Energy Efficiency by Retro-commissioning Critical Environments in Healthcare

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Synopsis

Peace Health, St Joseph Hospital in Bellingham, WA, has embarked on a thorough retro-commissioning of mechanical systems serving its most critical environments: Surgery Suites; Cath/EP Labs; Procedural Care Units; Sterile Processing. These systems were installed five years ago, but never commissioned. As a result, these areas have been functioning with no plan in place for energy management. Through retro-commissioning, the hospital is putting an accepted best practice strategy into place for controlling these environments and substantially improving energy performance. First year savings from modifications to the sequence of operations and scheduling alone are anticipated to be in excess of $100,000. Further efficiency gains are expected as unnecessary loads to Physical Plant equipment serving these areas are removed and capacity is freed up for other areas of the hospital. Thorough retro-commissioning, protocols will be put in place to sustain the efficiency gains indefinitely. Valuable hospital revenue previously needed to service energy waste can be redirected to support better patient care.

About the Author

Daniel received a Professional Energy Engineers Certificate from UCSD in 1985, while working at Scripps Clinic and Research Foundation in La Jolla, California. He also received his CEM and CCP from the Association of Energy Engineers in 1985 and 1986 and Certified Plant Engineer from AIPE in 1987. Daniels experience extends from basic forensics and troubleshooting to full support services leadership, capital planning, budgeting, and construction within a Healthcare environment.

He is a past President of the Washington State Society of Hospital Engineers and long term member of the organization and ASHE. He has focused his interests in operating facilities from a business perspective to sustain an aggressive asset management program and to maintain operations at cost and best in practice standards. He has been recognized by both the Washington and California State Departments of Energy and was awarded over $1.2 million in grants through the US Department of Energy.
With a high interest in energy conservation, he has developed successful programs in both the highest and lowest cost structure utilities in the nation.

He has received national recognition for his efforts and results from the Association of Energy Engineers, US DOE, AHA and others. Daniel also received the Washington State Governor's award for Energy Conservation in Healthcare in 1989. His programs have been presented to AHA, ASHE, AEE, IFMA, and others throughout the nation to help others define program elements and strategies that work universally throughout healthcare environments. His programs have included the development of benchmarking operating key performance indicators to track operations to maintain high standards and asset value.

His focus on construction is from a clinical perspective where "form follows function" to assure programs are being met within the design and not via change orders during construction. As a consultant his efforts often extend past the typical commissioning efforts into the quality assurance for compliance to the Basis of Design through gap analysis and design reviews.

Learning Objectives

- Appreciate the value of retro-commissioning in the acute healthcare sector.
- Understand the role retro-commissioning can play in achieving the goals of hospitals' Strategic Energy Management Plans.
- Show the value Commissioning Authorities can have in working closely with healthcare facilities personnel.

Retro-Commissioning in an Acute Care Setting

Stewardship & Sustainability

St. Joseph Hospital & Medical Center is located in Bellingham, Washington, and is part of the PeaceHealth System which operates hospitals within the Northwest region of the United States including Alaska. Their Executive team has initiated and embraced the development of a system wide Strategic Energy Management Plan. The vision of the plan is to integrate energy management into their organizational policies, business practices, and institutional culture to ensure the most efficient use of energy in their facilities. The plan for SJH was completed in 2006 and started the plan to look for additional savings through their complex.

Working at a facility where an Energy Policy is in place, supported and funded by the Executive team is refreshing. It is also exciting to see the pride and ownership from the Facility Engineers making the daily changes.

Basic Building Elements

Energy conservation in healthcare generally focuses on low hanging fruit like lighting control and minor HVAC control modifications. However in this case, SJH defined their energy hog as their East Tower. The East Tower is only six years old. The hospital contacted PSE and NEEA to evaluate their interest in tackling their critical care tower. The tower is 125,000 SF, three floors with a ground floor basement. (The tower houses SJH's surgery, cardio vascular department and cath labs; electrophysiology lab, central sterile, and other essential clinical departments.) These are the highest cost utility and clinical operating departments on the campus. Within the healthcare arena, these departments are typically considered sacred "do not touch", or when you do and need surgery; you will have a negative outcome.

