BURNS McDONNELL

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Denver International Airport Total Facility Optimization

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CAMPUSENERGY2015

AGENDA

- DIA Intro
- BMcD-DIA History
- Optimization Projects
- Results
- Conclusion

Denver International Airport

- Opened February 28, 1995
- 15th Busiest Airport in the World
- 34,000 Acres (Largest Land Area Airport in US)
- 76,000 Feet of Length on Six Runways
- >6M Square Feet of Space Under Roof
  - Terminal, 3 Concourses & Airport Office Building
- >52M Passengers per Year

Slide 3

OLA1 Add inforgraphic
Ash, Olivia L, 2/4/2015

DIA - Burns & McDonnell History

1980-1983	1989	1995-Present
City of Denver initiates site planning activities	Burns & McDonnell hired to assist in schematic design for terminal	Held various on-call contracts, numerous designs. Scopes: • MEP design throughout terminal

DIA CENTRAL UTILITY PLANT (CUP) MASTER PLAN

COMMISSIONED CUP UTILITY MASTER PLAN IN 2010

- South Terminal, Hotel and Concourse planned expansions
- Equipment performance, system demands, plant efficiency and useful life considered.

EQUIPMENT:

- 12,750 tons of mechanical cooling (5 Units)
- 6,650 tons of free cooling (3 Units)
- 8 cooling towers, 2 separate sumps
- 300,000 Btu/hr of boiler capacity

- CUP Master Plan Outcome:
  - Timeline for plant expansions
  - Site wide pumping system mods
  - Pressure independent control valves at Concourses
  - Cooling tower sump mods
  - Free cooling addition (4,150TR)
  - Plant Data Historian
  - R22 replacement master plan

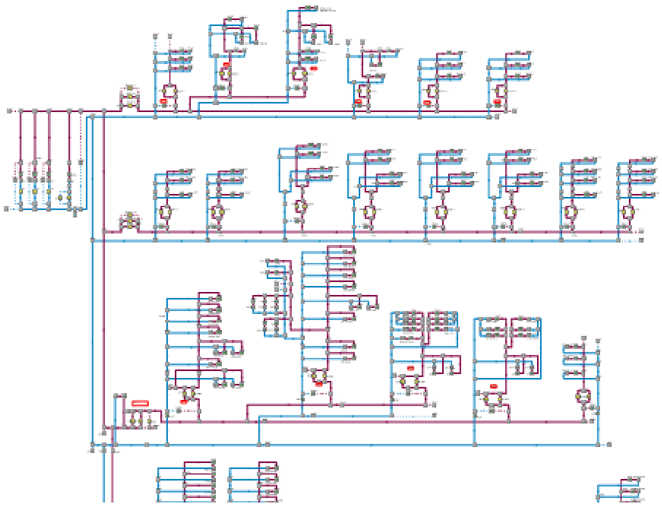
Roadmap for Future

HYDRONIC SYSTEM OPTIMIZATION

HYDRONIC SYSTEM OPTIMIZATION

PROJECT SUMMARY

- Original *BRDG-TNDR* blending system in place (HW & CHW)
- Poor delta T, three levels of pumping from CUP to users
- AFT Fathom models created



- Goals of Program:
  - Convert system to true variable primary, variable secondary
  - Eliminate tertiary loop
  - Eliminate all blending/3-way valves
  - Improve delta T at coils
  - Increase efficiency of CUP
  - Extend capacity of CUP
  - Energy efficiency gains
  - Better control and reporting at equipment level
  - Energy savings from eliminating pumps
  - Energy Rebates

HYDRONIC SYSTEM OPTIMIZATION

ENERGY IMPACT & COST SAVINGS

TERTIARY LOOP ELIMINATED:

- 168 Pumps
- >1,900 HP

PRESSURE INDEPENDENT CONTROL VALVES INSTALLED:

- >500 valves at AHUs,

DELTA T

- Energy Savings:
  - 6.8M kWh/yr
- Demand Savings:
  - 820 kW
- CO_2 Emissions
  - 15M lbs/yr
- Annual Cost Reduction:
  - >$400,000
- Xcel Energy Rebate:
  - $330,000

CONDENSER WATER SYSTEM OPTIMIZATION

CW SYSTEM OPT

PROJECT SUMMARY

- 8/10 Cooling Tower Cells Used
- One Common Sump
- Two Levels of Pumping
- Undersized HXs for Free Cooling
- Poor Maintenance Access in Sump

Goals of Program:

- Design sump separation for variety of uses:
  - Maintenance Access
  - Dual Temperature Abilities
- Free Cooling Addition (new HX)
- Variable speed pumping on CW system
- Temp CTs & piping needed during construction

CW SYSTEM OPTIMIZATION

ENERGY IMPACT & COST SAVINGS (est.)

