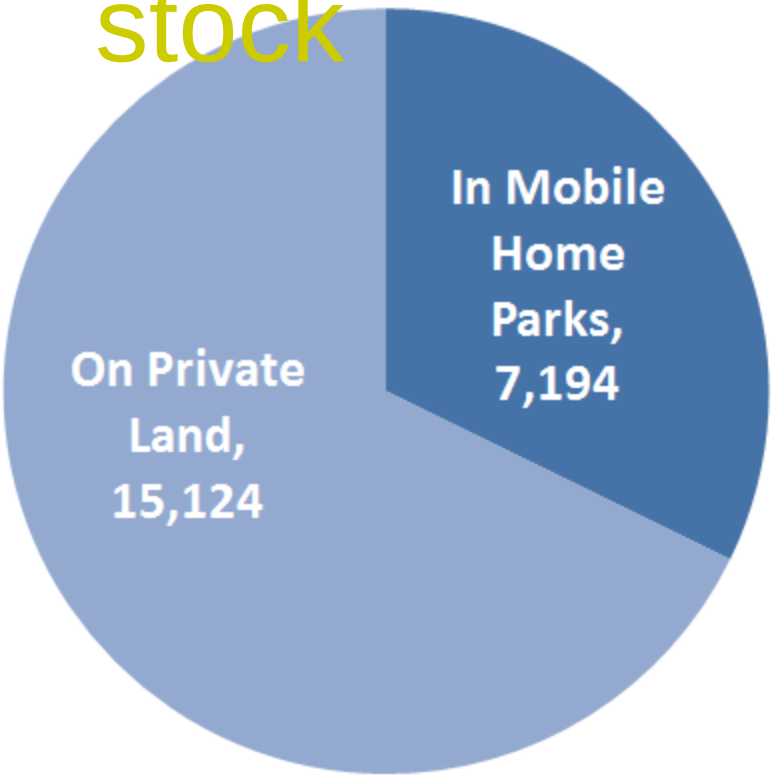
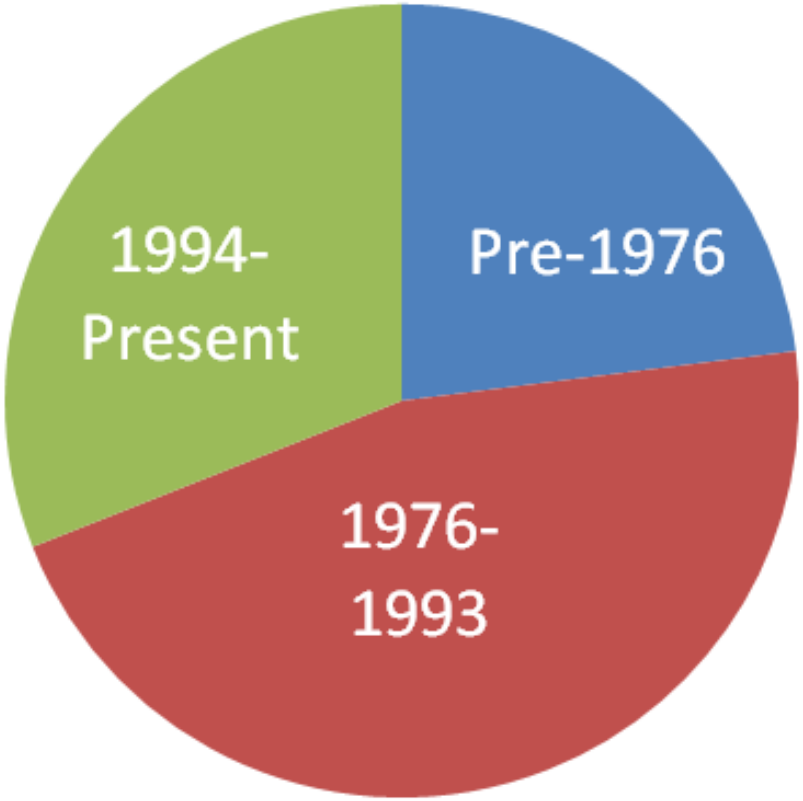
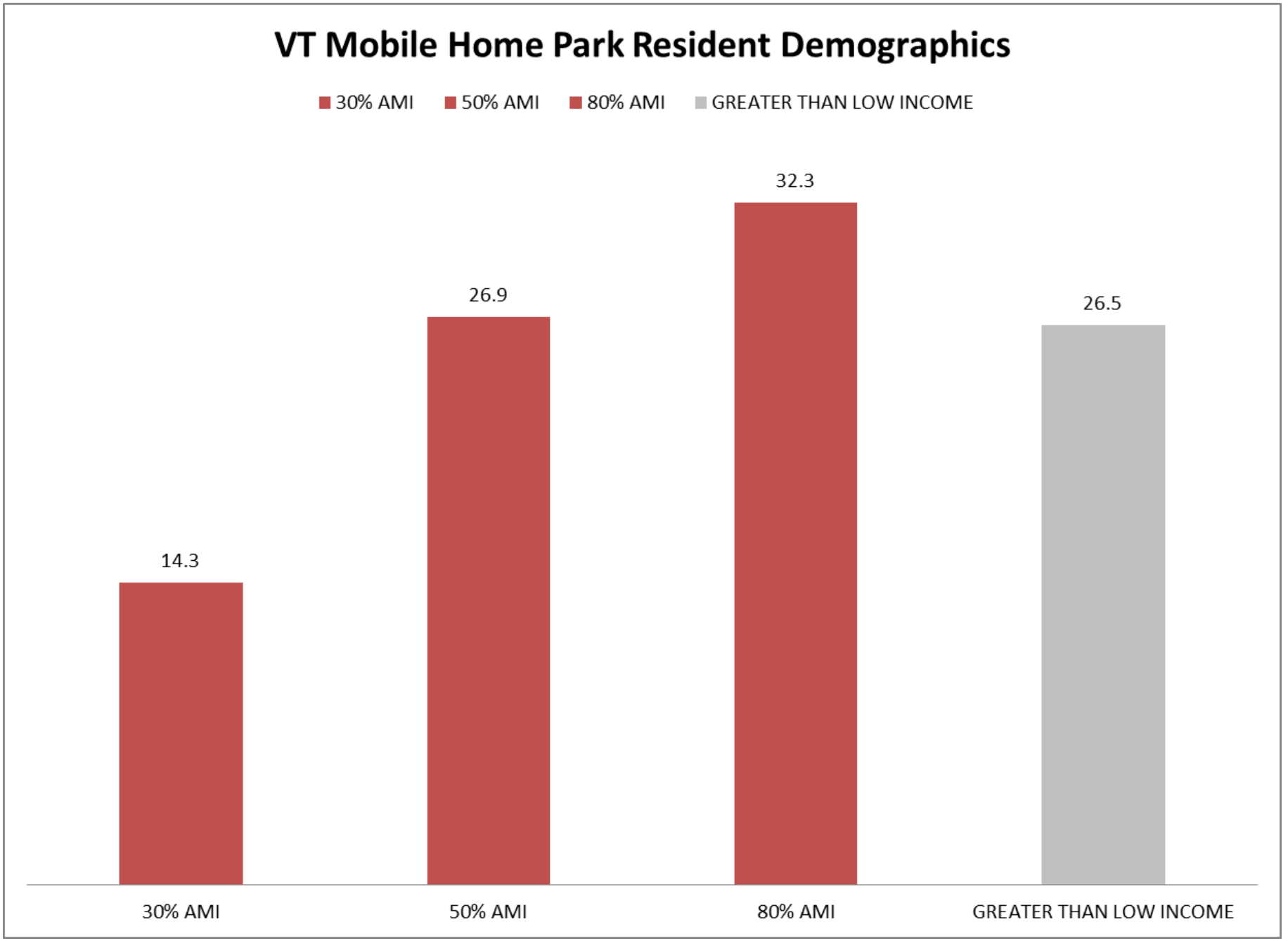
modular housing innovation project

vermont's manufactured housing stock







Source: Baker, D., Hamshaw, K., and Woodward, S. 2011 UVM Survey of 363 residents in 127 VT mobile home parks

High Performance Home on Purchased Land	
Median Lot Cost	$ 55,000
Site Work and Foundation	$ 47,775
VerMod Home Cost	$ 107,000
Total Price	$ 209,775
Income Req'd to Afford Home*	$ 62,641

High Performance Home in Mobile Home Park	
Average Monthly Lot Rent	$ 310
Site Work and Foundation	$ 24,275
VerMod Home Cost	$ 107,000
Total Price	$ 131,585
Income Req'd to Afford Home*	$ 39,476

EFG ENERGY FUTURES GROUP

Milne-Allen Appraisal Company

vhfa.org Vermont Housing Finance Agency

existing manufactured housing

existing manufactured

existing manufactured housing

manufactured versus stick built homeowners

66% more of their household income spent on energy

2X as much spent per square foot for energy

50% more LIHEAP assistance per square foot

new manufactured housing

Table 5. Home in Binghamton, NY with Propane Heating

28'x60' double section home		ENERGY STAR	Non-ENERGY STAR*
Envelope	Wall insulation	R-19	R-13
	Floor insulation	R-33	R-22
	Roof insulation	R-33	R-30
	Window U-value	0.35	0.59
	Window SHGC (max)	0.55	No requirement
	Air leakage (max)	7.0 ACH_{50}	No requirement
Heating and cooling	Heating efficiency (Propane heat)	0.90 AFUE	0.80 AFUE
	Cooling efficiency	13.0 SEER	13.0 SEER
	Thermostat	Programmable	No requirement
	Duct leakage (max)	5%	No requirement
	Crossover duct insulation	R-8	R-4
	Water heater efficiency	0.91 EF	0.88 EF
Annual heating, cooling and water heating cost		$2,764	$3,644
Savings with ENERGY STAR		**$880**	—

* These are typical home specifications only; specifications of actual homes will vary.

catalyst to action

"Tropical Storm Irene: Irene Spares Big Cities, but Vermont Sees Huge Floods"

– Huffington Post

"Raging Water in Vermont From Hurricane Irene"

– Weather Channel

USAToday.com

- 438 mobile homeowners were eligible for FEMA assistance
- 129 mobile homes required complete demolition or removal

vermont's comprehensive energy plan

…. a goal of having 30% of new buildings built to net-zero design standards by 2020 &100% by 2030.

high performance home approach

vermont's mobile home parks

rocket science?

it is **not** rocket science to design and build an affordable high performance net zero home in our climate.

