U.S. Department of Energy
Energy Efficiency and Renewable Energy

Zero Energy Buildings

Lew W. Pratsch
U.S. Department of Energy
Systems Approach to Solar Workshop
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ZEB Systems Approach to Management

- Meet National objectives articulated by Secretary and Assistant Secretary
- Optimize ZEB via building, renewable energy and utility sector R&D
- Initial emphasis--the residential sector, later commercial buildings
- Engage industry via ZEB Teams & aggressive incremental advancements

National Objectives: The Secretary

- Challenged DOE to take a bolder approach to our work
- He directed us to focus our efforts on programs that "revolutionize how we approach conservation and energy efficiency"
- He challenged us to "leapfrog the status quo" and pursue "dramatic environmental benefits" (The Mission and Priorities of the Department)

EERE Strategic Plan Goals & Success Indicators

- Goals
  - #1—Dramatically reduce, or even end, dependence on foreign oil
  - #2—Reduce the burden of energy prices on the disadvantaged
- Success Indicators
  - #3—Renewable energy is widely cost-competitive within the next 20 years
  - #4—A significant portion of the Nation's …power needs can be served by 2030 with clean, reliable & efficient distributed power
  - #5—Cost-competitive new buildings, which create as much energy as they use, are widely available within the next 20 years

Zero Energy Building Vision & Goals

- America's new homes and commercial buildings will produce as much energy as they use. These buildings will be affordable, durable, healthy, productive and more comfortable. (Adapted from Zero Energy Home Roadmap)
- Goals:
  - Affordable residential ZEB available by 2010
  - Commercial ZEB available by 2015

- Accomplishing Vision and Goals depends on a systems approach to buildings that satisfies multiple criteria

ZEB Strategic Approach

- Develop and integrate technologies to enable zero (net) energy use in buildings
- Build on Building America to dramatically reduce energy use and related emissions in the near term for new buildings
- Guide policies that stimulate demand for Zero Energy Buildings, enhance energy security, reduce pollution, and eliminate summer peak load

- Success depends on ability to integrate & optimize multiple technologies in different climates and building types that have different market constraints/opportunities

ZEB Benefits

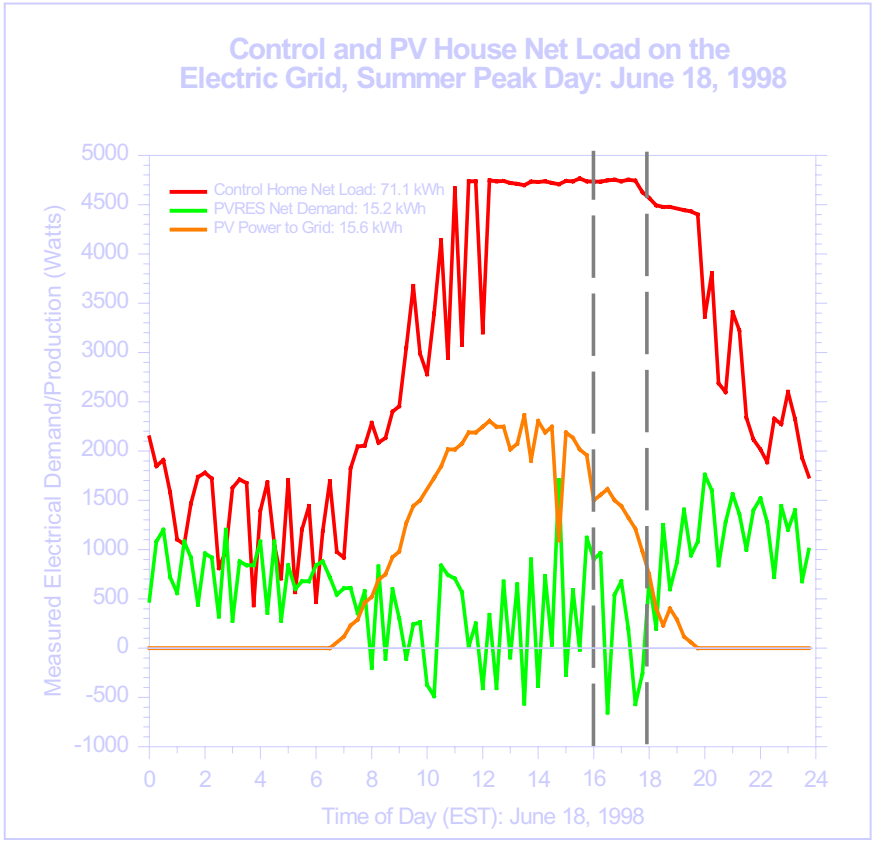
- Zero (net) Energy
- Zero Peak Load
- Zero Emissions
- Zero Utility Bill
- Zero Complaints (from new homebuyers & building occupants)
- And, affordable, durable, healthy, productive, and more comfortable

