Continuous Commissioning® of the Dallas/Fort Worth International Airport

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ABSTRACT

The DFW International Airport is one of the largest and busiest airports in the world. Located in North Texas, squarely between the cities of Dallas and Fort Worth, the DFW Airport not only serves a huge population in the North Texas area for domestic flights but also is a major airport for international flights.

The Energy and Transportation Management (ETM) Department, at the Airport, is responsible for reducing energy within their facilities, and they are very aggressive in energy management. In recent years they have renovated or replaced much of the equipment in their central utilities plant and added a huge 90,000 ton-hr (316.5 MWh) chilled water thermal storage system. The electric bills, for the accounts managed by ETM, was $29 million (€20 million) in 2007. Although the ETM staff had initiated many energy efficiency measures, they felt that the energy consuming systems could be optimized to realize additional energy and cost savings. The Energy Systems Laboratory was hired to apply the Continuous Commissioning® (CC®)[1] process at the airport. Five projects have been identified to date including:

1. An energy audit and assessment of Terminal B and a lighting demonstration pilot project.
2. CC of the Consolidated Rent-A-Car Center.
3. CC of the Airport Administration Building.
4. CC of the new International Terminal D (on-going).
5. CC of the Utilities Plant, Energy Plaza (on-going).

This paper will focus on the completed projects: the Consolidated Rent-A-Car Center, the Airport Administration Building, and the major on-going projects, CC of Terminal D and Energy Plaza.

[1] Both Continuous Commissioning and CC are registered trademarks of the Energy Systems Laboratory, Texas Engineering Experiment Station, Texas A&M University System, College Station, TX. For clarity of reading, the registration marks is omitted in the later portions of the report.

INTRODUCTION

The DFW Airport, located between the cities of Dallas and Ft. Worth in North Texas, USA, is the third busiest airport in the world in aircraft movements, the seventh largest in transporting passengers, and the fourth largest in land area. It is a huge complex of terminals, restaurants, shopping facilities, parking areas, hotels, and all the services necessary to support such a facility.

The ETM Department at DFW has been very aggressive in their energy management activities. Energy Plaza (EP) which houses the central utilities plant has been recently upgraded with new equipment, including a 90,000 ton-hr (316.5 MWh) chilled water thermal storage system. The latest new terminal, the International Terminal D was built with the latest day-lighting and HVAC controls technologies. However, rising utility costs $29,000,000 (€20,000), led the ETM to seek additional opportunities for reducing energy consumption and cost. The Energy Systems Laboratory at Texas A&M University was retained to provide Continuous Commissioning services. There are five major terminals at DFW, Terminals A through E. Terminal D, which is the largest and newest Terminal with 1,600,408 ft2 (148,678m2), was selected as the first terminal to be commissioned. Energy Plaza, which provides chilled water and hot water to the terminals, is also being commissioned. Two smaller buildings, the Consolidated Rent-A-Car Center and the DFW Airport Administration Building, have already been commissioned. This paper will focus on the two completed projects and the on-going CC work at Energy Plaza and Terminal D.

CONTINUOUS COMMISSIONING® PROCESS

Continuous commissioning is the process of existing building commissioning developed by the Energy Systems Laboratory at Texas A&M University. It is a trade-marked and licensed process, currently with four licensees. The CC process not only reduces energy consumption but also improves building comfort. For the occupants, the CC process optimizes the facility's energy usage as it is currently operated and does not attempt to restore the building to the original design intent.

The first step in the CC process, or Phase I, is an assessment of the building operation using a combination of utility consumption, analyses through the building automation system, discussions with operating staff, review of design drawings and original sequence of operation, on-site measurements of key control parameters such as temperature and airflows and identification of maintenance issues. After the initial assessment and report, the client and the CC providers agree to proceed with the implementation of CC measures, or Phase II. The CC provider, in consultation with the client, will develop the detailed CC plan, schedule of implementation and identify maintenance issues that require attention prior to getting started. Then the measures identified will be implemented, training of the operators will be initiated, both during and after the CC process, and additional maintenance items will be identified. Capital energy retrofit projects will be identified and costed if the client requests it. The final phase of the CC process is reporting, documentation of CC measures implemented, measurement and verification of savings, and follow-up with any operational problems.

