CONSERVATION SOLUTIONS CORPORATION
ENERGY & WATER EFFICIENCY

Bio-Based Phase Change Materials (BioPCMs)
- BioPCM® ENRG Blankets™
- Tempassist™
- PhaseStor® Thermal Energy Storage Systems
HVAC Energy Savings of 25 to 35%
Using Bio-Based Phase Change Materials

Conservation Solutions Corporation
Dan Cook
DEMAND FOR ENERGY SAVINGS

Architects, Engineers, Utilities and Hotel Owners are Demanding

- Lower HVAC Expense
- Shift Peak Electricity Demand to Off-Peak Hours
- Consistent, Comfortable Temperature Even During Peak Loads
- Reasonable Up-Front Cost and Rapid ROI
- Long Lifetime and Low / No Maintenance
- Sustainable Solutions
Opportunities for Recovering Wasted Heat in Hotels While Improving Comfort

Source: E SOURCE, data from U.S. Energy Information Administration
ENRG Blanket™ - Powered by BioPCM®

Install alongside insulation in Ceilings, Walls & Roofs

Provides Additional HVAC Energy Savings of 25% to 35% Beyond Insulation Alone
Phase Change Materials at Work

144 BTU/ lb.
ENRG BLANKET - FEATURES

- Bio-Based Phase Change Materials (BioPCM) is made from sustainably grown plant based products
- Biodegradable & recyclable
- Tunable “melt/freeze” temperature (-58°F to 275°F)
- Building Code Compatible Fire & Smoke Ratings
  - Class C, Class A & Plenum
- Stable chemical and physical properties
- Maintenance Free > 100 year life
- Fire-resistant
- Non-toxic
- Transitions to a gel
- Made in the USA
HEAT ABSORBED
Solid transition to Gel

When ambient air is warmer than the phase change material (PCM), the heat is absorbed and stored in the PCM thermal battery at 73°F
HEAT RELEASED

Gel transitions to Solid

When ambient air is cooler than the phase change material (PCM), the heat is released at the 73°F PCM thermal battery temperature.
Commercial Office – Early Morning
Ready for a new day
Commercial Office – Noon
Heat from numerous sources absorbed by BioPCM
- Reduces HVAC Energy Use 25% to 35%
- Shifts electricity demand to Off-Peak
- Reduces HVAC operating costs
- Reduces CO₂ emissions
- Creates a more comfortable environment
- Made in the USA

**Commercial Office – Nighttime**

Heat load being released by BioPCM to nighttime air
During typical daytime heat build up, BioPCM ENRG Blanket / Tempassist absorbs 27 - 75 BTU's per square foot for any temperature above 72 degrees.

During typical night time cooling, BioPCM ENRG Blanket / Tempassist releases 27 - 75 BTU's per square foot for any temperature below 72 degrees.
<table>
<thead>
<tr>
<th></th>
<th>Environmental Impact</th>
<th>Energy Density (BTU/lb)</th>
<th>Lifetime (years)</th>
<th>Cost of Production ($/ft²)</th>
<th>Super Cooling</th>
<th>Volume Change</th>
<th>Corrosive</th>
<th>Flammable</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioPCM</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Paraffin</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Salt Hydrates</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

Positive  ✗  Negative
There are very large differences between the chemical and physical composition of BioPCMs and salt hydrates. Salt hydrates do not have a sharp melt/freeze curve that allows BioPCMs to operate more efficiently in the target temperature zone. BioPCMs provide essentially all of their latent heat capacity across a narrow temp range. The benefit is almost all the available heat absorption and release capacity is available to do useful work.

For 1 lb of packaged PCM material used above drop ceiling (expected temperature excursion 69 F to 79 F):

- BioPCM delivers 100 BTU of useable heat absorption/ release
- Salt Hydrate delivers 22 BTU of useable heat absorption/ release
BioPCMs are chemically stable over a tested lifetime of 100 years. This graph demonstrates the minimal degradation of BioPCM through 36,500 melt/freeze cycles (100 years of use). At the end of the useful life the PCM is biodegradable and the encapsulating layers can be recycled.

Salt Hydrate (CaCl₂•6H₂O) products degrade with each cycle and must be replaced every 5 to 10 years, representing a major cost to the user. These products are not recyclable or environmentally sustainable.
A puncture of the blanket may occur if mishandled or installed improperly. If there is a leak, what might happen?

**BioPCMs**

- BioPCMs are non-toxic and non-corrosive.
- Made from food grade, sustainably-sourced plant materials.
- Actual Customer Experience: Leak onto light fixture - cleaned up with soap and water.

