



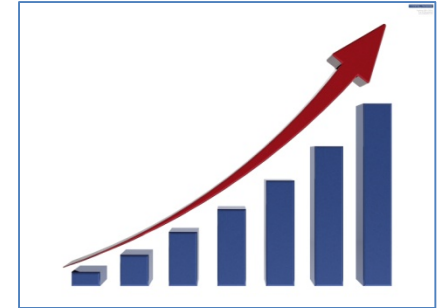
Home Energy Efficiency

Cary Weiner

Colorado State University Extension

Class Outline

- Residential energy use overview



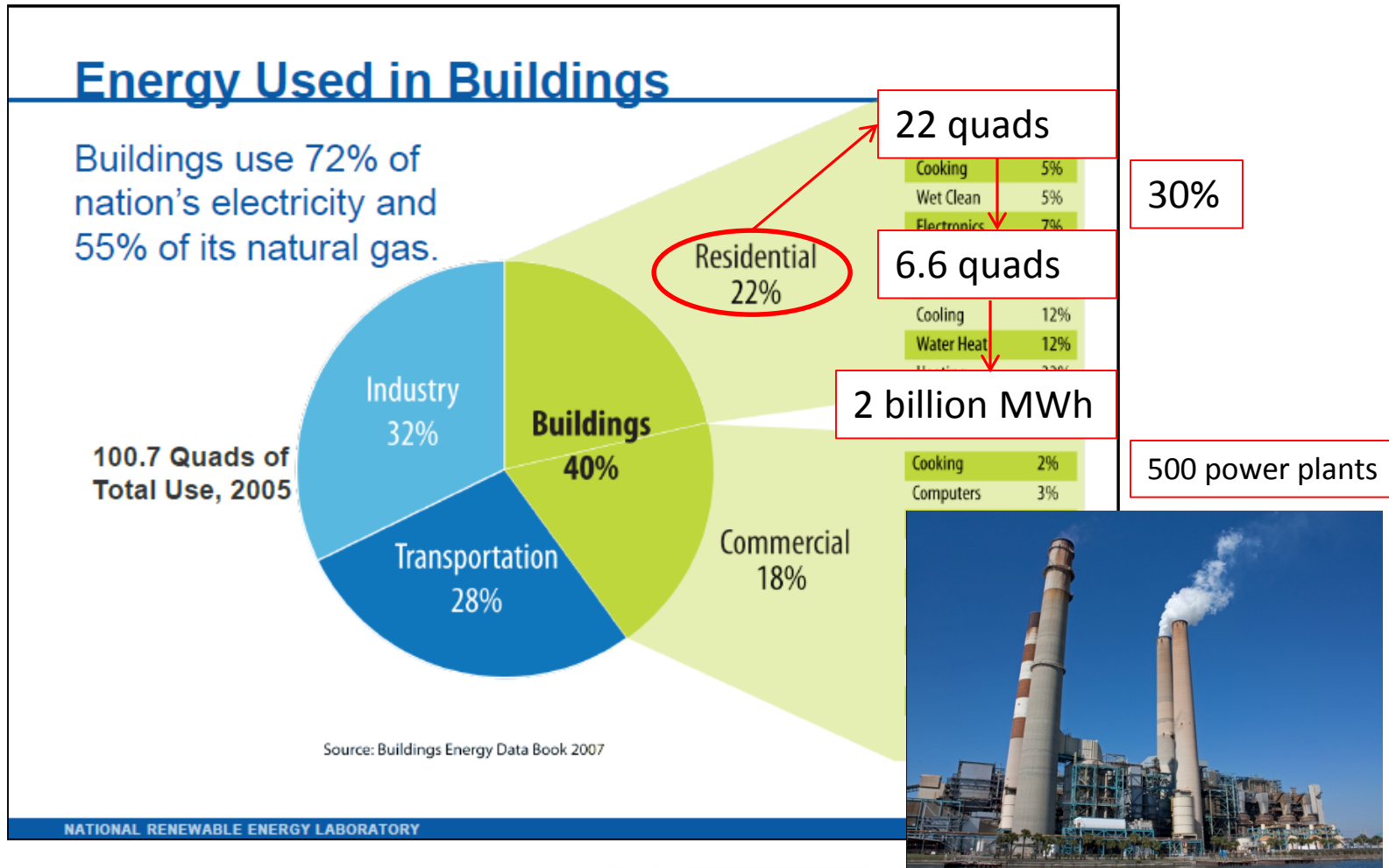
- Whole house approach



- Considerations for moving forward



Energy Use - Nationwide



Energy Use - Colorado

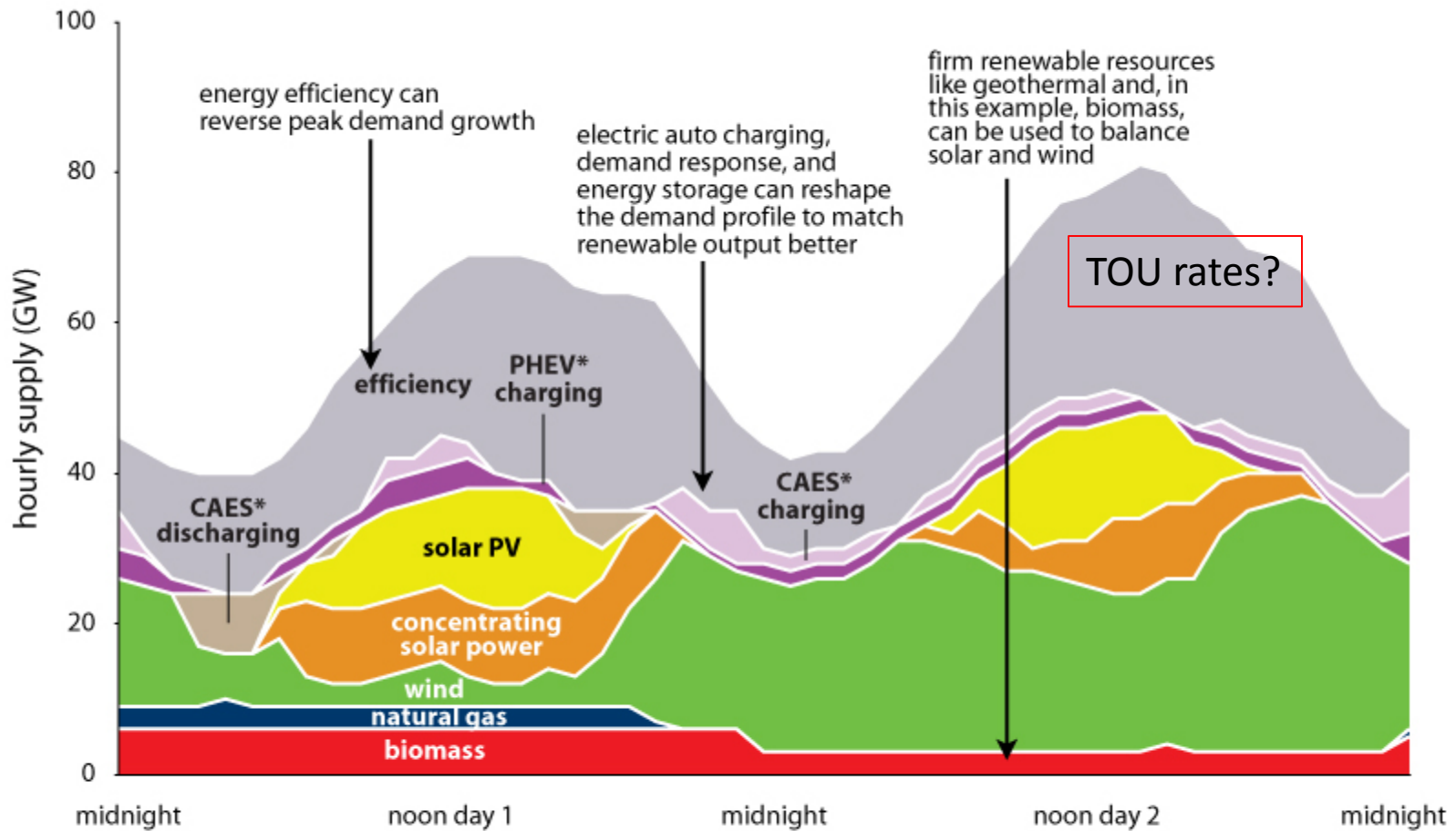
End-Use Sector	Energy Use (bil BTU)	Percent
Residential	332,692	22.9%
Commercial	291,763	20.1%
Industrial	409,873	28.2%
Transportation	417,897	28.8%

30% savings = 7 power plants

Source - www.eia.gov/state/state-energy-profiles-data.cfm?sid=CO#Consumption

Reinventing Fire: Vision

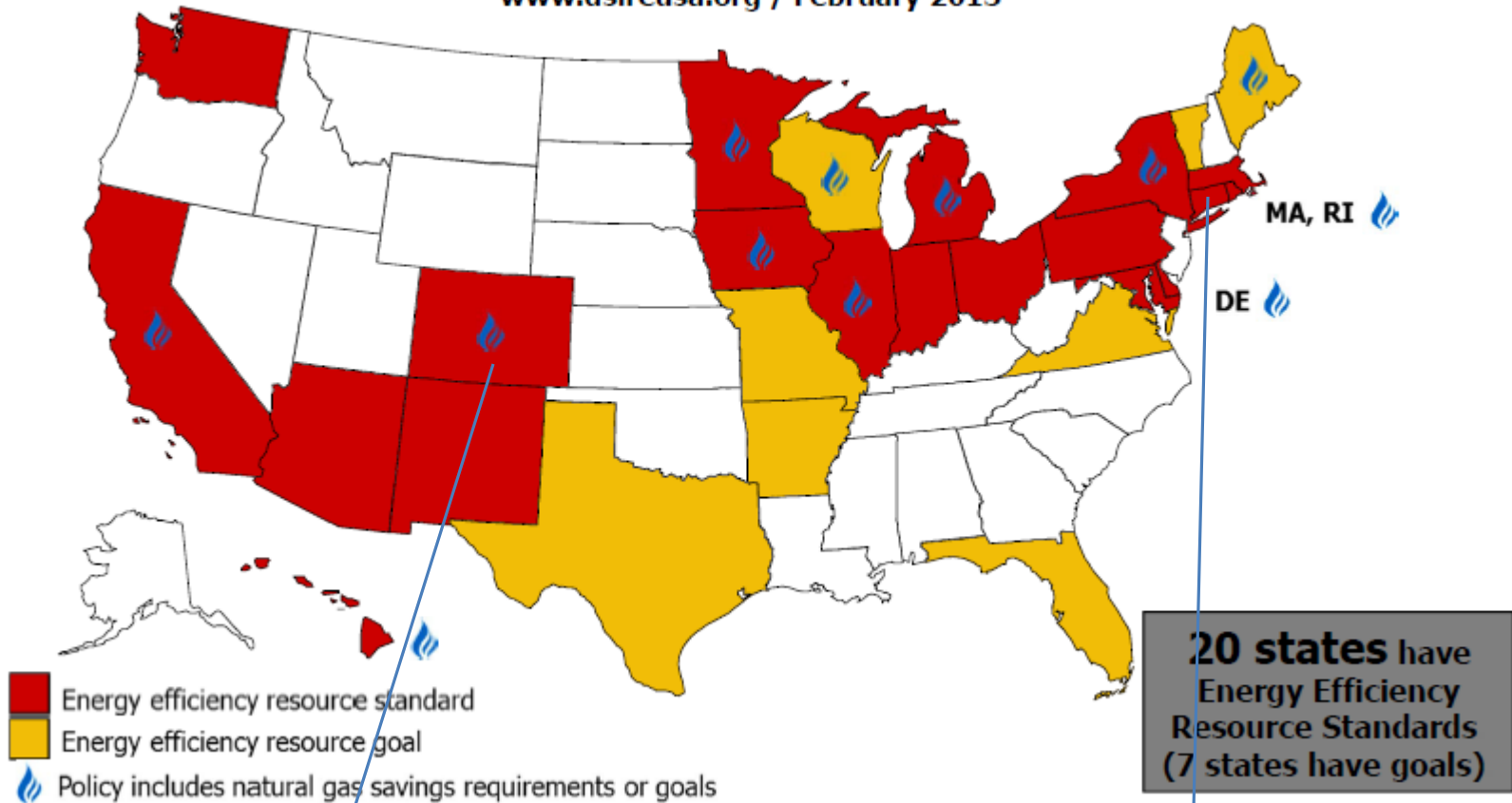
Hourly operability in a high-penetration renewables scenario



* PHEV is plug-in hybrid electric vehicle and CAES is compressed air energy storage

Energy Efficiency Resource Standards

www.dsireusa.org / February 2013



#16: 5% electric savings and peak demand reduction from 2006 levels by 2018. Gas utilities - 0.5% of previous year revenue. Integrated Resource Planning. Voluntary/mixed building codes.

#1: Annual electric savings from 2.5% to 2.6% from 2013-2015. Gas savings - 1.1% of retail sales annually. DECOUPLING for all utilities. 2012 IECC and voluntary stretch codes.

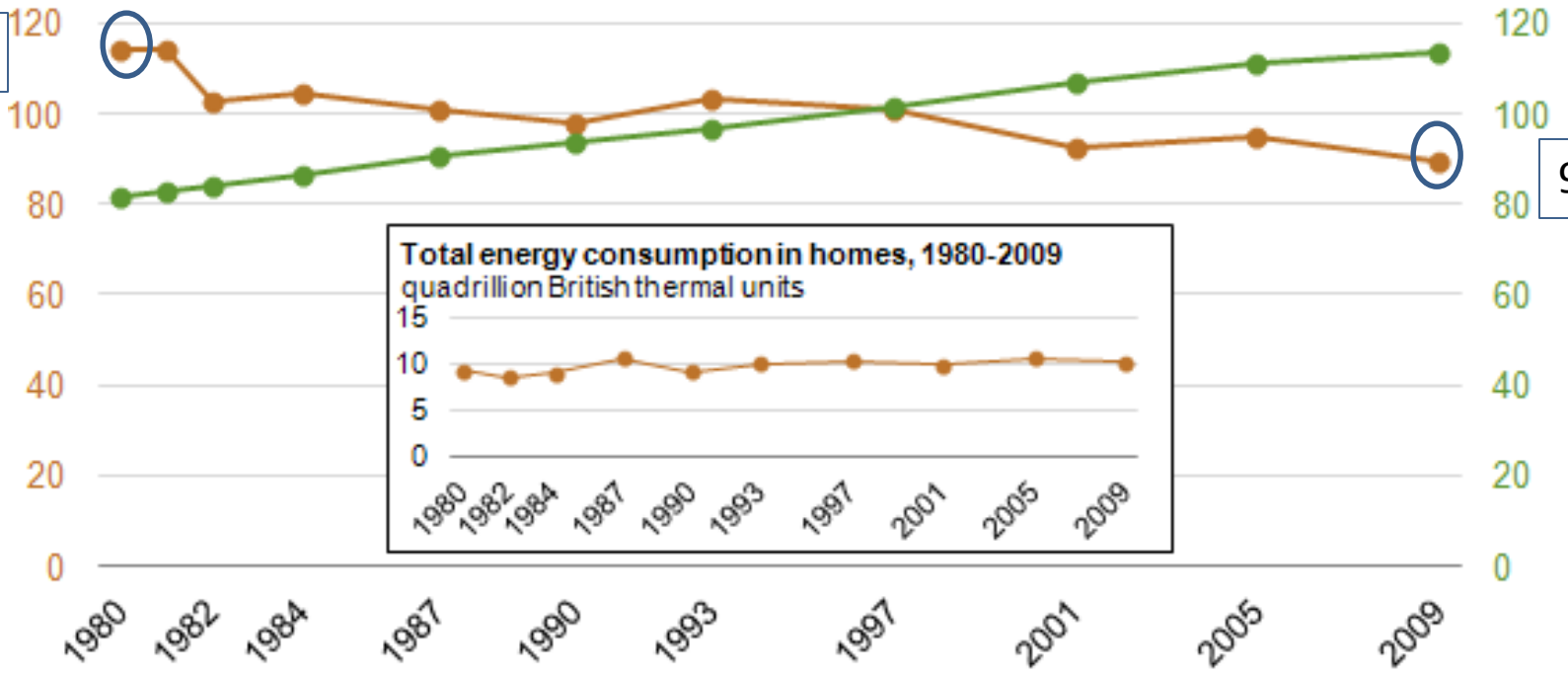


Average energy consumption per home and number of housing units, 1980-2009

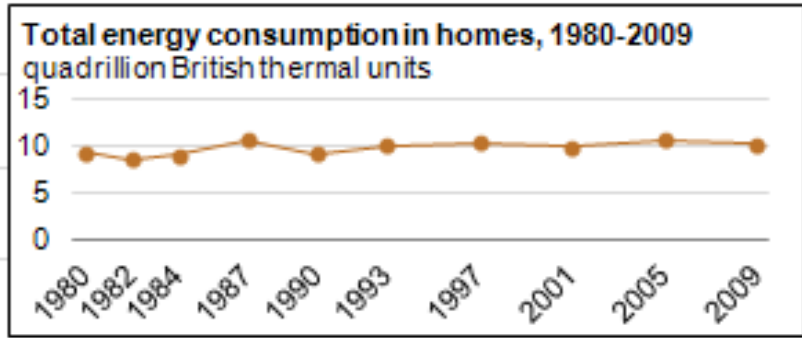
million British thermal units per housing unit

