Realizing residential emissions reductions: The case for a Web-based geospatial CBSM tool

US EPA – 17th International Emission Inventory Conference
June 04, 2008

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Program for Resource Efficient Communities
University of Florida IFAS Extension

Overview

- Climate change & buildings
  - The burden of the built environment
  - The (missed) opportunity of energy efficiency
- Web-based geospatial building performance and community-based social marketing (CBSM) tool
  - Why is it needed?
  - Why should it be transparent and address-based?
  - How can it serve as a catalyst for change?

Acknowledgements

- Acceleration
  - Rebecca Birx
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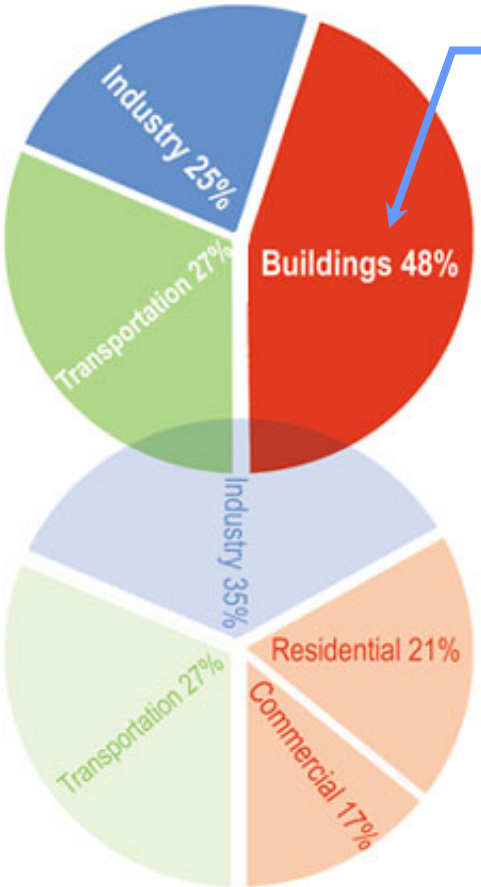
  - M. Jennison Kipp
  - Brent Philpot
  - Kathleen Ruppert
  - Sam Snyder
  - Nick Taylor

Climate Change

- The IPCC (AR4) Synthesis Report states "warming of the climate system is unequivocal…[and] most of the observed increase in global average temperatures since the mid-20th century is *very likely* (>90%) due to the observed increase in anthropogenic greenhouse gas concentrations" an increase in likelihood since the IPCC Third Assessment Report (IPCC, 2007, pp. 2, 6)

Buildings…Both Problem & Solution

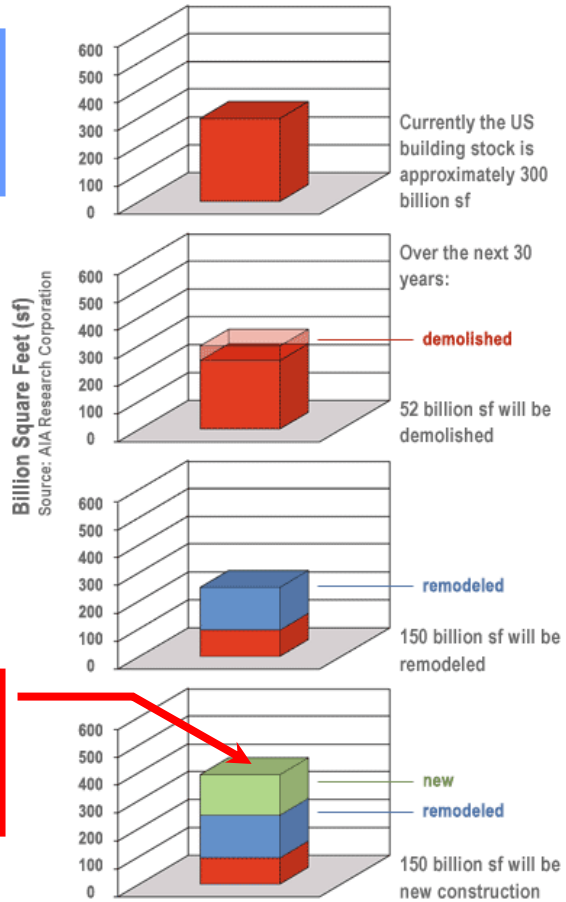
U.S. Energy Consumption (by Sector)



15-25% Const.
75-85% Ops.

75% Turnover
in 30 Years

U.S. Building Stock 2005 - 2035



Source: http://www.architecture2030.org/building_sector/index.html

The Wedge(s) of Efficiency

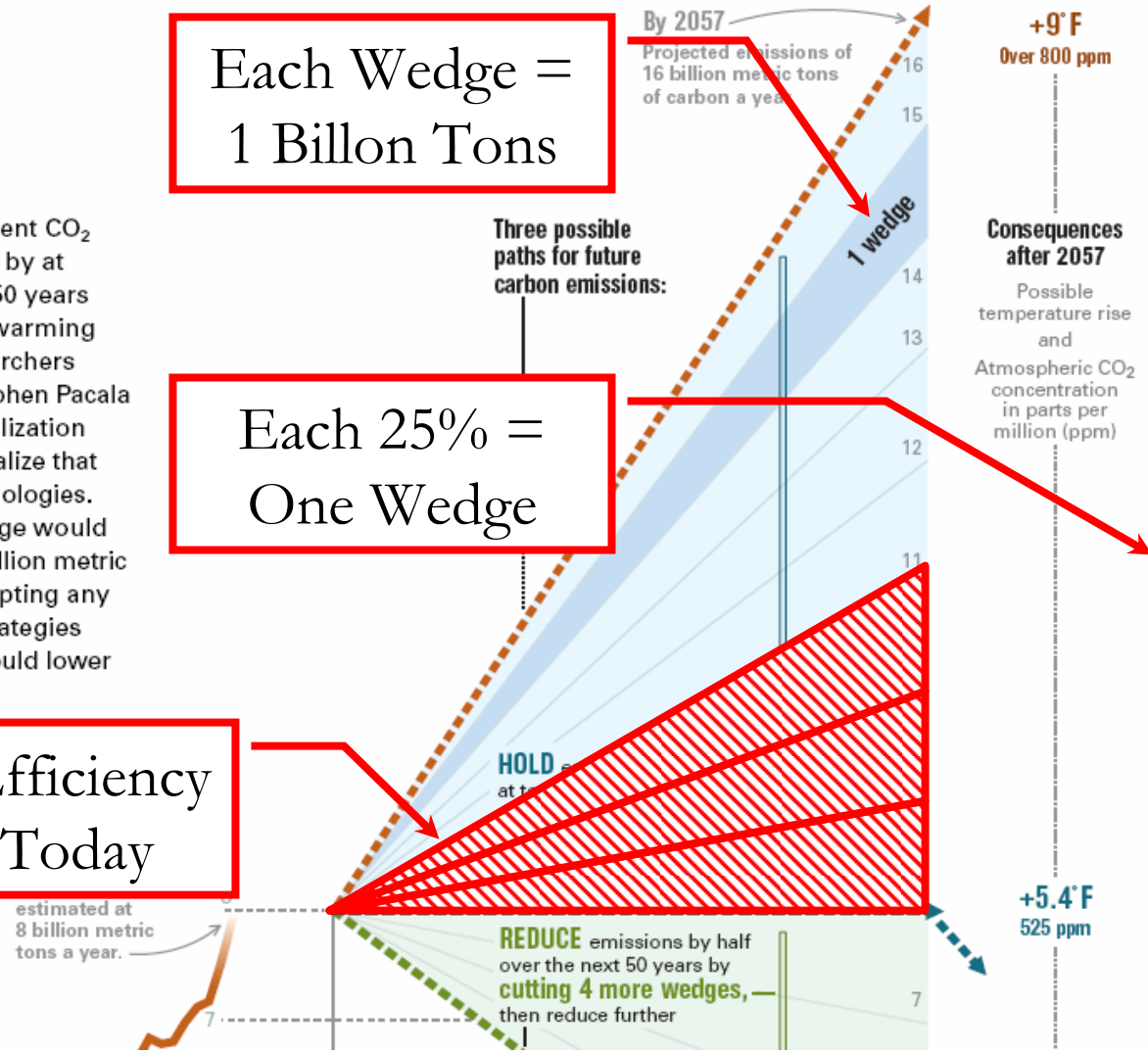
How to Cut Emissions

Scientists warn that current CO_2 emissions should be cut by at least half over the next 50 years to avert a future global warming disaster. Princeton researchers Robert Socolow and Stephen Pacala have described 15 "stabilization wedges" (far right) to realize that goal using existing technologies. Each carbon-cutting wedge would reduce emissions by a billion metric tons a year by 2057. Adopting any combination of these strategies that equals 12 wedges could lower emissions 50 percent.

