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Changing the Landscape of Ice Thermal Systems' Implementation & Optimization

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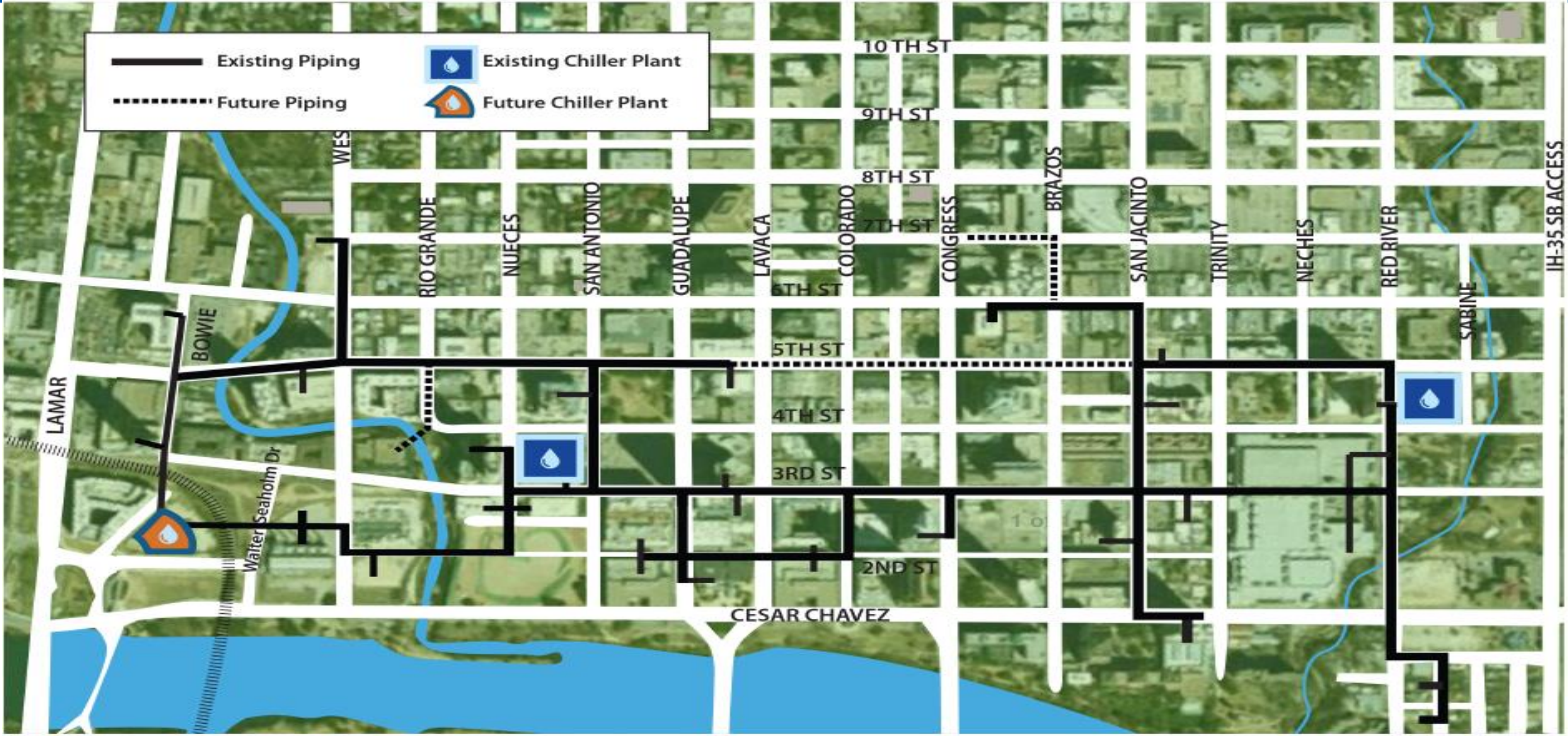
DCP1