million housing units

115

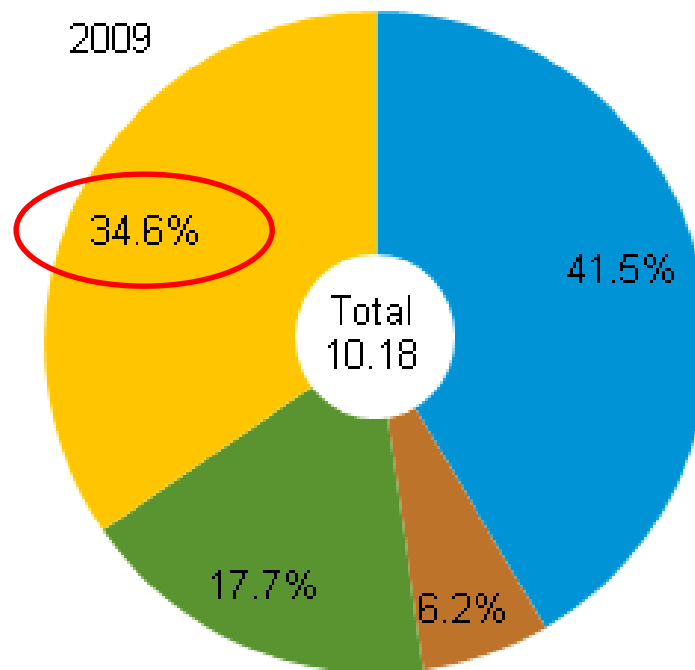
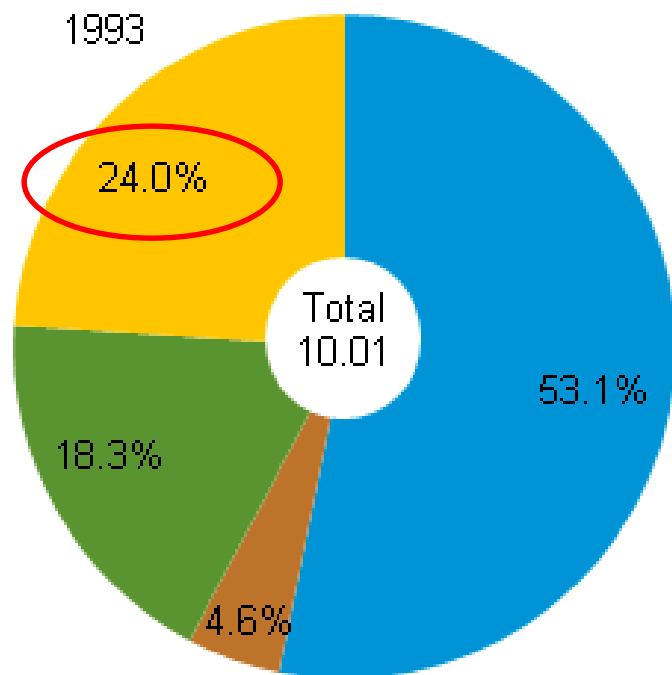


90

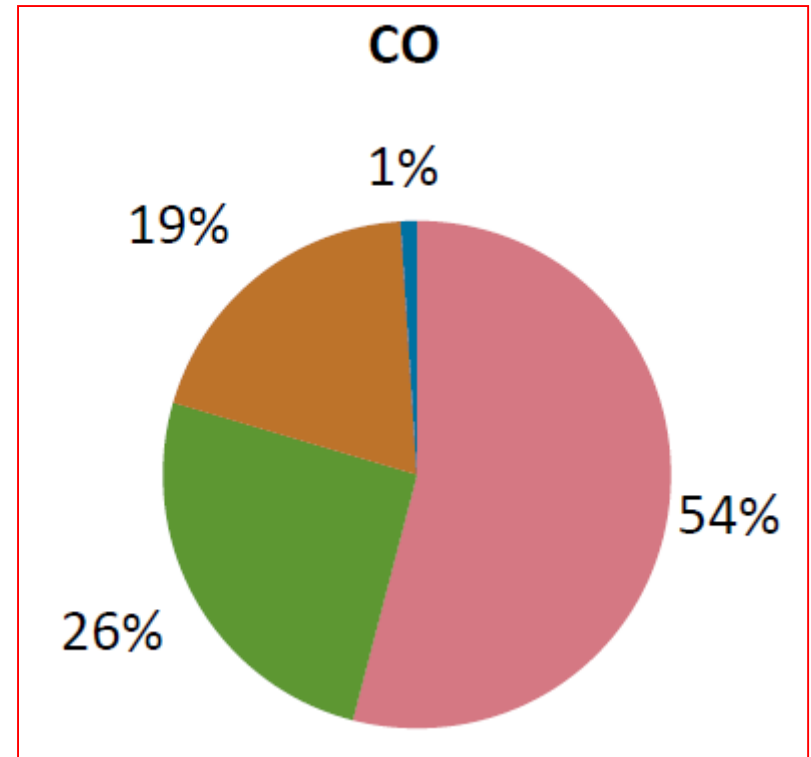
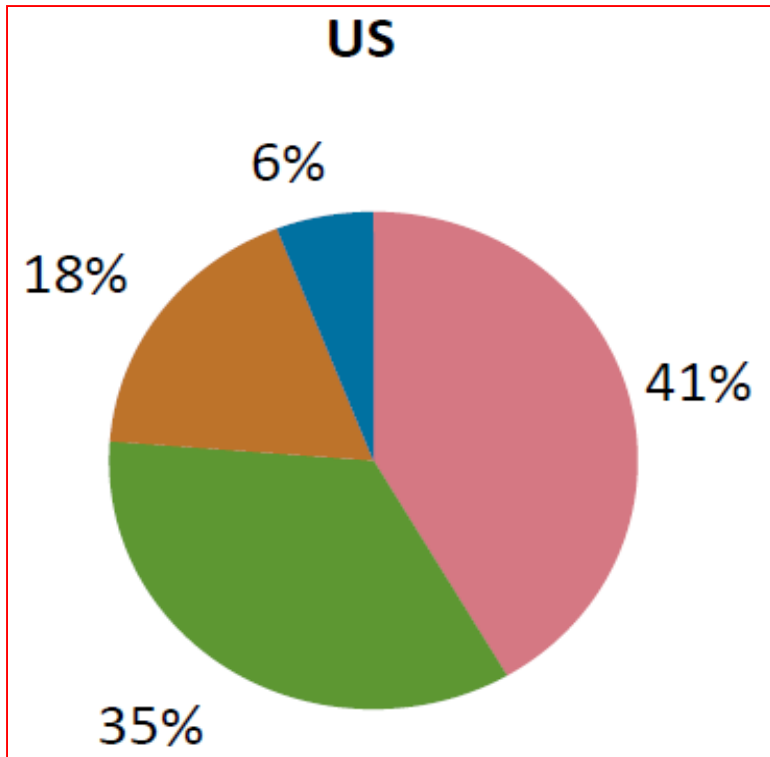


22% decrease per home

Energy consumption in homes by end uses quadrillion Btu and percent



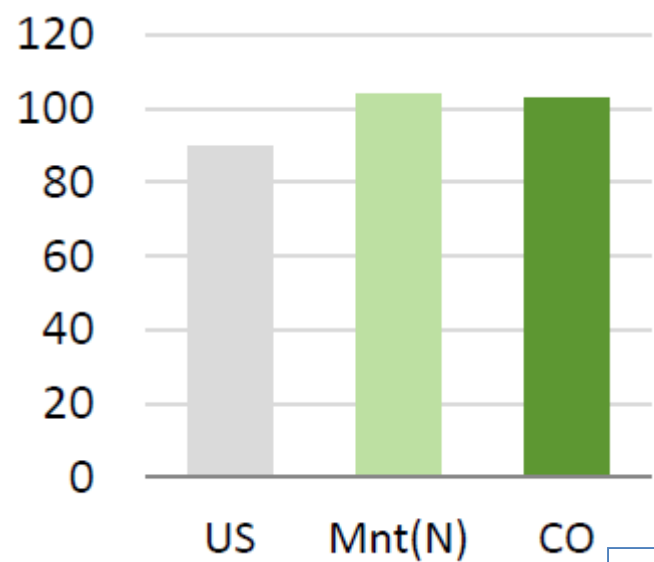
■ space heating ■ air conditioning ■ water heating ■ appliances, electronics, and lighting



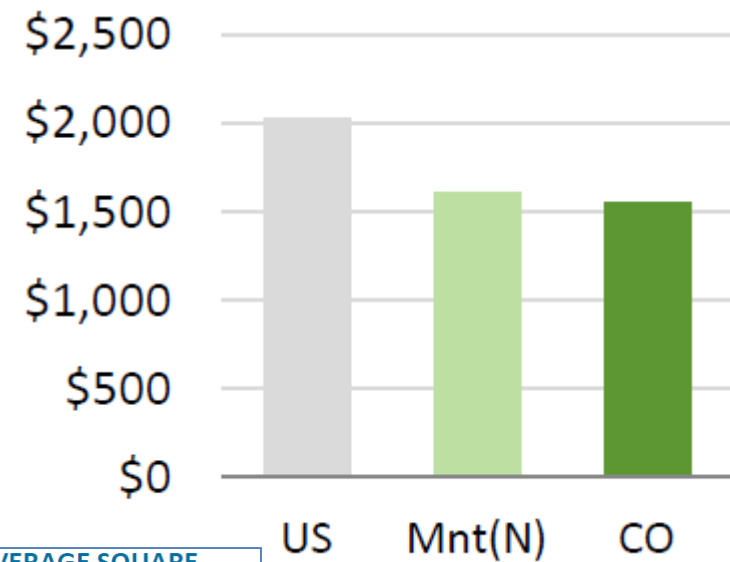
 Air conditioning  Water heating  Appliances, electronics, lighting  Space heating

