Johnson Controls Central Plant Optimization™
Topics for discussion

- Why optimize central chilled water plants?
- Key components of an optimized plant
- Characteristics of efficient and inefficient plants
- Optimization in existing buildings
- Johnson Controls Central Plant Optimization™ offerings
  - CPO 10
  - CPO 30
- Sustaining plant performance
- Case studies
- Comparison & Summary
Johnson Controls Central Plant Optimization™

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Why Central Plant Optimization?
Efficiency has never been more important

- Operating budgets are under pressure
- Organizations are under pressure to reduce carbon footprint, energy use.
- Energy costs are increasing
- Demand for energy is increasing.
- Plants must be maintained to stay efficient
- Plants must be retrofitted to get more efficient.
- Johnson Controls can help
Why Central Plant Optimization?
Efficiency has never been more important

- Operating budgets are under pressure

According to the 2010 Johnson Controls / IFMA Energy Efficiency Indicator:

- 65% are paying more attention to energy efficiency now than they did 1 year ago.
- 97% rate energy cost savings as the most important factor influencing their increased attention to energy efficiency.
- 75% believe significant legislation mandating energy efficiency and/or carbon reduction is likely within the next 2 years.

- Johnson Controls can help
Chiller plants are one of the largest energy savings opportunities

Typical commercial building energy usage profile

- **Chillers**: 64%
- **Boiler Plant**: 35%
- **Airside**: 25%
- **Chiller Plant Energy Use**: 35%
- **Pumps**: 22%
- **Other**: 28%
- **Lighting**: 26%
- **HVAC**: 38%

Total Building Energy Use
Johnson Controls Central Plant Optimization™

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Design decisions represent the foundation of potential plant efficiency

- Design Decisions
- Automation of system
- Application of components
- Selection of system components
- Design of system infrastructure
To maximize efficiency, plants should be designed and operated holistically.
Operating decisions can build upon the foundation of design decisions to enhance plant efficiency.

Operating Decisions

Design Decisions

- Measurement and Management
- Maintenance
- Optimization
- Automation of system
- Application of components
- Selection of system components
- Design of system infrastructure
Johnson Controls Central Plant Optimization™
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Ultimately, plant efficiency or potential for efficiency is determined by these design and operating decisions.
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Ultimately, plant efficiency or potential for efficiency is determined by these design and operating decisions.
CPO Matrix Spreadsheet – How Optimized is your plant today?
Johnson Controls Central Plant Optimization™

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In existing buildings there are 4 ways to maximize chiller plant efficiency

1. Correct design deficiencies
2. Address deferred maintenance issues
3. Add optimization software
4. Monitor, manage and maintain

Address pre-existing conditions, **then** implement optimization
1. Correct design deficiencies

- Upgrade system configuration (constant primary only to variable primary flow)
- Upgrade older, less efficient equipment
- Add VSDs to chiller, pumps, and fans
- Add automation if plant is operated manually
- Review and improve automation sequences
2. Address deferred maintenance issues

- Correct issues caused by deferred maintenance
  - Tube fouling
  - Water treatment
  - Sensor calibration
  - Operation outside of equipment design specifications
3. Add optimization software

- Johnson Controls offers two levels of chiller plant optimization software:
  - Johnson Controls® Central Plant Optimization™ 10
    Powered by Metasys
  - Johnson Controls® Central Plant Optimization™ 30
    Powered by Optimum HVAC™
4. Monitor, manage, and maintain

- Protect your investment through persistent HVAC system optimization
- Measure, verify and manage system performance in real-time with a web-based application
- Detect, diagnose and correct system faults as they occur
- Implement a comprehensive maintenance strategy
Johnson Controls Central Plant Optimization™
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Johnson Controls Central Plant Optimization™ offerings
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- Sustaining plant performance
- Case studies
- Comparison & Summary
Using our experience as the global leader in building management systems & chiller technology, we have incorporated our best practices from world class central plants into Metasys.

### Chilled Water System

<table>
<thead>
<tr>
<th></th>
<th>Headered</th>
<th>Dedicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Primary</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Primary / Secondary</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Constant Primary</td>
<td>E</td>
<td>F</td>
</tr>
</tbody>
</table>

### Condenser Water System *

<table>
<thead>
<tr>
<th></th>
<th>Headered</th>
<th>Dedicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Flow</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Constant Flow</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

### 24 Complete Chiller Plant Systems

A1, A2, A3, A4, ...... F1, F2, F3, F4

*3 tower configurations supported: common spray w/ common sump, individual spray w/ common sump and independent spray w/ independent sump.*

Not only will Metasys 5.1 will provide optimization for 24 plant configurations (as defined with Large Tonnage Solutions), there are literally thousands of combinations.

