The Future of Housing: The Path to Net-Zero and Beyond

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Zero-EnergyPlans.com

Learning Outcomes:

- You will learn twelve distinctive strategies for designing and building zero-energy and zero-energy ready homes.
- You will gain a better understanding of the difference between HVAC systems and indoor air quality systems.
- You will discover a new way of thinking about and approaching the design and building process that considers ALL the energy loads in a house, not just the big ones, to achieve cost-effective zero-energy results.
- You will learn cost-effective methods for gaining energy independence, for yourself, and your clients.
- You will learn how to build "next year's model" today!

Notes from William McDonnough: (Author of *Cradle to Cradle*)

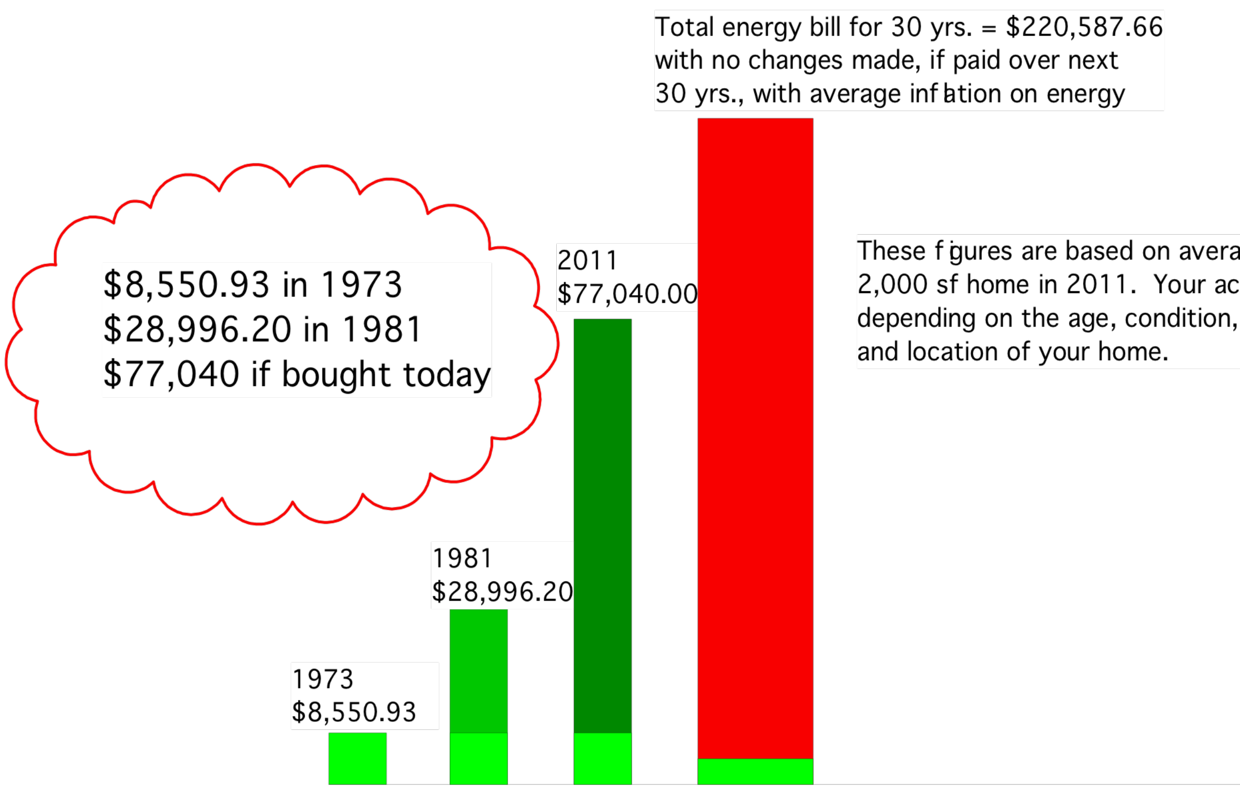
- Regulation is an indicator of design failure
- Fix the design, no need for regulation!
- Being less bad is not being good, it is still bad! Let's strive for good! After all, trashing the planet is not our intention as a species! Let's get the design right!

How "less bad" are your homes?

- Is a HERS rating of 40 good?
- Does everyone know what a HERS rating is? Home Energy Rating System
- HERS 100 is home built to the 2006 IECC
- HERS 0 is net-zero-energy home
- 2021 IECC would be about HERS 60, so a 40 would only be 2/3 AS BAD!

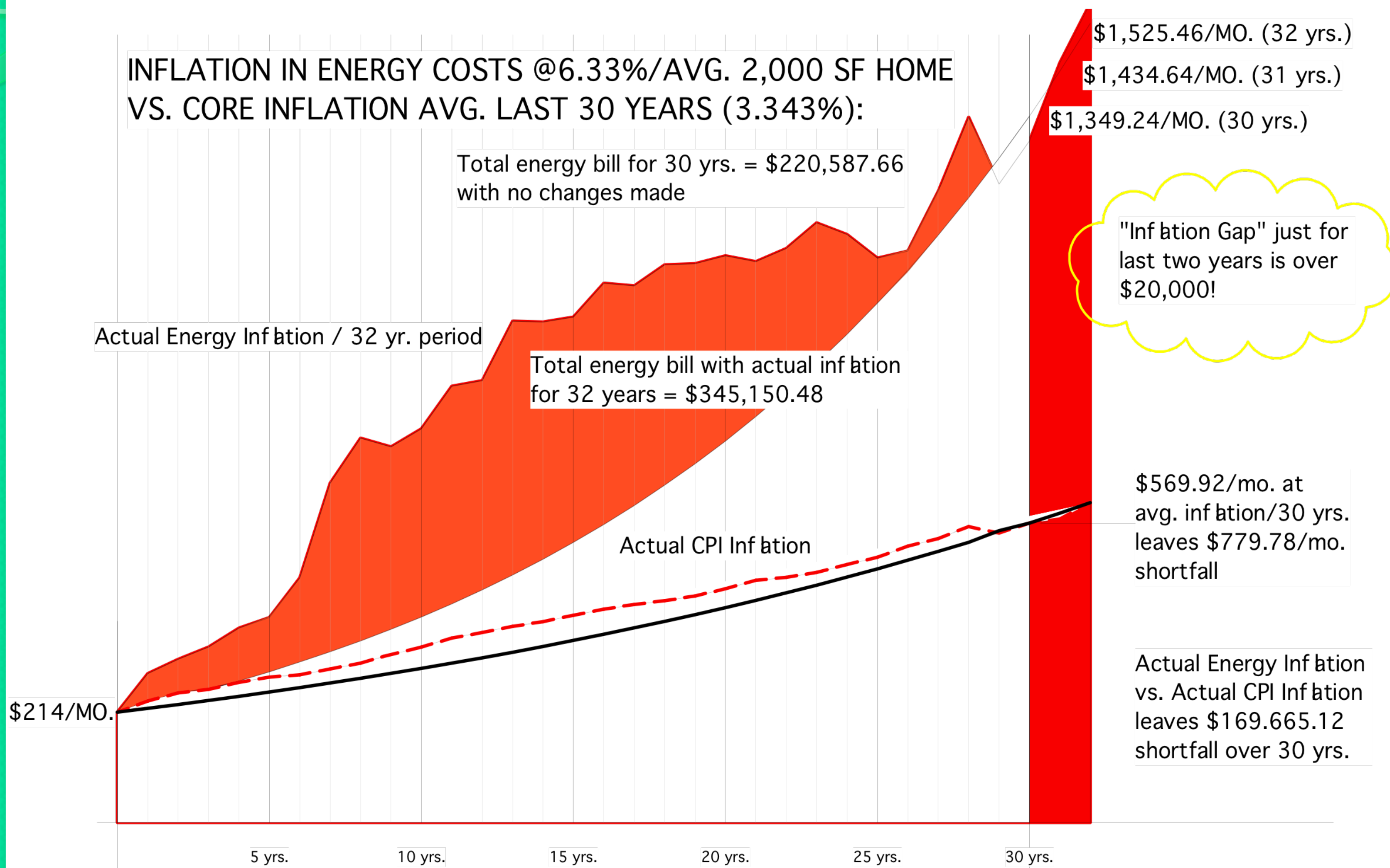
What if you bought all your energy at once?

HOW MUCH WOULD YOUR LAST 30 YEARS WORTH OF HOME ENERGY HAVE COST?



These figures are based on average energy used by 2,000 sf home in 2011. Your actual costs may vary, depending on the age, condition, heating fuel, and location of your home.

How much will your Future Energy Cost?



OK, so what can I do about it?

- Design & build better homes!
- Net-Zero Energy homes
- Positive NRG™ Homes

- But HOW????

- That is what this class is all about…

Course Objectives:

To learn how to design and build cost-effective net-zero-energy homes using:

- Building Orientation
- Simple Design
- Window Orientation
- Thermal Mass
- Tight Building Envelope
- Balanced Insulation Levels

Course Objectives (cont'd):

To learn how to design and build cost-effective net-zero-energy homes using:

- Balanced Ventilation
- Heat Pump Selection and Operation
- Water Heating Choices
- Efficient Appliances
- Efficient Lighting Systems
- Alternative Energy Sources

Who are you, and why are you here?

- Architects and Designers?
- Builders?
- Developers?
- Sub-Contractors? HVAC?
- Do-it Yourselfers?
- Policy-Makers?

- Who am I?

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Chapter 1

Building Orientation

Where is South?

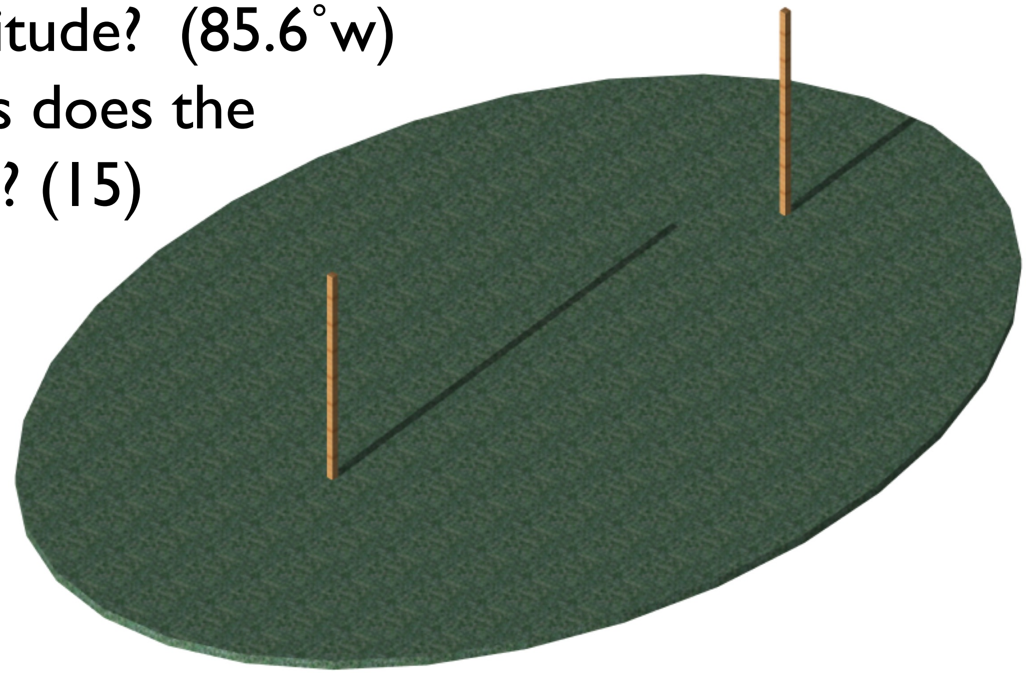
• Shadows from vertical objects will show true north at Local Apparent Noon (LAN)

• When is LAN?

• What is your Longitude? (85.6˚w)

• How many degrees does the sun move each hour? (15)

• Each minute? (1/4)

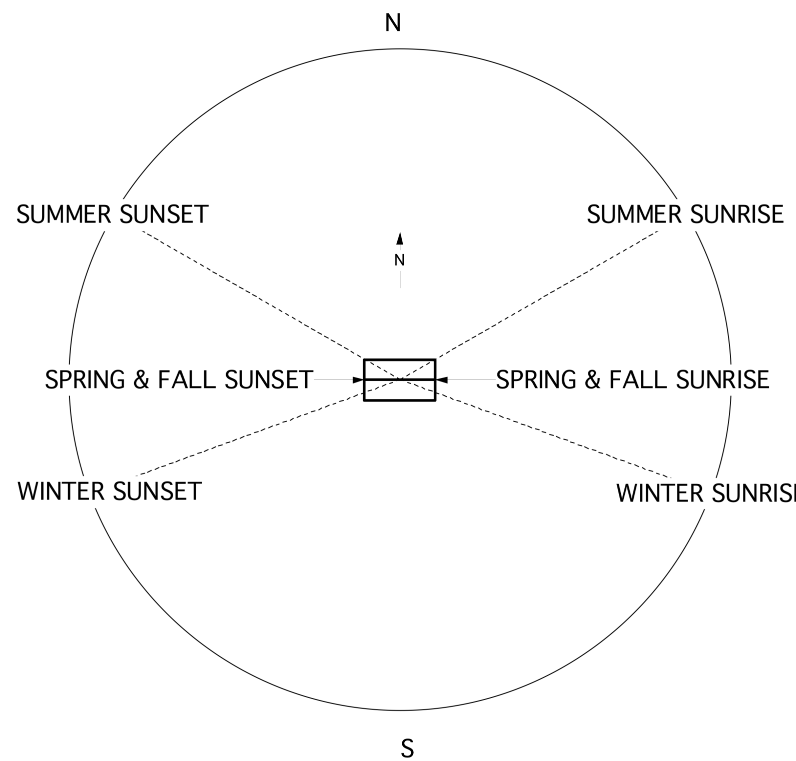


When is YOUR LAN?

(90-85.6 = -4.4˚ = 17.6 minutes before Noon on the clock)

Where Does the Sun Rise?

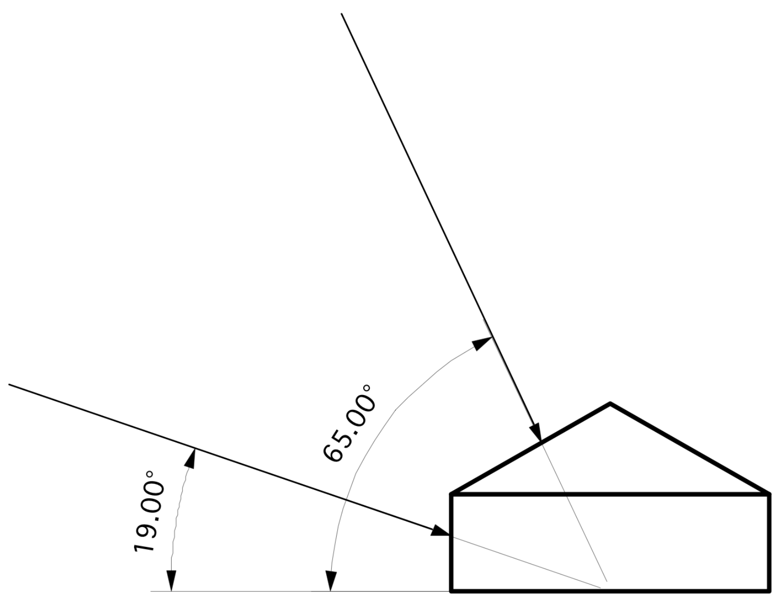
- In the Summer?
- In the Winter?
- In the Spring or Fall?



How High will the Sun Get?

- In the Summer?
- In the Winter?
- In the Spring or Fall?
- Where is the

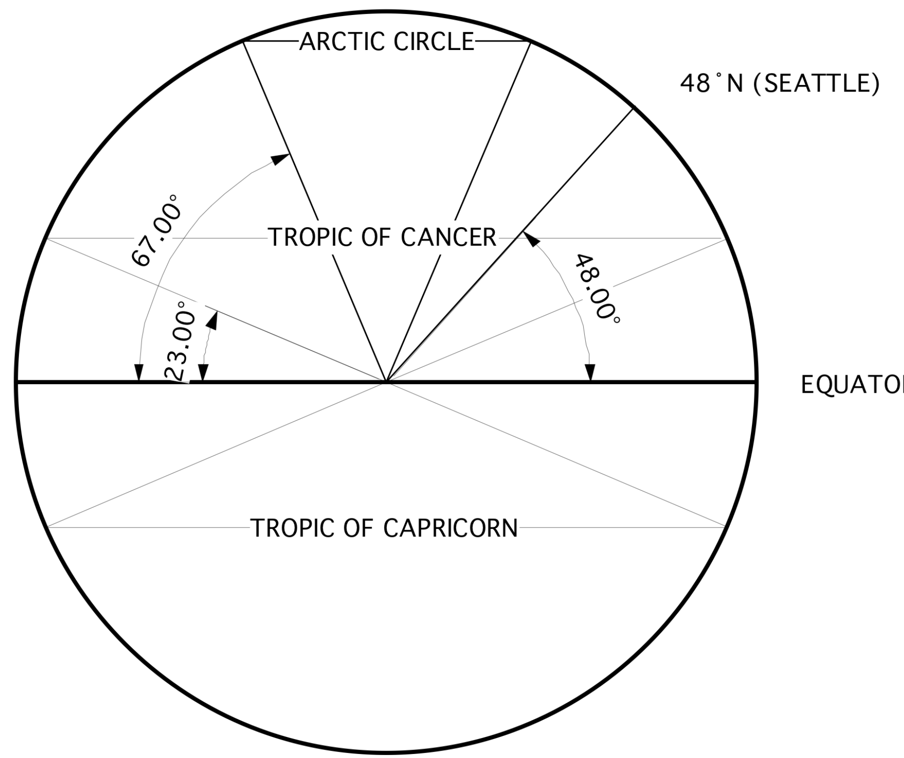
Tropic of Cancer?



