Net Zero Energy in Very Cold Climates

Habitat Studio has built over thirty five houses with Energuide Ratings of 86 or better (~HERS 20)

Our minimum energy specification results in a Energuide rating of 82

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Net Zero Energy

- Produces all of its own energy for Heating, DHW, Lighting and Appliances on site over the course of a year.
- Next to impossible without aggressive conservation and good solar orientation.

Habitat Studio NetZero Energy Houses so far

Edmonton

- 9360^{0}F (5200^0 C) HDD
- -31^0 F Design Temp

Anchorage

- 10570^0 F (5870^0 C)
- -20^0 F Design Temp

Fairbanks

- 13940^0 F (7750^0 C)
- -49^0 F Design Temp

Belgravia NetZero

Parkland NetZero

Riverdale NetZero

Mill Creek NetZero

South Windsor Park NetZero

Holyrood Near NetZero Retrofit

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Outline

1. Net zero energy building performance depends on an on site photovoltaic (PV) system to make up what energy is required after conservation and other renewables
2. Optimal solutions require shrinking the PV system so that:
    1. You can afford it
    2. It will fit on your roof
3. Carefully designed conservation + an Air Source Heat Pump can shrink the required PV system to a manageable size.

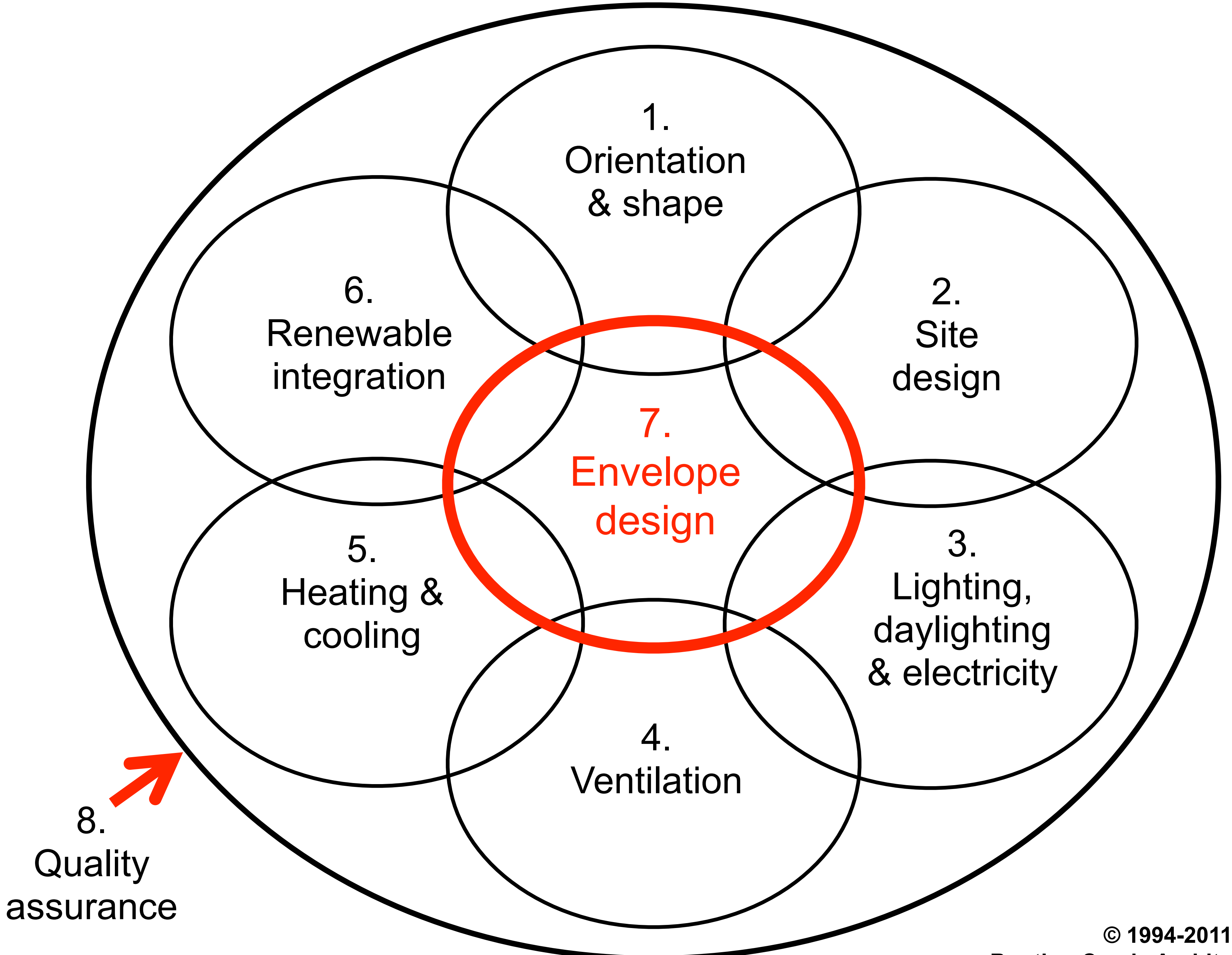
Cold Climate Net Zero Energy Challenges

- Long , dark, cold winter
- Yield from renewables is low and some are not available when most needed
- Net Zero is barely possible north of 60. You need to get everything right.
- Build in a cushion. Nothing ever works better than you think it will.

Building a Better Building Envelope

- Conservation is the simplest, most economical and most reliable route to energy/ carbon reduction - better than solar PV, solar Hot Water, better than geothermal
- Without aggressive conservation there's not much point in planning for renewable energy collection
- The most benign energy available is the energy don't ever need.
- Very hard to fix later

Integrated Design Process



Designing for Net Zero

- Site assessment
- Preliminary design

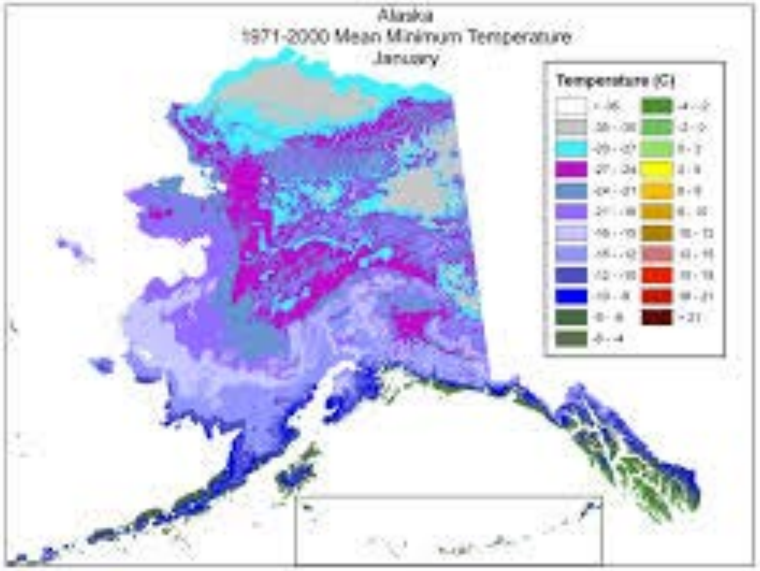
Energy Reduction

- Model Energy Performance of preliminary design
- Reduce base loads
  - Domestic hot water
  - Lighting and appliances
- Use the modelling results to optimize the Building Envelope and Passive solar gain

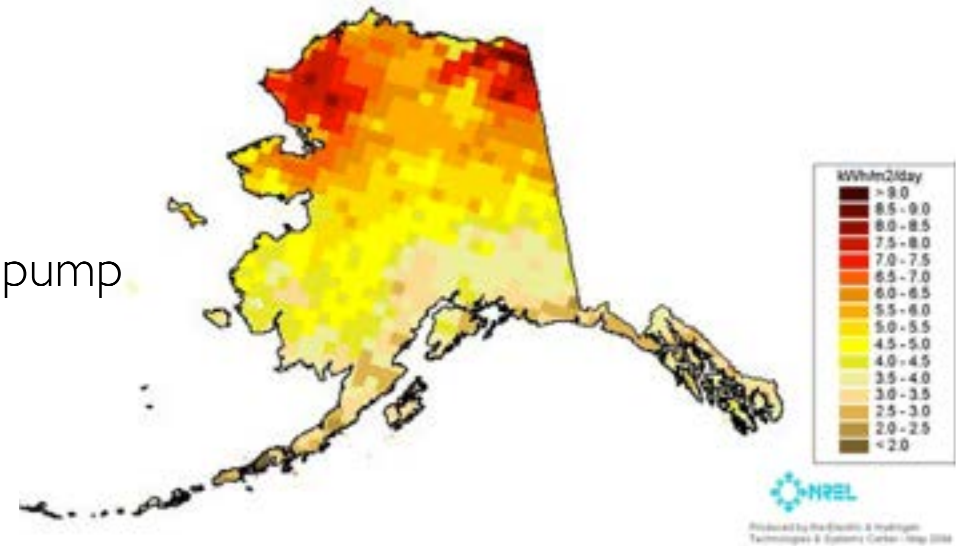
Renewable Energy Collection

- Examine / Model solar domestic hot water and heating
- Consider Air Source Heat Pumps or Geothermal
- Size PV to meet remaining total load
- Finish detailed architectural and system design

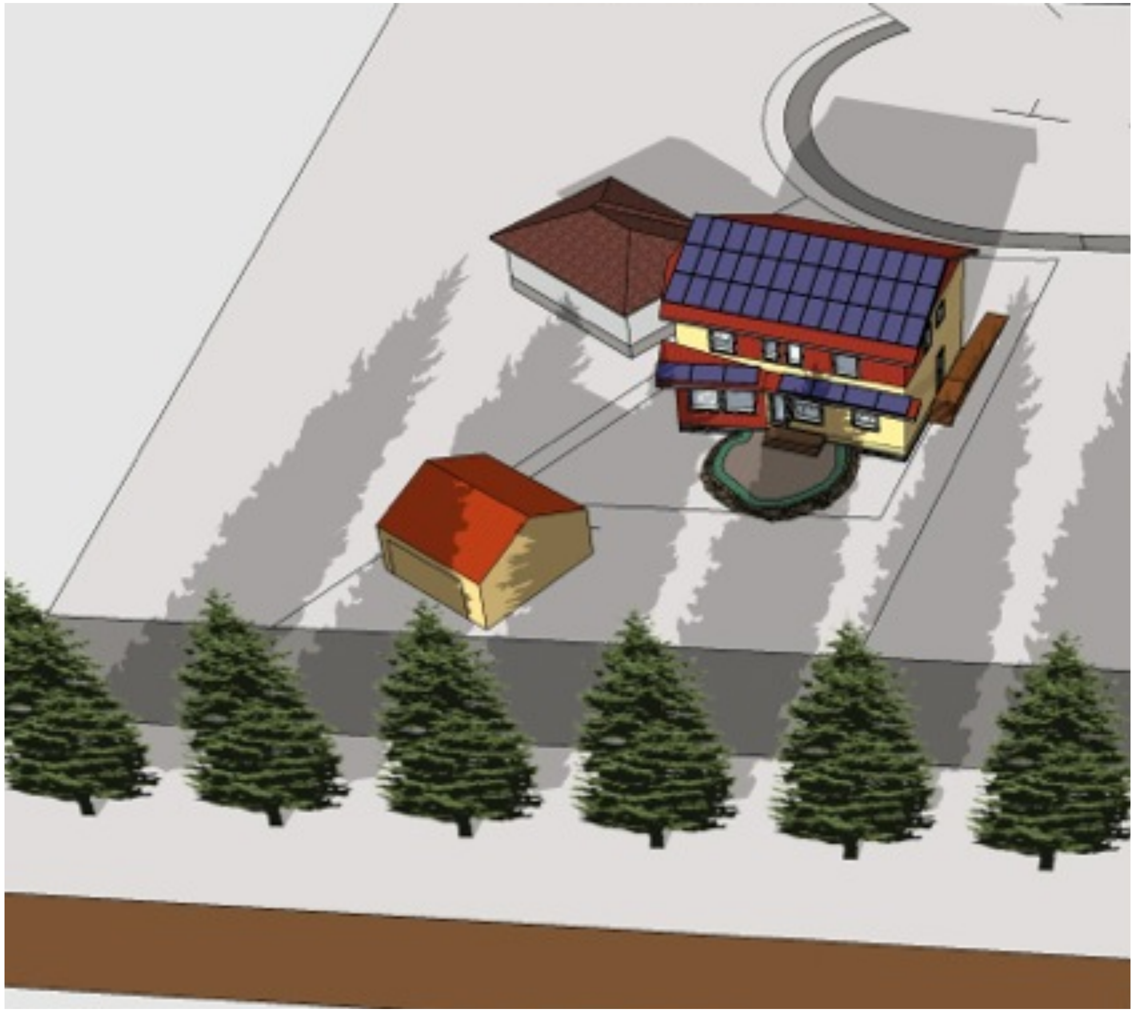
Regional Assessment



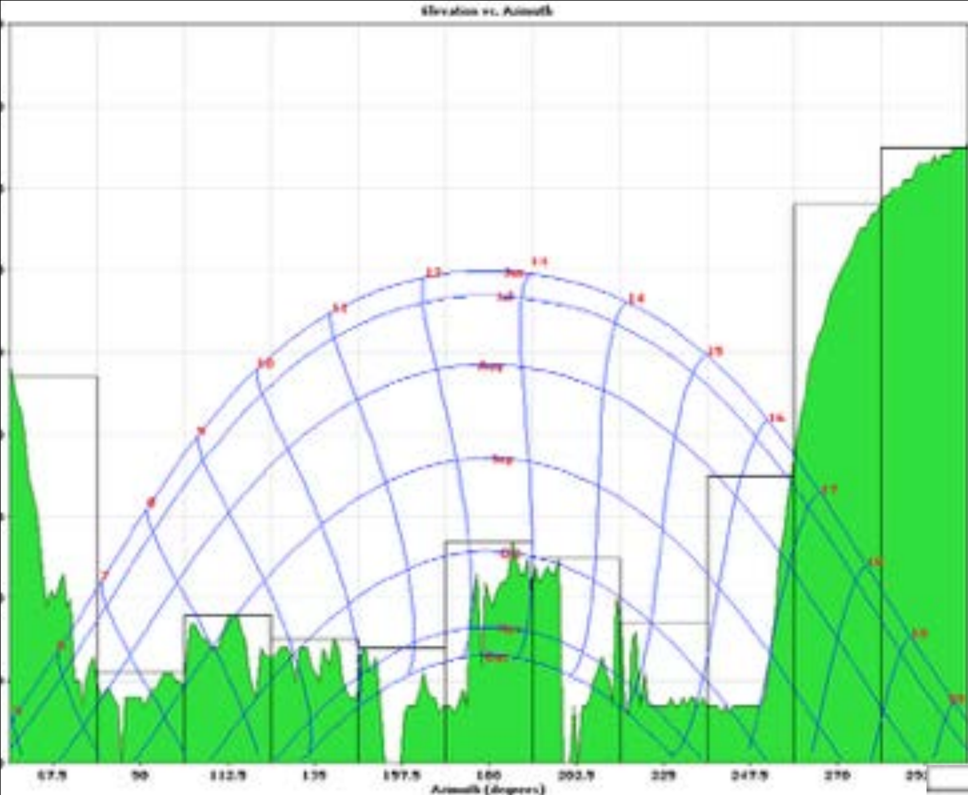
- Heating season degree days
- Local design temperature
- Operating range for air source heat pump
- Feasibility of Geothermal
- Regional Solar PV Potential

