Promoting Research and Education for Alaskans in Sustainable Development

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How to Zero Your Electric Bill

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

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APPROPRIATE TECHNOLOGY

INTRODUCTIONS

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

Notes for everyone to Share:

- **Name**
- **Where do you live?**
- **Did you bring a copy of your electric bill?**
- **What is your average daily electric usage in kwh?**
- **What's your average monthly bill?**
- **Total annual cost?**

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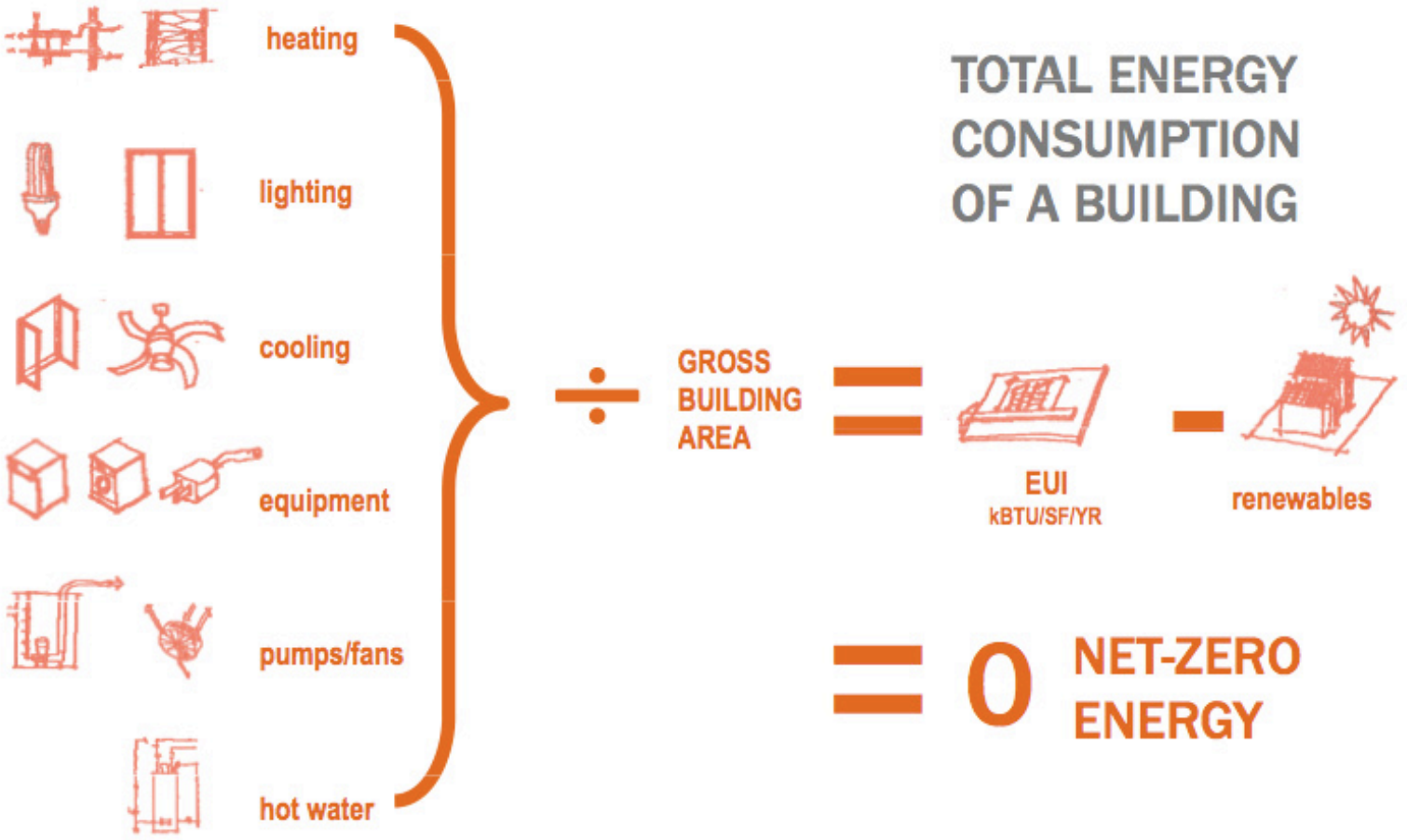
NET ZERO ENERGY BUILDING



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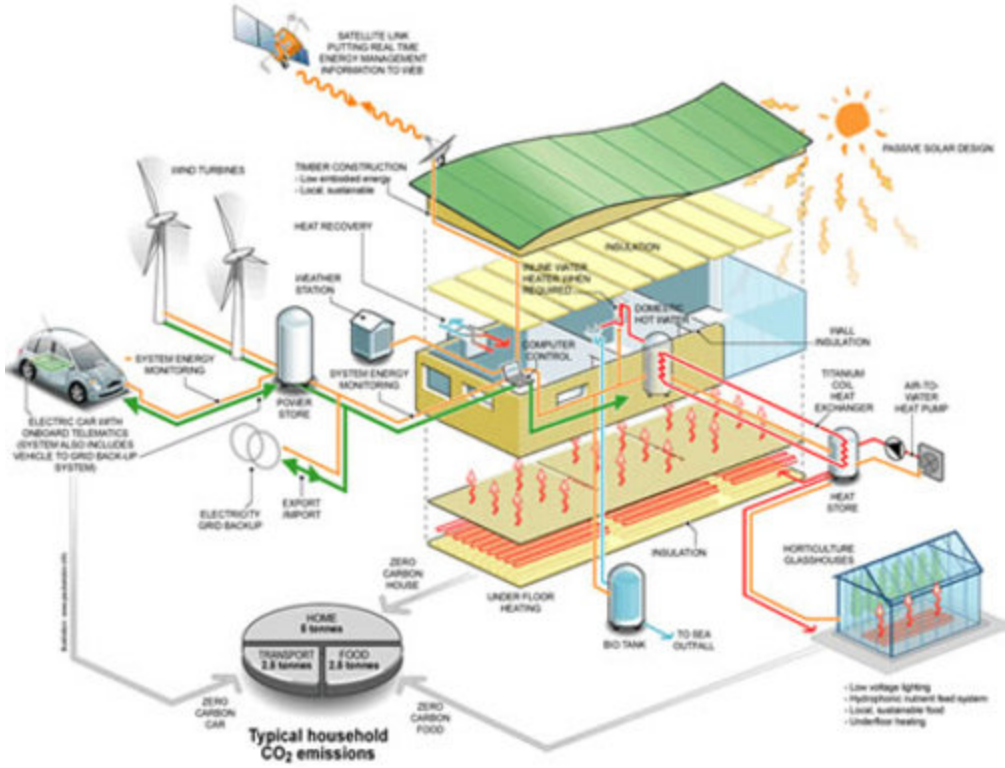
WHAT DOES NET ZERO ENERGY LOOK LIKE?



OR.

