DCP Capacity Upgrade
By Adding
Thermal Ice Storage

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Major Components of a District Cooling Plant
Major Components of a DCP

DCP Capacity Limiting Factors

• Chillers
  – Cooling Capacity
  – Flow and Temperature
• Cooling Towers
  – Cooling Range
  – Approach
  – Available Roof Area
• Chilled Water Pumps & Piping
  – Delta T
  – Flow Rate
  – Pressure Drop
• Switch Gears
• **Normal Practise:**
  Design for peak load conditions and select chillers to provide chilled water of 42°F (or lower)

• **Alternative Solution:**
  Add thermal energy storage
Cooling Capacity = Flow Rate $\times$ $\Delta T$ $\times$ $c_{\text{Water}}$ (specific heat water)
1) Increase Chilled Water Flow Rate and Keep $\Delta T$

\[
\text{Cooling Capacity} \uparrow = \text{Flow Rate} \uparrow \times \Delta T \times c_{\text{Water}}
\]

2) Increase $\Delta T$ and Keep Chilled Water Flow Rate

\[
\text{Cooling Capacity} \uparrow = \text{Flow Rate} \times \Delta T \uparrow \times c_{\text{Water}}
\]
Increase and Maximize DCP Capacity

Case 1

- Plant Designed for 18,750 ton
- Currently Installed Capacity: 15,000 ton
- Chilled Water Temperature: 40°F – 56°F

Increase CW Flow Rate and Keep $\Delta T$
Increase CW Flow Rate and Keep $\Delta T$

Conventional Solution

- Add Extra Chiller(s): 3,750 ton
- Maximum Plant Capacity: 18,750 ton (15,000 + 3,750)
- Further Increase Limited due to:
  - Heat Rejection Equipment
  - Power Supply
• Select extra chiller(s) to operate with glycol

• Maximum possible capacity of chillers:
  3,750 ton in day mode (40°F LWT)
  Night mode: 2,500 ton (22°F LBT)
Increase CW Flow Rate and Keep $\Delta T$

Thermal Ice Storage

Specific Project Data:

- Available space in basement: 30m x 20m x 5m
Increase CW Flow Rate and Keep $\Delta T$

Thermal Ice Storage

Available space: 30m x 20m x 12m

15,000 ton hours thermal ice storage
Increase CW Flow Rate and Keep $\Delta T$

Thermal Ice Storage

Specific Project Data:

- Available space in basement: 30m x 20m x 5m
- Available ice build time: 8-12 hours
Increase CW Flow Rate and Keep $\Delta T$

Ice Build Time vs Efficiency

![Graph showing ice build time vs efficiency with lines indicating different time periods: 8 hours, 10 hours, and 12 hours. The graph plots glycol supply temperature against time in hours.](Image)
Increase CW Flow Rate and Keep $\Delta T$

15,000 ton hours in 12 hours ice build time

1,250 ton
Chiller capacity required
in night mode
Thermal Ice Storage: Principle of Operation

- **Ice Storage Tank**
- **Glycol Chiller**
- **Cooling Load**

Increase CW Flow Rate and Keep $\Delta T$
Night Time: Ice Build

Increase CW Flow Rate and Keep $\Delta T$
Increase CW Flow Rate and Keep $\Delta T$

Night Time: Ice Build

- Ice Storage Tank
- Glycol Chiller
- Cooling Load
Increase CW Flow Rate and Keep $\Delta T$

Day Time: Discharge

- Ice Storage Tank
- Glycol Chiller
- Cooling Load
Increase CW Flow Rate and Keep $\Delta T$

Day Time: Discharge

Ice Storage Tank ➔ Glycol Chiller ➔ Cooling Load

Increase CW Flow Rate and Keep $\Delta T$
Increase CW Flow Rate and Keep $\Delta T$

Ice Storage in Parallel with Existing Chillers

- Ice Storage Tank
- Glycol Chiller
- Heat Exchanger
- Cooling Load
- Existing Chiller(s)
Increase and Maximize DCP Capacity

Case 2

- Plant Designed for 12,500 ton
- Currently Installed Capacity: 10,000 ton
- Chilled Water Temperature: 39.5°F - 55°F

Increase $\Delta T$ and Keep the CW Flow Rate
Increase $\Delta T$ and Keep the CW Flow Rate

Conventional Solution

- Add Extra Chiller(s): 2,500 ton
- Maximum Plant Capacity: 12,500 ton (10,000 + 2,500)
- Further Increase Limited by Flow Rate:
  - Piping
  - Pumps
Increase $\Delta T$ and Keep the CW Flow Rate

 Thermal Ice Storage

- Select extra chiller(s) to operate with glycol
- Maximum possible capacity of chiller(s):
  - 2,500 ton in day mode ($39.5^\circ$F LWT)
  - $\Rightarrow$ Night mode: 1,600 ton ($24^\circ$F LBT)
Increase $\Delta T$ and Keep the CW Flow Rate

<table>
<thead>
<tr>
<th>Actual CW Temperature</th>
<th>Actual Capacity</th>
<th>With Thermal Ice Storage</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>CW Temperature</td>
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<tr>
<td>Return (°F)</td>
<td>Supply (°F)</td>
<td>Ton</td>
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<td>55.5</td>
<td>39.5</td>
<td>10,000</td>
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Note: Calculated with CW Flow of 15,000 GPM
**Increase ΔT and Keep the CW Flow Rate**

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Note: Calculated with CW Flow of 15,000 GPM
Increase $\Delta T$ and Keep the CW Flow Rate

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Note: Calculated with CW Flow of 15,000 GPM
Specific Project Data:

Available space in basement: 14m x 14m x 4m => 784 m³

Max. 8,000 ton hours ice thermal storage capacity
Increase $\Delta T$ and Keep the CW Flow Rate

8,000 ton hours in 10 hours ice build time

800 ton
Chiller capacity required in night mode

1,250 ton
Chiller capacity required in day mode
Increase $\Delta T$ and Keep the CW Flow Rate

Thermal Ice Storage

- Heat Exchanger
- Glycol Chiller
- Existing Chiller(s)
- Ice Storage Tank
Lower CWT results in:

- Larger $\Delta T$ Results in Higher Cooling Capacity with the same CW Flow Rate
- Lower Pumping and Piping Cost
- Minimize Size and Cost of Heat Exchanger at ETS
Conclusion Case 1

Increase CW Flow Rate and Keep $\Delta T$

15,000 ton + 3,750 ton

15,000 ton hours

$\Rightarrow$

20% more DCP capacity than original design
Conclusion Case 2

Increase $\Delta T$ and Keep the CW Flow Rate

16% more DCP capacity than original design

10,000 ton + 2,500 ton + 8,000 ton hours
Conclusion

- Increased DCP Capacity can be achieved by good engineering practises and adding thermal ice storage.

- DCP capacity increases between 15 and 20% possible in the same plant footprint.

- Similar capacity increases can’t be achieved using chilled water storage due to the much higher storage volume needed and limited chilled water temperature.
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Thermal Ice Storage

Thank You!

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EVAPCO Middle East DMCC