



# FLORIDA SOLAR ENERGY CENTER

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*Creating Energy Independence Since 1975*

## **Putting Floridians and the Sun to Work in the Sunshine State?**

### **A Building Performance and Solar Energy Manhattan Project**

James Fenton and Philip Fairey

February 2008

A Research Institute of the University of Central Florida





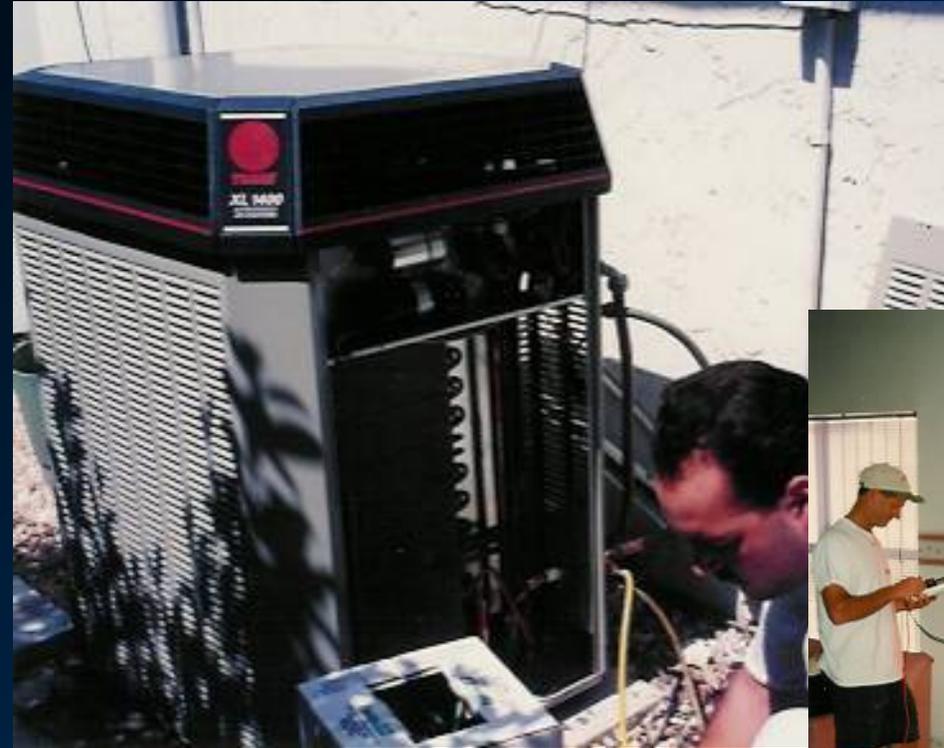
Not this. . . Or this. . .



TRINITY TEST SITE  
1945  
Contour interval in feet  
0 20  
MILES

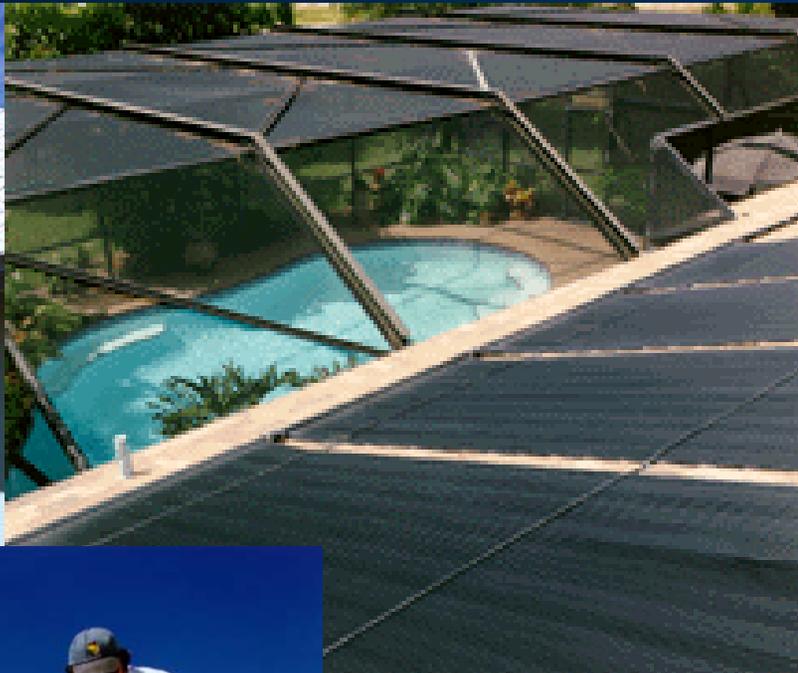


But this...





# Then this...

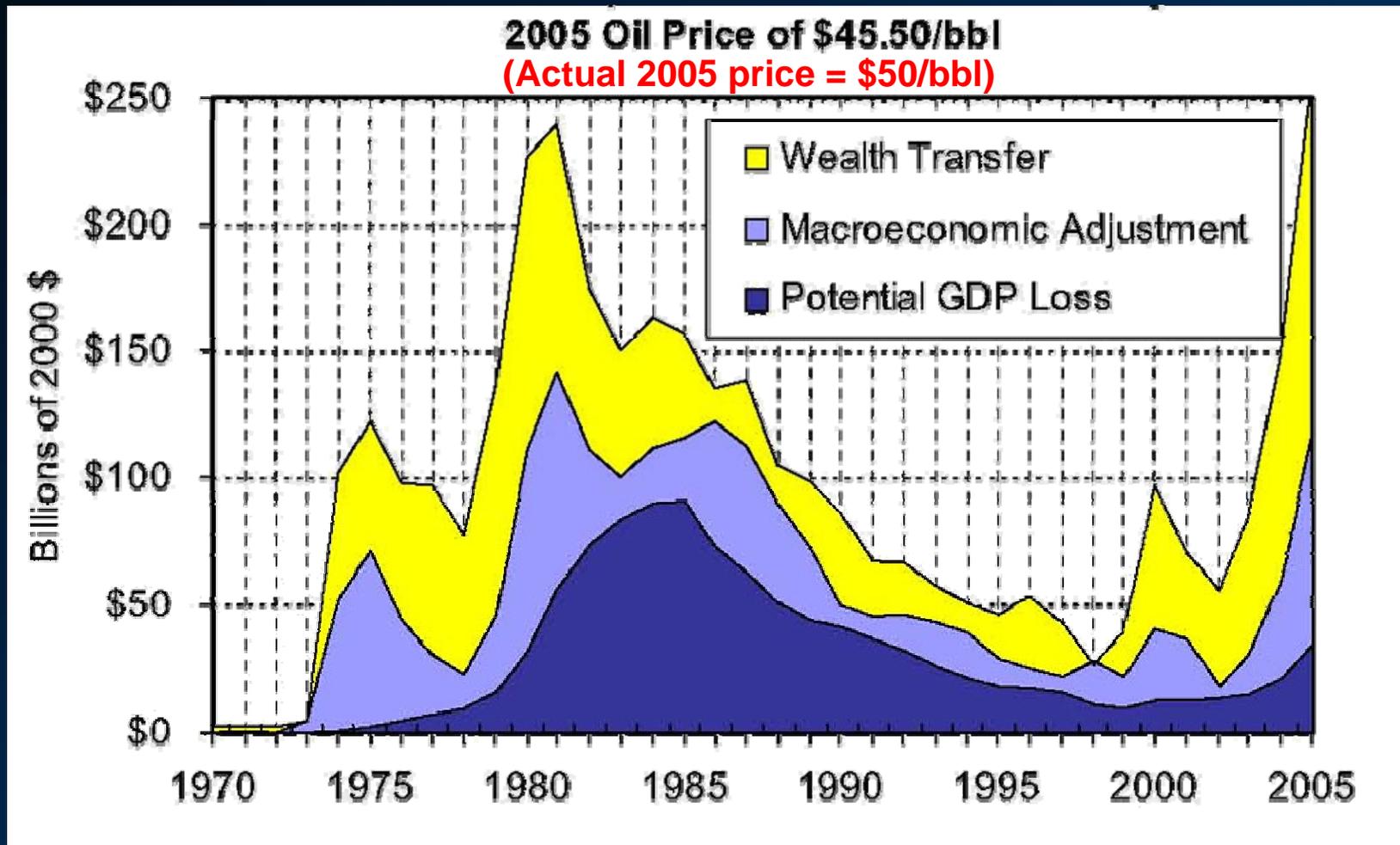


# Into the Storm





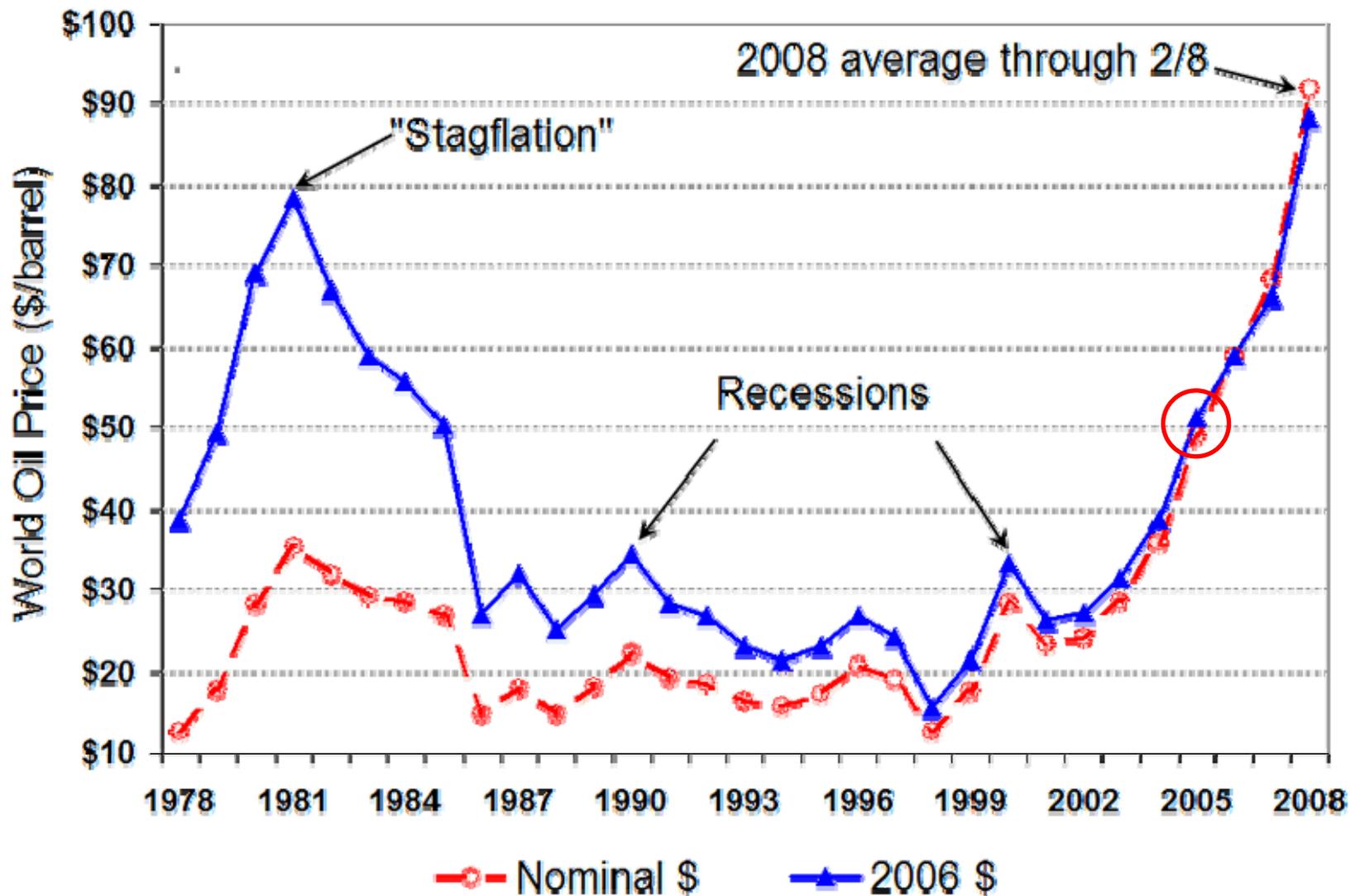
# The Cost of Oil Dependence



Source: Green, D. and S. Ahmed, "Cost of U.S. Oil Dependence: 2005 Update." Oak Ridge National Laboratory, Publication No. ORNL/TM-05/45, January 2005