The result: 5-15% energy savings.
Johnson Controls® Central Plant Optimization™ 10
Powered by Metasys

- 5-15% energy savings
- Cost effective optimization
- Based on proven best practices for any system type/configuration
- Algorithms are inherent in Metasys
- Uses feedback loop-based control & proportional/ integral/ derivative algorithms as well as adaptive tuning loops
- Web based user interface: Metasys Site Manager and/or Ready Access Portal
- Energy reporting: Metasys Advanced Reporting System featuring Energy Essentials
Johnson Controls® Central Plant Optimization™ 10

Installation Requirements

- Current revision level of Metasys 5.1
- Chiller plant complies with one of 24 chiller plant profiles
- System is configured on-site with no disruption to operations
- Programming and verification of operation completed in same day
- Additional time required for configuration of Energy Essentials
Any Questions?
Johnson Controls
Central Plant Optimization™ 30
Powered by OptimumHVAC™
Johnson Controls Central Plant Optimization™
Topics for discussion

- Why optimize central chilled water plants?
- Key components of an optimized plant
- Characteristics of efficient and inefficient plants
- Optimization in existing buildings

Johnson Controls Central Plant Optimization™ offerings
  - CPO 10
  - CPO 30

- Sustaining plant performance
- Case studies
- Comparison & Summary
20-60% energy savings

Based on patented Hartmann algorithms

Requires efficient plant design (all variable speed, variable-primary flow) and effective BAS

OptimumLOOP software plug-in to Metasys or 3rd party BAS

Web-based measurement, verification, and management for persistent results
The Building Automation System:
- controls the chiller and associated equipment
- receives data from the equipment

Because the BAS controls the equipment, the systems will continue to operate even if the Optimum Energy software is turned off.

OptimumMVM is a web-based measurement, verification and management service.

OptimumLOOP:
- receives data about system performance and building loads from the BAS
- calculates most energy efficient operating sequences of the entire HVAC system using patented algorithms
- feeds information back to BAS to adjust system operation
- repeats optimization process every 30 seconds

The OptimumMVM service:
- provides remote measurement, verification and management to detect, diagnose and correct system faults as they occur
- allows secure web-based access to current and historical performance information
- helps achieve consistent, persistent savings
How does the Metasys CPO30 solution save energy?

**Myth:** saving electrical power means running less equipment

**Fact:** HVAC systems operate more efficiently when optimized at the system level, running more equipment at part load

The CPO30 solution operates fans, pumps and motors at varying speeds based on power relationships and the demand placed on the system.

- Affinity Law
- Equal Marginal Performance Principle (EMPP)
- Relational Control
How does the Metasys CPO30 solution save energy?

Affinity Law impact on an all-variable speed chiller plant:

The affinity law states the energy used is proportional to the cube of the change in speed of the motor.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Required Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>90%</td>
<td>73%</td>
</tr>
<tr>
<td>80%</td>
<td>50%</td>
</tr>
<tr>
<td>70%</td>
<td>34%</td>
</tr>
<tr>
<td>60%</td>
<td>22%</td>
</tr>
<tr>
<td>50%</td>
<td>13%</td>
</tr>
<tr>
<td>40%</td>
<td>6%</td>
</tr>
</tbody>
</table>

Example: 2 pumps operating at 50% capacity use 75% less power than 1 pump operating at full capacity.
An all-variable speed plant has VSDs on every component
How does the Metasys CPO30 solution save energy?

Equal Marginal Performance Principle (EMPP) illustrates how OptimumLOOP continuously tunes the equipment to find the “sweet spot” for the plant based on the load.

✓ demand based, relational control to adjust VSDs according to load
✓ determines the most efficient place (piece of equipment) to shift/place load
✓ dynamic load placement
✓ saves on consumption, demand charges, and rachet charges

Equal Marginal Performance Principle:

“The energy performance of a system with multiple components is optimized when the change in system output per unit of energy is the same for all individual components”
Equal Marginal Performance Principle
Application to a Chilled Water Plant

Chiller plant baseline status for current load conditions
How does the Metasys CPO30 solution save energy?

