High Performance Systems for Low Energy Buildings

*Competitive Advantage on the Front Range*

Al Wallace
President, Energy Environmental Corporation
President, Colorado Geo Energy Heat Pump Association

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The children from generation to generation parents, grandchildren and generations. "Live beyond the age of the residents in order to deliver a Toyota Home is the industry's leading long-term support. "Live through much, that you live together," the thoughts from within."

※ ATORISU (ATOLIS) is called "A LL TO YOTAHOME LL FE SUSupe"
Overview

- Industry Trends and Challenges
- The Energy Conscious Consumer

- The Market: Business, Technology and Financial Case Studies
AIA 50>50 and 2030 Challenge

Active Solar Thermal Systems
Alternative Transportation
Appropriate Size and Growth
Building Form
Building Monitoring
Building Orientation
Carbon Offsets
Cavity Walls for Insulating Airspace
Codes, Regulations, and Incentives
Co-Generation
Commissioning
Conserving Systems and Equipment
Construction Waste Management
Cool Roofs
Daylighting
Deconstruction and Salvage Materials
Earth Sheltering
Efficient Artificial and Site Lighting
Embodied Energy
Energy Modeling
Energy Source Ramifications
Energy-Saving Appliances and Equipment
Environmental Education

Geoexchange
Green Roof
High-Efficiency Equipment
Integrated Project Delivery
Life Cycle Assessment
Mass Absorption
Materials and Assemblages
Natural Ventilation
Open, Active, Daylit Spaces
Passive Solar Collection Opportunities
Photovoltaics
Preservation Reuse of Existing Facilities
Radiant Heating and Cooling
Renewable Energy
Rightsizing Equipment
Smart Controls
Space Zoning
Sun Shading
Systems Tune-Up
Thermal Bridging
Vegetation for Sun Control
Walkable Communities
Waste-Heat Recovery
Water Conservation
Windows and Openings
Priorities

- Good Design – Holistic Approach
- Focus on Design and Process
- Building Envelope before HVAC Systems or Renewable Energy
- Select the best systems to meet requirements
Design and Process ... versus Product
Design and Process ... versus Product
Industry Trend #1 - Building Green, but ...

- Blue labels don’t sell “green” homes, especially in a tight economy
- The Green Pro Forma is Red
- First Cost versus Life Cycle Cost
- Green is not always superior comfort and indoor air quality

*In 2007, the demand for green building stock exceeded supply ... yet only 1 in 5 builders intend to build green.*

Industry Trend # 2 - Systems Integration

- Traditional HVAC moving to ground source heat pumps
  - Carrier & Trane – OEM Climate Master
  - York – OEM Water Furnace
  - Lennox – OEM Enertech Manufacturing
- Traditional hydronic using GHPs and vice-versa
  - Uponor, Grundfos, Wilo, Eagle Mountain
- Bosch Strategy – Integration & Renewable Energy
  - Next Step – Integrated Controls
Typical Buildings Use Separate “Dumb” Controls

- Advanced Systems – yet using a basic furnace/boiler/solar control?

| Ground Source Heat Pumps | Renewable Energy Smart Grid Appliance |

- [Image of various control systems and renewable energy sources]
Geo Heat Pumps Heat or Cool Water or Air

Water- Water GHP

Water to Air GHP
Forced Air Gas Furnace and Water-Air GHP
Heat Pump Ground Loops

- Vertical
- Slinky
- Horizontal
- Pond
## Industry Trend #3 – Radiant Distribution

<table>
<thead>
<tr>
<th>Region</th>
<th>2002</th>
<th>2008</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Baseboard</td>
<td>Radiant Floor</td>
</tr>
<tr>
<td>United States</td>
<td>1.9</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>New England</td>
<td>23.3</td>
<td>19.1</td>
<td>5.5</td>
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<tr>
<td>Mid-Atlantic</td>
<td>3.7</td>
<td>8.5</td>
<td>4.0</td>
</tr>
<tr>
<td>East North Central</td>
<td>4.2</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>West North Central</td>
<td>0.7</td>
<td>0.2</td>
<td>2.1</td>
</tr>
<tr>
<td>South Atlantic</td>
<td>0.8</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>East South Central</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>West South Central</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Mountain</strong></td>
<td><strong>1.3</strong></td>
<td><strong>3.0</strong></td>
<td><strong>13.5</strong></td>
</tr>
<tr>
<td>Pacific</td>
<td>0.0</td>
<td>0.6</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Modular Systems Reduce First Costs, Operations and Maintenance
Who Defines Green?  Buyer Profile

- **Energy Conscious Consumer**
  - 70% Women Centric, Age 40-55
  - Value-based Buying Decision
  - Above Average Household Income
  - Western or Southern United States
  - Prefer One Stop Shopping for Installing Contractor
  - Environmental Concerns, yet Not Primary Buying Motive
  - **Health, Comfort, Safety, and Energy Efficiency**
## Typical Client Benefits for New and Retrofit Building

