Thermal Energy Storage at Rockefeller Center

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Outline

• Why thermal energy storage (TES)?
• Rockefeller Central CHW System
• 45 Rockefeller Chiller & Thermal Storage Plant
• Modes of Operation
• Lessons Learned
• Q&A
Why Energy Storage?

- Reduced utility costs due to peak shifting
Why Energy Storage?

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Why Energy Storage?

- **Utility incentive programs**
  - Demand Response Rebates
    - NYISO ICAP/SCR (day-ahead notification)
    - Con Edison CSRP (minimum 2 hours ahead notification)
    - Con Edison DLRP (day-ahead notification)
    - Rebate payments combine for approximately $210 per kW enrolled per summer
  - Capital Project Rebates
    - Con Edison Demand Management Program (DMP)
      - Awards up to $2,500 per kW of demand reduction
Con Ed Demand Management Program (DMP)

<table>
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<tr>
<th>Project Type</th>
<th>2019 Incentive Rate ($/kW)</th>
<th>Project Cost Incentive Limit</th>
<th>Project Installation Deadlines to Qualify for Incentive</th>
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<td>Thermal Storage</td>
<td>$2,520/kW</td>
<td>Up to 70%</td>
<td>August 15</td>
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<td>Demand Response Enablement – Controls</td>
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<td>Steam Turbine Chiller, Double Stage Absorption Chiller, Gas Driven Chiller*</td>
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Thermal Storage

• HVAC makes up a significant portion of commercial building energy costs in summer months
• Need a CHW/glycol loop system to implement TES
• Pumping losses if in separate circuit
• Longer life cycle (30 yr)
• Low temperature CHW supply reduces secondary HVAC fan loads and extends free cooling hours

Battery Storage

• Can serve site during grid outage
• Serves diverse loads (not just HVAC)
• Hazardous waste disposal from batteries (Lithium ion, etc)
• Inverter/transformer losses
• FDNY permitting roadblocks in NYC
Rockefeller Center CHW Loop

- Rock Center cooling loads served by a central chilled water (CHW) loop
- Peak daytime cooling load is approximately 10,000 tons
- 30 Rock Central Chiller Plant serves 14 buildings with primary/secondary/tertiary pumping system with 14,500 tons of installed chiller capacity.
New 45 Rock Chiller & Thermal Storage Plant
45 Rockefeller Center Chiller Plant

- 45 Rock Chiller Plant rebuilt in 2018
- 2,500 tons electric centrifugal chillers
- 1,200 ton electric centrifugal ice chiller
- 12,000 ton-hr ice storage plant
- Serves 45 Rock and 50 Rock buildings
- Import capability from Central Plant Loop via CHW plate & frame HX
- Export capability from ice storage plant

45 Rockefeller (Chiller Plant in Basement)
45 Rockefeller Center Chiller Plant

• 2 x 1,250 ton electric centrifugal “day” chillers
  • 40° F / 54° F CHW
  • Low supply temp reduces AHU fan energy, captures additional latent load, and extends ΔT
  • Oversize 10° F ΔT evaporator and condenser bundles allow additional flow for operational flexibility

• 1 x 1,200 ton electric centrifugal glycol chiller
  • Next-gen HCFO-1233zd(E) refrigerant carries zero ODP and extremely low GWP (<5) as compared with R-123 (77)

• All chillers can operate on either 45 Rock cooling towers or 50 Rock cooling towers for operational flexibility
45 Rockefeller Center Chiller Plant

• Approximately 0.3 kW/ton improvement over previous chillers
• Previous chillers were 480V and 208V; one (1) day chiller and the ice chiller run at 4160V (40% reduction in daytime utility electrical demand charges)
• Future pump energy reductions are expected
  • Demand side control valves
Construction Schedule

