Turning Capital Projects Into Energy Projects

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ABSTRACT

Many commercial and institutional facilities have ongoing capital projects for replacing old equipment, ongoing maintenance, and expansion. Many of these projects are carried out with a focus on first cost, simplicity, and expediency, at the expense of energy and operational improvement. This article will describe how a typical capital project for New York Presbyterian Hospital (NYPH) was re-focused to become an energy savings project by broadening the scope beyond the mechanical room, shifting capital to energy savings measures, and taking advantage of energy incentives to offset costs. Key to the effort was the hospital's aggressive program to reduce its energy costs through conservation. These efforts have earned the hospital the Energy Star Partner of the Year award for 2004 and 2005.

The original project scope was the replacement of air conditioning units with higher tonnage units, duct cleaning, and other maintenance efforts. An "energy focused" analysis of the building, including an energy model for the occupied space, recommended high efficiency, smaller air conditioners, retro-commissioning of the air distribution system, variable frequency drives on condenser water pumps, and an energy management system in lieu of duct cleaning. The recommendations added little cost to the project and identified the potential to save over 1,500,000 kWh a year in electrical energy. In addition, approximately $200,000 in incentives were identified for the project under the New York State Energy Research and Development Authority's (NYSERDA's) Commercial and Industrial Performance Program (CIPP) and Peak Load Reduction Program (PLRP).

This article will compare the project scope and cost before the analysis and after the analysis. The energy conservation measures iden-

tified for the project and the M&V strategies used to confirm the energy savings will be discussed, along with some of the pre- and post-installation data.

BUILDING DESCRIPTION

NYPH occupies six floors of an 11-story commercial office building in midtown Manhattan. The space was used as "back-office" operations for the hospital, which includes a large data center that operates 24 hours a day, seven days a week. The rest of the space operates about 14 hours a day, five days a week. Each floor had a mechanical electrical room (MER) housing two (2) 50-ton self-contained air conditioning (AC) units that were at end of life. The 11th floor MER had one (1) 40-ton AC. Although the units originally had electrical heating coils, most of the space heating came from perimeter-based steam radiators operated by the base building. The hospital's operators have no control over the operation of the perimeter heating system, and the two systems were often fighting each other. Each AC had time clocks for starting and stopping and had two-speed fans.

ORIGINAL CAPITAL PROJECT SCOPE

The original project scope involved replacing the 50-ton AC with 70-ton units. The increased size specified by the engineering firm was primarily a result of complaints from occupants. The 11th floor 40-ton unit would be replaced with another 40-ton unit. The new units would have built-in controls, economizers (per code), and variable speed drives for the fans. Static pressure sensors in the supply duct would control fan speed. The budget for the new air conditioners was approximately $1.8 million.

Also included in the original scope was duct cleaning for the supply and return ducts for $300,000 and repairing or replacing the VAV boxes with pneumatic units for about $500,000. The total budget for the project, not including miscellaneous maintenance items, was approximately $2.6 million.

As part of its aggressive energy conservation program, NYPH asked Norgen Consulting Group (NCG) to audit the space and look for energy savings opportunities that could be incorporated into the project. The audit was to include space lighting, energy modeling to confirm the air conditioning sizing, and air supply and return systems. A central focus of the audit was to keep the recommendations within the current project budget and within the project schedule.

RESULTS OF THE ENERGY AUDIT

The energy audit identified several areas where the client could re-focus the project, save energy, and reduce first cost. In addition, the audit identified areas of concern that needed to be addressed to optimize the installation of new systems.

Lighting

The audit revealed that the space had T12 fluorescent lamps with magnetic ballast. For the most part, the lighting was controlled with wall switches distributed throughout the offices. Some floors had occupancy sensors installed in individual offices. The lighting in the MERs and the data center was also T12 fixtures, typically operated 24 hours a day, 7 days a week. A typical MER lighting fixture is shown in Figure 1.

