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AMERICA** <sup>SM</sup>  
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Research Leading to Zero Energy Homes

# Next Steps in Controlling Miscellaneous Electricity Energy Use in Building America Homes

Danny Parker and David Hoak

January 2006

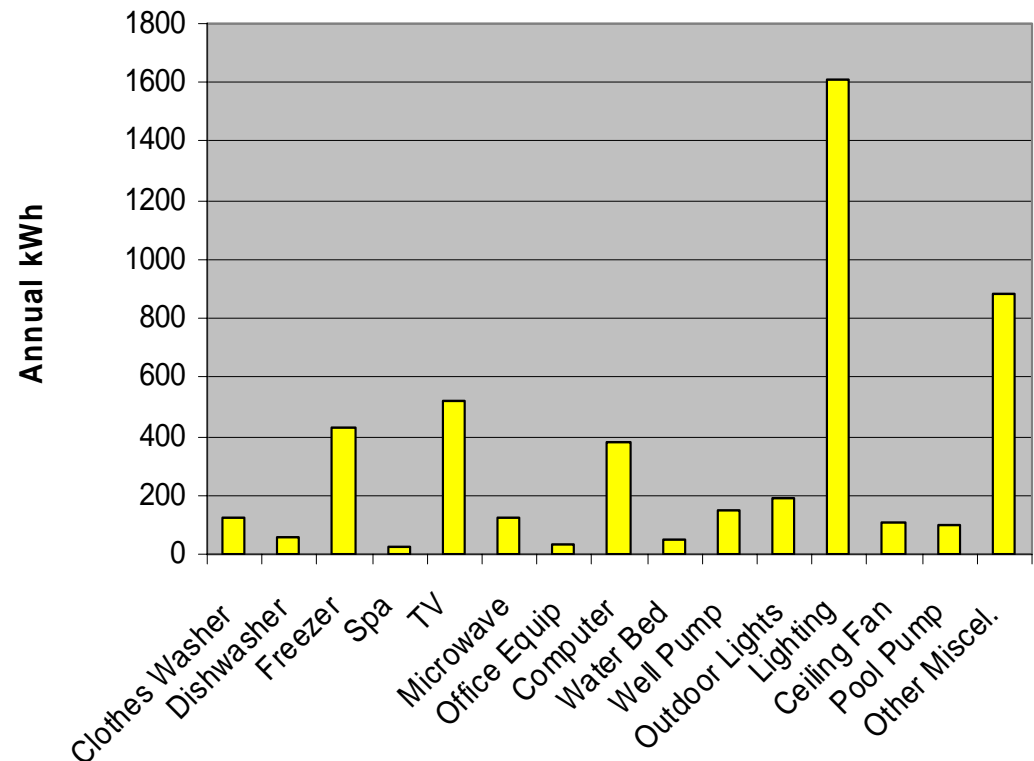




# Getting to know your problems...

- Miscellaneous loads
  - LAME: Lighting and Miscellaneous Appliance Electricity (IBACOS)
- Extremely diverse
- Over 2,100 kWh not including lighting
- TV/entertainment: large & growing end use
- Plasma TVs may use twice the energy as tube sets
- LCD TVs use less; efficiency developments
- Computing/office equipment grows

**Miscellaneous Electricity Use**





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# “I Want to Drink Your Vatts”

## ALL-DAY SUCKERS

Among the devices that need juice even when not in use:



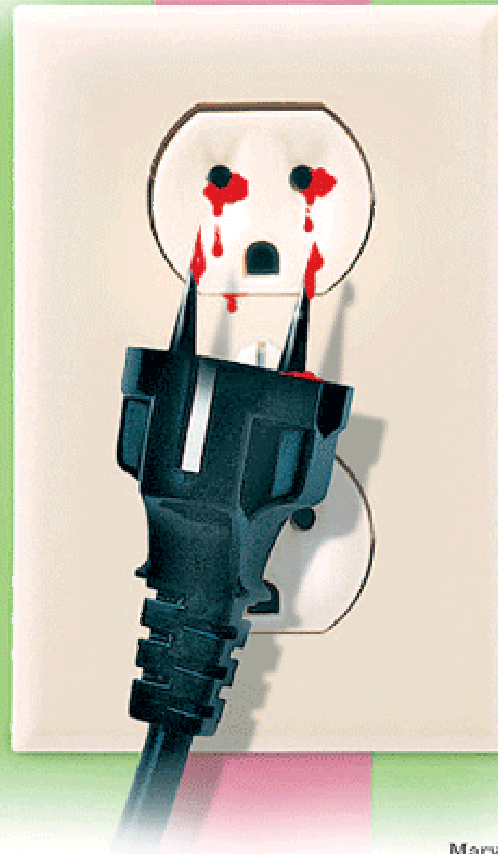
- Televisions and VCR's in continuous standby mode.



- Anything that works with a remote.



- Adapters for MP3 players and cellphones, which can waste half the energy they consume.

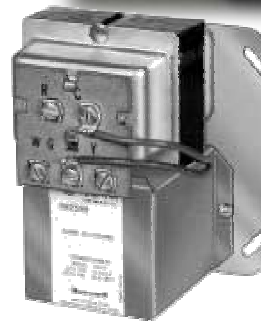


Mary Ann Smith



# Miscellaneous Electricity: How Big?

- 14% of average household electricity use
- Forecast to double in 20 years.
- New homes typically draw 50W of power before they are occupied.
- Peak power demand is significant
- Hard-wired appliances are installed by builder before owner takes occupancy
  - Eg. Doorbells, garage door openers, security systems, thermostats
- Hard-wired loads and “wall-warts” after occupancy can amount to 45-85% of consumption in low-energy homes (Duncan Prahl, IBACOS)