**Salt hydrates**

- Highly corrosive to metals and many other materials. Must be properly encapsulated for safety.
- Salt hydrates have potential toxicity issues. Care should be taken if the material is ingested and/or comes into contact with skin.
- Actual Customer Experience: Leak from above-ceiling installation onto an electrical panel cause corrosion and major issue.
## WHY WE AT PCES CHOOSE TO PURSUE BIOPCMS - SUMMARY

<table>
<thead>
<tr>
<th>BioPCMs</th>
<th>Salt Hydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost Per Usable BTU</strong></td>
<td>Although the low cost per pound seems less expensive, the actual cost per usable BTU of heat transfer is higher.</td>
</tr>
<tr>
<td>The right measure of cost is not $$/SqFt or $$ per pound, it is $$ per usable BTU of heat transfer. BioPCMs are less expensive to use</td>
<td></td>
</tr>
<tr>
<td><strong>Lifetime</strong></td>
<td>Useful life of only 5-10 years before replacement needed. Increases cost of use.</td>
</tr>
<tr>
<td>Thermal performance for over 100 years. Energy savings provided for the lifetime of the building.</td>
<td></td>
</tr>
<tr>
<td><strong>Hysteresis</strong></td>
<td>Wide separation between melt &amp; freeze temps, non-stability upon cycling, and segregation of salt hydrate components are major drawbacks. Energy savings performance degrades with time.</td>
</tr>
<tr>
<td>Transition temperatures are narrowly targeted and consistent over time. Energy savings performance is stable.</td>
<td></td>
</tr>
<tr>
<td><strong>Tunability</strong></td>
<td>In general, salt hydrates have limited temperature ranges available to meet specific temperature needs</td>
</tr>
<tr>
<td>Tunable to temperatures anywhere from -50°C to 135°C. Solutions customizable to meet the needs of a building.</td>
<td></td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td>Typically 70-130 J/g. Need much more weight of material for same usable BTUs of heat transfer. Increases strain on drop ceiling support system.</td>
</tr>
<tr>
<td>Higher latent heats, typically 200 J/g or more. BioPCMs deliver more usable heat transfer (more energy savings) for less weight</td>
<td></td>
</tr>
<tr>
<td><strong>Stability</strong></td>
<td>Corrosivity, toxicity, and volume changes. Leaks can cause corrosion of office equipment. Leaks can deposit toxic materials in the workplace.</td>
</tr>
<tr>
<td>Non-toxic, non-corrosive, non-flammable</td>
<td></td>
</tr>
<tr>
<td><strong>Sustainability</strong></td>
<td>Not recyclable or sustainable</td>
</tr>
<tr>
<td>Renewable materials, biodegradable and recyclable, minimal environmental impact</td>
<td></td>
</tr>
</tbody>
</table>
BIO-BASED PCM APPLICATIONS

- **Drop Ceiling**
  - Straight forward “easy” installation – Simply rolls out above the drop ceiling
  - Allows benefits to be applied to existing buildings
    Good fit for energy upgrade
    Good fit for building retrofit
    Good fit for repurposed buildings/spaces

- **Walls**
  - Straight forward installation
  - Typically new construction
  - Allows for strategic placement in space and based on building orientation
ENRG BLANKET™ INSTALLATION
- 1000 FT² PER HOUR / 4 PERSON CREW

Install It Tonight,
Start Saving Energy Tomorrow!

65% - 75% Coverage
BIO-BASED PCM APPLICATIONS

**Roof**
- Straight forward “easy” installation
- Allows benefits to be applied to existing buildings
  - Good fit for energy upgrade
  - Good fit for building retrofit

**Custom**
- Straight forward “easy” installation
- Allows benefits to be applied to difficult spaces
  - Good fit for energy upgrade
  - Good fit for building retrofit
  - Good for thermal security applications in walk-in refrigeration & freezers
NATIONWIDE INSTALLATION CAPABILITY & LOCAL NE APPROVED INSTALLERS

Installed >3,000 projects in past 12 months in 22 states

TruTeam (NYSE: BLD)
Nation’s largest installer of insulation

- 190+ Locations
- 3,000+ Trucks
- 5,000+ Employee Installers
- 5 Million+ Installations
- Commercial & retrofit specialists
ENRG BLANKET BEHIND THE PICTURES, MIRRORS, HEADBOARDS & ...
Features & Benefits

- **Sustainability**
  - 100% biodegradable & recyclable
  - LEED Compliant (energy efficiency standards)

- **Performance**
  - Delivers considerable cost savings on heating and cooling bills
  - Lowers HVAC maintenance costs
  - Downsizes HVAC equipment
  - Helps maintain a comfortable environment

- **Adaptive Re-use**
  - Derived from sustainable bio-based renewable resources.

