ALASKA CENTER FOR APPROPRIATE TECHNOLOGY

Promoting Research and Education for Alaskans in Sustainable Development

acat.org

ZERO ENERGY HOMES: A GROWING MARKET

Mark Masteller
Asst. Professor of Sustainable Energy
Mat-Su College

Jason Collins, AIA, LEED AP, CEA
Architect and Energy Auditor
Palmer, Alaska

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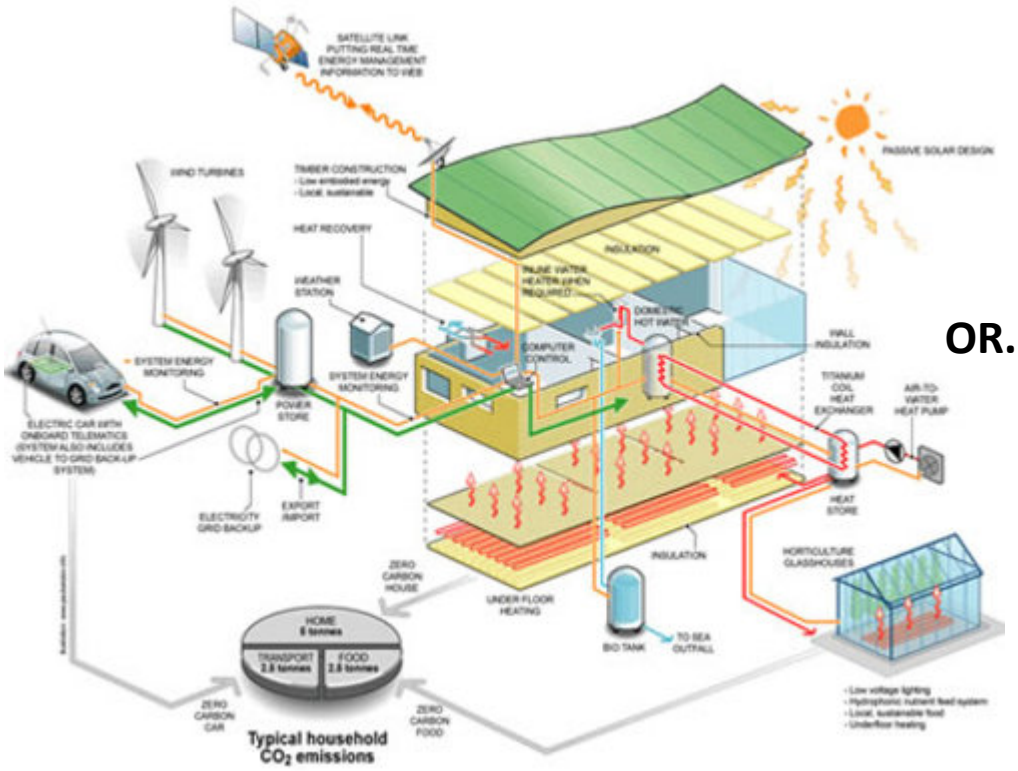
NAVIGATING YOUR PATH TO NET ZERO ENERGY



OR.

What are we thinking about when we hear Net Zero Energy?

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NET ZERO ENERGY BUILDING

Net Zero Energy Definition

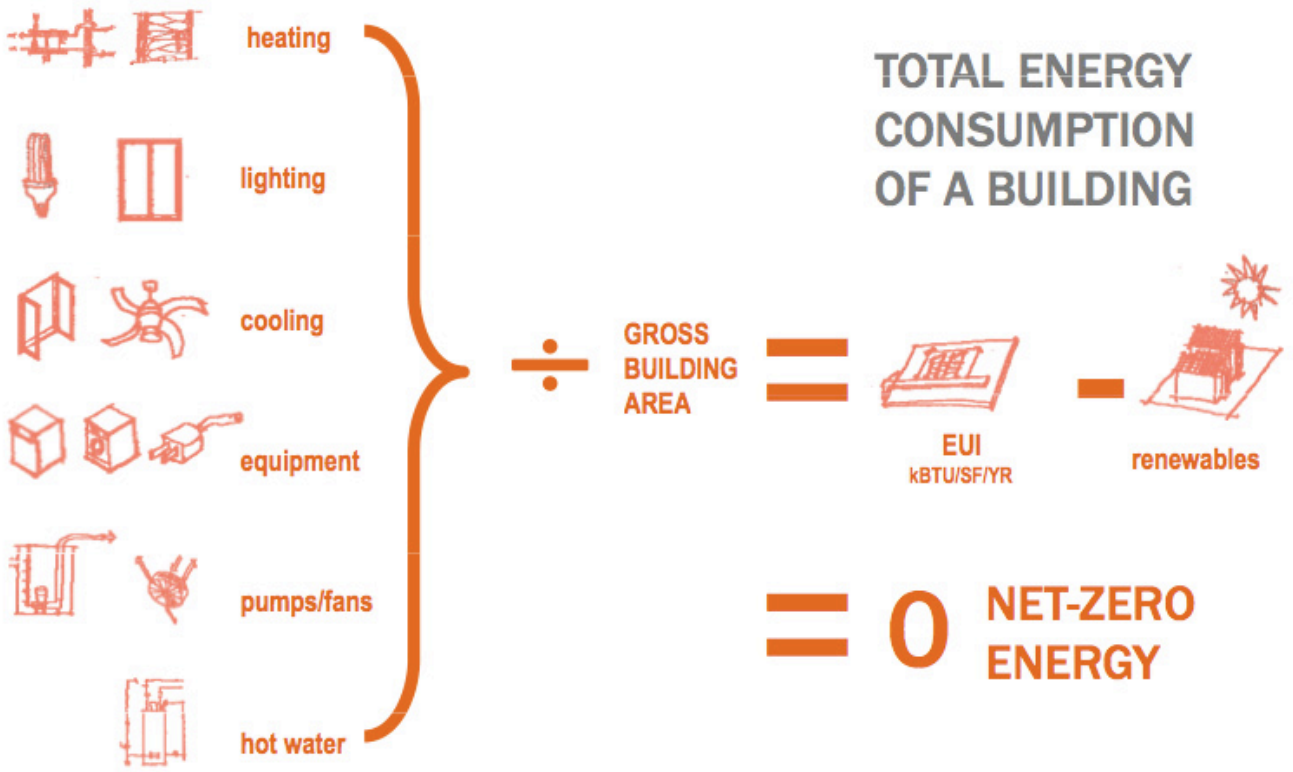
Envelope
- Spreadsheet
- Heat Loss
- Insulation

Heating
- Heating Methods
- Storage

Electric Usage
- Spreadsheet
- Reductions

Renewables
- PV Watts
- Grid-tie
- Storage

Overall Review



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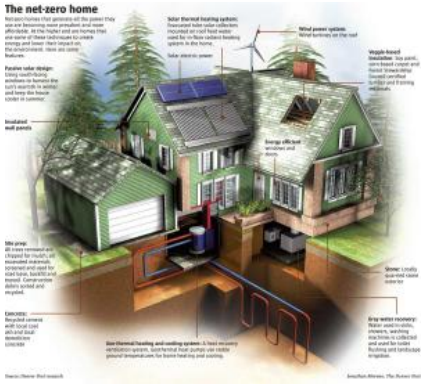
WHAT DOES A NET ZERO ENERGY BUILDING LOOK LIKE?



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IS NET ZERO ENERGY BUILDING POSSIBLE IN ALASKA?

HAVEN'T ALASKANS BEEN DOING NET ZERO FOR YEARS?

- **Is it net zero energy?**
- **Are you producing as much energy as you use?**
- **How does wood harvesting and burning enter in?**
- **Is it more energy intensive on the surrounding land?**
- **How much different is your lifestyle?**

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Alaska's First Net Zero Energy Homes

Thorsten Chlupp, REINA, LLC Fairbanks builder

Details:

- **R70 Cellulose Walls**
- **Triple Pane Window**
- **Thermal Shutters**
- **R100 Roof**
- **Solar Thermal**
- **5000ga Storage Tank**
- **Masonry Wood Heater**

"You wouldn't believe how many engineers have told me in the past year that it's impossible," Thorsten Chlupp said of the fossil-fuel free system. "I already know I need to build an outdoor swimming pool because I have too much heat."

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World's Tightest Home

Tom Marsik, UAF Dillingham Renewable Energy Professor

Details:

- **New (600sf)**
- **R90 Walls**
- **R100+ Roof**
- **Minimal glazing**
- **0.05 ACH at 50Pa**
- **3,700kwh annual (including heat)**
- **Testing an air to air heat pump**

"We are certainly excited about this. The purpose of this world record attempt was to help bring attention to energy efficiency, and hopefully motivate others to be energy efficient. With this official world record, I think it really helps emphasize our message of what's possible."

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Valley Near Net-Zero

Harvey and Sandy Bowers, Agate Inn, Wasilla

Details:

- **Retrofit**
- **R50 Walls**
- **R7 Fiberglass windows**
- **R70 Roof**
- **Solar Thermal (32 tubes)**
- **4 .3kw Solar PV and Tracking Array**
- **Water Storage Tank (2000ga)**

Harvey and Sandy founded ACAT and have been working on making their home and the buildings at the Agate Inn Net Zero Energy. They are currently working on a campus solar thermal and solar photovoltaic arrays for the Agate Inn.