Energy Profile - Residential

- Year 2000 data
- Of 19.9 quads, 65% is electricity and 26% is natural gas
- Residences consume 20% of all U.S. energy
- A/C dominates utility peak loads

End Use	Quad	%
Space Heating	6.6	33%
Space Cooling	2.0	10%
Water Heating	3.0	15%
Lighting	1.2	6%
Refrigeration	1.7	9%
Wet Clean	0.9	5%
Cooking	0.9	5%
Electronics	1.0	5%
Computers	0.1	1%
Other	0.7	3%
Total	**19.9**	**100%**

Early Modeling: Improved Grid + Less Energy



Source: Florida Solar Energy Center (FSEC)

- Grid-connected PV system, solar water heating, & energy-efficient equipment.
- 4kW PV supplied most of the home's daytime electrical needs on peak summer days
- Hottest summer day ZEH used:
  - 72% less power to run its AC
  - 93% less utility-supplied power

Energy Savings

	Power Use (kWh)	Net Power Use (kWh)	Monthly Cost of Power ($)
Zero Energy Home	837	335	$27
Control Home	1,839*	1,839*	$147

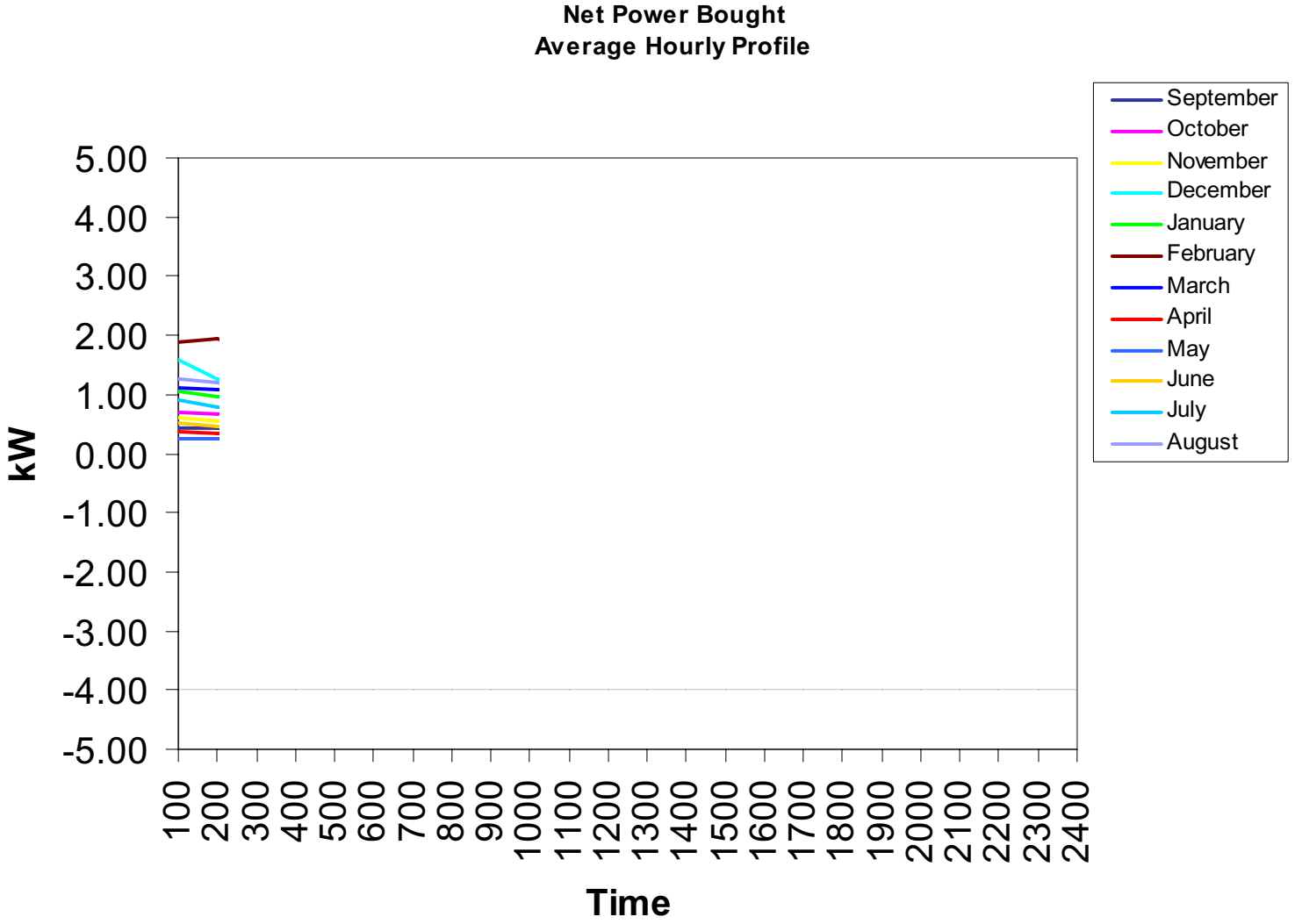
*Air-conditioning only

Source: FSEC

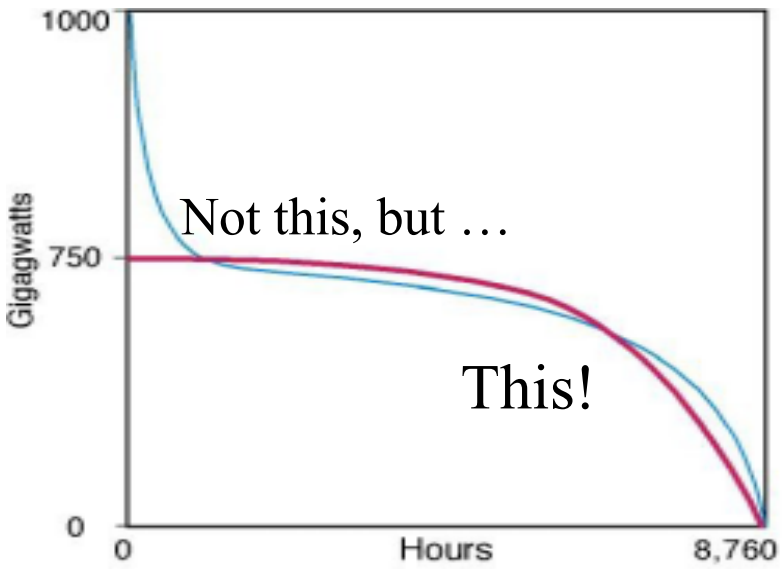
Solar Patriot House

- 3000 sq. ft. + Top Floor & Basement
- Full complement of modern appliances
- Produced “82%” of energy onsite in first year
- Expect to achieve ZEB status in 2003
- Monitored past year by NREL