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the high performance home

these houses may look different from each other, but they have the same components regardless of their economic and aesthetic requirements…….

vermod -high performance modular home

o

r

passive house

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from the factory down the road

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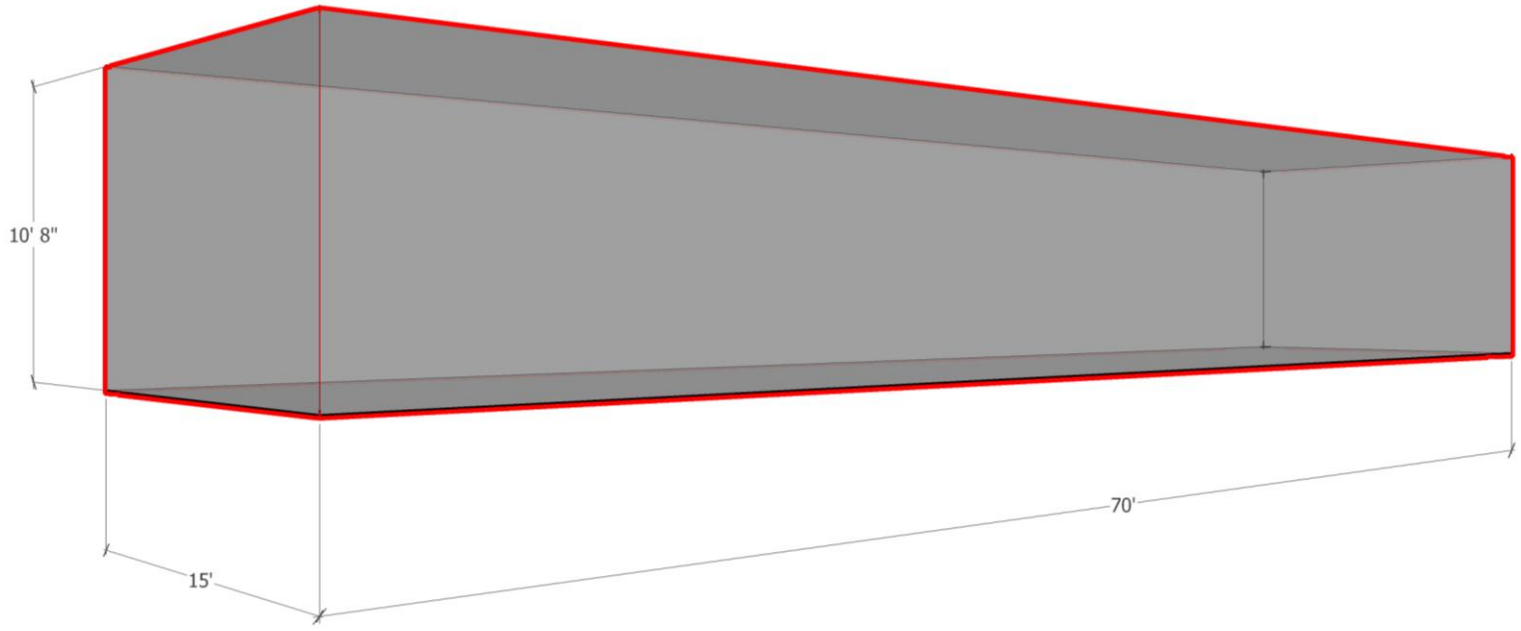
need to work within these dimensions



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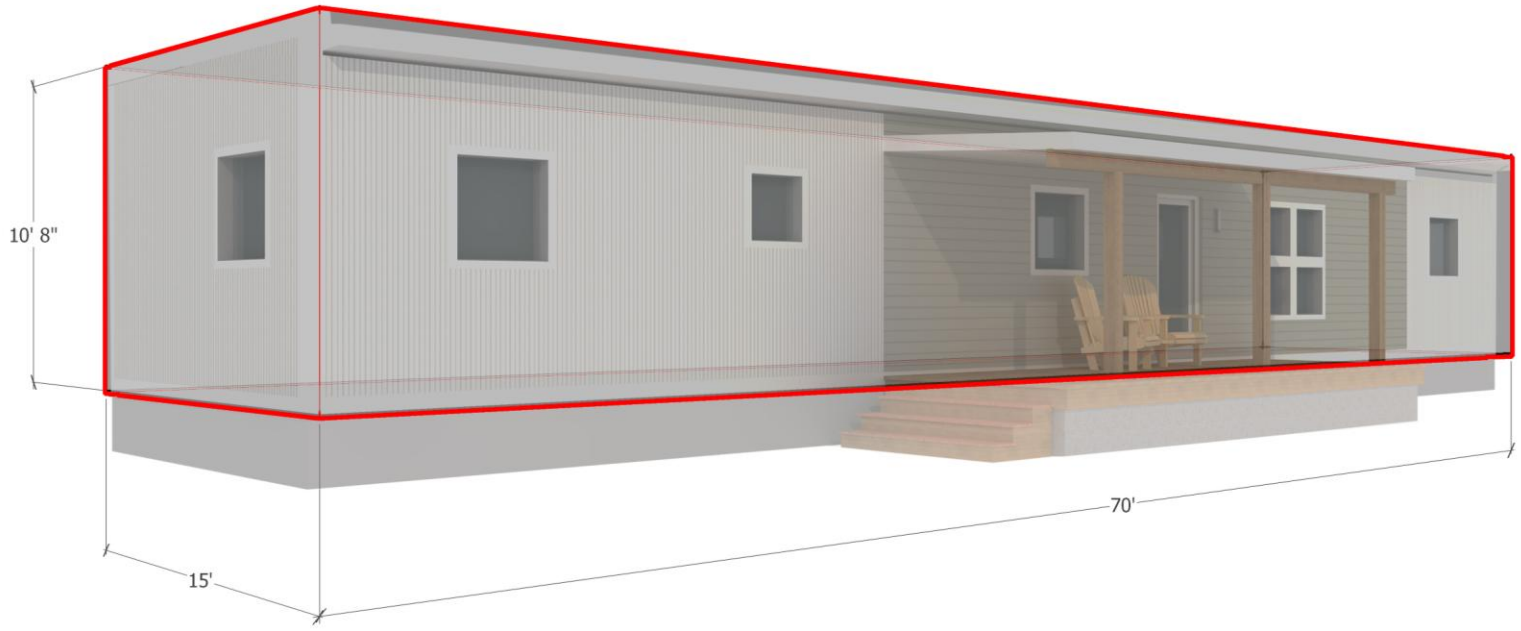

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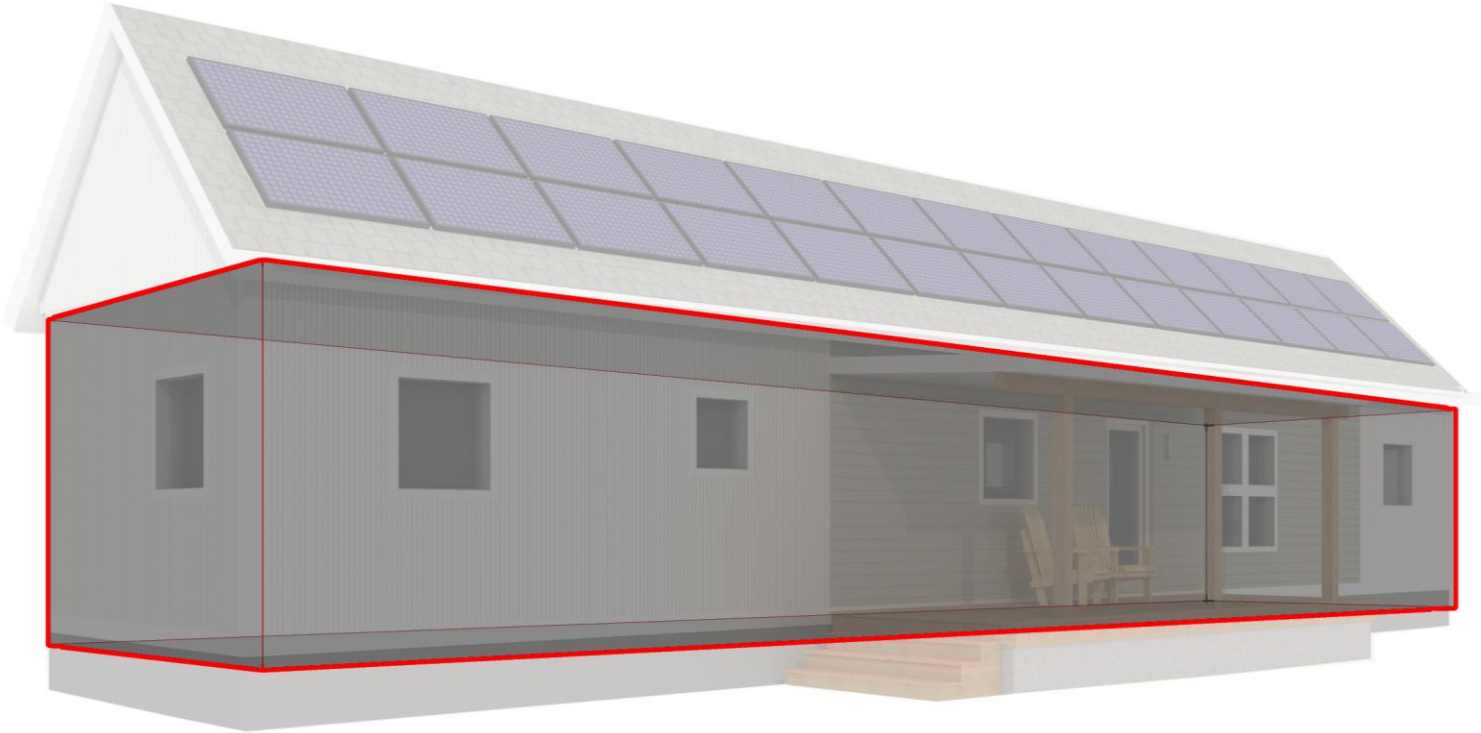

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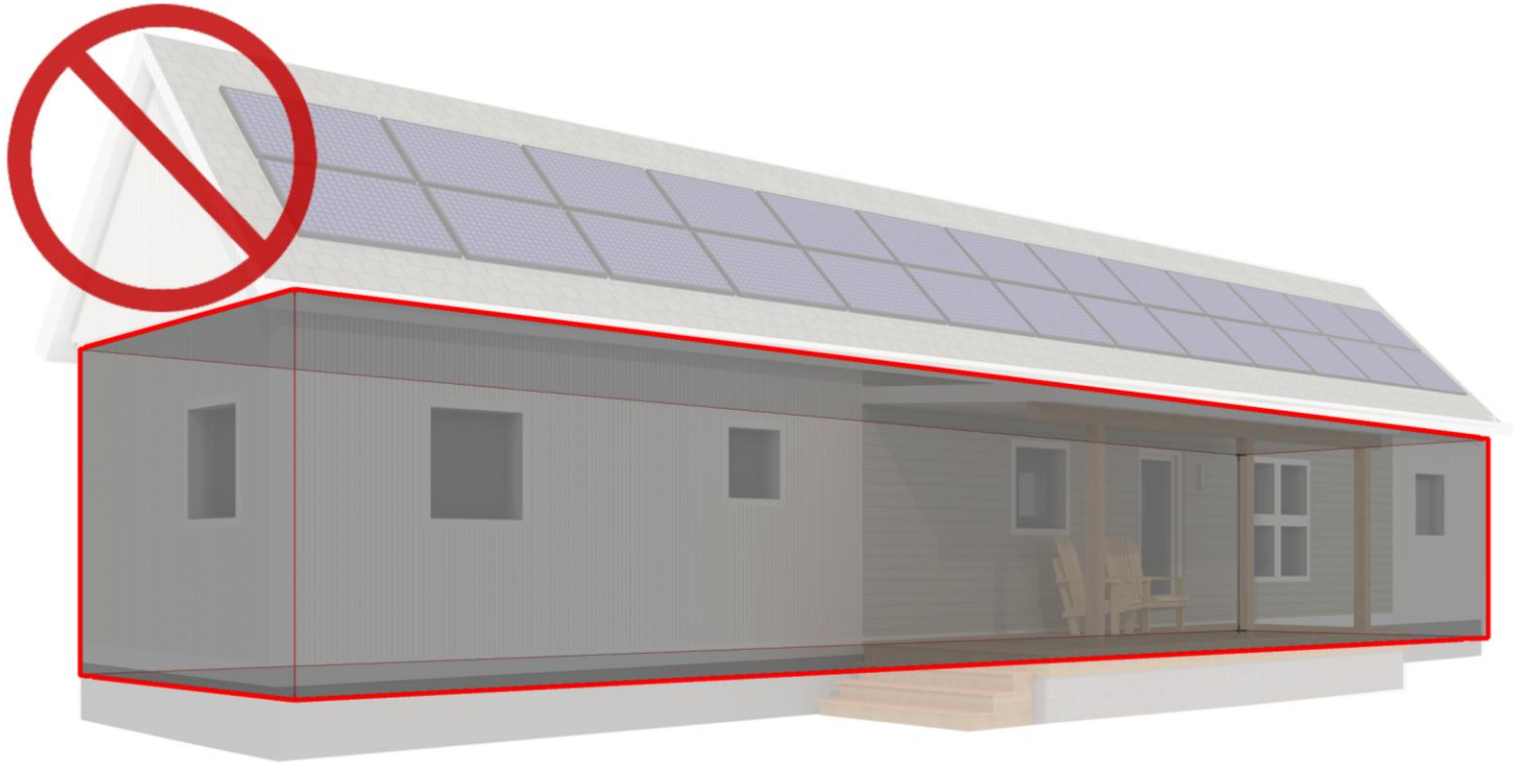
need to work within these dimensions