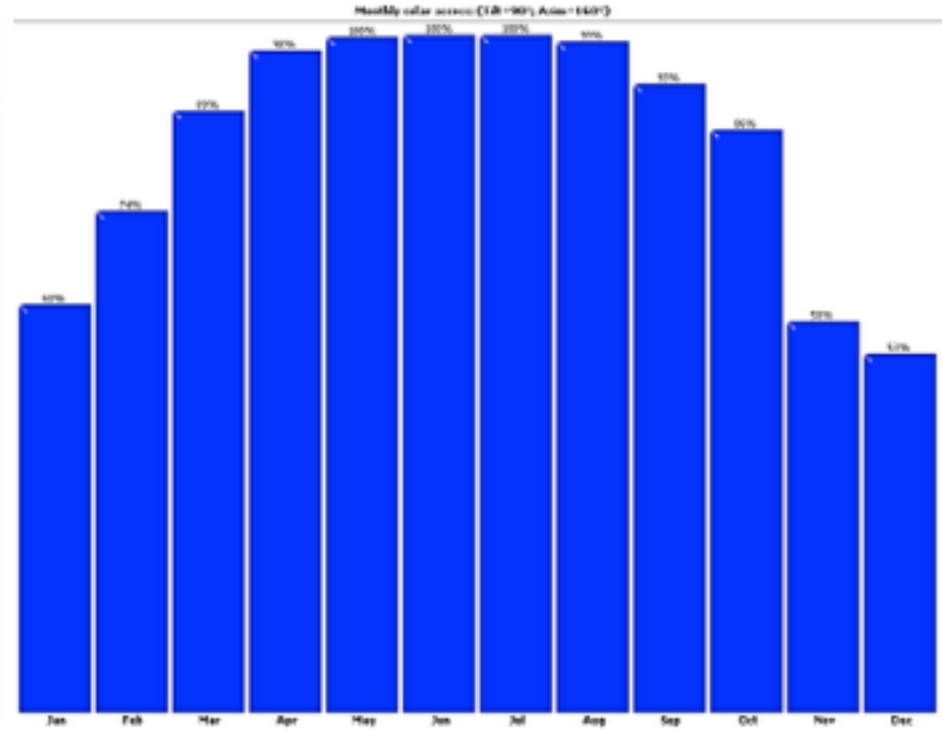


Site Assessment

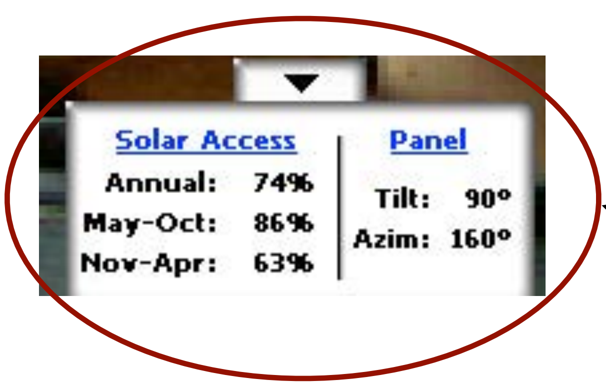


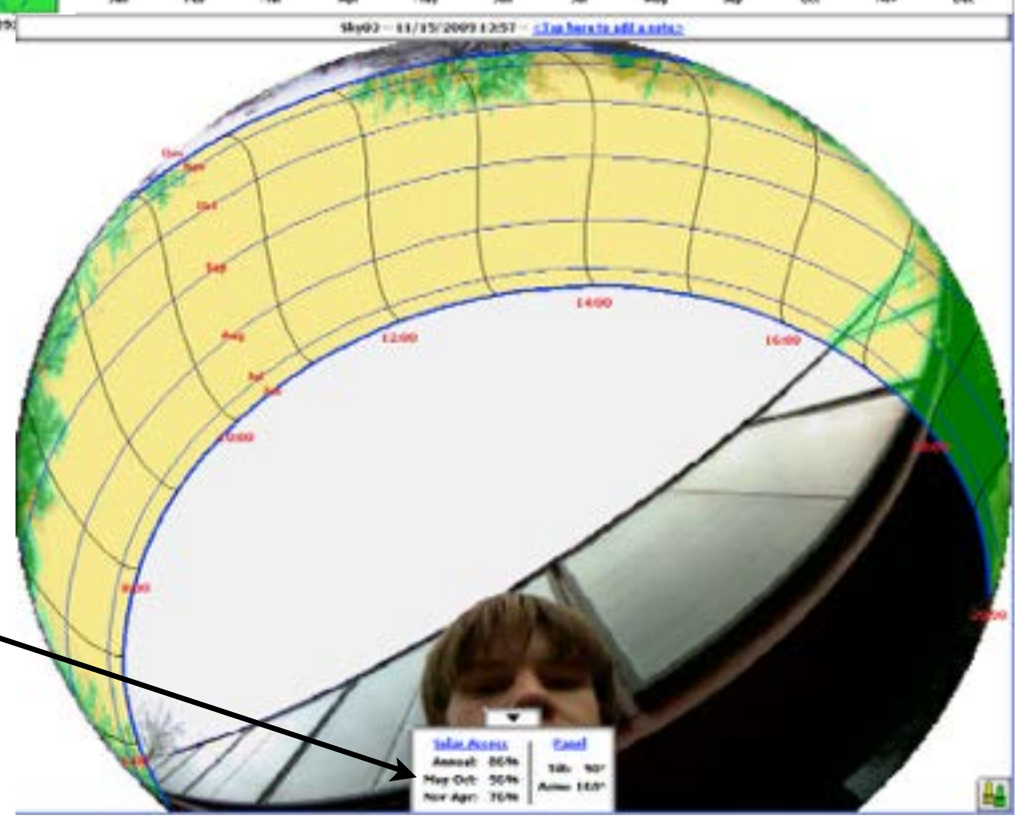
- Normal site assessment
- Evaluate the Solar Potential
- Consider potential shading from buildings, trees, etc.
- Potential for renewable energy harvesting





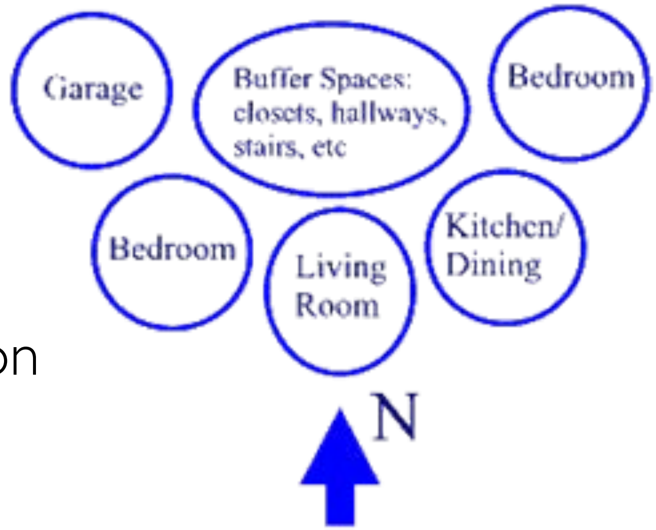
Solmetric Suneye shots from RNZ front porch





Preliminary Design

- Normal architectural considerations- Job #1 is to build a great place to live.
- Keep living spaces on the south side to make best use of Passive Solar potential
- Try to accommodate space for Solar DHW
- Try to accommodate space for Photovoltaic generation
- Keep the shape simple and compact



House Shape Considerations

- Smaller buildings use less total energy and are cheaper to build
- Bigger houses can use less energy per square foot of useful floor area
- Simpler shapes have less surface area per square foot of useful floor area
- Buildings with big cathedral ceilings have more surface area
- Making small simple buildings look great can be a challenge

Providing room for renewable energy collection: As PV gets cheaper, finding roof space will become the limiting factor

Windsor Park NetZero

Riverdale NetZero

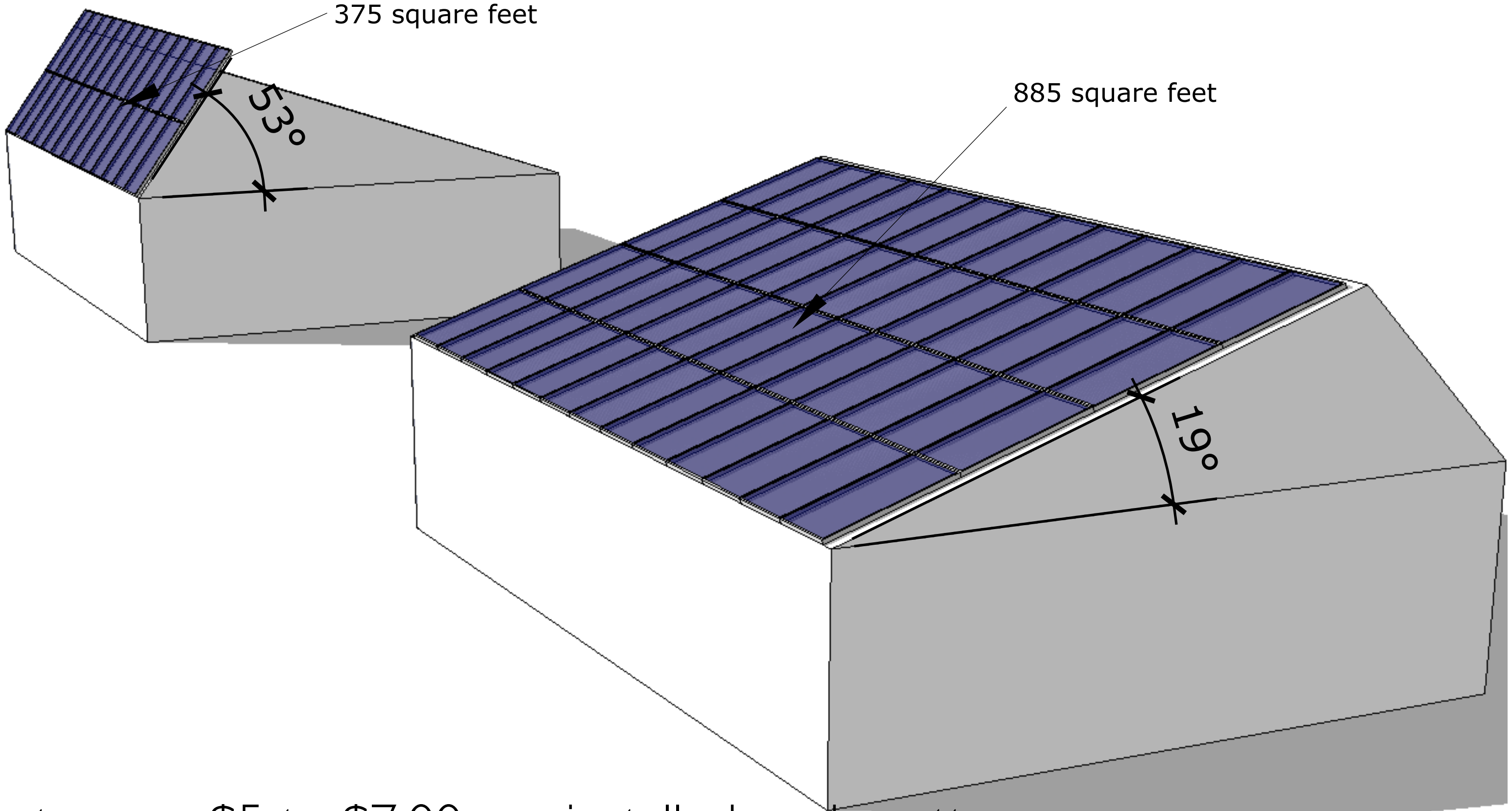
Mill Creek NetZero

Parkland NetZero

NRCan NZ Pilot

Belgravia NetZero

Roof shape



- When PV costs were \$5 to \$7.00 per installed peak watt we angled the roof to max out production per module
- With PV now costing \$3 to \$3.50 per installed peak watt we are trying get as many modules as possible and accepting lower output per module

Cost Optimization of Conservation Measures

Cost per kilowatt-hour/year (kWh/a) of any energy conservation measure = Cost of the measure / energy saving in kilowatt-hours per year(kWh/a)

For Net Zero Energy at the Lowest Cost

Cost per kWh/year of energy conservation = Cost per kWh/year of energy collection*

*Current cost of PV in Edmonton is $3.00 to $3.50 for the capacity to generate 1 kWh/year

* $4.00 for the capacity to generate 1 kWh/year in south central Alaska?

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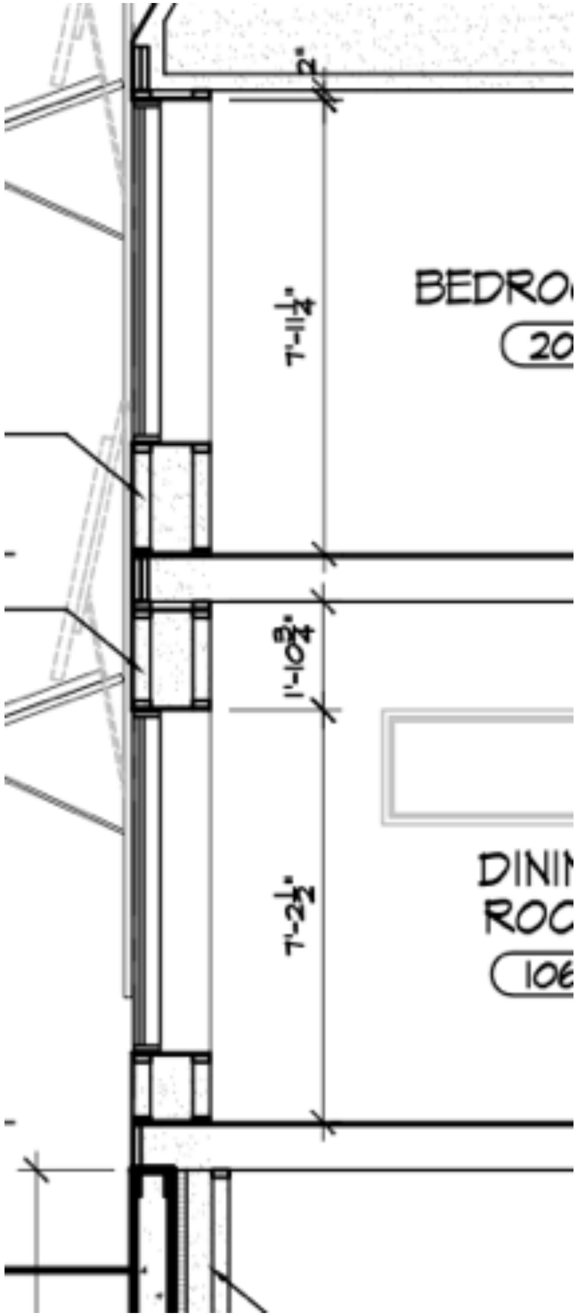
Modelling

- Good modelling is everything. Designing for net zero at an optimum cost. is impossible without it. You would be shooting in the dark
- Model early in the design process while it is still easy to make changes and before people get attached to particular configurations
- Model in house if possible, but if you can't you can still learn by playing with the input values in a model set up an expert evaluator.
- It gets easier - the second, third, and subsequent times.



Modelling Tools

- Passive House Planning Package (PHPP) is excellent. It gives by far the best feedback and the most control over critical details
- HOT2000 is tested, tried, and true. It is the basis for most Canadian labelling and rebate programs
- AKWarm - probably not good enough for optimizing NZ

Belgravia NetZero

Passive House/ PHPP Modelling Advantages over HOT2000

- PHPP's more detailed, finer grained analysis gives designers more control over important details
- PHPP is more transparent
- Allows designers to test and modulate thermal bridging
- Realistic input and design control over solar shading
  - HOT2000 assumes 100% of possible solar radiation reaches the building.
  - This disconnect from reality can lead to significant over estimation of useful solar gains.