DCP 2

Downtown District Cooling Loop



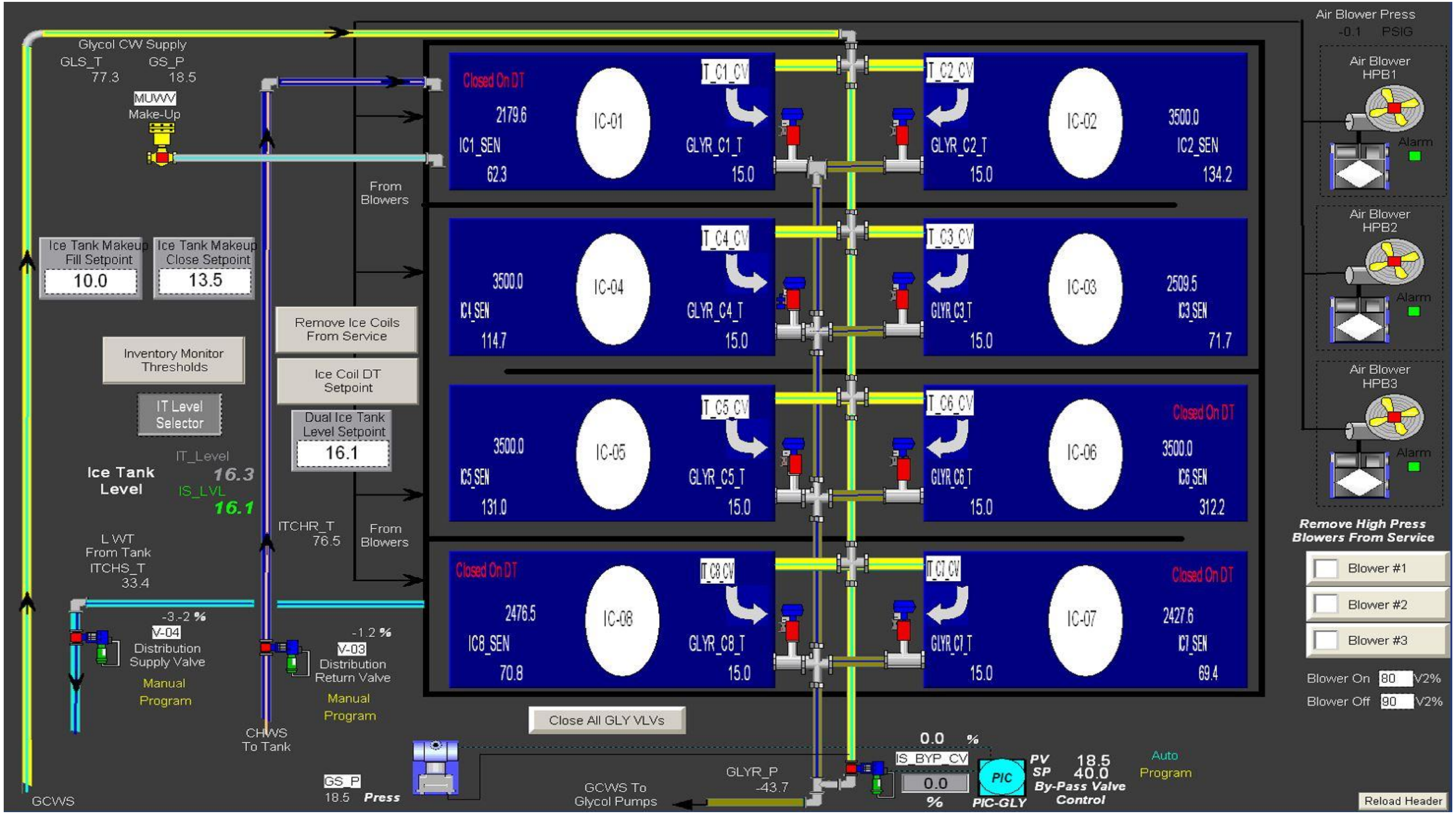
Ice Thermal Plant Operating Challenges

- Operating 2 Ice Tanks Simultaneously
- Maximizing Ice Tank Tonnage Throughput
- Optimizing the Ice Build Process
- Reducing Overall Pumping Costs
- Cooling Tower Chemistry
- Distribution System Hydraulic Issues
- Customer Temperature Control

Dual Ice Tank Issues

- DCP1 Ice Tank is half the size of DCP2
- DCP1 Ice Tank Elevation is 2' lower than DCP2
- DCP1 has only 12" before overflow vs. 8'
- DCP1 does not have separate plant isolation valves and ice tank valves