Existing Conditions

The mechanical systems serving the tower were not commissioned after installation. The air balancing was not working correctly at installation. Operations found and replaced numerous failed fire dampers, which fail closed, and created a fair amount of anxiety among clinicians and facility operators. Typical to all hospital environments, the tower went through a number of expansions into shell space, new clinical equipment upgrades, and modifications to existing clinical areas after the initial move in. However the record drawings were not revised with the changes and therefore created interesting challenges.

The controls are direct digital control (DDC) technology maintained, via service contract, by the original installing contractor since the towers first occupancy. The original design incorporated built up air handlers to service specific clinical areas. All air handler supply and return fans were matched up with variable speed drives. The terminal boxes were variable air volume room controls (wall thermostats) and were provided with local reset or override capability, remote monitoring and control. There were designated fan coil units which provided air to the corridors and public spaces. The DDC system was provided with three control modes for the HVAC equipment. Basically the control modes were; on, off, and safety. What is wrong with this picture?

As we started reviewing the graphical user interface (GUI), trend data, control sequences, and set points, it was clear that loop tuning and sensor calibration had been missed in the terms and conditions of the service contract. The controls, universally, in all areas were set to have a one degree dead-band between heating and cooling. What is wrong with this picture?

The surgery mechanical unit was configured with VAV boxes and squeeze box return tracking based off a percent of supply air to maintain pressurization. Two of the rooms, OR 7 and 8, were set up with DX super-coolers in the rooms to allow rapid space cooling. However, they could not be used because they have limited control, on or off. As it turns out, the reason for not utilizing the super coolers is that they were too efficient. They were oversized and were not thermostatically controlled; once again “on or off”.

Clinical practice for implant (e.g., pacemaker) procedures; there is a need to bring the patient’s core temperature down below normothermia for the implant, and then quickly bring their temperature back up. OR 7 and 8 were designed and set up to meet this need. But because there is no thermostatic control and because the unit was oversized, the temperature in the room would be brought down too quickly and by too much. Then when the room needed to be brought back up to normal temperature, the warmed air being brought in would condense on the cold room surfaces so it made the room unusable for its purpose.

As a result, they have had to go back to the thermostatic lockout release strategy that they have in place for OR 3 and 4. This is where they allowed the surgeons to lower the thermostat settings locally in the room. So they have enhanced the problem, which in turn started the whole RetroCx process. This constant temperature change in the rooms caused the chiller plant to maintain CHWS temperature at 42 degrees. Since the rooms were not designed for these conditions, the rooms were basically out of control. In other words, no one was happy.

Standards for Initiative Compliance

The codes for healthcare change frequently. Hospitals are generally regulated by the State Department of Health with the Federal or National Guideline. The Feds, under the Department of Health and Human Services have used the guidelines for Hospital and Medical Facilities manual developed by the AIA. Washington Administrative Code has recently or is about to adopt them as their guideline within the WAC's.

Codes are minimum standards and may not meet the clinical practice standard used by a particular hospital; and clinical practices differ regionally with common denominators. But it does not stop here. Each clinical department has their own set of clinical practice standards; for example, the AORN which govern clinical practice in surgeries, which in turn references the Center for Disease Control (CDC) for guidance which also refers to the Infectious Control Regulatory Association (ICRA) for final standards.

There are many others, but these are the important ones for this project. So first thing we needed to understand, within our efforts, are what are the limiting elements in developing energy initiatives for the Tower. We settled on the AORN and ICRA standards as the most restrictive and therefore compliance was imperative and non-negotiable. We reviewed the parameters with the Clinical Directors for validation of their standards of practice.

Initial Investigation

All evaluations or Retro Commissioning projects start with a plan. The idea is that once created, you work the plan. The stakeholders gathered, discussed and voiced opinions, cast out ideas but in the end created a plan. In the pure idealistic world you follow the plan. For the most part we did follow the plan, but when dealing in a critical environment you need to be flexible in delivery to keep people alive and clinicians happy. Our strategy was simple; understand the following: the existing environment, the existing operating strategies, and the clinical practice protocol utilized within the space.

We completed this project by following these steps:

- Understand and become knowledgeable in all past reports, drawings, evaluations, operations, physical plan limitations, liabilities, etc.
- Interview and assess operating engineers to learn what they know and what they are unsure of, and what they don't know.
- Interview the Clinical Directors to "listen" to how they operate their departments; hours of operation, staffing patterns, limitations, issues, environmental limits, etc.
- Assess the equipment condition, operating characteristics, and any limitations.
- Set up the DDC trends to further define operating characteristic.
- Verify the DDC system sequences of operations, set point, responses; what's been bi-passed, what is working and what is not.

