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

<table>
<thead>
<tr>
<th>End Use</th>
<th>Quad</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>6.6</td>
<td>33%</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>2.0</td>
<td>10%</td>
</tr>
<tr>
<td>Water Heating</td>
<td>3.0</td>
<td>15%</td>
</tr>
<tr>
<td>Lighting</td>
<td>1.2</td>
<td>6%</td>
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<tr>
<td>Refrigeration</td>
<td>1.7</td>
<td>9%</td>
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<tr>
<td>Wet Clean</td>
<td>0.9</td>
<td>5%</td>
</tr>
<tr>
<td>Cooking</td>
<td>0.9</td>
<td>5%</td>
</tr>
<tr>
<td>Electronics</td>
<td>1.0</td>
<td>5%</td>
</tr>
<tr>
<td>Computers</td>
<td>0.1</td>
<td>1%</td>
</tr>
<tr>
<td>Other</td>
<td>0.7</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19.9</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Early Modeling: Improved Grid + Less Energy

- 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

<table>
<thead>
<tr>
<th></th>
<th>Power Use (kWh)</th>
<th>Net Power Use (kWh)</th>
<th>Monthly Cost of Power ($)</th>
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</thead>
<tbody>
<tr>
<td>Zero Energy Home</td>
<td>837</td>
<td>335</td>
<td>$27</td>
</tr>
<tr>
<td>Control Home</td>
<td>1,839*</td>
<td>1,839*</td>
<td>$147</td>
</tr>
</tbody>
</table>

*Air-conditioning only

Source: Florida Solar Energy Center (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
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

<table>
<thead>
<tr>
<th></th>
<th>Jun-Aug</th>
<th>May &amp; Sep-Oct</th>
<th>Nov-Apr</th>
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</thead>
<tbody>
<tr>
<td>On-peak kWh</td>
<td>$0.18</td>
<td>$0.15</td>
<td>$0.10</td>
</tr>
<tr>
<td>Shoulder kWh</td>
<td>$0.12</td>
<td>$0.09</td>
<td>NA</td>
</tr>
<tr>
<td>Off-peak kWh</td>
<td>$0.06</td>
<td>$0.05</td>
<td>$0.03</td>
</tr>
<tr>
<td>Min bill/month</td>
<td>$6.78</td>
<td></td>
<td></td>
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</tbody>
</table>

*Tucson Electric Power Company
TEP’s Residential T-O-U vs Control

Guarantee vs Baseline Homes Total Sample
Year Ending July 2002
Both Samples Weather Normalized

kWh Consumption

Months of Year

Guarantee Homes
Baseline Homes
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
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

Graph showing energy consumption trends with labels for different categories and years.