ALL ENERGY *average per household (excl. transportation)*

Site Consumption
million Btu

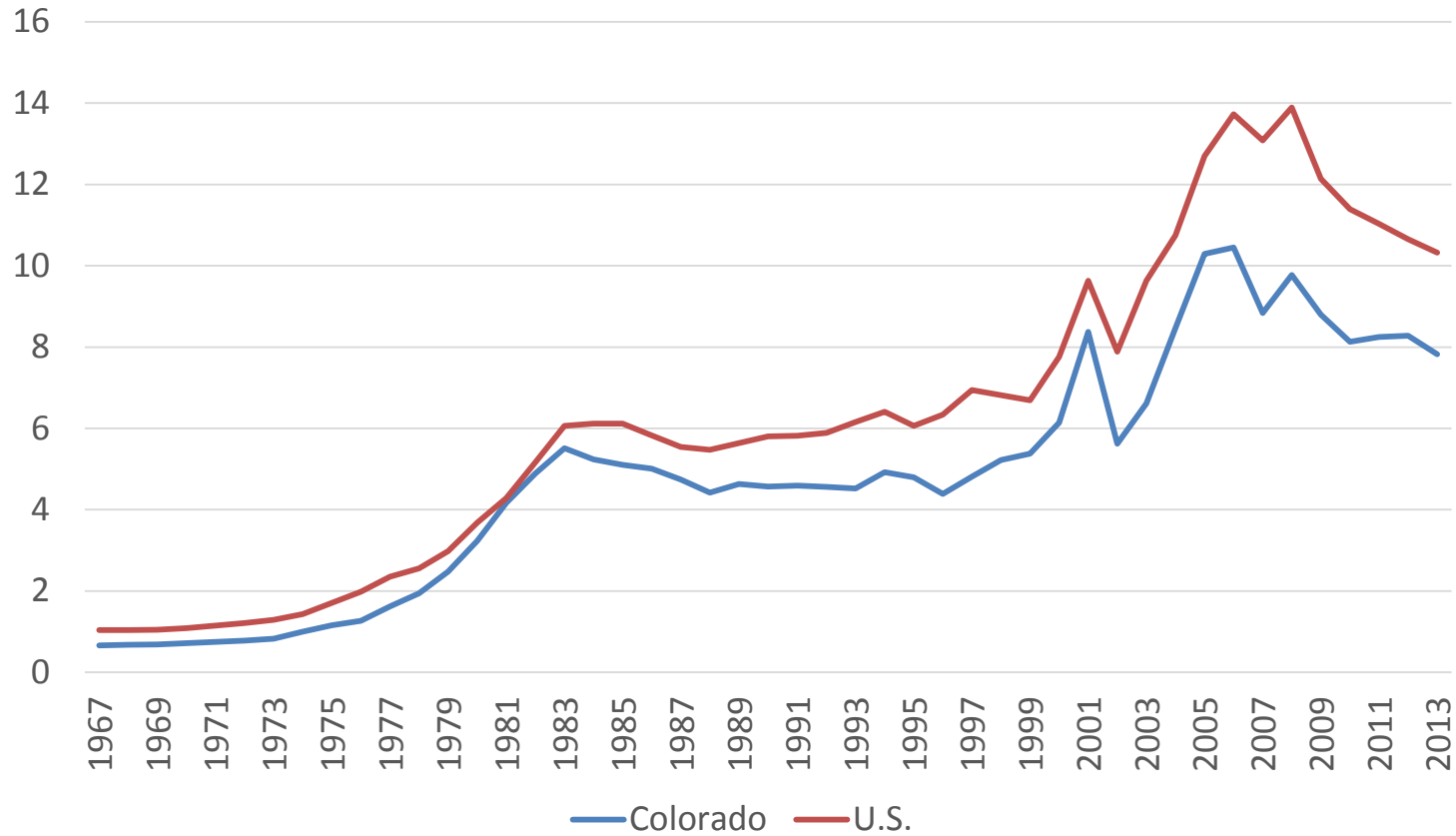


Expenditures
dollars



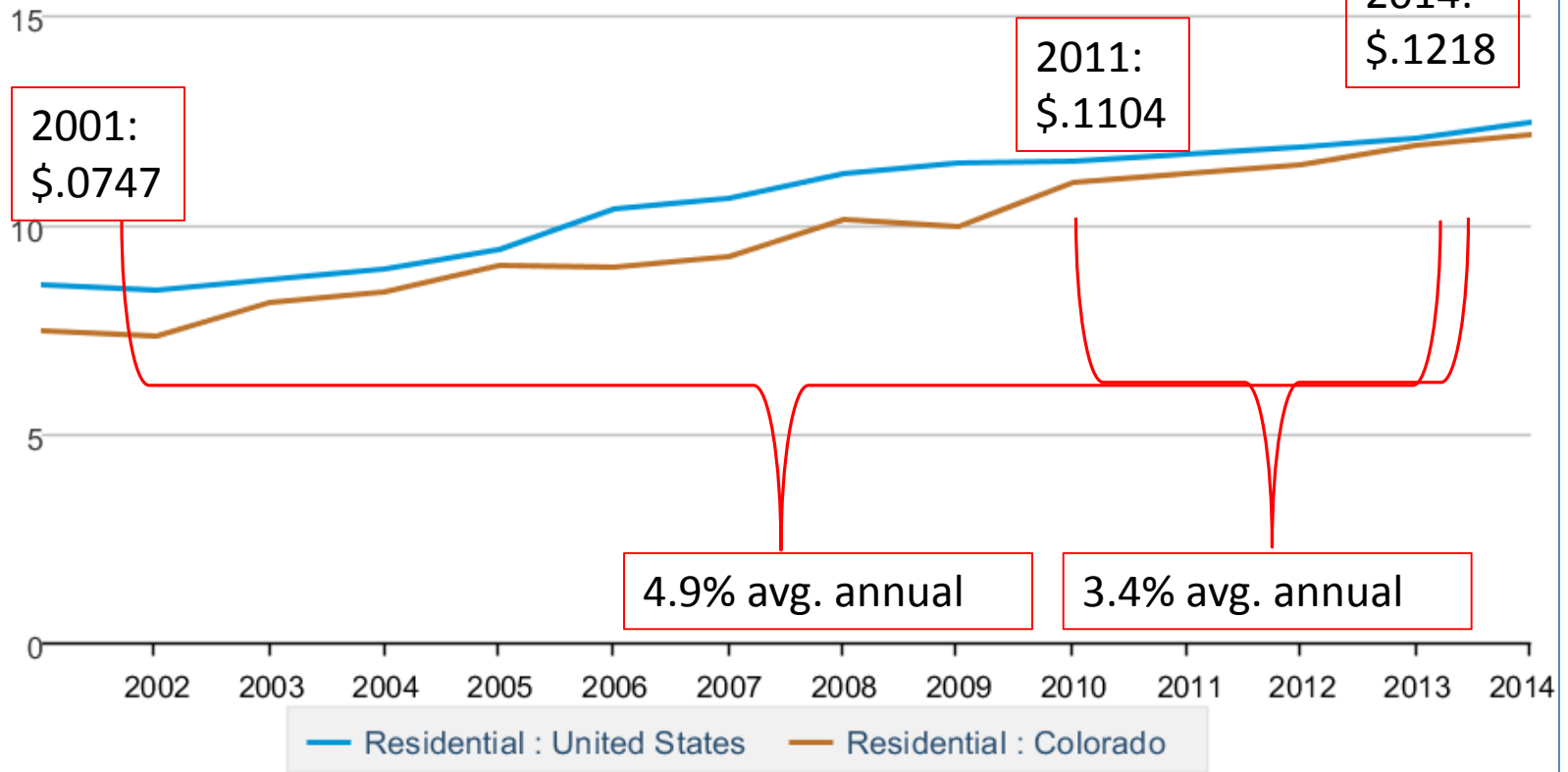
AVERAGE SQUARE FOOTAGE	
US	1,971
Mnt(N)	2,107
CO	2,082

Price of Natural Gas Delivered to Residential Customers (\$/mcf)



Average retail price of electricity, annual

cents per kilowatthour



Data source: U.S. Energy Information Administration

Weekly Heating Oil and Propane Prices (October - March)

\$/gal

4.0

3.5

3.0

2.5

2.0

1.5

1.0

0.5

0.0

1992

1994

1996

1998

2000

2002

2004

2006

2008

2010

2012

2014

— U.S. Propane Residential Price



Source: U.S. Energy Information Administration

Heating Fuel Comparison

Electricity	3,412	BTU per kWh	\$ 0.12	per kWh	\$ 35.17	per MMBTU
Natural Gas	1,000,000	BTU per Mcf	\$ 7.82	per Mcf	\$ 7.82	per MMBTU
Propane	91,500	BTU per gallon	\$ 2.50	per gallon	\$ 27.32	per MMBTU
Wood	22,000,000	BTU per cord	\$ 200.00	per cord	\$ 9.09	per MMBTU
Pellets	16,200,000	BTU per ton	\$ 250.00	per ton	\$ 15.43	per MMBTU

Read Your Bills

Electric Service - Account Summary

Invoice Number	0437053245			Residential General		
Meter No	00000S795978			Summer Tier 1*	396 kWh x 0.046040	\$18.23
Rate	R	Residential General		GRSA		\$3.51
Days in Bill Period	30			Trans Cost Adj	396 kWh x 0.000040	\$0.02
Current Reading	27555	Actual	08/29/2012	Elec Commodity Adj	396 kWh x 0.026650	\$10.55
Previous Reading	27159	Actual	07/30/2012	Demand Side Mgmt Cost	396 kWh x 0.001310	\$0.52
Kilowatt-Hours Used	396			Purch Cap Cost Adj	396 kWh x 0.006930	\$2.74
				Service & Facility		\$6.75
				Renew. Energy Std Adj		\$0.83
				Subtotal		\$43.15
				Total Amount		\$43.15

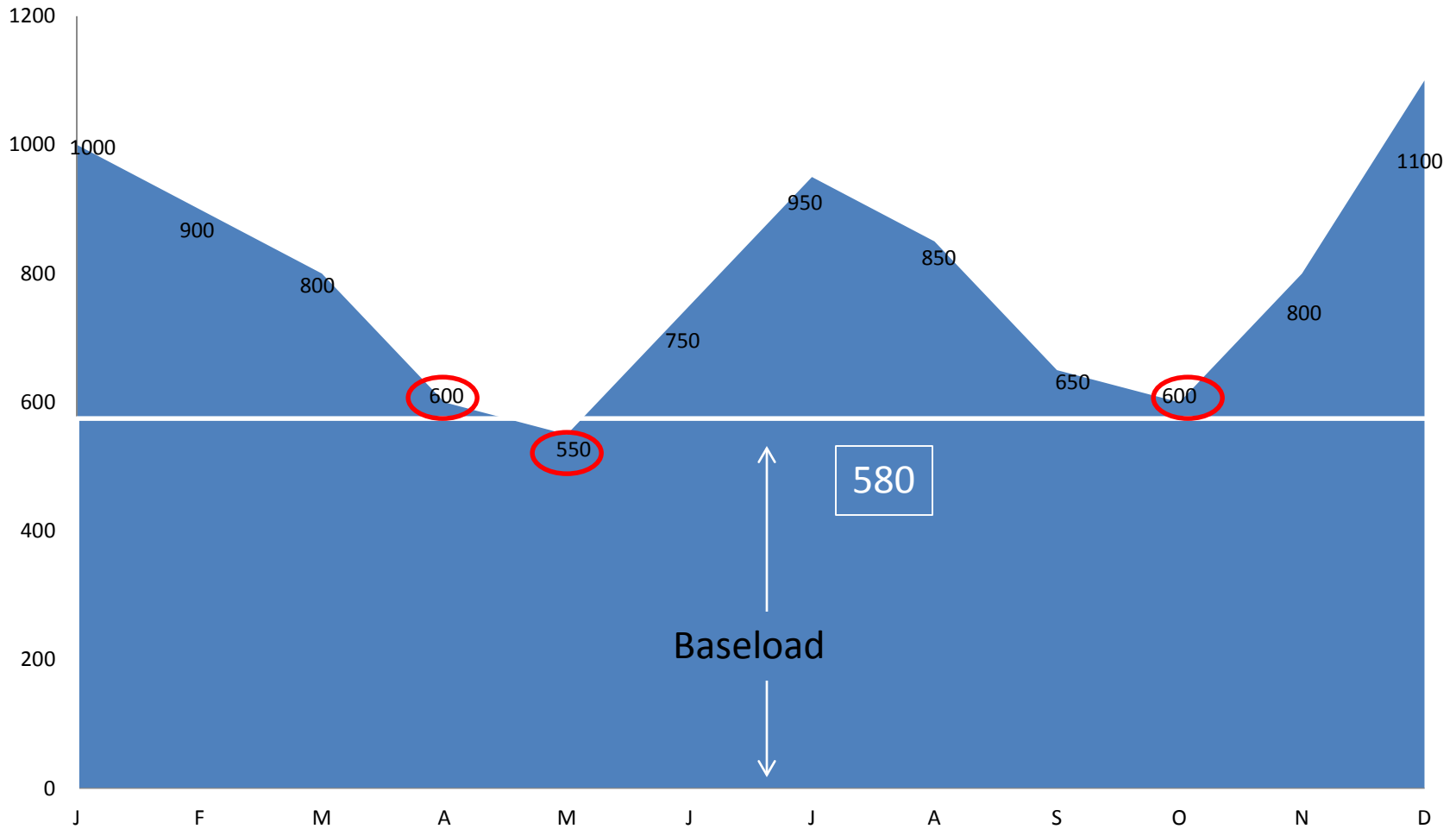
Gas Service - Account Summary

Invoice Number	0220968212			Residential		
Meter No.	0000AFC18991			Usage Charge	17 therms x 0.090000	\$1.53
Rate	RG	Residential		Interstate Pipeline	17 therms x 0.081790	\$1.39
Days in Bill Period	30			Natural Gas 3 Qtr	17 therms x 0.216770	\$3.69
Current Reading	4431	Actual	08/29/2012	Pipe Sys Int Adj	17 therms x 0.016880	\$0.29
Previous Reading	4412	Actual	07/30/2012	Service & Facility		\$11.78
Measured Usage	19			Subtotal		\$18.68
Therm Multiplier	0.8925			Total Amount		\$18.68
Therms Used	17.0					

Comparison Information

	Cost	Cost	Billing Period	Kwh Usage/Month	Therm Usage	Avg. Daily Temp.
Gas	\$18.68 per month	\$0.62 per day	This Year	396	17	73°
Electric	\$43.15 per month	\$1.44 per day	Last Year	21	0	75°

Determining a Baseload



Energy Audits

YOUR HOUSE

Current Capacity	50.0 GALLONS	\$ 100	Save \$100/year by upgrading to a high efficiency water heater
Current Age	7 YEARS		
Current Energy Factor	0.58		
Recommended Energy Factor	0.84		



Your Water Heater



Leaking Water Heater



High Efficiency Water Heater



Whole House Approach

REDUCE ENERGY DEMAND

- Behavior changes
- Air sealing
- Insulation
- Landscaping and windows

Use energy efficiently

- Heating and cooling equipment
- Transport
- Lighting and appliances

Use clean sources

- Solar
- Wind

The 7 Habits of Highly Efficient Homeowners

1.



3.



2.



4.



5.



7.

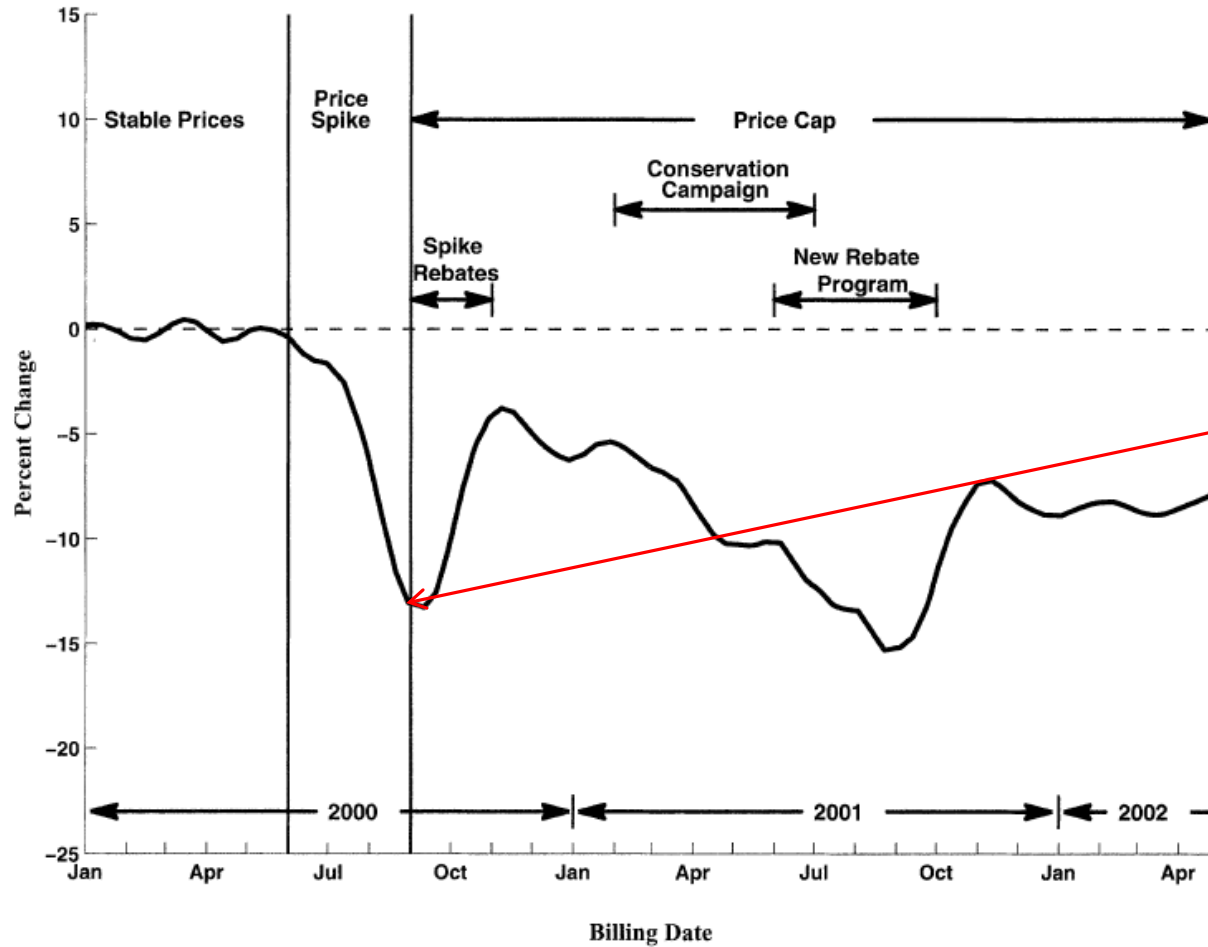


6.



What Affects Behavior?