Figure 1. Typical Light Fixture

Air Conditioning Units

The air conditioning units were in various states of disrepair. Although each unit had its own time clock, most of these clocks did not work or were not programmed. To maintain cooling, most units operated with the fans set to high. During the walkthrough, the units were observed operating well beyond office hours and subsequent measurements confirmed that all but two units operated 24 hours a day, 7 seven days a week, even if cooling was not required.

Condenser Water Pumps

Each floor had a 20-hp condenser water pump that moved water to the cooling tower above the 11th floor. The 10th floor MER had a 10-hp pump for the 11th floor air conditioning unit. The audit revealed that the 20-hp sizing was based on the 2nd floor requirement. Turn-down valves were used to balance the condenser water flow with the air conditioners. A typical condenser pump installation is seen in Figure 2.

Supply and Return Air Ducts

A review of the air supply and return ducts reviewed some damage and the need for a full scale retro-commissioning. Return air flow

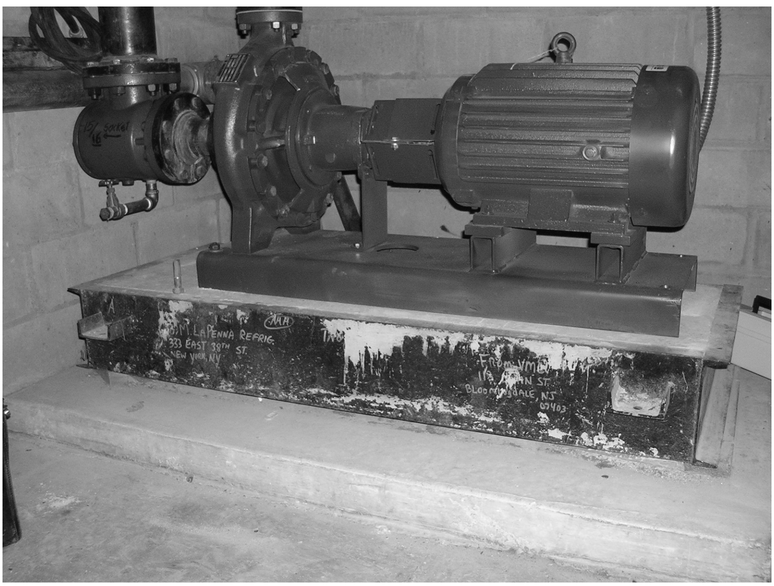

Figure 2. Typical Condenser Pump

into the MERs was restricted and resulted in significant negative pressures in most rooms. In addition, some return air dampers were not working properly and had broken linkages. Figures 3 and 4 show some of the damage identified.

Figure 3. Return Air Damper

Figure 4. Broken Supply Duct

Energy Model

To confirm the sizing of the air conditioning units, a computer model was constructed for each floor using eQuest 3.44. The model was constructed based on floor plans for the building and data collected during the audit for occupancy, hours of operation, and lighting load [1]. The graphical output for one of the middle floors is shown in Figure 5, and the results of the energy model are shown in Table 1.

The energy model suggested that the capacity of the existing ACs was more than adequate to provide cooling for the space. The peak cooling load for the 10^{th} floor, the floor with the most outside exposure,