Continuous Commissioning® of the Consolidated Rent-A-Car Center

Building Description

The Consolidated Rent-A-Car Center was the first building selected by the Airport for the continuous commissioning process. It is a stand-alone, six-year-old, all-electric building. It contains 130,000 ft2 (12,080m2) of conditioned space and 1.8 million ft2 (167,000m2) of parking garage space. The facility has two (2) 280-ton (985kW) centrifugal chillers, and six (6) variable air volume (VAV) air handling units with 133 terminal boxes. The building is equipped with a modern direct digital controls (DDC) building automation system.

Conditions Found During Phase I Assessment

The building was well maintained by a third-party contractor, but the operation was not optimal. A thorough checkout of the HVAC and controls system uncovered numerous problems. For example:

1. There was excessive outside air being brought into the building because of air flow sensor accuracy and the algorithm controlling return air fan speed.
2. Duct static pressure setpoints were higher than required.
3. Economizer cycle was not optimal.
4. Both chillers were required in hot weather even though the original design called for only one chiller.
5. Space temperatures varied widely, 65°F to 80°F (18° to 26.7°C), resulting in some simultaneous heating and cooling.
6. There was excessive reheat by the terminal boxes, even during summer operation.

7. Some of the parking garage lights were operating continuously.

CC® Measures Implemented

The key sensors used for control, such as AHU supply air temperature, duct static pressure sensors, air flow sensors, and outside air sensors were verified for accuracy. Malfunctioning devices such as control valves and dampers were also identified. The ESL CC engineers calibrated those sensors which could be calibrated, and the operational team replaced the faulty sensors and repaired the malfunctioning devices, including the contactor for the garage parking lights.

The specific CC measures implemented included:

1. Implemented an AHU supply air temperature reset schedule, based on outside air temperature.
2. Implemented an AHU duct static pressure reset schedule.
3. Optimized economizer operation.
4. Optimized chiller start/stop control sequence.
5. Developed and implemented a chilled water loop ΔP reset schedule.
6. Modified the return air fan control sequence.
7. Optimized the cooling tower condenser water temperature control.
8. Adjusted the VAV box minimum air flow settings.
9. Implemented heating and cooling deadbands
10. Implemented uniform space temperatures throughout the building

Energy Consumption Modeling and Energy Savings

A 4-P regression model was developed for the building in accordance with the IPMVP (International Performance Measurement and Verification Protocols). The baseline electrical energy consumption model is shown in Figure 1, along with four months of measured Post CC data. The “vee” shape of the baseline regression analysis is characteristic of an all-electric building, having high electricity consumption in both hot weather and cold weather.