Initial Findings

The initial findings from our on-site visits were what was to happen 24 hours a day was really happening 10-12 hours per day. Patients were not in the tower in the evenings or at night. Patients were there by exception, not on a regular basis. No patients reside in the tower over night. So this opens some thought towards a stand-by schedule for equipment as a normal sequence of operations when space is unoccupied. You cannot turn the HVAC equipment off as the original designers thought; but you can back it off as long as the rooms and areas maintain pressure relationship gradients as mandated by IRCA requirements.

Therefore, we started identifying the control zones and determining what required air controlled environment and what did not.

The findings are listed below:

- Clinical Departments were not fully staffed 24 hours per day.
- Patients did not stay in the tower 24 hours per day.
- Physicians dictated room temperature below AORN standards
- As-build drawings did not consistently match reality.
- Air balance was a continual operations issue.
- HVAC control system sensors were not calibrated on a regular basis.
- HVAC units were well maintained.
- Equipment installation was good, spaces were well maintained.
- There were very knowledgeable operating engineers.
- Clinical Directors really supported the Facility Engineers & Operators.
- Spaces varied in temperature based on who was on duty from a Physician perspective.
- Some areas or rooms had exhaust fans & some did not.
- Some areas, like ETO processing, could not be affected by any change in operations
- Sterile Processing Department operated 24 hours per day and could not be affected by changes in operations.

ECM Identification

We identified easiest operating opportunities first like; leaking ductwork, humidifier dry traps, reset schedules, missing insulation, damper positions, one degree dead-bands, set point opportunities, etc. However, the key energy hogs were found within the HVAC unit control strategies. If the areas are not staffed and patients do not stay 24 hours per day, a HVAC unit stand-by mode or set back for control points of operations could work.

The bulk of the work, for a stand-by mode of operation, was to define what terminal boxes served specifically what areas. The next step was to determine what air controlled environments were within each area under the terminal boxes. This is where the as build accuracy came into question. We had more terminal boxes than indicated on the DDC interface, balance report, or as build drawings. We left the verification of boxes up to the Owner, it was not in our scope to create the as build documents. However, the strategy to be followed was determined, reviewed, and accepted within the IRCA requirements. Positive required rooms with tracking boxes would reduce supply air flows per chart below and return boxes would reduce by 80% of supply. Negative, required, rooms supply and return air were not changed. Exhaust fans serving negative rooms were also left unchanged.

Table 1 (Stand-by Mode of Operations)

Unit	SA Reduction	Area Served
HVAC-31	44%	Surgery
HVAC-32	51%	PACU
HVAC-33	52%	EP Lab
HVAC-34	40%	MRI
HVAC-35	65%	Cath Lab & Cardio
HVAC-36	30%	ACU & CSS+ETO

Per the chart, there was no common denominator as to the percent supply air reduction. It was determined by the area function, criticality, operating hours, and the number and type of air controlled environments (ACE) rooms.

Testing

Testing needed to prove three elements: pressurization requirements were met, recovery rate to normal operation was within minutes and lastly you could control temperature. Proving out HVAC-31, which serves the surgery rooms, presented the most amount of difficulty. Within the surgery suite you have sterile core, circulating corridor, dirty utilities, sub-sterile rooms and the theaters themselves. Therefore, the pressure control across each one becomes critical and each time you change one element it impacts or affects an adjoining element and all elements had to be within the parameters of the IRCA requirements under any circumstances for the stand-by mode. The easy part of HVAC-31 was determining which set of boxes handled which room. The boxes are tested monthly as part of the Facilities quality assurance ICRA verification process as a preventive maintenance work order.

The temperature component became easy to handle since load is introduced gradually allowing time for controlling. That is as long as the temperature swings were not that great. We elected to use the following table as our starting point, off normal set-point;

Table 2 (Bead-Band Spread)

	AREA	SWING	FLOAT	Normal Set Point
1	Critical Space	+/- Two	1 degree either side	70
2	Patient Care	+/- Four	2 degrees either side	72
3	Staff, Back of House	+/- Five	2.5 degrees either side	72
4	Public & Corridors	+/- Six	3 degrees either side	72

We recommended that SJH reconsider their “normal” set points for a summer/winter range verses a single point. In San Diego we had 10 degree swings year round, but in Tacoma we had a summer 72-76 and a winter of 68-70. The environment and incentive makes all the difference.

