Energy-data Dashboards and Operators: Designing for Use in NYC Schools

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ABSTRACT

Feedback to operators is key to building performance improvement. Energy-information tools and training design are integrated toward this end. Experience in a large training program in NYC is discussed. Training materials are described and provided.

INTRODUCTION

We describe in this paper how energy data and computer-based data tools can be used in training of building operators. Effective feedback of energy data to the operator is a critical element in sustainable performance improvement (Bobker 2005). But few operators know how to work with energy data since it has not traditionally been a responsibility of the position. This is changing now, with mandates for reducing energy use and greenhouse gas emissions, increasing cost pressures and the industry's recognition that operations matter to actual, realized performance.

Barriers remain in the use of energy information, some of which can be addressed by portal and dashboard design. We can engineer better data access and visualization. But we also need to involve operators with the data as active, purposeful users. The design challenge becomes a training challenge: information engineering needs to be integrated with new skills and behaviors. Especially with practical people like building operators, learning occurs best through doing.

In this paper we present and discuss curricular materials and activities that have been developed in a large training program for the operators (Custodial Engineers) of NYC schools. Using energy data in practical projects, conducted in participants' home facilities, is a key pedagogical element. The training model is believed to be highly replicable for municipalities and property management organizations, is aligned with a nationally recognized certification, a national energy-use web-database and a major high-technology corporate initiative.

IBM And Smarter Cities

Anyone who has walked through an airport lately knows that "smarter cities" are all the rage with global high-tech companies. When we think of high tech future cities we probably don't visualize applications informing workers at the base rung of building operations, quite literally down in the basement. But anyone who has worked with buildings understands the significance of operations and operators to energy performance outcomes. Recent discussions of the range of energy outcomes in LEED certified new buildings point towards operations as one of the main causative variables (Turner and Frankel 2008).

IBM Research and IBM's Smarter Cities program recognized this phenomenon and sought to work jointly with the CUNY Institute for Urban Systems on a "first-of-a-kind" (FOAK) project to develop a dashboard and on-line analytic toolkit. The project selected EnergyStar Portfolio Manager (ESPM) as one of the primary data sources because it exists across many organizations, in both the private and public sectors (IBM 2010). In several states and localities including California, Washington state, New York City and Washington D.C. recent legislation and voluntary initiatives require public disclosure of building energy performance and ESPM is a preferred approach (US EPA (1)).

A specific objective articulated in the one-year FOAK development program was to produce an interface that would be useful to, and readily usable by, building operators and that could be introduced into their training. In contrast to the underlying ESPM, the IBM Buildings Energy and Emissions (i-BEE) dashboard was designed to facilitate legibility and data usability via pie chart and time-series graphics accompanying summary data tables. Figure 1 provides a screen shot view of this design, in this case for the entire portfolio of schools.

Figure 1 Screenshot from i-BEE Dashboard

During the course of the i-BEE project, IBM acquired an integrated property asset management system, Tririga, (IBM 2011) that is being deployed by NYC for its municipal property portfolio. The customized Tririga platform is not yet ready for user training. The FOAK dashboard provides, in effect, an early sketchpad for practicing data use so that basic understanding and skills are in place when the full new system is deployed. The FOAK dashboard also provides an opportunity to experiment with functionalities that might be most useful to have in the final database toolset.

NYC Municipal Commitment.

NYC, under the leadership of Mayor Michael Bloomberg, has committed to substantial sustainability goals in ten areas articulated in PlaNYC2030. One of these goals is a 30% reduction in energy use by 2030, accelerated to 2017 for NYC municipal buildings and major institutions who have signed "early compliance" pledges. This has become a driver for actions by the city's line agencies.

By Executive Order they city has made a ten year commitment to spend 10% of its annual energy expense on energy efficiency projects in municipal buildings, amounting to over $800 million per year. Of this annual budget, 80% goes to capital projects and 20% to O&M. This funding is administered by the Department of Citywide Administrative Services (DCAS). Training is included among the identified operational measures (Ryan 2010).

