Simulation Controlled Large Scale District Energy Chilled Water System Optimization

2014 IDEA Innovation Award
**Project Title:** Simulation Controlled Large Scale District Energy Chilled Water System Optimization

**Project Owner:** Pepco Energy Services – AC Thermal

**Project Location:** Midtown Thermal Control Center (MTCC), 1825 Atlantic Avenue, Atlantic City, NJ 08401

**Project Contact:** John Rauch, 1825 Atlantic Avenue, Atlantic City, NJ 08401, 609-402-7661, jrauch@pepcoenergy.com

**Executive Summary**

The Pepco Energy Services Midtown Thermal Control Center district energy system in Atlantic City, NJ provides over 50,000,000 ton-hours of chilled water to casinos year round for comfort cooling. As gaming revenue has dropped significantly in Atlantic City it is increasingly important to be a cost-effective provider to our customers. In 2011, a commitment was made to improve the operating efficiency of the 15 year old chilled water plant to reduce operating costs for electricity, more effectively manage asset utilization and provide an increase in consistent delivery of chilled water to our customers. The chilled water plant is comprised of four (4) York 4160v YK chillers and ten (10) York 480 VSD YK chillers piped in a series counter flow configuration. The load profile of the plant is heavily skewed to maximum utilization during the peak summer months and operated based on occupancy and events the remaining nine months of the year. Unfortunately, the operating staff was directed to operate the plant to meet the customer requests “at all costs”. This led to inefficiency during the spring and autumn shoulder months and the winter season.

The innovative and unique objective of the chiller plant optimization was to install the first ever simulation and model driven controlled district energy plant using a non-propriety, open protocol and fully modeled brute force optimizer. This approach is equipment model driven and is customized to MTCC’s plant and operations. At the heart of the software is an algorithm that is computing all possible chiller, pump and cooling tower sequencing permutations, modified flows, set points and load limits. These calculations find the combination of equipment and speeds that result in the lowest kW input and/or the lowest instantaneous cost of production (driven by a cost of operation goal seek algorithm as an electric device minimal kW search). The goal is to optimize the system, not just a group of equipment. To achieve the most efficiency while minimizing first cost, variable frequency drives were installed on the 480v condenser water pumps and cooling tower fans. VFDs were not installed on any the 4160v equipment, therefore, the plant is a mixture of constant speed and variable speed equipment. Image #1 summarizes the elements of the Brute Force Optimizer.
The most impressive element is the coordination of the optimization server and the Plant Control System (PCS). Without operator interaction, the system automatically commands the equipment, and on a fifteen minute cycle adjusts the amount of equipment, the specific flows and drive set points to reach the most efficient operation as measured in kw/ton – the amount of electricity used per ton of chilled water produced. This automation allows the operators to be more available to do maintenance, shutdowns, and system analysis, and can do so without missing critical control changes.

Since going live in October 2013 the kw/ton has dropped from 0.757kw/ton to 0.528 kw. The operational benefits of the system have been a near 30% reduction in the amount of electricity used versus the base line year -2011. This equates to nearly 10,000,000kwh of electrical savings per year. At current commodity pricing, this is approximately $500,000.00 per year in utility savings. Additional benefits are the ability to set plant electric consumption criteria which are useful for demand response participation. During an ISO demand response event, the maximum electrical limit can be manually entered as a constraint and the plant will operate to the limit determined, thus allowing a controlled use of electricity when grid demand is excessively stressed. In addition to the annual electrical savings of $500,000.00, the project received a $500,000.00 rebate from the NJ Office of Clean Energy’s NJ Smart Start program. The effective payback period of the project is just under 2.0 years.
The system is flexible and easily repeatable because the logic is based on the performance equipment profiles, models and operating conditions. Due to the predictable results and ease of repeatability, Pepco Energy Services is currently capturing the data at other facilities to implement the CPECS system. The ability to replicate is low on the difficulty scale.

**Project Innovation**

The unique feature of this system is that such a large system is operated “hands-off” by the operators. All adjustments to meet changing customer loads, ambient conditions and maximum efficiency are done without operator intervention – the system runs automatically. This eliminates inconsistent energy performance based on which operator is operating the plant. The optimization answers the questions of what equipment should be operating when, what are the best set points at any given point in time for each variable and for how long each variable should be implemented. This is all implemented on a 24/7/365 basis based on the operating efficiencies, equipment/system parameters, the operational goals of the plant and production reliability. The challenges of this project are the varying loads at the customer locations and the ability to properly supply the proper flow to each location at the desired delivery temperature while still maintaining a 10F delta T on the entire 2.4 million gallon loop.

In addition, the optimization project provides enhanced visibility into operations and equipment which enables operators to foresee challenges that may impact performance or operations. The optimization project provides predictive failure analysis and dynamic performance indicators. This is continually calculated in real time, and is presented in the form of ‘Target’, predicted output, and ‘High Alarm’ performance levels for the system and per piece of equipment. These values are continually compared to the real time levels. As the real time energy performance levels exceed the target and/or high alarm values, alarms and notices are provided. This predictive tool, in conjunction with the built in trends and custom report generator, enables the operators to implement **proactive and preventative responses**, such as equipment maintenance, to issues that impact MTCC’s financial performance, plant reliability, operational goals, energy consumption and equipment lifecycle cost. Image#2 is a screen shot of the chiller operating parameters in real time via the dashboard.

