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Building America Residential System Research



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BA Systems Research Approach



Systems Engineering Process



Building America Focus: Innovative and Emerging Systems

Residential Market Drivers

- Consumer can't buy system if builder doesn't offer it for sale
- Builder can't offer system for sale if it increases risk due to increased costs, lack of contractor training, low reliability, or lack of direct value to homeowner.



Building America Focus: Innovative and Emerging Systems

Develop specifications for cost effective, production-ready systems that meet residential market constraints:

- Easy to install
- Simple to operate
- Low maintenance

Validate performance benefits directly with builders, suppliers, contractors, and homeowners.

Industry-Driven Research Approach

- Cost-shared program
- Industry partners provide all construction labor and material costs
- Building America consortia and labs provide re-engineering, quality assurance and control, and testing support
- Major regional builders, suppliers, and contractors lead innovation process.

Cost/Performance Benefits of Accelerating Residential Innovation

Increase overall home energy efficiency and reduce peak loads (+\$)

• Downsize equipment (-\$)

- Reduce labor and materials (-\$)
- Increase homeowner and builder value (priceless)

Net Impact: Cost savings and increased value offset costs of upgrades!

Peer to Peer Diffusion Model



20% of Builders Account for 80% of Homes



Top 850 Builders Account for 50% of Homes

Largest Builder Cumulative Market Share 60 50 Cumulative Market Share (%) 40 30 20 10 0 85 127 169 211 253 295 337 379 421 463 505 547 589 631 673 715 757 799 841 1 43 **Builder Rank**

(Professional Builder and Builder Magazine 2002 Builder Survey Data)

Top 50 Markets Account for 50% of Homes

Cumulative Fraction of Total National Single Family Permits in Top 50 Markets



(2002 Builder Magazine Top Local Builder Survey Data and Census Bureau Data)

Top 10 Builders in Top Markets "Drive" Local Markets

Percent of Permits by Top Ten Builders in Each Metropolitan Area



(2002 Builder Magazine Top Local Builder Survey Data and Census Bureau Data)

Industry-Driven Research Approach

Top five Orange County builders account for 45% of new homes, top 10 account for 70% of new homes!

| 42 | Orange County, Calif. | TOTAL PERMITS: 6,823 | | | |
|-------|--|-------------------------|--------|--|--|
| RANK | | 2002 | Mkt | | |
| ('02) | Parent Company/ Company | Closin gs | Share | | |
| 1 | Lennar Corp./Grey stone Homes | 825 12.109 | | | |
| 2 | Standard Pacific Corp. | 790 11.60% | | | |
| 3 | Shea Homes | 569 8.30% | | | |
| 4 | William Lyon Homes | 457 | 6.70% | | |
| 5 | D.R. Horton/We stern Pacific Housing | 420 | 6.20% | | |
| 6 | John Laing Homes | 404 | 5.90% | | |
| 7 | Centex Homes | 372 5.50% | | | |
| 8 | KB Home | 343 | 5.00% | | |
| 9 | Brookfield Homes | 309 | 4.50% | | |
| 10 | California Pacific Homes | 262 | 3.80% | | |
| | | | 69.60% | | |

(2002 Builder Magazine Top Local Builder Survey Data and Census Bureau Data)

Energy Star/RESNET/Building America Partnerships Have Transformed Local Markets

| 2002 Housing Starts (Single Family Homes) | | | | |
|---|----------------|---------------------------|--------------------|--|
| Region | Energy Star | Total Permits, 2002 | Penetration (%) | |
| Chicago | 700 | 29862 | 2.3% | |
| Columbus | 1897 | 10455 | 18.1% | |
| Dallas & Houston | 12461 | 54061 | 23.0% | |
| Denver | 493 | 14133 | 3.5% | |
| Des Moines | 329 | 3194 | 10.3% | |
| Indianapolis | 1452 | 13176 | 11.0% | |
| Las Vegas | 4237 | 24691 | 17.2% | |
| Orlando | | 17293 | | |
| Phoenix* | 6000 | 39862 | 15.1% | |

Bold=estimated

*State website claims 20% market penetration in Phoenix

(Personal communication, Energy Star Homes, Kristen Taddonio, December 8, 2003)

