



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

Zero Energy Buildings

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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”



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



ZEB Benefits

- Zero (net) Energy
- Zero Peak Load
- Zero Emissions
- Zero Complaints (from homebuyers)
- Ideal for time-of-use rates
- Positive cash-flow in mortgage



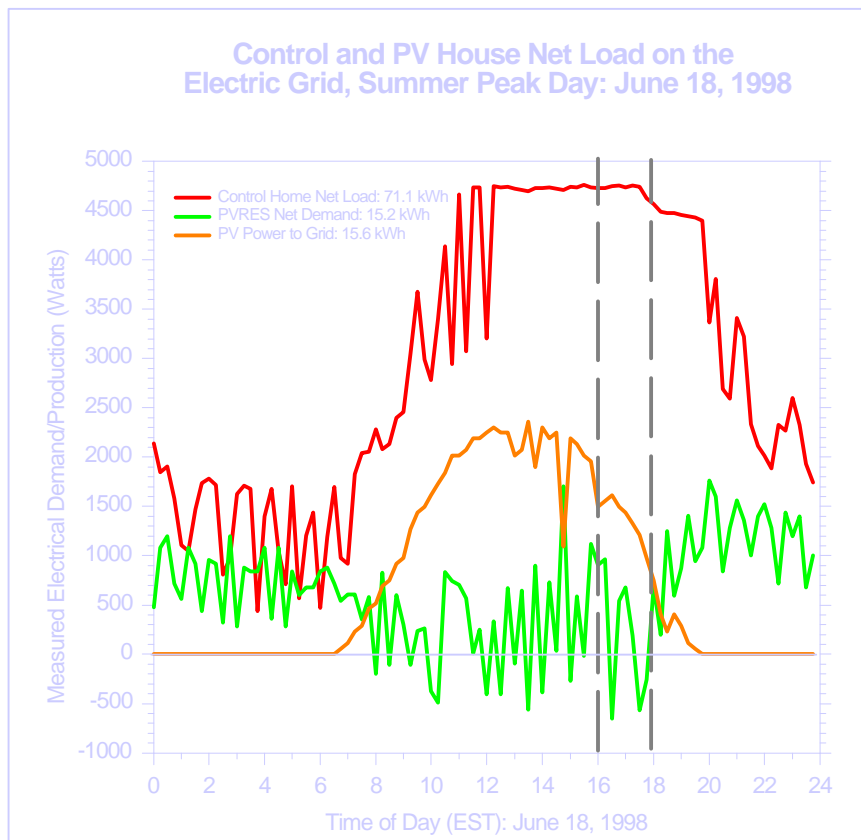
Energy Profile - Residential

- 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

<u>End Use</u>	<u>Quad</u>	<u>%</u>
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	<u>0.7</u>	<u>3%</u>
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

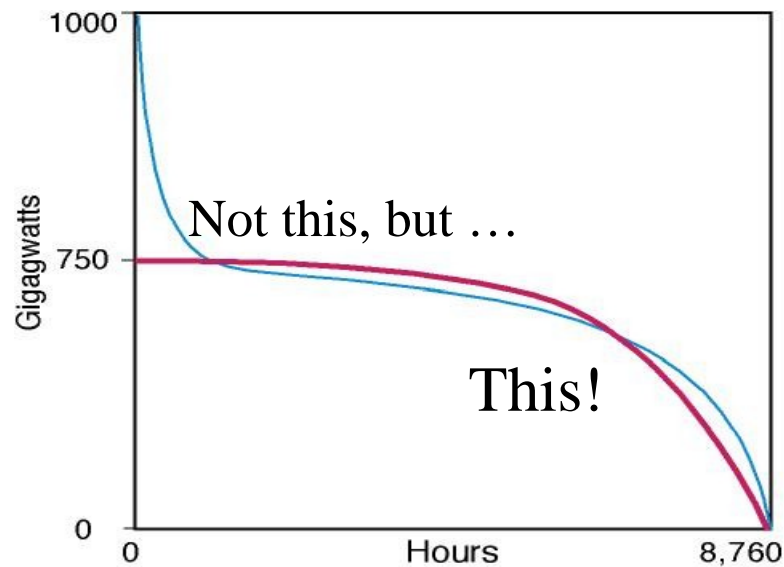
Energy Savings			
	Power Use (kWh)	Net Power Use (kWh)	Monthly Cost of Power (\$)
Zero Energy Home	837	335	\$27
Control Home	1,839*	1,839*	\$147