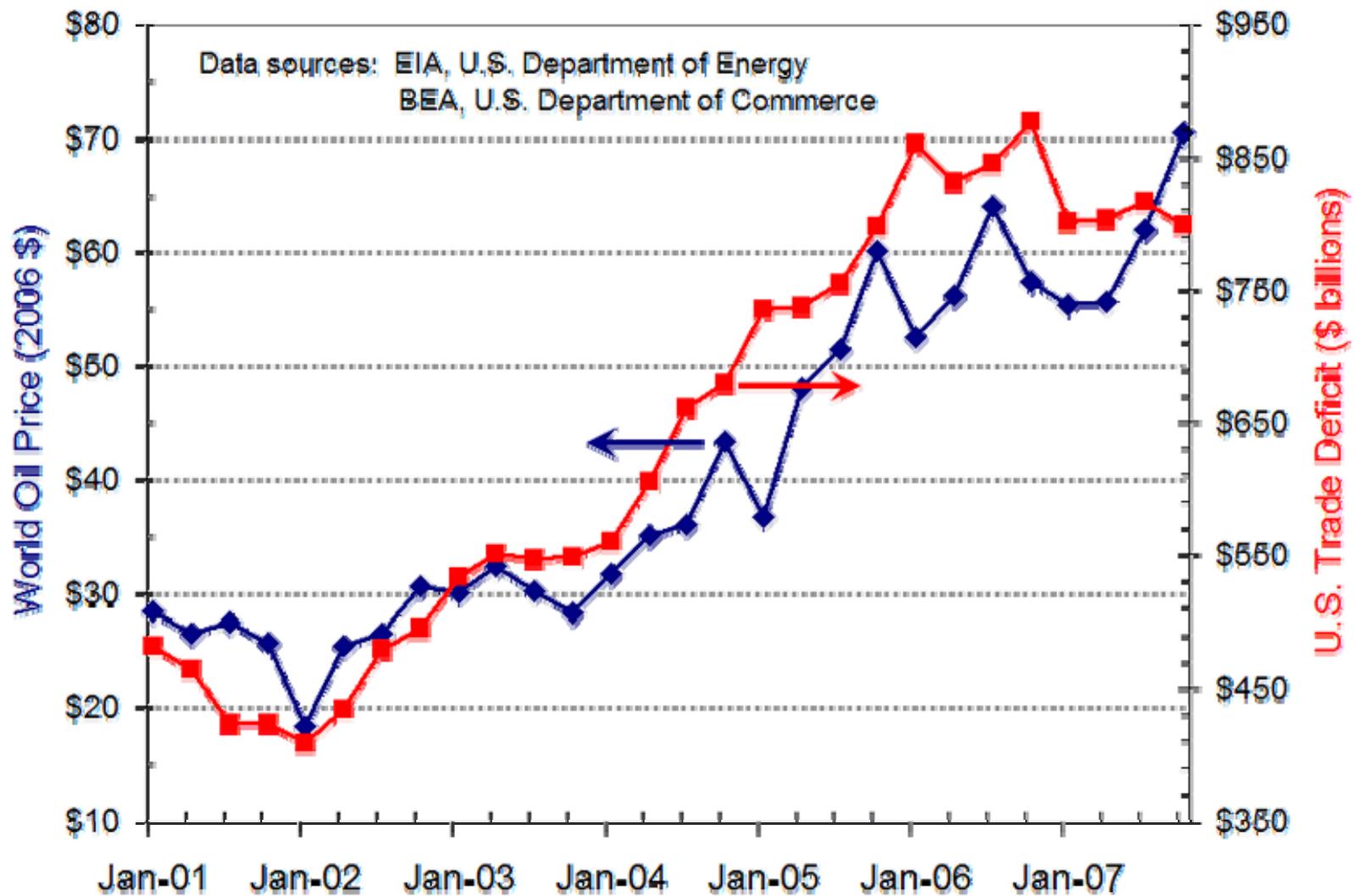


# World Oil Prices Since 1978



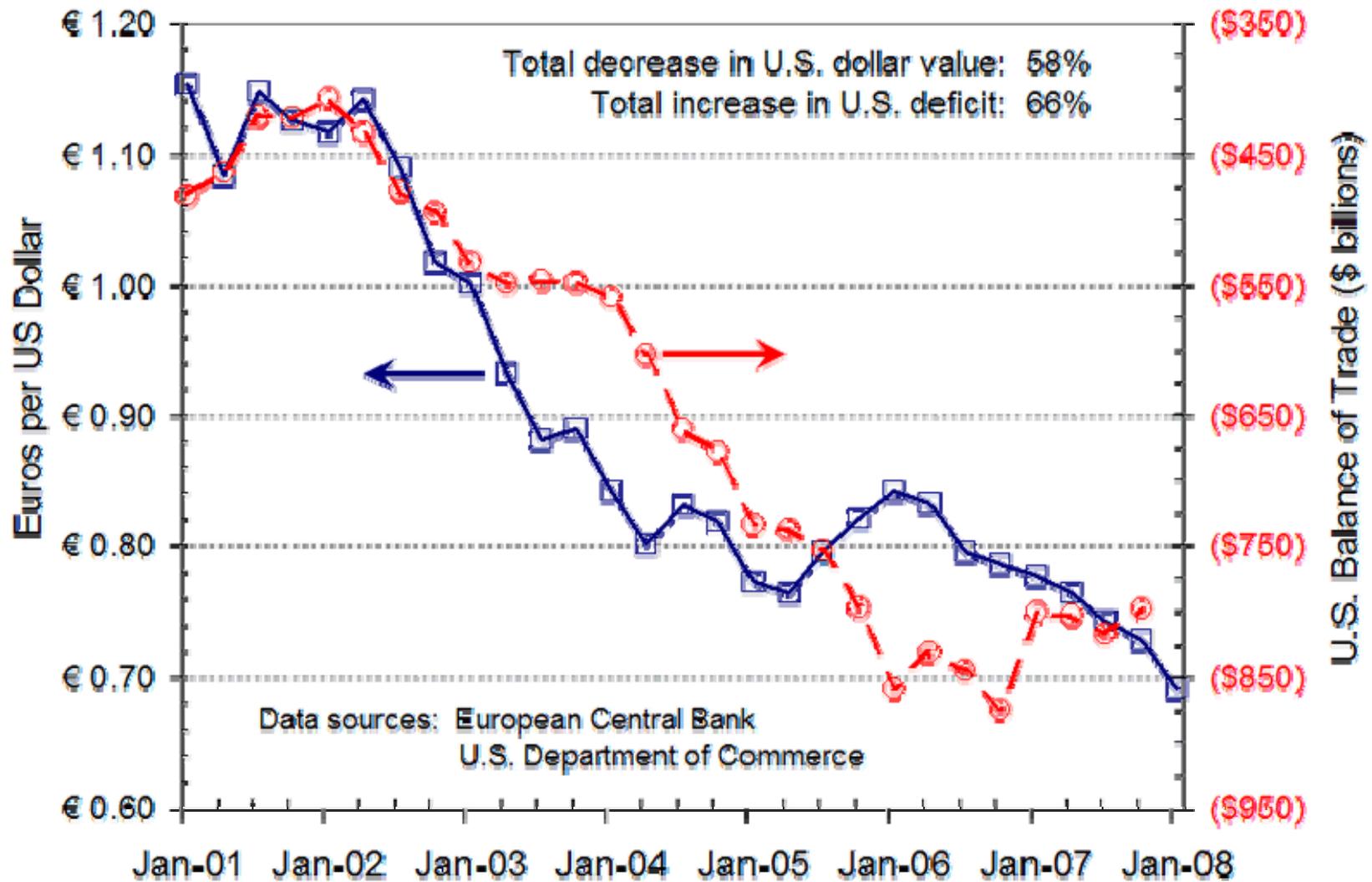


# U.S. Trade Deficit and Oil Price





# Value of The U.S. Dollar





## What Is This All About?

“It’s the economy stupid!”

*James Carville, 1992*

And, the corollary is “... *the cheapest, easiest and fastest kilowatt we can generate is the one we save through efficiencies.*”

*Jeb Bush, 2000*

In other words:

**It’s the efficiency stupid!**



# *Electricity Use*

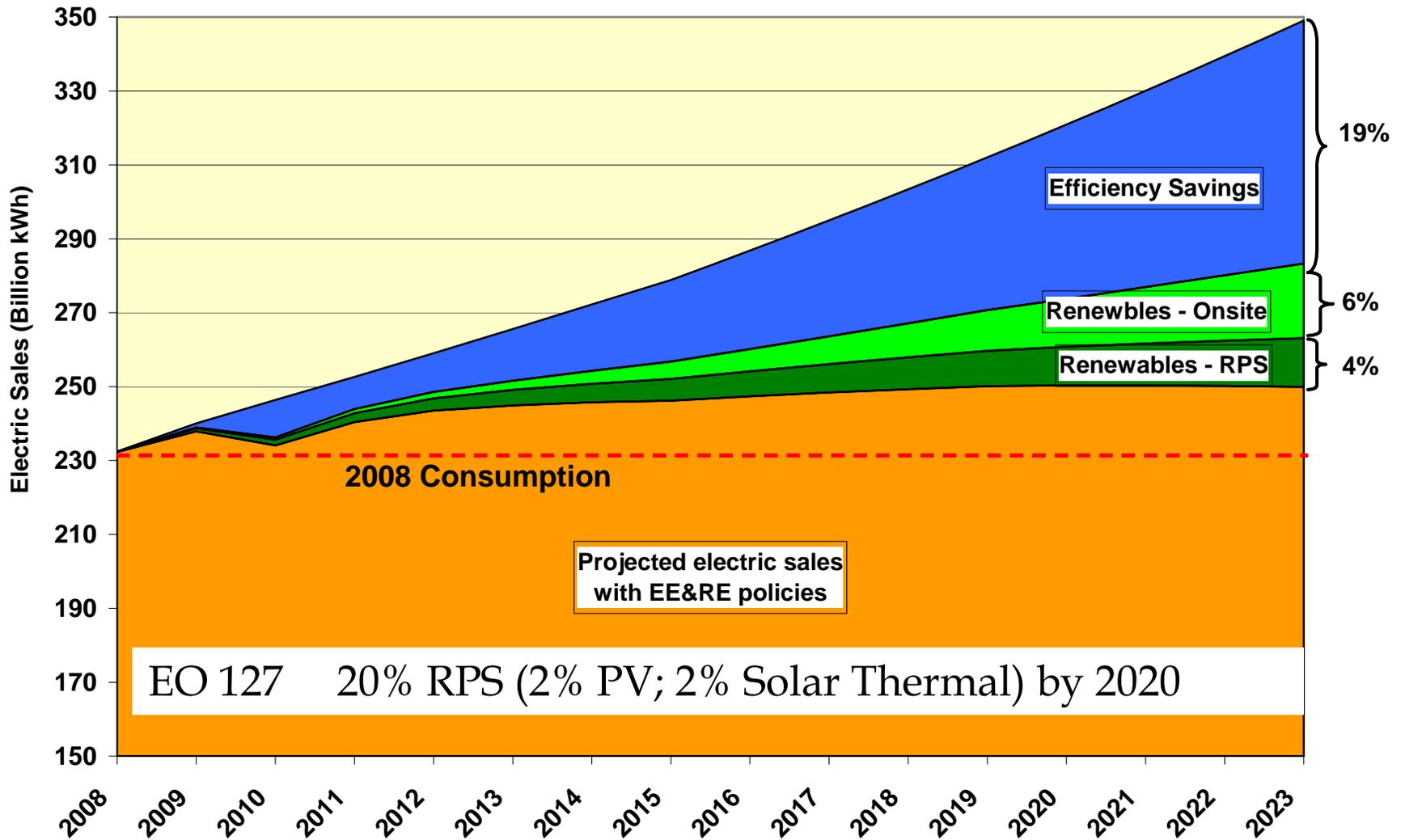
## **Efficiency, Efficiency, Efficiency....., Then Solar Thermal & PV**

- ❖ **Efficiency First** – The least expensive kWh is the one that we do not use (or produce)
- ❖ New homes (190,000 per year) can cost effectively achieve almost 40% greater efficiency than 2007 code requirements<sup>1</sup>
- ❖ Existing homes (7.3 million) can be cost effectively improved by more than 30%<sup>1</sup>
- ❖ Achieving this cost-effective efficiency would result in 53 billion kWh savings at a levelized cost of about \$0.05 per kWh.<sup>1</sup>

<sup>1</sup> ACEEE, June 2007. *Potential for Energy Efficiency and Renewable Energy to Meet Florida's Growing Energy Demands*

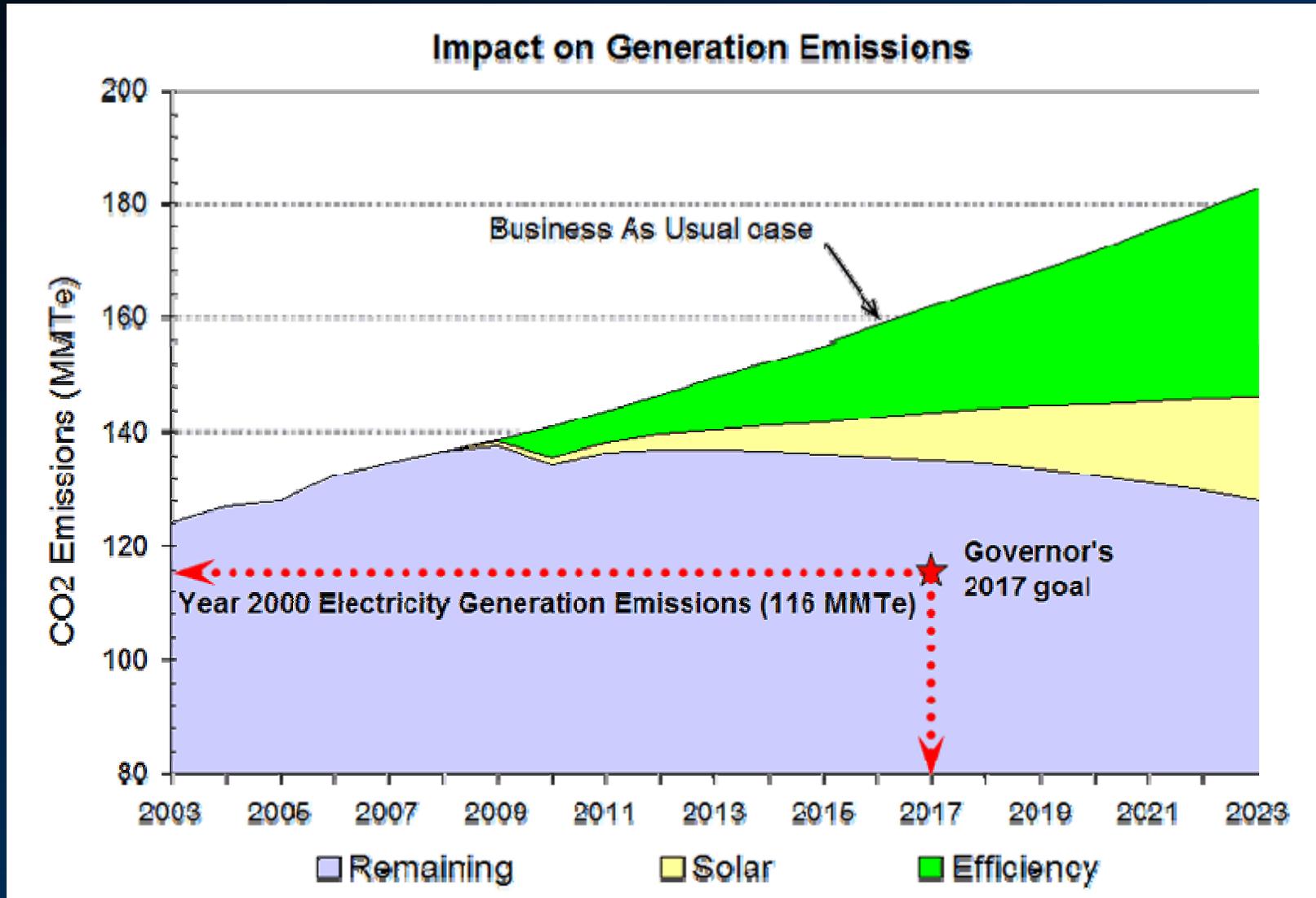


# ACEEE: Energy Savings





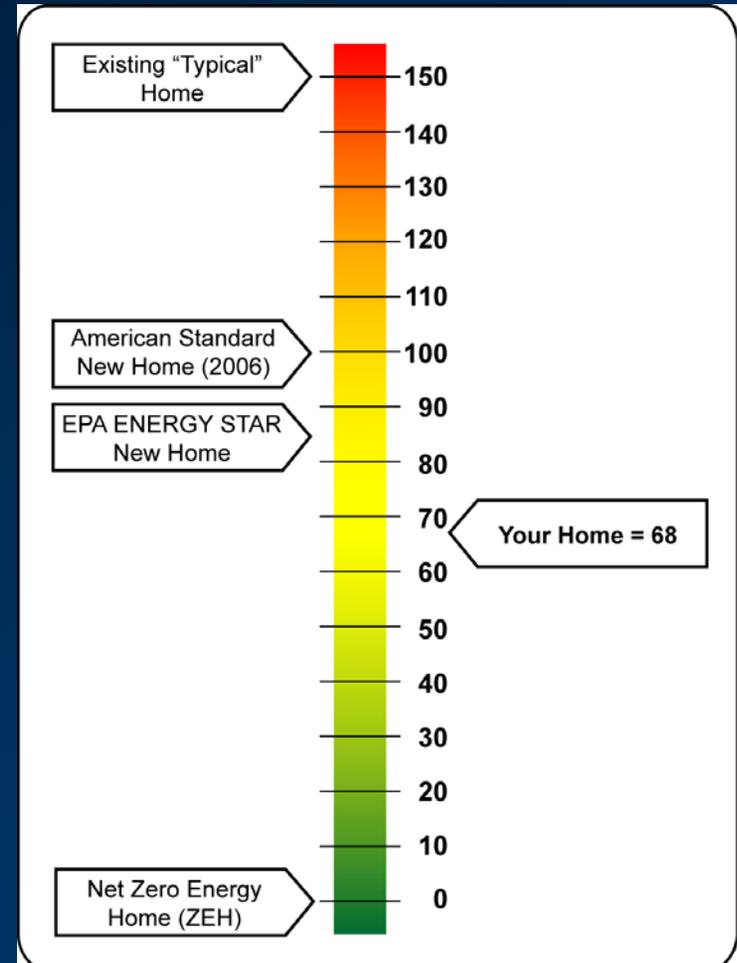
# ACEEE: Carbon Savings





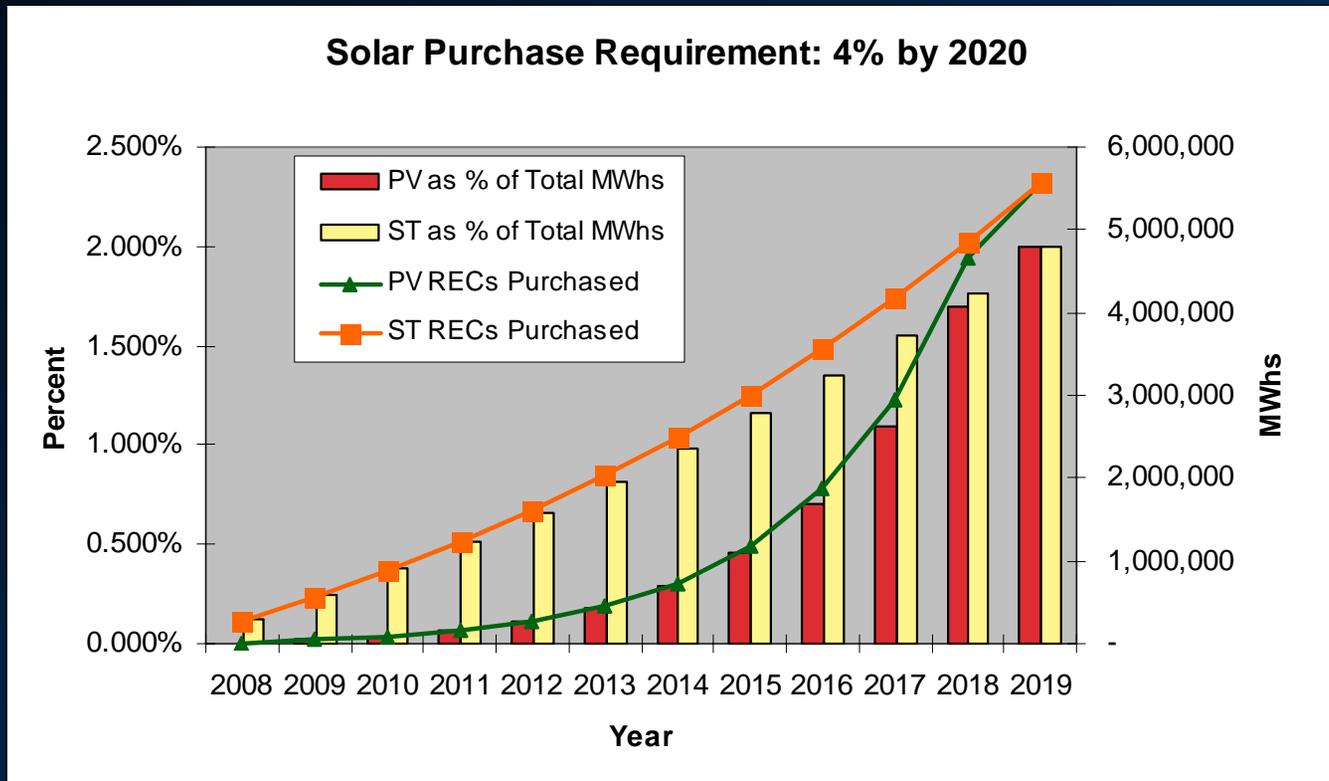
# Home Energy Measurement & Verification