Each Wedge = 1 Billon Tons

Each 25% = One Wedge

~ 70% ↑ Efficiency Possible Today



ONE WEDGE AT A TIME

Each strategy listed below would, by 2057, reduce annual carbon emissions by a billion metric tons.

EFFICIENCY AND CONSERVATION

- Improve fuel economy of the two billion cars expected on the road by 2057 to 60 mpg from 30 mpg.
- Reduce miles traveled annually per car from 10,000 to 5,000.
- Increase efficiency in heating, cooling, lighting, and appliances by 25 percent.
- Improve coal-fired power plant efficiency to 60 percent from 40 percent.

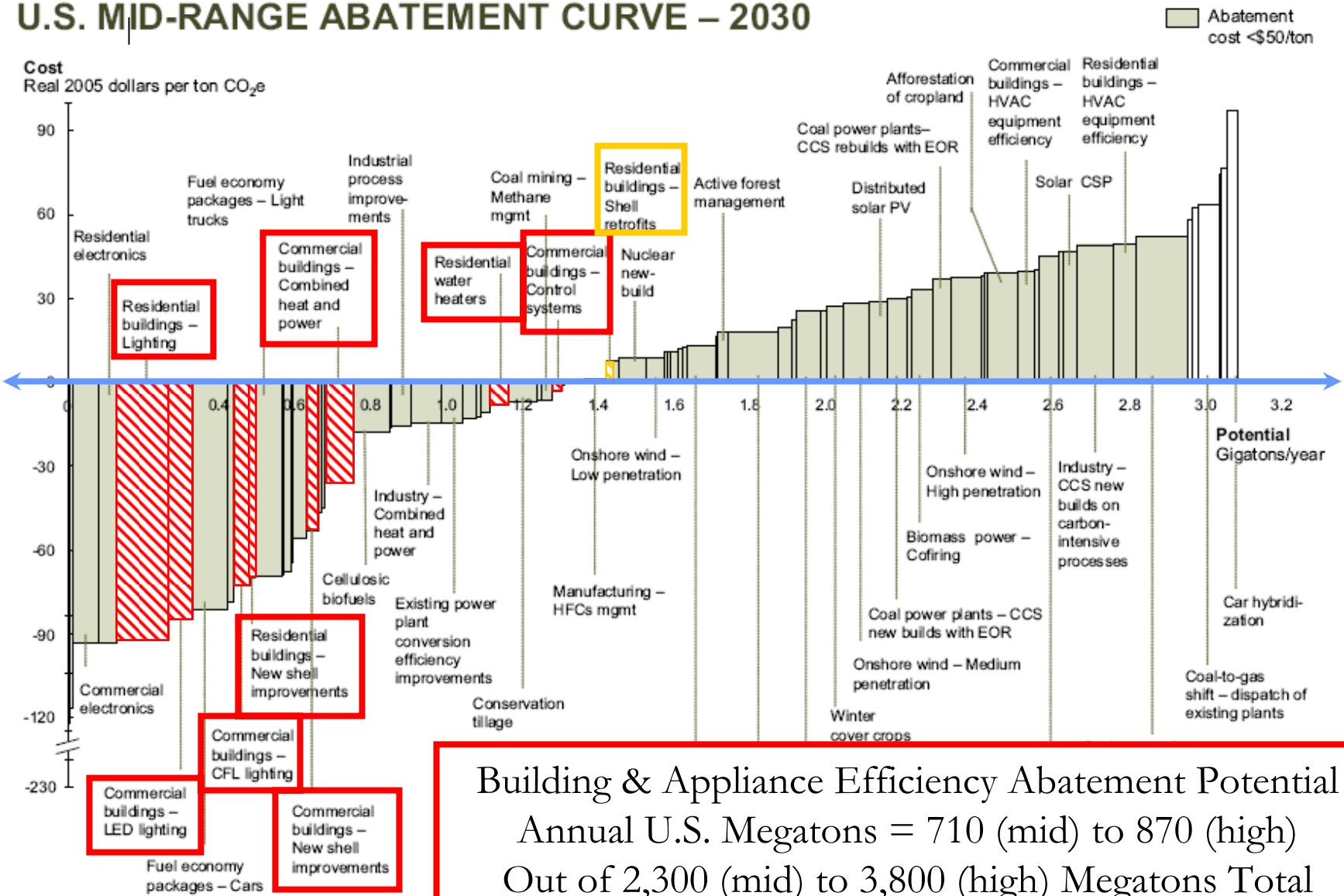
CARBON CAPTURE AND STORAGE

- Introduce systems to capture CO_2 and store it underground at 800 large coal-fired plants or 1,600 natural-gas-fired plants.
- Use capture systems at coal-derived hydrogen plants producing fuel for a billion cars.
- Use capture systems in coal-derived synthetic fuel plants producing 30 million barrels a day.

Sources: Robert H. Socolow & Stephen W. Pacala, Princeton University (Updated Report); Oak Ridge National Laboratory (Global Carbon Emissions Data); Icons by Jonathan Avery; Graphic by Juan Velasco, NGM Art

Exhibit B

U.S. MID-RANGE ABATEMENT CURVE – 2030



Building & Appliance Efficiency Abatement Potential
Annual U.S. Megatons = 710 (mid) to 870 (high)
Out of 2,300 (mid) to 3,800 (high) Megatons Total

Source: McKinsey analysis

Source: Creyts, J., Derkach, A., Nyquist, S., Ostrowski, K., & Stephenson, J. (2007, December 2007). *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?*, from http://www.mckinsey.com/clientservice/ccsi/greenhousegas.asp

Green Building Metrics are Proliferating

WE SELL ENERGY STAR

Building AMERICA U.S. Department of Energy

AUDUBON INTERNATIONAL

U.S. GREEN BUILDING COUNCIL

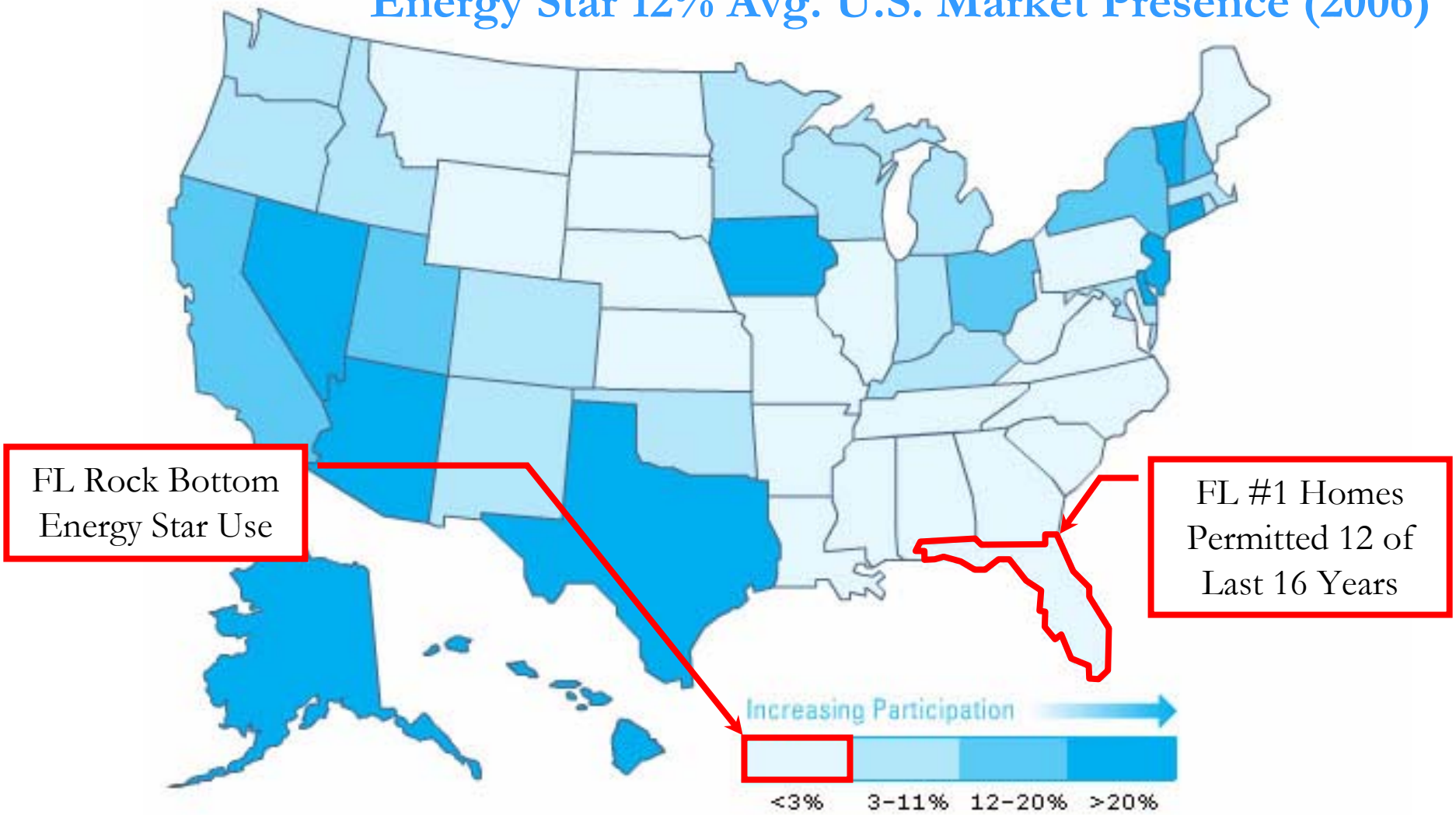
GREEN GLOBES

Florida Green Building Coalition, Inc.
Setting the standards for Green Building in the State of Florida

Green Built Homes of Florida
Save money. Save energy. Save resources.

