Go Solar!

Fort Collins Residential Environmental Program Series (1 April, 2015)

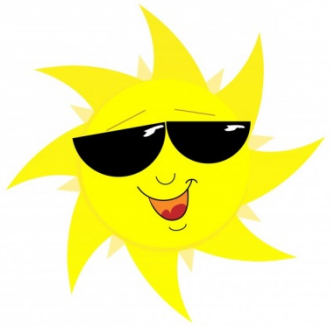
AGENDA

- 7:00 PM **Welcome and Intro** (Kelsey Doan, Norm Weaver)
- 7:10 PM **Overview of Ft Collins Solar Program**s (Norm Weaver)
- 7:30 PM **Update on Riverside Community Solar** (Mike Dow)
- 8:00 PM **5 minute break**

  8:05 PM **Revive Zero Energy Subdivision** (Paul Norton)
- 8:45 PM **Wrap up polling and door prizes**

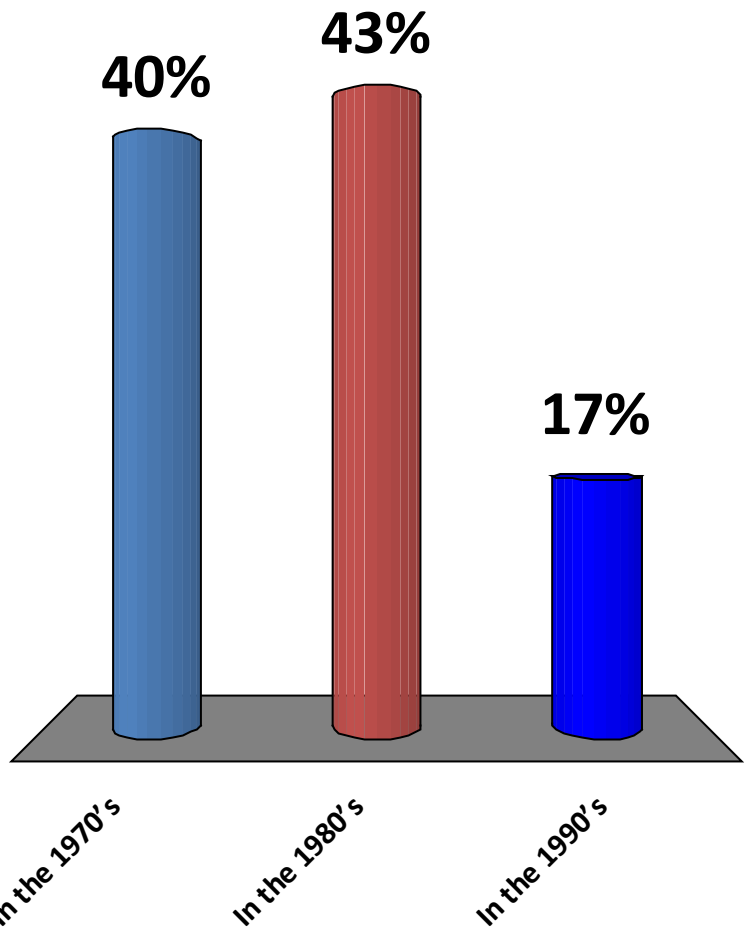
But First ... a warmup question

"The Future is so Bright, I gotta Wear Shades!"



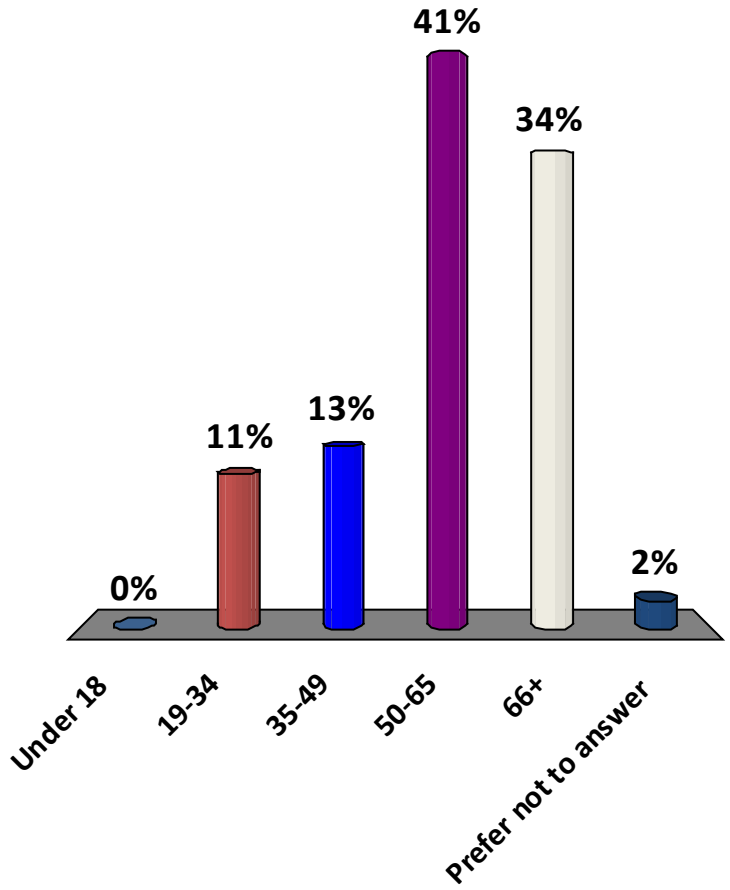
This "one hit wonder" popular song (by Timbuk 3) was released

A. In the 1970's
B. In the 1980's
C. In the 1990's



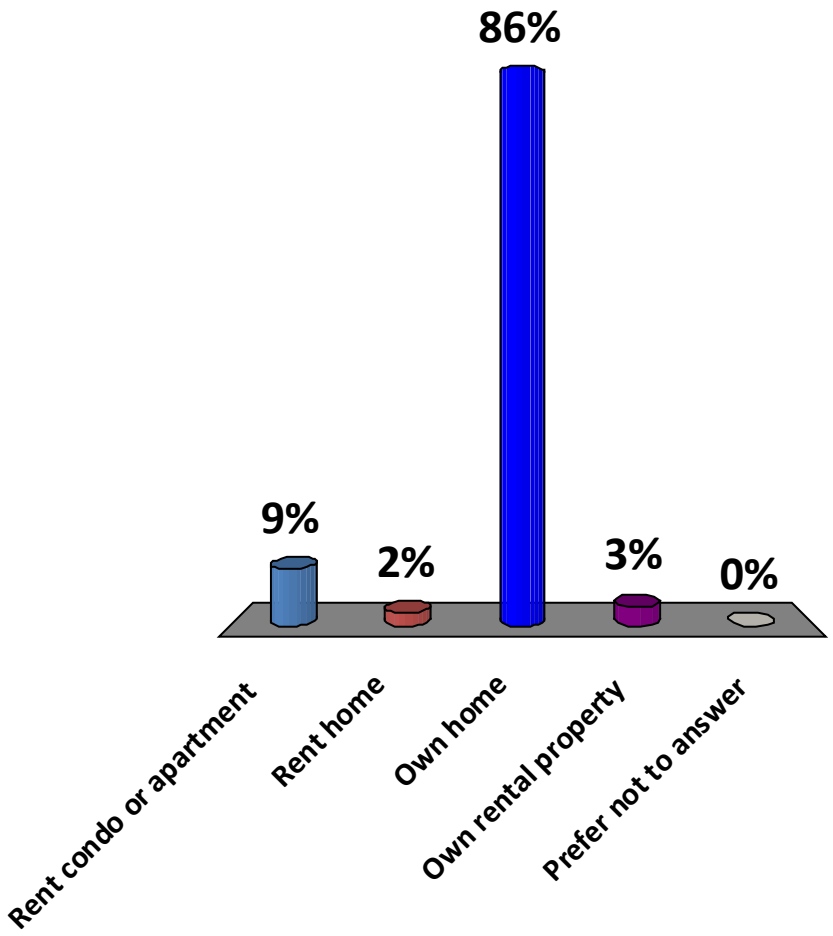
In what age range are you?

A. Under 18
B. 19-34
C. 35-49
D. 50-65
E. 66+
F. Prefer not to answer



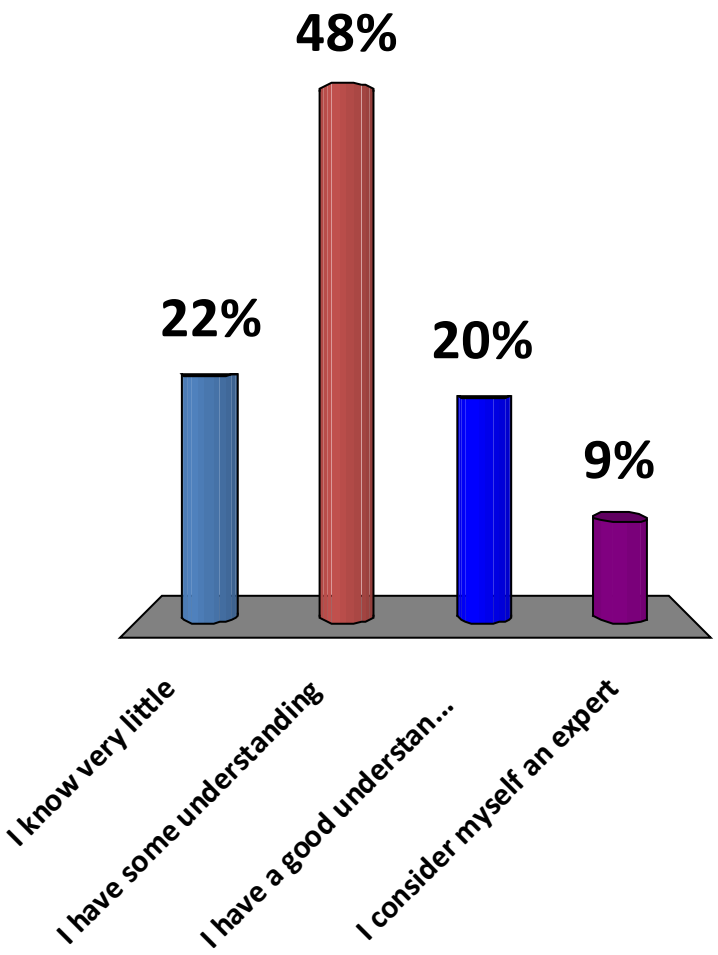
Do you rent or own your home?

A. Rent condo or apartment
B. Rent home
C. Own home
D. Own rental property
E. Prefer not to answer



How familiar are you with the presentation topic?

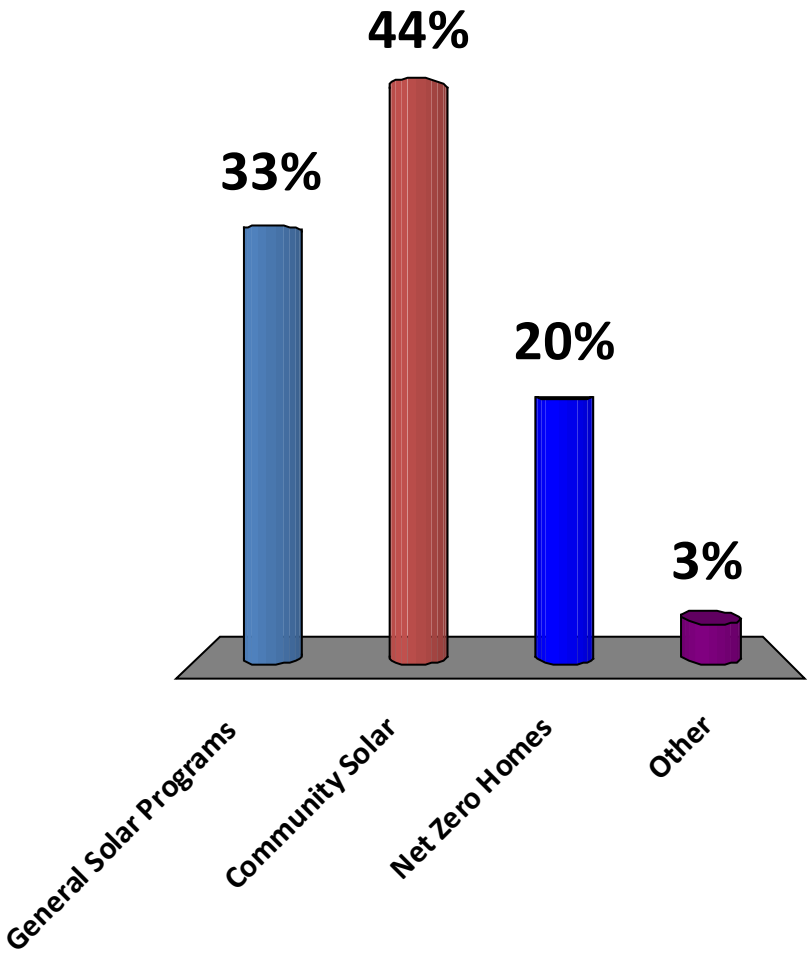
A. I know very little
B. I have some understanding
C. I have a good understanding
D. I consider myself an expert



Your Interest Tonight?

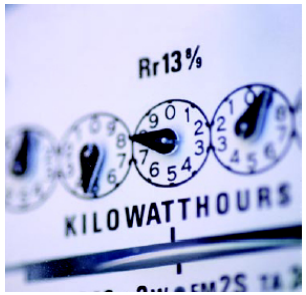
I am most interested to learn tonight about

A. General Solar Programs
B. Community Solar
C. Net Zero Homes
D. Other

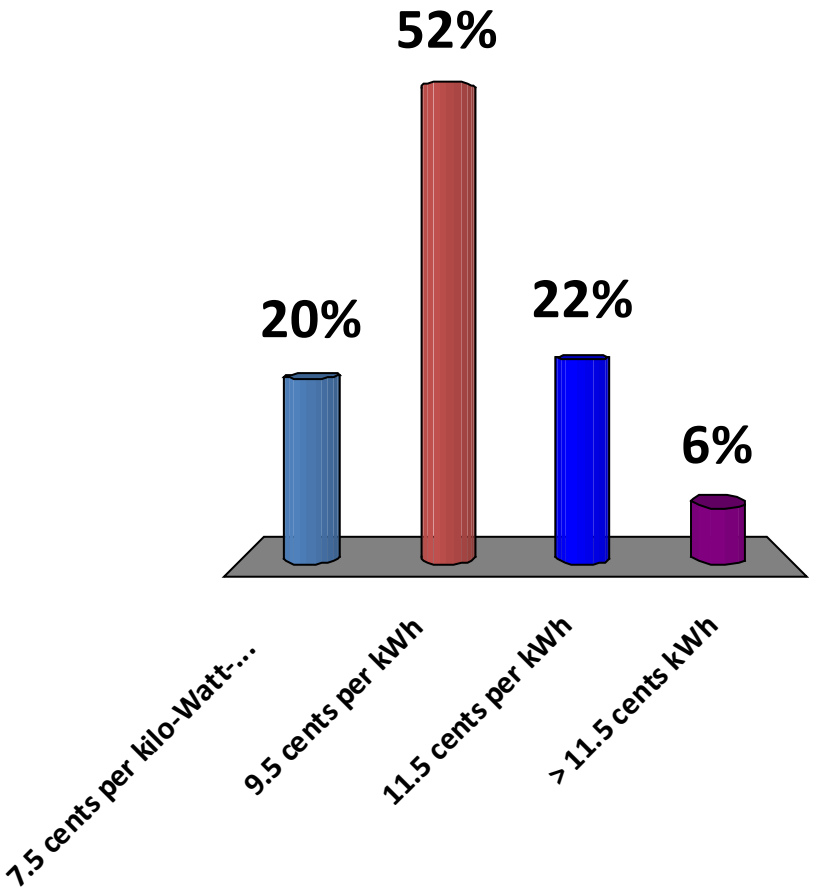


The Cost of Energy …

The average cost of residential electricity in Fort Collins is



A. 7.5 cents per kilo-Watt-hour (“kWh”)
B. 9.5 cents per kWh
C. 11.5 cents per kWh
D. > 11.5 cents kWh



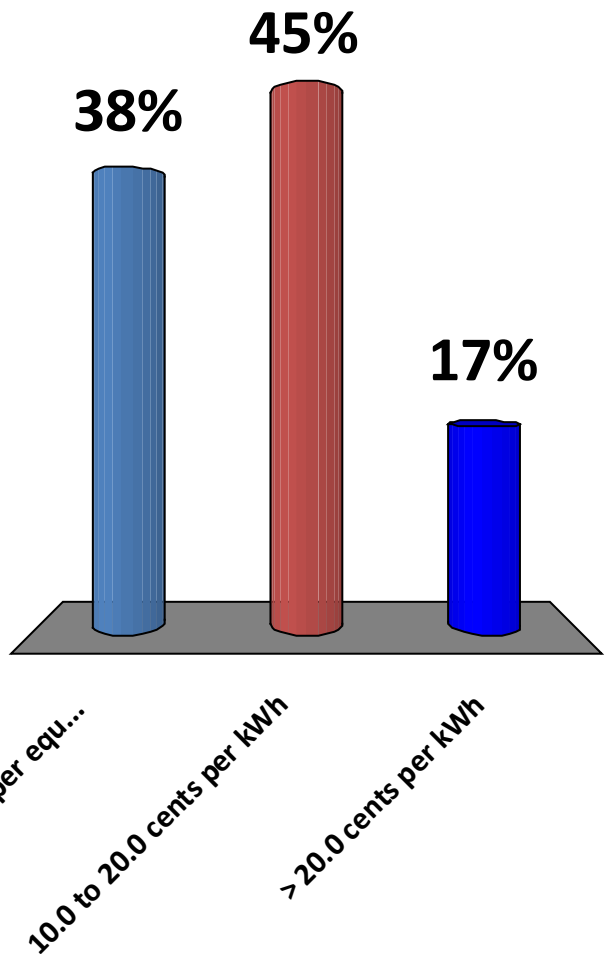
The cost of energy saved…

The average cost to a home owner of a saved energy (elec. and nat-gas) through energy efficiency is

A. 5.0 to 10.0 cents per equiv. kilo-Watt-hour (“kWh”)

B. 10.0 to 20.0 cents per kWh

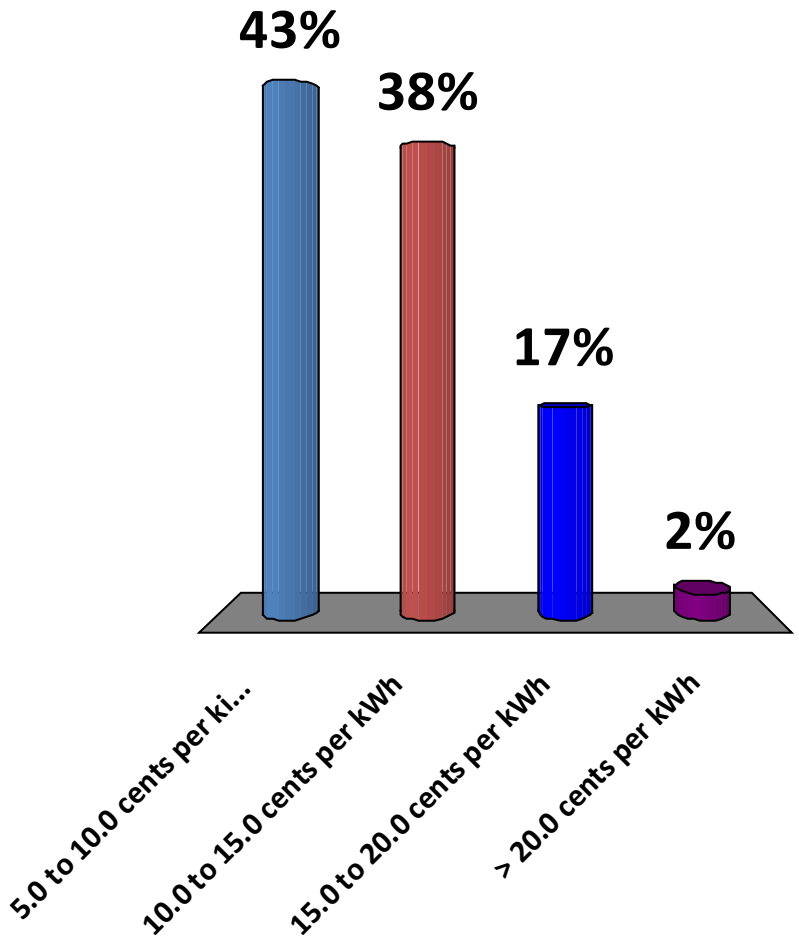
C. > 20.0 cents per kWh



The Cost of Solar …

The cost of electricity produced by a residential photovoltaic (“PV”) solar system averaged over 25 years is

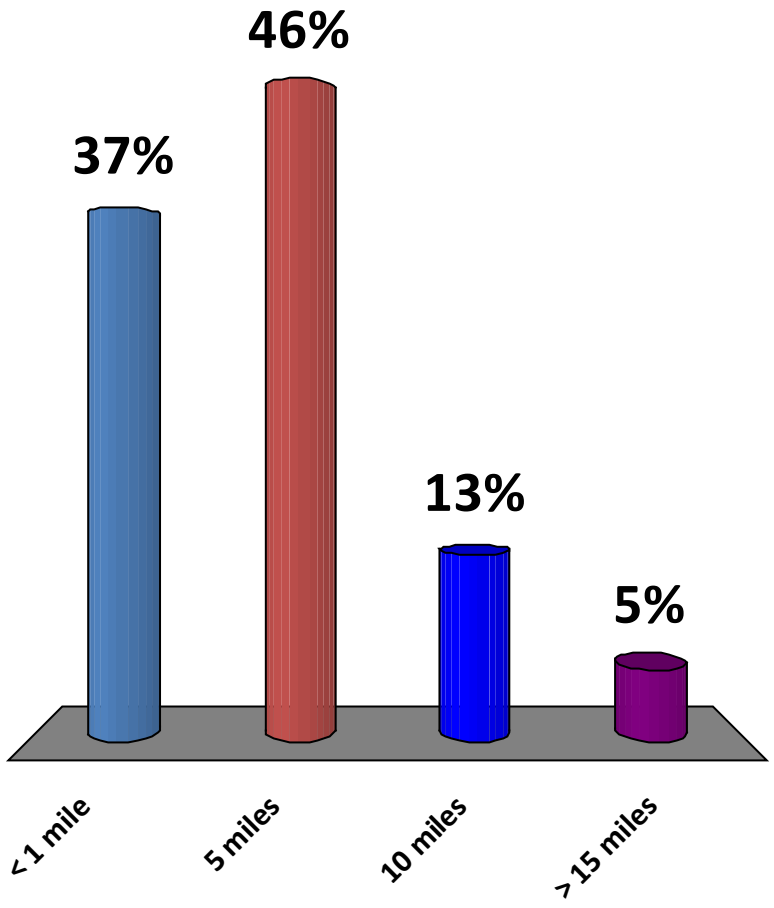
A. 5.0 to 10.0 cents per kilo-Watt-hour (“kWh”)
B. 10.0 to 15.0 cents per kWh
C. 15.0 to 20.0 cents per kWh
D. > 20.0 cents per kWh



Bonus Question …

The distance to the nearest installed PV solar system larger than 25kW is

A. < 1 mile
B. 5 miles
C. 10 miles
D. > 15 miles



(a typical residential PV system is 3kW)

Overview of Fort Collins Solar Programs

- Efficiency First - "Efficiency Works"
- Home Eff. Loan Program ("on-bill financing")
- Residential and Commercial PV Rebates
- Community Solar
- Commercial Solar Power Purchase Program
- PRPA 22 MW PV solar plant
- 2015 grant program for low income sector

Efficiency Works™

- Diagnostic Audit – Prioritized Recommendations
- Efficiency Rebates
- Certified Contractor List
- Home Efficiency Loan Program

Efficiency Works™

Home Efficiency Lone Program

- Term: 5,7,10,15 or 20 years
- Amount: $1,000 - $15,000
- Int. Rate: 2.5% fixed (for 2015)
- Fee: $150 origination fee
- Projects: Home Efficiency Measures, **Solar PV**, Water Service Repair

2015 Solar Rebates

- Up to $3000 residential and $20,000 for commercial projects
- 87 residential rebate reserved – now taking appl's to a waitlist
- 5 commercial rebates reserved – 2 slots remain.

