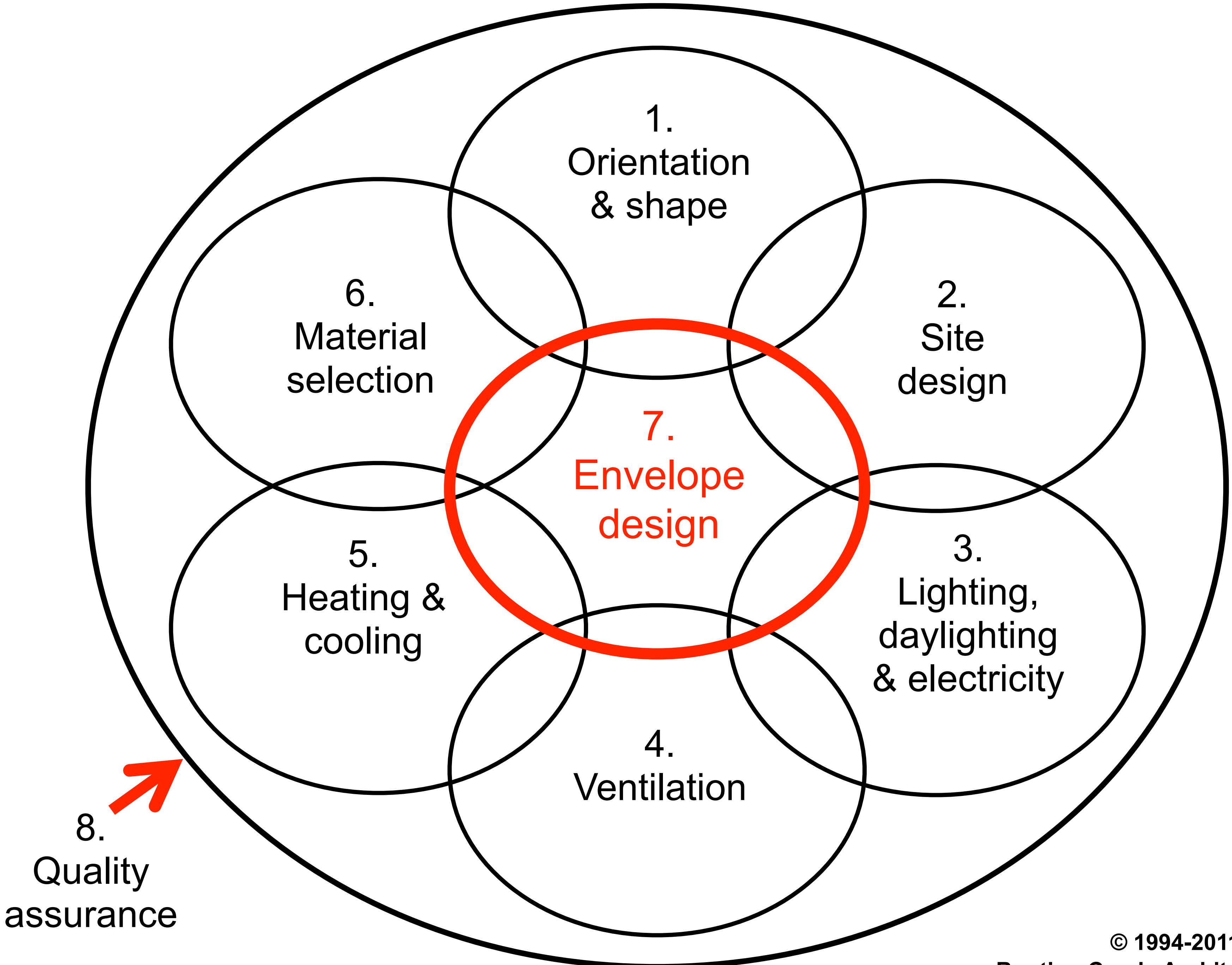
Designing For Net Zero Energy

Objective

- NetZero, Net Zero Ready or Near Net Zero at the lowest possible incremental cost.
- Optimal solutions will vary from site to site and from region to region

Integrated Design Process



Designing for Net Zero

- Site assessment
- Preliminary design
- Model Energy Performance in Hot 2000*
- Use the modelling results to optimize the Building Envelope
- Reduce DHW load
- Reduce lighting and appliances loads
- Optimize passive solar
- Examine / Model solar DHW
- Consider Geothermal
- Size PV to meet remaining total load
- Detailed architectural and system design

Energy Units

1 Kilowatt hour	=	3413 BTUs
1 Kilowatt hour	=	.025 US gallons of Heating Oil

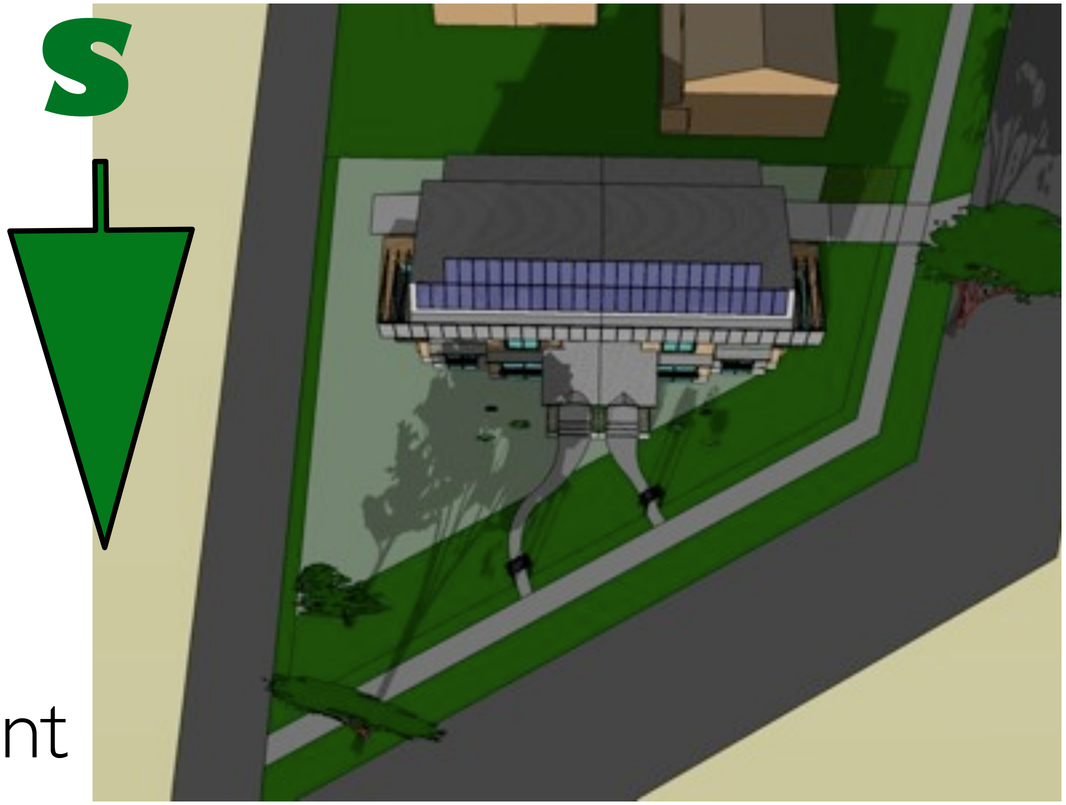
1 US Gallon of heating oil produces 138,690 BTUs of energy

1 US Gallon of heating oil used at 100% efficiency produces 40 kWh of energy

*kWh = Kilowatt hour

Cost per kWh/year of energy conservation measures = Cost per kWh/year of Energy collection

