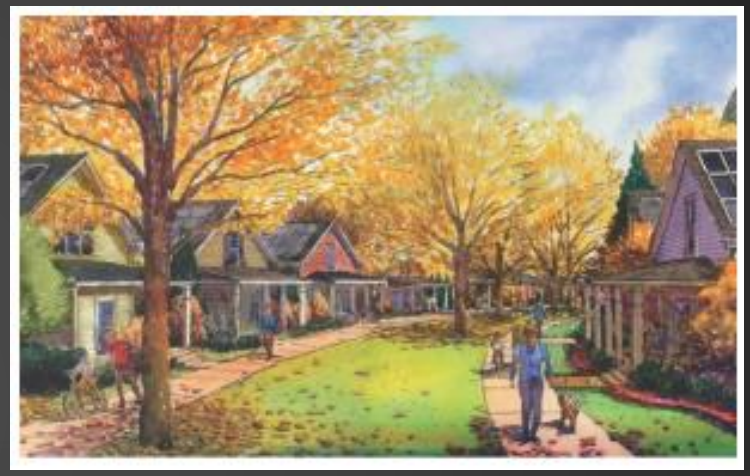
Wolf Penn Net Zero Demonstration Home

Drew Benado
Greg Davenport
Krisann Parks

Science fiction or Main Street USA?



Zero Energy Ready!

roof. Today, almost all single family houses, existing or being built, use way too much energy to be able to fit the solar panels they need to reach that goal.

Source: Bruce Sullivan

Net Zero Homes defined

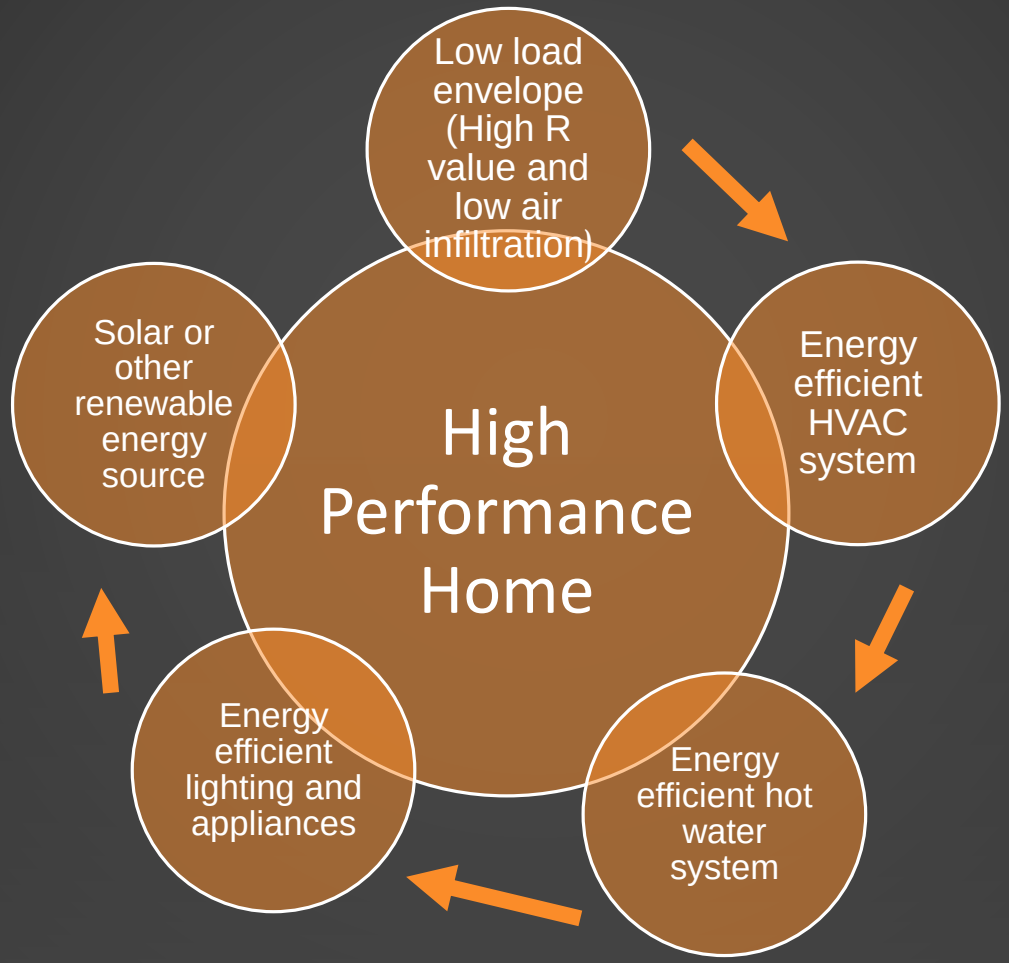
A net zero home is a high efficiency home.

Net zero homes have on site renewable power generation - most commonly PV (photovoltaic) solar panels.

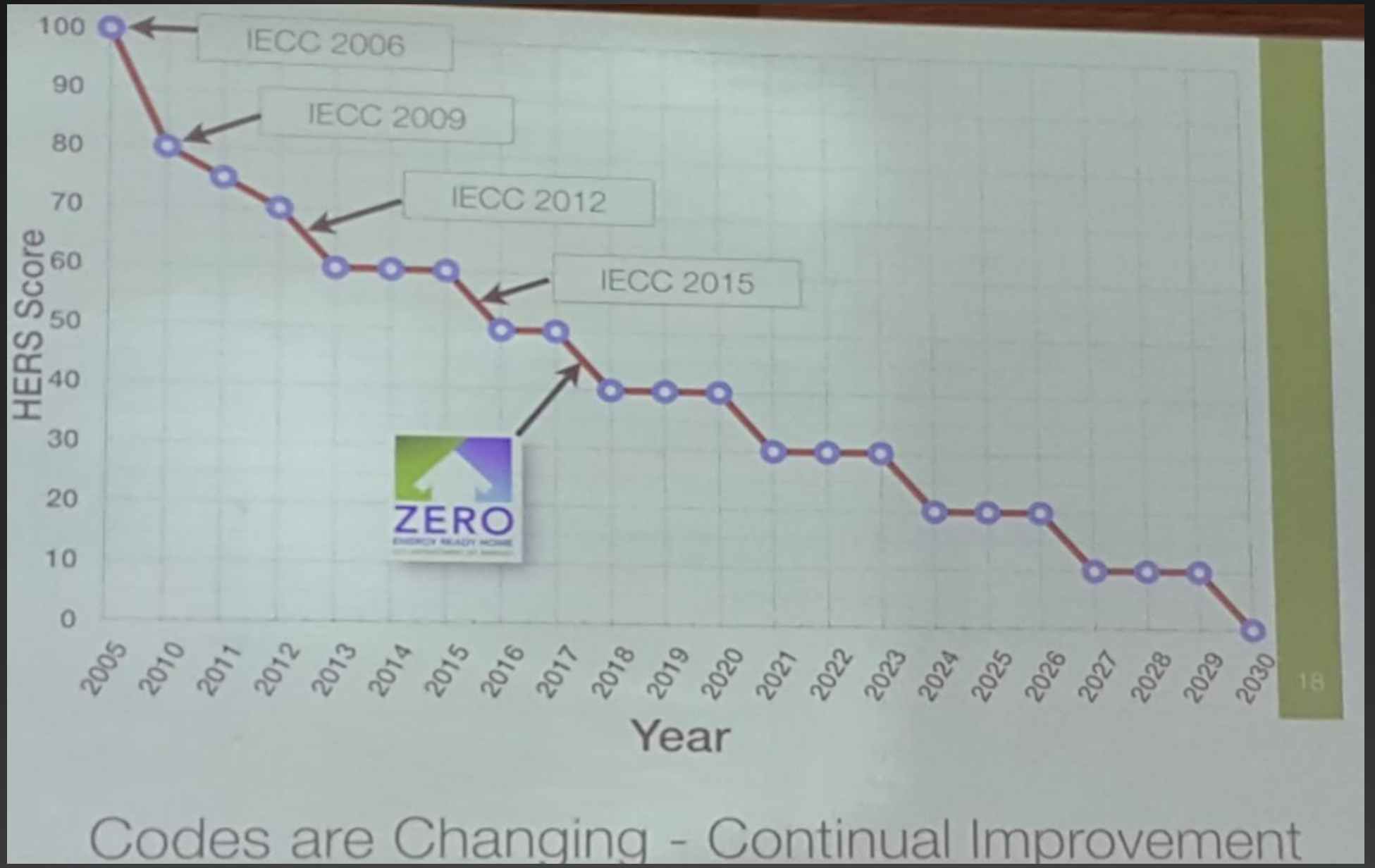
Net zero homes are designed to produce as much energy as they consume on an annual basis.

Net zero homes utilize either net metering and/or battery storage systems.