How Do we Know this Stuff?

- The tropics are at 23˚ N & S
- Sun will be below the Azimuth by our Latitude (48˚)

Winter sun will be 23˚ lower
Summer sun will be 23˚ higher



How do we Capitalize on this?

- Building Orientation
- Roof Height and Orientation
- Window Orientation
- Landscape Design & Orientation
- Must be Climate Specific!

We will look at each in turn…

How do we Optimize Building Orientation?

- Long side south if possible?
- Orient roof ridge east-west
- Locate rooms within the house to optimize daylighting during the hours of most activity in those rooms
- Move building location on lot to maximize (or minimize) solar exposure due to natural or man-made restrictions

How do we Optimize Window Orientation?

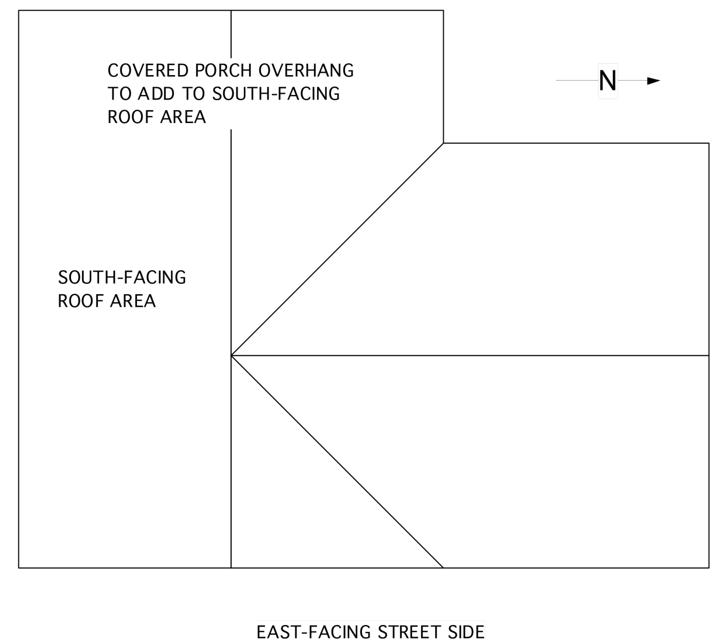
- Most windows facing South?
- East-facing windows will provide morning warmth (when it is most needed)
- Locate rooms within the house to optimize daylighting during the hours of most activity in those rooms
- Consider likely furniture arrangements, make sure windows are not wasted!
- Each Window should provide more than one function!

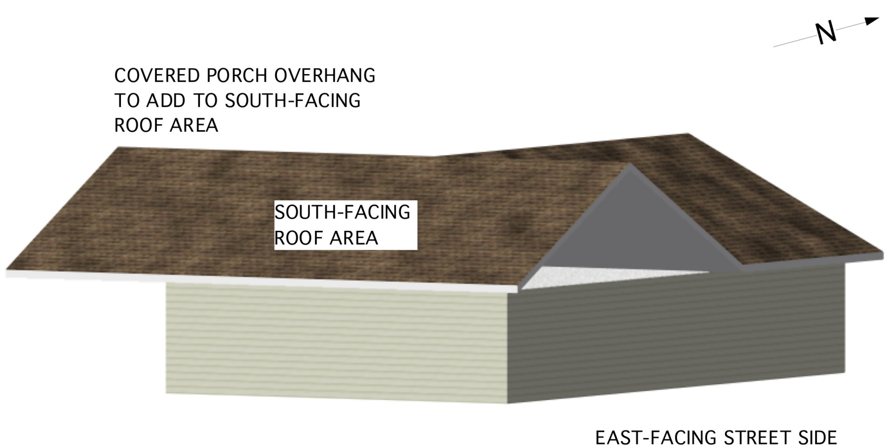
How do we Optimize Roof Height and Orientation?

- Largest face of roof should face South
- Eave height should get roof up above natural and man-made restrictions
- Keep plumbing vents and other impediments on the north side of the ridge line
- NO south-facing dormers (unless they are shed-style, and angled to support solar panels)
- Use T-shaped roof where main ridge cannot face south

How do we Optimize Roof Height and Orientation?

- T-shaped roof:
- 28'x48' east-facing house has 42' of roof facing South!





How do we Optimize Landscaping Choices?

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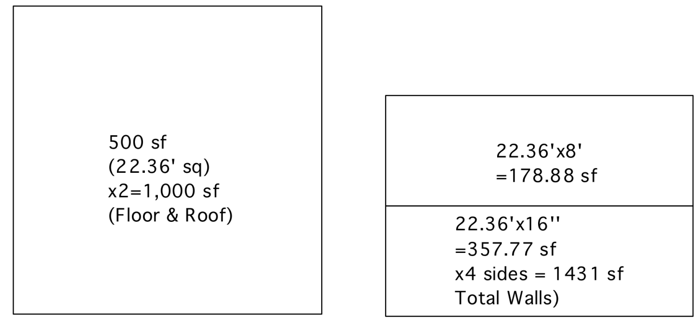
Chapter 2

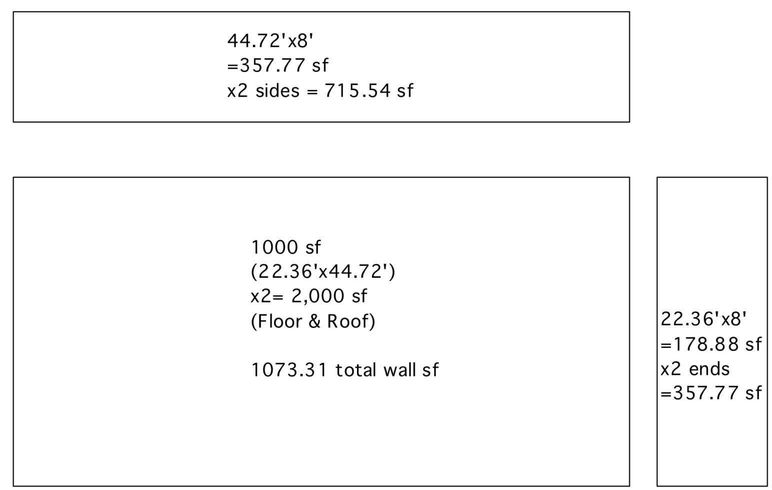
Simple Design

What is the Effect of Surface Area?

- Two-story vs. Single story
- Single story house of same size will have about 25% more surface area!



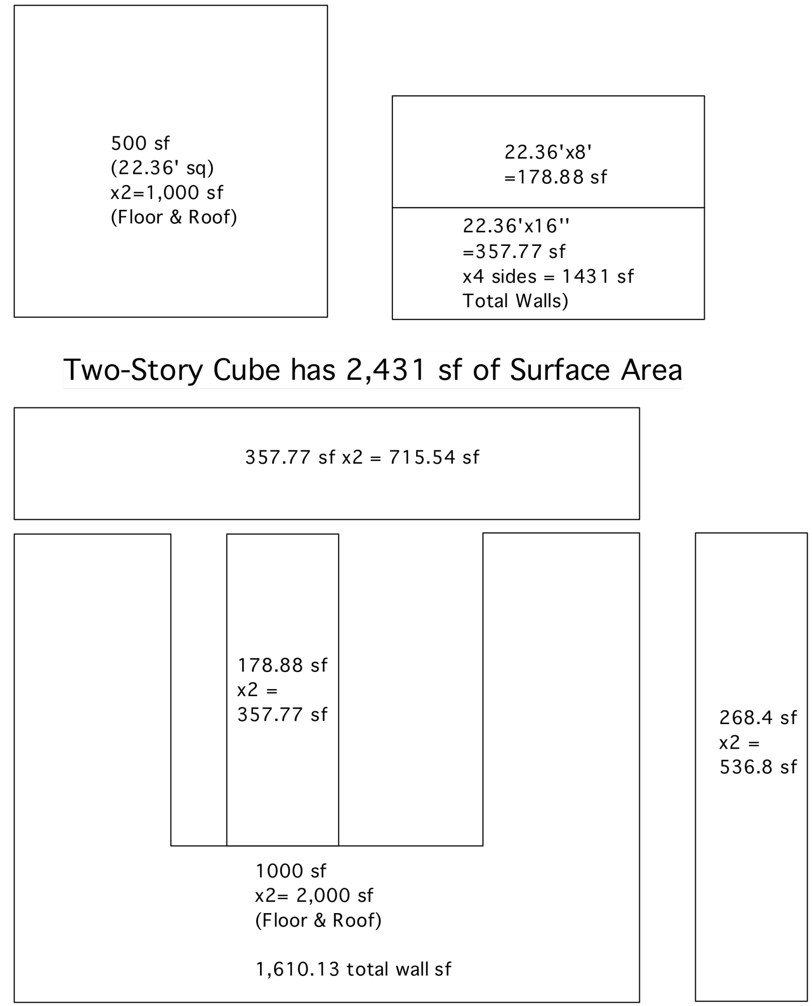
Two-Story Cube has 2,431 sf of Surface Area



Single-Story same size house has 3,073 sf of Surface Area
a 26% Increase!

What is the Effect of Surface Area?

- More complex shape?
- Single story house of same size will have about 48.5% more surface area!



Single-Story Complex same size house has 3,610 sf of Surface Area, a 48.5% Increase!

Why do we not want Surface Area?

- Surface area is where we lose Energy!
- Surface area is what costs you Money!
  - To build
  - To finish
  - To maintain
  - To dispose of at the end of its life-cycle

What is the real cost in Energy Loss?

OK, so how do we make a cube look good??

OK, so how do we make a cube look good??

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Chapter 3

Window Orientation

How much South-Facing Glass?

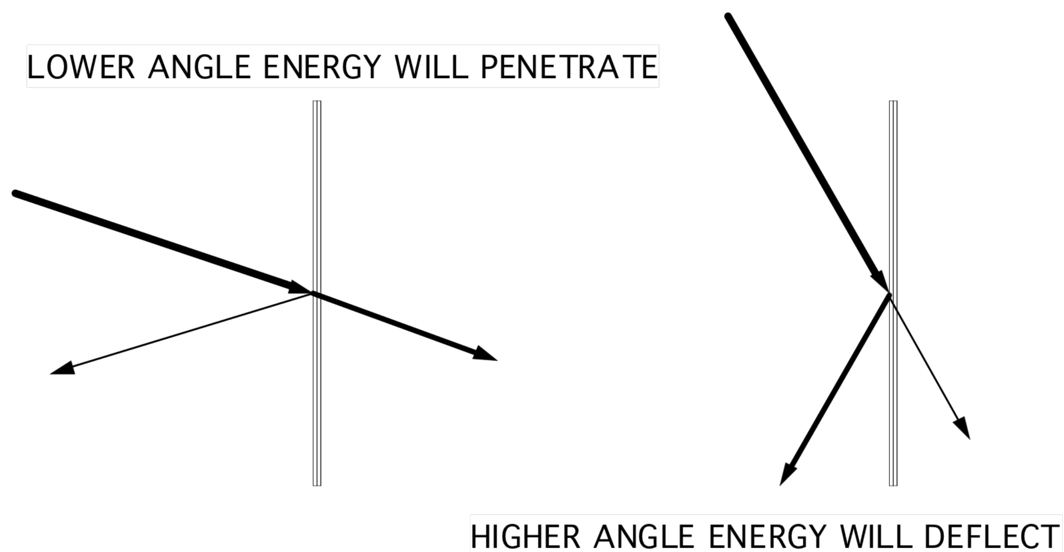
- ICC-700 recommends 7%-10% of floor area in South-Facing Glass, depending on Climate Zone
- ICC-700 recommends not more than 4% for East or West-Facing Glass
- One of our 2,408 sf Net-Zero homes has 208.5 sf (8.66%) of South-Facing Glass, and 85 sf (3.5%) of East-Facing Glass, and zero North or West-Facing Glass!

Why have East-Facing Glass?

- In most climates and seasons, homes will lose heat over night, and will need to be heated in the morning hours.
- East-facing glass can allow the sun to provide free solar energy to warm the house in the morning.
- Care must be taken not to over-heat the home in warmer climates or seasons.

What are the consequences of West-Facing Glazing?

- West-facing glass can over-heat the house in the afternoon, when the house is already warm from the heat of the day.
- The sun is lower in the sky in the late afternoon, so the energy penetrates the low-e glass more directly



What are the consequences of North-Facing Glazing?

- Little heat energy is gained from North-Facing Glazing
- Daylight gained must be reconciled against heat energy lost:
  - Calculate lighting energy needs
  - Balance lighting against 24/7/365 heat loss
  - Can the area be lighted indirectly through other south-facing rooms in the house?

What are the consequences of North-Facing Glazing?

- Example 1, Light Cost:

4 hours per day @ 13 watts = 52 w/day

52 x 365 = 18,980 w, or 18.98 Kwh

18.88 Kwh @ .15¢ per Kwh = $2.85/yr.

- Example 2, Heat Cost:

3-0x4-0 window uses 165 btu/hr @ DDD

(50 degree Δt) x 24 hrs x110 (5500 HDD) = 435,600 Btu/year = 127.66 Kwh

127.66 Kwh @ .15¢ per Kwh = $19.15/yr.

Provide Shading:

- On East Side during late morning hours in Summer
- On South-facing during Late Spring, Summer, and Fall
- On all West-Facing

What can we do with glass options?

What can we do with Glass Options?

		Visible Light						Center of Glass		Center of Glass	
			Reflectance					Winter U-Value		R-Value	
	IG	Trans.						Btu/hr/ft²/°F			
Product	Construction	%	% Out	% In	SHGC	SC	RHG	Air	Argon 90%	Air	Argon 90%
Two Pane LoE-179 #2	3.0C7/13.0/3.0	79	14	14	0.65	0.75	153	0.32	0.28	3.13	3.57
Two Pane LoE-179 w/i81 #4	3.0C7/13.0/3.0i81	71	21	22	0.59	0.68	139	0.25	0.22	4.00	4.55
Two Pane LoE-272	3.0E4/13.0/3.0	72	11	12	0.41	0.48	98	0.30	0.25	3.33	4.00
Two Pane LoE-272 w/i81 #4	3.0E4/13.0/3.0i81	64	16	20	0.38	0.44	89	0.23	0.20	4.35	5.00
Two Pane LoE-270	3.0E0/13.0/3.0	70	12	13	0.37	0.42	88	0.30	0.25	3.33	4.00
Two Pane LoE-270 w/i81 #4	3.0E0/13.0/3.0i81	63	17	21	0.34	0.39	80	0.23	0.20	4.35	5.00
Two Pane LoE-366	3.0X3/13.0/3.0	65	11	12	0.27	0.31	66	0.29	0.24	3.45	4.17
Two Pane LoE-366 w/i81 #4	3.0X3/13.0/3.0i81	58	15	20	0.25	0.28	59	0.23	0.20	4.35	5.00
Triple Pane LoE-366/Clear/LoE-179 #5	3.0X3/9.8/3.0/9.8/3.0C7 #5	57	14	17	0.25	0.29	60	0.19	0.15	5.26	6.67
Triple Pane LoE-366/LoE-179 #4/i81 #6	3.0X3/9.8/3.0C7/9.8/i81 #6	51	18	24	0.22	0.26	53	0.16	0.13	6.25	7.69
Triple Pane LoE-272/Clear/LoE-179 #5	3.0E4/9.8/3.0/9.8/3.0C7 #5	63	15	17	0.38	0.43	89	0.19	0.15	5.26	6.67
Triple Pane LoE-272/LoE-179 #4/i81 #6	3.0E4/9.8/3.0C7/9.8/i81 #6	57	19	24	0.34	0.39	80	0.16	0.13	6.25	7.69
Triple Pane LoE-179/Clear/LoE-179 #5	3.0C7/9.8/3.0/9.8/3.0C7 #5	69	18	18	0.57	0.65	133	0.20	0.16	5.00	6.25
Triple Pane LoE-179/LoE-179 #4/i81 #6	3.0C7/9.8/3.0C7/9.8/i81 #6	63	24	25	0.51	0.59	119	0.17	0.14	5.88	7.14
Triple Pane LoE-366/Clear/LoE-179 #5	3.0X3/13.0/3.0/13.0/3.0C7 #5	57	14	17	0.25	0.28	59	0.16	0.13	6.25	7.69
Triple Pane LoE-366/LoE-179 #4/i81 #6	3.0X3/13.0/3.0C7/13.0/i81 #6	51	18	24	0.22	0.25	52	0.14	0.12	7.14	8.33
Triple Pane LoE-272/Clear/LoE-179 #5	3.0E4/13.0/3.0/13.0/3.0C7 #5	63	14	17	0.38	0.43	88	0.17	0.13	5.88	7.69
Triple Pane LoE-272/LoE-179 #4/i81 #6	3.0E4/13.0/3.0C7/13.0/i81 #6	57	19	24	0.34	0.39	80	0.14	0.12	7.14	8.33
Triple Pane LoE-179/Clear/LoE-179 #5	3.0C7/13.0/3.0/13.0/3.0C7 #5	69	18	18	0.57	0.65	133	0.17	0.14	5.88	7.14
Triple Pane LoE-179/LoE-179 #4/i81 #6	3.0C7/13.0/3.0C7/13.0/i81 #6	63	24	25	0.51	0.59	119	0.15	0.12	6.67	8.33
Triple Pane LoE-366/Clear/LoE-366 #5	3.0X3/13.0/3.0/13.0/3.0X3 #5	47	13	13	0.24	0.27	56	0.15	0.12	6.67	8.33
Triple Pane LoE-366/LoE-366 #4/i81 #6	3.0X3/13.0/3.0X#/13.0/i81 #6	42	15	22	0.19	0.22	46	0.13	0.11	7.69	9.09

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Chapter 4

Thermal Mass

How Important is Thermal Mass?