*Air-conditioning only

Source: FSEC



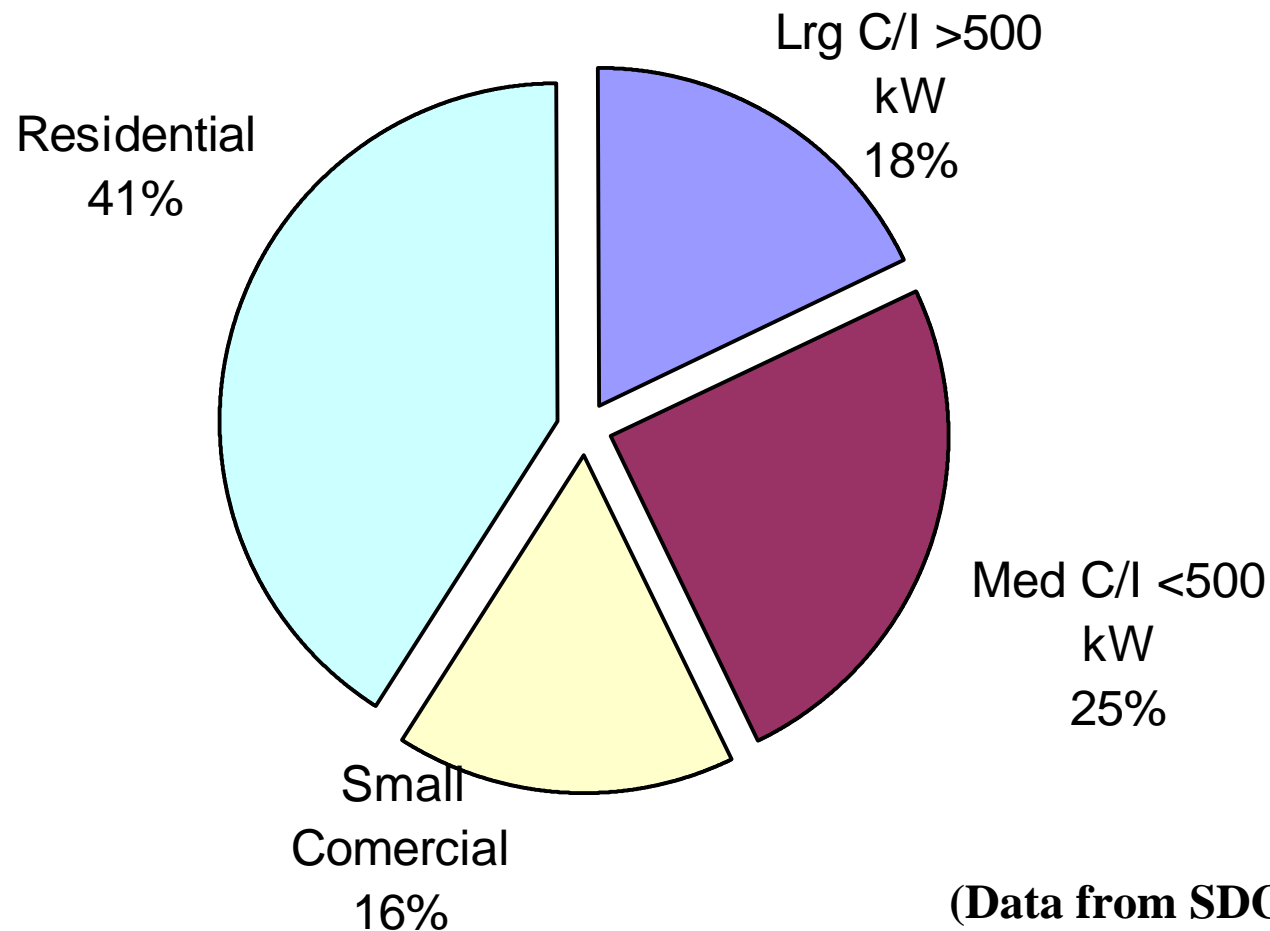
A “Flat” Load Profile Would Save Big \$



- 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)