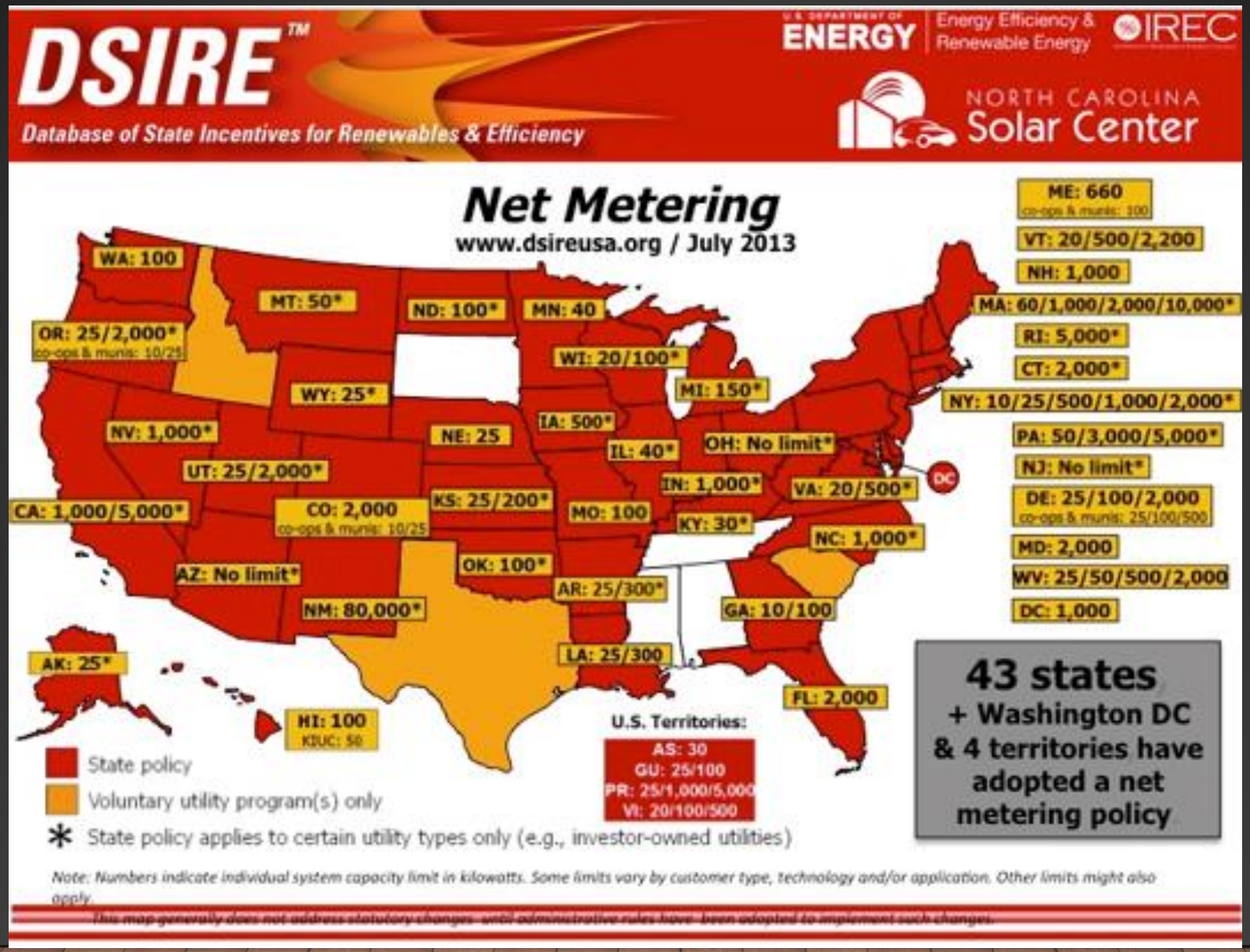
The path to Zero Energy home building



We are on the tipping point of Net Zero Home building

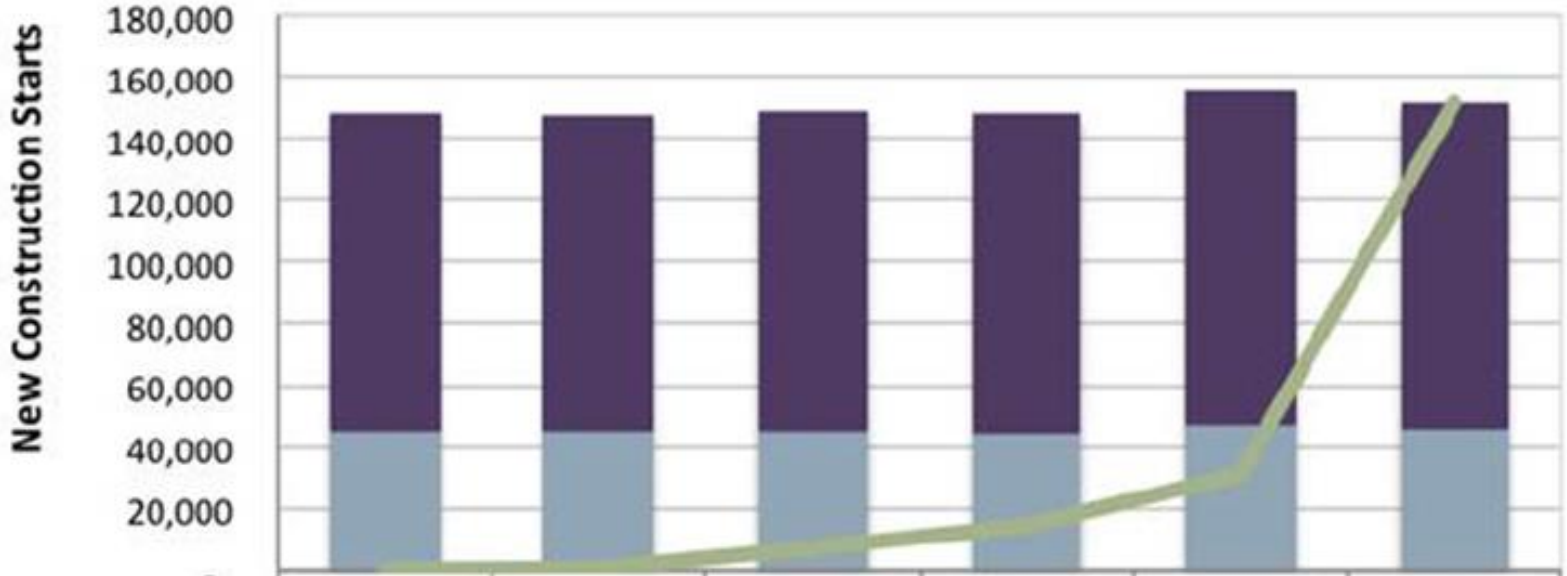


Codes are Changing - Continual Improvement


DSIRE™
Database of State Incentives for Renewables & Efficiency
U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
IREC
NORTH CAROLINA Solar Center
Net Metering
www.dsireusa.org / July 2013
WA: 100
OR: 25/2,000*
co-ops & munis: 10/25
CA: 1,000/5,000*
NV: 1,000*
MT: 50*
WY: 25*
UT: 25/2,000*
AZ: No limit*
CO: 2,000
co-ops & munis: 10/25
NM: 80,000*
ND: 100*
NE: 25
KS: 25/200*
OK: 100*
TX
MN: 40
IA: 500*
MO: 100
AR: 25/300*
LA: 25/300
WI: 20/100*
IL: 40*
MI: 150*
IN: 1,000*
KY: 30*
OH: No limit*
VA: 20/500*
NC: 1,000*
SC
GA: 10/100
FL: 2,000
DC
ME: 660
co-ops & munis: 100
VT: 20/500/2,200
NH: 1,000
MA: 60/1,000/2,000/10,000*
RI: 5,000*
CT: 2,000*
NY: 10/25/500/1,000/2,000*
PA: 50/3,000/5,000*
NJ: No limit*
DE: 25/100/2,000
co-ops & munis: 25/100/500
MD: 2,000
WV: 25/50/500/2,000
DC: 1,000
AK: 25*
HI: 100
KIUC: 50
U.S. Territories:
AS: 30
GU: 25/100
PR: 25/1,000/5,000
VI: 20/100/500
State policy
Voluntary utility program(s) only
* State policy applies to certain utility types only (e.g., investor-owned utilities)
43 states
+ Washington DC
& 4 territories have adopted a net metering policy
Note: Numbers indicate individual system capacity limit in kilowatts. Some limits vary by customer type, technology and/or application. Other limits might also apply.
This map generally does not address statutory changes until administrative rules have been adopted to implement such changes.

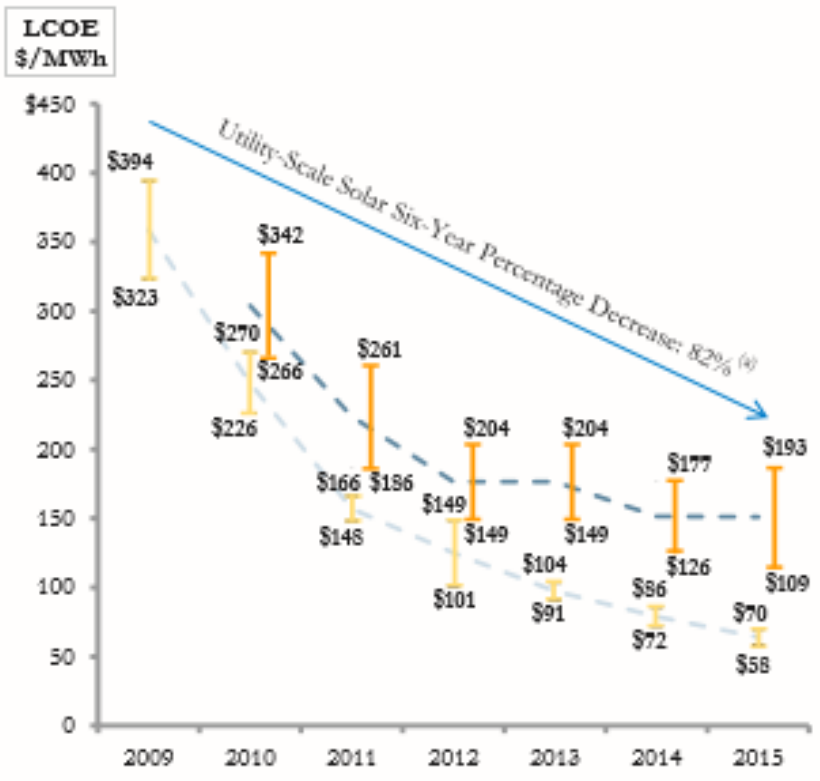
Benchmarks

Estimated Number of ZNE Homes Per Year Compared to New Construction Starts

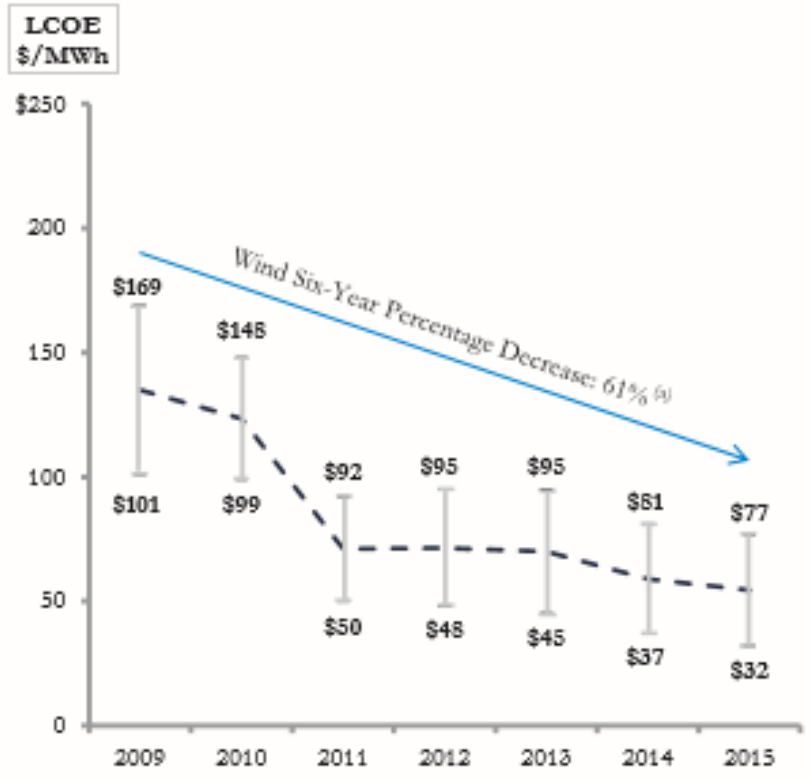


	2015	2016	2017	2018	2019	2020
Est. Single Family	103,077	102,847	103,542	103,181	108,189	105,450
Est. Multifamily	45,354	44,906	45,107	44,708	47,159	45,982
ZNE Projections	140	480	7,432	14,789	31,070	151,342