Solar Patriot House

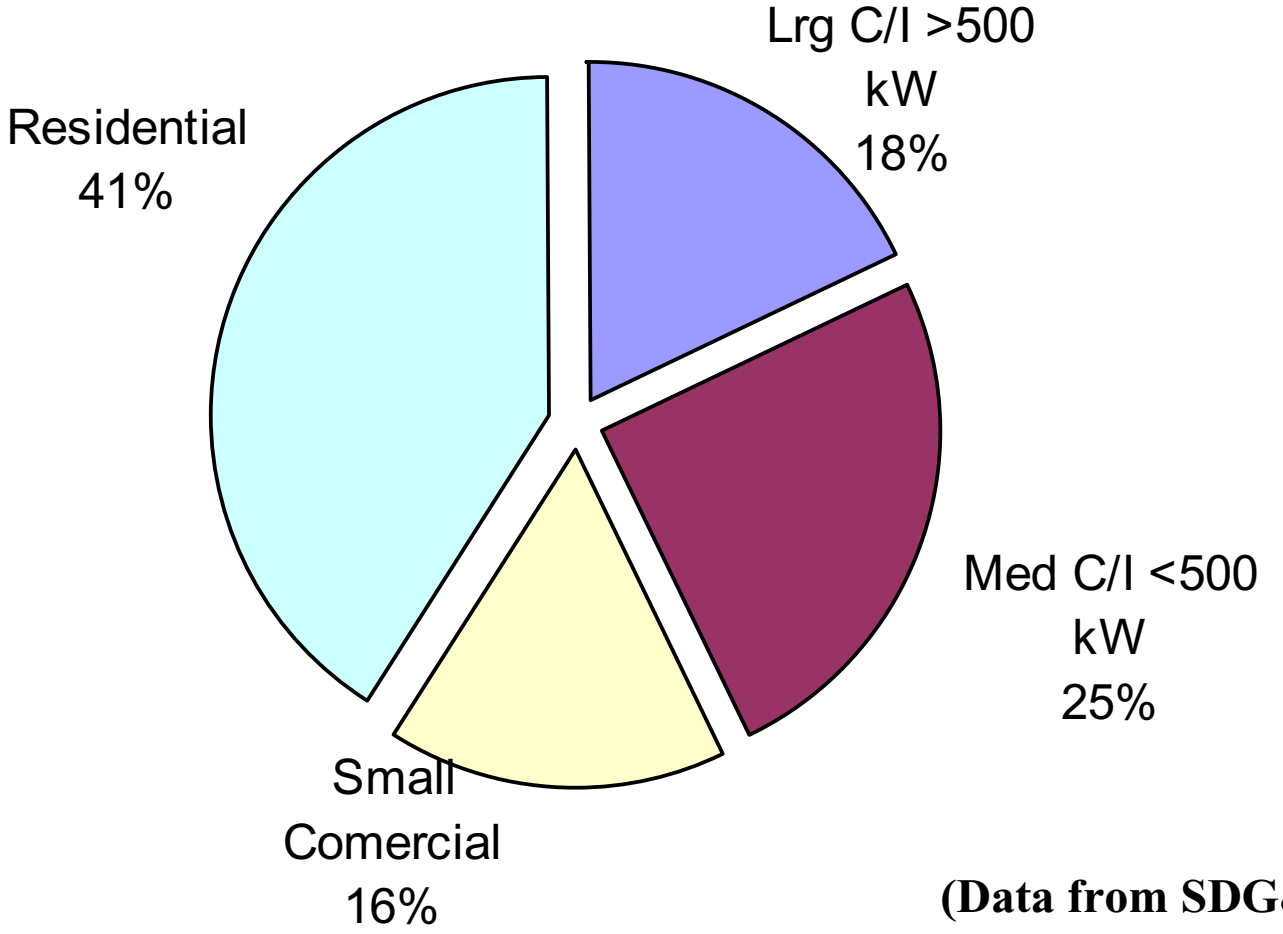


A "Flat" Load Profile Would Save Big $



- Flattening the load curve could eliminate the need for ~20% or more of generation, transmission, and distribution capacity!
- A flatter load curve could change the types of power plants, how they operate, and overall fuel efficiency of the power system.
- A flatter load curve could reduce power costs and price volatility for all consumers.