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HOT2000 Modelling Advantages

- Input is very quick - model takes one to two hours when built on an existing file
- Tested and verified in Canadian climates*
- More realistic treatment of internal gains
- Ground heat loss computation uses finite element analysis rather than approximations.
- Great comparative reports

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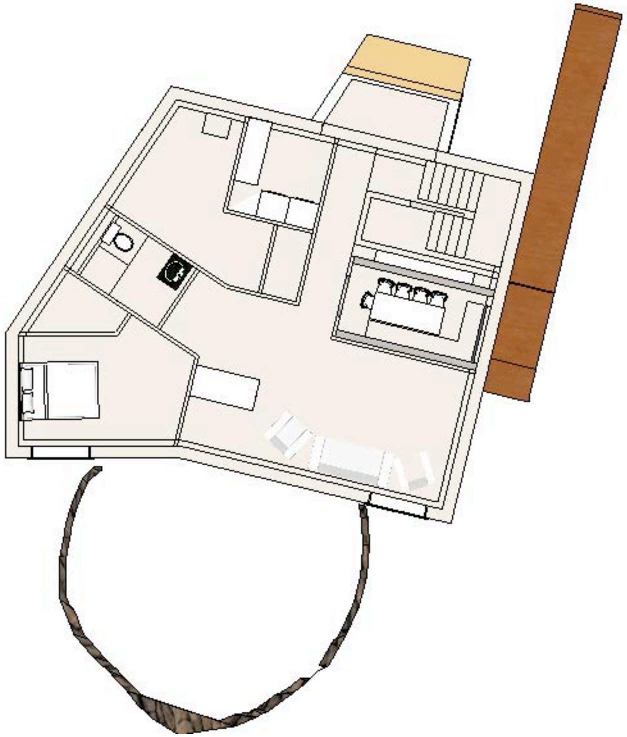
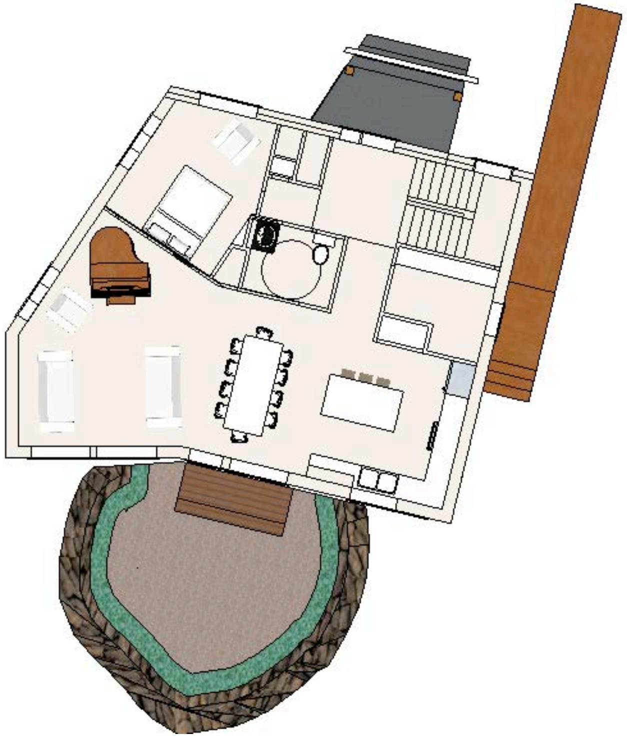
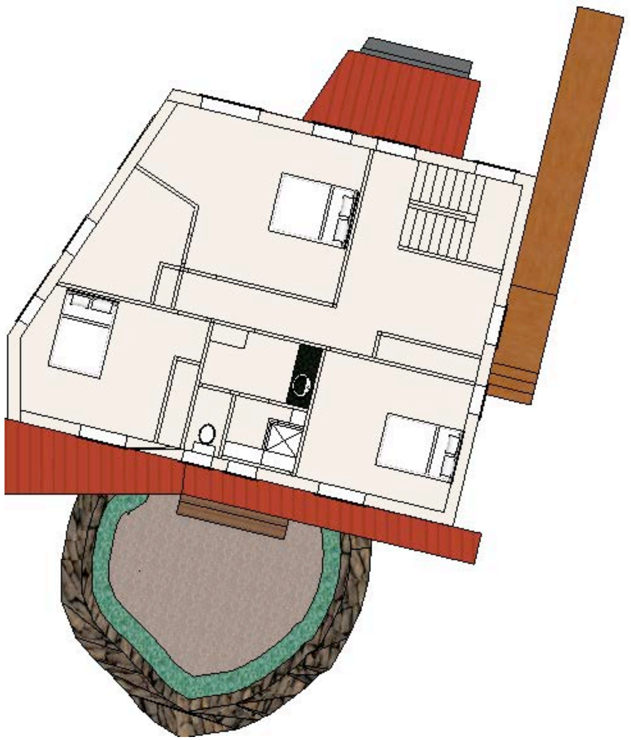


Basement

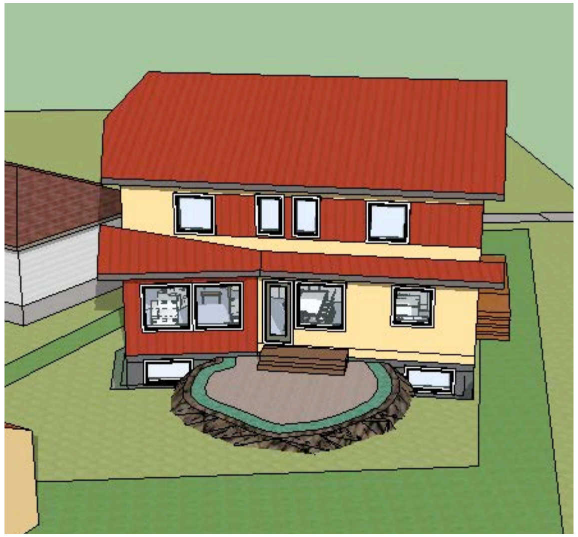


Main



Second

North

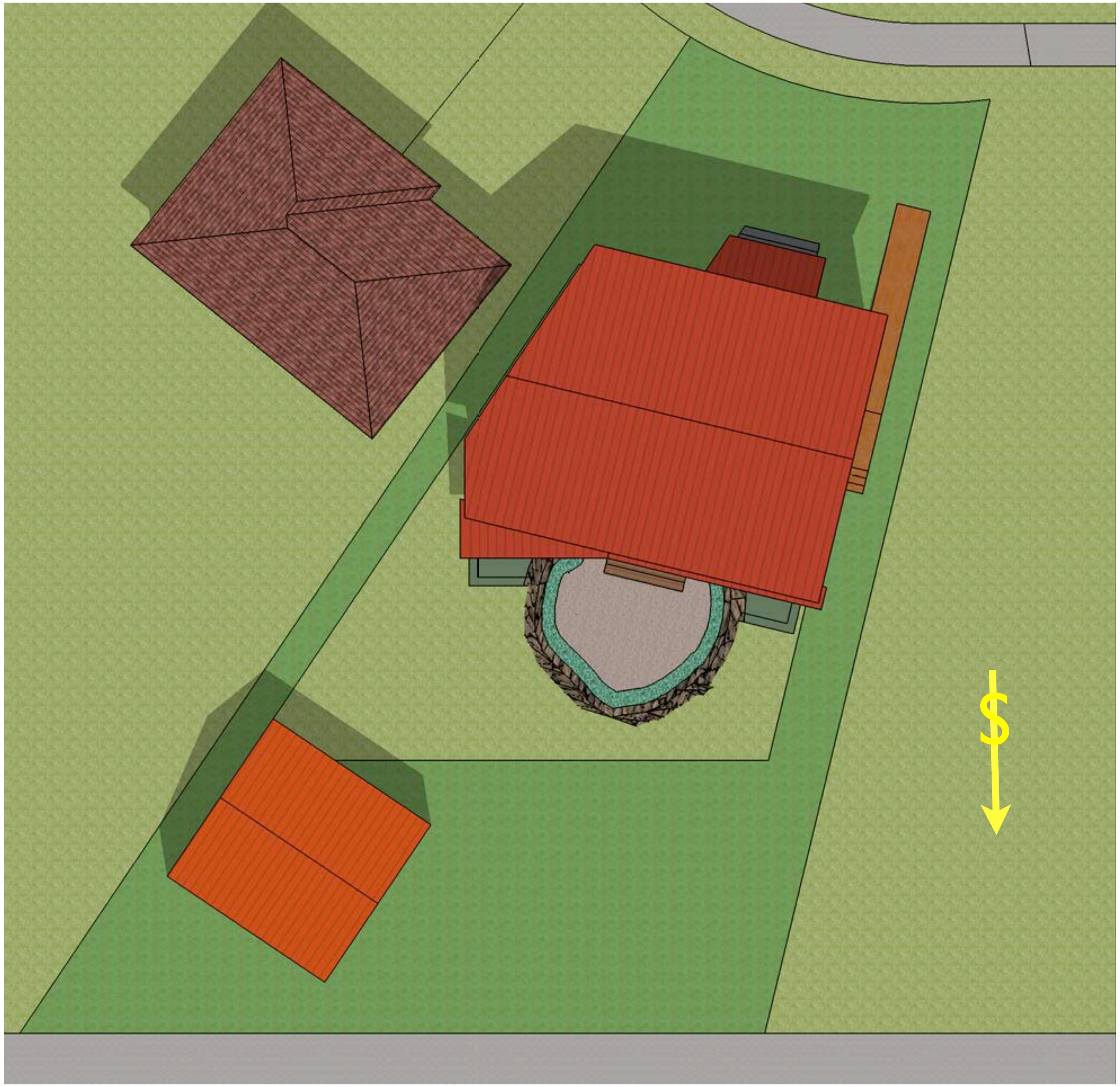


South

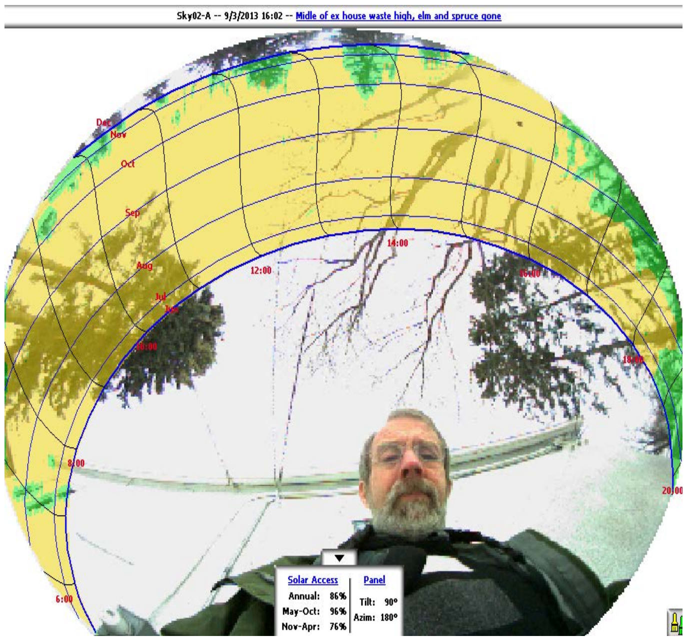
Kennepohl Franchuk Residence

- House area is ~ 2250 sq. ft plus finished basement
- ~900 sqft of roof area
- TFA is 2626 sq.ft (245m^{2})

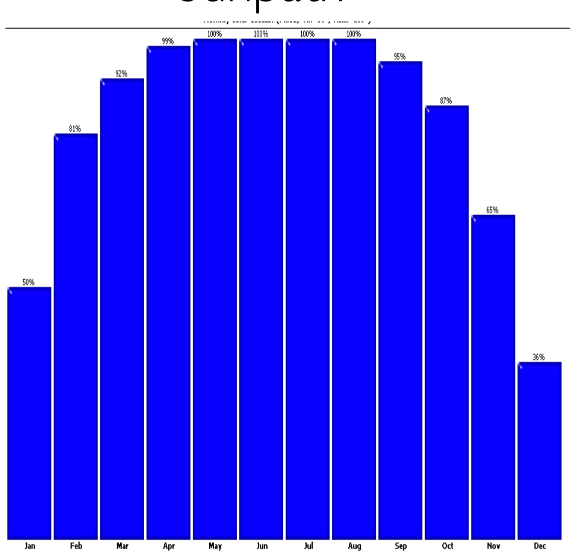
NRCan R2000 NZ Pilot



Site Plan



Sunpath



Monthly solar access

Energy Units

Because we talking about all of the energy needed to run the house for a year it is easier to stick to kilowatt-hours

1 Kilowatt - hour	=	3413 BTUs
1 Btu	=	.00029 Kwh

Watts of peak load per heating degree as a metric for comparing envelopes in different climates

Anchorage

- R56 walls
- R85 Attic
- R16 Slab
- R 50 foundation wall
- .6 ACH 50
- Tri glazed fibreglass R9 COG, SHGC.5 Windows

Fairbanks

- R70 walls
- R100 Attic
- R20 Slab
- R 60 foundation wall
- .6 ACH 50
- Tri glazed fibreglass R9 COG, SHGC.5 Windows

8720 watts @ -31^{0}F = 88 watts/^{0}F

9541 watts @ -49^{0}F = 81 watts/^{0}F

Also a useful comparison when considering air source heat pumps

Designing for Net Zero

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- Preliminary design

Energy Reduction

- Model Energy Performance of preliminary design
- **Reduce base loads**
    - Domestic hot water
    - Lighting and appliances
- Use the modelling results to optimize the Building Envelope and Passive solar gain

Renewable Energy Collection

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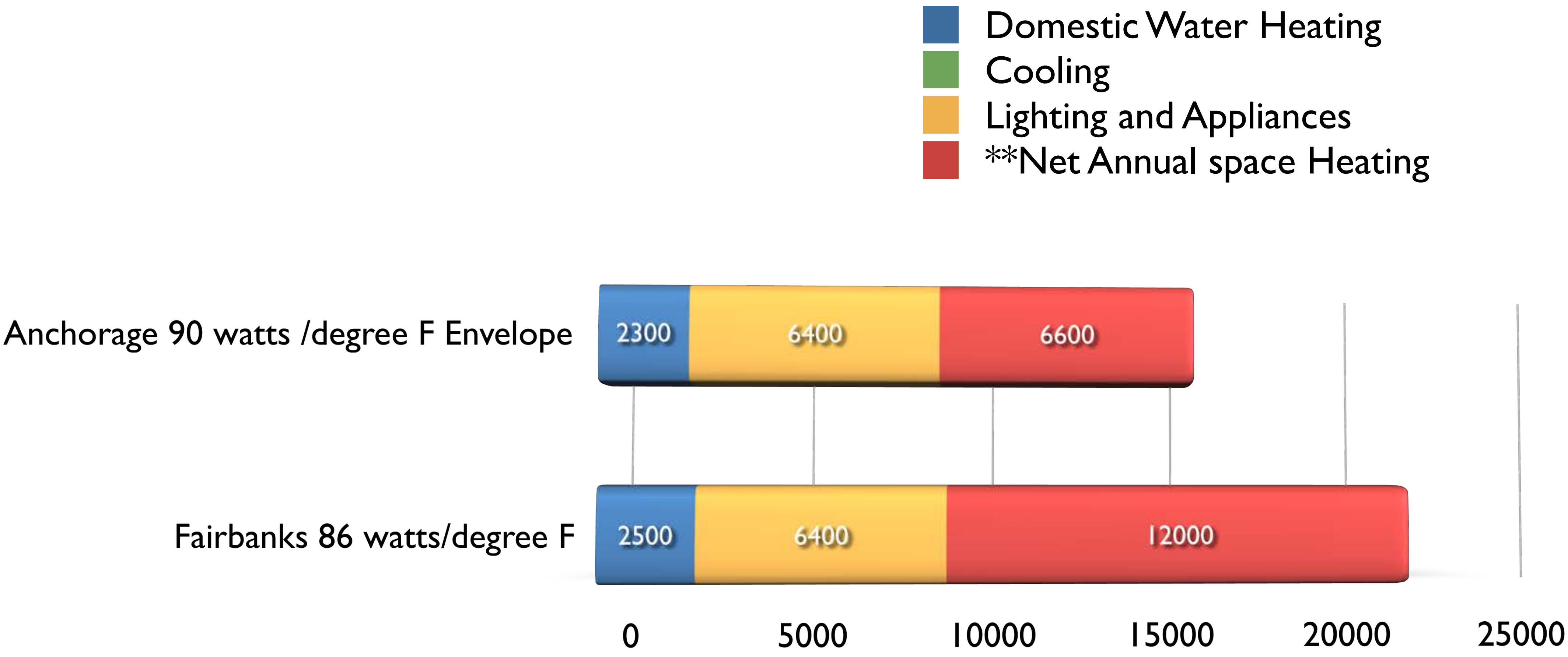
Base Load Reduction*



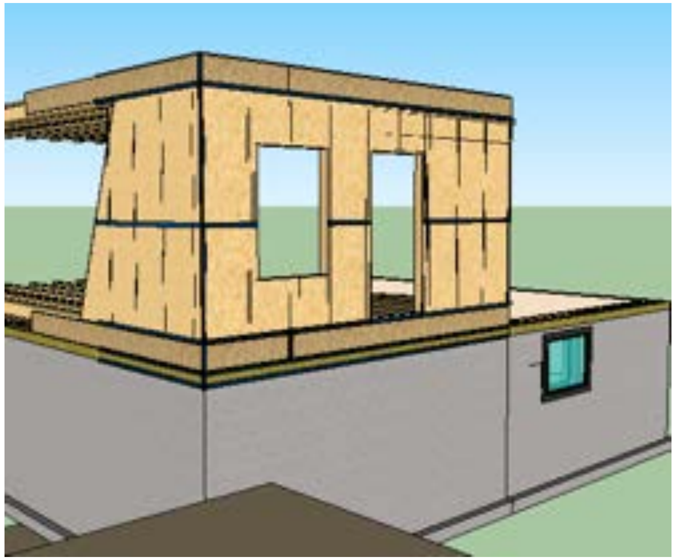
*Nailing down the base loads will a have a big impact on heating energy and payback calcs for various envelope improvement strategies

** Assuming straight electric with no COP and after accounting for passive solar and internal gains

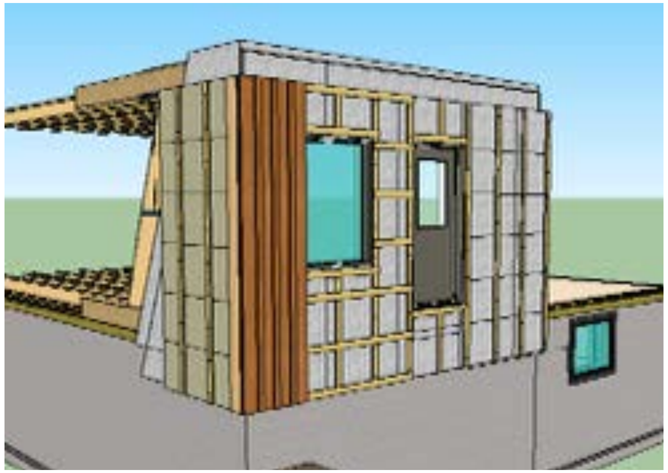
Building envelope checklist

- Lowest cost per effective R value
- Ease of getting ultra air tightness.
- Continuous insulation layer- no thermal thermal bridges
- Durability- vapour openness.
- Ease of construction
  - not too disruptive of normal construction sequence
  - minimal work from scaffolding

Options for walls with better performance than2x6 16" O.C.

