INCREASED CAPACITY AND INCREASED SAVINGS:

How the Changing Utility Market Impacted Expansion of a 15-year-old Chiller Plant

Iowa State University

NV5

BACKGROUND

PROJECT SCOPE

- ISU campus has had cogeneration capabilities for more than 125 years and has utilized steam turbine chillers for more than 50 years
- In 2003, NV5 teamed with ISU to design and construct a satellite chiller plant that housed one 4,000-ton steam turbine chiller with provisions to install an identical chiller
- By 2016 additional chiller tonnage was required to support a fast-growing campus

BACKGROUND

CHILLER INVENTORY

- In 2016 ISU had two chiller plants:
  - Power Plant
    - Three 5,000-ton Steam Turbine Chillers
    - One 2,000-ton Electric Chiller
    - Field-erected Cooling Towers
    - No footprint for additional tonnage
    - Plant also houses
      - Two coal and three gas boilers
      - Four steam turbine generators
  - North Chiller Plant
    - One 4,000-ton Steam Turbine Chiller
    - Field-erected Cooling Tower
    - Footprint designed for an Identical Steam Turbine Chiller

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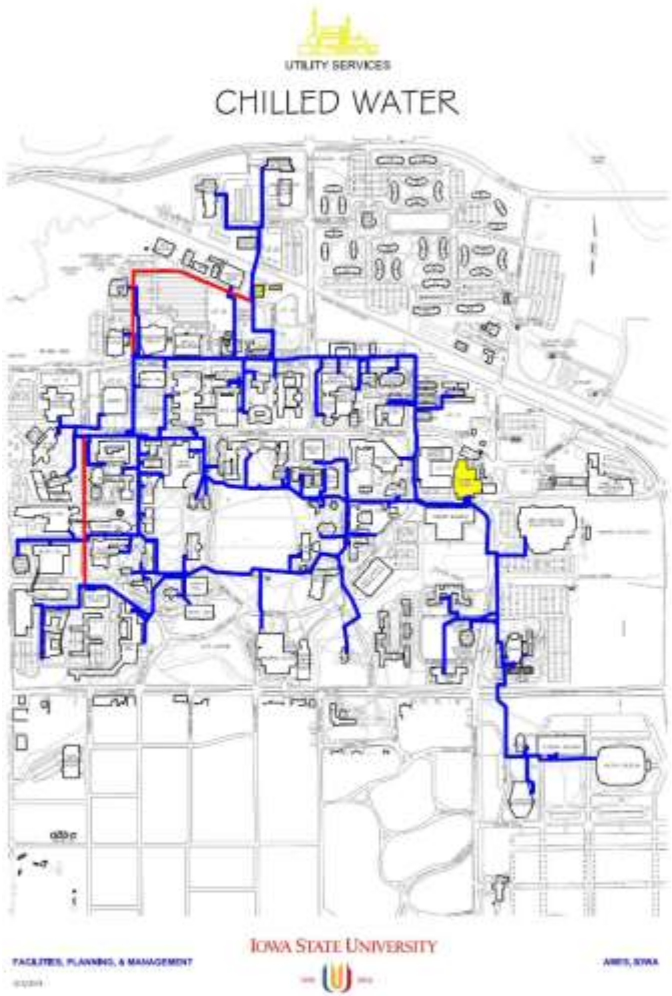
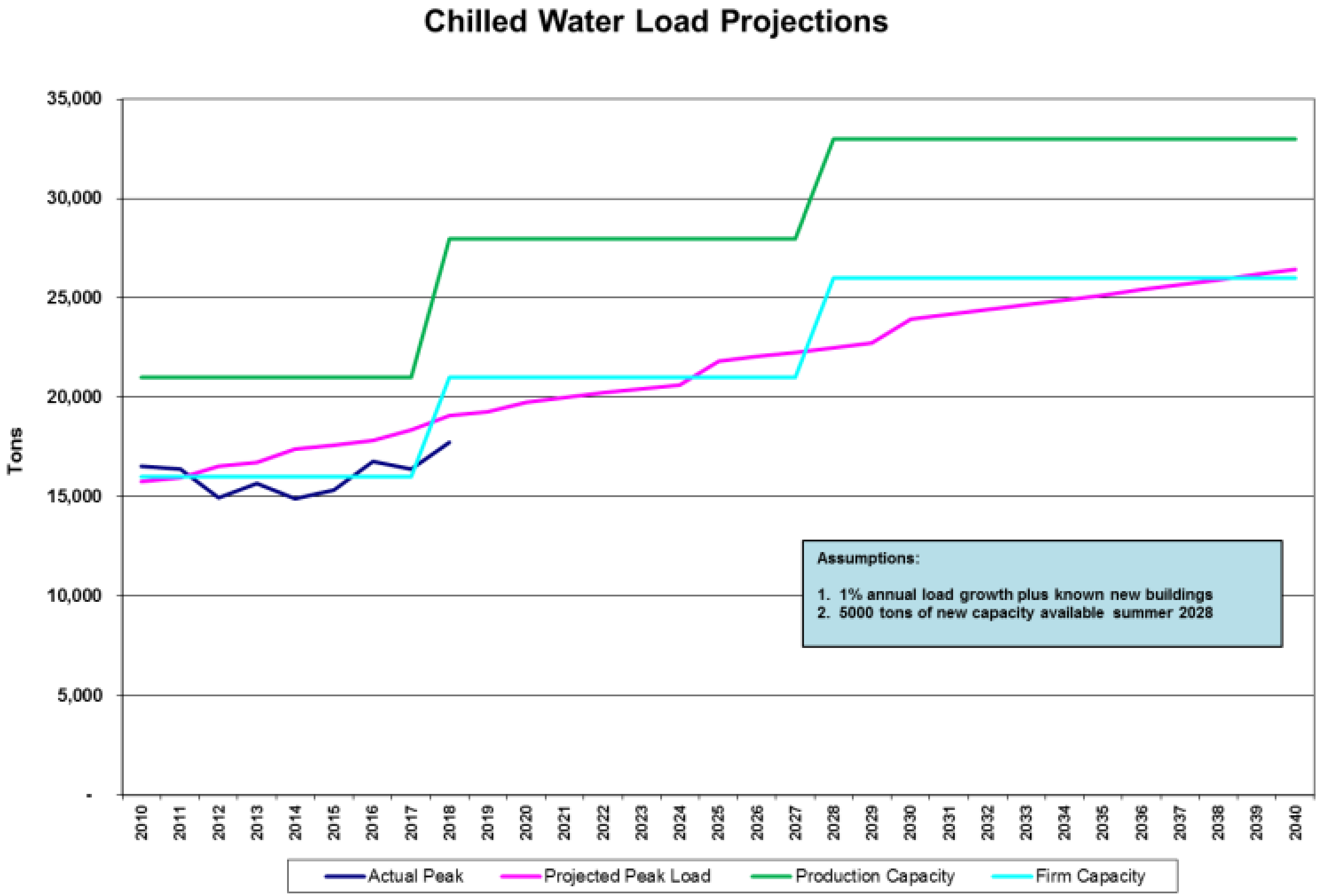
DISTRIBUTION SYSTEM

