Phase Change Material and Thermal Energy Storage Case Studies

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Typical Rail Car Track Level Warehouse
Building Built in the early 40’s
Warehouse 303 on Right, 302 on Left
Installation: R-19 Foil Faced Insulation and 51 btu per sq. ft. BioPCM Mats.

Installed appx. 400 tons of passive storage (over 5 million btu’s)
Gas Consumption & Temperature

- Control Building
- Building with PCM

April:
- 33% Reduction

May:
- 56% Reduction
Feb-Mar Temperature

- Readings taken every 15 minutes
- Control Building
- Building with PCM

February March
Feb-Mar Temperature Difference \( (T_{\text{Bldg 303}} - T_{\text{Bldg 302}}) \)
Apr-May Temperature Difference \( (T_{\text{Bldg 303}} - T_{\text{Bldg 302}}) \)
Huntsville City School System
Blossomwood Elementary Pilot

Blossomwood Elementary School Huntsville, Ala
Other options are being investigated including installing inside the occupied space.
Selecting the Right PCM Melt Temperature

• Data is collected where the PCM will be installed. For open systems like schools the data should be collected in the entire building. Hard to evaluate open systems a piece at a time.
• Collection period must be long enough, often as much as a year to accurately measure the essential parameters
• The PCM selection must account for room to room variance
• More than one temperature is usually necessary to extend the months where the pcm is effective and to improve the ROI or SIR
• Effects on ancillary equipment, especially boilers and chillers must be included in the design stage and to determine ROI.
Result of using multiple melt temperatures
Data Courtesy of the US Army AMRDEC Energy Lab

*Delaying the day using PCM for Equipment Conditioning*

MIL STD 810G Thermal Load Test: Table 501.5-III

TBOX-3 Objective: PCM curve using 3 different Hi-Temp Set Points
This Room is on the Southwest Corner and Would Need 4 Change Temps to Extend the Effectiveness
This room has southern exposure and this data indicates 4 separate change temps would be best.
This room is adjacent to 204. The wintertime set-point is 68F. A pcm that melts/freezes at 68 is indicated for winter.
PCM Works in winter because the stored heat from daytime keeps the attic warmer overnight, reducing the heat load.

Data courtesy Oak Ridge Natl. Lab

Figure 15. Winter attic temperature variation
This room has full western exposure. The installation design for this school must consider melt/freeze temps of 68, 72, 74 & 76°F.
July 2015 Hot Week (Max 100F, Min 65F, Avg. Daytime 95F)
Room 206 has 18,000 btu of 75F PCM above the tiles
July 2015 Hot Week (Max 100F, Min 65F, Avg. Daytime 95F)
Room 207 Has No PCM. Notice the Attic Heat blows thru 75F
Notice the effect on the occupied room that the PCM above the tiles has. The energy saved in not having to drive the temp down is money saved.
Before install, 206 outperforms 204 by 13%
After install, 206 underperforms 204 by 7%
Installed Phase Change Material on April 25, 2016

- On April 25, 2016, TriVector installed 77°F phase change material in Room 204 (test room)
- Room 206 was left unchanged (control room)
- The results show a 20% swing in improved performance for the test room vs. control room
- Control room went from outperforming 204 by 13% to underperforming 204 by 7%, a 20% swing.

<table>
<thead>
<tr>
<th></th>
<th>Room 204</th>
<th>Room 206</th>
<th>Control Room</th>
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</thead>
<tbody>
<tr>
<td>Before Install</td>
<td>1291</td>
<td>1120</td>
<td>87%</td>
</tr>
<tr>
<td>After install</td>
<td>4271</td>
<td>4549</td>
<td>107%</td>
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</tbody>
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Keys to Successful PCM-based TES

- The missing link and true enabler of successful PCM based TES is to competently engineer and then actively monitor, control and manage the TES system.
- Success with TES requires a well designed system and most always has to be actively managed.
- The thermal conductivity of the PCM and of the package has to be considered.
- Electronic monitoring and control is best, especially to benefit from off peak billing.
- Look for ways to use the existing HVAC and water systems to manage and control the PCM.
- Consider the heating and/or cooling deficit when designing the amount of TES necessary.