- Controlling the Day/Night temperature swing is the key to Energy Efficiency:

		btu/cf/degree F	Btu/degree	
Cubic volume of house	10088	0.0183	184.6104	Loss w/o Thermal Mass:
btuh on DDD	7800	(from CP Wksht)	42.2511408	Degrees/Hour heat loss
Btuh/12 hours	93600		507.013689	Degrees/night heat loss
Note that the house would not REALLY lose hundreds of degrees in twelve hours, the number shown is merely a reflection of the number of Btus required to keep the home at the desired temperature for this amount of time at the Design Degree Temperature.				
square feet of 2nd floor	584	(concrete slab)		
thickness of 2nd floor	6	292.00	cubic feet	
square feet of lower floor	544	(concrete slab)		
thickness of lower floor	4	181.33	cubic feet	
	125	3,000	Enter Square feet of GWB	
	92.79167	1700	Enter Board Feet of Interior Lumber	
Adjusted volume of	691.125	31.61	22031.0717	Loss w/Thermal Mass:
thermal mass		(Btu/cf/degree f	0.35404542	Deg. F/Hr.
		Concrete)	4.24854503	Deg. F/12 Hrs.

What will Thermal Mass really Save us?

- We can replace the lost Btus using Passive Solar Energy! Really? Yes, Really!
- Even without good window orientation, or a sunny day, a heat pump will be more efficient when running at warmer daytime temperatures.
- We will explore that further in the Heat Pump chapter below. (27%!)

How much Energy Can We Get From the Sun? Try CC-6:

Climate Consultant 5.0 (Build 3, Oct 19, 2010)

WEATHER DATA SUMMARY

LOCATION: **Seattle Seattle Tacoma Intl A, WA, USA**
Latitude/Longitude: 47.47° North, 122.32° West, **Time Zone from Greenwich** -8
Data Source: TMY3 727930 WMO Station Number, **Elevation** 400 ft

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	44	68	89	118	132	141	150	130	109	79	48	38	Btu/sq.ft
Direct Normal Radiation (Avg Hourly)	45	72	75	97	96	112	140	130	112	86	45	51	Btu/sq.ft
Diffuse Radiation (Avg Hourly)	30	39	49	58	66	61	52	48	48	40	33	25	Btu/sq.ft
Global Horiz Radiation (Max Hourly)	116	166	227	272	323	299	308	278	237	198	130	99	Btu/sq.ft
Direct Normal Radiation (Max Hourly)	271	281	289	297	290	289	294	294	277	285	264	254	Btu/sq.ft
Diffuse Radiation (Max Hourly)	68	87	144	141	181	170	164	156	115	117	69	70	Btu/sq.ft
Global Horiz Radiation (Avg Daily Total)	321	568	895	1375	1735	1879	1975	1598	1165	718	370	282	Btu/sq.ft
Direct Normal Radiation (Avg Daily Total)	340	633	769	1145	1286	1523	1892	1648	1239	818	354	391	Btu/sq.ft
Diffuse Radiation (Avg Daily Total)	226	336	500	685	876	819	703	604	518	368	255	183	Btu/sq.ft
Global Horiz Illumination (Avg Hourly)	1404	2185	2849	3768	4189	4487	4650	4099	3449	2516	1550	1230	footcandles
Direct Normal Illumination (Avg Hourly)	1168	2017	2173	2840	2828	3332	4085	3766	3223	2423	1204	1264	footcandles
Dry Bulb Temperature (Avg Monthly)	40	42	47	51	55	60	64	66	59	52	46	41	degrees F
Dew Point Temperature (Avg Monthly)	34	35	37	41	45	47	50	53	51	44	41	36	degrees F
Relative Humidity (Avg Monthly)	80	76	71	71	71	66	64	66	76	76	83	82	percent
Wind Direction (Avg Monthly)	167	152	167	202	199	207	199	215	145	192	150	136	degrees
Wind Speed (Avg Monthly)	8	8	8	9	8	9	8	8	4	9	8	7	mph
Snow Depth (Avg Monthly)													inches
Ground Temperature (Avg Monthly of 3 Depths)	48	44	43	43	46	50	54	58	60	59	56	52	degrees F

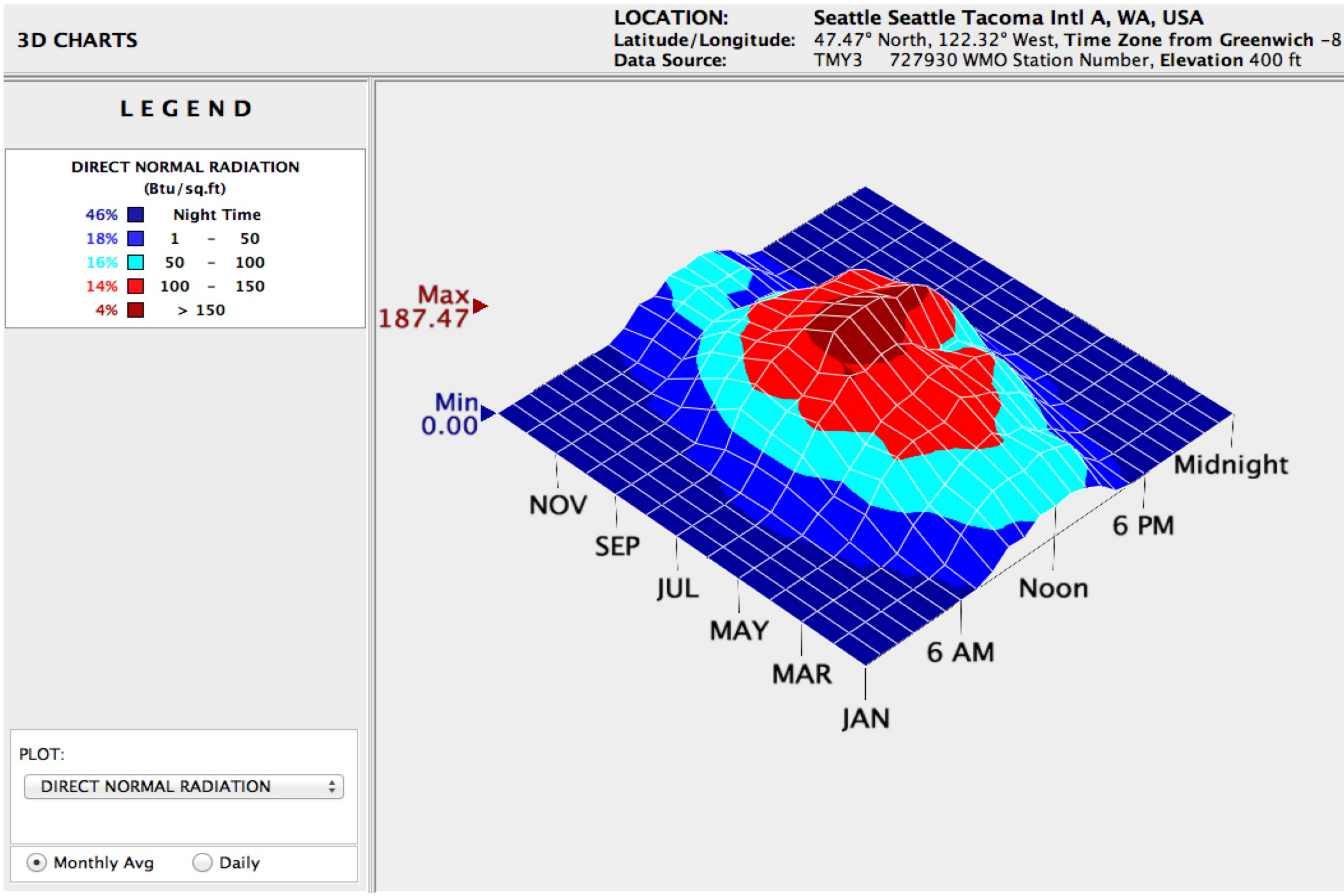
Back Next

How much Energy Can We Get From the Sun?

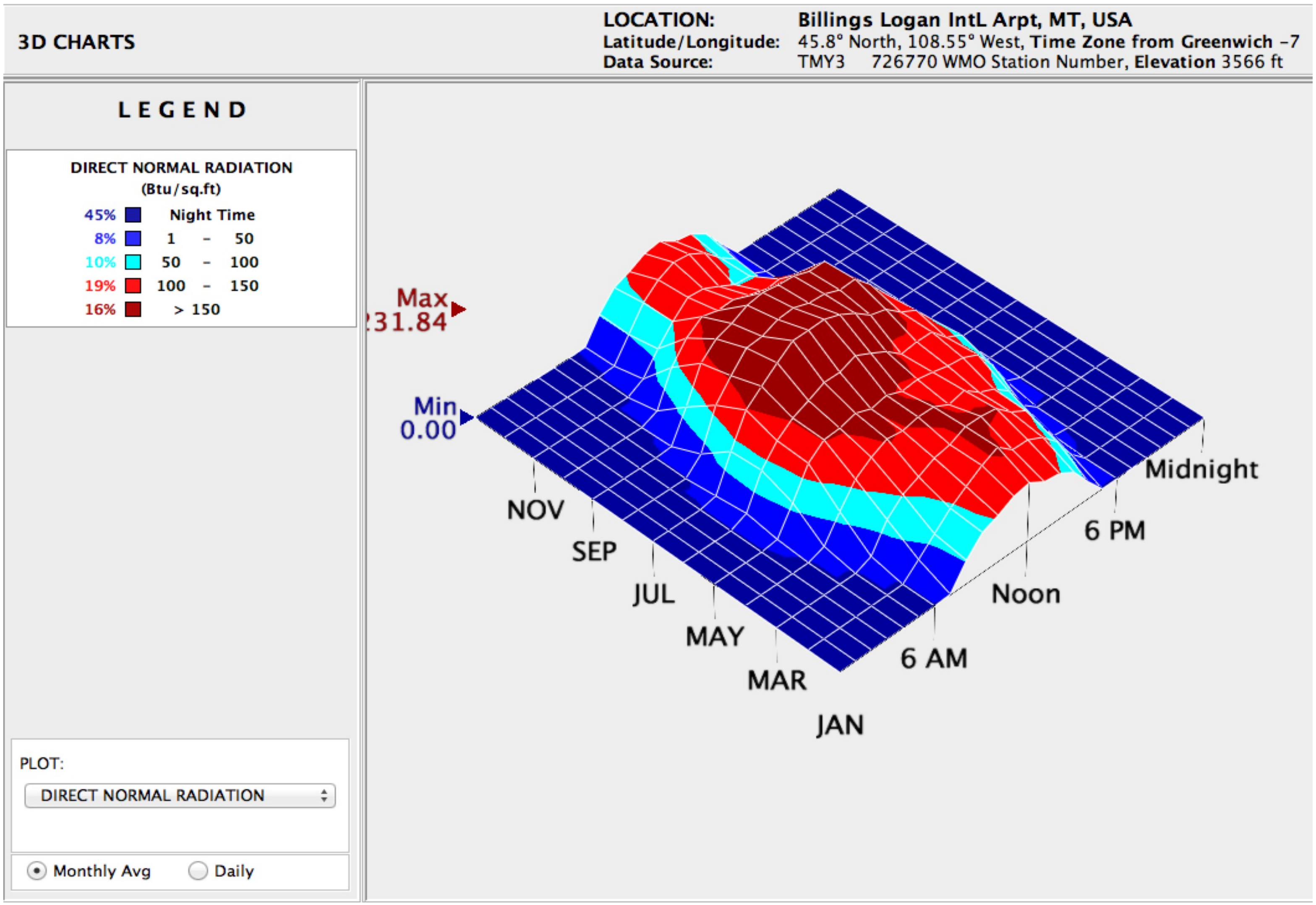
- The previous slide showed that Seattle gets up to 1,892 Btu per day per square foot of Direct Normal Radiation in the Summer
- Seattle gets at least 340 Btu per day of Direct Normal Radiation even in the winter
- Diffuse Radiation is less, but still at least 183 Btu/sf/day during the darkest Winter Month!

So how much is that, and what can we do with it?

How does that graph out?



Compare to Billings, Montana:



How much Energy Can We Get From the Sun? Let's Calculate:

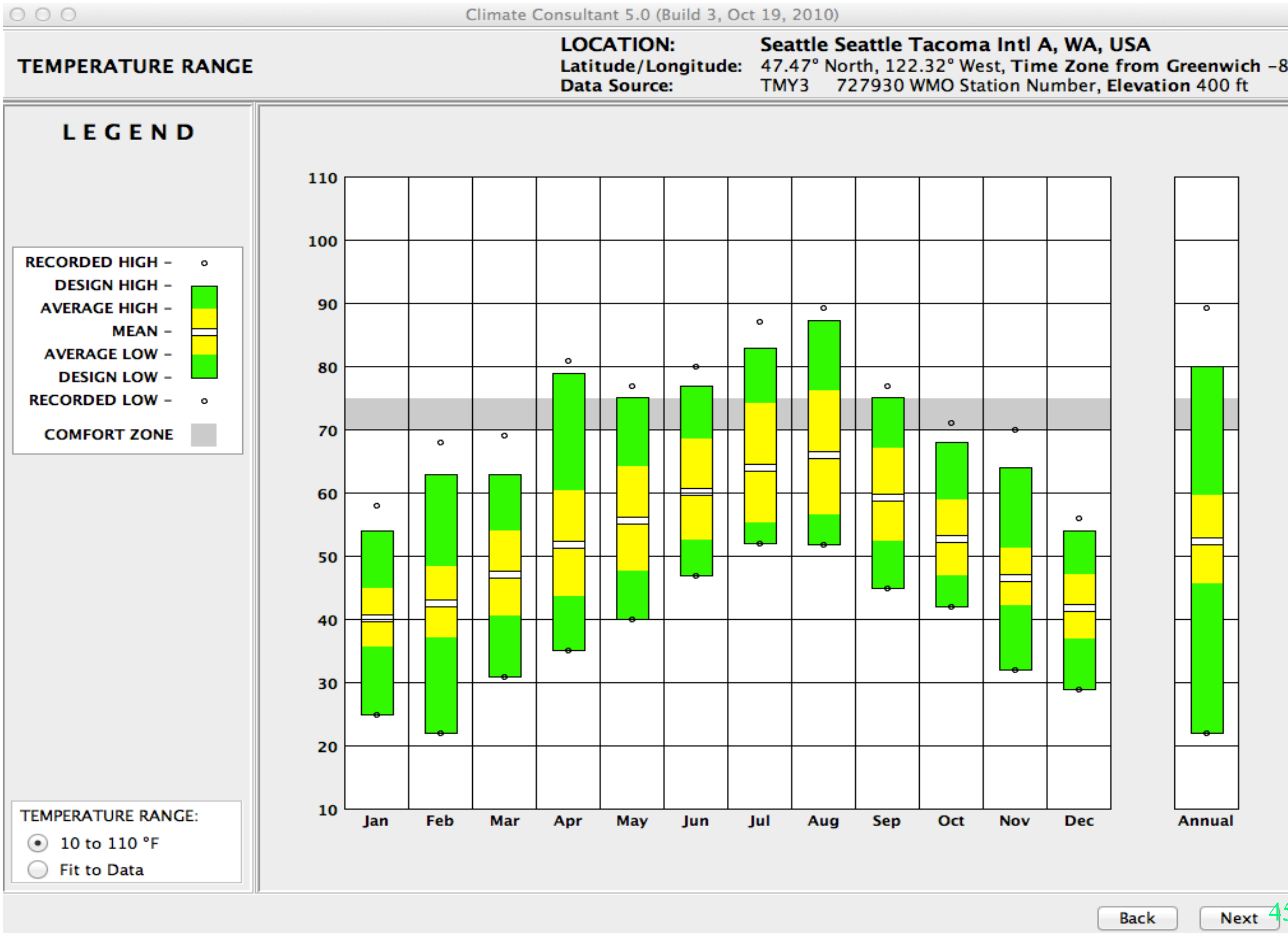
- Diffuse Radiation is less, but still at least 183 Btu/sf/day during the darkest Winter Month!
- If we have 200sf of South-Facing Glass, with an SHGC of .5, we would get 100 times 183, or 18,300 Btu on a cloudy winter day!
- That is about one hour worth of energy on the Design Degree Day for the house in our example
- On a Sunny Winter Day, we would gain about double that amount, 34,000 Btu.