Riverside Community Solar

- CEC is building out both phase 1 and 2, 620kW total
- Approx. 250 rebates supported (2013-15 funds)
- Ceremonial Groundbreaking March 24
- ~ 2000 modules are now on-site
- “Don’t change that dial!” – more to come with **Mike Dow** from Clean Energy Collective

Commercial **S**olar **P**ower **P**urchase **P**rogram ("SP3")

- Program to help Fort Collins meet Colorado renewable energy standard and climate action goals
- Applications Closed February 2014
- 4 sites operating, 15 total in 2015
- 3.7 MW total

Platte River Power Authority

- **22 MW in 2016**

- Increase the amount of solar serving Fort Collins by a factor of three (in 2016)
- Increase the percentage of renewable energy for the community by 2% (from the solar project alone)
- Provide solar energy equivalent to the use of approximately 3400 typical Fort Collins homes
- Reduce GHG emissions by approximately 25,000 metric tons, or a little over 1% of the total community emissions in 2014

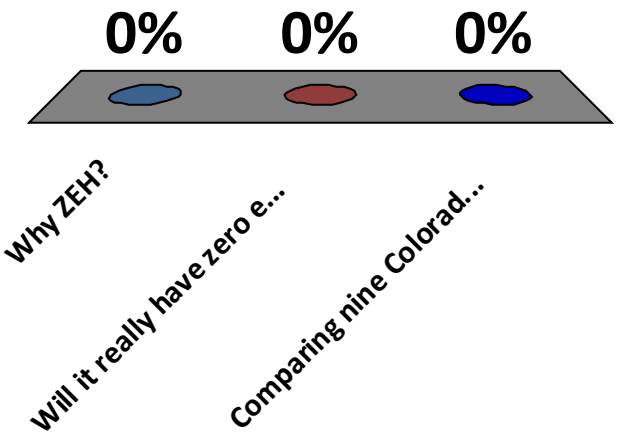
Low Income Solar

- 2015 – Working with Social Sustainability Dept. to request and select from solar grant proposals from Low Income Housing providers
- Emphasis on the direct benefit of lower utilities cost to low income families

At this point ….

What would you like to hear about the most?

A. Why ZEH?
B. Will it *really* have zero energy *performance?*…..how the home and occupants meet or miss ZE together.
C. Comparing nine Colorado ZEH projects.



Background: Typical Residential Solar Economics

- A 3000 Watt (3 kilo-watt, 3kW) PV system offsets roughly 50% of electric use in an average Fort Collins home.
- A 3kW system costs roughly $12k to install
- Typical first year utility bill savings are roughly $380
- Final cost to a typical homeowner after rebates and tax credits is roughly $5400 leading with a payback period of 12 to 14 years.

Community-Owned Solar for Fort Collins

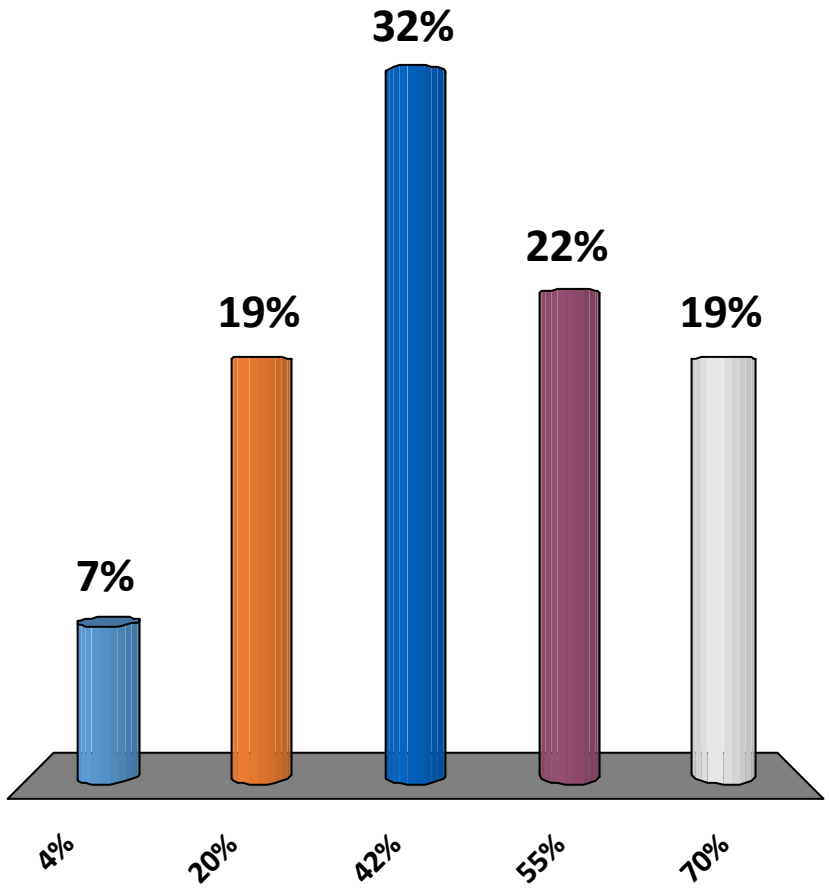
A New Spin on Solar

April 1, 2015

CEC | Our Growing List of Partners

According to Department of Energy estimates, what percentage of homes in the US are ideally sited for rooftop solar?

A. 4%
B. 20%
C. 42%
D. 55%
E. 70%



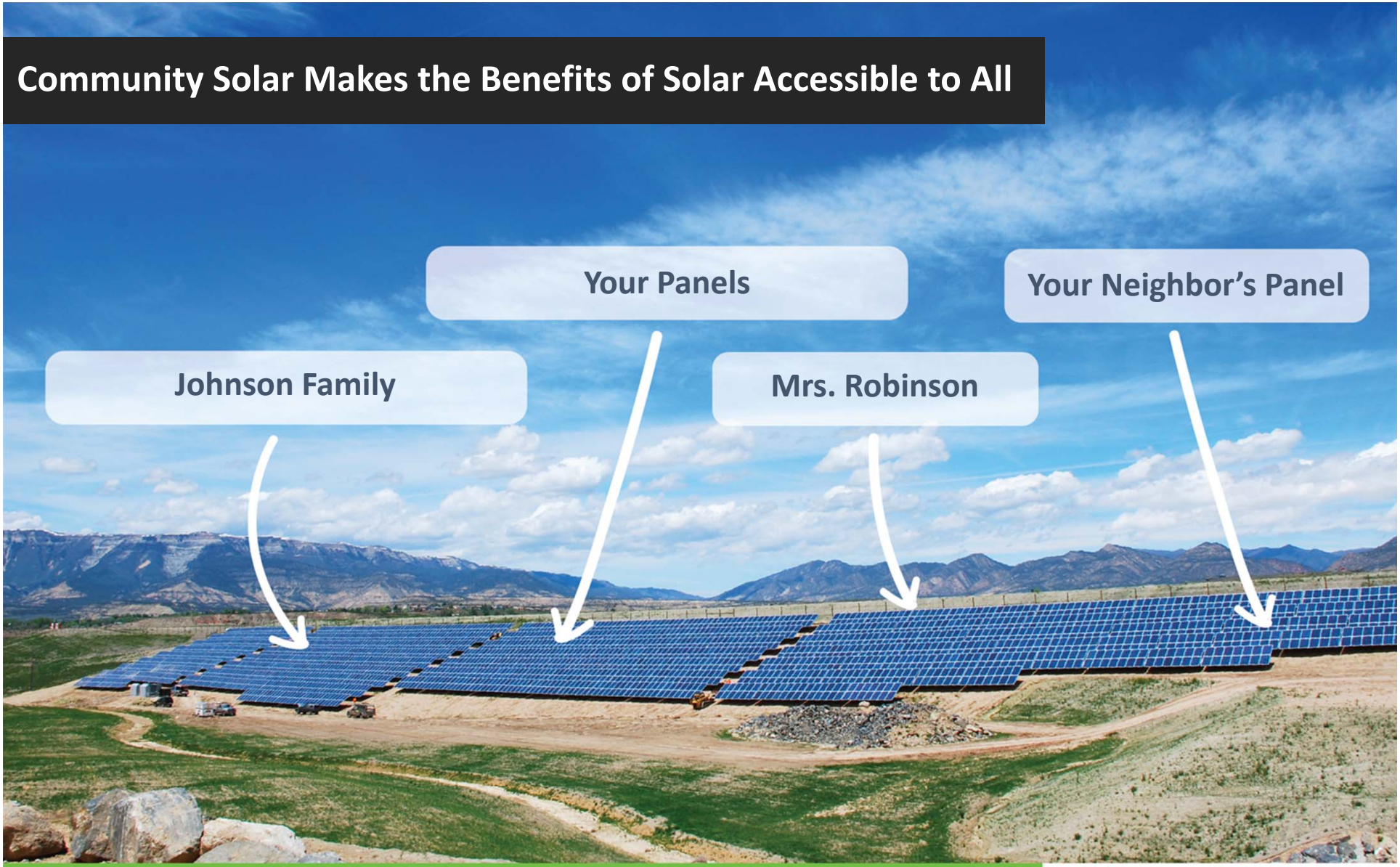
Solar Accessibility - Across the US

According to Department of Energy estimates, what percentage of homes in the US are ideally sited for rooftop solar?

a. 4%
b. 20%
c. 42%
d. 55%
e. 70%

There are many reasons for this, including roof orientation, space limitations, shading from trees and other buildings, shared roof ownership (condos), structural issues, financial barriers, and others.

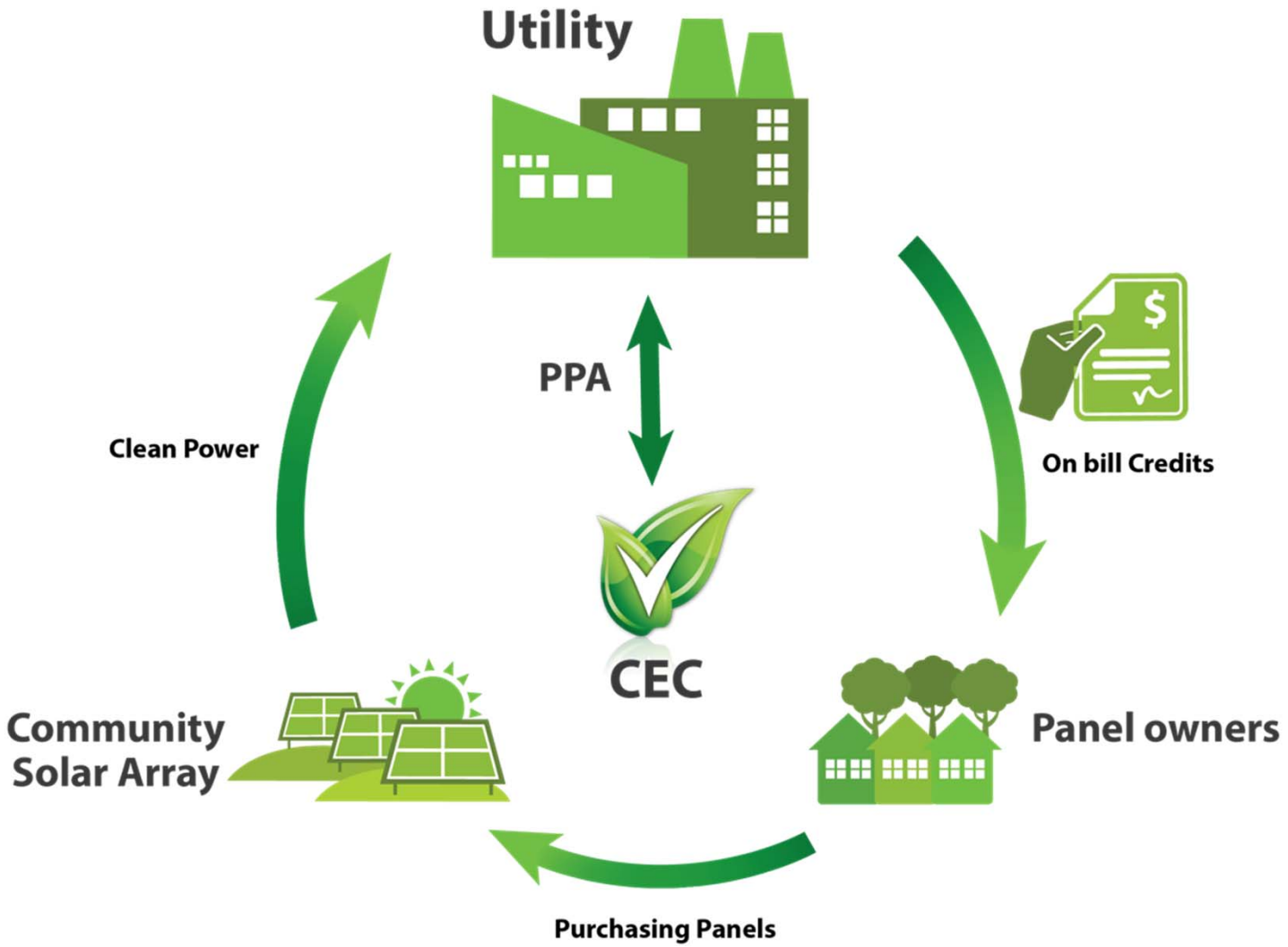
Community Solar Makes the Benefits of Solar Accessible to All



- Centralized, ideally sited facility
- A customer-owned asset that generates payback
- Operations and maintenance handled by CEC for system lifetime

Clean Energy COLLECTIVE

How Does It Work?



Community Solar offers Flexibility

What if I move within the utility network?

No problem! Your system can move with you.

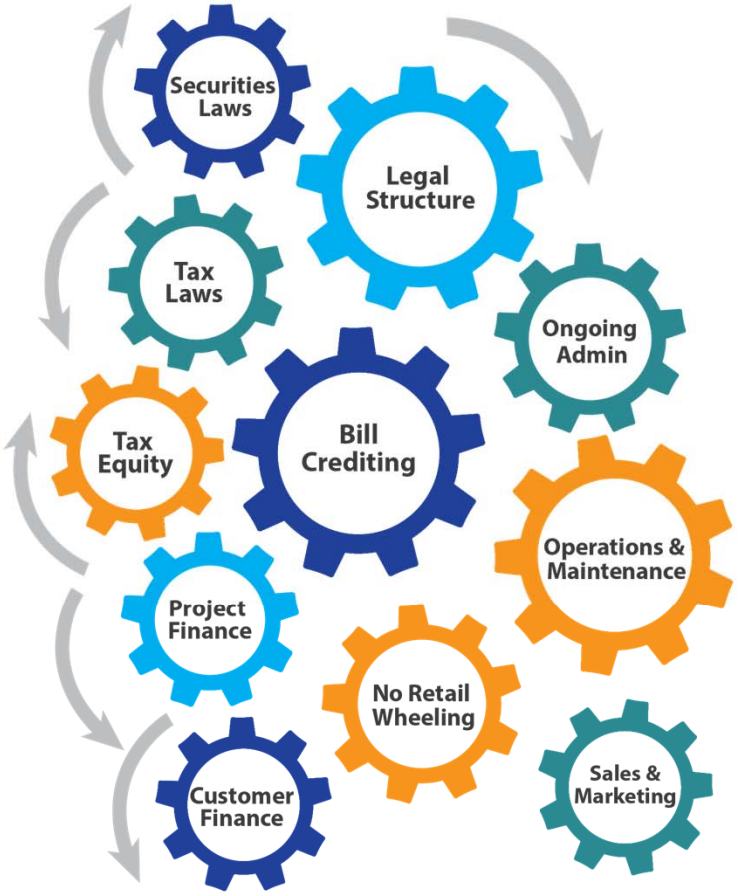
What if I'm leaving the area?

Customers have options:

- Wrap it up into the sale of your home
- Sell it separately to any utility customer
- Gift it to a relative or include it in your estate planning

Making Solar Simple & Financially Smart

To do a utility-scale community solar project, there is a lot of complexity to wade through….



- No site visits, roof assessments, or costly improvements to your property are necessary
- No aesthetic or structural integrity issues to consider
- Comprehensive operations and maintenance program included

…CEC's goal is to make it easy and hassle-free the customer.

Operations & Maintenance Program

O&M Trust Account

- Held in the name of the community solar array's LLC
- CEC seeds the account with proceeds from initial sales
- Funded over time by a percentage of array's production

Warranties

- 25 year warranty on panels
- 10 year warranty on inverter

Insurance

- Ongoing insurance for the entire array
- Comprehensive coverage against loss

Fort Collins Community Solar | Timeline

- **May 2014:** Power Purchase Agreement signed
- **June 2014:** Program Launch Date
- **November 2014:** Additional Rebate Funding – Phase II of Array initiated
- **March 2015:** Groundbreaking Event
- **Currently:** Equipment on site, site surveying; Construction imminent
- **June 2015:** Expected Completion Date

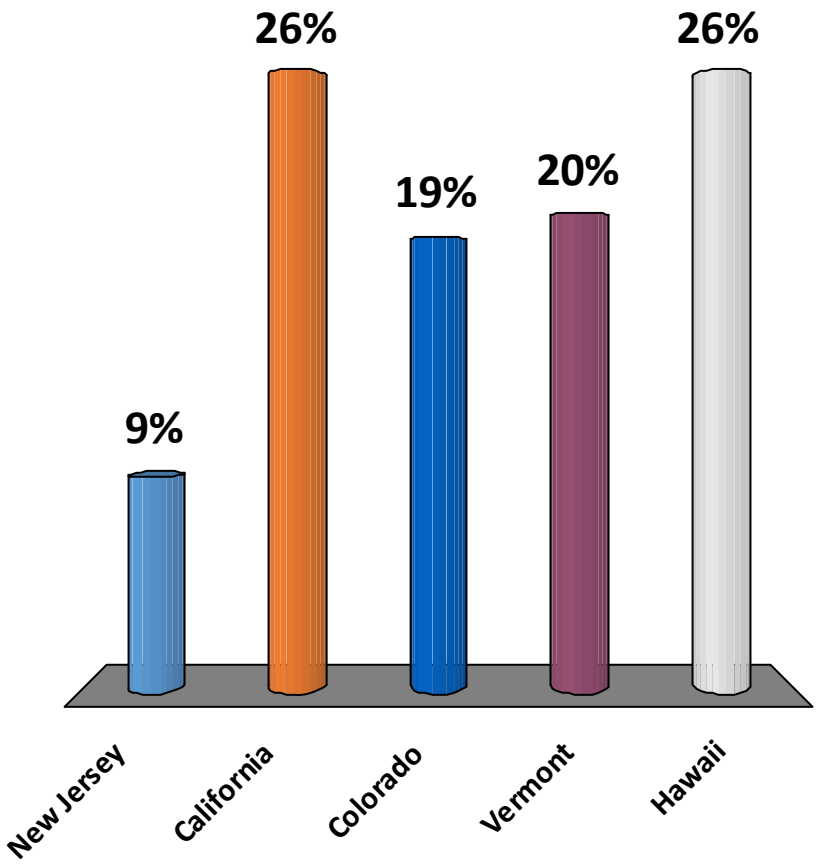
Riverside Community Solar Array

CEC | About Us

- **Clean Energy Collective (CEC)** was founded in 2009
- **Pioneered** the country's first large-scale community-owned solar arrays
- **40 producing solar systems online** or under development, >26 MW of power
- Currently serving customers of **18 utilities in 9 states**
- **Our vision** is to bring the opportunity to own solar to every grid-connected customer across the country

What state leads the US in solar on a per-capita basis?