- Plants are tied together via an underground chilled water distribution system
- Serves approximately 85 buildings on campus



CAMPUS GROWTH PLAN



BACKGROUND

WHOLESALE ELECTRICITY

- ISU has been a wholesale electric customer since 1993
- Since 2005, ISU has purchased electricity from the Midcontinent Independent System Operator (MISO)
- Electricity is purchased on the MISO a day ahead or real-time market with no demand charges
  - Average power price (delivered to campus) for the past three years was $0.0164 per kilowatt-hour
  - Favorable electric rates made utilizing electric chillers for chilled water generation more economical than operating in cogeneration mode

PROJECT DISCUSSION

ORIGINAL CHILLER CAPACITY GOALS

- Add approximately 6,000 tons of electric-driven chiller capacity in North Plant
- Utilize the footprint originally allotted for 4,000 tons of steam-turbine chiller capacity
- Cover projected campus load growth through 2025

PROJECT DISCUSSION

PROJECT STUDY PHASE (FINANCIALS)

- Reviewed time-stamped campus chilled water trend data from previous three years
- NV5 found there was an opportunity to base-load electric variable speed drive (VSD) chillers year-round at an annual savings of approximately $2M versus running equivalent load from the steam-turbine chillers
- Electric VSD chillers would provide a substantial cost savings in winter months versus a constant speed electric chiller or steam turbine chiller
- Fitting additional electric chiller tonnage into the North Plant would further increase savings

PROJECT DISCUSSION

PROJECT STUDY PHASE (CHILLER CONFIGURATION OPTIONS)

- Series-Counterflow Benefits
  - Increased energy efficiency by approximately 10-12% by reducing chiller lift (approximated by difference between leaving condenser water and leaving evaporator water temperatures)
- Parallel Benefits
  - Able to take one chiller offline without taking down the other
  - Able to reduce pressure drop at instances of low delta T
- Both!