Big whoop, one hour of Energy…

- Ah, but that is at the Design Degree Day, Based on an outside temperature of 19 degrees…
- What is the average outside temperature during that same cold winter month?

Let’s take another look at Climate Consultant 5:

What is our Average Winter Temperature?



What is our Average Winter Temperature?

- Looks like about 41 degrees in January…
- Only 57% of the way to the Design Degree Day!
- This means a sunny day would provide at least 3 1/2 hours of energy
- A cloudy day would provide 1 ¾ hours of energy…

This might not seem like much, but it adds up fast over time!

What is our Average Annual Temperature?

- Looks like about 52 degrees…
- Only 35% of the way to the Design Degree Day!
- Seattle's Average Annual Direct Normal Radiation is just under 100 Btu/sf/hr
- Six hours of sun will provide 60Kbtu, or enough energy to heat the house for nine hours on the average day.

What Happens in the Summertime?

- Does the slab get too hot?
  - It can, in some climates
- Can we cool it off at night?
  - Yes, in most climates
- Where will the excess energy go?
  - Some will be transferred to air, and exhausted to the outside
  - Some can be transferred into the ground
  - Keep your thermal mass stable!

What can we do to optimize Thermal Mass?

- Keep all Thermal Mass completely within the Building Envelope
- Add Thermal Mass even on second floors, by pouring a slab over your framed wood floor, or use phase-change materials.
- Orient windows to provide direct access to your Thermal Mass.
- Use Thermal Mass walls or stairs to better capture energy from East or West-facing windows

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Chapter 5

Tight Envelope

What is the Effect of a Tight Building Envelope?

- How much energy is lost through convection?
  - Air contains .0183 Btu per cubic foot per degree (at sea level)
  - If your house is 1,000 sf, with an 8' ceiling (as in our Cube House diagram earlier) you have 8,000 cubic feet of air to lose.
  - Let's do the math: 8,000 x .0183 = 146.4 Btu per degree of temperature difference
  - Our DDD is 50˚ Δt, 50 x 146.4 = 7,320 Btu

What is the Effect of a Tight Building Envelope?

- How much energy is lost through convection?
  - Our DDD is 50° Δt, 50 x 146.4 = 7,320 Btu
  - At .6 ACH, you will lose 4,392 Btu/hr.
  - In a 24-hour day, that would be 105,408 Btu
  - At .35 ACH, you would lose 2,562 Btu/hr.
  - In a 24-hour day, that would be 61,488 Btu
  - At .1 ACH, you would only lose 17,560 Btu in a day. I like that better!

How does that compare to the Conductive Heat Loss for the same house?

- With 12% glazing, and a good wall assembly, the 1000 sf Two-Story design will use a total of 10,866 Btuh on the DDD including .6 ACH
- 4,392 Btuh are from air infiltration alone!
- If this is a 2-bedroom home, ASHRAE 62.2 only requires 32.5 cfm, or 1,784 Btuh
- How about we save the other 2,608 Btuh?

How much does this save us in a Year? Let's do the math:

- 2,608 Btuh x 24 hours x 110 (HDD/DDDΔt) = 6,885,120 Btu per year
- If heating with 92% efficient Natural Gas at $1.20 per therm, this would save $89.91 per year.
- Remember, this is just for a tightening up a tiny 1,000 sf house!
- A 2,000 sf house would save twice as much, and a more complex-shaped house would save even more!

Walls as Filters? Not a good idea!

- Walls that "Breathe" trap pollens, mold and mildew spores, odors, steam and grease from cooking, and all other sorts of undesirable elements in the insulation layers.
- These can build up, and cause health problems, and degrade the structural integrity of the walls.
- Wall Cavities Must Be Tight!

The Future of Housing: The Path to Net-Zero and Beyond

Chapter 6

Balanced Insulation

Why are we building houses this way?

- Consider a 10’x10’ room, with R-60 insulation on the lid.
- Then remove the insulation from a one-foot square area, what is the net R-value of the entire roof assembly?

Let's try something…

Start with any house for which you have an energy model (we will show one here using the WSU UA Alternative Worksheet)

- Skew your insulation levels so that you have very disparate levels in different areas, but so that they add up the same
  - For example, if you downgrade 1000 sf of walls from R-21 to R-11, upgrade the 1000 sf of roof from R-38 to R-49

What Happened? Original:

Washington State Energy Code: Component Performance Worksheet, Type R-3 Occupancies

Heating System Size

Ducts are located in unconditioned space.	
Equipment size over design load	100%
Btu/hour output	12,602
KW	3.7

Conditioned Floor Area	1915
Conditioned Building Volume	2127.217
Weather Station	Seattle: Sea-Tac AP

ɔonent Performance, R-3 occupancies

	Code Target Values Area	Code Target Values UA	Proposed Design Values Area	Proposed Design Values UA
Vertical Glazing U = 0.300	287	86.2	255	44.5
Overhead Glazing U = 0.500	0	0.0	0	0.0
Doors U = 0.200	38	7.6	38	9.1
Flat/Vaulted Ceilings U = 0.027	1315	35.5	1315	36.2
Wall (above grade) U = 0.056	2088	116.9	2121	101.8
Floors U = 0.029	0	0.0	0	0.0
Slab on Grade F = 0.360	136	49.0	136	44.9
Below Grade				
2' depth, wall U = 0.042	0	0.0	0	0.0
2' depth, slab F = 0.590	0	0.0	0	0.0
3.5' depth, wall U = 0.041	0	0.0	0	0.0
3.5' depth, slab F = 0.640	0	0.0	0	0.0
7' depth, wall U = 0.037	0	0.0	0	0.0
7' depth, slab F = 0.570	0	0.0	0	0.0

Target UA Total	295.2	Proposed UA Total	236.6
Target Credits from Chpt. 9	1.0	Proposed Credits from Chpt. 9	4.5

Qualifies

What Happened? Skewed:

The house uses 14% more energy!

Washington State Energy Code: Component Performance Worksheet, Type R-3 Occupancies

Conditioned Floor Area	1915	Ducts are located in unconditioned space.	
Conditioned Building Volume	2127.217	Equipment size over design load	100%
Weather Station	Seattle: Sea-Tac AP	Btu/hour output	14,323
		KW	4.2

Heating System Size

ponent Performance, R-3 occupancies	**Code Target Values** Area	UA	**Proposed Design Values** Area	UA
Vertical Glazing U = 0.300	287	86.2	255	44.5
Overhead Glazing U = 0.500	0	0.0	0	0.0
Doors U = 0.200	38	7.6	38	9.1
Flat/Vaulted Ceilings U = 0.027	1315	35.5	1315	28.9
Wall (above grade) U = 0.056	2088	116.9	2121	150.6
Floors U = 0.029	0	0.0	0	0.0
Slab on Grade F = 0.360	136	49.0	136	40.9
Below Grade				
2' depth, wall U = 0.042	0	0.0	0	0.0
2' depth, slab F = 0.590	0	0.0	0	0.0
3.5' depth, wall U = 0.041	0	0.0	0	0.0
3.5' depth, slab F = 0.640	0	0.0	0	0.0
7' depth, wall U = 0.037	0	0.0	0	0.0
7' depth, slab F = 0.570	0	0.0	0	0.0

Target UA Total	295.2	Proposed UA Total	274.0
Target Credits from Chpt. 9	1.0	Proposed Credits from Chpt. 9	4.5

Qualifies

Consider what Happens when we add windows:

- Remove 12 square feet of R-21 Wall
- Replace it with an R-3 Window
- What do you suppose just happened to the net-R-value of your R-21 Wall?
- Now do that about ten times!
  - Our Cube House just increased Btuh by 21%!
  - With U-.21 windows, only 14.6% increase!
- That is how we are now building houses!
- We need to do better on our windows & doors!

If we use Better Windows, can we use More Glass?

- If we can save 1/3 of the energy loss by using better windows, we could add 33% more windows and get the same result!
- Could we add only those windows that will result in capturing the solar heat gains outlined above?
- Those are questions that must be answered individually for each project.

Balanced Insulation Levels, Summary: Heat goes to Cold!

- The closer all the insulation levels are to each other, the better the home will perform, relative to the cost and depth of the insulation.
- We tend to put more insulation in the roof, and less in the walls, only because it is cheaper to do so, not because there is more needed in that location!

Balanced Insulation Levels, Summary: Heat goes to Cold!

- The closer all the insulation levels are to each other, the better the home will perform, relative to the cost and depth of the insulation.
- Before considering adding even more attic insulation or crawl-space insulation, consider ways of adding more wall insulation, to help even out the insulation levels

Balanced Insulation Levels, Summary: Heat goes to Cold!

- The closer all the insulation levels are to each other, the better the home will perform, relative to the cost and depth of the insulation.
- Before considering adding even more attic insulation or crawl-space insulation, consider ways of adding more wall insulation, to help even out the insulation levels
- Use the Lowest U-value Windows and Doors you can find!
- Remember that every cost needs to be weighed against the cost of providing renewable energy!

The Future of Housing:
The Path to Net-Zero and Beyond

Chapter 7

Balanced Ventilation

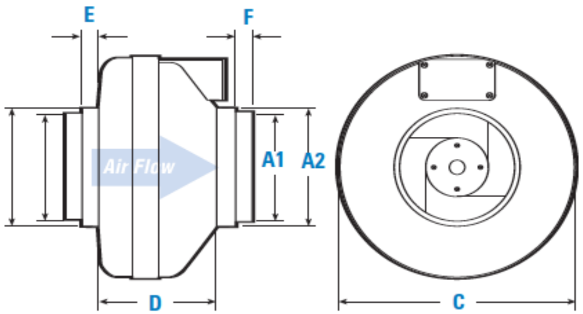
Balanced Ventilation, Why?

- You can’t really suck the spots off a leopard!
- Tight house will not allow air to come in through wall cavities
- Exhaust-only ventilation will not work at design values, and therefore will not provide adequate fresh air
- Cost of operation will be lower when balanced ventilation strategies are used

Balanced Ventilation, How?

- Commercial Kitchens are required to have balanced ventilation for the class-one hood system! Air in = Air out.
- Without make-up air, efficiency drops
- Two smaller fans working in concert with each other will use less energy than one fan struggling by itself!
- Compare (2) FR100s, vs (1) FR160:

Balanced ventilation uses just 1/4 the energy of exhaust-only:



Model	†A1	A2	C	D	E	F
FR 100	4	5	9½	6⅛	⅞	⅞
FR 110	4	5	9½	6⅛	⅞	⅞
FR 125	–	5	9½	6⅛	⅞	–
FR 140	6	6¼	11¾	5⅞	1	⅞
FR 150	6	6¼	11¾	5⅞	1	⅞
FR 160	6	6¼	11¾	5⅞	1	⅞
FR 200	8	10	13¼	6¼	1½	1½
FR 225	8	10	13¼	6¼	1½	1½
FR 250	–	10	13¼	6¼	1½	–

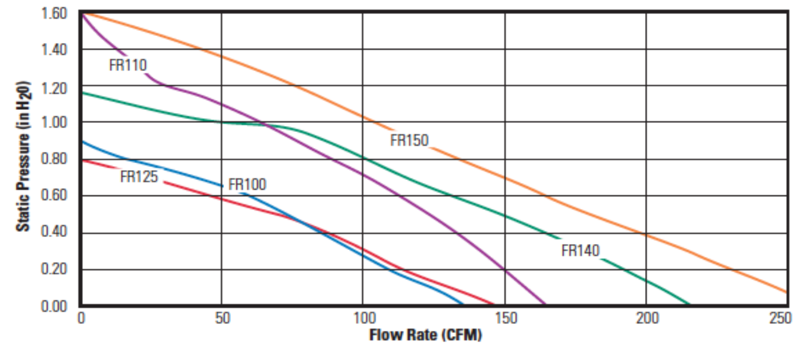
All dimensions in inches.
† Duct connections are 1/8" smaller than duct size.

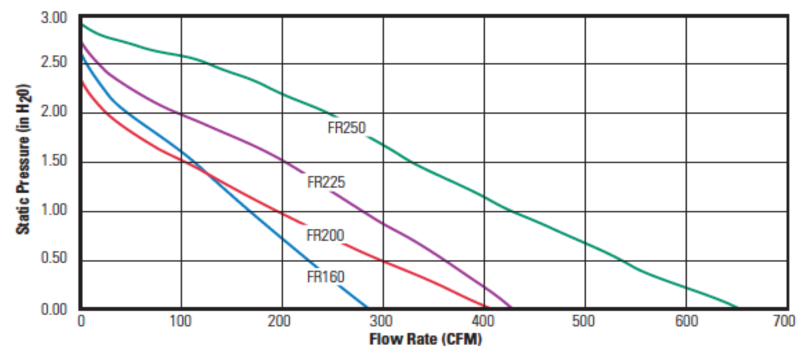
FIVE YEAR WARRANTY

HVI 2100 CERTIFIED

ENERGY STAR

Look for the Energy Star Rated Models in Performance Data Chart.





PERFORMANCE DATA

Fan Model	Energy Star	RPM	Voltage	Rated Watts	Wattage Range	Max. Amps	Static Pressure in Inches W.G.							Max. Ps	Duct Dia.
							0"	.2"	.4"	.6"	.8"	1.0"	1.5"		
FR 100	✔	2950	120	21.2	13 – 22	0.18	137	110	83	60	21	—	—	0.9"	4"
FR 110	—	2900	115	80	62 – 80	0.72	167	150	133	113	88	63	4	1.60"	4"
FR 125	✔	2950	115	18	15 – 18	0.18	148	120	88	47	—	—	—	0.79"	5"
FR 140	✔	2850	115	61	47 – 62	0.53	214	190	162	132	99	46	—	1.15"	6"
FR 150	✔	2750	120	71	54 – 72	0.67	263	230	198	167	136	106	17	1.58"	6"
FR 160	—	2750	115	129	103 – 130	1.14	289	260	233	206	179	154	89	2.32"	6"
FR 200	✔	2750	115	122	106 – 128	1.11	408	360	308	259	213	173	72	2.14"	8"
FR 225	✔	3100	115	137	111 – 152	1.35	429	400	366	332	297	260	168	2.48"	8"
FR 250	—	2850	115	241	146 – 248	2.40	649	600	553	506	454	403	294	2.58"	10"

Performance shown is for installation type D - Ducted inlet, Ducted outlet. Speed (RPM) shown is nominal. Performance is based on actual speed of test. Performance ratings do not include the effects of appurtenances in the airstream.

Balanced ventilation uses 1/4 the energy of exhaust-only:

- Example:
  FR-100 uses 13w @ 0”wc, 137 cfm
  x 2 = 26w, moving 274 cfm of air

  FR-160 uses 106w @ .2”wc, 260 cfm!

What about Air Quality?

- Should our incoming air be filtered?
  - For pollens & other allergens?
  - For dust & dirt?
  - For molds & mildew?
  - For Smoke!!!

Let's look at how:

- Passive filters
- Active filters

What about Air Quality?