Dual position charger  
with LED display

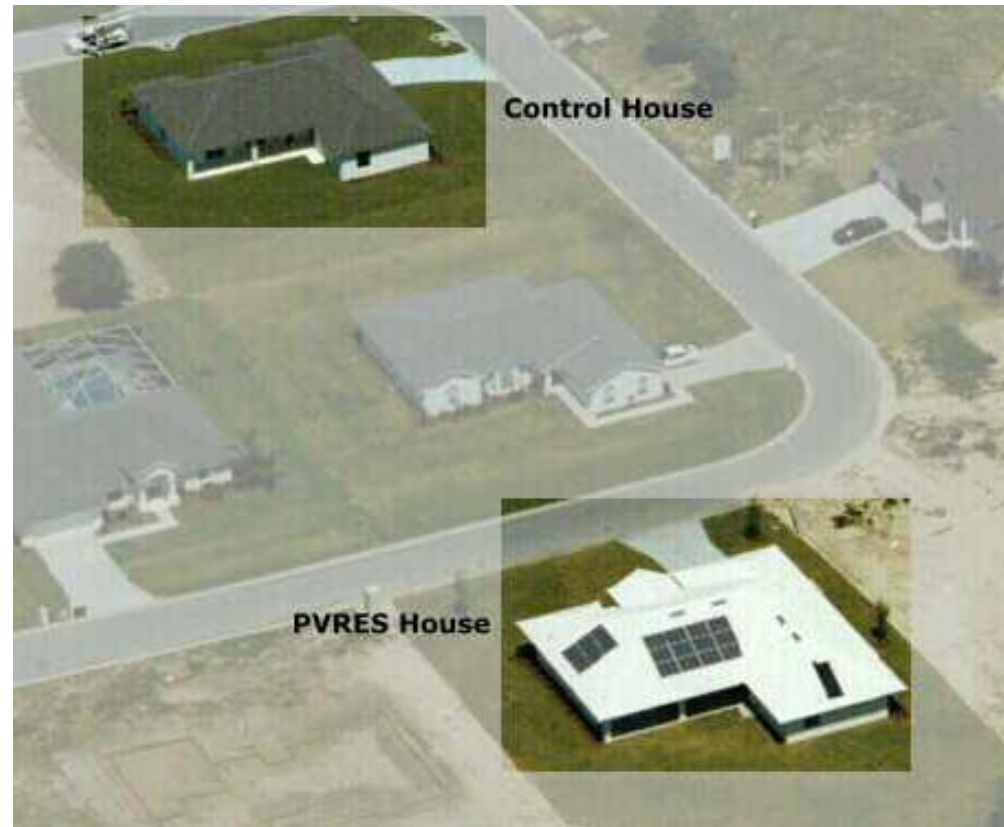






# Zero Energy Homes

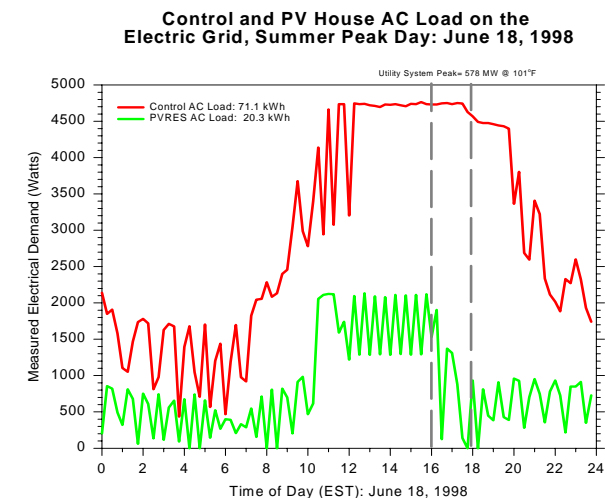
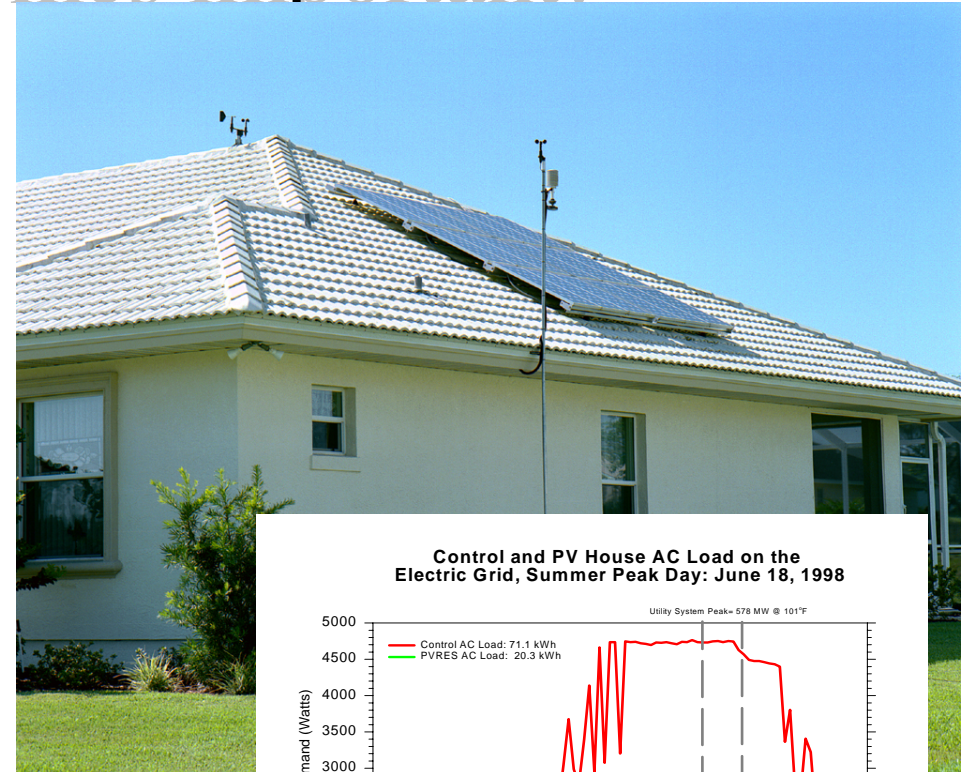
- Side-by-side test
- ZEH used 75% less measured cooling.
- 90% of energy use generated
- No peak demand when solar included
- First FL ZEH home still active in Lakeland, FL





# “Miscellaneous” becomes important!

- Hi-performance ZEH designs
  - HVAC & DHW loads are cut by 50-70%
  - Lighting and refrigeration loads are also cut
- Remaining loads become major loads
- 500 W at night