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need to work within these dimensions

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need to work within these dimensions

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Setting the Vermod in place

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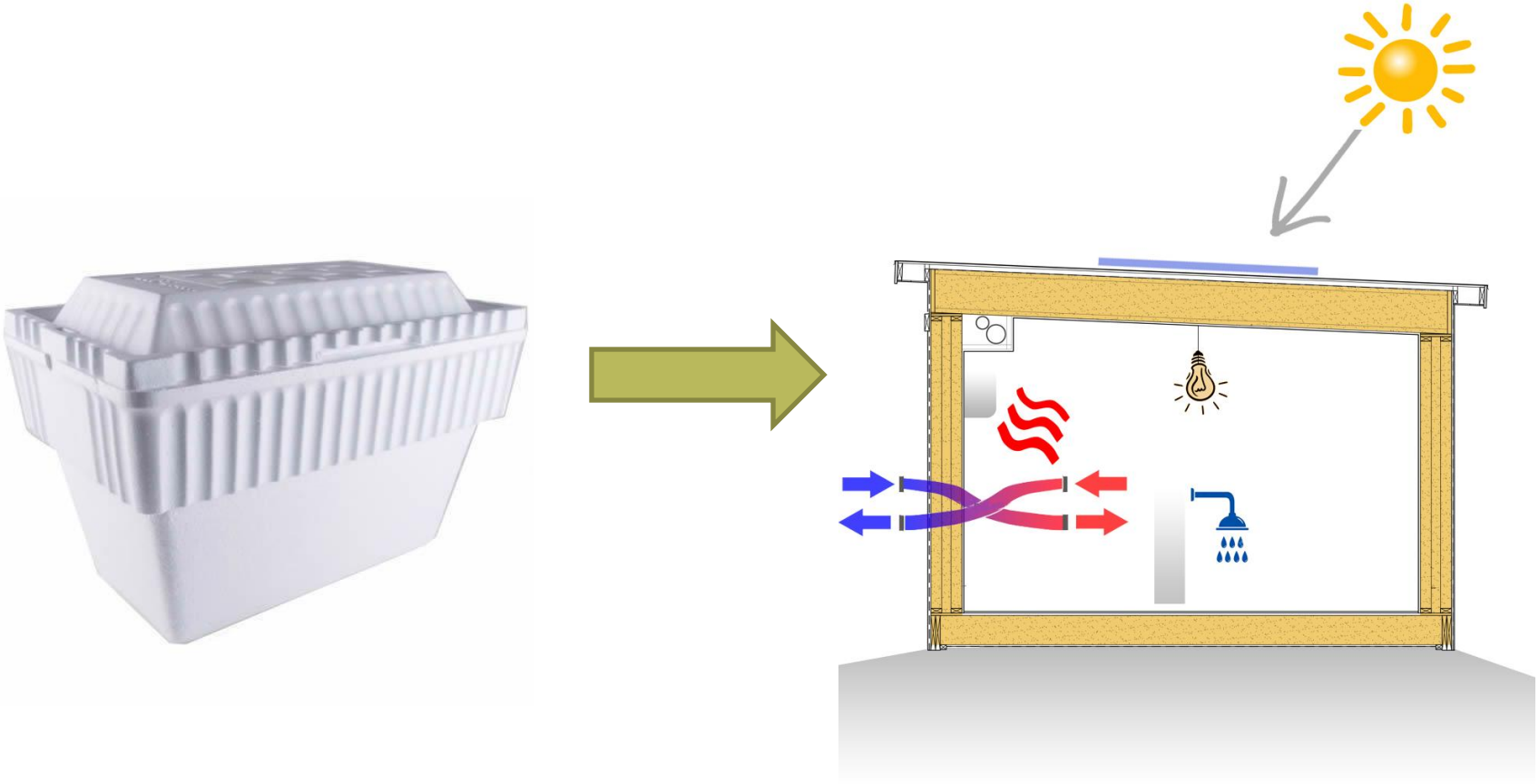
how do we get there ?



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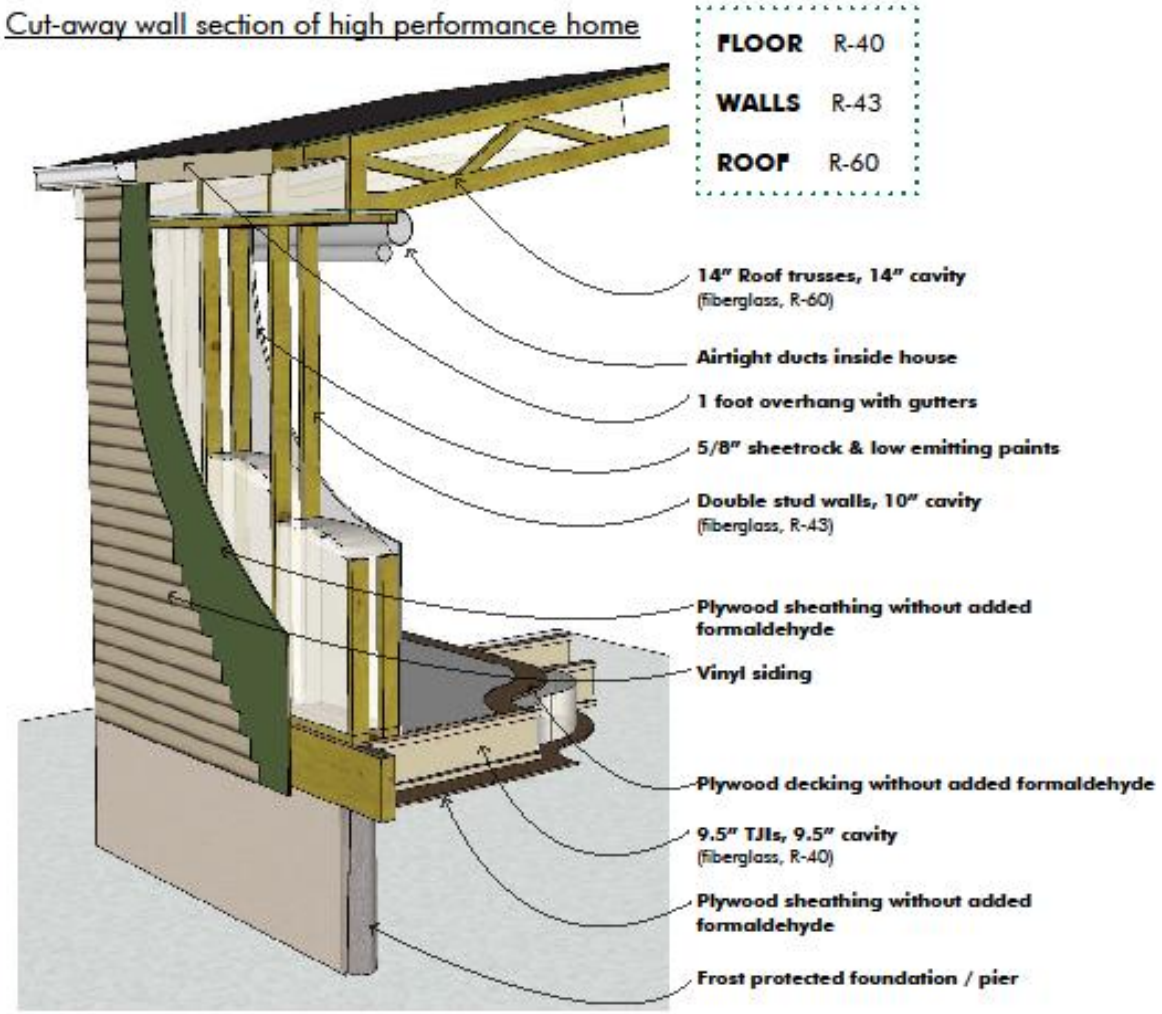
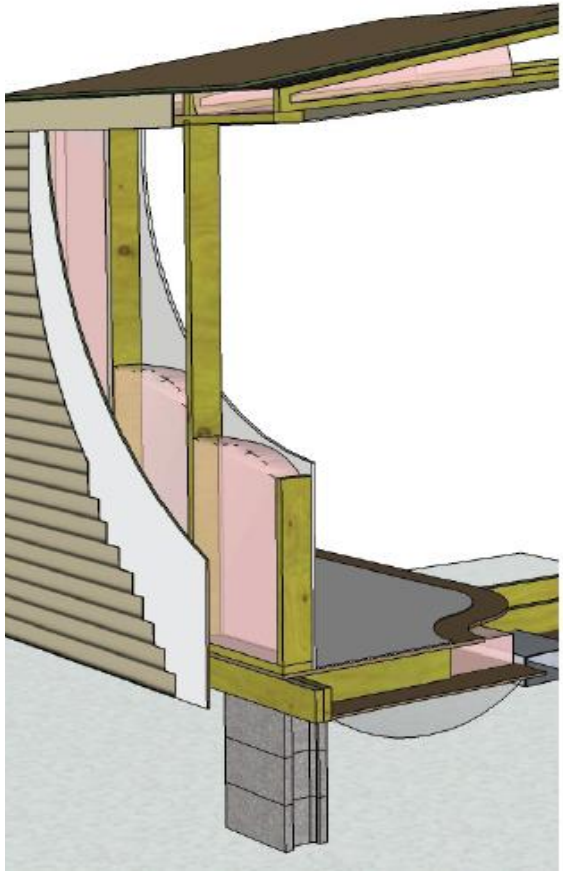
how do we get there ?

high performance envelope vs. a typical mobile home

Cut-away wall section of high performance home





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how do we get there ?

efficient mechanical and electrical systems

- led lighting
- energy star appliances
- washer and condensing dryer
- cold climate heat pump “mini-split” heat pump water heater
- CERV – Conditioning Energy Recovery Ventilator

