SWEEP Workshop on Zero Energy Homes in New Mexico: Introduction to Near-Zero Energy Homes

Rob Hammon, Ph.D.
What is Building America (BA)?

• National Department of Energy program
  – Marketable, cost-effective net-Zero Energy Homes (ZEHs) by 2020

• Today’s near-Zero Energy Homes
  – Advanced energy efficiency
  – Solar energy technologies
  – Utility bill reductions >50%
  – Goal: 40%-70% energy efficiency savings plus savings from solar
What is BIRA?

• Building Industry Research Alliance
  – Collaborative team; over 100 industry partners
  – Led by ConSol

• One of seven Building America teams
  – Only West Coast team
  – Only team that is part of the building industry
Building America Research Process

House designs are compared to the “BA Benchmark” to predict savings level.

Systems Research

Prototype Homes

Communities
Benefits of Building ZEHs with BA

- Monetary benefits
  - Cost savings from making the best materials and equipment choices
  - Reduced risks, increased productivity, and fewer callbacks
  - Sells faster than competition
- Additional benefits
  - Competitive advantage in the marketplace
  - Customer satisfaction and referrals
  - Beneficial to the environment
Albuquerque, New Mexico – Building America’s Mixed Dry Climate Zone
What features are currently being used?*

*based on 2003 IECC standards

<table>
<thead>
<tr>
<th>Building Features</th>
<th>Appliance Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Insulation</td>
<td>Refrigerator</td>
</tr>
<tr>
<td>R19 batts, 2x6, 24&quot;o.c.</td>
<td>Energy Star</td>
</tr>
<tr>
<td>Ceiling Insulation</td>
<td>Cooking Range</td>
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<tr>
<td>R30 fiberglass</td>
<td>Gas</td>
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<tr>
<td>Infiltration</td>
<td>Dishwasher</td>
</tr>
<tr>
<td>10.0 ACH50</td>
<td>Energy Star</td>
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<tr>
<td>Foundation</td>
<td>Clothes Dryer</td>
</tr>
<tr>
<td>Slab, uninsulated</td>
<td>Gas</td>
</tr>
<tr>
<td>Window Type</td>
<td>Clothes Washer</td>
</tr>
<tr>
<td>0.35 U-value, 0.35 SHGC</td>
<td>Energy Star</td>
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<tr>
<td>Air Conditioner</td>
<td>Hardwired Lighting</td>
</tr>
<tr>
<td>SEER 13</td>
<td>50% CFL</td>
</tr>
<tr>
<td>Furnace</td>
<td></td>
</tr>
<tr>
<td>AFUE 80%</td>
<td></td>
</tr>
<tr>
<td>Water Heater</td>
<td></td>
</tr>
<tr>
<td>Gas standard (59%)</td>
<td></td>
</tr>
<tr>
<td>Ducts</td>
<td></td>
</tr>
<tr>
<td>Improved, R8</td>
<td></td>
</tr>
</tbody>
</table>
2003 IECC Achieves 30% Savings

Current Building America goal: 50% energy efficiency savings
What can be done to improve efficiency?

- Increased wall insulation
- Increased ceiling insulation
- Adding a radiant barrier
- Better sealing for a tighter envelope
- Improved windows (U-value & SHGC)
- Increased fluorescent lighting
- High efficiency heating and cooling systems
- Improved water heater
- Improved duct insulation
<table>
<thead>
<tr>
<th>Feature</th>
<th>Standard Practice (30%)</th>
<th>40% Savings</th>
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</thead>
<tbody>
<tr>
<td>Wall Insulation</td>
<td>R19 batts, 2x6, 24&quot;o.c.</td>
<td>R21 batts, 2x6, 24&quot;o.c.</td>
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<td>R40 fiberglass</td>
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<td>Radiant Barrier</td>
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<td>10.0 ACH50</td>
<td>10.0 ACH50</td>
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<td>Foundation</td>
<td>Slab, uninsulated</td>
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<tr>
<td>Hardwired Lighting</td>
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<td>Furnace</td>
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<td>AFUE 92.5%</td>
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<td>Gas standard (59%)</td>
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<td>---------------------</td>
<td>--------------------------------------------</td>
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<tr>
<td>Wall Insulation</td>
<td>R19 batts, 2x6, 24&quot;o.c.</td>
<td>R21 batts, 2x6, 24&quot;o.c.+1&quot; foam</td>
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<tr>
<td>Ceiling Insulation</td>
<td>R30 fiberglass</td>
<td>R50 fiberglass</td>
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<tr>
<td>Radiant Barrier</td>
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<td>Infiltration</td>
<td>10.0 ACH50</td>
<td>6.0 ACH50</td>
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<td>Slab, uninsulated</td>
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<tr>
<td>Window Type</td>
<td>0.35 U-value, 0.35 SHGC</td>
<td>0.31 U-value, 0.25 SHGC</td>
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<tr>
<td>Refrigerator</td>
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<td>100% CFL</td>
</tr>
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<td>Air Conditioner</td>
<td>SEER 13</td>
<td>SEER 16</td>
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<tr>
<td>Furnace</td>
<td>AFUE 80%</td>
<td>AFUE 94%</td>
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<tr>
<td>Water Heater</td>
<td>Gas standard (59%)</td>
<td>Gas tankless (80%)</td>
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<tr>
<td>Ducts</td>
<td>Improved, R8</td>
<td>Buried in insulation</td>
</tr>
</tbody>
</table>

