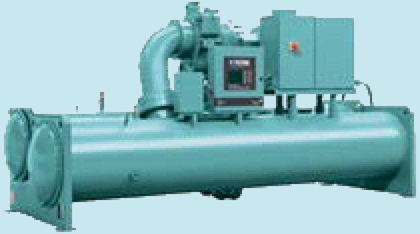
DCP Capacity Upgrade
By Adding
Thermal Ice Storage

Jelle Wagelmans

Sales Manager

EVAPCO Middle East DMCC

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

Design DCP Plant

- 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

DCP: Cooling Capacity Output

Cooling Capacity = Flow Rate x ΔT x c_{Water} (specific heat water)

How to Increase DCP Cooling Capacity?

1) **Increase Chilled Water Flow Rate and Keep ΔT**

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

2) **Increase ΔT and Keep Chilled Water Flow Rate**

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

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 ∆ T

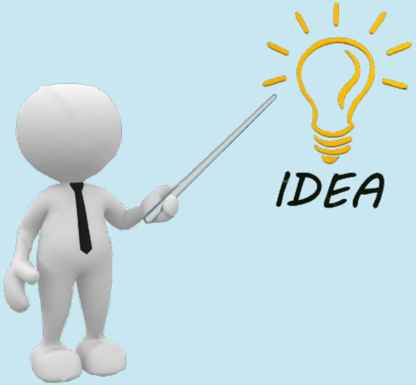
Increase CW Flow Rate and Keep ∆T

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

Increase CW Flow Rate and Keep ΔT

➔ Thermal Ice Storage



- 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 ∆T

Thermal Ice Storage

<u>Specific Project Data:</u>

- Available space in basement: 30m x 20m x 5m

Increase CW Flow Rate and Keep ΔT

Thermal Ice Storage

Available space: 30m x 20m x 12m

15,000 ton hours thermal ice storage