- ❖ A national energy use index that measures whole-home energy efficiency on a relative scale
  - 100 = The energy use of the “American Standard Home”
  - 0 = No net purchased energy use – the “Zero Energy Home”
- ❖ ENERGY STAR homes have a HERS Index of 85 or lower
- ❖ Widely used in the “Beyond Code” marketplace





# 20% RPS by 2020 (4% Solar)



As System costs decline (greater demand, maturing industry), solar requirements increase in later years. Solar Thermal today with no incentives \$0.09 kWh; PV with no incentives \$0.28 kWh today; \$0.15 kWh 2011; \$0.09 kWh 2020. Out of the wall \$0.08 kWh 2000; \$0.12 kWh today; \$?? kWh 2011.

## Governor Crist Highlights Top 3 Legislative Priorities

FEBRUARY 19, 2008

*HEALTH CARE • EDUCATION • ENERGY & ECONOMIC DEVELOPMENT*

### **\$200 M for Energy and Economic Development**

\$50 million for solar, wind and the other renewable technologies

\$42.5 million for biofuels

\$7.5 million R & D for businesses and projects that reduce greenhouse gas emissions and diversify Florida's energy consumption.

\$100 million for the Innovation Incentive Program in the Office of Tourism, Trade and Economic Development budget.



# RPS, PBF → Industries & Jobs

## Solar PV

- ❖ Average 13 direct job-years/MW
  - (VS study of 5 models)
- ❖ Industry estimates that:
  - Residential: 10 job-yrs/MW
  - Small Commercial: 9 job-yrs/MW
  - Large Commercial: 7 job-yrs/MW

### **Benefit of 2% Goal:**

- ❖ **31,600 job-years (low)**
- ❖ **50,000 job-years (high)**

**Orange County Convention Center  
1 MW Solar PV**

## Solar Thermal

- ❖ One job-year created for every 50 systems installed

### **Benefit of 2% Goal:**

- ❖ **32,800 job-years**



MOSCOW CENTER  
6700 Solar Panel of



# How Much Can We Spend?

- ❖ 8.5 million homes
- ❖ Low hanging fruit:
  - \$1500 per home
  - Saves 1,250 kWh/yr
  - Saves 25 therms/yr
- ❖ Extensive Retrofit:
  - \$10,000 per home
  - Saves 5,000 kWh/yr
  - Saves 100 therms/yr





# It's All About the Financing

- ❖ Low hanging fruit
  - \$13 billion
  - 7.2 year payback
- ❖ Big intervention
  - \$88 billion
  - 12 year payback





# Other Benefits

- ❖ Thousands of new jobs
- ❖ Billions of dollars in annual savings to the public
- ❖ Large multiplier impact to Florida economy
- ❖ Improved Homes! Lower operating cost, better durability, safety and IAQ!
- ❖ Genuine national leadership





# Energy and Economic Development

## We must:

- ❖ Improve energy efficiency in existing homes (8.5 million) by more than 30% (about two-thirds of all buildings that will be in use in 2050 are already built.)
- ❖ New Homes 45% more efficient by 2018. All with PV and Solar Thermal
- ❖ Government provides \$0.75 per kWh/yr saved
- ❖ 2% PV and 2% Solar Thermal RPS 2020; Public Benefit Fund provides 50% cost
- ❖ Fund FSEC to measure and verify energy efficiency, and solar energy production!



## Action Plan – Step One

- ❖ Make aggressive renewable energy and energy efficiency market development Florida's 1<sup>st</sup> energy priority.



## Action Plan – Step Two

- ❖ Make advanced photovoltaic research and development a Florida priority.
- ❖ The R&D challenges facing PV technologies are to
  - Dramatically increase cell efficiency
  - Reduce the cost/watt
  - Increase manufacturing capacity.



## Action Plan – Step Three

- ❖ Significantly enhance Florida's renewable energy and energy efficiency research, education, job training, certification and demonstration capacity (approximately \$2.5 million/year)
- ❖ This enhanced capacity would require additional space of approximately 50,000 ft<sup>2</sup> at an estimated cost of about \$20 million.

# Questions?





# Extra Slides Follow



# Smaller Carbon Footprint?

- ❖ Building energy is 27% of average per person's carbon emissions
- ❖ More than transportation!
- ❖ Five times as much as our own energy source (food!)





# The Average American Home\*

- ❖ 107 million residential units in 2001
- ❖ 10,700 kWh a year in electricity
- ❖ 700 Therms Natural gas
  - or 730 gallons Fuel oil
  - or 488 gallons LPG
- ❖ ~12.5 tons of CO<sub>2</sub>
- ❖ About 8.3 tons from electricity
- ❖ Represents 21% of U.S. primary energy use
- ❖ **Most Important:** about two-thirds of all buildings that will be in use in 2050 are already built.



\*RECS 2001: <http://www.eia.doe.gov/emeu/recs/>

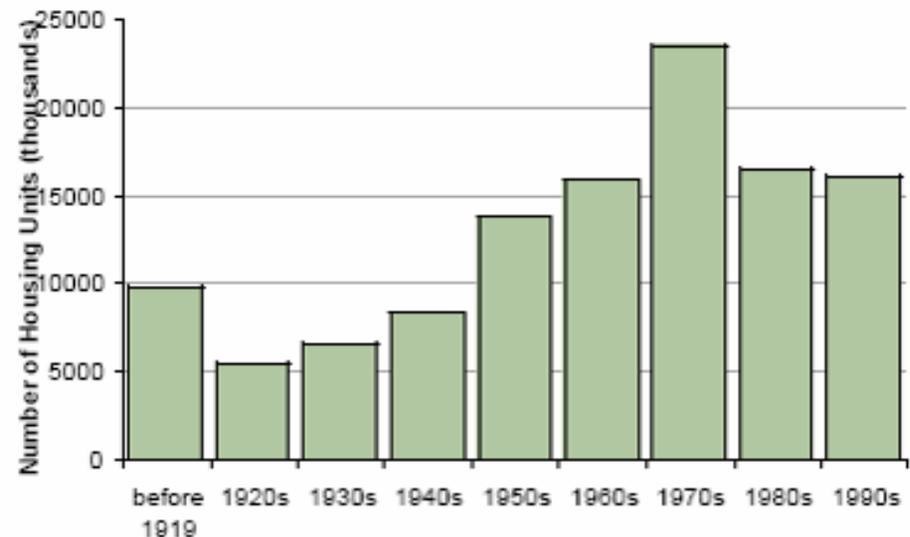


# New vs. Existing Buildings

- ❖ We love to work on new buildings
- ❖ So much more flexibility
- ❖ And not so much messiness— no difficult occupants with fickle preferences
- ❖ But...here is the work and this is where the jobs will be!

## Existing Housing Stock

Age of US Housing Stock (all unit types)



Source: US Census Bureau, Annual Housing Survey:  
<http://www.census.gov/hhes/www/housing/ahs/ahs.html>



# Case: Comprehensive Retrofit

- ❖ Extensive retrofit without structural modifications
- ❖ Radiant barrier with better ventilation
- ❖ Hi-Efficiency AC with Variable Speed AH
- ❖ Smaller pool pump
- ❖ CFL lighting
- ❖ Efficient refrigerator
- ❖ Solar water heater





# Comprehensive Retrofit

- ❖ \$9000 cost over one year period as retrofits were installed
- ❖ 45% reduction in measured electricity use (12,000 kWh)
- ❖ \$1450 saved per year
- ❖ CCE = 6 cents per kWh
- ❖ Improved comfort reported
- ❖ Greater potentials; Example of Hazards, Missed opportunities
  - Tile floor
  - Attic to R49
  - Ductless mini-split AC
  - Low-e window replacement
  - Tight house with ventilation