**Image #2:** Chiller Operating Information  
(Real time view of compressor characteristics)
Energy Efficiency

The MTCC chiller plant optimization system was installed during the spring and summer of 2013 and was fully online in October 2013 with meaningful results. Table #1 is a graphic of the baseline energy consumption from 2011 and the 2013 electrical consumption for the period October 1, 2013 – March 28, 2014. The red line is the 2011 base line electric consumption and the green line is the electric consumption since the system came on line. The electrical savings in the first 4,136 hours of operation have been nearly 4,000,000kwh. Table #2 is a comparative table of the chiller plant kw/ton on a monthly basis from 2012 through March 2014. The kw/ton has dropped over 25% month over month since the optimization was installed.

Table #1: Baseline Performance Data: October 1, 2013 – March 28, 2014
(Total electric savings for the period 3,850,848 kwh)
Table #2: MTCC Chiller Plant kw/ton performance January 2012 - March 2014

Financial Benefits

The total project cost was $1,670,000.00. The utility rebate, which was received in full in February 2014, reduced the project cost to $1,170,000.00. The expected electrical savings of $500,000.00 per year is based on an annual electric reduction of 10,000,000 kwh at an average cost of $0.054/kwh. However, this may be exceeded in 2014 because the actual electric commodity cost in each of the months since startup has been higher than the estimate depicted in Table #3. The expected payback of the system is approximately two years. Monetary advantages also pertain to the financial health of the environment and the reduction of costs to maintain our living standards. The approximate 10,000,000kwh saved each year is the equivalent of 81,000 tons of CO₂ not emitted into the atmosphere, enough electricity to power 833 average homes per year, and the equivalent of planting 405,000 trees per year!

Table #3: Calculation Methodology of Load Weighted Commodity Pricing for MTCC
(Load weighting is used to accurately balance higher and lower usage months)
Future Applications / Projects

There were several challenges associated with the project. The first challenge was garnering buy in from senior management that an automation project could yield a 20-25% reduction in electric consumption. The savings were perceived as too good to be true and nearly six months of detailed analysis was required in order to satisfy the requests and gain funding. Since the plant was 15 years old, had several modifications and all the previous management had departed, there was a challenge validating the actual pump curves, cooling tower equipment and instrumentation quality. Each challenge was overcome and every element in the chilled water system was measured and verified.

Given the success of this installation at the largest system in our portfolio we intend to implement the optimization system at our 12,000-ton Taj Mahal chilled energy plant. Implementing this system has allowed Pepco Energy Services to offer very competitive rates in a new contract to the largest customers on the MTCC district loop.

Attachments

Photo#1: Dashboard Output of Real Time Performance
Photo#2 Detail View of Chiller Plant Including Real Time Savings & Operating Conditions;
Photo #3: View of Pepco Energy Service Midtown Chiller Plant
Photo #4: Photo of Plant Control System (PCS) – Optimization Control Cabinet
Photos #5a-5c: NJ Smart Start Letter and Check Image

Photo #1: Dashboard Output of Real Time Performance
(Yellow line is current performance – kw/ton; Red line is baseline performance; Green line is tons)
Photo #2: Detail View of Chiller Plant Including Real Time Savings & Operating Conditions
(Clicking on a chiller brings up the machine operator panel interface. Equipment in operation is highlighted in green)
Photo #3: View of Pepco Energy Service Midtown Chiller Plant
(A total of 14 chillers are in the plant – 16,200T)
Photo #4: Photo of Plant Control System (PCS) – Optimization Control Cabinet
(This cabinet communicates with the optimization server and PCS)
March 18, 2013

Commercial / Industrial Market Manager
New Jersey’s Clean Energy Program
e/o TRC Energy Services
900 Route 9 North, Suite 404
Woodbridge, NJ 07095

RF: Pepco Energy Services NJ Smart Start Application for Midtown Thermal Control Center – Atlantic City, NJ

Please find attached the completed 2013 NJ Smart Start Custom Electric Application for a chiller plant optimization project at our Midtown Thermal Control Center, MTCC, located in Atlantic City, NJ.

This project intends to save over 10,000,000 kwh of electricity per year in the generation of chilled water for our customers.

We look forward to your response and eventual meeting to discuss our application.

John Rauch
Manager, Plant Operations
jrauch@pepcoenergy.com
609 572-7105

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Photo #5a: Image of Pepco Energy Services Cover Letter of Rebate Application
(The Application for approval was submitted in March 2013)
Date: 2/7/2014

John Rauch
Pepco Energy Services, Inc.
1825 Atlantic Ave.
Atlantic City, NJ 08401

Application # 20401  Technology: Custom Electric
Project Location: 1825 Atlantic Ave Atlantic City, NJ
Account #: 123783699952
40401 Approved: 5/23/2013

Dear New Jersey SmartStart Buildings Program Participant:

Thank you for participating in the New Jersey SmartStart Buildings Program, a New Jersey Board of
Public Utilities sponsored program. Enclosed please find an incentive check for the energy efficiency
project that was recently completed at the above facility. This check covers the full incentive for this
project.

The New Jersey SmartStart Buildings Program is one of many energy efficiency and renewable energy
initiatives that make up New Jersey’s Clean Energy Program. These programs are designed to help reduce
the State’s energy usage and peak demand, and to transform the marketplace for the next generation of
energy efficiency technologies. More information about New Jersey’s Clean Energy Program can be found

Please feel free to contact TRC, the Commercial & Industrial Market Manager, at 866-433-4479 if you
have any questions regarding this check or if you are interested in additional program support.

We look forward to assisting your company with any of its future energy efficiency needs.

Very truly yours,
TRC Energy Services

Joseph Dillon
Program Coordinator

CC:

Photo #5b: Image of the NJ SmartStart Rebate Letter
(The rebate was received in February 2014. The entire was project implemented in under 12 months)
Photo #5c: Image of the NJ SmartStart Project Rebate Check