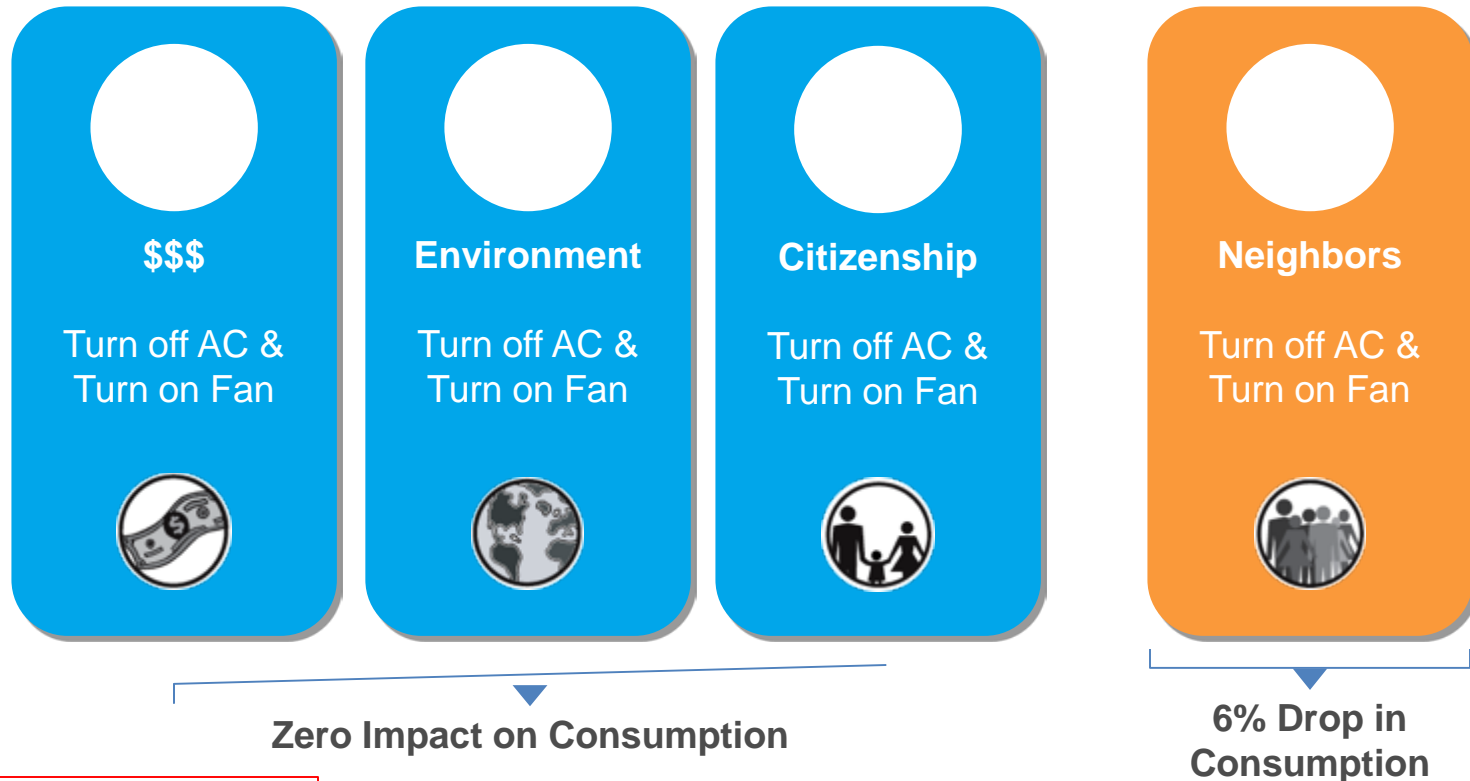
AVERAGE WITHIN-HOUSEHOLD CONSUMPTION CHANGES, 2000–2002



Source: Changes are relative to the same months during pre-crisis years, with weather and trend removed.

Reiss & White 2008

What Affects Behavior II?



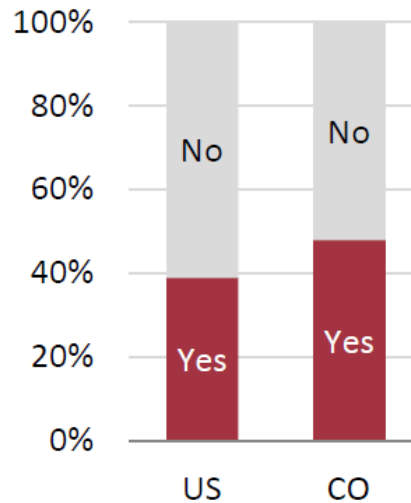
Comfort?
"Home performance"?

Slide courtesy Jeff Lyng

Schultz & Cialdini (OPOWER Scientists)
Hewlett Foundation San Marcos Study



HAVE A PROGRAMMABLE THERMOSTAT



Lutz et. al:
 47% in program mode

Bouchelle et. al:
 Habits more important than technology



Smart Homes



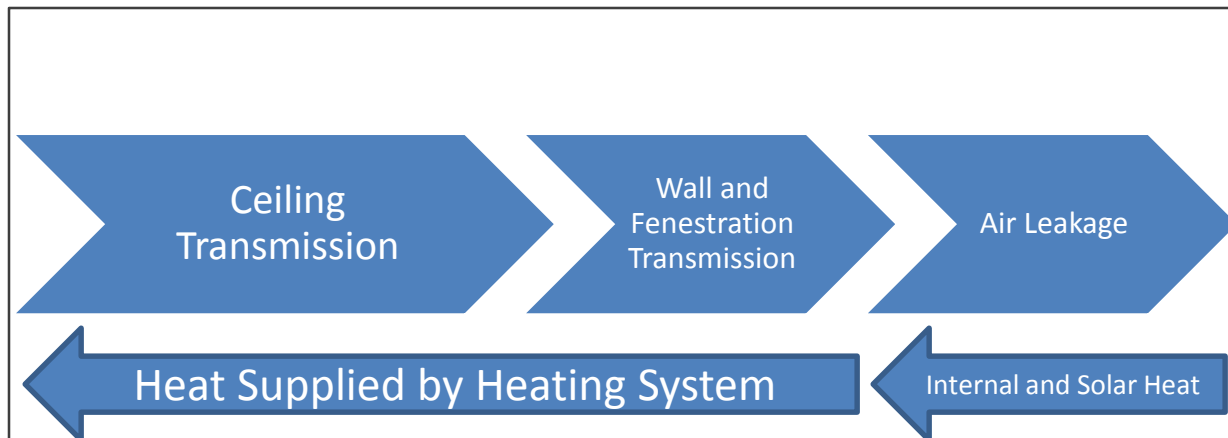
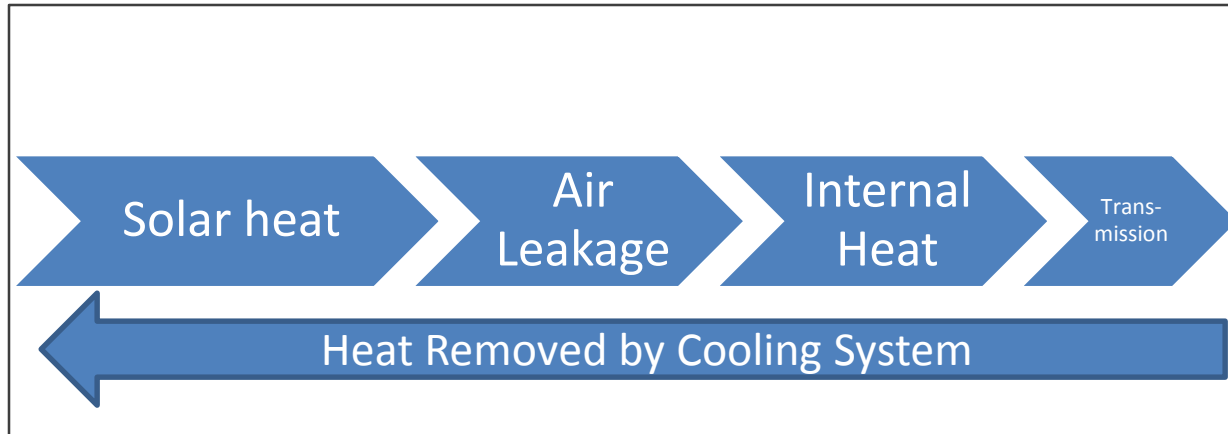
GE Z-Wave



Nexia

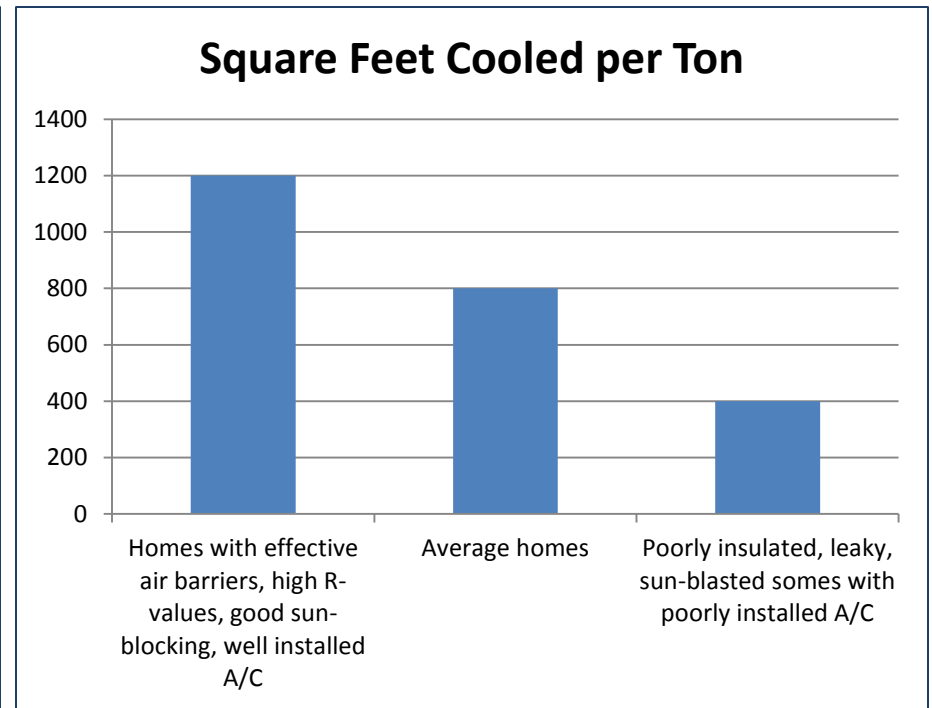
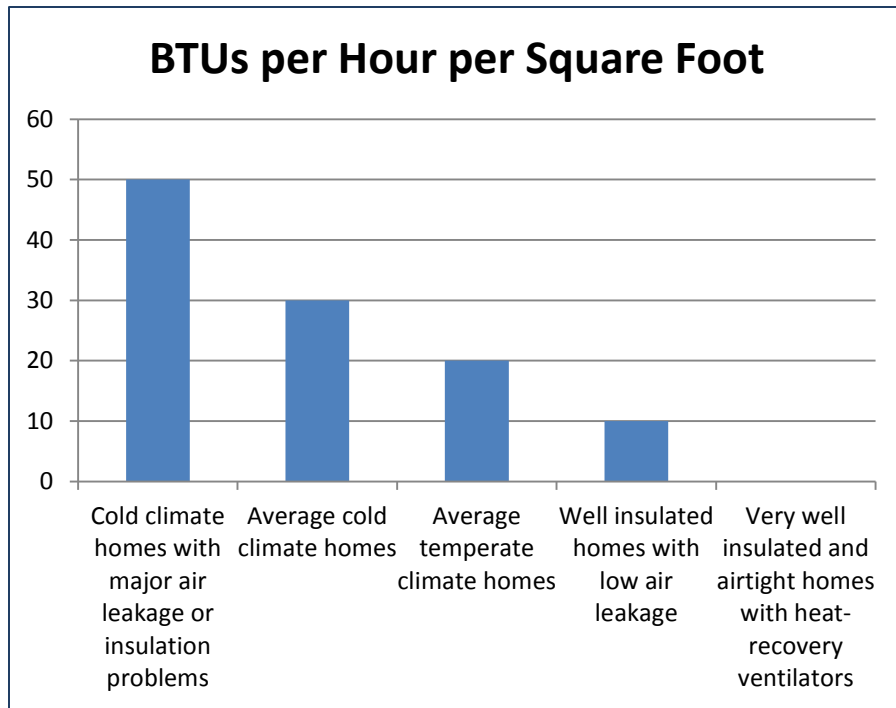
VIDEO: <http://insynctive.pella.com/motorized-blinds>

Comfort and the Building Shell



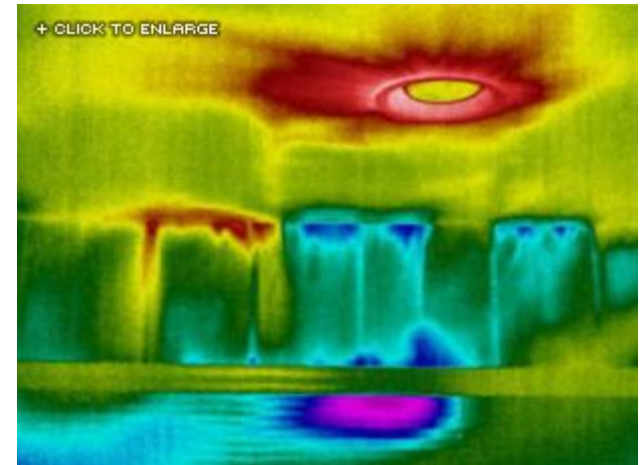
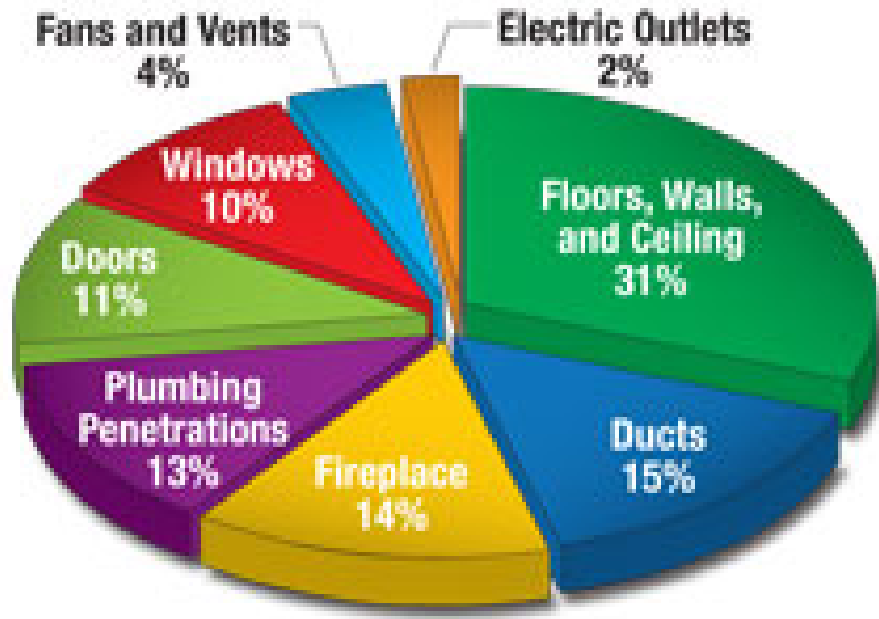
Source: Residential Energy, 5th Edition

Variations in Load



Source: Residential Energy, 5th Edition

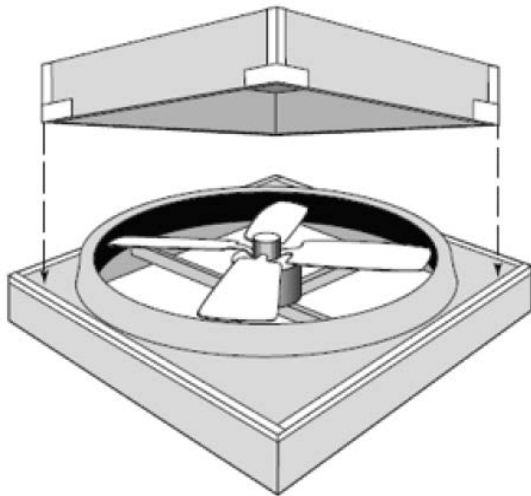
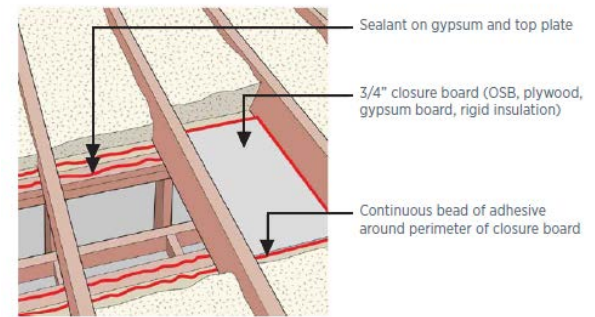
Air Leaks: Diagnosis



Source: www.energysavers.gov

<http://www.infraredimagingervices.com/residential-energyscan>

Stack Effect



Source: National Park Service

Air Leaks - Other



Source: www.bbc.co.uk

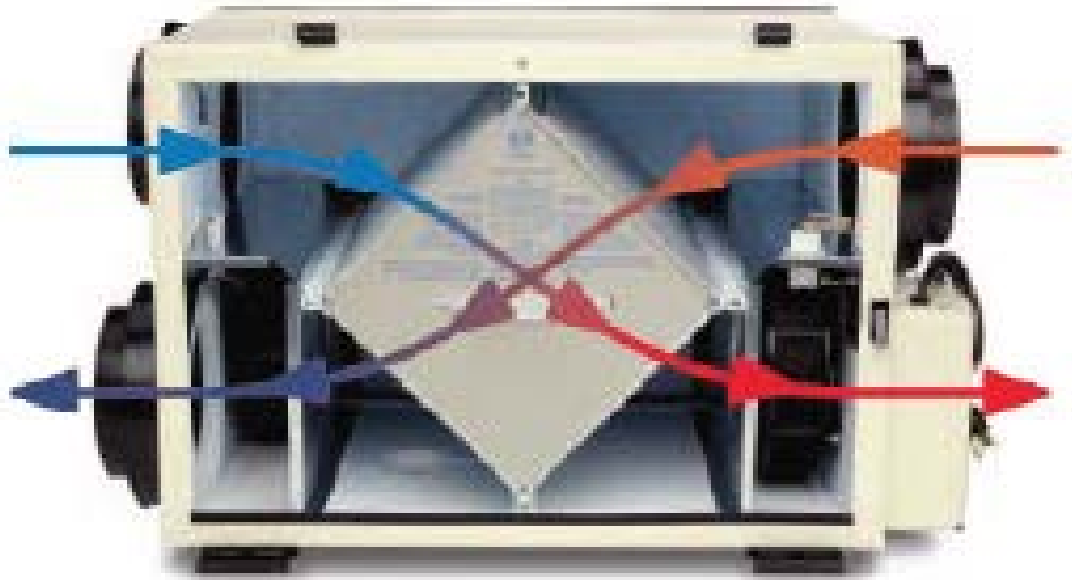


Source: www.greenhomelogic.com



Too Tight?