PROJECT DISCUSSION

PROJECT DESIGN

- Two variable speed chillers, totaling 7,000 tons, were specified and procured by ISU and NV5
- Chillers piped in series-counterflow and parallel arrangement
- Electric-actuated control valves included for automatic changeover
- Chillers and VSDs located on upper level chiller floor
- Pumps located on lower level
- Field-erected cooling tower cells located outside on-grade
- Integrate control of new electric chillers to the main power plant control system

DESIGN/CONSTRUCTION CHALLENGES AND RESOLUTIONS

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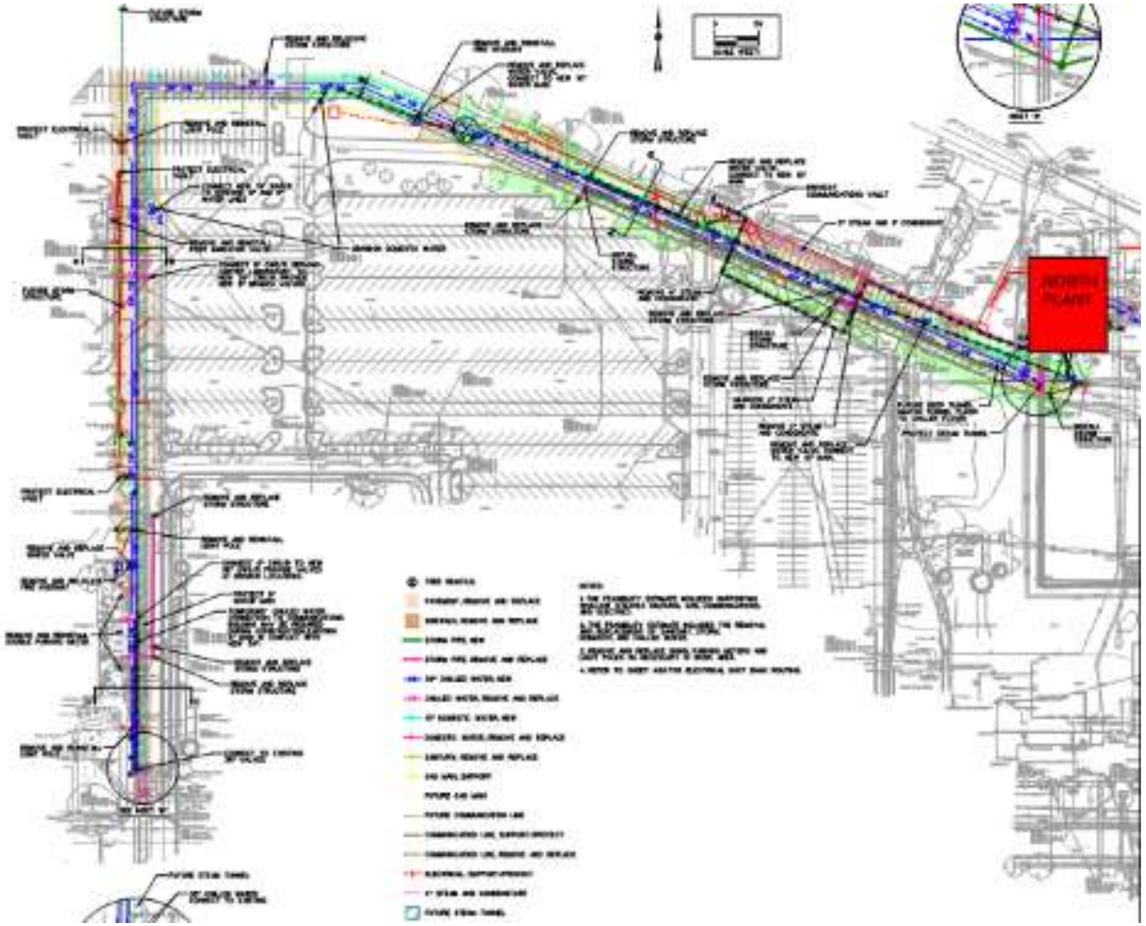
DESIGN CHALLENGES (CAMPUS CHILLED WATER LOOP)

- Completing chilled water loop through an existing campus to support additional chilled water production and distribution