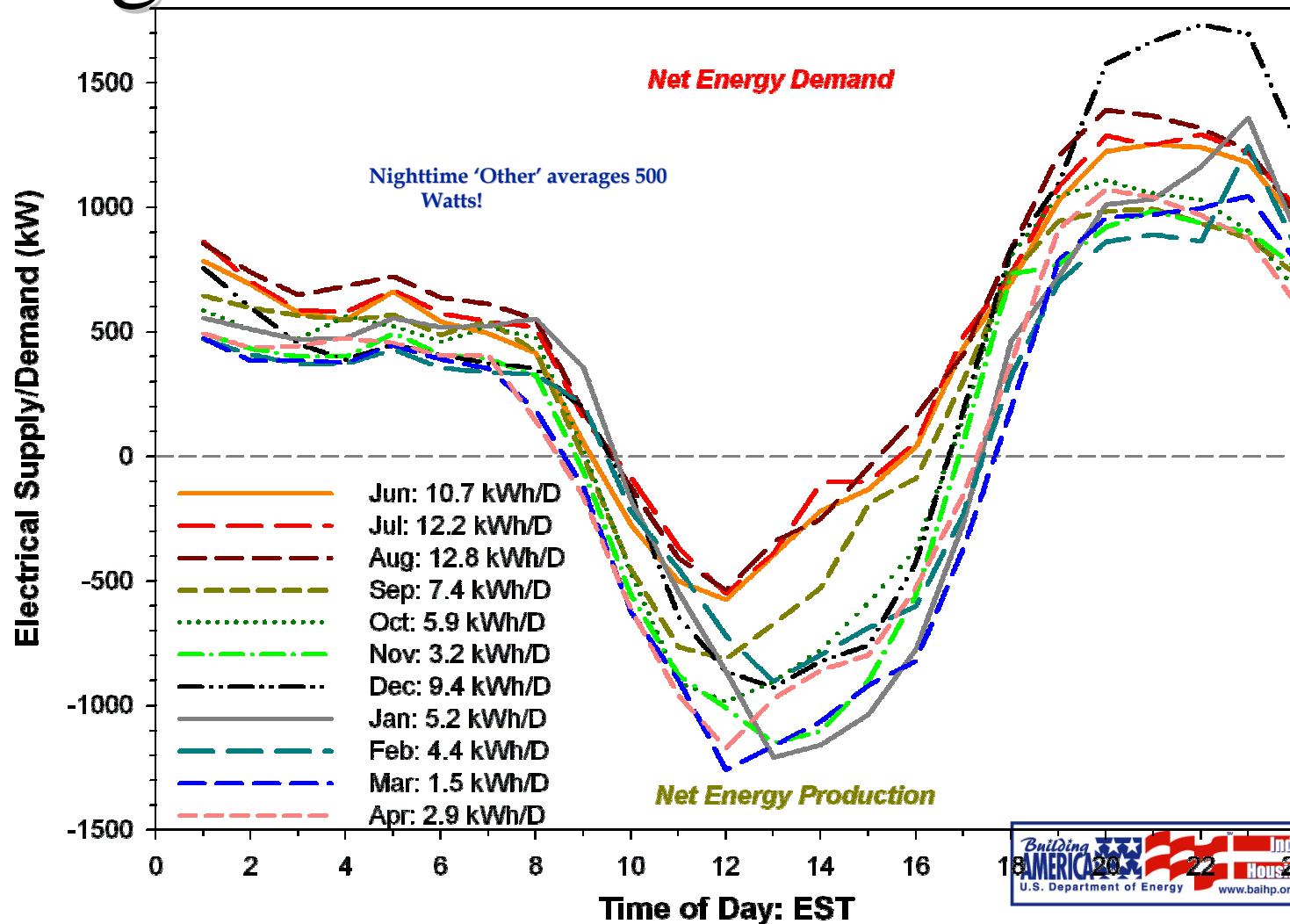
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# Long term Performance

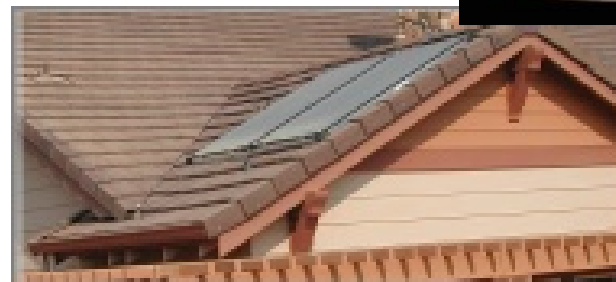






# CA ZEH #1: Livermore, CA

- 3,079 sqft conditioned
- High efficiency
  - Insulation package/RBS
  - Trellis shading
  - High effic. windows
- *NightBreeze* smart economizer/ ventilation system
- SDHW with instantaneous gas auxiliary







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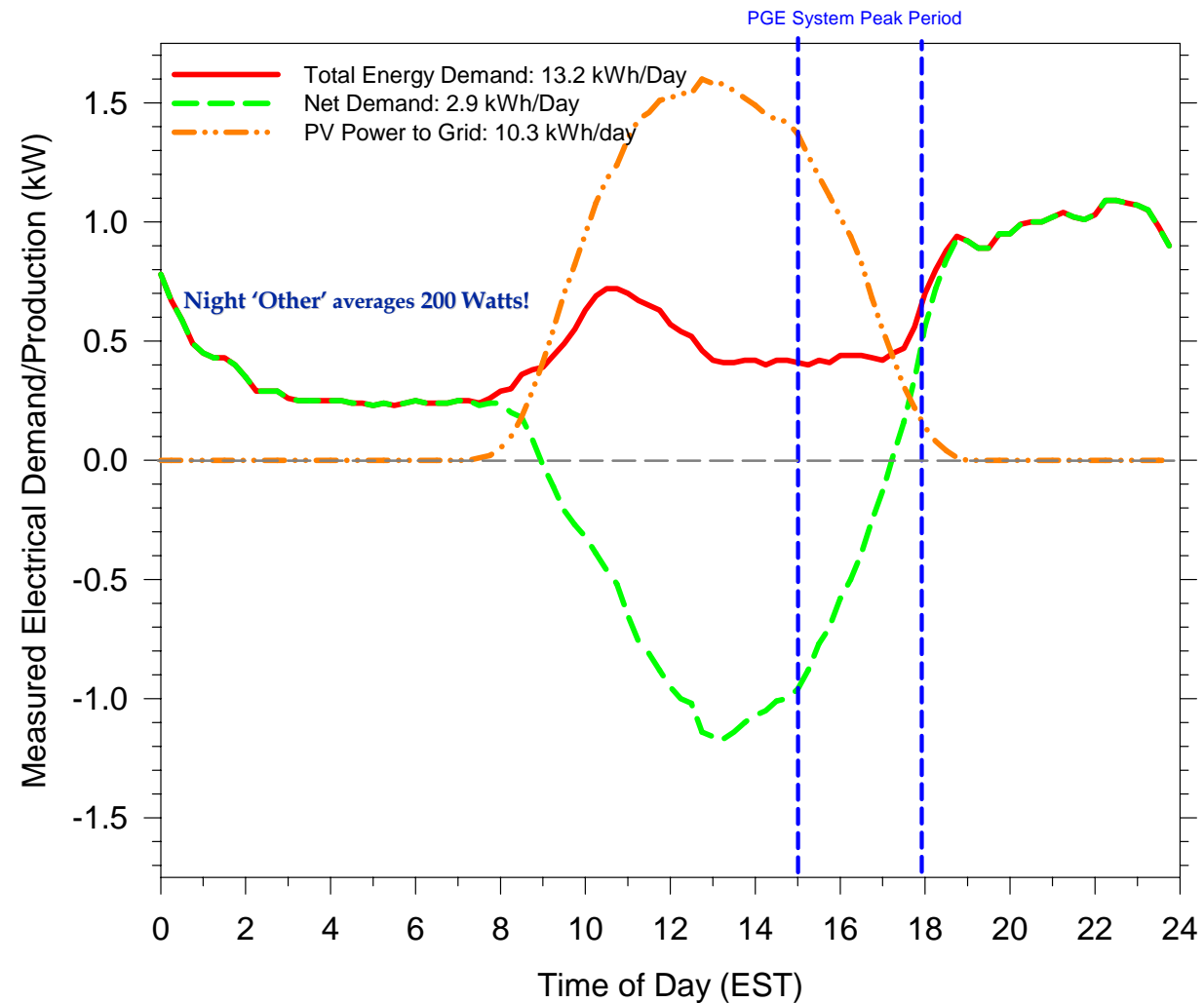
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## CA ZEH Total Load, PV Generation & Net Load August 1 2003 - March 10, 2004