- .35 air changes/hour
- Moisture, VOCs, CO, Particulates
- Spot ventilation



Insulation



4-8



3.2



4-8



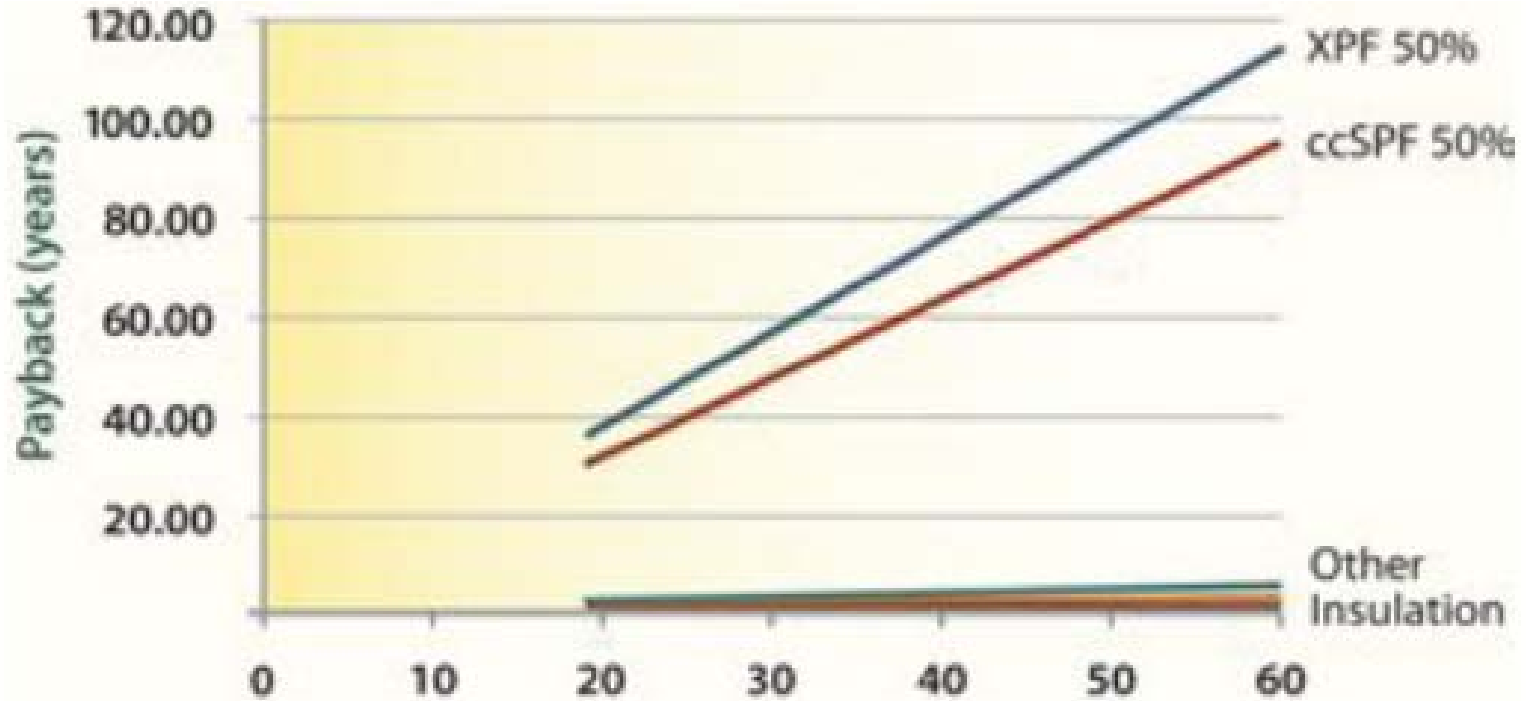
3.2



2.5

- Density
- Installation
- DIY?
- Air sealer?
- Cost

Greenwashing?



Recommended R-Values for Colorado

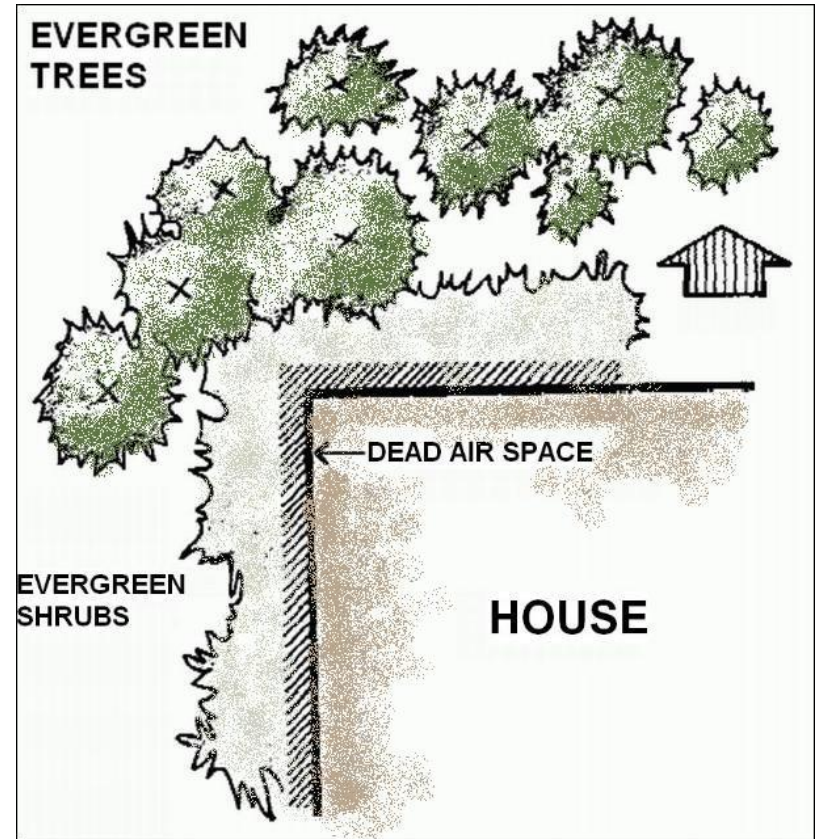
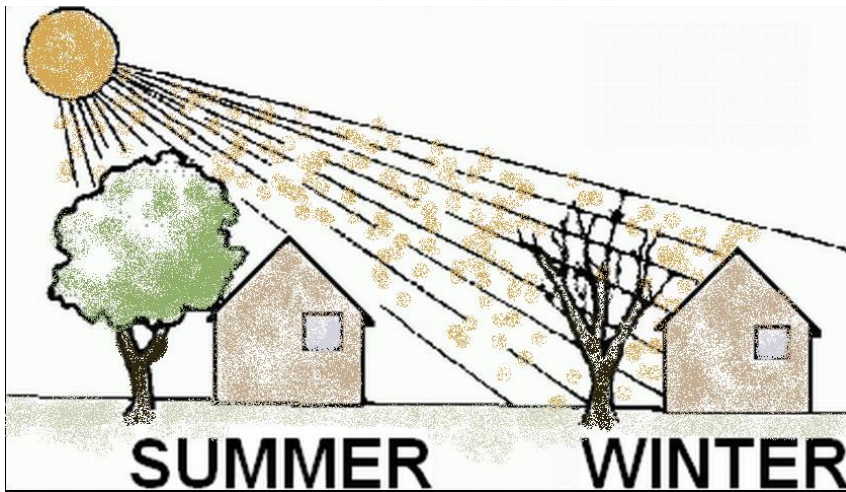
Space	Recommended R-Value
Attic	49
Wall	18
Floor	25
Crawlspace	19
Basement	11

Source: Colorado Governor's Energy Office

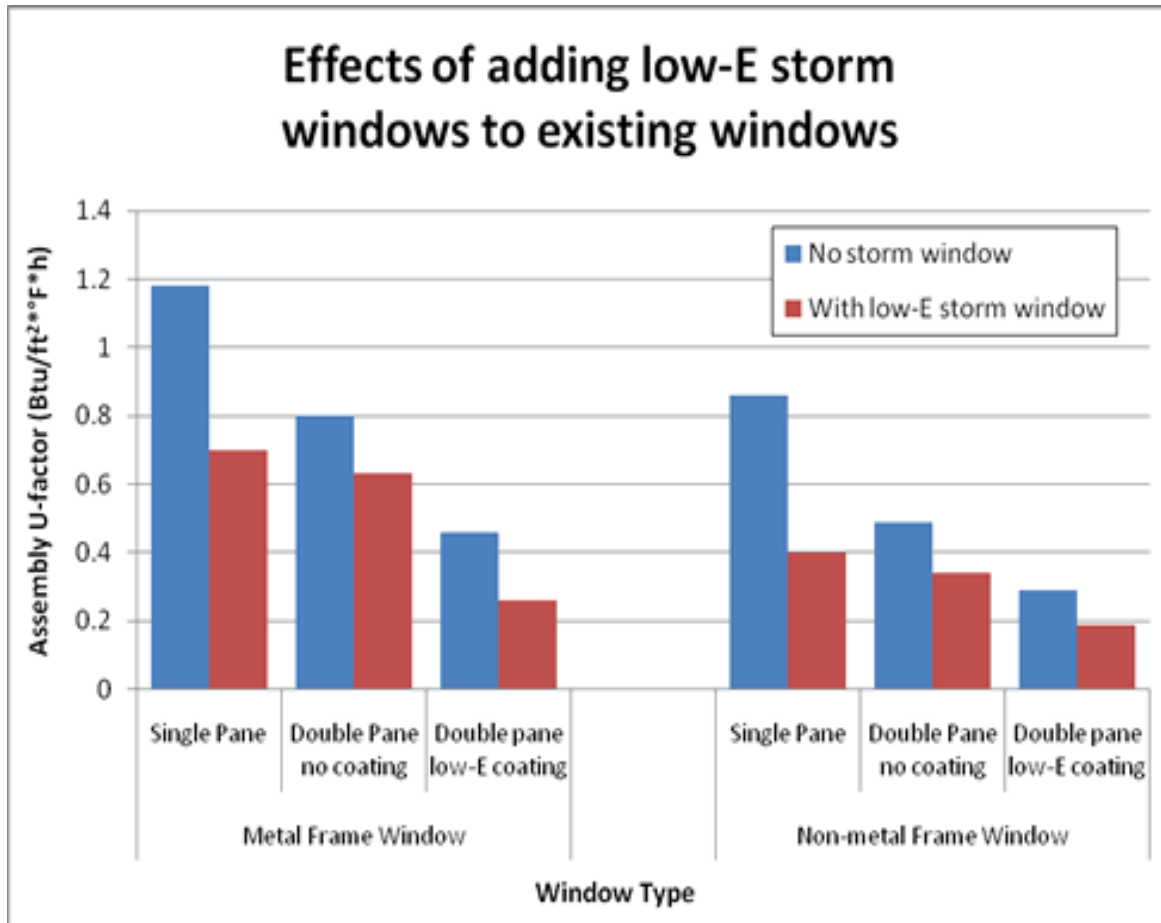
Which is better?



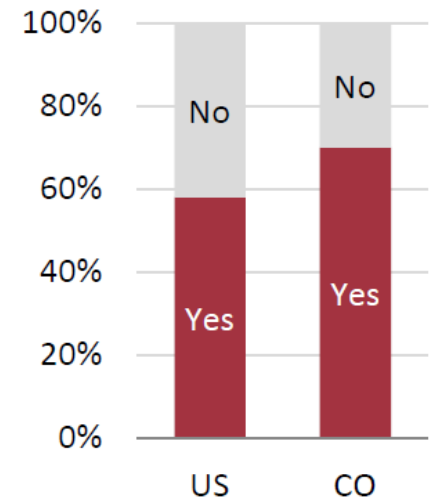
Landscaping



Existing Windows – Adding Storms



HAVE DOUBLE/TRIPLE PANE WINDOWS



US DOE Chicago study:

- 13-20% reduction in heating load
- 5-10 year simple payback

Existing Windows – Adding Treatments

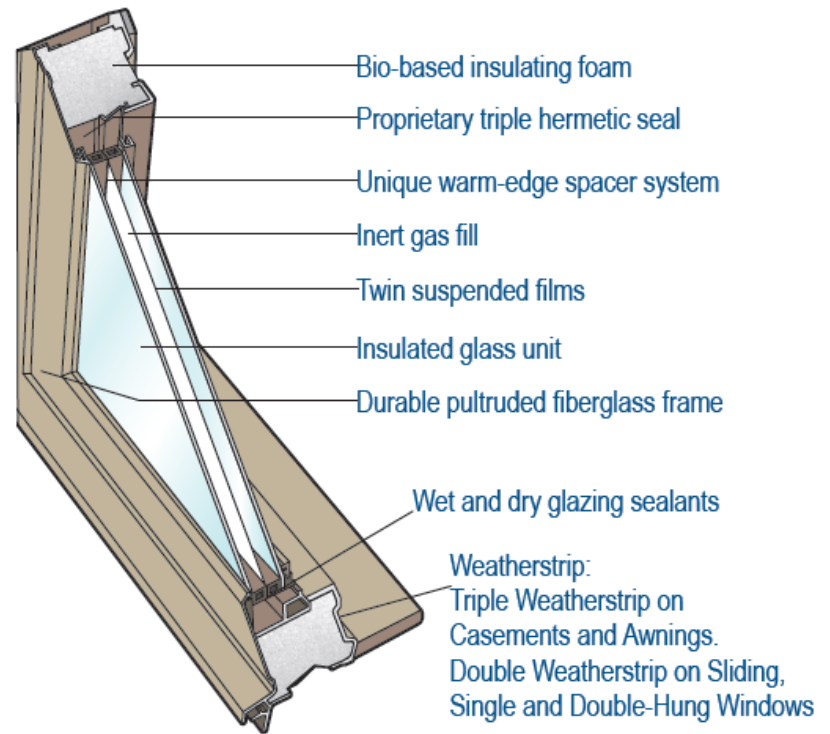
Treatment	Heat Gain/Loss Potential	Other Comments
awnings	65-77% gain reduction	no heat loss potential
interior blinds	45%	if highly reflective
draperies	heat loss by 25% if sealed and heat gain by 33%	highly variable based on fabric and color
shades	variable	some shades can insulate and control air infiltration
shutters	variable	reduce heat gain/loss and offer storm protection (exterior)

Source: US DOE



New Windows?

