Towards Zero Energy Homes
(Six Case Studies)

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www.buildingscience.com
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Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

4: MULTI-FAMILY - CLEVELAND, OH

2002 Cleveland, OH Eco-Village Infill Town-Houses

2400 sq. ft. @$80/sq. ft. Utilities = $75/month with PV's = $35/month

2002 Cleveland, OH Eco-Village Infill Town-Houses

2002 Cleveland, OH Eco-Village Infill Town-Houses

Cleveland EcoVillage Townhouses

Project Highlights (1666 sf House)

Building Enclosure	R-19 2x6 24 oc + R-5 walls R-38 vented attic Low E windows (U-0.36, SHGC-0.45) R-10: 2" XPS on basement walls R-8 2" EPS under entire slab BSC BA Airtightness (2.5 ins/100 sf)
Mechanical	90%+ AFUE Sealed-Combustion Furnace 12 SEER Air Conditioner Split System 0.59 EF Power-Direct Vent Water Heater Fan cycler ventilation system
Solar Site Collection	3.8 kW Peak PV system

Energy Performance

	MMBtu/yr
Heating	38.6
Cooling	5.4
Hot water	21.4
Light/Appl	n/c
Sub-total	65.4
Solar PV Collection	-13.5
Total Predicted Use	51.9
MEC 95 Predicted Use	130.8
% Savings vs MEC 95	60%

Enclosure Details

- R-38 ceiling
- R-19 24" o.c. walls with 1" XPS sheathing
- R-10 basement walls
- R-8 slab insulation
- Double glazed low e windows (U=0.36, SHGC=0.45)
- 2.5 sq in leakage area per 100 sf envelope

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Utility Bill Analysis

- 20 units in development
- Gas & electric bills for 11 units
- Mix of four different floor plans; end and middle units
- Each unit ~1600 sf (above grade only)
- Mix of basement & slab on grade units