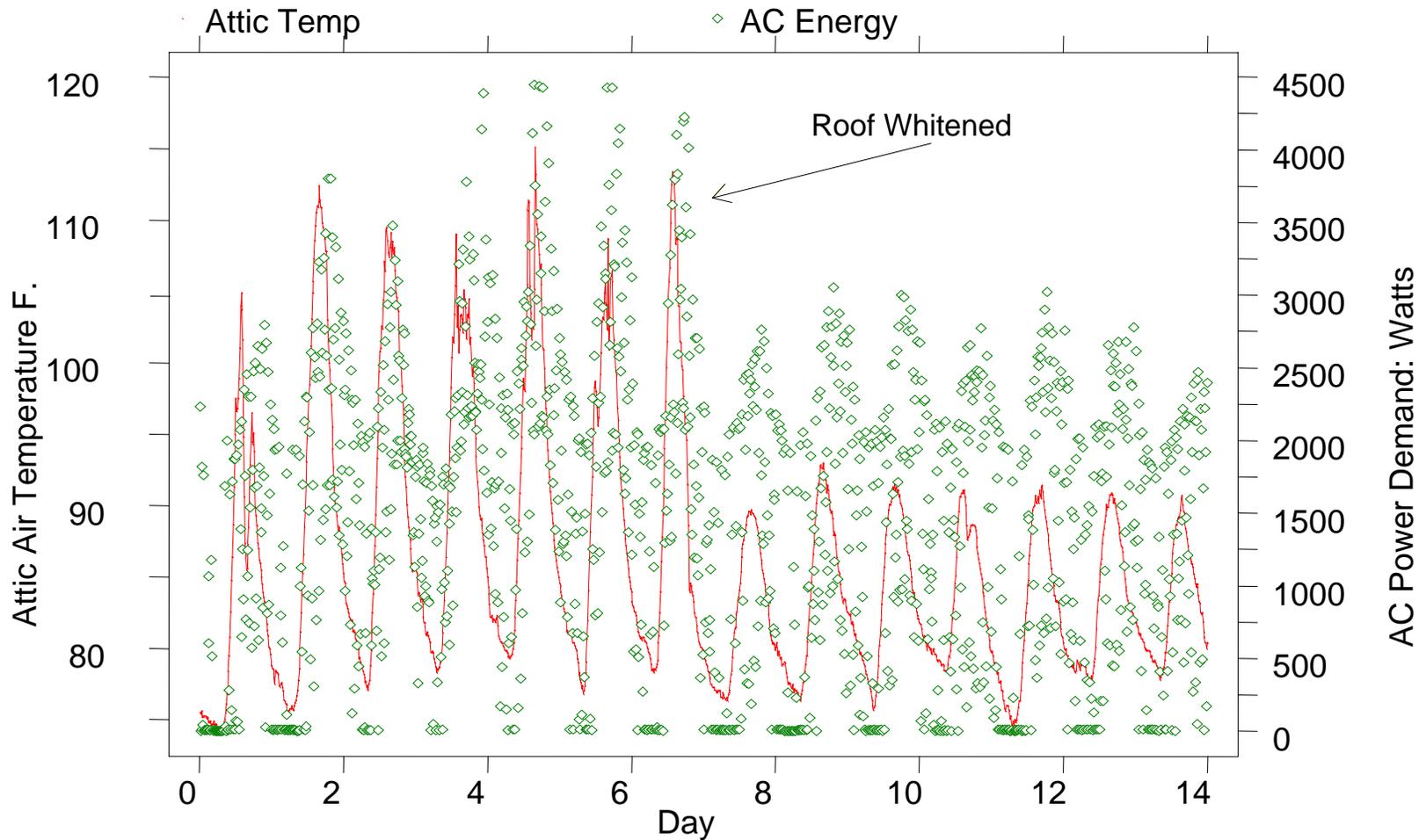
# Deep Retrofit: Deep South

- ❖ New roof
- ❖ Interior ducts
- ❖ Insulated walls
- ❖ Floor treatment
- ❖ New windows
- ❖ BIG remodel
- ❖ Expensive, but offers savings beyond 50%
- ❖ Lost opportunities: Will attic ducts, R30 ceilings and R11 walls be acceptable in 2030?





# Does it Make a Difference?





# Retrofit for Next 100 Years



## Four Square Renovation



- ❖ R60 Roof
- ❖ R41 Walls
- ❖ R28 Basement Walls
- ❖ R10 Basement Floor
- ❖ U=0.33 Windows
- ❖ 92% AFUE boiler
- ❖ 80% EF water heater
- ❖ Ventilation
- ❖ 3.6 kW PV
- ❖ Savings:
  - 67%

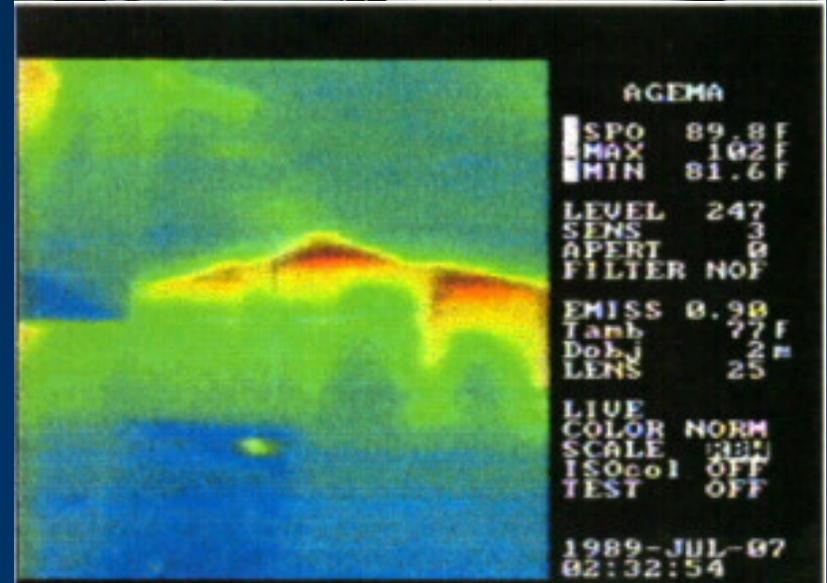




# How Many Homes?

- ❖ Millions of Homes 2001\*
  - 73.7 Single Family Homes
  - 28.5 Apartments & Multifamily
  - 6.8 Manufactured Homes
  - 107 Million total

\*2001 EIA RECS data & Annual Review of Energy [www.EIA.com/recs](http://www.EIA.com/recs)





# Compared to What?

- ❖ *Iraq War* now costs \$200 Billion/year\*
- ❖ ***Iraq War Equivalent*** = \$200 Billion/year
- ❖ Our costs are small: 10 months of war cost to intervene in all homes!
- ❖ Major retrofits: 5.6 yrs
- ❖ 42 years – ***WE*** to do massive retrofit to all homes in the U.S. with 3 kW of PV on all eligible



\* Linda Bilmes (Harvard) and Joseph Stiglitz (Columbia University), “The Economic Costs of the Iraq War,” presentation at the Allied Social Sciences Associations, Boston, January 2006. Also, “What 1.2 Trillion Can Buy,” David Leonhardt, New York Times, 17 January 2007.



# Economic Impact of Creating New Industries and Jobs

- ❖ PV can generate an estimated 50,000 to 94,650 jobs by 2020.
- ❖ These jobs imply an economic gain of:
  - \$3.9 to \$6.9 billion in payroll,
  - An industry potential of \$20 to \$35 billion,
  - International trade at \$2 billion
  - Total economic impact of \$22 to \$37 billion/year.



# Florida Solar Energy Center

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A Research Institute of the University of Central Florida



# What's the Payback?

- ❖ Low level audit pays for itself in 7 years
  - 120 Million Tons of CO<sub>2</sub> reduction
- ❖ Even most extreme case with PV pays for itself in less than 35 years
  - Over a billion tons lower annual CO<sub>2</sub> = 20% reduction for U.S.





## Large Federal Project

<u>Federal Program (thru year)</u>	<u>2006\$ (G)</u>
Manhattan project (1945)	\$26
Interstate highway system (1956)	\$179
Apollo moon landing (1969)	\$136
Afghanistan / Iraq War (2007)*	\$1,200
Economic stimulus package (2008)	\$152

\* Congressional Budget Office – over 6 year period equals about \$400 billion per year or more than \$1 billion per day.

Florida Governor's legislative package \$200 M to stimulate economic development in the renewable and alternative energy field.



# Federal Economic Stimulus

## 2008 Federal Economic Stimulus Act:

- \$152 billion
- Estimate is that about 75% gets into the real economy
- Remainder gets used to pay down debt

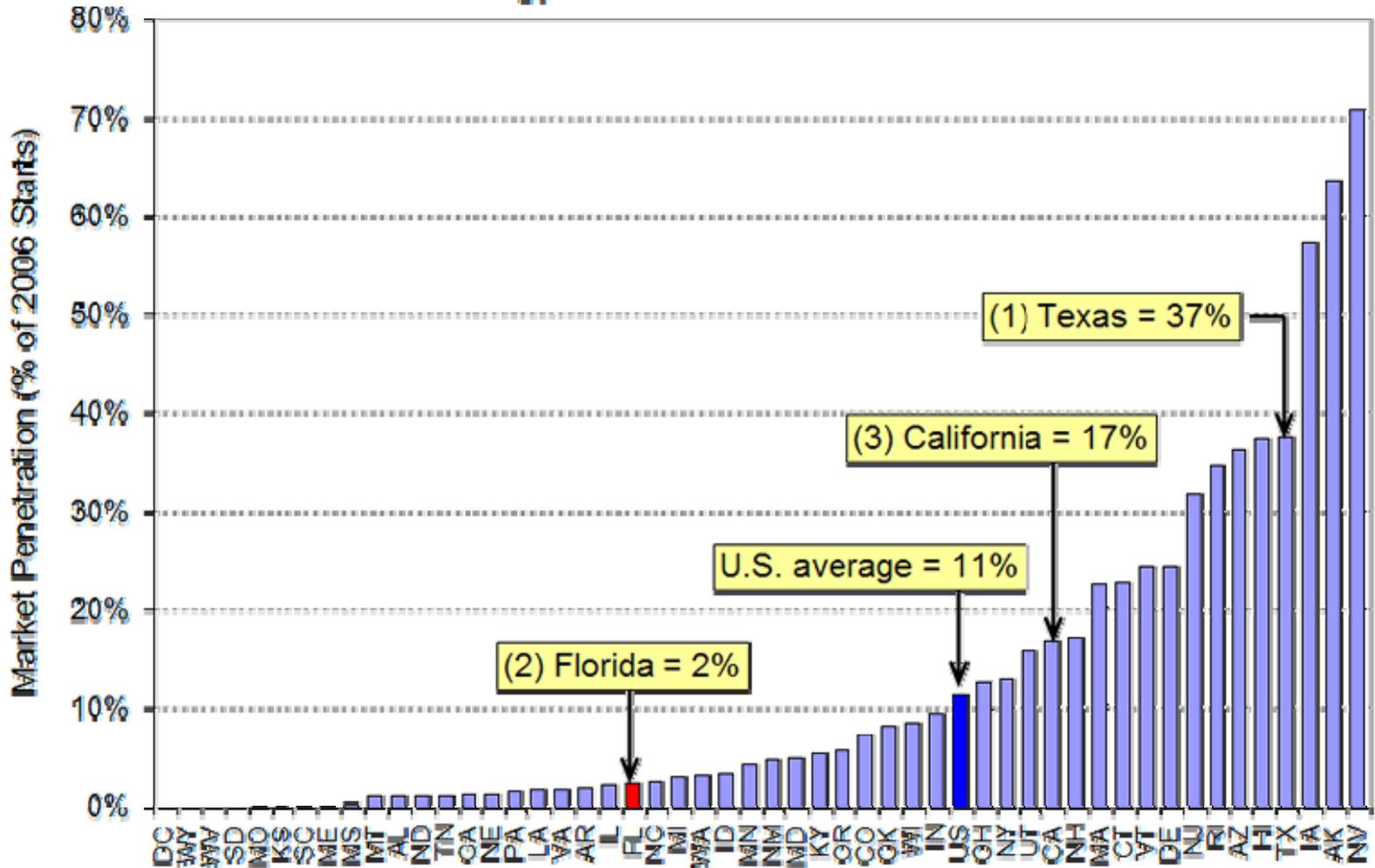
## 2008 Better Alternative:

- Provide cash incentives for work that needs to be done
- Incentives = 50% of cost
- 200% of government cash gets into real economy
- Government provides \$0.75 per kwh/yr saved <sup>41</sup>