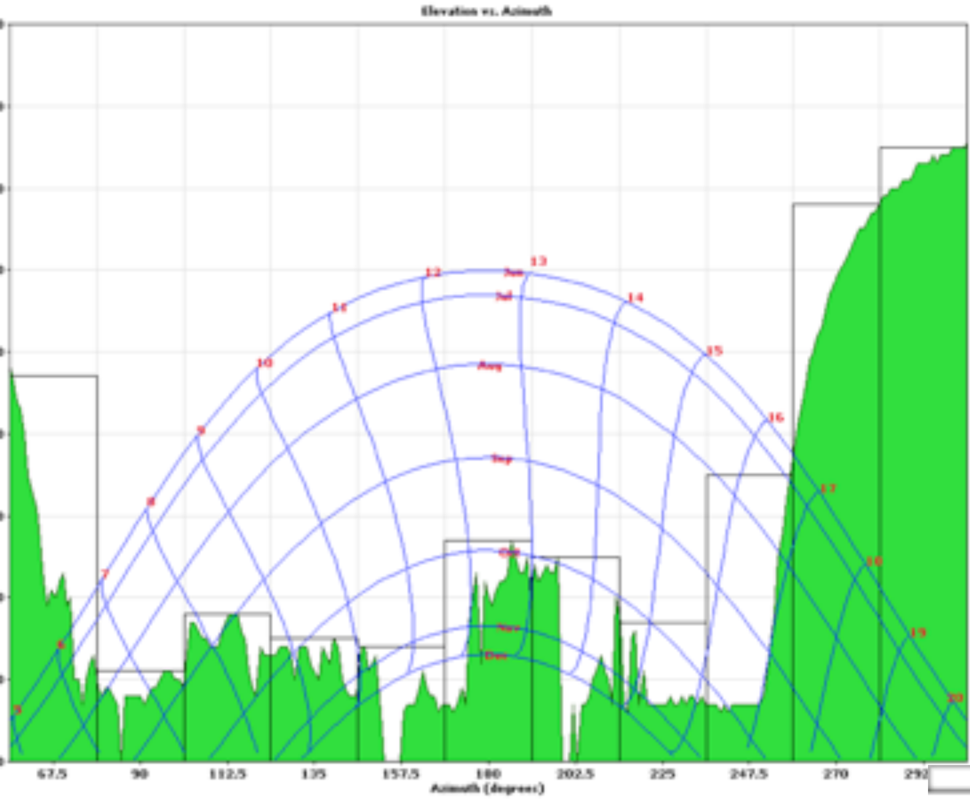
Site assessment

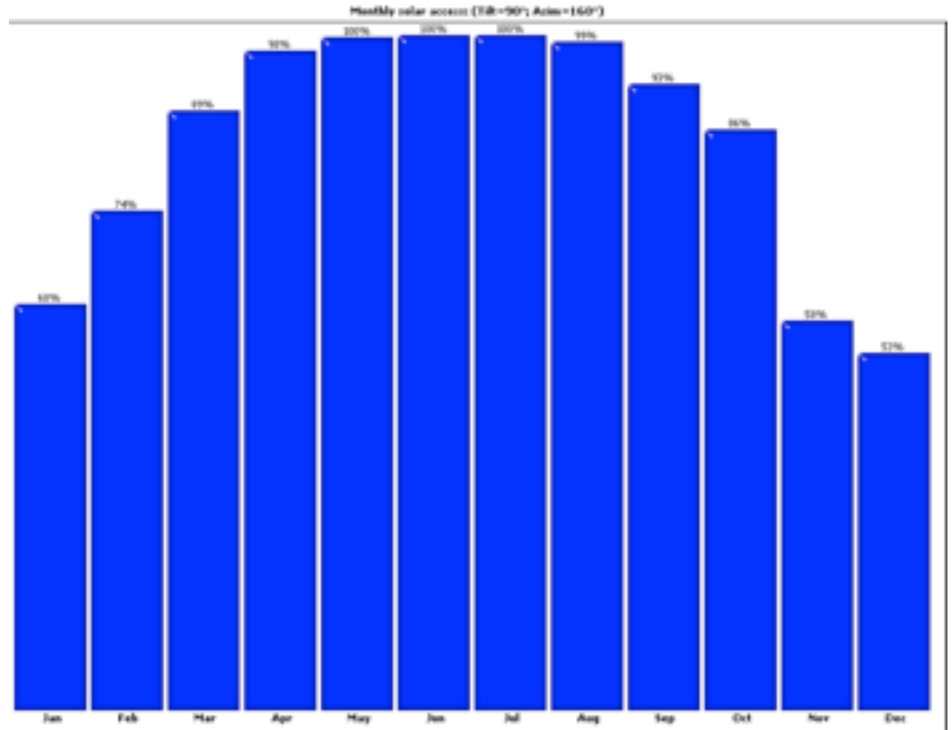


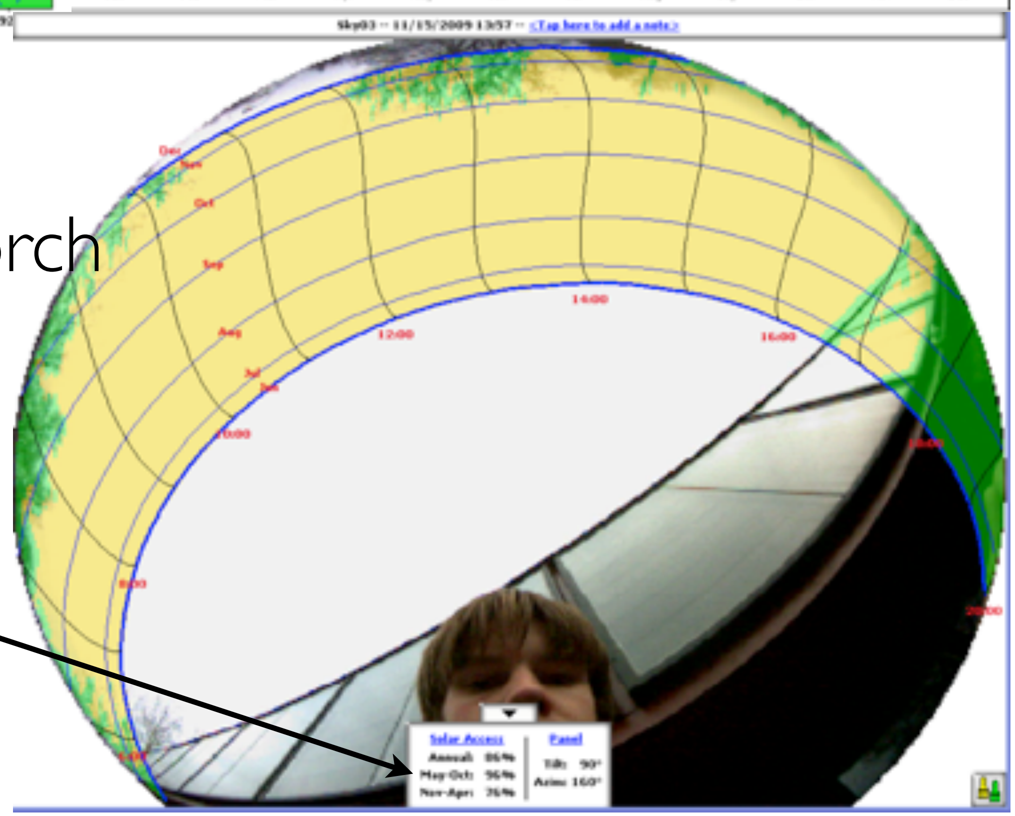
- Normal site assessment
- Evaluate the Solar Potential
- Consider potential shading from buildings, trees, etc.

Renewable Energy Collection
(kWh/year)

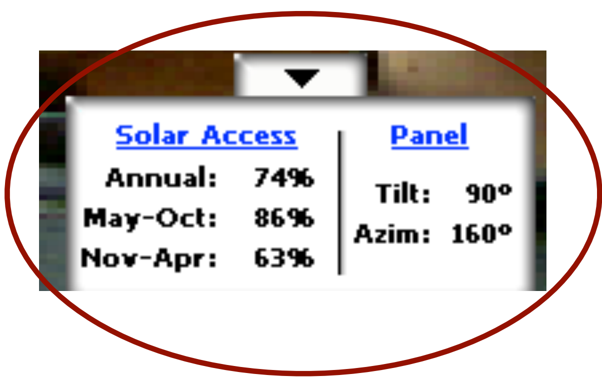
	Mill Creek	Belgravia	Belgravia in Anchorage
Useable Passive Solar	8,200	8,300	7350
Solar thermal	2500	0	??
Photo voltaic	8000	9900	7600
Total	18,700	18,200	??