A. New Jersey
B. California
C. Colorado
D. Vermont
E. Hawaii



Solar Leaders | US

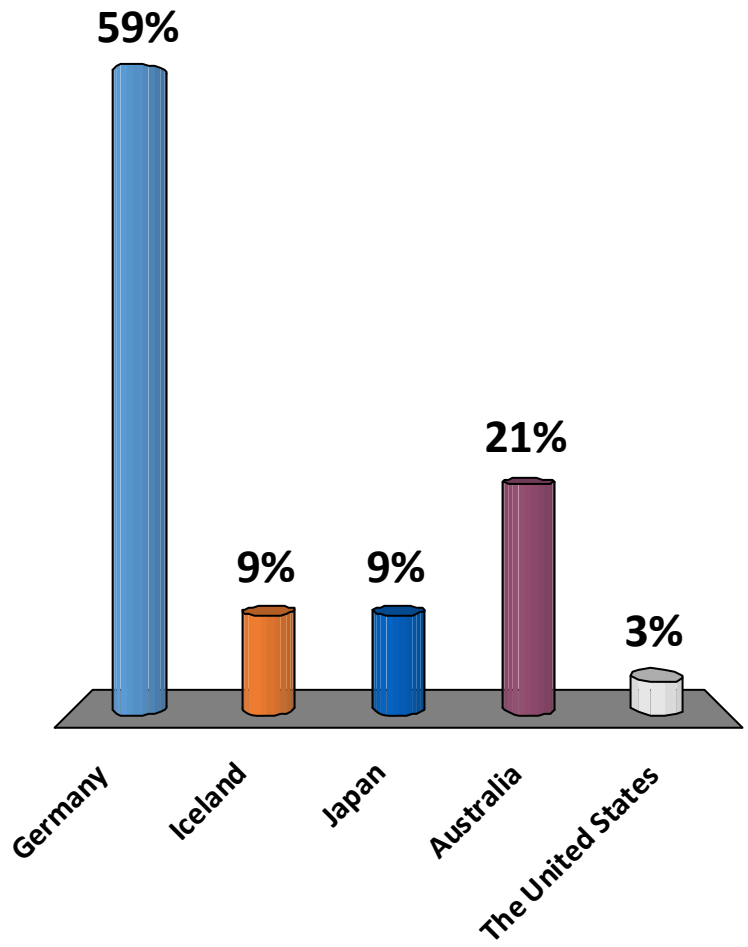
What state leads the US in solar on a per-capita basis?

a. New Jersey
b. California
c. Colorado
d. Vermont
e. Hawaii

…Colorado is number 10 on that list, placing us behind New Jersey, North Carolina, and Vermont.

What country leads the world in solar measured by total capacity?

A. Germany
B. Iceland
C. Japan
D. Australia
E. The United States



Solar Leaders | Globally

What country leads the world in solar measured by total capacity?

a. Germany
b. Iceland
c. Japan
d. Australia
e. The United States

…The US comes in at number 5, with about 1/3 of Germany's total capacity.

Thank you

Welcome to the renewable energy future!

Mike Dow
Product Manager
720-460-5114
mike.dow@easycleanenergy.com

Ft. Collins Revive Community: Zero Energy Homes

Paul Norton
Norton Energy R&D (NERD)
Go Solar, Ft. Collin Utility April 1, 2015

2005 NREL/Habitat for Humanity
Wheatridge, CO

1280 sq ft – R40 walls – solar water heating - 4 kW PV

2005 Solar Harvest House
Boulder, CO

4600 sq ft – R34 walls – active and passive solar heating – 8.7 kW PV

2008 Solar Row Townhomes
Boulder, CO

1250 to 1700 sq ft – R33 walls – 96 ft^2 solar thermal - 3 kW PV

A SUPPLEMENT TO PENTON MEDIA PUB

GREEN MECHA

zero net energy residential

energy upgrade CALIFORNIA

2020 Planning and Information for California ZNE Homes

REVIVE Fort Collins

(970) 420.0000

The future of quality living

Just minutes from Old Town Fort Collins

Renewable, Sustainable and Healthy

construction in California will be zero net energy by 2020, and all new commercial construction in California will be zero net energy by 2030.

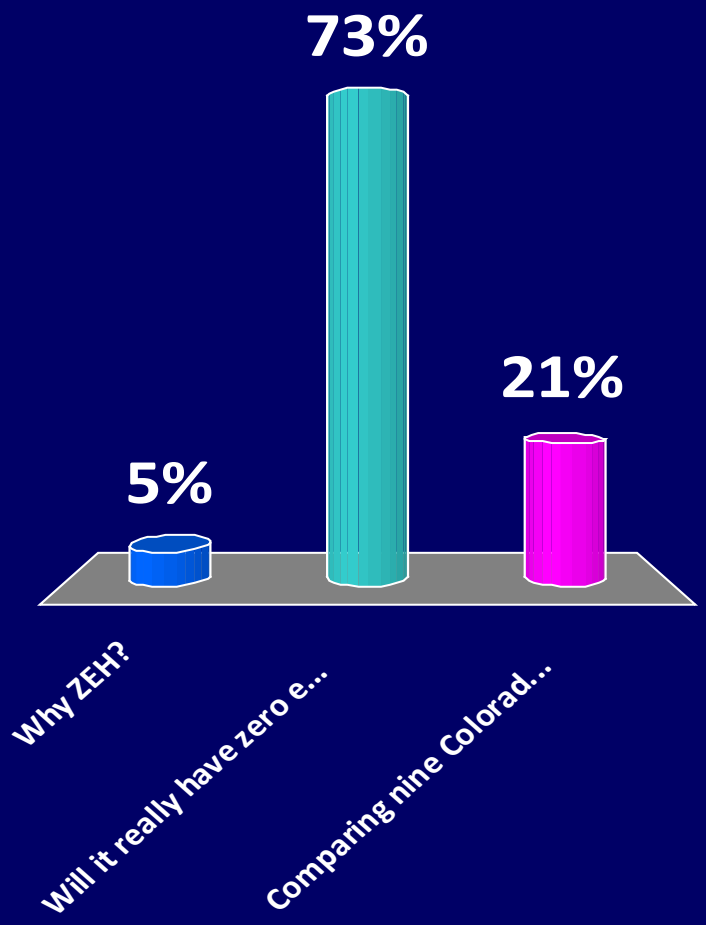
- 3 kW PV

At this point ....
What would you like to hear about the most?

A. Why ZEH?

B. Will it *really* have zero energy *performance?*.....how the home and occupants meet or miss ZE together.

C. Comparing nine Colorado ZEH projects.



- The Zero Energy Homes: What and How?

- The Fort Collins Revive ZEH Community

- Other possible topics:

  A Why make ZEH?

  B Will it *really* have zero energy *performance?*.....how the home and occupants meet or miss ZE together.

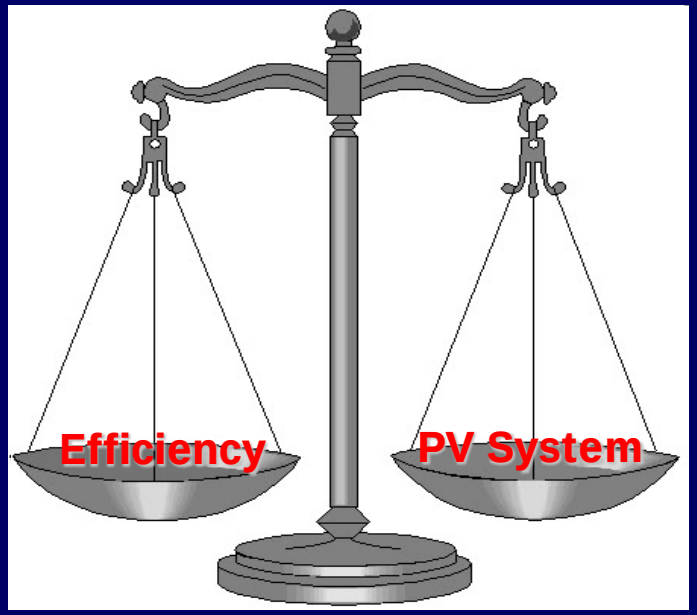
  C Comparing nine Colorado ZEH projects.

What?

What is a Zero Energy Home?


Zero Energy Homes
consume NO energy!

What is a Zero Energy Home?



Zero Energy Homes

produce

as much energy as they

consume

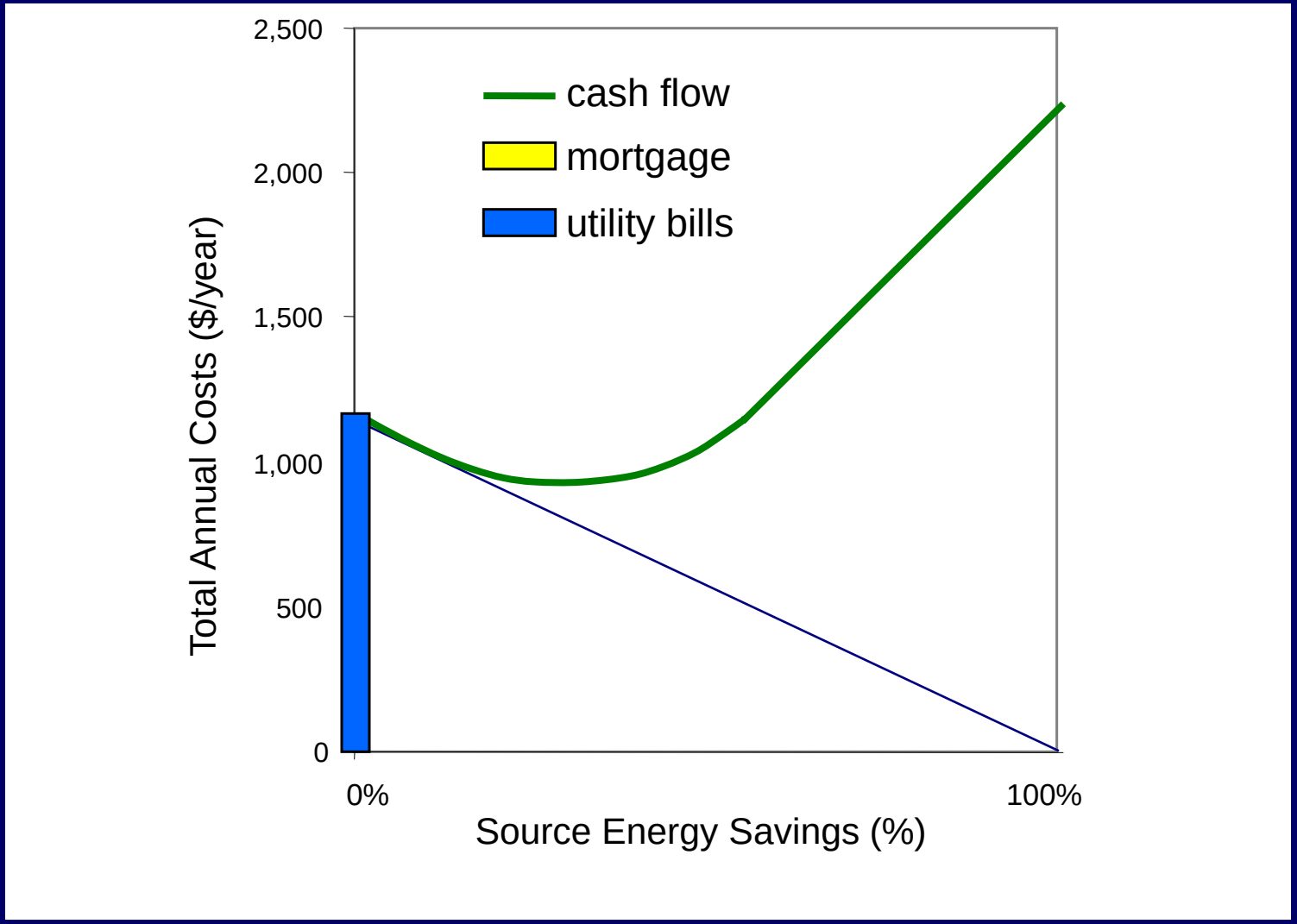
on an annual basis.

Zero NET Energy Home

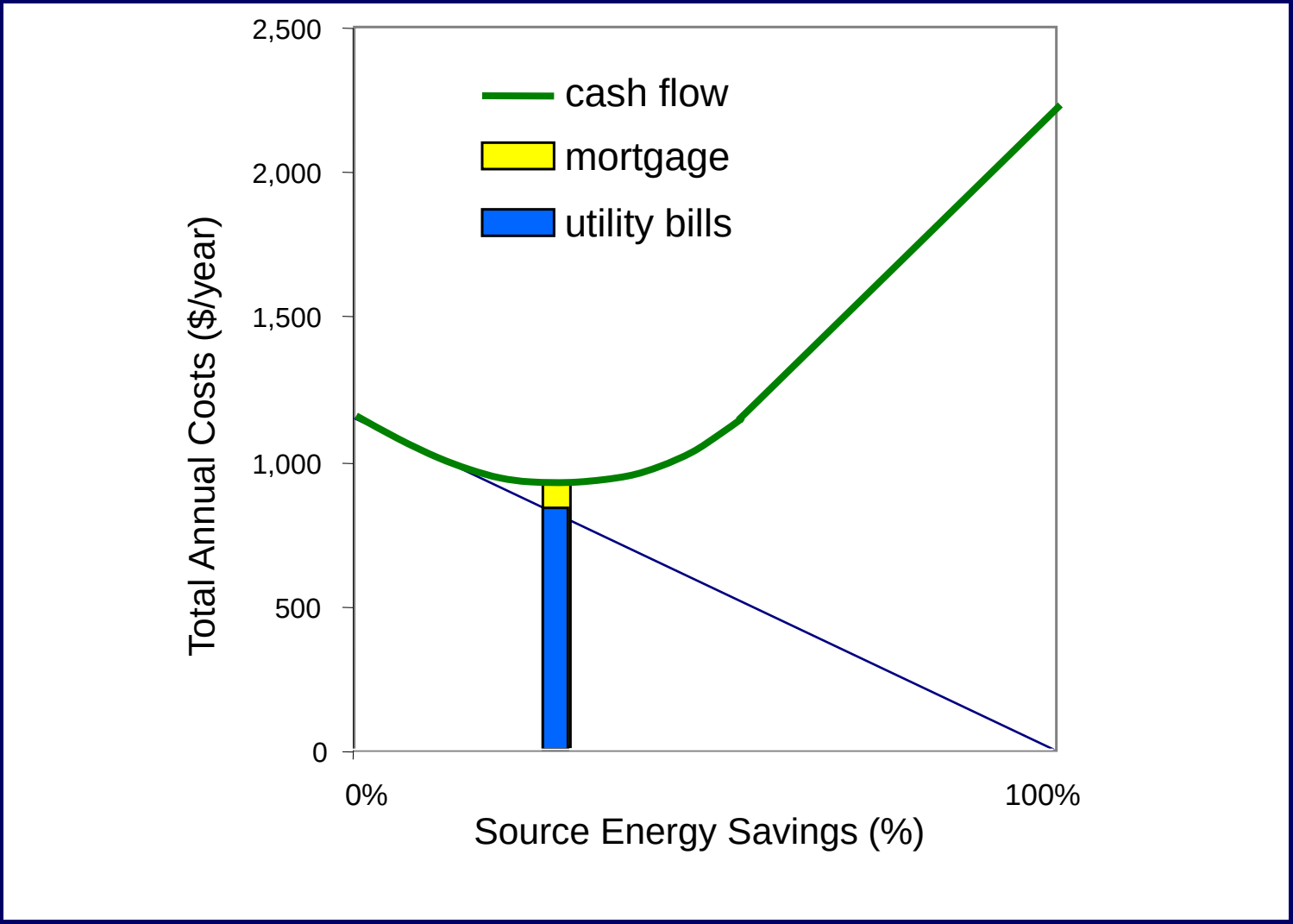
How?