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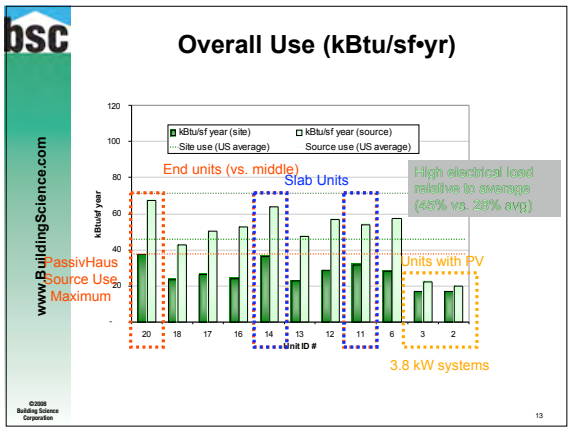
Overall Use (kBtu/sf•yr)
www.BuildingScience.com
kBtu/sf year (site)
kBtu/sf year (source)
Site use (US average)
Source use (US average)
End units (vs. middle)
Slab Units
High electrical load relative to average (45% vs. 28% avg)
PassivHaus Source Use Maximum
Units with PV
3.8 kW systems
kBtu/sf year
Unit ID #
20 18 17 16 14 13 12 11 6 3 2
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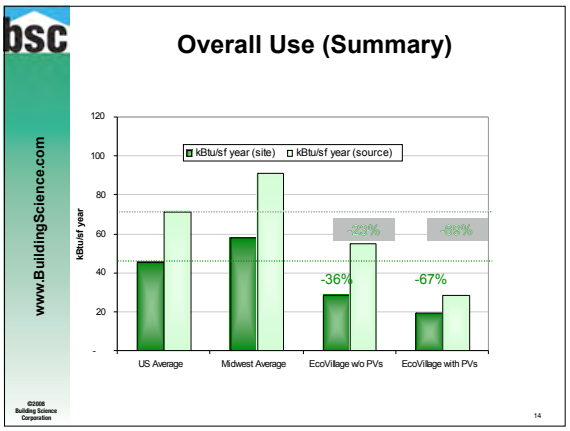
Overall Use (Summary)
www.BuildingScience.com
kBtu/sf year (site)
kBtu/sf year (source)
kBtu/sf year
-23%
-88%
-36%
-67%
US Average
Midwest Average
EcoVillage w/o PVs
EcoVillage with PVs
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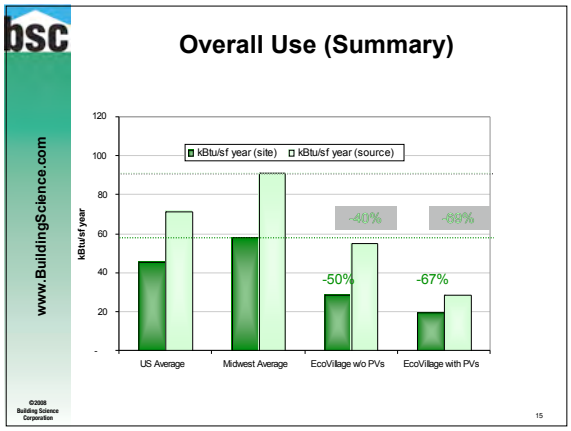
Overall Use (Summary)
www.BuildingScience.com
kBtu/sf year (site)
kBtu/sf year (source)
kBtu/sf year
-40%
-88%
-50%
-67%
US Average
Midwest Average
EcoVillage w/o PVs
EcoVillage with PVs
