Simplifying the Selection of Thermal Energy Storage for District Cooling

Steve Benz
Director of Global Thermal Storage and District Energy
Energy Demand vs. Supply

Electric Power (mW) vs. Time of Day

- The graph shows the variation of electric power demand throughout the day.
- There is a peak in the afternoon and a trough in the early morning.
- The x-axis represents the time of day, ranging from 0 to 24 hours.
- The y-axis represents the electric power demand in milliwatts.
Addressing Energy Supply Problems

- Rolling blackouts
We are likely to load shed on most days in the near future

<table>
<thead>
<tr>
<th>Jan-15</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>Mon</td>
<td>Tue</td>
<td>Wed</td>
<td>Thu</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feb-15</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>Mon</td>
<td>Tue</td>
<td>Wed</td>
<td>Thu</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mar-15</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>Mon</td>
<td>Tue</td>
<td>Wed</td>
<td>Thu</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td>29</td>
<td>30</td>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Apr-15</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>Mon</td>
<td>Tue</td>
<td>Wed</td>
<td>Thu</td>
<td>Fri</td>
<td>Sat</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Addressing Energy Supply Problems

- Rolling blackouts
- Cash incentives
- Higher energy costs
  - Demand charges
  - Energy charges
  - Connection charges

Tariff-Based or Market-Based
Southern California Edison, Schedule TOU-8-RTP
General Service-Large, Real Time Pricing*

Hourly Energy Rate

$0.00
$1.00
$2.00
$3.00
$4.00

Time of Day

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Summer Day

Mild
Moderately Hot
Very Hot
Extremely

* Hourly UG Rate – From 2 kV to 50 kV; Effective January 1, 2018
Buy Low-Sell High Discharge Strategy
Addressing Energy Supply Problems

- Rolling blackouts
- Cash incentives
- Higher energy costs
  - Demand charges
  - Energy charges
  - Connection charges
- Industry mandates or regulations
Thermal Energy Storage (TES) Typical Project Drivers / Benefits

Shift cooling from peak to off-peak periods.
Reduce peak power demand & energy costs.
Provide low-capital-cost peaking capacity.
Add redundancy / reliability / resiliency.
Improve operational flexibility.
Improve balance of thermal & electric loads for CHP.
Enhance DC network capacity (via temp or location)
Types of TES for District Cooling

Latent Heat TES Systems (phase change)
• Typically, Ice TES

Freeze water at night; melt it the next day.

Sensible Heat TES Systems (temp change)
• Typically, Chilled Water (CHW) TES
• Also, Low Temp Fluid (LTF) TES

Chill water (or fluid) at night; use it the next day.
Inherent Characteristics of TES (typical generalizations only)

Volume
Footprint
Modularity
Economy-of-Scale
Energy Efficiency
Low Temp Capability
Ease of Retrofit
Rapid Charge/Dischrg Capability
Simplicity and Reliability
Can Site Remotely from Chillers
3 Key Decision Drivers

- Chiller selection
- Size
- Chilled water temperatures
Chiller Selection Considerations

**Chilled Water Storage**  
- Water as heat transfer fluid

**Ice Storage**  
- Glycol as heat transfer fluid
Stratified Chilled Water Storage

Recharging Cycle

Discharging Cycle

Figures courtesy of CB&I.
Ice Storage Storage

Glycol Chiller

Water Chiller

Cooling Loads

Charging Cycle
Chiller Selection Considerations

Chilled Water Storage

- Water as heat transfer fluid
- Lift capability
- Higher production efficiency
- Ease of retrofit
- Can locate TES tank at remote loop location

Ice Storage

- Glycol as heat transfer fluid
- Lift capability
Size Matters

Chilled Water Storage is 6 to 8 times larger than Ice Storage
Entergy Solutions – Houston, Texas
88,000 Ton-Hours (310 mW-Hours)

2008: 3rd International District Cooling Conference & Trade Show – Dubai
District Energy is Green Energy!
Advantages of Colder Chilled Water Supply Temperature

• Reduced CHW loop flow
  – Reduced pumping energy
  – Maximize distribution piping asset value

• More economical building isolation (energy transfer station) with smaller heat exchangers
Ice Storage System Types

Ice-on-Coil
Internal Melt or External Melt
Chilled Water Supply Temperatures

- Internal Melt With Air Agitation with Glycol to Chilled Water HX
- Encapsulated or Frozen Solid with Glycol to Chilled Water HX
- External Melt Without HX
- Chilled Water Storage
3 Key Decision Drivers

• Chiller selection
• Size
• Chilled water temperatures
Questions?

Steve Benz
Director of Global Thermal Storage and District Energy