SOLAR LCOE

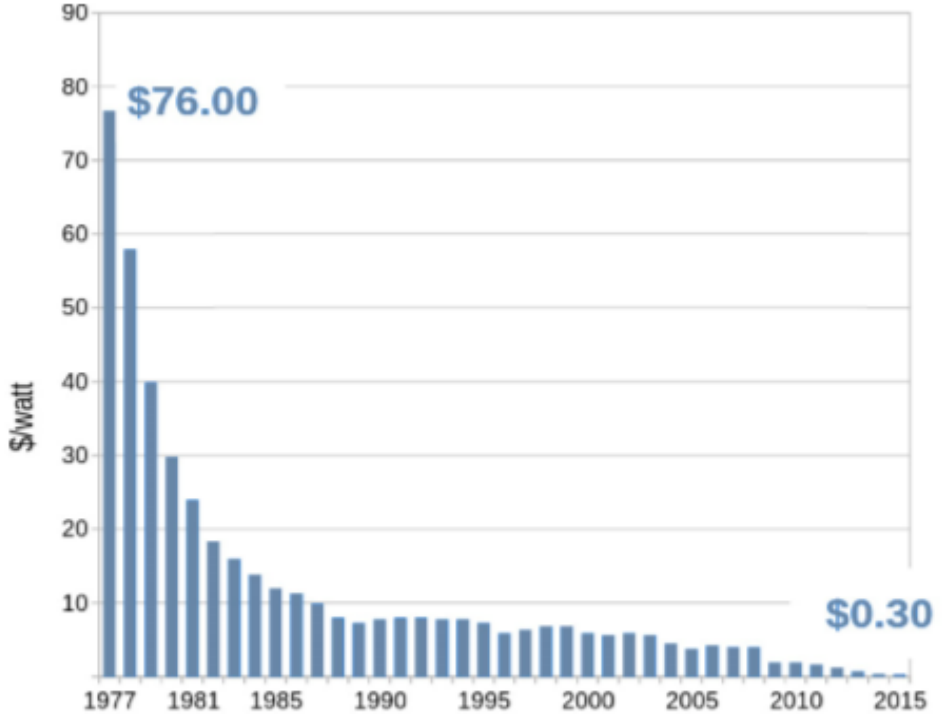


WIND LCOE



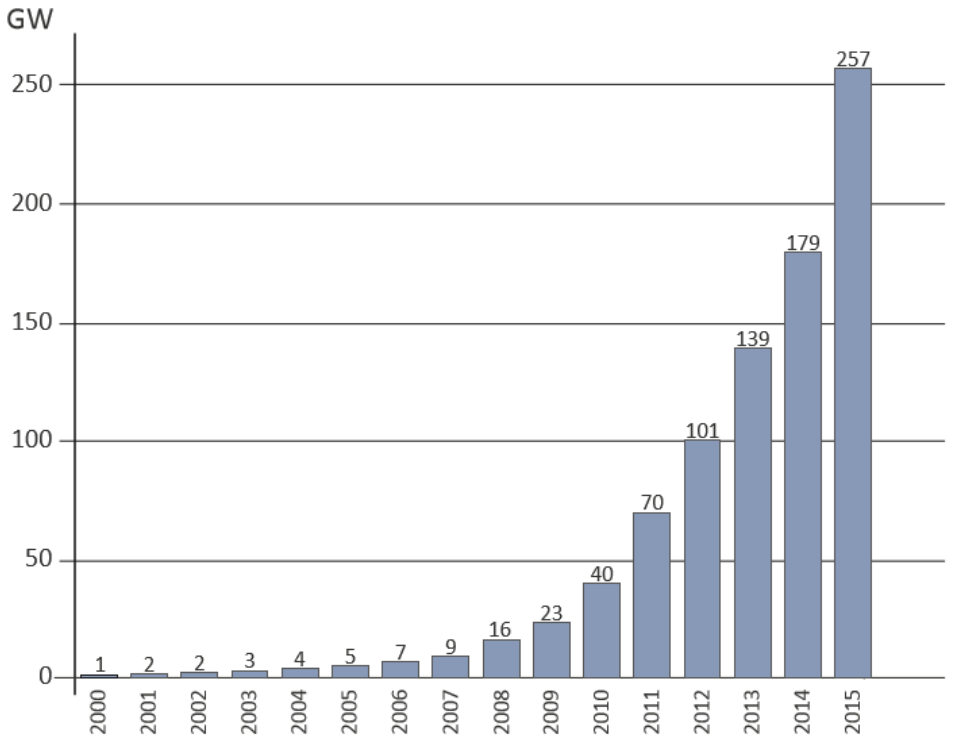
LEVELIZED COST OF ENERGY - SOLAR & WIND

IMAGE COURTESY © LAZARD, LCOE STUDY 9.0



SWANSON'S LAW - PRICE OF SOLAR PANELS

IMAGE SOURCE: BLOOMBERG NEW ENERGY FINANCE



GLOBAL SOLAR ENERGY CAPACITY

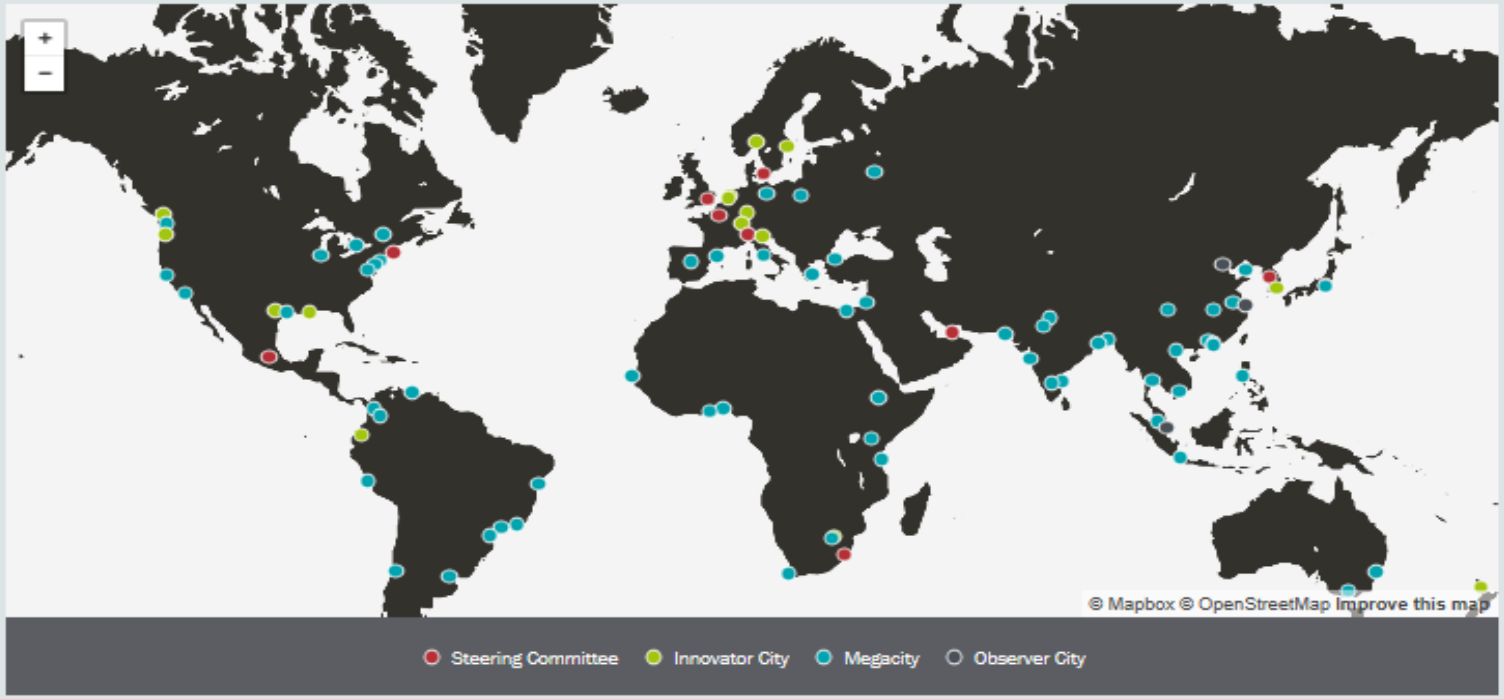
DATA SOURCE: IRENA

C40 CITIES

EN | 中文

Cities Networks Programmes Research Events Media Blog About

Search



C40 CITIES *account for*

91
affiliated cities

25 %
of global GDP

1 in 12
people worldwide

10,000
actions to combat climate change

TAKE ACTION IN YOUR COMMUNITY

The CITY OF PORTLAND Oregon

City Home | Government | Bureaus & Offices of the City of Portland

Planning and Sustainability

Innovation. Collaboration. Practical Solutions.

Home Energy Score Policy

City Council unanimously adopted the home energy score policy Portland City Code Chapter 17.108 on December 14, 2016.

The new policy is effective January 1, 2018, and requires sellers of single-family homes to incorporate the following practices prior to listing a home for sale in the City of Portland:

- Obtain a home energy performance report, including a home energy score, from a licensed home energy assessor.
- Provide a copy of the home energy performance report to all licensed real estate agents working on the seller's behalf.
- Include the home energy score and the attached home energy performance report in any real estate listings.
- Provide a copy of the home energy performance report to prospective buyers who visit the home while it is on the market.
- Provide a copy of the home energy performance report to the City of Portland for quality assurance and policy compliance.

MITSUBISHI ELECTRIC COOLING & HEATING

Utility bills

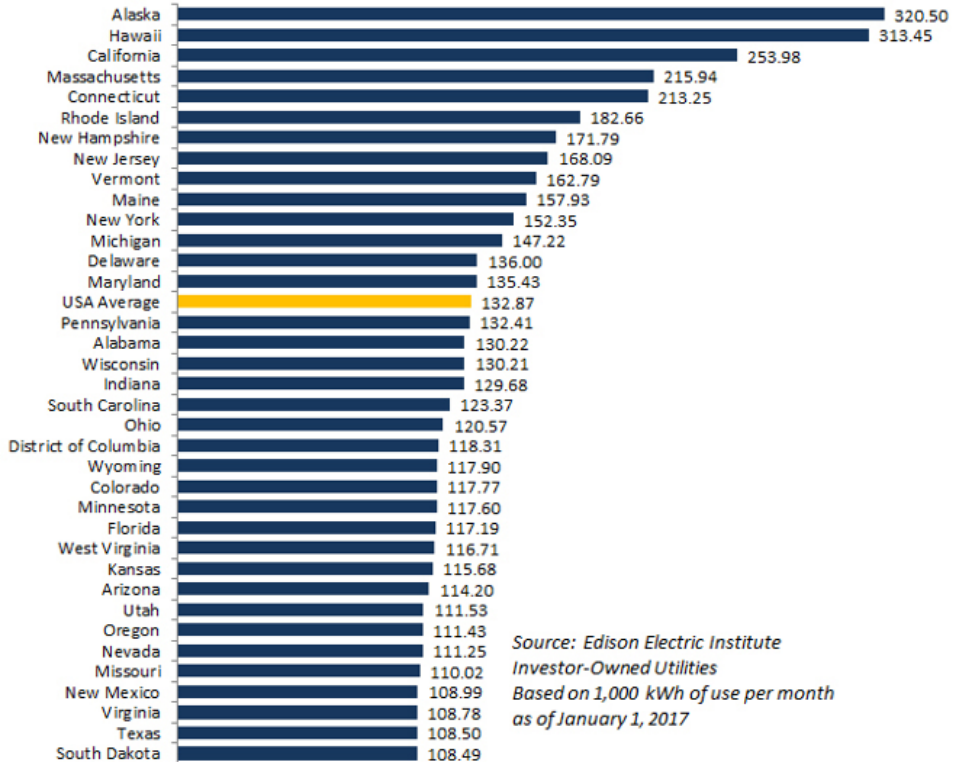
The Second Mortgage that people rarely consider when buying a home

You can see our effort to keep rates low in the Northwest when you compare them to national averages:

Avista Idaho: $94.95
Avista Washington: $92.59

US Average: $132.87

Here's a detailed breakdown:



Source: Edison Electric Institute
Investor-Owned Utilities
Based on 1,000 kWh of use per month
as of January 1, 2017

Avista requests natural gas rate increase in Idaho

Tue., Sept. 5, 2017, 10:02 a.m.

If regulators approve an Avista request for higher natural gas rates, a typical Idaho household using 61 therms each month would see its bill increase from $51.10 to $51.38, a 28-cent monthly increase. (The Spokesman-Review)

From staff reports

Twitter | Facebook | Email | Reddit

Avista is asking Idaho regulators to approve a slight increase in natural gas rates, effective Nov. 1.

If the request is approved, a typical Idaho household using 61 therms of natural gas each month would see its bill increase from $51.10 to $51.38, a 28-cent monthly increase.

The Spokane-based utility asks for yearly price adjustments based on wholesale power costs and other factors. A similar request is pending in Washington.

The requested increase is separate from the utility's request for higher base rates for electricity and natural gas, which was filed with the Idaho Public Utilities Commission in June.

Hypothetical Value Proposition

Code built home @ $300,000 80% LTV - $240,000 loan **30 year loan @ 3.75%**	**Same house with high performance upgrades @ $312,000 80% LTV - $249,600 loan** **30 year loan @ 3.75%**	**Same house with high performance and solar upgrades @ $332,000 80% LTV - $265,600 loan** **30 year loan @ 3.75%**
Monthly payment = $1,111	Monthly payment = $1,156	Monthly payment = $1,230
Monthly utility bills = $82	Monthly utility bills = $58	Monthly utility bills = $-6
Total monthly payment = $1,193	Total monthly payment = $1,214	Total monthly payment = $1,224

gtm.
A Wood Mackenzie Business

Community Is Coming to California's Central Valley

As the state prepares for a new building code, this 36-unit development will shed light on how such homes benefit the grid and homeowners alike.

by Julian Spector
August 29, 2017

That group's work with an earlier net-zero home project built by Meritage in Fontana had a felicitous outcome. The extra cost to achieve net zero was less than $20,000, or about $8 per square foot, Narayanamurthy said. When you break that out into additional monthly mortgage payments versus energy bill savings, the customers save more than they spend.

Wolfe Penn Net Zero Demonstration Home

Greenstone

ENRICHED LIVING. LASTING VALUE.

Building a DOE Zero Energy Ready Home

By: Drew Benado

Who We Are

- Largest builder in the Inland NW
- Build single family detached and attached homes
- Sales in 2016: 290 homes
- Average price point in 2016: $317,000

Who We Are

Building in the Inland NW

- Low Energy Rates
- Minimal consumer requests for energy efficient homes
- Local builders uneducated
- Real estate market uninformed on what energy efficient homes are

Project Goals

- Build a home with numerous components
- Survey the market understanding and demand
- Understand how we can educate the market
- Find a niche that we can sell to

Teamwork


Greenstone
MITSUBISHI ELECTRIC
COOLING & HEATING
HEATING
R&R
AIR CONDITIONING
LIFEBREATH
Indoor Air Systems


NESPRESSO
NEW ZEALAND
CAMPER
OMEGA

+ Renewable photovoltaic solar energy

High performance shell

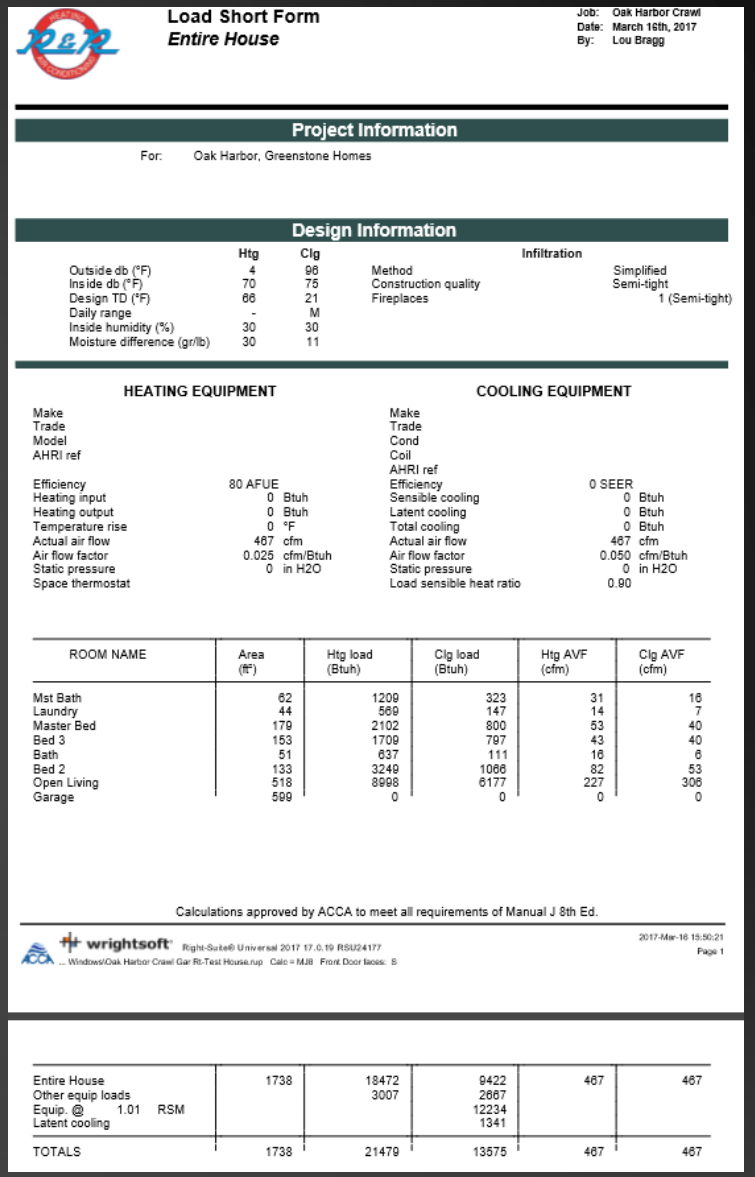
Energy efficient heating and cooling

Room by room heating and cooling load calculation Manual J

Heating load 21,479 BTU

Cooling load 13,875 BTU

Very low loads in bed 3



Load Short Form
Entire House

Job: Oak Harbor Crawl
Date: March 16th, 2017
By: Lou Bragg

Project Information

For: Oak Harbor, Greenstone Homes

Design Information

	Htg	Clg
Outside db (°F)	4	96
Inside db (°F)	70	75
Design TD (°F)	66	21
Daily range	-	M
Inside humidity (%)	30	30
Moisture difference (gr/lb)	30	11

Infiltration

Method	Simplified
Construction quality	Semi-tight
Fireplaces	1 (Semi-tight)

HEATING EQUIPMENT

Make	
Trade	
Model	
AHRI ref	
Efficiency	80 AFUE
Heating input	0 Btuh
Heating output	0 Btuh
Temperature rise	0 °F
Actual air flow	467 cfm
Air flow factor	0.025 cfm/Btuh
Static pressure	0 in H2O
Space thermostat	