**Features necessary to reach 40%**
- Radiant Barrier

**Features necessary to reach 50%**
- 50% Savings
Savings Levels at 40% and 50%

- Building America Benchmark: 258.7 MBtu
- 40% Energy Efficiency Savings: 153.6 MBtu
- 50% Energy Efficiency Savings: 123.4 MBtu

- 40.6% Annual Source Energy Savings
- 52.3% Annual Source Energy Savings
HERS Index Comparison

- Features providing **50% savings** compared to the Building America Benchmark = 64 HERS in Albuquerque, NM

- **50% savings + solar domestic hot water** = 60 HERS in Albuquerque, NM
  - NM Residential Sustainable Building Tax Credit
Options to Further Improve Savings

• OVE/External Insulation/SIP walls
• MELs Reduction
• Geothermal heat pump
  – Trench/bore system
  – Water main system

• Solar
  – Passive heating
  – Hot water
  – Photovoltaics (PV)
  – PVT
OVE Walls (Optimum Value Engineered)

Uses engineering principles to minimize material usage while meeting model building code structural performance requirements.

Less framing provides room for more insulation.
External Foam Insulation

- Provides more R-value per inch than batts
- Acts as a thermal break between studs and outside air
SIPs (Structural Insulated Panels)
MELs Reduction (Misc. Electric Loads)

- Feedback display
- “Green switch”
- “Smart strip”
- Efficient electronic devices (TVs, etc.)
Geothermal Heat Pump

**GEOTHERMAL HEAT PUMPS**
- Ductwork
- Heat exchanger
- Warm liquid from the ground
- Fan
- Buried, closed loop containing water or antifreeze

Trench (horizontal) system

Bore (vertical) system
Benefits

• Heat & cool savings up to 70%
• Lower install costs
• Lower maintenance costs
• Reduced pumping
• Reduces mechanical space
• No roof penetrations
• No combustion
• Longer system life
• Provides source of revenue
• Flexible & easily expandable
• Uses GeoExchange technology
Financial Benefits

• **WaterGrid** utility owned, installed and maintained
• No first cost to developer/owner
• No water supply system costs
• No wastewater system costs
• No HVAC/DHW system costs
• Lower user energy costs
• Secondary treatment for use on-site and off-site (parks, etc.)
• Owner/user pays metered water use rate or a flat fee to utility
Passive Solar Heating/Cooling

- Window orientation
- Overhangs
- Shading
  - Landscaping
  - Exterior
  - Interior
- Mass
- Controls (night cooling)
SDHW (Solar Domestic Hot Water)

Can be implemented in mixed climates using an indirect system with propylene glycol
PV Panels (Photovoltaic)

May not be cost effective for the homeowner unless combined with efficiency measures

BIPV (Building Integrated) shown here
PVT (PV-Thermal)

Utilizes previously wasted heat generated by PV system
PVT (PV-Thermal)
ZEH Example

Includes:
- SIPs walls
- Geothermal heat pump
- PVT
- 25% reduction in MELs
• 50% efficiency measures
  – Currently developing cost effective strategies with builders in the Mixed Dry Climate Zone

• PV/PVT Systems
  – Can be cost effective when combined with efficiency measures and available incentives

• Other advanced systems
  – May not be cost effective currently but will be soon as energy costs continue to rise and mature market costs develop
Do ZEH Communities Really Work?
Building America Case Studies
Climate: Hot Mixed/Dry  BA Savings: 38%

Builder/Developer:
• Premier Homes

Community & Location:
• Premier Gardens
• Sacramento, CA

Number of Homes:
• 95 Total

Unique Elements of Project:
• First standard ZEH community in Sacramento
• 100% solar PV
• 59% savings with PV
• Built in 2004
Side-By-Side Developments

Near-ZEH

Control
Side-By-Side Developments

Near-ZEH
(60% Whole House Energy Savings)

VS.