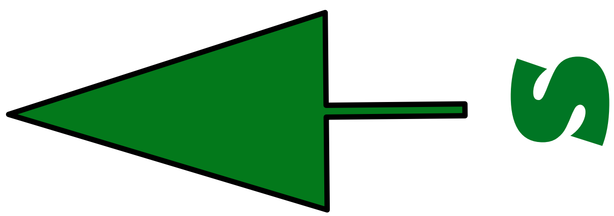




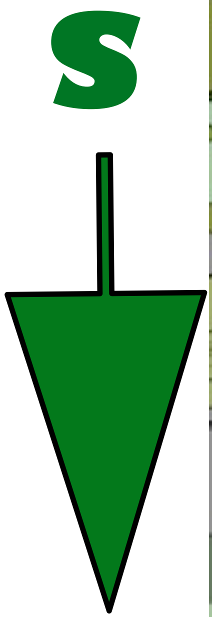
Solmetric Suneye reports from RNZ front porch



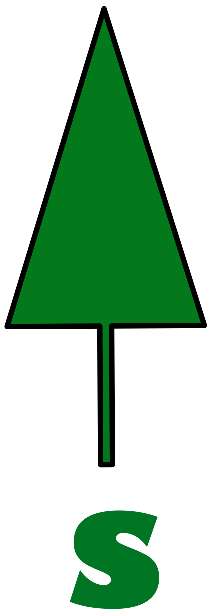
East - West Facing Sites

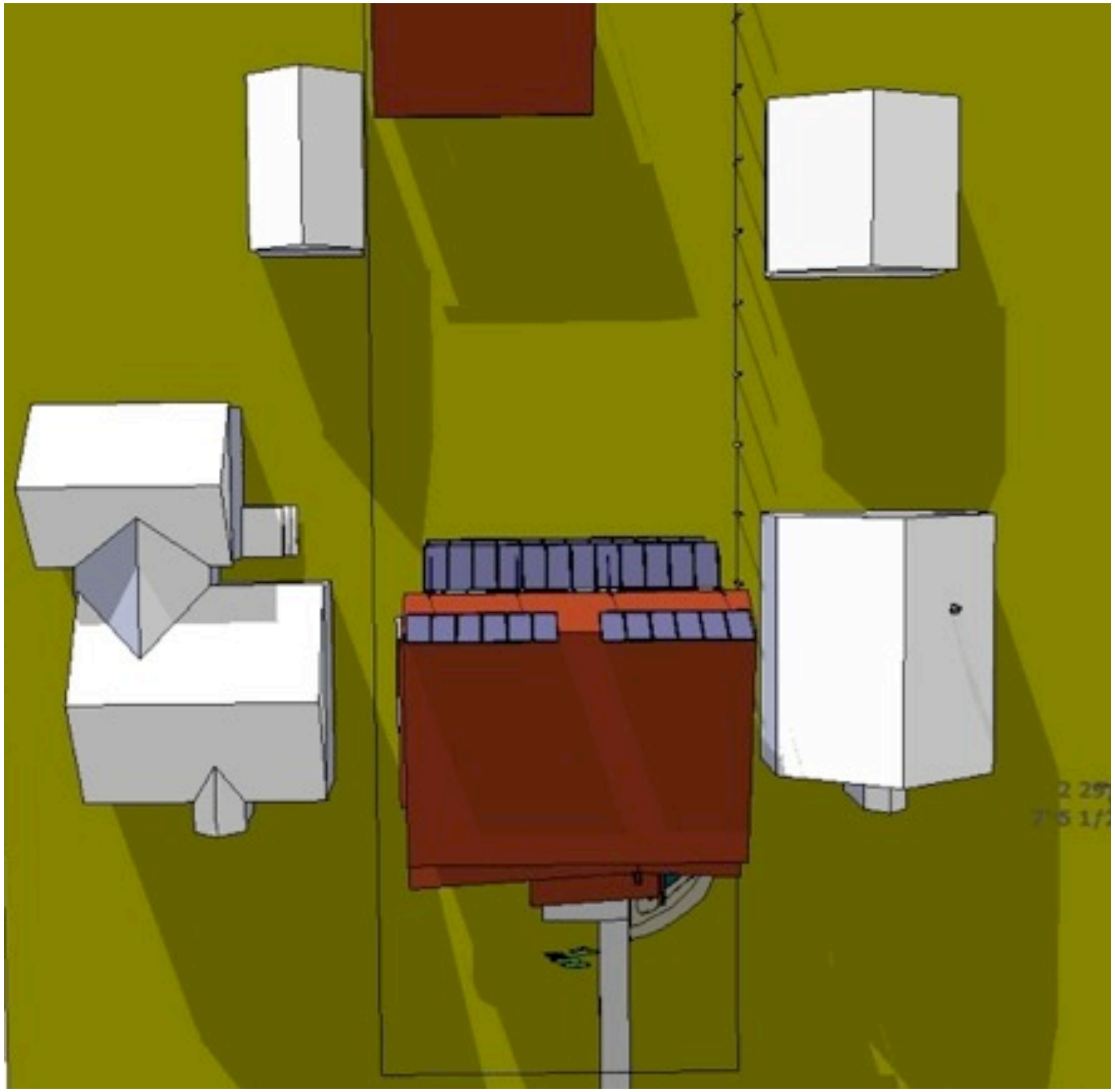


South Facing Front Yard



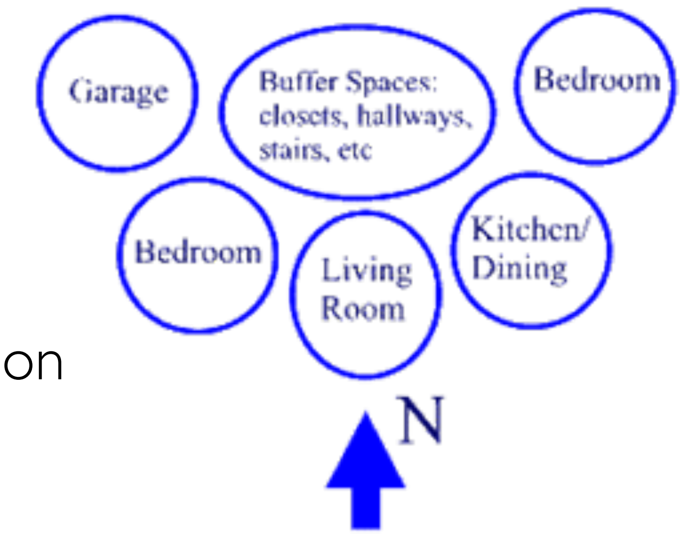
South Facing Back Yard





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 is a major challenge

House Shape Considerations

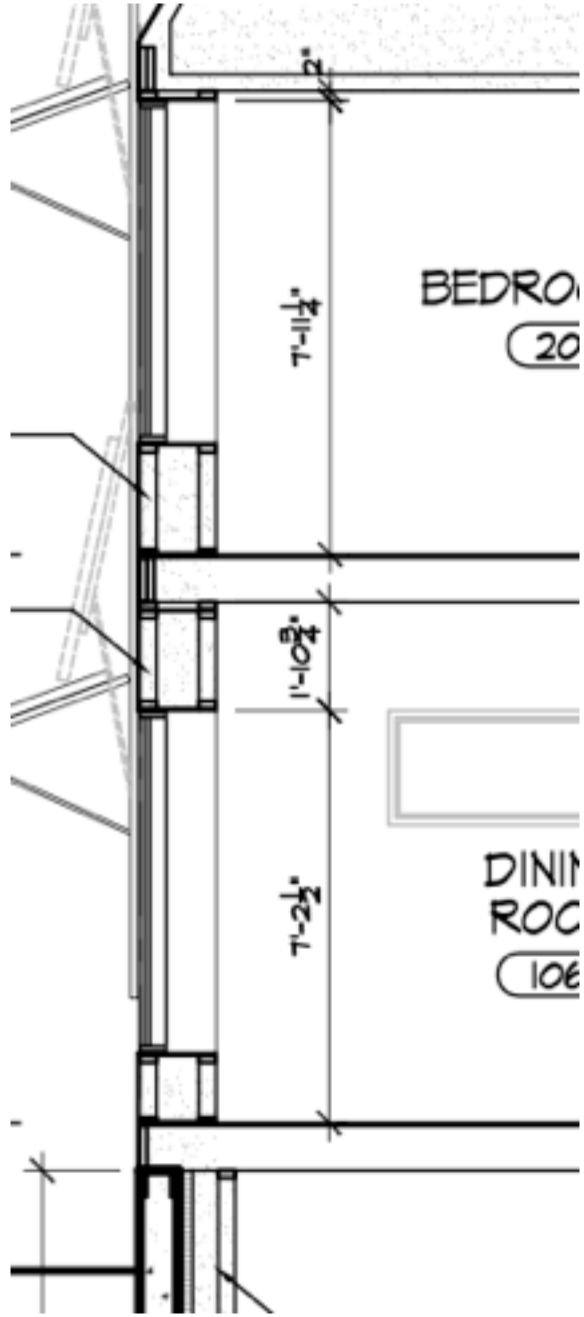
	Riverdale	Mill Creek	Belgravia	Parkland	Windsor Park
House square footage (sqft)(NIC Basement)	1850	2260	1920	4000	3360
House Volume (ft^3)	22389	23370	22500	60750	44539
House Total Surface Area (sqft)	4197	5317	4692	12301	7458
House volume to square footage ratio (ft^3/sqft)	12.1	10.3	11.8	15.15	13.25
House surface area to square footage ratio	2.26	2.35	2.44	3.08	2.21





Modelling

- Modelling is essential design for net zero at an optimum cost.
- Model before it too late to make changes
- Model early in the design process before people get attached to particular configurations
- Model in house if possible, but it is worth learning to play with the inputs of modelling by expert evaluators
- It is much easier the second and subsequent times.