How to make a Zero Energy Home

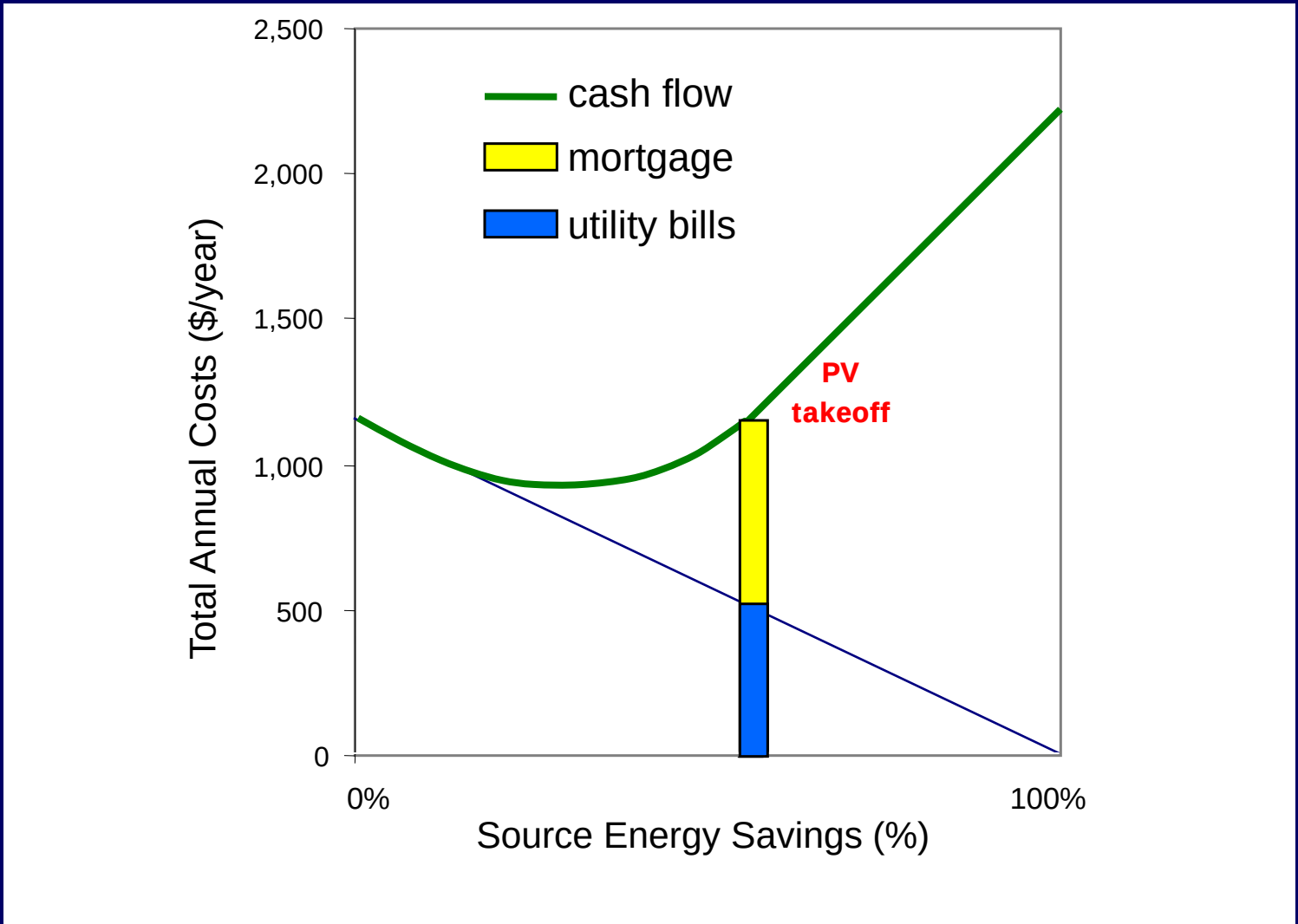
The cost effective path to Zero Energy



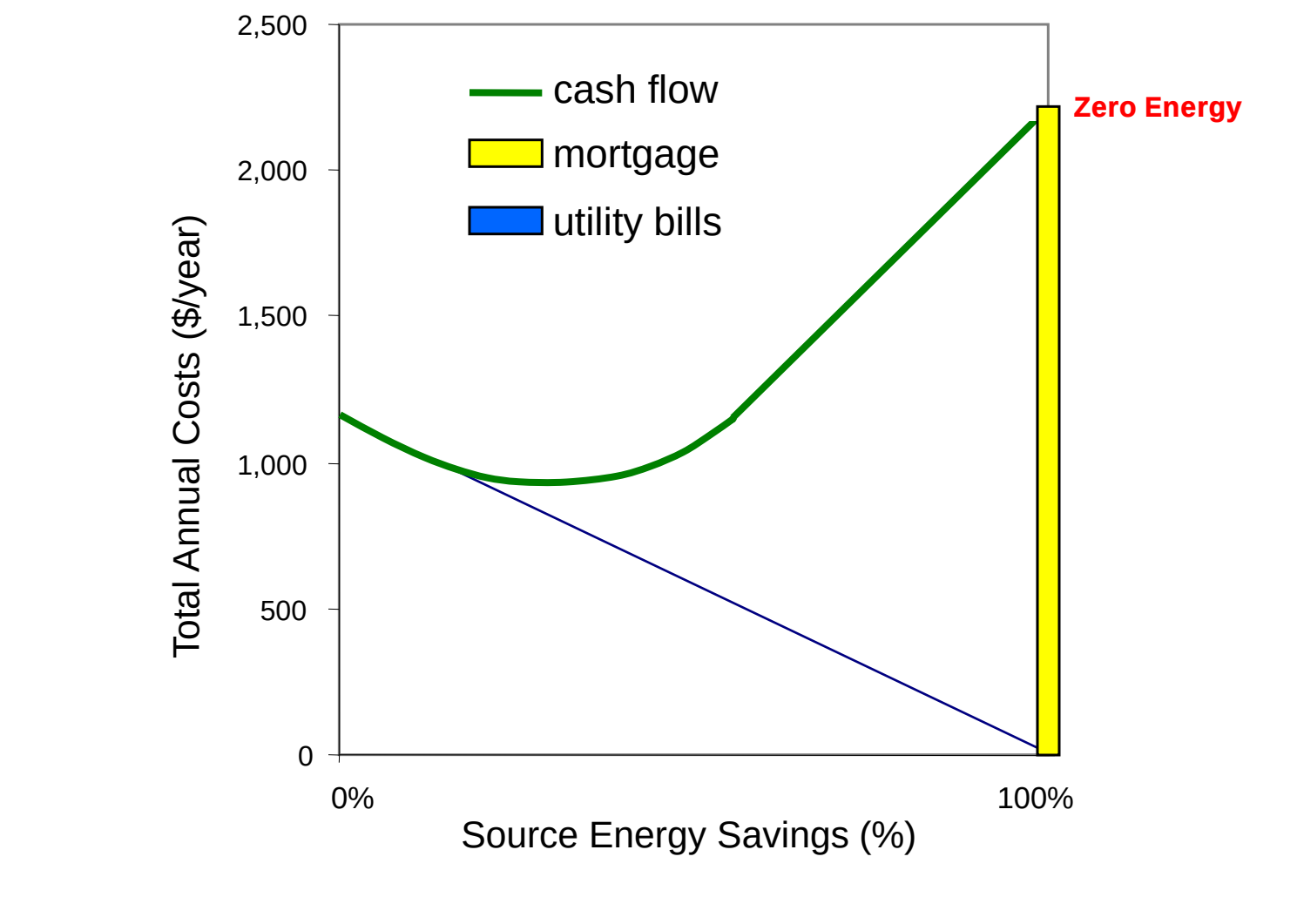
The cost effective path to Zero Energy



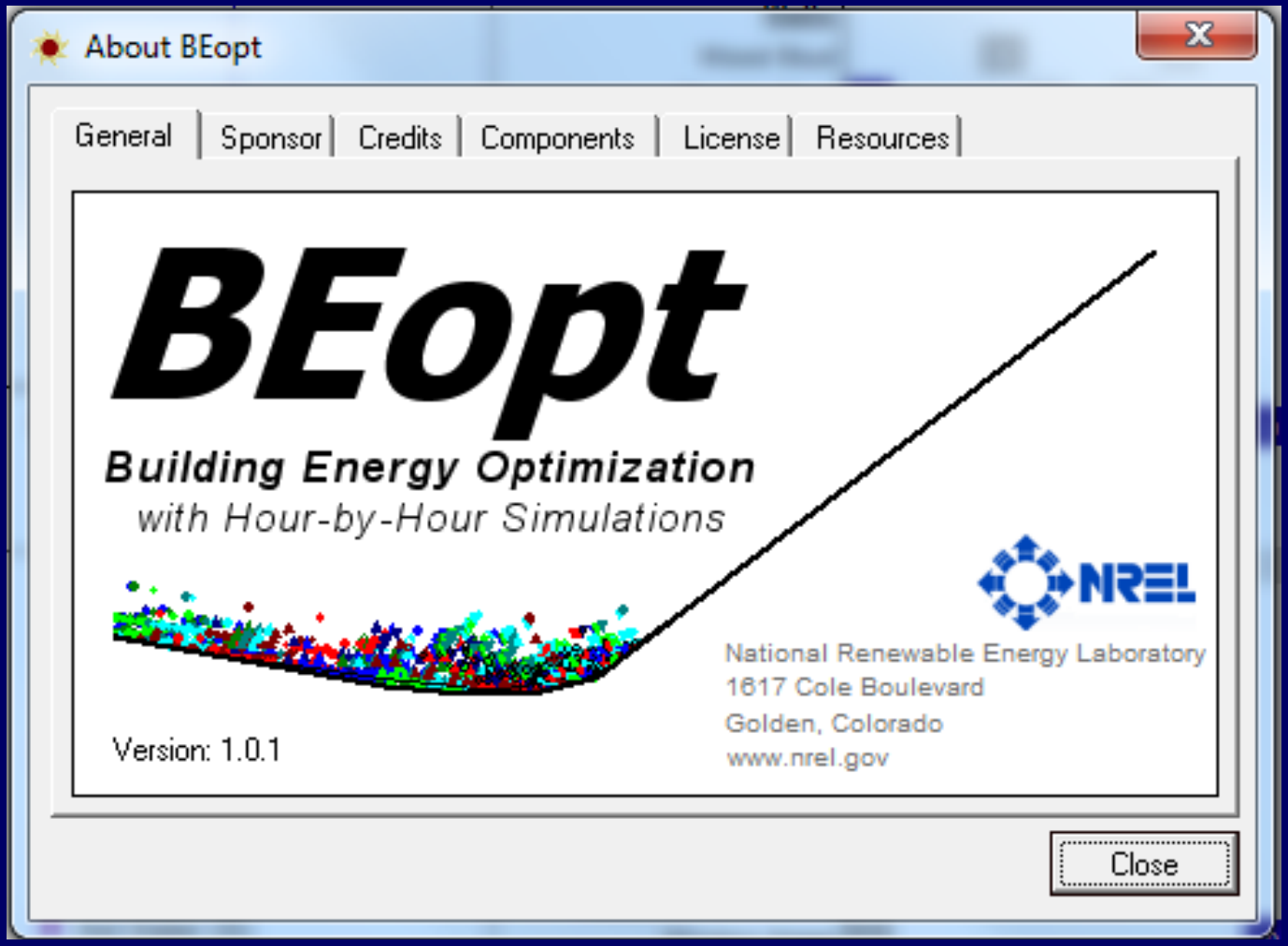
The cost effective path to Zero Energy



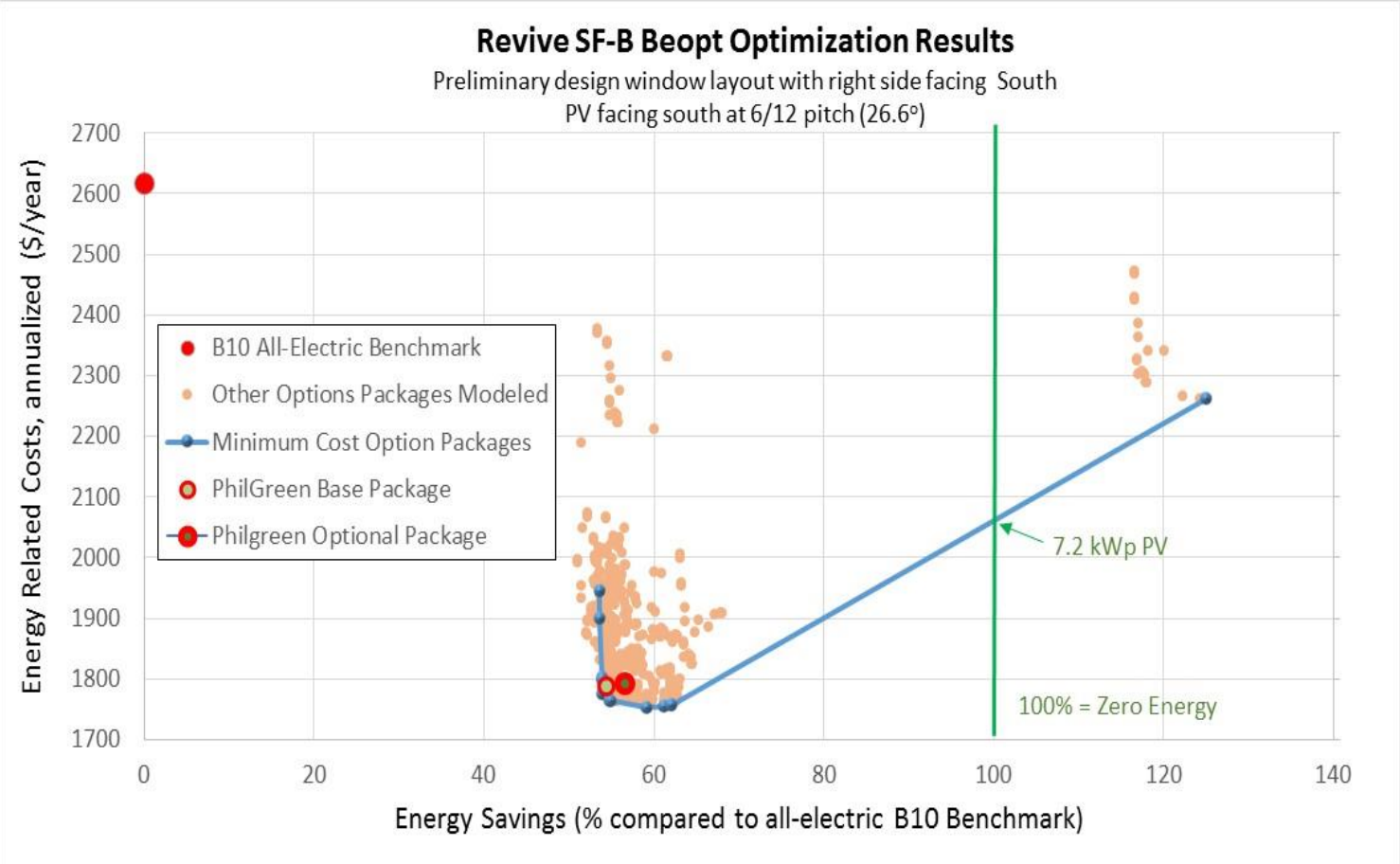
The cost effective path to Zero Energy



BEopt
Building Energy Optimization



Revive Initial BEopt Results



- PV is south facing at 6/12 pitch (27° tilt)
- Single-family (no second kitchen and appliance loads)
- National average construction costs (RSMeans)

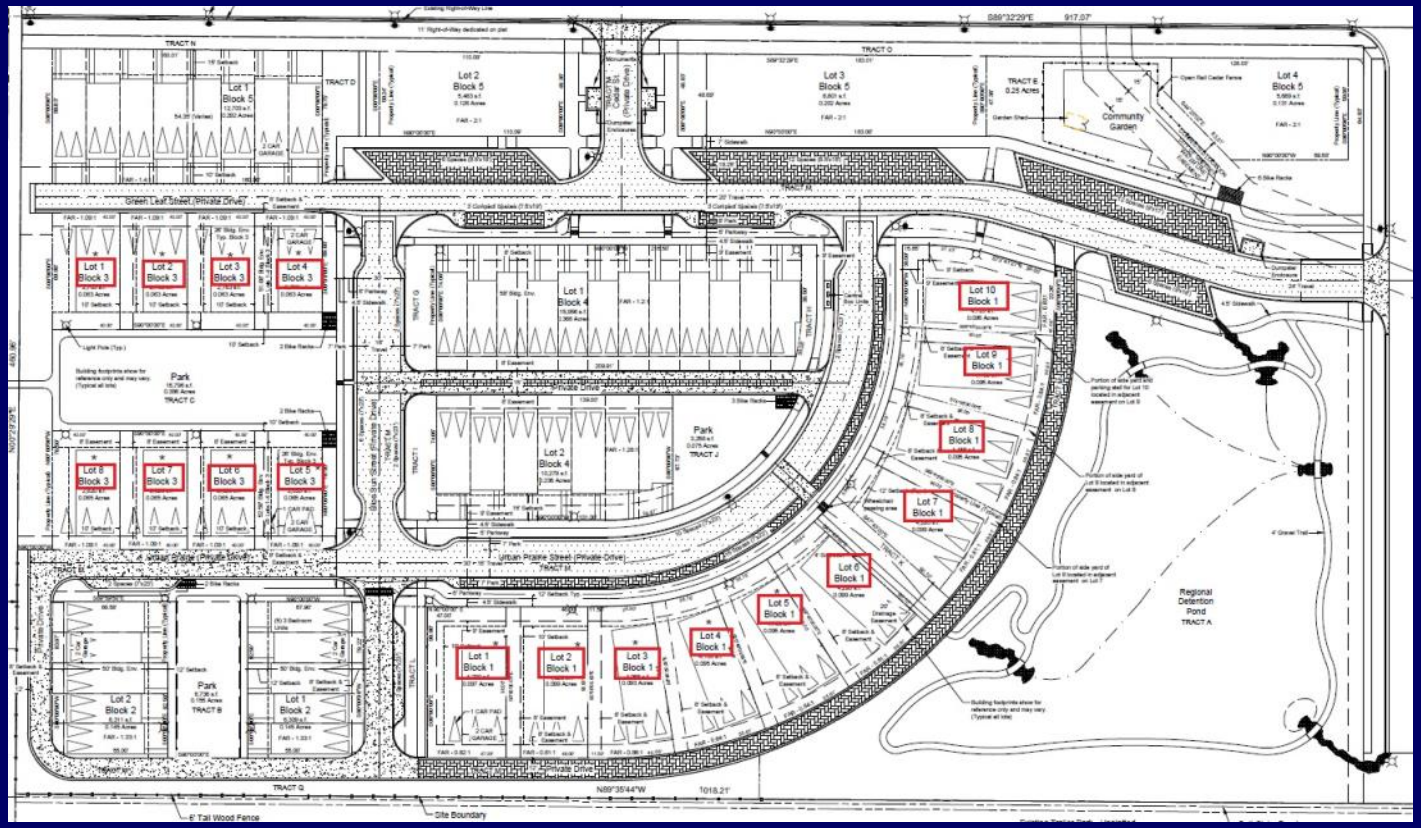
The Real World

- Local pricing and other cost tradeoffs
- Builders and trades experience, “Buildability”
- Specific equipment choices
- Actual air tightness achievable
- Lot orientations
- Architectural variations
    - Window areas and orientations
    - Window overhangs
    - Rooflines

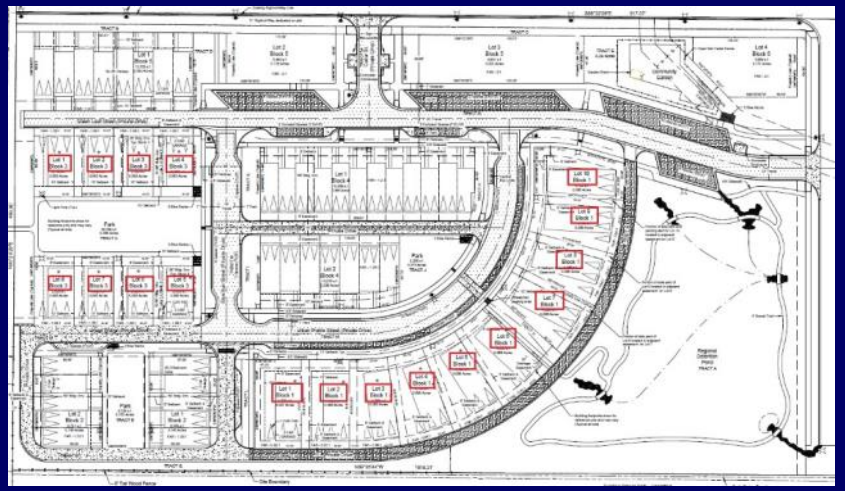
Group Name	Category Name	Beopt Optimum Package	Philgreen Base Package	Philgreen Options Package	High Efficiency Package
Walls	Wood Stud	Ft Collins Revive 2x6 24"OC Cellulose	same	same	same
	Wall Sheathing	OSB, R-10 XPS	Ft Collins Revive R6.6 1 in xps	Ft Collins Revive R6.6 1 in xps	OSB, R-15 XPS
	Interzonal Walls	R-21 Fiberglass Batt, Gr-1, 2x6, 24 in o.c.	same	R-21 Fiberglass Batt, 2x6, 24 in o.c. with R6.6 XPS sheathing	R-21 Fiberglass Batt, 2x6, 24 in o.c. with R6.6 XPS sheathing
Ceilings/Roofs	Finished Roof	R-38 Fiberglass, 2x10	R-47.5 SIPs	R-47.5 SIPs	R-47.5 SIPs
Foundation/Floors	Slab	Whole Slab R10, R10 Gap XPS	same	Whole Slab R20, R10 Gap XPS	Whole Slab R20, R10 Gap XPS
	Interzonal Floor	R-38 Cellulose	Ft Collins Revive flash and fill R44.5	Ft Collins Revive flash and fill R44.5	Ft Collins Revive flash and fill R44.5
Windows	Window Areas	Ft Collins Revive Preliminary designs (~17% of floor area)	same	same	12% of floor area
	Windows	Double-Pane, High-Gain Low-E, Insulated Frame, Argon Fill	Ft Collins Revive Double Low-E Argon 2	Triple glazed - U = .18 SHGC = .22	Triple glazed - U = .18 SHGC = .22
	Eaves	1 ft	same	same	same
	Overhangs	None	same	same	same
Airflow	Air Leakage	1 ACH50	same	same	same
	Mech Ventilation	Exhaust, 100% of ASHRAE 62.2	same	same	Exhaust, 50% of ASHRAE 62.2
Lighting	Lighting	100% Fluorescent, Hardwired & Plugin	100% LED	100% LED	100% LED
Space Conditioning	Ground Source Heat Pump	Ft Collins Revive - Bosh SM Geo 6000 TA35	same	same	same
	Ducts	In Finished Space	same	same	same
Water Heating					
	Water Heater	HPWH, 80 gal	Electric Premium	Electric Premium	HPWH, 80 gal
	Solar Water Heating	None	same	same	same
SF-A Results	units	**Beopt Optimum Package**	**Philgreen Base Package**	**Philgreen Options Package**	**High Efficiency Package**
Annual Site Energy Consumption	kWh/yr	**13,573**	**15,706**	**14,863**	**12,063**
Site EUI w/o PV	kWh/yr ft2	**5.7**	**6.6**	**6.2**	**5.0**
	kBtu/yr ft2	**19.3**	**22.4**	**21.2**	**17.2**
PV required for ZEH	DC rated peak kW	**9.0**	**10.5**	**9.9**	**8.0**
PV required for ZEH with apartment appliances	DC rated peak kW	**10.0**	**11.5**	**10.9**	**9.0**
Site EUI with PV	Btu/yr ft2	**0**	**0**	**0**	**0**
SF-B Results	units	**Beopt Optimum Package**	**Philgreen Base Package**	**Philgreen Options Package**	**High Efficiency Package**
Annual Site Energy Consumption	kWh/yr	**10,827**	**13,007**	**12,374**	**9,804**
Site EUI w/o PV	kWh/yr ft2	**5.5**	**6.6**	**6.3**	**5.0**
	kBtu/yr ft2	**18.8**	**22.6**	**21.5**	**17.0**
PV required for ZEH	DC rated peak kW	**7.2**	**8.7**	**8.2**	**6.5**
PV required for ZEH with apartment appliances	DC rated peak kW	**8.2**	**9.7**	**9.2**	**7.5**
Site EUI with PV	Btu/yr ft2	**0**	**0**	**0**	**0**

Final Options Package

Group Name	Category Name	As-Built
Walls	Wood Stud	2x6 24"OC, Open-cell spray foam, R20
	Wall Sheathing	1" Styrofoam SIS, R5.5
	Interzonal Walls (shared with garage)	2x6 24"OC, Open-cell spray foam, R20
Ceilings/Roofs	Finished Roof	Open-cell spray foam, R49
Foundation/Floors	Slab	Whole Slab R10, R10 perimeter
	Interzonal Floor (above garage)	11 7/8" TGI, open cell spray foam , R49
Windows	Window Areas	Ft Collins Revive Preliminary designs (~17% of floor area)
	Windows	Double-Pane, High-Gain Low-E, Insulated Frame, U = 0.29, SHGC = 0.23
	Eaves	1 ft
	Overhangs	None
Airflow	Air Leakage	1 ACH50
	Mech Ventilation	Heat Recovery Ventilation, flow rate = 100% of ASHRAE 62.2, sensible recovery efficiency = 70%
Lighting	Lighting	100% LED, Hardwired & Plugin
Space Conditioning	Ground Source Heat Pump	Bosh SM Geo 6000 TA35, COP = 4.1, EER = 18.4 Btu/Wh
	Ducts	In conditioned space
Water Heating	Water Heater	HPWH, 80 gal
	Solar Water Heating	None
Appliances	Main house refrigerator	Energy Star, 18 cu. ft, 480 kWh/yr
	Main house range	Electric, standard, 584 kWh/yr
	Main house dishwasher	Energy Star, 318 kWh/yr
	Main house clothes washer	Energy Star
	Main house clothes dryer	Electric, standard
	Carriage house refrigerator	Energy Star, 18 cu. ft, 480 kWh/yr
	Carriage house range	Electric, standard, 584 kWh/yr
	Carriage house dishwasher	Energy Star, 318 kWh/yr
	Carriage house clothes washer	Energy Star
	Carriage house clothes dryer	Electric, standard
Other Loads	Miscellaneous Electric Loads	BA Benchmark, SF-A 2606 kWh/yr
	(as specified by the Building America	BA Benchmark, SF-B 2225 kWh/yr
	Home Simulation Protocol)	BA Benchmark, SF-C 2477 kWh/yr



Orientation of the right side of the home	Azimuth angle (degrees, south = 0)	Number of lots	SFA Consumption (kWh/yr)	SFB Consumption (kWh/yr)	SFC Consumption (kWh/yr)
South	0	2	14,997	12,605	14,396
East	270	4	15,155	12,717	14,461
West	90	6	15,152	12,720	14,314
Revive lot 8	16	1	15,017	12,646	14,393
Revive lot 7	27	1	15,044	12,685	14,443
Revive lot 6	40	1	15,091	12,564	14,443
Revive lot 5	55	1	15,120	12,629	14,408
Revive lot 4	60	1	15,123	12,649	14,358
Revive lot 3	80	1	15,141	12,702	14,296
Weighted average			**15,956**	**13,389**	**15,176**