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

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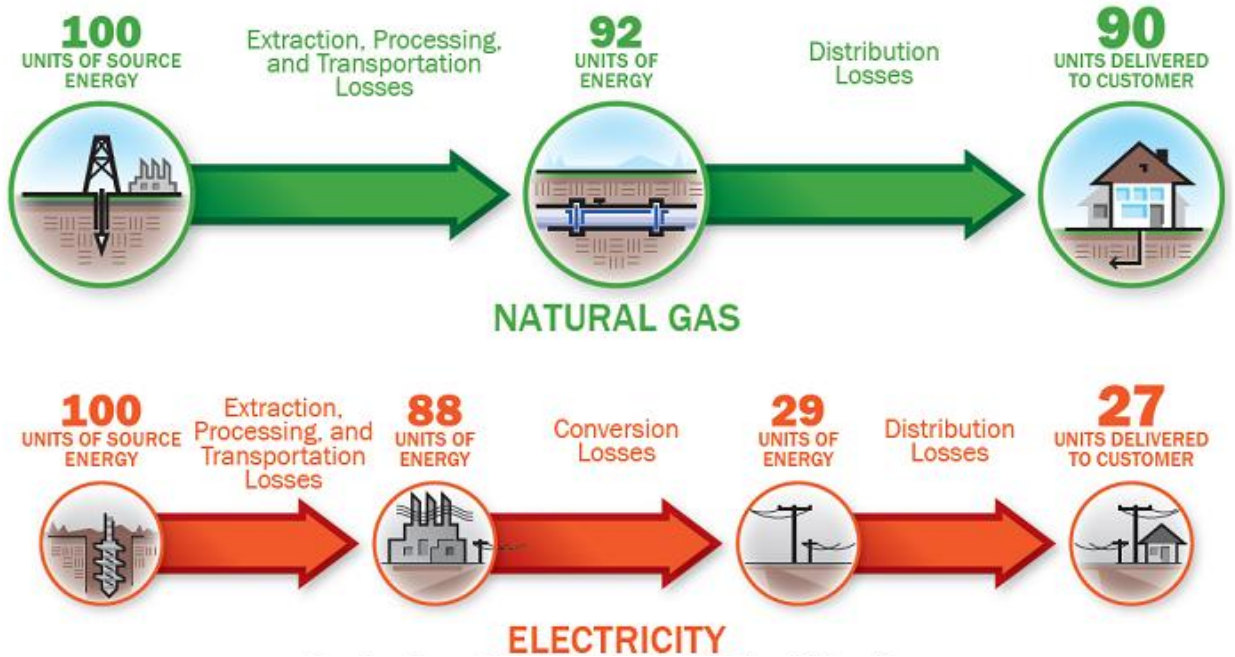
NET ZERO ENERGY BUILDING

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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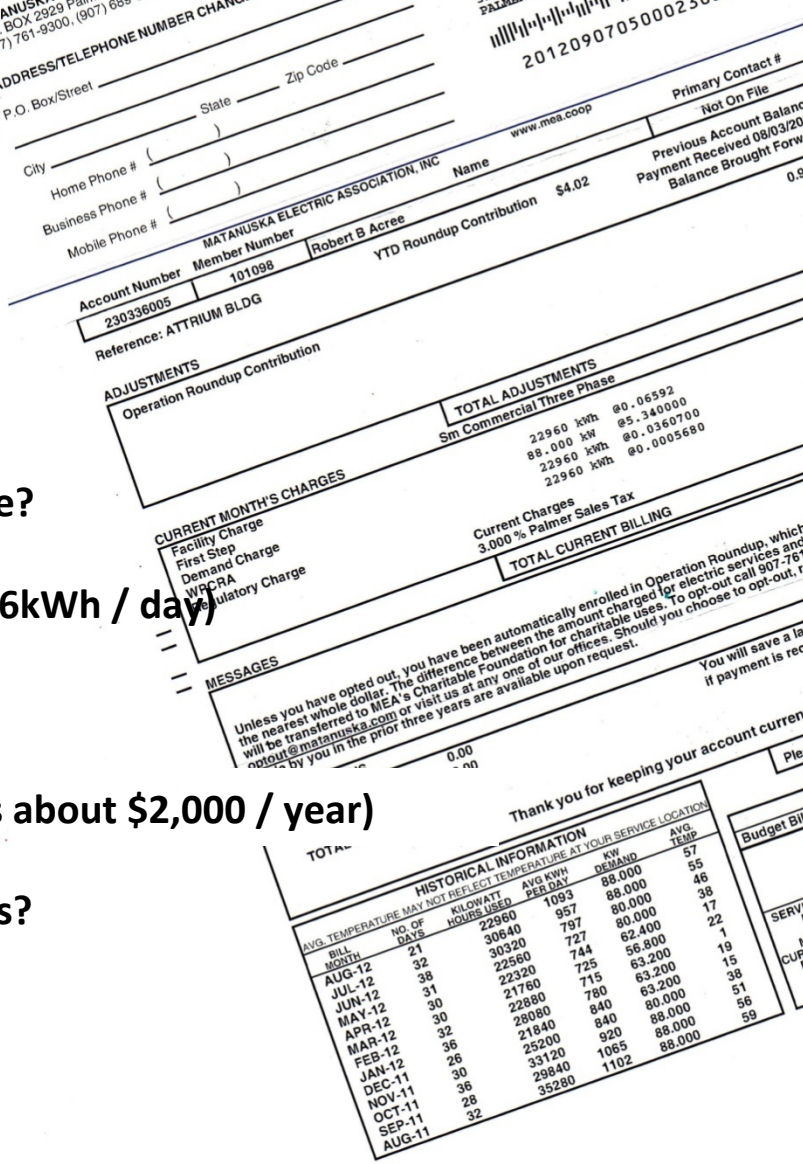
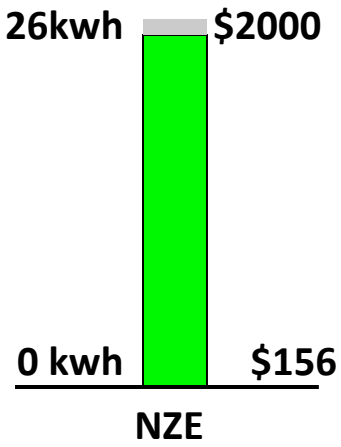
Electric Usage



What is your current electric usage?

- **kWh per day? (Valley averages 26kWh / day)**
- **Summer versus winter?**
- **Cost per year? (Valley averages is about $2,000 / year)**
- **What are the biggest contributors?**
- **Can you reduce it?**



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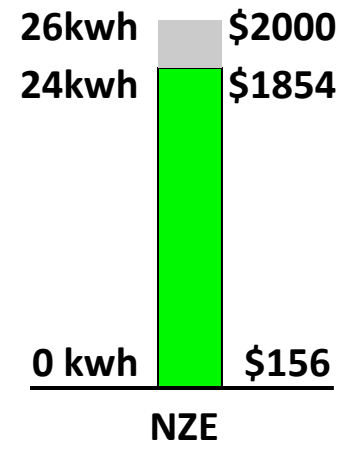
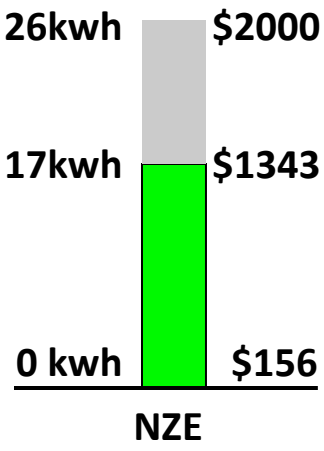
Electric Usage - Reductions