But Are These Metrics Working?

Energy Star 12% Avg. U.S. Market Presence (2006)



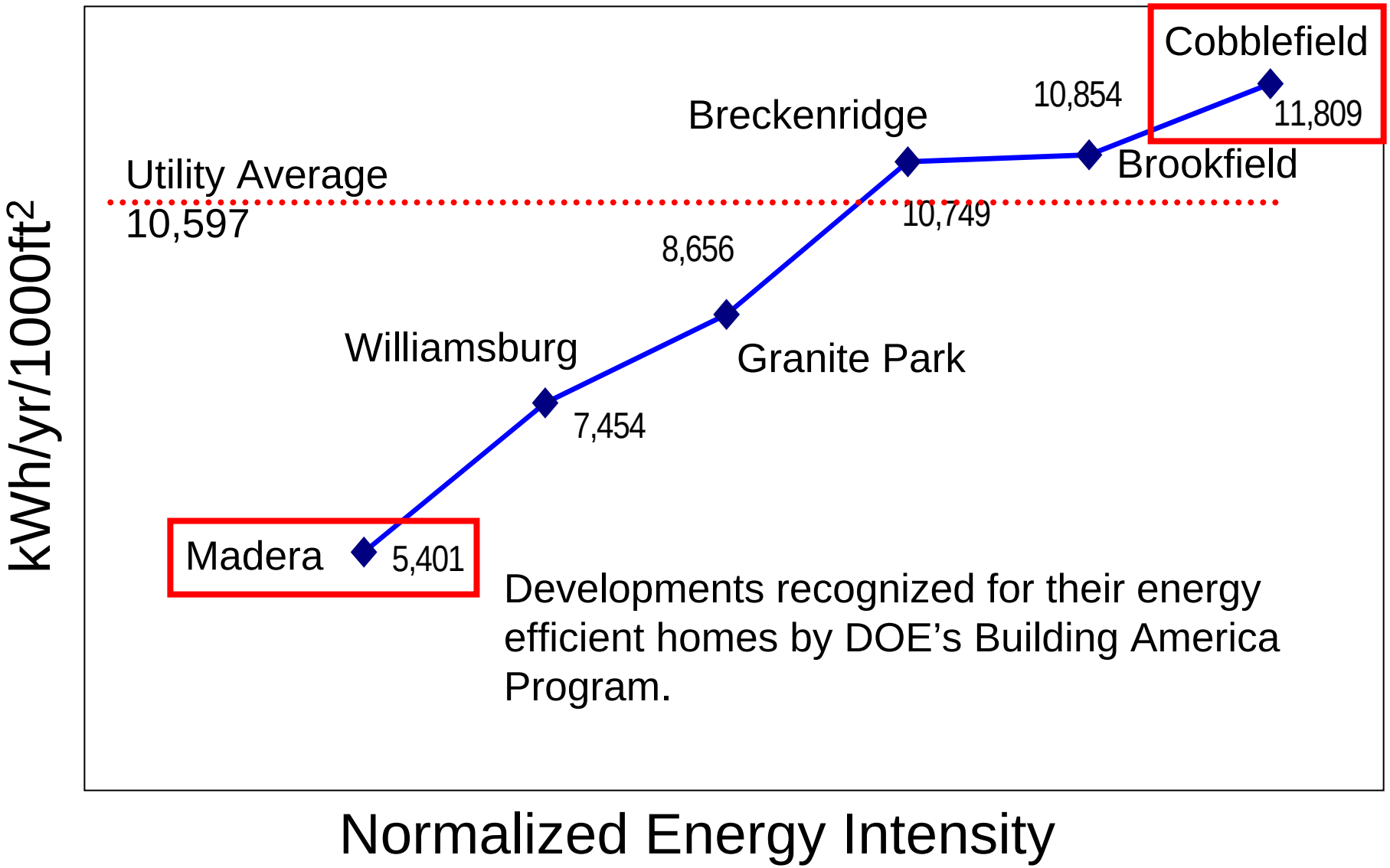
Source: http://www.energystar.gov/index.cfm?fuseaction=qhmi.showHomesMarketIndex

Which Home is More Efficient per S.F.?

- Madera (Gainesville, FL)
  - 4073 SW 21st Terrace
  - Built 2004
- $445,000 (Sold 11/2006)
- 4 bed / 3 bath @ 2,900 s.f.

- Cobblefield (Gainesville, FL)
  - 1220 SW 90th Terrace
  - Built 2004
- $549,900 (List 05/2008)
- 5 bed / 3 bath @ 3,245 s.f.

Efficiency is More than a Label



Source: University of Florida (NOTE: Preliminary Data)

Are Models Predictors of Reality?

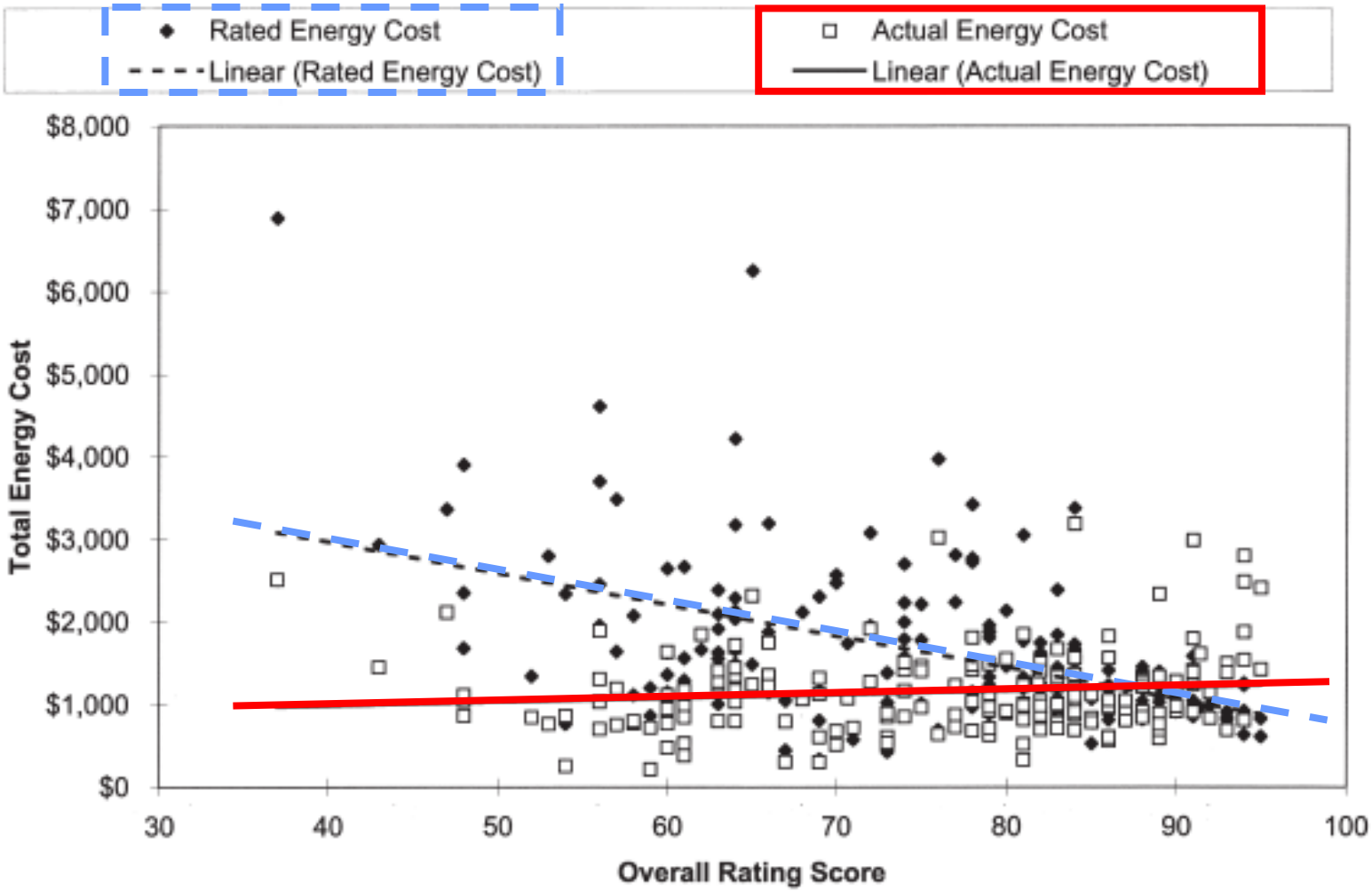


Fig. 1. CHEERS: actual energy use versus rating score.