COOLING EQUIPMENT

Make	
Trade	
Cond	
Coil	
AHRI ref	
Efficiency	0 SEER
Sensible cooling	0 Btuh
Latent cooling	0 Btuh
Total cooling	0 Btuh
Actual air flow	467 cfm
Air flow factor	0.050 cfm/Btuh
Static pressure	0 in H2O
Load sensible heat ratio	0.90

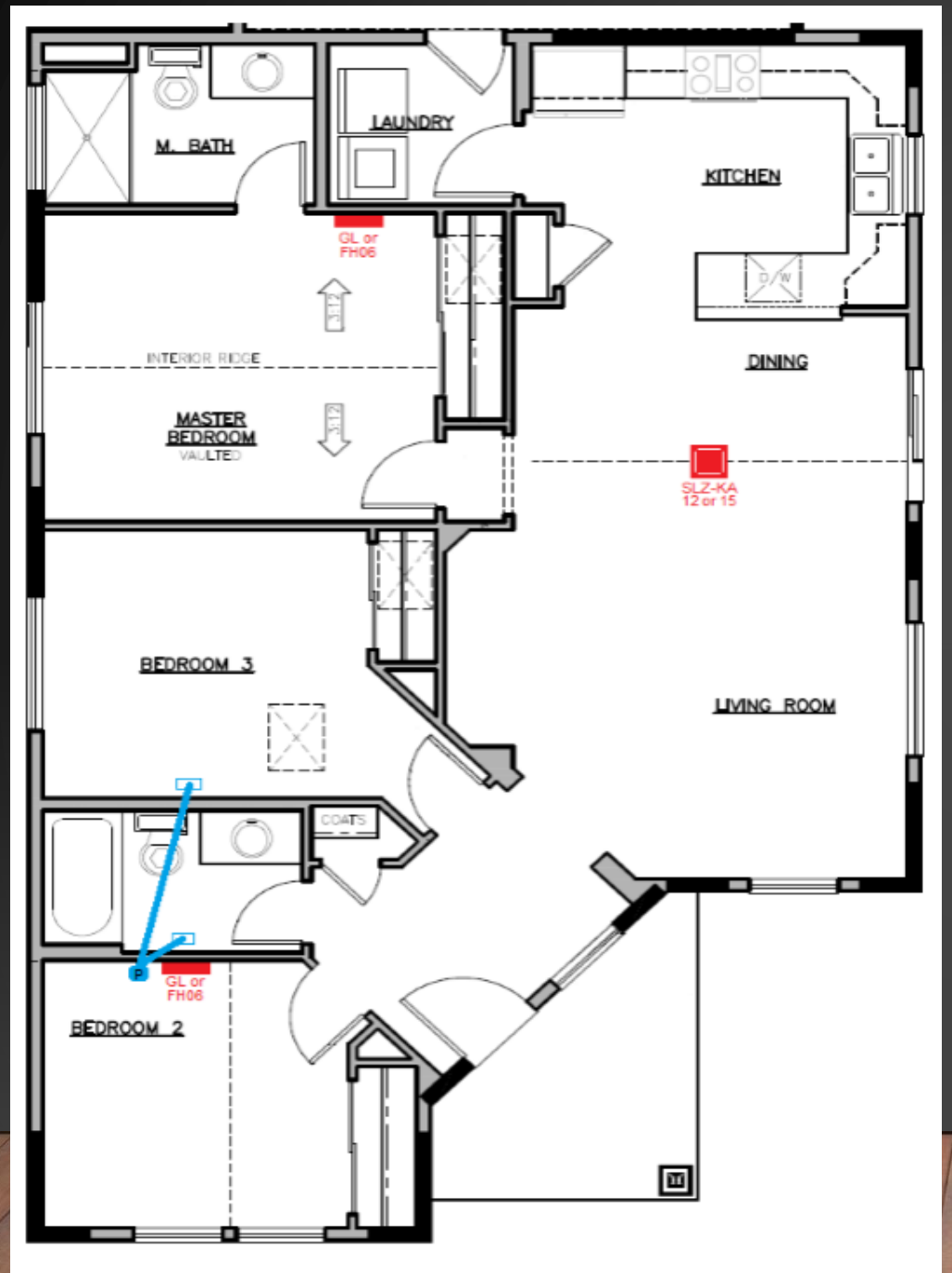
ROOM NAME	Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Mst Bath	62	1209	323	31	16
Laundry	44	569	147	14	7
Master Bed	179	2102	800	53	40
Bed 3	153	1709	797	43	40
Bath	51	637	111	16	6
Bed 2	133	3249	1066	82	53
Open Living	518	8998	6177	227	306
Garage	599	0	0	0	0

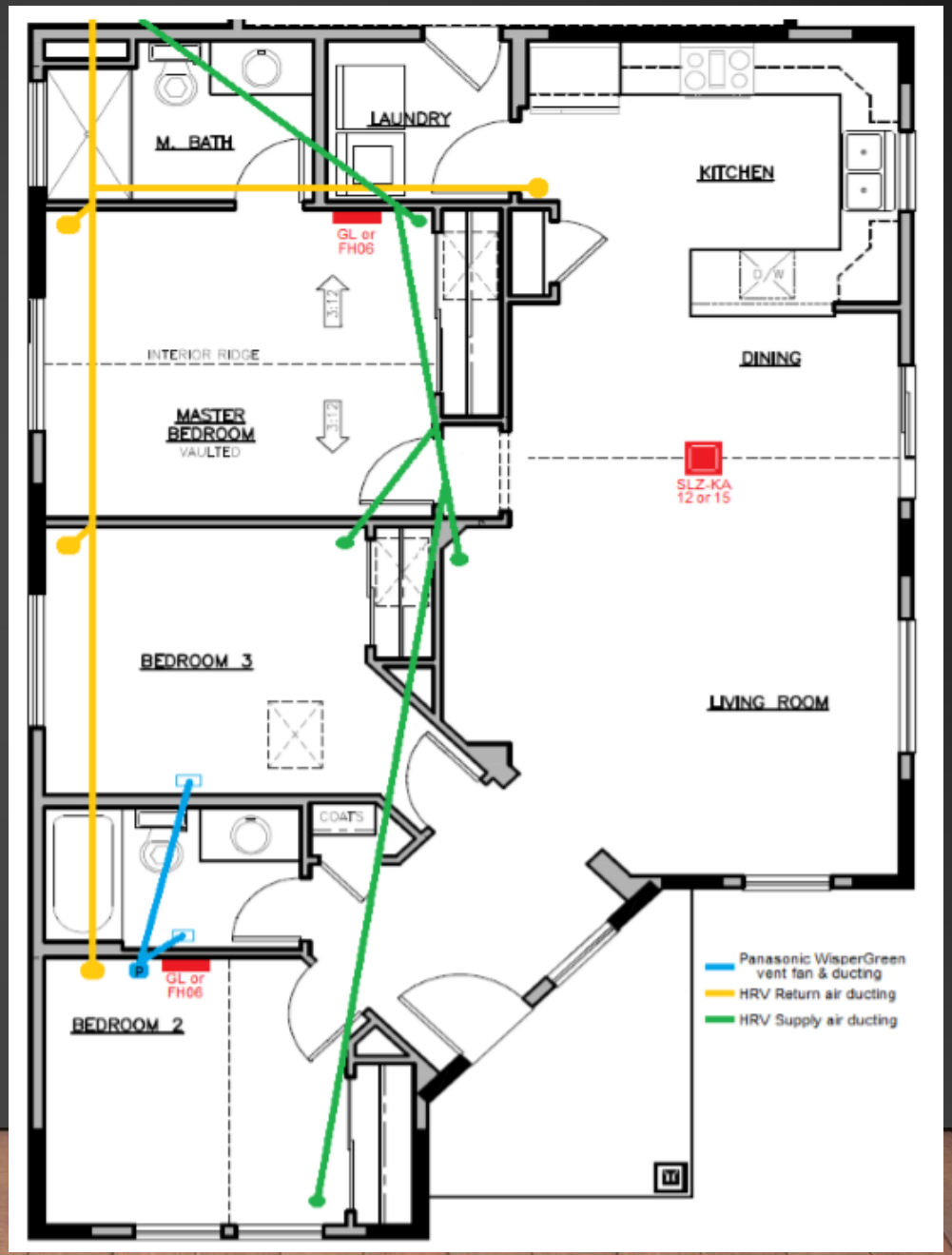
Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

wrightsoft Right-Suite® Universal 2017 17.0.19 RSU24177
... Windows\Oak Harbor Crawl Gar Rt-Test House.rup Calc = MJ8 Front Door faces: S

2017-Mar-16 15:50:21
Page 1

Entire House	1738	18472	9422	467	467
Other equip loads		3007	2667		
Equip. @ 1.01 RSM			12234		
Latent cooling			1341		
TOTALS	1738	21479	13575	467	467


M. BATH
LAUNDRY
KITCHEN
GL or FH06
3:12
INTERIOR RIDGE
DINING
MASTER BEDROOM
VAULTED
3:12
SLZ-KA 12 or 15
BEDROOM 3
LIVING ROOM
COATS
GL or FH06
BEDROOM 2


M. BATH
LAUNDRY
KITCHEN
GL or FH06
3:12
INTERIOR RIDGE
DINING
MASTER BEDROOM
VAULTED
3:12
SLZ-KA 12 or 15
BEDROOM 3
LIVING ROOM
COATS
GL or FH06
BEDROOM 2
Panasonic WisperGreen vent fan & ducting
HRV Return air ducting
HRV Supply air ducting

Together, Building a Better California

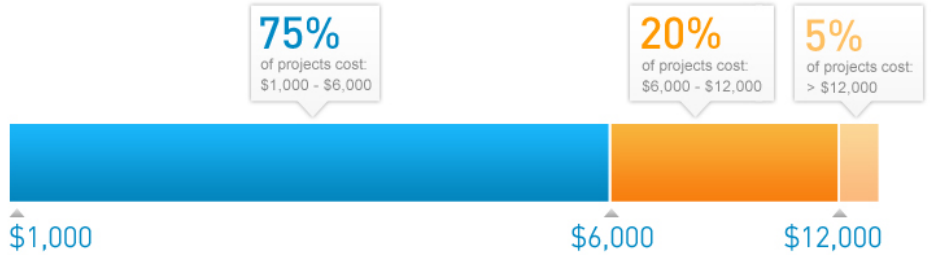
Español | 中文 • Contact Us

Search

Residential | Business | Outages | Safety | In Your Community

My Account | Customer Service | Rates | Save Energy & Money

Residential New Gas Service



Low end range

- No Right of Way or Easement Required
- Trenching Outsourced

High end range

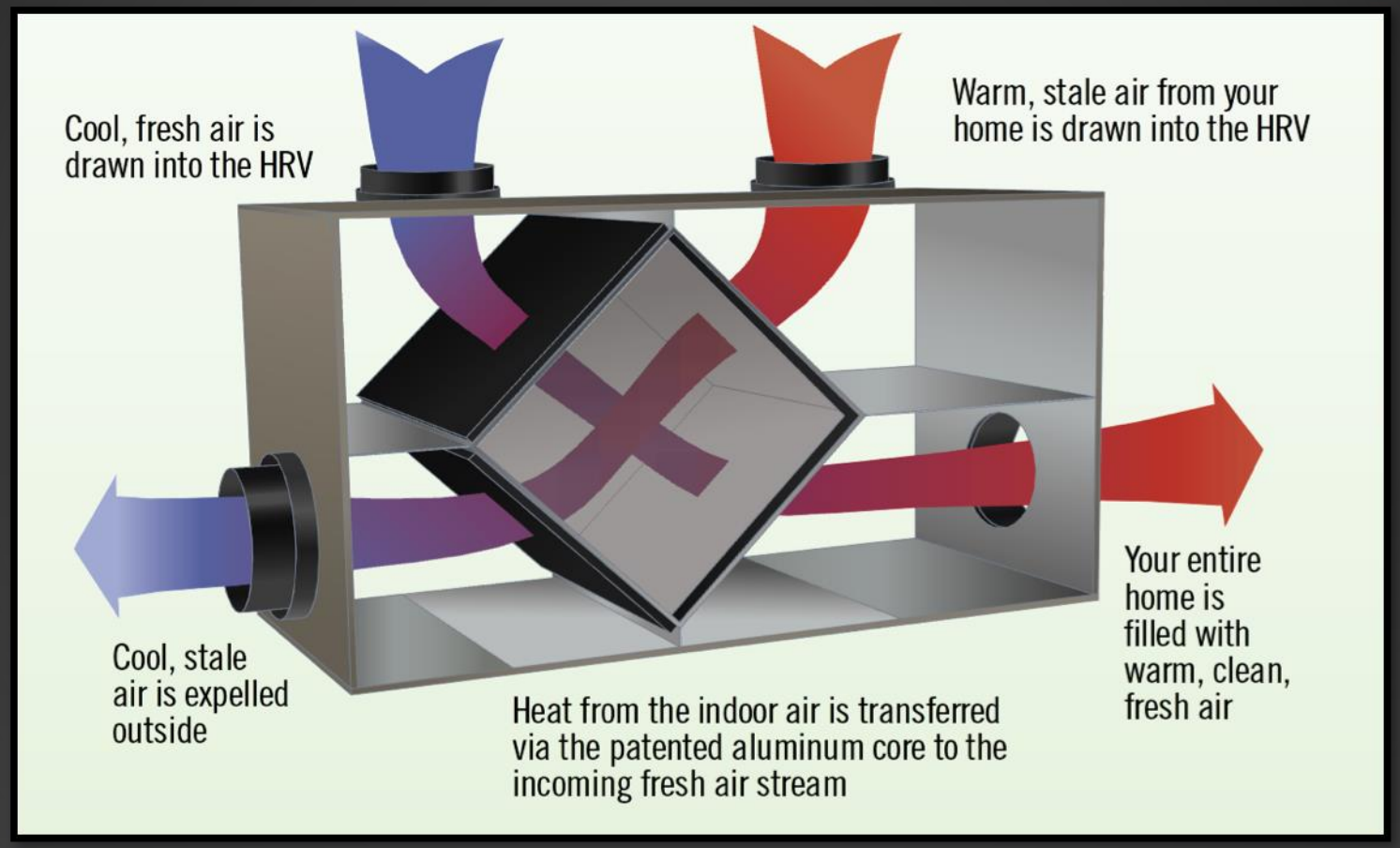
- Right of Way or Easement Required
- Trenching Completed by PG&E
- Difficult Conditions or Long Trench Required