- In-line Filters:

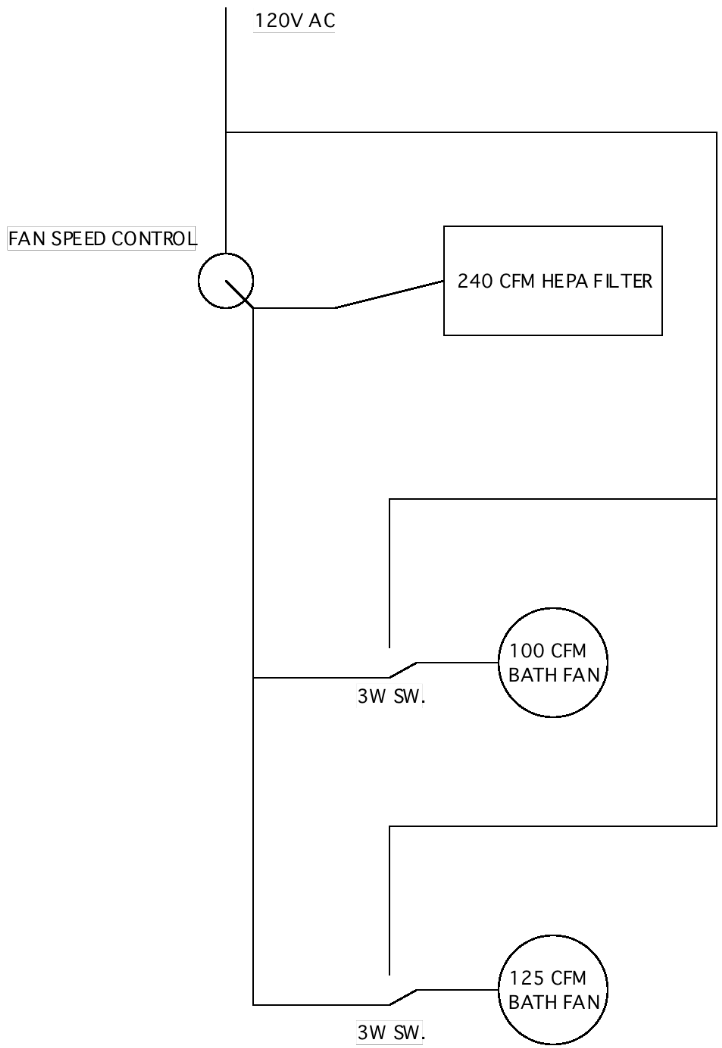
- Provide filtration
- Do not provide balanced ventilation

What about Air Quality?

- Powered filters:

- Provide filtration
- <u>Can</u> provide balanced ventilation

Possible Electrical Schematic:



NOTES:

1. MAKE SURE THAT FANS YOU ARE USING ARE COMPATIBLE WITH SPEED CONTROLS. PANASONIC FANS CANNOT BE USED WITH THIS SYSTEM

2. HEPA FILTER CFM SHOULD BE EQUAL TO OR JUST ABOVE THE COMBINED CFM OF THE BATH FANS TO ACHIEVE NEUTRAL OR SLIGHTLY POSITIVE PRESSURE

3. THE HEPA FILTERS AND FANS I AM USING ARE FAN-TECH BRAND, THE BATH FANS ARE REMOTE FANS, DRAWING AS LITTLE AS 18-19W PER FAN. THE 125 CFN FAN USES 5" PIPE, THE 100 CFM FAN USES 4". THE REMOTE FANS ARE EXTREMELY QUIET, AND LEAVE ONLY A SMALL PENETRATION IN THE CEILING, LOOKING MUCH LIKE A 4" OR 5" RECESSED CAN TRIM. CHECK OUT www.efi.org/wholesale

4. LOCATE THE 3-WAY SWITCH IN THE BATHROOM OR OTHER ROOM SERVED BY THE EXHAUST FAN FOR CONVENIENCE.

5. LOCATE THE SPEED CONTROL IN THE AREA SERVED BY THE HEPA FILTER, FOR BEST COOLING AND AIR HANDLING CONTROL.

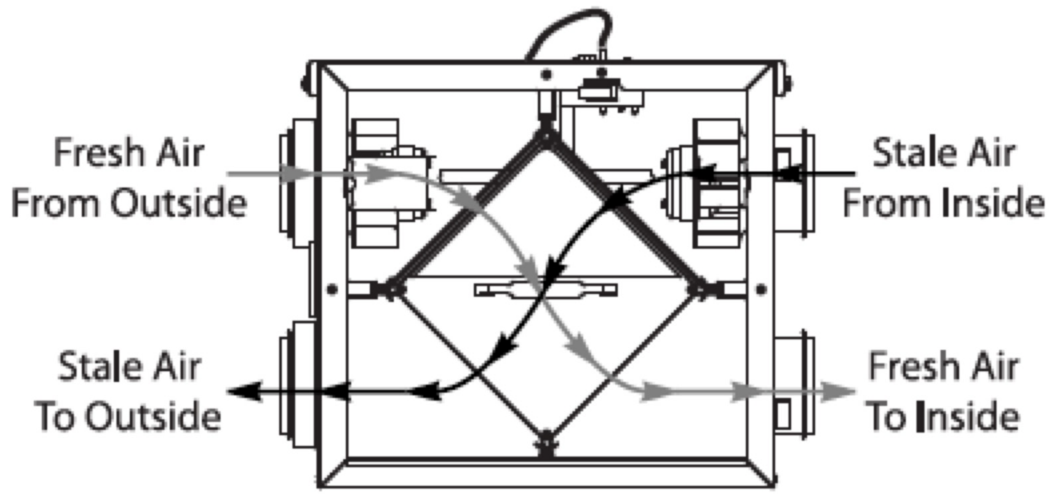
6. OTHER MORE AUTOMATED CONTROLS COULD BE USED TO ADJUST THE SPEED CONTROL, BUT MY EXPERIENCE HAS BEEN THAT SIMPLE IS BEST, MY HOMEOWNERS SEEM TO LIKE THE MANUAL CONTROLS OF THIS SYSTEM. NO COMPLICATED BUTTONS OR MANUALS TO READ.

How about HRVs & ERVs?

- The more extreme your winter and summer temperatures, the more energy you will save with an HRV or ERV
- What is the difference between HRV and ERV?
- Energy Recovery Ventilator (ERV) also re-captures moisture content
- Heat Recovery Ventilator only re-captures a percentage of the sensible heat

How much energy will an HRV recover?

- It depends on the efficiency of the unit:



- This cross-flow unit is rated at around 60%, depending on temperature and pressure

How much energy will an HRV recover?

- It depends on the efficiency of the unit:
- This counter-flow unit is rated at around 95%, depending on temperature and pressure
- What does that mean in real dollars?

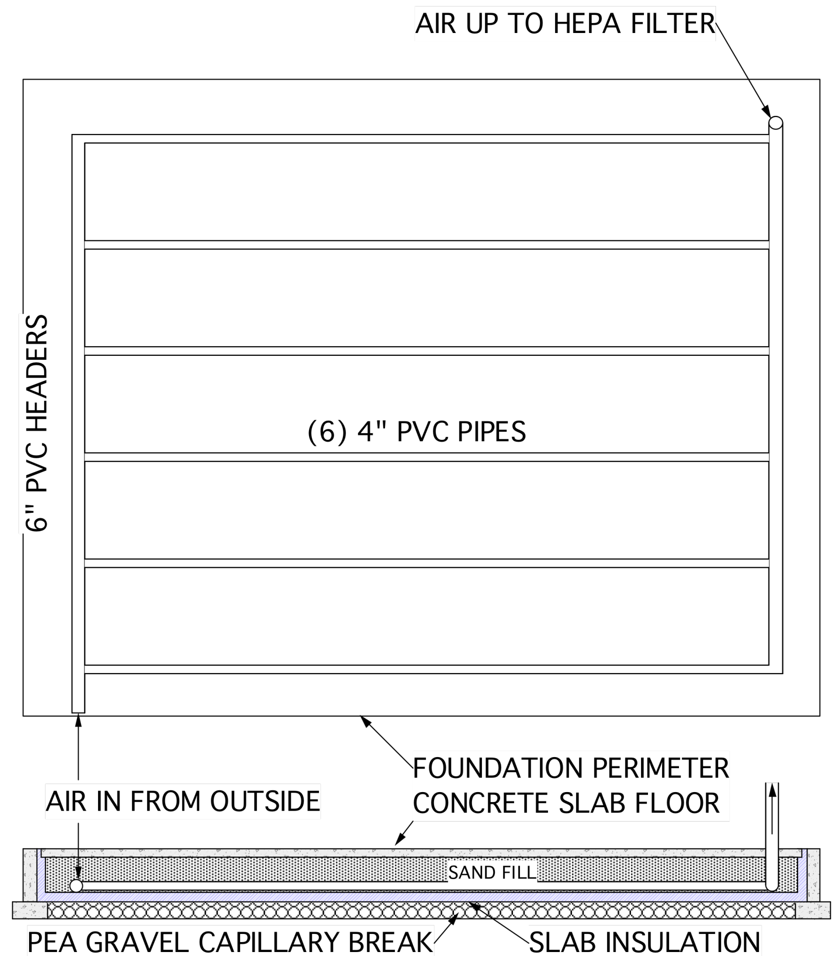
How much energy will an HRV recover? Will it be worth the cost?

Fan Vs HRV?

Project Name:	Carlson House		Elect. cost/Kwh:	0.11
Location:	Street Address		Heat system HSPF	15.4
City:	Your City		Heat system COP	4.51
State:	Your State		Heating Degree Days	5400
ZIP:			Avg. Ext. Temp:	51
			ASHRAE 62.2 Req.(CFM)	50
	Copyright 2012 Zero-Energy Plans LLC			
	Intended for comparison purposes only			
Fan Model:	Panasonic Whisper Green		Zehnder ComfoAir 200	
Fan Watts	11		HRV Watts	143
Fan CFM	80		HRV CFM	118
			Reovery %	95%
Fan cost:*	$132.00		Hrv cost:**	$1,495.00
Fan Hrs/Day	15		HRV Hrs/Day	10.1694915
Fan Btuh/Yr lost	9137556		HRV Btuh/Yr. lost	456877.8
Fan Heat Kwh/Yr:	2678.06448	<using HSPF>	HRV Heat Kwh/Yr:	133.903224
Heating system heat recovery Kwh:	593.347792		Heating system heat recovery Kwh:	29.6673896
Fan Op. Kwh/yr:	60.225		HRV Op. Kwh/Yr:	530.79661
Fan Total Kwh/Yr:	653.57		HRV Total Kwh/Yr:	560.46
Fan Total Cost/Yr:	$71.89	interest rate	HRV Total Cost/Yr:	$61.65
20-Yr Ammortization:	($9.71)	4.00%	20-Yr Ammortization	($110.00)
Total cost w/Ammort:	$81.61		Total cost w/Ammort:	$171.66

Is there another way?

- Under-slab piping
- Cools incoming air during summer
- Warms incoming air during winter
- Must know soil temperatures!
- Works best with in-floor radiant systems!



And yet another way…

- Two opening windows, on opposite sides of the house, will allow for Balanced Ventilation
- Remember, warm air rises…
- Even without wind, the stack effect can cause sufficient air movement to ventilate a house, especially two and three stories
- Incorporate this idea into your window placement!

Ventilation Summary:

- Always balance large ventilation loads, especially in small, tight homes
- Smaller venting loads can be exhaust-only, especially short-duration loads
- Consider appropriate filtration for ALL incoming air
- Install controls that allow automatic operation, but allow user-adjustment
- Keep it simple!

The Future of Housing:
The Path to Net-Zero and Beyond

Chapter 8

Why Heat Pumps?

Why Heat Pumps?

- We can replace electricity with Wind, Solar, Hydro, and Nuclear Power
- Once Gas is used, it is GONE!
- When Gas is burned, it contributes to Climate Change (carbon & methane)
- A Heat Pump only moves heat from one place to another, does not create heat!
- Heat pumps have lower maintenance costs, and higher ultimate efficiency

Why Heat Pumps?

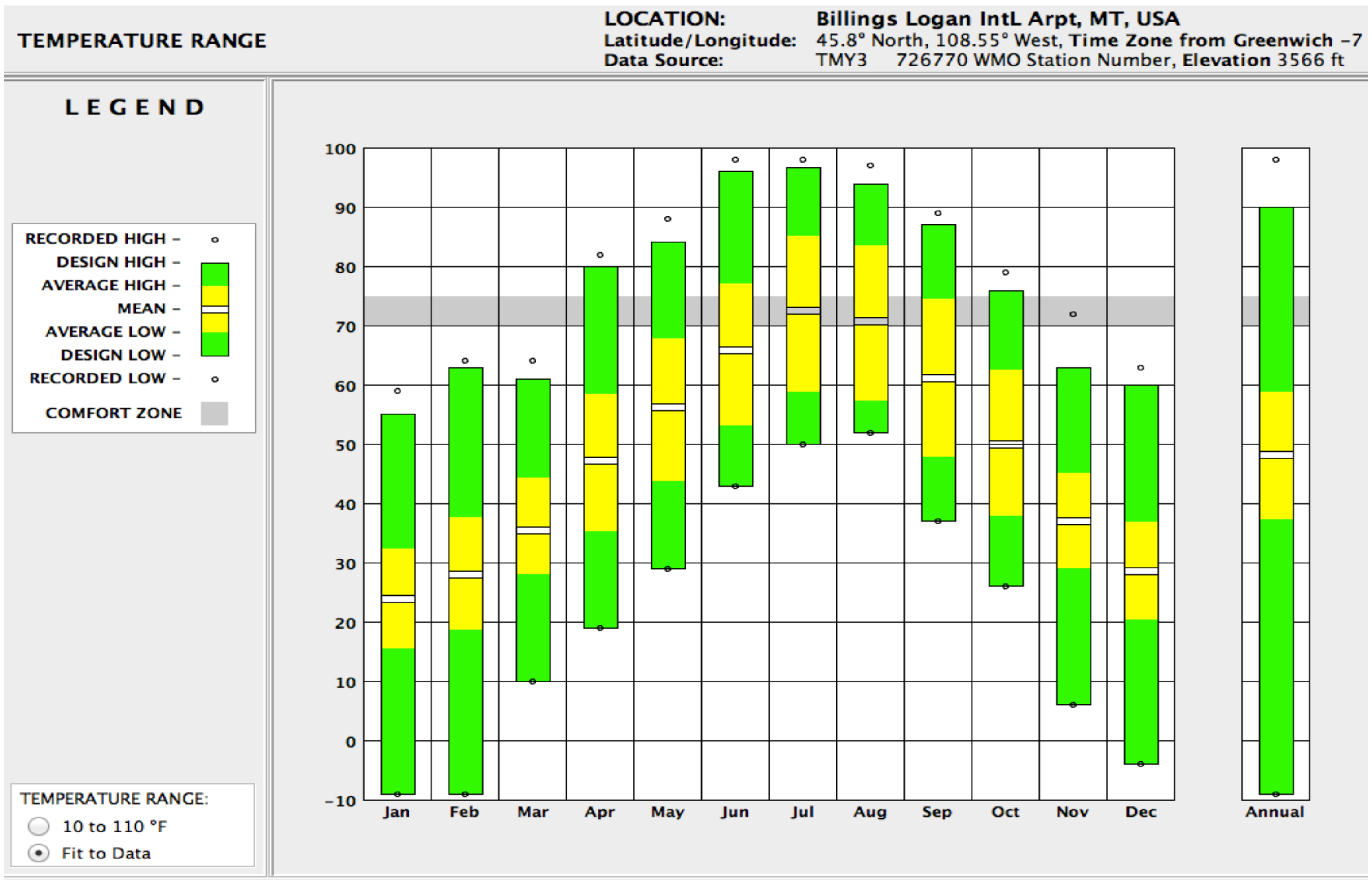
- Consider ONLY the efficiency factor:
  - Modern Gas Power Plants produce electricity at about 63% efficiency, delivered to the grid
  - They can be located right in the middle of town, so potentially no line-losses
  - Operate a Heat Pump and see the net energy savings:
  - At 240% efficient x .63 = 151% net efficiency with use of gas, only requires HSPF of 8.2!

Why Heat Pumps?

- How efficient are Heat Pumps?
  - Most newer units are 300% efficient, HSPF around 10.1 or better.
  - This would be 189% net-efficiency with the gas used to make the electricity!
  - A Ground Source Heat Pump can be up to 450% efficient, which would be 283.5% efficient with its use of gas!
  - Air-source heat pumps are now available that will work down to -15˚F at 200% efficiency!

Where will Air-source Heat Pumps NOT work?