# How Are We Doing?

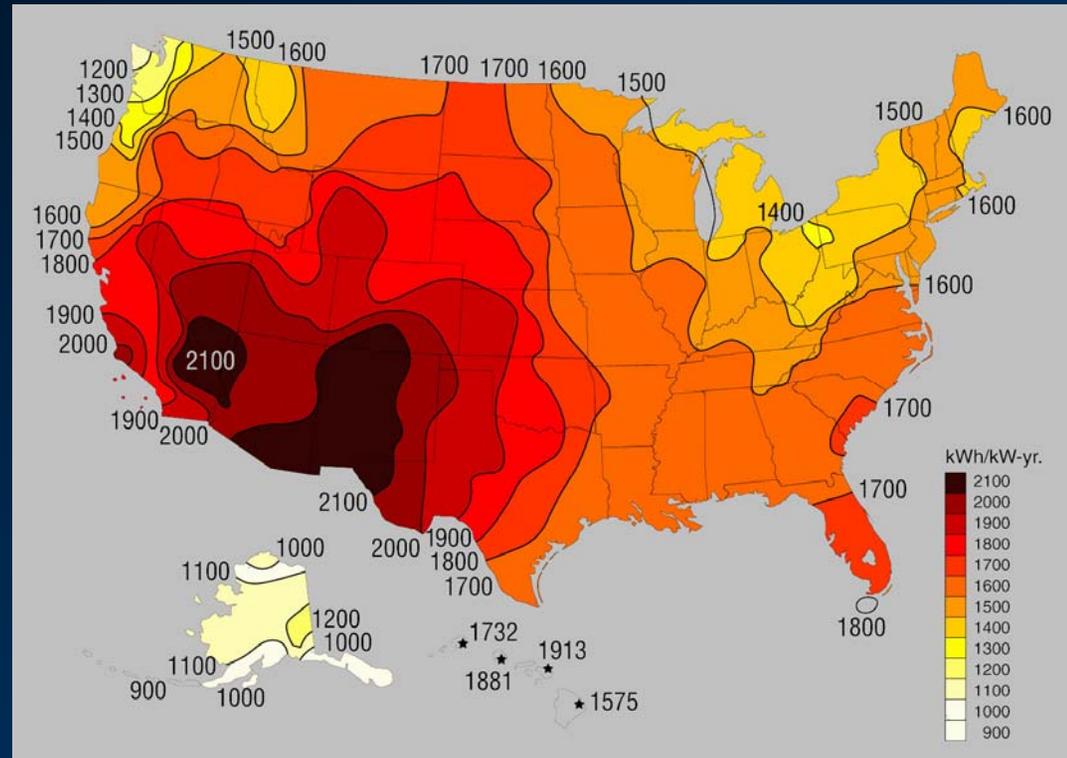
## 2006 Energy Star New Homes Penetration





# Solar Energy

## Most Abundant US Energy Resource



*Florida Sunshine Resource 2X Today's Largest Market - Germany*

# President's Vision for the Solar America Initiative

## Changing the Way We Power Our Homes and Businesses



“I believe that with the proper amount of research, whether it be public or private, we will have solar roofs that will enable the American family to be able to generate their own electricity.”

- President Bush, National Renewable Energy Conference, St. Louis, MI, October 2006

“One day, technologies like solar panels and high-efficiency appliances and advanced insulation could even allow us to build ‘zero-energy homes’ that produce as much energy as they consume.”

- President Bush, 16<sup>th</sup> Annual Energy Efficiency Forum, Washington, DC, June 2005

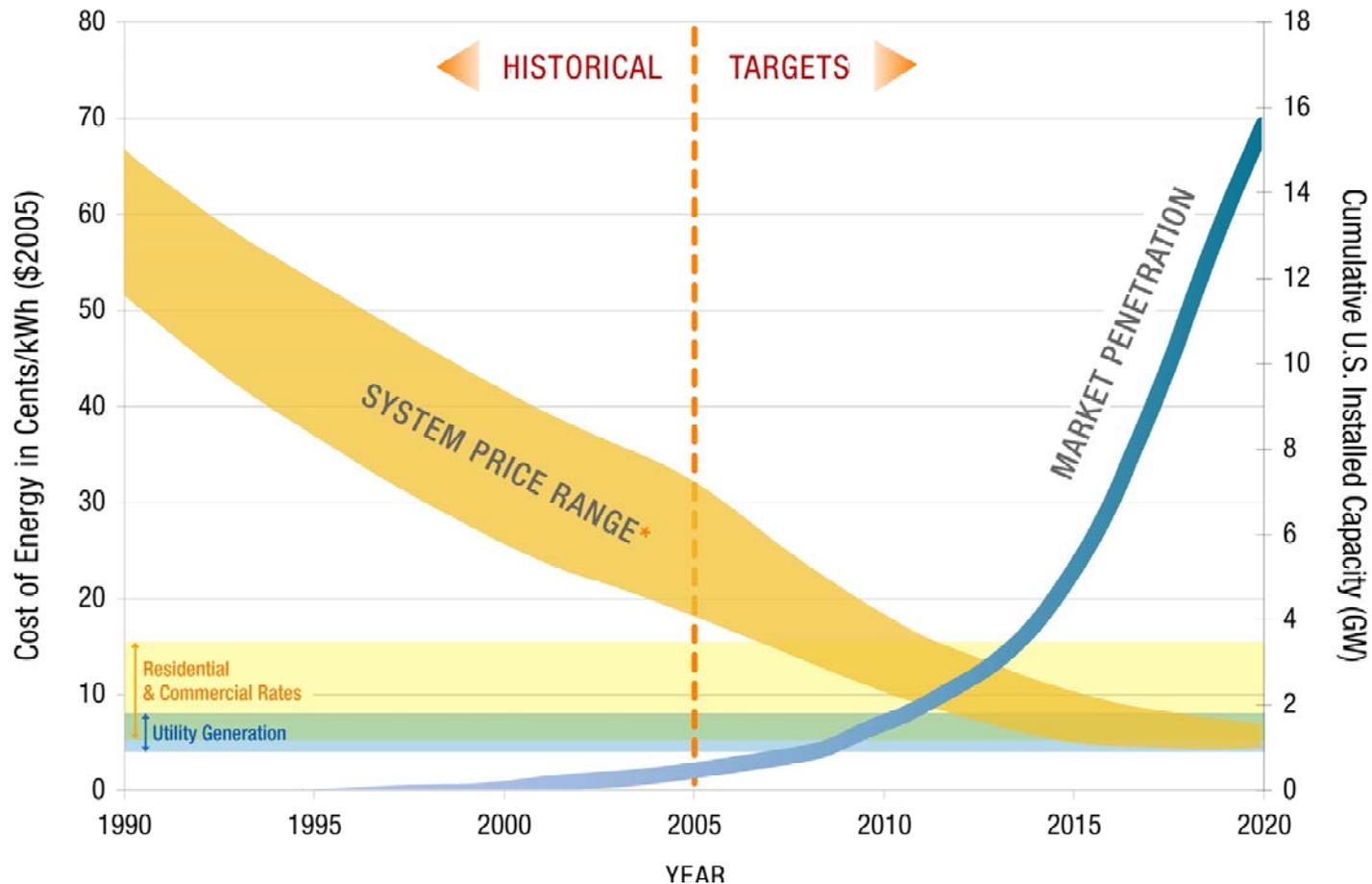


*“So tonight, I announce the Advanced Energy Initiative -- a 22-percent increase in clean-energy research -- at the Department of Energy, to push for breakthroughs in two vital areas. To change how we power our homes and offices, we will invest more in zero-emission coal-fired plants, revolutionary solar and wind technologies, and clean, safe nuclear energy.”*

- President George Bush,  
2006 State of the Union Address

*The goal of the Solar America Initiative is to reduce the cost of solar photovoltaic technologies so that they become cost-competitive by 2015.*

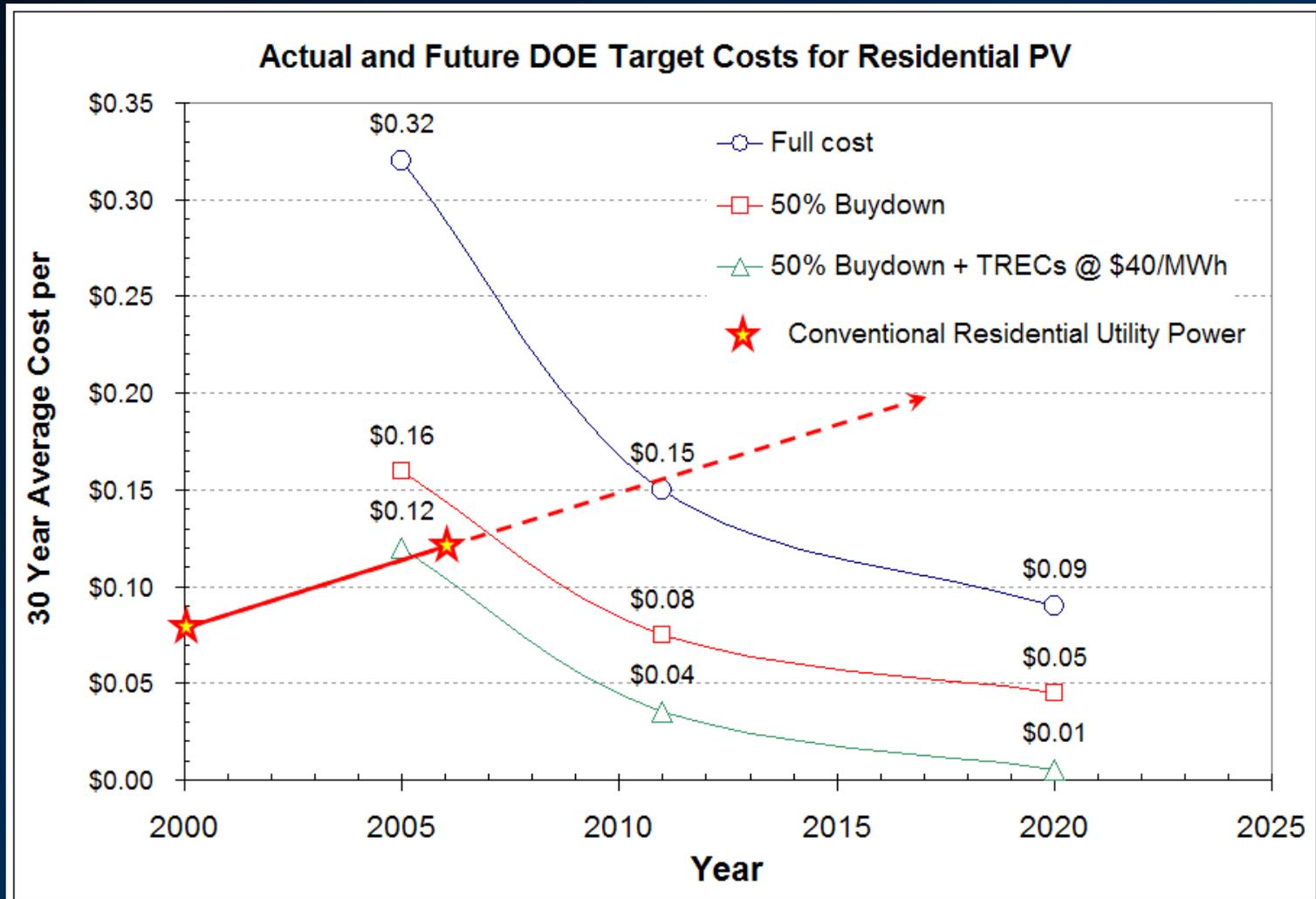
# President's Goal for the Solar America Initiative (SAI) Making Solar Cost-Competitive Nationwide by 2015



Market Sector	Current U.S. Market Price Range (¢/kWh)	Cost (¢/kWh) Benchmark 2005	Cost (¢/kWh) Target 2010	Cost (¢/kWh) Target 2015
Residential	5.8-16.7	23-32	13-18	8-10
Commercial	5.4-15.0	16-22	9-12	6-8
Utility	4.0-7.6	13-22	10-15	5-7



# Photovoltaic Costs





# Strong Public Support For Solar in Florida

QUESTION: Would you support or oppose having the Florida Legislature encourage solar energy investment in Florida if it would cost you one dollar or less per month on your utility bill?