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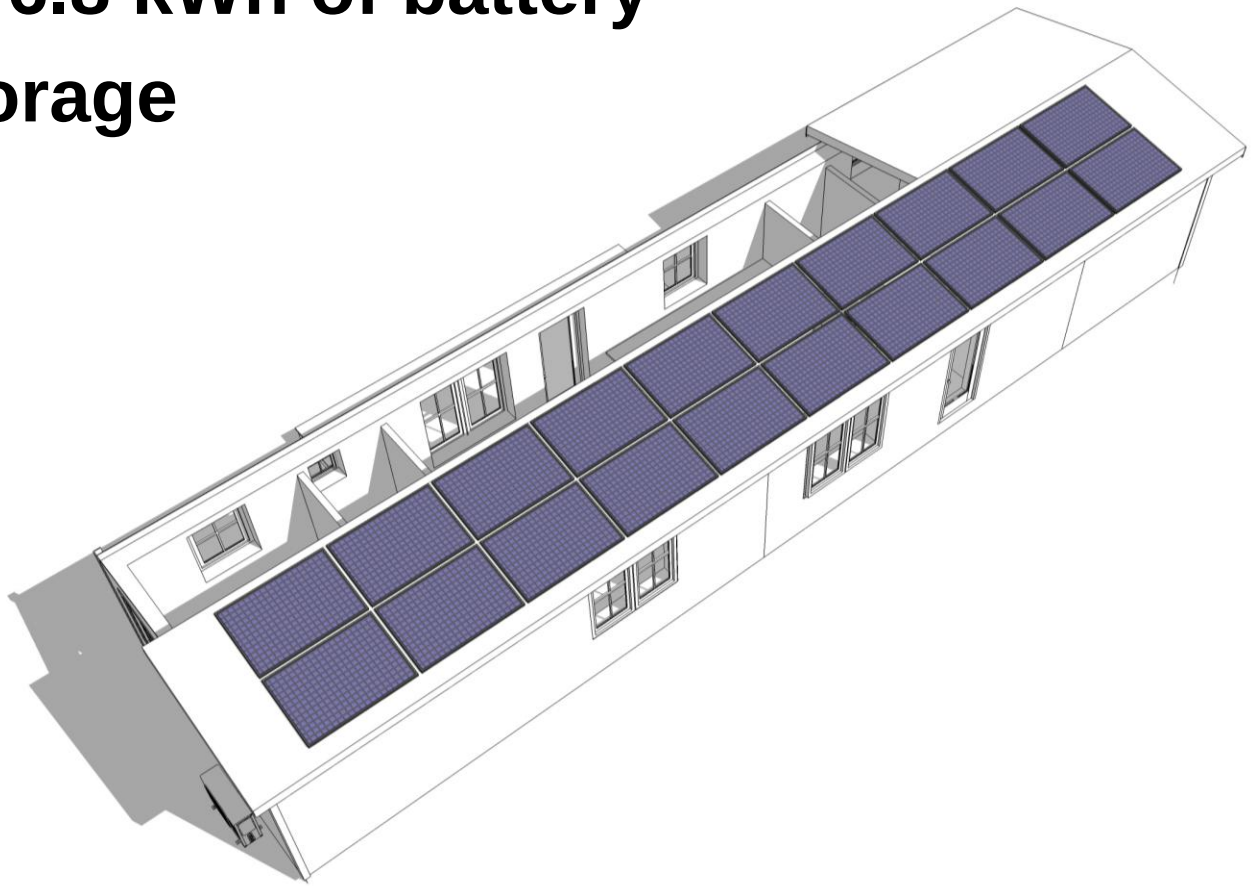
how do we get there ?

6kW roof mounted PV

w/ 6.8 kWh of battery

storage



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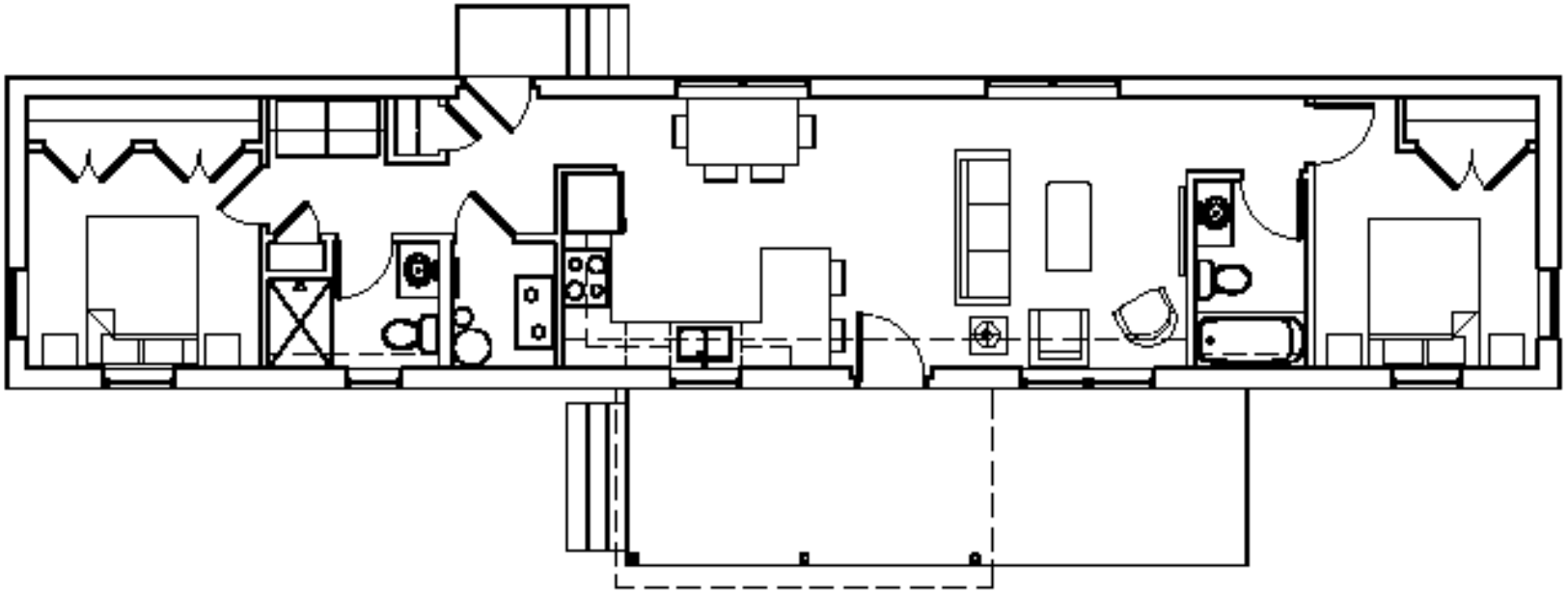
original 2 bed 2 bath plan



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“traditional” and “modern” design

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interiors

interiors

interiors

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exterior

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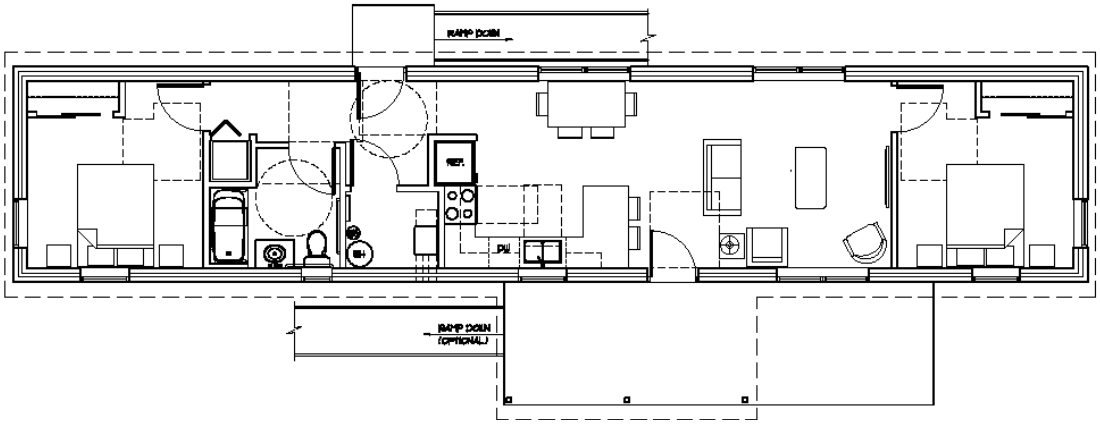
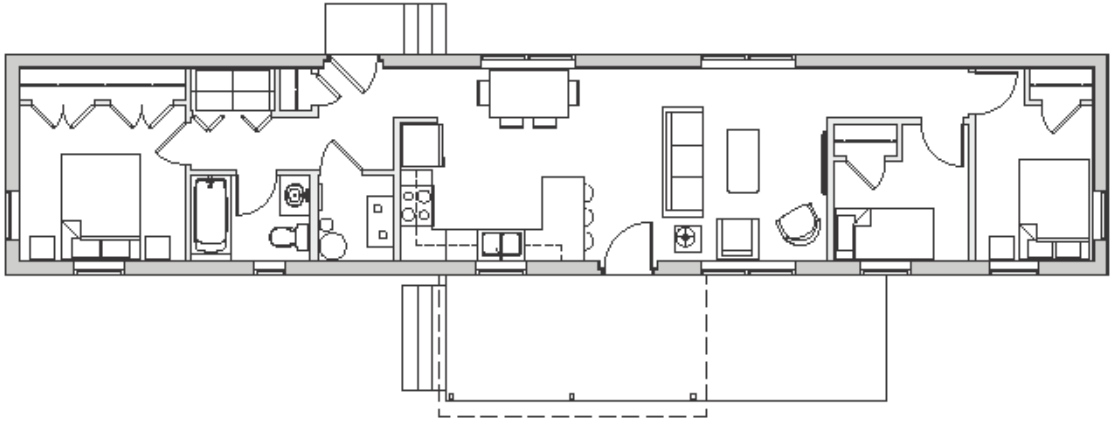
plans

2 bed 1 bath ADA compliant



3 bed 1 bath



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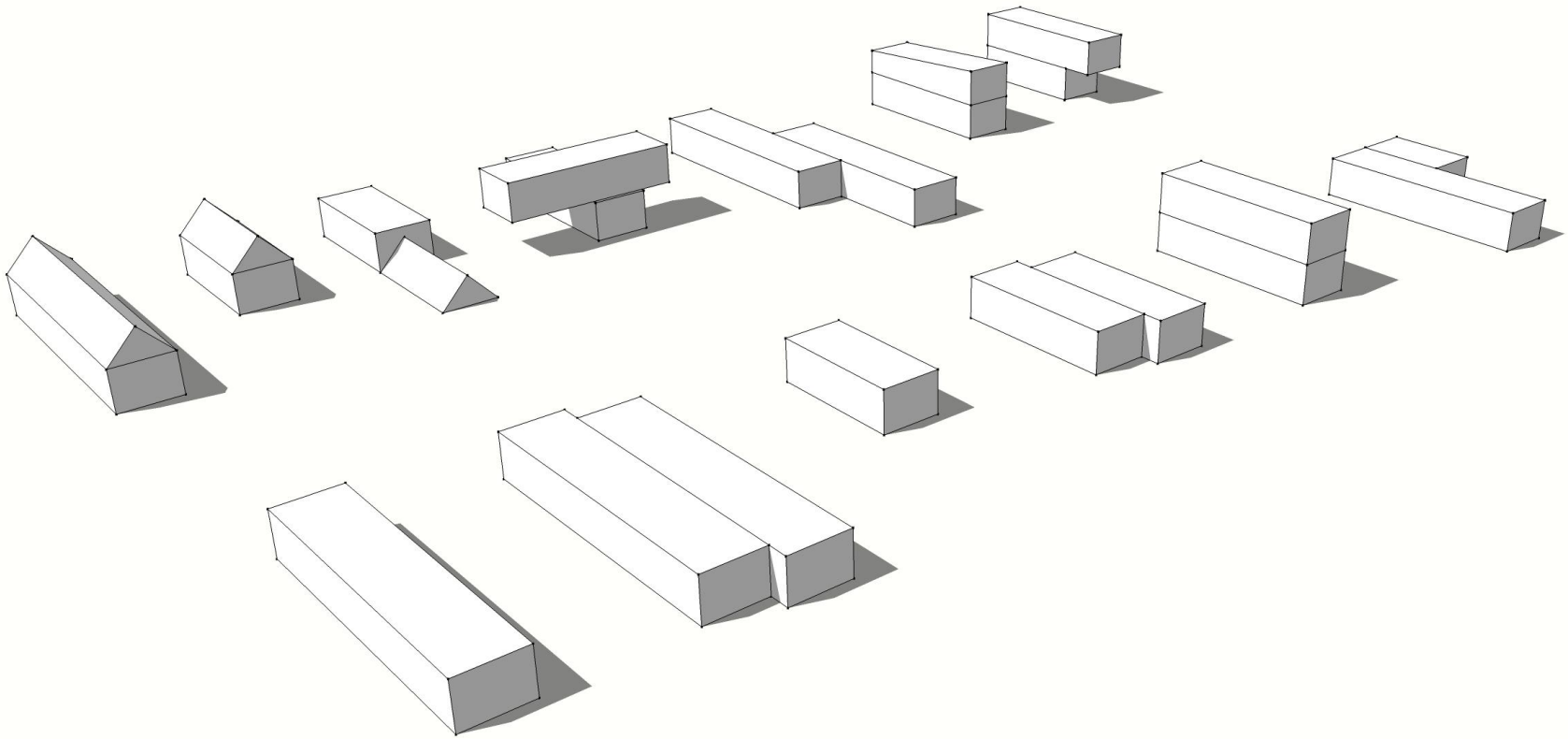
flexibility