Building Operator Training

Consultants engaged by the City's task force on implementing PlaNYC2030 goals in its own facilities, identified the importance of operational staff training (AECOM 2009) and this was accepted as a cornerstone of the city's program.

In the course of curriculum development work under an NSF project at CUNY's Bronx Community College, the Building Performance Lab identified the national Building Operator Certification, originating with the Northwest Energy Efficiency Council, as the most appropriate certification program for use in institutional properties. The BOC is now represented in NYC by the Building Performance Lab (BPLab) of the City University of NY (CUNY), the city's public university.

NYC DCAS and Department of Education Training Programs. Since 2008 DCAS has offered energy and operations training at its NYC Training Center. The Association of Energy Engineers Certified Energy Manager (CEM) training and the national Building Operator Certification (BOC) have been offered. The BPLab, working with CUNY's central continuing education entity, the School of Professional Studies (SPS), provides the BOC training. Building operating and supervisory staff from the city's major line agencies have taken the course sequence with good success.

Based on the experience of school facility supervisors in the BOC training, the **Department of Education (NYC DOEd)** determined that it wanted to offer this training and certification to all 1,100 Custodial Engineers (CE) in the school system and to do so within the two-year time frame of a federal ARRA grant. CUNY developed a program to meet this goal, formidable especially in so far as the CUNY-BOC Level 1 certification requires 90 hours of classroom instruction. The program has three rounds of thirty weeks, each week with fourteen weekly sections of 25 students each. The program is run in a dedicated training area of the Division of School Facilities (DSF). Direct instructional and administrative costs are just under $1.5 million. Valuing the commitment of CE time in the classroom at $100 per hour suggests an additional investment in training of $9.9 million.

Benchmarking. Pursuant to PlaNYC, the City Council passed a set of four laws called the " Greener, Greater Buildings" laws. One of these, Local Law 84, calls for annual benchmarking of all buildings over 50,000 square feet, using EnergyStar Portfolio Manager. To lead on this, all NYC agencies, coordinating through DCAS, benchmarked, completing this work during 2010. One of the goals of the DOEd training was to enable Custodial Engineers in individual schools to see their energy performance.

NYC PUBLIC SCHOOLS.

The public school system comprises the largest single-agency energy expense in the city's nearly $1 billion energy budget. The schools comprise 40% of municipal building property by floor area and use 25% of all energy. There are over 1,100 school buildings with over 145 million square feet, serving over 1 million students, making it one of the largest public school systems in the world. While designed for ease-of-access to the individual building level or any grouping desired, the iBEE dashboard also makes it simple to get a consolidated overview of portfolio statistics; the pie charts in Figure 1 show portfolio-wide dominance by fuel (oil and natural gas) in energy use but by electricity in energy expense, as well as how these vary with source/site conversion of electricity.

The fleet of school buildings is relatively old, with the largest cohort of buildings built between 1921- 1940; see Figure 2.

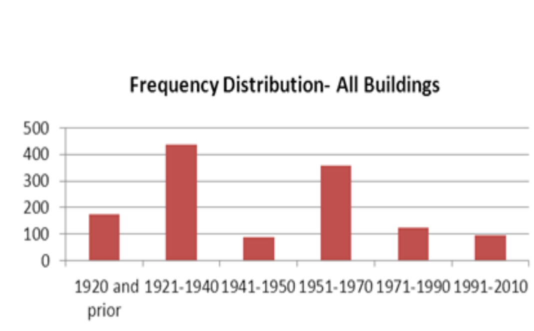

Figure 2: Number of School Buildings By Age

The building age statistics, however, do not fully represent the age of building systems which have been retrofitted over the years. For example, buildings built before 1940 had coal-fired boilers that were later up-graded to fuel oil, usually #6 heavy oil, even though the last of the remaining coal-fired boilers were only replaced (with dual fuel gas/oil fired systems) in the late 1990's. This level of data, however, is not captured by ESPM and while available in DOEd records is not at present recorded in a searchable database.

All but the newest schools have relatively simple systems. Less than 10% of the stock has DDC controls and building automation, so monitoring via building performance data is only beginning.

