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Integrating Enhanced Building Operations into Municipal Sustainability Programming: A Report from NYC

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Abstract

With municipalities setting goals for greenhouse gas reductions, there is an emerging need for model program designs based on quantitative analysis. Evidence is cited that commercial-institutional building retrofit programs can be significantly improved by commissioning and enhanced operation activities. Dimensions are defined along which program value is added: capture of high-payback O&M measures, early action, achievement of projections, and persistence. Based on parameters in the NYC Mayor's Office PlaNYC2030, a spreadsheet model is developed to quantify the value of including an EBO component with a Capital Projects program. Given project-cycle considerations, including EBO enables actions and associated energy reduction to begin more quickly under Operating Budget allocations.

Although impressive quantified benefits are indicated, market difficulties will inhibit the expansion of EBO. Engineering consultants, mechanical-electrical contractors, ESCOs, and facilities staff are at a relatively low level of readiness for undertaking true operational improvement programs. Root cause of this market condition is suggested to lie in the predominant capital-projects business model of the engineering and construction industry. Large municipal programs can be a lever in changing these market conditions. A set of recommendations is developed for program design that will facilitate incorporation of long-term EBO into more traditional energy efficiency programs.

INTRODUCTION: MUNICIPAL ACTION ON GREENHOUSE GASSES

With heightened public awareness of global climate change and sluggish national policy-making, "green" actions, especially those attempting to reduce carbon emissions, has swelled at the local level. Municipalities, large and small, have become a focal area for Greenhouse Gas (GHG) reduction commitments. Guided most often by the International Council of Local Environmental Initiatives (ICLEI), numerous municipalities have conducted GHG inventories and signed on to reduction commitments structured by sector and generally focusing first on government activities. In collaboration with consultants, ICLEI developed, maintains and licenses a software tool for the quantification required under its program.[1]

Of participating cities, New York is perhaps the most recent and the largest city to have completed an inventory and reduction commitment. The commitment is part of "PlaNYC2030" that was released by Mayor Michael Bloomberg in April 2007.[2] The GHG Inventory showed over 75% of energy use to be attributable to buildings. PlaNYC2030 sets a reduction target of 30% of 2005 consumption. However, when taking projected urban growth into account, the reduction target is actually over 50% of the business-as-usual projected 2030 energy use.

To meet this target, aggressive building sector energy programming is called for by the plan. Retro-commissioning is specifically named as a technology to be applied. This has actually caused some confusion as few understand what retro-commissioning means in detail and how it differs from "retrofitting."[3] Programming is to start with the city government's own properties. The Plan commits the City to invest 10% of its energy expense into energy reduction measures. At current energy use and price levels, this suggests an annual program of $80 – $100 million. In addition, at the Mayor's urging, major institutions have signed on to early adoption commitments, pledging as "Mayoral Challenge Partners" to meet the 30% reduction goal by 2017..

The specific inclusion of "retro-commissioning" is both judicious and challenging.

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1 http://www.iclei.org for a review of activities, programs, etc. Details of the GHG Inventory tool are available only to ICLEI members but a good overview can be found in Appendix B of the NYC GHG Inventory www.nyc.gov/html/om/pdf/ccp_report041007.pdf

2 www.nyc.gov/planyc2030

3 "Retrocommissioning" – operational improvements, often based on highly instrumented, data-intensive analysis. "Retrofitting - the major modification or replacement of systems.

Practice-based research has shown the effectiveness of operationally-based measures in achieving significant (10% – 30%), highly cost-effective savings both on their own and in securing and enhancing the performance of retrofit measures.[4] However, these program concepts are relatively new and the engineering detail not well understood in the broad marketplace. *While guidance documents do exist,[5] it would be all too easy for specification and procurement of the services to be flawed. A poorly specified set of requirements would almost certainly produce low-bidders who will deliver deficient services and outcomes by those not properly trained, educated, or experienced in retro-commissioning.*

ENHANCED BUILDING OPERATIONS (EBO)

EBO can best be considered a family of practices:

- Functional and Performance commissioning of all new systems under extended warranty provisions;
- Retro-Commissioning, Monitoring-based Commissioning,[6] and/or Continuous Commissioning©,[7] to identify and implement existing system optimizations;
- Conditions monitoring and diagnostics, employing existing digital control systems, new information interfaces, added sensors, etc.;[8]
- Diagnostic, tune-up and adjustment procedures as part of planned maintenance;
- Systematic identification, logging and root-cause analysis of chronic comfort condition complaints;
- Application of new technologies for data-capture and assessment of building conditions;
- Indoor Air Quality (IAQ) and other environmental factor monitoring and assessment;
- Demand-response market participation via building control functions;[9]
- Documentation and reporting of energy and emissions reductions from established baselines;[10]
- Training for building engineering staff and service providers for participation in all of the above.

Dimensions of Benefit Defined EBO can be expected to have beneficial bottom-line impacts on an energy efficiency program, as described in a growing practice-based literature, as referenced above. From this literature certain specific dimensions of performance improvements can be

[4] See, for example, D. Claridge et.al. "Can You Save 150% of Retrofit Projections" among many publications of the Energy Systems Lab at Texas A&M University, focusing in especially on the Texas LoanStar program for government buildings, http://esl.eslwin.tamu.edu/ . Early experience from other state programs, in New York, California, Colorado and Connecticut can be found in papers presented at the 2005 National Conference on Building Commissioning, http://www.peci.org/ncbc/proceedings/2005/session.htm#18

[5] See for example T.Haasl "Practical Guide for Commissioning Existing Buildings" PECI 1999 http://eber.ed.ornl.gov/commercialproducts/retrocx.htm
Also US DOE, FEMP Operations and Maintenance Best Practices Guide
http://www1.eere.energy.gov/femp/operations_maintenance/om_bpguide.html

[6] A term developed and used by the California Institute for Energy and Environment: see for example Brown, K., and M. Anderson "Monitoring-Based Commissioning: Early Results from a Portfolio of University Campus Projects." Proceedings of the 13th National Conference on Building Commissioning 2007. http://www.peci.org/ncbc/ncbc.htm or http://ciee.ucop.edu

[7] Although in widespread generic use, the term "Continuous Commissioning" is a copyrighted trademark of the Energy Systems Lab, Texas A&M University, reflecting their pioneering work in developing the methodology and documenting results.

[8] In particular work by the Buildings Technology Department, Lawrence Berkeley National Lab. See for example, Piette, M.A., S. Kinney, and P. Haves "Analysis of an Information Monitoring and Diagnostic System to Improve Building Operations" *Energy and Buildings* 33 (8) 2001

[9] Work especially in New York (NYSERDA) and California. (PIER Demand Response Research Center http://drrc.lbl.gov/drrc.html). See for example, Kiliccote S., Piette M.A. and Hansen D "Advanced Controls and Communications for Demand Response and Energy Efficiency in Commercial Buildings" 2006 *Proceedings of Second Carnegie Mellon Conference in Electric Power Systems: Monitoring, Sensing, Software and Its Valuation for the Changing Electric Power Industry*, http://gaia.lbl.gov/btech/pubs/pubs.php?code=Demand%20Response

[10] Often separately specified as Monitoring and Verification (M&V) activities, generally guided by the International Protocol for Monitoring and Verification Procedures, IPMVP. IPMVP is maintained by the non-profit Efficiency Value Organization. http://www.evo-world.org/index.php?option=com_content&task=view&id=60&Itemid=148

inferred, through direct impacts of EBO measures and also through the impact of EBO practice on newly installed or retrofitted systems.

1. *Better realization of projected energy savings from system upgrades*
   New construction commissioning checks conformance to specification and initial testing at start-up but typically does not include provision for extended monitoring that can check operation across a full range of operating conditions and in relation to actual energy performance.

2. *Stronger persistence of savings as a result of on-going data feedback and operator attention*
   Under typical operating regimes, if there are no adverse comfort consequences "drift" in system operation and performance can go unnoted over years. Operators may even increase energy use to adjust for system deficiencies in response to comfort complaints. Better operational metrics and feedbacks under EBO will alter these patterns. Accountability of operators for energy performance is a fundamental change in the provision of building services.