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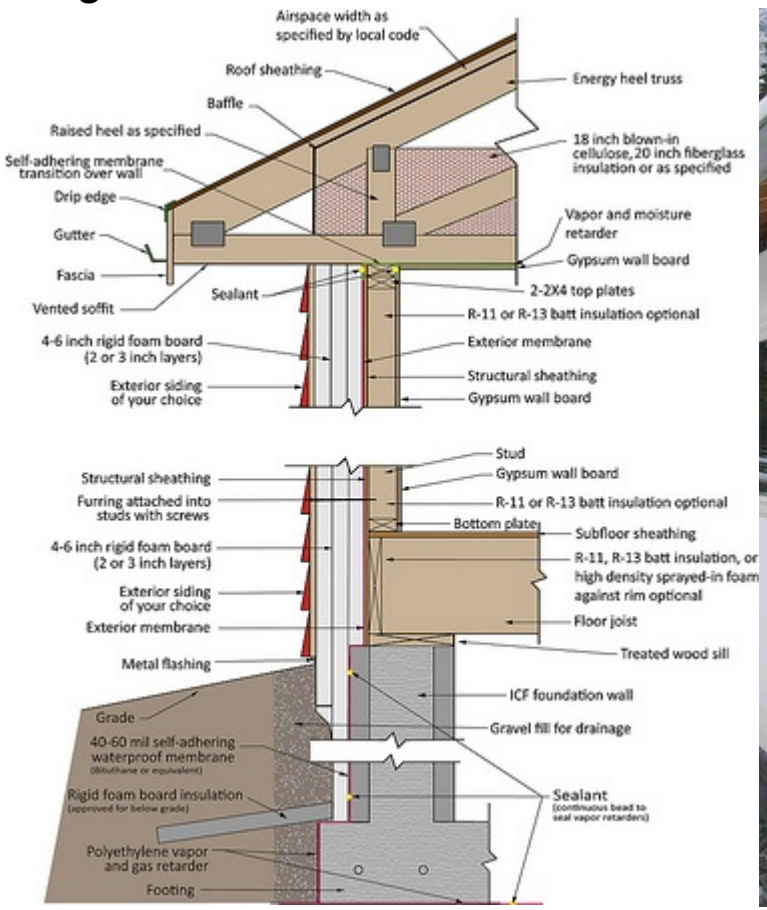
Exterior Wall Retrofits

Margie Subers, Palmer

Details:

- **REMOTE Wall 8” Foam on Walls**
- **R60 Roof**
- **Triple pane windows**
- **Heat Recovery Ventilation**
- **Geothermal pre-heat loop**



Margaret built her own home using exterior insulation technology and has shared her knowledge and experience. Her workshop shared a mock up example of a wall section utilizing this technique, including some basic details for window and wall penetration techniques.

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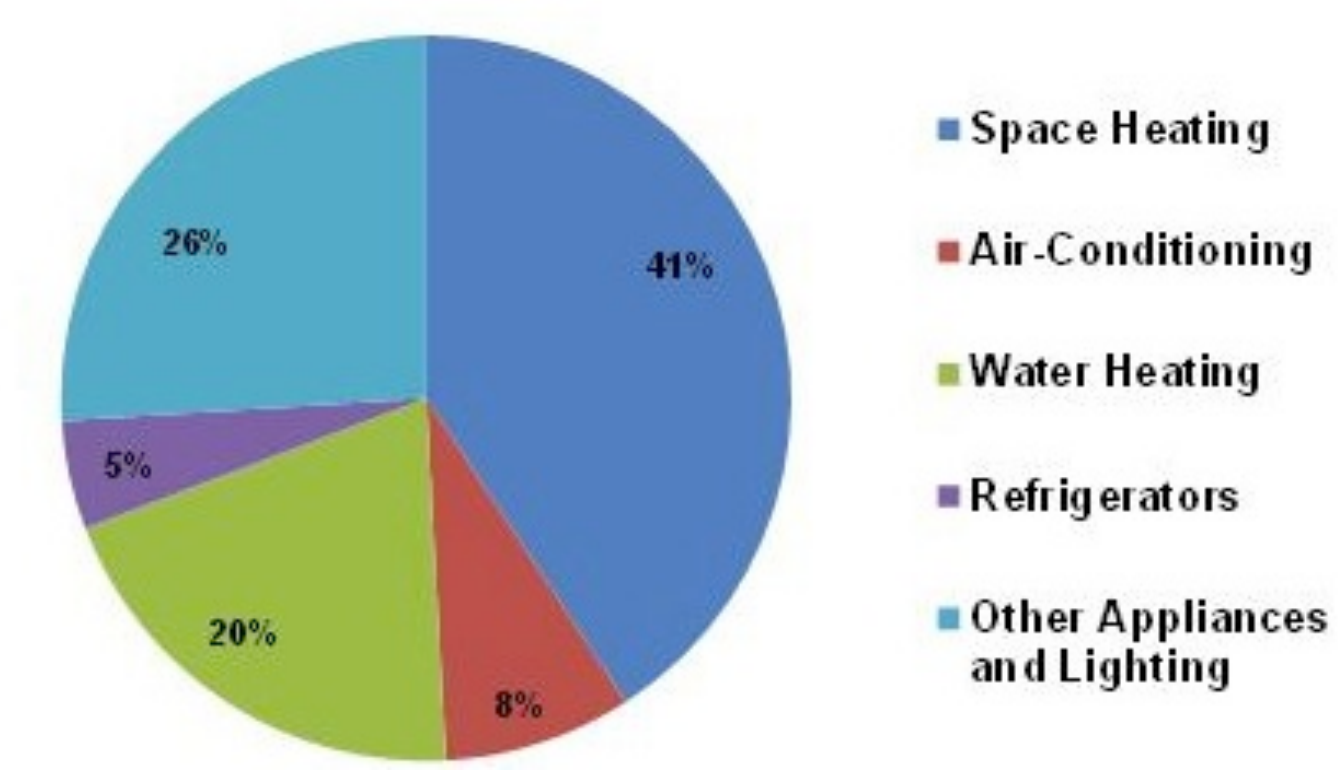
Building Energy Use

Where does all the energy go?



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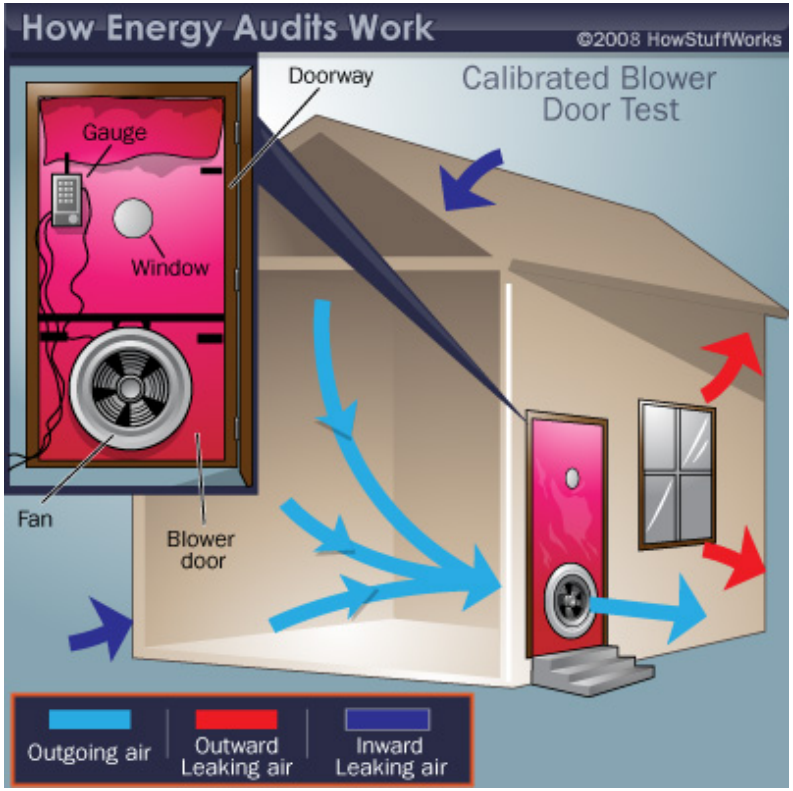
Energy Audits / Energy Rating

How do we measure where energy is being used?