NYC DOEd has a Sustainability initiative, which began with mandatory recycling and has spread into other areas. The national **"Green Cup Challenge"** has been introduced, with cash awards for winning schools. This program is administered by the DOEd's Sustainability Office within the Division of School Facilities. Interestingly, while the DSF operates solely on the facilities side of operations, the Green Cup Challenge extends its involvement to the academic side. The GCC requires involvement of students and teachers and therefore more significantly engages the Principal's attention. Energy improvement as shown in ESPM is a required dimension for success in the GCC.

TRAINING DESIGN

The design and intent of CUNY's BOC training and certification, down to the level of learning objectives and key pedagogical methods, is described elsewhere (Bpbker 2010). In summary, it is focused on the introduction of energy management and indoor environmental quality (IEQ) practices at the operational staff level, based on a deepened understanding of the building and its systems. A key element in the training is the completion of a series of practical projects to be carried out by each participant in his or her home facility. Engineers may find the detailed review of class design in this section of little interest; the difficulties of having engineers responsible for the training of operators has been raised elsewhere (Bobker 2008).

Even though Custodial Engineers in the NYC schools have long had the responsibility of daily reading and recording of meters, energy management is a new, still-emerging area of responsibility.[1] CE have also long borne baseline responsibility for IEQ, in the form of cleaning requirements. But this area has seen heightened attention with statewide regulation of allowable cleaning chemicals and heightened awareness of indoor health hazards such as lead, PCBs and asthma triggers. Broadening from this base, the BOC program introduces indoor thermal and lighting conditions as elements that impact both learning outcomes and energy use.

Operational Focus. As with many operators, the CE work in the context of organization and bureaucracy through which many of their requests are channeled. Frustration levels can be high and there are chronic debates over priorities and responsibilities. The training seeks to draw a line early in the program that focuses on elements clearly within the CE's domain of authority and ability to act. Classroom discussions highlight significant things that the CE does for energy management and IEQ. We attempt to make clear the message that "while many projects will have to be undertaken in a broad organizational framework, there are specific things that matter that you, the CE can take on directly." Thus, for example, defective boiler controls cannot be replaced by the CE, but manual control to prevent systems from running wild can be established; moreover, better-described work requests can help the system (centralized shops) to respond more efficiently to site conditions. Documentation of conditions is essential to providing a consistent long-term approach to improvement and redress of problems.

Getting from Knowledge to Outcomes. The CE learners are, for the most part, not abstract thinkers. Class design follows the dictum "Telling

[1] It should be noted that a split-incentive exists in the city's administration of energy costs. Energy expenses, with the exception of fuel oil, are paid centrally by the DCAS. Cost increases or decreases do not directly affect the budget of the individual school or of the DOEd. DCAS has recently promoted policies to change this arrangement but these have not yet gone into effect.

Ain't Training" and employs a model. Figure 3, emphasizing rapid transfer of topical knowledge to used skills and implemented practices that (can) result in facility outcomes:

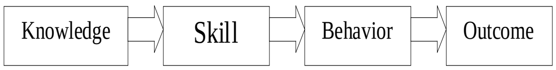

Figure 3: Training Design KSBO Pathway

Outcomes are defined in terms of projects that can be formulated to improve efficiencies and/or indoor environmental conditions. Measurement to establish such impacts is an on-going challenge.

Facility-based Practical Projects. Central to this "knowledge use" model is the series of six inter-related projects. Projects begin with assignments to describe and document building systems. System configuration and operating conditions are emphasized along with basic skills in site sketching, schematic sketching of systems, and creation/use of basic equipment schedules. In the second half of the course project emphasis shifts to energy performance data and the identification of operational projects that can be implemented by operators with minimal outside support or capital budget. *The goal is to get CE students working with data in ways that will be meaningful to them.*

Software and Computer Labs. A first-tier learning objective is basic ability to work with energy data. In earlier versions of the BOC offering, students were required to assemble an energy history spreadsheet from billing data or data from DCAS's energy reports provided in pdf format. A pre-formatted spreadsheet from the Wisconsin Energy Center's "Focus on Energy" was used. However, with centralized entry of energy data into ESPM and the city's planned migration to the IBM-Tririga platform, the ability to assemble data directly from bills was dropped in favor of an ability to access and work with data from a website such as Portfolio Manager. "Working with" this energy data means understanding how it can be transported to and manipulated in tables and spreadsheets.