3. *Capture of low-cost, low-hanging fruit*
   Under EBO operator attention will be focused on realizing energy efficiencies, especially if accountability and incentives are applied. In the traditional capital projects model, O&M measures may be listed but are typically not funded and little emphasized. Despite their very high cost-effectiveness, O&M measures do not fit into the traditional capital-projects-based business model, as is discussed further below.

   Low-hanging fruit may be defined as measures that have less than a 2-year payback. The initial "harvest" may be quite significant, although as facility maintenance improves it probably becomes more difficult to continue to find such attractive measures. Note also that as these savings are realized under EBO, the payback of the portfolio of capital measures is likely to increase (ie-grow longer) as less savings potential can be attributed to the capital measures.

4. *Early action and results*
   This may be the most important point politically. Operational changes can be achieved more quickly than the cumbersome Capital Projects process. Early success sets a positive psychological attitude and can also defend the program in future budget battles. Early savings can be also quantified as of greater value than later ones if inflation and discount factors are considered.

Note that the dimensions of benefit listed here refer only to direct energy savings. EBO is also related to a movement towards strategic maintenance – preventive and predictive procedures – that will bring other kinds of benefits, such as extended equipment life, reduced loss of production from unanticipated equipment failures, and lower costs from overtime and emergency repairs.[11]

MAKING A QUANTIFIED CASE FOR EARLY ACTION WITH EBO

The PlaNYC2030 energy reduction target (ERT) makes capital investment for major upgrading and replacement of energy-using systems in buildings an obvious and necessary programming element. The industry (energy services, engineering and construction) is familiar with this kind of program. Under the typical program design and procedure, comprehensive energy audits are commissioned by specialist firms to identify opportunities and investments on a building-by-building basis, projects are prioritized, authorized and the individual scopes-of-work designed and implemented. This work process can be carried out in a traditional construction format or under a design-build performance contract structure.

While the performance contract structure may streamline aspects of the process, in either case for a program of the scale envisioned for NYC, there is likely to be *at least* a three-year lag from original concept and intent to initial projects' completion and energy-savings. A comprehensive NYC government building energy audit program undertaken during the early 1980's with multiple engineering providers took more than three years to complete for the stock of over 300 properties.[12]

In NYC, the Department of Citywide Administrative Services (DCAS) handles energy procurement for all line agencies. DCAS's Office

[11] For a review of this literature, see National Center for Energy Management and Building Technology Final Report Energy Reduction through Practical Scheduled Maintenance 2006 http://www.ncembt.org/downloads.html NCEMBT-061102

[12] Personal communication, Charles Copeland, GoldmanCopeland Associates PC, who served as the engineering manager for the program.

of Energy Conservation has been responsible for procuring energy efficiency projects under an agreement with the state's public sector energy supplier, the New York Power Authority. Major construction under the city's capital budget is managed through the city's Department of Design and Construction (DDC) which maintains an Office of Sustainable Design. New municipal construction is governed by the recently passed Local Law 86 which requires meeting a LEED standard (although not certification). The Mayoral PlaNYC2030 mandates a budget allocation for a program but does not specify how it is to be conducted. Administrative wrangling and rule-making are likely to take some time. Given administrative and project-cycle considerations, there is ample reason for considering an approach based on enhanced building operations (EBOs) where actions and most importantly, energy reduction, can begin more quickly under Operating Budget allocations.

The impact of the EBO benefit-dimensions described above were modeled in a spreadsheet projecting yearly results 2007 – 2030 for NYC municipal properties. **The spreadsheet model compares investment and energy-saving cash-flows under two scenarios: (1) a traditional capital projects only program and (2) a program with an EBO element added.** Selected results, including cumulative totals to 2030 are shown below. The spreadsheet is available upon request from the author.

The spreadsheet provides for selection of specified variables, **Figure 1**. That these are readily viewed makes the model quite transparent. A small number of easy-to-understand, adjustable inputs show differences between programs with and without EBO and drive the spreadsheet results. Specific variables are discussed fur ther below.