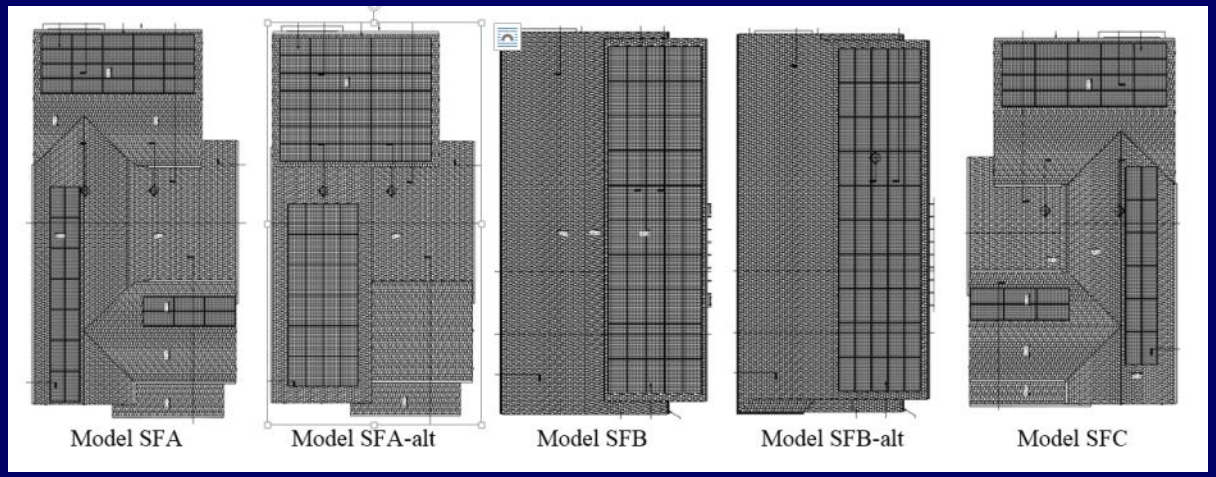

Model SFA
Model SFA-alt
Model SFB
Model SFB-alt
Model SFC

Table 5 – SFA PV output for each array and the whole house by orientation

			Model SFA																	
			Array 1					Array 2					Array 3					TOTALS		
Orientation of the right side of the home	Azimuth angle (degrees, south = 0)	Number of lots	Number of Panels	Size (rated kW)	Pitch	Orientation (degrees)	Output (kWh/yr)	Number of Panels	Size (rated kW)	Pitch	Orientation (degrees)	Output (kWh/yr)	Number of Panels	Size (rated kW)	Pitch	Orientation (degrees)	Output (kWh/yr)	Size (rated kW)	Output (kWh/yr)	kWh/year per rated kW
South	0	2	6	1.5	9:12	270	1653	14	3.5	9:12	180	2194.5	20	5.0	9:12	270	5510	10.0	9358	936
East	270	4	6	1.5	9:12	180	940.5	14	3.5	9:12	90	3580.5	20	5.0	9:12	180	3135	10.0	7656	766
West	90	6	6	1.5	9:12	0	2124	14	3.5	9:12	270	3857	20	5.0	9:12	0	7080	10.0	13061	1306
Revive lot 8	16	1	6	1.5	9:12	286	1803	14	3.5	9:12	196	2299.5	20	5.0	9:12	286	6010	10.0	10113	1011
Revive lot 7	27	1	6	1.5	9:12	297	1894.5	14	3.5	9:12	207	2432.5	20	5.0	9:12	297	6315	10.0	10642	1064
Revive lot 6	40	1	6	1.5	9:12	310	1992	14	3.5	9:12	220	2667	20	5.0	9:12	310	6640	10.0	11299	1130
Revive lot 5	55	1	6	1.5	9:12	325	2074.5	14	3.5	9:12	235	3006.5	20	5.0	9:12	325	6915	10.0	11996	1200
Revive lot 4	60	1	6	1.5	9:12	330	2097	14	3.5	9:12	240	3129	20	5.0	9:12	330	6990	10.0	12216	1222
Revive lot 3	80	1	6	1.5	9:12	350	2145	14	3.5	9:12	260	3622.5	20	5.0	9:12	350	7150	10.0	12918	1292
Weighted Averages							1117					902							10418	1042

Table 6 – SFA-alt PV output for each array and the whole house by orientation

			Model SFA-alt												
			Array 1					Array 2					TOTALS		
Orientation of the right side of the home	Azimuth angle (degrees, south = 0)	Number of lots	Number of Panels	Size (rated kW)	Pitch	Orientation (degrees)	Output (kWh/yr)	Number of Panels	Size (rated kW)	Pitch	Orientation (degrees)	Output (kWh/yr)	Size (rated kW)	Output (kWh/yr)	kWh/year per rated kW	Percent Difference With SFA
South	0	2	24	6.0	3:12	180	5820	35	8.8	3:12	270	10281	14.8	16101	1092	16.7%
East	270	4	24	6.0	3:12	90	6804	35	8.8	3:12	180	8488	14.8	15292	1037	35.4%
West	90	6	24	6.0	3:12	270	7050	35	8.8	3:12	0	11541	14.8	18591	1260	-3.5%
Revive lot 8	16	1	24	6.0	3:12	196	5910	35	8.8	3:12	286	10666	14.8	16576	1124	11.1%
Revive lot 7	27	1	24	6.0	3:12	207	5994	35	8.8	3:12	297	10929	14.8	16923	1147	7.8%
Revive lot 6	40	1	24	6.0	3:12	220	6174	35	8.8	3:12	310	11209	14.8	17383	1178	4.3%
Revive lot 5	55	1	24	6.0	3:12	235	6402	35	8.8	3:12	325	11436	14.8	17838	1209	0.8%
Revive lot 4	60	1	24	6.0	3:12	240	6486	35	8.8	3:12	330	11489	14.8	17975	1219	-0.2%
Revive lot 3	80	1	24	6.0	3:12	260	6858	35	8.8	3:12	350	11594	14.8	18452	1251	-3.2%
Weighted Averages							1048					1148		16331	1107	6.3%

Table 7 – SFB and SFB-alt PV output for each array and the whole house by orientation

			Model SFB						Model SFB-alt						
			Only one array						Only one array						
Orientation of the right side of the home	Azimuth angle (degrees, south = 0)	Number of lots	Number of Panels	Size (rated kW)	Pitch	Orientation (degrees)	Output (kWh/yr)	kWh/year per rated kW	Number of Panels	Size (rated kW)	Pitch	Orientation (degrees)	Output (kWh/yr)	kWh/year per rated kW	Percent difference with SFB
South	0	2	50	12.5	6:12	0	17437.5	1395	50	12.5	9:12	0	17700	1416	1.5%
East	270	4	50	12.5	6:12	270	14287.5	1143	50	12.5	9:12	270	13775	1102	-3.6%
West	90	6	50	12.5	6:12	90	13450	1076	50	12.5	9:12	90	12788	1023	-4.9%
Revive lot 8	16	1	50	12.5	6:12	16	17287.5	1383	50	12.5	9:12	16	17513	1401	1.3%
Revive lot 7	27	1	50	12.5	6:12	27	17037.5	1363	50	12.5	9:12	27	17188	1375	0.9%
Revive lot 6	40	1	50	12.5	6:12	40	16525	1322	50	12.5	9:12	40	16563	1325	0.2%
Revive lot 5	55	1	50	12.5	6:12	55	15750	1260	50	12.5	9:12	55	15613	1249	-0.9%
Revive lot 4	60	1	50	12.5	6:12	60	15500	1240	50	12.5	9:12	60	15275	1222	-1.5%
Revive lot 3	80	1	50	12.5	6:12	80	14175	1134	50	12.5	9:12	80	13663	1093	-3.6%
Weighted Averages							13976	1118					13630	1090	-2.5%

Table 8 – SFC PV output for each array and the whole house by orientation

- Two homes per building (i.e. second set of appliance and kitchen loads)
- Efficiency package somewhat different than BEopt optimum package
- Variation in consumption with lot orientation
- Multiple roof planes
- Non-optimal PV orientations

Average PV size needed for ZEH performance

12 to 14 kW/building

(6 to 7 kW/home)

REVIVE Fort Collins

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The future of quality living

Just minutes from Old Town Fort Collins

Renewable, Sustainable and Healthy

Time remaining?

A Why make ZEH?

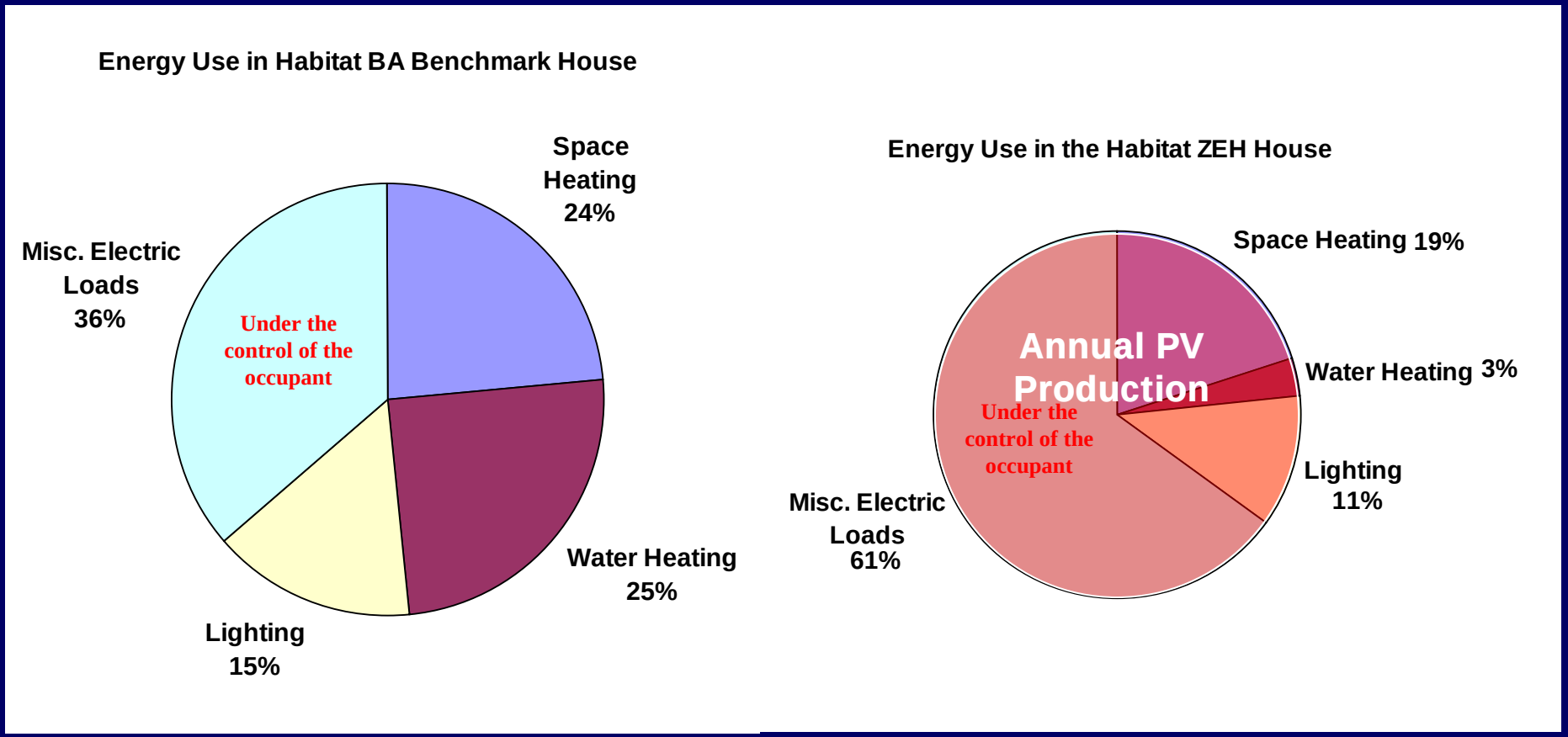
B Will it *really* have zero energy *performance?*.....how the home and occupants meet or miss ZE together.

C Comparing nine Colorado ZEH projects.

Paul Norton
Norton Energy R&D
paul@paulnorton.net
303-579-3377

WILL IT *REALLY* HAVE ZERO ENERGY *PERFORMANCE?*.....

HOW THE HOME AND OCCUPANTS MEET OR MISS ZE TOGETHER.


Energy Use in Habitat BA Benchmark House
Space Heating 24%
Misc. Electric Loads 36%
Under the control of the occupant
Water Heating 25%
Lighting 15%
Energy Use in the Habitat ZEH House
Space Heating 19%
Water Heating 3%
Annual PV Production
Under the control of the occupant
Lighting 11%
Misc. Electric Loads 61%

Will it *really* be ZERO??

It could be!

In any given year, it depends on….

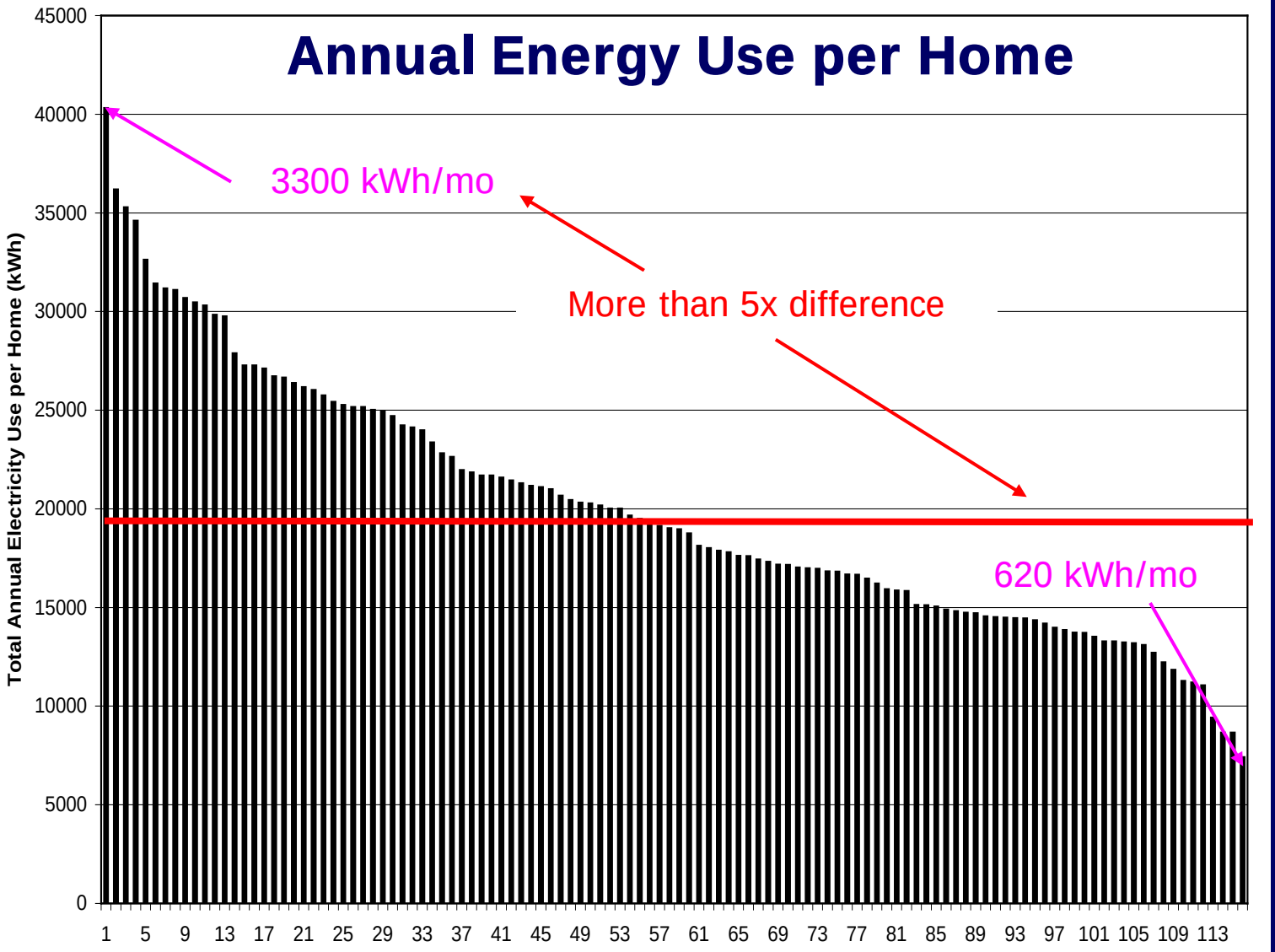
- **Plug loads**

  (TVs, DVDs, Microwave, computers, stereo, toaster, electric blanket, hair dryer, …. the list goes on!)

- **Specific weather conditions**
- **Temperature set points**
- **Hot water use**

The house AND the occupants
meet or miss the zero energy target *TOGETHER*

Energy use depends on us!



Las Vegas Homes with identical energy efficiency features

Example: Premier Gardens, CA

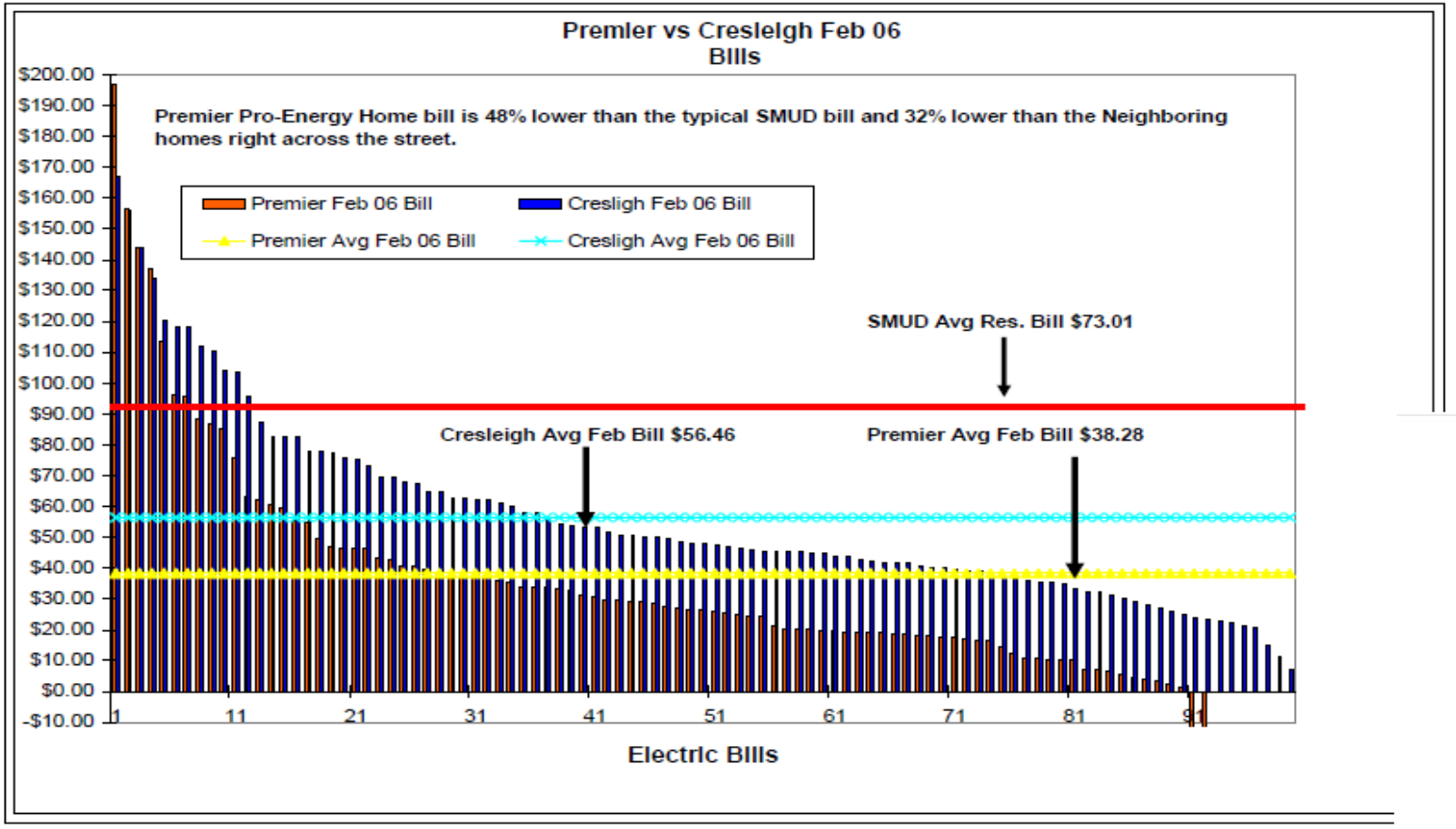
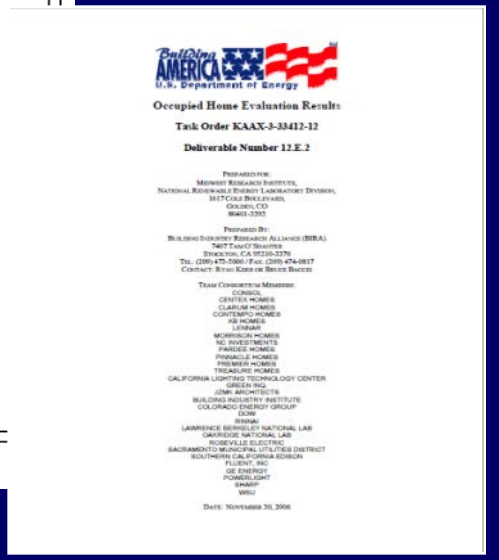


Figure 10: Premier vs. Cresleigh Feb 06 Bills (courtesy of SMUD)