<table>
<thead>
<tr>
<th>Traditional Feedback (PID) Control</th>
<th>Demand based Relational Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional temperature or pressure setpoint control</td>
<td>Control of all-variable-speed chiller water plant</td>
</tr>
<tr>
<td>Device level control based on single variable</td>
<td>System level control based on power relationships between components</td>
</tr>
<tr>
<td>0.1 to 5.0 second feedback required</td>
<td>0.5 to 5.0 second response time required. Feedback every 30 seconds to BAS</td>
</tr>
<tr>
<td>Energy optimization is external to control loop – adds complexity</td>
<td>Energy optimization is the basis for control - inherent in control method</td>
</tr>
</tbody>
</table>
Johnson Controls Central Plant Optimization™
Topics for discussion

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How does the Metasys CPO30 solution save energy?

Whole System Approach

- Before installation – Retro Commissioning of chiller plant addresses deficiencies and return to design conditions
- Detailed Engineering baseline of current chiller plant operation
- Detailed Engineering of optimized state of chiller plant operation
- After installation - OptimumMVM (Maintenance/Measurement, Verification & Management) ensures “persistence” of savings by identifying operational changes that affect performance so they can be addressed and keeps plant optimized and a high efficiency

Results: Lower HVAC CPO energy consumption by 20-60%
Both new construction & existing buildings

Step 5: Measure, Verify & Manage

- Protect your investment in optimization
- Measure, verify and manage system performance in real-time with a
- Web-based applications are ideal
- Detect, diagnose and correct system faults as they occur
- Implement a comprehensive maintenance strategy
Johnson Controls Central Plant Optimization™ 10
Metasys Ready Access Portal for mobile monitoring

- Web-based user interface for remote access via standard web browser
- Graphics compatible with mobile devices
- Enables remote monitoring and diagnostics
- Enhanced visibility of trends and reports
- Alert notification, annotation and escalation
- Summaries reflecting operation, not architecture, tailored to the user needs.
- Long-term data storage and management
Johnson Controls Central Plant Optimization™ 10
Metasys Energy Essentials for energy reporting

- 7 essential reports, including energy consumption and energy cost details
- Incorporates weather data and daily building load profiles
- Incorporates equipment runtime, plus equipment starts and stops.
- Simple and easy to configure
- Can be saved for comparisons and as templates for re-use.
OptimumLOOP: Chiller Plant Optimization

Chiller

VSDs on pumps, cooling tower fans

Sensors

OptimumMVM: Measurement and Management

Customer Service Center

Client Desktop

Customer site

Metasys or 3rd party BAS: Building Automation, Management

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Johnson Controls Central Plant Optimization™ 30
OptimumMVM software for persistent performance
Prevent system degradation with performance measurement, verification and management service

- Web-based for 24/7 access to real-time and historical performance information
- Data presented in easy-to-read graphs, charts and plant overview display
- Operators have immediate visibility to inefficient system operation.
- Analysis capabilities enable fast system fault diagnosis
- Simplified reporting with at-a-glance energy dashboard and quarterly reports
Chilled Water Plant Dashboard

- **Chiller System**: Enabled
- **Operating Efficiency**: 0.467 kW/Ton
- **Plant kW Usage**: 58.4 kW
- **Tons Supplied**: 125.0 Ton
- **kWH used Today**: 714.0 kW-hr

**Efficiency kW/Ton**

**kW/Ton Delta**

**kW Usage**

**Temperatures**

**Energy Savings**

**Building Information**
- 2 - 450 Ton Water Cooled Centrifugal Chillers
- 2 - 555 GPM CHW Pumps
- 2 - 1115 GPM CDW Pumps
- 2 - Cooling Towers, 15HP fans
- Operation: 12hrs 5-7 Day Week
- BAS Control: BACnet System
- Building Type: Commercial

**Contact: Steve Kaplan**
steve.kaplan@optimumenergyco.com

**Plant Operating Efficiency (Today) kW/Ton**

- **kWH Savings**
- **CO2 Savings**
- **Dollar Savings**

- **kWH Saved This Hour**: 76.9 kWh
- **lbs CO2 Saved This Hour**: 23.4 lbs
- **$ Saved This Hour**: $9.6

**Date Range**
- Today: 941.3
- Month: 424.6
- Year: 174.0

**Graphs**: Realtime Performance vs Est.Old Plant Performance
Metasys CPO30 Solution v. Non-optimized System
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Johnson Controls/Optimum Energy Case Study: Sotheby’s Building

**Situation**
- 470,000 sq. ft. facility in New York City
- Houses rare antiques & priceless art
- Needed a reliable, efficient chiller plant

**Solution**
- VSD retrofits on two 700-ton York centrifugal chillers, cooling tower fans, condenser water pumps and chilled water pumps.
- Implemented Central Plant Optimization.