DESIGN/CONSTRUCTION CHALLENGES AND RESOLUTIONS

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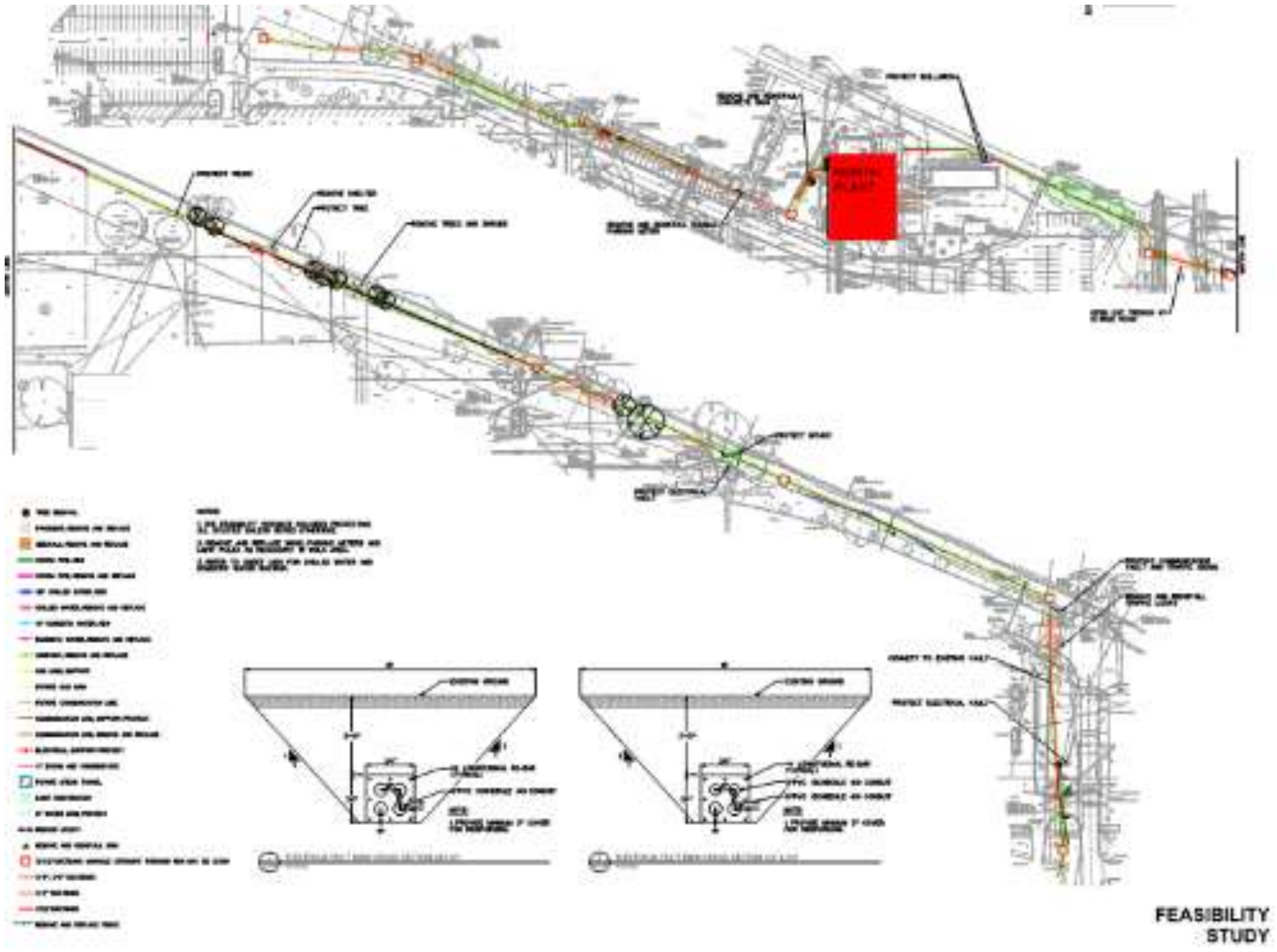
DESIGN CHALLENGES (POWER)