# AstroPower Sunchoice Meter

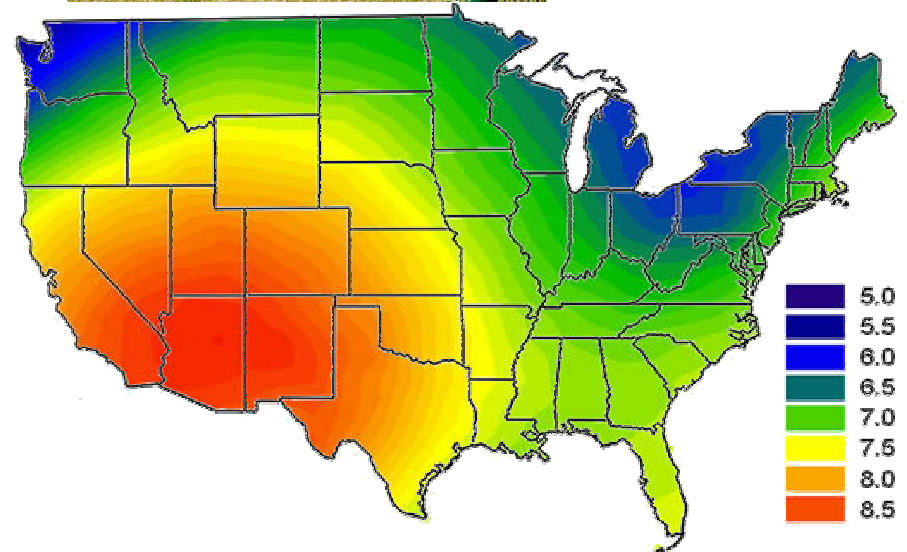
- Shows instantaneous
  - Solar PV Power (kW)
  - Power Uses (kW)
- *Example* →
  - 1.498 kW PV power
  - 0.376 kW Power used
- Simple to see and understand by thermostat
- Altered behavior of CA ZEH homeowners





# PV Performance: How much electricity?

- Generic 2 kW PV system
  - NOCT= 45
  - Temperature Coef= 0.43%/°C
  - Line losses: 3.5%
- Grid-tied with an 2 kW inverter (90% effic).
- 239 U.S. TMY2 locations
- Annual solar electric power production= 5.0 – 8.5 kWh/Day
- Cost: \$10,000 - \$15,000





# Measured Standby Power & ZEH

- 70 Watts in CA ZEH Home
- 45 Watts in FL ZEH House
- 1-2 kWh/day
- Loads are constant; increase nighttime demand when PV cannot assist
- Standby power= 20% of PV output for 2 kW array!
- Another perspective: If you can afford to spend \$3000 to produce the power you can economically spend half that to get rid of it