SMUD Advantage
(30% Cooling Reduction)
# Energy Efficiency Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Non-ZEH</th>
<th>Premier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
<td>R-13 + 1” Foam with Stucco</td>
<td>R-30</td>
</tr>
<tr>
<td>Ceiling Ins.</td>
<td>R-30</td>
<td>R-38</td>
</tr>
<tr>
<td>Windows</td>
<td>Vinyl-Framed Low-E2</td>
<td></td>
</tr>
<tr>
<td>AFUE</td>
<td>80</td>
<td>92</td>
</tr>
<tr>
<td>SEER</td>
<td>10</td>
<td>14 w/TXV</td>
</tr>
<tr>
<td>Air Flows</td>
<td>Normal</td>
<td>ACCA - Tested</td>
</tr>
<tr>
<td>Ducts (attic)</td>
<td>R-4.2</td>
<td>Buried in ceiling Ins</td>
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<tr>
<td>Duct Sealing</td>
<td>Normal</td>
<td>Sealed</td>
</tr>
<tr>
<td>Air Infiltration</td>
<td>Normal</td>
<td>&lt;3 SLA, tested</td>
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<tr>
<td>Water Heater</td>
<td>40gal 0.60EF</td>
<td>Tankless 0.82EF</td>
</tr>
<tr>
<td>Lights</td>
<td>Incandescent</td>
<td>Fluorescent</td>
</tr>
<tr>
<td>Solar</td>
<td>None</td>
<td>2.4kW BIPV</td>
</tr>
</tbody>
</table>
Demographics

- Similar size and price
- Contemporaneous sales
- Near-ZEH
  - More-experience buyers
  - More educated
  - Did more research prior to buying
- Control
  - Larger families (larger bedrooms)
  - More wage-earners (2-3/household), more income
Comparing the Near-ZEHs Monthly Average Electricity Use (kWh) to Predicted Use

*Revised assumptions include 80% electric ranges, 70% electric dryers, and 50% 2nd Refrigerator

Near-ZEH w/o PV
Near-ZEH w/ PV

March '05 - Feb '06
Benchmark Assumptions

591
303
581
296
Peak Reduction from EE & PV

No East, Eleven South, And Seven West

- New Avg Net Grid Load (E2W,W,S)
- Previous Avg Net Grid Load (E,S,W)
- Average of Non-ZEH Net Grid Load (kW)
- Avg of PV Pwr (W,S)
- Avg Gross loads (Kw)

Key Points:
- 2.9 kW
- 1.6 kW
- 1.3 kW; 55%
- 0.86 kW; 67%
- -0.3 kW; 119%

Peak Reduction from EE & PV
Climate: Hot Mixed/Dry  BA Savings: 42%

Builder/Developer:
• Treasure Homes

Community & Location:
• Fallen Leaf at Riverbend
• Natomas, CA

Number of Homes:
• 32 Total

Unique Elements of Project:
• 100% solar PV
• 57% savings with PV
• Beutler SmartVent Fresh Air system
• Built-out in 2007
Energy Efficiency Features

- R-38 attic insulation
- R-13 fiberglass batts + 1” EPS foam
- 3.1 SLA infiltration
- Dual pane vinyl-frame windows
- Engineered HVAC system
  - 90% AFUE furnace
  - 13 SEER A/C with thermal expansion valve (TXV)
- R-4.2 buried ducts with tight duct and ACCA Manual D
- 0.82 EF tankless water heater and R-4 insulation on all trunk lines
- 100% fluorescent lighting
- Gas dryer stub provided
Renewable Energy Feature

2.0 kW PV system by BP Solar
Energy Cost Comparison

Treasure vs. Cresleigh Monthly Electricity Bills

Total Annual Electricity Bill:
- Treasure Homes: $412.38
- Cresleigh Homes: $853.73

Avg. Mo. Bill:
- Treasure Homes: $34.37, $28.84, $38.04, $52.72, $36.33, $34.59, $20.04, $16.83, $20.11, $32.21, $52.03, $53.77
- Cresleigh Homes: $71.14, $66.10, $46.41, $67.45, $70.36, $62.77, $52.50, $47.46, $53.63, $64.49, $101.55, $96.43, $124.57