LIFEBREATH®
Indoor Air Systems

High performance Lifebreath Fresh Air system

Heat recovery whole home ventilation fan plus whole home filter for healthy indoor air quality

How a HRV fresh air ventilation system works

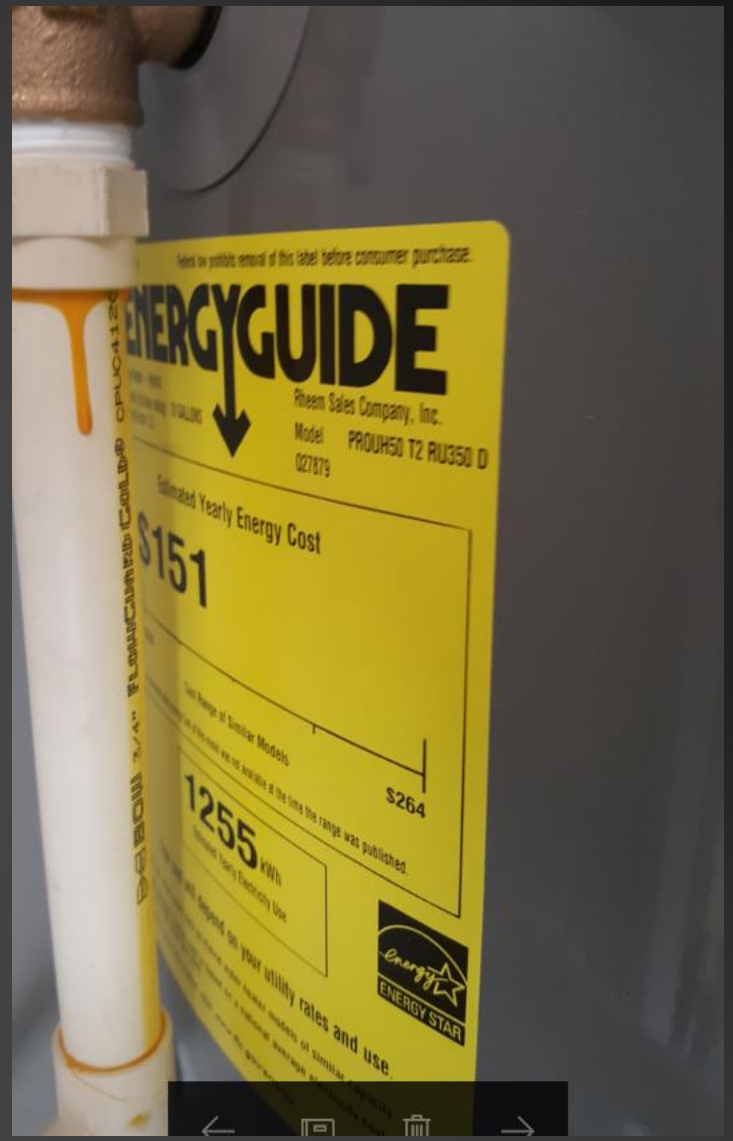


LIFEBREATH
Indoor Air Systems

Whole home air filter for healthy indoor air quality

LIFEBREATH
Indoor Air Systems

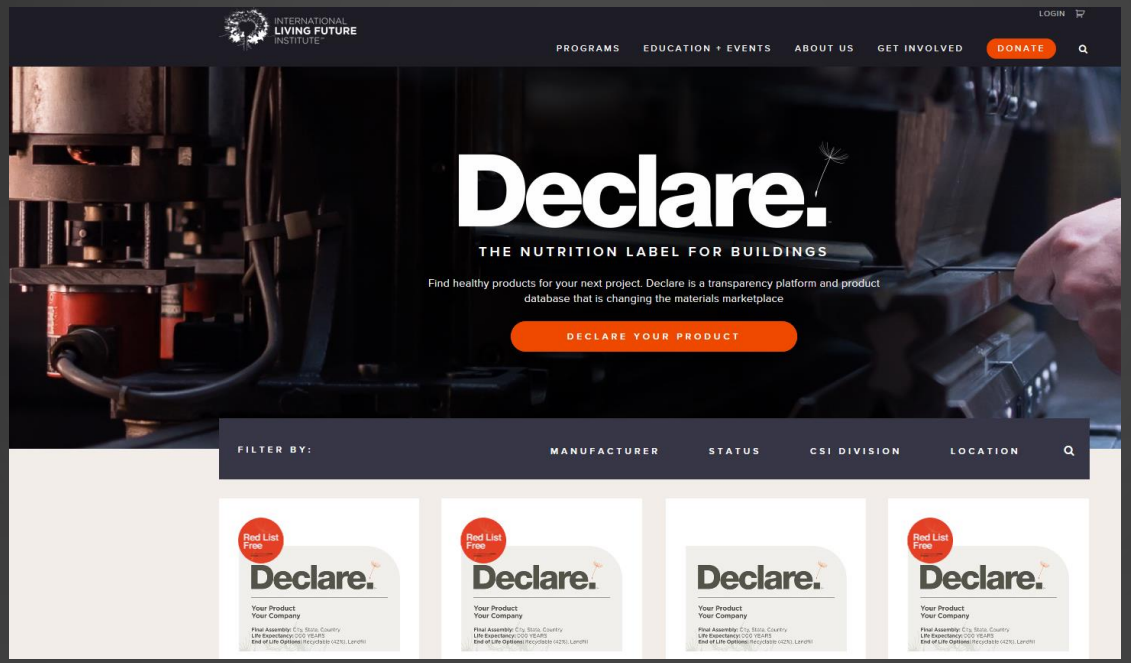
Rheem high efficiency heat pump hot water system 3.55+ COP

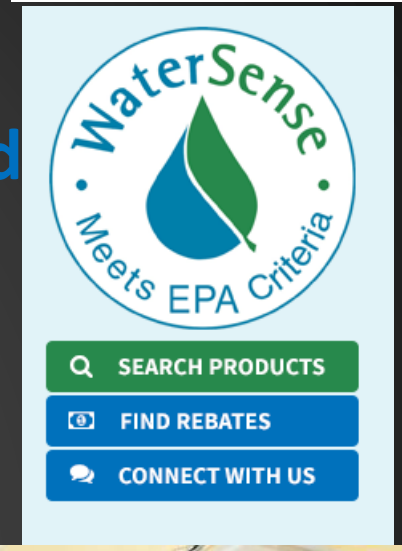


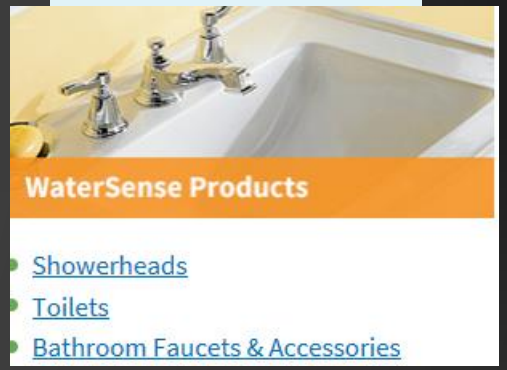
ENERGY STAR lighting and appliances

WaterSense plumbing fixtures save water and energy

Low toxicity building materials improve indoor air quality and health







Photovoltaic solar panels should produce enough energy to power home on an annual basis

This house is so energy efficient it only needs 19 solar panels to produce all the electricity to be net zero

Anderson Consulting provided energy modeling, program certification testing, and building science consulting for project

ESTIMATED ELECTRICITY	COST FOR THIS HOME
This high performance home with Net Zero solar system	-$78 YEAR (-$6 MONTH)
This high performance home without solar system	$702 YEAR ($58 MONTH)
This home if built to local building codes	$985 YEAR ($82 MONTH)

Demonstration project will be monitored to test

Comfort
transfer fan performance
IAQ
Energy use

Monitoring data will be shared by builder, Mitsubishi, Lifebreath, and home buyer

Amazon.com: Boardwalk Em | Netflix | KING FM 98.1 - Classic Radi | SiteSage Portal

sitesage.net/home/index.php

Welcome, Greg (Wolfe Penn Model) Not Greg?

Settings | Support | Log Out

power wise

HOME | Circuits | Alerts | Ways to Save | Report Card | Local Weather

SiteSage Status:

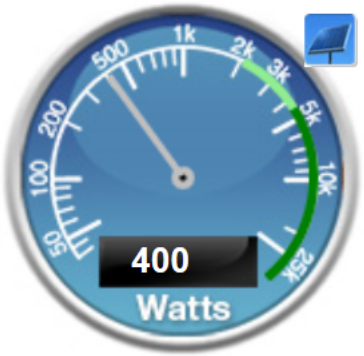
Current use: 0.68 kW | $0.02/hr | Current voltage 122v | Outside Temp: 53°F

Share My SiteSage Window

Utility Meter

683w
Power Usage Now

Power Production



Top Appliances/Circuits On Now

- Bedrooms / Guest Bath / E... (177w)
- Living Rm / Kitchen Lts (157w)
- A/C (123w)
- Air Handler (76w)
- Microhood (46w)
- Master Bed/Bath, Garage L... (35w)
- Refrigerator (35w)
- Unmonitored Power (22w)

13-Day Carbon Footprint

WA Avg.	My CO_2
457 lbs.	0 lbs.

13-Day Phantom Power $2

Sensors

Bed 2 Temp	76°F
Master Temp	77°F

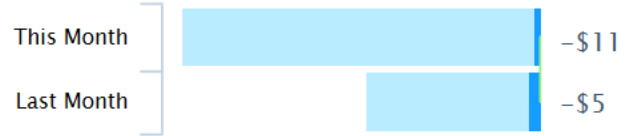
Where I've used electricity in the past 13 days: Top 12 Circuits

Click a slice or label for detail / View All Circuits

Master $0

A/C

Electricity Cost by Month



Support & Feedback

Type here to search

ENG 4:39 PM 10/2/2017

Amazon.com: Boardwalk En | Netflix | KING FM 98.1 - Classic Radi | SiteSage Portal