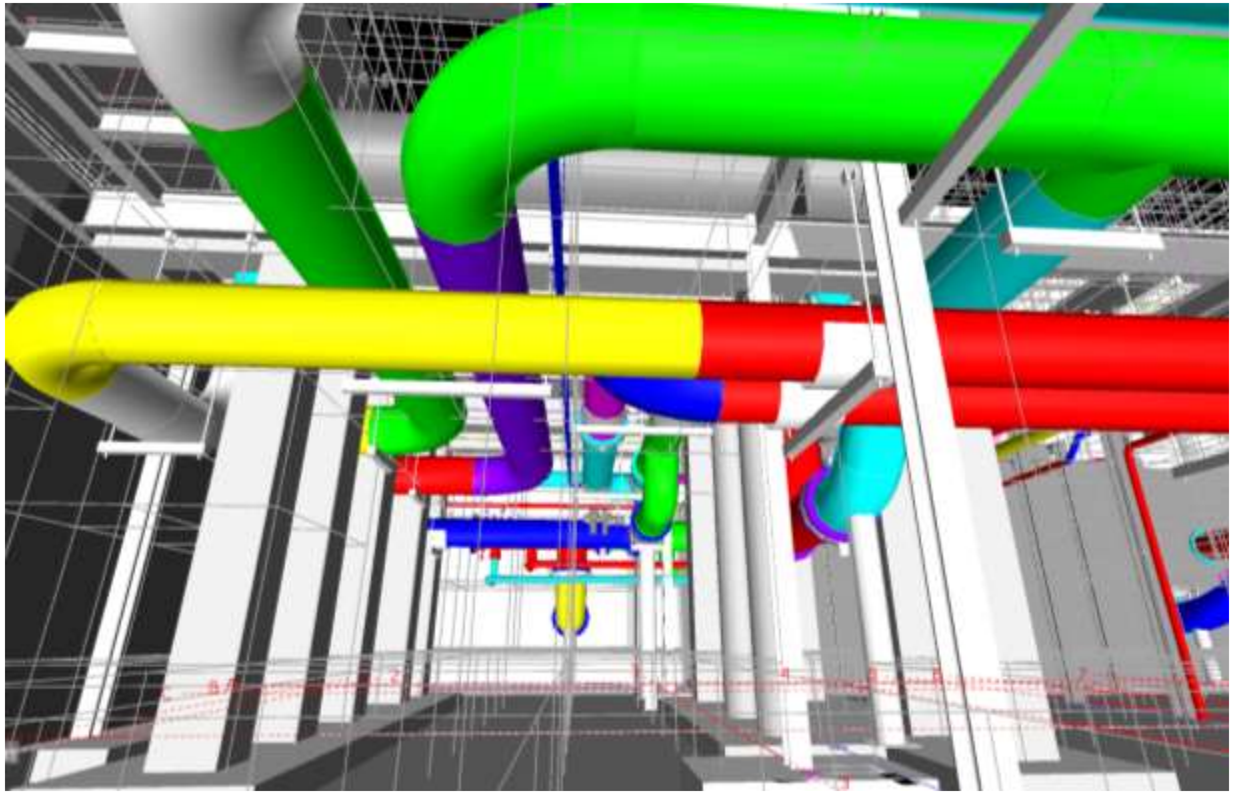
- North Plant was not set up for electric chillers so we routed a 13.8 kV power feed approximately 1/2 mile through the campus
- These two chillers were a substantial load to campus so we elected to utilize active front-end variable frequency drives to mitigate power quality issues



DESIGN/CONSTRUCTION CHALLENGES AND RESOLUTIONS

DESIGN CHALLENGES (PIPING INSIDE NORTH PLANT)

- Significant amount of piping and structural support on lower level. NV5 designed the piping layout and structural supports using 3D software to ensure avoidance of pipe clashes
- Installing contractor utilized our modeled system and conducted their own 3D laser scan. Majority of the large diameter piping was prefabricated using the 3D model and laser scan.
- Communication between NV5 and installing contractor on routing of large piping was done early in construction phase by utilizing a Navisworks 3D file.
  - Avoided large change orders
  - Avoided project delays



DESIGN/CONSTRUCTION CHALLENGES AND RESOLUTIONS

DESIGN CHALLENGES (HVAC)

- VSD cabinets
  - Installed on the main chiller floor (ventilation-only cooling) since the existing electrical room did not have space.
  - Conditioned air provided via a supply air duct routed through the floor between the two cabinets.
- Chillers
  - Original ventilation system designed for two (2) steam turbine chillers
  - Upgraded ventilation to handle increased heat generation from open-drive electric motors.

DESIGN/CONSTRUCTION CHALLENGES AND RESOLUTIONS

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DESIGN CHALLENGES (STRUCTURAL/SHORING/CHILLER INSTALLATION)

- Chiller structural platform increased in size
- Replacement of existing bridge crane
- Each chiller was shipped and rigged in three major parts
  - Evaporator Shell
  - Condenser Shell
  - Compressor and Motor
- Significant shoring required on lower level

DESIGN CHALLENGES (SHORING)

RESULTS

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RESULTS

- Chillers were brought online July 2018
- Chillers have already demonstrated substantial operational savings, utility resiliency, and operational flexibility
- Estimates from this winter are a 60% savings in energy versus using the existing 2,000-ton constant speed electric chiller
- Chiller performance rates observed down to 0.2 KW/ton

QUESTIONS?

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