- **Mass Customization**
  - Ability to be fine tuned to average desired temperature
  - Versatility to make a wide range of decorative / non decorative wall solutions

- **Livability**
  - Non-toxic
  - Maintenance free
  - Natural fire suppression

- **Resilience**
  - Long Life – products temp. control material lasts 100+ years

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The bio based phase change material we are using is protected by a number of patents that cover the material properties, packaging, potential competitive options, as well as trade secrets.
1. **HEAT** enters the room
2. Tempassist absorbs the **HEAT**
   - keeping the comfortable and the HVAC Off

1. **COLD** enters the room
2. Tempassist releases **HEAT**
   - keeping the comfortable and the HVAC Off
ATLANTA LOCATION: NOV. 19 – DEC 16

- Occupied Test / 509 total guest rooms
- Comparable test data from 2 paired room sets with LJ telemetry (1)

GOAL:
- Review overall viability of Tempassist™
- Maintain guest comfort by limiting spikes in heat or cold and reduced on/off cycles
- Reduce HVAC system run times and stress on equipment
- Save cost

EXTERNAL VALIDATION
- Hotel Service Corp: customer-selected measurement & analysis partner
- Levy Partnership: Independent 3rd party selected by LJ for measurement and analysis support.
### ON/OFF CYCLE RESULTS

<table>
<thead>
<tr>
<th>Room Pairing 2</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>701 Cycle Times - Cooling - 5 Days</td>
<td>100 On/Off Cycles</td>
</tr>
<tr>
<td>1601 Cycle Times - Cooling - 5 Days</td>
<td>51 On/Off Cycles</td>
</tr>
</tbody>
</table>

**A Significant Reduction in On/Off Cycle Times**

**49% Reduction**
# RUNTIME & ON/OFF CYCLE RESULTS

## Runtime Results

<table>
<thead>
<tr>
<th>Room</th>
<th>Heating Runtime</th>
<th>Cooling Runtime</th>
<th>Total Runtime</th>
<th>Cooling Cycles</th>
<th>Room</th>
<th>Heating Runtime</th>
<th>Cooling Runtime</th>
<th>Total Runtime</th>
<th>Cooling Cycles</th>
<th>Heating % Runtime Reduction</th>
<th>Cooling % Runtime Reduction</th>
<th>Total % Runtime Reduction</th>
<th>Cycle % Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1624</td>
<td>40.7</td>
<td>306.3</td>
<td>347.0</td>
<td>225</td>
<td>830</td>
<td>39.5</td>
<td>137.4</td>
<td>176.9</td>
<td>122</td>
<td>2.8%</td>
<td>55.2%</td>
<td>49.0%</td>
<td>45.8%</td>
</tr>
<tr>
<td>701</td>
<td>38.9</td>
<td>119.3</td>
<td>158.2</td>
<td>100</td>
<td>1601</td>
<td>15.9</td>
<td>38.5</td>
<td>54.4</td>
<td>51</td>
<td>59.1%</td>
<td>67.7%</td>
<td>65.6%</td>
<td>49.0%</td>
</tr>
<tr>
<td>Total</td>
<td>79.6</td>
<td>425.6</td>
<td>505.2</td>
<td>325</td>
<td></td>
<td>55.4</td>
<td>175.9</td>
<td>231.3</td>
<td>173</td>
<td>30.4%</td>
<td>58.7%</td>
<td>54.2%</td>
<td>46.8%</td>
</tr>
</tbody>
</table>

## Runtime Totals (Hrs)

<table>
<thead>
<tr>
<th>Room</th>
<th>Heating Runtime</th>
<th>Cooling Runtime</th>
<th>Total Runtime</th>
<th>Cycle % Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1624</td>
<td>252.8</td>
<td>115.7</td>
<td>1624</td>
<td></td>
</tr>
<tr>
<td>830</td>
<td>237.0</td>
<td>176.9</td>
<td>830</td>
<td></td>
</tr>
<tr>
<td>701</td>
<td>169.9</td>
<td>158.2</td>
<td>701</td>
<td></td>
</tr>
<tr>
<td>1601</td>
<td>138.3</td>
<td>54.4</td>
<td>1601</td>
<td></td>
</tr>
</tbody>
</table>

A significant reduction in run & on/off cycle times:

<table>
<thead>
<tr>
<th>Heating</th>
<th>Cooling</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Runtime Reduction</td>
<td>% Runtime Reduction</td>
<td>% Runtime Reduction</td>
</tr>
<tr>
<td>30.4%</td>
<td>58.7%</td>
<td>54.2%</td>
</tr>
</tbody>
</table>
### Test Results Comparisons (Delta T as recorded)