ConSol
## Energy Cost Savings

Assumes $1.00/therm and $0.08/kWh

<table>
<thead>
<tr>
<th>End Use</th>
<th>Annual Utility Bill Savings vs. Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Heating</td>
<td>$228.24</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>$262.43</td>
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<tr>
<td>DHW</td>
<td>$108.55</td>
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<tr>
<td>Lighting</td>
<td>$104.83</td>
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<tr>
<td>Appliances and MELs</td>
<td>$62.20</td>
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<tr>
<td><strong>Total Annual Utility Bill Savings w/o Site Gen.</strong></td>
<td><strong>$766.26</strong></td>
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<tr>
<td>Site Generation</td>
<td>$232.79</td>
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<tr>
<td><strong>Net Annual Utility Bill Savings w/Site Gen.</strong></td>
<td><strong>$999.04</strong></td>
</tr>
</tbody>
</table>
## Annual Mortgage Cost

Assumes 7% mortgage over 30 years

<table>
<thead>
<tr>
<th>Energy Efficiency Feature</th>
<th>Builder Cost</th>
<th>10% Markup</th>
<th>Total</th>
<th>Monthly Cost</th>
<th>Annual Cost</th>
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</thead>
<tbody>
<tr>
<td>R38 Attic Insulation</td>
<td>$133.80</td>
<td>$13.38</td>
<td>$147.18</td>
<td>($0.98)</td>
<td>($11.75)</td>
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<td>Attic Radiant Barrier</td>
<td>$321.00</td>
<td>$32.10</td>
<td>$353.10</td>
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<td>($28.19)</td>
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<td>90% AFUE Furnace</td>
<td>$450.00</td>
<td>$45.00</td>
<td>$495.00</td>
<td>($3.29)</td>
<td>($39.52)</td>
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<td>13 SEER Air Conditioning w/ TXV</td>
<td>$95.00</td>
<td>$9.50</td>
<td>$104.50</td>
<td>($0.70)</td>
<td>($8.34)</td>
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<tr>
<td>Beutler SmartVent System</td>
<td>$700.00</td>
<td>$70.00</td>
<td>$770.00</td>
<td>($5.12)</td>
<td>($61.47)</td>
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<td>82% EF Tankless Water Heater</td>
<td>$750.00</td>
<td>$75.00</td>
<td>$825.00</td>
<td>($5.49)</td>
<td>($65.86)</td>
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<td>R-4 Pipe Insulation</td>
<td>$75.00</td>
<td>$7.50</td>
<td>$82.50</td>
<td>($0.55)</td>
<td>($6.59)</td>
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<tr>
<td>ComfortWise Program</td>
<td>$615.00</td>
<td>$61.50</td>
<td>$676.50</td>
<td>($4.50)</td>
<td>($54.01)</td>
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<td>Gas Dryer Stub</td>
<td>$75.00</td>
<td>$7.50</td>
<td>$82.50</td>
<td>($0.55)</td>
<td>($6.59)</td>
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<td>Fluorescent Lighting</td>
<td>$400.00</td>
<td>$40.00</td>
<td>$440.00</td>
<td>($2.93)</td>
<td>($35.13)</td>
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<td><strong>Totals w/o Site Gen.</strong></td>
<td><strong>$3,614.80</strong></td>
<td><strong>$361.48</strong></td>
<td><strong>$3,976.28</strong></td>
<td><strong>($26.45)</strong></td>
<td><strong>($317.45)</strong></td>
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<tr>
<td>2.0 kW BP Solar Electric System</td>
<td>$16,397.00</td>
<td>$1,639.70</td>
<td>$18,036.70</td>
<td>($120.00)</td>
<td>($1,439.98)</td>
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<tr>
<td><strong>Totals w/Site Gen.</strong></td>
<td><strong>$20,011.80</strong></td>
<td><strong>$2,001.18</strong></td>
<td><strong>$22,012.98</strong></td>
<td><strong>($146.45)</strong></td>
<td><strong>($1,757.43)</strong></td>
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## Cost Effective Analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Total Annual Utility Bill Savings w/o Site Gen.</td>
<td>$766.26</td>
</tr>
<tr>
<td>Total Annual Mortgage Cost w/o Site Gen. or Incentives</td>
<td>($317.45)</td>
</tr>
<tr>
<td>Net Annual Cash Flow to Consumer w/o Site Gen. or Incentives</td>
<td>$448.80</td>
</tr>
<tr>
<td>Net Annual Utility Bill Savings w/Site Gen.</td>
<td>$999.04</td>
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<tr>
<td>Total Annual Mortgage Cost w/Site Gen.</td>
<td>($1,757.43)</td>
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<td>Net Annual Cash Flow to Consumer w/Site Gen.</td>
<td>($758.39)</td>
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<tr>
<td>SMUD Rule 15 Hook Up Discount ($500 one-time credit)</td>
<td>$39.92</td>
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<tr>
<td>Incentive for Lighting and Energy Star ($200 one-time credit)</td>
<td>$15.97</td>
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<tr>
<td>SMUD PV Buydown ($6,126 one-time credit)</td>
<td>$489.08</td>
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<tr>
<td>Federal Tax Credit for 50% Above IECC ($2,000 one-time credit)</td>
<td>$159.67</td>
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<tr>
<td>PV Tax Credit to the Homeowner ($2,000 one-time credit)</td>
<td>$159.67</td>
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<tr>
<td>Total Annual Mortgage Cost w/Site Gen. and Incentives</td>
<td>($893.13)</td>
</tr>
<tr>
<td>Net Annual Cash Flow to Consumer w/Site Gen. and Incentives</td>
<td>$105.92</td>
</tr>
</tbody>
</table>
Impact on Peak