Two computer lab sessions, 1.5 hours each, are provided in the energy data section of the course (weeks 20 – 25). Each lab is half of that week's 3-hour class. There is no question that more computer lab time would be desirable. It should be noted that as much as half of the CE population has very limited computer skill. From early in the class, students are required to download, read and work with web documents (US EPA, US FEMP) – both for the content and for the skill-building in web access.

The first lab session walks students through the ESPM site including access to their own individual account as established and maintained by DCAS and the DOEd. This first lab starts with very basic skills and progresses, for those capable, up to how to copy-and-paste a table into an Excel worksheet. Teamwork and a buddy system are emphasized in the lab. ESPM account passwords are provided and CE's are encouraged to practice accessing their accounts from their offices. ESPM records multiple years of energy use history. But use of a custom-report feature is necessary to get these histories to total and to show as graphs and charts.

In the second lab session, focus shifts from ESPM to the iBEE dashboard as a means of accessing and viewing the ESPM data. Students were seen to respond visibly to iBEE's much enhanced visual experience in data presentation. Lab instructor Daniella Leifer noted *"The CE's in the BOC class left with a new appreciation of energy data analysis software tools. They were very interested in the data history available in Portfolio Manager - being able to simply see their usage & billing history and having a list of it readily available any time. The graphing and analysis of that data using PM, however, was more daunting.*
That seemed to have made the subsequent class on IBM more warmly received, because it performs the graphing and analysis for you - so they appreciated now having much easier access to the infomation that's hidden in their energy data."

Project 5 – Energy Use Data. Project 5 requires students to develop a tabular account of their facility's energy use by completing two tables,. Students must abstract data from ESPM and enter it on to pre-formatted tabular spreadsheets, presented as **Figures 6 and 7** at the end of the paper It is important that students have the first table assignment before going into the first computer lab and that they understand that they are to continue work on it in the second computer lab, the following week.

The first table, Figure 6 at end of paper, is first distributed as a blank worksheet with instructions by column for all the derived values. They are also told that the table is available as a pre-programmed spreadsheet on the course website. This communicates quite powerfully how useful a spreadsheet can be.

In the first lab students are shown how to use ESPM data to input annual totals for each energy type and associated cost. They can add up the annual totals from the ESPM data entry tables, they can copy-paste to a blank Excel spreadsheet, or they can do custom reports in ESPM. Understandably, students have been observed to breathe a sigh of relief when they are introduced to the iBEE dashboard the following week and find that annual totals are automatically calculated and graphed.

The iBEE also calculates energy unit costs, energy and cost per square foot and percentage distribution by energy type. Consequently, part of the second lab pedagogy is to have students compare their data with that of others in the class and then, using the peer-group selection feature, Figure 4, to other schools, types, or groups of schools.

Figure 4: I-BEE Menu-driven Peer-Group Selection Screen

This feature was observed to create a significant "buzz" in the class as participants realized that they could readily compare their own performance to significant others. This feature was designed into the iBEE dashboard tool specifically to achieve this kind of peer-group impact. It can be used not only for comparative analysis but also for designing competitions and impact evaluation, as will be discussed further below.

Once Table 1 is completed, students must transfer data into Table 2, Figure 7 at end of paper, to see their Energy by End-Use. Once again, this table is provided as a blank worksheet with advisement that it is available on the course website as a pre-programmed Excel spreadsheet. Word quickly spread that this somewhat intimidating worksheet would automatically calculate once linked to the cells in Table 1. Students used the second lab to make sure they got this done and many even requested follow-up lab time, sacrificing a lunch hour.