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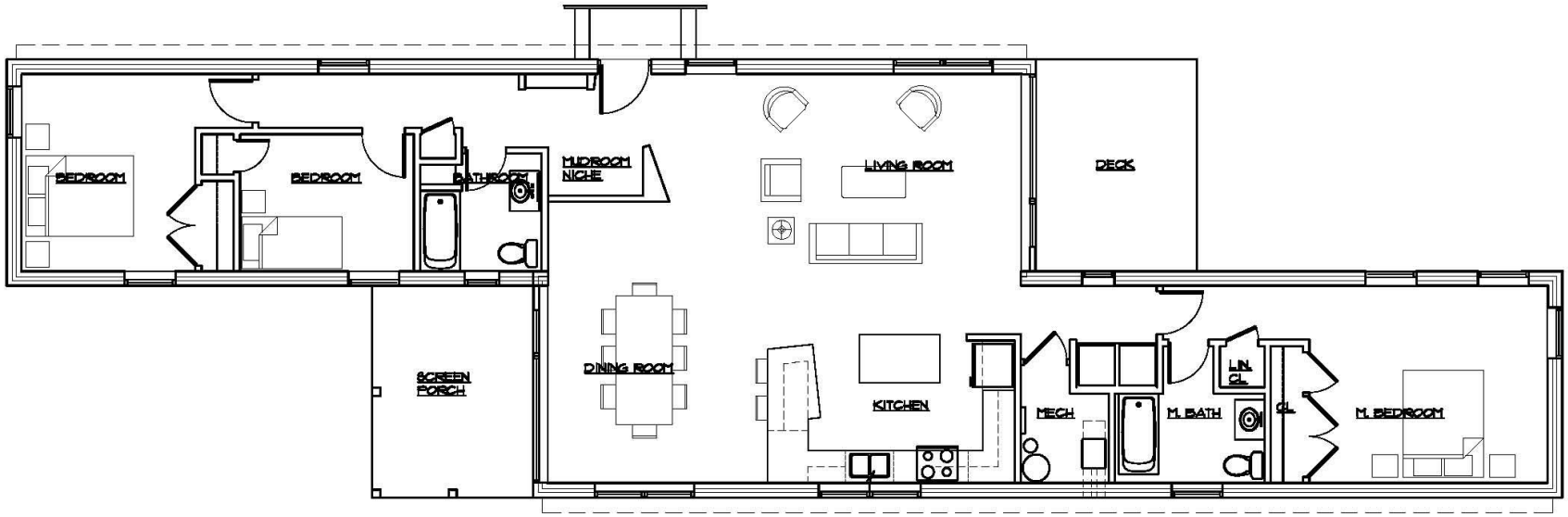
custom “double wide”



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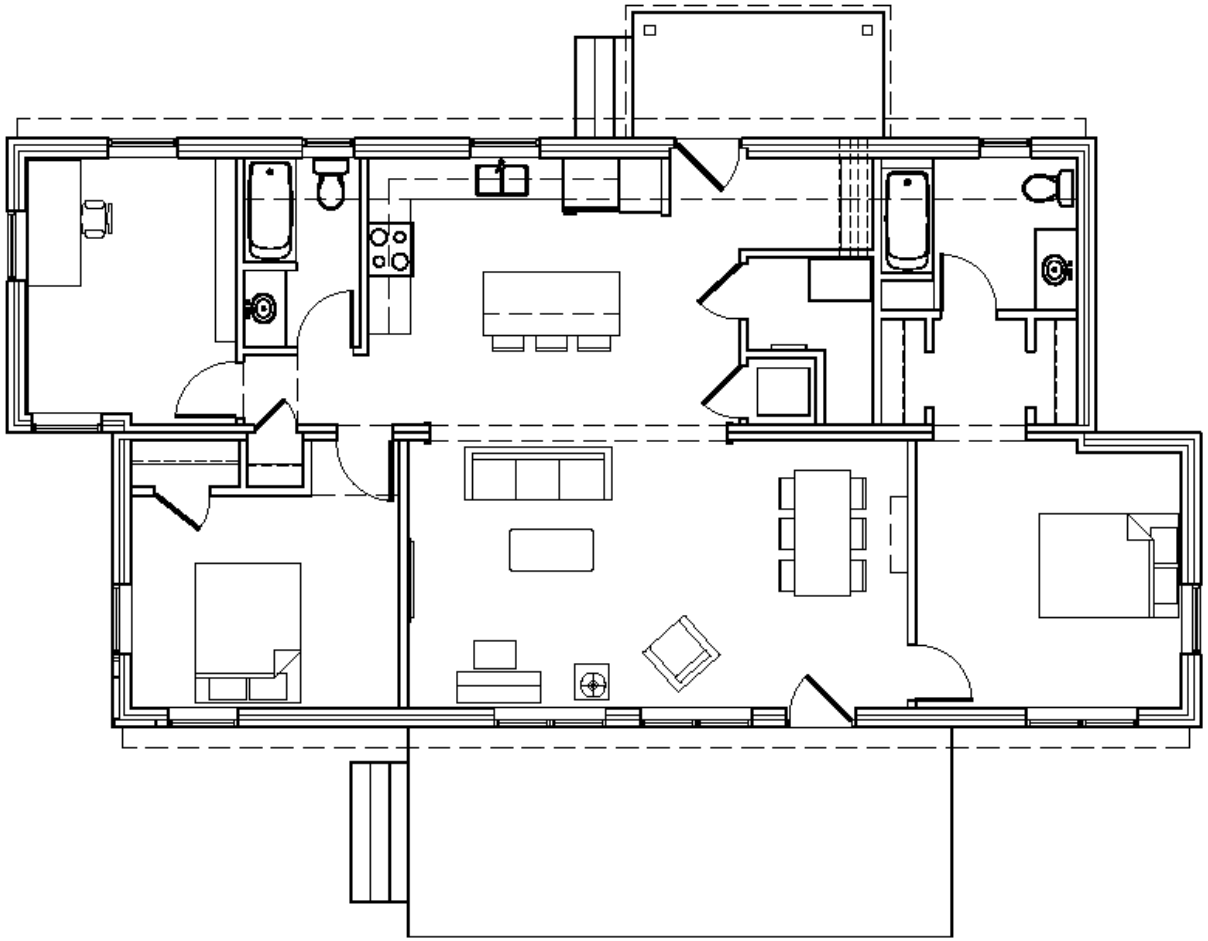
custom “double wide”



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custom “double wide”

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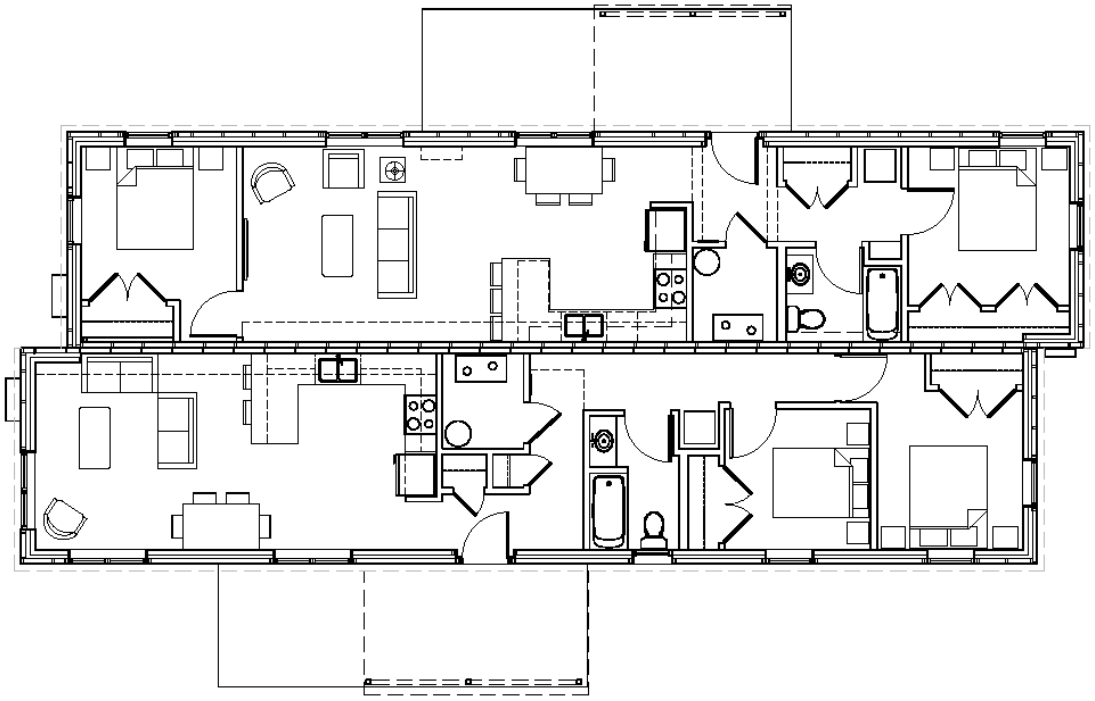
McKnight lane duplexes – waltham, vt



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McKnight lane duplexes – waltham, vt

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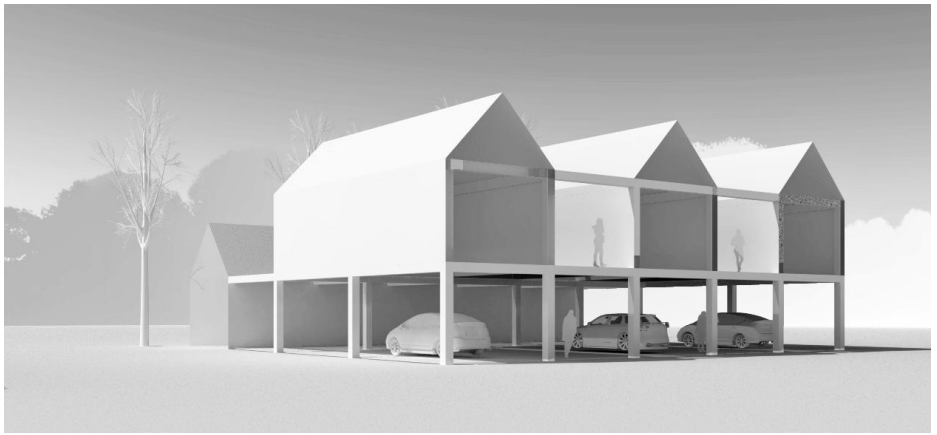
on the boards and the future