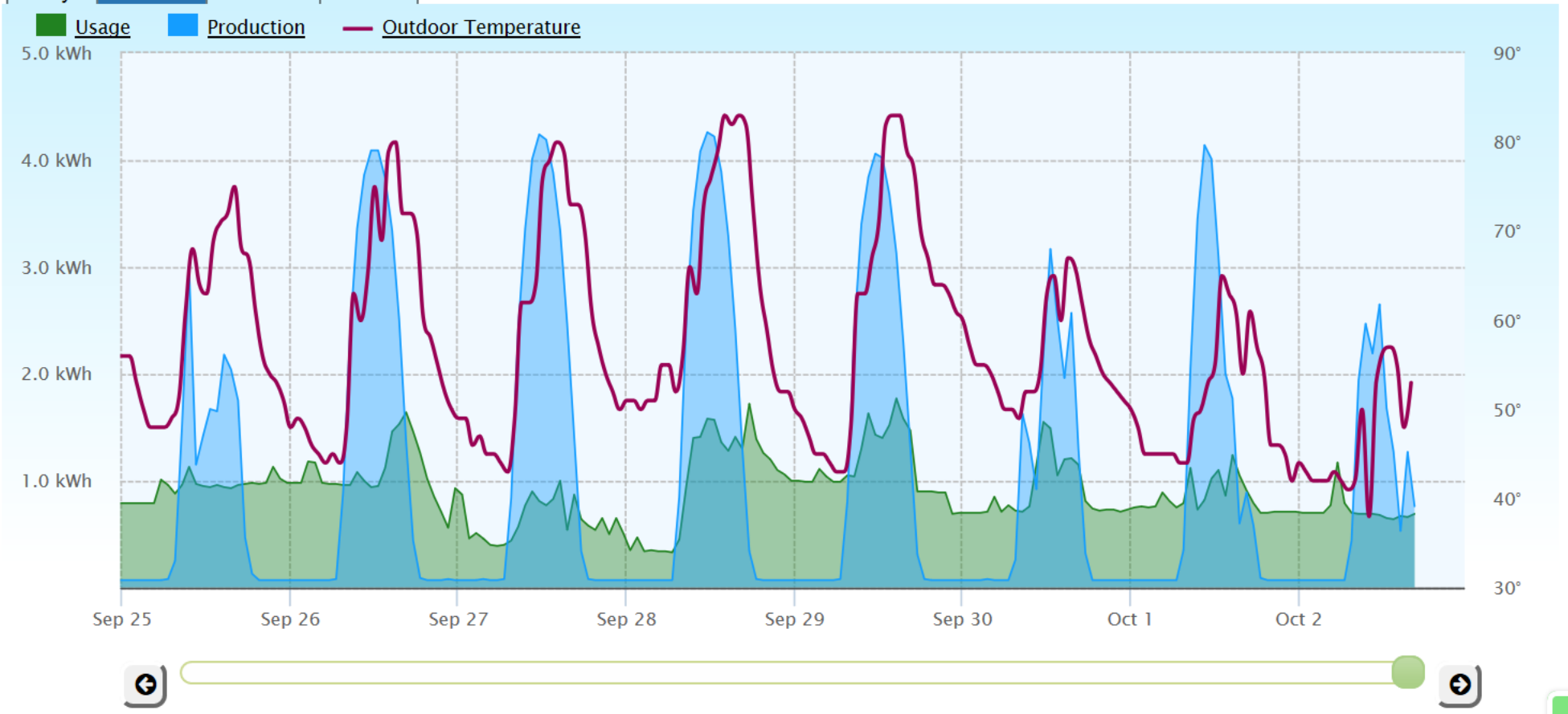
sitesage.net/home/index.php#

Bed/Bath, Garag / Kitchen Lt / Guest Bath

kWh Cost

Day Week Month Year

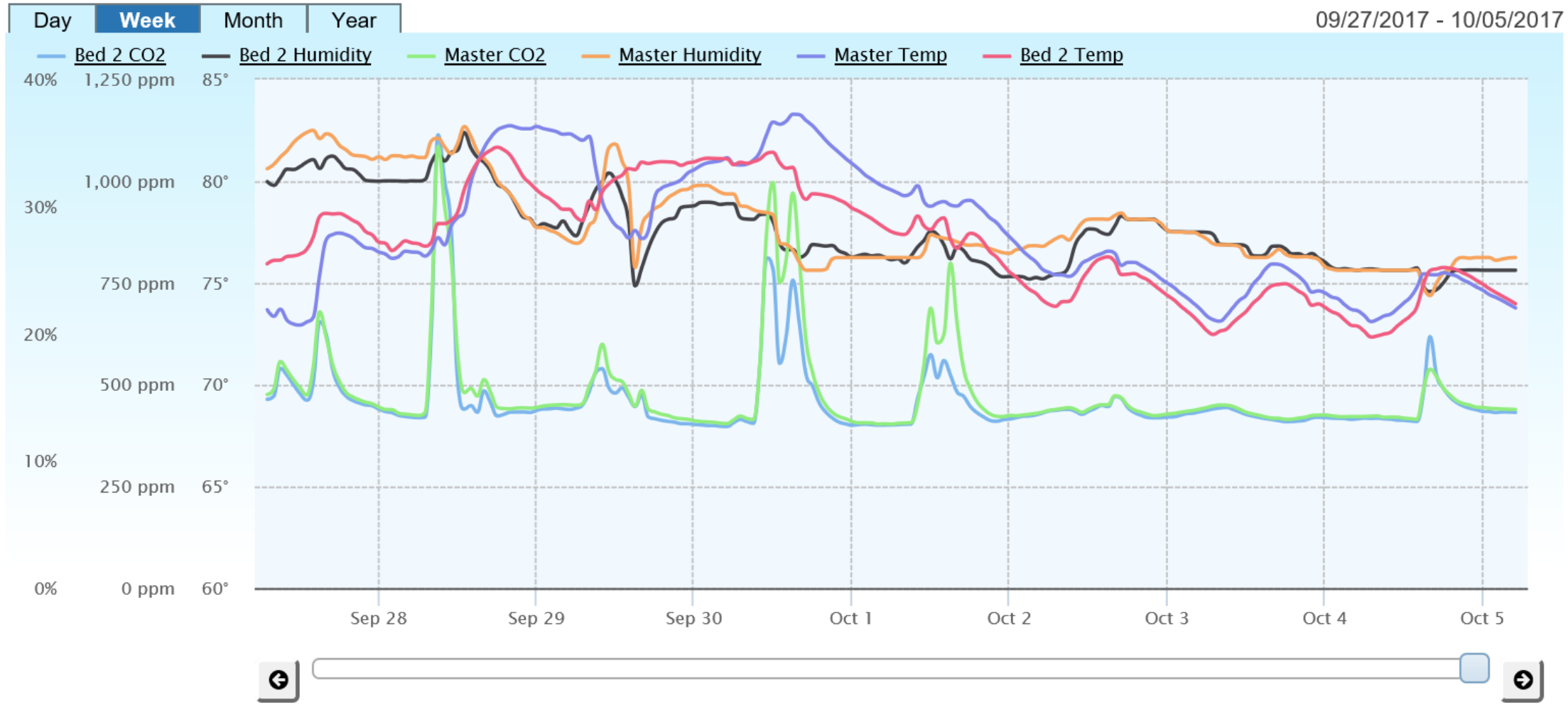
09/24/2017 - 10/02/2017



Support & Feedback

Type here to search

ENG 4:40 PM 10/2/2017


Day
Week
Month
Year
09/27/2017 - 10/05/2017
Bed 2 CO2
Bed 2 Humidity
Master CO2
Master Humidity
Master Temp
Bed 2 Temp
40%
30%
20%
10%
0%
1,250 ppm
1,000 ppm
750 ppm
500 ppm
250 ppm
0 ppm
85°
80°
75°
70°
65°
60°
Sep 28
Sep 29
Sep 30
Oct 1
Oct 2
Oct 3
Oct 4
Oct 5

Hi visibility project selected to maximize value

Net zero home will be used as a training venue for other training events targeted at high performance builders and HVAC contractors in the Spokane and North Idaho market

Spokane Fall Home Tour

Greenstone model home

Greenstone is learning how to build net zero and test the market

Mitsubishi and Lifebreath provided high performance home training to Greenstone Homes sales team

Greenstone, Mitsubishi, and Lifebreath are cooperating with marketing for project

All three project partners are watching the monitoring data to learn from this project

HVAC Academy Awards

Mini splits are faster to install = lower labor costs

HVAC Academy Awards

Low load homes and value engineered DHP systems have comparable costs to traditional systems


Greenstone
ENRICHED LIVING. LASTING VALUE.
OAK HARBOR
Greenstone Net Zero Demonstration Home
This Net Zero Home features:
• Built to DOE Zero Energy Ready Home Specification
• Built to EPA Indoor Air Plus Specification
• Solar system designed to meet energy needs of home
• Energy efficient walls, windows, and doors
• Energy efficient Mitsubishi Electric mini split heating and cooling system for improved comfort
• High performance Lifebreath fresh air system for improved indoor air quality
• Energy efficient lighting and appliances
ZERO
MITSUBISHI ELECTRIC
COOLING & HEATING


Greenstone
Greenstone Net Zero Demonstration Home
This Net Zero Home features:


LIFEBREATH
Indoor Air Systems
PURE PERFORMANCE™
LIFEBREATH STANDS FOR QUALITY INDOOR AIR
HEAT RECOVERY VENTILATOR (100 ECM)
Replace stale indoor air with fresh, pure outdoor air.
LIFEBREATH
TFP 3000 HEPA
Revolutionizing home air cleaning, combining two particle capture technologies to ensure clean, healthy air throughout your home

Sales team training day before home tour opens

Spokane HBA
Fall Home Tour

Tracking incremental costs

Approximately $20,000 for solar system

Used made in Washington solar panels

could have used other solar panels and reduced cost

Approximately $12,000 to go from code built to Zero Energy Ready

Costs would be lower if builder repeated

These costs do not include monitoring expenses

Tracking lessons learned

A few examples of things on the lessons learned list:

Collaboration is a winning strategy on high performance homes

Design support and training is essential for success

Need a monitoring drawing

Need a pre drywall site visit after all systems are roughed in

HVAC contractors need more training on cold climate DHP installation, Kumo Cloud, value engineering space conditioning distribution in low load homes, and HRV design

Transfer fans and supplemental heat can be tricky

Be sure to place sensors in smart locations

Builder Suggestions

- Suppliers be more proactive
- Make rating software more accessible
- Find a way to add value
- Ask questions (a lot of them)
- Help builders sell and implement the idea of home efficiency

Potential Next Steps

- Construct a collection of homes
  - Mini-split system
  - HRV
  - Small array of solar panels
  - Market healthy, comfortable and energy efficient homes with HERS score
  - Increase in sales price: $

Change is coming!

Greenstone

MITSUBISHI ELECTRIC
COOLING & HEATING

LIFEBREATH
Indoor Air Systems

ZERO NET ENERGY

Using a source energy-based definition

Presented by: Gary Heikkinen, PE
October 5, 2017

NW Natural®

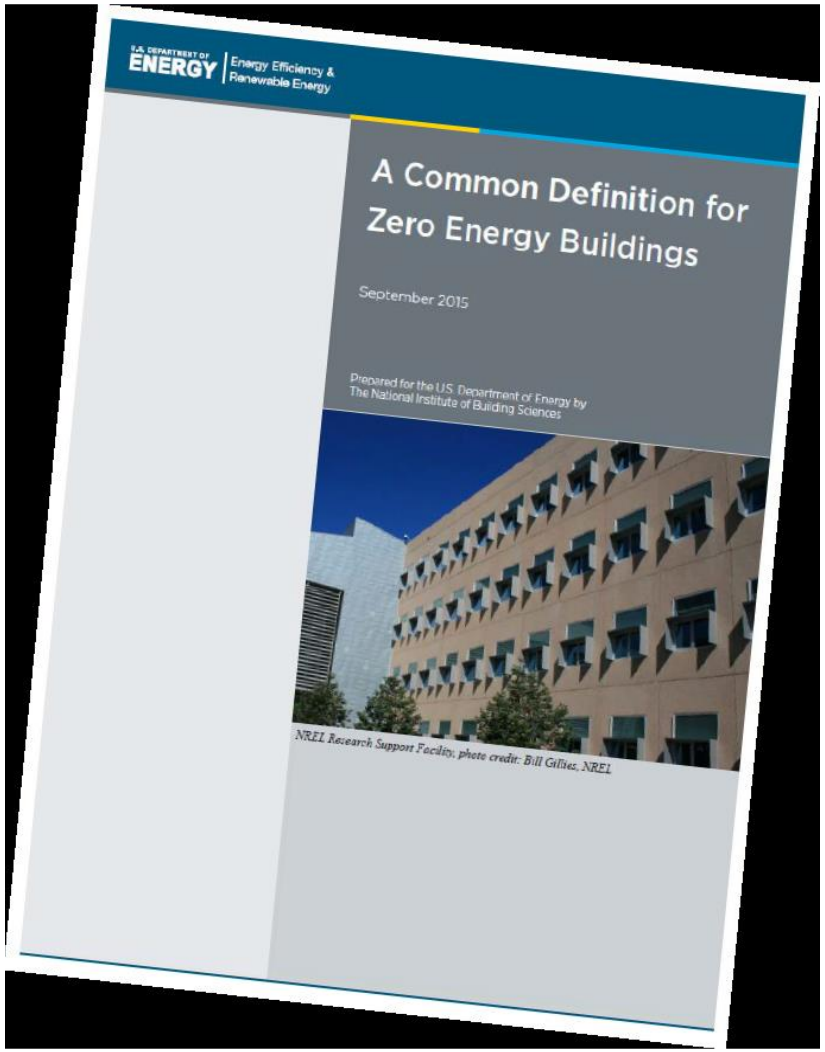
Learning Objectives

- Learn about USDOE's new definition for Zero Net Energy as measured on a source energy basis.
- Learn the difference between site and source energy.
- Learn about and understand the reasons for using marginal energy resources rather than average.
- Review study by Gas Technology Institute comparing all-electric and mixed-fuel homes.
- See how these ZNE homes compare on a source energy, first cost and energy cost basis.

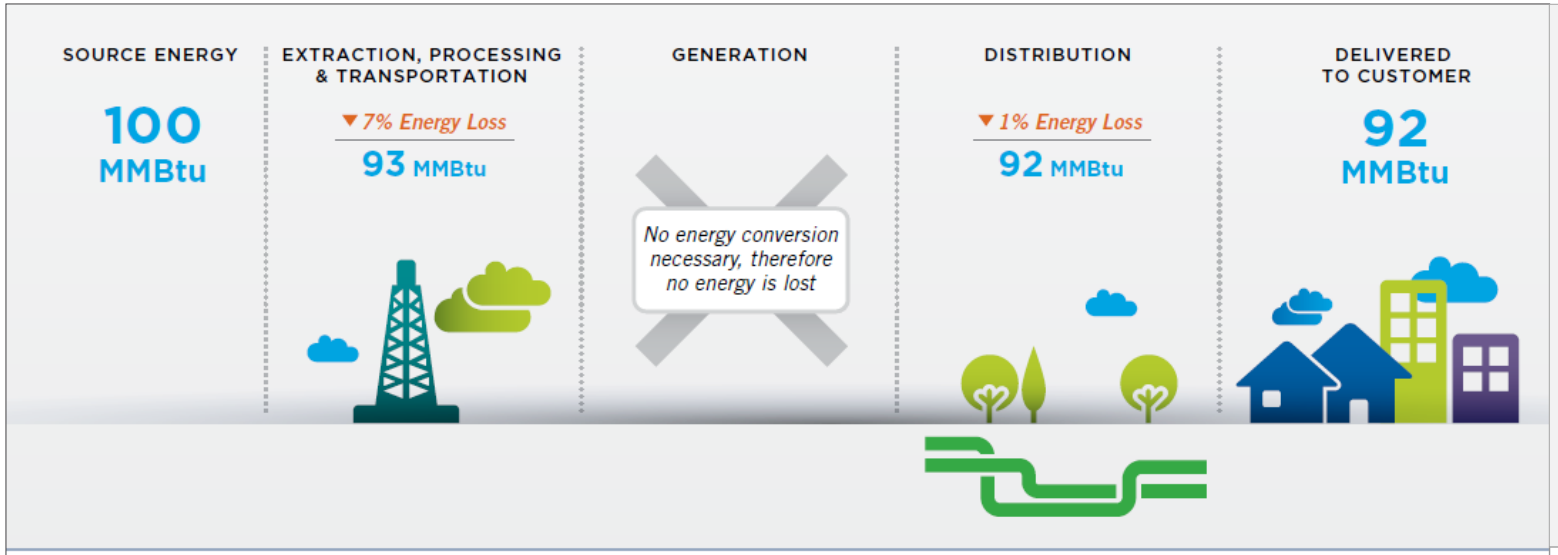
ZNE Definition

USDOE definition finalized September, 2015:

- “An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.”
  - Source Energy: Site energy plus the energy consumed in the extraction, processing and transport of primary fuels such as coal, oil and natural gas; energy losses in thermal combustion in power generation plants; and energy losses in transmission and distribution to the building site.