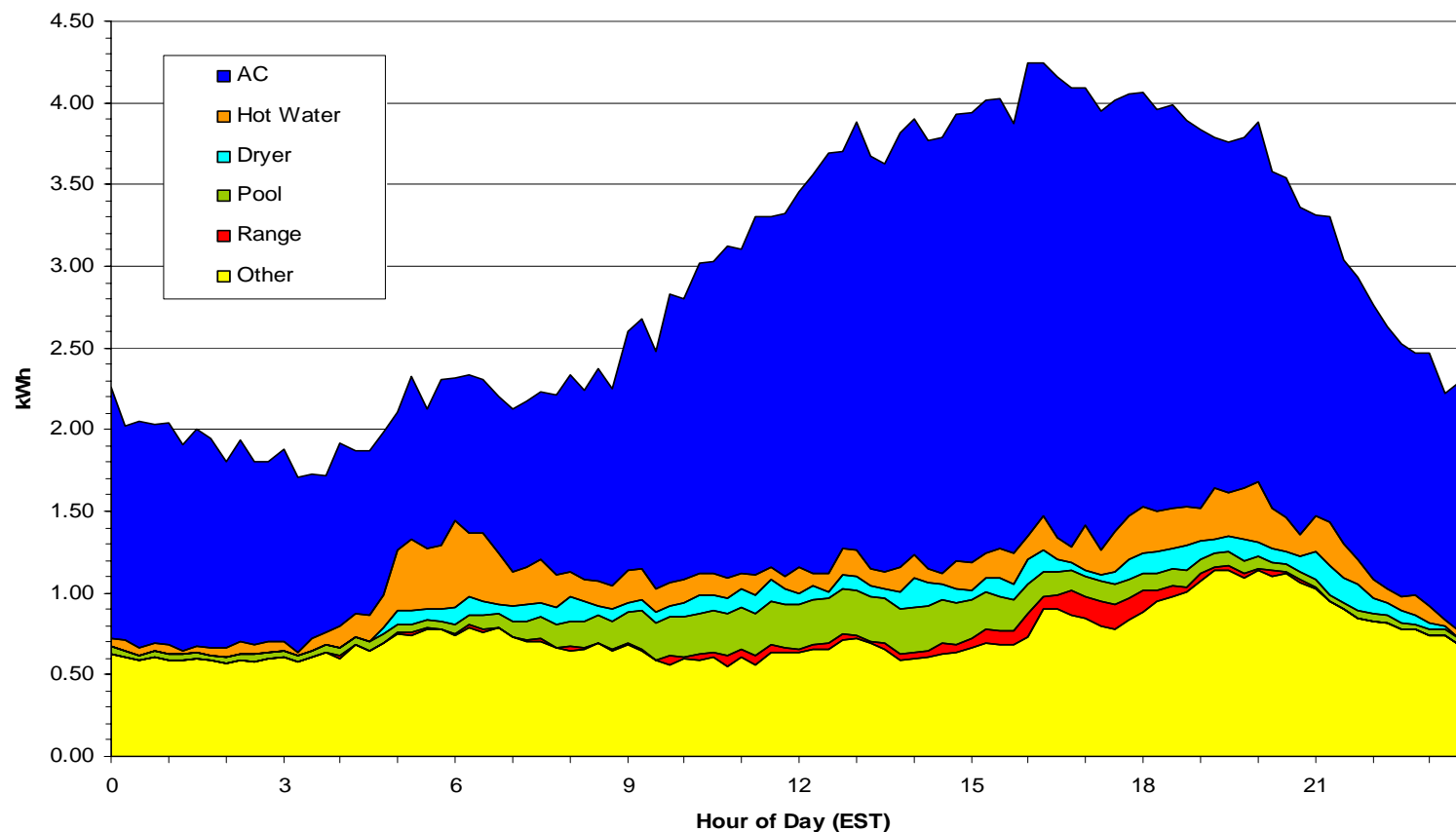






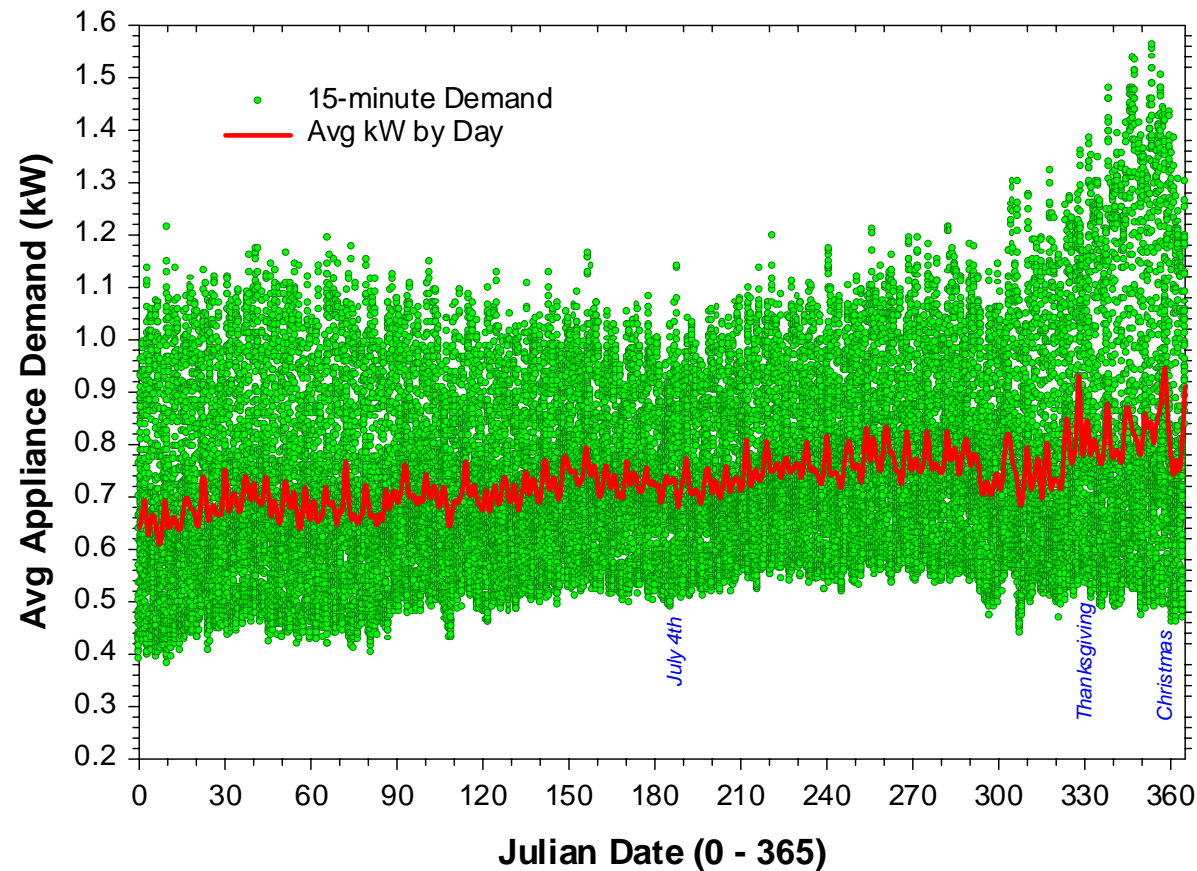
# End-use Load Profiles on Peak Summer Day

Peak Day 15-Minute End Uses





# Utility Study: Other Grows (1999-2000)





# Needs for Building America

- Low standby hard-wired appliances
  - Doorbells
    - 18 W
  - Thermostat transformer
    - 4 W
  - Security system
    - 15 W
  - Smoke detectors/GFI
    - 0.4 -1.0 W ea.
  - Garage door openers
    - 5 W
  - Server/routers