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2X10 16oc Floors


10” Thick Walls
ZIPsystem
FEATHERLITE


Insulated Corners – Not a Weak Spot

14” Truss & TJI Roof Systems

Ceiling Sheathed Before Interior Walls Installed and Vapor Barrier Primer

Duct Chase within Envelope

ProPink L77:
R-4.3/inch
1.8/lbs per cuft

Cellulose:
R-3.6/inch
3.5-4/lbs per cuft

~6,000lbs

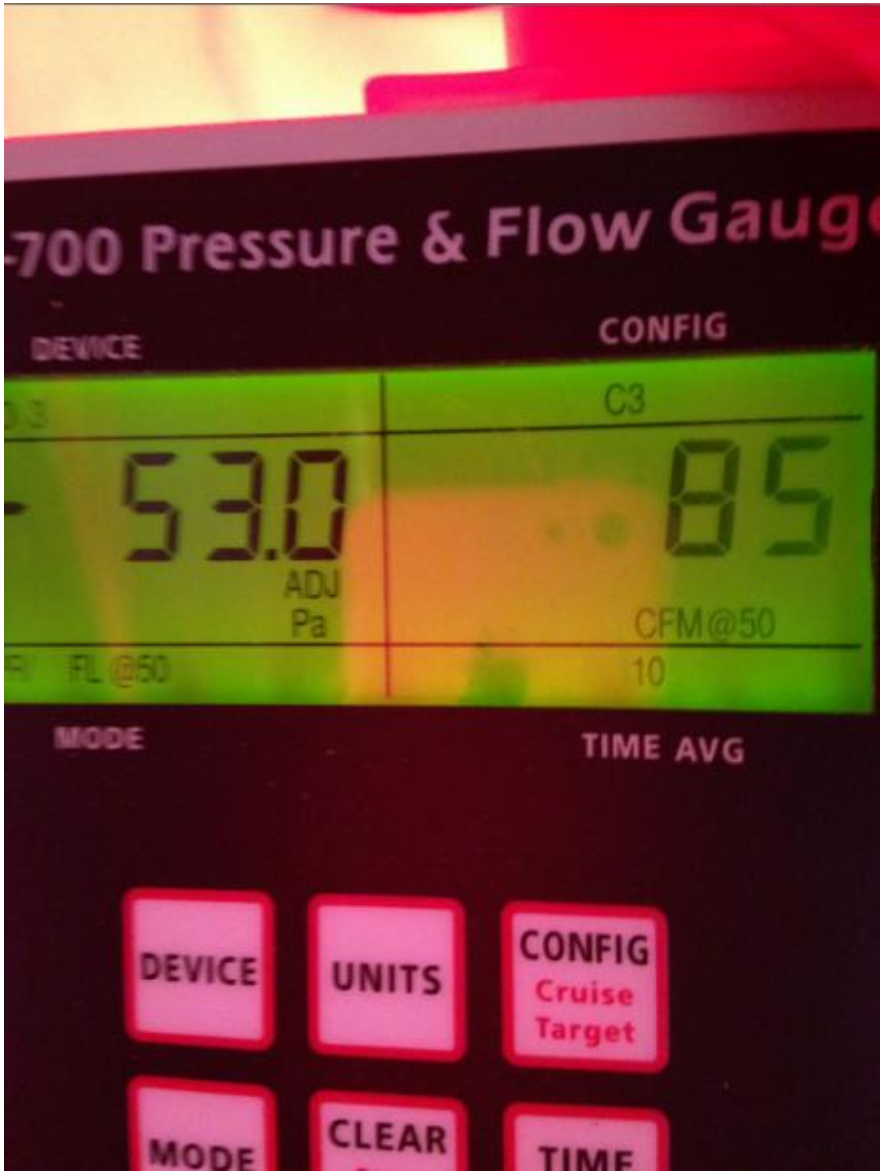
Floor, Walls & Roof Dense-Packed with Fiberglass

Air barrier transitions and vented roof assembly

earthwise
WINDOWS & DOORS

U-0.19 SHGC-Low or High

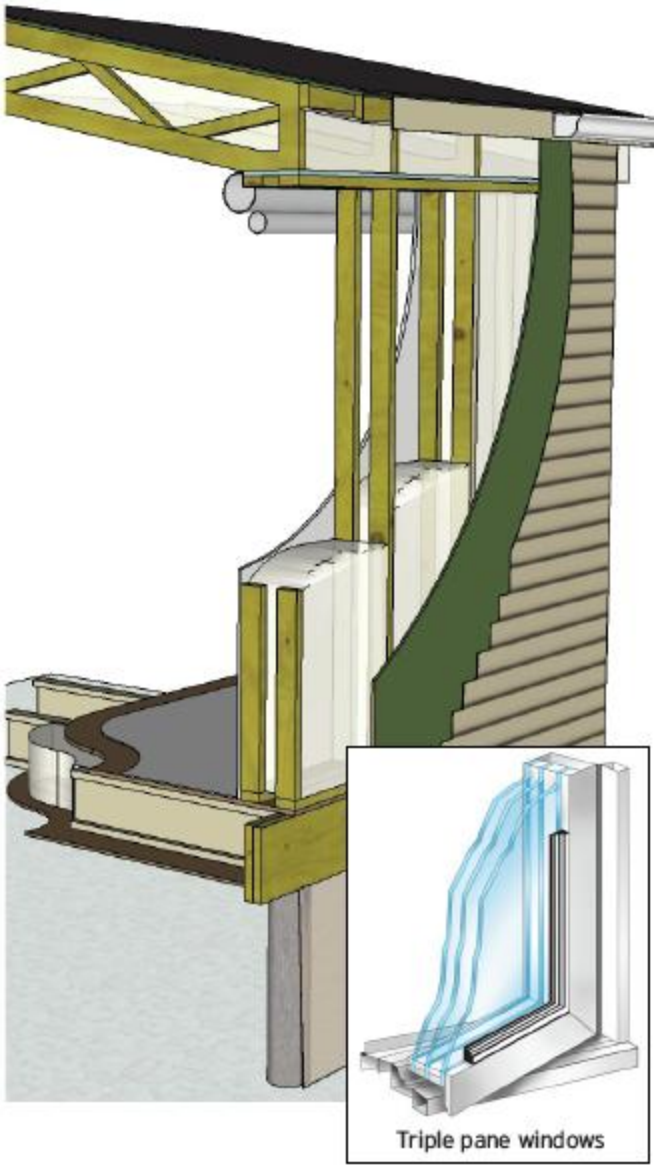
Air Tightness <1 ACH50



Accessing the Belly

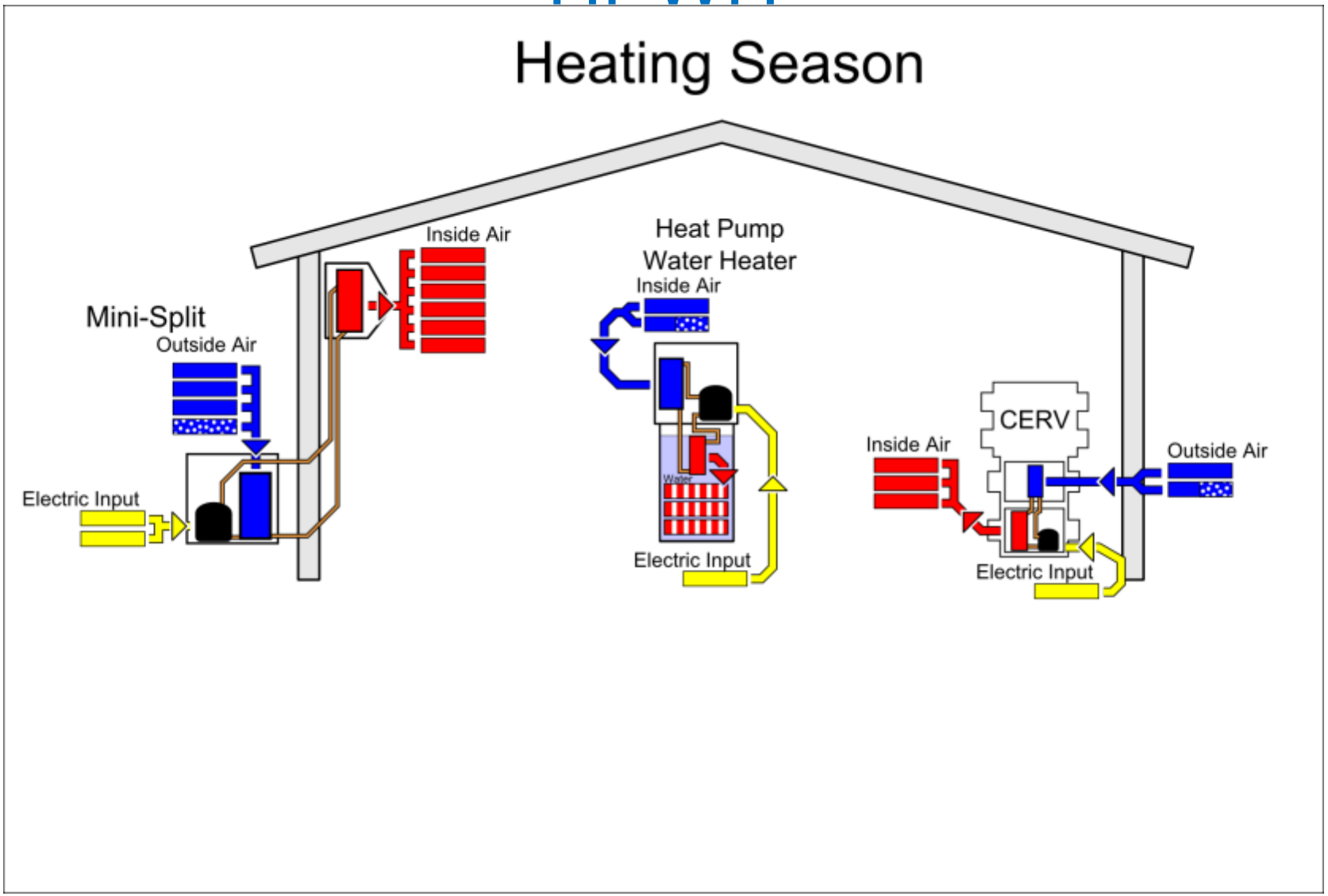
Accessing the Belly

Certification Requirements	Efficiency Vermont Certified: Base Level*	Efficiency Vermont Certified: High Performance Level
Energy Code Compliance	Meet Vermont energy code and file RBES certificates	
Foundation Wall Insulation– Minimum R-Value	R-15 continuous or R-20 cavity	R-30
Slab Edge Insulation (when within 12" finished grade)	R-15 Must extend a total of 4 ft. vertical or horizontal	R-30: slab on grade R-20: unheated fully below grade Footing: ≥ R-8
Insulation Under Slab	R-15 under heated slab only	R-20: unheated below grade R-30: unheated on grade R-30: all heated slabs
Floor Insulation (exposed)	R-38 or R-30 + R-5 continuous	R-40
Wall Insulation (above grade & band joist)– Minimum R-Value	R-20 cavity or R-13 cavity + R-10 continuous	R-40
Ceiling Insulation (flat & sloped)– Minimum R-Value	R-49 sloped R-60 flat	R-60