Integrated heating, cooling, ventilation and energy systems

<table>
<thead>
<tr>
<th>Comfort</th>
<th>Indoor Climate</th>
<th>Environment</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Room-by-Room Sensors and Control</td>
<td>✓ Fresh Filtered Air</td>
<td>✓ Less Energy Use</td>
<td>✓ 50% Total Savings</td>
</tr>
<tr>
<td>✓ Uniform Temperature</td>
<td>✓ Lower Allergens</td>
<td>✓ Zero Carbon Emissions</td>
<td>✓ 8-12% Simple ROI</td>
</tr>
<tr>
<td>✓ Ideal Humidity</td>
<td>✓ No Indoor Combustion</td>
<td>✓ Zero Greenhouse Gas Emissions</td>
<td>✓ 12-15 Year Payback</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>✓ Excludes Tax Credits</td>
</tr>
</tbody>
</table>
Platinum LEED Home (PLH) Lessons Learned

Solar PV

Solar Thermal

Domestic Hot Water

Radiant Heat/Cool

Hot Tank

Smart Grid Enabled

 Heating and Cooling, Controls, Plumbing, Fire Suppression, and Renewable Energy

Net Zero HVAC/DHW, No Carbon, No GHG, No VOCs

* Patent Pending
Can’t Get There with Business As Usual

Lack of Integration
Disparate Specialty Contractors

- Heating, Cooling, and Ventilation
- Radiant Hydronics
- Plumbing
- Electrical
- Solar Hot Water
- Solar Photovoltaic
- Small Wind Power
- Ground Source Heat Pumps
- Driller/Ground Loop Installers
- Smart Grid Integration
- Energy Rating & Certification
- Systems Integration Controls?
Integrated controls are needed to gain the full benefits of sustainable systems technology.
Climate Control Network Screen Shot of Platinum LEED Home

Hydronic Cooling Mode

Solar Thermal

DHW

Hot Buffer

Cold Buffer

W-W GHP

W-A HP

Wine Cellar Temp 70.8

Ground Loop

Water - Air GHP in Fan Mode

ERV

Energy Environental

CoGEHPA

Colorado Green Energy Heat Pump Association
Imagine a Ground Source Heat Pump ...  

If You Pay $1 in kWh and you get $4 in kWh of heat or cool  

The Coefficient of Performance (COP) is 4

Imagine the same Heat Pump with no ground loop ...  

You Pay $1 in kWh and you get $4 in kWh of cool + $4kWh of Heat  

The Coefficient of Performance (COP) is 8
# Selling Integrated Systems

## 2700 SF Home, Natural Gas Furnace, Average Construction

<table>
<thead>
<tr>
<th>CURRENT GAS AND ELECTRIC UTILITY BILL</th>
<th>Monthly Average $</th>
<th>Forecasts Assume NO Energy $$$ Increases</th>
<th>Installed Parts and Labor</th>
<th>Net Cost with Tax Incentives</th>
<th>Estimated Monthly Savings</th>
<th>Simple ROI (%)</th>
<th>Simple Payback (years)</th>
<th>Payment at 6% in Mortgage</th>
<th>Change Monthly Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INSULATION &amp; AIR SEALING</strong></td>
<td>325</td>
<td></td>
<td>$5,500</td>
<td>$3,850</td>
<td>$45</td>
<td>14.0</td>
<td>7.1</td>
<td>$23</td>
<td>$22</td>
</tr>
<tr>
<td><strong>GEOTHERMAL SOLAR HW HEATING</strong></td>
<td></td>
<td></td>
<td>$47,500</td>
<td>$33,250</td>
<td>$200</td>
<td>7.2</td>
<td>13.9</td>
<td>$199</td>
<td>$1</td>
</tr>
<tr>
<td><strong>SOLAR HOT WATER SPACE HEATING</strong></td>
<td></td>
<td></td>
<td>$22,500</td>
<td>$18,750</td>
<td>$110</td>
<td>7.0</td>
<td>14.2</td>
<td>$112</td>
<td>($2)</td>
</tr>
<tr>
<td><strong>GEOTHERMAL HORIZONTAL LOOP</strong></td>
<td></td>
<td></td>
<td>$29,500</td>
<td>$20,650</td>
<td>$120</td>
<td>7.0</td>
<td>14.3</td>
<td>$124</td>
<td>($4)</td>
</tr>
<tr>
<td><strong>GEOTHERMAL VERTICAL LOOP</strong></td>
<td></td>
<td></td>
<td>$34,000</td>
<td>$23,800</td>
<td>$130</td>
<td>6.6</td>
<td>15.3</td>
<td>$143</td>
<td>($13)</td>
</tr>
<tr>
<td><strong>SOLAR DOMESTIC HOT WATER ONLY</strong></td>
<td></td>
<td></td>
<td>$9,000</td>
<td>$6,300</td>
<td>$32</td>
<td>6.1</td>
<td>16.4</td>
<td>$38</td>
<td>($6)</td>
</tr>
<tr>
<td><strong>ENERGY RECOVERY VENTILATOR</strong></td>
<td></td>
<td></td>
<td>$3,400</td>
<td>$2,380</td>
<td>$12</td>
<td>6.1</td>
<td>16.5</td>
<td>$14</td>
<td>($2)</td>
</tr>
<tr>
<td><strong>10KW WIND TURBINE 120FT TOWER</strong></td>
<td></td>
<td></td>
<td>$57,000</td>
<td>$39,900</td>
<td>$200</td>
<td>6.0</td>
<td>16.6</td>
<td>$239</td>
<td>($39)</td>
</tr>
<tr>
<td><strong>1.7 KW WIND TURBINE 33FT TOWER</strong></td>
<td></td>
<td></td>
<td>$13,000</td>
<td>$9,100</td>
<td>$35</td>
<td>4.6</td>
<td>21.7</td>
<td>$55</td>
<td>($20)</td>
</tr>
<tr>
<td><strong>TANKLESS ELECTRIC PARTIAL</strong></td>
<td></td>
<td></td>
<td>$2,500</td>
<td>$1,750</td>
<td>$4</td>
<td>2.7</td>
<td>36.5</td>
<td>$10</td>
<td>($6)</td>
</tr>
<tr>
<td><strong>SOLAR PHOTOVOLTAIC 6KW</strong></td>
<td></td>
<td></td>
<td>$48,000</td>
<td>$33,600</td>
<td>$72</td>
<td>2.6</td>
<td>38.9</td>
<td>$201</td>
<td>($129)</td>
</tr>
<tr>
<td><strong>TANKLESS WHOLE HOUSE GAS</strong></td>
<td></td>
<td></td>
<td>$4,850</td>
<td>$3,395</td>
<td>$5</td>
<td>1.8</td>
<td>56.6</td>
<td>$20</td>
<td>($15)</td>
</tr>
</tbody>
</table>
Conventional versus Geo Systems Cost