- Sump Pit Wall Erected with Slide Gates
- CW Piping Modifications (new 48" isolation in CW header)
- 4,150 TR Heat Exchanger Installed
- BAS Sequence Updates

ENERGY SAVINGS:
- 2.4M kWh/yr

NEW AVAILABLE TON-HRS
- 5.7M Ton-Hrs

ANNUAL COST REDUCTION:
- >$140,000

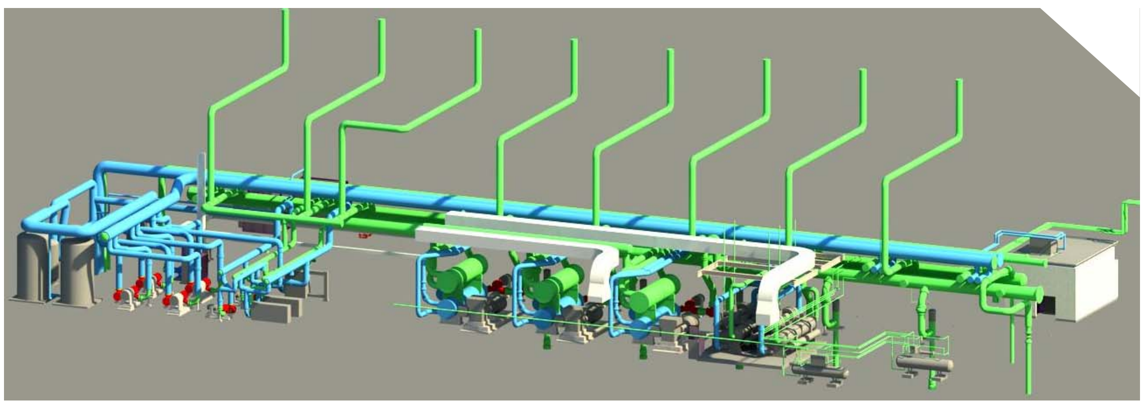
XCEL ENERGY REBATE:

CHILLER ADDITION AND DISPATCH OPTIMIZATION

CHILLER ADDITION & DISPATCH OPTIMIZATION

PROJECT SUMMARY

- Chiller #4 Failure
  - Stapleton chiller moved to DIA, chiller froze multiple times in recent years



- Goals of Program:
  - Evaluate mult. chiller configurations, quantities, sizes & dispatch models
    - Single/Dual Chiller(s)
    - Parallel/Series Setup
    - Single/Dual Compressor(s)
    - Variable/Constant Compressor
  - Evaluate variable primary CHW and CW conversions
  - Perform LCCA for each config
  - Install additional capacity in CUP
    - 2 x 2,500 TR
  - Space constraint in Chiller Room
  - Created BIM model of plant to prove fit

CHILLER ADDITION & DISPATCH OPTIMIZATION

PROJECT PHOTOS

CHILLER ADDITION & DISPATCH OPTIMIZATION

ENERGY IMPACT & COST SAVINGS

- Ultimate Design:
  - Two chiller setup, parallel configuration
  - Dual compressor machines
  - Variable speed compressors
  - 2,500 TR each
  - Variable CHW flow
  - CHW/CW pumping improvements

ENERGY SAVINGS:
- 1.5M kWh/yr

DEMAND SAVINGS
- 140kW

XCEL ENERGY REBATE:
- $150,000

DIA - Central Plant Chiller Addition

Life Cycle Economic Analysis
PROJECT NO.:67715
Rev 3-Centrifugal Water Chillers — July 2012
York-JCI Equipment — J. Foerschler

Burns & McDonnell SINCE 1898

Inputs - Implementation	Selection	Inputs - Financing	
Trane(CDHF) Dual Machine, Dual Compressor - 2500 TR	10	Financing Term (Years)	20
		Payments per Year	12
Operating Scenario	AHRI	# of Payments	240
Chiller Install Cost	$ 1,660,000	Financing Rate	5.00%
Cash Investment		Percent Project Financed	0%
Final Cost	$ 1,660,000	Total Project Amount Financed	$ -

Chiller Bid Tab Results		Inputs - Escalation & NPV Calculation	
Yearly Chiller Consumption (kWh)	5,330,369		
Yearly Pumping Consumption1 (kWh)	200,255	Utility Escalation[2]	3.0%
Yearly Chiller & Pump Operating Cost	$ 442,450	Discount Rate	4.0%
		Equipment Escalation	3.5%
Life Expectancy (Years)	25		

ENERGY PROGRAM	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Period[11]	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
ENERGY REVENUE												
TBD												
TOTAL REVENUE	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
OPERATING ACTIVITIES												
Annual O&M Costs												
Annual Energy Usage	$ (442,450)	$ (455,723)	$ (469,395)	$ (483,477)	$ (497,981)	$ (512,921)	$ (528,308)	$ (544,158)	$ (560,482)	$ (577,297)	$ (594,616)	$ (612,454)
INVESTMENT ACTIVITIES												
Chiller Plant Activities	$ (1,660,000)											
Cash Investment												
FINANCING ACTIVITIES												
Borrowed Funds[1]	$ -											
Debt Service[3]		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TOTAL EXPENSE	$ (2,102,450)	$ (455,723)	$ (469,395)	$ (483,477)	$ (497,981)	$ (512,921)	$ (528,308)	$ (544,158)	$ (560,482)	$ (577,297)	$ (594,616)	$ (612,454)