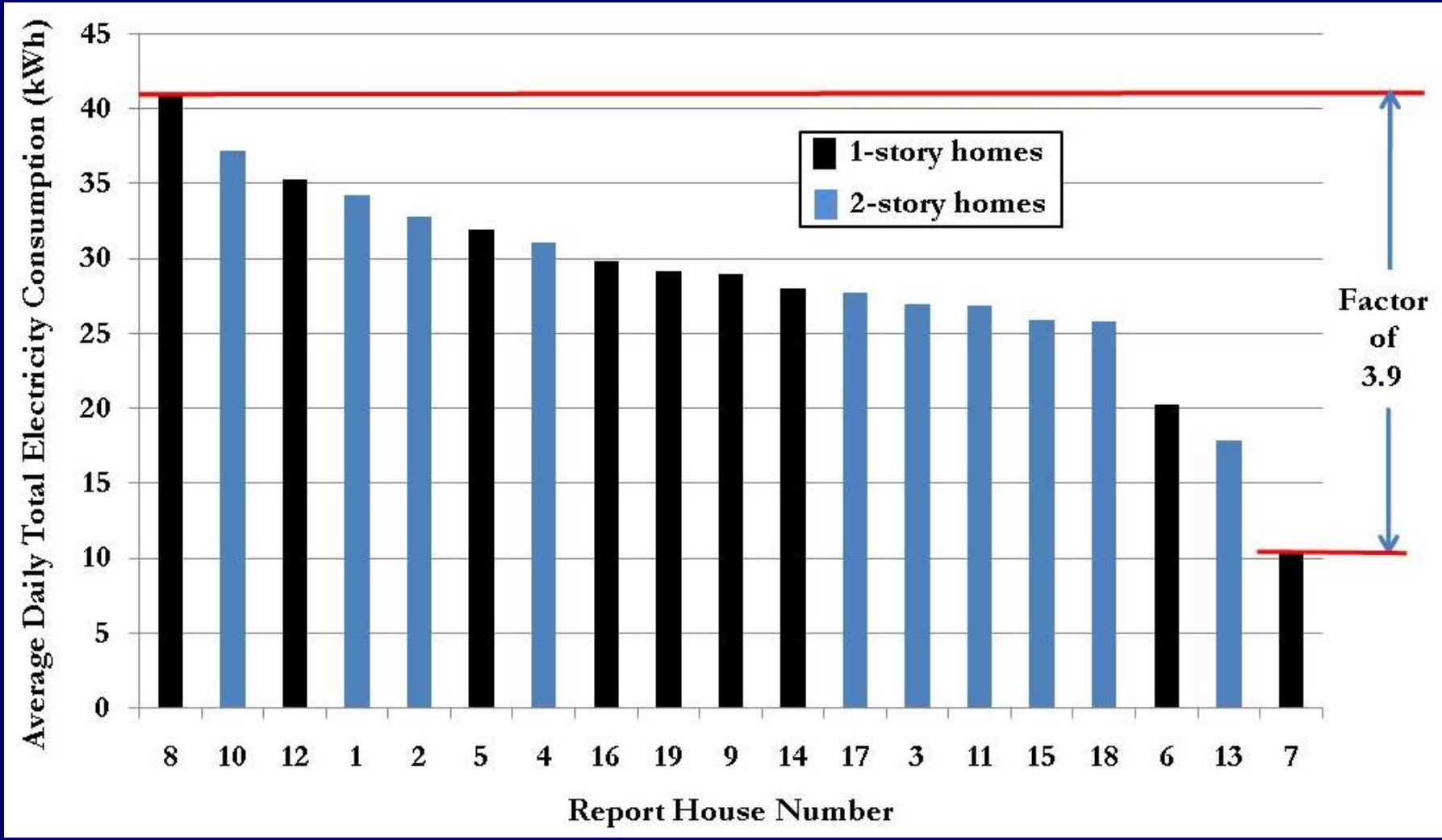
Building America
U.S. Department of Energy

Occupied Home Evaluation Results

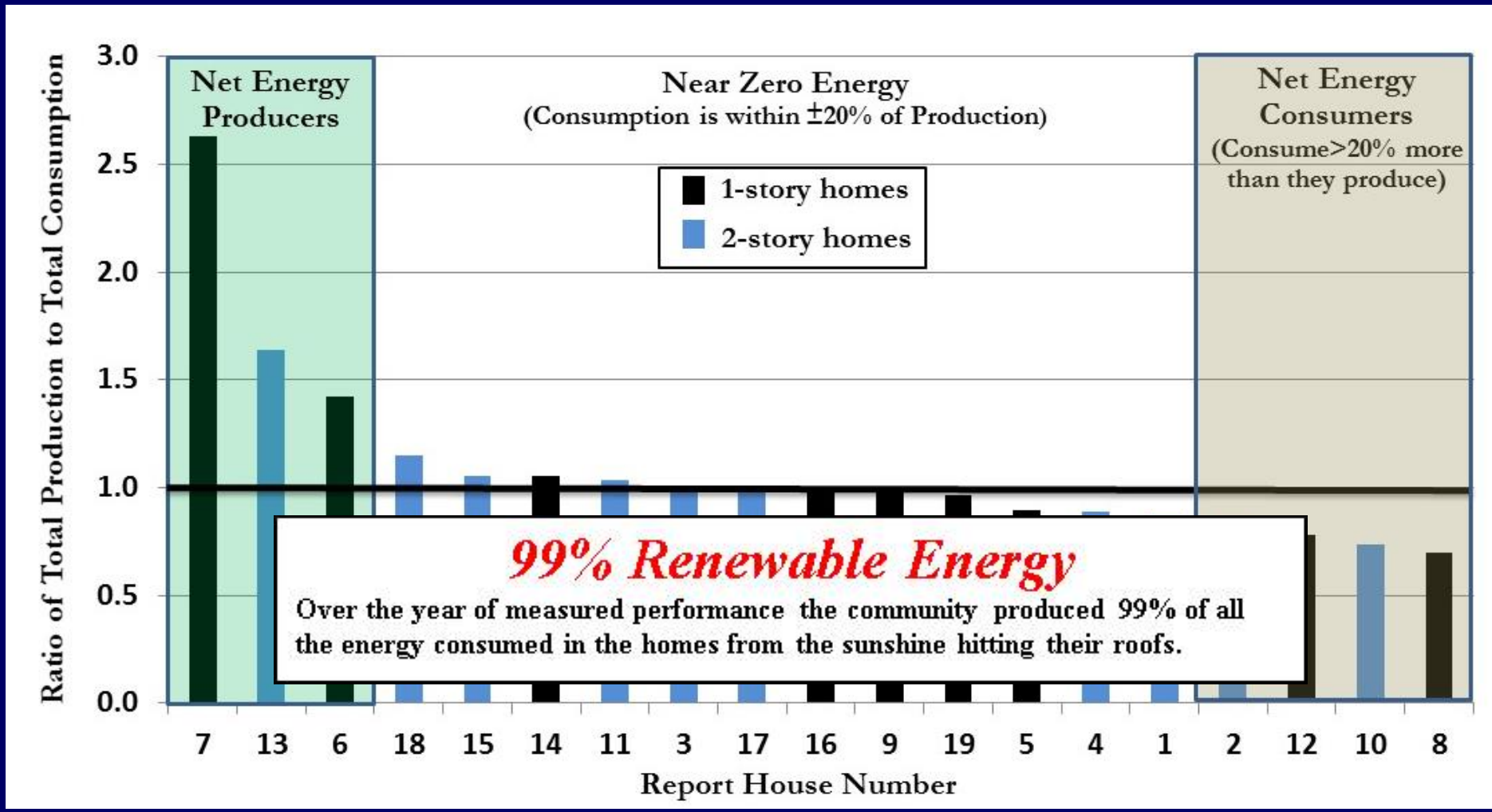
Task Order KAAX-3-33412-12

Deliverable Number 12.E.2

There are large home-to-home variations in energy use



There are large home-to-home variations in energy use



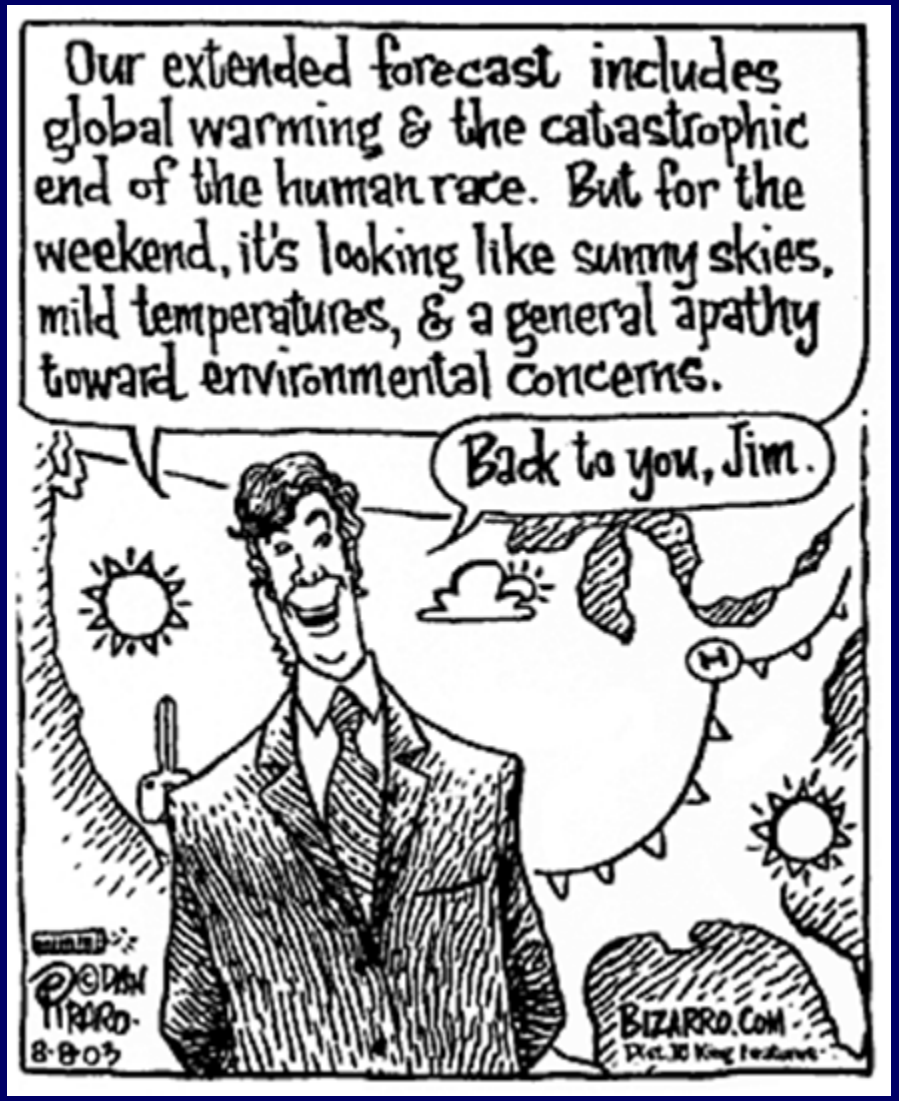
Why?

Why make Zero Energy Homes?

Why Zero Energy Homes?

20%

of all carbon dioxide emissions
in the U.S. are due to our home energy use.



Why Zero Energy Homes?

Homes account for

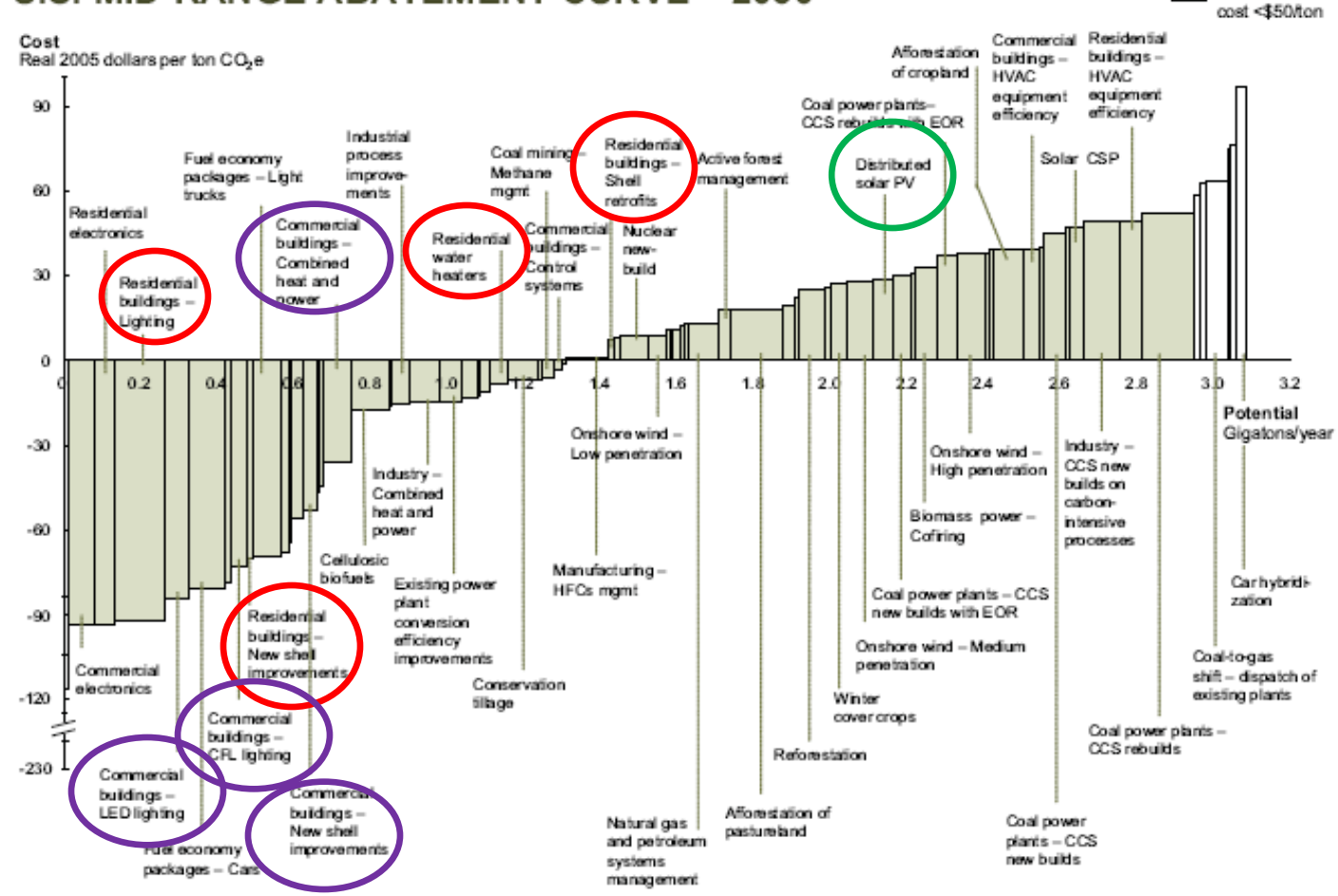
37%

of **all** U.S. electricity use

McKinsey&Company THE CONFERENCE BOARD

Exhibit B

U.S. MID-RANGE ABATEMENT CURVE – 2030



Source: McKinsey analysis

Zero Energy Homes: Boulder/Denver case studies

Outline

- Present nine case studies of cold climate *completed* ZEH in this area (mostly in Boulder)
- Compare attributes of these homes
- Discuss some issues with ZEH

Boulder/Denver area ZEH or near ZEH

1. The Solar Harvest House	2005	New, single-family
2. NREL/Habitat For Humanity	2005	
3. The Next West House	2008	
4. The NZE House	2008	
5. The Balsam Project	2010	
6. Solar Row	2007	New, multi-family
7. BCHA Paradigm	2009	
8. Scrub Oak	2007	Retrofit, single-family
9. Boulder ZED 2	2008	

1. The Solar Harvest House

1. The Solar Harvest House

7.9/6.0/5.3 (45/34/30)

8.7 kW

Boulder, CO
Built in 2005
Builder: Ecofutures
HDD: 3035 (18C base)
5500 (65F base)

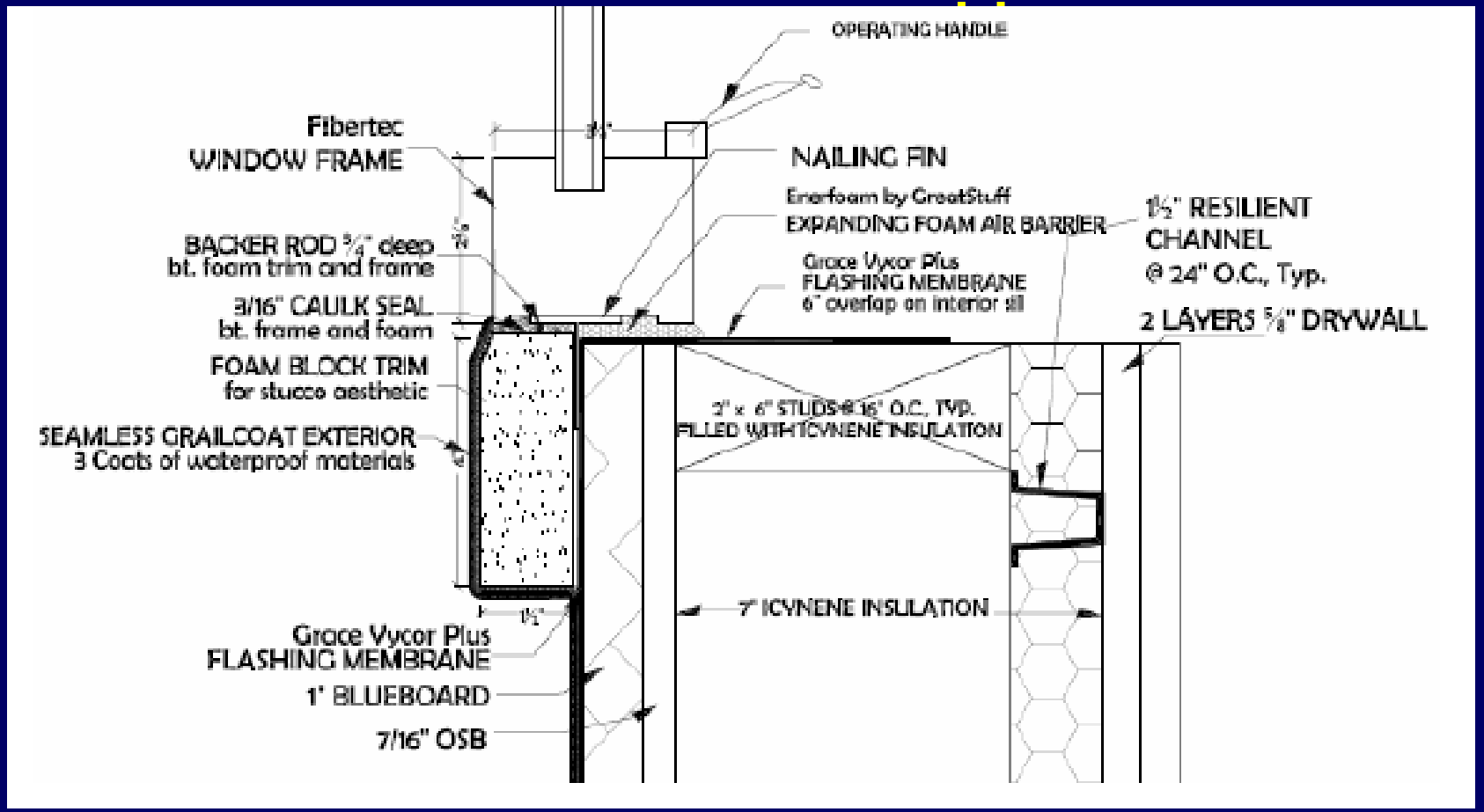
English units for R-value are hr ft^2 ^{o}F/Btu

Size:	426 m^2 (4585 ft^2)
Attic Insulation:	7.9 K m^2/W (R-45)
Wall Insulation:	6.0 K m^2/W (R-34)
Basement wall Insulation:	5.3 K m^2/W (R-30)
Window U-value:	N: 0.68 W/K m^2 (0.12 Btu/hr ft^2 ^{o}F)
	W&E: 1.14 (0.20)
Air leakage:	0.09 ACHn

Heating System: Sunspace, Active solar, elect. backup
Cooling System: Indirect evaporative system (Coolerado), whole house fan, earth tube for ventilation air
Ventilation System: Energy Recovery Ventilator (ERV)

PV System:	8.7 kW

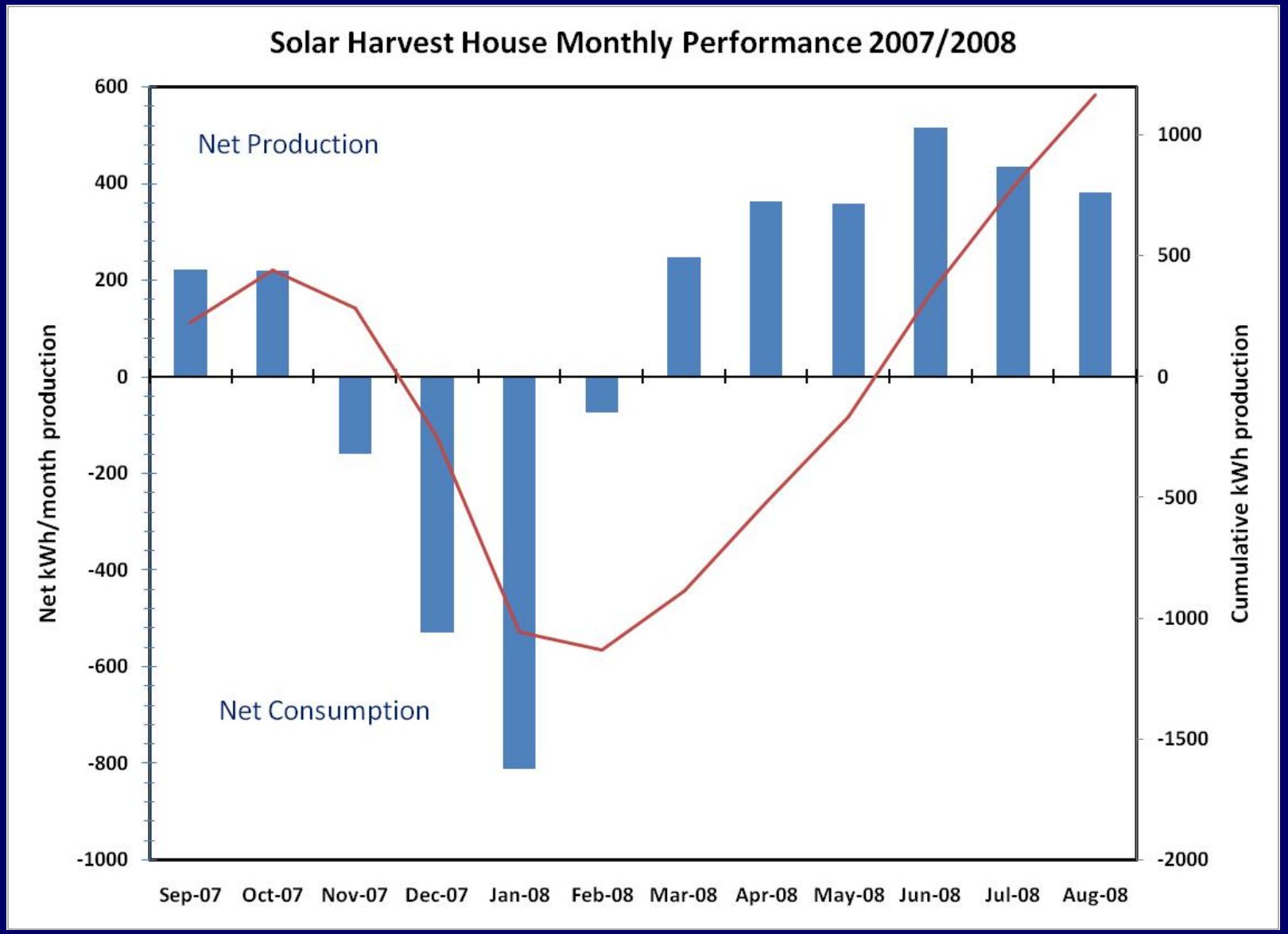
1. The Solar Harvest



Wall Insulation: 6.0 K m^2/W (R-34)