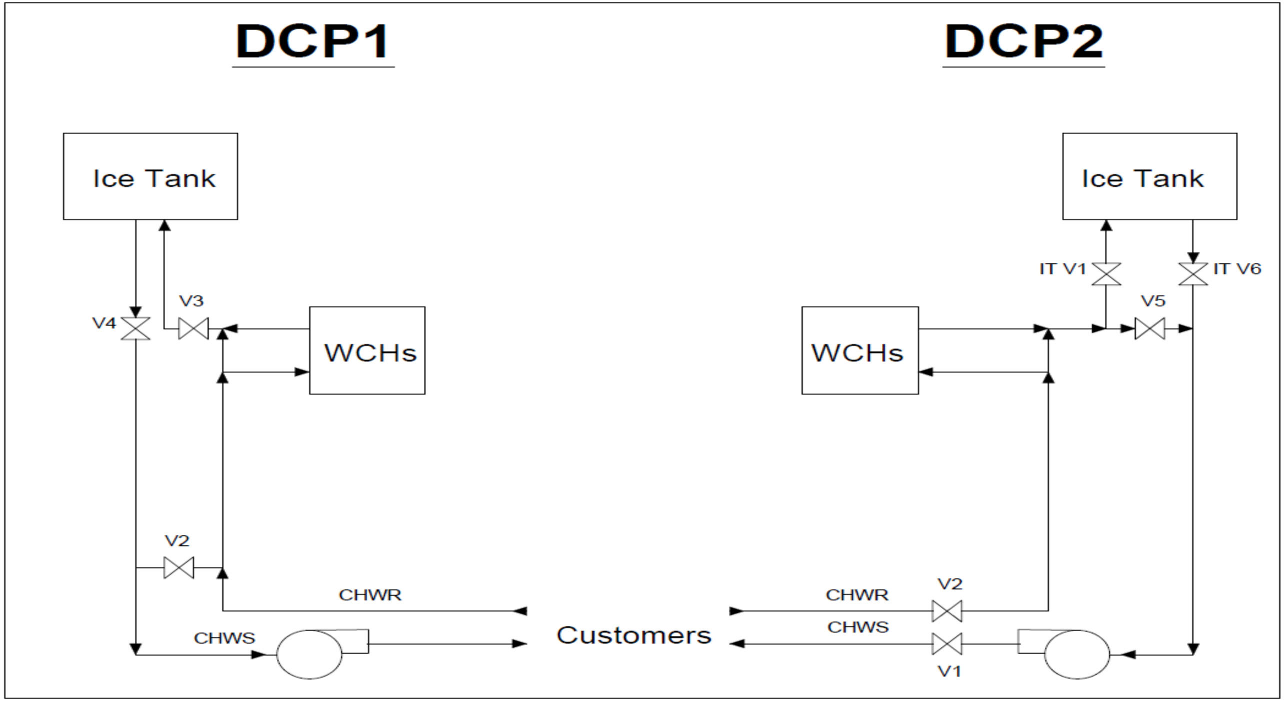
DCP1 Ice Tank



Dual Ice Tank Solutions

- Level Control Implemented at DCP1
- Determining which Valves to Use for Level Control
- Differential Pressure
  - What happens with a 50/50 DP split versus 30/70 DP split
  - How we solved the issues using different DP control setpoints at each plant