Source: (Stein & Meier, 2000)
http://dx.doi.org/10.1016/S0360-5442(99)00072-9

Models: Background & Limitations

- US DOE archives 342 energy software tools
- Limitations (Mills, 2004; Stein & Meier, 2000)
  - Minimal availability of measured end-use data
    - Utilities often prevent disclosure
  - Inability to facilitate meaningful comparisons
  - Very little published data on HERS' predictive ability
  - Actual occupant behavior = single largest determinant of energy use
  - Few HERS providers archive records and/or freely release data

Models: Background & Limitations

- "Perhaps the most valuable finding of the FSEC analysis is the fact that it was possible to improve significantly the predictive ability of the rating tool based on the data collected"

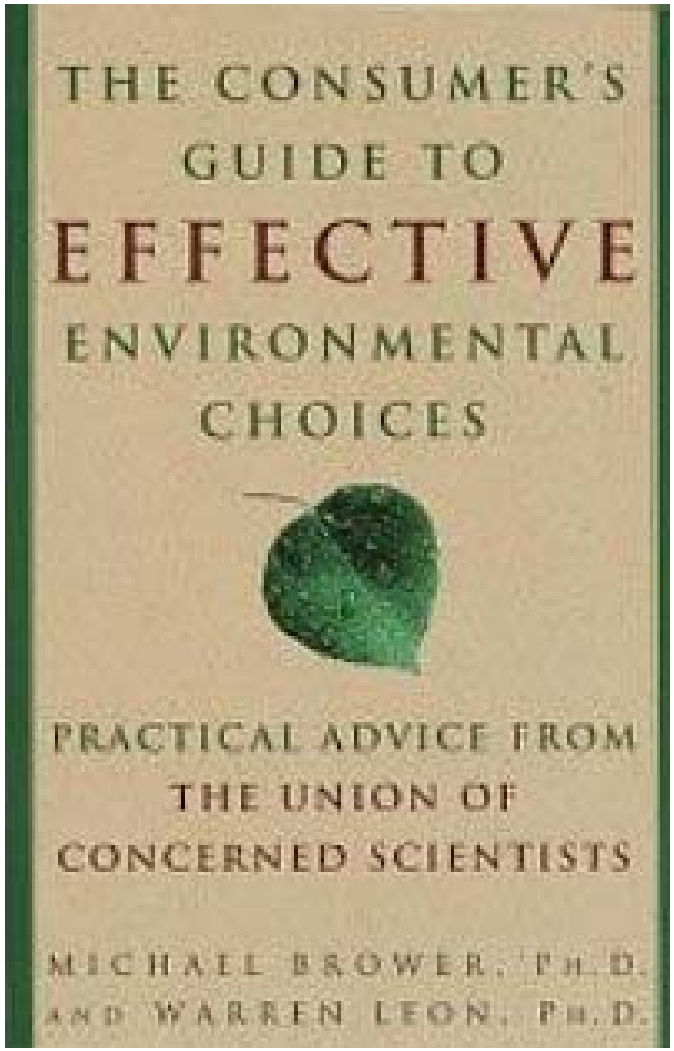
  (Stein & Meier, 2000, p. 344)

- "The design of residential energy analysis tools should be grounded in social science as well as engineering, with close attention given to the intended use and audience"

  (Mills, 2004, pp. 878-879)

Consumer Behavior & Non-Point Sources

- 4 Leading Environmental Problems
  - Air pollution
  - Climate change
  - Habitat alteration
  - Water pollution
- 7 Most Harmful Activities
  - Cars & light trucks
  - Meat & poultry
  - Fruit, vegetables, & grains
  - Home heat, hot water, & AC
  - Household appliances & lighting
  - Home construction
  - Household water & sewage



The Spread of Obesity in a Large Social Network over 32 Years

Article date: 2007/07/26

"…people's perceptions of their own risk of illness may depend on the people around them. Smoking- and alcohol-cessation programs and weight-loss interventions that provide peer support — that is, that modify the person's social network — are more successful than those that do not…The observation that people are embedded in social networks suggests that both bad and good behaviors might spread over a range of social ties."

Source: http://content.nejm.org/cgi/content/full/357/4/370

Home Improvement

- Common Home Problems
- Home Energy Yardstick
- Home Energy Audits
- Air Seal & Insulate
- Heat & Cool Efficiently
- Home Performance with ENERGY STAR
- Home Improvement FAQs
- For Contractors
- For Insulation Manufacturers

Join ENERGY STAR

Home > Home Improvement > **Home Energy Yardstick**

Home Energy Performance Results

Energy & Environmental Performance

Your score: 9.6 out of 10

Your score is excellent and your energy use is well below average. 96% of U.S. homes use more energy than you.

Tell us about your home

Your home energy use is in the top 20% of U.S. homes. What is your story? What did you do to achieve such a low energy use?

Take Action

1. Replace your 5 most frequently used lights or the bulbs in them with ones that have earned the ENERGY STAR.
2. Look for ENERGY STAR Products. Available in more than 50 product categories, including lighting and home appliances.
3. Heat and cool efficiently. Have your heating and cooling equipment serviced annually and remember to replace air filters regularly. Use a programmable thermostat, and when it's time to replace old equipment, choose an ENERGY STAR qualified model.
4. Seal up your home. Seal air leaks, add insulation and choose ENERGY STAR qualified windows when replacing.

About Your Home & Energy Use [Edit Info]

User Must Input All Utility Bill Data

About Your Home

Zip Code: 32605
People Living in Home: 2
Square Footage of Home: 1440
Home Built: 1950s
Heating Degree Days: 1315
Cooling Degree Days: 2333

Energy Use from 01-Apr-2007 to 31-Mar-2008

Billing Period	Use (Natural Gas)	Bill Amount (Natural Gas)	Use (Electricity)	Bill Amount (Electricity)
1	0 CCF or Therms	$7	634 kWh	$59.44
2	0 CCF or Therms	$7	269 kWh	$23.31
3	0 CCF or Therms	$7	587 kWh	$56.55
4	0 CCF or Therms	$7	537 kWh	$51.46
5	0 CCF or Therms	$7	921 kWh	$94.90
6	0 CCF or	$7	589 kWh	$57.54

Home Energy Saver Making It Happen

About HES | What's New | Energy Librarian | Glossary | FAQ | Search | Help

Help us improve the site.Click here

General Info | Heating & Cooling | Water Heating | Major Appliances | Small Appliances | Lighting

Session ID: 1075470
Zipcode: 32605
Location: Gainesville, Florida

Initial Results: Your Energy Bill ($/year)

Existing Home **$1396**

with Selected Upgrades **$1115**

	Heating	Cooling	Water Heating	Major Appliances	Lighting	Small Appliances
Existing Home	$ 434	$ 213	$ 291	$ 161	$ 190	$ 107
With Selected Upgrades	$ 330	$ 149	$ 244	$ 159	$ 126	$ 107

Potential Annual Savings	
Money:	$281
Energy:	2,382 kWh & 28 Therms
CO_2 Emissions:	3,711 lb. CO_2

More detail on energy and CO_2 emissions...

Map Your Home's Carbon Footprint

Instructions | **Existing Home Configuration:** View | Change | Map

View or Modify Upgrade Details **View Upgrade Report**

From < 10 to > 180 User Inputs

Selected Upgrade Package for your Home

Upgrades Requiring Investment

1. Electric water heater
2. Electric clothes dryer
3. Indoor lights
4. Duct Sealing
5. Windows
6. Air sealing
7. Refrigerator
8. Duct Insulation
9. Ceiling fan
10. Cool roof
11. Attic insulation
12. Clothes washer
13. Slab insulation
14. Gas furnace

Comparing Results to your Utility Bill | See typical costs of running various appliances

Home Energy Saver Carbon Footprint

Footprint map | Summary Stats | Add your home | Making it Happen | Librarian | About

Scale

- 0-5 + | - 5.1-15 + | - 15.1-999

defaults | Prefs | Save & Re-render New Scale Values ?