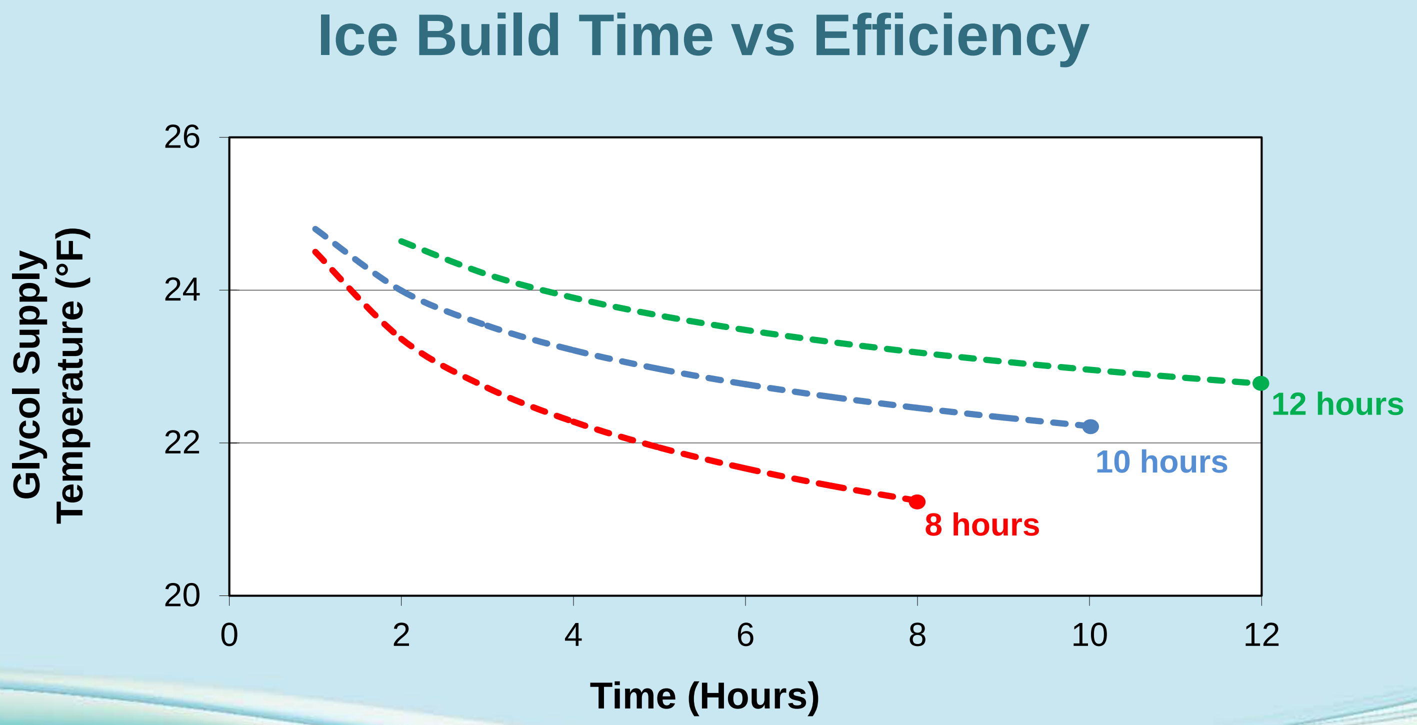
Increase CW Flow Rate and Keep ΔT

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 ΔT



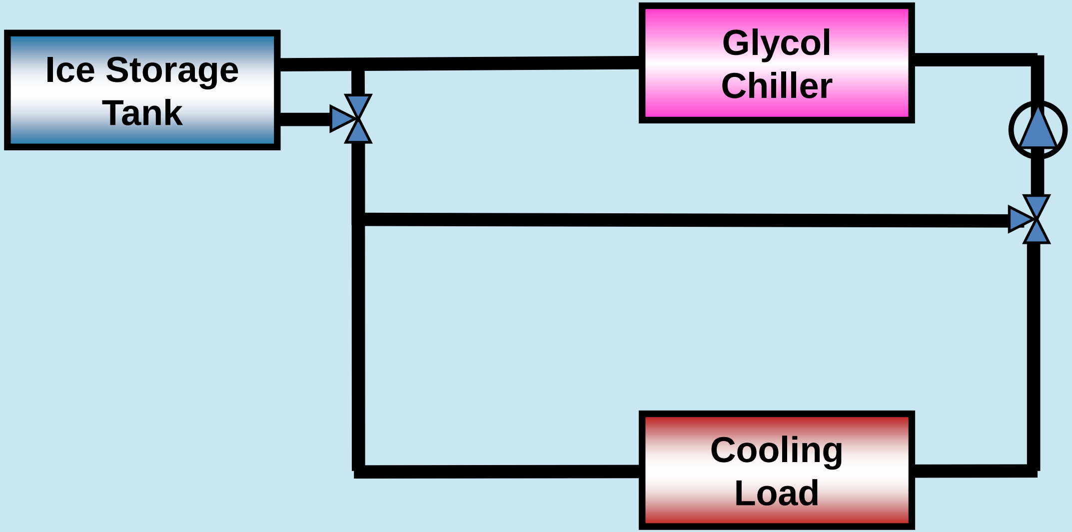
Increase CW Flow Rate and Keep ΔT

15,000 ton hours in 12 hours ice build time

1,250 ton
Chiller capacity required
in night mode

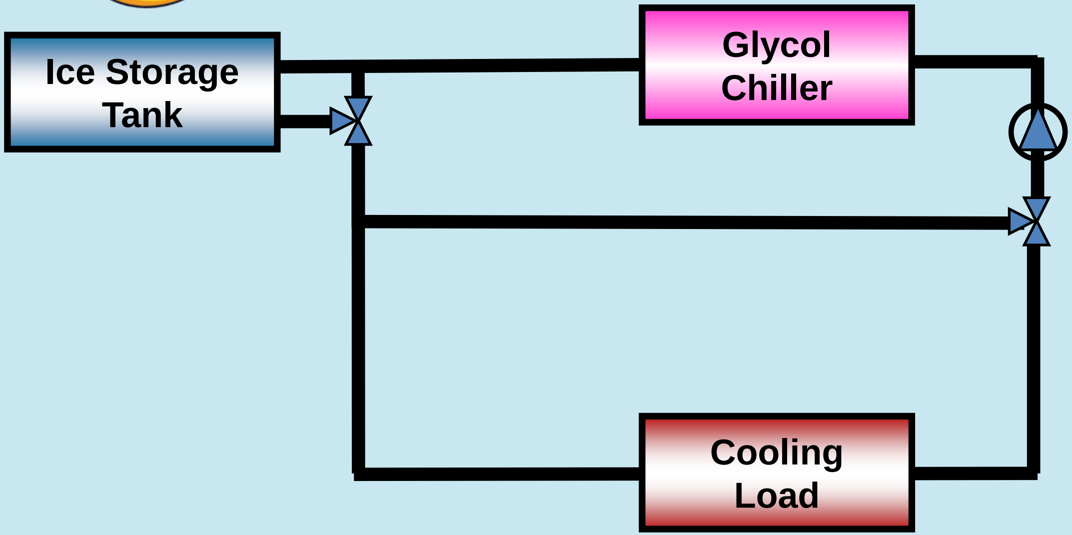
Increase CW Flow Rate and Keep ΔT

Thermal Ice Storage: Principle of Operation



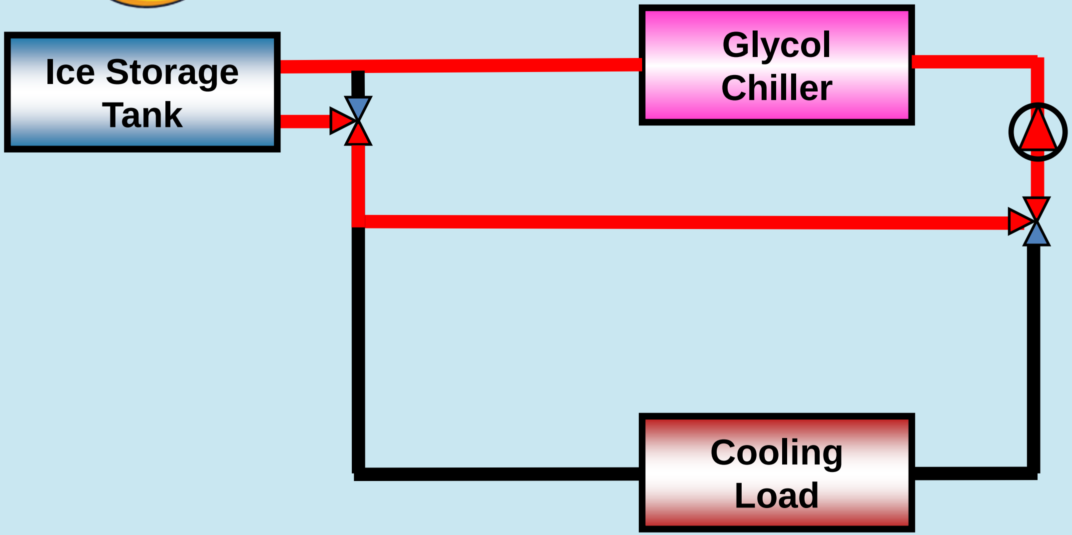
Increase CW Flow Rate and Keep ΔT

Night Time: Ice Build



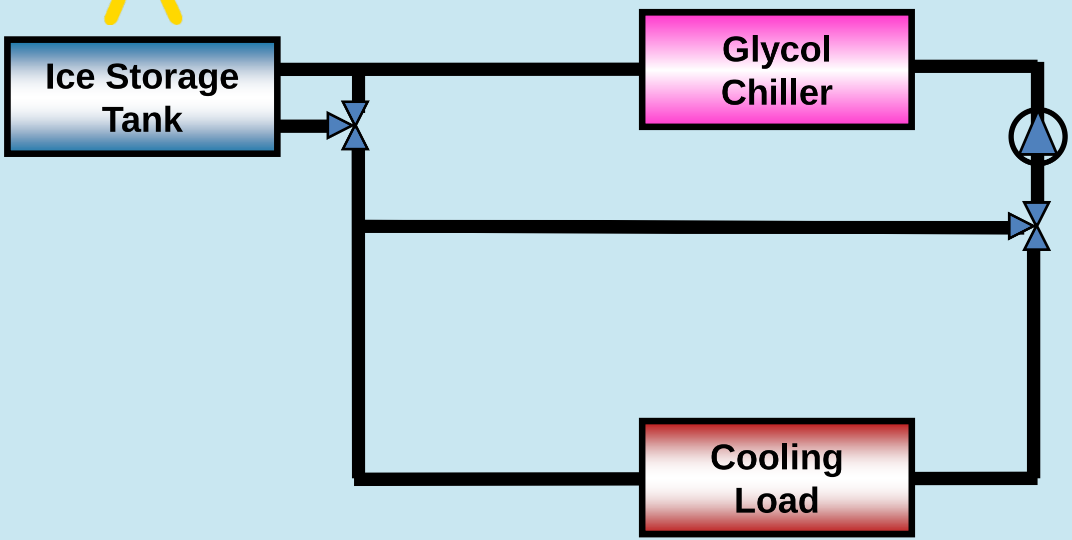
Increase CW Flow Rate and Keep ΔT