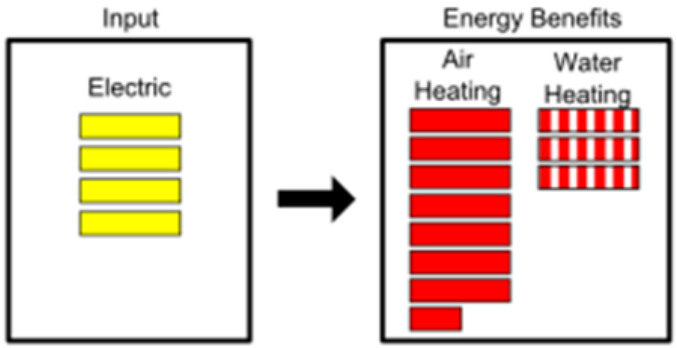


Triple pane windows

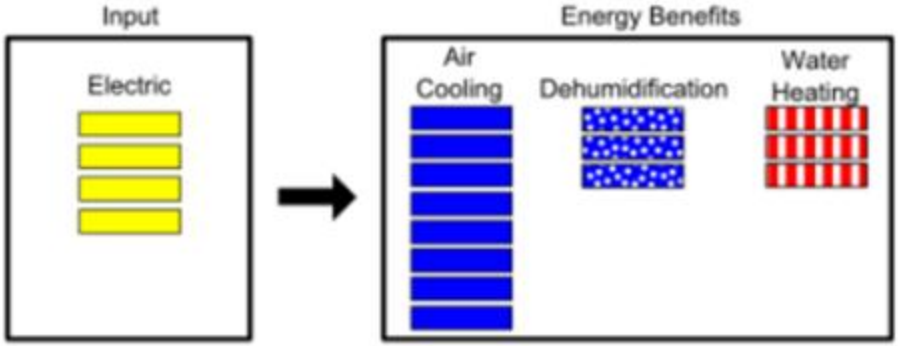
Cold Climate Heat Pump - CERV - HPWH



Cold Climate Heat Pump - CERV - HPWH

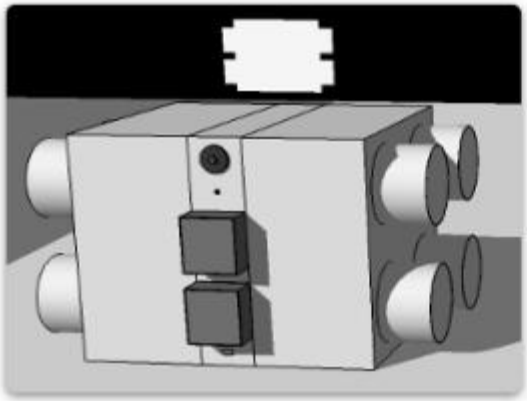


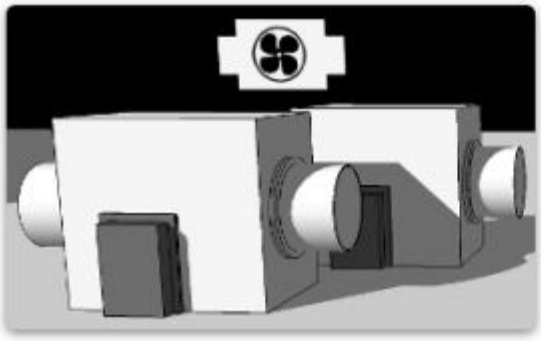
Total Home Efficiency
~ 260%



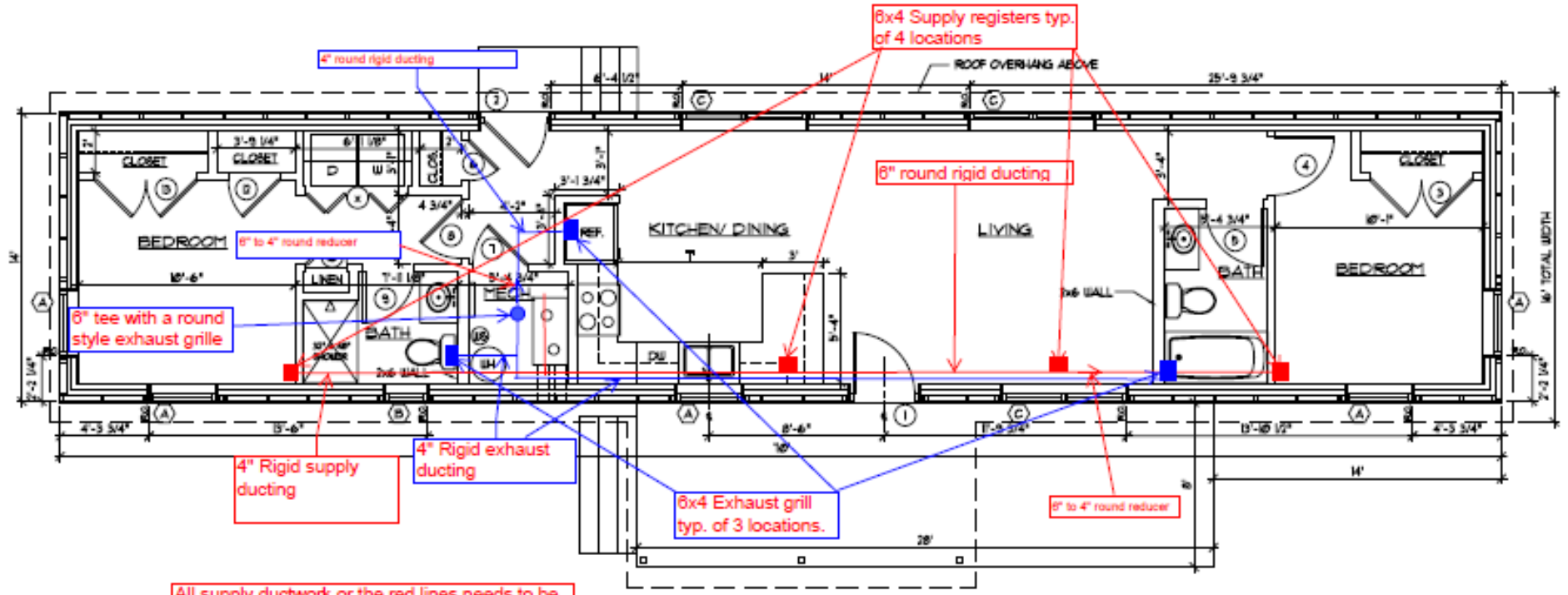
Total Home Efficiency
~350%

All Electric, High Efficiency HVAC

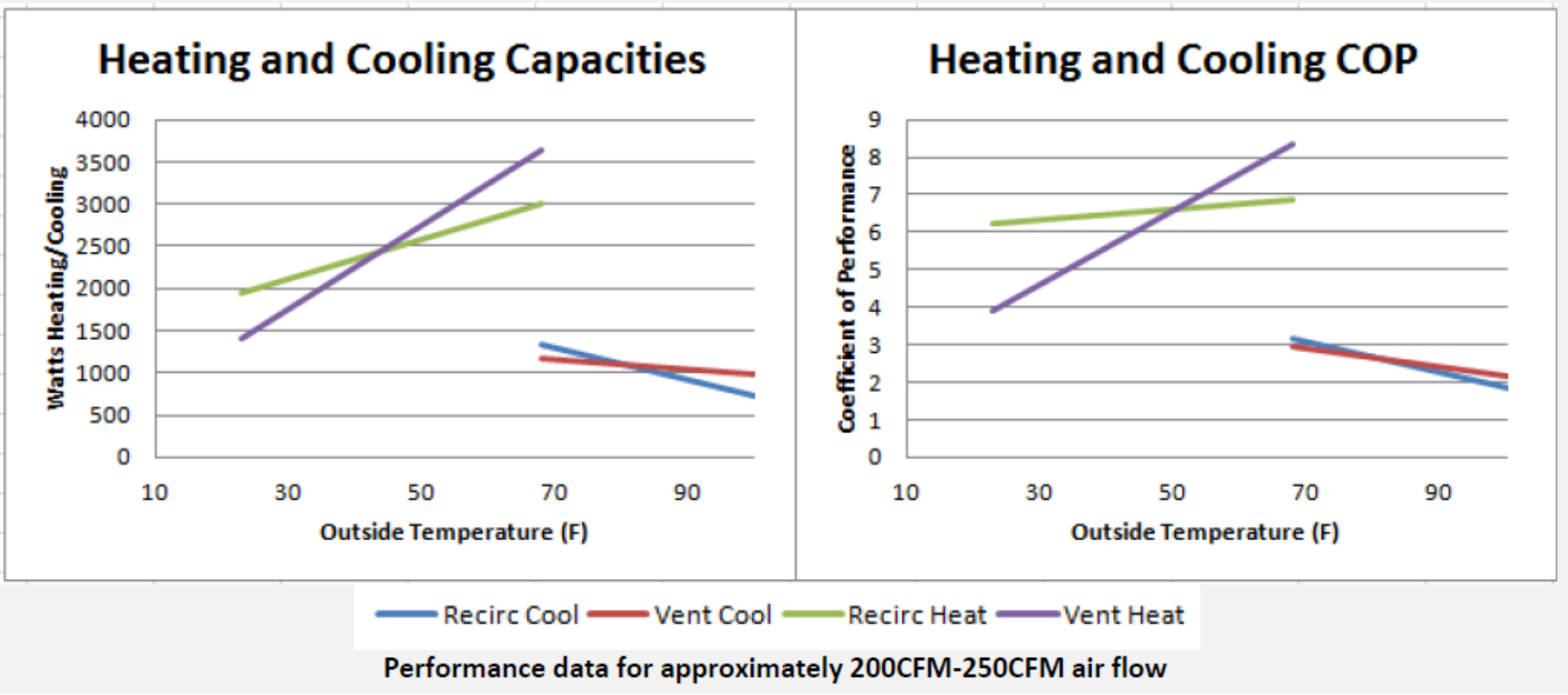




Duct Design

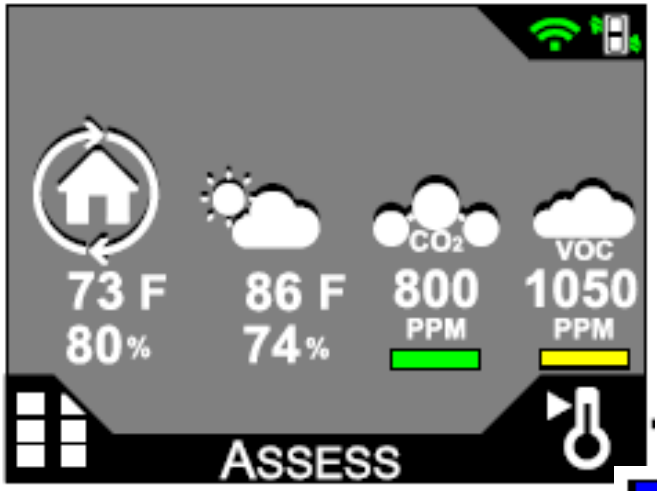

6x4 Supply registers typ. of 4 locations
4" round rigid ducting
ROOF OVERHANG ABOVE
6" round rigid ducting
KITCHEN/ DINING
LIVING
BEDROOM
BATH
CLOSET
LINEN
MECH.
REF.
6" to 4" round reducer
6" tee with a round style exhaust grille
4" Rigid supply ducting
4" Rigid exhaust ducting
6x4 Exhaust grill typ. of 3 locations.
6" to 4" round reducer
All supply ductwork or the red lines needs to be wrapped with bubble wrap type insulation.
All ductwork seams to be sealed with duct sealer or foil tape.