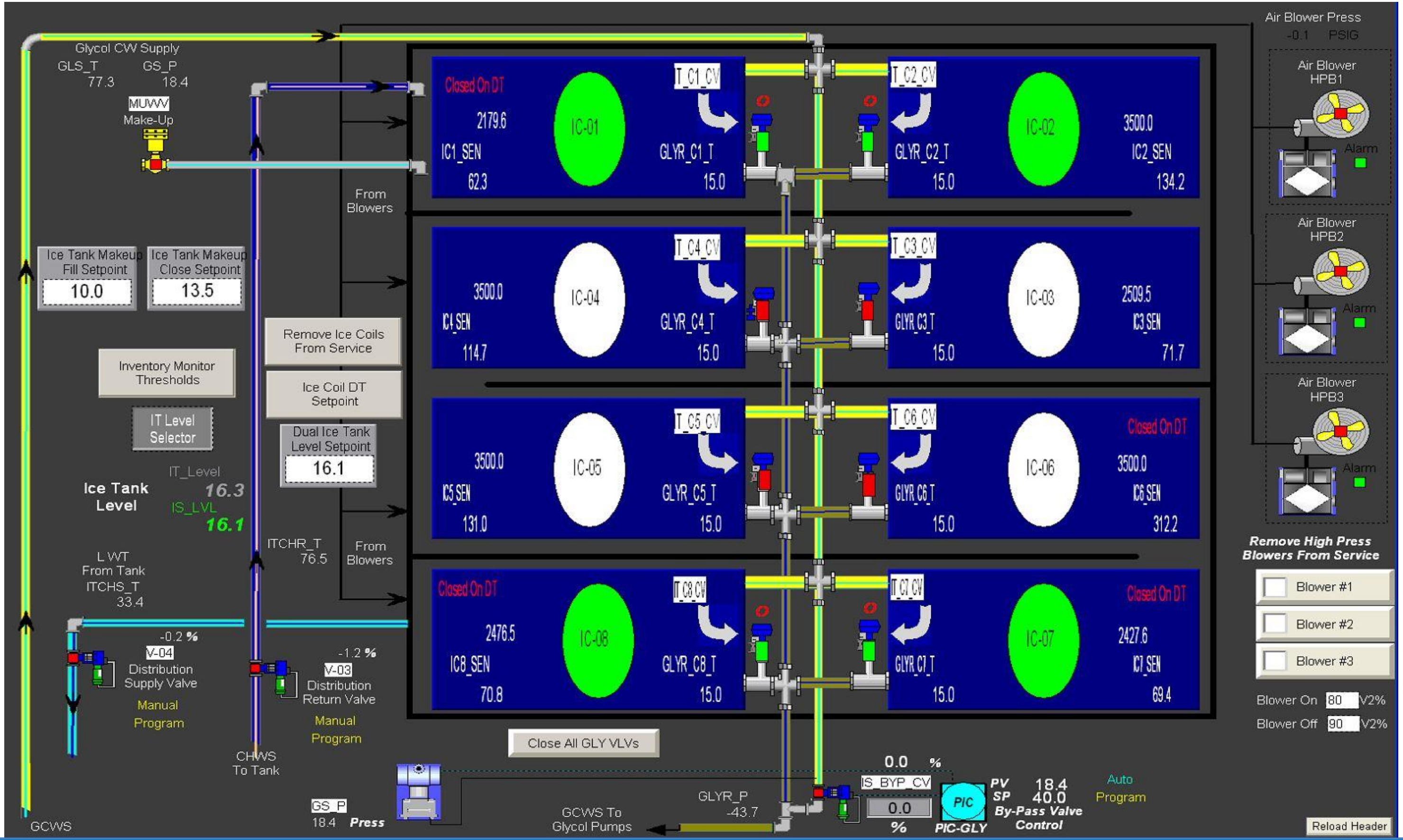
Overall Plant Layout



Maximizing Ice Tank Tonnage Throughput

- 40 Deg CHW Output Limitation
- Increased our 24,000 ton-hr tank to a 28,000 ton-hr tank
  - Added 18” to baffles so water must go thru all coils
    - The warm CHW serpentines thru all coils before discharging to distribution system
  - Implementing a Glycol Melt Out procedure when the ice tank will be completely melted
    - When the first 2 coils are melted out we start the melt out process.
    - Glycol runs through the first two and last two coils.
    - When the CHW outlet temperature reaches 36 deg. All 8 valves are opened.
    - Glycol warms up the back end coils allowing for more melting.