System Re-Design Benefits

•Ductwork within the house

•Shorter Duct Runs

•Registers at Interior Walls

•Fewer Penetrations into the Attic

Downsized Space Conditioning Equipment



Key System Improvements "Best Practice" Ducts: Before



Key System Improvements Best Practice Ducts: After



NRELComprehensive Field MonitoringTesting

Test Procedure

The thermostat is turned off so that it will not call for any heating or cooling. Temperature sensors are placed in all the rooms of the home, along with an electric heater plugged into an outlet in each room. Whenever the temperature drops below the set point in the room, the electric heater is turned on. In this way, the entire home is maintained at a uniform temperature using only the electric heaters.



System Re-Design Benefits

Duct Location & Tightness

The improvements in duct design resulted in 25% energy savings compared to the Base house.



Integration of System and Component Improvements



(Engineering Analysis: Furnaces and Boilers Standards Rulemaking 9/19/2002, p 5-20)

Residential Options Analysis (No Market or Technical Barriers)



<u>BA Research</u> <u>Benchmark</u>

| Category | Option |
|------------------------|-------------------|
| Basement insul. | none |
| Glass Type | dbl-gl |
| Walls | R11 |
| Ceiling | R30 |
| Lighting | 23% CFL |
| Refrigerator | Kenmore-5128 |
| Infiltration | typical |
| Window Distribution | equal |
| HVAC | AFUE80% SEER10 |
| Ducts | typical |
| Dishwasher | Frigidaire-FDB126 |
| Washer/Dryer | GE-WWSE5200 |
| Solar DHW | none |
| Water Heater | Gas Storage |
| | |

<u>Sequential Optimal Points</u> (No Technical or Market Barriers)

| BOULDER | | Option | Utility Bill |
|--------------|-----------------------|----------|--------------|
| Category | Option | Inc.Cost | Savings |
| | | (\$) | (\$/yr) |
| Base | BA Benchmark | | |
| Lighting | 100% CFL | 42 | 12 |
| Water Heater | high efficiency | 63 | 24 |
| Walls | R19 | 351 | 97 |
| Washer/Dryer | GE- WPXH214 | 350 | 97 |
| Ducts | inside | 576 | 73 |
| HVAC | AFUE92.5% | 534 | 49 |
| Water Heater | tankless | 526 | 24 |
| Refrigerator | Kenomore- 5329 | 600 | 37 |
| waiis | R33 | 1740 | 01 |
| Dishwasher | Frigidaire- FDB658 | 250 | 12 |
| Ceiling | R41 | 270 | 12 |
| Glass Type | low-e | 566 | 24 |
| Infiltration | tight | 978 | 18 |
| Ceiling | R49 | 432 | 6 |
| Ceiling | R57 | 558 | 9 |
| Solar DHW | 32 ft2 ICS | 2654 | 40 |

Measuring Savings: BA 40% Whole House Energy Savings Target Compared to 2001 RECS Data and Benchmark



BA Research Benchmark: Whole House Energy Loads



Yuma Army **Proving Grounds**

(IBACOS Project with NREL monitoring and analysis)