Energy Audits
- Analyze existing utility bills
- Recommend improvements

Tools
- Measurement
- Blower Door test
- Energy Model

Residential
- Heating load typically highest
- Air sealing most cost-effective

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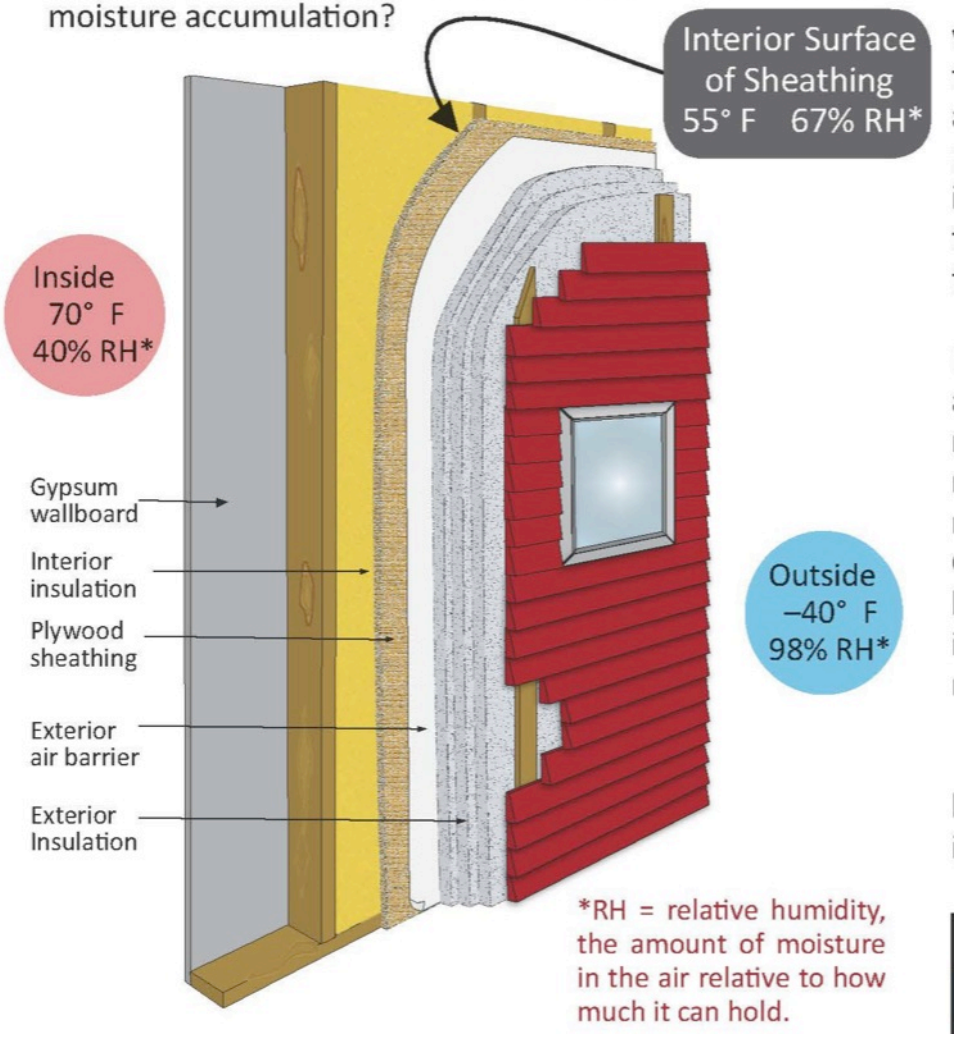
Remote Wall - Exterior Insulation

- Does the presence of a vapor retarder and exterior foam insulation create a "double vapor barrier" that can cause moisture accumulation?



Be sure to read the CCHRC reports and studies.
See Margie Suber's 2011 Wrap It Up presentation at ACAT.org.

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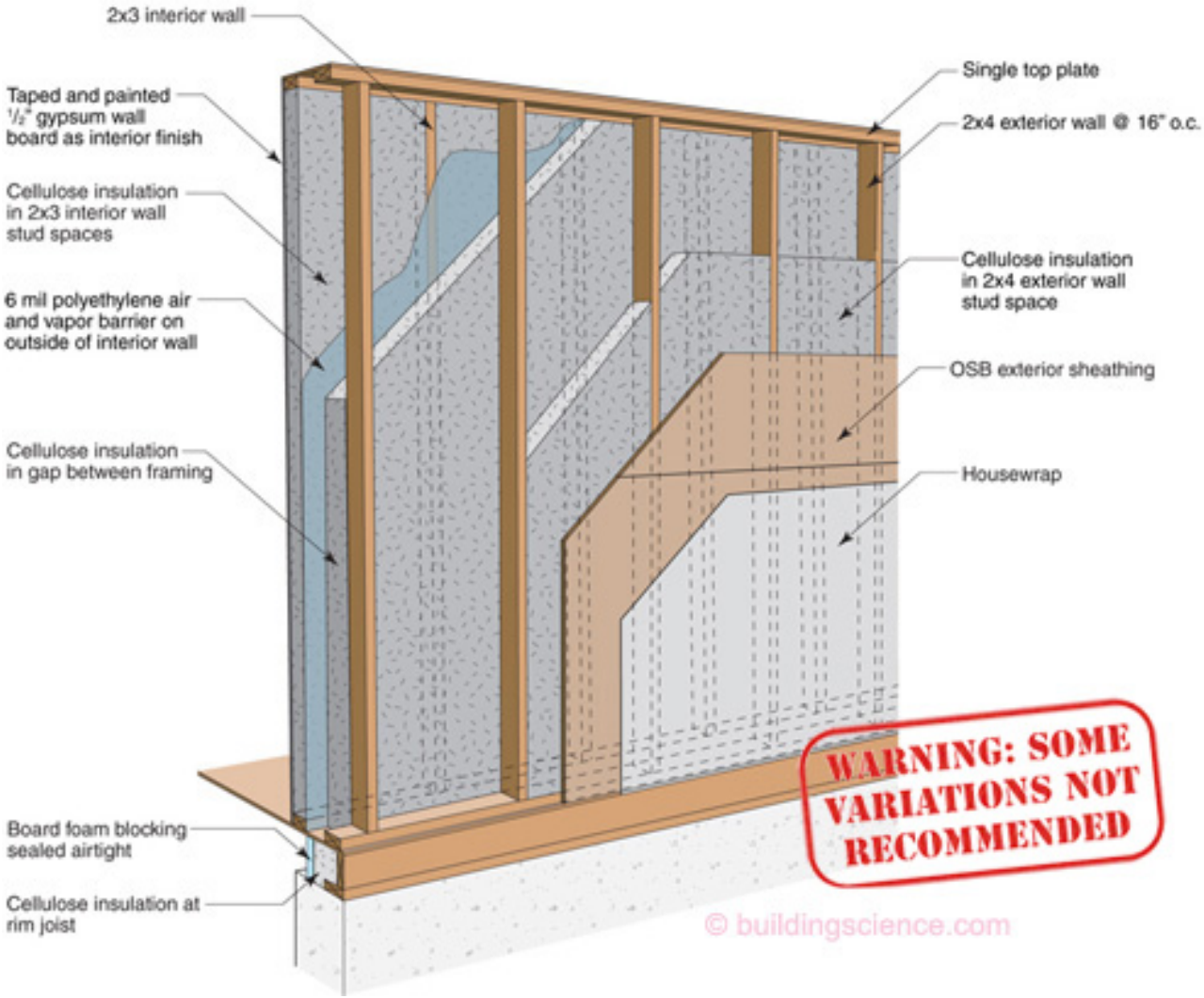
Arctic Wall - Double Stud with Cellulose Insulation



See Thorsten and Canadian Equilibrium presentations at ACAT.org.

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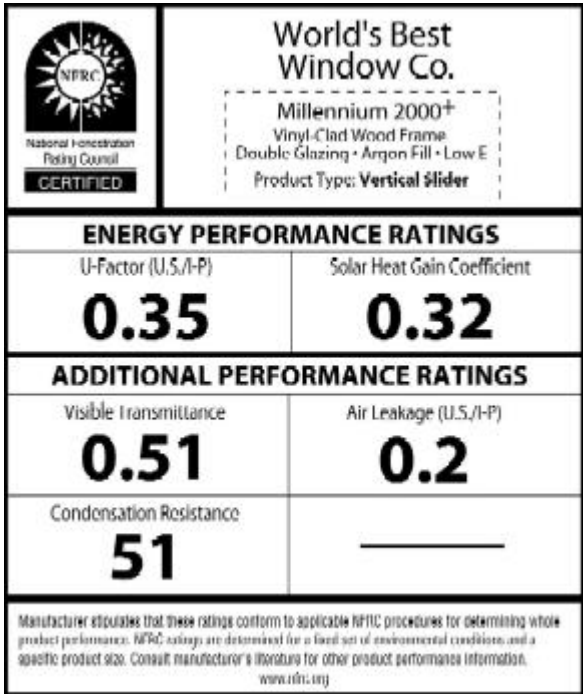
Windows



World's Best Window Co.

Millennium 2000+
Vinyl-Clad Wood Frame
Double Glazing • Argon Fill • Low E
Product Type: **Vertical Slider**

National Fenestration Rating Council CERTIFIED

ENERGY PERFORMANCE RATINGS

U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.35	0.32

ADDITIONAL PERFORMANCE RATINGS

Visible Transmittance	Air Leakage (U.S./I-P)
0.51	0.2
Condensation Resistance	
51	———

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information. www.nfrc.org

U-factor = insulation
= 1/R-value (ie. U=0.33, R=3)

SHGC = Solar Heat Gain Coefficient
(% of solar heat allowed through glass)

VT = Visible Transmittance
(% of visible light allowed through glass)

Air Leakage – Passiv Haus requirement

See Nancy Clanton's Lighting presentation at ACAT.org.
See Bronwyn Barry's Passiv Haus Window presentation at ACAT.org.
See UAF Co-Ops Alaska Solar Guide.