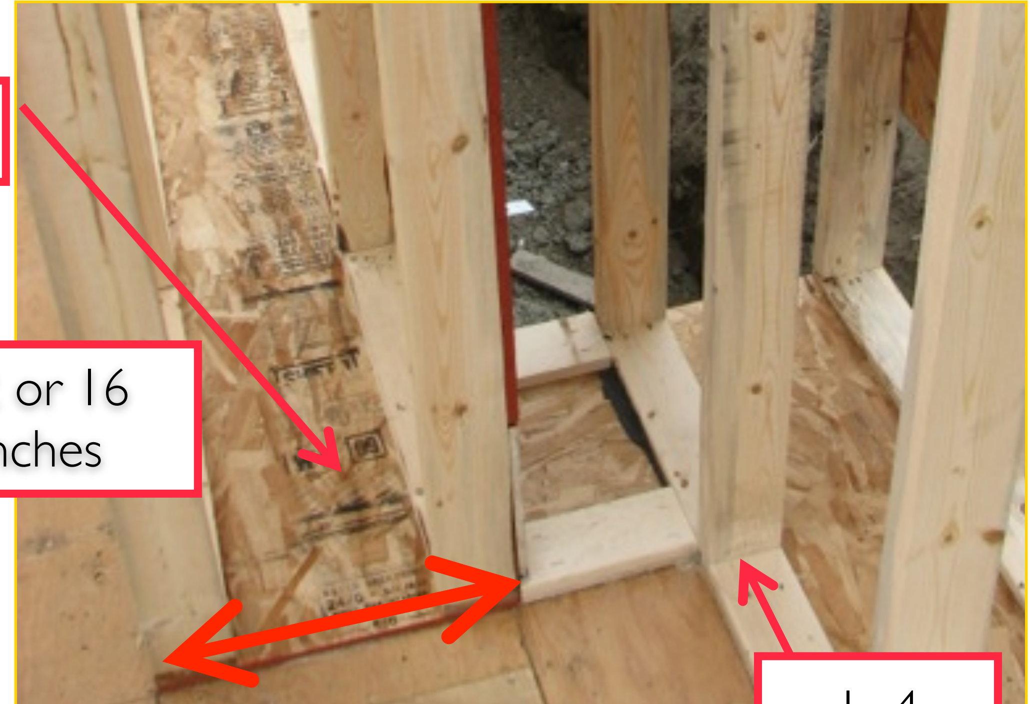


- 2x6 with high density foam
- SIPs (Structurally Insulated Panels
- 2x6 with 2x3 Strapping
- 12 or 16" Double 2x4
- REMOTE walls - see CCHRC site for some great pamphlets



Walls

- Double-stud 2x4
- Follows normal construction sequence
- 16" results in a true R-56 value. (12" R40-41)
- Same amount of lumber as a typical 2x6 16"OC wall
- Good airtightness with some care and attention
- Cellufibre insulation
- Most economical High R- value wall there is



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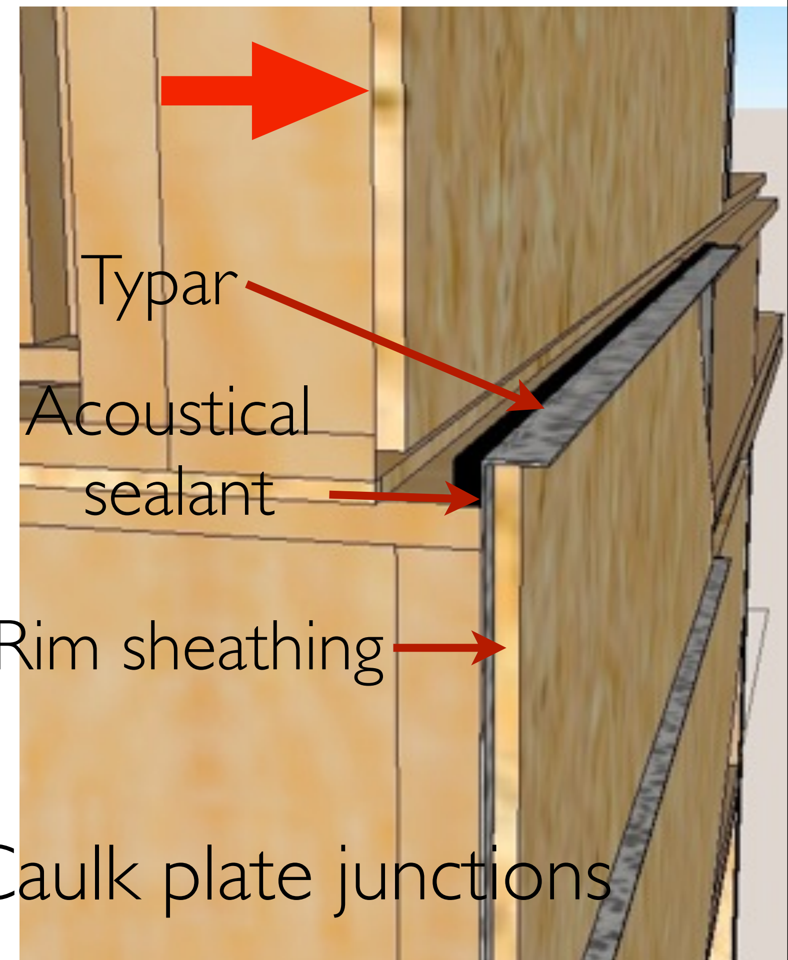
Assembly



Caulk plate junctions

Rim Joist Typar and Acoustical Sealant

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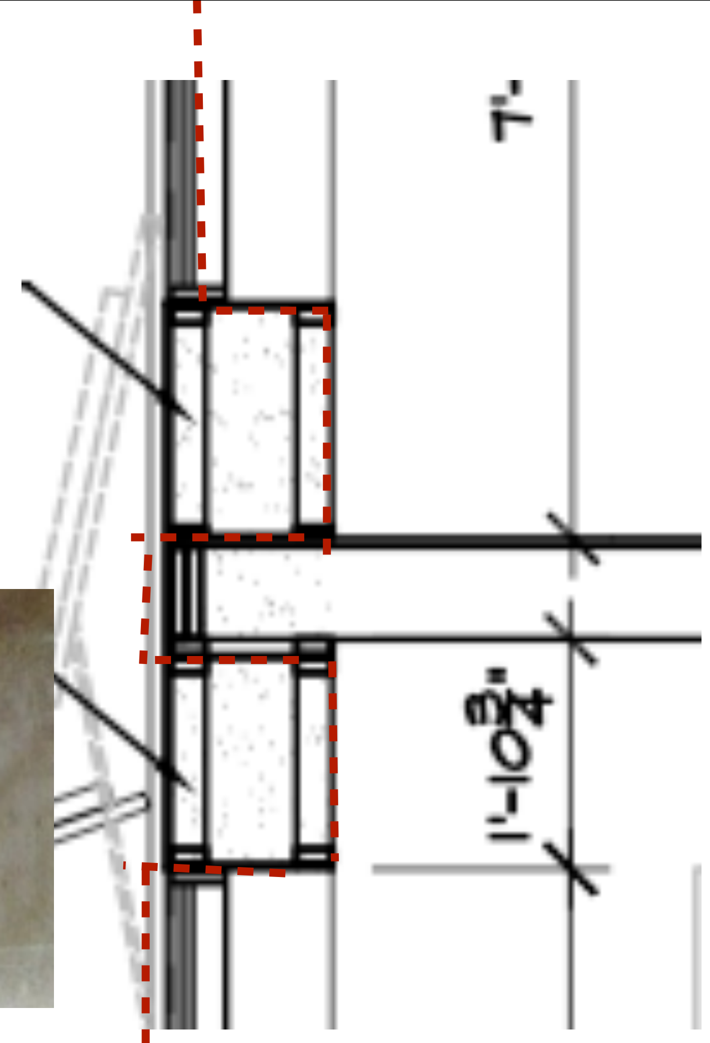
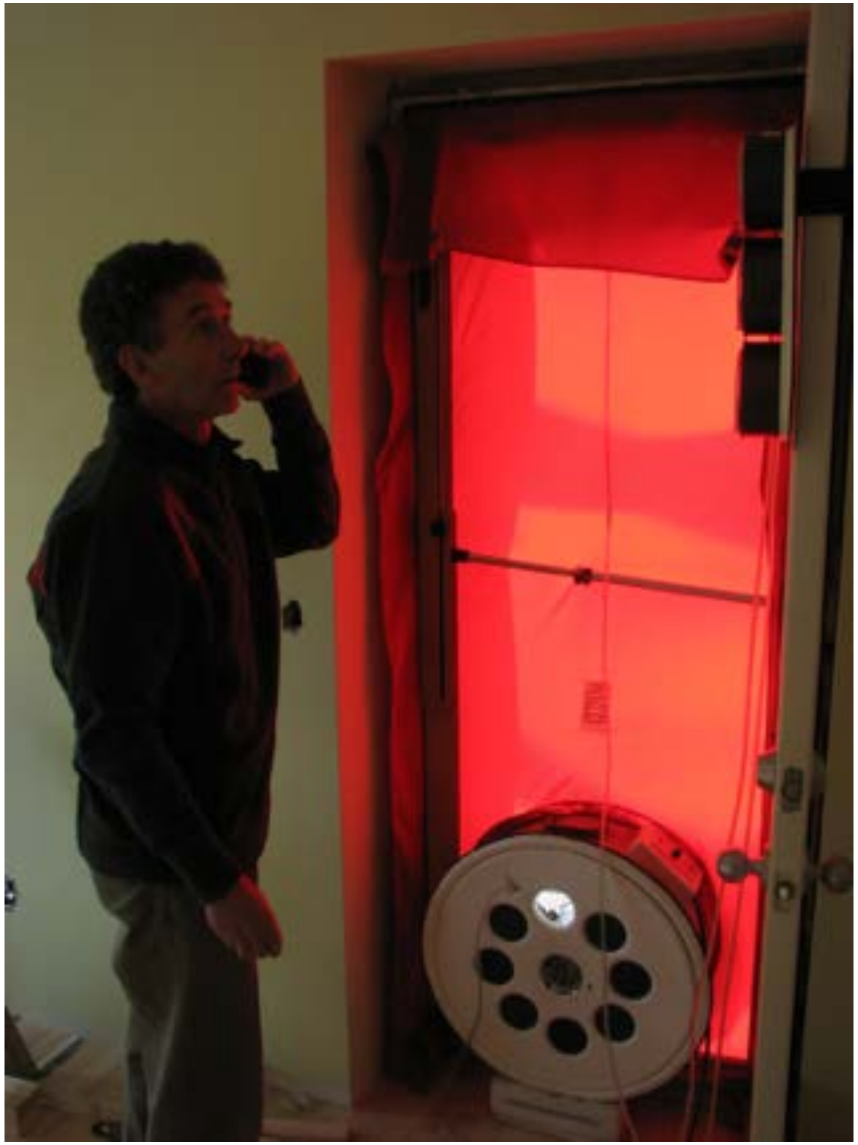
Pre-insulation Sealing

- Seal around wires and pipes where they go through the air barrier
- Provide backing for more durable seas around air barrier penetrations





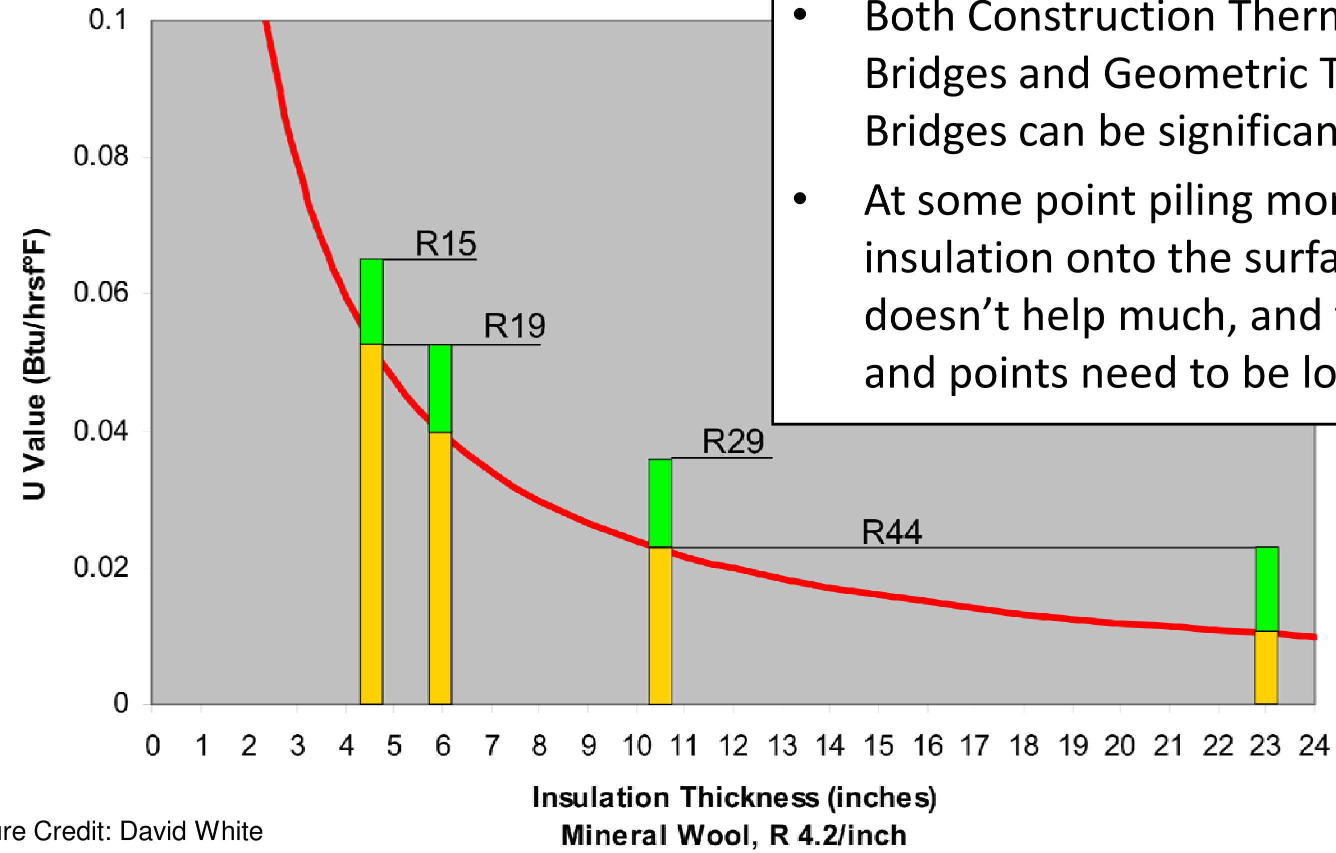
- Air tightness is by far the best investment you can make
- Air test results of 0.6ACH 50 are achievable and also enhance long term durability.
- New hygrothermically safe air sealing products and techniques are one of the biggest benefits of the Passive House approach.