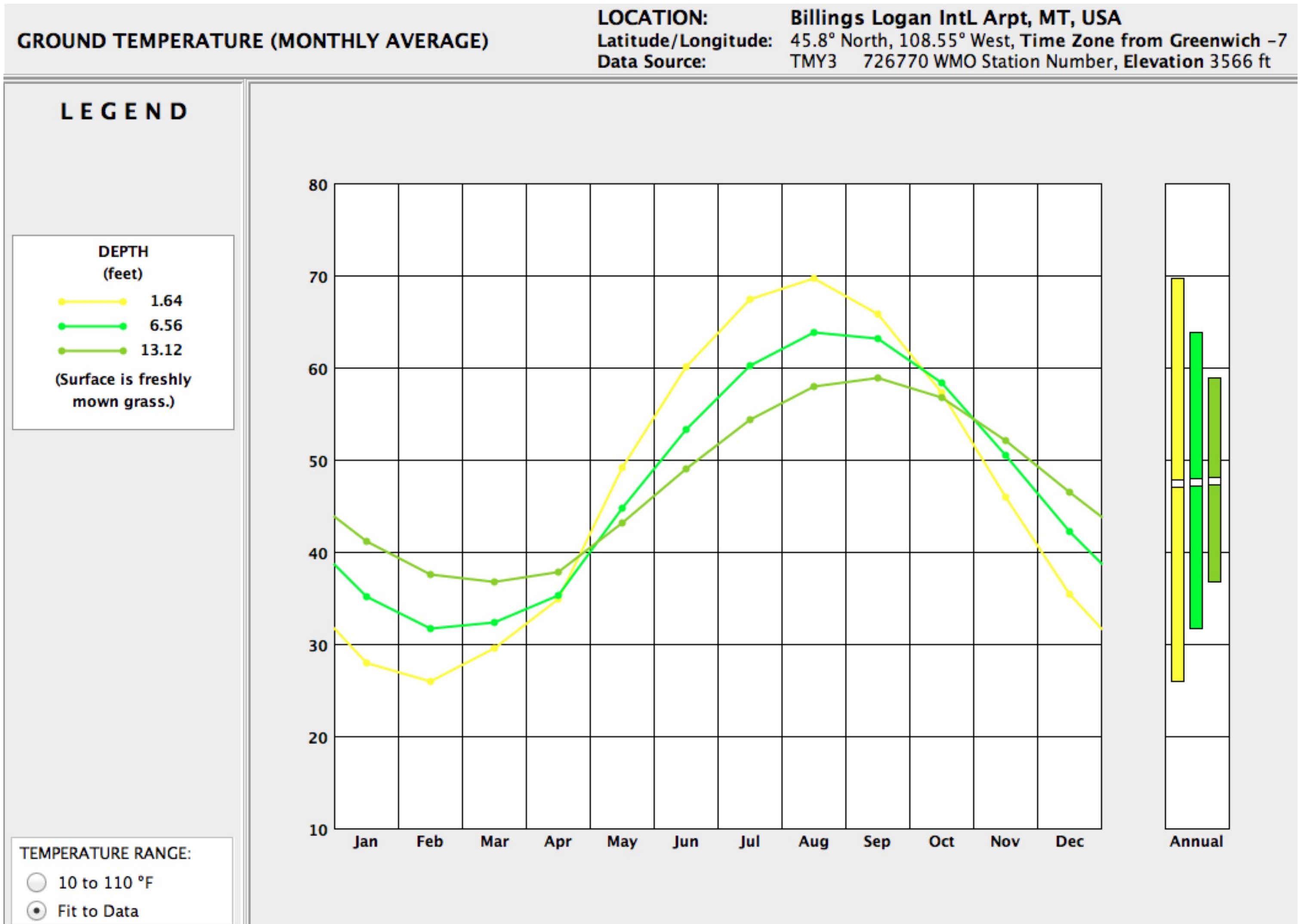
- Consider Billings, Montana:



Where will Air-source Heat Pumps NOT work?

- Consider Billings, Montana:
  - Remember our section on Thermal Mass!
  - For overnight, store heat in the slab
  - Re-heat the home during the day using the air-source heat pump
  - The difference between the low (-9˚F) and the average winter temperature (+26F) is 35˚F!
  - This represents a 44% savings in energy required to heat the home!

Where might Ground Source Heat Pumps have problems?



Where might Ground Source Heat Pumps have problems?

- Again, look at Billings, MT:
  - Ground temperature drops to near 32˚F at 2 meter depth
  - Ground temperature at 4 meter depth is warm enough to operate safely

HEATING PERFORMANCE

Based on 5.3 GPM load and 6.5 GPM source fluid flow

Leaving Load Fluid (F)	Entering Source Fluid (F)	Heating Capacity (MBtuH)	Power Input (kW)	COP	Heat of Absorb. (MBtuH)
100º	35º	25.73	2.01	3.75	18.87
	40º	27.33	2.00	4.01	20.50
	50º	30.82	1.97	4.57	24.08
	60º	34.74	1.95	5.23	28.09
	70º	39.11	1.92	5.96	32.55
110º	35º	25.53	2.28	3.28	17.74
	40º	27.06	2.27	3.49	19.31
	50º	30.40	2.24	3.97	22.75
	60º	34.15	2.21	4.53	26.60
	70º	38.34	2.18	5.15	30.89

How to make the Ground Source Heat Pump work in Billings, MT?

- Deep bore system may be preferred!
- Thermal Mass slabs will take several days, or even weeks to initially bring up to temperature, so take your time on start-up!

Limitations on Air-Source Heat Pumps:

- Cold weather hard limits (-15˚F)
- Reduced capacity at the lower end of the operating range
  - Requires careful sizing of unit to match peak demand
  - Could require back-up system

What can inverter-based units do for you?

Inverter-based Heat Pumps

- Ductless Mini-splits, and other newer heat pump designs now operate using DC motors (inverter-based)
  - Can start slow, & ramp up to full load as needed
  - Can operate at part-load conditions at greater than rated efficiency
  - This is because they can operate at lower temperatures, using their larger, oversized surface areas

Heat with Heat, Cool with Air!

- Put your hand against your mouth, & puff softly… warm, isn't it? 98.6˚ air!
- Now move your hand a few inches away, and blow hard… it feels cold! Still 98.6˚ air, but now it is moving
- Lesson: When warm air moves, it feels cold.
- Factor this into your HVAC plan
- Radiant heat will be more comfortable!

HVAC summary:

- Heat Pumps provide superior ultimate efficiency
- Augment Heat Pumps in colder climates, do not eliminate them!
- Use newer, inverter-based heat pumps when available
- Use Thermal Mass to allow your Air-Source Heat Pump to operate only during the day in colder climates
- Heat with heat, cool with air!

The Future of Housing: The Path to Net-Zero and Beyond

Chapter 9

Water Heating

How Important is Water Heating?

- Is usually the largest energy use, after space conditioning
- Can be the largest energy use, when the right measures are put into the building envelope, passive solar, thermal mass, etc.
- Water heating loads can be cut by more than 90%!

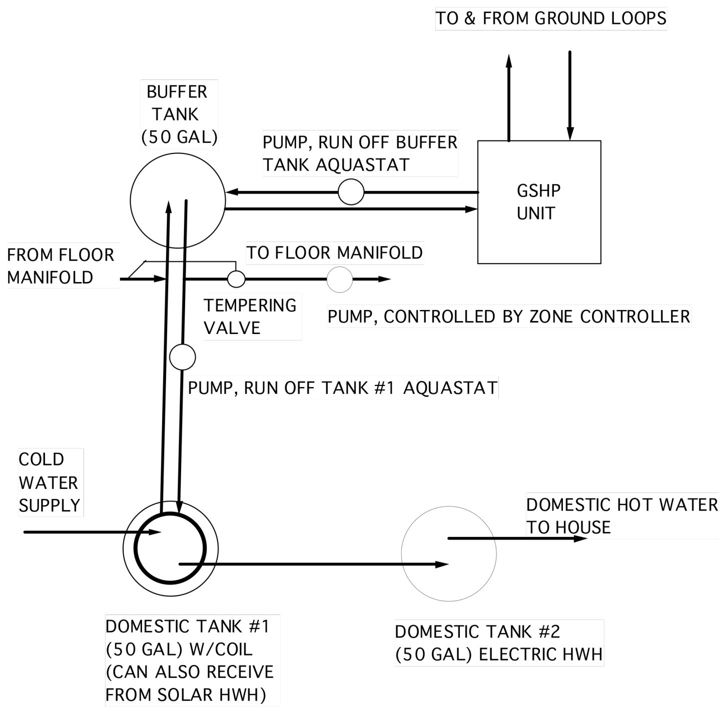
Water Heating, What are the Options?

- Tank-type water heaters
  - Electric (100% efficient, x.63 = 63% net use of gas)
  - Fossil Fuel (up to 95% efficient for condensing units
- On-demand water heaters
  - Electric (same efficiency, no storage capacity)
  - Fossil Fuel (up to 98% efficient, no storage)
- Heat Pump water heaters
  - Up to 335% efficient (x .63 = 211% NU/Gas)

Water Heating, What are the Options, Cont'd

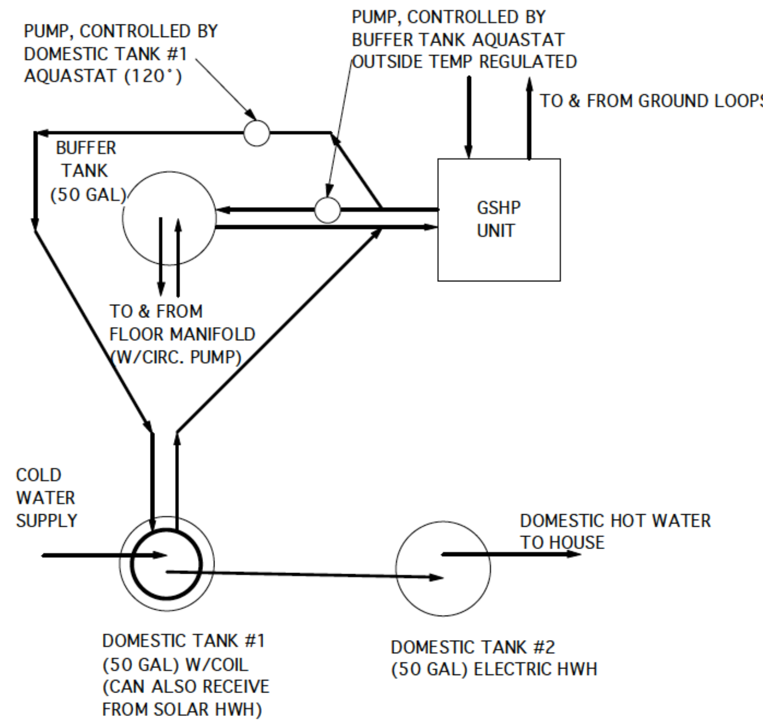
- GSHP Desuperheaters
  - Up to 450% efficient (x .63 = 283.5% NU/Gas
  - How about without a Desuperheater?
  - Desuperheaters only work when GSHP is heating the house
  - These two options prioritize the production of Domestic Hot Water:

Two GSHP/Domestic HW options:



THIS SYSTEM REQUIRES KEEPING THE BUFFER TANK AT 120˚ TO 125˚, AND THE DOMESTIC TANK #1 AT 110˚+

GSHP OPTION #1
(AS WE DID IT WITH UNICHILLER IN BALLARD)



THIS SYSTEM ALLOWS A TEKMAR OR SIMILAR OUTSIDE TEMPERATURE SENSOR TO CONTROL THE BUFFER TANK TEMPERATURE, WHILE THE DOMESTIC TANK #1 ALWAYS IS ABLE TO CALL FOR 120˚ WATER, RESULTING IN HIGHER ULTIMATE ENERGY EFFICIENCY FOR BOTH THE DOMESTIC AND IN-FLOOR SYSTEMS.

GSHP OPTION #2 (PREFERRED)

Water Heating, What are the Options, Cont'd

- GSHP Desuperheaters
  - Up to 450% efficient (x .63 = 283.5% NU/Gas
- Solar hot water heaters
  - Require electricity to run pumps only
  - May not provide enough hot water during cold & rainy weather
  - Can be used in combination with other heating sources
  - Match very well with Ground Source Heat Pumps, and Air-to Water Heat Pumps

Solar Water Heating Options?

- Flat-plate collectors
  - Work best in sunny climate
- Evacuated-tube collectors
  - Work best in cloudy climate
- Closed-loop system
- Drain-back system
  - Avoids potential for freezing up overnight

Why, and where, to use a Tank…

- In cold climate, if tank is inside the conditioned building, residual heat is used by the building
- In warm climate this is not desirable, it adds to the cooling loads

  What effect will a Heat Pump Water Heater have?

Why, and where, to use a Heat Pump Water Heater…

- In cold climate, if HPWH is inside the conditioned building, it will be robbing heat from the building…
- In warm climate this <u>is</u> desirable, it <u>reduces</u> the cooling loads!
- In a moderate climate, the HPWH can be placed in an attached garage. On average, the garage temperature will be warm enough to benefit the HPWH
- Tier-3 units exhaust to the outside

Why, and where, to use an On-Demand Water Heater…

- In a cold climate, the On-Demand unit is only effective when hot water use is irregular (as for vacation homes)
- In warm climate the On-Demand water heater will not contribute to the cooling loads
- On-Demand units can be located nearest the point of use
- They can be used as back-up to Solar Hot Water Heaters

Water Heating Summary:

- Water Heating is VERY climate specific!
- Water Heating can also be user-specific
- Calculate your loads, consult your climate, then specify your system!
- In a moderate or cold climate, residual heat is usually desirable, and can help offset space-heating loads

The Future of Housing: The Path to Net-Zero and Beyond

Chapter 10

Efficient Appliances

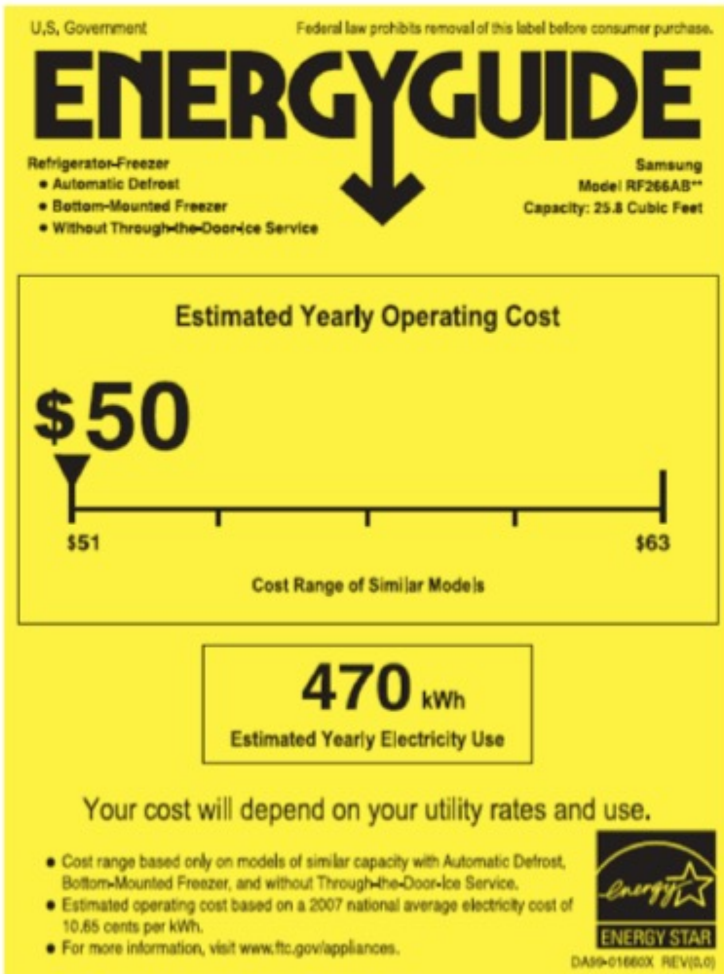
Define the Loads:

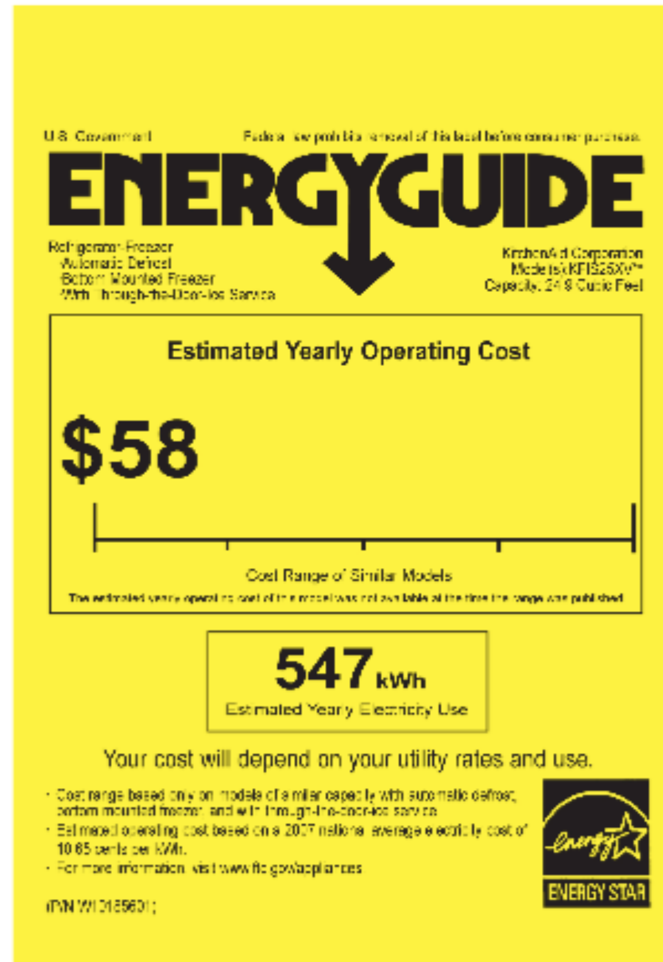
- In most Net-Zero-Ready homes, Cooking will be the largest remaining energy load!
- Clothes Dryers could be the next largest Appliance load
  - They not only create a lot of heat, they also suck conditioned air out of the house!
- The Refrigerator will likely come next
- The Dishwasher will use two to three times as much energy as the Clothes Washer

Get out the Hatchet!