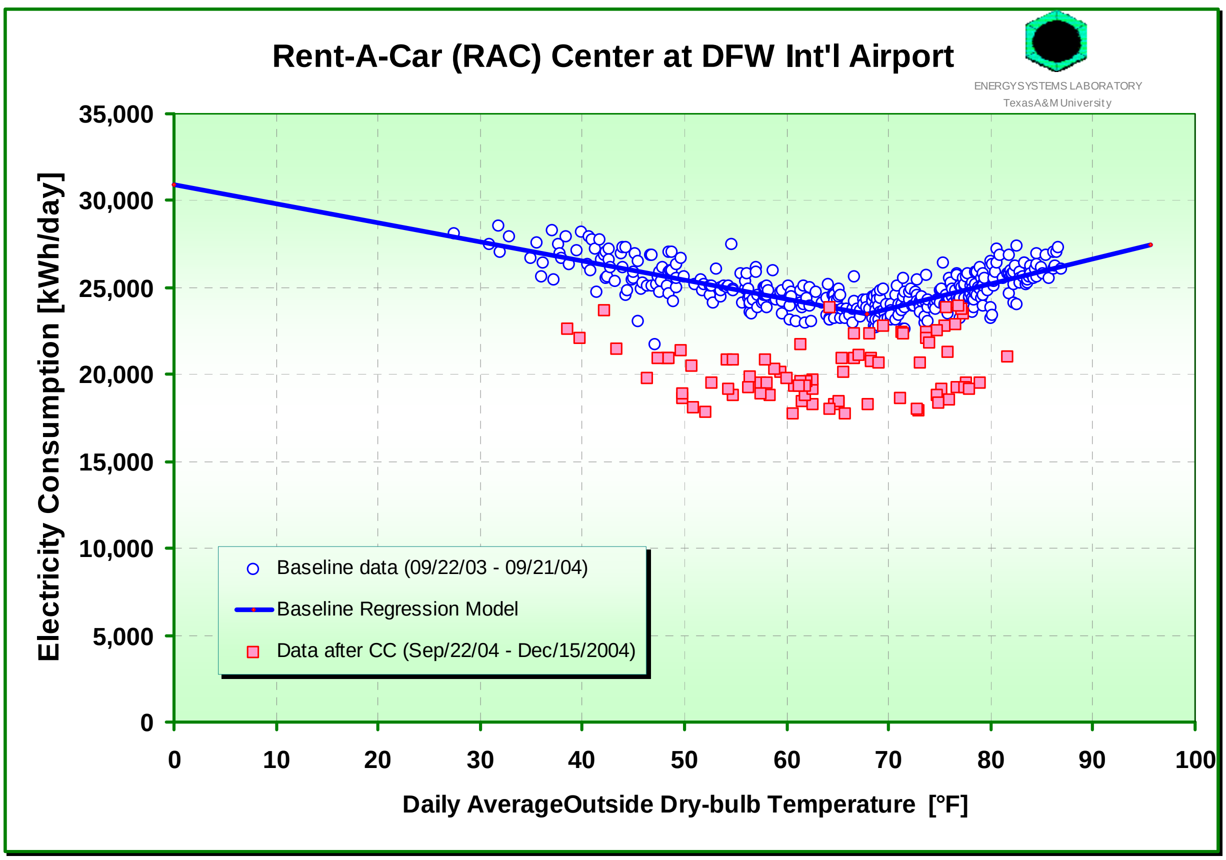

Figure 1. Rent-A-Car Center at DFW International Airport

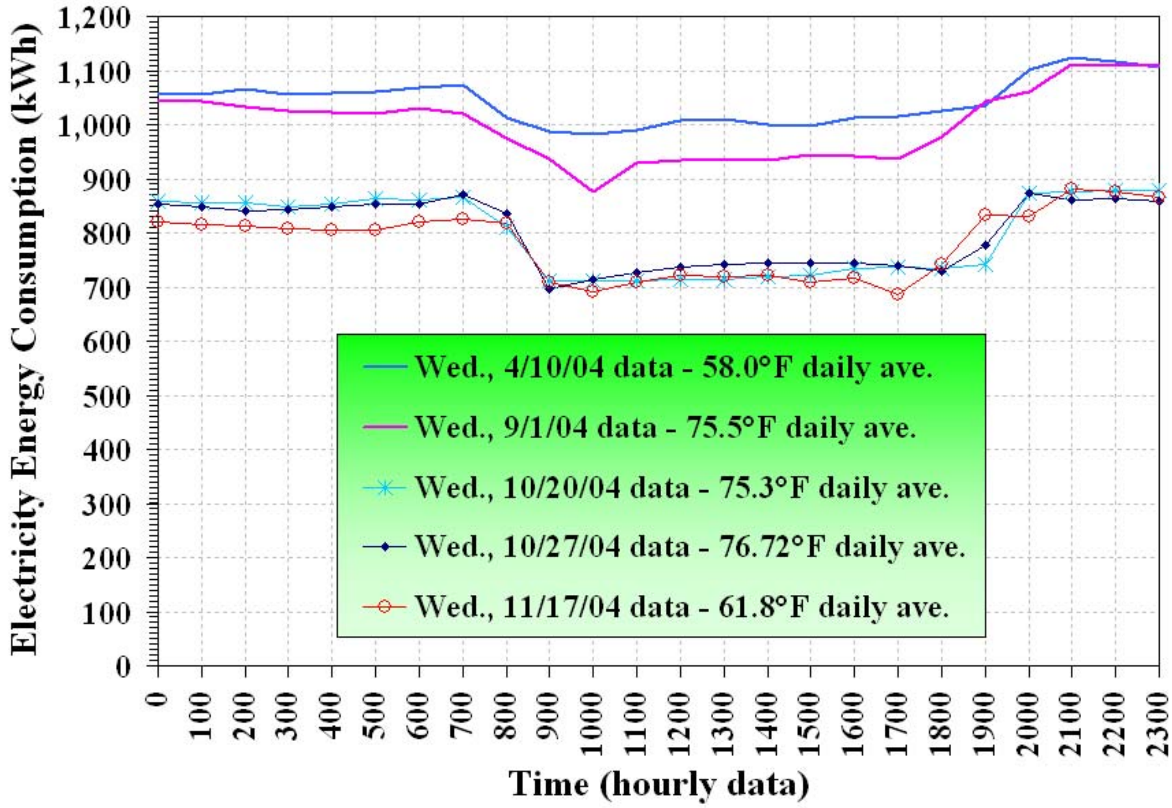

Figure 2. Consumption Comparison—Wednesday

Figure 2 is a daily profile for five different Wednesdays, two before CC and three days afterward. The profiles clearly show the drop in energy consumption after the CC measures were implemented. Again, note that the electrical profiles are not typical. The huge parking garage lighting load causes this building to "peak" at night.

The savings from the CC process are in excess of 18% of the total building energy consumption, including lighting. The dollar savings amounted to about $0.80 per ft2 or €5.50 per m2).

DFW Administration Building

The second building selected for CC is the Administration Building, which houses many of the Airport's executive offices and supporting staff. The building completed an energy retrofit in 2005, which resulted in an increase in energy costs and many comfort complaints.

Table 1and Table 2 are a history of utility bills for the building prior to the initiation of the CC process. The energy retrofit and building renovations were completed in mid 2005. Note the natural gas bills increased dramatically in June 2005 and remained very high throughout the next 20 months. In fact, the summer gas usage after the renovation generally equaled or exceeded the peak winter usage, and the winter consumption more than doubled. There was also a 20-30% increase in electricity consumption after the energy retrofit!