PHIUS
Passive House Institute US

slide 12

Passive buildings need to have low thermal bridging.

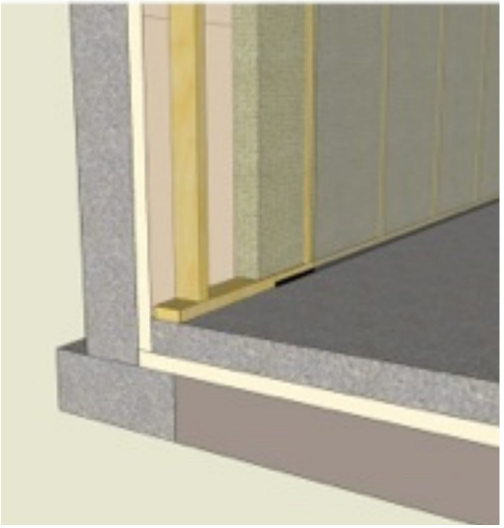
- Both Construction Thermal Bridges and Geometric Thermal Bridges can be significant.
- At some point piling more insulation onto the surfaces doesn't help much, and the joints and points need to be looked at.

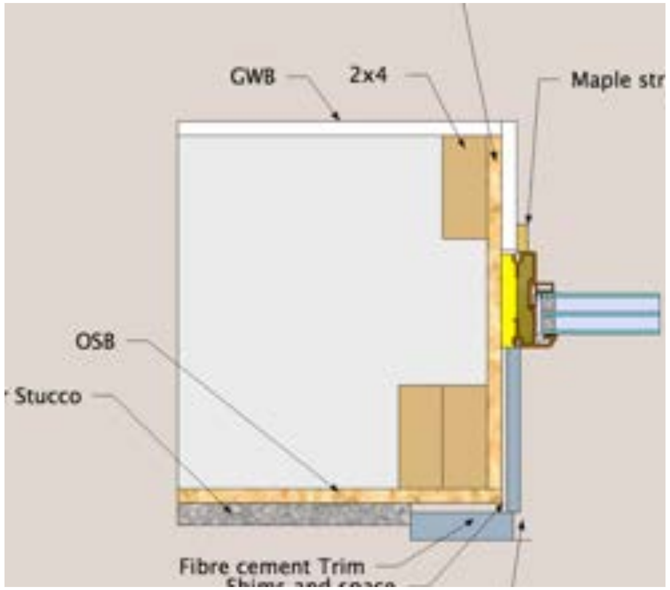


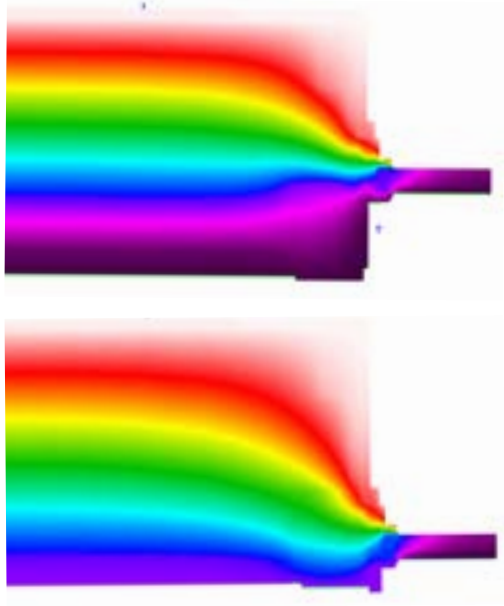
Picture Credit: David White

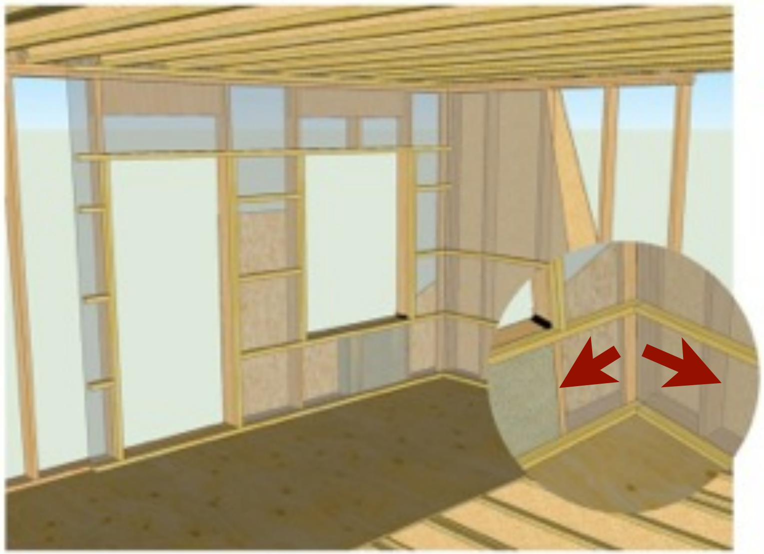
Thermal Bridging Control

- HOT2000 is responsive to thermal bridging control is a few areas, but isn't transparent.
- Effective R values depend on continuous insulation layers.
- Passive House Planning Package (PHPP) requires detailed input and gives good feedback.
- Eliminating thermal bridging will reduce heat loss substantially whether you can calculate it or not.

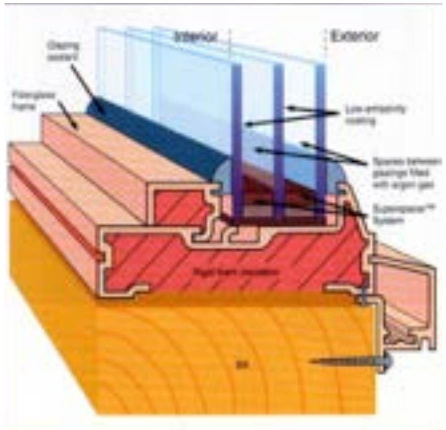




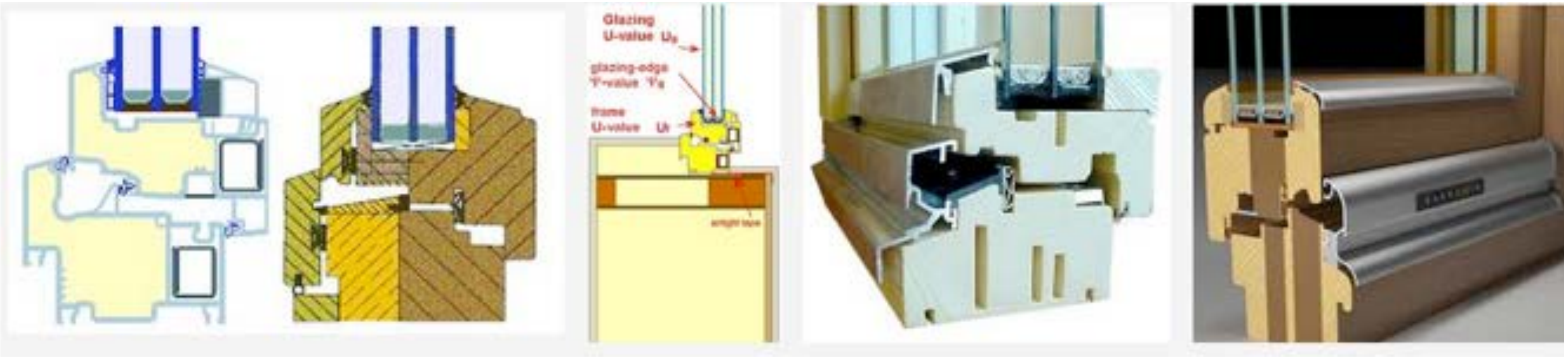




Windows



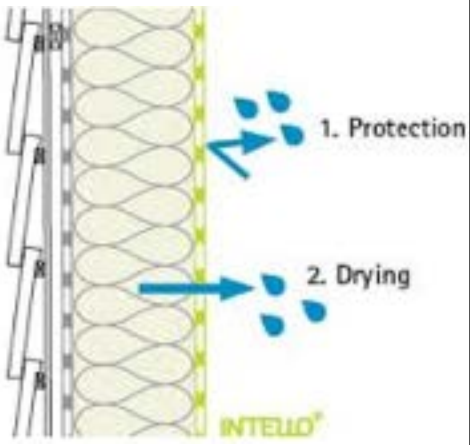
- Windows and doors are the single biggest source of transmission heat loss - often 40% or more.
- It is difficult to justify the high cost of European Windows



Moisture Control- Hygrothermic Safety

- Vapour drive from inside to out is directly proportional to temperature difference between inside and out. Solutions from more temperate climates will not necessarily work in very cold climates.

- As walls get thicker and tighter it gets harder for them to dry out.



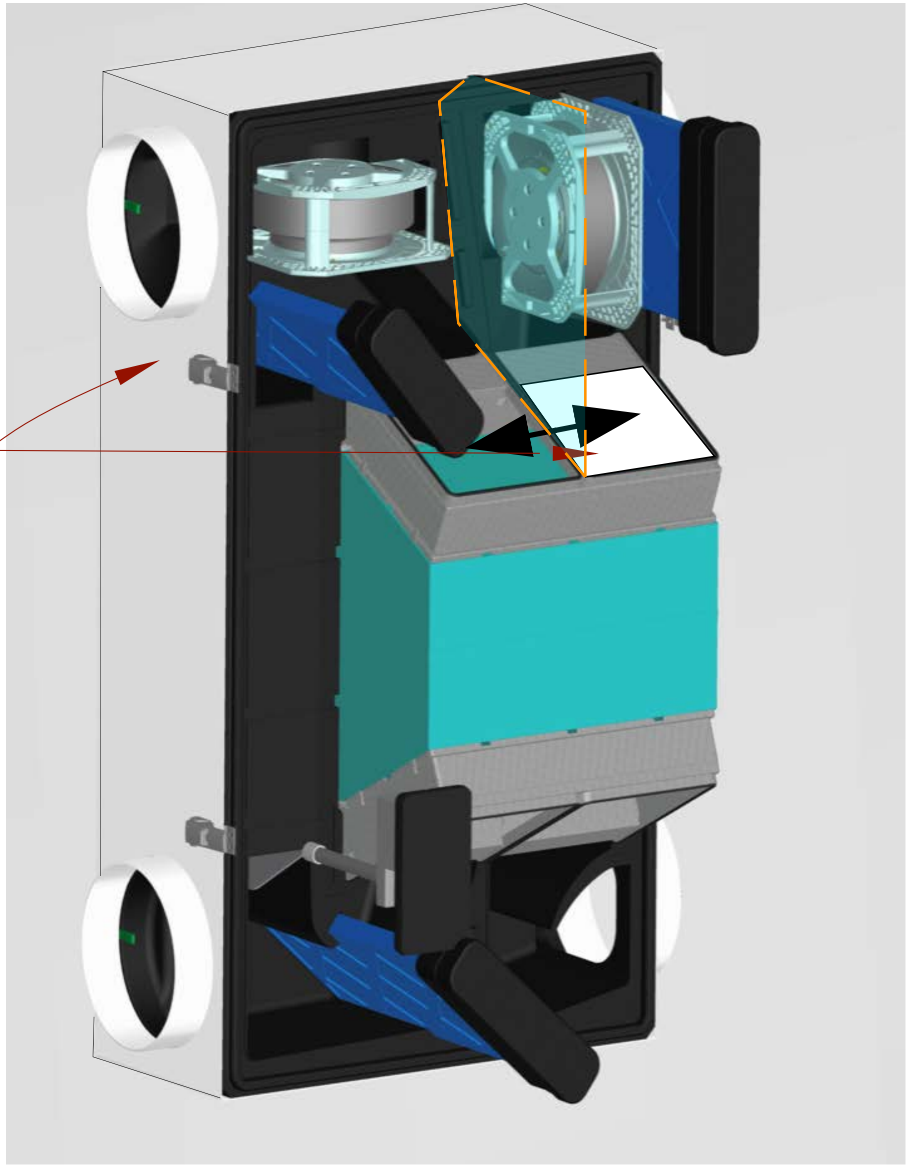
Good source of info

- CCHRC report on Moisture in REMOTE walls

- Building Science Corporation http://www.buildingscience.com/documents/bareports/ba-1316-moisture-management-for-high-r-value-walls/view

- Air tightness of older-generation energy efficient houses in Saskatoon in Journal of Building Physics Volume 36 Issue 3, January 2013 (email pamerongen@habitat-studio.com for a .pdf)

Air Pohoda ERV Ultima 240E



Sliding gates on both sides of core alternate air flow through heat exchanger channels

- 90 to 95% efficient recovery
- Self defrosting without preheat or indoor air recirculation
- Decent electrical consumption (.65 watts/cfm at 118 cfm)
- Easily homeowner control of humidity levels
- High quality components, durable construction

Notes regarding the cost optimization that follows

- The following data are snapshots only. Points along a continuum for a particular house , a particular site and particular climate (Edmonton).
- The costs that follow are conservative on low side and based on Habitat Studio experience. They do not include builder markup.
- 2 scenarios / snap shots in Edmonton.
  - incremental costs of going from EGH 88 (**102w/^{0}F**)/(38.6 kWh/m^2/a) to EGH92(**85w/^{0}F**)/(27.0 kWh/m^2/a)
  - incremental costs to go from EGH92(**85w/^{0}F**)/ (27 kWh/m^2/a) to full Passive House compliance (**76w/^{0}F**)/(14.6 kWh/m^2/a)
- For context, the typical cost for the capacity to generate 1 Kilowatt hour per year from PV in south central Alaska would be \$3.25 per installed peak watt / .825 annual kWh per installed peak watt = ~\$4.00

	EGH 88(102w/^{0}F)	EGH 92 (85w/^{0}F)			
Costs to upgrade from EGH88 to NZ	**Initial spec**	**Upgrade**	**Total incremental cost of Upgrade**	**Net energy saved (kWh/y)**	**Cost per unit energy saved ($/ kWh/y)**
Slab	4" Type 2 EPS	6" Type 2 EPS	$1,199.10	724	$1.66
Foundation Walls	4" Type 2 EPS with 6" frost wall(R37)	2" Type 2 EPS+2" Polyiso with 8" frost wall(R49)	$681.85	363	$1.88
Walls	12' Double 2x4 R40	16"Double 2x4 R56	$7,090.76	1023	$6.93
Ceiling	23" cellulose R79	27" cellulose R86	$581	360	$1.61
Air Tightness	.6 ACH	.5 ACH	$650	306	$2.12
Windows	FG Frame R5.7/R8.3	Same as EGH 88	$0	0	-
Window Ψ Install(BTU/ hr.ft.°F)	0.06	0.023	$2,300	778	$2.96
HRV	Ultimate AirDX200	Ultimate AirDX200	$0	0	-
HRV Ground loop preheat	None	Ground loop preheat	$2,600	500	$5.20
Total Upgrade Cost/Benefit			**$15,102.71**	**3748**	**$4.03**

	EGH92 (85w/^{0}F)	PH (76w/^{0}F)			
Costs to upgrade from NZ to PH	NZ Spec	Upgrade	Total incremental cost of Upgrade	Net energy saved (kWh/y)	Cost per unit energy saved ($/ kWh/y)
Slab	6" Type 2 EPS	8" Type 2 EPS	$1,199.10	396	$3.03
Foundation Walls	2" Type 2 EPS+2" Polyiso with 8" frost wall(R49)	2" Type 2 EPS, 4" Polyiso with 8" frost	$1,153.90	169	$6.85
Walls	16"Double 2x4 R56	16"Double 2x4 with 2x4 wire chase R67	$9,560.82	585	$16.34
Ceiling	27" cellulose R86	30" cellulose R100	$813.40	89	$9.16
Air Tightness	.5 ACH	.3 ACH	$1,250.00	613	$2.04
Windows	Same as EGH 88	Internorm Windows	$16,826.00	2643	$6.37
Window Ψ Install(BTU/hr.ft.°F)	0.02	0.02	$0.00	0	-
HRV	Ultimate AirDX200	Zehnder Novus 300	$3,000.00	540	$5.56
HRV Ground loop preheat	Ground loop preheat	Ground loop preheat	$0.00	0	-
Total Upgrade Cost/Benefit			**$33,803.22**	**4422**	**$7.64**

Comparing PHPP results with HOT2000

EGH88 (102w/^{0}F)(38.6 kWh/m²/a) to EGH92 (85w/^{0}F) (27.0 kWh/m²/a)