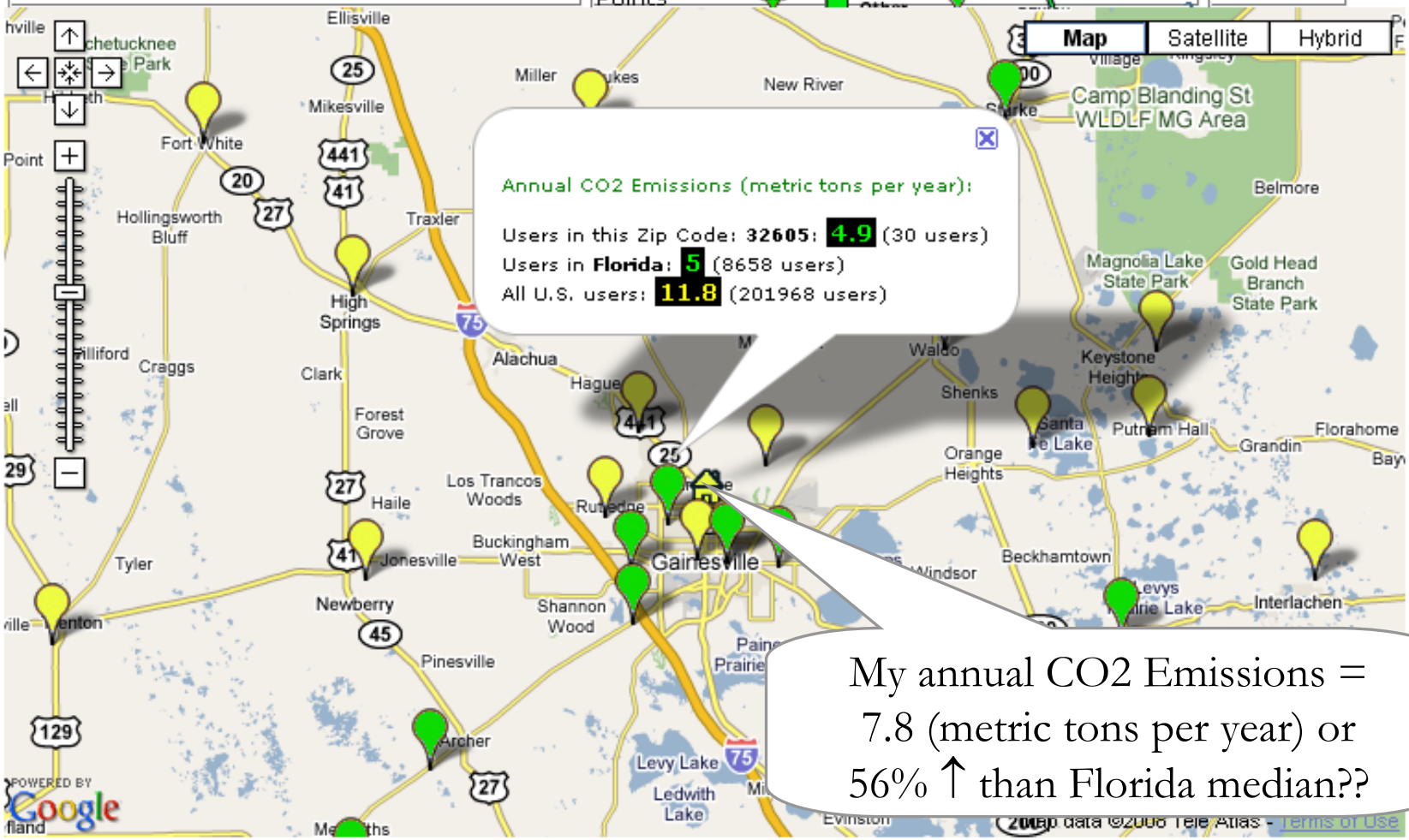
Map Points Selector

☑ Medians by Zipcode/State (depends on zoom level) ?

☐ Individual users

Points

Map Activity



My annual CO2 Emissions = 7.8 (metric tons per year) or 56% ↑ than Florida median??

Counts

Median:Pin Count =27

Zip Locator

Zip Search(5 digit): Berkeley CA 94708 Find!

Current View

Zip-code level

A Vision for Change

- "The long-term vision held by many in the building science community is one [energy analysis tool] involving virtual (collaborative) 'life-cycle' building tools that simulate actual buildings and their construction coupled with intelligent systems that monitor and archive design intent and performance and feed the results back to the simulation tools, which in turn, grow more refined through integrating better empirical data"
  (Mills, 2004, p. 865)

Data Transparency is Expanding

- California Assembly Bill No. 1103, Chapter 533, Section 25401.10 of the Public Resources Code
  - By January 1, 2009 electric and gas utilities must disclose ≥ 12 months consumptive use data for non-residential buildings (via Energy Star Portfolio Manager)
- EU mandates Energy Performance Certificates & Home Information Packs
- However, campaigns that rely solely on providing information often have little or no effect upon behavior
  - GIS Web-tool is a platform, not an end in itself
  - CBSM is a process in need of a platform

Zillow.com®
Your Edge in Real Estate

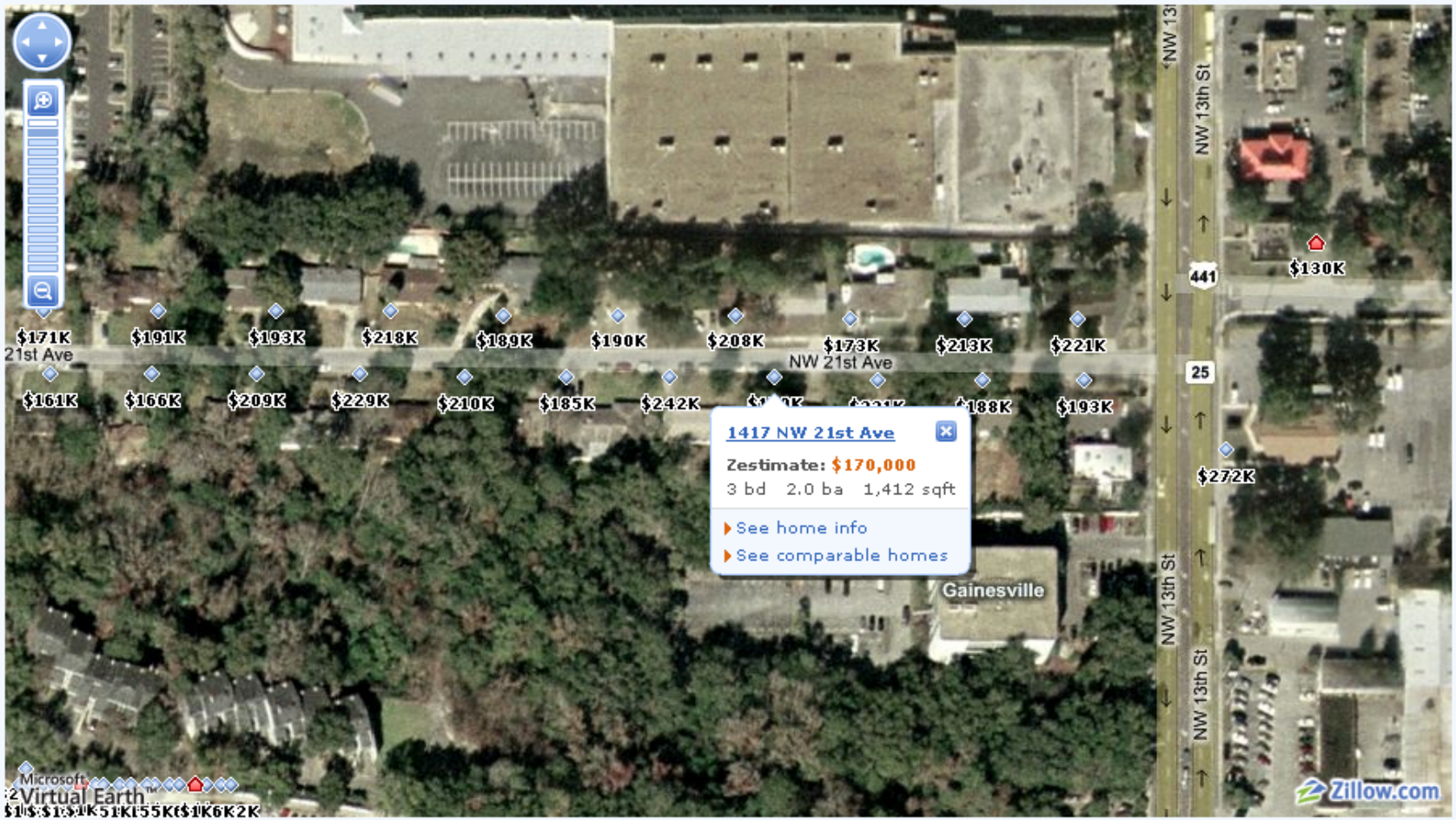
Welcome! Sign In or

Map & Search | NEW! Mortgage | Real Estate Guide | Discussions | My Zillow | Post a home for sale