1. The Solar Harvest House

1. The Solar Harvest



2. The NREL/Habitat ZEH

2. The NREL/Habitat ZEH

10.6/7.0/5.3 (60/40/30)

4.0 kW

Wheat Ridge, CO
Built in 2005
Builder: Habitat for Humanity of Metro Denver
HDD: 3300 (18C base)
6000 (65F base)

English units for R-value are hr ft^2 ^{o}F/Btu

Size:	119 m^2 (1284 ft^2)
Attic Insulation:	10.6 K m^2/W (R-60)
Wall Insulation:	7.0 K m^2/W (R-40)
Basement wall Insulation:	5.3 K m^2/W (R-30)
Window U-value:	S: 1.70 W/K m^2 (0.30 Btu/hr ft^2 ^{o}F)
	N,W,&E: 1.31 (0.23)
Air leakage:	0.15 ACHn

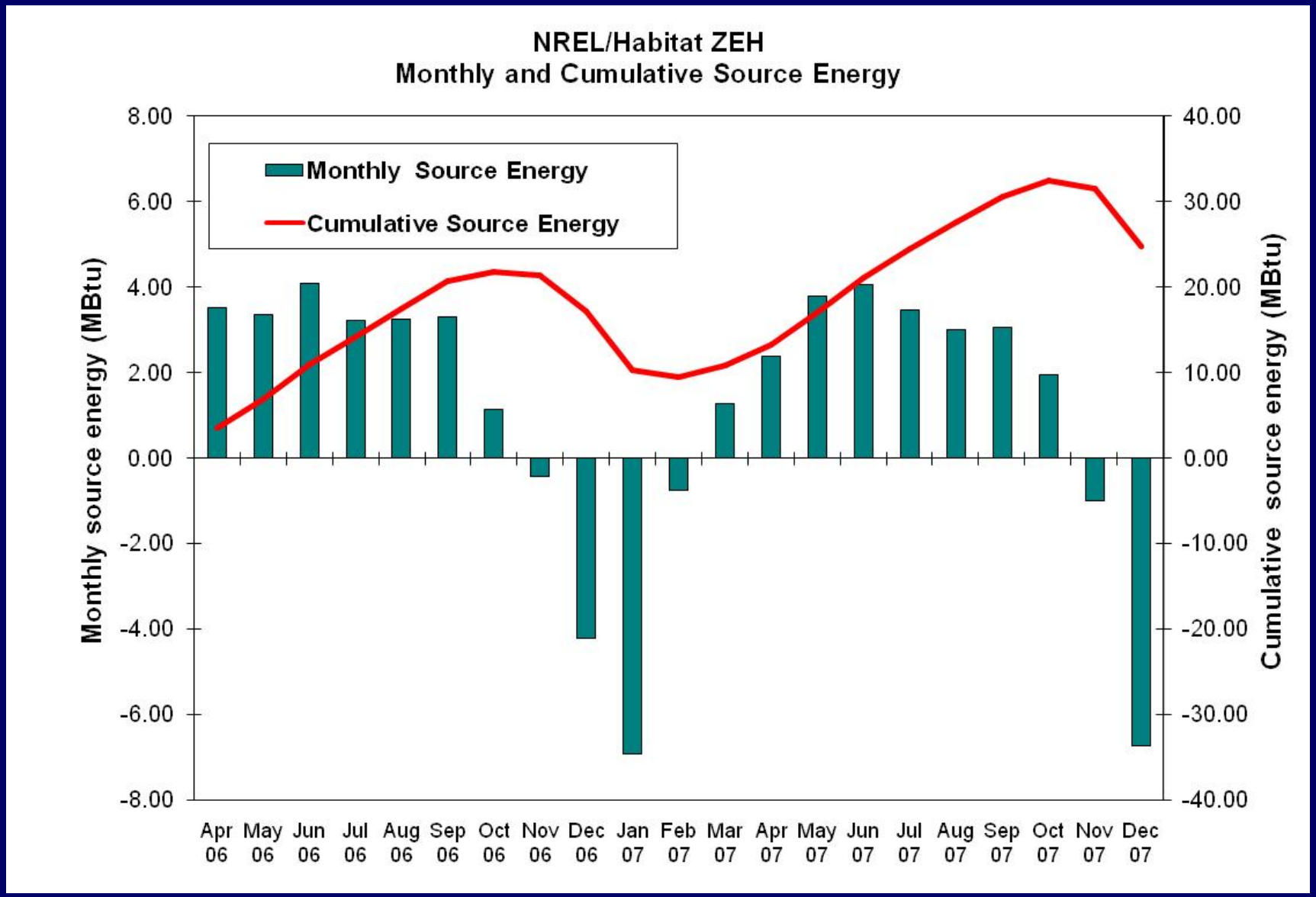
Heating System: Sun tempered, gas single-point heater, electric baseboards
Cooling System: None
Ventilation System: Energy Recovery Ventilator (ERV)

PV System:	4.0 kW

2. The NREL/Habitat ZEH

2. The NREL/Habitat

H


NREL/Habitat ZEH
Monthly and Cumulative Source Energy
Monthly Source Energy
Cumulative Source Energy
Monthly source energy (MBtu)
Cumulative source energy (MBtu)
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
-40.00
Apr 06
May 06
Jun 06
Jul 06
Aug 06
Sep 06
Oct 06
Nov 06
Dec 06
Jan 07
Feb 07
Mar 07
Apr 07
May 07
Jun 07
Jul 07
Aug 07
Sep 07
Oct 07
Nov 07
Dec 07

3. The Next West House

3. The Next West House

13.2/8.8/?
(75/50/?)

9.7 kW

Boulder, CO
Built in 2008
Owner: Bruce Oreck
Arch: Jim Logan
Builder: Hughes Const.
HDD: 3035 (18C base)
5500 (65F base)

English units for
R-value are
hr ft^2 ^oF/Btu

Size:	336 m^2 (3617 ft^2)
Attic Insulation:	13.2 K m^2/W (R-75)
Wall Insulation:	8.8 K m^2/W (R-50)
Basement wall Insulation:	not available (ICF construction)
Window U-value:	not available
Air leakage:	not available

Heating System: Ground source heat pump
Cooling System: Ground source heat pump
Ventilation System: Heat Recovery Ventilator (HRV)

PV System: 9.7 kW

3. The Next West House

- SIPs walls
- LEED Platinum rated
- LED lighting throughout
- Grey water system
- Induction cooktop
- Battery back-up system (900 amp-hours)

4. The NZE House

4. The NZE House

7.0/6.2/4.2 (40/35/24)

7.2 kW

Boulder, CO
Built in 2008
Ach: Architropic
HDD: 3035 (18C base)
5500 (65F base)

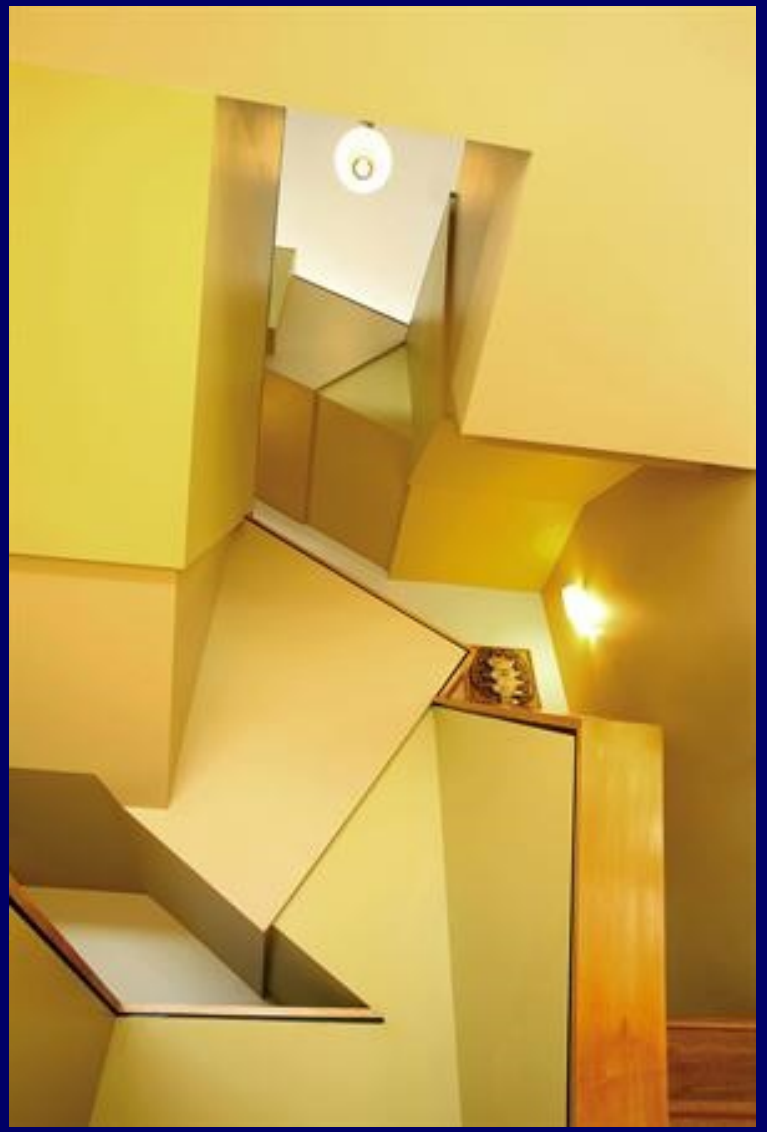
English units for R-value are hr ft^2 ^{o}F/Btu

Size:	279 m^2 (3000 ft^2)
Attic Insulation:	7.0 K m^2/W (R-40)
Wall Insulation:	6.2 K m^2/W (R-35)
Basement wall Insulation:	4.2 K m^2/W (R-24)
Window U-value:	0.44 W/K m^2 (0.08 Btu/hr ft^2 ^{o}F)
Air leakage:	0.068 ACHn

Heating System: Active solar, electric boiler backup
Cooling System: closed loop earth tube for ventilation air
Ventilation System: Heat Recovery Ventilator (HRV)

PV System: 7.2 kW

4. The NZE House



4. The NZE House

Net energy consumption

	Total kWh	Intensity kWh/m^2	Intensity kWh/ft^2
Year 1	1700	6.1	0.57
Year 2	2000	7.2	0.67

(Family of four with two teenagers)

5. The Balsam Project

5. The Balsam Project

8.5/4.2/1.8 (48/24/10)

4.9 kW

Boulder, CO
Built in 2010
Builder: Ecofutures
HDD: 3035 (18C base)
5500 (65F base)

English units for R-value are hr ft^2 ^{o}F/Btu

Size:	411 m^2 (4421 ft^2)
Attic Insulation:	8.5 K m^2/W (R-48)
Wall Insulation:	4.2 K m^2/W (R-24)
Basement wall Insulation:	1.8 K m^2/W (R-10)
Window U-value:	1.87 W/K m^2 (0.33 Btu/hr ft^2 ^{o}F)
Air leakage:	0.042 ACHn

Heating System: Geothermal heat pump
Cooling System: Geothermal heat pump
Ventilation System: Heat Recovery Ventilator (HRV)

PV System:	4.9 kW

6. Solar Row

6. Solar Row

7.4/5.8/2.1
(42/33/12)

3.0 kW

Boulder, CO
Built in 2007
Builder: Wonderland
HDD: 3035 (18C base)
5500 (65F base)

English units for
R-value are
hr ft^2 ^{o}F/Btu

Size: End units: 158 m^2 (1700 ft^2) Interior units: 117 m^2 (1258 ft^2)

Attic Insulation:	7.4 K m^2/W (R-42)
Wall Insulation:	5.8 K m^2/W (R-33)
Basement wall Insulation:	2.1 K m^2/W (R-12)
Window U-value:	1.70 W/K m^2 (0.30 Btu/hr ft^2 ^{o}F)
Air leakage:	0.19 ACHn

Heating System: Natural gas boiler combi system
Cooling System: Whole house fan, Ductless mini-split or AC
Ventilation System: exhaust only

PV System: 3.0 kW

6. Solar Row

11 Market rate units
Two different heating designs
NREL monitoring 3 units

Initial sales prices (2007)

Interior unit:	$390,000
End unit:	$560,000

Two of the 11 units had produced more electricity than consumed in the 3 years from 2007 to 2010.

7. BCHA Paradigm

7. BCHA Paradigm Project

8.6/4.4/3.9 (49/25/40)

2.2 kW

Lafayette, CO
Built in 2009
HDD: 3035 (18C base)
5500 (65F base)

English units for R-value are hr ft^2 ^{o}F/Btu

Size: Duplex units: 145 m^2 (1560 ft^2) detached: 84 m^2 (960 ft^2)

Attic Insulation:	8.6 K m^2/W (R-49)
Wall Insulation:	4.4 K m^2/W (R-25)
Basement wall Insulation:	3.9 K m^2/W (R-22)
Window U-value:	1.14 W/K m^2 (0.20 Btu/hr ft^2 ^{o}F)
Air leakage:	n/a

Heating System: Geothermal heat pump
Cooling System: Geothermal heat pump
Ventilation System: Energy Recovery Ventilator

PV System: 2.2 kW (2.6 kW more planned)

7. BCHA Paradigm

7. BCHA Paradigm

153 units planned

8. Scruboak Retrofit

8. Scruboak Retrofit

12.3/4.9/5.3 (70/28/30)

6.0 kW

Boulder, CO
Built in 2007
HDD: 3035 (18C base)
5500 (65F base)

English units for R-value are hr ft^2 ^{o}F/Btu

Size:	251 m^2 (2700 ft^2)
Attic Insulation:	12.3 K m^2/W (R-70)
Wall Insulation:	4.9 K m^2/W (R-28)
Basement wall Insulation (new):	5.3 K m^2/W (R-30)
Basement wall Insulation (existing):	0.9 K m^2/W (R-5)
Window U-value:	0.79 W/K m^2 (0.14 Btu/hr ft^2 ^{o}F)
Air leakage:	n/a

Heating System: Active solar with electric boiler backup
Cooling System: None
Ventilation System: Energy Recovery Ventilator

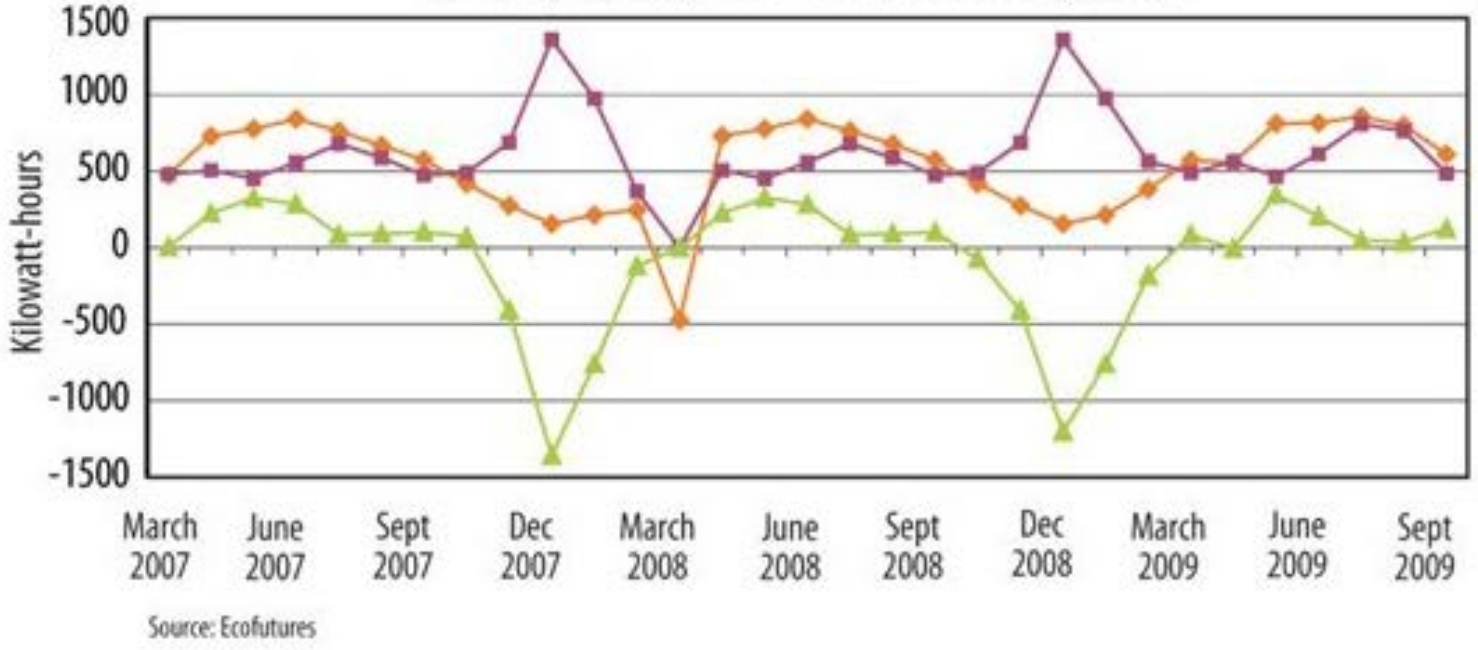
PV System: 6.0 kW

& Scrubbook Retrofit

Net-Energy Production 2007-2009

Graham Family House net consumption was 2,163 kilowatt-hours over 31 months

PV array averaged 86% capacity during the summers, when trees were in leaf. If the modules had not been shaded, then the system would have produced at 100% of seasonal capacity over two years and given the house a positive energy balance.



Source: Ecofutures

9. The ZED2 Retrofit

9. The ZED2 Retrofit

10.6/7.0/?
(60/40/?)

5.25 kW

Boulder, CO
Built in 2009
HDD: 3035 (18C base)
5500 (65F base)

English units for
R-value are
hr ft^2 ^{o}F/Btu

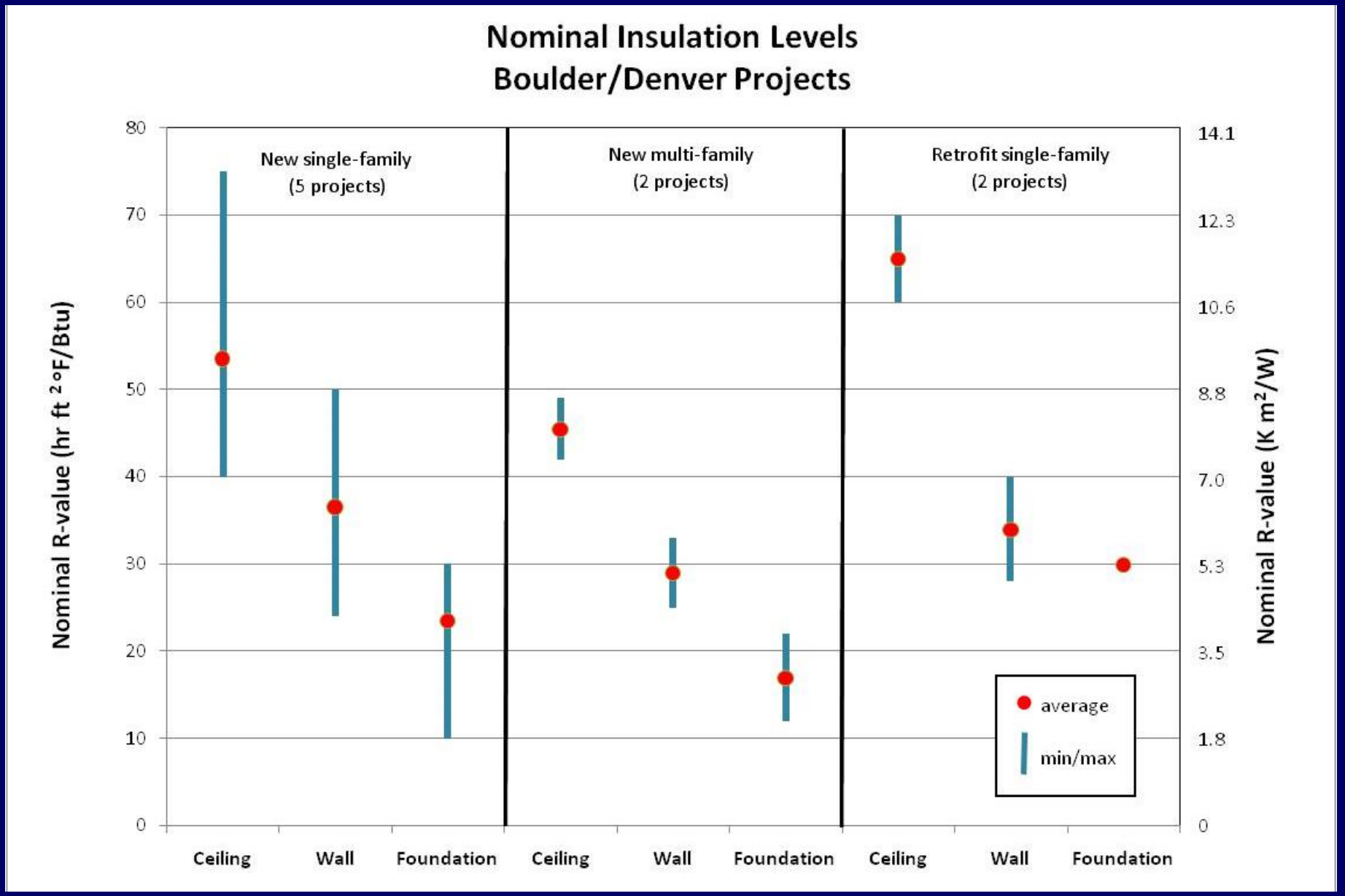
Size:	353 m^2 (3800 ft^2)
Attic Insulation:	10.6 K m^2/W (R-60)
Wall Insulation:	7.0 K m^2/W (R-40)
Basement wall Insulation:	n/a
Window U-value:	1.25 W/K m^2 (0.22 Btu/hr ft^2 ^{o}F)
Air leakage:	n/a