Reductions – order of ease and cost payback

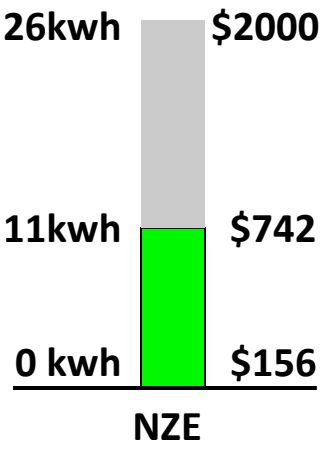
Step 1: Phantom Loads



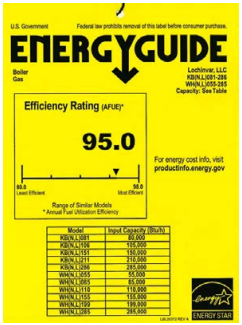
Step 2: Lighting

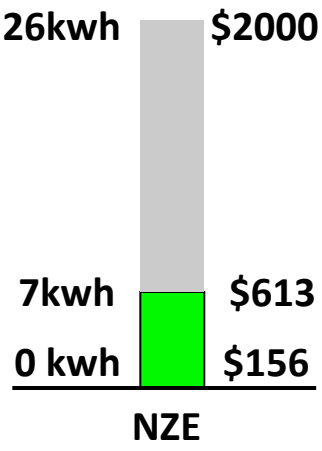


Step 3: Appliances

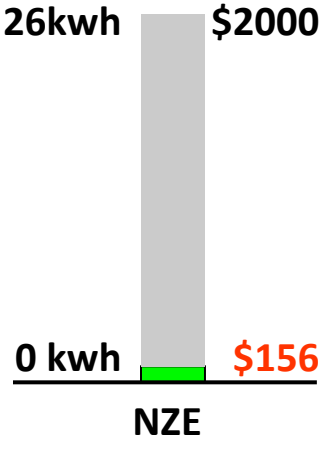


Step 4: HVAC Equipment





Step 5: Solar Panels



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Unplugging, Plug Loads and Phantom Loads

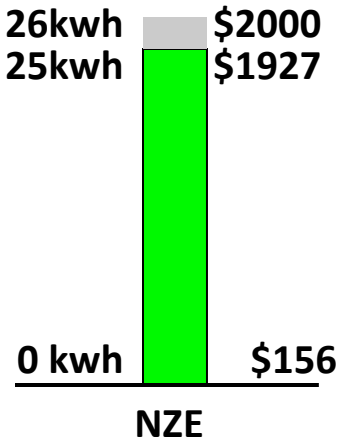
Plug Loads and Phantom Loads are the things that we plug into the wall outlets and forget about. They are easy to forget about. But just because they aren't "on" doesn't mean they're using no energy.

- **Anything with a remote (TV, DVD, DVR, Stereo)**
- **Anything with a transformer or "wall-wart" (Phones, chargers)**
- **Power Strips**
- **Chargers**

How do we reduce these loads?

- **Unplug chargers**
- **Power Strips**
- **Turn off wifi when not being used**

Simply unplugging chargers and turning items off when not in use is an easy way to see electrical savings. The example house saw a 1kwh per day reduction from this and about $73 savings per year.



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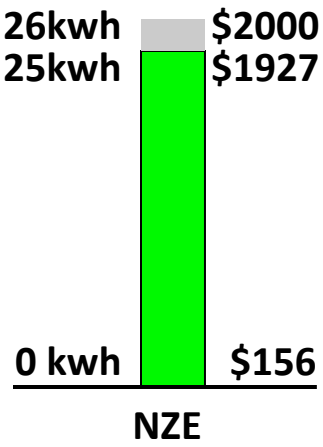
Plug Loads and Phantom Loads

Member household phantom load example[1]					
Product type	Total phantom loads[2]	Monthly phantom load - energy use (kWh) and cost		Annual phantom load - energy use (kWh) and cost	
Plasma TV (<40")	3 Watts	2.19	$0.20	26.28	$2.37
DVR	37 Watts	27.01	$2.43	324.12	$29.17
DVD player	1 Watt	0.73	$0.07	8.76	$0.79
Audio system	8 Watts	5.84	$0.53	70.08	$6.31
Cordless phone	2 Watts	1.46	$0.13	17.52	$1.58
Desktop Computer, monitor and speakers	8 Watts	5.84	$0.53	70.08	$6.31
Computer modem	5 Watts	3.65	$0.33	43.80	$3.94
Multi-function printer	6 Watts	4.38	$0.39	52.56	$4.73
Power tool charger	4 Watts	2.94	$0.26	35.04	$3.15
Totals	**74 Watts**	**54.04 kWh**	**$4.87**	**648 kWh**	**$58.35**

Totals shown only reflect the device's use when turned off. Many electronic devices use significantly more energy when on, and on but not running. The above scenario is just an example, your actual phantom loads and total electronics use may be more or less depending on the amount of electronics in your home and how often they are used. If you have more than one of any device, multiply the monthly or yearly totals by the amount of your devices to get your totals.

**Costs based on an average rate of 9 cents per kilowatt-hour*



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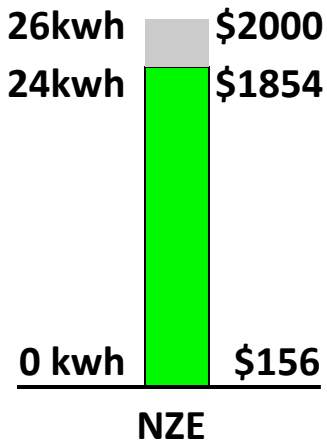
Plug Loads and Phantom Loads

Here's what we had in the example case:

- **DVD - 1w**
- **Stereo - 8w**
- **Phone - 2w**
- **Computer 8w**
- **Modem 5w**
- **Printer 6w**
- **TV 5w**

Subtotal = 35w x24hrs = 840w x365days = 306kwh (1kwh/day) = $62

In order to avoid these loads, we used a power strip at the entertainment center and another at the office computer. The auto-off power strip is used at the office.



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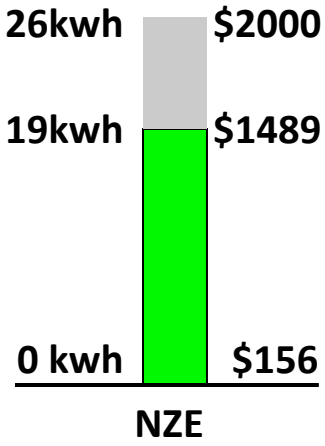
Lighting

Lighting is essential to our living and working environments. Depending on how much light comes in from windows and what time of year it is, lights can be on 8hrs a day. For our example, we'll assume some daylighting and use 4hrs a day.

- Incandescent – 100w x4hrs x 365days = 146kwh/year x$0.20 = $29
- CFL –FLourescent - 23w x4hrs x 365days = 33.6kwh/year x$0.20 = $7
- LEDs - 14wx4hrs x 365days = 20.4kwh/year x$0.20 = $4

That's either $25 or $22 savings per year, depending on bulb type.



LED 100w equivalent bulb is $4.57. So, the LED will pay back in 2-3 months.

For our example house, we have about 50 lightbulbs and let's assume 10 of those are still incandescent. So that saves us:

- 1788 kwh (or 5 kwh per day)
- $358 /year
- Total bulb cost: $228

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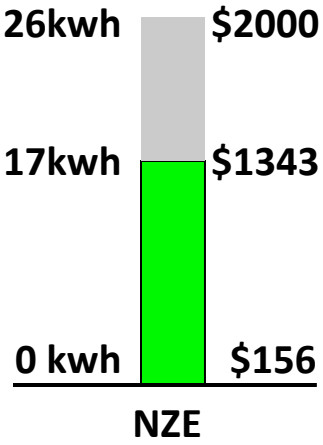
Lighting – Exterior Lights

Similar to interior lighting, exterior lighting use can be dependent on time of the year. During the winter, it is not uncommon to see folks turn on exterior lights when they leave in the morning and then leave them on for when they come home at night (10-12hrs).