Solar Patriot House

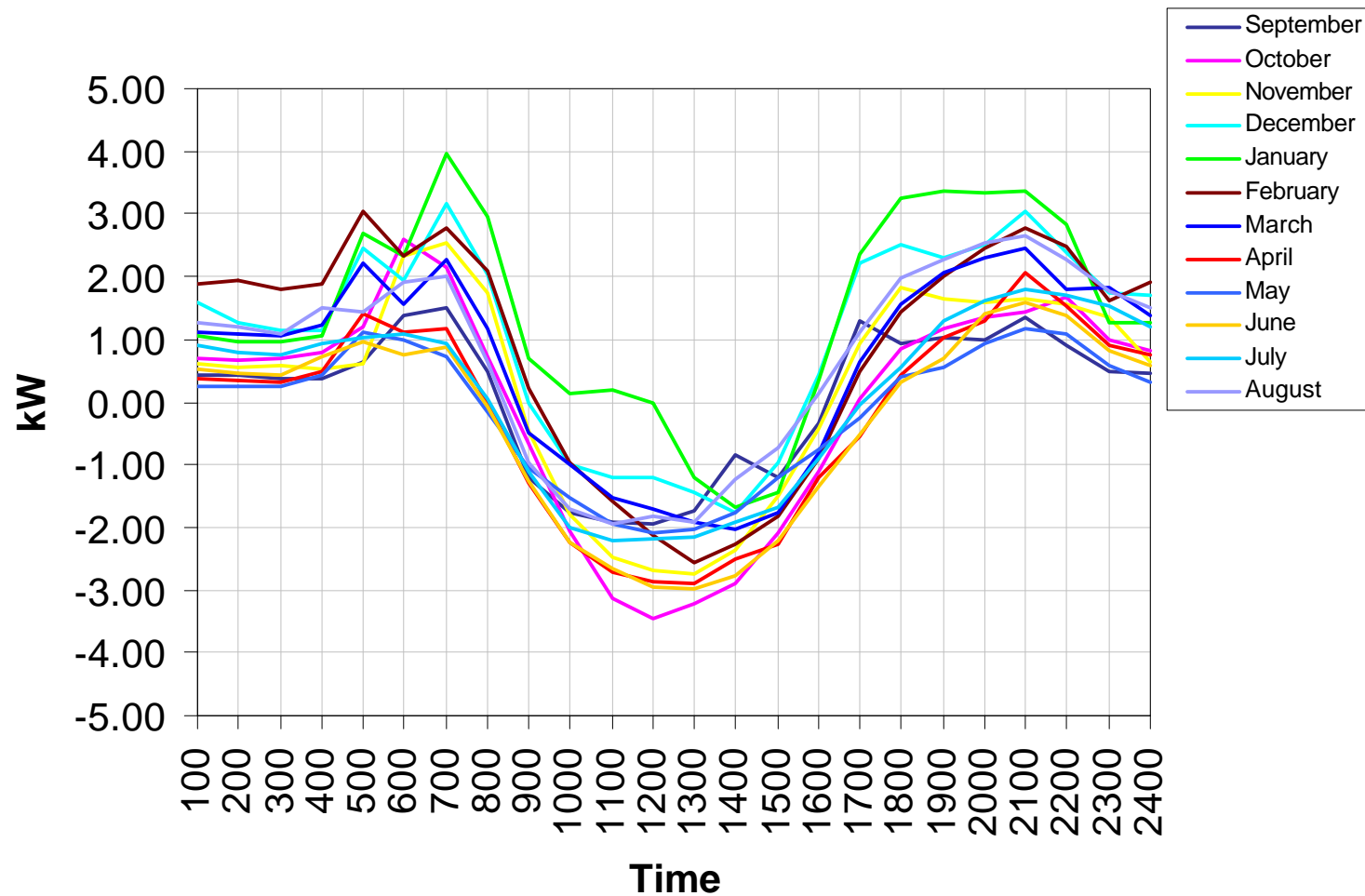
- 3000 sq. ft. + top floor & basement
- Full complement of modern appliances
- Produced “82%” of energy onsite in first year
- Expect to achieve ZEB status in 2003
- Monitored past year by NREL