Searching for Peak Savings



(Data from SDG&E 1999)

ZEH Homebuilder Teams

- Four ZEH teams awarded contracts this year
- Teams will design, build marketable prototypes, monitor, & build subdivisions
  - Consol (Morrison, Shea, WL Homes & Pardee)
  - Davis Energy Group (Centex)
  - NAHB (John Wesley Miller)
  - Steven Winter Associates (Beazer, Mercedes & Bradley)

Shea's High Performance Homes

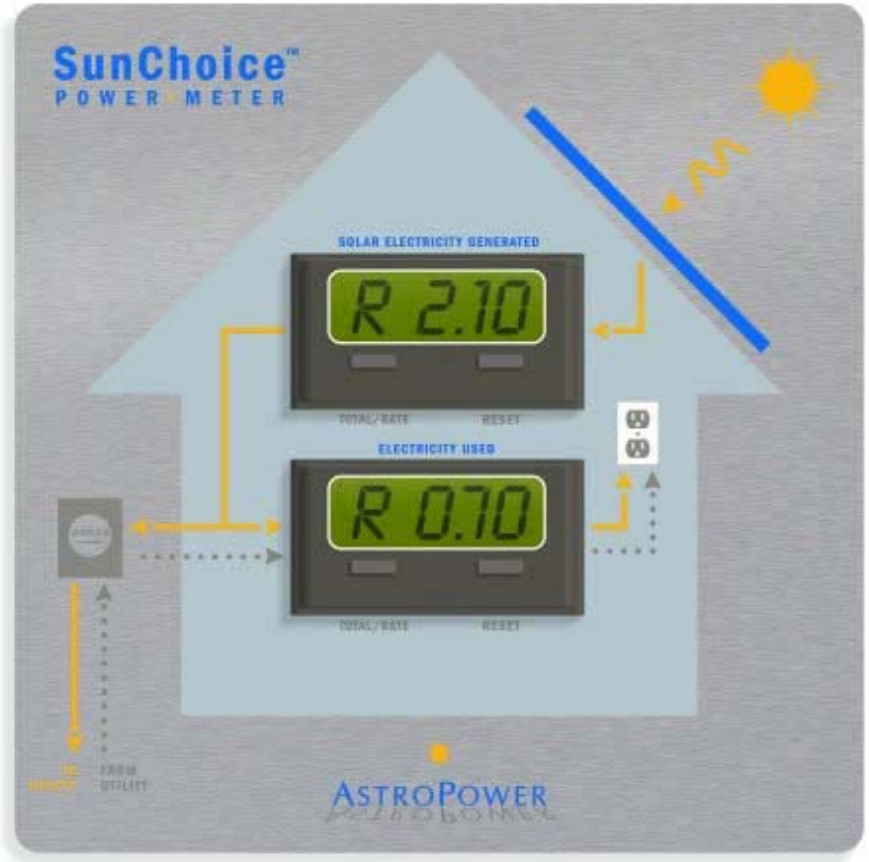
- 306 homes under construction
- Homes about 40% better than Title 24
- All will have Solar Water Heaters
- About 100 will have 1.2 kw
- Many have option to upgrade to 2.4 kw
- 250 homes sold—will complete subdivision early
- Homes selling as fast as they can be built
- Solar features often mentioned one of top 3 reasons for purchase

Shea's San Angelo Subdivision

Shea's Homebuyer Comments

- Energy-efficiency & solar features a "bonus" –a nice surprise
- "We feel the builders know what they are doing, so if they offer the solar as part of the package, there must be a reason."
- "They are finally listening to what consumers want."
- "All the builders should be doing it."
- One homeowner was blown away—1200 sq ft condo had a higher utility bill than 4000 sq ft house

SunChoice™ Power Meter



Centex ZEB Home

- First ZEB Team Home
  - Open House—July 02
  - Davis Energy Group
  - Expects to have Zero Energy Bill
- Key Features
  - Photovoltaics--3.6 KW
  - Night Breeze (Smart Economizer)
  - Slab insulation
  - Window Shading
  - Cellulose insulation