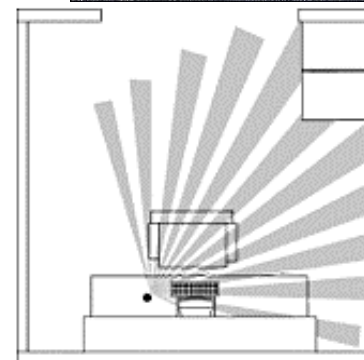






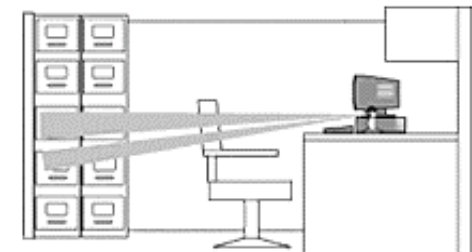
# Growing Load: Home Computer

- Home computer, Screen, printer and DSL box, speakers, wireless router
- My home 25 Watts standby
- Robb Aldrich: 20-30 Watt standby for wireless router/cable modem
- Smart Power Strip: Watt-Stopper (1 Watt standby)
- Senses occupancy: time delay 30m sec. To 30 min.
- Turns off all but CPU when no occupancy after time delay
- Reduction 24 Watts
- Retail: \$15
- Assume 12 hour increase in “off” time= 0.3 kWh/day saved
- Payback in 14 months; 87% ROR



Overhead view of typical coverage

PIR Coverage



Side view of typical coverage





# Meet the New Refrigerator...

- TiVO: 29 Watts standby,  
30-44 Watts on
  - ~265 kWh/yr
- HDTV DVR: 25 Watts off;  
30-40 Watts on!
  - ~265 kWh/yr
- Must be left on to record upcoming shows...
- Gratification on demand is *addictive*...



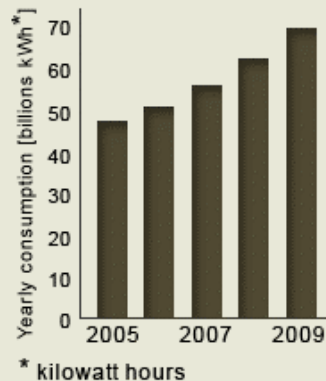


# Home Entertainment Center

- Average Energy Use (California RASS Study; RECS 2001)
  - Television: 520 kWh/yr
  - VCR/DVD: 58 kWh
  - Cable box: 220 kWh
  - TiVO: 265 kWh
  - Rack Audio: 81 kWh
  - Satellite stn: 131 kWh
- Avg 2.5 TVs/household
- 5-10% of house energy
- Home entertainment energy use expected to grow by 50% by 2009

## Power to the TV

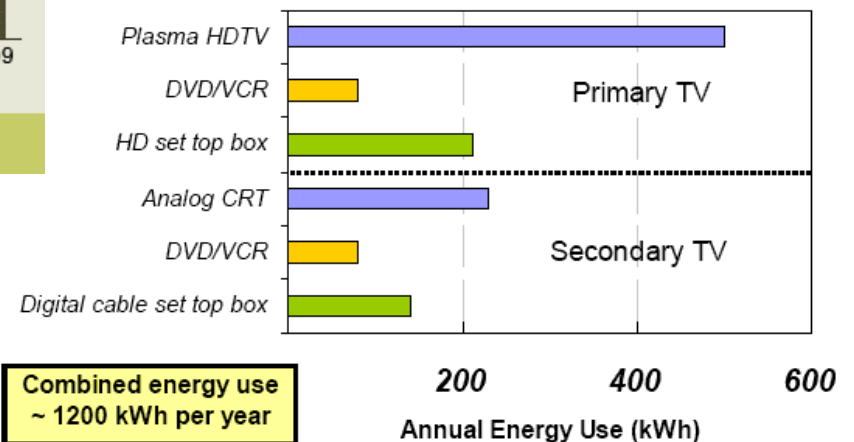
The amount of energy consumed by TVs in the U.S. each year is set to rise, the NRDC predicts. The growth will come from more TVs in the home, greater TV viewing time, growing screen size and higher-resolution displays, it says.



Source: Natural Resources Defense Council



## Household Energy Use for Entertainment Electronics





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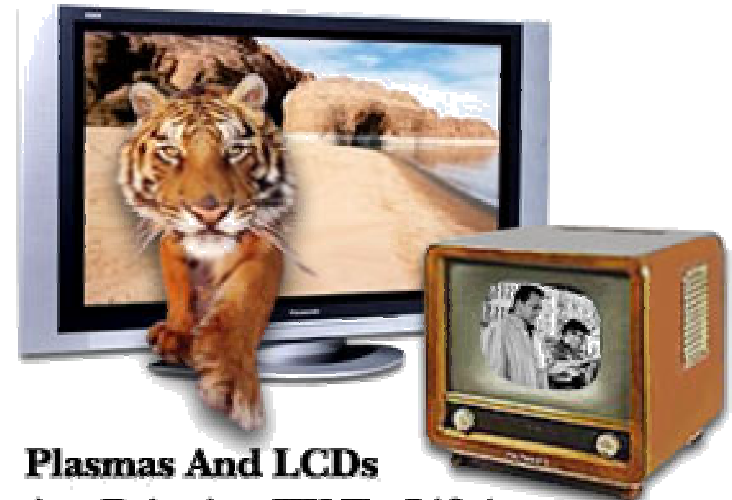
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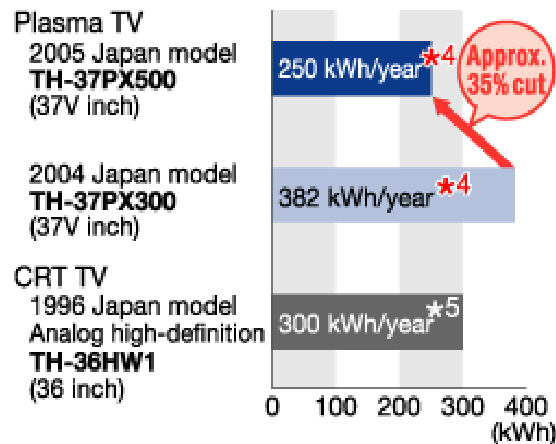
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# Changing TV Technology

- Historically plasma TVs have used about 70% more power for similar sized display
- Eg. 42" display
  - Plasma: 250 W
  - LCD: 150 W
  - 32" CRT Analog TV= ~150 W
- Panasonic*: significantly improved plasma efficiency
- EnergyStar* versions reduce standby (<3 W)



**Plasmas And LCDs  
Are Bringing TV To Life!**







# *My Big Gulp:* Home Entertainment Center

- 37" LCD Television
- VCR/DVD
- Cable Box, HDTV DVR
- Stereo Receiver
- Home Theater
- CD Player
- Sub-woofer