Solar Patriot House

Net Power Bought
Average Hourly Profile





ZEH Homebuilder Teams

- Four ZEH teams awarded contracts last year
- Teams are designing, building marketable prototypes & subdivisions, & monitoring
 - Consol (Pardee, Shea, Morrison, Clarem)
 - 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 of PV
- Many have option to upgrade to 2.4 kw of PV
- 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



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Shea's San Angelo Subdivision





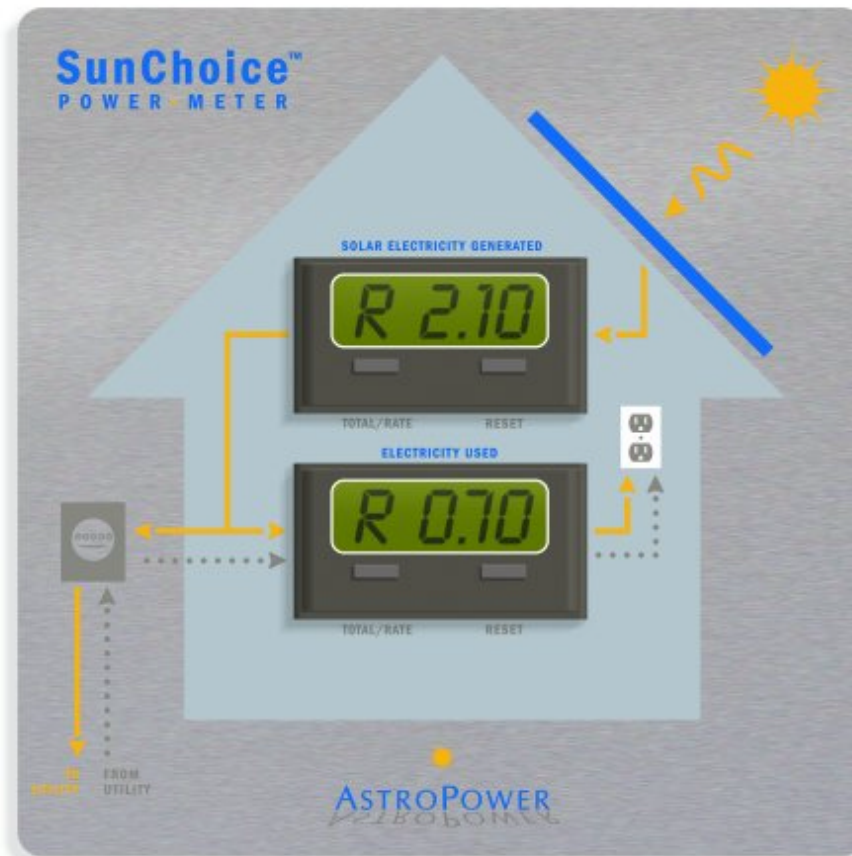
Shea's Homebuyer Comments

- 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
- “We wanted to get this house because the system was already there. We didn’t have to decide about it.”



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SunChoice™ Power Meter





Centex ZEB Home

- First ZEB Team Home
 - Open House—July 2002
 - 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



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Centex ZEB House





John Wesley Miller

- Teaming with NAEHB 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 & 1 kw solar electric
 - Masonry walls for thermal storage
 - Pre-wired with cable TV/Fiber optics
 - Central vacuum & two car garages
 - Pedestrian-friendly neighborhood



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Armory Park Del Sol—Tucson, AZ