My experience in actual operations; the swings can be increased by understanding the space utilization. We recommended to SJH Operating Engineers that they should move very slowly in changing area 1, but all others could be expanded on a box by box basis. That of course would increase energy savings but also increase recovery time. In most cases the occupant would have little to no knowledge of the change if modified carefully.

From the Surgery air handler unit we ventured into the typical HVAC patient care unit scenario. This is a typical configuration for this facility in a patient care area. Testing followed the plan and we commanded the supply fans down to the stand-by mode and began testing the rooms. Once again it was determined that the as builds did not follow actual built or existing condition. We made minor changes to our plan and continued our testing. What we initially found was that we could not control negative pressure rooms like soiled utilities, toilets rooms, janitor closets, etc. What we determined to be our problem was that the exhaust fans were not performing per the TAB report. Not rocket science, under normal operations they were marginal at best. One could conclude that the supply fan was pushing the exhaust air out. Once we reduced the supply air the problem worsened. In speaking with the Operating Engineers, the exhaust system fire dampers have been an on going issue ever since the Tower's grand opening. Engineers have been replacing the fire dampers as they failed. We found them a renewed priority for replacement.

We essentially stopped testing at this point. We verified that the strategy works for the crucial areas of the tower, both the worst case and the normal case. Given the clinical space untested matched the "normal" tested space we accepted the stand by mode as an acceptable ECM scenario.

The Results

The methodology worked and tested true to the plan. The team was challenged due to working with an open facility. As we started, surgery was happening in OR#1 and they were closing up a patient in OR#2. So we went room by room, testing between each, until we effectively moved six of the eight rooms to the stand-by mode. Recovery was in minutes, fully acceptable by the clinical staff on duty. The potential savings for this ECM was modeled at plus $80,000 per year, teamed with the other ECM's we identified over a $100,000 first year saving and a 1.8 year simple payback.

Universal Use

I have worked with a lot of hospitals over the past +30 years. Each is different; they have environment or culture issues, differing incentives, and unique design characteristics. The SJH facility fit a scenario that proved out to work and we had clinical and facility support. It will be interesting to see if they will gain Executive Team support to put these initiatives into operations. I have successfully employed these strategies in the past.

This scenario as outlined is not a cookbook for all facilities; there are many variables to consider. However, the strategy works with some variation within many healthcare critical environments. The strategy should be explored until it is proven to be physically impossible from a control or mechanical perspective (existing conditions), clinically unsound or not clinically supported.

Lessons Learned

- We had an initial stakeholder meeting with the various agencies to help them understand our scope of work and help us understand their expectations. Their understanding of critical environments was misunderstood or understated and their clarity of expectations created a fair amount of issues in the multiple attempts to closeout the project. We vastly under estimated the number of hours responding to stakeholder issues.
- Maintaining as build documentation is critical, especially in an environment where the only constant is change.
- If there is a HVAC control service contract they should have a standard for calibrating sensors and loop tuning as a deliverable and accountability within their terms and conditions for service.
- Designers need to design in flexibility within their designs; they can only do this by understanding clinical practice and the golden rule “form follows function”.
- Clinical integration is required in plant operations for best of practice protocols.
- Retro-commissioning works.

The Clinical Program (CP) defines two levels of efforts, clinically; how the space is to be used, patient requirements, clinical staffing requirements, standards of practice, space use, etc. Financially, basis of the business plan and project financial viability is important.

Basis for Design (BOD) document takes the CP and defines it in space develop, use, characteristics, utilities, furnishing, finishes, equipment, environmental limits, critical set points, etc.

Institutional Boiler Plate defines the Owners specific standards for material, equipment, quality, etc which outlines the Owners expectations for standardizations and quality.

The AIA schematic design and outline specifications pulls the three above documents together to outline the specific projects elements for integration into the development of the Construction documents.

The CD project phase defines specifically all the project elements for actual construction. It is where the rubber meets the road.