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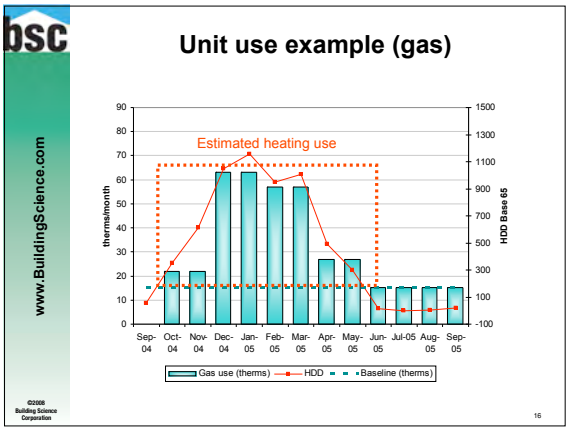
Unit use example (gas)
www.BuildingScience.com
Estimated heating use
therms/month
HDD Base 65
Sep-04 Oct-04 Nov-04 Dec-04 Jan-05 Feb-05 Mar-05 Apr-05 May-05 Jun-05 Jul-05 Aug-05 Sep-05
Gas use (therms)
HDD
Baseline (therms)
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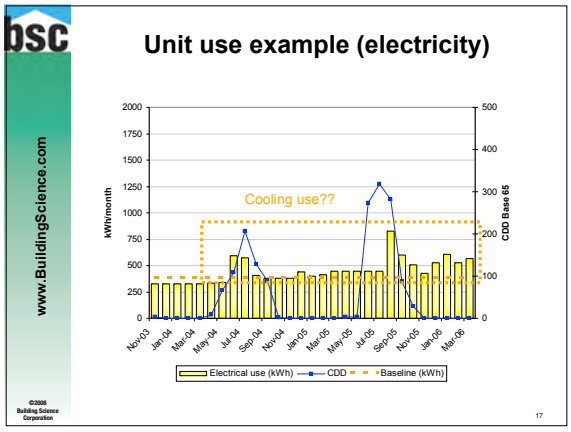
Unit use example (electricity)
www.BuildingScience.com
Cooling use??
kWh/month
CDD Base 65
Nov03 Jan-04 Mar-04 May-04 Jul-04 Sep-04 Nov-04 Jan-05 Mar-05 May-05 Jul-05 Sep-05 Nov-05 Jan-06 Mar-06
Electrical use (kWh)
CDD
Baseline (kWh)
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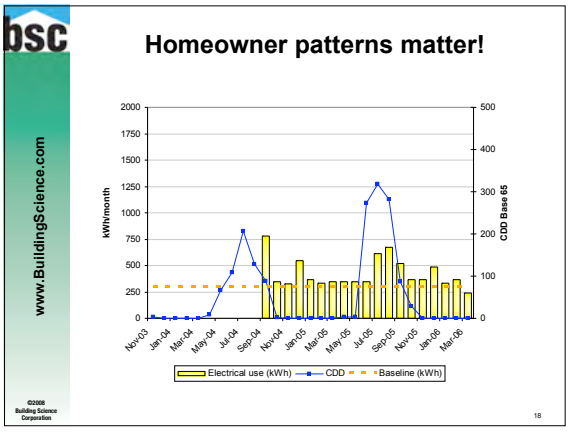
Homeowner patterns matter!
www.BuildingScience.com
kWh/month
CDD Base 65
Nov03 Jan-04 Mar-04 May-04 Jul-04 Sep-04 Nov-04 Jan-05 Mar-05 May-05 Jul-05 Sep-05 Nov-05 Jan-06 Mar-06
Electrical use (kWh)
CDD
Baseline (kWh)
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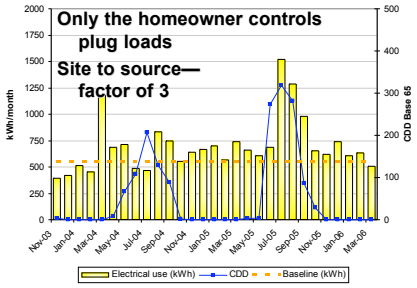
Homeowner patterns matter!