Tucson's* Time-of-Use Rate

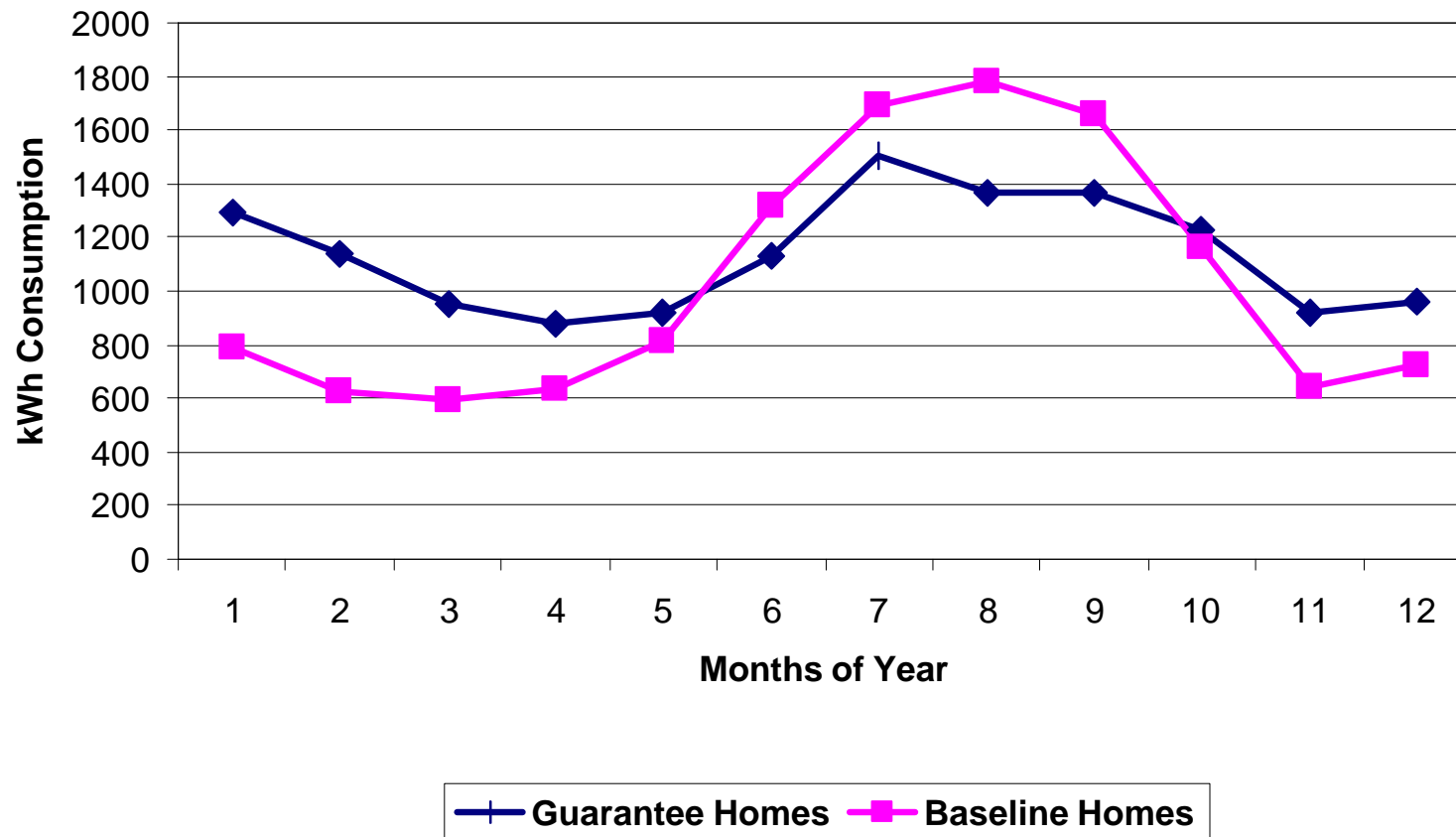
	Jun-Aug	May & Sep-Oct	Nov-Apr
On-peak kWh @	\$.18	\$.15	\$.10
Shoulder kWh	\$.12	\$.09	NA
Off-peak kWh	\$.06	\$.05	\$.03
Min bill/month	\$6.78		

*Tucson Electric Power Company



TEP's Residential T-O-U vs Control

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





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



ZEH Rating Considerations

- Whole house rating
- ZEH minimum standard—cut utility bills by 50%
- Time-of-use impact
- Shaving utility peak loads
- Smart Appliances—automatically shave peaks
- Mortgage impact
- Guaranteed bills
- Net energy producer HERS rating > 100



The ZEB Challenge

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