Find homes: Address OR Street: 1417 nw 21st avenue | Neighborhood, City, State OR ZIP: gainesville, fl | GO

FL » Alachua county » Gainesville » 32605 » Showing Homes

Street Aerial Hybrid



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Sort by: Weeks On Zillow | Low to High

See homes in a list

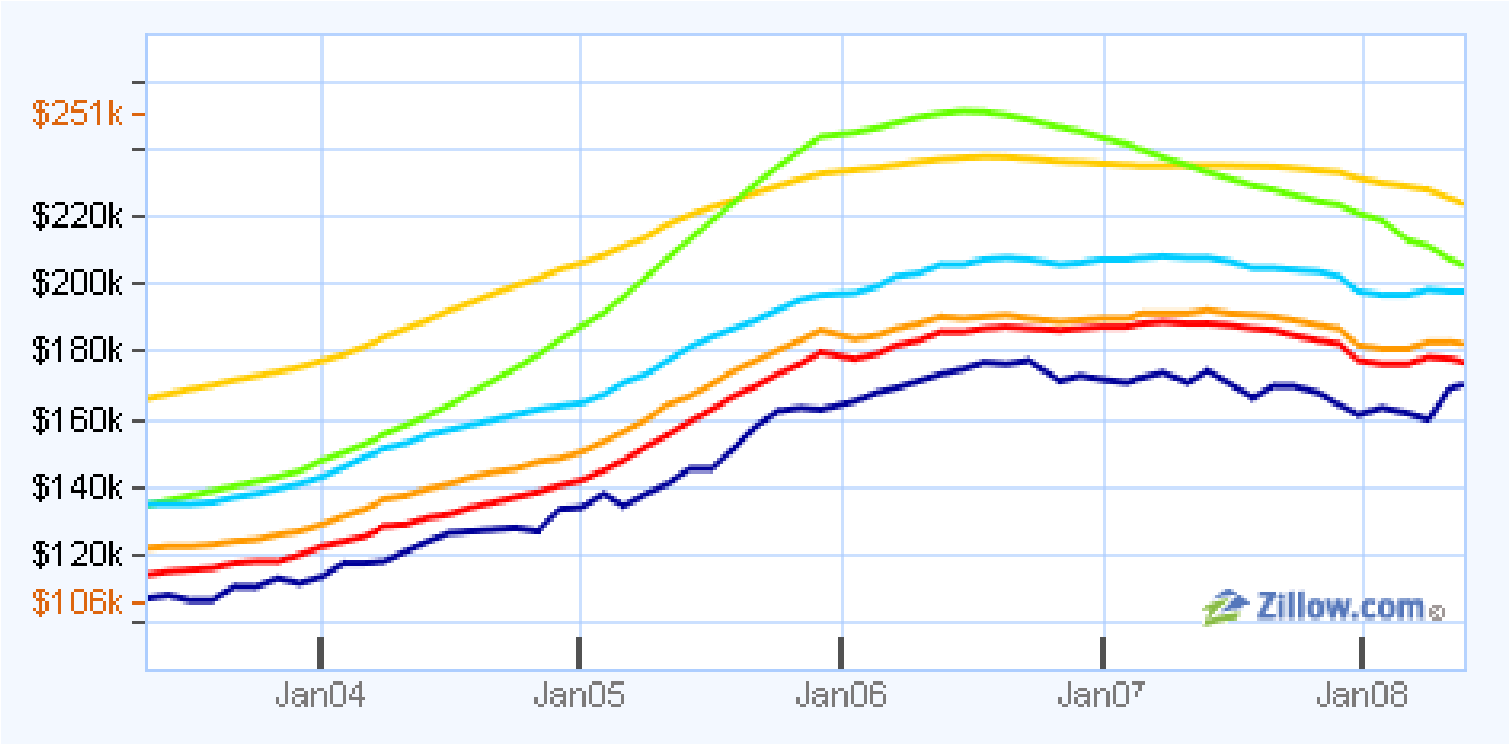
Source: http://www.zillow.com/

Market Value Change

Show: $ Dollar | % Percentage

Time frame: 1yr | 5yr | 10yr | Since last sale

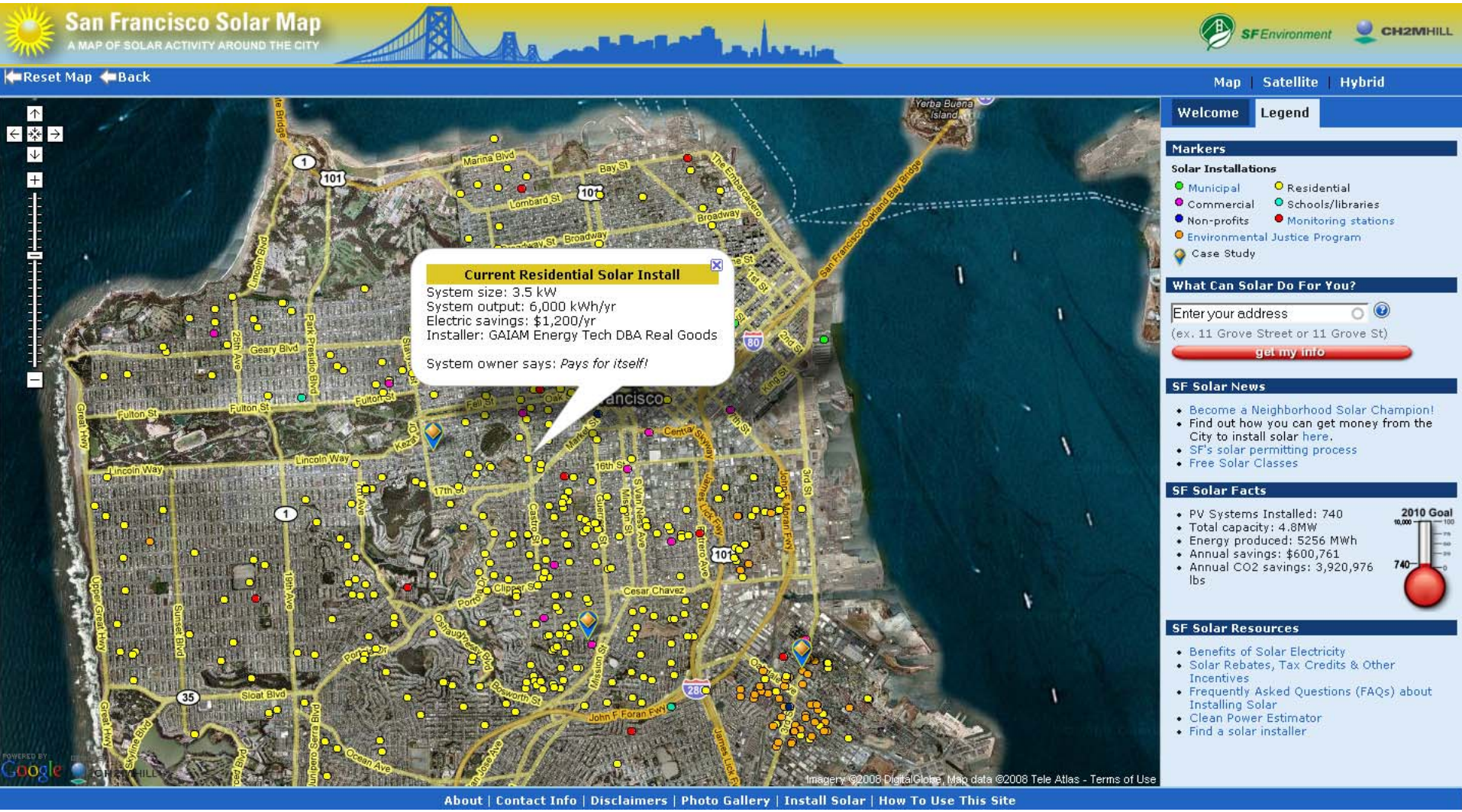
sponsored by charles SCHWAB



Compare:

- [x] This home
- [x] 32605
- [x] Gainesville
- [x] Alachua
- [x] FL
- [x] USA
- [ ] Show sales

Source: http://www.zillow.com/



Source: http://sf.solarmap.org/

Welcome

Gainesville Green Beta

Welcome | FAQ | Subdivision List | Search Homes | Baseline

Welcome to Gainesville-Green.com, your locally focused carbon tracking solution.