- Incandescent – 100w x12hrs x 365days = 438kwh/year x$0.20 = $88
- CFL –FLourescent - 23w x12hrs x 365days = 100kwh/year x$0.20 = $20
- LEDs - 14wx12hrs x 365days = 61kwh/year x$0.20 = $12

That's either $68 or $76 savings per year, depending on bulb type.



If we use a photocell to turn the light off when there is enough daylight:

- LED w/ Photocell - 14wx6hrs x 365days = 30kwh/year x$0.20 = $6

For our example, we have about 2 lights on photocells. So that saves us:

- 754 kwh (or 2 kwh per day)
- $150 /year
- Total bulb/photocell cost: $20

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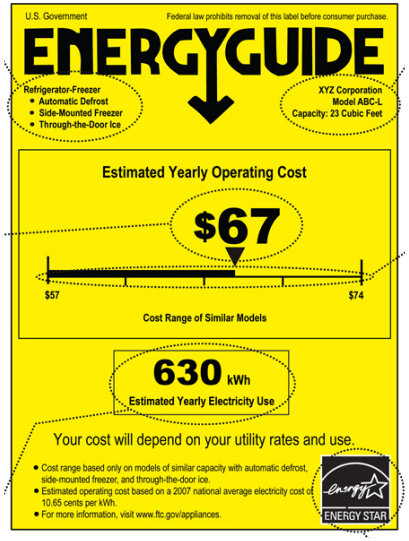
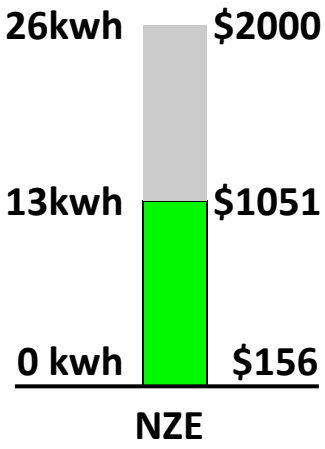
Appliances





Energy Star provides ratings for many household appliances. They are available in viewable spreadsheets comparing similar size and types. They are typically rated with an estimated average annual usage.

Appliance	Average	E-Star	Savings	$/Year
•Refrigerator	1000kwh	725kwh	275kwh	$55
•Freezer	329kwh	218kwh	111kwh	$22
•Dishwasher	833kwh	315kwh	518kwh	$104
•Washer	590kwh	95kwh	495kwh	$99
•Dryer	769kwh	607kwh	162kwh	$32
		Subtotal=1561kwh		$312
			(4.2kwh/day)	

Appliances that are not Energy Star rated:

- **Microwave (700-1500w)**
- **Oven/Range (oven typically 4000w)**
  - **Induction 2,800w, 84%**
  - **Elect Smooth Top 2,500w, 74%**
  - **Elect Coils 2,000w, 55%**

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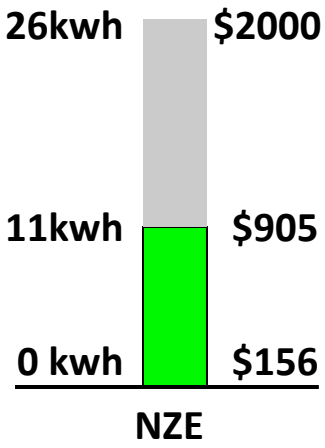
Other Energy Star Items

Energy Star provides ratings for a number of other household items and equipment. Many of these are also tested for low phantom load use.

Appliance	Average	E-Star	Savings	$/Year
•Humidifiers	125kwh	70kwh	55kwh	$11
•Air Cleaners	408kwh	183kwh	225kwh	$45
•TVs	150kwh	38kwh	112kwh	$22
•Audio/Video	164kwh	24kwh	140kwh	$28
•Telephones	131kwh	1kwh	130kwh	$26
•Fans	120kwh	87kwh	33kwh	$6
•Computer	150kwh	72kwh	78kwh	$16
•Monitor	75kwh	20kwh	55kwh	$11
•UPS/Backup	50kwh	25kwh	25kwh	$5
		Subtotal =	853kwh	$171
			(2.3kwh/day)	



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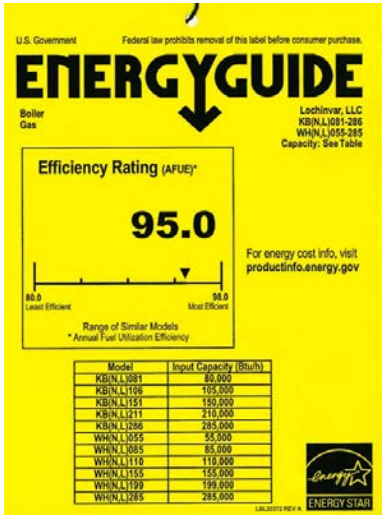
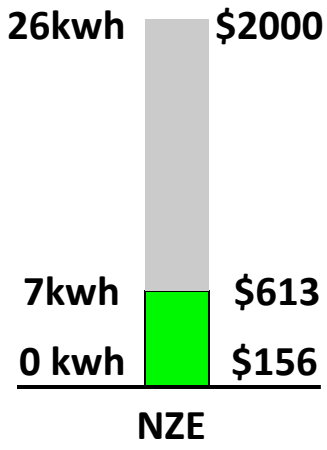
Heating and Hot Water



Typically in our area, this equipment is natural gas or fuel-oil fired. But most of the heating appliances still have electrical fans, pumps or controls associated with them. Newer equipment should have lower electrical use, but it's good to check on it if you're replacing a heater.

Equipment	Average	E-Star	Savings	$/Year
•Furnace	2285kwh	1371kwh	914kwh	$183 (or)
•Boiler	1705kwh	1021kwh	684kwh	$138
•Unit Heater	209kwh	156kwh	52kwh	$10 (turned off)
•Hot Water Heater	NA			
•Bathroom Fans	25kwh	5kwh	20kwh	$4
		Subtotal =	986kwh	$197
			(3kwh per day)	



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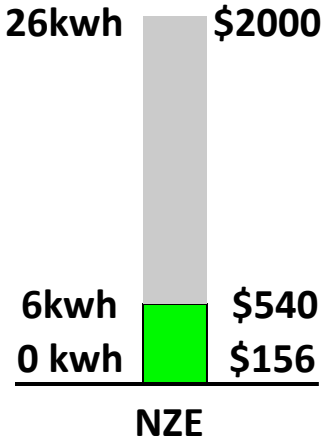
Phantom Loads - Advanced

Similar to the Plug Loads and Phantom Loads that we talked about earlier, there are a number of items in our houses that are "always on". These items are more involved to modify to eliminate their phantom load.