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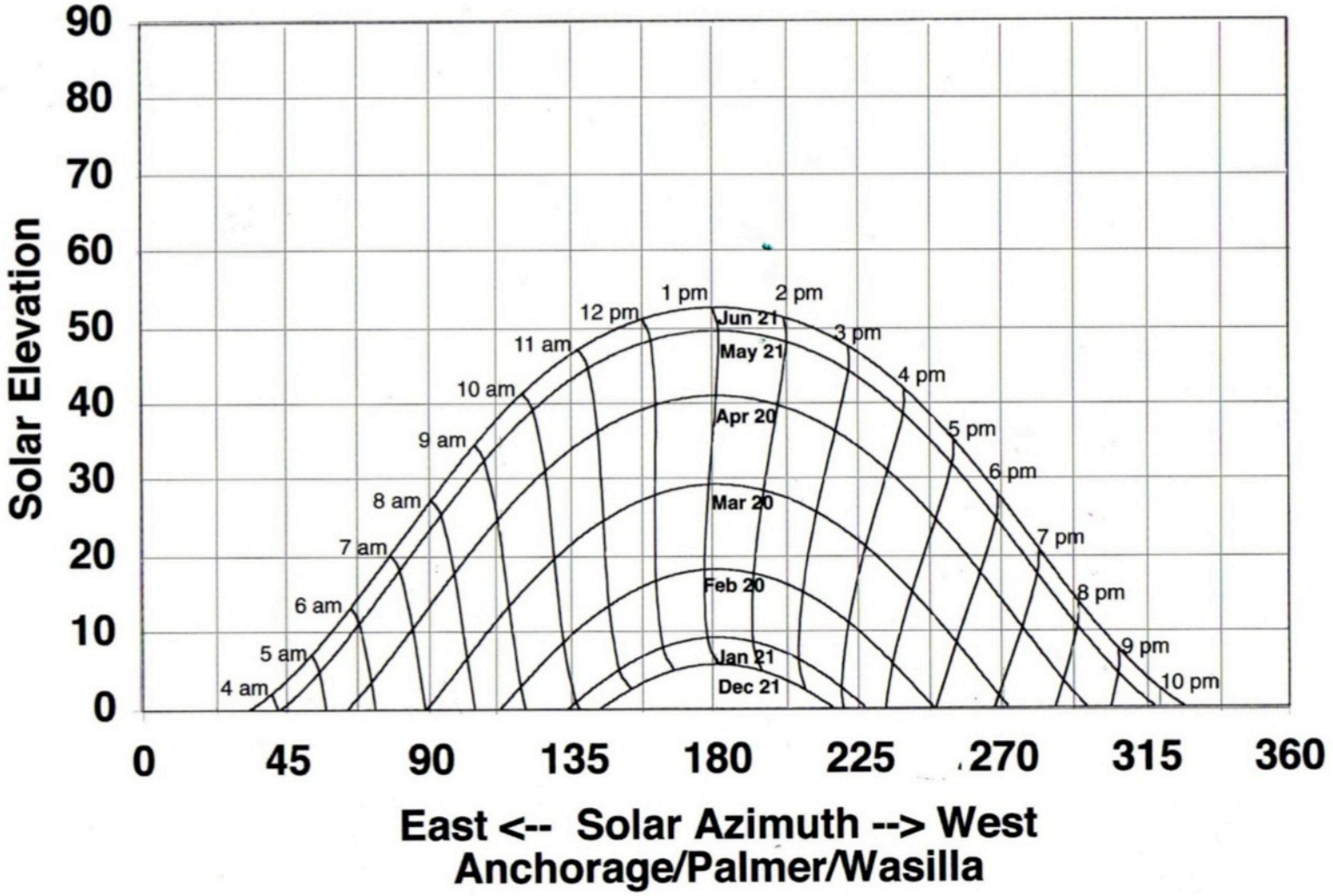
PASSIVE SOLAR



See UAF Co-Ops Alaska Solar Guide.

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PASSIVE SOLAR

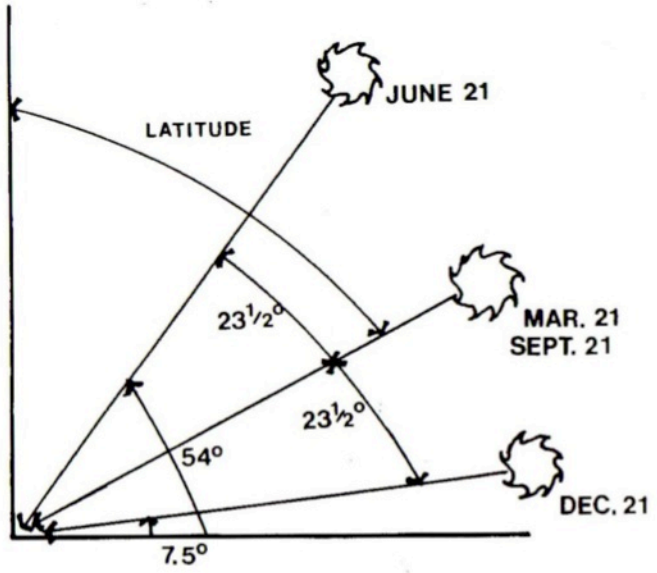

Figure 68a. The range of solar elevation angles at the latitude of Anchorage, Alaska (60°30′N). The maximum elevation is 54° on June 21, and the minimum is 7.5° on December 21.

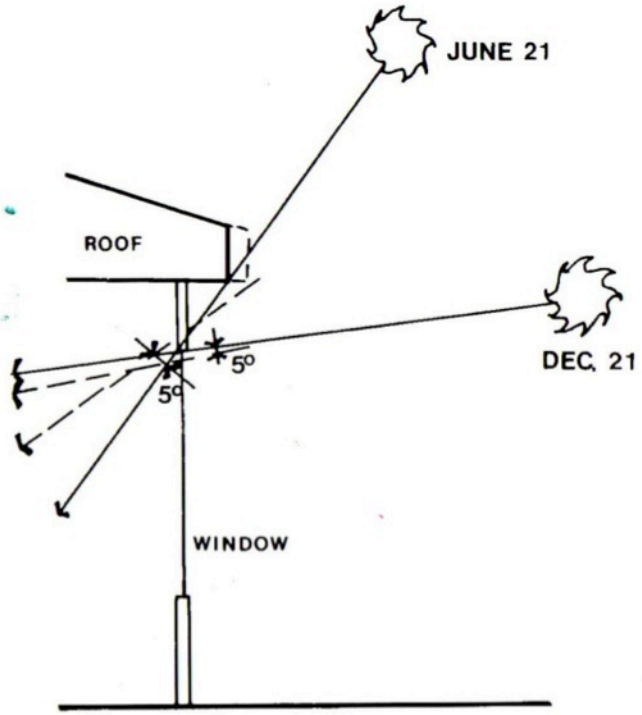

Figure 68b. Unlike the lower latitudes, a small overhang has little effect on shading the summer sun in Alaska. Larger overhangs are required in Alaska because of the lower solar elevation angles.

See UAF Co-Ops Alaska Solar Guide.
See Matt Oster's Alaska Greenhouse presentation at acat.org

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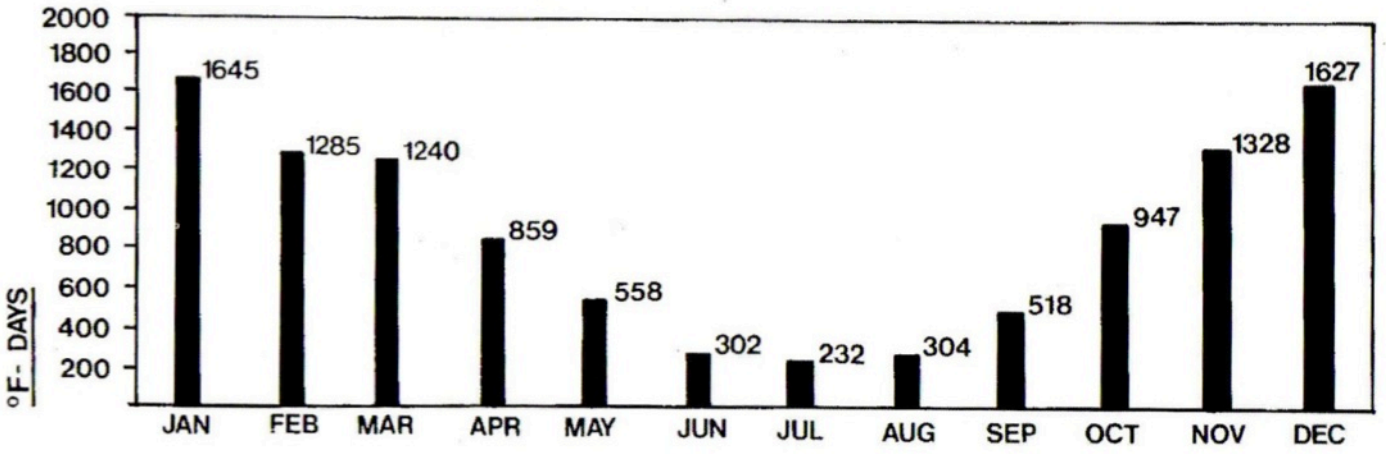
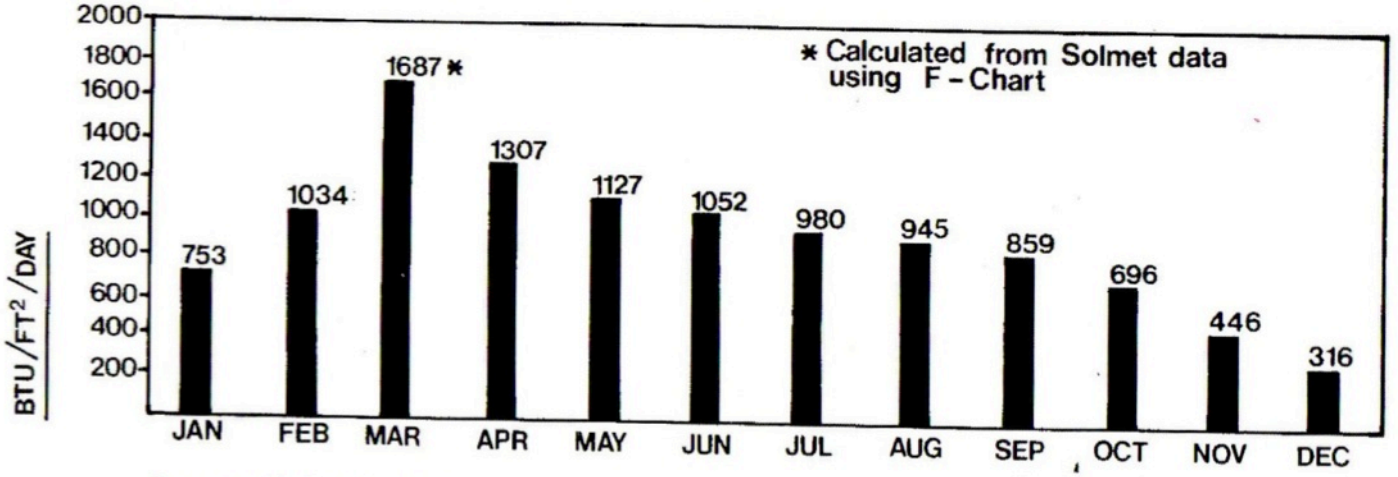
PASSIVE SOLAR vs. HEATING DEGREE DAYS