**Result**
- Qualified for incentives: $167,000
- Est. first year savings: $201,000
- To-date improved kW/ton: 30%
- Simple payback for the entire project: 3.6 yrs
Johnson Controls/Optimum Energy Case Study: University of Texas at Austin

Situation
- District Cooling station serving 135 buildings (17 million sq ft)
- Total campus load: 145 million ton-hours / year
- Rising energy prices, increasing cooling load

Solution
- Replaced plant with a new, all-VSD plant
- Installed 3 new 5000 ton York Titan chillers
- Johnson Controls / Optimum LOOP

Result
- Plant efficiency: 0.33 to .87 kW/ton, depending on wet bulb and campus load
- Estimated first year savings: 5 million kWh
- Simple payback for LOOP install: 12 months
Johnson Controls Central Plant Optimization™

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Operating decisions can build upon the foundation of design decisions to enhance plant efficiency.

- Design Decisions:
  - Design of system infrastructure
  - Selection of system components
  - Application of components
  - Automation of system
  - Optimization
  - Measurement and Management

- Operating Decisions:
Johnson Controls Central Plant Optimization™
Summary and review

- The chiller plant is the right place to start.
- Efficient equipment and a capable BAS only gets you so far.
- A holistic, system-level approach to design and operation is required to reach a plant’s full efficiency potential.
- Visibility to system performance over time is critical to persistent results.
- We offer two powerful solutions for two different needs:
  - Johnson Controls Central Plant Optimization™ 10
  - Johnson Controls Central Plant Optimization™ 30
- Optimization is today’s opportunity and tomorrow’s mandate.
### Johnson Controls Central Plant Optimization™

Comparing CPO-10 and CPO-30

<table>
<thead>
<tr>
<th></th>
<th>Johnson Controls Central Plant Optimization™ 10 Powered by Metasys</th>
<th>Johnson Controls Central Plant Optimization™ 30 Powered by OptimumHVAC™</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Approach</strong></td>
<td>System-level optimization</td>
<td>System-level optimization</td>
</tr>
<tr>
<td><strong>User interface</strong></td>
<td>Web-based</td>
<td>Web-based</td>
</tr>
<tr>
<td><strong>Role of BAS</strong></td>
<td>Executes logic inherent in Metasys BAS programs</td>
<td>Executes logic provided through plug-in to Metasys or other BAS</td>
</tr>
<tr>
<td><strong>Basis of optimization</strong></td>
<td>Based on proven best practices and standards</td>
<td>Based on optimal power relationships among components</td>
</tr>
<tr>
<td><strong>Basis of control</strong></td>
<td>PID, feedback-based control and empirical efficiency curves</td>
<td>Relational Control calculations based on real-time building loads</td>
</tr>
<tr>
<td><strong>Adjustments</strong></td>
<td>Programmatic setpoint adjustments</td>
<td>Continuous adjustment of setpoints and flows</td>
</tr>
<tr>
<td><strong>Approximate energy savings</strong></td>
<td>5-15%</td>
<td>20-60%</td>
</tr>
<tr>
<td><strong>Plant design configuration</strong></td>
<td>Can be applied to any chiller plant design configuration with Metasys</td>
<td>Requires all-variable primary flow plant design configuration</td>
</tr>
</tbody>
</table>
Review the Building Assessment form results with Optimum Energy to evaluate the opportunity.
Building Assessment

- Optimum Energy uses the building assessment form to clarify the mutual steps a customer, Optimum Energy and Johnson Controls will take to proceed with the project.
- Optimum Energy generates ROI assessment to provide preliminary estimate of project benefits and budget.

Review the ROI estimate with Optimum Energy to evaluate the opportunity.
Johnson Controls Central Plant Optimization™ plaque
If you implement Johnson Controls CPO…

- For customers who have installed CPO 10 or CPO 30
- Centrally display in lobby or in central plant or office
- Opportunity to showcase commitment to energy efficiency
Wrap-Up

Questions, comments, final thoughts?

Thank you!