	<u>SUPPORT</u>	<u>OPPOSE</u>	<u>NOT SURE</u>
<b>STATE</b>	78%	16%	6%
<b><u>REGION</u></b>	<b><u>SUPPORT</u></b>	<b><u>OPPOSE</u></b>	<b><u>NOT SURE</u></b>
North Florida	71%	21%	8%
Central Florida	78%	17%	5%
Gulf Coast	81%	14%	5%
South Florida	79%	14%	7%
<b><u>SEX</u></b>	<b><u>SUPPORT</u></b>	<b><u>OPPOSE</u></b>	<b><u>NOT SURE</u></b>
Men	75%	20%	5%
Women	81%	12%	7%
<b><u>AGE</u></b>	<b><u>SUPPORT</u></b>	<b><u>OPPOSE</u></b>	<b><u>NOT SURE</u></b>
18-34	84%	11%	5%
35-49	76%	18%	6%
50-64	79%	15%	6%
65+	74%	19%	7%
<b><u>RACE</u></b>	<b><u>SUPPORT</u></b>	<b><u>OPPOSE</u></b>	<b><u>NOT SURE</u></b>
Whites	78%	16%	6%
Blacks	76%	17%	7%
Hispanics	83%	12%	5%
<b><u>PARTY AFFILIATION</u></b>	<b><u>SUPPORT</u></b>	<b><u>OPPOSE</u></b>	<b><u>NOT SURE</u></b>
Democrats	81%	15%	4%
Republicans	71%	22%	7%
Independents	76%	19%	5%

This poll was conducted by Mason-Dixon Polling & Research, Inc. of Washington, D.C. from February 20 through February 22, 2007. A total of 625 registered voters were interviewed statewide by telephone. The margin for error is plus or minus 4%.



# McKinsey-Vattenfall Curve

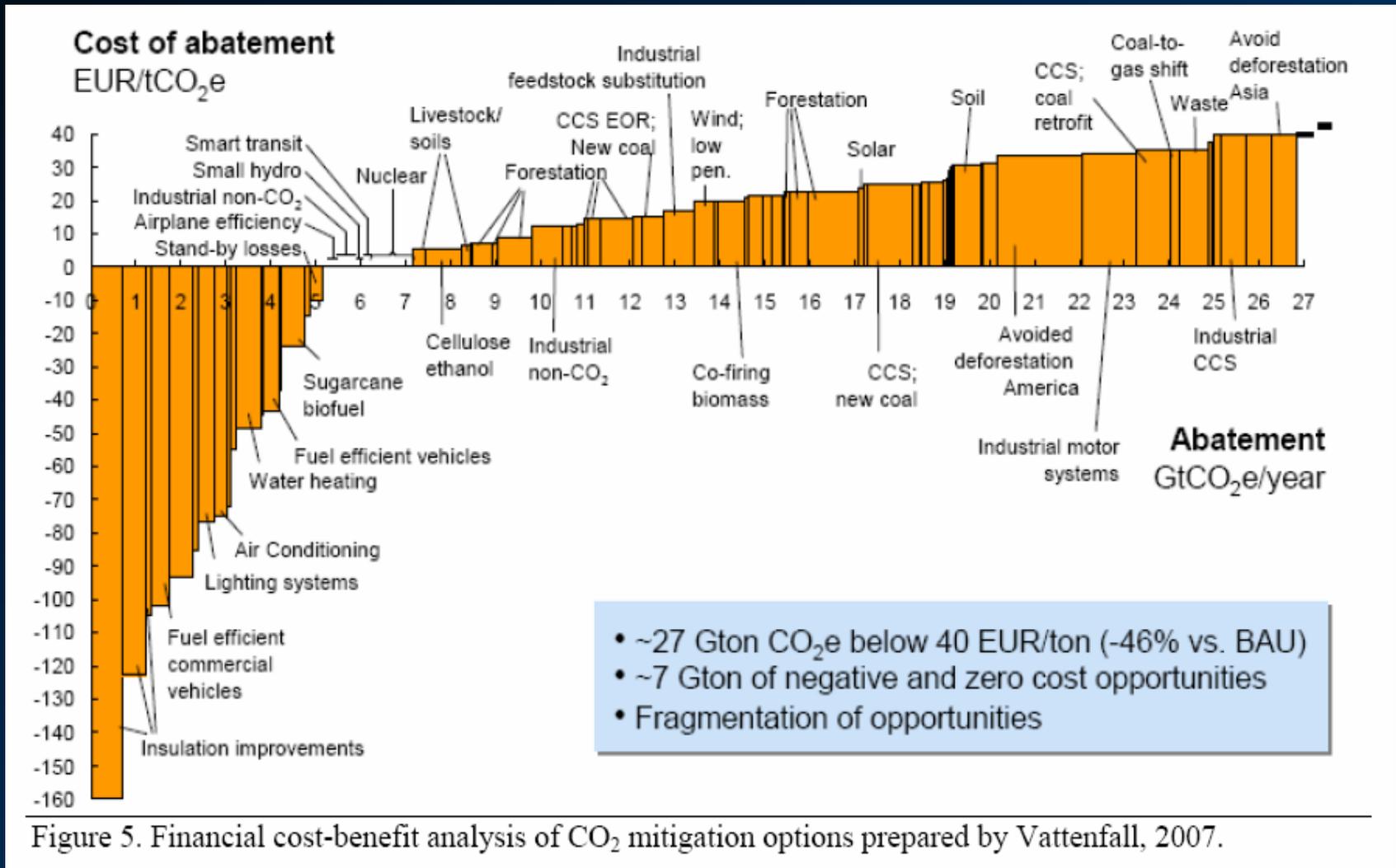
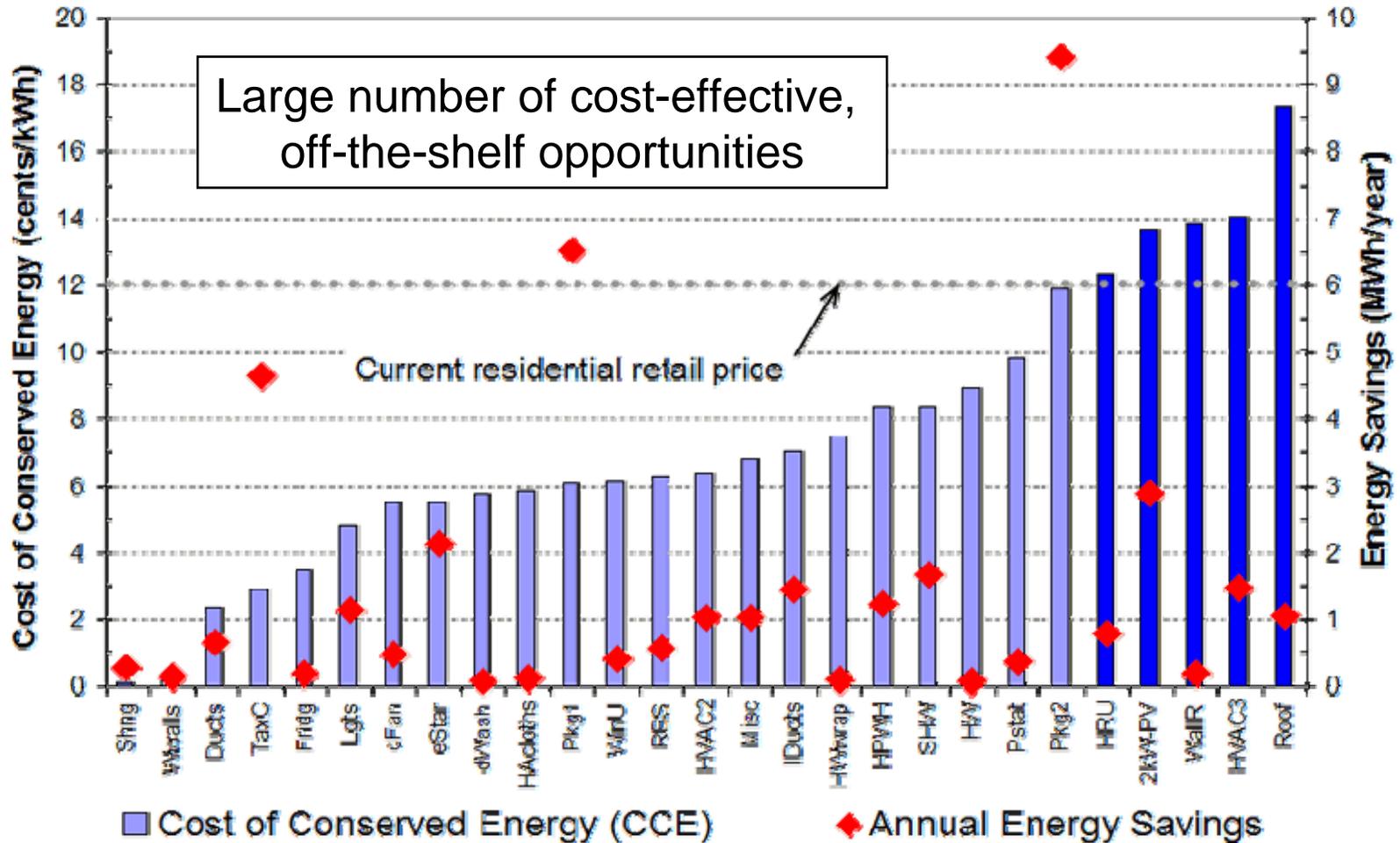


Figure 5. Financial cost-benefit analysis of CO<sub>2</sub> mitigation options prepared by Vattenfall, 2007.