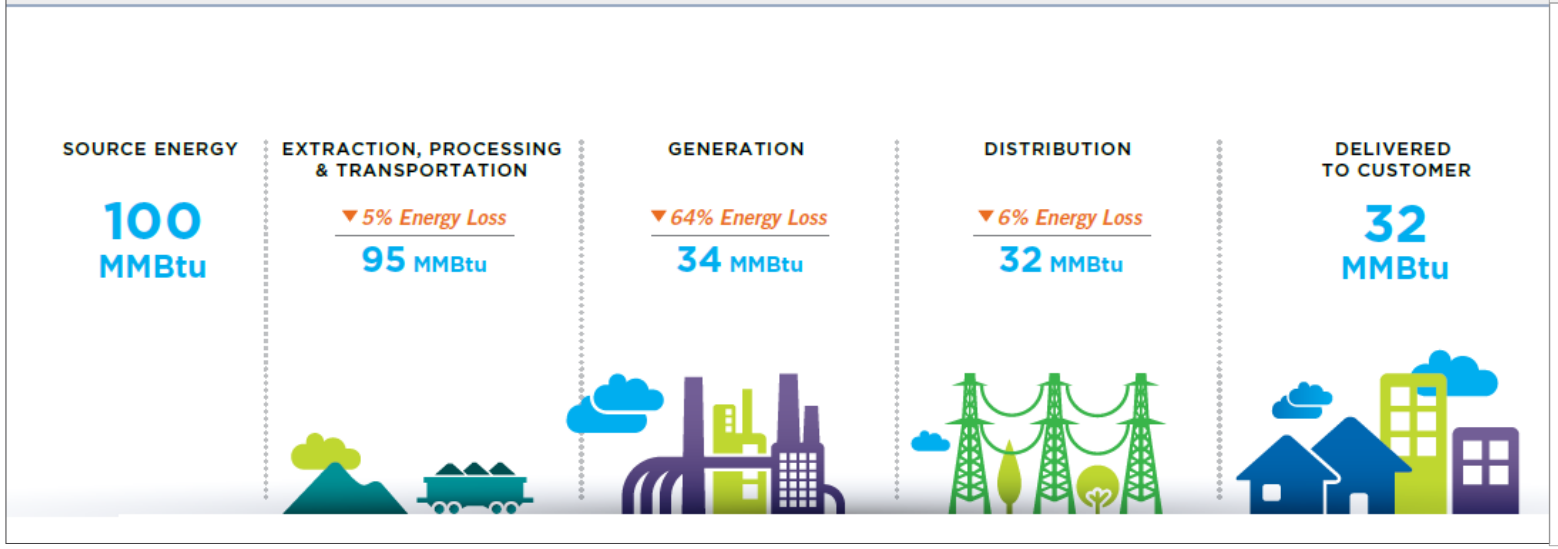


Source to Site Comparison



Natural gas from wellhead to burner tip

92% efficient

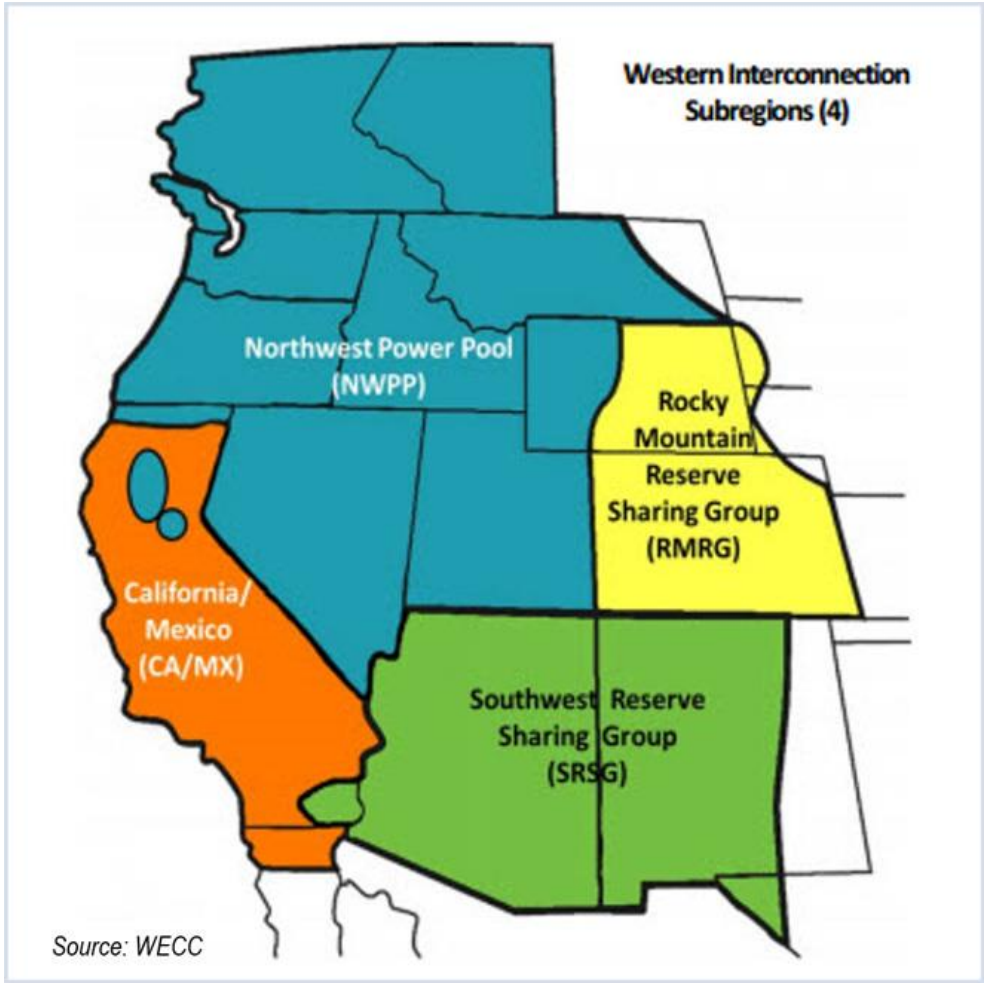


Converting fossil fuels into electricity and delivering to homes

32% efficient

Source Energy & Emissions Factors

- The study used the NW Power Pool Non-Baseload (marginal) category replacing all non-baseload coal generation with natural gas, resulting in the following resource mix: 95.7% gas, 4% biogas, and 0.3% oil
- This resulted in a Source Energy Factor (SEF) of 2.75 for electricity.
- The SEF for the direct use of NG used is 1.09.



Example Calculation

- Electricity use:
  - 1000 kwh (site) x 2.75 = 2750 kwh (source)

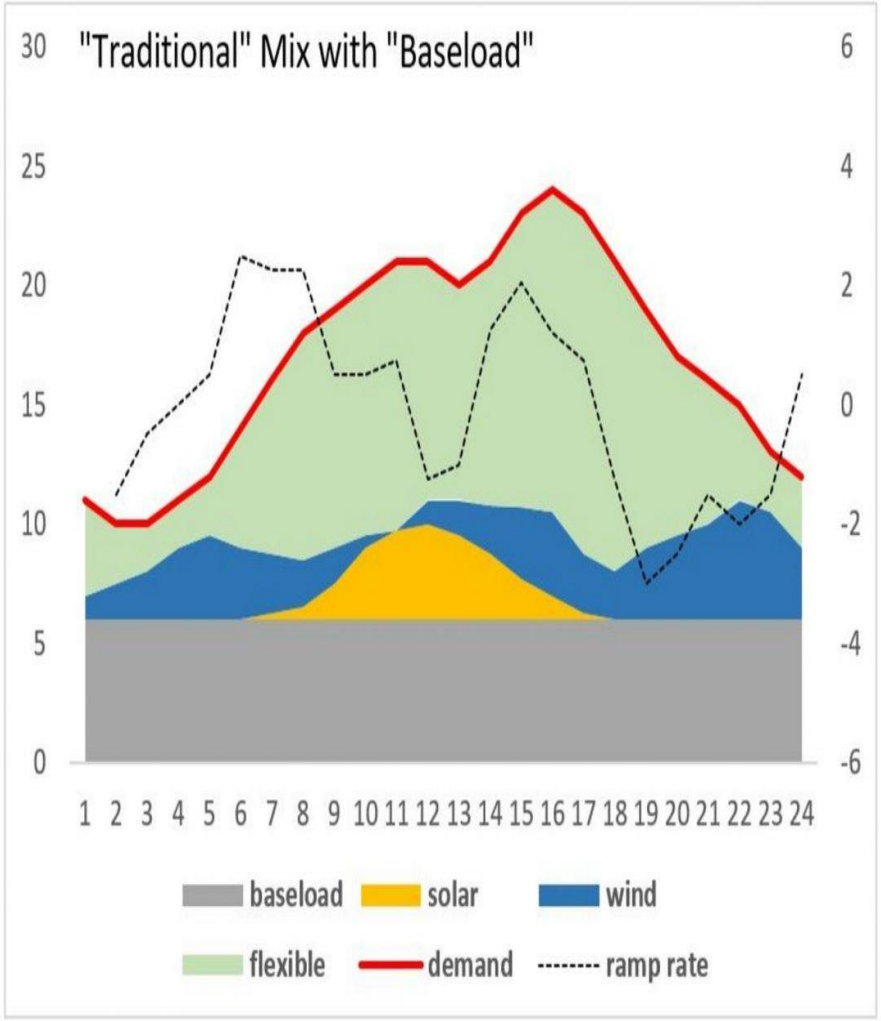
- Natural Gas use:
  - 300 therms (site) x 1.09 = 327 therms (source)

- Renewable energy (PV) exported:
  - 1000 kwh (site) exported x 2.75 = 2750 kwh (source)

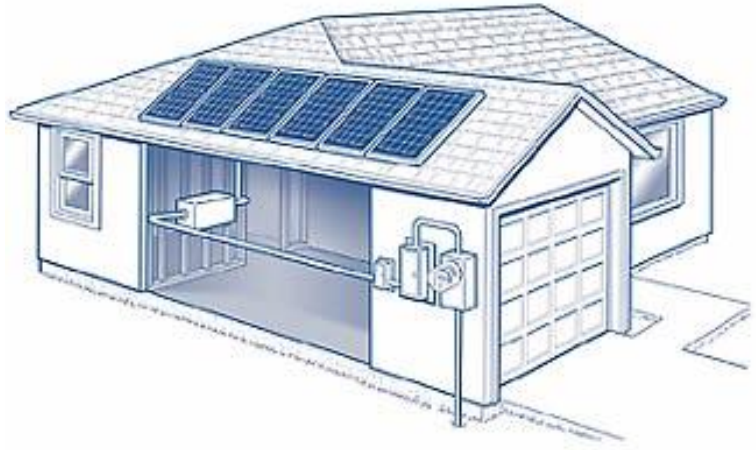
Marginal (Non-Baseload) Electricity Resource

Marginal generation may be a more appropriate increment.

- Renewable generation in the U.S. is rarely considered a marginal power plant because it will always be dispatched when available.
- Fossil fuel plants are considered marginal power plants under the economic dispatch model, with natural gas or coal plants nearly always being the marginal plants.



GTI Study



Objectives:

- Evaluate alternative new construction single-family measure packages from code to zero energy in Portland
- Present market-appropriate building packages for mixed-fuel and all-electric designs. Compare:
  - First costs + Operating costs
  - Energy use
  - CO2e emissions
- Identify key energy and economic drivers, emphasizing societal and consumer benefits

GTI Study Details

A single-family home representing a typical new home in Portland was developed for use with all cases.

- 2-story home on crawlspace with vented attic
- 2,178 sq ft - 3 bed – 2.5 bath
- Home's exterior walls (e.g. front) feature same length, height, and glazing area to minimize orientation bias (modeled as north facing)

- Four basic designs were developed from Oregon Code Compliant to zero energy. (Code, Good, Better, Best)
- Features selected based on regional practices with a bias towards minimizing the introduction of rare practices.
- The Best Home design is paired with on-site solar PV to reach zero energy.