Heating System: Natural gas tankless water heater
Cooling System: Evaporative cooler
Ventilation System: Heat Recovery Ventilator

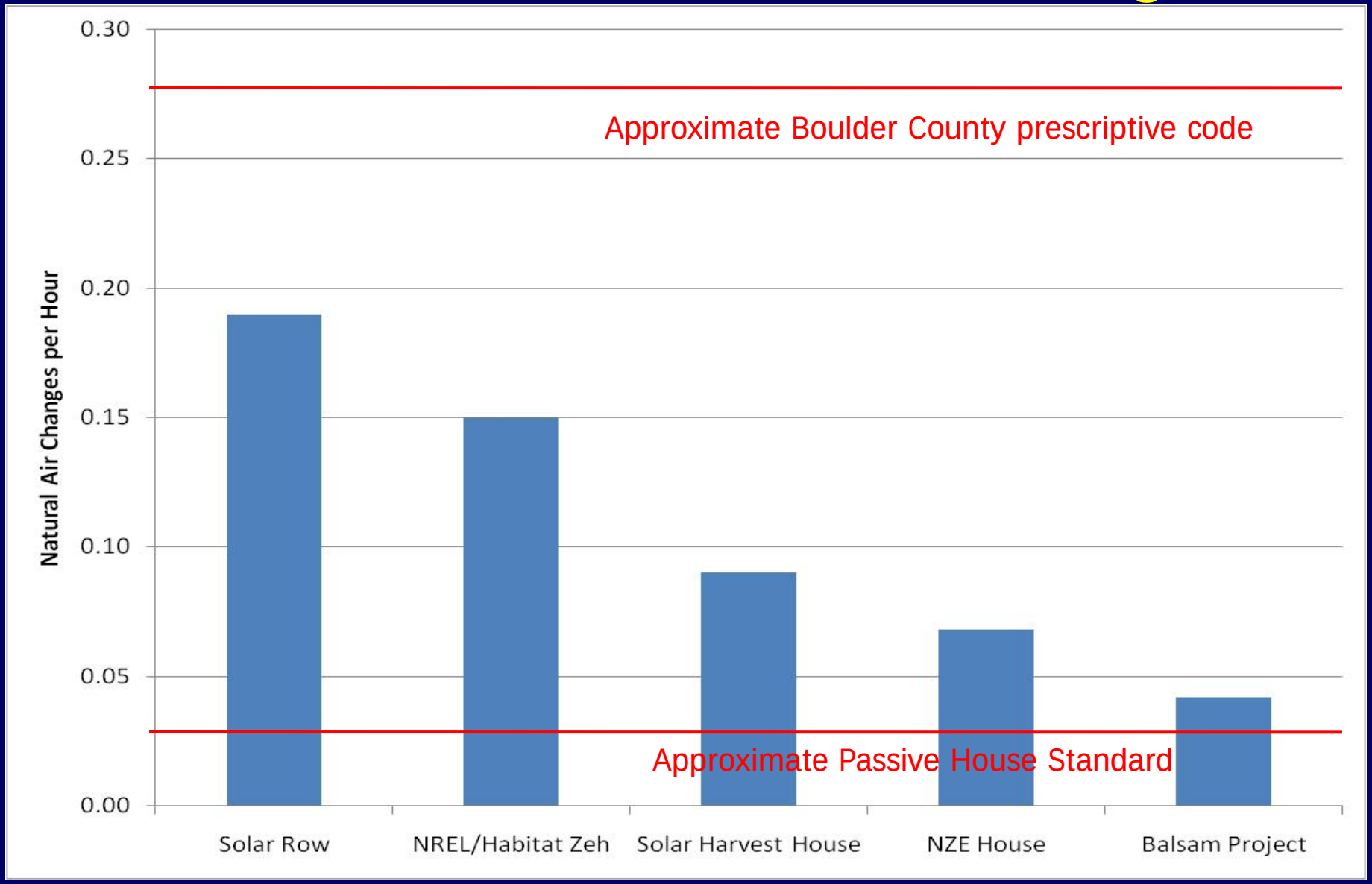
PV System: 5.25 kW

ZEH Comparisons

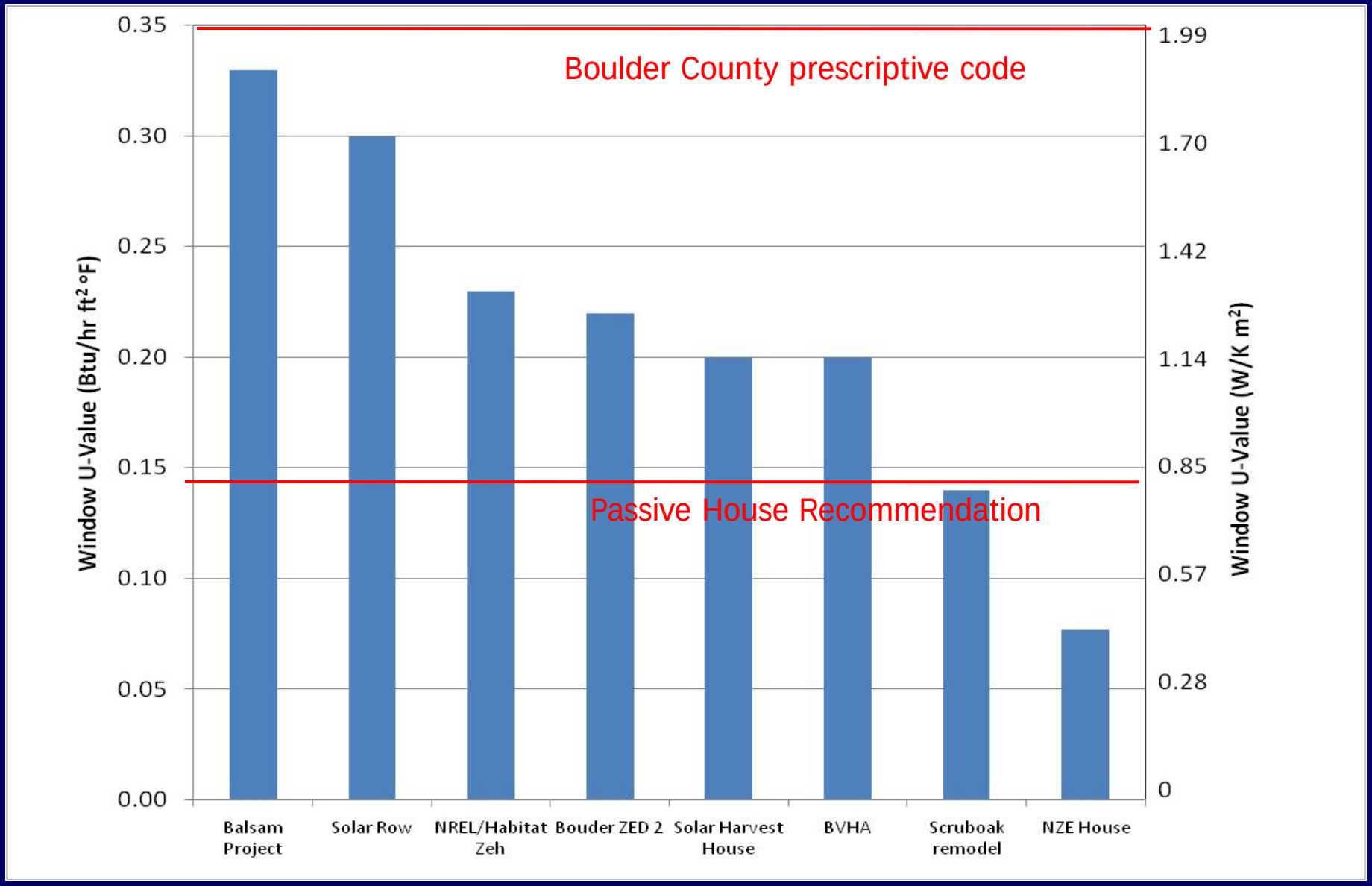
Insulation


Nominal Insulation Levels
Boulder/Denver Projects
New single-family
(5 projects)
New multi-family
(2 projects)
Retrofit single-family
(2 projects)
Nominal R-value (hr ft ²°F/Btu)
Nominal R-value (K m²/W)
80
70
60
50
40
30
20
10
0
14.1
12.3
10.6
8.8
7.0
5.3
3.5
1.8
0
average
min/max
Ceiling
Wall
Foundation
Ceiling
Wall
Foundation
Ceiling
Wall
Foundation

Air Leakage


0.30
0.25
0.20
0.15
0.10
0.05
0.00
Natural Air Changes per Hour
Approximate Boulder County prescriptive code
Approximate Passive House Standard
Solar Row
NREL/Habitat Zeh
Solar Harvest House
NZE House
Balsam Project

Window U-Value Comparison



Wall constructions

1. Solar Harvest	2x6 w/1.5” int. channel, 1” ext. foam
2. Habitat ZEH	Double 2x4 stud wall
3. Next West	SIPs
4. NZE House	Double 2x4 stud walls
5. Balsam	SIPs
6. Solar Row	2x6 w/1” ext foam
7. BCHA	2x6
8. Scruboak	existing walls: double 2x4 stud wall addition: SIPs
9. ZED 2	existing walls: 2x4 studs w/3” ext. foam

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Heating Systems

1. Solar Harvest	Sunspace; active solar; electric back-up
2. Habitat ZEH	Single point gas heater; electric baseboards
3. Next West	Ground source heat pump
4. NZE House	Active solar; electric boiler backup
5. Balsam	Ground source heat pump
6. Solar Row	Natural gas boiler; solar combisystem
7. BCHA	Ground source heat pump
8. Scruboak	active solar; wood stove; electric boiler
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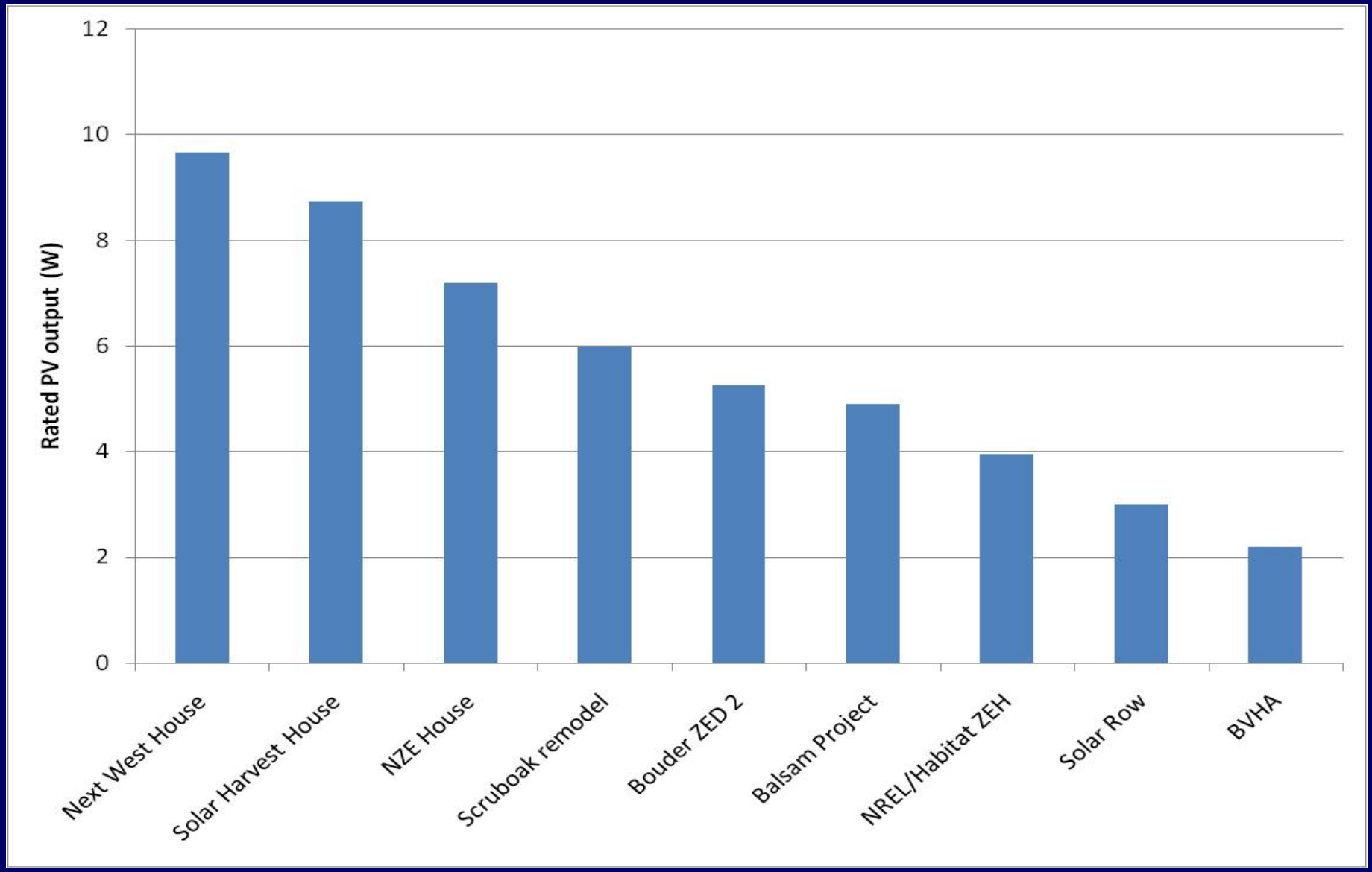
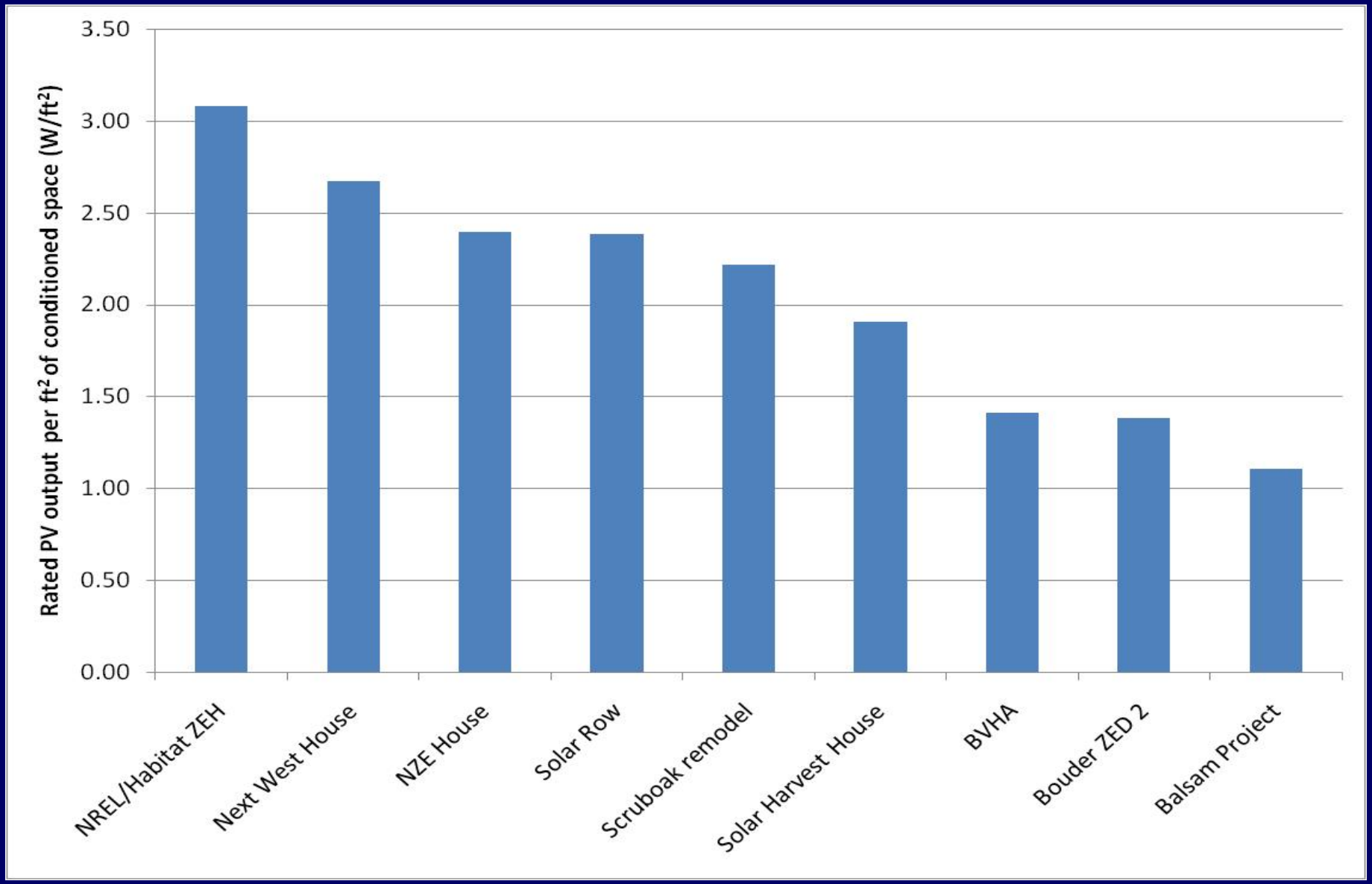
PV system size



PV per ft² of conditioned space



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ZEH/Utility thoughts

- Voltage regulation on distribution lines with high penetration of PV
- Distributed PV cannot currently be curtailed which could lead to more curtailment of centralized RE at higher RE penetrations
- Cost of small rooftop PV can be twice that of utility-scale PV and much more expensive than utility-scale wind.

ZEH/Utility thoughts

- Peak PV production does not coincide with most utility demand peaks
- How can ZEH be designed to better support the grid? Can we design in more dispatchable loads or peak shifting strategies?

ZEH Retrofits....

- Very high efficiency is more expensive to achieve in existing homes than in new homes, therefore the balance of investments is shifted towards larger PV systems
- A significant percentage of existing homes are not ideal for active solar thermal or PV systems due to lack of roof area, wrong orientation, or excessive shading
- Why is ZE in homes so fixed on rooftop PV? Why not long-term contracts with utility-scale RE?

Other thoughts...

- Aiming for ZE performance can lead to overproduction which is economically unfavorable with most net-metering rates.
- ZEH can be made at a lower first cost by heating with natural gas and offsetting the source energy of the natural gas with excess PV electricity production.

Other thoughts...

- In the BEopt paradigm, as PV costs go down we will build less efficient ZEH with larger PV systems
- Are there alternative philosophies on how much to invest in efficiency before turning to RE production?

ZEH and Passive House

Zero Energy Home	Passive House
Produce as much energy as consumed	Reduce consumption by about 90%
Invest in all efficiency that costs less than PV	Invest in efficiency until the elimination of a conventional space heating system
Single design metric	Three design metrics
No certification	Formal certification

NOT included in this ZEH approach

- Embodied energy
- Life cycle analysis
- Externalized costs analysis (environmental, health and social impacts)

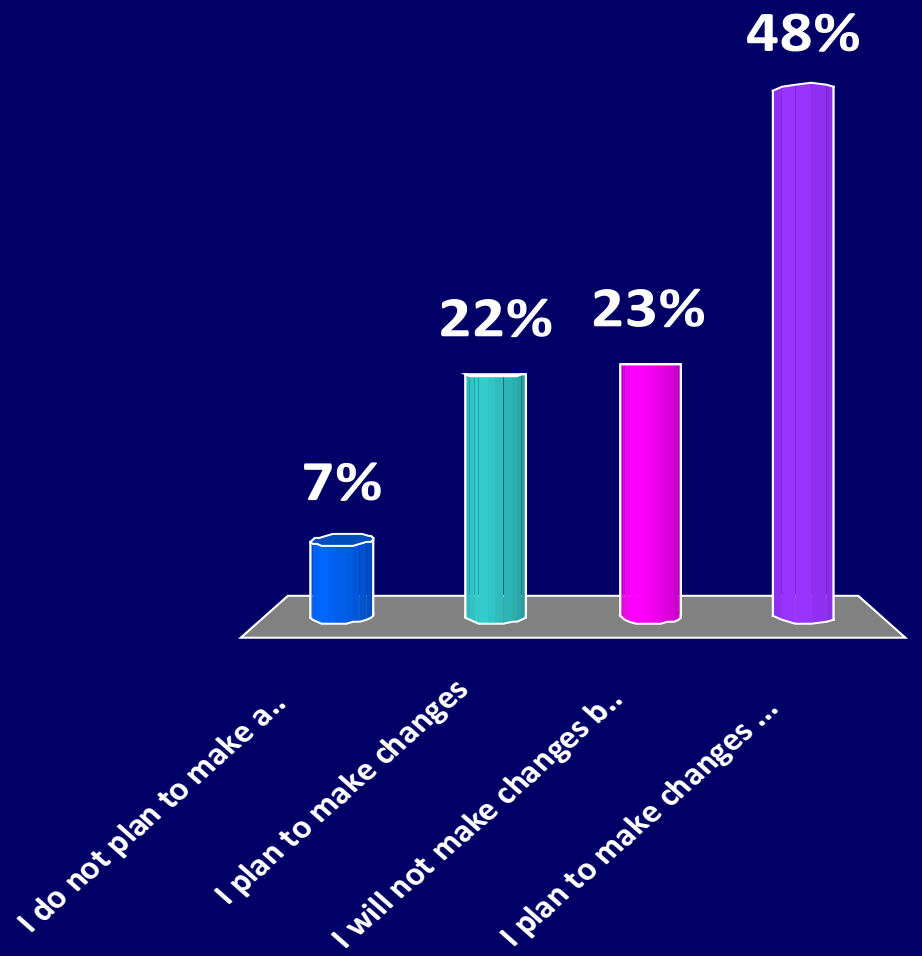
What is your intention to make changes or share information from the presentation?

A. I do not plan to make any changes

B. I plan to make changes

C. I will not make changes but will share what I learned

D. I plan to make changes and share what I learned



How much did you learn from the presentation?

A. I didn't learn anything new

B. I'm leaving with a few tips and tools

C. I learned a great deal about the topic