Our goal is to provide Gainesville with a premier tool to help visualize and track carbon emissions. It is our hope that making this data available to consumers in a transparent way, will enable individuals to make better decisions about their utility usage. Hopefully, this will result in energy savings that benefit everyone! **The best place to start is to** search for your home.

This tool will also allow city planners to investigate which parts of Gainesville contribute most to our fair city's emissions and to plan accordingly. Gainesville-Green also provides feedback to local developers about which efficiency investments work best, allowing for smarter development that can better utilize our precious resources.

If you perform any interesting analyses of this data, or have any comments please let us know. If we think that many people will find it useful, we will attempt to incorporate it into the site.

Powered by ACCELERATION

Source: www.gainesville-green.com

VALWOOD - 91 Homes

Gainesville Green Beta

Welcome | FAQ | Subdivision List | Search Homes | Baseline

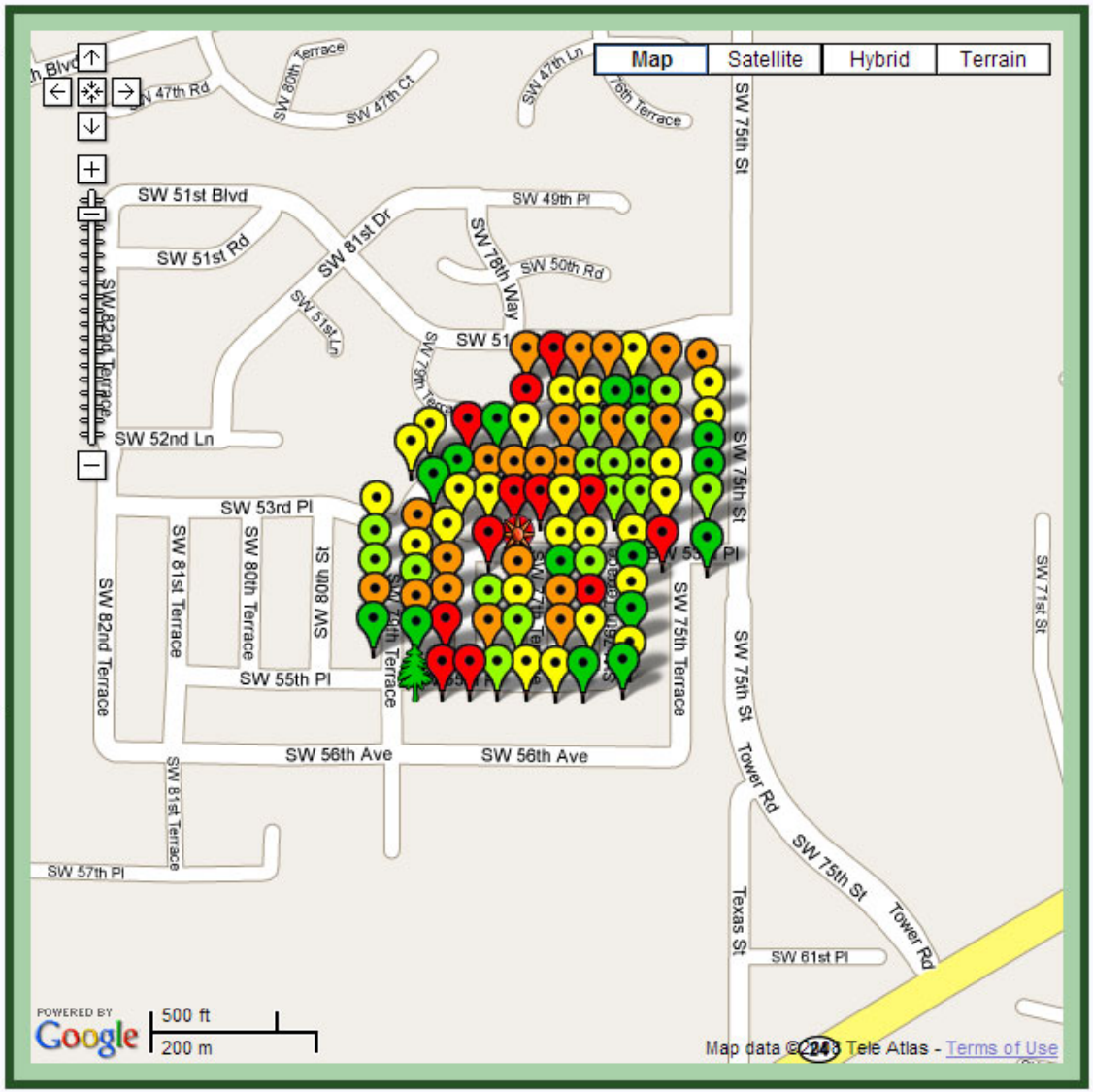
Export Homes in these Subdivisions Export Homes Utility Usages for these Subdivisions

- Your House
- No Energy Usage Data
- Most Efficient
- Very Efficienct
- Efficient
- Average Efficiency
- Inefficient
- Very Inefficient
- Most Inefficient

Comparing homes with all the homes in the same subdivision.

You can also compare with:

- Other homes in the same baseline
- All other homes in the Gainesville area



Powered by ACCELERATION

Source: www.gainesville-green.com

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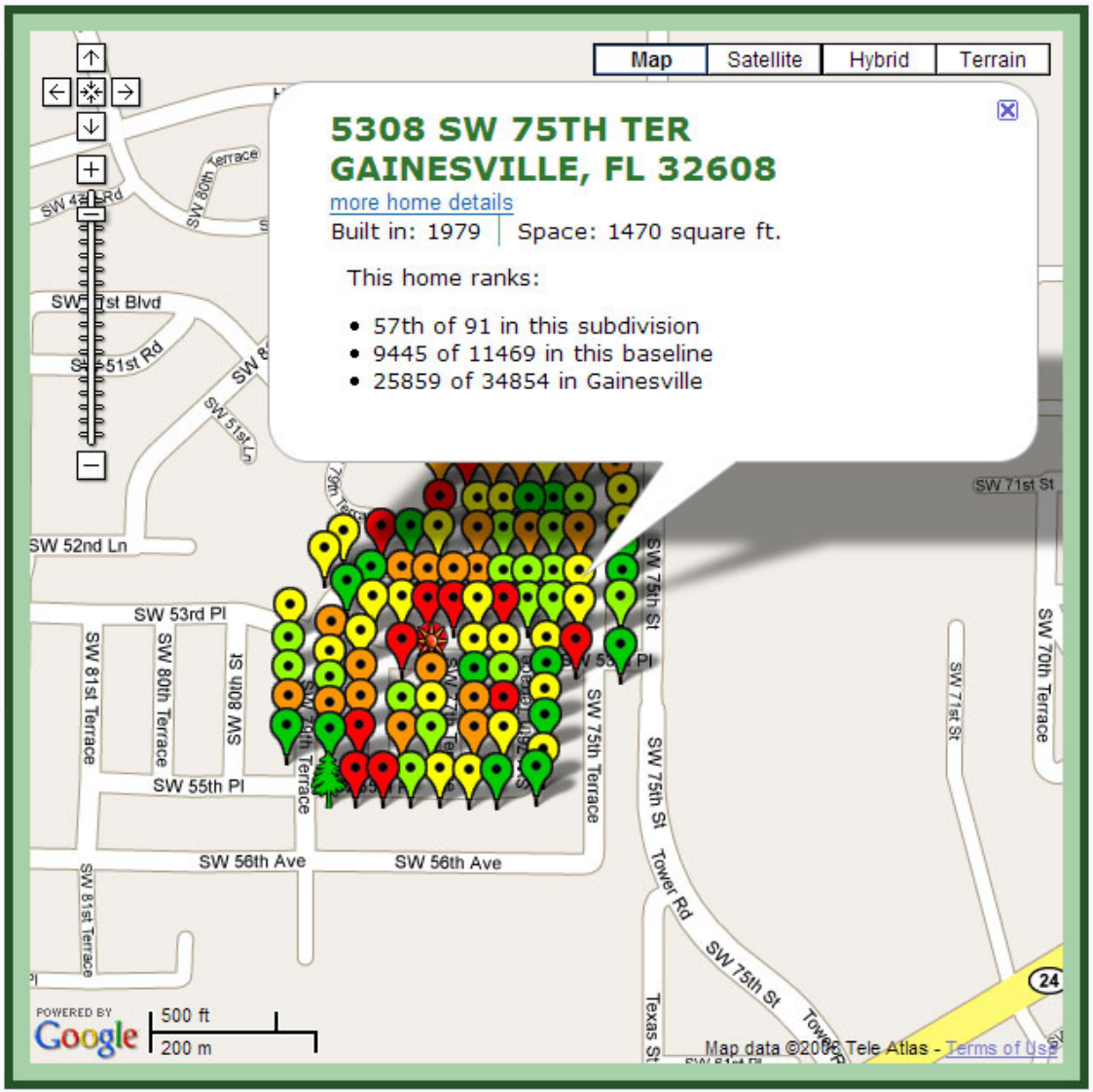