FIGURE 1
INPUT VARIABLES SECTION OF SPREADSHEET

Annual Allocation to EE	10%
Annual Svgs at paybck, in years =	8.0
Initial Annual Allocation to EBO	20%
Ann Svgs from EBO at pybk, yrs =	1.5
Cap Savings Realization	90%
Cap Savings Realization w/ EBO	98%
Annual Svgs degradation (persistence)	0.50%
Annual Svgs degradation w/ EBO	0.00%

Varying the Input Variables allows sensitivity analyses to be easily conducted to compare assumptions and program outputs. Because there is little definitive guidance for the input variables, it is useful to be able to establish the range of outcomes within a band of assumptions. It may also be useful to vary individual assumptions in order to evaluate how much budget to allocate towards various aspects of EBO. For example, Persistence effects will continue and increase across the full term of the project while Low-Hanging-Fruit opportunities would be concentrated in the earlier years. The present paper presents the modeling tool and its broadest results but does not pursue various questions that could be addressed with it. .

Some characteristics of the spreadsheet model:

- For simplification purposes, all units are in dollars, current value without inflation or discounting. Discounting of future savings would make early savings more valuable.
- Energy-savings dollars are projected, "top down," based on an assumed overall average cost-effectiveness (simple-payback) of the portfolio of measures. The portfolio cost-effectiveness is an adjustable parameter, shown in the Input Variables section, Figure 1, as the line(s) "Annual Savings at Payback in years = ." There are separate cost-effectiveness variables for Capital Projects and for EBO. With the investment amount and payback known, the projected annual value of energy savings is readily computed.
- It is assumed that enough measures can be found to meet the annual budgetary allocations for both capital improvements and EBO measures. One cannot, however, assume that ever-larger portions of the allocation could be shifted to EBO.
- **O&M opportunities** are modeled as becoming less available over time (as O&M improves) first by a reduction in the EBO allocation and shifting funds back to Capital Projects, starting in year 6. Then, after year 10, savings from implementation of further EBO measures is reduced by 50%.
- **Realization of Projected Measure Savings** shows the effect of Performance-based Commissioning of Capital Projects by setting a realization rate without performance-based commissioning (Scenario 1) and a higher rate with performance-based commissioning (Scenario 2). This "realization rate" affects each year's new capital projects as they are brought on line. It is distinct from "persistence", treated separately.
- **The Persistence effect** from on-going monitoring and commissioning activities is

treated as an annual percentage savings degradation, set in the Input Variables section. There is a separately settable factor for scenario 1 (no EBO) and scenario 2 (with EBO). The factors are applied to the Cumulative Savings row in their respective scenarios. More complex patterns could be established in these rates to show the effects of periodic retro-commissioning or possible non-linearities in performance degradation.

Some Results from the Spreadsheet Model Using the Variable Inputs shown in Figure 1, the model produces scenario results, cumulative to 2030, as shown in **Figure 2**. As noted, these results are in current dollars – undiscounted and without inflation, in thousands of dollars (ie - $13,234 is $13 million).

FIGURE 2
MODEL RESULTS, CUMULATIVE TO 2030

For the same $2.3 billion expenditure, EBO adds over $150 million in additional energy savings – more than a 50% improvement over the Capital Projects only.

Moreover, if we assume a 2005 city energy budget of $800 million, the 30% savings target (ignoring projected growth), suggests a $240 million savings goal. The model is able to suggest that, under the assumptions used, Capital Projects alone are *just* able to meet this goal.[13] The model can readily show the effect of relaxing the portfolio payback criteria or of under-achieving in savings realization or persistence.

The difference between the scenarios in the early years is most significant. **Figure 3** shows results for years 1 – 5. Refer to Figure 2 for the row labels, corresponding by number. The difference between scenarios is driven by assumptions about start-up time for a complex Capital Projects program, compared to faster mobilization of operational actions.

FIGURE 3
MODEL FOR YEARS 1-5

The faster resources can be trained and mobilized, the sooner savings will result, which is critical politically. Administrations will change during the course of the program and demonstrated early success could well be necessary for acceptance and continuance of the program by future administrations. Especially in an environment where external economics can cause municipal revenues and budgets to decline rather suddenly, investment programs that show concrete financial returns will be much more likely to survive.