Centex ZEB House

John Wesley Miller

- Teaming with NAHB Research Center
- ZEB Groundbreaking—November 4, 2002
  - Includes 4 kw of solar electric
- 99 homes all have:
  - Utility guaranteed htg/clg bills @ about $1/day
  - Solar water heaters & solar electric
  - Masonry walls for thermal storage
  - Pre-wired with cable TV/Fiber optics
  - Central vacuum & two car garages
  - Pedestrian-friendly neighborhood

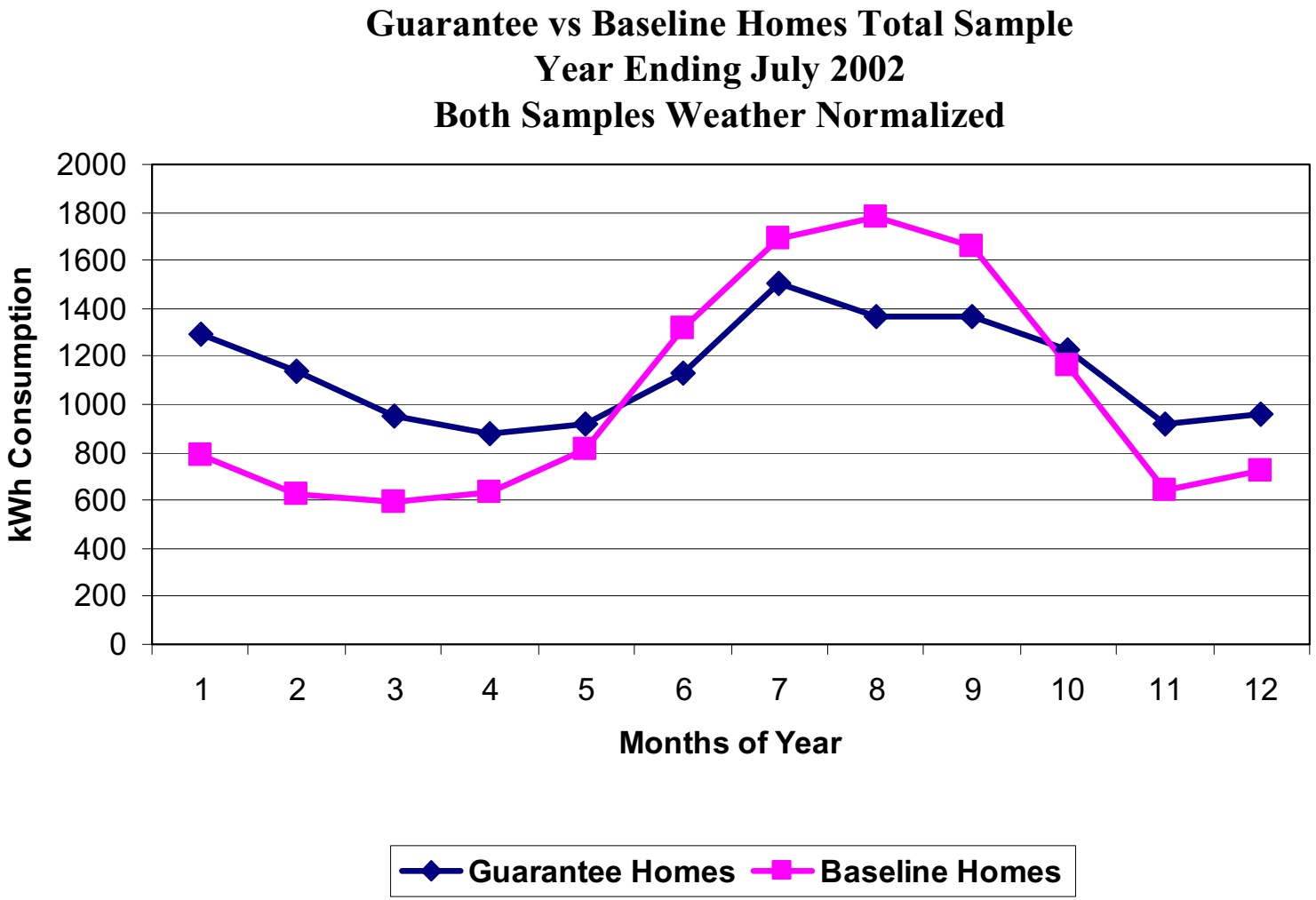
Armory Park Del Sol—Tucson, AZ

Tucson's* Time-of-Use Rate

	Jun-Aug	May & Sep-Oct	Nov-Apr
On-peak kWh @	$.18	$.15	$.10
Shoulder kWh	$.12	$.09	NA
Off-peak kWh	$.06	$.05	$.03
Min bill/month	$6.78		

*Tucson Electric Power Company

TEP's Residential T-O-U vs Control



Roadmaps by EERE/Industry

- Window Industry Technology Roadmap
- Building Envelope Technology Roadmap
- Lighting Technology Roadmap
- HVAC & Refrigeration Roadmap
- Zero Energy Homes Roadmap
- Appliances and Equipment Roadmap
- The U.S. Photovoltaic Industry Roadmap
- Technology Pathways for the DOE Zero Energy Buildings Program (With DOE's labs)

Possible Solar Energy Tech. R&D

- Cut installed price of PV 50%
  - Lower-cost thin-film technologies
  - More reliable modules and systems
  - Improved manufacturing
- Develop polymer based solar water heater
- Develop polymer based solar space heating system
- Develop building integrated solar on roofing membrane
  - PV over thermal
  - PV & thermal side-by-side
- Low cost storage for critical needs
- Develop solar based combined heat & power system for commercial buildings

Astropower's SunChoice™ Solar Electric Home Power System

- New roof-integrated product with enhanced aesthetics, same reliability and performance