Average Monthly Heating Degree Days

Matanuska, Alaska



Average Solar Radiation on a Vertical South Facing Surface

Matanuska, Alaska

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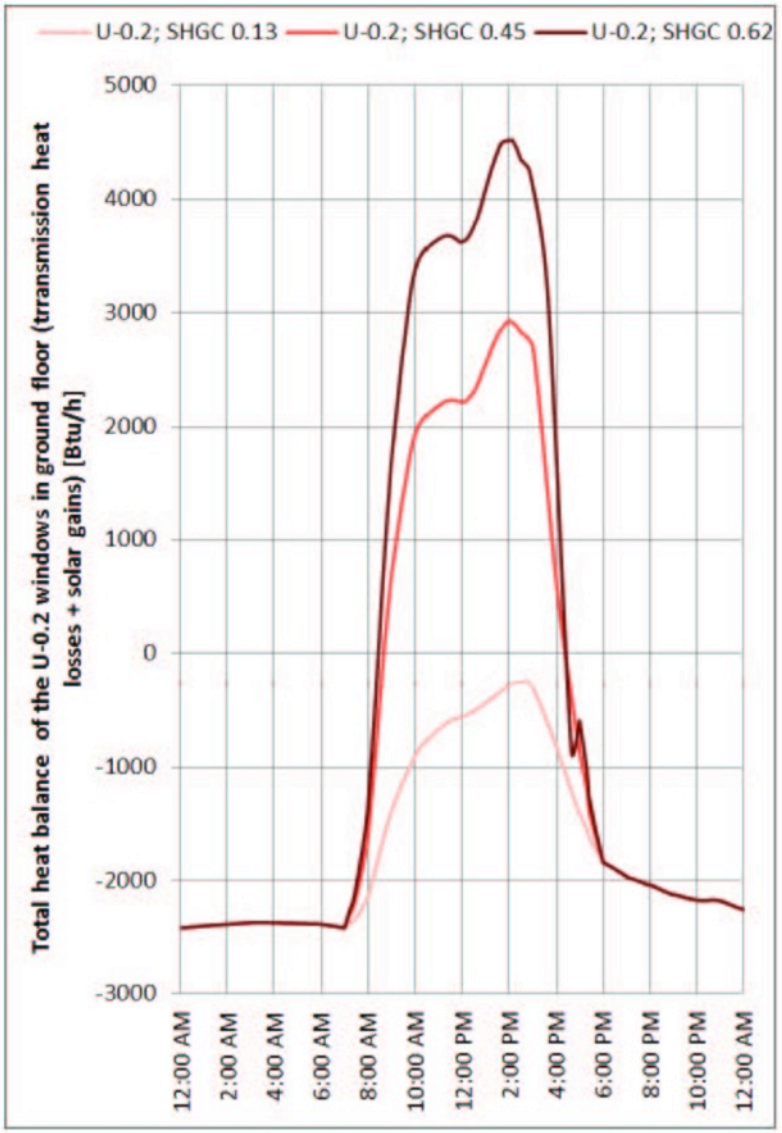

Figure 3. Heat balance of U-0.2 windows on March 1 with different SHGC.

See CCHRC Martin Window Study

Windows

How do we determine the balance between gains from passive solar vs. heat losses from poor R-value?

Passive Solar Gains
- Heat Losses
Total Heat Balance

Day-time: Gains depending on SHGC and orientation

Night-time: all loss

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Windows
Exterior Insulated Shutters

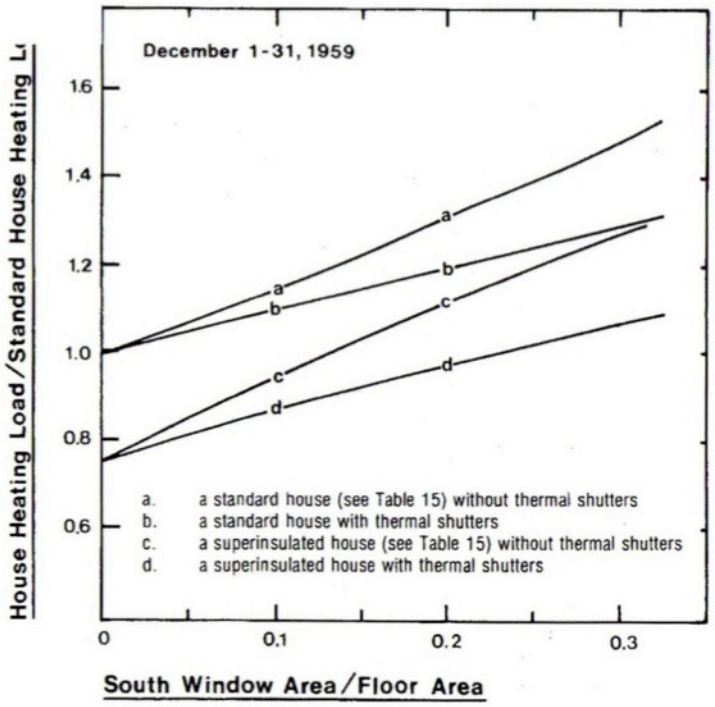

Figure 61. Increasing the window area of a structure to improve solar gain always results in increased heat loss for the month of December.

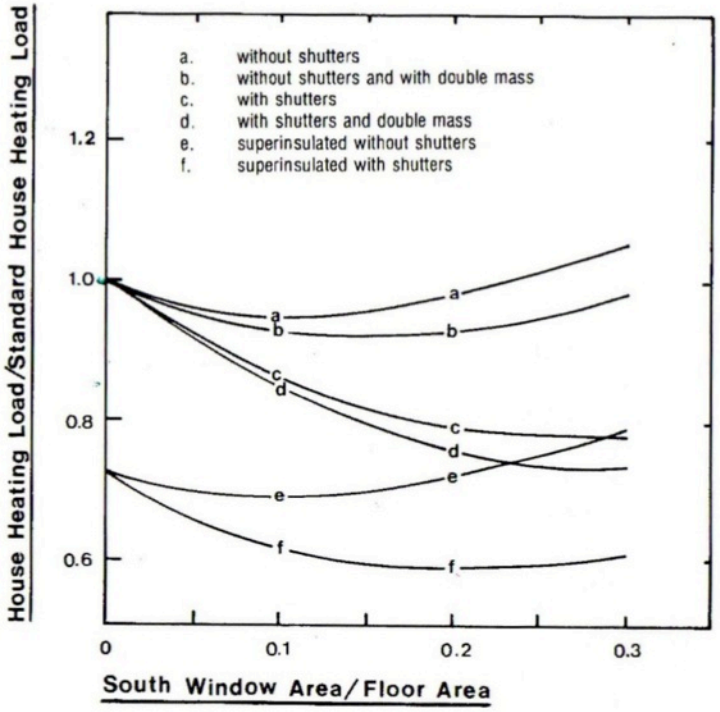

Figure 62. Annual heating requirements for houses with and without thermal shutters and various amounts of south-facing windows.

See Thorsten's presentation at ACAT.org.
See Bronwyn Barry's Passiv Haus Window presentation at ACAT.org.

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Masonry Wood Heat

Mat-Su College, Wasilla & Alaska Folk School, Talkeetna

Details:

- **Multiple levels of masonry**
- **Chambered flue manifold**
- **1 Hour hot burn**
- **12-24 heat radiates**
- **Dedicated outside air intake**

Harry and Erin Aulman used 4.5 cords of wood in their masonry wood stove last winter to heat their 1600sf Talkeetna home! No oil for heating!
Mark Masteller installed on in his house in Wasilla as well.