- Start by chopping the largest loads
  - Induction Ranges are saving up to 60% of cooking loads!
- Then the next largest
  - Condensing clothes dryers re-circulate the same air, wringing the moisture out of it
  - Heat gets recovered, and re-used!
- Then tighten up on the smaller loads
  - Check the Energy Star stickers closely!

Check the EnergyGuides carefully: Both are Energy Star!





What is $8 over time?

Year	inflation	Cost/Kwh	Make/Model	Alt. Make/Model	size	cost/year	cost/ time	save/ time	alt. cost/yr	alt. cost/time
1	1.0605	0.1070	R-1/XX	R-2/YZ	26 Cu.Ft.	$60.00	$60.00	$8.00	$52.00	$52.00
2	1.0605	0.1135	R-1/XX	R-2/YZ	26 Cu.Ft.	$63.63	$123.63	$16.48	$55.15	$107.15
3	1.0605	0.1203	R-1/XX	R-2/YZ	26 Cu.Ft.	$67.48	$191.11	$25.48	$58.48	$165.63
4	1.0605	0.1276	R-1/XX	R-2/YZ	26 Cu.Ft.	$71.56	$262.67	$35.02	$62.02	$227.65
5	1.0605	0.1353	R-1/XX	R-2/YZ	26 Cu.Ft.	$75.89	$338.56	$45.14	$65.77	$293.42
6	1.0605	0.1435	R-1/XX	R-2/YZ	26 Cu.Ft.	$80.48	$419.05	$55.87	$69.75	$363.17
7	1.0605	0.1522	R-1/XX	R-2/YZ	26 Cu.Ft.	$85.35	$504.40	$67.25	$73.97	$437.15
8	1.0605	0.1614	R-1/XX	R-2/YZ	26 Cu.Ft.	$90.52	$594.91	$79.32	$78.45	$515.59
9	1.0605	0.1712	R-1/XX	R-2/YZ	26 Cu.Ft.	$95.99	$690.91	$92.12	$83.19	$598.79
10	1.0605	0.1815	R-1/XX	R-2/YZ	26 Cu.Ft.	$101.80	$792.71	$105.69	$88.23	$687.01
11	1.0605	0.1925	R-1/XX	R-2/YZ	26 Cu.Ft.	$107.96	$900.67	$120.09	$93.56	$780.58
12	1.0605	0.2042	R-1/XX	R-2/YZ	26 Cu.Ft.	$114.49	$1,015.16	$135.35	$99.22	$879.80
13	1.0605	0.2165	R-1/XX	R-2/YZ	26 Cu.Ft.	$121.42	$1,136.57	$151.54	$105.23	$985.03
14	1.0605	0.2296	R-1/XX	R-2/YZ	26 Cu.Ft.	$128.76	$1,265.34	$168.71	$111.59	$1,096.62
15	1.0605	0.2435	R-1/XX	R-2/YZ	26 Cu.Ft.	$136.55	$1,401.89	$186.92	$118.35	$1,214.97
16	1.0605	0.2583	R-1/XX	R-2/YZ	26 Cu.Ft.	$144.81	$1,546.70	$206.23	$125.51	$1,340.48
17	1.0605	0.2739	R-1/XX	R-2/YZ	26 Cu.Ft.	$153.58	$1,700.28	$226.70	$133.10	$1,473.57
18	1.0605	0.2904	R-1/XX	R-2/YZ	26 Cu.Ft.	$162.87	$1,863.15	$248.42	$141.15	$1,614.73
19	1.0605	0.3080	R-1/XX	R-2/YZ	26 Cu.Ft.	$172.72	$2,035.87	$271.45	$149.69	$1,764.42
20	1.0605	0.3267	R-1/XX	R-2/YZ	26 Cu.Ft.	$183.17	$2,219.04	$295.87	$158.75	$1,923.16
21	1.0605	0.3464	R-1/XX	R-2/YZ	26 Cu.Ft.	$194.25	$2,413.29	$321.77	$168.35	$2,091.52
22	1.0605	0.3674	R-1/XX	R-2/YZ	26 Cu.Ft.	$206.00	$2,619.29	$349.24	$178.54	$2,270.05
23	1.0605	0.3896	R-1/XX	R-2/YZ	26 Cu.Ft.	$218.47	$2,837.76	$378.37	$189.34	$2,459.39
24	1.0605	0.4132	R-1/XX	R-2/YZ	26 Cu.Ft.	$231.68	$3,069.44	$409.26	$200.79	$2,660.18
25	1.0605	0.4382	R-1/XX	R-2/YZ	26 Cu.Ft.	$245.70	$3,315.14	$442.02	$212.94	$2,873.12
26	1.0605	0.4647	R-1/XX	R-2/YZ	26 Cu.Ft.	$260.57	$3,575.71	$476.76	$225.82	$3,098.95
27	1.0605	0.4928	R-1/XX	R-2/YZ	26 Cu.Ft.	$276.33	$3,852.04	$513.61	$239.49	$3,338.43
28	1.0605	0.5226	R-1/XX	R-2/YZ	26 Cu.Ft.	$293.05	$4,145.09	$552.68	$253.98	$3,592.41
29	1.0605	0.5542	R-1/XX	R-2/YZ	26 Cu.Ft.	$310.78	$4,455.87	$594.12	$269.34	$3,861.75
30	1.0605	0.5878	R-1/XX	R-2/YZ	26 Cu.Ft.	$329.58	$4,785.45	$638.06	$285.64	$4,147.39

Appliance Efficiency Summary

- Small reductions in larger loads will have more impact!
- Ratchet down all loads as much as feasible
- Be on the watch for newer technology, such as Induction Ranges, Condensing Dryers… Remember the Microwave?
- Without spending any extra money, better energy efficiency numbers can be found
- Counter-top cooking appliances are more efficient than ranges or cook-tops!

The Future of Housing:
The Path to Net-Zero and Beyond

Chapter 11

Efficient Lighting

Energy Efficient Lighting: It begins with the Design!

- Remember to light Surfaces, not Rooms!
  - Surfaces may be stationary, like counter tops
  - They can be portable, like a newspaper or book
  - Think about where these surfaces will be, and design for them!
- Design multi-purpose lighting systems
  - Task lighting can also provide general room illumination
  - Ambience lighting can also be used for general illumination
  - Fewer systems means fewer lights to be left on when not being used!

Also consider Lighting Controls:

- Dimmers can reduce loads when brightness is not required
- Specialty controls can light scenes instead of rooms
  - Can aid in reducing total connected load
  - Can provide dimming where full brightness is not needed
- Motion sensors or infrared detectors can shut lights off when not in use

What type of fixture should you use?

- Linear LED strips are the most economical, but not often popular in homes
- Compact fluorescent lamps have already almost disappeared!
  - Select fixtures that use type A screw-in bulbs!
  - More LEDs are being made for this type of base!
- LEDs are improving in quality and price, and have wiped the CFL off the planet!

What is the difference, over time?

Light bulb cost/time

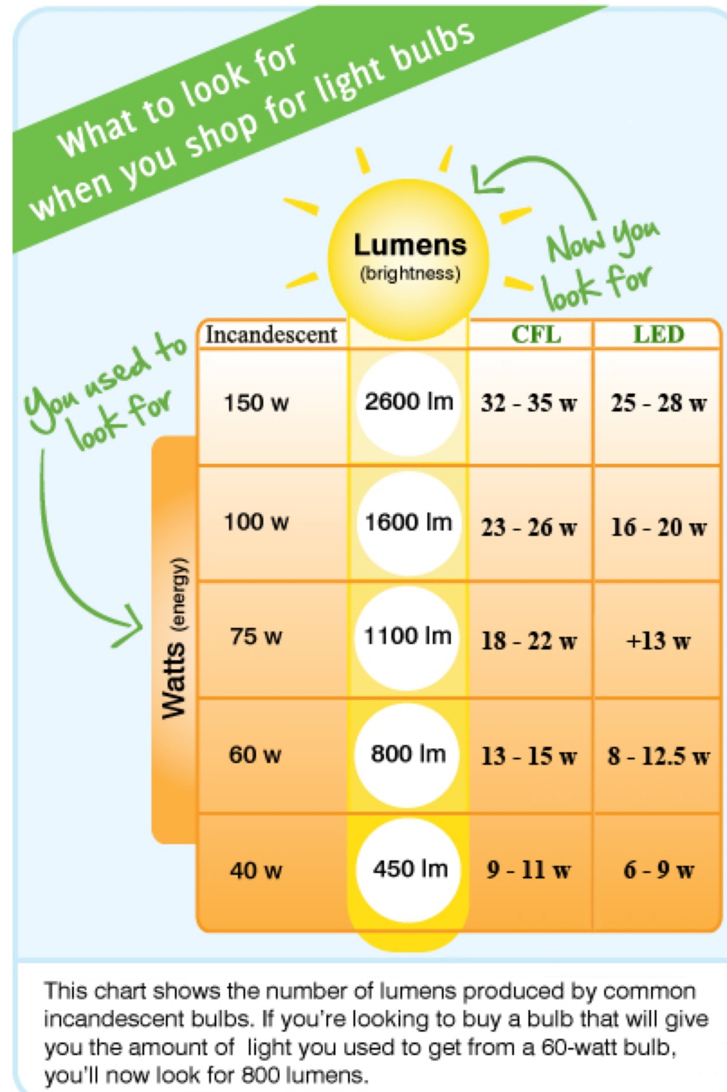
Year	inflation	Cost/Kwh	watts	alt. watts	hours /day	cost/day	cost/year	cost/ time	save/ time	alt. cost/yr	alt. cost/time
1	1.0605	0.1070	100	23	4	$0.0428	$15.62	$15.62	$12.03	$3.59	$3.59
2	1.0605	0.1135	100	23	4	$0.0454	$16.57	$32.19	$24.79	$3.81	$7.40
3	1.0605	0.1203	100	23	4	$0.0481	$17.57	$49.76	$38.31	$4.04	$11.44
4	1.0605	0.1276	100	23	4	$0.0510	$18.63	$68.39	$52.66	$4.29	$15.73
5	1.0605	0.1353	100	23	4	$0.0541	$19.76	$88.15	$67.88	$4.54	$20.27
6	1.0605	0.1435	100	23	4	$0.0574	$20.96	$109.11	$84.01	$4.82	$25.09
7	1.0605	0.1522	100	23	4	$0.0609	$22.22	$131.33	$101.12	$5.11	$30.21
8	1.0605	0.1614	100	23	4	$0.0646	$23.57	$154.90	$119.27	$5.42	$35.63
9	1.0605	0.1712	100	23	4	$0.0685	$24.99	$179.89	$138.51	$5.75	$41.37
10	1.0605	0.1815	100	23	4	$0.0726	$26.51	$206.39	$158.92	$6.10	$47.47
11	1.0605	0.1925	100	23	4	$0.0770	$28.11	$234.50	$180.57	$6.47	$53.94
12	1.0605	0.2042	100	23	4	$0.0817	$29.81	$264.31	$203.52	$6.86	$60.79
13	1.0605	0.2165	100	23	4	$0.0866	$31.61	$295.93	$227.86	$7.27	$68.06
14	1.0605	0.2296	100	23	4	$0.0919	$33.53	$329.45	$253.68	$7.71	$75.77
15	1.0605	0.2435	100	23	4	$0.0974	$35.55	$365.01	$281.05	$8.18	$83.95
16	1.0605	0.2583	100	23	4	$0.1033	$37.70	$402.71	$310.09	$8.67	$92.62
17	1.0605	0.2739	100	23	4	$0.1096	$39.99	$442.70	$340.88	$9.20	$101.82
18	1.0605	0.2904	100	23	4	$0.1162	$42.41	$485.10	$373.53	$9.75	$111.57
19	1.0605	0.3080	100	23	4	$0.1232	$44.97	$530.07	$408.16	$10.34	$121.92
20	1.0605	0.3267	100	23	4	$0.1307	$47.69	$577.76	$444.88	$10.97	$132.89
21	1.0605	0.3464	100	23	4	$0.1386	$50.58	$628.34	$483.82	$11.63	$144.52
22	1.0605	0.3674	100	23	4	$0.1469	$53.64	$681.98	$525.12	$12.34	$156.85
23	1.0605	0.3896	100	23	4	$0.1558	$56.88	$738.86	$568.92	$13.08	$169.94
24	1.0605	0.4132	100	23	4	$0.1653	$60.32	$799.18	$615.37	$13.87	$183.81
25	1.0605	0.4382	100	23	4	$0.1753	$63.97	$863.15	$664.63	$14.71	$198.53
26	1.0605	0.4647	100	23	4	$0.1859	$67.84	$931.00	$716.87	$15.60	$214.13
27	1.0605	0.4928	100	23	4	$0.1971	$71.95	$1,002.94	$772.27	$16.55	$230.68
28	1.0605	0.5226	100	23	4	$0.2090	$76.30	$1,079.24	$831.02	$17.55	$248.23
29	1.0605	0.5542	100	23	4	$0.2217	$80.92	$1,160.16	$893.32	$18.61	$266.84
30	1.0605	0.5878	100	23	4	$0.2351	$85.81	$1,245.97	$959.40	$19.74	$286.57

How do I get my customers to accept LEDs?

- Select the right LEDs!
  - Remember 2700˚ Kelvin Temperature
  - This is the best color range (warm white)
  - Select LEDs that are instant-on
  - Select dimmable LEDs where needed
- Use the LEDs in the highest use locations, they will provide the biggest benefit there!
- Just DO IT, they never need to know! <☺

Lumens vs. Watts?

- Learn to select bulbs by the number of lumens they produce, not the number of watts they consume!



Incandescent	Lumens	CFL	LED
150 w	2600 lm	32 - 35 w	25 - 28 w
100 w	1600 lm	23 - 26 w	16 - 20 w
75 w	1100 lm	18 - 22 w	+13 w
60 w	800 lm	13 - 15 w	8 - 12.5 w
40 w	450 lm	9 - 11 w	6 - 9 w

What about Plug Loads?

- Education is the key to Consumer Awareness!
- Advise your customers on the selection process, so they can choose TVs and other large energy users based on energy loads
  - LED backlit LCD TVs use just a fraction of the energy of a similar-sized plasma TV, with similar clarity!
  - Install switches to turn off plugs at night

Typical HERS for ZER home:

Home Energy Rating Certificate

Property	HERS			
Lee DADU	Rating Type:	Confirmed	Certified Energy Rater:	Elizabeth Coe
105 Front St NE	Rating Date:	7/23/2020	Rating Number:	
Coupeville, WA 98239	Registry ID:			

Confirmed: - No Registry ID

HERS Index: 39

General Information

Conditioned Area	694 sq. ft.	House Type	Single-family detached
Conditioned Volume	5875 cubic ft.	Foundation	Unconditioned basement
Bedrooms	1		

Mechanical Systems Features

Water Heating:	Heat pump, Electric, 2.33 EF, 80.0 Gal.
Air-source heat pump:	Electric, Htg: 10.3 HSPF. Clg: 17.0 SEER.
Duct Leakage to Outside	NA
Ventilation System	Balanced: 30 cfm, 30.0 watts.
Programmable Thermostat	Heat=Yes; Cool=Yes

Building Shell Features

Ceiling Flat	NA	Slab	None
Sealed Attic	NA	Exposed Floor	R-30.0
Vaulted Ceiling	R-44.0	Window Type	U-Value: 0.170, SHGC: 0.390
Above Grade Walls	R-29.0	Infiltration Rate	Htg: 2.88 Clg: 2.88 ACH50
Foundation Walls	R-29.0	Method	Blower door

Lights and Appliance Features

Interior Fluor Lighting (%)	0.0	Range/Oven Fuel	Electric
Interior LED Lighting (%)	100.0	Clothes Dryer Fuel	Electric
Refrigerator (kWh/yr)	563	Clothes Dryer CEF	4.20
Dishwasher (kWh/yr)	200	Ceiling Fan (cfm/Watt)	0.00

Estimated Annual Energy Cost

Use	MMBtu	Cost	Percent
Heating	2.6	$63	14%
Cooling	0.0	$0	0%
Hot Water	2.1	$52	12%
Lights/Appliances	9.7	$241	55%
Photovoltaics	-0.0	$-0	-0%
Service Charges		$84	19%
Total	**14.3**	**$440**	**100%**

Criteria

This home meets or exceeds the minimum criteria for the following:

TITLE
Company
Address
City, State, Zip
Phone #
Fax #

REM/Rate - Residential Energy Analysis and Rating Software v15.8

The Home Energy Rating Standard Disclosure for this home is available from the rating provider.