The electrical consumption includes lighting, plug loads, and HVAC fans and pumps. The chilled water is supplied by an external chiller plant. At the recommendation of the ESL, the whole building chilled water flow meter was calibrated to obtain accurate chilled water data in order to obtain an "energy balance" for the building.

The Phase I CC assessment was conducted in February 2007. Numerous opportunities for saving energy and improving comfort were identified. The project was paid for by energy savings; however, a major motivator in deciding to conduct CC on this building was comfort. The building was averaging 1-2 comfort complaints daily, and these needed to be resolved.

Table 1. Monthly Natural Gas Usage for the Administration Building (MCF)

Month	FY02	FY03	FY04	FY05	FY06	FY07
Oct	50.4	221.0	6.1	0.0	217.9	441.6
Nov	206.7	266.2	75.8	63.8	443.4	446.1
Dec	351.2	292.2	251.8	116.8	578.0	536.4
Jan	243.0	303.8	250.7	87.3	592.9	742.5
Feb	252.4	230.9	323.8	157.1	487.2	
Mar	171.0	142.9	207.2	135.6	440.8	
Apr	2.7	33.5	0.9	24.9	502.6	
May	3.3	23.3	7.9	56.2	416.2	
Jun	0.0	0.0	0.0	272.0	445.4	
Jul	0.0	0.0	0.0	351.9	399.3	
Aug	0.0	6.1	0.0	230.6	315	
Sep	23.4	20.8	0.0	243.0	370.3	