Night Time: Ice Build

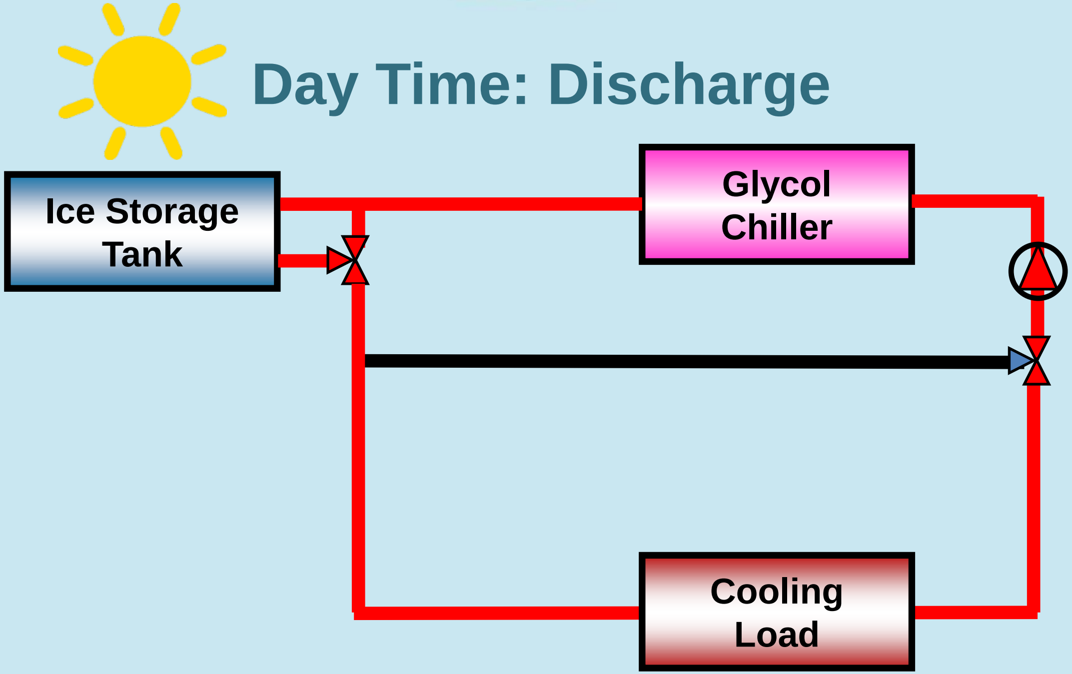


Increase CW Flow Rate and Keep ΔT

Day Time: Discharge

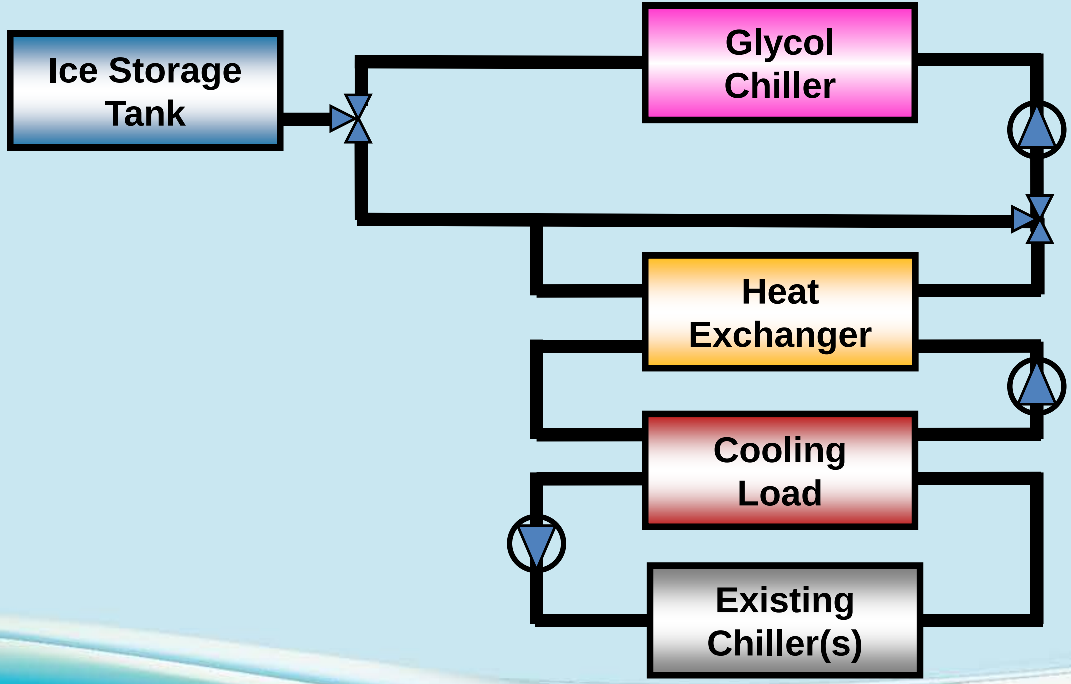


Increase CW Flow Rate and Keep ΔT



Increase CW Flow Rate and Keep ΔT

Ice Storage in Parallel with Existing Chillers



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 ΔT and Keep the CW Flow Rate

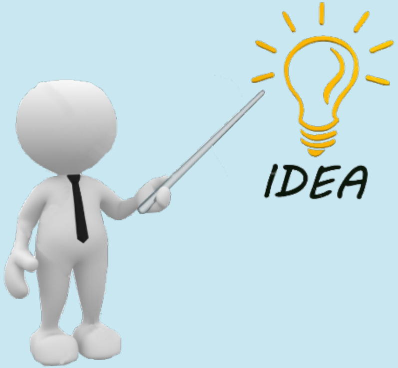
Increase ΔT and Keep the CW Flow Rate

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 ΔT 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°F LWT)
  => Night mode: 1,600 ton (24°F LBT)

Increase ΔT and Keep the CW Flow Rate

Actual CW Temperature		Actual Capacity	With Thermal Ice Storage		
			CW Temperature	Extra Cooling By Ice	Total Capacity needed for 5 hours
Return (°F)	Supply (°F)	Ton	Supply (°F)	Ton	Ton hours
55.5	39.5	10,000	38.3	742	3,710

Note: Calculated with CW Flow of 15,000 GPM

Increase ΔT and Keep the CW Flow Rate

Actual CW Temperature		Actual Capacity	With Thermal Ice Storage		
			CW Temperature	Extra Cooling By Ice	Total Capacity needed for 5 hours
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55.5	39.5	10,000	**38.3**	**742**	3,710