- **U-factor**
rate of heat loss through an assembly
- **Solar Heat Gain Coefficient**
solar radiation admitted through a window
- **Visible Transmittance**
the higher the number the more light let in



<http://www.alpenhpp.com>

Window Basics II

Frames		
Frame Type	Thermal Resistance	Other Comments
Aluminum/Metal	Poor	Strong and low maintenance
Composite	Good	Better moisture/decay resistance than conventional wood
Fiberglass	Good-Excellent	Can fill cavities with insulation for excellent thermal resistance
Vinyl	Good - Excellent	Vulnerable to warping/cracking at extreme temperatures; color fading
Wood	Good	Maintenance intensive

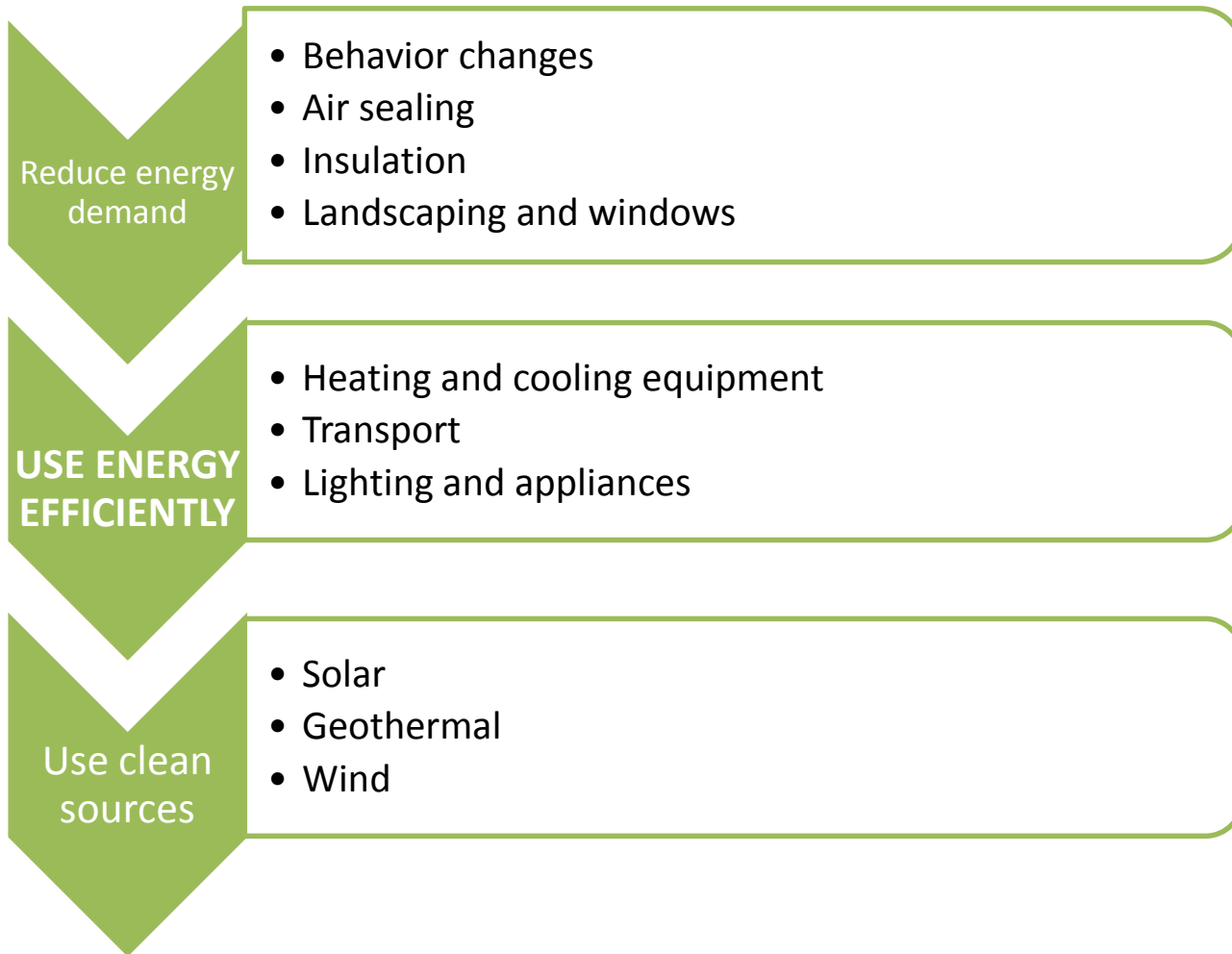
Glazing	
Glazing Feature	Performance Characteristics
Gas fills	Enhance thermal resistance
Tints	Reduce SHGC, VT
Insulated	Reduce U-factor, SHGC
Low-E Coating	Reduce U-factor; significant cost and energy savings potential; can reduce VT

Source: US DOE

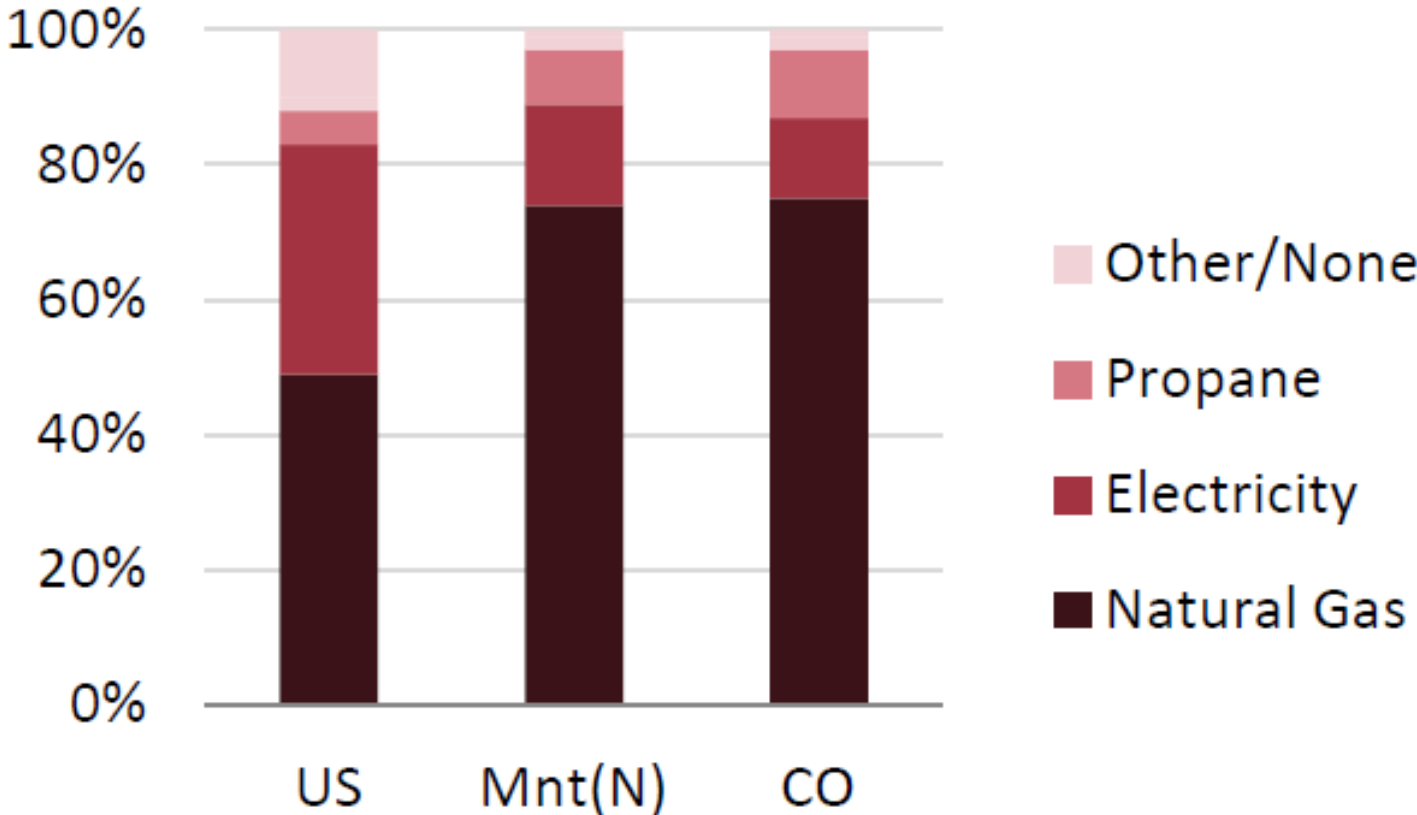
BREAK



Whole House Approach



MAIN HEATING FUEL USED



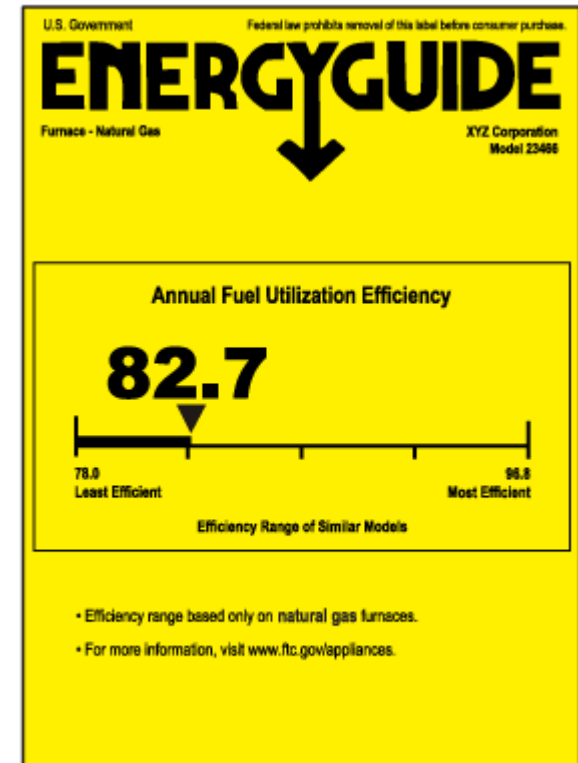
Furnaces and Boilers

70% = \$11.17

Table 1. Annual Estimated Savings for Every \$100 of Fuel Costs by Increasing Your Heating Equipment Efficiency*

Existing System AFUE	New/Upgraded System AFUE								
	55%	60%	65%	70%	75%	80%	85%	90%	95%
50%	\$9.09	\$16.76	\$23.07	\$28.57	\$33.33	\$37.50	\$41.24	\$44.24	\$47.36
55%	----	\$8.33	\$15.38	\$21.42	\$26.66	\$31.20	\$35.29	\$38.88	\$42.10
60%	----	----	\$7.69	\$14.28	\$20.00	\$25.00	\$29.41	\$33.33	\$37.80
65%	----	----	----	\$7.14	\$13.33	\$18.75	\$23.52	\$27.77	\$31.57
70%	----	----	----	----	\$6.66	\$12.50	\$17.64	\$22.22	\$26.32
75%	----	----	----	----	----	\$6.50	\$11.76	\$16.66	\$21.10
80%	----	----	----	----	----	----	\$5.88	\$11.11	\$15.80
85%	----	----	----	----	----	----	----	\$5.55	\$10.50
90%	----	----	----	----	----	----	----	----	\$5.30

*Assuming the same heat output



Source: U.S. Federal Trade Commission

Source: US DOE

Sizing and Efficiency

- Square footage
- Climate
- Heat loss and gain
- Occupant comfort

Manual J from AC
Contractors of America

Concepts

- $U * A * \Delta T =$ Transmissive load
- $0.018 * F * \Delta T =$ Exchange load
- $TL + EL =$ Output rating
- $Output / Efficiency =$ Input

Payback Time

	No Air Sealing/Insulation, Low Efficiency	Air Sealed & Insulated, Low Efficiency	Air Sealed & Insulated, High Efficiency
Furnace size	60,000 BTU	50,000 BTU	40,000 BTU
AFUE	82%	82%	95%
Installed furnace cost	\$1,500	\$1,300	\$2,200
Insulation and air sealing cost	\$0	\$1,000	\$1,000
Utility rebates	\$0	\$150	\$300
Net cost	\$1,500	\$2,150	\$2,900
Incremental cost	-	\$650	\$1,400
Therms per year	1,112	623	538
Annual operating cost	\$890	\$499	\$430
Annual savings	-	\$391	\$459
Payback period (years)	-	1.7	3.0
ROI		60.2%	32.8%
Lifetime operating cost	\$17,795	\$9,975	\$8,610
Lifetime savings	-	\$7,820	\$9,185

Divided by

Plus motor electrical savings...

Which site has the most heating efficiency?



Heating Fuel Comparison

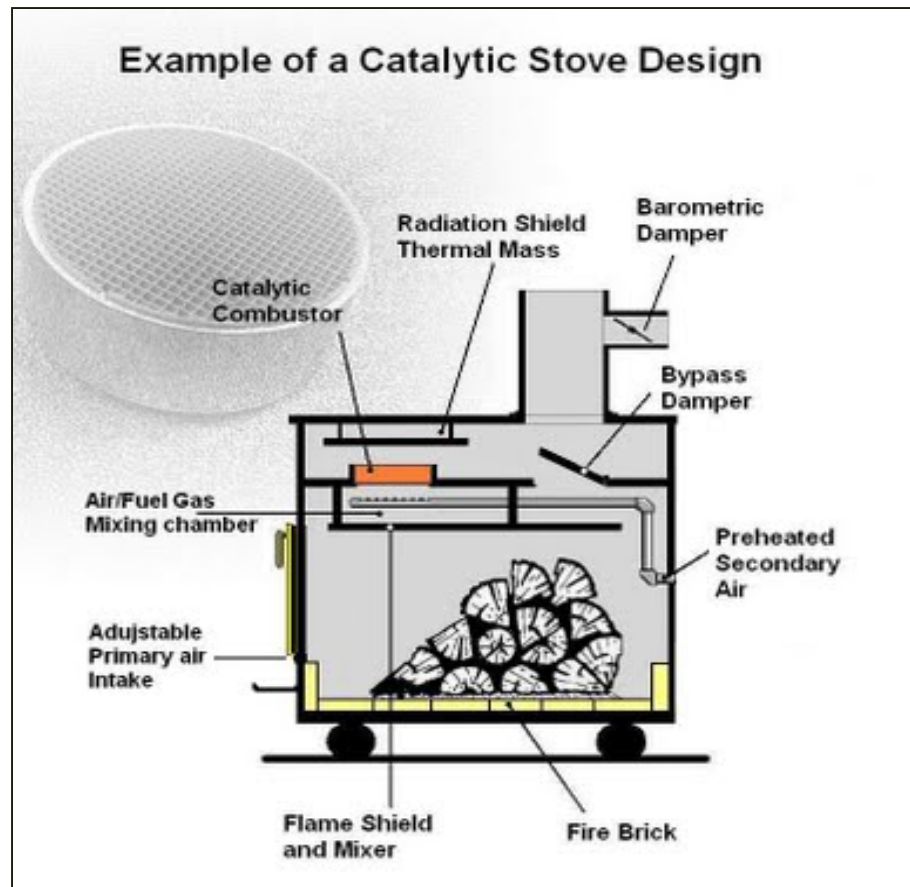
70% = \$11.17

			Cost per Unit	Fuel Price per MMBTU	Efficiency	Cost per Delivered MMBTU
Natural Gas	1,000,000	BTU per Mcf	\$7.82	\$7.82	90%	\$8.69
GSHP	3,412	BTU per kWh	\$0.12	\$35.17	300%	\$11.72
Wood	22,000,000	BTU per cord	\$200	\$9.09	72%	\$12.63
Pellets	16,200,000	BTU per ton	\$250	\$15.43	78%	\$19.78
Propane	91,500	BTU per gallon	\$2.50	\$27.32	90%	\$30.36
Electric Furnace	3,412	BTU per kWh	\$0.12	\$35.17	98%	\$35.89

Are GSHPs Really Green?