	EGH 88 (102w/^{0}F)	EGH92 (85w/^{0}F)	PHPP kWH/Y Saved	H2K kWH/Y Saved	Cost of Upgrade	PHPP Saving cost/kWh/y	H2K cost per kWH/Y Saved
Slab and foundation below grade	4" Type 2 EPS/ R39 Frost Wall	6" Type 2 EPS/R49 Frost Wall	1087	485	$1,881	$1.77	$3.88
Walls	12' Double 2x4 R40	16"Double 2x4 R56	1023	1085	$7,091	$6.93	$6.54
Ceiling	23" cellulose R79	27" cellulose R86	360	99	$581	$1.61	$5.89
Air Tightness	.6 ACH	.5 ACH	306	218	$650	$2.12	$2.98

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Comparing PHPP results with HOT2000

EGH92 (85w/^{0}F) (27.0 kWh/m²/a) to PH (76w/^{0}F) (14.6 kWh/m²/a)

	EGH92 (85w/^{0}F)	PH (76w/^{0}F)	PHPP kWH/Y Saved	H2K kWH/Y Saved	Cost of Upgrade	PHPP Saving cost/kWh/y	H2K cost per kWH/Y Saved
Slab and foundation below grade	6” Type 2 EPS Slab. 2" Type 2 EPS +2" Polyiso with 8" frost wall(R49)	8”type 2EPS Slab. 2" Type 2 EPS, 4" Polyiso with 8" frost wall(R64)	565	347	$2,353	$4.16	$6.78
Walls	16"Double 2x4 R56	16"Double 2x4 with 2x4 wire chase R67	585	446	$9,561	$16.34	$21.44
Ceiling	27" cellulose R86	30" cellulose R100	89	59	$813	$9.16	$13.81
Air Tightness	.5 ACH	.3 ACH	306	431	$1,250	$2.90	$2.04

HABITAT studio
Building your vision

Designing for Net Zero

- Site assessment
- Preliminary design

Energy Reduction

- Model Energy Performance of preliminary design
- Reduce base loads
  - Domestic hot water
  - Lighting and appliances
- Use the modelling results to optimize the Building Envelope and Passive solar gain

Renewable Energy Collection

- **Examine / Model solar domestic hot water and heating**
- Consider Air Source Heat Pump or Geothermal
- Size PV to meet remaining total load

- Finish detailed architectural and system design

Optimize Passive Solar

- Cheapest, simplest, renewable energy strategy.
- Maximize solar gain
- Check for Shading from nearby obstacles
- Check Model for Overheating
- Adjust overhangs
- Add thermal mass if warranted

Overhangs/ Shading

June 21

January 17

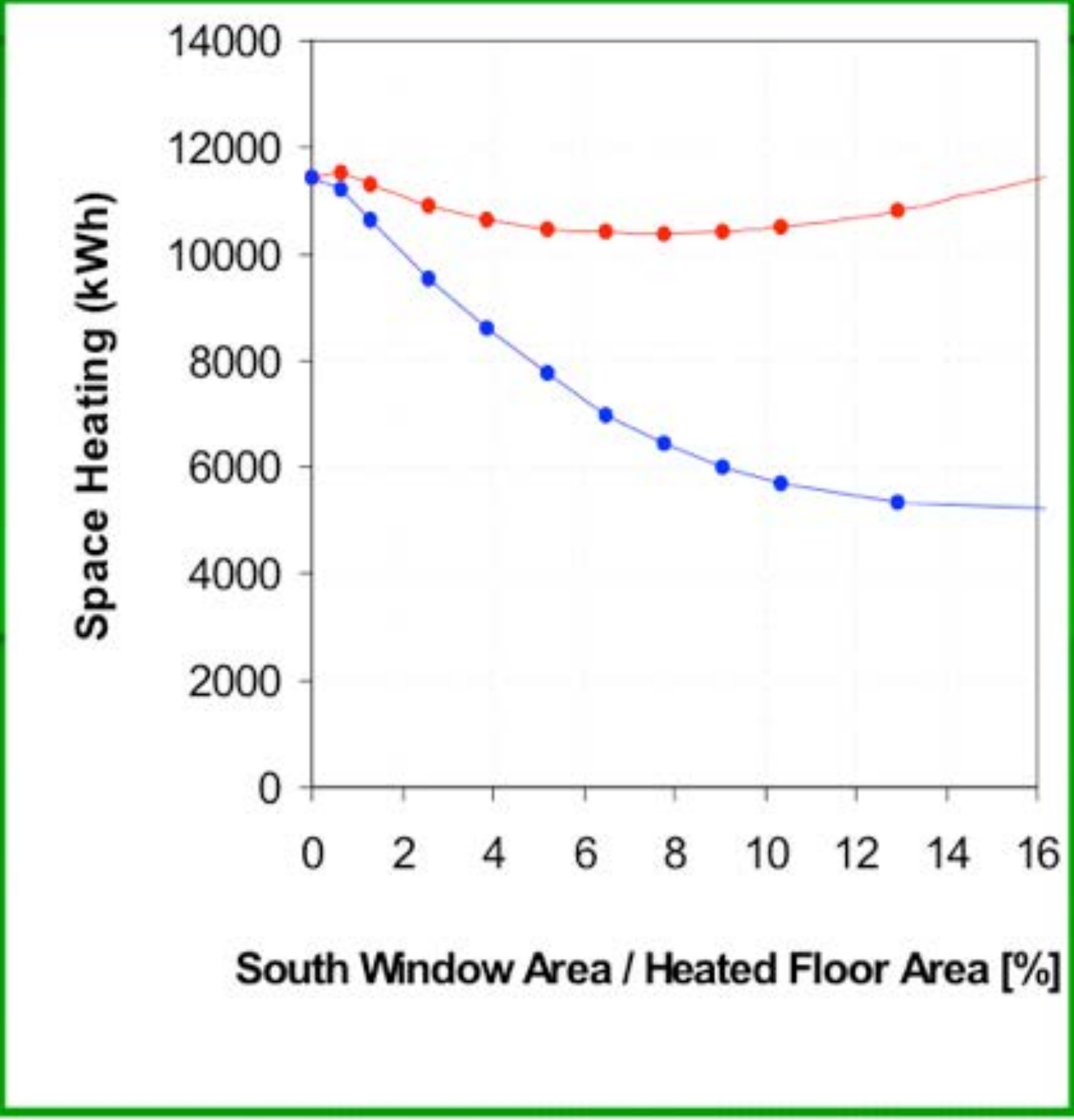
Cranbrook Sun Angles

Optimizing South Glazing Area

(From the HOT2000 House Comparison Report)

	Minus 4 South Windows	Minus 2 South Windows	Plus 2 South Windows	Original Belgravia design
ANNUAL SPACE HEATING SUMMARY				
Design Heat Loss (Watts)	6394	6693	7462	7080
Gross Space Heat Loss (MJ)	35380.1	38218.1	45491.0	41872.5
Sensible Occupancy Heat Gain (kWh/day)	1.60	1.60	1.60	1.60
Usable Internal Gains (MJ)	9506.3	9772.9	10401.7	10113.9
Usable Internal Gains Fraction (%)	26.9	25.6	22.9	24.2
Usable Solar Gains (MJ)	15528.5	19085.3	26231.1	22818.3
Usable Solar Gains Fraction (%)	43.9	49.9	57.7	54.5
Vent. Electrical Contribution (MJ)	5916.0	5916.0	5916.0	5916.0
Auxiliary Energy Required (MJ)	8791.6	7765.9	7264.4	7346.4
SPACE + DHW ENERGY (MJ)	21687.1	20661.5	20159.9	20241.9
R-2000 SPACE + DHW TARGET (MJ)	59188.9	59188.9	59188.9	59188.9
ANNUAL FUEL CONSUMPTION SUMMARY				
Electricity (kWh)	10157.3	9963.7	10049.2	9959.3

Higher Performance Windows & High Thermal Mass



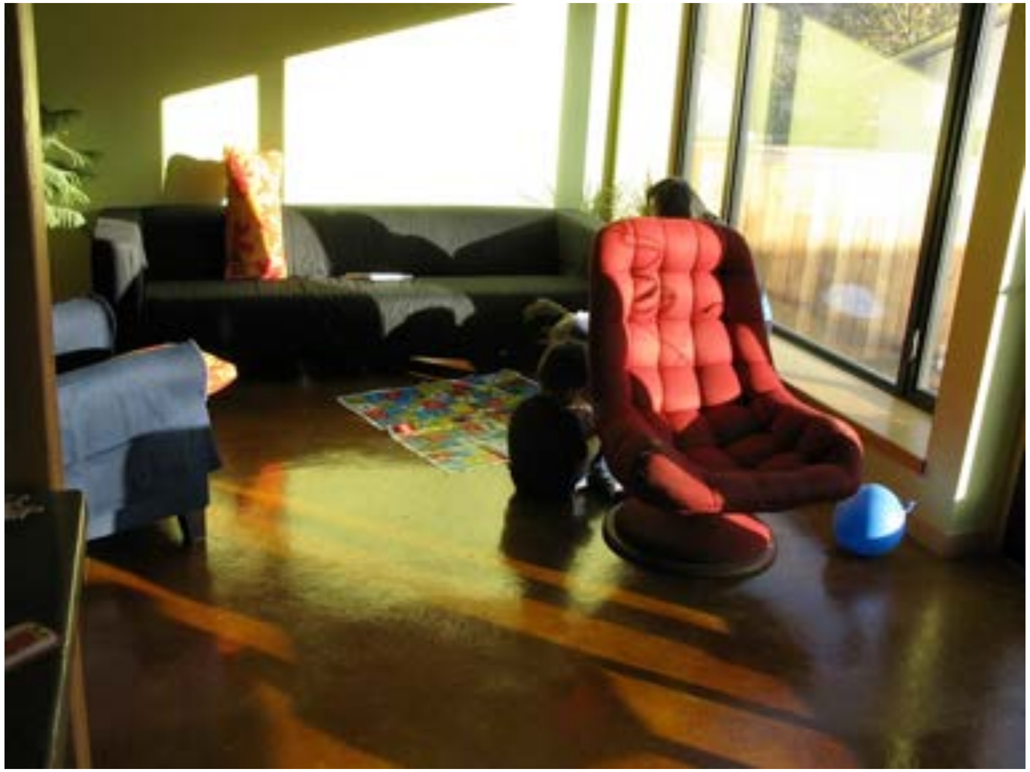
Upper Line
Light, wood frame, construction

Triple paned, low-e, argon filled, windows

Lower Line

Change construction to very high thermal mass and install new windows

Mill Creek Passive Solar



- Maximum south window area - 11.5% of floor area
- 64 mm concrete floor overlay provides effect thermal mass.
- Adjustable PV awning provides summer shading
- Over 50% of total annual space heat needs

Mill Creek NetZero

Moveable PV Awning

September 10

October 17

Useable Monthly Solar Gains (Megajoules(3.6 mj= 1kWh))

HOT2000 assumes that 100% of the theoretical annual solar gain is coming through your window and heating your house

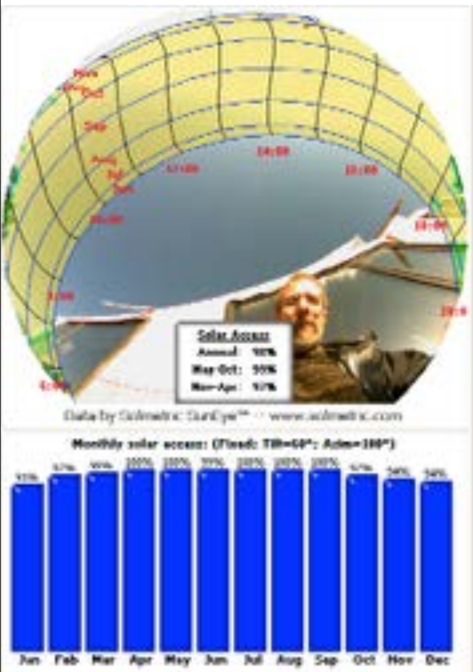
Anchorage

MONTHLY ENERGY PROFILE

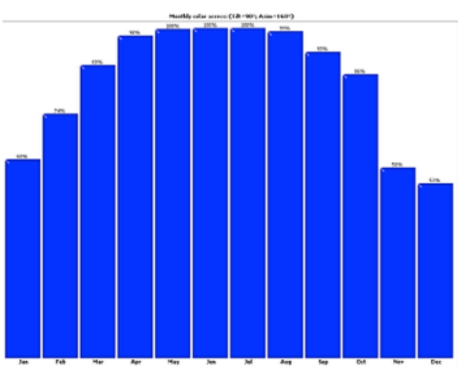
Month	Energy Load (MJ)	Internal Gains (MJ)	Solar Gains (MJ)	Aux. Energy (MJ)	HRV Eff. %
Jan	8128.1	1792.1	1346.9	4989.1	90.4
Feb	6522.3	1613.0	3168.8	1740.5	90.6
Mar	6364.0	1783.8	2086.6	2493.6	90.7
Apr	4529.5	1728.2	2263.3	537.9	90.7
May	3243.3	1770.0	1471.4	1.9	0.0
Jun	1634.5	1254.6	379.8	0.0	0.0
Jul	1301.1	1108.5	192.6	0.0	0.0
Aug	1478.7	1203.2	275.4	0.0	0.0
Sep	2317.3	1436.2	881.1	0.0	0.0
Oct	4717.3	1814.2	1200.0	1703.1	90.7
Nov	6492.6	1750.0	793.5	3949.2	90.6
Dec	7932.5	1800.2	1519.6	4612.7	90.4
Ann	54661.3	19054.2	15579.1	20028.0	90.6

Done General

Second Guessing HOT2000 Solar Gains for Belgravia Net Zero



Solmatic Suneye Reading for Belgravia



Solmatic Suneye Reading for Rvierdale

Adjustments to HOT2000 Solar Gain Predictions					
Monthly Solar Gains	H2K Solar gain predictions (KWH)	Suneye %	Adjustment (kWh)	Adjustment for dirty windows	
Jan	1224	91%	110	5.00%	56
Feb	1251	97%	38	5.00%	61
March	1234	98%	25	5.00%	60
April	704	100%		5.00%	
May	0	100%		5.00%	
June	0	100%		5.00%	
July	0	100%		5.00%	
August	0	100%		5.00%	
September	377	100%		5.00%	
October	710	97%	21	5.00%	34
November	1067	94%	64	5.00%	50
January	1075	94%	65	5.00%	51
Deduct From HOT2000 useable solar gains	7642		322		312
Adjusted Energy Useable Solar Gain Predictions	**7,008**				

HOT2000 assumes that 100% of the theoretically available solar radiation will hit your window

Monthly Heating Energy Required (Megajoules(3.6 mj= 1kWh))

Anchorage

Net heating required from Solar Thermal, ASHP, Geothermal, etc

MONTHLY ENERGY PROFILE

Month	Energy Load (MJ)	Internal Gains (MJ)	Solar Gains (MJ)	Aux. Energy (MJ)
Jan	8128.1	1792.1	1346.9	4989.1
Feb	6522.3	1613.0	3168.8	1740.5
Mar	6364.0	1783.8	2086.6	2493.6
Apr	4529.5	1728.2	2263.3	537.9
May	3243.3	1770.0	1471.4	1.9
Jun	1634.5	1254.6	379.8	0.0
Jul	1301.1	1108.5	192.6	0.0
Aug	1478.7	1203.2	275.4	0.0
Sep	2317.3	1436.2	881.1	0.0
Oct	4717.3	1814.2	1200.0	1703.1
Nov	6492.6	1750.0	793.5	3949.2
Dec	7932.5	1800.2	1519.6	4612.7
Ann	54661.3	19054.2	15579.1	20028.0

Done

Solar Domestic Hot Water

+

- A small simple system can provide 65% of domestic hot water needs
- Good use of limited roof space. Higher energy yield per sq. meter than PV
- Direct energy collection - no reliance on grid storage
- Somewhat less expensive than PV

–

- More complicated than PV
- Pipes and pumps are more complicated and need more maintenance than wires.

Is Solar Thermal Heating really practical in Alaska?