Note: Calculated with CW Flow of 15,000 GPM

Increase ∆T and Keep the CW Flow Rate

Actual CW Temperature		Actual Capacity	With Thermal Ice Storage		
			CW Temperature	Extra Cooling By Ice	Total Capacity needed for 5 hours
Return (°F)	Supply (°F)	Ton	Supply (°F)	Ton	Ton hours
55.5	39.5	10,000	**38.3**	**742**	3,710
55.5	39.5	10,000	**37.4**	**1,304**	6,520
55.5	39.5	10,000	**37.0**	**1,585**	7,925

Note: Calculated with CW Flow of 15,000 GPM

Increase ∆T and Keep the CW Flow Rate

Thermal Ice Storage

<u>Specific Project Data:</u>

Available space in basement: 14m x 14m x 4m => 784 m^3

↓

Max. 8,000 ton hours ice thermal storage capacity

Increase ΔT and Keep the CW Flow Rate

8,000 ton hours in 10 hours ice build time

800 ton

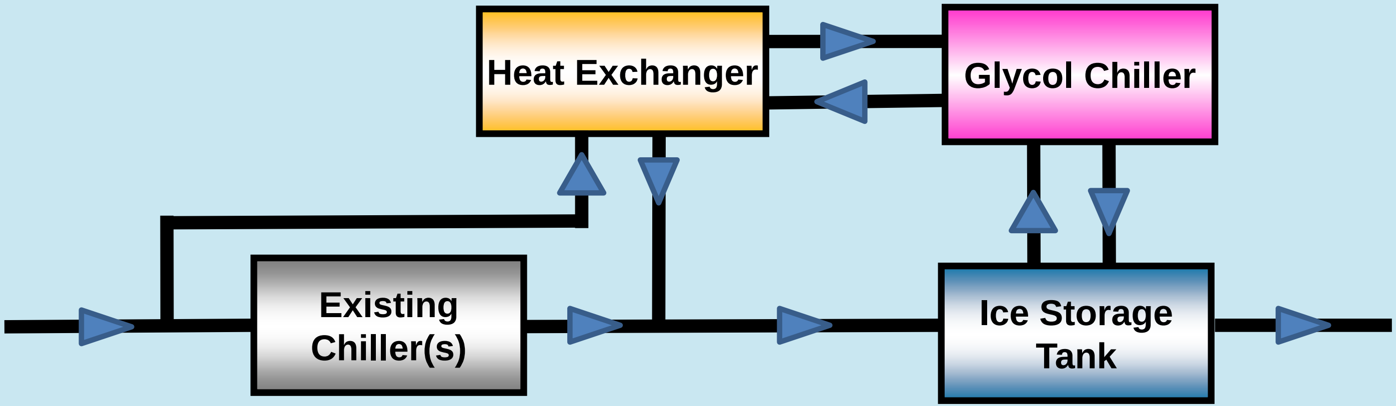
Chiller capacity required in night mode

1,250 ton

Chiller capacity required in day mode

Increase ΔT and Keep the CW Flow Rate

Thermal Ice Storage



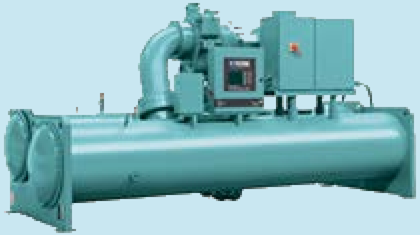
Increase ΔT and Keep the CW Flow Rate

Lower CWT results in:

- Larger ΔT 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 ΔT



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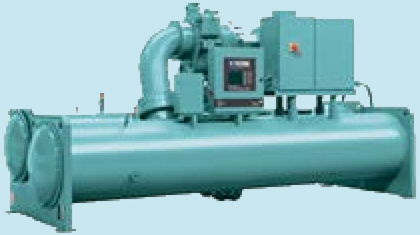
20% more DCP capacity than original design

15,000 ton
+
3,750 ton

15,000 ton hours

Conclusion Case 2

Increase ΔT and Keep the CW Flow Rate



10,000 ton
+
2,500 ton

+

8,000 ton hours

➔

16% more DCP capacity than original design

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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By Adding
Thermal Ice Storage

Thank You!

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Sales Manager

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