Table 2. Monthly Consumption for the Administration Building, kWh

Month	FY02	FY03	FY04	FY05	FY06	FY07
Oct	130,815	144,810	134,866	132,660	166,590	192,600
Nov	134,055	133,695	123,345	142,020	153,855	171,990
Dec	149,670	139,770	134,145	126,765	148,320	169,830
Jan	166,725	148,185	132,975	129,645	161325	
Feb	147,240	133,020	139,725	124,335	154440	
Mar	137,295	128,340	128,385	127,125	154170	
Apr	137,070	137,070	125,100	131,805	176715	
May	142,965	126,180	129,375	149,895	162225	
Jun	129,555	138,195	129,420	178,875	181080	
Jul	130,770	132,525	141,030	187,425	197145	
Aug	141,030	138,330	134,100	156,735	189045	
Sep	133,020	139,320	130,815	160,560	189720	

Building and HVAC Description

The Administration Building is approximately 80,000 ft2 (7435 m2). An energy renovation and retrofit to half the building updated the controls system and added new variable air volume (VAV) boxes. The other half of the building was upgraded to DDC down to the AHU level, but retained the existing dual duct AHUs and pneumatic terminal boxes. Air handling units 1, 2, and 3 provide cool and dry air to the building, while AHU 4 is a heating only unit.

Operational Issues Identified in Phase I Assessment

There were numerous operational problems identified in the assessment.

1. Air handling units
   a. Running 24/7, although building is largely a weekday operation
   b. Supply air temperatures were generally constant at 56°F (13°C)
   c. Return air fan on AHU #1 was manually turned off
   d. One AHU was in manual operation, and static pressures were high
   e. Economizer operation was not optimal.
   f. The chilled water valve on one AHU was leaking by when commanded closed.

2. Terminal Boxes
   a. No separation between heating and cooling setpoints
   b. Wrong size of VAV boxes programmed into BAS
   c. Many airflow sensor readings were fluctuating widely, causing simultaneous heating and cooling.

d. Volume dampers on some boxes could not close and led to over cooling of the spaces.

3. Heating hot water system
   a. One boiler not operational
   b. Hot water temperature of 160°F (71°C) maintained 24/7 year round
   c. A system discharge water pressure sensor instead of a ΔP sensor was used for pump speed control

CC® Measures Implemented

A number of CC measures were implemented, including:

1. Static pressure reset schedules for both occupied and unoccupied conditions
2. Lowering of maximum static pressure for all AHUs
3. Turned off AHU #4 (heating only unit) when OAT is greater than 70°F (21°C)
4. Turned off the boiler when not needed during summer.
5. Optimized the AHU supply air temperature reset schedule
6. Optimized economizer cycle to operate as an enthalpy-based, temperature bounded, vent cycle
7. Restarted AHU #1 return fan
8. Corrected control system errors for sizing of terminal boxes
9. Adjusted minimum flow rates for some terminal boxes and widened the deadband between heating and cooling for unoccupied periods
10. Reprogrammed terminal boxes so that the volume damper can close when commanded.

Baseline Model and Energy Savings

Energy consumption baselines were established for electricity, natural gas, and chilled water, as shown in Figures 3, 4, and 5 respectively. Three-parameter (3-P) regression models were fitted to the pre-CC baseline data. The open rectangles represent the energy consumption after CC. The most dramatic energy reduction has occurred in natural gas, followed closely by chilled water.

