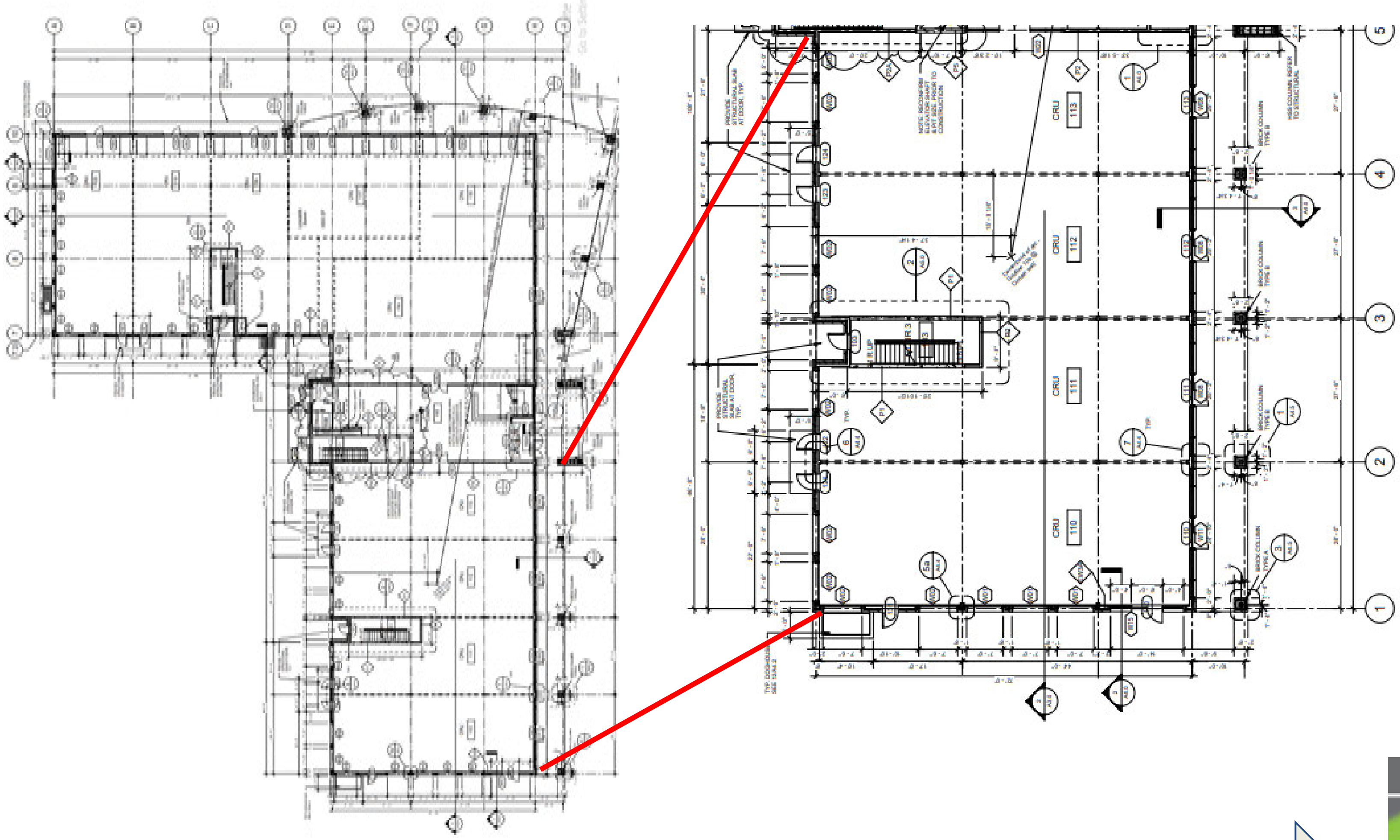
Number of Superintendents - CO_2 Emissions



The reduction of trucks will lead to 4.37 ton less CO_2 emissions per month, 52.46 ton less per year