Energy Efficient Lighting Summary:

- Not all that shines brightly is gold!
- Light surfaces, not rooms
- Use LEDs for most applications
- Use dimmable LEDs for multi-use areas
- Educate your customers
- Learn to select bulbs by the number of lumens they produce, not the number of watts they consume!

The Future of Housing: The Path to Net-Zero and Beyond

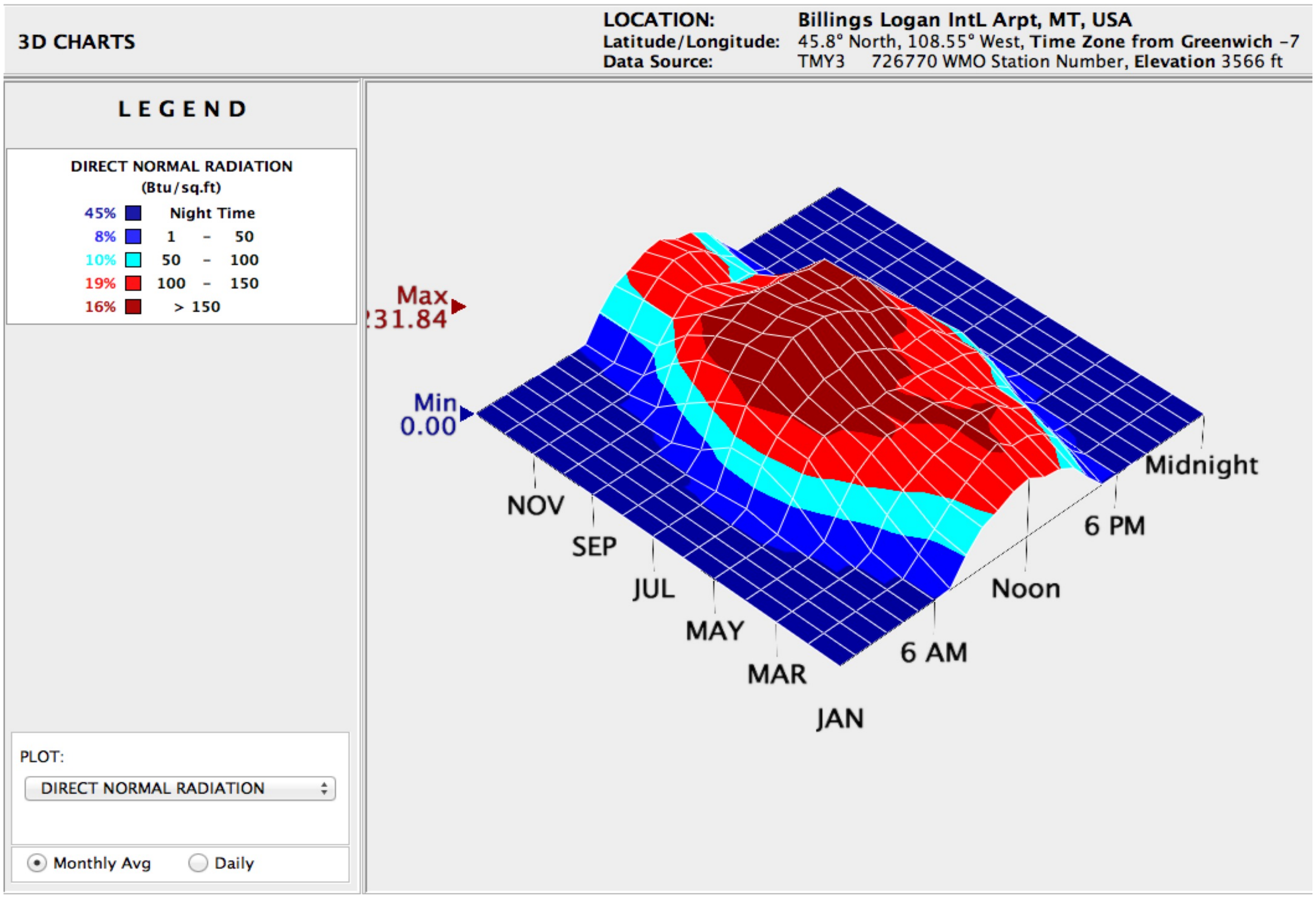
Chapter 12

Alternative Energy

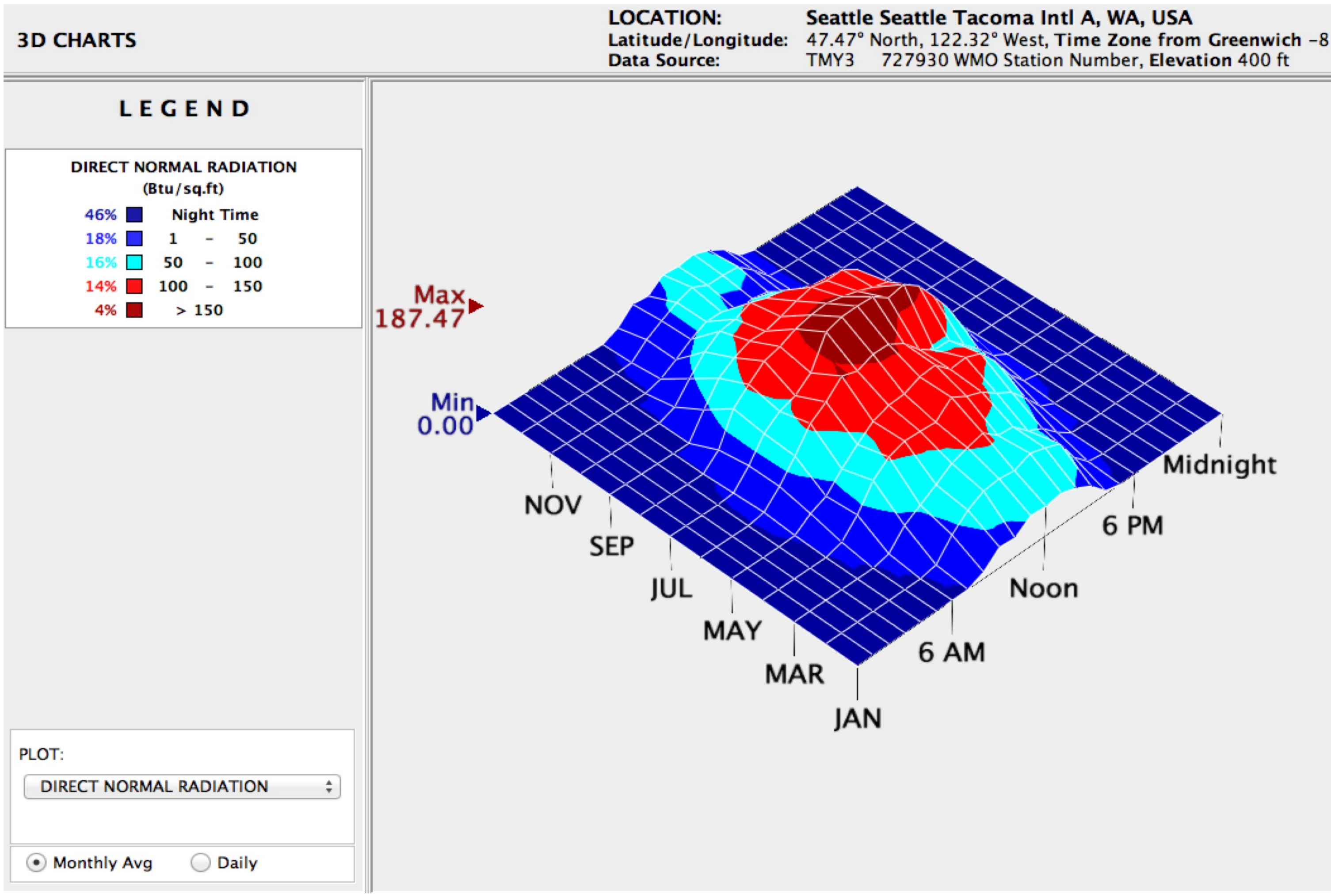
What are your design tools?

- Climate Data (CC-6)
  - What time of year you get sun will help determine ideal roof pitch
- Web-based Solar Calculators or I-Phone Apps, http://pvwatts.nrel.gov
  - Estimates annual production based on location, roof pitch and direction
- Local Installer
  - Will have more specialized tools for more accurate and specific assessment

Climate Consultant 5:



Climate Consultant 5:



Calculate Energy Needs

- HERS rating will provide annual estimate of power usage
  - For heating & cooling
  - For water heating
  - For appliances
  - For lighting & plug loads

RemRate Energy Usage Report:

Weather Site:	Seattle, WA	Rating Type:	Confirmed Rating
File Name:	Thomas_final.blg	Rating Date:	9/28/2011

		Thomas
Annual Energy Cost ($/yr)		
Annual End-Use Cost ($/yr)		
Heating	$	85
Cooling	$	0
Water Heating	$	92
Lights & Appliances	$	476
Photovoltaics	$	-665
Service Charges	$	87
Total	$	74
Annual End-Use Consumption		
Heating (kWh)		968
Water Heating (kWh)		1063
Lights & Appliances (kWh)		5527
Photovoltaics (kWh)		-7716

Annual Energy Demands (kW)	
Heating	3.0
Cooling	0.7
Water Heating (Winter Peak)	0.2
Water Heating (Summer Peak)	0.1
Lights & Appliances (Winter Peak)	0.4
Lights & Appliances (Summer Peak)	1.2
Total Winter Peak	3.6
Total Summer Peak	2.0

Be sure to deduct Service Charges from actual usage!

Match Energy Production to Needs:

- Use Web-based, Cell-phone App or Local Solar Installer's Estimate for system sizing
- Explore electric car usage:
  - Chevy Volt will go 2.86 miles per Kwh
  - Nissan Leaf will go 3.45 miles per Kwh
  - Tesla Model 3 will go up to 4.5 miles per Kwh

A surplus of 2,500 Kwh per year could power a car for 11,250 miles!

How much is that worth?

- My Honda Civic got 34.5 MPG avg.
  - At $4.85 per gallon, 13,000 miles cost me $1,897.83
- My Tesla Model 3 gets 4.5 Miles/Kwh
  - If the 3,000 Kwh required to go 13,500 miles is worth the same as my gasoline, then it is worth $1,506.52, or 50.2¢ per Kwh!
  - Average that out with the 7,000 Kwh of production that ran the house:

How much is that worth?

- 3,000 x 50.2¢ = $ 1,897.83
- 7,000 x .15¢ = $ 1,050.00
- Total value of Energy = $2,947.83
- Value per Kwh = 29.5¢ per Kwh!
- This is in addition to any State or Federal incentives!

How about Wind Power?

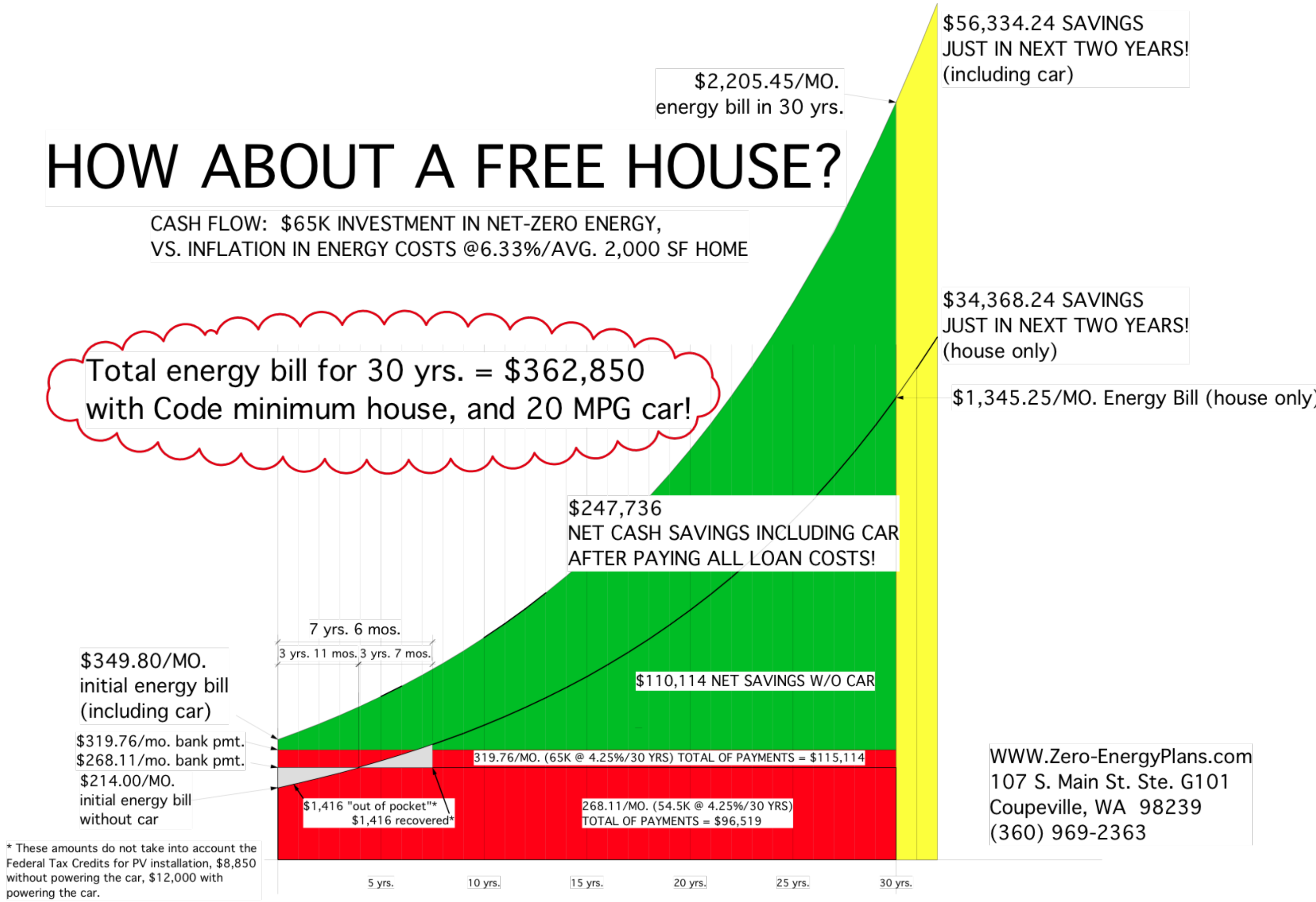
- It depends on where you are!
  - Billings, Montana looked pretty good!
- Trees and tall buildings are Major impediments to successful wind power
  - Trees could make Western Washington pretty difficult!
- All renewable energy sources are Local!
- Consult with your Local Installer!

How much does it cost to get to Net-Zero-Energy?

Thomas House additional costs over code-minimum house

Item	Description	Cost
Foundation Insulation	4" XPS foam	$1,250
SIPS Walls & Roof	6.5" walls, 10.25" roof	$12,000
Air Sealing Labor	Saved 8 hrs labor w/SIPS	-$800
Heating System	Unico UniChiller in-floor Radiant	$10,000
Balanced Ventilation	FanTech HEPA Filter system	$1,000
Water Heating	Unichiller, extra tank w/coils, pump	$1,500
PV System	6.44 KW	$29,500
Total:	(As-Built, to power house only)	$54,450
Less Federal Tax Credits:		$8,850
Net Out of Pocket:	(net-zero home only)	$45,600

How much does a new Positive NRG™ Home Cost? How fast does it Pay Off?



Questions????

Zero-EnergyPlans.com

www.zero-energyplans.com

Ted L. Clifton