- **GFCI Outlets (and Weatherproof receptacles) – 1w-5w draw**
  - **1w X 24 hrs X 365 days = 8760 wh or 8.7 kwh per year**
  - **5w X 24 hrs X 365 days = 42,800 wh or 42.8 kwh per year**
  - **$1.74 - $8.56 per year**
  - **Assuming 10 outlets, that's 87-428kwh and $17 - $86 per year (about 1kwh per day)**



- **What's a good solution?**
  - **GFCI's are important as a protection device in wet locations**
  - **Limit # of locations**
  - **GFCI Breaker still has a constant draw**
  - **Put GFCI Outlets on a switch, LED switch to show it's on**

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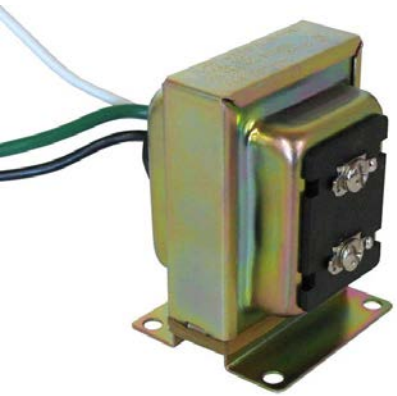
Phantom Loads - Advanced

Similar to the Plug Loads and Phantom Loads that we talked about earlier, there are a number of items in our houses that are "always on". These items are more involved to modify to eliminate their phantom load.



•Doorbell – 7w

- **Doorbells are low voltage and use a transformer to change from AC to DC. The transformer is always on.**
- **7w X 24 hrs X 365 days = 61,320 wh or 61 kwh per year**
- **$12 per year**

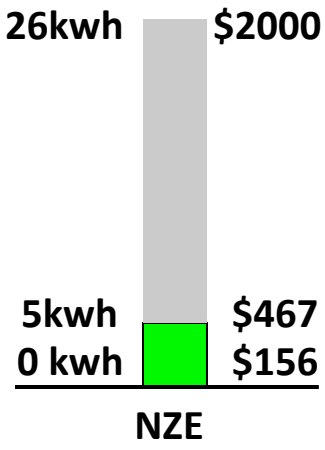
•Garage Door – 5-7w

- **Garage Doors have remote controls, right?**
- **In order to engage the remote, the unit is always on.**

•HRV Controls – 5-7w

- **The low voltage control panel has a constant draw.**

7w X 24 hrs X 365 days = 61,320 wh or 61 kwh per year
$12 per year
If you have all 3 of these, that's $36 or 183kwh/year. (0.5kwh/day)



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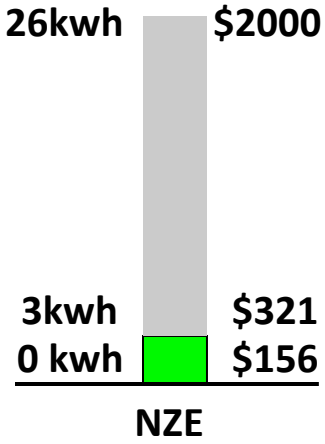
Phantom Loads - Advanced

Similar to the Plug Loads and Phantom Loads that we talked about earlier, there are a number of items in our houses that are “always on”. These items are more involved to modify to eliminate their phantom load.

- Dimmer Switches – many of these cool looking devices have a phantom load of 1w plus. Imagine all your switches = 219kwh, $44/year.
- Occupancy Sensors
- Heat Exchanger Water Heaters
- Geothermal Heat Pumps



Daylighting and passive strategies also play a big part. During the summer and shoulder seasons, the electrical use drops another 2kwh per day. This is mostly due to natural daylighting being used rather than the lighting.

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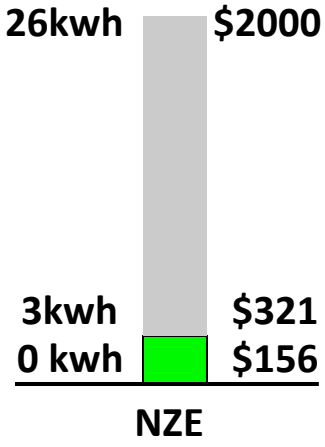
Lastly… Renewables

Solar Photovoltaic

- **Type of system**
  - **Fixed, building mounted**
  - **Tracking Array**
- **How big a system? (kw)**
  - **How many kwh per year are you using?**
  - **What's your budget?**
- **What area is available for solar panels?**
  - **Building or ground mount**
  - **Is it partially shaded?**



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

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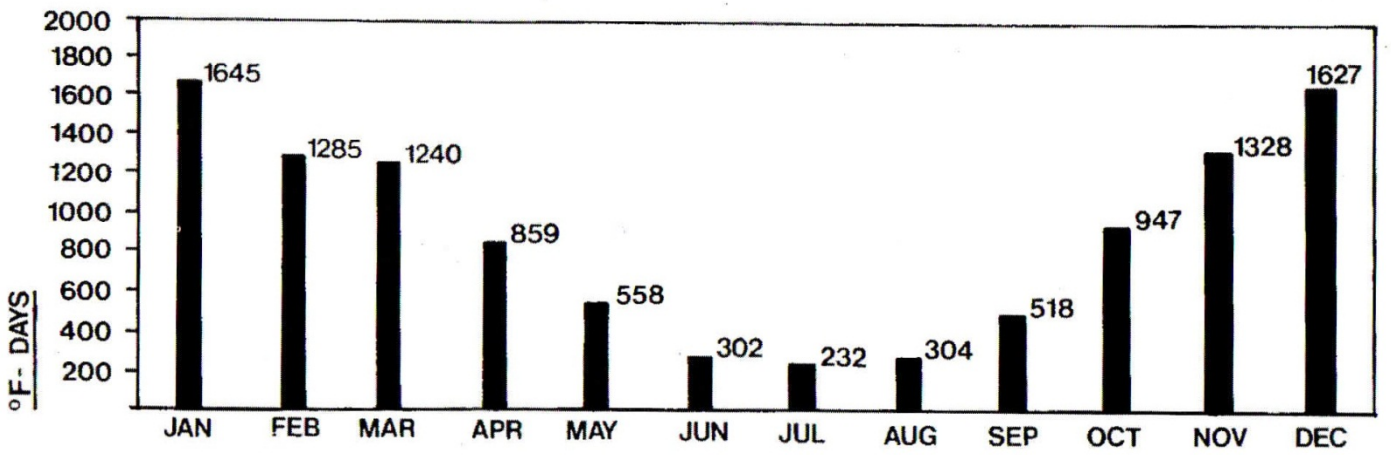
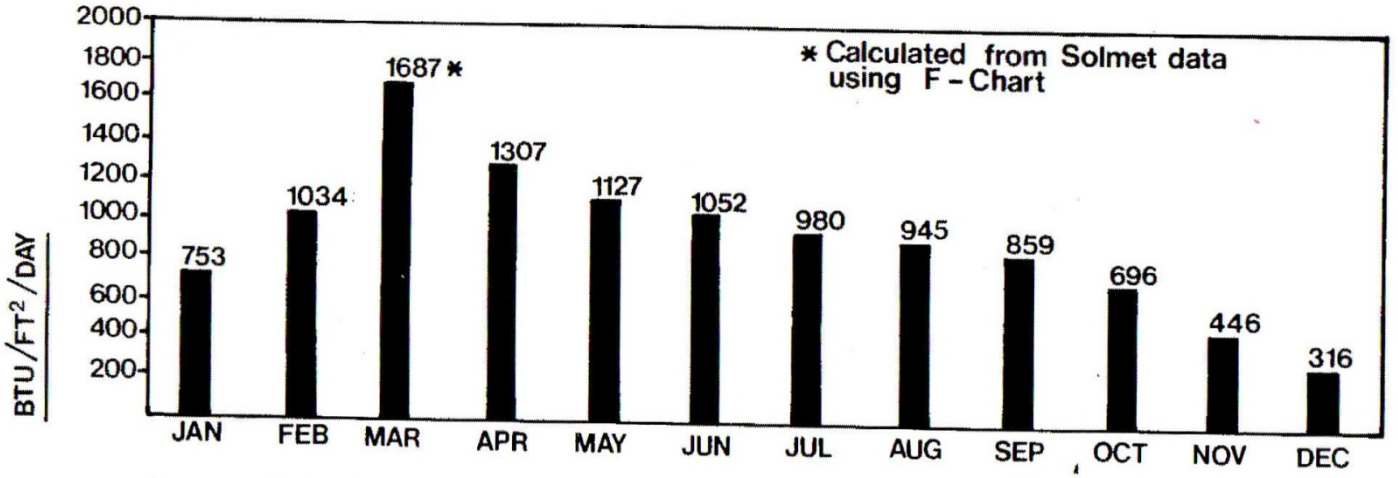
PASSIVE SOLAR vs. HEATING DEGREE DAYS