Office Area Change





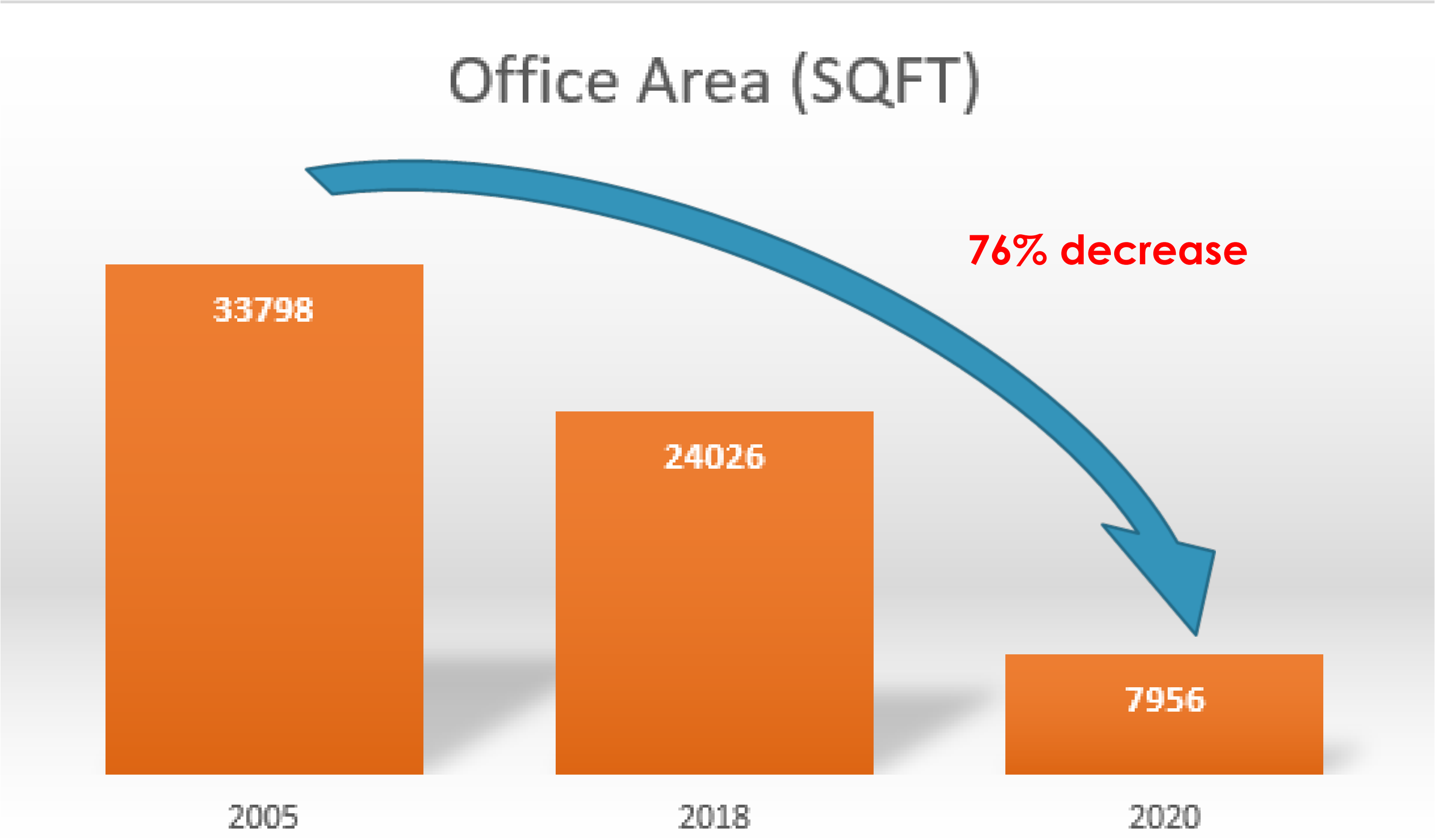
2005 33798 Sqft

2014 24026 Sqft

2019 7956 Sqft

Office Area Change

The required office area will reduce from to 33798 SQFT 7956 SQFT



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Resilience
Frank Lohmann

- **Extreme Heat**
- **Flooding**
- **Rain Storm/Hail**
- **Tornado**
- **Wildfire**

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Resilience

Finished Home

Risk / Resilience	On-site	In-factory
Overheating Protection	**same** (by A/C, window orientation, shading devices)	
Flood Protection	**same** (site design, onsite plumbing, some electrical changes)	
Rain/Hail Resistance	**same** (by roofing material)	
Tornado Resistance	**code compliance** (structural)	**+ greater resistance** (transport)
Wildfire Resilience	**same** (by non-combustible or ignition-resistant building material)	

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Resilience

During Construction

Risk / Resilience	On-site	In-factory
Overheating Protection	*depends on degree of completion of mechanical*	protected from sunlight, (conditioned environment) !
Flood Protection	possible building damage	site damage only !
Rain/Hail Resistance	possible building damage	**no damage while in factory**
Tornado Resistance	possible building damage	**no damage while in factory**
Wildfire Resilience	possible building damage	**no damage while in factory**

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Canadian Home Builders' Association | Association Canadienne Des Constructeurs D'Habitations

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MODULAR AND THE ENVIRONMENT

Questions?

Next modular webinar: November 2, 2022

Recordings: https://www.chba.ca/modular