Challenges with EBO scenarios should not be under-estimated, especially around training, motivating, and energy auditing. To achieve the results indicated assumes a process that (a) educates, trains and motivates in-house labor to find low-hanging opportunities and (b) programs energy audits by outside technical firms which will ultimately deepen the internal process by focusing on detailed operational measures that can be implemented without an extensive procurement and construction process. Operating staff must be given the mandate, incentive, and resources to pursue EBO opportunities in their facilities. Specialized consultants need to be available even before integration of EBO analysis into the full energy audit program.

That city government has good reason to utilize the EBO program design is fortuitous. It can help transform the market so that the EBO model can be more readily adopted in the commercial marketplace. There are already publicly supported efforts underway to make this happen in the private real estate sector.[14] But an actual procurement program of the size anticipated for NYC municipal properties provides a major opportunity for addressing problems and barriers.

THE BUSINESS MODEL PROBLEM AND ITS RAMIFICATIONS

If the quantitative business case is so dramatically strong for EBO as a part of a capital improvements program, we need to ask why it is not or has been a standard part of such energy programs. The author believes the answer lies significantly in the business models that govern these programs and, more generally, the engineering and construction industry.

Conventional Model: The “conventional model” for engineering and construction (E&C) focuses on capital projects. The large market in equipment sales is also a central element of the construction industry. It is these large projects that are seen as requiring extensive consulting and construction

[13] Meeting a dollarized proxy target reflects energy savings albeit with a probable over-weighting of more expensive electricity. However, because NYC’s electricity is sourced significantly from nuclear (30%) and hyrdo (20%), the corresponding carbon reduction may be significantly less.

[14] Note NYSERDA’s Building Performance program, its Commercial Real Estate Initiative and parallel efforts by BOMA and the Real Estate Board of NY (REBNY)

services. Design fees and construction margins are related to the cost of projects. Operational enhancements are generally the first to be eliminated in value engineering to preserve budgets. In this business model, O&M considerations receive little attention.

Operations and Maintenance is seen as a cost-center. The "correct" approach to such necessary evils is cost containment. Only rarely is the Facilities Department seen as making a strategic contribution to the organization's mission. Funding O&M is usually not thought of as generating improvements to the corporate bottom-line. Perhaps this may be changing with the Green Buildings movement's "triple bottom line" highlighting such quantifiable aspects of corporate citizenship as Indoor Environmental Quality and its relation to health and productivity. But it is yet to be seen how far this new logic will penetrate the market.

The classic Energy Audit reflects the conventional model. Attention is focused on finding the major equipment replacement or upgrading projects and in quantifying their costs and benefits (energy savings) in order to make the funding case in the capital budgeting process. A section of the report may list O&M recommendations but they are usually not specifically quantified. They are for "in-house" implementation under the Operating Budget, so quantification is not deemed really necessary. Besides, these O&M measures can be devilishly difficult to quantify with audit fees that are always tight and so is it really worth the effort? What clients wants to see is the large-project capital investment recommendations, right? Moreover, if savings are attributed to O&M improvements, there may have to be some corresponding (downward) reductions in the savings attributable to various capital projects!

Impact on EBO. The effect of this prevailing business model is that a relatively small volume of work is done with a non-capital, operational focus. A small volume of operational work leads to limited resources for doing the work. Shortage of resources makes it more difficult and expensive to do this kind of work. Only the most convinced and committed client will persist in pursuing EBO when their trusted long-term engineering consultant tells them that it will be very expensive to do.

The resources in short supply include both manpower with appropriate skills and wage levels, relationships between mainstream and specialist firms, in-house skills, and project tools such as template contract and specification language, cookbook instrumentation and testing procedures, and appropriate, specifically-designed training opportunities. Over the past five years pilots across the country have begun to address these resource needs but their impacts have been thus far restricted to a small number of firms and early adopters.