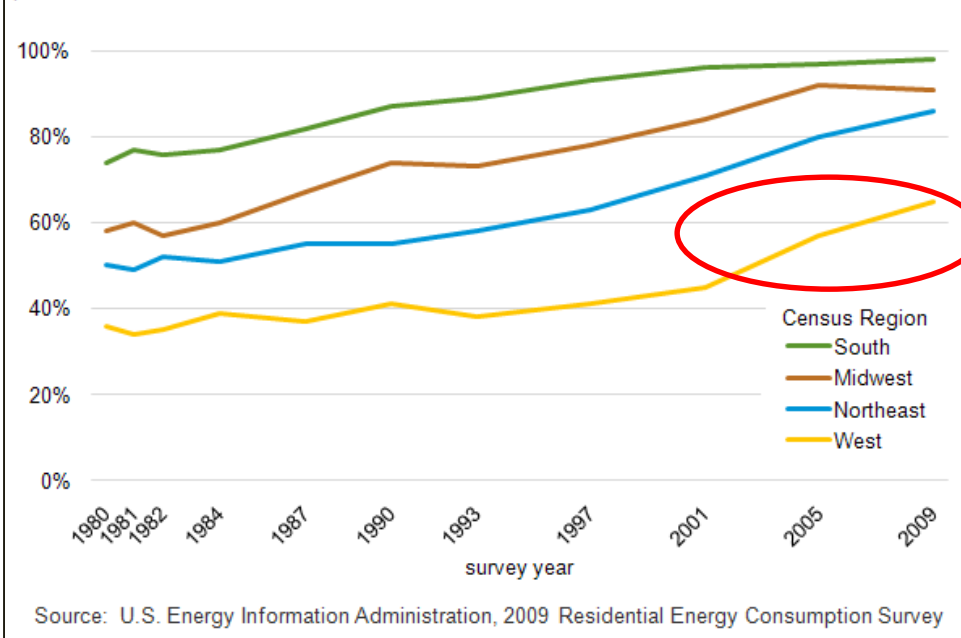
683	therms input
0.82	efficiency
560	output
56,000,000	btu output
16,413	kWh output
3	efficiency
5,471	kWh input
11.7	lbs/therm
1.4	lbs/kWh
7,990	lbs from gas
7,659	lbs from gshp
4.3%	difference

Retrofitting Wood Stoves



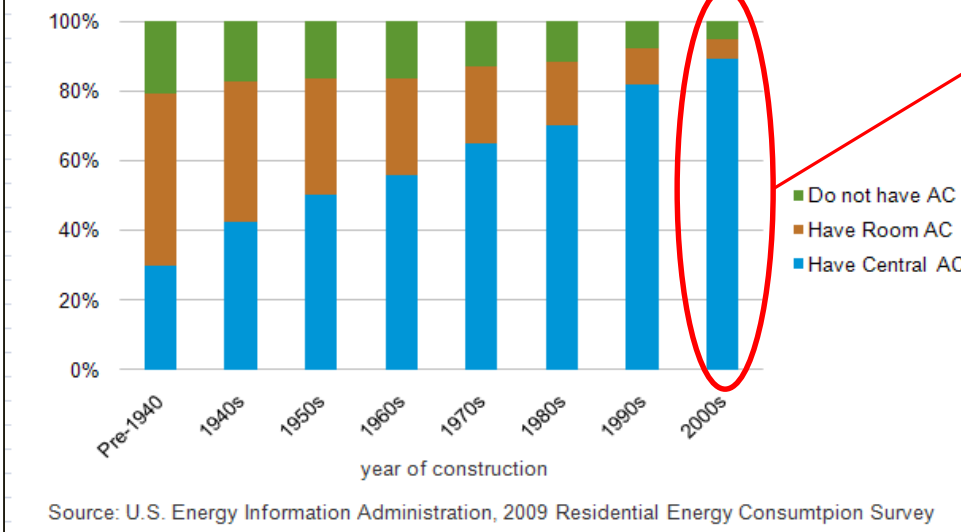
<http://firecatcombustors.blogspot.com/2010/03/where-is-catalytic-combustor-in-my.html>

Figure 1. Steady rise in air conditioned homes in all regions of the U.S.
percent of homes with AC



Population growth
+ capacity

Figure 2. Increase in central air conditioning in newer homes
percent of homes



Cooling Systems




Swamp Cooler Performance

Temperatures Delivered by Evaporative Coolers

% Relative Humidity

	2	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
75	54	55	57	58	59	61	62	63	64	65	66	67	68	69	70	71	72
80	57	58	60	62	63	64	66	67	68	69	71	72	73	74	76	76	77
85	61	62	63	65	67	68	70	71	72	73	74	75	76	77	79	81	
90	64	65	67	69	70	72	74	76	77	78	79	81	82	83	84	86	
95	67	68	70	72	74	76	78	79	81	82	84	85	87				
100	69	71	73	76	78	80	82	83	85	87	88						
105	72	74	77	79	81	84	86	88	89								
110	75	77	80	83	85	87	90	92									
115	78	80	83	86	89	91	94										
120	81	83	86	90	93	95											
125	83	86	90	93	96												

 Optimum conditions for Evaporative Coolers

Source: Ed Phillips, Arizona Almanac

Source: California Energy Commission

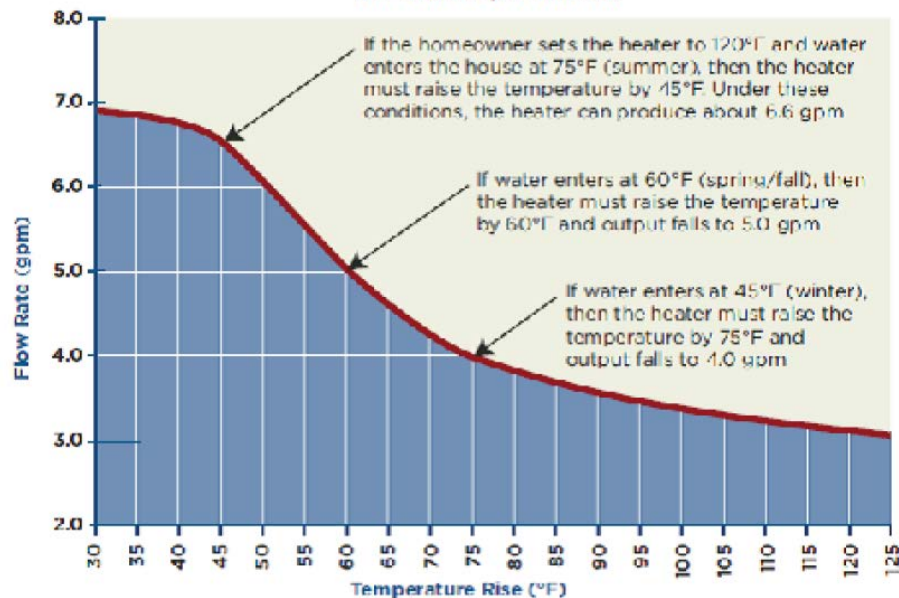
Domestic Hot Water: which one is different?



Use	Average gallons per use		Maximum times used in 1 hour		Gallons used in 1 hour
Shower/bath	10	x	2	=	20
Shaving (0.05 gpm)	2	x	1	=	2
Hand dishwashing/food prep	4	x	1	=	4
Automatic dishwashing	6	x	1	=	6
Clothes washing	7	x	2	=	14
Total peak hour demand					46

Vs.

**Comparison of Temperature Rise to Flow
(In Gallons per Minute)**



Source: "Installing On-Demand Water Heaters",
Journal of Light Construction, Feb. 2006

Transport – Ducts and Pipes



Insulate room as well?



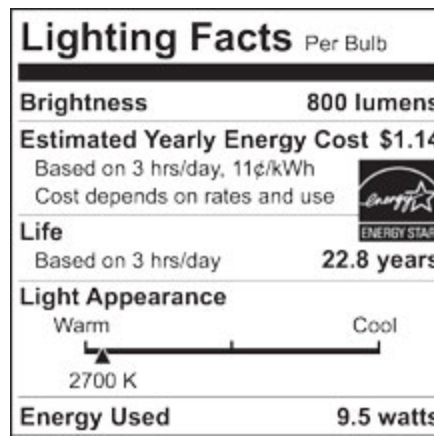
Lighting



Lighting Costs and Bennys

Bulb	Lumens	Watts	Lumens per watt	Initial cost	kWh per year	Cost per year	Lifetime (years)	# of bulbs needed over LED life	Cost of bulbs over LED life	kWh over LED life	Cost of kWh over LED life	Total costs over LED life
Incan.	630	60	10.5	\$1.50	66	\$7.23	1	23	\$34.50	1,511	\$166.22	\$200.72
Hal.	750	43	17.4	\$1.25	47	\$5.18	1	23	\$28.75	1,083	\$119.13	\$147.88
CFL	900	13	69.2	\$2.00	14	\$1.57	11	2	\$4.00	327	\$36.01	\$40.01
LED	815	11	74.1	\$7.00	12	\$1.32	23	1	\$7.00	277	\$30.47	\$37.47

Assumes 3 hours/day and \$0.11/kWh

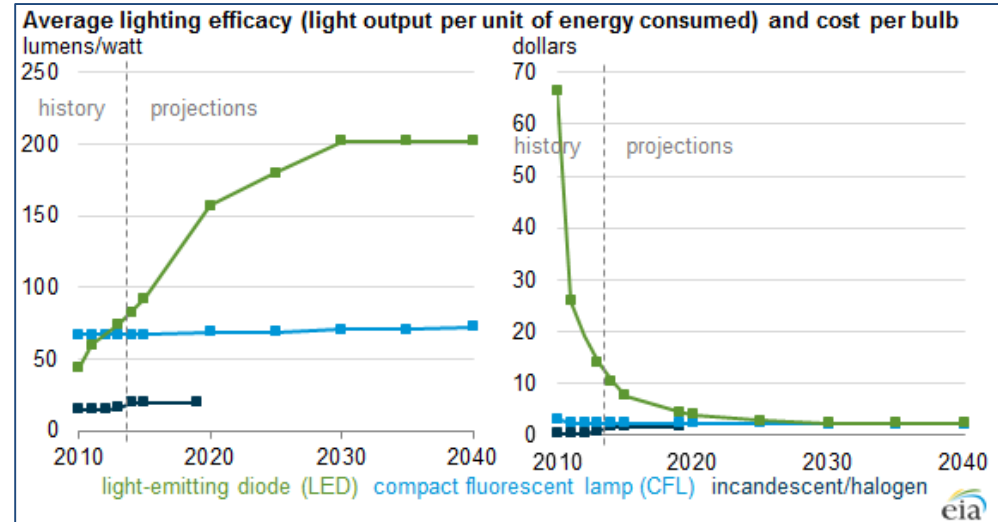


CFL vs. LED

CFL



LED

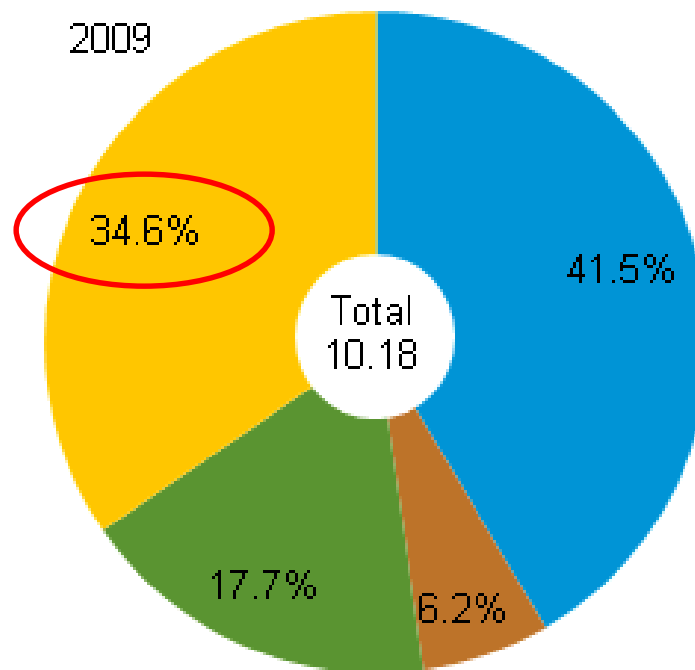
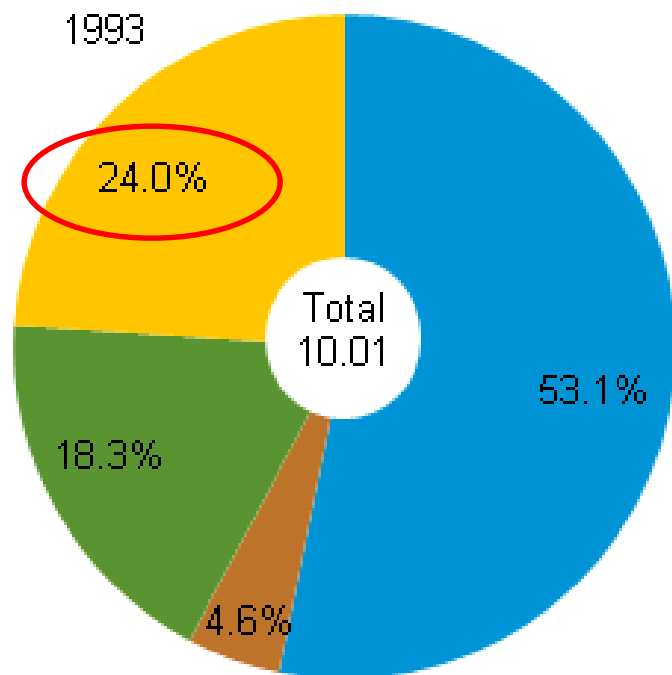


The Myth of Mercury

22.68	grams per Gwh*
0.02268	milligrams per kWh
77	watts saved from 100 watt incandescent to 23 watt CFL
4	hours/day
365	days/year
112	kWh/year
2.5	milligrams saved per CFL per year
5	milligrams in average CFL
2.0	mercury "payback" period
	(2,920 hours)

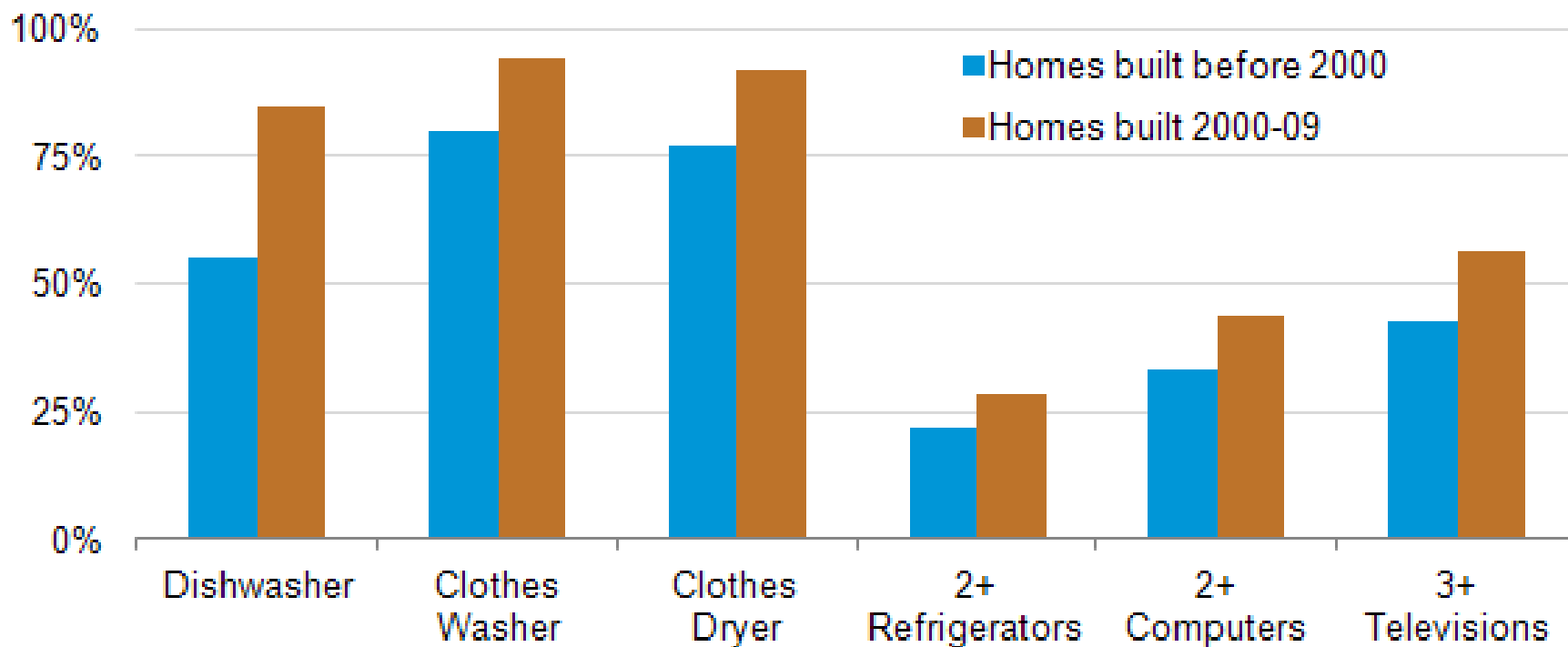
From: Focus on Energy Public Benefits Evaluation Estimating Seasonal and Peak
Environmental Emissions Factors—Final Report May 21, 2004

