Thermal Energy Storage for District Cooling

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

Electric Power (mW)

Time of Day

0 2 4 6 8 10 12 14 16 18 20 22
Addressing Electric Supply Problems

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

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<th>Jan-15</th>
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**Jan-15**
- Sun: 1
- Mon: 2
- Tue: 3
- Wed: 1
- Thu: 2
- Fri: 3
- Sat: 4

**Feb-15**
- Sun: 1
- Mon: 2
- Tue: 3
- Wed: 4
- Thu: 5
- Fri: 6
- Sat: 7

**Mar-15**
- Sun: 1
- Mon: 2
- Tue: 3
- Wed: 4
- Thu: 5
- Fri: 6
- Sat: 7

**Apr-15**
- Sun: 1
- Mon: 2
- Tue: 3
- Wed: 4
- Thu: 5
- Fri: 6
- Sat: 7

Legend:
- Green: Adequate generation capacity available to meet demand and reserves.
- Orange: Constrained generation capacity with sufficient supply to meet demand and reserves. Medium probability of load shedding.
- Red: Insufficient generation capacity unable to meet demand and reserves. High probability of load shedding.
Addressing Electric 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

Moderately Hot
Very Hot
Extremely Hot

Mild

$0.038
$3.80
Buy Low-Sell High Discharge Strategy

DCP Electric Load mW

Wholesale Energy Cost $/mWhr

July 01    July 02    July 03    July 04    July 05
Addressing Electric 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

Charging Cycle

Water Chiller

Cooling Loads

Glycol Chiller
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, USA
88,000 Ton-Hours (310 mW-Hours)

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

- Reduced CHW loop flow
  - Reduced pumping energy
  - Maximize distribution piping asset value
- More economical building isolation (indirect interface) 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**
- **Chilled Water Storage**
- **External Melt Without HX**

Graph showing chilled water supply temperature (% discharged vs temperature) for different conditions.
3 Key Decision Drivers

- Chiller selection
- Size
- Chilled water temperatures
Questions?

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