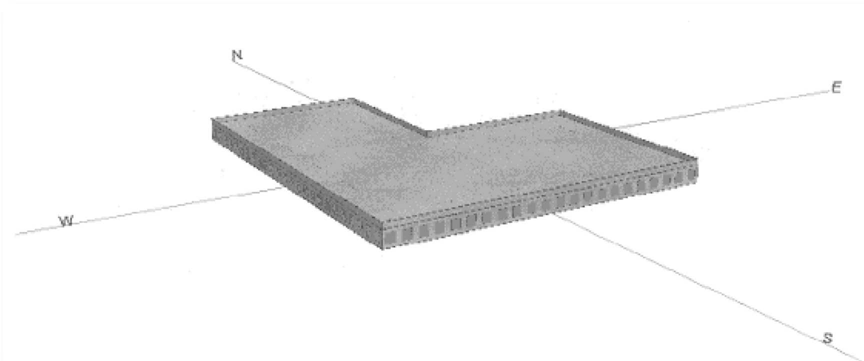

Figure 5. eQuest Model Output

Table 1. Energy Model Results

	Existing Cooling		Model Results
Floor	Unit Size (Tons)	Total Cooling (Tons)	Peak Cooling Load for Entire Floor (tons)
2	50	50	66.6
3	50	100	64.8
7	50	100	63.4
8	50	100	68.8
10	50	100	71.2
11	40	40	22.3
		490	357.1

was 71 tons out of the existing 100 tons. Installing two (2) 70-ton units per floor would have significantly exceeded the spaces' cooling requirements.

Other Observations

The space occupied by NYPH had limited HVAC control. The pneumatically controlled VAV boxes that were scheduled to be replaced had thermostats in each space to control temperatures. However, the audit identified water in the pneumatic air supply which made installing pneumatic systems subject to immediate damage.

The scope, as proposed, did not call for a centralized building management system. This meant that each air conditioner could only be operated from its on-board control system. In addition, each VAV would be controlled from its connected thermostat and the operator would not be able to control them or monitor them remotely.

ENERGY AUDIT RECOMMENDATIONS

The energy audit made the following recommendations to the scope of the project to optimize the installation, reduce costs, and increase energy savings:

- Replace all of the lighting with T8 lamps and electronic ballasts, compact fluorescent lamps, and occupancy sensors;
- Install high efficiency 50-ton units instead of 70 ton units;
- Install a BMS system in lieu of duct cleaning;
- Install variable frequency drives on the condenser water pumps instead of using the turn down valves;
- Complete a full scale retro-commissioning of the supply and return air ducts prior to installing the new systems;
- Install digitally controlled VAV boxes instead of pneumatically controlled boxes;
- Tie VAV boxes and air conditioning units to the BMS;
- Set up energy savings routines like night set-back, smart start/stop, and economizer cycles.

A summary of the recommended energy savings measures for the project are shown in Table 2.

Table 2. Recommendations

ECM	First Cost	First Cost with Incentive	Annual Energy Cost Savings	Simple Payback	IRR
Lighting	$ 158,400	$ 120,000	$ 50,345	2.4	35%
BMS	$ 287,220	$ 185,000	$ 148,200	1.2	50%
VFD	$ 69,000	$ 64,000	$ 8,000	8.0	4%
Recommended ECM	$ 514,620	$ 369,000	$ 206,545	1.8	

The recommended measures were estimated to save approximately 1.5 million kWh a year and over $200,000 in energy costs. In addition, these measures would qualify for energy incentives from NYSERDA in excess of $200,000.

CONCLUSION AND RESULTS

NYPH proceeded with the installation of the 50-ton units, the BMS, the digitally controlled VAV boxes, and the VFD on the condenser pumps.

By installing the BMS in lieu of duct cleaning, the client was able to reduce its operating costs by nearly $150,000 and provide the operator a way to operate and monitor the systems from one location. A large part of the energy savings resulted from controlling and monitoring the AC units remotely, instead of relying on local controls. Figure 6 shows the operating profile of the 3rd floor AC unit before the installation of the BMS, where the unit ran most of the time (irrespective of occupancy or need). This operating profile was typical for most of the units in the space. Figure 7 shows the operating profile of the new 3rd floor unit after installation of the BMS, and shows that the unit only operates weekdays during typical office hours.

The BMS allows the space operator to monitor space temperatures throughout the six floors and set high-low temperature limits. Trend reporting allows the operator to monitor ongoing problem areas for further analysis. The BMS installation was cheaper than the proposed duct cleaning. A regression analysis is being used to confirm the savings from the BMS. This analysis takes the total calculated savings for the space from the utility bills and subtracts measured savings for the ACs and the pump VFDs.