House Common Features

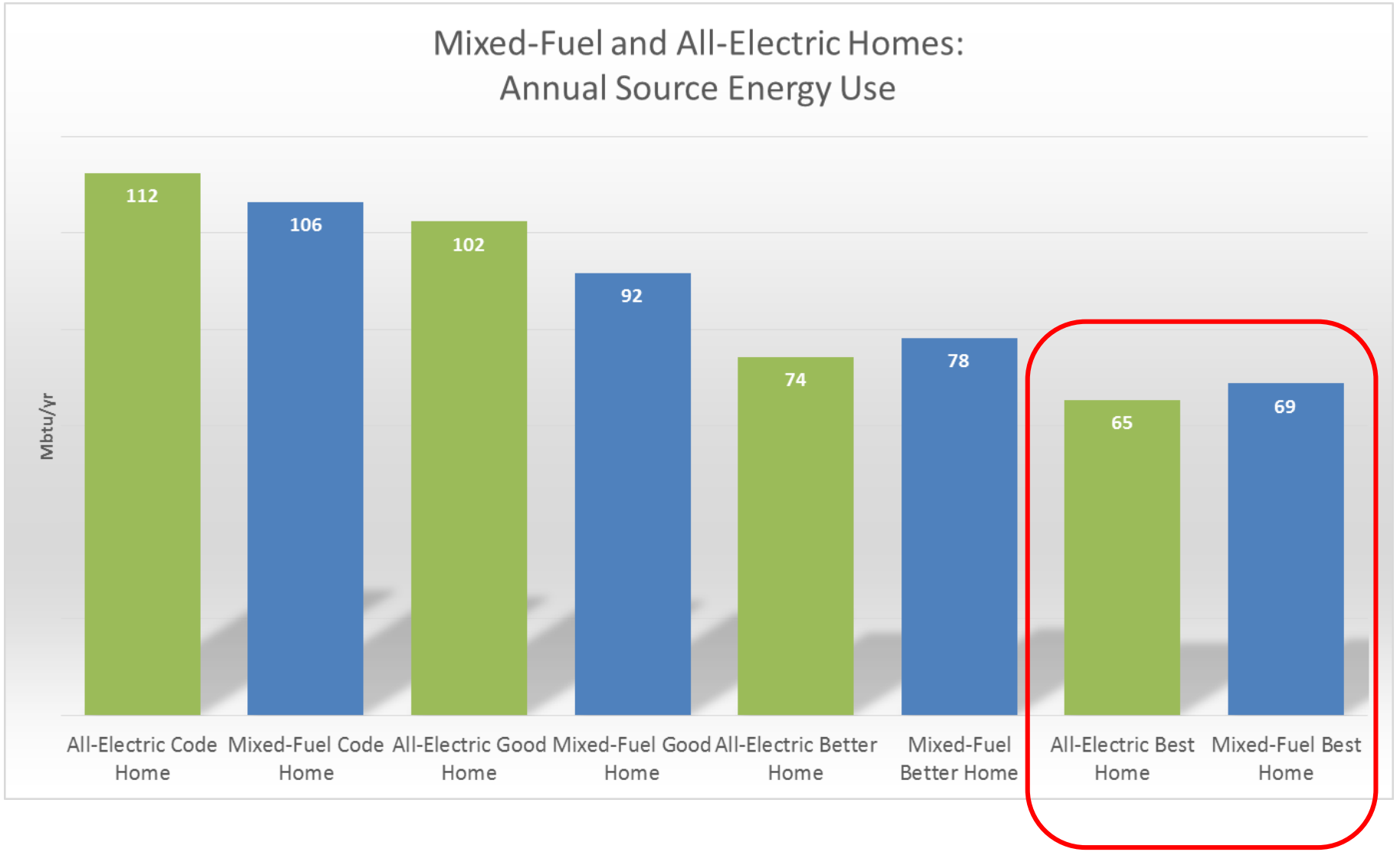
Portland, OR Home Designs (Common Features for Both Electric-Only and Mixed-Fuel Homes) 2-Story - Crawlspace - Vented Attic - 2,178 sq ft - 3 bed – 2.5 bath				
Category	**Code Home**	**Good Home**	**Better Home**	**Best Home**
Foundation- Crawl, Underfloor	R 30	R 30	R 38	R 38
Attic- Ceiling	R 38	R 49	R 60	R 60
Wall (Construction)	2*6 24 ioc	2*4 16 ioc	2*4 16 ioc (OVE)	2*4 16 ioc (OVE)
Wall (Cavity; Sheathing)	R 21 batts	R 21 batts	R 21 batts; R5 XPS	R 36 foam; R5 XPS
Windows (U-Factor/SHGC)	0.35/0.44	0.30/0.40	0.21/0.40	0.18/0.40
Infiltration (Air Tightness)	6 ACH 50	4 ACH 50	2 ACH 50	1.5 ACH 50
Ventilation	Mechanical; Exhaust Only	Mechanical; Exhaust Only	Mechanical; Exhaust Only	Mechanical; Exhaust Only
HVAC System Location	Conditioned Space	Conditioned Space	Conditioned Space	Conditioned Space
Lighting (% High Efficacy)	50% CFL	90% CFL	100% LED	100% LED
Low Flow Fixtures	No	Yes	Yes	Yes
Thermostat Set point	68/78	68/78	68/78	68/78
Refrigerator	573 kWh/yr	458 kWh/yr	427 kWh/yr	427 kWh/yr
Dishwasher	318 Rated kWh	290 Rated kWh	270 Rated kWh	270 Rated kWh
Clothes Washer	Standard	Standard	Energy Star	Energy Star
Plug Loads	Standard	Standard	Standard	25% Reduction

All-Electric & Mixed-Fuel Designs

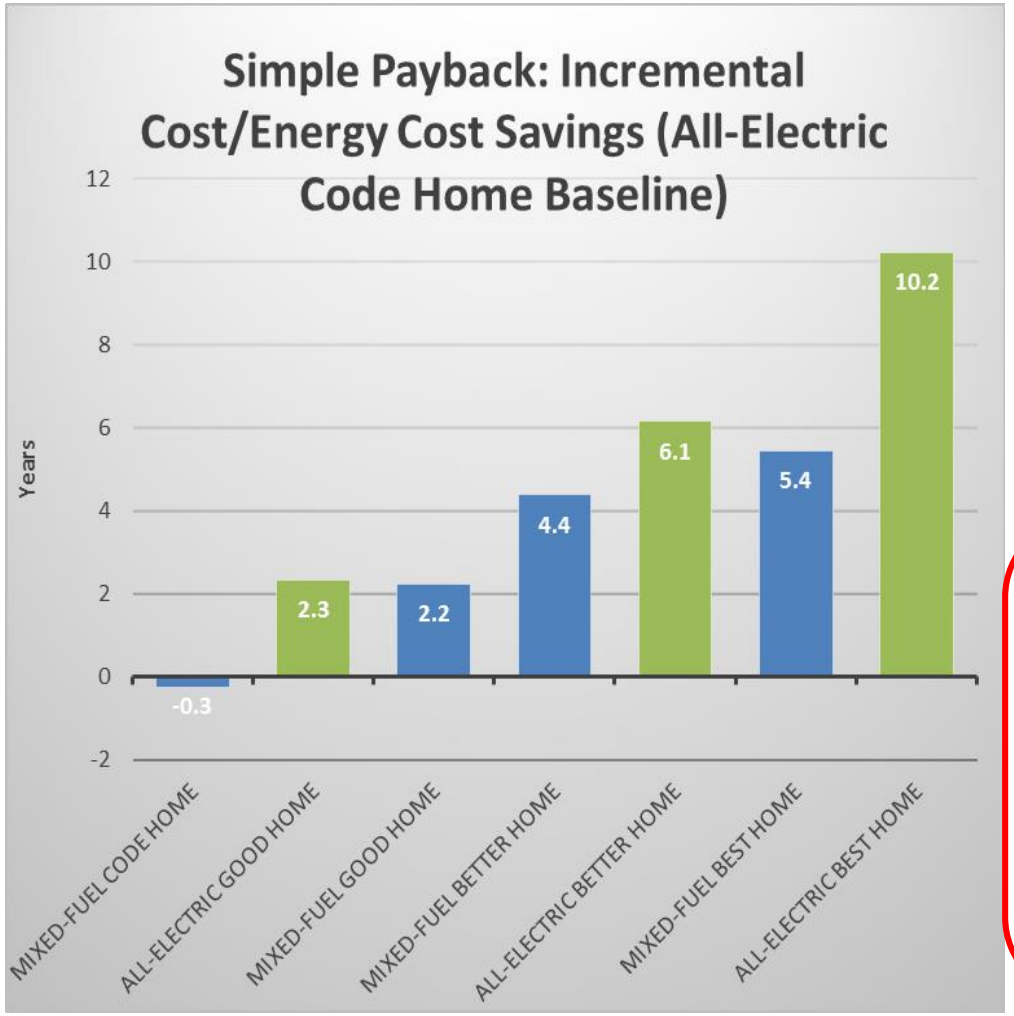
Portland, OR Home (All Electric Designs)				
End Use	**Code Home**	**Good Home**	**Better Home**	**Best Home**
HVAC (Air Source HP)	8.2 HSPF/14 SEER	8.7 HSPF/17 SEER	9.3 HSPF/18 SEER	10 HSPF/22 SEER
Water Heat	0.95 EF 50 Gallon Storage Tank	0.95 EF 50 Gallon Storage Tank	2.35 EF Heat Pump 65 Gallon (Inside)	2.35 EF Heat Pump 65 Gallon (Ducted, Balanced)
Clothes Dryer	3.1 EF (Standard)	3.1 EF (Standard)	3.93 EF (Energy Star)	4.2 EF (Heat Pump, Unvented)
Cooking	Electric (Standard)	Electric (Standard)	Electric (Standard)	Electric (Induction)

Portland, OR Home (Mixed Fuel Designs)				
End Use	**Code Home**	**Good Home**	**Better Home**	**Best Home**
HVAC (Furnace and Elec AC)	80 AFUE; 13 SEER	90 AFUE; 15 SEER	95 AFUE; 18 SEER	98 AFUE; 21 SEER
Water Heat	0.62 EF 40 Gallon Storage Tank	0.67 EF 40 Gallon Storage Tank	0.82 EF Tankless	0.96 EF Tankless
Clothes Dryer	2.75 EF (Standard)	2.75 EF (Standard)	3.48 EF (Energy Star)	3.48 EF (Energy Star)
Cooking	Gas (Standard)	Gas (Standard)	Gas (Standard)	Gas (Standard)

Source Energy Use Results



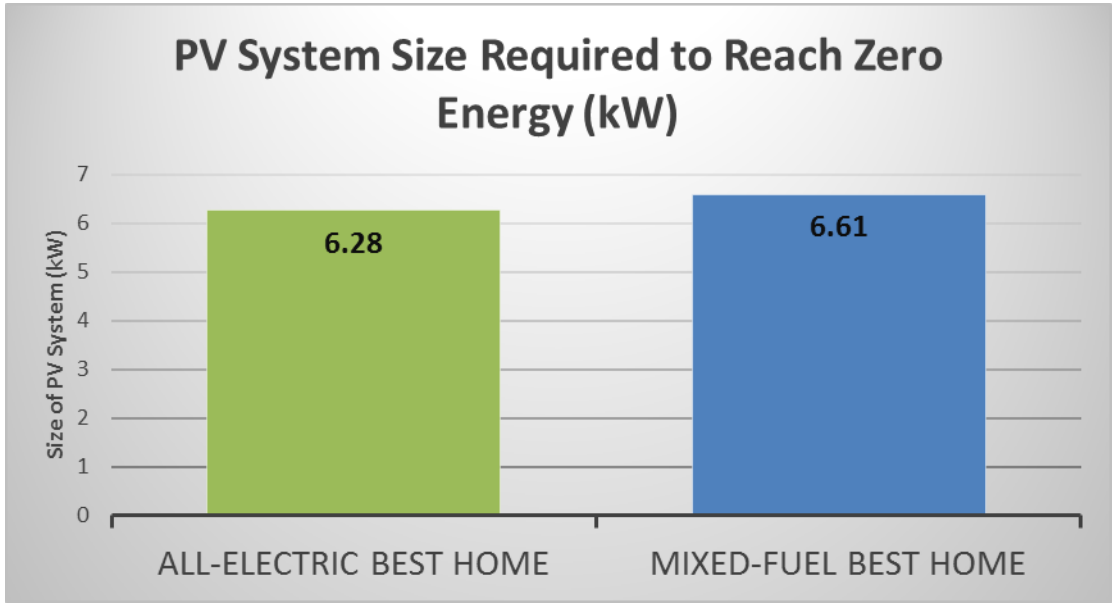
Simple Payback Analysis



- The All-Electric Code Home uses the most source energy at 112 MBTU/YR. As such, it's incremental cost serves as the baseline for the simple payback analysis.
- The chart shows how many years each home must operate to repay first costs with operational energy savings.
- **The Mixed-Fuel Code Home uses 106 MBTU/YR (less than electric code home) and cost $68 less to build.**
- **The Mixed-Fuel Best, or Zero Energy Ready Home, pays back in 5.4 years vs. 10.2 for the All-Electric version.**

Final ZNE Comparisons

- Generally, high performance home designers endeavor to reduce the home's annual energy use until the next available measure offers diminishing or uneconomic returns.
- In this case, each Best Home design represents this philosophy. To reach zero energy use on an annual basis, on-site solar photovoltaic (PV) is added to offset on-site energy use.
- For illustrative purposes, only the exact amount of PV was applied to each home to reach zero annual source energy use. The PV system is modeled as entirely south-facing, regardless of available roof area.
- ***The Mixed-Fuel Zero Energy Home costs less to build and operate*** *than the comparable All-Electric Home*



Portland, OR Single-Family Home	All-Electric Zero Energy Home	Mixed-Fuel Zero Energy Home
Energy Cost ($/yr)	$0.00	-$105.32
Cost for Non-Common Measures ($)	$11,133	$8,817
Cost for PV ($4,000/kW)	$25,126	$26,434
Total Non-Common Measures Cost with PV	$36,259	$35,251

Summary

1. On a source energy basis, the Mixed-Fuel ZNE-Ready home is comparable with an All-Electric ZNE-Ready home.
2. Incremental first cost and annual energy cost of a Mixed-Fuel ZNE-Ready home is slightly less than an All Electric ZNE-Ready home.
3. After adding PV to achieve ZNE, the incremental first cost is slightly less for the Mixed-Fuel home.
4. A Mixed-Fuel ZNE home is achieved more cost effectively and at lower paybacks than an All-Electric ZNE home.
5. Home builder has more equipment options to attain ZNE home.

THANK YOU

Gary Heikkinen, PE
gwh@nwnatural.com
503.997.9334