Admittedly, the procedures around this second table are debatable. The percentage distributions are arbitrary and, for any given case, will be at least somewhat inaccurate. That the spreadsheet version self-calculates means that students do not have to struggle with getting numbers. The response is that we are training users not analysts, so that it is more important that they see some kind of result rather than getting stuck and frustrated in calculations that they are unlikely to be asked to do in the future. The goal is that they see how their facility uses energy and where cost centers are, so that they can determine where best to focus energy in improvement projects.[2]

Project 6 – Operational Improvement Project. Project 6 completes a first cycle of "energy data to behavior." For this final project element, the CE must identify and characterize an operational improvement project. The project must be within the capability of the CE, that is it cannot be dependent upon external support. The characterization includes a clear verbal description and quantification based on the energy use data developed in Project 5. The objective is to make the CE apply what they have learned about their systems to define a behavior that they can implement and for which they can expect to see a specific energy and/or IEQ impact. They must think a project through in some detail and verbalize the steps they would take and outcomes they would expect to see.

Figures 8 and 9, at the end of the paper, show, respectively, the project form (three pages in actual use) and a table of measures that is provided to help students select a project and quantify its savings.

OUTCOMES AND EVALUATION

The training process is incomplete without evaluation of outcomes and feedback of the evaluation findings into the training process. There is a range of evaluation methodologies, ranging from simple course evaluation to post-training surveys, interviewing, behavioral change assessment and impact analysis (Robinson and Robinson 1989). The obvious holy grail of energy program evaluation is to show the energy reduction. However, individual operational measures often lie within the "noise range" of normal variation in energy use due to multiple varying factors. Even with sufficient information in hand for normalization, such adjustments often compromise the perceived significance of findings. Intervening variables that can be established with better clarity and certainty, improve the quality of evaluation. They may serve as useful proxies when muddy waters obscure savings.

Past Evaluation Findings. CUNY BOC offerings have been evaluated from their inception with a pre/post participant self-evaluation of skills.

[2] This is a message communicated by the text for this section, Herzog Energy Efficiency in Commercial Buildings

This has been reported on in a previous paper (Bobker 2010). Overall, pre/post results show a self-perceived improvement from an average of 2 to an average of 3.5 on a scale of 1 to 5. This result is validated by the fact that virtually no improvement is reported on several of the more challenging dimensions – "importance of complaint response as part of the job" and "frequency of trend-logging from BAS". A significant area of questioning is the likelihood of making or recommending operational improvements to various building systems. Self-perception, of course, does not directly or necessarily lead to behavior change or implementation of projects.

The national BOC program has had several independent evaluations conducted, with consistently positive findings (Opinion Dynamics 2009; RLW Analytics 2005 ; Research Into Action 2006; Navigant Consulting 2011). These evaluations use a generally shared framework that examines student satisfaction with the course and then, for impact evaluation, combines a rating of "likelihood to implement" with calculated savings for a range of specific measures. This produces metrics like energy-saved per participant and per square foot which can in turn be used to project measures of cost-effectiveness against training costs.

Bear in mind that, unlike the NYC program, a large portion of BOC offerings are conducted through a local utility. Utilization of incentives is considered another metric, particularly important to utility sponsors. Until recently, utility incentives were available for retrofit measures but not for purely operational measures (ie – measures implemented without equipment change or capital expense). Therefore, the emphasis on incentive utilization raises the question of the BOC training's role in decision-making about projects, as factored in by at least one evaluator (Navigant p.35). Perhaps more significantly, BOC training can be expected to enhance the maintenance and persistence of savings from capital measures. A spreadsheet-based method for estimating this effect on a municipal portfolio of projects was provided in a previous paper (Bobker 2008).

Early Analysis of CE Projects. From initial review of the first class cohort of over three hundred projects, a majority of projects address lighting, in particular turning off lights in areas that are unused for parts of the day. In terms of obviousness and ease of implementation, this outcome should perhaps not be surprising. Turning off lights also aligns with efforts on the educational side to compete in the schools' city-wide Green Cup Challenge, where teacher and student involvement are emphasized. A significant minority of projects address heating systems and, in particular, boiler plant control. Detailed analysis of the first batch of projects is still underway.

The CE projects provide a good jumping-off point for follow-up evaluation. A significant number of CE indicated that they had already implemented their project or initiated work on it. The curriculum's emphasis on quantified project descriptions aligns well with the recommendations of at least one evaluator of other BOC programs (Navigant p.41).