• Accelerated 5-month design/build construction schedule
  • July 2017: Feasibility Study and DMP Application
  • November 2017: Design release
  • December 2017: Demolition and equipment pre-purchase
  • January 2018: Contractor RFP’s released from 50% DD
  • April 2018: Chillers ship, make-ready work
  • May 2018: Instant swing over to new variable primary pumping
  • June 2018: Day chillers online
  • August 2018: Ice system online, post M&V and DMP testing
  • September 2018: Awarded DMP incentive
16" Central CHW Loop Supply/Return
Ice Storage Tanks

• Ice-on-Coil type tank
• Each tank contains spiral wound heat exchanger tubes in close proximity
• Counterflow design builds and melts ("burns") ice evenly across the mats and the tank as a whole
Ice Storage Tanks

- Each tank approx. 8’ diameter
  - Two sizes utilized due to headroom constraints:
    - (30) x 8 foot tall tanks →
    - (31) x 11 foot tall tanks
- Tanks connected in parallel in branch groups of 1-3
- Reverse return piping for hydraulic balancing – first tank supplied is last tank returned
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Ice Storage Tank Layout
Ice Storage Plant Operation – Build Mode

- Glycol chiller RM-3 supplies 22°F glycol to ice tanks, freezing the water inside.
- Build ends when glycol return temperature from tanks reaches 28°F.
- Do not overbuild – freezes water over HX intended to allow expansion during freezing (“ice cap”), causing shortage of water around HX coils and impairing performance.
- Low overnight temperatures improve chiller efficiency.
Ice Storage Plant Operation – Burn Mode

- CHW flow control through Ice HX drives ice burn rate
- Higher glycol return temperature to tanks (HX outlet) extends ton hour capacity of tanks
Ice Storage Plant Operation – Day Mode

- Ice Chiller runs as normal chiller
- Some flow may divert through ice bank to meet blended supply temperature setpoint
- Mode not utilized unless one or more day chillers are out of service on peak summer day
### Design Day System Analysis

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<th>CHILLER UPSTREAM - SERIES FLOW</th>
<th>NOMINAL CHILLER SIZE = 1767</th>
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<td>NUMBER OF TANKS = 57 MODEL 1220</td>
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<td>SYSTEM RETURN TEMPERATURE (F) = 52.0</td>
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<td>FLOW (GPM) : DISCHARGE = 5686</td>
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Why Energy Storage?

- Steam Chiller
- Existing Ice Plant
- Central Plant Electric Chillers
- 45 Rock Electric Chillers

Existing Chilled Water Demand July 13, 2017

89°F (DB), 81°F (WB)

-Chilled Water kW-
-Chilled Water Tonnage-

Existing kW

9:00 AM 10:00 AM 11:00 AM 12:00 PM 1:00 PM 2:00 PM 3:00 PM 4:00 PM 5:00 PM 6:00 PM 7:00 PM
Why Energy Storage?

Electric Chillers

Existing Ice Plant

New Ice Plant

Steam Chiller

DR Day Post 45 Rock Plant Rebuild

Existing kW

DR Day kW

6.5 MW
Ice Storage Review & Lessons Learned

• **Surge**
  • Max 90 F leaving CWR temp
  • Oversize condenser bundles

• **Footprint = $$$** especially in cities

• **Utility Capital Incentives**
  • Can make/break ROI even with high utility costs
Ice Storage Tips & Lessons Learned

• **Insulation** - 1.5” minimum for glycol

• **Reverse return** piping for hydraulic balancing – first tank supplied is last tank returned

• Complete **full burn** prior to building more ice.

• Design for **low approach** over HX to widen ice delta T, boost ice bank capacity, reduce pumping.
Ice Storage Review & Lessons Learned

- **Warming cycle** over your glycol-CHW HXs – heat the trapped cold glycol
- **Leave HX glycol valves open** after burn cycles
- Include **glycol management system** to maintain system pressure and glycol concentration, with eye wash station nearby
- Every two years, **replenish biocide** in water tanks after full tank burn
- **ASHRAE 15** refrigerant monitoring and exhaust apply normally at chillers
  - Configure refrigerant monitor for each refrigerant type employed
Thank You!

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