Energy consumption in homes by end uses quadrillion Btu and percent



■ space heating ■ air conditioning ■ water heating ■ appliances, electronics, and lighting

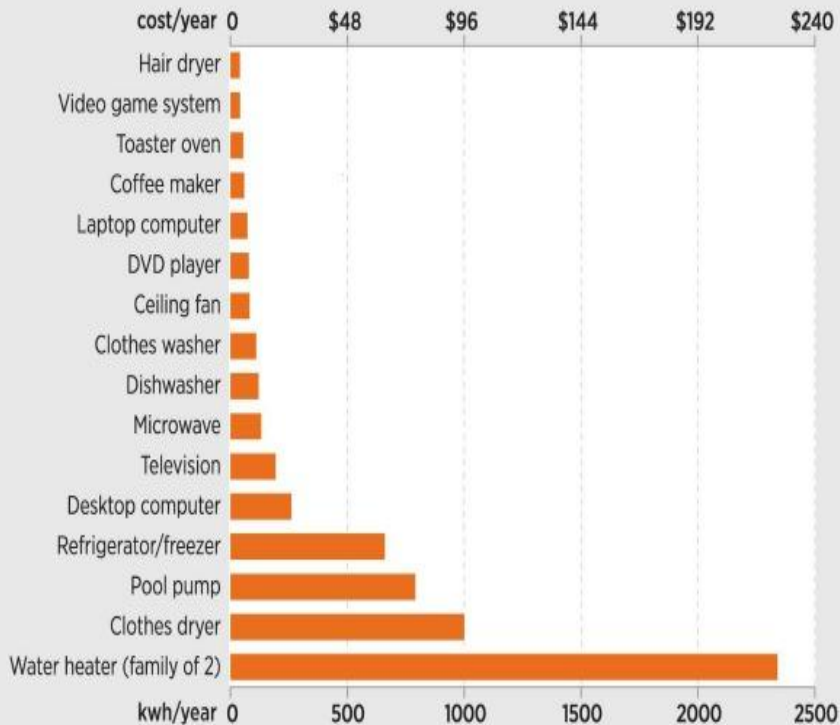
Households with selected appliances and electronics, 2009 percent of households



Appliances

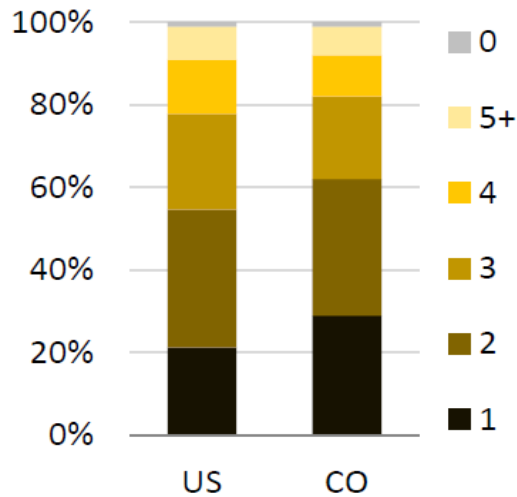


How Much Electricity Do Appliances Use?

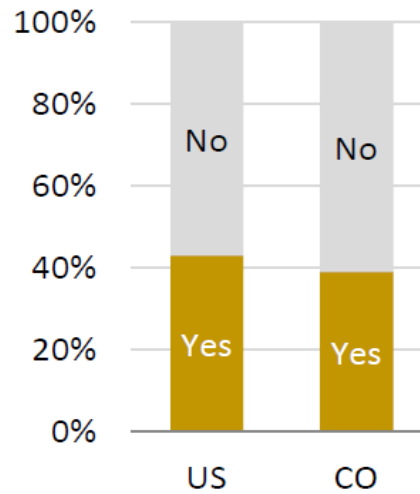


Book readin', meat lovin', front loaders

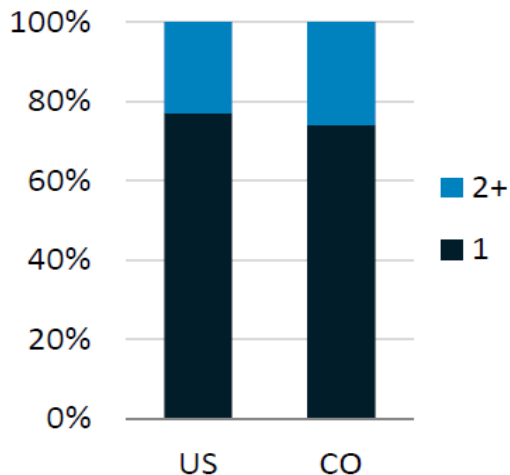
NO. OF TELEVISIONS



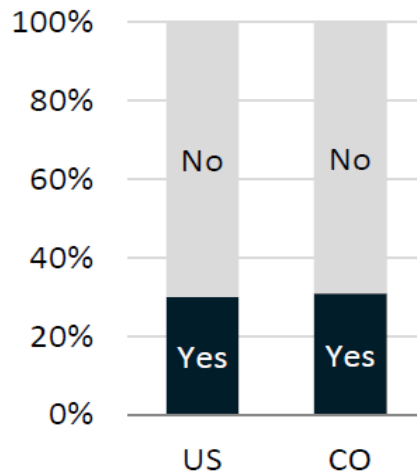
HAVE A DVR



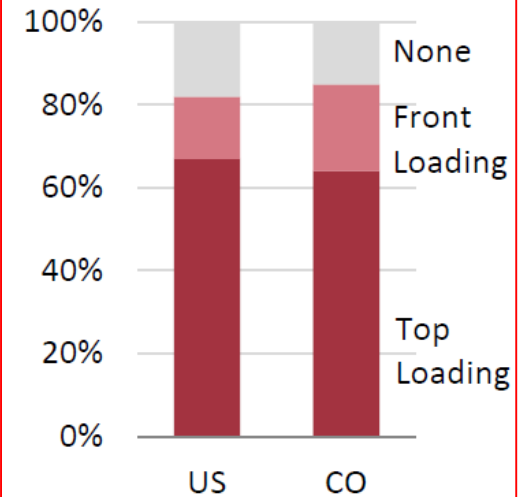
NO. OF REFRIGERATORS



HAVE A SEPARATE FREEZER



TYPE OF CLOTHES WASHER



Phantom Loss



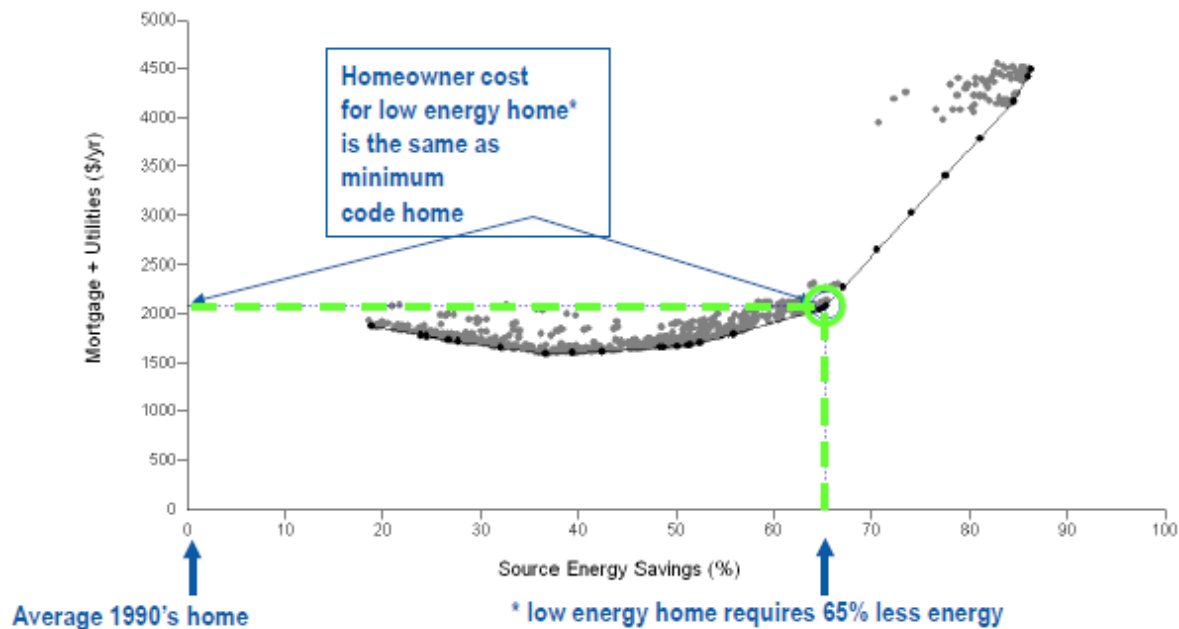
Radon Fans

- Typical radon fan = 60 watts vs. high efficiency fan = 20 watts
- Need 4" pipe
- \$130
- Payback period at \$0.10/kWh?



Net-Zero Energy Homes That Are Cashflow Neutral

• NREL Analysis using BEOpt software for Boulder,CO climate



Example taken from the "GEOS" Neighborhood. Courtesy of Wonderland Hills Development, Boulder, Colorado

NATIONAL RENEWABLE ENERGY LABORATORY

Colorado Energy Savings Mortgage

New homes

HERS Index Rating 50-40	\$2,000 benefit (State Max \$1,500)
HERS Index Rating 39-25	\$3,000 benefit (State Max \$2,000)
HERS Index Rating 24-11	\$4,000 benefit (State Max \$3,000)
HERS Index Rating 10 and below	\$8,000 benefit (State Max \$6,000)

HERS Index Rating Improvement of 10 to 20 points**	\$2,000 benefit (State Max: \$1,500)
HERS Index Rating Improvement of 21-35**	\$3,000 benefit (State Max: \$2,500)
HERS Index Rating Improvement of 36-50**	\$4,000 benefit (State Max: \$3,500)
HERS Index Rating Improvement of 51-65**	\$5,000 benefit (State Max: \$4,000)
HERS Index Rating Improvement of 66 or greater**	\$6,000 benefit (State Max: \$5,000)

Existing homes

Green MLS

TAXES *Taxes: \$ _____ *Tax Year: _____ **LOT SIZE** Approx. Acres: _____ Lot Size (sq. ft.): _____

SCHOOLS *School District: _____ *High School: _____

*Middle: _____ *Elem: _____ Elem 2: _____

UTILITIES

*Water Supplier: _____ Elec Supplier: _____ Gas Supplier: _____

CONTRACT & COMPENSATION

*Listing Contract: (Check one)

- Exclusive Right to Sell, Transaction Broker
- Exclusive Right to Sell, Agency
- Exclusive Agency/Brokerage
- Exclusive Rt to Sell, Trans Broker, with Variable Rate Commission
- Exclusive Rt to Sell, Agency, with Variable Rate Commission
- Exclusive Agency with Variable Rate Commission

*Short Pay?: Y/N

*Buyer Agency: _____

*Transaction Broker: _____
(Enter % or \$ amount above)

*Buyer Exclusion: Yes / No

Min. Earnest Money: \$ _____

Earnest Money Recipient _____

* Limited Service?: Y/N If "yes", the listing broker (select one option): _____ will arrange appts for cooperating broker OR _____ gives co-op brokers authority to make appts with seller

For Showings, contact: None / Listing Office / Listing Agent / Other: _____

MISC *Year Built _____ *New Const: Y / N *If Yes, Const. Completed?: Y / N *If No, Const. Started?: Y / N *If yes, Est. Completion Date: _____

New Construction Notes (limited to 250 characters)

Model Name _____ Builder _____ *Water Meter Installed? Y/N

*Water Rights? Y / N Well Permit # _____ Waterfront? Y / N

ENERGY/GREEN FIELDS -Note: If "Yes, Year Certified/Installed and Score are required. Documents verifying certification are also required and should be uploaded with this listing.

Certifications:	HERS Rating:	Y / N	*Year Certified: _____	*Score: _____ (0-240)
	ENERGY STAR® Qualified New Home :	Y / N	*Year Certified: _____	
	LEED for Homes:	Y / N	*Year Certified: _____	
	NAHB/NGBS-ICC 700:	Y / N	*Year Certified: _____	
Solar:	Solar PV:	Y / N	*Year Installed: _____	* Kilowatts _____
	Solar Thermal:	Y / N	*Year Installed: _____	* Type _____ (e.g. "Water")
	"Green Features Addendum" uploaded?	Y / N		

*Has an HOA? Y/N If Yes, HOA Name: _____ HOA Phone: _____ Has Covenants? Y/N

*Has Assn Fee? Y / N If Yes, *Assn.Fee = \$ _____ per _____ *Assn.Transfer Fee? Y / N *Assn. Reserve? Y / N

Green Features Addendum

1. Home Performance Programs Home Performance with ENERGY STAR
2. Construction Type: SIPS ICF Material Efficient Framing
 Improved Insulation Straw Bale Earthen Build/Rammed Earth
 Other _____
3. Heating, Cooling and Ventilation: (check box for each type)
 Ground Source Heat Pump High Efficiency Furnace/Boiler (eg. $\geq 90\%$ AFUE)
 Tankless/On Demand Water Heater High Efficiency Water Heater (eg. $\geq 90\%$, or EF $\geq .82$ for gas)
 Evaporative Cooling Whole House Fan Ceiling Fans
 High SEER A/C SEER Rating: _____ Insulation Air Sealing Upgrades Completed
 Home Orientation (South Facing Overhangs)
4. Water Efficient Features: Low Flow Toilets Low Flow Fixtures/Shower Heads
 Low Water sod Hot Water Recirculation Pump/Structured Plumbing
 Xeriscaping Greywater System
 WaterSense by ENERGY STAR
5. Indoor Air Quality: Indoor Air Quality Plus by ENERGY STAR No or Low VOC Paint
 Heat Recovery Ventilator/Fresh Air System Radon Mitigation System
 Green Guard Certified Carpet / Flooring (documentation required)
 No Formaldehyde Certified Cabinetry (documentation required)
6. Sustainable Materials: FSC Certified Lumber FSC Certified Cabinets Recycled Content
 Reclaimed Flooring Sustainable Flooring Regionally Harvested
7. Energy Features: ENERGY STAR/Low E Windows (documentation required) Automated Lighting Controls
 Orientation/Passive Solar Design High Efficiency Lighting
 ENERGY STAR Rated Roof (documentation required) Programmable Thermostat
8. ENERGY STAR Appliances: Refrigerator Range/Oven Dishwasher Clothes Washer

Mixed Results

- 2009 study in WA (Griffin et. al):
 - Value Increased When Descriptions for Sustainable/Green Features Are Added to an MLS Listing
 - Referencing Third Party Verification in the MLS is Important
 - Consumers are Willing to Pay More for Environmentally Friendly / Cost Saving Homes
- Appraisers need comparables
- Only 1/3 of eligible green features entered properly into CO MLS
- Green MLS fields optional in CO

David W. Scott, Colorado
Landmark, Realtors

Closing Thoughts

- Challenges –
 - low energy prices
 - peer chicken and egg
 - where to start?
 - impact?
- Opportunities –
 - audit/HERS a reference doc/score
 - some sexy techs
 - financing, rebates, and adding value
 - low-hanging fruit and the conservation identity

What's Right for You?