Monitoring with i-BEE. iBEE provides time-series data with projection of future use based on weather normalization, so that operators can readily see how they are doing in relation to past performance. A measure-log feature is available to record when steps are taken and these are marked onto the time-series display, Figure 5. Another dashboard screen shows usage bounded by a standard deviation to allow visualization of "out-of-bound" performance.

Figure 5: Time-series with notation of measures from i-BEE dashboard

That i-BEE provides an individual building baseline is important. The baseline concept is emphasized in class for energy and other conditions. Improvement from baseline is part of the Green Cup Challenge. But equally important is that the baseline can be viewed in the context of other buildings, defined by pre-formatted filters, such as age, kind of school, or as customized sets. The concept of **peer-comparisons and social competitions to drive behavior change** has become part of the practice set for implementing sustainability (McKenzie-Mohr 2011; Precourt). We discussed above, see Figure 4, how peer group selection was facilitated in lab and classroom sessions. We hope that on-going data comparisons will be fostered by the development of an on-line community for program graduates.

While we hope to involve all CE with data comparisons, we have identified the **regional supervisor DDF** as the most significant community upon which to focus. The DDF are on average more sophisticated computer users than the CE. They have managerial and reporting responsibilities over portfolio sets. We will attempt to work with the group of DDF who have completed training in the first round and will pay special attention to the DDF groups in the current and final rounds to prepare them for monitoring use of the I-BEE dashboard.

CONCLUSION: DESIGN FOR FEEDBACK

Once we accept the importance of information feedback and the operator in achieving energy performance, it behooves us to design appropriate tools and train operators on them. Databases, spreadsheets and dashboard data visualization are new elements in the industry and even more so to typical building operators. Just making information available will not lead to its effective use. This is a challenge for training and on-going management, not simply engineering.

Our training experience shows several key features. Data visualization is seen to be key in making information accessible and gaining engagement of trainees who are not, fundamentally, data-oriented. Putting that data to use in a structured way is a key part of the learning experience. Making it real for trainees' home facilities is, ultimately, what it is all about. It is a goal that can be achieved by good training design.

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ADDITIONAL FIGURES, 6 – 9: MATERIALS FOR PROJECTS 5 AND 6

TABLE 1 SUMMARY OF ANNUAL ENERGY USE BY ENERGY TYPE							GROSS FLOOR AREA =		SF	
FOR THE YEAR SEPT 1, 2009 - AUGUST 31, 2010 UNLESS OTHERWISE NOTED										
	unit	QTY	MMBTU	$	unit cost	$ / MMBTU	MMBTU / SF	$ / SF	% of BTU	% of Cost
Electricity	kwh		0		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Nat Gas	therm		0		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Fuel Oil, #__	gallon		0		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Steam	mlb				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
other					#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Total			0	0		#DIV/0!	#DIV/0!	#DIV/0!	100%	100%

NOTES:				per million	
1. MMBTU of all energy types are calculated at the Site Value		kwh	3414	0.003414	kwh
2. Building area (SF) is gross square footage, including basement		nat gas	100000	0.100	therm
		oil, #2	140000	0.140	gal
		oil, #4	145000	0.145	gal
		oil, #6	152500	0.153	gal

Figure 6 Project 5 Table 1 Summary of Annual Energy by Type

TABLE 2 ANNUAL ENERGY USE BY END-USE FUNCTION									
FOR THE YEAR SEPT 1, 2009 - AUGUST 31, 2010 UNLESS OTHERWISE NOTED									
	FUELS USED	default %	adjusted %	MMBTU	MMBTU/SF	% of TOTAL MMBTU	$	$ / SF	% OF TOTAL $
OIL, GAS, STEAM									
HEATING		70%							
HOT WATER		20%							
COOKING		10%							
OTHER		0%							
SUB-TOTAL		100%	100%						
ELECTRICITY									
LIGHTING		45%							
MOTORS		25%							
COMPUTERS & OFF EQUIP		10%							
AC		10%							
KITCHEN-REFRIG		10%							
HEATING & HOT WATER		see Note 1							
OTHER		0%							
SUB-TOTAL		100%	100%						
TOTAL						100%			100%