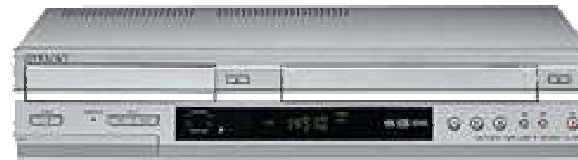




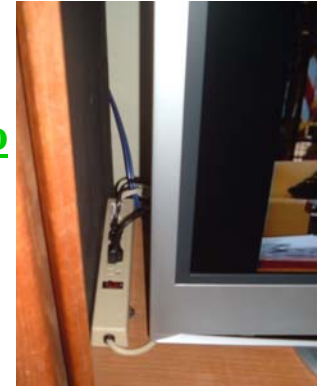


# *My Big Gulp:* Home Entertainment Center

- Energy Star 37" LCD TV
  - 1W Stdbby, 149 W On
- VCR/DVD
  - 7 W Stdbby, 17W On
- Cable Box, HDTV DVR
  - 25 W Stdbby, 35 W On
- Stereo/Home Theater
  - 2 W Stdbby, 65 W On
- CD Player
  - 2 W Stdbby, 10 W On
- Sub-woofer
  - 7 W Stdbby, 15 W On



Power strip  
Saves 0.5  
kWh/day





# Another real world example...

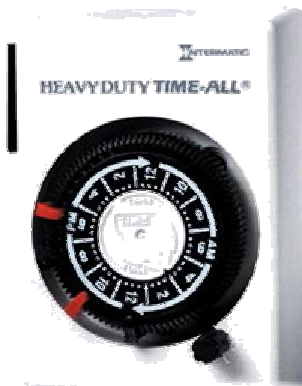
- Home Theater use 150 Watts when idle!
  - 33 Watts for Plasma TV
  - 19 W for idle power amp
  - TiVO: 29 W continuously
  - HDTV DVR: 44 Watts
  - Audio Receiver: 5 Watts
  - UPS: 20 Watts
- *Kill-a-Watt* or similar devices allow determination of plug loads





# The Stuff in the Garage

- Cordless tools
  - DeWalt Drill, flashlight: 4 W standby each, 34 Watt charging
- LiHi Battery charger: 4 W standby
- Rechargeable lawn tools
  - 4 W standby for weed trimmer
- 16 Watts of Standby; use 2 hr daily *Intermatic timer*; (2 W)
- Or occupancy based control...
- Many garages have a radio/TV!
- Save 0.3 kWh/day







# Structured Wiring Solution for New Homes...

- Home Security System used to turn off unneeded loads when home is unoccupied
  - Dedicated interruptible wall plate in each room
  - Overhead lighting in each room to include lights and ceiling fans
- Remote magnetic breakers are dispatched by 12 volt “away” signal from security system (eg. *DSC Security Systems*)
- Potentially turns off 200 W or more when home is unoccupied
- More than compensates for 13W power consumption of security system







## Several Alarm Panel Interface solutions...

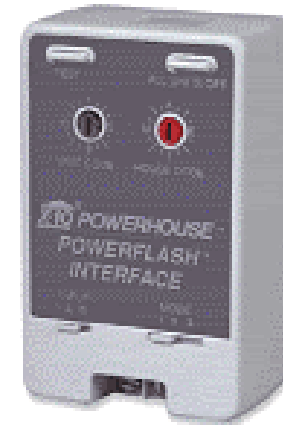
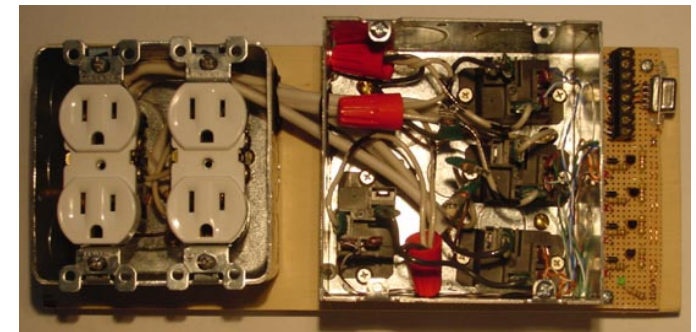
- **Remote controlled breakers:** (*Carling Technologies*) breaker state is controlled by the alarm panel's programmable output. Cost = \$375 per block of four breakers plus wiring.
- **Automatic Transfer Switch:** (*Generac*) switch is usually used for generator automatic generator power transfer, but can be easily configured to be controlled by alarm panel's programmable output. Price: \$300 plus wiring.





## Low cost alarm panel interface solutions...

- **Custom made Relayed Control box:**  
Simple relay control box can be built from off the shelf parts (*Radio Shack* and *Home Depot*) for about \$75 plus wiring. Control box responds to alarm panel's armed state & switches the controlled load.
- **X-10 controls:** An X-10 *Powerflash* module reads alarm panel state and transmits signals to control X-10 receptacle. Cost depends upon the number of receptacles controlled - \$25 for the controller and \$20 per receptacle. No additional wiring.





# Lack of Information

- Energy: No see / taste/touch
- What if we saw what was happening?
- Immediate feedback
- Whole House Meter
- Instantaneous Watts
- Several manufacturers:
  - *Energy Viewer*
  - *The Energy Detective (TED)*







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# How much electricity?



**Windward II**  
This revolutionary fan features five large 54" aerodynamically optimized Gossamer Wind<sup>®</sup> blades that effortlessly cut through and move up to 40% more air than standard blades. Energy saving dimmable fluorescent light fixture saves over 75% in energy costs and lasts over 8000 hours. Includes fluorescent bulb.

Brushed steel with black blades (523-127)

White finish with white blades (523-343)

Thermostatic remote control





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# How much electricity?

500 Watts



53 Watts



3000 Watts

**Windward II**

This revolutionary fan features five large 54" aerodynamically optimized Coosamer Wind<sup>®</sup> blades that effortlessly cut through and move up to 40% more air than standard blades. Energy saving dimmable fluorescent light fixture saves over 75% in energy costs and lasts over 8000 hours. Includes fluorescent bulb.