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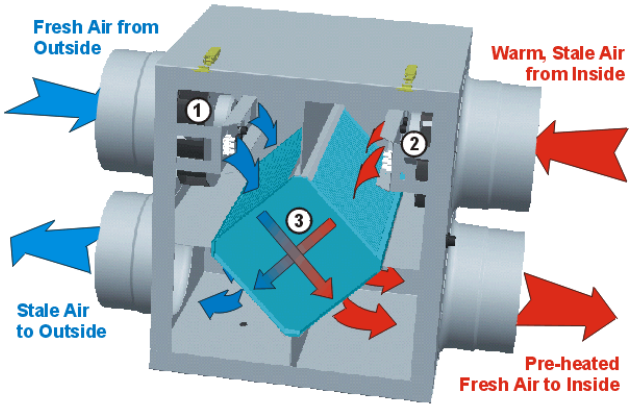
HEAT RECOVERY VENTILATION

Build Tight, Ventilate Right… but still keep an eye on the kWh



- kW usage? kWh per day?
- HRV continuous - 35cfm Examples
  - Zehnder Focus 200 (93% Eff.) – 118cfm, 62w, 1.5kwh/day, 550kwh/year
  - Fantech 1504 (76% Eff.) – 160cfm, 72w, 1.7kwh/day, 630kwh/year
- HRV continuous use vs. 20min / hour
  - Zehnder example – 62w, 0.5kwh/day ,179 kwh/year
- Through-wall "breather" vents (paired) – 17cfm x 8 = 136cfm
  - Lunos E2 (85% Eff.) – (5.6w ea.) 45w, 1kwh/day, 365kwh/year

See Canadian Equilibrium Housing presentation at ACAT.org.
See Akenergyefficiency.org

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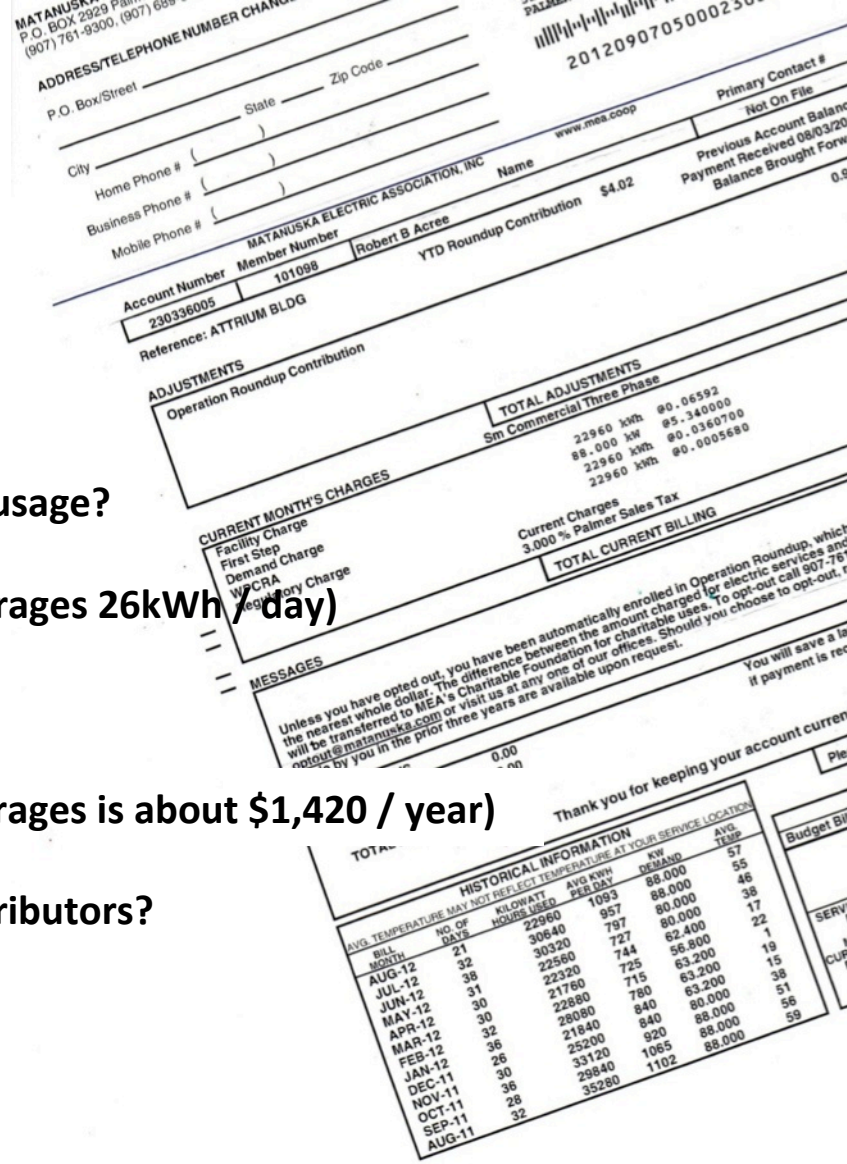
Electric Usage



- **What is your current electric usage?**
- **kWh per day? (Valley averages 26kWh / day)**
- **Summer versus winter?**
- **Cost per year? (Valley averages is about $1,420 / year)**
- **What are the biggest contributors?**
- **Can you reduce it?**

See Canadian Equilibrium Housing presentation at ACAT.org.
See Solar PV presentation at ACAT.org.
See Akenergyefficiency.org

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Electric Usage - Reductions

Reductions

- **Lighting – CFLs, LEDs, occupancy sensors, lighting surfaces**
- **Appliances – Energy Star listings**
- **Computer / Office – auto power strips**
- **Entertainment / Miscellanious – auto power strips**
- **Electric (Heat Pumps or Geothermal)**
- **Heating system fans or pumps – efficiencies**
- **GFI and Weatherproof receptacles – 1w-2.5w draw**

See Canadian Equilibrium Housing presentation at ACAT.org.
See Akenergyefficiency.org
See Energy Star

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Lastly… Renewables

- Solar
  - Photovoltaic
    - Fixed, building mounted
    - Tracking Arrary
  - Solar Thermal
    - Flat Plate
    - Evacuated Tubes

See presentations at acat.org
See Electric Storage – Eayrs 2011 presentation at acat.org

Not Reviewed

- **Wind**
- **Electric (Heat Pumps or Geothermal)**
- **Micro-hydro**
- **Off – Grid Systems**

See Off Grid Homes 2011 presentations at acat.org
See Electric Storage 2011 presentations at acat.org

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- Net Zero Energy
  - Definition
- Envelope
  - Spreadsheet
  - Heat Loss
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- Heating
  - Heating Methods
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- **Renewables**
  - **PV Watts**
  - Grid-tie
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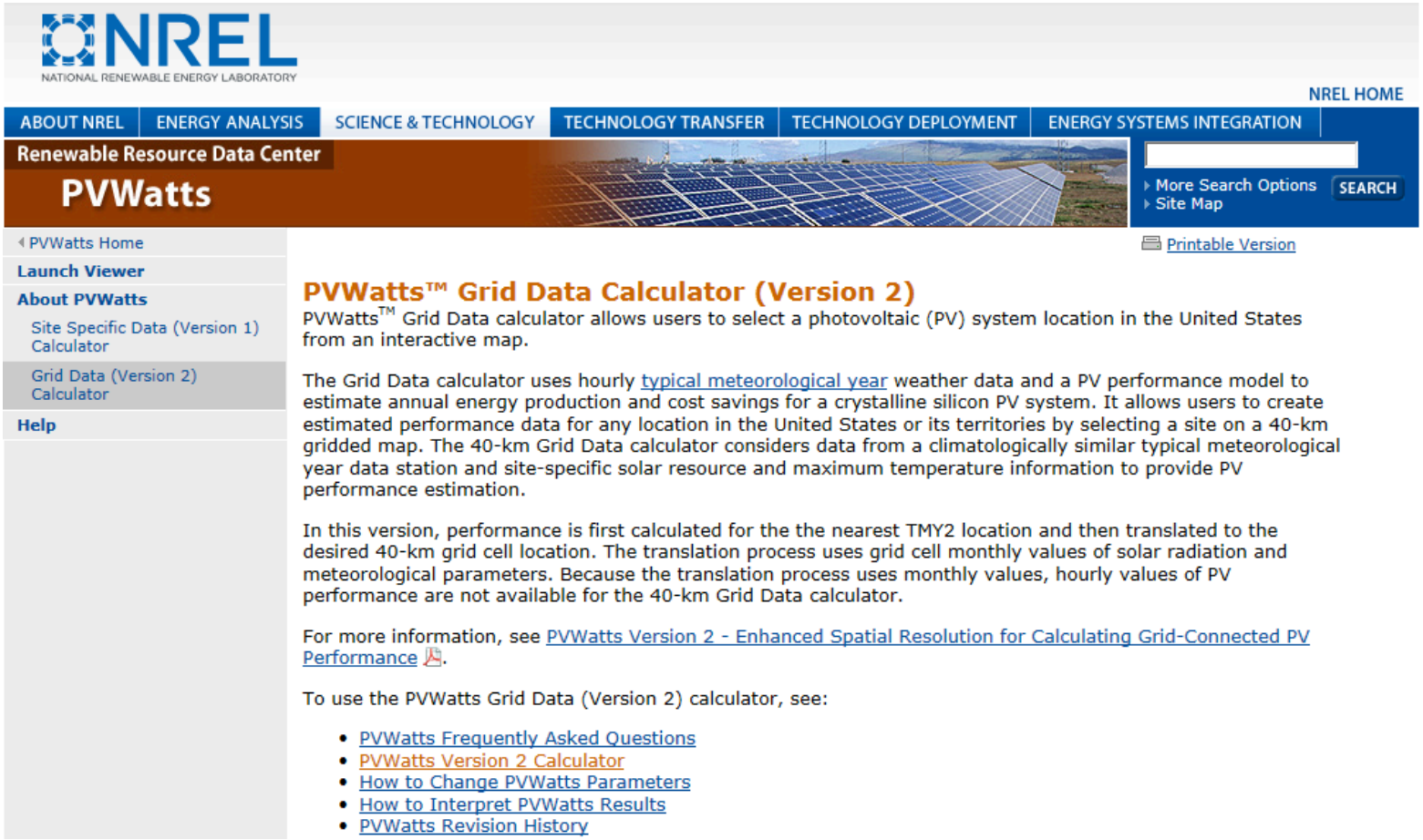
- Overall Review