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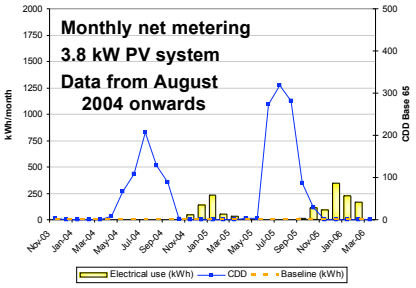
As do photovoltaics…



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5: MULTI-FAMILY - ASPEN, CO

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2006 Aspen, Colorado Burlingame Ranch

1000 sq. ft. @ $150/sq. ft. Utilities = $50/month

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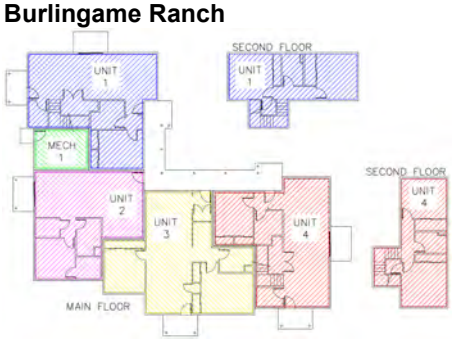
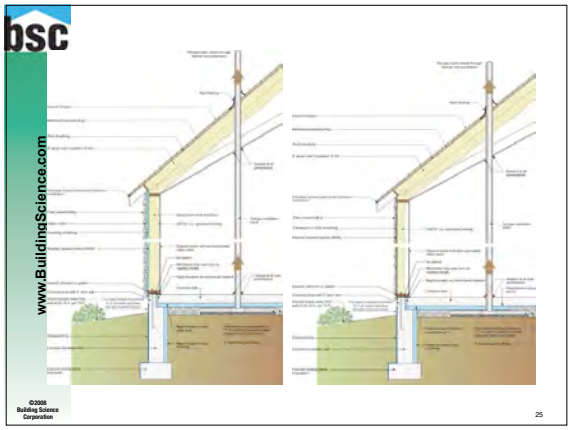
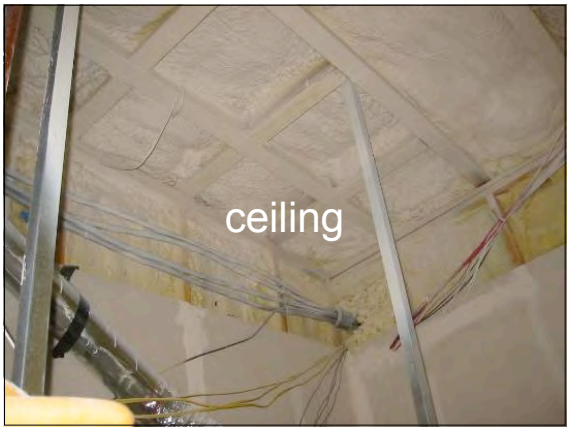
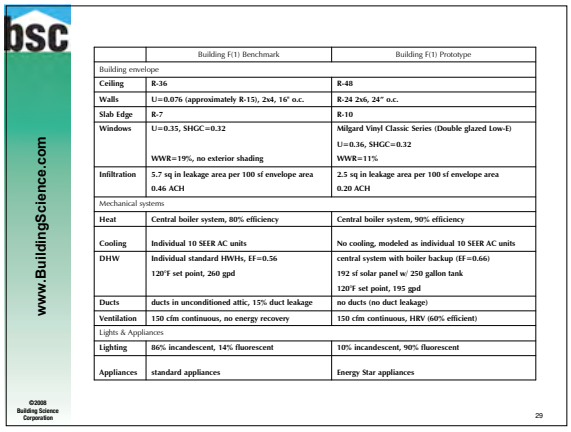
Burlingame Ranch