Average Monthly Heating Degree Days

Matanuska, Alaska



Average Solar Radiation on a Vertical South Facing Surface

Matanuska, Alaska

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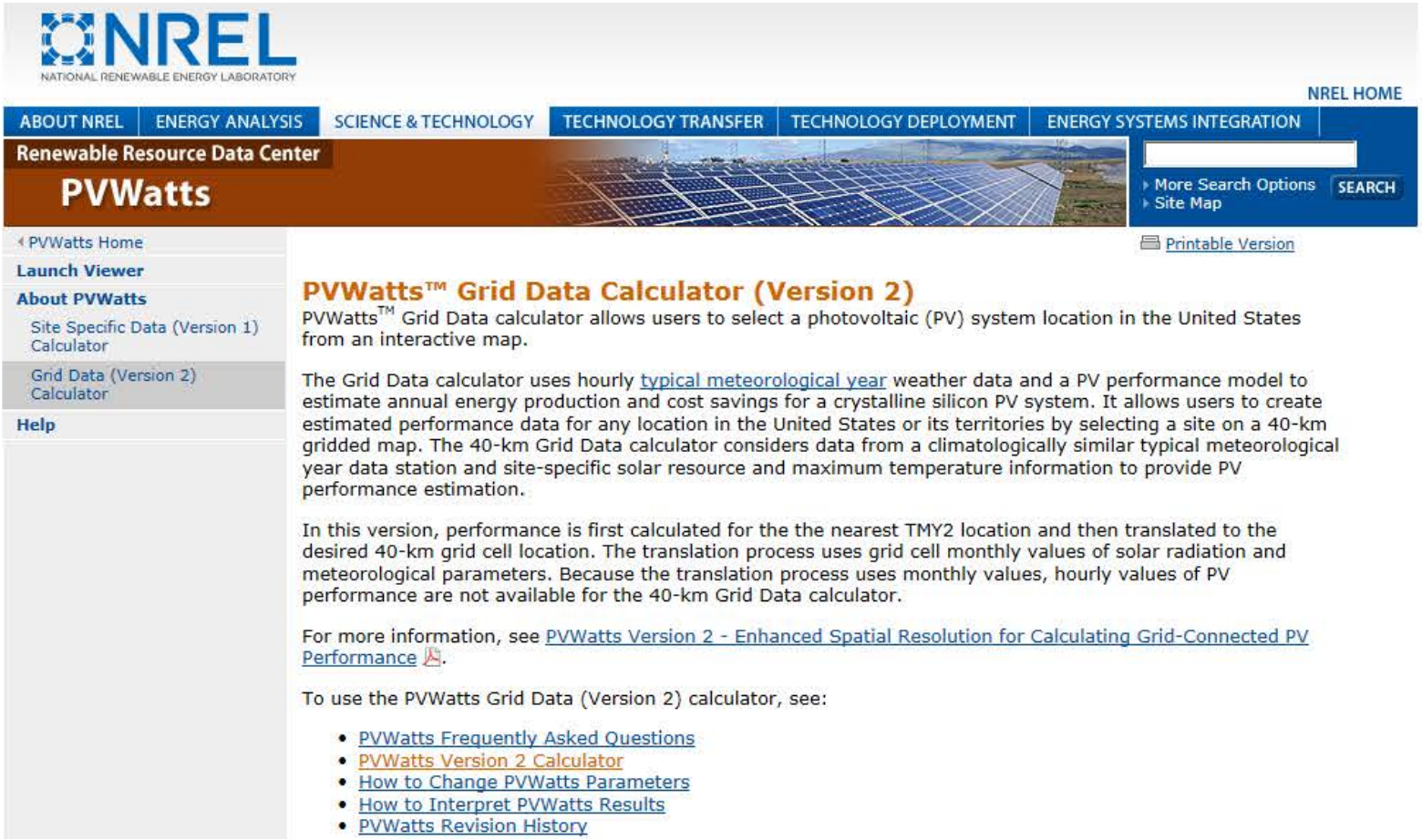
Solar – PV Watts2

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



See nrel.gov – PV Watts 2

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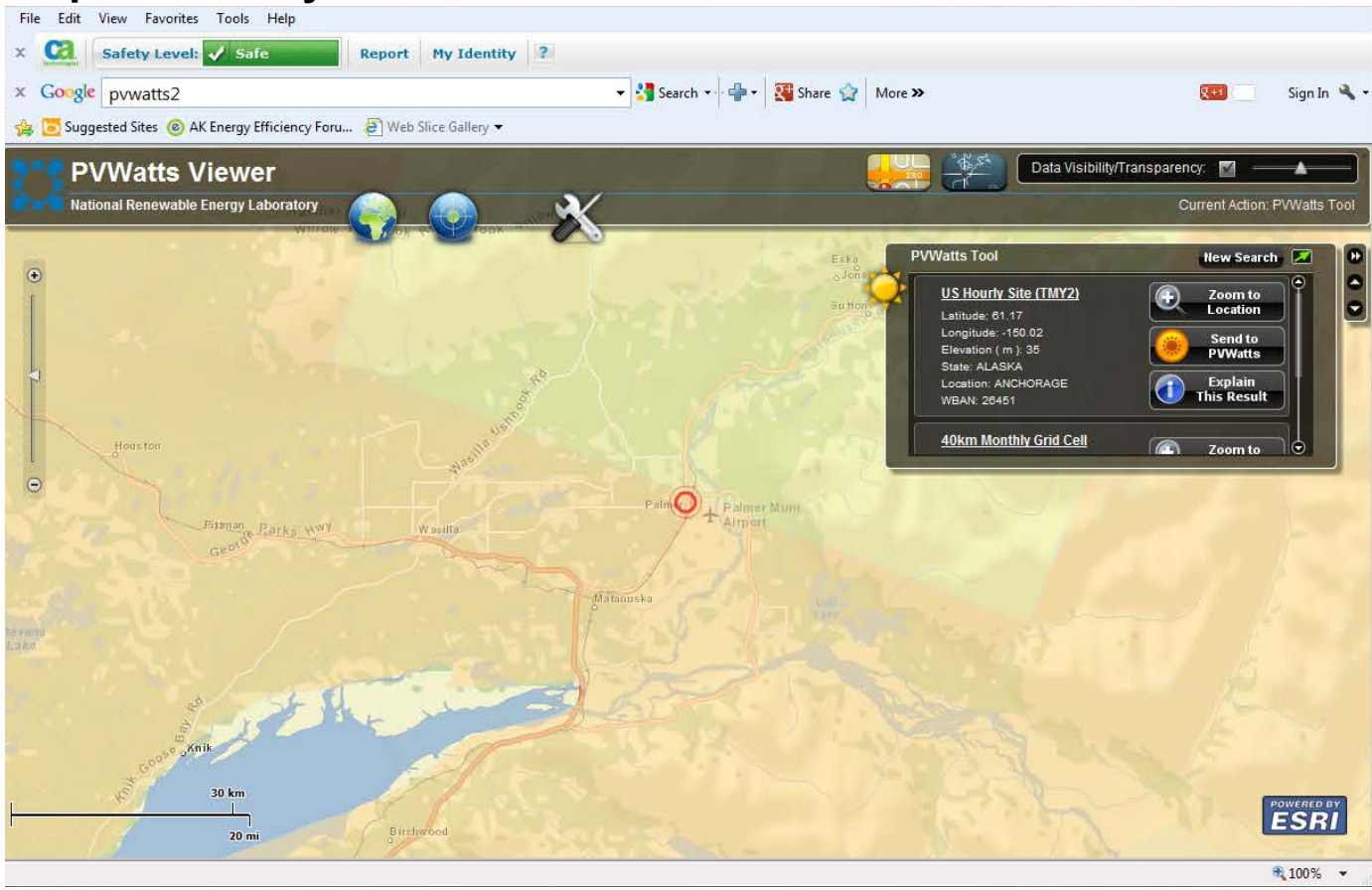
Solar – PV Watts2