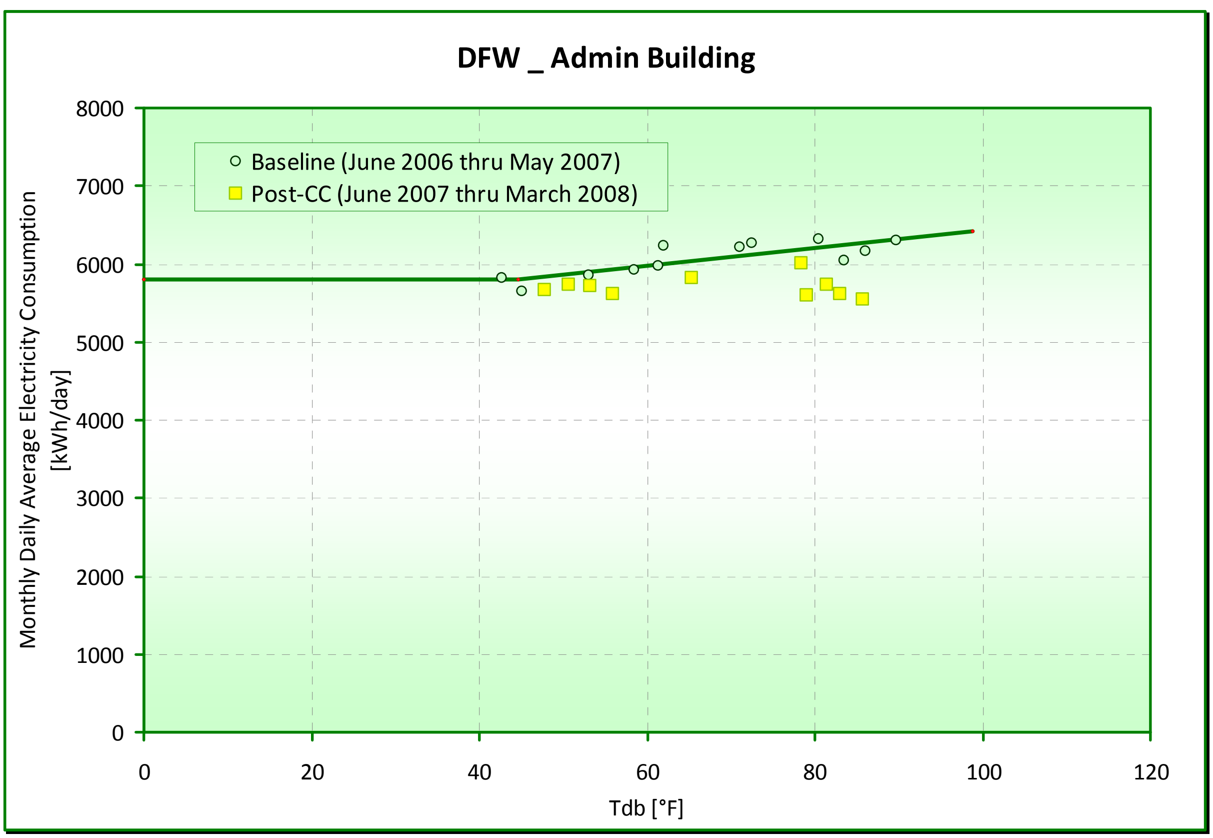

Figure 3. Compairson of baseline model and post-CC period electricity consumption