ANALYSIS												
Period[11]	0	1	2	3	4	5	6	7	8	9	10	11
ANNUAL NET CASH FLOW[12]	$ (2,102,450)	$ (455,723)	$ (469,395)	$ (483,477)	$ (497,981)	$ (512,921)	$ (528,308)	$ (544,158)	$ (560,482)	$ (577,297)	$ (594,616)	$ (612,454)
CUMMULATIVE NET CASH FLOW	$ (2,102,450)	$(2,558,173)	$(3,027,568)	$ (3,511,045)	$ (4,009,027)	$ (4,521,948)	$ (5,050,256)	$ (5,594,413)	$ (6,154,896)	$ (6,732,193)	$ (7,326,808)	$ (7,939,262)
CASH FLOW BREAKEVEN CALCULATION	-	-	-	-	-	-	-	-	-	-	-	-
CUMMULATIVE INVESTMENT NET	$ (2,102,450)	$ (2,558,173)	$ (3,027,568)	$ (3,511,045)	$ (4,009,027)	$ (4,521,948)	$ (5,050,256)	$ (5,594,413)	$ (6,154,896)	$ (6,732,193)	$ (7,326,808)	$ (7,939,262)
CUM INVEST BREAKEVEN CALCULATION	-	-	-	-	-	-	-	-	-	-	-	-

CUP CONTROLS UPGRADE & CHW OPTIMIZATION (HARTMAN LOOP)

CUP CONTROLS UPGRADE + CHW OPTIMIZATION

PROJECT SUMMARY

- Original DIA Building Automation System in Place
  - Multiple generations, terminals
- BRDG-TNDR Panel Still in Place
- Constant Speed CT Fans

Before

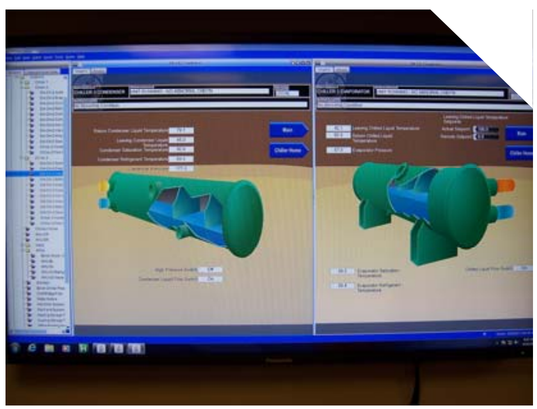
After

- Goals of Program:
  - Update BAS system
  - CHW Optimization via Hartman LOOP technology
  - Implement energy efficiency measures & advanced sequences
  - Increase level of reporting and trending for DIA personnel
  - Convert CT to variable speed
  - Motor and VFD installations

CUP CONTROLS UPGRADE + CHW OPTIMIZATION

ENERGY IMPACT & COST SAVINGS (est.)

- >10,000 Points on New BAS System
- Hartman LOOP integration
- BAS Sequence Updates
- Plant Efficiency Increase:
  - 0.921 to **0.615** kW/ton



ENERGY SAVINGS:
- 7.3M kWh/yr

DEMAND SAVINGS:
- 322 kW

CT WATER SAVINGS:
- 4M gal/yr

CO2 EMISSIONS REDUCTION:

TOTAL FACILITY OPTIMIZATION RESULTS

TOTAL FACILITY OPTIMIZATION RESULTS

DIA OPERATORS HAVE WITNESSED…

- Matched Plant & System CHW & HW flows
- Chilled Water Delta T increase from 9 to **14^{O}F**
- Hot Water Delta T increase from 40-50 to **70^{O}F**
- Ability to project tonnages with outside air, and match-load CUP chillers to achieve **best KW/ton**
- Ability to load 64MM BTU boilers up to desirable 70–90% load (most efficient)
  - *“This year alone, compared to last year, we only had to run one boiler 90% of the time between the months of December thru February vs. last year we ran both boilers 100% of the time.* ***Projected all time high gas savings this year****.”*
- Addition of VFDs to all pumps & modulating control valves on the decoupler allows up to **5,000 TR “free cooling”**
- Higher sump temperatures lead to less run time on cooling fans
  - *“In free cooling mode this year alone, we are seeing* ***record low electric usage****.”*

Conclusion

So what are we saying?

- Commit to a client, develop a relationship, get to know their facilities/systems
- Start with a Utility Master Plan, set the roadmap for future projects
- Identify all energy-efficiency & system optimization projects…even if little to no funding available!
- Work with client to execute projects one at a time, work towards the goal of completion

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