12,000 SF Custom Home, Radiant Heat, Pool and 2,500 SF Snowmelt

<table>
<thead>
<tr>
<th>Conventional System</th>
<th>Geothermal System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Cost</strong></td>
<td><strong>First Cost</strong></td>
</tr>
<tr>
<td>$517,600</td>
<td>$620,000</td>
</tr>
<tr>
<td><strong>REMP/Eco Fee</strong></td>
<td><strong>Fed Tax Credit</strong></td>
</tr>
<tr>
<td>$ 92,400</td>
<td>$130,000</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td><strong>TOTAL COST</strong></td>
</tr>
<tr>
<td>$610,000</td>
<td>$490,000</td>
</tr>
</tbody>
</table>

Optional Solar Offset to Fees

<table>
<thead>
<tr>
<th>Conventional System</th>
<th>Geothermal System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Cost</strong></td>
<td><strong>Additional Capabilities</strong></td>
</tr>
<tr>
<td>$517,600</td>
<td><strong>DDC Controls ($50K value)</strong></td>
</tr>
<tr>
<td>14.8kW Solar $ 72,520</td>
<td>Radiant on 2 floors</td>
</tr>
<tr>
<td>(1075 SF roof)</td>
<td>Radiant Floor Cooling as</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td>Option to full A/C</td>
</tr>
<tr>
<td>$590,120</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monthly Savings</th>
<th>Monthly Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ 222</td>
<td>$ 860</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>Annual Savings</td>
</tr>
<tr>
<td>$2,664</td>
<td>$10,300</td>
</tr>
<tr>
<td>(solar PV array)</td>
<td></td>
</tr>
</tbody>
</table>

** EEC is waiving Design Fees (8% of First Cost) through September 15, 2011
Ideal Applications for GeoExchange (GHPs)

- Best - Propane – forced air heating or hydronic in-floor heating
- Best – Pool collocated with high air conditioning cooling demand
- Better – All Electric Heating and/or Cooling
- Good – older Natural Gas furnace – 80% or less efficiency
- Remodel Client desires to add air conditioning with furnace replacement, or boiler/DX Cooling in Large Homes with Radiant Heating
- Radiant Cooling – Excellent - large spaces with direct solar gains
- Commercial Applications – PERFECT when there is a simultaneous need for both cooling and heating year round.

Need to insure access by drilling rig and or access to large pond
POOR Applications for GeoExchange (GHPs)

- Baseboard or Radiators with boiler in older home where client does not want to replace heat distribution system
  - Boilers operate up to 180 degrees, GHPs at maximum 130 deg F
  - New Refrigerants providing temps to 150 degrees due in late 2011
- Tight lots with little or no access, or extensive landscaping with no access for vertical or horizontal boring
- High efficiency natural gas furnace recently installed
  - Payback does not justify the investment
- Poor ductwork or air distribution
  - Very high temp gas furnace may be able to overcome poor duct design in existing home – though uncomfortable to client
  - Variable speed ECM motors on GHPs provide some offset
Questions & Discussion

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