Premier vs. Cresleigh vs. Treasure Net Load, July 2007

- Average of Premier Net Grid Load (kW) (18 home sample)
- Average of Power Produced by Premier PV (kW)
- Average of Cresleigh Net Grid Load (kW) (18 home sample)
- Average of Treasure Net Grid Load (kW) (6 home sample)
- Average of Power Produced by Treasure PV (kW)
Climate: Hot Mixed/Dry

Builder/Developer:
• Grupe Homes

Community & Location:
• Carsten Crossings
• Rocklin, CA

Number of Homes:
• 144 Total

Unique Elements of Project:
• Strong focus on sales and marketing
• Courtesy of The Grupe Company and Davis Energy Group
Efforts Necessary for Success

- Involved the entire Grupe team
- Sales Training
  - Created Technical Sales Resource (Sales Binder)
  - Conducted formal training (4 hours)
  - Ongoing training
- GrupeGreen Garage Display
  - Solar and efficiency features displayed & explained to customers
- Media Outreach
- GrupeGreen DVD
Efforts Necessary for Success: Sales Training

- Overview
- Financial Benefits for Homeowner
- Solar Power for Homes
- Energy Efficiency
- Energy and Utility Information
- Environmental Benefits
- Photo Gallery
- Related News
- Frequently Asked Questions

Sales Agent Walking Through Financial Benefits
Efforts Necessary for Success: Sales Displays

Sales Office, Rocklin, CA

Courtesy of The Grupe Company and Davis Energy Group
Baseline Absorption

- Baseline Absorption = Competition’s Absorption

- Competition Absorption
  - Eight (8) communities with comparable product
  - Each open an average of 14.8 months as of April 29
  - Competition sold 225 homes in total, an average of 28 homes each
  - Sold an average of 1.9 homes per month

- Baseline Absorption Pace = 1.9 homes per month
Sales Acceleration

- Additional Cost of Grupe Green Features
  - $2,642,000

- Monthly Cost of Carry at Carsten Crossings
  - $311,000

- Sales Acceleration Required to Recover Additional Cost
  - $2,642,000 ÷ $311,000 = 8.5 months
Adjusted Baseline Absorption

- Baseline – Required Sales Acceleration
  - Baseline = 144 homes @ 1.9 homes month = 76 months
  - Required Sales Acceleration = 8.5 months

- Adjusted Baseline Absorption
  - 76 – 8.5 = 67.5 months

- Adjusted Pace to Breakeven
  - 144 homes ÷ 67.5 months = 2.1 homes per month

Courtesy of The Grupe Company and Davis Energy Group
Sales to Date

Courtesy of The Grupe Company and Davis Energy Group
Absorption Rate

- GrupeGreen: 4.6 Homes/month
- Break Even: 2.1 Homes/month
- Competition: 1.9 Homes/month

Courtesy of The Grupe Company and Davis Energy Group
Results

- 31 months to sell 144 homes
- 45 months saved compared to competition

Money Saved

- 45 months x $311,000 per month = $14 million
Results

- $2,642,000 \text{ cost} \div $14,000,000 \text{ saved} = 18.8\%

- If just 18.8% of the acceleration was due to the GrupeGreen features, the program has paid for itself
Thank You!

Questions?

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