Modelling Tools

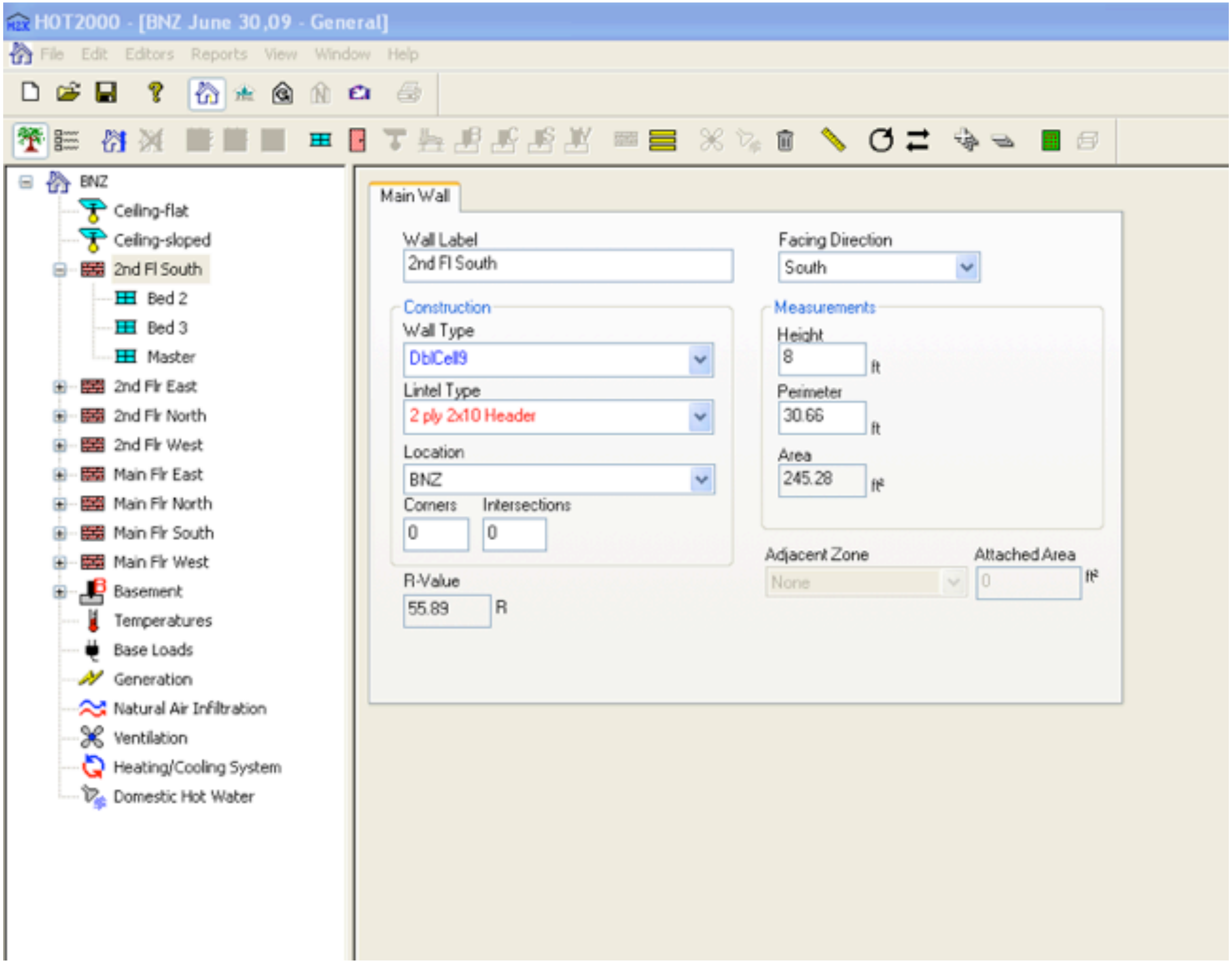
- HOT2000 tried and true, but makes no allowance for shading by adjacent structures
- Passive House Planning Package is excellent but a lot more more time consuming
- AkWarm
- Other programs- BeOPT, Energy Plus, HERS