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

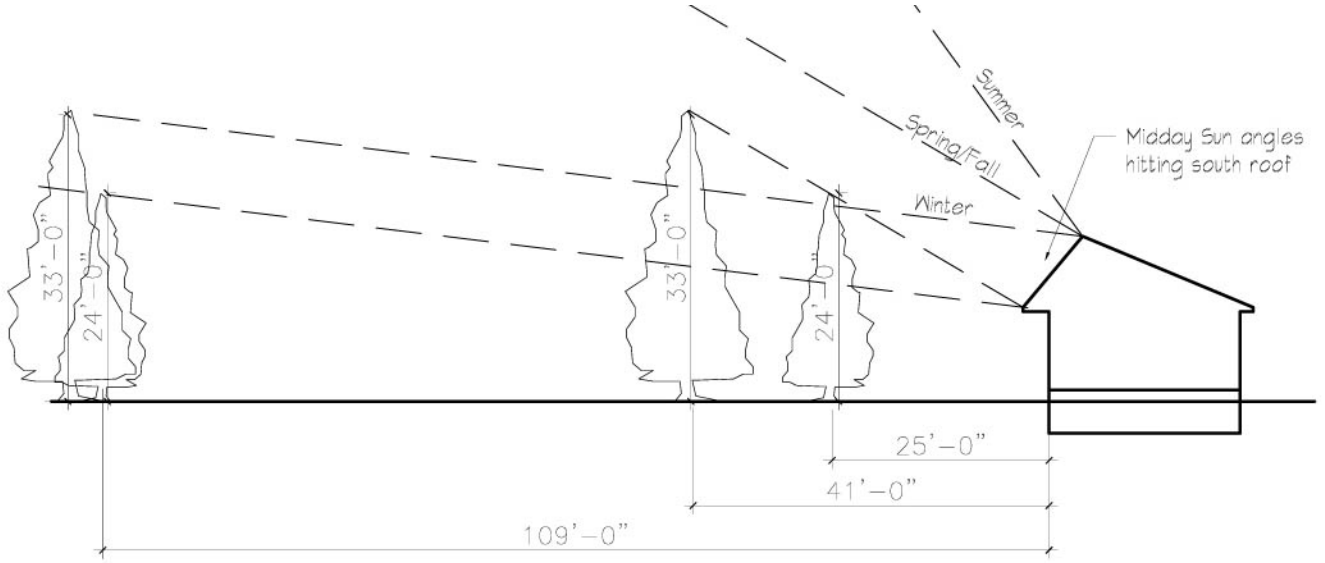
(Type comments here to appear on printout; maximum 1 row of 80 characters.)

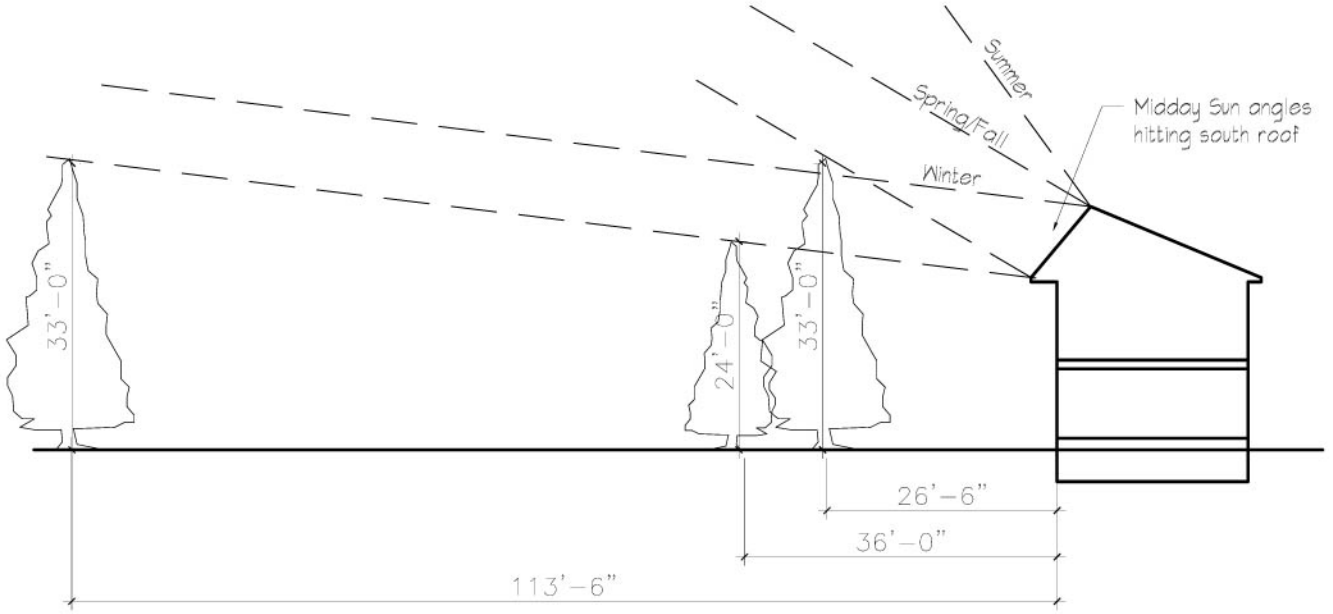
Station Identification	
City:	Anchorage
State:	Alaska
Latitude:	61.17° N
Longitude:	150.02° W
Elevation:	35 m
PV System Specifications	
DC Rating:	4.0 kW
DC to AC Derate Factor:	0.770
AC Rating:	3.1 kW
Array Type:	Fixed Tilt
Array Tilt:	61.2°
Array Azimuth:	180.0°
Energy Specifications	
Cost of Electricity: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

Results			
Month	Solar Radiation (kWh/m ^{2}/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