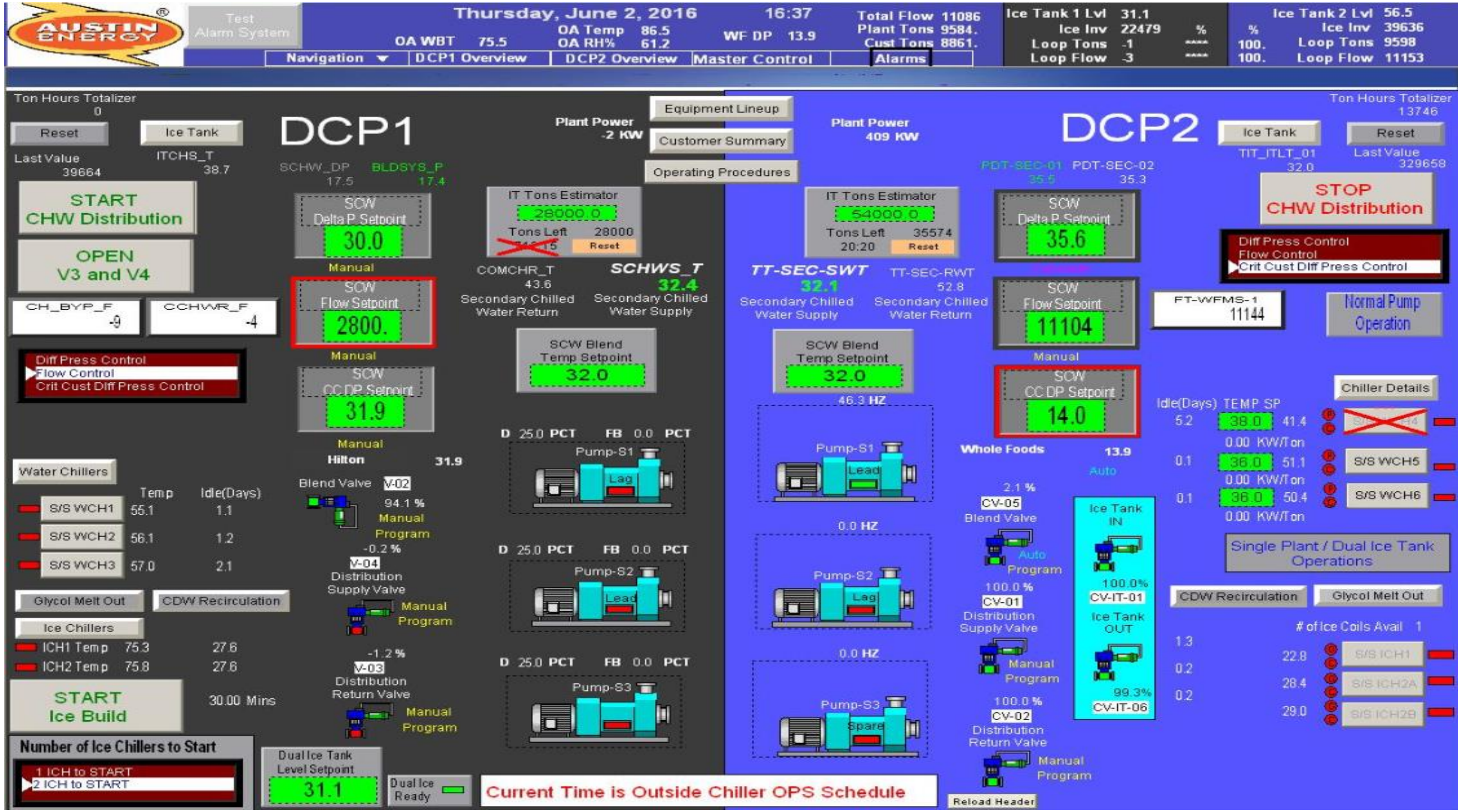
DCP1 Ice Tank Start of Glycol Meltout



Optimizing Ice Build Process

- Even temperature across Ice Tank before starting Ice Build
- Use of differential temperature to identify when coil is full of ice instead of ice thickness sensor or switch
  - We use 4 deg DT in first set of valves, 4.5 DT in mid set of valves and 5 DT in last set of valves. Less ice on coils at hard to melt coils and more ice on easy to melt coils
- Only build on coils that are greater than 60% melted
- Ice Build process fully automated.

Main Control Screen



Reducing Overall Pumping Costs

- Implementation of Critical Customer for Secondary CHW Pumps
- Condenser and Primary CHW Pumps controlled via Differential Pressure
- Dual Plant operation – using both plant to minimizes costs and maximize tonnage output

Cooling Tower Chemistry

- We currently use pure ClO_2 generated On-Demand with no storage tank of ClO_2
  - Reduced our chemical costs by at least 25%
  - Reduced our inventory of caustics from over 1500 gals to less than 700 gals
  - Reduced our biologicals from over 80,000 ppm to less than 10,000 ppm

Distribution Hydraulic Issues

- Two 50% Heat Exchangers at each customer site with approach temperatures from 2 to 7 degrees
- Pump sizing issues and pipeline sizes
  - Reduced outlet CHW temp to 36 deg
    - reduced our pump kW output
    - Increased our CHWR temperature
    - Determined that in summer, spring and fall the Chiller increase in kW due to decrease in chiller setpoint is less than the pumping power required if we maintained 38 deg setpoint.

Customer Temperature Control

- Each customer is control based on customer supply temperature ranging from 42 to 45 degrees.
- Customer controllers use a cascade control so customers do not see a change in flow when swapping from one plant to another.
- Each customer has their own PLC that controls the temperature control valve.
- All communication is relayed back to plant via fiber

Conclusions

- Increased ice tonnage out of ice tank by 10,000 ton-hrs over design
- Increased efficiency went from a total annual kw/ton from 1.0 to 0.88 kw/ton average for the entire year. This is an all in total including air conditioning, lightening etc.
- Decreased microbio by 87%

Questions?