Cost per kWh/year of energy conservation measures

=

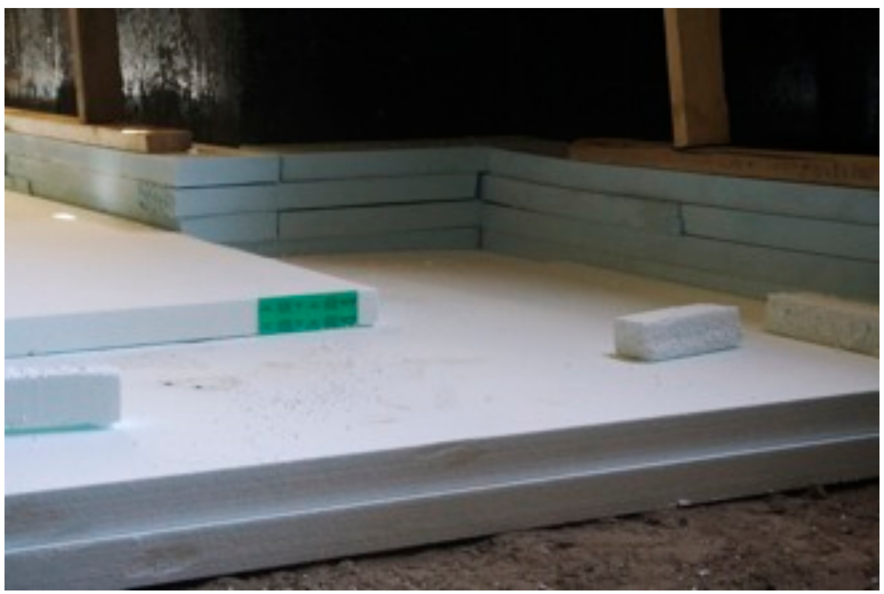
Cost per kWh/year of Energy collection

HOT2000 Wall Window

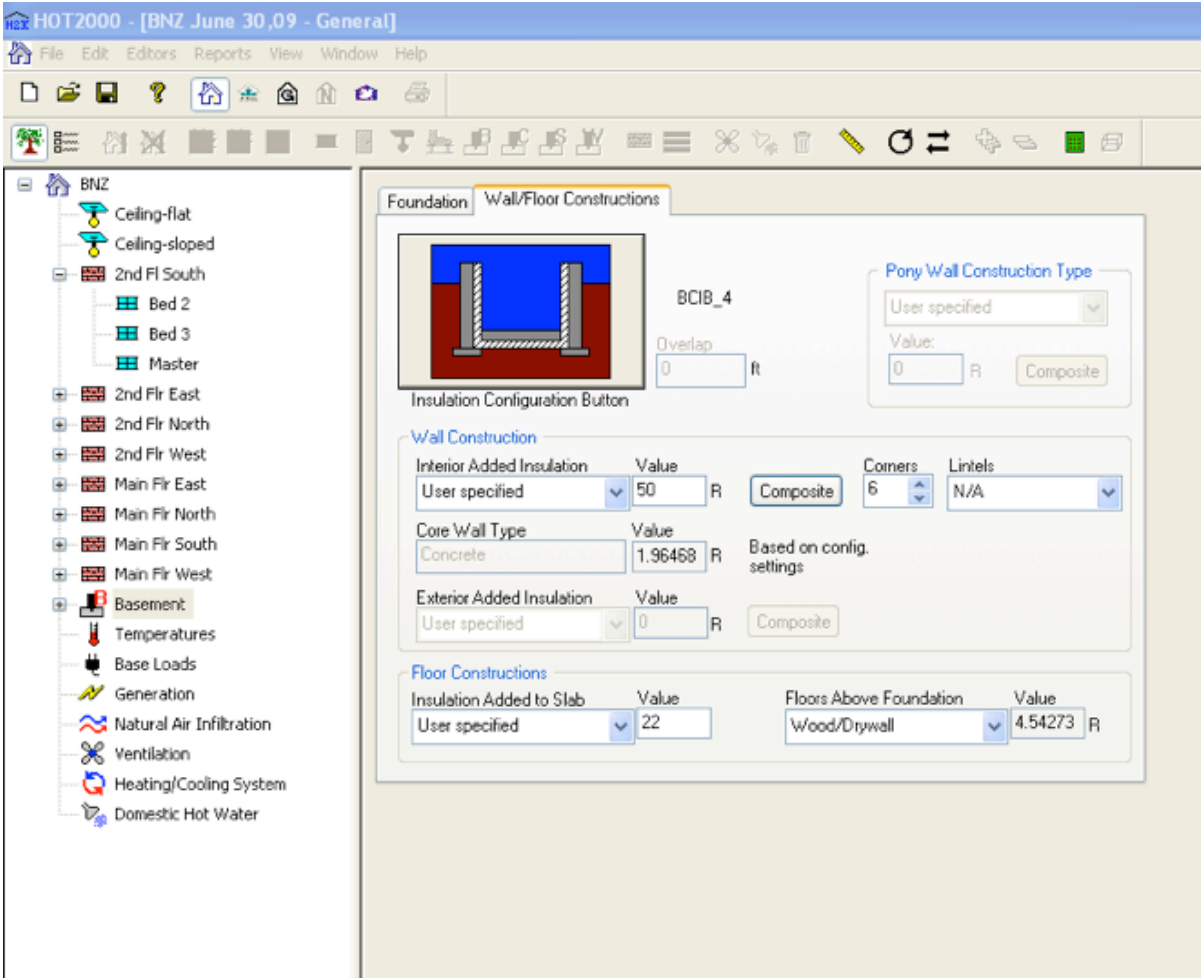


Envelope Modelling/Optimization

- Determine Current PV cost or benchmark energy price.
- Evaluate envelope upgrades with respect to cost per kWh/year
- Optimize envelope specifications
- Extra conservation cost can often be offset by simpler mechanical systems



HOT2000 Basement Window



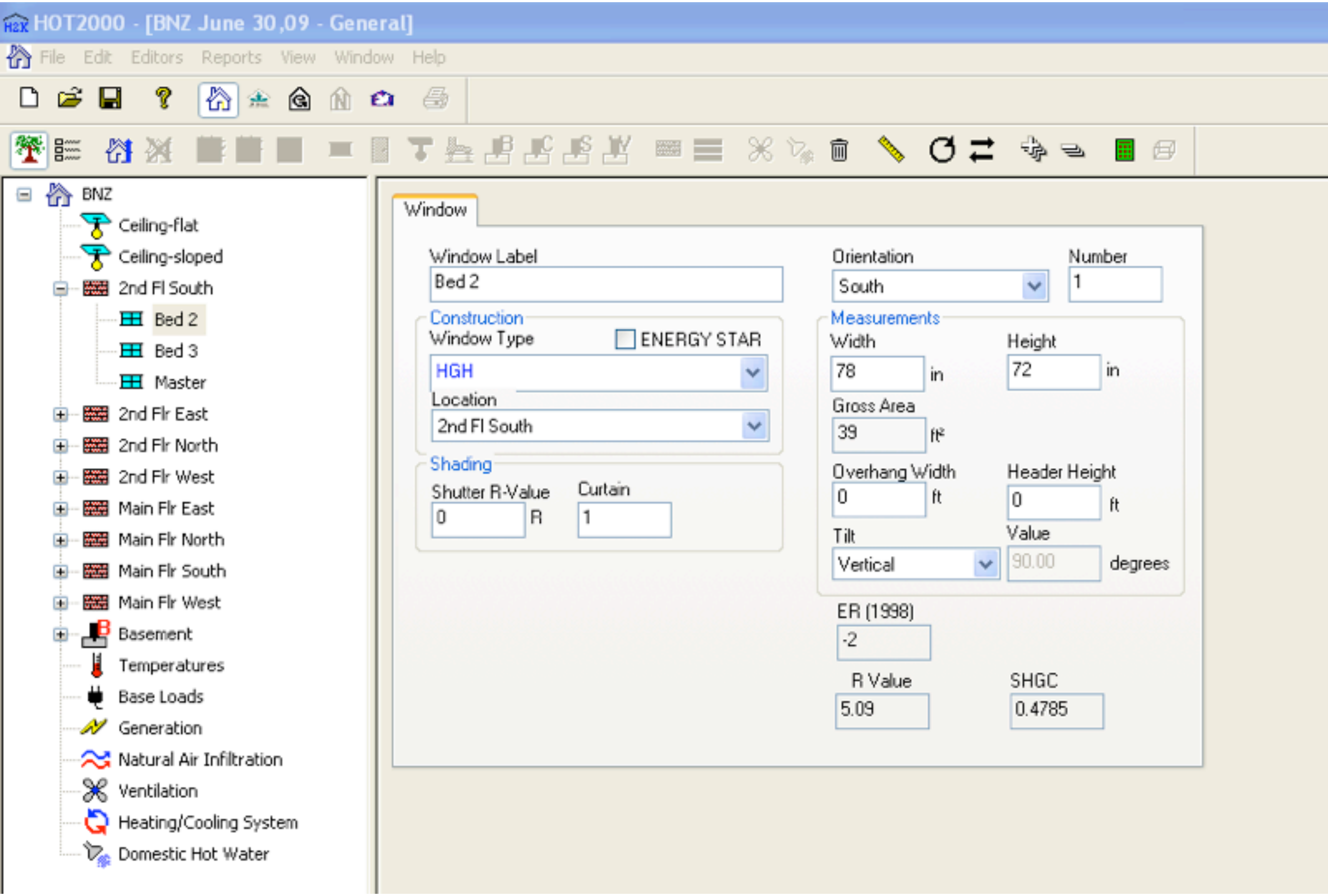
U .78, SHGC .57 (COG)

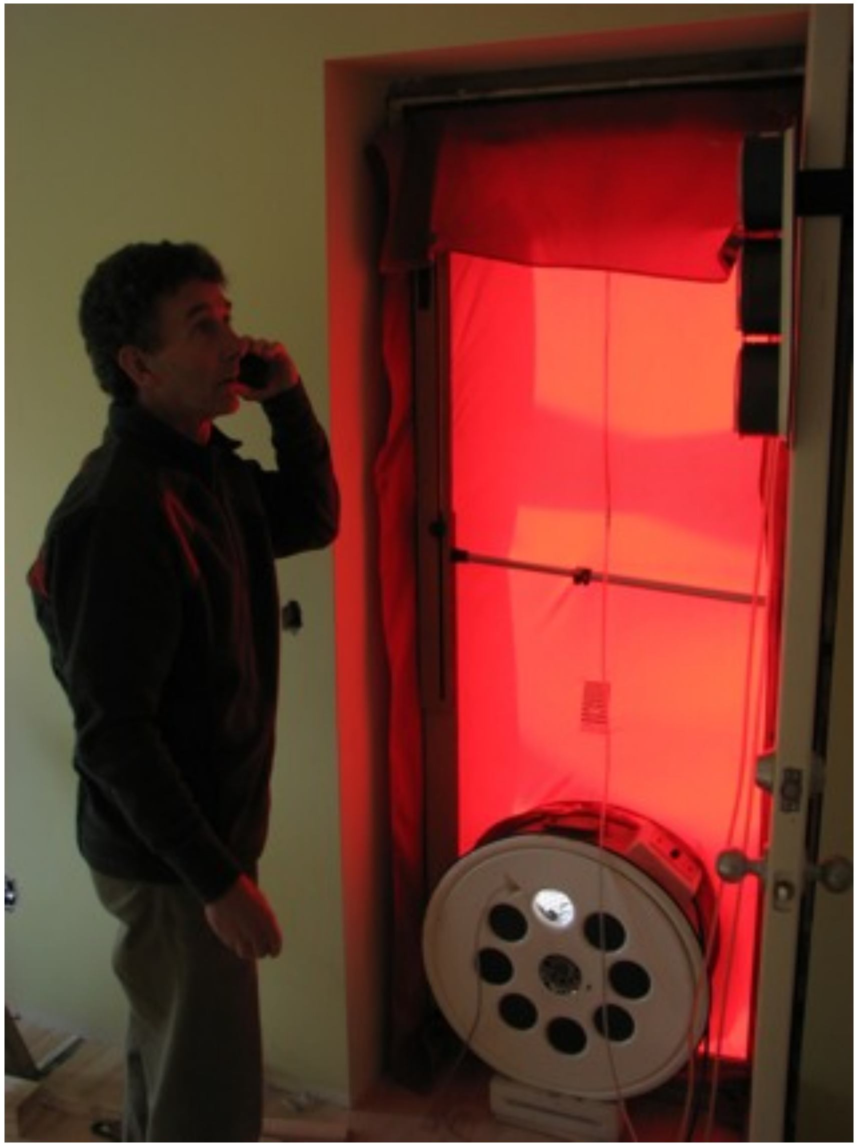
U .68, SHGC .37 (COG)

Windows

- Minimize South U value
- Maximize South SHGC
- Minimize East, West and North U value
- Minimize frame and spacer losses.