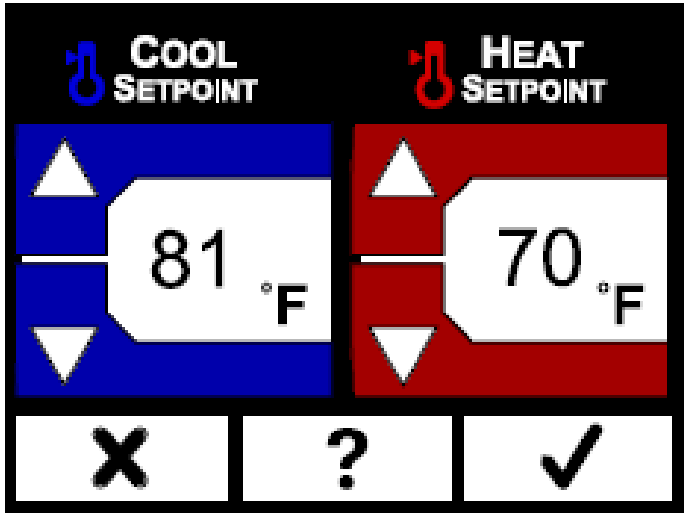
Conditioning Energy Recovery Ventilator - CERV

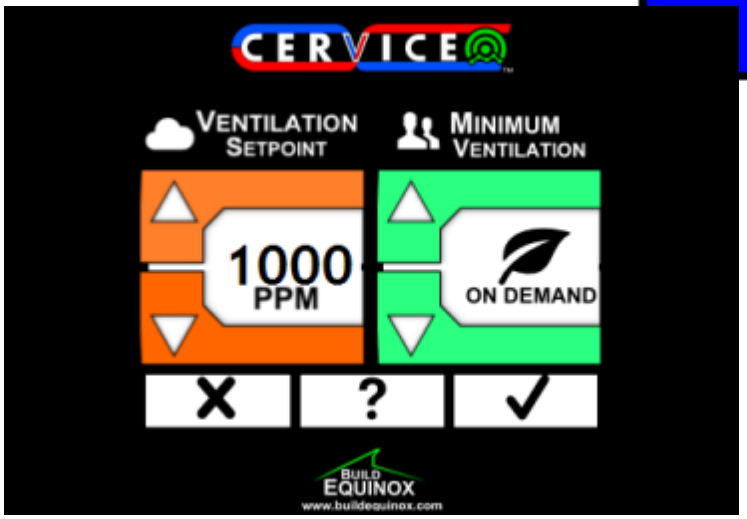


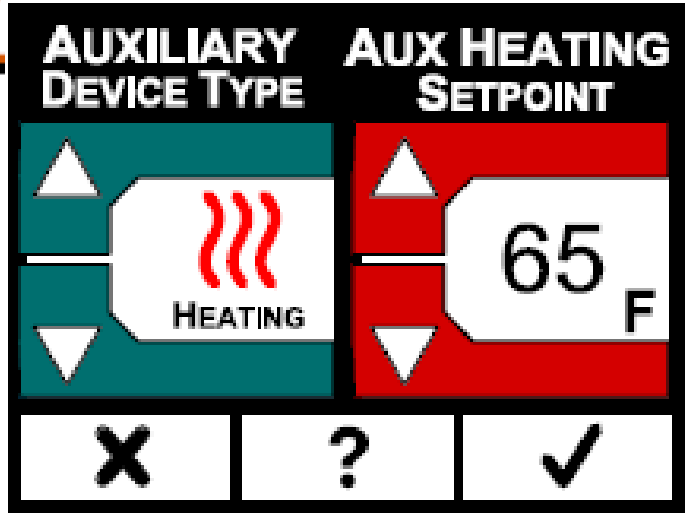
Performance data for approximately 200CFM-250CFM air flow

CERV Controller









Heat Pump Hot Water Heater

1ST HOUR RATING (GAL) BY MODE		
EFFICIENCY	HYBRID	ELECTRIC
42.1	67.5	59.1

GE APPLIANCES

50 GALLON GEOSPRING HYBRID ELECTRIC WATER HEATER

GEH50DFEJSR

- 50 Gallon Capacity
- 3.2 Energy Factor
- Abundant Hot Water with 67 gallons first-hour delivery
- Electronic controls with 4 operating modes including a vacation setting
- Limited 10 year warranty

A.O. Smith
Innovation has a name.

MODEL	GALLON CAPACITY	ENERGY FACTOR BY MODE		
		EFFICIENCY	HYBRID	ELECTRIC
SHPT-50	50	2.78	2.75	0.89

Primary Heating and Cooling

- Fujitsu 9RLS3h
- Mitsubishi MSZ/MUZ FH09

Primary Heating and Cooling

Mitsubishi

Model Name	Indoor Unit		MSZ-FH09NA
	Outdoor Unit		MUZ-FH09NA
Cooling *1	Rated Capacity	Btu/h	9,000
	Capacity Range	Btu/h	2,800-9,000
	Rated Total Input	W	560
	Energy Efficiency	SEER	30.5
	Moisture Removal	Pints/h	0.6
	Sensible Heat Factor		0.920
Heating at 47° F *2	Rated Capacity	Btu/h	10,900
	Capacity Range	Btu/h	1,600 - 18,000
	Rated Total Input	W	710
	HSPF (IV)	Btu/h/W	13.5
Heating at 17° F *3	Rated Capacity	Btu/h	6,700
	Rated Total Input	W	600
	Maximum Capacity	Btu/h	12,200
Heating at 5° F	Maximum Capacity	Btu/h	10,900

Fujitsu

	9RLS3H Heat Pump
Nominal Cooling *BTU/h*	9,000
Min.~Max. Cooling *BTU/h*	3,100~12,000
Nominal Heating *BTU/h*	12,000
Min.~Max. Heating *BTU/h*	3,100~22,000
HSPF *BTU/hW*	14.0
SEER *BTU/hW*	33.0
EER *Clg/Htg*	18.0
Clg. Operating Range °F(°C)	14~115 (-10~46)
Htg. Operating Range °F(°C)	-15~75 (-26~24)

High Performance Heating

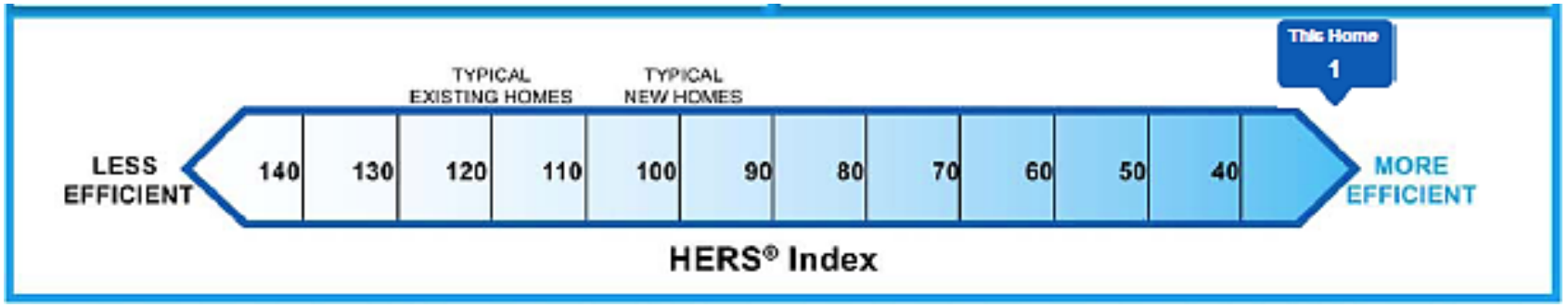
Heating capacity at low outdoor temperatures was improved by adopting a large heat exchanger and a high capacity compressor. Standard rated heating capacity is maintained down to 3°F. RLS3H models will deliver more than 73% of rated heating capacity at -15°F.


OVERSIZE LOAD

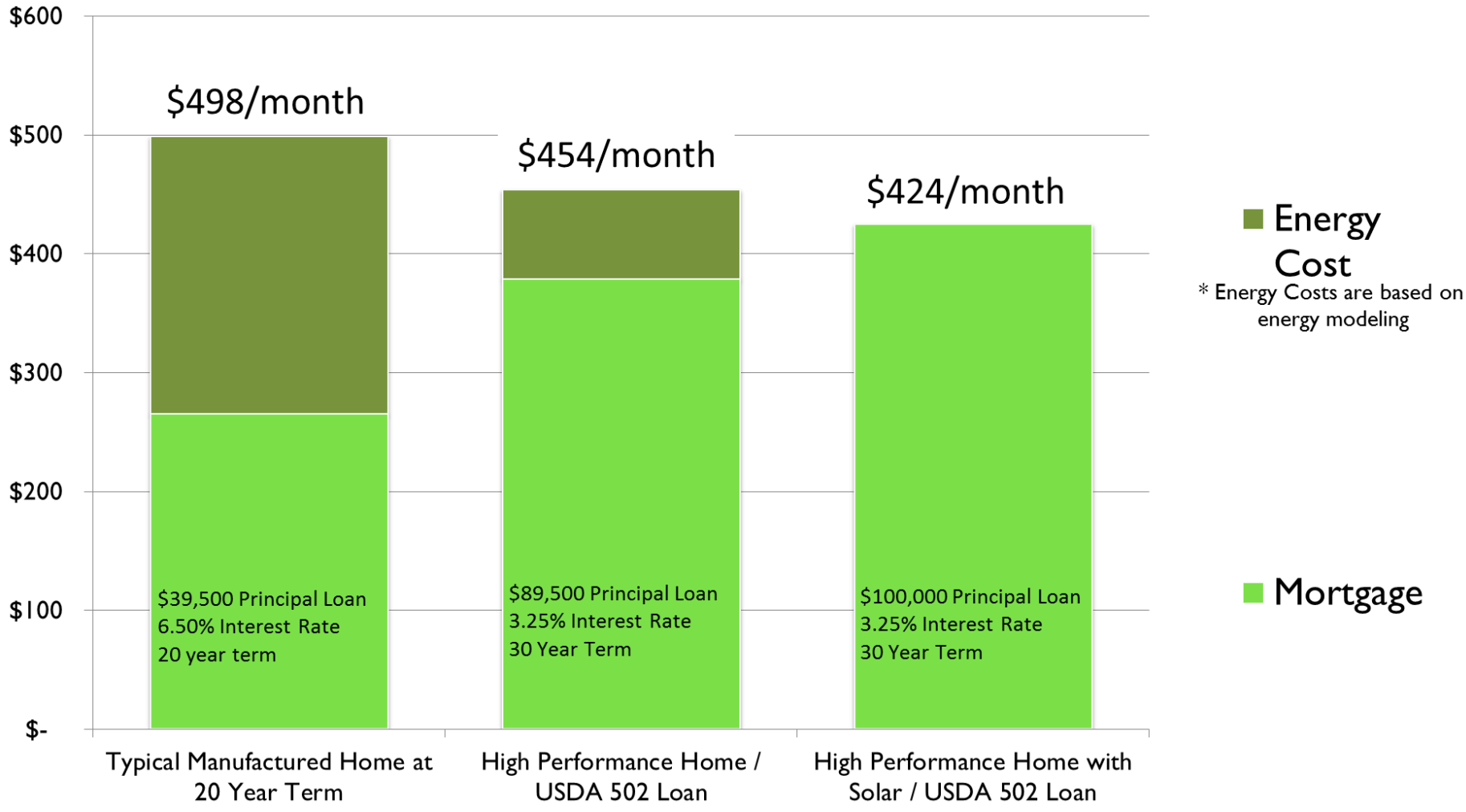

CAT


MILLER
CRANE SERVICE
MILLER CONST., INC.
OVERSIZE LOAD


REALGOOD
www.RealGoodsSolar.com


This Home
1
TYPICAL
EXISTING HOMES
TYPICAL
NEW HOMES
LESS
EFFICIENT
140
130
120
110
100
90
80
70
60
50
40
MORE
EFFICIENT
HERS® Index

Monthly Cost Comparison



Sample Cost Comparison

	Typical Manufactured Home	VERMOD Home
Factory Home	$ 56,000	$ 109,500
Site Work	$ 16,500	$ 16,500
Delivery & Set	$ 2,000	$ 7,000
Solar Package - 6kW		$ 10,500
VHFA Tax Credit	$ (35,000)	$ (35,000)
Efficiency Vermont Incentive		$ (8,500)
Purchase Price	$ 39,500	$ 100,000
Annual Energy Cost	$ 2,800	$ -
Down Payment	$ 3,950	$ 2,500
Interest Rate	6.50%	3.25%
Term	20	30

Thank you.