<table>
<thead>
<tr>
<th>Room</th>
<th>Heating Cost</th>
<th>Cooling Cost</th>
<th>Delta T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1624</td>
<td>$8.94</td>
<td>$64.95</td>
<td>4.4</td>
</tr>
<tr>
<td>701</td>
<td>$8.55</td>
<td>$12.81</td>
<td>2.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$17.49</td>
<td>$77.76</td>
<td></td>
</tr>
</tbody>
</table>

### Test Results Comparisons (Average Delta T)

<table>
<thead>
<tr>
<th>Room</th>
<th>Heating Cost</th>
<th>Cooling Cost</th>
<th>Delta T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1624</td>
<td>$8.94</td>
<td>$59.32</td>
<td>4.0</td>
</tr>
<tr>
<td>701</td>
<td>$8.55</td>
<td>$23.08</td>
<td>4.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$17.49</td>
<td>$82.4</td>
<td></td>
</tr>
</tbody>
</table>

### Runtime % Savings

<table>
<thead>
<tr>
<th></th>
<th>Total ($) Savings</th>
<th>% ($ Savings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>$22.17</td>
<td>30.00%</td>
</tr>
<tr>
<td>60%</td>
<td>$8.56</td>
<td>40.07%</td>
</tr>
<tr>
<td>54%</td>
<td>$30.73</td>
<td>32.26%</td>
</tr>
</tbody>
</table>

### Runtime % Savings

<table>
<thead>
<tr>
<th></th>
<th>Total ($) Savings</th>
<th>% ($ Savings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>$33.01</td>
<td>48.36%</td>
</tr>
<tr>
<td>66%</td>
<td>$18.22</td>
<td>57.60%</td>
</tr>
<tr>
<td>54%</td>
<td>$51.23</td>
<td>51.29%</td>
</tr>
</tbody>
</table>
NATIONAL BANK CASE STUDY
INSTALLED IN +1,500 BANK LOCATIONS

LOCATION: Elmhurst, NY

- 2,000 Sq. Ft. of ENRG Blanket™ installed
- Covering 70% of the surface area above the ceiling tiles
- No disruption to normal operations
LOCATION: Elmhurst, NY

Financial Summary - First Year Results

kWh Cost ................................................................. $0.184
Annual Savings .......................................................... $7,347
Cost of ENRG Blanket™ @ $4.69/ ft² (installed)…. $9,380
ROI (simple payback)................................................... 1.28 Years

*Independent Testing: Noveda Technologies
24 HOUR COMPARISON OF PRE-PCM AND POST-PCM HVAC CURRENT USAGE
- ROLLING HILLS, CA

- TWO DAYS WERE SELECTED PRE-PCM AND POST-PCM WHICH HAVE SIMILAR WEATHER AS INDICATED BY HDD, CDD AND TDD.

Rolling Hills, CA - 24 Hour Electricity Usage Comparison Pre-PCM vs Post-PCM
Overall amp-hr Reduction = 19.8%

<table>
<thead>
<tr>
<th>Rolling Hills, CA</th>
<th>11/30/2015 Pre-PCM HDD = 8.5 CDD = 0</th>
<th>1/11/2016 Post-PCM HDD = 8.6 CDD = 0</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total amp-hrs</td>
<td>54.2</td>
<td>43.5</td>
<td><strong>19.8%</strong></td>
</tr>
</tbody>
</table>

Phase Change Energy Solutions Confidential Information
U of Washington Molecular Science Engineering Building
New Construction

- Construction in 2012
- Building uses ENRG Blanket for passive cooling
- 98% HVAC Energy Savings
Easton Olympic Archery Center – New Construction
Chula Vista, CA

- ROI <12 months
- 43,800 ft² of ENRG Blanket installation
- Bob Easton Architect, Kiewit Corporation
RMI’s Innovation Center is ranked as the highest performing building in the coldest climate zone in the U.S.
BioPCM ENRG Blanket & tempassist™

Benefits Summary

• Reduce HVAC Energy Costs 25% - 35%
• Stabilize Room Temperatures
• Reduce Peak Demand Energy Use
• Help Reduce Overheating and Overcooling Issues
PHASE CHANGE ENERGY SOLUTIONS
OTHER DIVISIONS HARD AT WORK!

Vesture
Thermal Management System

PhaseStor
Large Thermal Storage System

ColdChainPCM
Temperature Controlled Thermal Transport

OEM supplier to major cold chain manufacturers
THANK YOU

CONSERVATION SOLUTIONS CORPORATION
ENERGY & WATER EFFICIENCY

Contact Us to Recover Wasted Energy & $
Using ENRG Blanket & tempassist - Powered by BioPCM

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