HOT2000 Window Window





- Air tightness is the very best investment you can make
- The reduction from 1.5ACH to .5 ACH saves 2048 kWh/ year. At $6.00 per annual kilowatt for PV, the capacity to generate that much energy every year will cost $12000.

Final Air Test results (-50pascals):
Riverdale 0.5
Mill Creek 0.36

kWh/year *savings of a few upgrades from standard construction

2x6 16" OC to 12" double wall (R40)	3860
12" double wall to 16" double wall (R56)	546
1.5 ACH to .5 ACH	1128
No thermal break at foundation	1280
R 60 attic to R 90 attic	215
Increase mass from light frame to heavy	1464

*Belgravia Net Zero with Anchorage weather data

BUILDING PARAMETERS SUMMARY

ZONE 1 : Above Grade

Component	Area ft^2 Gross	Area ft^2 Net	Effective (R)	Heat Loss Mil.BTU	% Annual Heat Loss
Ceiling	826.00	826.00	90.00	3.16	4.39
Main Walls	2064.61	1671.47	54.58	10.99	15.26
Doors	38.72	29.78	5.57	2.07	2.88
South Windows	254.19	254.19	5.12	19.25	26.73
East Windows	13.33	13.33	6.11	0.85	1.17
North Windows	79.83	79.83	5.56	5.56	7.72
West Windows	16.00	16.00	4.79	1.30	1.80
		ZONE 1 Totals:		**43.17**	**59.95**

INTER-ZONE Heat Transfer : Floors Above Basement

Area ft^2 Gross	Area ft^2 Net	Effective (R)	Heat Loss Mil.BTU
795.00	795.00	4.543	0.14

ZONE 2 : Basement

Component	Area ft^2 Gross	Area ft^2 Net	Effective (R)	Heat Loss Mil.BTU	% Annual Heat Loss
Walls above grade	182.40	122.90	-	1.24	1.72
Doors	20.50	17.22	6.47	1.03	1.43
South windows	42.28	42.28	4.80	3.40	4.73
Basement floor header	94.62	94.62	56.00	0.85	1.18
Below grade foundation	1524.60	1524.60	-	10.17	14.12
		ZONE 2 Totals:		**16.69**	**23.18**

Ventilation

House Volume	Air Change	Heat Loss Mil.BTU	% Annual Heat Loss
22500.01 ft^3	0.180 ACH	12.148	16.87

Building Envelope Details

	Riverdale	Mill Creek	Belgravia	Typical
Air Tightness ACH at -50 pascals	0.5	0.36	0.5	2-4
Wall Insulation (R)	56	56	56	15
Roof/ Ceiling Insulation (R)	100	90	90	30- 40
Basement walls (R)	50	50	50	12
Basement Floor (R)	24	22	22	0

Domestic Hot Water Reduction

- Low Flow Showers and Faucet Aerators
- Efficient Appliances
- Aim for 150 litres of hot water per day or less

Reduce Water Heating Energy

- Drain Water Heat Recovery - Configure plumbing for shower water collection
- Electric or Condensing Natural Gas - 90% + efficiency
- Demand Hot Water Tanks
- Insulate Hot Water Tanks

Electrical Load Reduction

- Energy Efficient Appliances
  - refrigerator
  - clothes washer
  - cooking
- Energy Efficient Lighting
  - compact fluorescents
  - LEDs
  - task lighting
  - day lighting
- Energy Efficient Motors
  - ventilation
  - heating
- Phantom Load Control
- Consumption Monitors

Envelope Modelling/Optimization

	Belgravia NZ in Anchorage *	Belgravia NZ in Edmonton
Total Annual Heating(kWh/year)	5678	3570
Total Annual DHW(kWh/year)	3191	2987
Total Annual LAME (kWh/year)	3832	3833
Total Annual Energy Use (kWh/year)	12701	10390

* as built in Edmonton

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Optimize Passive Solar

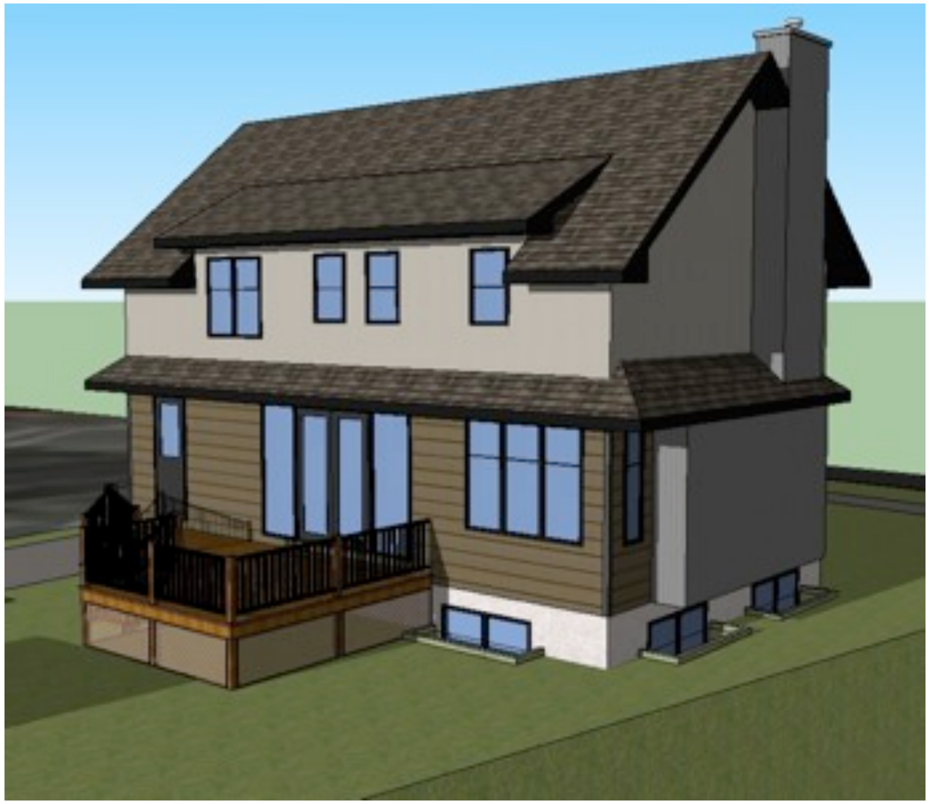
- Maximize solar gain
- Check Model for Overheating
- Add overhangs
- Add thermal mass

Optimizing South Glazing Area

(From the HOT2000 House Comparison Report)

ANNUAL SPACE HEATING SUMMARY	Original Belgravia design	Minus 2 South Windows	Minus 1 South Window	Plus 1 South Window
Design Heat Loss (BTU/hr)	27163	25583	26306	28074
Gross Space Heat Loss (Mil.BTU)	53.7	49.0	51.2	56.5
Sensible Occupancy Heat Gain (Mil. Btu/day)	1.60	1.60	1.60	1.60
Usable Internal Gains (Mil.BTU)	10.9	10.8	10.9	11.0
Usable Internal Gains Fraction (%)	20.4	22.0	21.2	19.5
Usable Solar Gains (Mil.BTU)	25.1	19.8	22.1	27.7
Usable Solar Gains Fraction (%)	46.7	40.4	43.2	49.1
Vent. Electrical Contribution (Mil.BTU)	7.4	7.4	7.4	7.4
Auxiliary Energy Required (Mil.BTU)	17.7	18.4	18.2	17.7
SPACE + DHW ENERGY (Mil.BTU)	30.3	31.0	30.7	30.3
R-2000 SPACE + DHW TARGET (Mil.BTU)	70.2	70.2	70.2	70.2