There seems to be so little solar energy available when it is needed the most. It would take 161000 litres (42,000 US gal.)of water with a 20°C (36°F) ΔT to store the November to late January short fall; 13,900mJ (13 milBTU)

MONTHLY ENERGY PROFILE

Anchorage

Month	Energy Load (MJ)	Internal Gains (MJ)	Solar Gains (MJ)	Aux. Energy (MJ)
Jan	8128.1	1792.1	1346.9	4989.1
Feb	6522.3	1613.0	3168.8	1740.5
Mar	6364.0	1783.8	2086.6	2493.6
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May	3243.3	1770.0	1471.4	1.9
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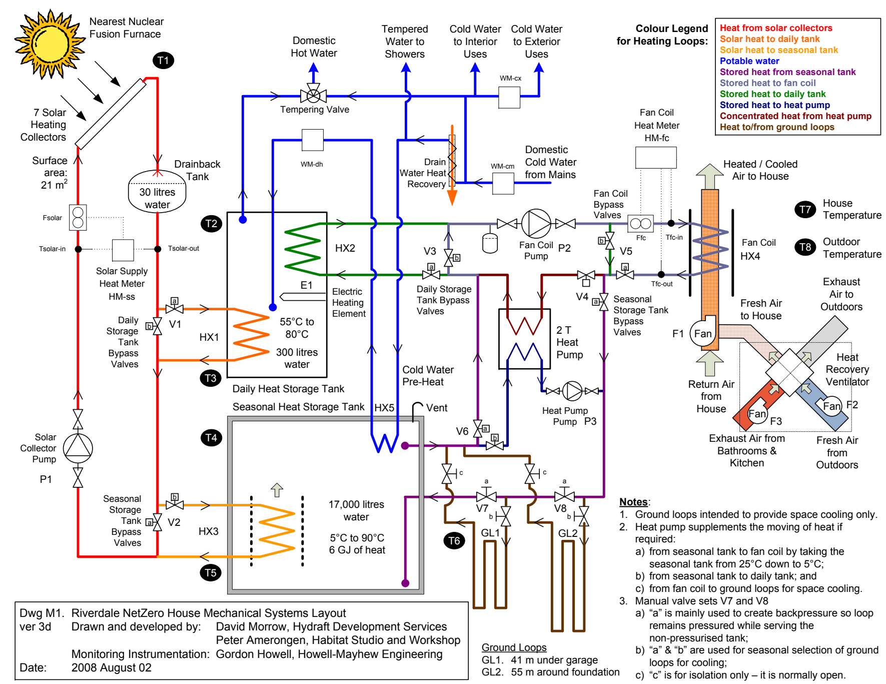
Jul	1301.1	1108.5	192.6	0.0
Aug	1478.7	1203.2	275.4	0.0
Sep	2317.3	1436.2	881.1	0.0
Oct	4717.3	1814.2	1200.0	1703.1
Nov	6492.6	1750.0	793.5	3949.2
Dec	7932.5	1800.2	1519.6	4612.7
Ann	54661.3	19054.2	15579.1	20028.0

Done

Solar Thermal Space Heating

- Not enough energy there when you need it most
- Can be very complicated
- Potential to harvest more useful energy per sq. ft than PV (~20 kWh/sq.ft./year)
- Incremental cost at Riverdale~ $50000 per unit
- 21,000 litre storage tank insulated to R50 loses 1.5°F per day.



Riverdale NZ Heating Schematic

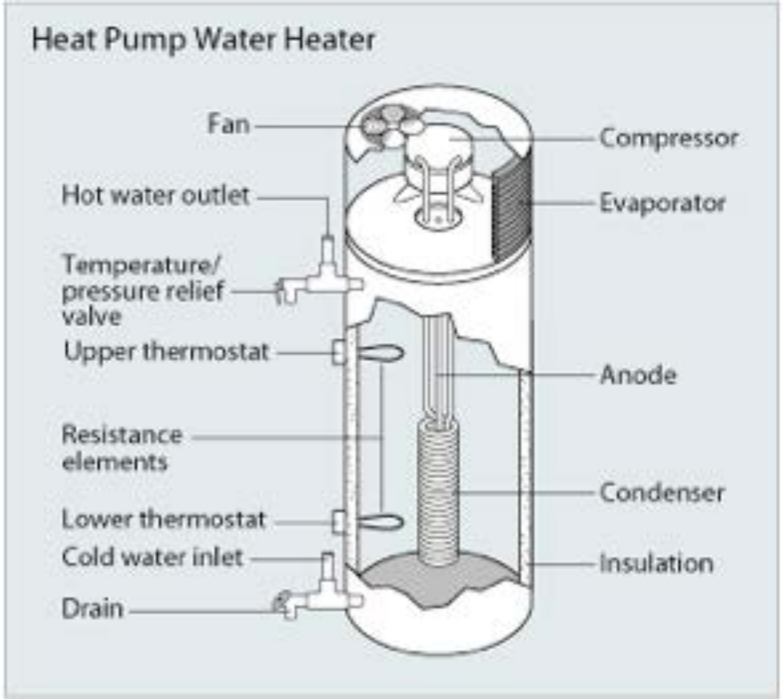
Air Source Heat Pumps for Domestic Hot Water

+

- Relatively low cost $1500-2000
- Provide a small summer cooling benefit
- Work well in tandem with Air Source Heat Pump or Geothermal heating.
- Will shrink the size of the PV array
- Annual COP of ~1.50 to1.75 is possible
- Provides a small amount of summer cooling

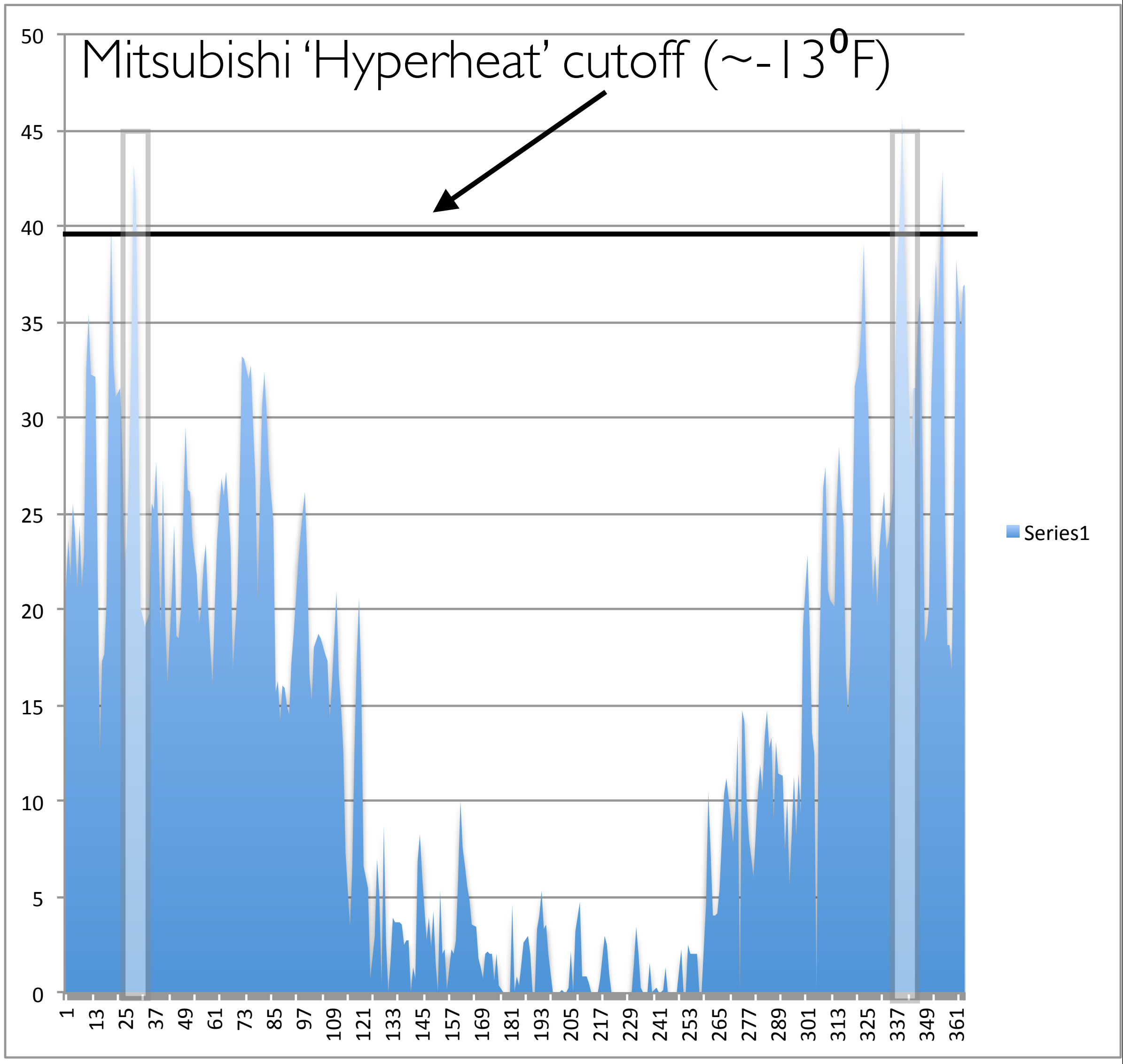
–

- Will increase winter heating load
- Noisy



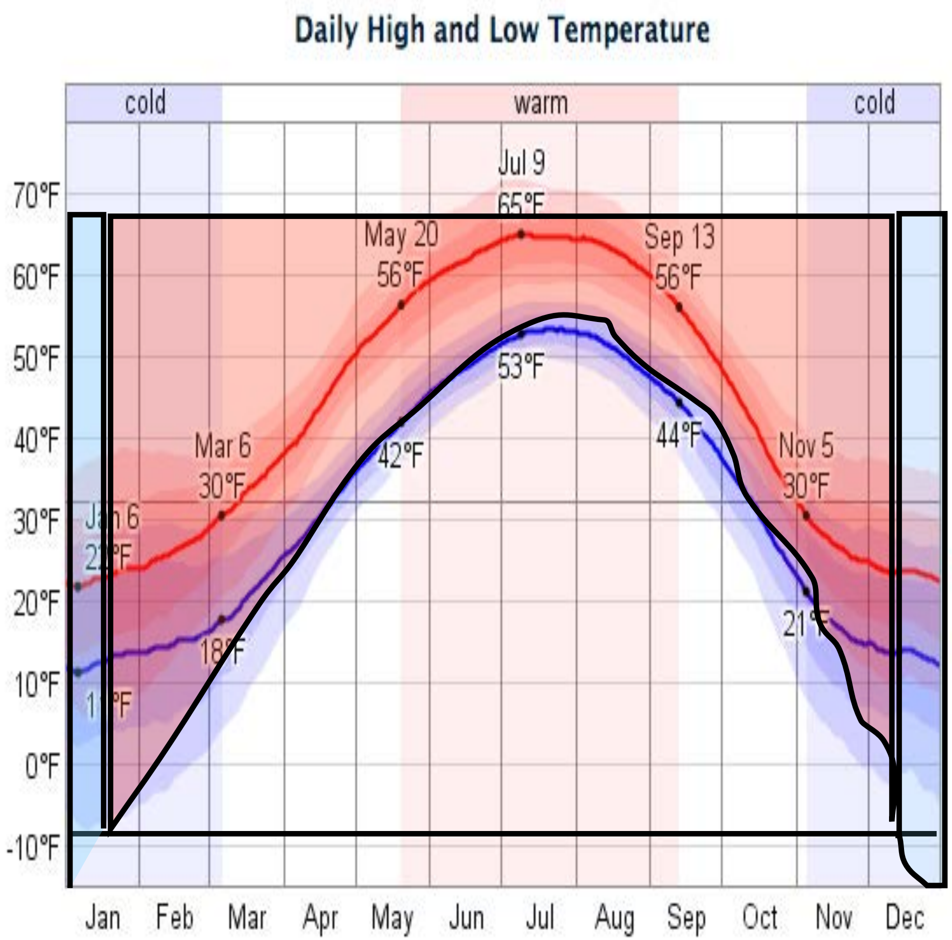
Air Source Heat Pump operating range

- The energy harvested by Air Source Heat Pumps is 100% renewable - solar energy with no direct sun.
- It is possible to get C.O.P.'s* of 2 or better in Anchorage.
- C.O.P. drops off as temperature get colder.
- Mitsubishi 'Hyperheat' units have shown C.O.P.'s of greater than 1.0 at temperatures as low as -25°F.
- They can make or break net zero energy.

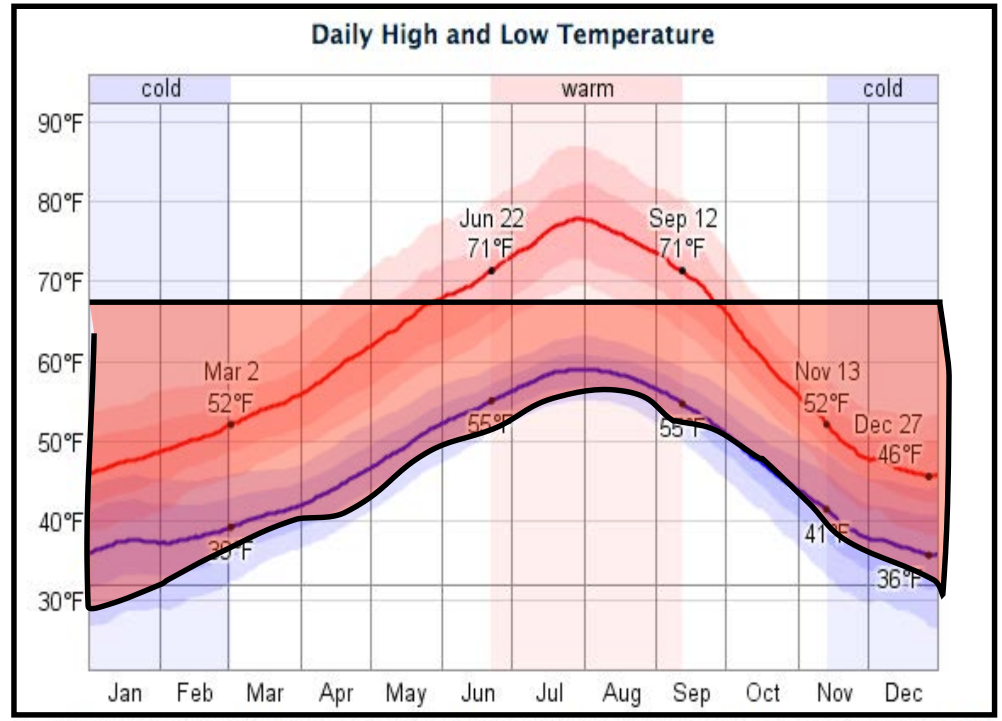


Edmonton Heating Degree Days 2013

*C.O.P. - Coefficient of Performance
C.O.P. of 2 indicates 2 units of energy out for every 1 unit of electricity in.