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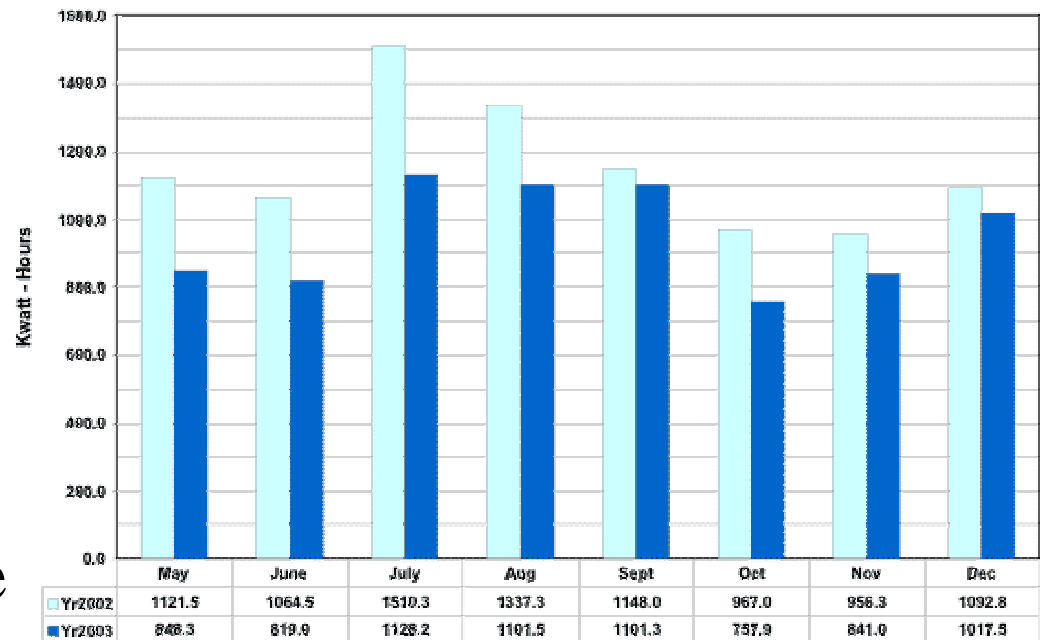
65 Watts



# Few Studies...

- 5-15% drop in total energy use
  - Ontario Hydro: 4-5%
  - Japan 12%
- \$300 cost
- Similar to large expenditure on equipment or envelope
- Immediate impact
- Motivation
- What is persistence?

**Yr2003 ELECTRICAL ENERGY USE COMPARED  
TO PREVIOUS YEAR Yr2002**  
Case Study #1 - Energy Viewer Installed May, 2002

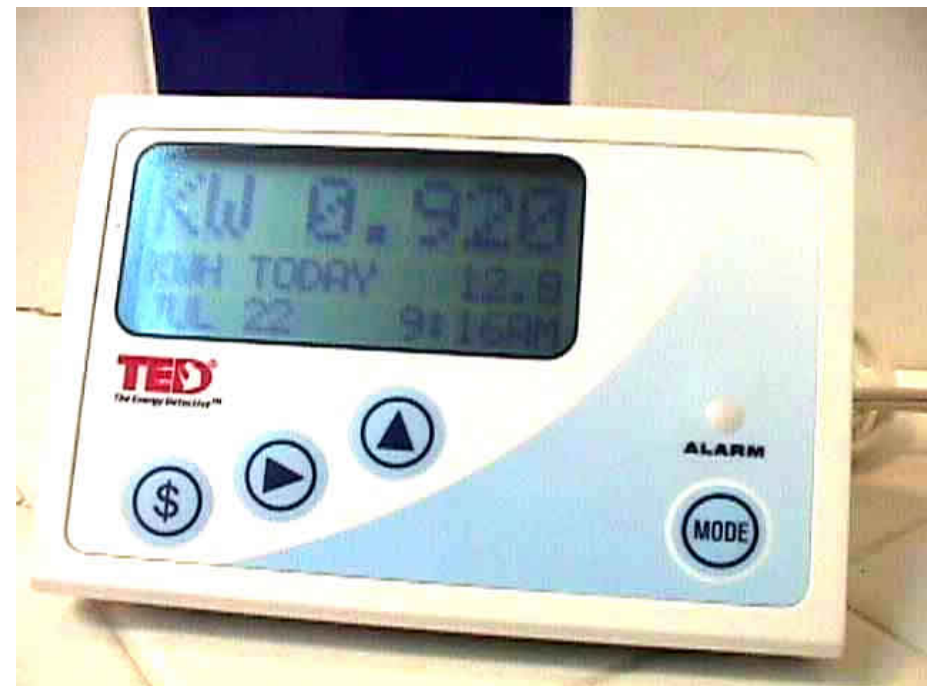






# Several Manufacturers....

- *The Energy Detective (TED)*
- \$240; installs in minutes
- Instantaneous feedback
- True kW
- Send signals over house wiring
- Records data; monthly cost





# Some stunning insights...

- Gas Dryer uses 700 Watts when operating!
- Gas oven uses 400 W when operating!
- Don't turn off after gas is lit!
- Both have electric resistance hot surface igniters
- 120 V, 3.5 amps (420 W)
- *Peerless* manufacturers gas range with 2 Watt solid state ignition
- Low energy/ZEH homes are compromised by such loads

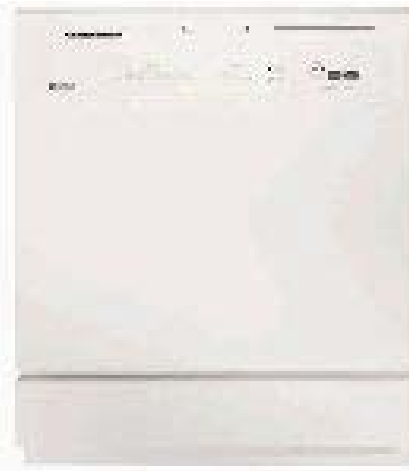


Hot Surface  
Igniter



# *EnergyStar* Dishwasher: Oxymoron?

- New Kenmore Ultrawash *EnergyStar* dishwasher:  
**House Power with Dishwasher Off** →
- Solar hot water providing 134° F feed water
- Electric resistance booster heat can't be turned off! No way to deactivate...
- **Dishwasher On: 1.17 kW difference!** →
- Need list of dishwasher manufacturer/models that allow deactivation of booster heater.







# Challenges & Questions

- Miscellaneous electricity: increasingly important to BA objectives
- Energy efficient entertainment center choices
- Low energy hard-wired appliances: critical need
- Need measurement and cataloging
- Need systems which interrupt non-critical end-uses during periods of non-occupancy
- Feedback influence is behavioral
  - What is impact of information?
  - What is the persistence?
- Critical research needs each area:
  - Low-energy hard-wired appliances
  - Interruptible load scheme for BA homes
  - Impact of Feedback on Home Energy Use