Solar – PV Watts2

http://www.nrel.gov/rredc/pvwatts/grid.html



See nrel.gov – PV Watts 2

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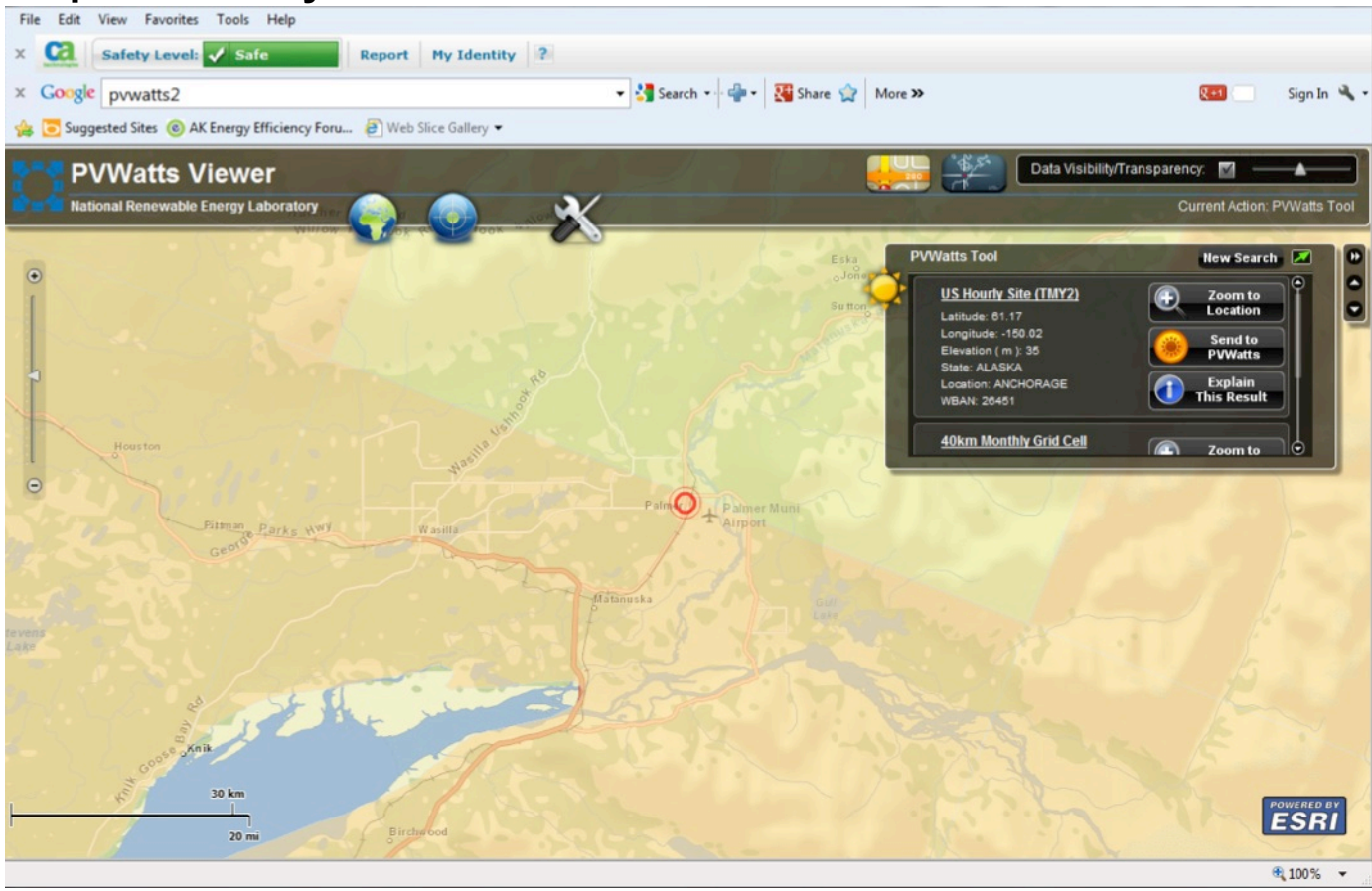
Solar – PV Watts2

Step 2. Locate your site…



See nrel.gov – PV Watts 2

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Solar – PV Watts2

Step 3. Input PV design data…

PVWatts

Click on **Calculate** if default values are acceptable, or after selecting your system specifications. Click on **Help** for information about system specifications. To use a DC to AC derate factor other than the default, click on **Derate Factor Help** for information.

Site Location:

WBAN Number:	26451
City:	Anchorage
State:	Alaska
Latitude:	61.17°N
Longitude:	150.02°W
Elevation:	35 m

PV System Specifications:

DC Rating (kW): 4.0

DC to AC Derate Factor: 0.77 [Derate Factor Help]

Array Type: Fixed Tilt

Fixed Tilt or 1-Axis Tracking System:

Array Tilt (degrees): 61.17 (Default = Latitude)

Array Azimuth (degrees): 180 (Default = Equator-Facing)

Energy Data:

Cents per kWh: .146 (Default = State Average)

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Solar – PV Watts2

Step 4. Output PV design data…

PVWatts

AC Energy & Cost Savings

Cautions for Interpreting the Results

(Type comments here to appear on printout; maximum 1 row of 80 characters.)

Station Identification	
City:	Anchorage
State:	Alaska
Latitude:	61.17° N
Longitude:	150.02° W
Elevation:	35 m
PV System Specifications	
DC Rating:	4.0 kW
DC to AC Derate Factor:	0.770
AC Rating:	3.1 kW
Array Type:	Fixed Tilt
Array Tilt:	61.2°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity:	14.6 ¢/kWh

Results			
Month	Solar Radiation (kWh/m²/day)	AC Energy (kWh)	Energy Value ($)
1	0.83	73	10.66
2	2.16	189	27.59
3	3.77	364	53.14
4	4.35	392	57.23
5	4.88	440	64.24
6	4.74	394	57.52
7	4.50	382	55.77
8	3.77	322	47.01
9	3.28	279	40.73
10	1.88	166	24.24
11	1.39	125	18.25
12	0.61	50	7.30
Year	3.02	3177	463.84

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Navigating Your Path to Net Zero Energy

Jason Collins, Architect and Energy Auditor, Palmer

Net Zero Energy Home Dashboard

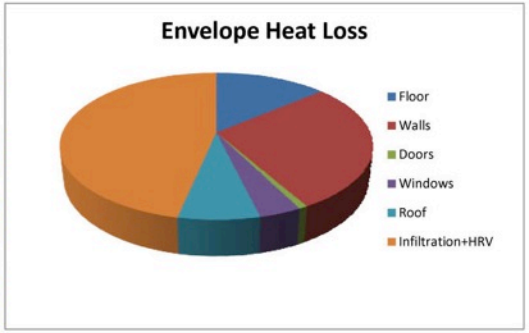
Component	Width	Length		R Value
Building Footprint (Floor)	28	42		0
Average Floor Depth Below Grade			0.0	
Walls	Height			
Wall - crawlspace	0			30
Walls	17			30
Doors	Height	Width	#	
Garage Doors	8	10	0	4
Doors	7	3	1	10
Window Areas	Area	SHGC		U-Value
Windows - South	24	0.3		0.3
Windows - East and West	10	0.3		0.3
Windows - North	0	0.35		0.3
Roof/Ceiling				60

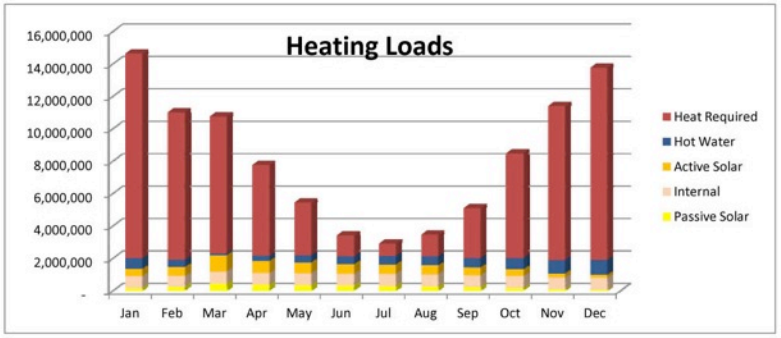
	Interior	Design	
Temperatures	68	-18	
Air Changes per Hour	0.33	(Natural)	
Number of Occupants	2		

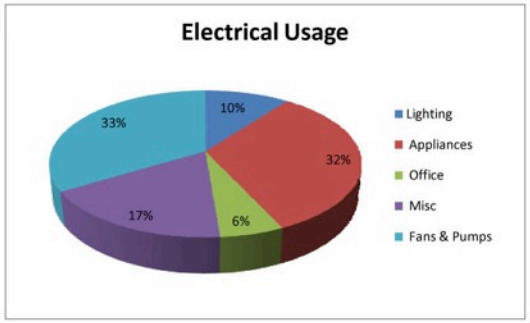
Renewables	# Units	
Evacuated Solar Tubes	32	# Tubes
Flat Plate Solar Collectors	0	# Flat Plates
Photovoltaic Array	7.0	kW

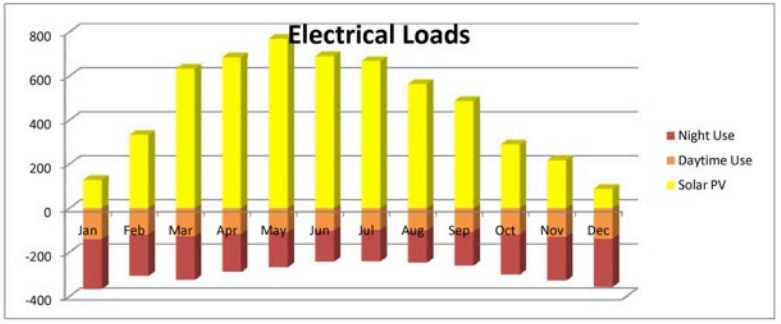
Annual Energy Usage		
Net Heat Usage	73,308,559	Btu
Net Electric Usage	-2021	kWh
NET ENERGY USAGE	**72,982**	kBtu
EUI (Energy Use Intensity)	**31**	kBtu/SF

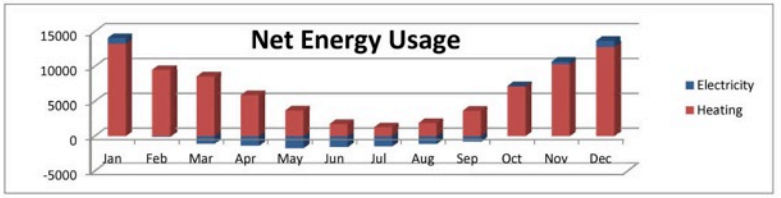
Heating Annual Cost	**$928**
Electric Annual Cost	**-$45**
Total Annual Cost	**$883**











Jason Collins, architect and energy auditor, walks you through some basic steps for navigating the sometimes overwhelming process of planning for Net Zero Energy.