ALASKA CENTER FOR APPROPRIATE TECHNOLOGY

Solar PV seasonal site angles





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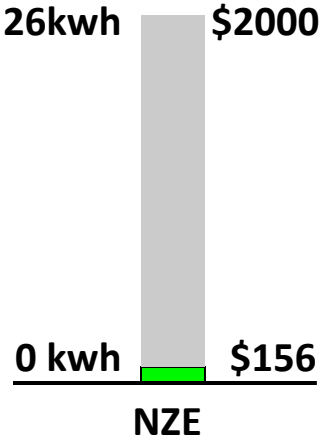
Solar PV Array



My Solar PV System

- 14 x 280w panels = 3955watt or 4kw
- Power Optimizers to control voltage during shading
- Central Inverter

Results - what I am seeing with my system (and other similar systems)

- Total Array wattage = about # of kwh per year
- Payback 12-15 years, DIY with Tax Credit
- 5% (simple) Return on Investment
- NZE for electrical only for year?
- PV Watts calcs 50 degrees as most output

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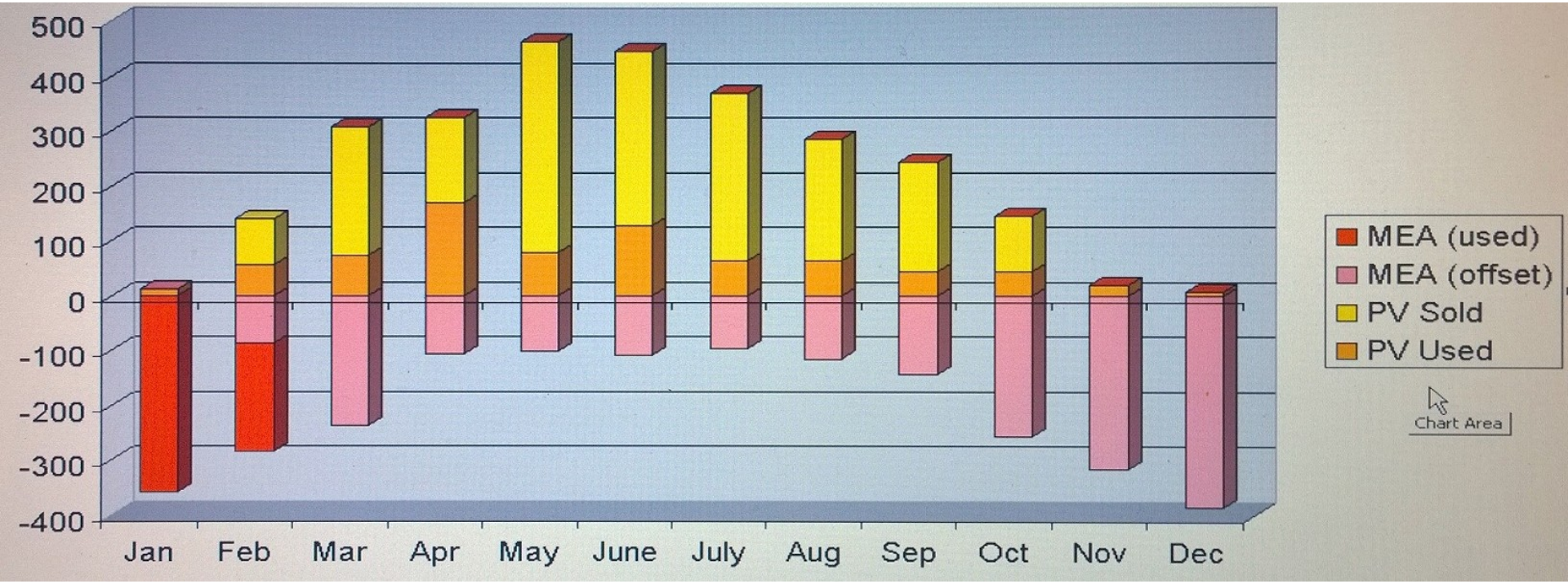
Solar PV Array



At the end of the year, any remaining additional production is paid out for a zero balance.

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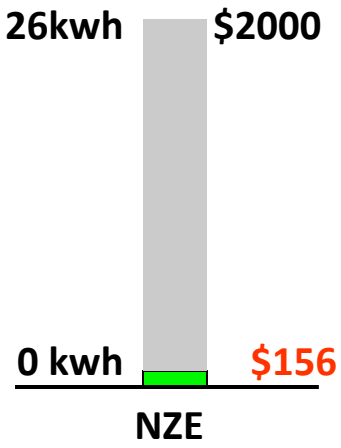
NET ZERO ELECTRICAL METERING

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 = $0.07 / kwh**
- **Power purchased from grid = $0.12 / kwh plus tariffs**
  $0.20 / kwh with tariffs
- **Difference in bought – sold = $0.13 /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 more than energy than you use.



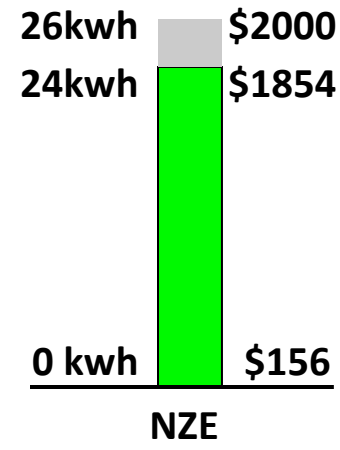
FEES AND TARIFFS – utility providers have fees and tariffs isolated from actual usage cost. Even if you make as much energy as you use, you will still have a utility bill.

- **MEA Monthly fee = $13**
- **Annually = $156**

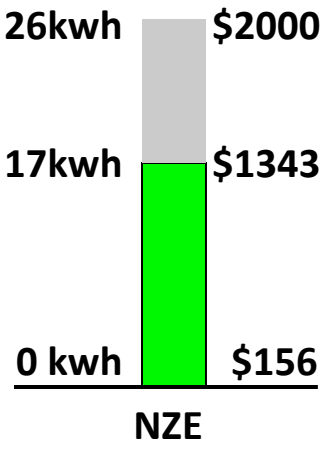
ALASKA CENTER FOR APPROPRIATE TECHNOLOGY

SUMMARY – IN REVIEW

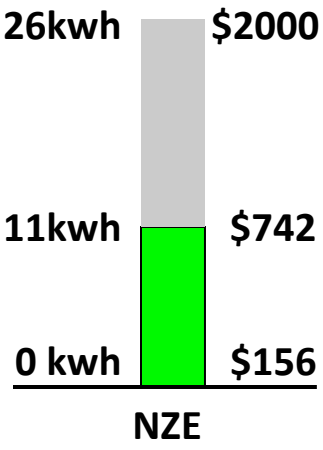
Step 1: Phantom Loads



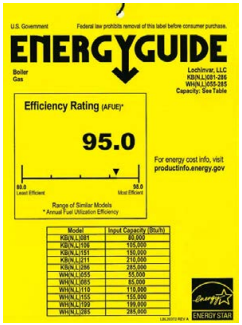
Step 2: Lighting

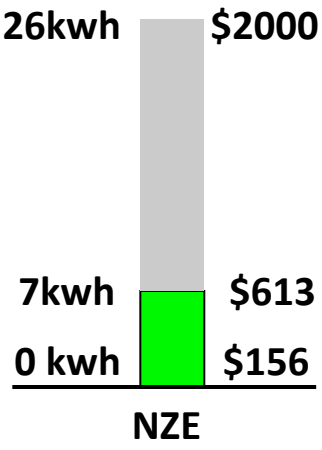


Step 3: Appliances



Step 4: HVAC Equipment





Step 5: Solar Panels