- Builder partners:
  - Shea,
  - Pardee,
  - Centex,
  - Standard Pacific,
  - Clarum,
  - US Home,
  - Lennar

Possible Buildings Technologies

- 70% reduction in building envelope energy use
  - Insulation/air infiltration
  - Advanced windows/automated exterior shading
  - Slab & foundation insulation
- Smaller, more efficient HVAC
  - Possibly no ductwork
- Individual room control for HVAC, lights
- Smart water heaters & appliances
- Wireless, automated systems
- Zero Energy commercial building analysis
- Codes & standards

Possible Zero Energy Home R&D

- ZEH Homebuilder Team Support
  - Build prototypes and subdivisions
  - Recommend R&D
- Zero Energy Home monitoring
  - Utility load curves/factors
  - Homebuyer satisfaction
- ZEH integration & optimization for various climates
- ZEH automation & system integration
  - Automatic operation of home's energy systems
  - Accommodate Time-of use rates
  - Interact with utility/weather
- Initial Zero Energy Commercial Building analysis

Residential Energy Saving Pgms.

- Energy Star Homes (EPA)
  - 30% better than code or 15% better than state code
- Building America (DOE)
  - New homes–40-70% reduct. in whole house energy use
  - Existing homes – 20-40% lower energy bill
- Zero Energy Homes (DOE)
  - ZEH-50 -- Cut utility bills 50% by 2004
  - ZEH-75 -- Cut bills 75% by 2007
  - ZEH-100 – Zero Energy Bill

Why should builders build ZEHs?

- "ZEHs can help builders compete smartly – not on the basis of cost – but on the basis of product differentiation, thereby expanding their sales in both the conventional home and higher margin markets." Zero Energy Homes Roadmap—Final Draft, September 2002

- Sell two more houses per week!