| Table 5. Weasure Sav | /ings | | | | | | | | | | | | |
|---------------------------------------|--------|--------|--------|-----------|------|--------|-----------|----------|-----------|-------|-----------|-----|------------|
| | | | | | Na | tional | Average | Buil | der Stand | ard (| Local | Cos | ts) |
| | Site E | nergy | Source | Energy | | Energ | y Cost | Energ | y Cost | Mea | asure | Pa | ckage |
| Increment | kWh | therms | MBTU | Savings % | \$/ | /yr | Savings % | \$/yr | Savings % | value | e (\$/yr) | sav | ings \$/yr |
| Base (Bldg America) | 20981 | 0 | 215.0 | | \$ 2 | 2,098 | | \$ 2,067 | | | | | |
| Base (Regional Std Practice) | 18340 | 0 | 187.9 | 13% | \$ | 1,834 | 13% | \$ 1,807 | | | | | |
| Base (Builder Std Practice) | 18340 | 0 | 187.9 | 13% | \$ | 1,834 | 13% | \$ 1,807 | | | | | |
| Base + improved w alls/roof | 16850 | 0 | 172.7 | 20% | \$ | 1,685 | 20% | \$ 1,660 | 8% | \$ | 147 | \$ | 147 |
| Base ++ Low -E Window s | 14991 | 0 | 153.6 | 29% | \$ | 1,499 | 29% | \$ 1,477 | 18% | \$ | 183 | \$ | 330 |
| Base ++ Energy Recovery Ventilator | 14289 | 0 | 146.4 | 32% | \$ | 1,429 | 32% | \$ 1,407 | 22% | \$ | 69 | \$ | 399 |
| Base ++ Smaller A/C (4 -> 3 tons) | 14201 | 0 | 145.5 | 32% | \$ | 1,420 | 32% | \$ 1,399 | 23% | \$ | 9 | \$ | 408 |
| Base ++ SEER 14 HP | 13194 | 0 | 135.2 | 37% | \$ | 1,319 | 37% | \$ 1,300 | 28% | \$ | 99 | \$ | 507 |
| Base ++ Solar DHW | 12086 | 0 | 123.8 | 42% | \$ | 1,209 | 42% | \$ 1,190 | 34% | \$ | 109 | \$ | 616 |
| Base ++ Lighting, Appl. & Plug | 10261 | 0 | 105.1 | 51% | \$ | 1,026 | 51% | \$ 1,011 | 44% | \$ | 180 | \$ | 796 |
| Site Generation | | | | | | | | | | | | | |
| Base ++ PV | 7101 | 0 | 72.8 | 66% | \$ | 710 | | \$ 699 | 61% | \$ | 311 | \$ | 1,107 |





Research Partnerships: DER Advanced HVAC Laboratory



Full-scale HVAC equipment evaluation
Advanced diagnostic techniques
Unsurpassed Speed, Accuracy, and Flexibility

Ultra Coolers

- Prototype consistently achieves 120% wetbulb effectiveness
- No moisture added to supply air
- High EER in Dry
 Climates





Ultra Coolers

- Cooling purge air in stages creates successively colder heat exchange sinks
- Dewpoint temp is lower bound
- Cut required flowrates in half by doubling cooling effect





Geothermal: Tabbed Fin Heat Exchanger



Tabs stamped onto plate fins

Flow visualization: Tabs improve heat transfer and reduce wake size



Geothermal: Organometallic Polymer Coating

- Aluminum heat exchanger components corroded in coastal environments
- Corrosion protection available now with waterbased polymer coating
- 1 micron thick, stable up to 300°C
- Excellent resistance in salt spray tests enables coastal economizers
- Field testing of coated HVAC heat exchangers recommended

OMP Salt Spray Tests



OMP-coated fin unaffected by salt spray

Plain fin pitted

DOE Residential System Cost/Performance Goals Tracking

Note: Market value of high performance homes (i.e. increased durability, comfort, health, security, lowered risk...) may exceed value based solely on energy savings.



6% Real Discount Rate. 0.2 % Fuel Escalation Rate. 2000 ft2 Home. Annual Utility Bill: \$1600, Existing Home. \$1250, New Home. Financing Term: 15 Years, Existing Home, 30 Years, New Home.

We have the Power: Baby Boomers Control 70% Of Nations Wealth and 50% of All Discretionary Income

The Baby Boom Effect: Persons Turning 55 Over the Next Decade *(In millions)*

| YEAR | NUM 348 | CUMULATIVE |
|------|---------|------------|
| 2001 | 3.2 | 3.2 |
| 2002 | 3.7 | 6.9 |
| 2003 | 3.5 | 10.4 |
| 2004 | 3.5 | 13.9 |
| 2005 | 3.7 | 17.7 |
| 2006 | 3.6 | 21.3 |
| 2007 | 3.9 | 25.2 |
| 2008 | 3.9 | 29.2 |
| 2009 | 4.1 | 33.2 |
| 2010 | 4.2 | 37.4 |

NAHB, Housing Facts, Figures, and Trends, June, 2001

www.BuildingAmerica.gov