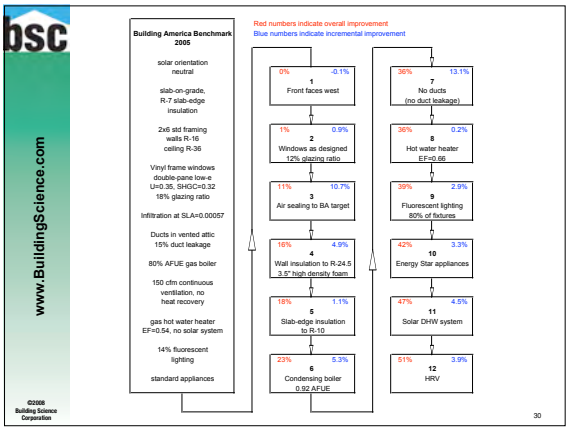
Four units: One 1 bedroom + one 2 bedroom + two 3 three bedroom = 5,500 sq. ft.

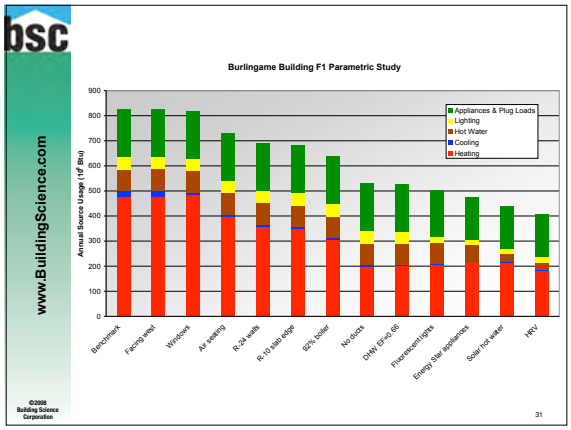


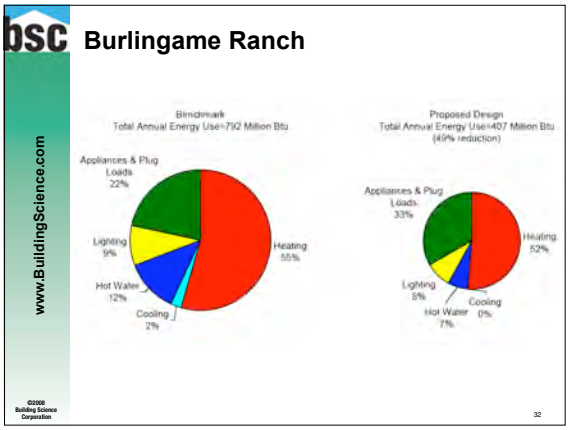


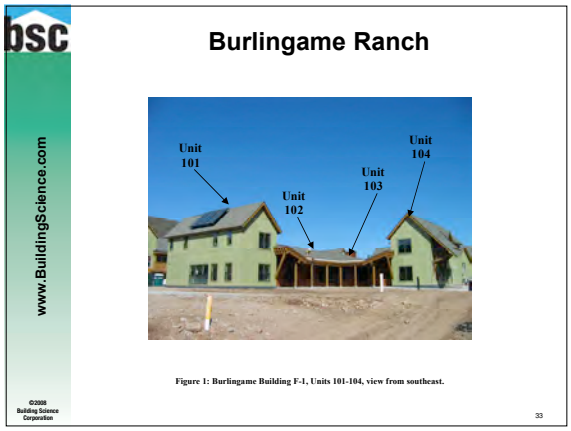


	Building IECC Benchmark	Building IECC Prototype
Building envelope		
Ceiling	R-36	R-48
Walls	U=0.076 (approximately R-15), 2x4, 16" o.c.	R-24 2x6, 24" o.c.
Slab Edge	R-7	R-10
Windows	U=0.35, SHGC=0.32 WWR=19%, no exterior shading	Milgard Vinyl Classic Series (Double glazed Low-E) U=0.36, SHGC=0.32 WWR=11%
Infiltration	5.7 sq in leakage area per 100 sf envelope area 0.46 ACH	2.5 sq in leakage area per 100 sf envelope area 0.20 ACH
Mechanical systems		
Heat	Central boiler system, 80% efficiency	Central boiler system, 90% efficiency
Cooling	Individual 10 SEER AC units	No cooling, modeled as individual 10 SEER AC units
DHW	Individual standard HWHs, EF=0.56 120°F set point, 260 gpd	central system with boiler backup (EF=0.66) 192 sf solar panel w/ 250 gallon tank 120°F set point, 195 gpd
Ducts	ducts in unconditioned attic, 15% duct leakage	no ducts (no duct leakage)
Ventilation	150 cfm continuous, no energy recovery	150 cfm continuous, HRV (60% efficient)
Lights & Appliances		
Lighting	86% incandescent, 14% fluorescent	10% incandescent, 90% fluorescent
Appliances	standard appliances	Energy Star appliances









Burlingame Ranch

Surface	ELA (in^2) (4 Pa)	EqLA (in^2) (10 Pa)	As-Built EqLA/100 ft^2	Target EqLA/100 ft^2
Unit 101 to Outside	32.4	60.9	1.5	<2.5
Unit 101 to Unit 102	15.1	28.4		
Unit 102 to Outside	13.1	24.6	0.8	<2.5
Unit 102 to Unit 103	13.6*	25.6*		
Unit 103 to Outside	25.3	47.6	2.0	<2.5
Unit 103 to Unit 104	3.8	7.1		
Unit 104 to Mechanical Room	2.1	3.9		
Unit 104 to Outside	32.1	60.4	1.4	<2.5

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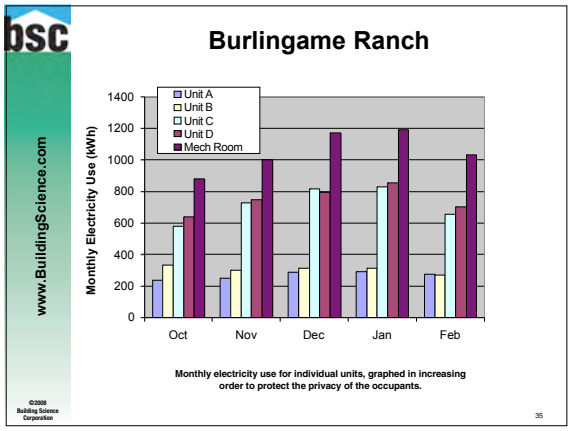

Actual Measured Savings

End Use	Estimated Annual Source Energy Benchmark (MBtu/yr)	Prototype (MBtu/yr)	Percent of End-Use (MBtu/yr)	Percent of Total (MBtu/yr)
Space Heating	623	324	48%	30%
Space Cooling	2	2	0%	0%
DHW	90	44	51%	5%
Lighting	80	32	60%	5%
Appliances + MELs	186	158	15%	3%
OA Ventilation	8	19	-138%	-1%
Total Usage	989	580	41%	41%
Site Generation	0	0		
Net Energy Use	**989**	**580**	**41%**	**41%**

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