# Ranked Efficiency Measures

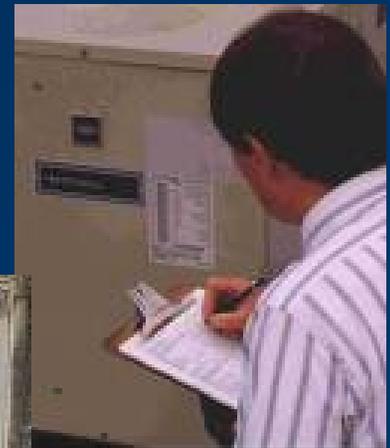
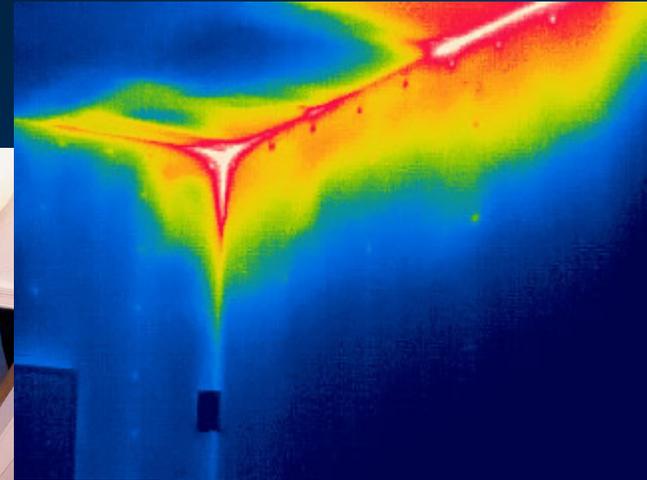
EERE Measures for Miami (Sorted by increasing CCE)





# Oh, the Complications!

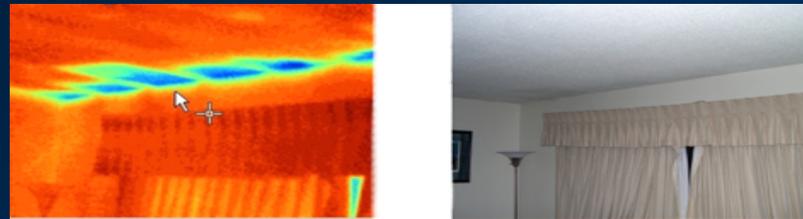
- ❖ Non-homogenous
- ❖ Terribly different
- ❖ With different occupants of different levels of cooperation
- ❖ Regional differences (lots)
- ❖ Each one potentially a cases study in what will work





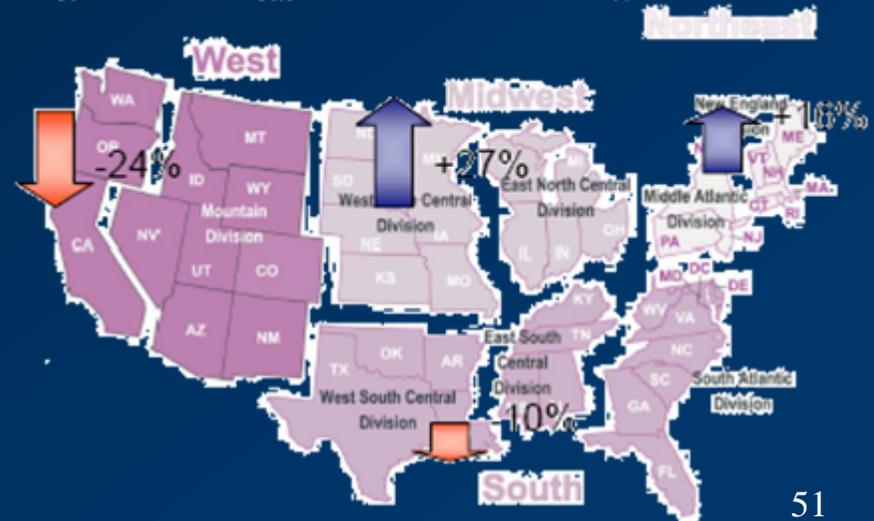
# With Huge Variability

- ❖ Regional differences
- ❖ Different vintages
- ❖ Different maintenance
- ❖ Different equipment
- ❖ Different installed appliances
- ❖ Plugs loads and amenities
- ❖ Different occupant sensibilities
- ❖ “No size fits all”



Location affects consumption!

Regional energy use vs. US average





# Attack of the Monster Homes

- ❖ Contradiction: Banks will never finance spending \$150K on efficiency
- ❖ Wrong: Banks are financing 5,000 sqft homes
- ❖ Consider: Max 2,500 sqft
- ❖ Cost per sqft is > \$150-200
- ❖ Save \$150-200K
- ❖ Spend half on super efficiency & solar features
- ❖ Greater appreciation potential
- ❖ Saves energy and PV cost/  
responsible social signal
- ❖ Find your family without a household intercom!





# Case Study: 10 Habitat Homes

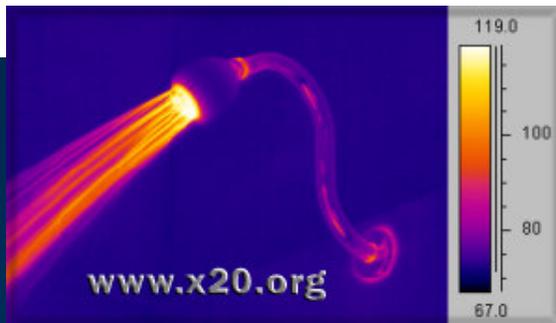
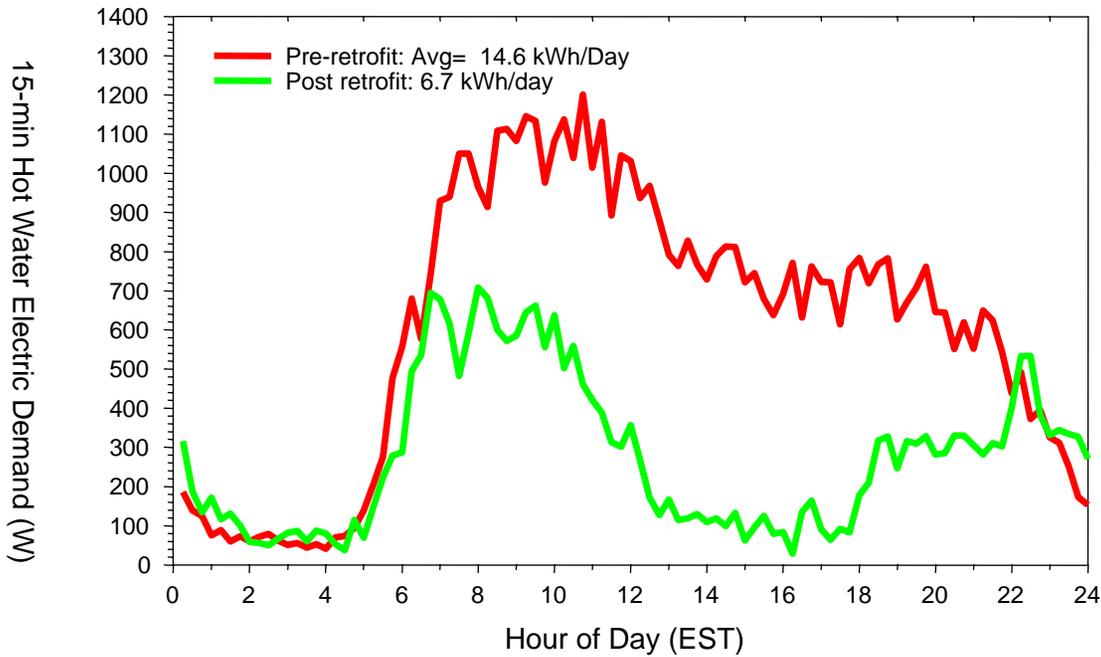
- ❖ Homestead, FL
- ❖ 1000 - 1100 sqft ft
- ❖ Repair duct leakage
- ❖ Adjust refrigerators
- ❖ Low flow showerheads & solar hot retrofit
- ❖ CFL lighting
- ❖ 2,100 kWh savings
- ❖ 14% of total use





# Solar Water Heater & New Showerheads

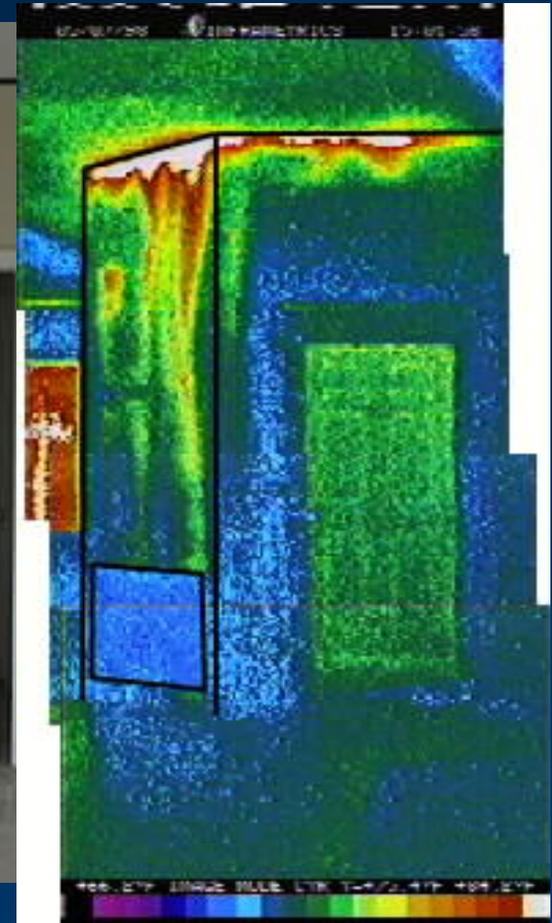
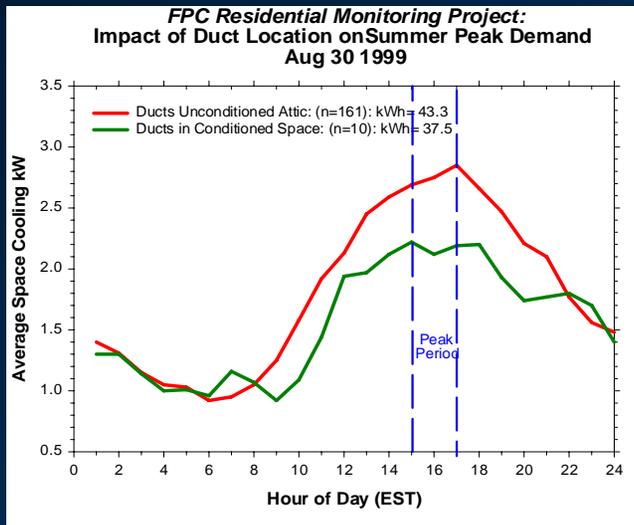
## 54% Saved !





# Interior Ducts

- ❖ Not this...
- ❖ Ducts inside insulated envelope
- ❖ Tested 3% leakage or lower to outside





# Imagine Several levels

- ❖ Why? Appetites are so large; mouths are so finite...
  - Immediate success= more political traction for next phases
  - Characterize housing stock
  - Chewable chunks
  - Maturation of technologies; create demand
- ❖ What are the levels?
  - I. Immediate survey: audit and mass measures (non-tailor made, but huge implementation).
  - II. Tailored implementation: Evaluation for specific home and occupants; home owner & computer driven evaluation
  - III. Factor Ten Implementation: May include measures not currently feasible or economically attractive
- ❖ Hazard: Drive by audit and medium level retrofits may miss big opportunities– challenging issue



# Chinese menu approach

- ❖ Improve each household element from top to bottom
- ❖ But include flexibility
- ❖ Choose from a list: (e.g. for hot climate roof/attic)
  - Radiant barrier with attic ventilation
  - More insulation
  - Reflective surfaces with sealed attic & deck insulation
- ❖ Best opportunity to make major changes