Overhangs/ Shading

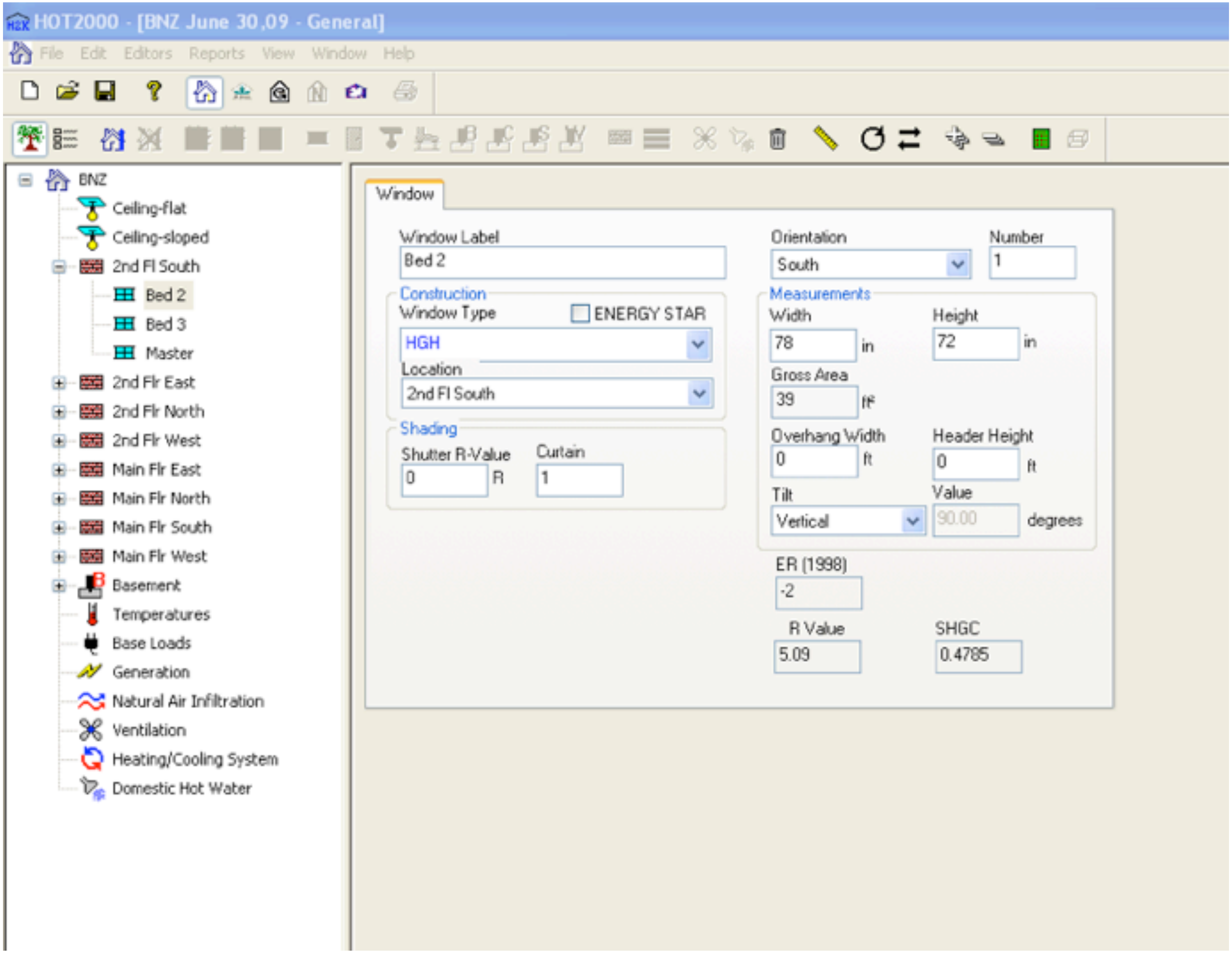


January 17

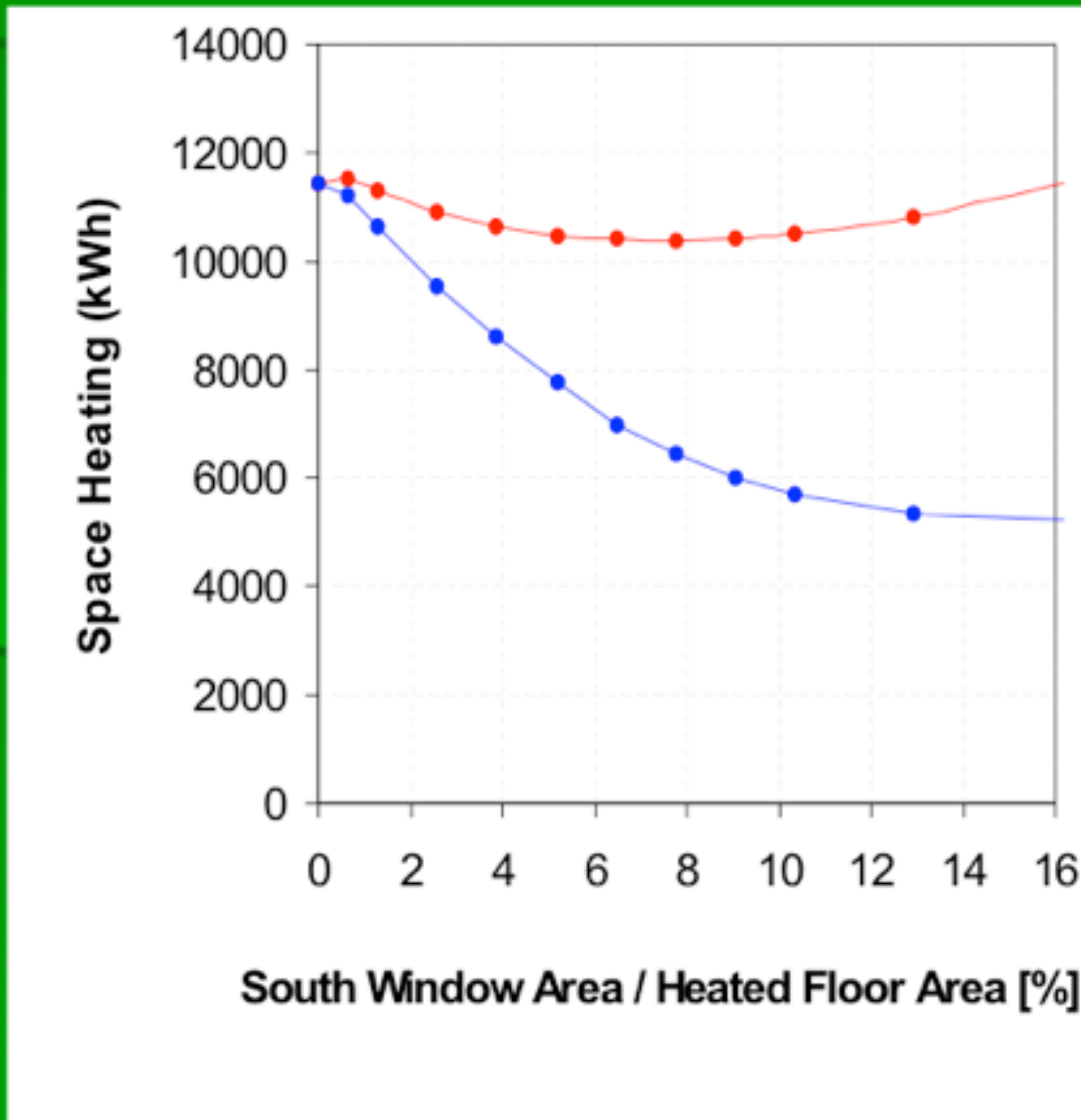
June 21

Juneau Sun Angles

HOT2000 Window Window



Higher Performance Windows & High Thermal Mass



Upper Line
Light, wood frame, construction

Triple paned, low-e, argon filled, windows

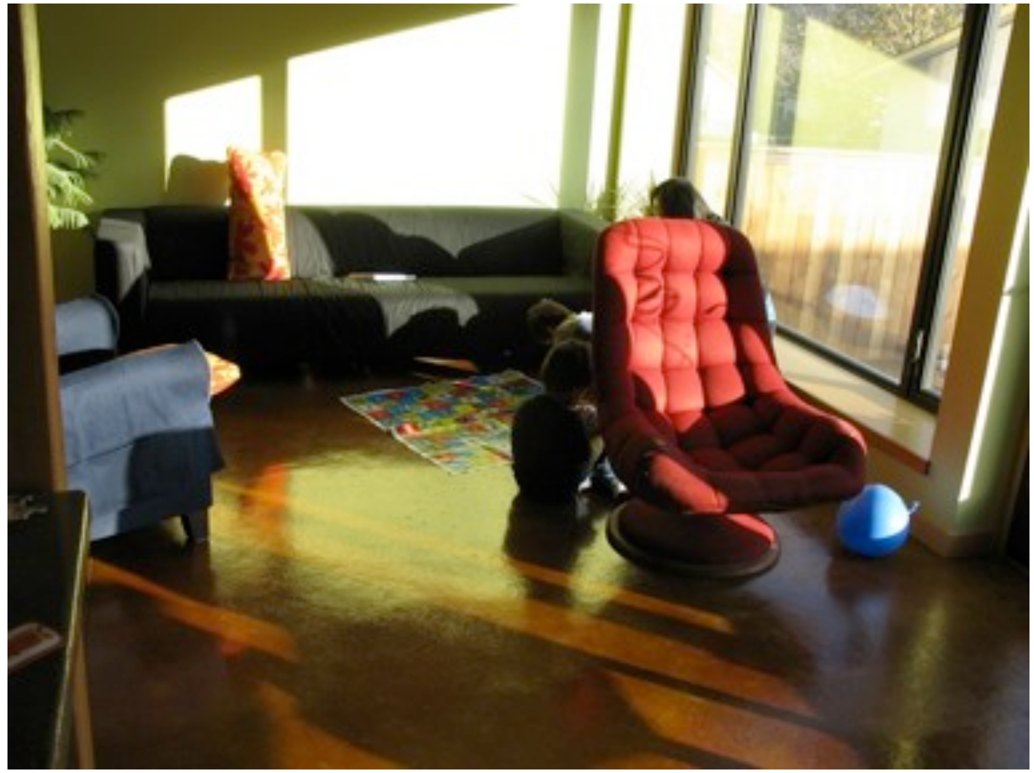
Lower Line

Change construction to very high thermal mass and install new windows

Riverdale NetZero Passive Solar Energy

- 35–40% of heating energy
- 18 m^2 of south glazing
- 10% south glazing to floor area ratio
- Added 7000 kg mass

Mill Creek Passive Solar



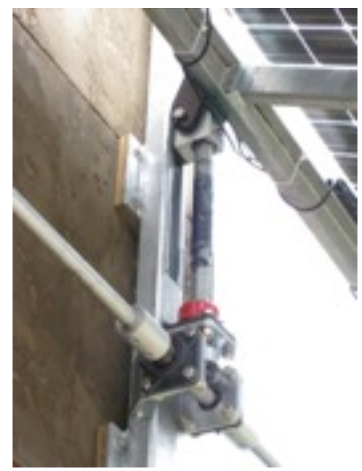
- Maximum south window area
- 64 mm concrete floor overlay
- Summer shading
- Over 50% of total annual space heat needs

Mill Creek NetZero

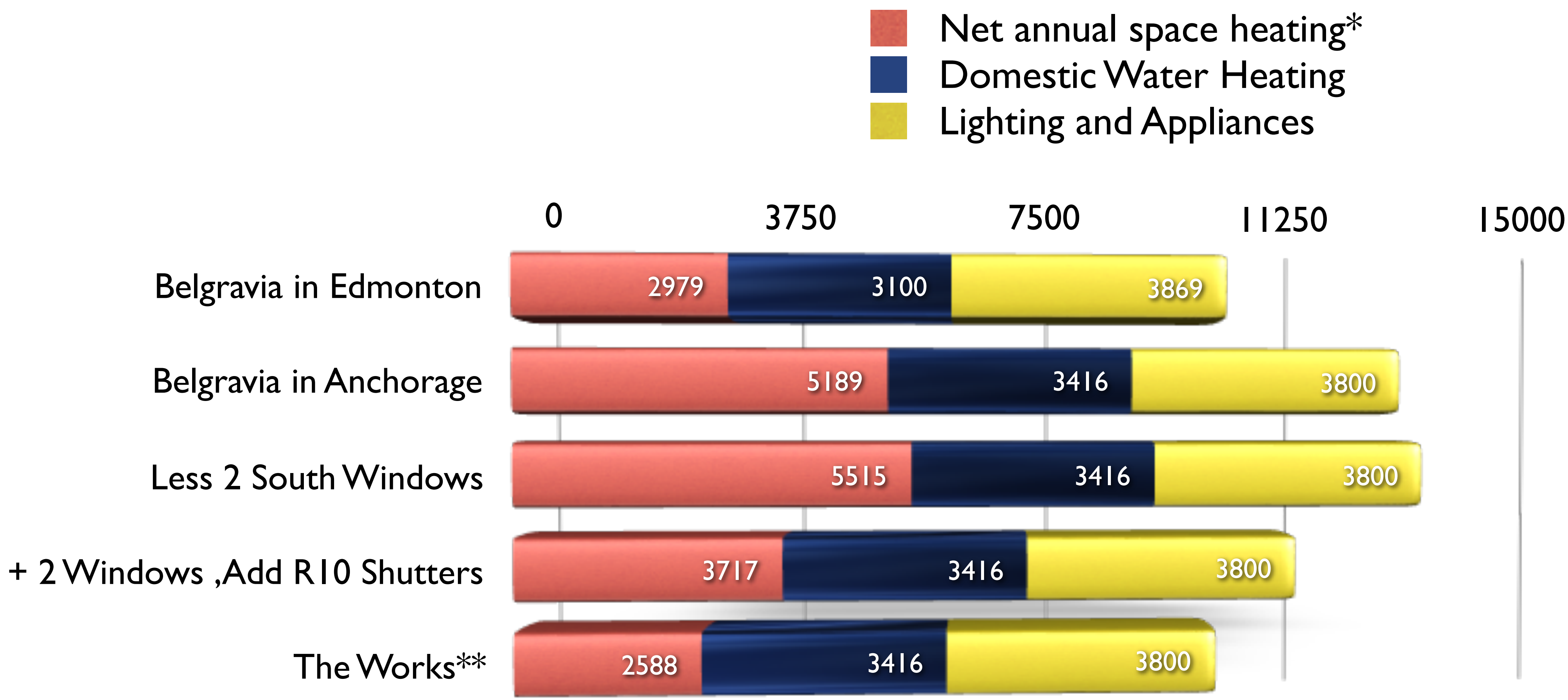
Moveable PV Awning

September 10

October 17



Total Annual Energy Use Summary(kWh/year)



**R75 Wall, R100 Roof .Add 2 Windows, R20 Shutters Reduce North Windows, Increase Foundation Insulation to R60

*After including passive solar and <u>internal</u> gains