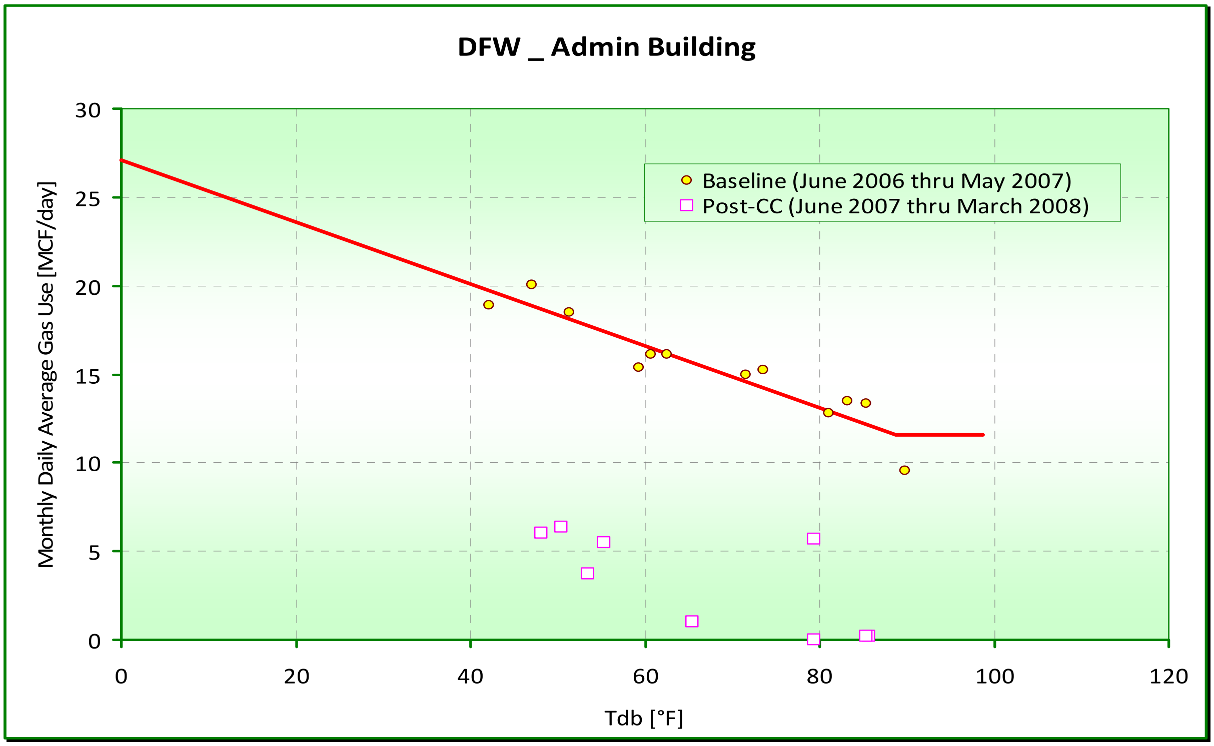

Figure 4. Comparison of baseline model and post-CC period natural gas consumption