NOTES
1. If electricity is used for heating and/or hot water (other than for pump and fan motors), see Instructor

Figure 7 Project 5 – Table 2 Annual Energy by End-Use

Brief Description of measure	
Problem Addressed:	
Expected Impacts Energy:	
Expected Impacts IEQ	
Pre-project Measurements	
Project Steps	
Observable Outcomes	
Project Requirements:	
Materials	
Manpower (internal)	
External resources	
Space access	
Timeframe	
Cost Estimate	
Internal manpower, __ man-hours @ $50 per hour =	
External manpower, __ man-hours @ $75 per hour =	
Materials (itemized)	
Supervision & overhead, 10%	
Contingency, 10%	
Total Estimated	

Figure 8 Project 6 Form for Preparation of Operation Project Description and Characterization. Three pages in actual use. Required for submission of project.

CATEGORY / MEASURES	CALCULATION GUIDANCE
BOILER PLANT	
Test and improve combustion efficiency Firing rate modulation Š reduce cycling Improve boiler sequencing Š reduce cycling Optimize start-up Optimize shut-down	1. Test CE. (84 Š test) / test = % improvement. 2. For cycling reduction, 1 Š 10% improvement based on how bad current operation is assessed to be 3. estimate how many operating hours/day can be saved; divide by total operating hours/day = % improvement. 4. Note Š if you are reducing boiler operating hours, you also have motor savings (see below).
HEATING SYSTEM	
Balance steam distribution, reduce overheating Reduce pneumatic air leakage Zone system for after-school programming Maintain steam traps (replace disc elements)	1. 1% reduction for every degree of overheating removed; pro-rated by portion of school affected. 2. For zoning, calculate portion (%) of school to be removed from heating and % of hours to be zoned off 3. For traps, use 5% for all trap elements, higher if you know you have very hot condensate 4. For pneumatic air leakage, estimate motor hours reduced and see ÒMotorsÓ below; note also relation to temperature control.
LIGHTING	
Get better turn-off of unoccupied areas Manually turn-off major areas when unoccupied (eg Š cafeteria) Use occupancy sensors in appropriate areas Reduce lighting during cleaning hours Introduce manual day-lighting in appropriate areas	1. Calculate the wattage affected in the area(s) to be controlled. Estimate the hours for which this lighting will be off. Watts x Hours = Watts saved. 2. Add 10% for the ballast energy saved.
MOTORS	
Change start-up and shut-down of motors Change kind of belts, adjust tension Check loading, reduce speed with sheaves and pulleys Adjust variable frequency drives (if present)	1. For change in motor operating hours, HP x .55 x hours off = kwh saved 2. For belt adjustment, use 5% of motor energy, motor energy as calculated above. 3. For speed changes, follow Herzog Appendix A.
AIR-C0NDITIONING & REFRIGERATION	
Clean coils and check/clear air flows Have refrigerant charge checked and adjusted Better control of air-conditioners after hours Raise refrigerator and freezer temperatures Increase air-conditioning set-points	1. For cleaning and charge, use 15% of AC usage 2. For AC hours reduction, apply % defined as [(hours eliminated) / (total on-hours)] 3. For kitchen refrigeration measures, use 10% of estimated refrigeration load
VENTILATION	
Change start-up and shut-down times Test and adjust exhaust fans Test and adjust Uni-vents Adjust kitchen hood Change kitchen hood operating schedule Use economizer cycle (rooftop units, air-handlers)	1. For reduction in fan electricity, see motors above (Herzog Appendix A) 2. For reduction in fuel, estimate the ventilation reduction in CFM and calculate to BTU as CFM x 1.08 x degree-days x 24. Use 2,500 degree-days.
IAQ/IEQ	
Improve kitchen hood performance Improve Uni-vent performance	1. Calculate per guidance above if you are

Figure 9 Project 6 Guidance Sheet for Identification and Quantification of Operational Project