A Performance Contract Alternative? Performance Contracts[15] represent alternatives in various ways to construction industry conventional practice. It would seem that their contractual commitment to reduce energy cost would lead them to take advantage of EBO opportunities. Perhaps. But there are relational and contractual issues that may inhibit this motivation. Typically, the PC does not assume responsibility for plant staff and all equipment operations (as in the French form, chauffage), so there are thorny issues for who gets credit for what actions. For example, if M&V (monitoring and verification) is established on the basis of a particular measure, the Performance Contractor is unable to take advantage of benefits he might see outside of that measure; in fact, he may actually gain from inefficiencies outside of the measure and not want them corrected. For example, if savings for a chiller replacement are based on the number of chiller run-hours recorded, the PC will not want to see chiller hours reduced even if they can be done so cost-effectively.

In the U.S. at least, the Performance Contract is most often seen as a means to access alternative project finance, i.e., replacing capital equipment using a lease and thus falling under the operating budget, rather than as a way of outsourcing all plant operation. So in this sense, it reflects and follows the conventional Engineering-and-Construction model. The PC could be harnessed for EBO low-hanging fruit harvesting, but the contract would have to be carefully structured to do so.

Other analysts have looked towards third-party property managers as technology brokers and gate-keepers who could facilitate the introduction of

[15] Treatment of Performance Contracts can be found in S.Hansen Performance Contracting, 1996 and 2006. Also see the website for the National Association of Energy Service Companies, www.NAESCO.org . While there is mixed opinion in the public sector regarding the use of performance contracts, useful guidance originally prepared for federal agencies can be found at http://www1.eere.energy.gov/femp/financing/superespcs.html

new practices.[16] The property manager does have a broader scope than the PC and would have the direct authority to address maintenance practices if he were convinced of benefits such as equipment life and improved tenant satisfaction and retention. The Property Manager, however, often does not bear responsibility for energy costs where they are passed on to tenants. Even the motivated manager will be inhibited by difficulties in procurement and expense of services. Individual managers do not have enough market pull to create transformative change in the marketplace.

CONCLUSION: USING THE MUNICIPAL PROGRAM TO CRAFT SOLUTIONS FOR THE MARKET

It is at the need for transformative change in the marketplace where municipal programs, especially one as large as that projected for NYC, can play a leading role. There have been a series of market-priming efforts by state governments around the country – Texas, California, Colorado, New York – aimed at leveraging new practices into effect. These have accomplished much valuable groundwork. The municipal programs offer a long-term market for services and thus can be used to build up the industry that will be necessary to cost-effectively service the private commercial sector.

If a municipal program is going to include EBO activities, such as existing building commissioning and operator training, in its portfolio of measures, it will have to face the weaknesses and difficulties posed by the existing marketplace. Failing to address these weakness will result in deficiencies and under-performance of the EBO component. Solving them will make concrete contributions to the market's ability to provide EBO services cost-effectively. What is expected of both third-party engineering service providers and of in-house operating engineers will be changed in ways that can spread out to the broader commercial real estate industry.

The following list of EBO elements are recommendations for NYC's municipal program design in order to make the program operate better and to guide its change-impact on the broader market.

- Develop model contract provisions that build EBO activities into project general conditions, warranties, service and instrumentation;
- Identify and build into project specifications instrumentation for specific types of retrofits and new equipment installations, coordinating with EBC monitoring and reporting activities;
- Deepen training opportunities and program participation requirements at several levels to increase firm-specific and overall market appreciation of and capabilities for EBO activities: consultants, property managers, service mechanics, operating engineers, and technical students;
- Encourage teaming arrangements for traditional engineering consultants and/or property management firms with specialist EBC firms;
- Develop energy audit procedures that direct consideration of operational measures and prescribe methods to avoid double-counting of projected savings;
- Create program rules that credit in-house labor as matching funding to encourage operating engineer participation. This, more than anything else, will help change the perception of O&M as a cost center where cost minimization rules apply.;
- Institute reporting requirements with financial incentives for documented persistence of savings over extended time periods. This reporting may be integrated with carbon market participation.

With a conscious approach, large city governments can show true leadership and provide real bottom-line value to their local real estate industries, while achieving superior benefits to their real property budgets.

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16 Shockman, Christine and Mary Ann Piette. *Innovation Adoption Processes for Third Party Property Managers*, Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings. Pacific Grove, CA: August 2000.

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