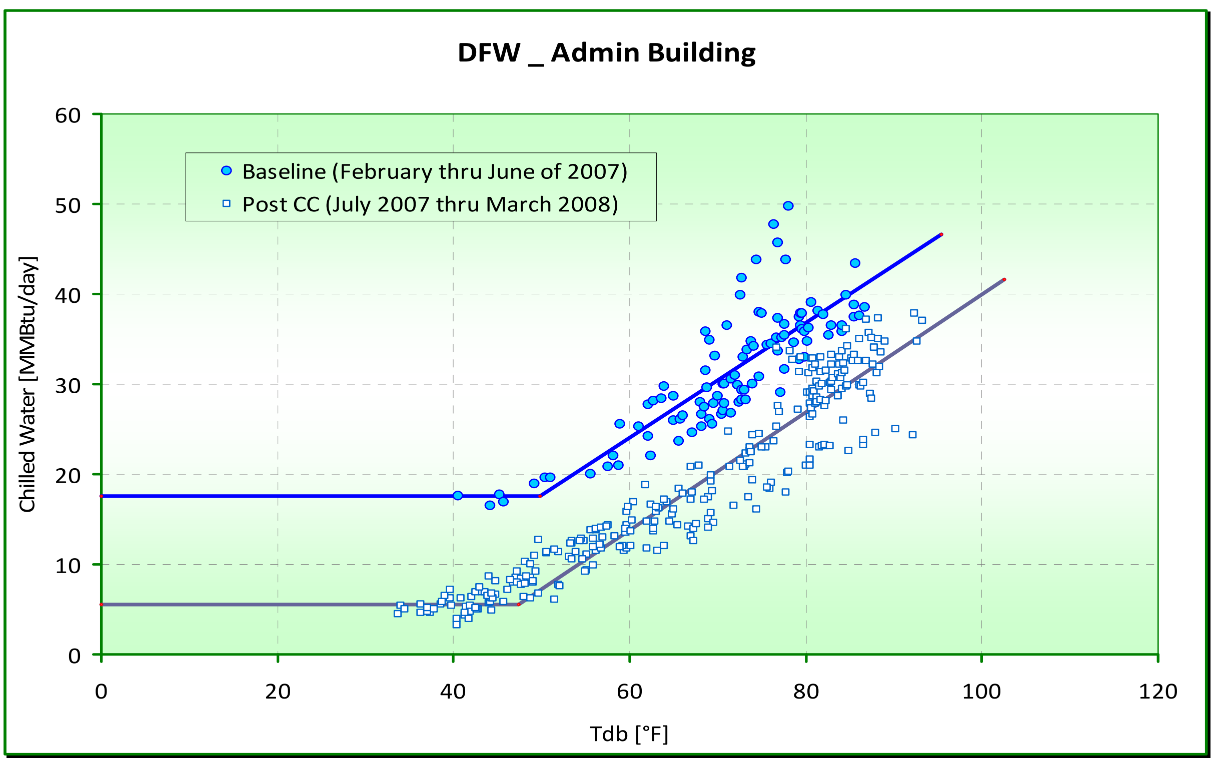

Figure 5. Comparison of baseline model and post-CC period chilled water consumption

Figure 6 is the cumulative savings from the CC work. The savings are approximately $60,000 (€40,000) for nine months. Projected 12-month savings are $80,000 (€53,000), representing a savings of approximately $1 per square foot per year (€6.2/m^2 per year). There are still some design issues with the boilers, and even more savings are expected when the boiler and hot water pump operations are also optimized.

Continuous Commissioning® of Energy Plaza and Terminal D

The CC of Energy Plaza and the DFW International Terminal, Terminal D, is on-going. Both facilities are state-of-the-art, with modern equipment, new DDC controls, and a huge, chilled water thermal storage system. The commissioning, as of this date, is about 25% completed. HHS Associates, one of the CC licensees, is assisting ESL with the commissioning of Energy Plaza and Terminal D.

Energy Plaza CC® Opportunities

The opportunities include:

1. Optimizing boiler steam pressure (already implemented a reduction in boiler steam pressure from 120-125 psig (825-860kPa) to 110 psig (755kPa). Expected savings exceed $100,000 per year (€67,000 per year).
2. Optimize thermal storage tank operation to reduce off-peak electrical demand charges. (Already implemented and expected savings are $140,000 per year or €93,000 per year).
3. Optimize cooling tower fan staging control (this fall)
4. Improve condenser water pump schedule (this fall)
5. Implement a chiller cooling water reset schedule (to be implemented this fall and winter)
6. Reduce glycol switchover times from heating and cooling (this winter)

Terminal D CC® Opportunities

1. Implement AHU occupancy schedules during lightly occupied periods (10pm – 5am)---Implemented
2. Reduce outside airflow during low occupancy periods
3. Broaden and standardize heating and cooling setpoints to eliminate simultaneous heating and cooling---Implemented
4. Reduce minimum airflows for terminal boxes
5. Optimize duct static pressure for VAV AHUs---Implemented
6. Optimize supply air temperature for all AHUs---Implemented
7. Optimize the return fan speed control
8. Reset heating hot water temperature---Implemented
9. Convert some large constant volume AHUs to VAV operation by reprogramming the control sequence and utilizing the existing VFDs on the supply and return air fans.

Expected Savings

When completed, the CC of the Energy Plaza and Terminal D are expected to save in excess of $700,000 annually (€467,000). This is in addition to the savings already achieved from the Consolidated Rent-A-Car Center and Administrative Building.

SUMMARY

The existing building commissioning program at the DFW Airport is a cooperative effort among the DFW Energy Management team, Energy Systems Laboratory, HHS and Associates (a CC licensee), and the facility operators, Meridian Management for Terminal D. It is a very successful team effort. In addition to completing the Continuous Commissioning of Terminal D and the Energy Plaza in 2008-2009, additional terminals may be added for Continuous Commissioning, as well as the office building for the Energy Plaza. Tune-ups will also be given to the Consolidated Rent-A-Car Center and the Administration Building.

The team commissioning approach is working very well at the DFW Airport, and significant energy and dollar savings are being achieved, as well as improving comfort in the buildings.

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