Monthly Heating Energy

MONTHLY ENERGY PROFILE

Month	Energy Load (/m3)	Internal Gains (/m3)	Solar Gains (/m3)	Aux. Energy (/m3)
Jan	7.7	0.9	2.5	4.2
Feb	6.1	0.8	4.5	0.8
Mar	6.0	0.9	3.4	1.7
Apr	4.3	0.9	2.9	0.5
May	3.0	0.9	1.6	0.4
Jun	2.0	0.9	0.8	0.3
Jul	1.7	0.8	0.6	0.3
Aug	1.9	0.9	0.8	0.2
Sep	2.7	0.9	1.5	0.3
Oct	4.6	1.0	2.2	1.4
Nov	6.2	0.9	1.5	3.8
Dec	7.5	0.9	2.9	3.7
Ann	53.7	10.9	25.1	17.7

Net heating required from Solar Thermal or PV

Solar DHW Design

- Small solar domestic hot water systems make sense. Consider:
  - Flat Plate vs Evacuated Tube
  - Roof Space and Access
  - Pathway through the house
  - Optimum angle considerations.
  - Drain back tank location
- Modelling
  - Retscreen
  - Watsun 2009

PV Considerations

- Solar array is mounted at 53°tilt or steeper to :
  - Maximize annual electricity production
  - Minimize snow cover,
- Match roofing and module longevity
- Higher efficiency modules cost more per watt
- Cost is coming down slowly