Powered by ACCELERATION

Source: www.gainesville-green.com

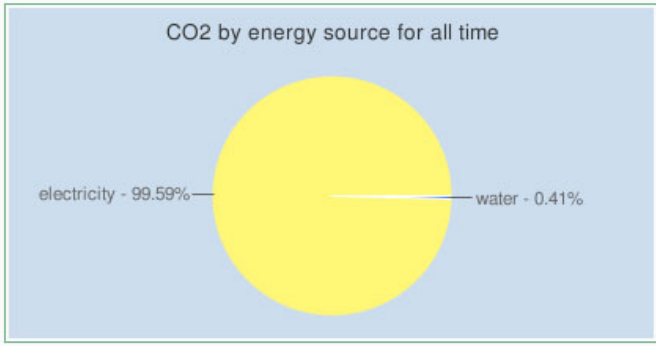
Viewing Home: Parcel 06857-002-039

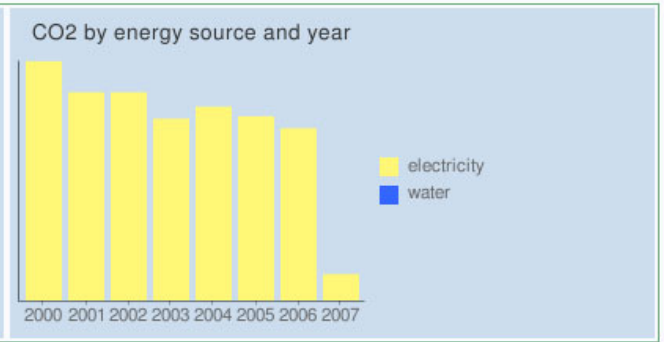
Gainesville Green Beta

Welcome | FAQ | Subdivision List | Search Homes | Baseline

Compare to VALWOOD Compare to similar homes Property Appraiser Record

5308 SW 75TH TER GAINESVILLE, FL 32608





This home ranks:

- 57th of 91 in this subdivision
- 9445 of 11469 in this baseline
- 25859 of 34854 in Gainesville

Tons of CO2 per month				
	This Home	Baseline	Subdivision	All Homes
avg:	.59	.43	.54	.49
stddev:	.65	.74	.66	.90

Download all usage data for this home

Built in: 1979
Beds/Baths: 3/2
Roof: ASPH/COMP SHNGL
A/C: CENTRAL AIR

Conditioned Space: 1470 square ft.
Stories: 1
Lat: 29.6043802
Lon: -82.4236230

water per month (kGal)				
	This Home	Baseline	Subdivision	All Homes
avg:	6.82	7.17	7.80	15.32
stddev:	5.13	7.23	6.23	14.94

Show Usage Data Download water data

electricity per month (kWh)				
	This Home	Baseline	Subdivision	All Homes
avg:	1259.09	1070.32	1302.11	1820.73
stddev:	448.34	1006.58	578.98	1028.52

Show Usage Data Download electricity data

Powered by ACCELERATION

Source: www.gainesville-green.com

CBSM: Why It is Needed

(McKenzie-Mohr & Smith, 2006)

- About 80% Americans express environmental values yet only 20% translate concern into lifestyle changes
- Why do people fail to engage in a new activity?
  - Don't know about activity or its benefits
  - Perception of significant barriers (internal or external) to engagement
  - Perception of benefit via continuation of present behavior
- CBSM view of behavior change
  - People gravitate to actions with ↑ benefits & ↓ barriers
  - Perceived barriers and benefits vary dramatically among individuals and activities
  - Behavior competes with behavior…choice matters

CBSM: The Approach
(McKenzie-Mohr & Smith, 2006)

- Four major steps
  - Identifying barriers and benefits to a sustainable behavior
  - Designing strategies that utilize behavior change tools
  - Piloting the strategy with a small segment of a community
  - Evaluating the program once it has been implemented across a community

Web Tool Interface & CBSM

(McKenzie-Mohr & Smith, 2006)

- Tools of behavior change
  - Commitment
    - Alters perceptions of self & taps desire for consistency
  - Prompts
    - Provides reminder to perform activity
  - Community/social norms
    - Taps into social phenomena of compliance & conformity
  - Communication
    - Utilizes principles of persuasion
  - Incentives
    - Provide motivation
  - Removing external barriers
- Tools work best in combination

Sign up now!

How it works

Why get involved

What you can win

Supporters

About us

News

Join the contest to save energy and the planet.

See the Winners and Awards

A project of One Atmosphere, The Sierra Club & SF Environment

SF Climate Challenge

Contest rules | Privacy notice | Terms of Use | Help

Tips: Switch to Compact Fluorescent bulbs! (*then return them to the hardware store*)

Source: http://www.sfclimatechallenge.org/

Sign up now!

How it works
who can participate?
when is the competition?

Why get involved

What you can win

Supporters

About us

News

How it works

The contest begins October 25th. You spend your next PG&E* billing period doing everything you can to reduce your energy use. The more energy your team saves, the better your chances of winning.

It can be as simple as turning off a few lights and lowering the thermostat, to as dramatic as installing solar panels on your roof or creating a human-powered generator. It's all up to you.

At the end, we compare the contest period with your bills from the same time last year, and dish out cash and prizes to the teams who've done the best and come up with the most creative solutions. Even if that isn't you, you'll still have saved some money on your power bill and helped fight global warming. So in a sense, everyone wins.

* PG&E is not affiliated with the SF Climate Challenge.

A project of One Atmosphere, The Sierra Club & SF Environment

SF Climate Challenge

Contest rules | Privacy notice | Terms of Use | Help

Tips: Buy Phosphate-free detergent. Reduce your risk of toxic exposure; look for non-toxic, biodegradable, chlorine-free, non-petroleum based products.

Source: http://www.sfclimatechallenge.org/

Conspicuous Reduction: Identity

Honda Civic Hybrid Sedan
2008 MPG = 40 city / 45 hwy
2006 MPG = 49 city / 51 hwy

Toyota Prius
2008 MPG = 48 city / 45 hwy
2006 MPG = 60 city / 51 hwy

Source: http://www.edmunds.com

Web *2.0* Tool with GIS & CBSM

- Maximum consumptive use *transparency*
  - Promotes full baseline accounting
    - Absolute necessity for carbon markets
  - Increases ease & *joy of use*
  - Platform for real estate marketplace integration
  - Instant green building case studies
- *Open* and *adaptable*
  - Capacity for integration with other Web services
  - Potential for downloadable applications
    - Energy rater forms, product selection guides, etc.

Web *2.0* Tool with GIS & CBSM

- *Participatory* & *collaborative* at multiple scales
  - Three tier validation
    - Tier 1: Normalized raw end-use data (utility bills, MLS, etc.)
    - Tier 2: Refined metadata via occupant self-assessment
    - Tier 3: Independent 3rd-party verification
- Fully integrated performance rating systems (i.e., *data driven*)
  - Energy modeling for new construction
  - Measurement & feedback for existing construction
    - *Perpetual beta* for continuous improvement

Web 2.0 Tool with GIS & CBSM

- *Social networking*
  - Fosters social norms via true comparables
  - Personalization of address-based metadata
  - Entrepreneurial opportunities for small businesses
  - Creation of games/competitions drive efficiency
- Incentivization
  - Rebates based on performance not prescription/products
- Public policy
  - Feebates & other innovations based on pivot points

Summary

- The climate challenge is fundamentally a built environment & behavior change challenge
  - Energy efficiency interventions & programs are failing
  - Building science cannot be separated from its associated social science counterparts
- Feedback is critically needed but is scarce
  - Distributed end-use transparency is imperative
- A Web 2.0 strategy merged with CBSM can provide a platform & a process for change

Thank You!

Hal S. Knowles, III

University of Florida

Program for Resource Efficient Communities

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hknowles@ufl.edu