ZEB Benefits

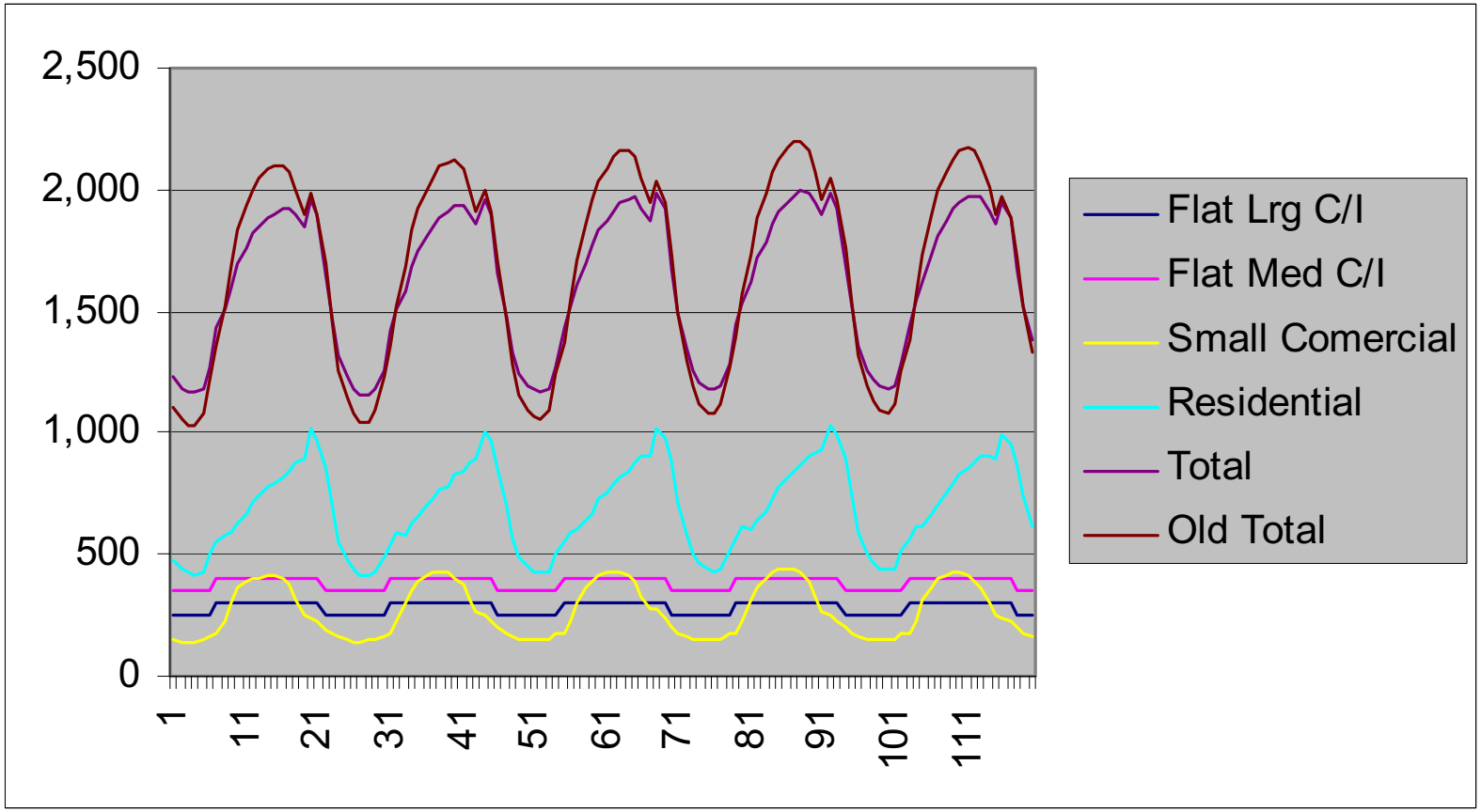
- By 2020 EIA projects buildings will consume 47 Quads
  - Today--High-efficiency homes about 5% of market
  - Establish new paradigm to drastically cut energy use
- First major program to fully integrate energy efficiency & renewable energy
- Ideal for time-of-use rates
- Improves grid by shedding summer peak load growth
- Positive cash-flow in mortgage

The ZEB Challenge

- Excellence in RD&D
- Excellence in design
- Excellence in construction
- Excellence in load management
- Excellence in marketing
- Excellence in comfort
- And, Industry excitement

Searching for Peak Savings

Medium & large C/I shave peaks



Searching for Peak Savings

Smart res. & small com. save day