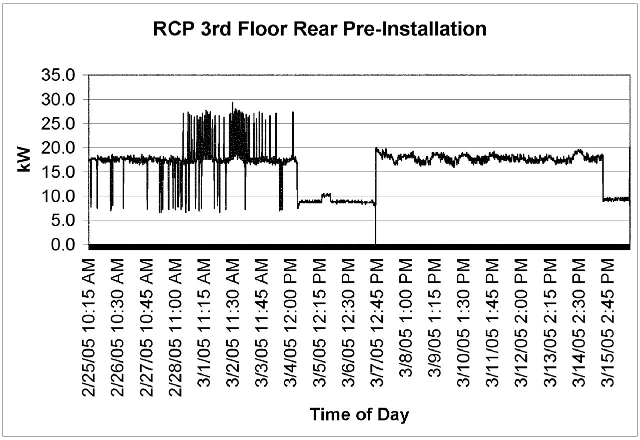

Figure 6. Baseline Operating Profile for AC

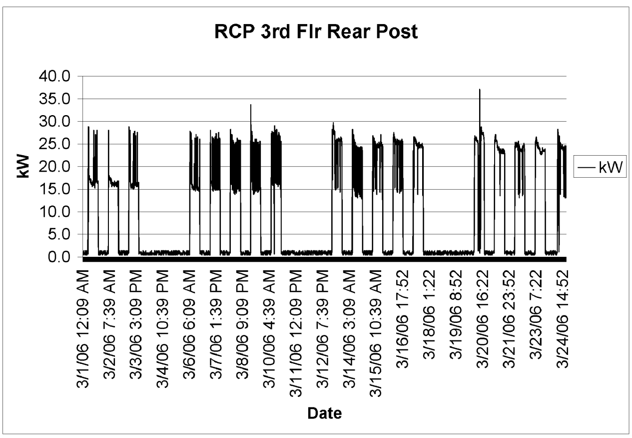

Figure 7. Post-installation Operating Profile

The energy model helped confirm that the air conditioning unit sizing was appropriate. This recommendation reduced the first cost for the project by $120,000. Because they are properly sized, the units provide better humidity control, better air balance, and lower operating costs. HOBO data loggers were installed on each unit to calculate energy usage. This usage is subtracted from the regression analysis results to establish the BMS impacts. The AC consumption is also used to calculate the savings of the new units over the previous AC.

As stated earlier, the VFDs on the pump motors were used to balance the flow through the AC. Measurements of the kW demand with and without the VFD established the energy savings. The hours of operation come from the data loggers since the condenser pumps operate when one or more of the ACs run. This consumption is also subtracted from the regression analysis results to establish BMS savings.

Subsequent measurement and verification activities demonstrate that the VFDs are saving nearly double the original estimate, or 100,000 kWh per year. Once installed, the VFD was used to reduce the motor speed to balance the condenser water flow. Once balanced, the VFD setting was left in place. Figure 8 shows a condenser pump with the VFD in place.

A subsequent retro-commissioning study of the duct work resulted in recommendations that are currently pending. The lighting project would have resulted in an increase to the original capital project budget and was put on hold until other interior space use decisions are made. It is anticipated that this project will also move forward in the near future.

Reference

[1] Energy model completed by Amicus Energy Solutions, East Brunswick, New Jersey.

ABOUT THE AUTHOR

Rafael M. Negron has worked in the energy industry for over 15 years. As principal of Norgen Consulting Group, Inc., he oversees energy savings projects for some of the largest commercial and institutional clients in New York City. He conducts energy audits, energy modeling, and rate schedule analysis. Mr. Negron is also involved in identifying energy savings measures, project managing installations, and securing energy incentives from public and private entities. In addition to energy-related consulting, Mr. Negron has helped clients review the technical requirements and compliance options for meeting New York State's proposed NO_x emissions standards and has provided project management services for various environmental testing projects.

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