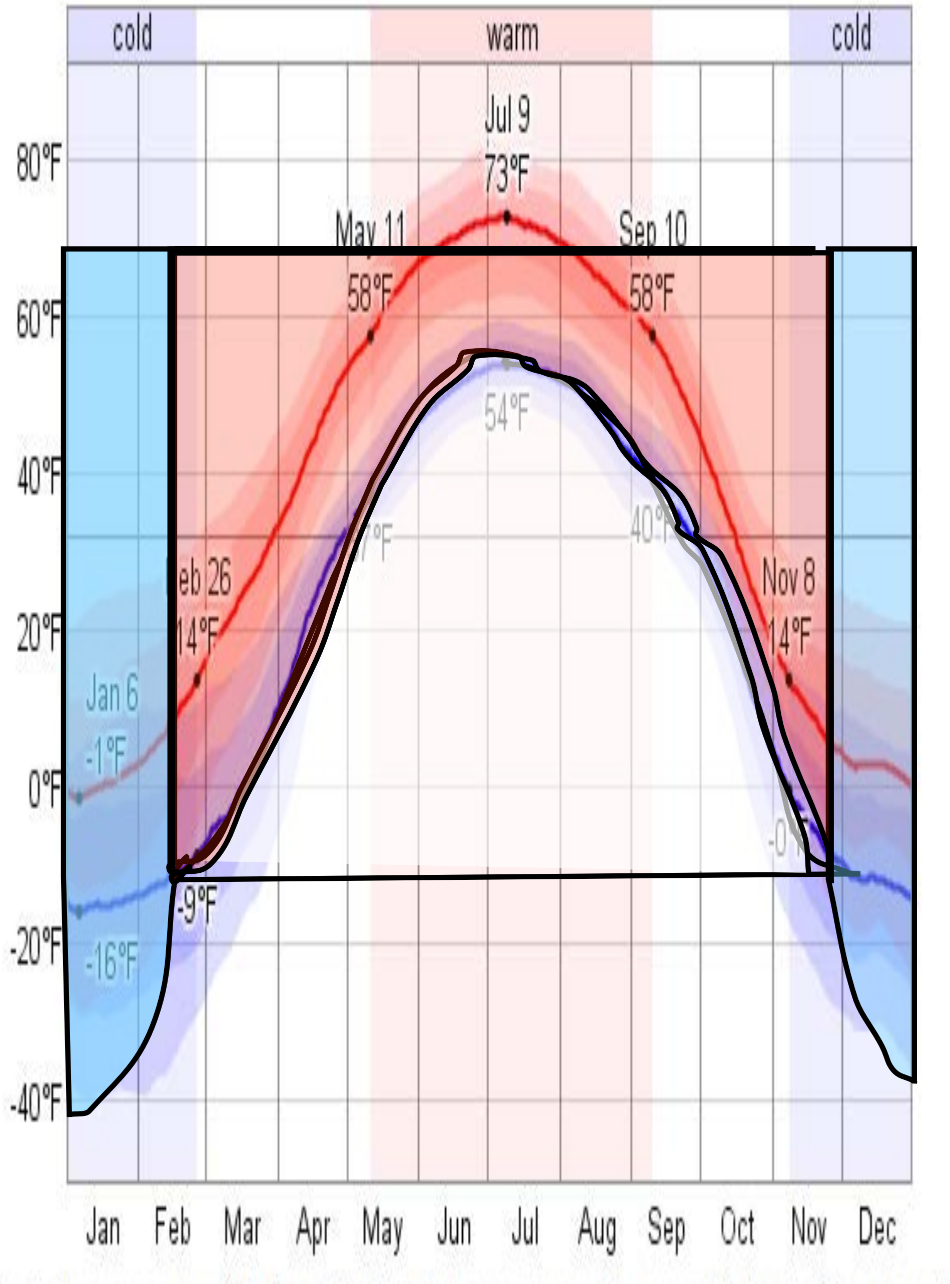


Anchorage

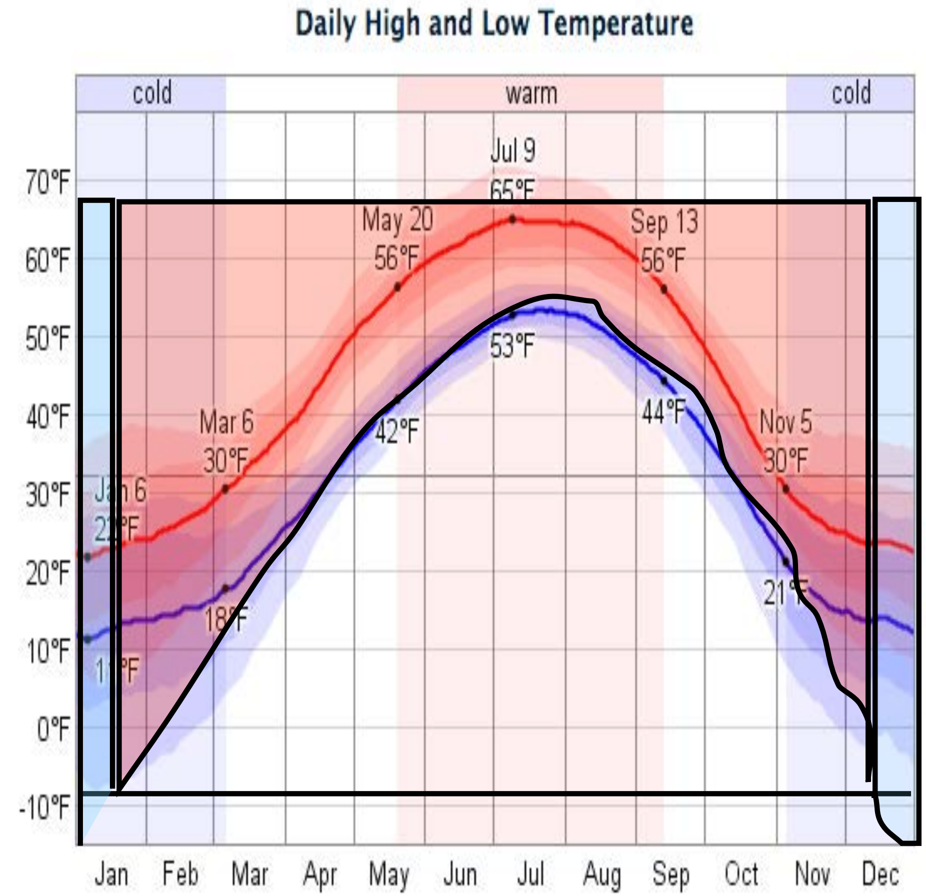


he daily average low (blue) and high (red) temperature with percentile bands (inner band fr
25th to 75th percentile, outer band from 10th to 90th percentile).

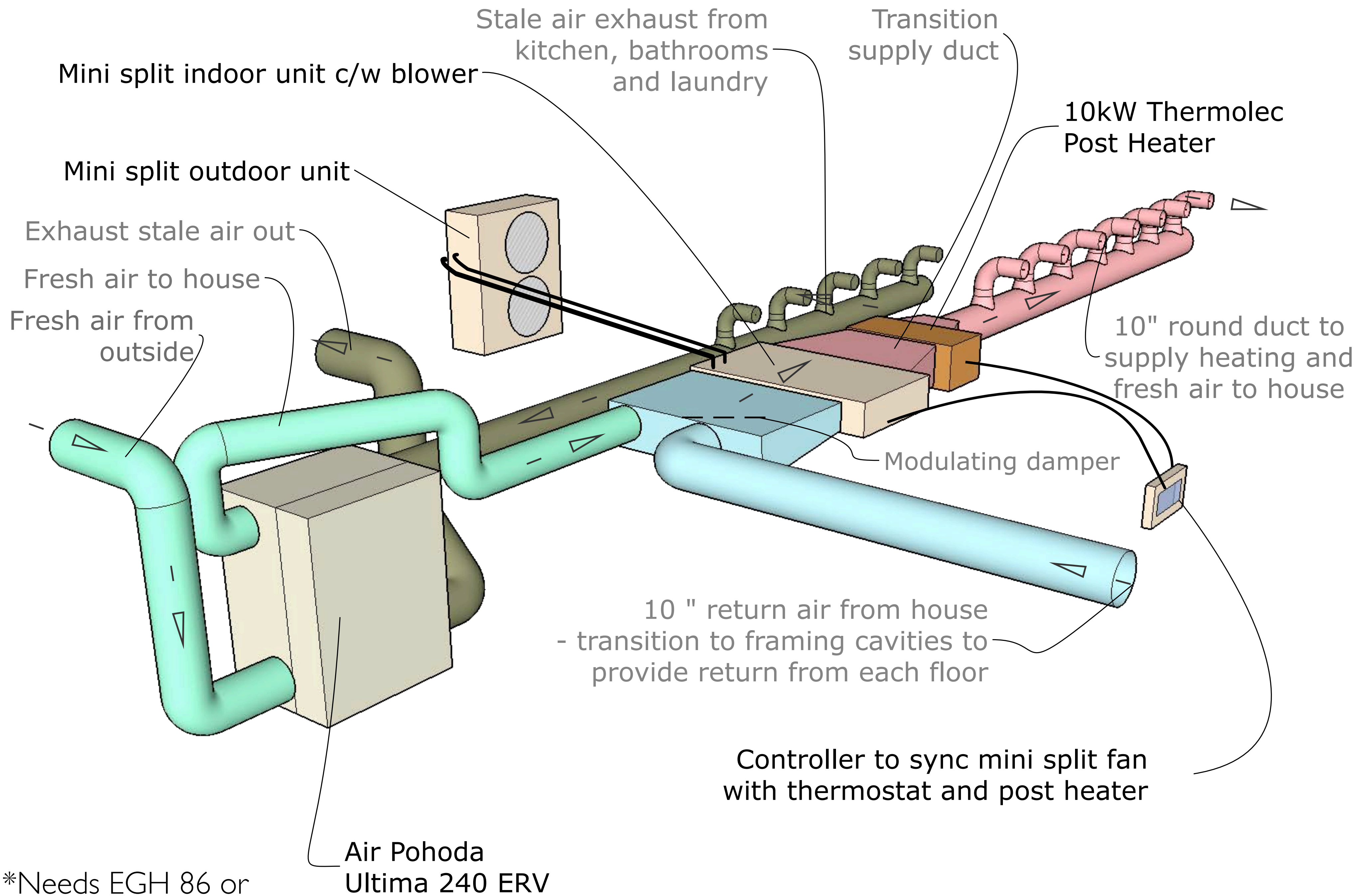
Seattle



Fairbanks



Anchorage



*Needs EGH 86 or better envelope

Proposed Heating and Ventilating System

Mini splits vs Central systems

- Mini splits can save heating system dollars if the loads are small enough to be met with point source heating and electric baseboard back up.
- Big central ASHP's like the Mitsubishi Zuba Central will add ~$8000 to heating system costs.
- Even at that price central systems can pay for themselves in offset PV costs. If it saves 3000kWh/year if will offset $12,000 worth of PV and also reduce roof space.

Hunt for the NZ Sweet Spot

	ERS 82	ERS 86	Passive House
		Envelope Specifications	
Foundation	R25- 2" EPS +R20 frost wall	R37- 4"EPS + R22 Frost wall	R52- 6" EPS + R28 Frost wall
underlab insulation	R9- 2" Type 2 EPS	R18- 4" Type 2 EPS	R27
Walls	R 24 - 2x8, 24"O.C. R28 Batt	R40- 12" Double 2x4 , 24" OC	R67- 16" Double 2x4with 2x4 wiring chase, Cellulose plus R14 roxul
Ceiling	R60- cellulose	R80 - cellulose	R100- cellulose
Windows	Duxton fbreglass wih R5.33/R8.33 COG	Duxton fbreglass wih R5.33/R8.33 COG	~R 10 COG Passive House windows
Air tighness	1.5 ACH -Caulked poly with Habitat details	.5 ACH - Caulked Poly with Siga tape and extra care and attention	.03 ACH- Taped OSB, even more care and attention, Passive house windows
		Mechanical Systems	
Heating system	Large central air source heat pump- Zuba Central	Ducted mini split air source heat pump- Mitsubishi SEZ	Electric baseboards
HRV	VanEE 2000HE	Air Pohoda Ultima 240E	Air Pohoda Ultima 240E
Hot Water	Air source DHW	Air source DHW	Air source DHW

Lowest Cost Net Zero with EGH 82 Envelope*

Air Source HP with Air Source DHW	Space Heat*	Cooling*	DHW	L.A.M.E.	Total
	9100	1000	4550	5840	20490
C.O.P.	2.0	4.1	1.6	1.0	
Remaining Electrical Load	4550	243	2844	5840	13477
Installed PV watts	13477	Shading Adjustment %		1	13477
Panel Size - 18 sq ft , 250 Watts		Modules needed		54	
PV Area Available	900 Sq feet.	PV Area Needed		970	Sqft.
Envelope upgrade cost**	$0				
Zuba Central cost**	$8,000				
Air source DHW cost**	$0				
Ducted Mini Split cost**	N/A				
PV Cost	$43,800				
Total Net Zero Upgrade Cost	$51,800				

* Annual Heating and Cooling from HOT2000

** Costs in relation EGH 82 envelope with gas furnace and DHW

Lowest Cost Net Zero with EGH 86 Envelope

Air Source HP with Air Source DHW	Space Heat*	Cooling*	DHW	L.A.M.E.	Total
	4200.0	1400.0	4200.0	5840.0	15640
C.O.P.	2	4	2	1	
Remaining Electrical Load	2100	341	2625	5840	10906
Installed PV watts with no shading	10906	Shading Adjustment %		1	10906
Panel Size - 18 sq ft , 250 Watts		Modules needed		44	
PV Area Available	900 Sq feet.	PV Area Needed		785	Sqft.
Envelope upgrade cost**	$18,000				
Zuba Central cost**	N/A				
Air source DHW cost**	$0				
Ducted Mini Split cost**	-$2,000				
PV Cost	$35,443				
Total Net Zero Upgrade Cost	$51,443				

* Annual Heating and Cooling from HOT2000

** Costs in relation EGH 82 envelope with gas furnace and DHW

Lowest Cost Net Zero with ~ Passive House Envelope*					
Baseboard Heaters with Air Source DHW	Space Heat	Cooling*	DHW	L.A.M.E.	Total
	2100	1600	4200	5840	13740
C.O.P.	1.0	1.0	1.6	1.0	
Remaining Electrical Load	2100	1600	2625	5840	12165
Installed PV watts with no shading	12165	Shading Adjustment %		1	12165
Panel Size - 18 sq ft , 250 Watts		Modules needed		49	
PV Area Available	900 Sq feet.	PV Area Needed		876	Sqft.
Envelope upgrade cost**	$45,000				
Zuba Central cost**	N/A				
Air source DHW cost**	N/A				
Savings re electric baseboard **	-$8,000				
PV Cost	$39,536				
Total Net Zero Upgrade Cost	$76,536				

* Annual Heating and Cooling from HOT2000

** Costs in relation EGH 82 envelope with gas furnace and DHW

	ERS 82	ERS 88	Passive House
		Envelope Specifications	
Foundation	R25- 2" EPS +R20 frost wall	R37- 4"EPS + R22 Frost wall	R52- 6" EPS + R28 Frost wall
underlab insulation	R9- 2" Type 2 EPS	R18- 4" Type 2 EPS	R27
Walls	R 24 - 2x8, 24"O.C. R28 Batt	R40- 12" Double 2x4 , 24" OC	R67- 16" Double 2x4with 2x4 wiring chase, Cellulose plus R14 roxul
Ceiling	R60- cellulose	R80 - cellulose	R100- cellulose
Windows	Duxton fbreglass wih R5.33/R8.33 COG	Duxton fbreglass wih R5.33/R8.33 COG	~R 10 COG Passive House windows
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Heating system	Large central air source heat pump- Zuba Central	Ducted mini split air source heat pump- Mitsubishi SEZ	Electric baseboards
HRV	VanEE 2000HE	Air Pohoda Ultima 240E	Air Pohoda Ultima 240E
Hot Water	Air source DHW	Air source DHW	Air source DHW

Rough Cost of Net Zero in Fairbanks

Air Source HP with Air Source DHW	Space Heat	Cooling	DHW	L.A.M.E.	Total
	10315	0	2500	6400	19215
C.O.P.	1.5	4.1	1.5	1.0	
Remaining Electrical Load	6877	0	1667	6400	14943
PV yield per installed Peak Watt	0.912				
Installed PV watts with no shading	16385	Shading Adjustment %		100%	16385
Panel Size - 18 sq ft , 250 Watts		Modules needed		66	
PV Area Available	900 Sq feet.	PV Area Needed		1180	Sqft.
Envelope upgrade cost	$?				
Zuba Central incremental cost	$?				
Air source DHW incremental cost	$?				
Ducted Mini Split incremental cost	$?				
PV Cost at $3.25 installed watt	$53,252				
Total Net Zero Upgrade Cost	$?				

Rough Cost of Net Zero in Anchorage

Air Source HP with Air Source DHW	Space Heat	Cooling	DHW	L.A.M.E.	Total
	6117	0	2300	6400	14817
C.O.P.	2.2	4.1	1.7	1.0	
Remaining Electrical Load	2780	0	1533	6400	10574
PV yield per installed Peak Watt	0.785				
Installed PV watts with no shading	13471	Shading Adjustment %		100%	13471
Panel Size - 18 sq ft , 250 Watts		Modules needed		54	
PV Area Available	900 Sq feet.	PV Area Needed		970	Sqft.
Envelope upgrade cost	$?				
Zuba Central incremental cost	$?				
Air source DHW incremental cost	$?				
Ducted Mini Split incremental cost	$?				
PV Cost at $3.25 installed watt	$44,356				
Total Net Zero Upgrade Cost	$?				

Conclusions and Questions

- Net Zero energy in Alaska is a tough challenge
- Air source heat pumps look to be a key ingredient
- Air source heat pumps change the economics of energy conservation.
- Net Zero Energy Sweet Spot - a near Passive House envelope with an cold climate mini split.

For more info on how to do practical net zero energy design and construction consider taking Marc Rosenbaum's on line course at http://nesea.cammpus.com/courses/zero-net-energy-homes--online

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