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PATH TO NET ZERO WORKSHOP SERIES

Non-profit education outreach for Net Zero Energy

Register Online: www.ACAT.org

Full Day Workshops

- $80 -160 General Admission
- $40-80 Students and members
- $225+ w/ Continuing Ed. Certificate

Lectures, Shorter Workshops

- $20 General Admission
- $10 Student*
- $75 w/ Cont. Ed. Certificate

*Scholarships Available

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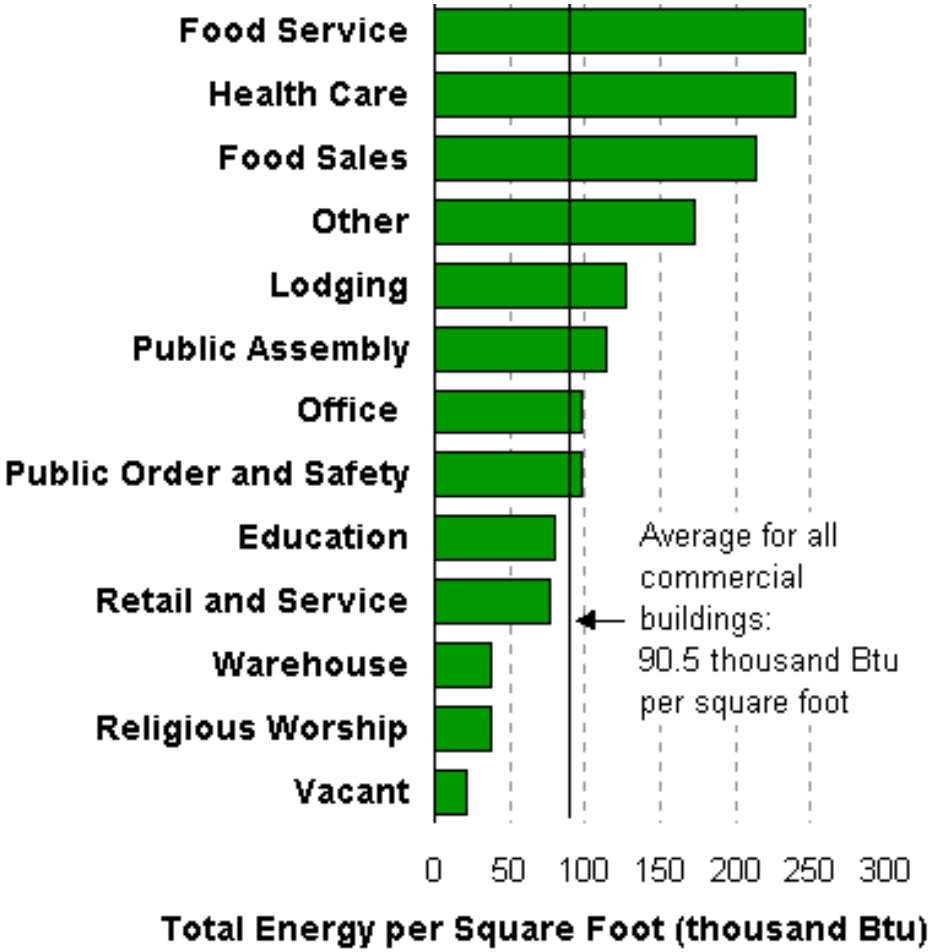
EUI – ENERGY USE INTENSITY BY BUILDING TYPE



Energy Use Intensity –

- CBECS – Commercial Building Energy Consumption Survey
- Kbtu/SF/Year
- Homes – 45 kbtu
- Multi-family – 60 kbtu
- Passivhaus - 4.7 kbtu

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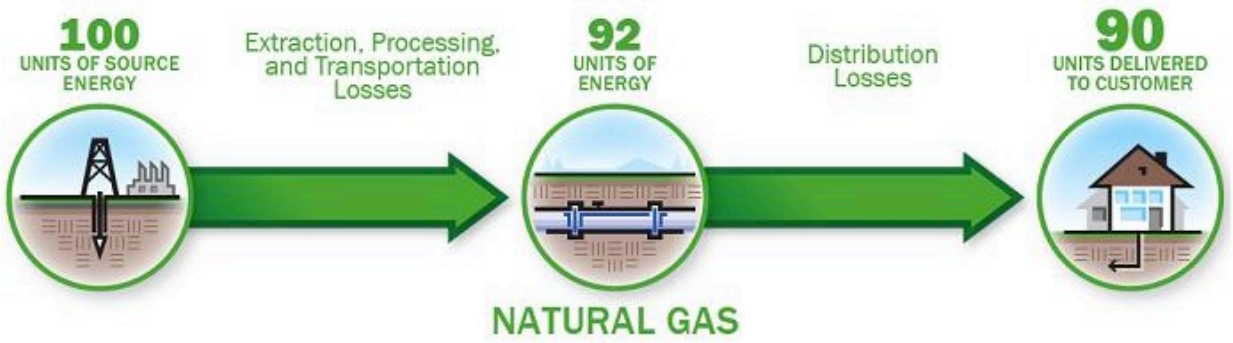
NET ZERO ENERGY BUILDING

SOURCE ENERGY – energy that is produced off-site. This includes production and transmission losses (can be 70% energy loss from original plant usage).



So if we are grid-tied and using electricity, do we need to provide 100% of what we use on site (Site Energy)?
Or do we need to account for power production loss (Source Energy)?
If we are equaling the Source Energy, do we provide 300%?

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NET ZERO ENERGY BUILDING

NET METERING – energy produced and energy used are measured at the building location. Equal utility rates?

- **MEA Rates for power purchase vary quarterly.**
- **Power sold back into grid = $0.04 / kwh (to $0.07/kwh)**
- **Power purchased from grid = $0.10579 / kwh plus tariffs**
  $0.146408 / kwh with tariffs
- **Difference in bought – sold = $0.10 /kwh (to $0.07/kwh)**

What does this mean? If you are using the grid as a "battery" and trying to pay for your winter/evening energy usage with summer/daytime production, you'll need to produce 3.6x more than energy than you use.

FEES AND TARIFFS – utility providers have fees and tariffs isolated from actual usage cost. Even if you make as much energy as you use, you will still have a utility bill.

- **MEA Monthly fee = $5.65**
- **Annually = $67.80**

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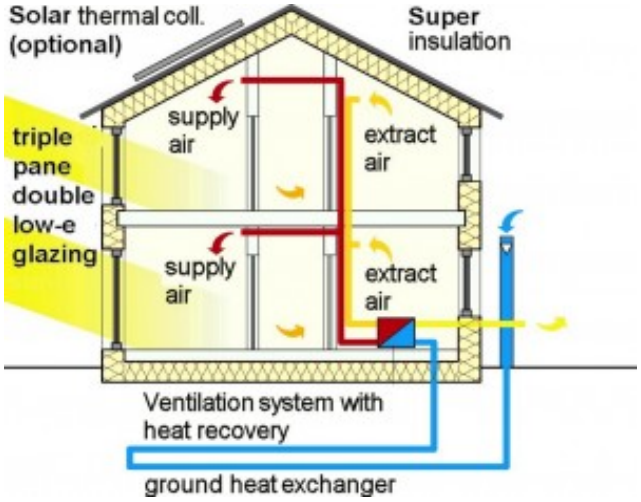
Passiv Haus



- German Standard, now International
  - Based on work US and Canada did back in the mid 70s
  - Ultra low energy building
    - Super-insulated
    - Air tightness
    - Passive solar design
  - Standards
    - 15 kwh/m2 or 4.7 kbtu/sf per year heating
    - 10w/m2 peak heat load
    - Total energy per year: <120kwh/ m2 or 37.9 kbtu/sf
    - Air Leakage: <0.6ACH 50
  - Thermal Breaks – careful attention
  - Ventilation – Heat Recovery Ventilator, 80%+ eff.

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Windows

How many windows?

What kind of windows? (Can I afford that kind of window?)

Are there too many windows?

Overheating vs. heat loss?

Thermal mass storage?

Exhaust air strategies?

How do we calculate?

What are some good rules of thumb?

See Nancy Clanton's Lighting presentation at ACAT.org.
See Bronwyn Barry's Passiv Haus Window presentation at ACAT.org.
See UAF Co-Ops Alaska Solar Guide.